TRIAX ENGINEERING

GEOTECHNICAL ENGINEERING❖QA/QC TESTING AND INSPECTIONS❖ENVIRONMENTAL SITE ANALYSES

Preliminary Geotechnical Investigation

Shelton Studio Ranch

850 Shelton Rd

Golden, CO

Mr. Nate Herman

850 Shelton Rd

Golden, CO 80401

	PHONE	FAX	WEB
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November 26, 2018

Mr. Nate Herman
850 Shelton Rd
Golden, CO 80401

Re: **Preliminary Geotechnical Investigation Report**
Shelton Studio Ranch
850 Shelton Rd
Golden, CO

Project No: D18G158

Mr. Herman:

Pursuant to your request, Triax Engineering, LLC ("Triax") has completed the Preliminary Geotechnical Investigation for Shelton studio ranch at 850 Shelton Rd in Golden, CO. The attached report presents the results of the field investigation and laboratory testing and other recommendations related to the proposed residential subdivision.

We appreciate and wishes to thank you for the opportunity to be of service to you on this project. If we can be of additional assistance, please contact us at (720) 230-1931.

Very Truly Yours,
Triax Engineering, LLC

COLORADO LICENSED VINOD RAVINDRAN PROFESSIONAL ENGINEER

Digitally signed by Vinod Ravindran
cn=Vinod Ravindran, o= Triax Engineering, LLC, l= Denver, st= Colorado, c= US, email= vravindran@triaxgeo.com
Date: 2018.11.28 15:07:39 MST

Vinod Ravindran, PE
President

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Attachments:
Boring Location Plan
Boring Logs
Key to Classification Terms
Laboratory Test Results

EXECUTIVE SUMMARY

The soil conditions at the site of the proposed Residential subdivision located at 850 Shelton Rd Shelton Studio Ranch in Golden, CO, was explored by drilling six borings to depths of up to 20-ft each. Laboratory tests were performed on selected specimens to evaluate the engineering characteristics of various soil strata encountered in our borings.

This report presents a description of subsurface conditions encountered at the site. Our scope of investigation is limited to pavement thickness design, slope stability analysis for Lot 5 roadway access and general earthwork recommendations for underground utilities.

- The subsurface conditions may generally be grouped into two generalized strata with similar physical and engineering properties. For detailed descriptions, the boring logs provided at the end of this report. Soils encountered at project site are clays, sandy clay and their variation.
- Ground water seepage was not encountered in our borings during the time of our field exploration. However, ground water levels will fluctuate with seasonal climatic variations and changes in the land use.
- Pavement subgrade soils encountered are mostly clayey sands and silty sands. Per AASHTO soil classification, silty sands and clayey sands are rated as excellent to good. Over excavation and other soil modifications can be considered to improve the performance of the pavement.
- Weathered sandstone bedrock was encountered between depths of 2.5-ft to 20-ft in our borings.
- A minimum factor of safety of 1.65 was calculated for the final grading conditions at the drive access for Lot 5 at proposed grading conditions.
- Additional exploration and analyses will be required, specific to each planned improvement in order to develop final structural design parameters and to confirm and/or modify the preliminary recommendations and conclusions contained in this report.

1. Introduction:

This report presents the results of our Preliminary Geotechnical Investigation Report for the proposed residential subdivision at 850 Shelton Rd in Golden, CO. The object of this investigation was to evaluate the physical properties of the soils underlying the site.

2.0 Proposed Construction:

The proposed Shelton Studio Ranch subdivision will consist of thirteen single family residences, located within an approximate total area of 9.28 acres. The proposed development will have associated roadways, drives, community and private open spaces. The proposed single family residences will consist of a concrete floor system with masonry walls and wood frame construction above grade. Should designs details differ from those presented, this firm should be notified so we can provide additional recommendations, if required.

3.0 Purpose and Scope of Services:

The purpose of our geotechnical investigation was to evaluate the site's subsurface and ground water conditions. Our scope of services includes the following:

1) Drilling and sampling of six borings to depths of 20-ft each.
2) Evaluation of the in-place conditions of the subsurface soils through Standard Penetration tests
3) Observation of the ground water conditions during field exploration operations;
4) Performing laboratory tests such as Atterberg limits, gradations and moisture content tests;
5) Review and evaluation of the field and laboratory test programs during their execution with modifications of these programs, when necessary, to adjust to subsurface conditions revealed by them;

The Scope of Services did not include any environmental assessment for the presence or absence of wetlands or hazardous or toxic materials in the soil, surface water, groundwater, or air, on or below or around this site. Any statements in this report or on the boring logs regarding odors, colors or unusual or suspicious items or conditions are strictly for the information of the client.

