

Geotechnical Engineering Report

Proposed CNG Fueling Facility
Salina Flying J
2250 North Ohio Street
Salina, KS

November 28, 2011
Terracon Project No. 02119525

Prepared for:
Clean Energy
Seal Beach, CA

Prepared by:
Terracon Consultants, Inc.
Lenexa, KS

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Terracon

Geotechnical ■ Environmental ■ Construction Materials ■ Facilities

November 28, 2011



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Salina Flying J
2250 North Ohio Street
Salina, KS
Terracon Project No. 02119525

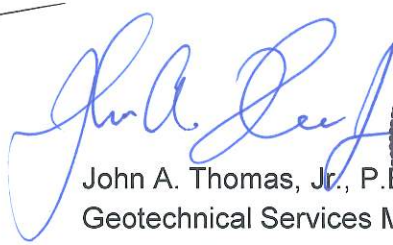
Dear Mr. Farmand:

Terracon Consultants, Inc. (Terracon) has completed the Geotechnical Engineering Services for the above referenced project. This study was performed in general accordance with your MSA Work Order executed November 9, 2011. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design of foundations for the proposed structures.

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

Sincerely,
Terracon Consultants, Inc.


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11/28/2011

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TABLE OF CONTENTS

	Page
EXECUTIVE SUMMARY	i
1.0 INTRODUCTION.....	1
2.0 PROJECT INFORMATION.....	1
2.1 Project Description	1
2.2 Site Location and Description.....	2
3.0 SUBSURFACE EXPLORATIONS AND CONDITIONS.....	2
3.1 Typical Profile.....	2
3.2 Groundwater.....	2
4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION.....	3
4.1 Geotechnical Considerations.....	3
4.2 Earthwork	3
4.2.1 Site Preparation	3
4.2.2 Fill Materials.....	3
4.2.3 Compaction Requirements	4
4.2.4 Grading and Drainage	5
4.2.5 Construction Considerations.....	5
4.3 Foundation Recommendations.....	5
4.3.1 Design Recommendations.....	5
4.3.2 Shallow Footing Construction Considerations	6
4.4 Seismic Site Class.....	6
4.5 Alternate Slab-on-Grade Foundation.....	7
4.5.1 Slab-on-Grade Design Recommendations	7
4.5.2 Slab-on-Grade Construction Considerations	7
4.6 Retaining Walls	8
4.6.1 Wall Foundation Design Recommendations.....	8
4.6.2 Lateral Earth Pressures	8
4.6.3 Construction Considerations.....	9
4.7 Pavements	10
4.7.1 Subgrade Preparation.....	10
4.7.2 Design Recommendations.....	11
4.7.3 Heavy Truck Traffic.....	12
4.7.4 Pavement Surface Drainage.....	13
4.7.5 Pavement Maintenance	13
5.0 GENERAL COMMENTS.....	13

APPENDIX A – FIELD EXPLORATION

Exhibit A-1	Site Location Map
Exhibit A-2	Exploration Location Diagram
Exhibit A-3	Field Exploration Description
Exhibit A-4	Boring Logs – B-1 & B-2

APPENDIX B – LABORATORY TESTING

Exhibit B-1	Laboratory Testing
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APPENDIX C – SUPPORTING DOCUMENTS

Exhibit C-1	General Notes
Exhibit C-2	Unified Soil Classification System

EXECUTIVE SUMMARY

A Geotechnical Engineering Report has been completed for the proposed CNG Fueling Facility at 2250 North Ohio Street in Salina, KS. One (1) boring was advanced to a depth of about 20 feet below existing grade to provide geotechnical information. The samples from the boring were reviewed in our laboratory. This report specifically addresses the recommendations for the proposed fueling facility.

Based on the information obtained from our exploration and testing program, the site can be developed for the proposed project. Geotechnical conclusions and recommendations are summarized in the table below.

ITEM	CONCLUSIONS AND RECOMMENDATIONS
Site Conditions	
Surficial soils	11 inches of asphaltic concrete over silty clay fill to a depth of 3 feet. Fill underlain by fat clay and lean clay.
Groundwater	More than 20 feet below existing grade, based on B-1.
Seismic Design Parameters	
IBC 2009 ¹	Site Class D
Site Development	
Grading	Minor grading anticipated, less than about ½-foot to achieve finished grade.
Compaction	9 inches or less loose fill thickness, 95% maximum standard Proctor dry density (ASTM D-698)
Foundations – Spread Footings	
Minimum depth for frost protection	36 inches
Minimum width	18 inches
Net allowable bearing pressure	2,500 psf
Passive earth pressure coefficient (K_p)	2.5 (ultimate)
Coefficient of sliding friction	0.46 (ultimate)
Foundations – Alternative Slab-on-Grade	
Slab support	12-inch thick layer of compacted ¾-inch crushed stone aggregate
Modulus of subgrade reaction	150 pounds per square inch per in (psi/in)
Minimum depth for frost protection	36 inches or dense insulation boards to provide equivalent of 36 inches of earth cover
Coefficient of sliding friction	0.46 (ultimate)

Geotechnical Engineering Report

Proposed CNG Fueling Facility ■ Salina, KS

November 28, 2011 ■ Terracon Project No. 02119525



ITEM	CONCLUSIONS AND RECOMMENDATIONS
Retaining Walls	
Active	Equivalent fluid density of 51 pcf for level backfill (30% increase for 2H:1V backfill)
At-Rest	Equivalent fluid density of 72 pcf
Asphalt Concrete (AC) Pavements	
Standard duty	2 inches surface AC, 4 inches base AC, prepared subgrade
Heavy duty	2 inches surface AC, 6 inches base AC, prepared subgrade
Heavy truck pavements	2 inches surface AC, 8 inches AC base, prepared subgrade 2 inches surface AC, 6 inches AC base, 6 inches granular subbase, prepared subgrade
Portland Cement Concrete (PCC) Pavements	
Standard duty	6 inches PCC, 4 inches granular subbase course, prepared subgrade
Heavy duty	7 inches PCC, 4 inches granular subbase course, prepared subgrade
Heavy truck pavements	8 inches PCC, 4 inches granular subbase course, prepared subgrade
1. Based on the International Building Code 2009, Table 1613.5.2	

This summary should be used in conjunction with the entire report for design purposes. Details are not included or fully developed in this section; the report should be read in its entirety for a comprehensive understanding of the items contained herein. The section titled **GENERAL COMMENTS** should be read for an understanding of the report limitations.

**GEOTECHNICAL ENGINEERING REPORT
 PROPOSED CNG FUELING FACILITY
 SALINA FLYING J
 2250 NORTH OHIO STREET
 SALINA, KS**

Terracon Project No. 02119525
 November 28, 2011

1.0 INTRODUCTION

A Geotechnical Engineering Report has been completed for the proposed compressed natural gas (CNG) fueling station to be located at the Flying J facility at 2250 North Ohio Street in Salina, KS. One (1) boring was advanced to a depth of approximately 20 feet below the existing ground surface beneath the proposed canopy and in the compressor/storage vessel area. A boring location diagram and log of the boring are included in Appendix A of this report.

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

- subsurface soil conditions
- groundwater conditions
- earthwork
- foundation design and construction
- slab design and construction
- seismic considerations
- retaining wall design and construction
- pavement design and construction

2.0 PROJECT INFORMATION

2.1 Project Description

ITEM	DESCRIPTION
Site location	Appendix A, Exhibit A-1, Boring Location Diagram.
Proposed structures	The proposed fueling station includes a canopied dispenser area, an IMW compressor and a storage vessel within a fenced compound, and associated pavements.
Structure loads	The single cylindrical storage vessel has an estimated weight of about 7,000 pounds. The compressor weight is estimated at about 30,000 pounds.
Maximum allowable settlement	Total Settlement: 1 inch (assumed) Differential Settlement: ½ inch (assumed)
Grading	Plans were not provided. We expect only minor grading, less than about ½ foot, will be required to achieve finished grade.

ITEM	DESCRIPTION
Cut and fill slopes	None expected.
Retaining walls	No information provided at the time of this report.

2.2 Site Location and Description

ITEM	DESCRIPTION
Location	2250 North Ohio Street in Salina, KS
Existing improvements	The site is currently developed for truck parking at the Flying J Travel Center.
Current ground cover	Asphaltic concrete pavement.
Existing topography	Nearly level.

3.0 SUBSURFACE EXPLORATIONS AND CONDITIONS

3.1 Typical Profile

Based on the results of the exploration and observations at the time of drilling, subsurface conditions on the project site can be generalized as follows:

Stratum	Approximate Depth of Bottom of Stratum (feet)	Material Encountered	Consistency/Relative Density
1	11 inches	Asphaltic concrete	N/A
2	3 feet	Fill: Lean clay	Stiff
3	7 feet	Fat clay	Hard
4	Not encountered ¹	Lean clay	Medium stiff to very stiff

1. The boring was terminated in this stratum at a depth of about 20 feet.

Conditions encountered at the boring location are indicated on the individual boring log. Stratification boundaries on the boring log represent the approximate location of changes in soil types; in-situ, the transition between materials may be gradual. Details for the boring can be found on the boring log in Appendix A of this report.

3.2 Groundwater

Groundwater was not encountered in the boring while drilling, or at the completion of drilling. However, fluctuations in groundwater level may occur because of seasonal variations in the amount of rainfall, runoff, and other factors. Groundwater levels during construction or at other times in the life of the structure may be different than the observations during our recent investigation.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

Based on the subsurface conditions encountered at the boring location, we recommend the proposed CNG fueling facility structures be supported by shallow footings bearing directly on stiff native clays or on compacted engineered fill. As an option, the lightly loaded equipment may be placed on a concrete slab-on-grade supported on an approved subgrade and at least 12 inches of clean granular aggregate. Foundations should not bear on existing fill that has not been approved by the geotechnical engineer.

We recommend that the exposed subgrades be thoroughly evaluated after excavation to proposed grade. We recommend that the geotechnical engineer be retained to evaluate the bearing material for the foundation subgrade soils. Subsurface conditions in the exploration have been reviewed and evaluated with respect to the proposed construction plans known to us at this time.

4.2 Earthwork

4.2.1 Site Preparation

Site preparation should commence with removal of all pavements, unapproved fill, and any loose, soft, or otherwise unsuitable material from the proposed construction area. Existing fill materials, if encountered, should be evaluated by the engineer to determine their suitability to remain in place. Unsuitable fill materials should be removed.

Following completion of stripping and rough grading but prior to placement of any fill, the exposed soil subgrades should be proofrolled to help delineate soft or disturbed areas. Unsuitable areas observed during proofrolling should be improved by compaction or by undercutting and placement of controlled engineered fill. Proofrolling may be accomplished with a fully loaded, tandem-axle dump truck or other equipment providing an equivalent subgrade loading. A minimum gross weight of 25 tons is recommended for the proofrolling equipment.