Our scope of investigation is limited to pavement thickness design, slope stability analysis for Lot 5 roadway access and general earthwork recommendations for underground utilities.

4.0 Site Conditions:

The project site was approximately 9.28 Acres in total area. At the time of our subsurface exploration, the project site did not appear to have any improvements. The project site was located in the east facing slopes below lookout mountain, to the west of Hwy 6. The existing residence and out buildings were located within Lot 3 as identified in the site plan. The remainder of the site appeared to be in its native conditions.

Ground surfaces across the majority of the site slope downward to the east from maximum elevations of about 6,140 feet above sea level down to minimum elevations of about 6,000 feet above sea level to the east. Grades measured from existing topographic maps and visually estimated ranged from 10 percent to 20 percent, with steeper grades along the upper parts of the site to the west and along the sides of Kenny's Run Tributary. Vegetation consists of native grasses, weeds and brush over most of the site with dense scrub oak in Kenny's Run Tributary. Scrub oak, conifer and deciduous trees are scattered across the site and are most prevalent in the southern part of the site.

5.0 Geologic Setting:

The general site geology information was gathered from the geological maps published by United States Geological Survey (USGS) and through our experience in the general project area. The southwest corner of the site and slopes above are underlain by crystalline igneous rocks of Precambrian aged basement complex. The remainder of the site is underlain by sandstones of the Pennsylvanian-aged to Permian-aged Fountain Formation. Bedrock orientation of the Fountain Formation is judged to strike north-south with steep dip downward to the east.

Overlying the bedrock are various surficial deposits that include several Quaternary-aged glacial deposits from subsequent glacial episodes and recent deposits not shown on the published mapping consisting of colluvium, alluvium and some debris flow deposits.