Prior to placement of fill, the moisture content of the exposed grades should be evaluated in all construction areas. Where moisture contents are outside the range recommended for controlled fill, the exposed grade should be scarified to a minimum depth of 6 inches, moisture conditioned and compacted according to the recommendations presented in Section 4.2.3 of this report. If desiccated clay soils are encountered to greater depths, additional undercutting and moisture conditioning will be required.

4.2.2 Fill Materials

All materials incorporated in engineered fill sections free of organic matter and debris. Fill materials should not be frozen and should not be placed on a frozen subgrade. A sample of

each material type should be submitted to the geotechnical engineer for classification testing prior to being used on the site. Materials commonly used as site fills, trench backfill and backfill against structures in this locale and our opinions of locations acceptable for use are presented below.

Material Description	USCS Classification	Acceptable Location for Placement
Lean clay	CL	All locations and elevations.
Fat clay ¹	CH	>2 feet below building and parking areas finished grade.
Clean gravel or crushed stone	GW & GP	All locations and elevations.
Gravel or crushed stone with fines	GM & GC	Most locations; should not be used around foundation drains and elsewhere where free-draining backfill is required

1. Must be placed with strict moisture and density control.

4.2.3 Compaction Requirements

ITEM	DESCRIPTION
Fill Lift Thickness	9-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
Compaction Requirements ¹	95% of the materials maximum standard Proctor dry density (ASTM D 698)
Moisture Content Cohesive Soil (LL < 40)	Within the range of optimum moisture content to 2 percent below to 2 percent above the optimum moisture content value as determined by the standard Proctor test at the time of placement and compaction
Moisture Content Cohesive Soil (LL > 40)	Within the range of optimum moisture content to 4% above the optimum moisture content value as determined by the standard Proctor test at the time of placement and compaction
Moisture Content Granular Material ²	Workable moisture levels

1. We recommend that engineered fill be tested for moisture content and compaction during placement. Should the results of the in-place density tests indicate the specified moisture or compaction limits have not been met, the area represented by the test should be reworked and retested as required until the specified moisture and compaction requirements are achieved.
2. Specifically, moisture levels should be maintained low enough to allow for satisfactory compaction to be achieved without the cohesionless fill material pumping when proofrolled.

4.2.4 Grading and Drainage

The areas surrounding the site should be sloped to promote surface drainage away from foundation excavations during and after construction. Some water may accumulate in excavations as a result of precipitation, runoff and subsurface seepage. In our opinion, it should be possible to remove accumulations of water from foundation excavations using sump pits and pumps.

4.2.5 Construction Considerations

Although the exposed subgrade is anticipated to be relatively stable upon initial exposure, unstable subgrade conditions could develop during general construction operations, particularly if the soils are wetted and/or subjected to repetitive construction traffic. Should unstable subgrade conditions develop, stabilization measures will need to be employed.

Upon completion of filling and grading, care should be taken to maintain the subgrade moisture content prior to construction of floor slabs and pavements. Construction traffic over the completed subgrade should be avoided to the extent practical. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. The completed subgrade should be evaluated by a Terracon representative upon completion of filling operations. Care should be taken to maintain the subgrade moisture content prior to construction. If the subgrade should become desiccated, the affected material should be removed or these materials should be scarified, moistened and recompacted prior to floor slab placement. Likewise, completed subgrades that have become saturated, frozen, disturbed or altered by construction activity should be restored to the condition recommended in this report.

4.3 Foundation Recommendations

In our opinion, the proposed equipment can be supported by a shallow footing foundation system bearing on the stiff native clay or newly placed engineered fill. Design recommendations for shallow foundations for the proposed equipment are presented in the following paragraphs.

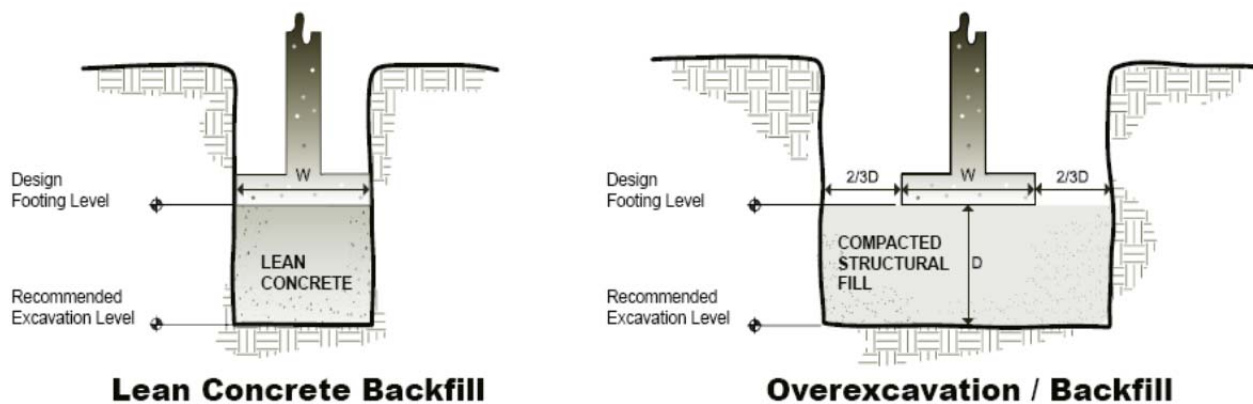
4.3.1 Design Recommendations

Description	Column	Wall
Net allowable bearing pressure ¹	2,500 psf	2,500 psf
Minimum dimensions	30 inches	18 inches
Minimum embedment below finished grade for frost protection	36 inches	36 inches
Approximate total settlement ²	<1 inch	<1 inch
Estimated differential settlement	<¾ inch between columns	<¾ inch over 40 feet
Ultimate passive earth pressure coefficient (Kp) ³	2.5	
Ultimate coefficient of sliding friction ³	0.46	

1. The allowable net bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation.
2. Foundation settlements are a function of applied load, footing size and embedment depth and subsurface profile. Settlement estimates consider loading conditions and subsurface profiles do not vary significantly and a maximum footing width of 6 feet for column footings and 2 feet for continuous footings.
3. The sides of the excavation for the shallow footing foundation must be nearly vertical and the concrete should be placed neat against these vertical faces for the passive earth pressure values to be valid. If the loaded side is sloped or benched, and then backfilled, the allowable passive pressure will be significantly reduced. Passive resistance in the upper 3 feet of the soil profile should be neglected.

4.3.2 Shallow Footing Construction Considerations

If unsuitable bearing soils are encountered in footing excavations, the excavations should be extended deeper to suitable soils and the footings could bear directly on these soils at the lower level or on lean concrete backfill placed in the excavations. The footings could also bear on properly compacted structural fill extending down to the suitable soils. Overexcavation for compacted structural fill placement below footings should extend laterally beyond all edges of the footings at least 8 inches per foot of overexcavation depth below footing base elevation. The overexcavation should then be backfilled up to the footing base elevation with well-graded granular material placed in lifts of 9 inches or less in loose thickness and compacted to at least 98 percent of the material's maximum standard Proctor dry density (ASTM D-698). The overexcavation and backfill procedures are described in the following figure.



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

4.4 Seismic Site Class

CODE REFERENCE	SITE CLASS
2009 International Building Code, Table 1613.5.2	D ¹

1. The 2009 International Building Code (IBC) Site Class definitions are based on the average properties in the top 100 feet of the subsurface profile. Borings conducted for this study extended to a maximum depth of 20 feet. The site class definition considers that similar soils continue below the maximum boring depth. Exploration to greater depths can be performed to confirm the conditions below the current depth of exploration. Geophysical studies can also be performed.

4.5 Alternate Slab-on-Grade Foundation

As an alternative to spread footings, consideration may be given to supporting lightly-loaded structures on a slab-on-grade. The slab-on-grade should be underlain by at least a 12-inch thickness of compacted granular fill consisting of ¾-inch crushed stone placed on the prepared subgrade surface which should be thoroughly compacted. Design recommendations for the slab-on-grade are presented in the following paragraphs. The option does not account for frost protection or shrink/swell considerations.

4.5.1 Slab-on-Grade Design Recommendations

DESCRIPTION	VALUE
Slab support (compacted structural fill or minus ¾-inch crushed stone)	12-inch thick layer
Modulus of subgrade reaction	150 pounds per square inch per in (psi/in)
Minimum embedment below finished grade for frost protection^{1,2}	36 inches
Approximate total settlement³	<1 inch
Estimated differential settlement	<1 inch
Coefficient of sliding friction	0.46 (ultimate)

1. Consideration should be given to using dense insulation boards (Dow Styrofoam Highload, or similar) under and adjacent to lightly loaded slabs-on-grade, to provide the equivalent of 36 inches of earth cover, thus reducing frost penetration.
2. Air entraining admixtures should be used for concrete exposed to freezing.
3. Settlement will depend upon the variations within the subsurface soil profile, the structural loading conditions, the thickness of compacted fill, and the quality of the earthwork operations.

4.5.2 Slab-on-Grade Construction Considerations

Site grading is generally accomplished early in the construction phase. However, as construction proceeds, the subgrade may be disturbed by foundation excavations, construction traffic, rainfall, etc. As a result, the slab subgrade may not be suitable for placement of granular fill and corrective action will be required.

We recommend the area underlying the slabs be rough graded and then thoroughly proofrolled prior to final grading and placement of granular fill. Particular attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas previously filled or backfilled. Areas where unsuitable or unstable conditions are located should be repaired by removing and replacing the affected material with properly compacted granular fill.

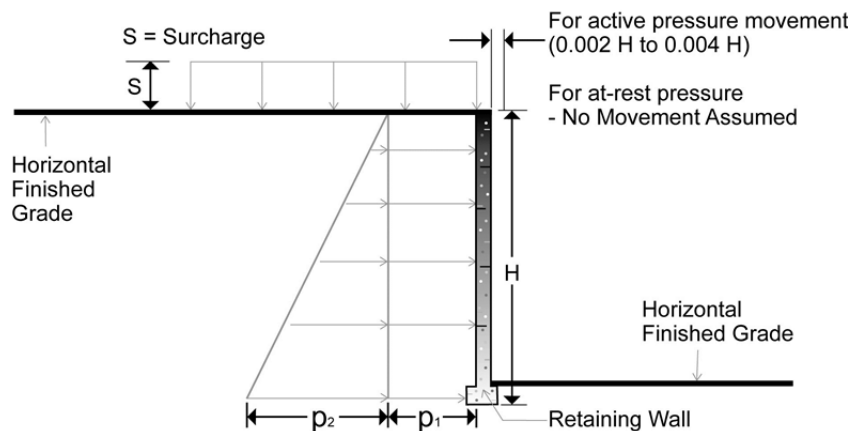
4.6 Retaining Walls

4.6.1 Wall Foundation Design Recommendations

DESCRIPTION	VALUE
Net allowable bearing pressure	2,500 psf
Bearing stratum	Lean clay or engineered fill
Minimum embedment below finished grade for frost protection	36 inches
Ultimate coefficient of sliding friction	0.46 (ultimate)

4.6.2 Lateral Earth Pressures

Reinforced concrete walls with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to those indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained. Two wall restraint conditions are shown. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. The at-rest condition assumes no wall movement. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls.