Figure 1 Project Vicinity and Approximate Boundaries

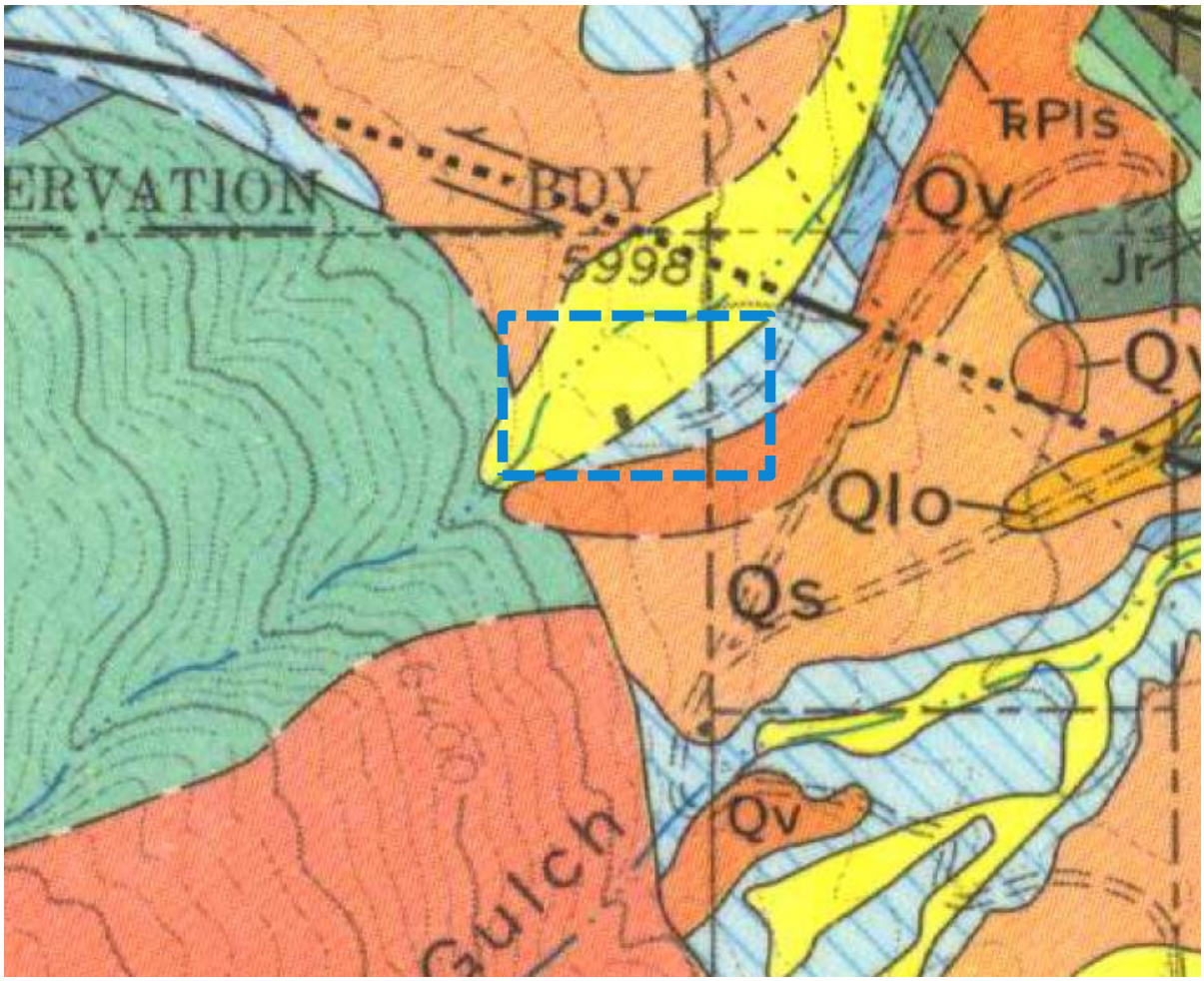

Figure 2 Geological setting of project site

6.0 Geotechnical Investigation:

Subsurface conditions were investigated by drilling six borings to depths of up to 20-ft each, from the existing grade at the locations indicated on the Site Map. The borings were advanced using a 4-inch diameter continuous flight auger powered by a CME-45 drilling rig. Samples were taken at selected intervals using a Standard split spoon and a California ring sampler, which was driven into the soil by dropping a 140-pound hammer through a free fall of 30 inches. The number of blows required to drive the sampler into the soil is known as a penetration test. The number of blows required for the sampler to penetrate 12 inches is evaluated and gives an indication of the consistency or relative density of the soils and bedrock encountered. The results of the

penetration test and log of materials encountered are presented in the Logs of Exploratory Boring. Samples were returned to the laboratory where they were visually classified and testing was assigned to evaluate the engineering properties of the soil layers. Laboratory testing consisted of moisture and density determinations, and gradation tests. The results of the laboratory testing are also presented in this report.

The results of the penetration test and log of materials encountered are presented in the Logs of Exploratory Borings. Samples were returned to the laboratory where they were visually classified and testing was assigned to evaluate the engineering properties of the soil layers. Laboratory testing consisted of moisture and density determinations, and gradation tests. The results of the laboratory testing are also presented in this report.

Table 1 Summary of Field Exploration

Boring No.	Depth (ft)
B-1	20-ft
B-2	20-ft
B-3	20-ft
B-4	Auger Refusal at 8-ft
B-5	Auger Refusal at 2.5-ft
B-6	Auger Refusal at 7-ft

7.0 General Subsurface Conditions:

The subsurface conditions may generally be grouped into two generalized strata with similar physical and engineering properties as per the boring logs provided at the end of this report.

Majority of the soils encountered in our exploratory borings were Slilty / Clayey Sands (SM, SC). Weathered sandstone bedrock was encountered between depths of 2.5-ft and 17-ft in our borings.

Table 2 Subsurface Stratigraphy

Material Description	Approximate Depth (ft)	Consistency
Silty Sand	0-17	Dense to Very Dense
Weathered Sandstone / Conglomerate	2.5-25	Very Dense

Fill soils were not recognized in our exploratory borings, but can be present in localized areas. Delineation of the complete lateral and vertical extents of fills at the site, or their compositions, was beyond our present scope of services. If fill soil volumes and compositions at the site are of significance, they should be evaluated using test pits.