Earth Pressure Coefficients

Earth Pressure Conditions	Coefficient for Backfill Type	Equivalent Fluid Density (pcf)	Surcharge Pressure, p_1 (psf)	Earth Pressure, p_2 (psf)
Active (K_a)	Granular - 0.33	41	$(0.33)S$	$(41)H$
	Lean Clay - 0.41	51	$(0.41)S$	$(51)H$
At-Rest (K_o)	Granular - 0.50	63	$(0.50)S$	$(63)H$
	Lean Clay - 0.58	72	$(0.58)S$	$(72)H$
Passive (K_p)	Granular - 3.0	375	---	---
	Lean Clay - 2.5	310	---	---

Applicable conditions to the above include:

- For active earth pressure, wall must rotate about base, with top lateral movements of about $0.002 H$ to $0.004 H$, where H is wall height
- For passive earth pressure to develop, wall must move horizontally to mobilize resistance
- Uniform surcharge, where S is surcharge pressure
- In-situ soil backfill weight a maximum of 125 pcf
- Horizontal backfill, compacted between 95 and 98 percent of standard Proctor maximum dry density
- Loading from heavy compaction equipment not included
- No hydrostatic pressures acting on wall
- No dynamic loading
- No safety factor included in soil parameters
- Ignore passive pressure in frost zone

Backfill placed against structures may consist of granular soils or clay soils. For the granular values to be valid, the granular backfill must extend out from the base of the wall at an angle of at least 45 and 60 degrees from vertical for the active and passive cases, respectively. To calculate the resistance to sliding, a value of 0.46 should be used as the ultimate coefficient of friction between the footing and the underlying soil.

To reduce buildup of hydrostatic pressure behind the wall, we recommend that a drain be installed at the foundation level. Foundation drains should be sloped, where possible, to a reliable down-gradient discharge or to one or more sump pits equipped with pumps of sufficient capacity to remove accumulating water.

If drainage is not possible, then the below-grade walls should be designed to resist the combined hydrostatic and lateral earth pressures. In our opinion, walls backfilled using clay soils should be designed using an equivalent fluid weighing 90 and 100 pcf for active and at-rest conditions, respectively. For granular backfill, an equivalent fluid weighing 85 and 90 pcf should be used for active and at-rest, respectively. These pressures do not include the influence of surcharge, equipment or floor loading, which should be added. Heavy equipment should not operate within a distance closer than the exposed height of retaining walls to prevent lateral pressures more than those provided. Walls that will be subjected to hydrostatic pressure should also be covered with appropriate waterproofing materials and water stops should be used at all construction joints.

4.6.3 Construction Considerations

The contractor should be required to maintain a stable subgrade during construction. The contractor should prevent water, if encountered, and surface water runoff from collecting in the excavation. Subgrade soils that become unstable because of water and/or reworking by

construction activity should be replaced with compacted engineered fill or minus ¾-inch crushed stone aggregate, as necessary.

Retaining walls designed as free-standing walls under active case earth pressures can normally be backfilled upon completion of the wall. Retaining and foundation walls designed as braced walls and at-rest earth pressure conditions should not be backfilled until the bracing is in place.

As a minimum, temporary excavations should be sloped or braced as required by Occupational Health and Safety Administration (OSHA) regulations to provide stability and safe working conditions. Temporary excavations will probably be required during grading operations. The contractor, by his contract, is usually responsible for designing and constructing stable, temporary excavations and should shore, slope or bench the sides of the excavations, as required, to maintain stability of both the excavation sides and bottom. All excavations should comply with applicable local, State, and federal safety regulations, including the current OSHA Excavation and Trench Safety Standards.

The geotechnical engineer should be retained during the construction phase of the project to observe earthwork and to perform necessary tests and observations during subgrade preparation; proofrolling; placement and compaction of controlled compacted fills; backfilling of excavations into the completed subgrade, and just prior to construction of foundations.

4.7 Pavements

4.7.1 Subgrade Preparation

Pavement areas should be initially developed as recommended in Section 4.2.1 of the **Earthwork** section this report. Fills should be placed and compacted as recommended in Section 4.2.3.

On most project sites, the site grading is accomplished relatively early in the construction phase. Fills are placed and compacted in a uniform manner. However, as construction proceeds, excavations are made into these areas, rainfall and surface water saturates some areas, heavy traffic from concrete trucks and other delivery vehicles disturbs the subgrade and many surface irregularities are filled in with loose soils to improve trafficability temporarily.

As a result, the pavement subgrades, initially prepared early in the project, should be carefully evaluated as the time for pavement construction approaches. We recommend the moisture content and density of the top 9 inches of the subgrade be evaluated and the pavement subgrades be proofrolled within 2 days prior to commencement of actual paving operations. Areas not in compliance with the required ranges of moisture or density should be moisture conditioned and recompacted. Particular attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas where backfilled trenches are located. Areas where unsuitable conditions are located should be repaired by removing and replacing the materials

with properly compacted fills. After proofrolling and repairing deep subgrade deficiencies, the entire subgrade should be scarified to a depth of 9 inches and uniformly compacted to at least 95% of standard Proctor to provide a uniform subgrade for pavement construction. Areas that appear severely desiccated following site stripping may require further undercutting and moisture conditioning. If a significant precipitation event occurs after the evaluation or if the surface becomes disturbed, the subgrade should be reviewed by qualified personnel immediately prior to paving. The subgrade should be in its finished form at the time of the final review.

4.7.2 Design Recommendations

The proposed facility may require the removal and replacement of the existing pavement. The table below presents recommended Asphalt Concrete (AC) and Portland Cement Concrete (PCC) pavement sections for anticipated standard and heavy-duty traffic levels.

Traffic Area	Asphalt Concrete Top Surface Course (inches)	Asphalt Concrete Binder Base Course (inches)	Portland Cement Concrete (inches)	Granular Subbase Course (inches)	Total Thickness (inches)
AC Standard Duty	2	4	N/A	0	6
AC Heavy Duty	2	6	N/A	0	8
PCC Standard Duty	N/A	N/A	6	4	10
PCC Heavy Duty	N/A	N/A	7	4	11

Pavement designs were based on *AASHTO Guide for Design of Pavement Structures (1993)* and our experience with similar projects. The thickness of each course is a function of subgrade strength, traffic, design life, serviceability factors, and frost susceptibility. The design of pavement thickness was based on the following:

- 60,000 18-kip Equivalent Axle Loads (EALs) for standard-duty parking lot
- 100,000 18-kip EALs for heavy-duty driveways and truck access lanes
- Soil characterization of “fair”, based on the encountered subsurface conditions
- Design life of 20 years

Pavements subjected to high traffic volumes and heavy trucks require thicker pavement sections. Portland cement concrete pavement is recommended for areas subjected to concentrated and repetitive loading conditions, such as the dispenser island and ingress/egress aprons.

Pavement specifications should conform with the Kansas Department of Transportation (KDOT) specifications.

4.7.3 Heavy Truck Traffic

Based on our understanding of the proposed use of the pavements and AASHTO guidelines for design of pavements, we considered the following.

- The pavements will be subjected to truck traffic 5 days a week for 52 weeks per year
- Truck traffic: 40 per day
- Performance period: 20 years
- Annual traffic growth rate of 1.5%
- CBR of 2 (estimated)
- Terminal serviceability of 2.0
- Reliability of 85%
- Estimated 18 kips Equivalent Single Axle Loads (ESALs) of 1,000,000

Based on these considerations and using AASHTO pavement design methods, the estimated minimum AC pavement thicknesses are summarized below. Should weather and schedule become a concern, an alternate pavement section using aggregate base is provided.

Heavy Truck Pavement Section Alternatives

ASPHALTIC CONCRETE (AC)	HEAVY TRUCK PAVEMENT	
AC Surface Course	2-inch (minimum)	2-inch (minimum)
AC Base Course	8-inch (minimum)	6-inch (minimum)
KDOT AB-3 Aggregate Base	none	6-inch (minimum)
Total Thickness	10 inches	14 inches

Portland cement concrete (PCC) pavements may also be considered for heavy truck traffic and in any other areas subjected to heavy wheel loads and/or turning traffic. We recommend placement of a minimum 4-inch thick leveling and drainage course of open-graded crushed rock (such as ASTM C 33 Size No. 57 aggregate, or equivalent) below all PCC pavements. The pavement subgrade should be graded to provide positive drainage within the granular base section. Appropriate subdrainage or connection to a suitable daylight outlet should be provided to remove water from the granular subbase.

PORTLAND CEMENT CONCRETE (PCC)	HEAVY TRUCK PAVEMENTS
PCC Surface Pavement	8-inch (minimum)
ASTM C 33 Size No. 57	4-inch (minimum)

4.7.4 Pavement Surface Drainage

Pavements should be sloped to provide rapid drainage of surface water. Water allowed to pond on or adjacent to the pavements could saturate the subgrade and contribute to premature pavement deterioration. The pavement sections provided in this report represent minimum recommended thicknesses and, as such, periodic maintenance should be anticipated. All cracks and joints should be periodically sealed and proper surface drainage should be maintained.

4.7.5 Pavement Maintenance

Pavement thickness determination methods are intended to provide adequate thickness of structural materials over a particular subgrade such that wheel loads are reduced to a level that the subgrade can support. The subgrade support parameters for pavement thickness design do not account for shrink/swell movements of a subgrade constructed of expansive clay soils like those encountered in parts of this site. Therefore, the pavement may be adequate from a structural standpoint, yet still experience cracking and deformation due to shrink/swell related movement of the subgrade. Moisture changes in the subgrade should be minimized to reduce shrink/swell movements. All pavements should be sloped to provide rapid drainage of surface water. Water allowed to pond on or adjacent to the pavements could saturate the subgrade and contribute to premature pavement deterioration. Periodic maintenance of all of the pavements, including sealing of all cracks and joints and maintenance of proper surface drainage, should be anticipated. Even with periodic maintenance, some movements and related cracking may still occur and repairs may be required.