Clayey / Silty Sands

Clayey sands and silty sands were encountered between 0-ft to 17-ft in our exploratory borings. Silty sands encountered were generally dry, consisting of medium to fine sands with 3% to 25% of gravel.

Our lab tests indicated low to moderate risk of swell potential for the shallow underlying soils at the project site.

Sandstone Bedrock

Very dense sandstone, interbedded with siltstone / claystone bedrock was encountered below a depths ranging from 3-ft to 15-ft.

8.0 Groundwater Conditions:

Ground water seepage was not observed in our borings during drilling operations. However, ground water levels will fluctuate with seasonal climatic variations and changes in land use. It is not unusual to encounter shallow ground water during snow melt or during or after periods of precipitation. The surface water tends to percolate down until it encounters a relatively impervious layer.

Table 3 Groundwater Conditions

Boring No.	Date of Measurement	Depth from Existing grade (ft)
B-1	10/5/18	N/a
B-2	10/5/18	N/a
B-3	10/5/18	N/a
B-4	10/5/18	N/a
B-5	10/22/18	N/a
B-6	10/5/18	N/a

Accurate determination of the groundwater elevation may not be possible even after several days of observation. Seasonal variation, temperature, recent precipitation and localized construction activities that influence drainage characteristics may influence the groundwater table and volumes of water will depend on the permeability of soils. Groundwater conditions can differ between borehole locations and in areas not explored.

9.0 Preliminary Design Engineering Analysis:

The recommendations presented below are based on the data obtained from our field and laboratory tests, our past experience with geotechnical conditions similar to those at this site, and our engineering design analysis. The purpose of the investigation is to determine existing general soil conditions at the project site. This report

provides general recommendations to help mitigate the effects of soil shrinkage and expansion. However, even if these procedures are followed, some movement should be anticipated.

The design engineering analysis did not consider any particular building or building type, rather general soil conditions at the project site. The proposed use of the project site is a residential development at the time of our investigation.

10.0 Seismic Considerations:

Based on the Chapter 20 of ASCE 7 / 2012 IBC Table No. 1613.3.2, a site classification of "D" shall be used for the structures in the proposed structure. The project site falls in to AASHTO Seismic design category A. The site classification is based on the available geological data to an average depth of 100-ft and our previous experience with soil conditions in the general project area.

11.0 Slope Stability Analysis:

A slope stability analysis was performed at the location of the roadway access to lot 5, using the geotechnical data from our field exploration (B-5 and B-6). Our study utilized simplified Bishop Method to perform a computerized slope stability analysis using Geostru Slope Stability Software Package.

- Correlations from raw standard penetration test (blow counts) were utilized to obtain strength parameters for the analysis. Soil stratigraphy was extrapolated from available geotechnical data to perform our analysis.

- Test data available, such as blow counts and unconfined compressive strength provides short term strength parameters. Since limited long term strength data available, we estimated the long term strength of the soil based on the short term strength values and our experience with the soils in this area.

Table 4 Slope Stability Parameters

Soil Type	Cohesion (psf)	Undrained Cohesion (psf)	Angle of internal friction (undrained)	Unit Weight (pcf)
Clayey Sands	--	--	36	112
Sandstone	--	--	30	115

- The failure plane for the slope is forced to occur in the overburden and will not penetrate into the harder underlying layers unless failure planes are already existing in these layers. A 200 psf surcharge is utilized for the load imposed by traffic.
- Using the generalized stratigraphy from the geotechnical data, the previously mentioned soil strength values and soil profile provided the following factor of safeties. The critical failure surface is shown on the attached plates.
- The factor of safety of the failure surface passing through the overburden and fill is controlled by the strength of the proposed fill. It is very important that the fill to be used be tested to determine the actual strength as compared to the values assumed in our report. If the strength varies significantly from our assumed values it will be necessary to reanalyze the stability of the slope.

Table 5 Slope Stability Factor of Safety

Condition	Minimum Factor of Safety Identified
Grading conditions according to Sheet 4 dated 11/11/2018	1.65

12.0 Pavement Design Recommendations:

It is our understanding that there will be light-duty, pavement/parking associated with the proposed construction. The following designs have been based on American Association of State Highway and Transportation Officials (AASHTO) Guideline for Design of Pavement Structures. Areas within the proposed

pavement on the site have been divided into two categories based upon anticipated usage. We assume that the final pavement grades will provide adequate drainage for the pavement areas and that water will not be allowed to enter the pavement system by either edge penetration adjacent to landscape areas or penetration from the surface due to surface ponding, or inadequate maintenance of pavement joints, or surface cracks that may develop.