5.0 GENERAL COMMENTS

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

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

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

Geotechnical Engineering Report

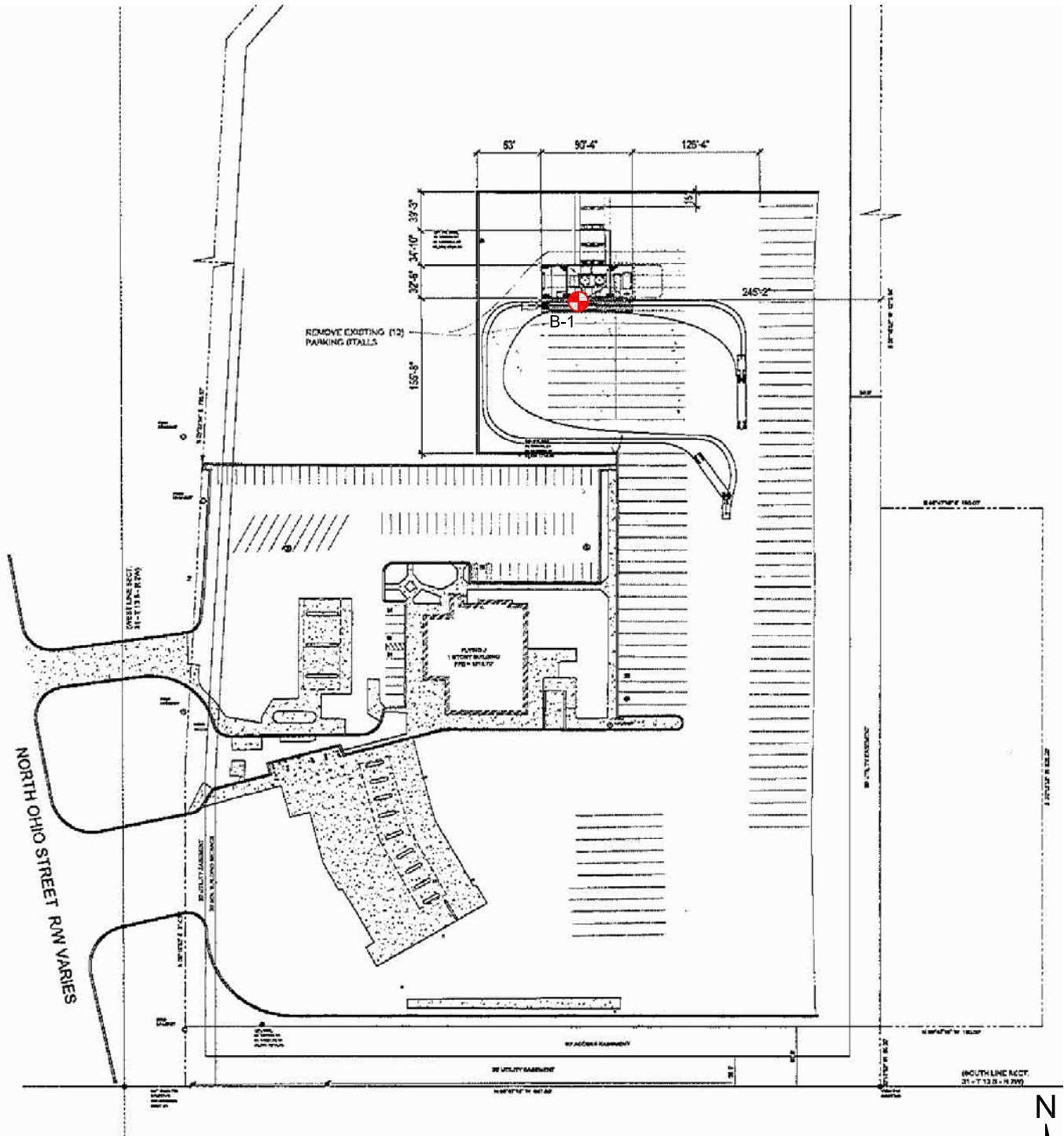
Proposed CNG Fueling Facility ■ Salina, KS

November 28, 2011 ■ Terracon Project No. 02119525



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

APPENDIX A
FIELD EXPLORATION



LEGEND

 BORING LOCATION

DIAGRAM IS INTENDED FOR GENERAL USE ONLY, AND IS NOT FOR CONSTRUCTION PURPOSES. LOCATIONS ARE APPROXIMATE.

Project Mng:	EMK
Approved By:	DBM
Checked By:	EMK
Drawn By:	DBM
Project No.	02119525
Scale:	1" = 150'
Date:	11/21/11
File No.	119525.DWG

Terracon
 Consulting Engineers and Scientists
 13910 W. 96TH TERRACE LENEXA, KS 66215
 PH. (913) 492-7777 FAX. (913) 492-7443

EXHIBIT 1 - BORING LOCATION DIAGRAM
 SALINA FLYING J - CNG FUELING FACILITY
 2250 NORTH OHIO STREET
 SALINA, KS

EXHIBIT
 1

LOG OF BORING NO. B-1

CLIENT <p style="text-align: center;">Clean Energy Company</p> SITE <p style="text-align: center;">2250 North Ohio Street Salina, KS</p>	PROJECT <p style="text-align: center;">Salina Flying J CNG Fueling Station</p>
--	--

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	SAMPLES				TESTS						
			USCS SYMBOL	NUMBER	TYPE	RECOVERY, in	SPT-N BLOWS / ft.	WATER CONTENT, %	DRY UNIT WT pcf	UNCONFINED STRENGTH, psf	Liquid Limit	Plastic Limit	Plasticity Index
	Approx. Surface Elev.: 93.5 ft												
0.9	11" ASPHALTIC CONCRETE	92.5			PA								
3	FILL, lean clay, gray, stiff	90.5	CL	1	ST	6		23	97	4000*	44	22	22
7	FAT CLAY, gray, brown, hard	86.5	CH	2	ST	21		25	97	9000*			
	LEAN CLAY, silty, light brown, medium stiff to very stiff				PA								
			CL	3	ST	8		21	100	2000*			
					PA								
			CL	4	ST	7		21	104	5500*			
					PA								
			CL	5	ST	10		21	102	4000*			
	BOTTOM OF BORING	73.5											

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

*Calibrated Hand Penetrometer

WATER LEVEL OBSERVATIONS, ft			
WL	∇ NONE	WD	∇ NONE AB
WL	∇		∇
EXHIBIT A-2			



BORING STARTED		11-13-11	
BORING COMPLETED		11-13-11	
RIG	D-50	FOREMAN	KK
APPROVED	EMK	JOB #	02119525

BOREHOLE 02119525.GPJ TERRACON.GDT 11/28/11

Geotechnical Engineering Report

Proposed CNG Fueling Facility ■ Salina, KS

November 28, 2011 ■ Terracon Project No. 02119525



Field Exploration Description

The boring location was staked by Terracon at a location shown on a preliminary site plan supplied by Clean Energy. The ground surface elevation indicated on the boring log is rounded to the nearest ½-foot and was obtained by the drill crew using a surveyor's level and rod. The elevation was referenced to the north entrance of the existing building. An assumed elevation of 100.0 feet was used for this reference. The location and elevation of the boring should be considered accurate only to the degree implied by the means and methods used to define them.

The boring was drilled with a truck-mounted rotary drill rig using continuous flight solid-stem augers to advance the borehole. Samples of the soil encountered in the borings were obtained using the thin-walled tube sampling procedures.

In the thin-walled tube sampling procedure, a thin-walled, seamless steel-tube with a sharp cutting edge is pushed hydraulically into the soil to obtain a relatively undisturbed sample. The samples were tagged for identification, sealed to reduce moisture loss, and taken to our laboratory for further examination, testing, and classification. Information provided on the boring log attached to this report includes soil descriptions, consistency evaluations, boring depth, sampling intervals, and groundwater conditions. The boring was backfilled with auger cuttings prior to the drill crew leaving the site.

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

APPENDIX B
LABORATORY TESTING

Geotechnical Engineering Report

Proposed CNG Fueling Facility ■ Salina, KS

November 28, 2011 ■ Terracon Project No. 02119525



Laboratory Testing

Soil samples were tested in the laboratory to measure their natural water content and dry unit weight. A calibrated hand penetrometer was used to estimate the approximate unconfined compressive strength of the samples. The calibrated hand penetrometer has been correlated with unconfined compression tests and provides a better estimate of soil consistency than visual examination alone. An Atterberg limits test was also conducted on sample no. 1. The test results are provided on the boring log included in Appendix A.

Descriptive classifications of the soils indicated on the boring log are in accordance with the enclosed General Notes and the Unified Soil Classification System. Also shown are estimated Unified Soil Classification Symbols. A brief description of this classification system is attached to this report. All classification was by visual manual procedures.

APPENDIX C
SUPPORTING DOCUMENTS

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

SS:	Split Spoon - 1- ³ / ₈ " I.D., 2" O.D., unless otherwise noted	HS:	Hollow Stem Auger
ST:	Thin-Walled Tube – 2" O.D., 3" O.D., unless otherwise noted	PA:	Power Auger (Solid Stem)
RS:	Ring Sampler - 2.42" I.D., 3" O.D., unless otherwise noted	HA:	Hand Auger
DB:	Diamond Bit Coring - 4", N, B	RB:	Rock Bit
BS:	Bulk Sample or Auger Sample	WB:	Wash Boring or Mud Rotary

The number of blows required to advance a standard 2-inch O.D. split-spoon sampler (SS) typically the middle 12 inches of the total 24-inch penetration with a 140-pound hammer falling 30 inches is considered the "Standard Penetration" or "N-value".

WATER LEVEL MEASUREMENT SYMBOLS:

WL:	Water Level	WS:	While Sampling	BCR:	Before Casing Removal
WCI:	Wet Cave in	WD:	While Drilling	ACR:	After Casing Removal
DCI:	Dry Cave in	AB:	After Boring	N/E:	Not Encountered

Water levels indicated on the boring logs are the levels measured in the borings at the times indicated. Groundwater levels at other times and other locations across the site could vary. In pervious soils, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater levels may not be possible with only short-term observations.

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.

CONSISTENCY OF FINE-GRAINED SOILS

<u>Unconfined Compressive Strength, Qu, psf</u>	<u>Standard Penetration or N-value (SS) Blows/Ft.</u>	<u>Consistency</u>
< 500	0 - 1	Very Soft
500 – 1,000	2 - 4	Soft
1,000 – 2,000	4 - 8	Medium Stiff
2,000 – 4,000	8 - 15	Stiff
4,000 – 8,000	15 - 30	Very Stiff
8,000+	> 30	Hard

RELATIVE DENSITY OF COARSE-GRAINED SOILS

<u>Standard Penetration or N-value (SS) Blows/Ft.</u>	<u>Relative Density</u>
0 – 3	Very Loose
4 – 9	Loose
10 – 29	Medium Dense
30 – 50	Dense
> 50	Very Dense

RELATIVE PROPORTIONS OF SAND AND GRAVEL

<u>Descriptive Term(s) of other constituents</u>	<u>Percent of Dry Weight</u>
Trace	< 15
With	15 – 29
Modifier	≥ 30

GRAIN SIZE TERMINOLOGY

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

RELATIVE PROPORTIONS OF FINES

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

PLASTICITY DESCRIPTION

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

UNIFIED SOIL CLASSIFICATION SYSTEM

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

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

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

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

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

^E $Cu = D_{60}/D_{10}$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

^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 ≥ 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.