12.1 Subgrade Soils:

Pavement subgrade soils encountered are mostly silty sands. Per AASHTO soil classification, onsite soils are rated as excellent to good. Over excavation and other soil modifications can be considered to improve the performance of the pavement. We estimated a design R-value of 7 for the pavement design, a resilient modulus (M_R) of 3230 psi and a modulus of subgrade reaction (k-value) of 80 pci by correlation.

12.2 Water Soluble Sulfates:

Laboratory test results indicate 0.0% by dry weight of water soluble sulfates, for selected samples. Severity of potential exposure to water soluble sulfates is classified minimal for this site.

12.3 Traffic Estimates:

Traffic estimates were not available during the preparation of this report. For the purpose of this report, it has been assumed that the two designs will be for general automotive parking areas and drive areas.

Table 6 Traffic Estimates

Areas	20 year ESAL
Parking Areas	18,500
Drive Areas	18,500

12.4 Drainage:

For design purposes, local drainage characteristics of proposed pavements areas are considered fair. These characteristics, coupled with the approximate duration of saturated subgrade conditions, results in a design drainage coefficient of 0.90 when applying the AASHTO criteria for design.

For the flexible pavement design, a terminal serviceability index of 2.00 was utilized along with an initial serviceability of 4.2. An inherent reliability of 70% and design life of 20 years was assumed.

The recommendations provided shall be compared to the local agency pavement design standards and in the event of any conflict; the more stringent specification shall be adopted.

In addition to the flexible pavement design analysis, a rigid pavement design analysis was completed, based upon AASHTO design procedures. Rigid pavement design is based on an evaluation of the Modulus of Subgrade Reaction of the soils (K-value), the Modulus of Rupture if the concrete, and other factors previously outlined. A modulus of rupture of 600 psi was used for the pavement concrete.

Table 7 Pavement Design Alternatives

Traffic Area	Moisture Conditioned Subgrade Thickness	Alternative	Recommended Pavement Section Thickness (inches)			
			Aggregate Base Course	Plant Mixed Bituminous Pavement	Portland Cement Concrete Pavement	Total
Automotive Parking /Driveways	12 Inches	A		5.0 in.		5.0 in.
	12 Inches	B	4.0 in.	4.0 in.		8.0 in.
	12 Inches	C			5.0 in.	5.0 in.
Sidewalks	12-inches				5.0 in.	5.0 In.
Fire Lanes/Trash Dump Areas/Loading Docks	12 Inches			8.0 in.		8.0 in.
	12 Inches				7.0 in.	7.0 in.

12.5 Subgrade Preparation:

For the pavement to perform adequately, final grades shall provide adequate drainage and that water will not be allowed to enter the pavement system by either edge penetration adjacent to landscape areas or penetration from the surface due to surface ponding, or inadequate maintenance of pavement joints, or surface cracks that may develop. If water is allowed to enter the pavement subgrade, swelling of the moisture conditioned subgrade soils may occur.

Each alternative should be investigated with respect to current material availability and economic conditions. Rigid concrete pavement, a minimum thickness of 7 inches is recommended for fire lanes, locations of loading docks and dumpsters where trash trucks park and load.

The subgrade shall be proof rolled using a rubber tired equipment with a gross vehicle weight not less than 30,000 lbs; such as a fully loaded water truck. A minimum of three passes should be made. The proof rolling should be observed by Triax Engineering. If proof roll cannot be achieved, the subgrade shall need to be stabilized.

Aggregate base course (if used on the site) should consist of a blend of sand and gravel that meets specifications for quality and gradation. The use of materials meeting Colorado Department of Transportation (CDOT) Class 6 base course specifications is recommended. All asphalt pavements shall conform to specifications in CDOT section 401 Standard Specifications for Road and Bridge Construction.

The pavements constructed on the subgrades such as the one encountered at this site may be subjected to swell / consolidation related movements. Hence, periodic maintenance such as crack sealing and surface finishing are anticipated. Longitudinal and transverse joints should be provided as needed in concrete pavements for expansion/contraction and isolation. The location and extent of the joints should be based upon the final pavement geometry and should be placed (in feet) at roughly twice the slab thickness (in inches) on center in either direction. Sawed joints should be cut within 24-hours of concrete placement and should be a minimum of 25% of the slab

thickness plus ¼ inch. All joints should be sealed to prevent entry of foreign material and dowelled where necessary to provide load transfer.

It is important that any existing organic and compressible soils (the upper soils which contain organic materials such as leaves, roots, etc.) be removed and the exposed subgrade be properly prepared prior to pavement installation. The subgrade should be scarified to the required depth and then compacted to 95 percent of the Maximum Dry Density ("MDD") as obtained by ASTM D698 and moisture content between -2 to +2 percentage points of Optimum Moisture Content ("OMC"). Base course material should be placed immediately upon completion of the subgrade compaction operation to prevent drying of the soils due to exposure.

13.0 Excavation and Embankment:

Based on the site topography, cut and fill operations will be necessary to achieve final grades at the project site. Auger refusal was encountered at the vicinity of borings B-4, B-5 and B-6, therefore some rock excavation and presence of boulders within excavation depths shall be estimated.

We estimate utility trenches will be approximately 5-ft to 20-ft or deeper at this project site. Based on the soils encountered at the project site, high power earth moving equipment will be required. Utility connections and couplings shall be flexible to allow for some movement.

Table 8 Auger Refusal

Boring No	Depth (ft)
B-4	8-ft
B-5	2.5-ft
B-6	7-ft

Utility trenches located underneath structural elements and embankments shall be compacted to minimum of 95% of MDD as obtained by ASTM D698. All other areas shall be compacted to a minimum of 90% of MDD. Onsite / imported silty sands and granular soils shall be compacted to within +/-2 percentage points of OMC. Onsite / imported clayey soils shall be compacted to within 0 to +3 percentage points of OMC.

Fill placed for embankments and other fill operations shall be compacted as out lined in the table below.

Table 9 Compaction Specifications

Location	Soil Type	Dry Density	Moisture Content
Embankment / Fill / Trench Backfill / Pavement Subgrade	Granular / Sandy	Min. 95% (ASTM D 698)	-2 to +2% of OMC
	Sandy Clays / Clays	Min. 95% (ASTM D 698)	0 to +3% of OMC
	Class 6 ABC	Min. 95% (ASTM D 698/1557)	-2 to +2% of OMC

Table 10 Maximum Lift Thickness

Location	Max. Lift Thickness (in.)
Embankment	12 in.
Trench backfill	< 10-ft 12 in. >10-ft 24 in.
Fill operations	12 in.
Structural	6 in.

14.0 Excavations and Shoring:

Excavations should not remain open for extended periods of time, permitting wetting or drying of the bearing materials. Moisture changes of the bearing materials may increase the risk for movement. Care should be taken when working near the sides of excavations at all times, and the slopes should be monitored by onsite personnel during construction for evidence of sloughing, bulging or toppling of the sidewalls or cracking at the ground surface. Surcharge loading at the top of the cut by equipment, materials, or vehicles must be avoided,

since surcharge loading will increase the risk of caving. Spoils of the excavation must be placed a minimum of 5 horizontal feet from the edge of the excavation. Final evaluation of excavations, excavation slopes and soil and bedrock materials exposed in excavations should be done during construction by the contractors "competent person" as required by OSHA guidelines.

Due to the soil types present, shoring or stabilization of the excavation may be necessary at this site. An open-hole observation should be performed if required by the local municipality or if there are any concerns regarding excavation safety or stability. If the proposed excavation is within 10' of any existing structure, or if potential property damage or safety is an issue, some form of shoring may be required.

15.0 Further Investigations:

We recommend the following investigations to be conducted during the design and construction phases of the project.

- Structure specific geotechnical investigation for design documents
- Construction observation / materials testing during construction phase.

16.0 Limitations:

In any subsurface investigation, limited data is available from which to formulate soil descriptions and generate recommendations for foundations and related construction components. The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations. The report does not reflect variations that may occur between borings across the site. The samples taken are indicative of the subsurface materials at the time and at the location the samples were taken. Precipitation, seasonal changes, and excavating are just a few of the factors, which may create changes in the composition of the site. This report provides general subsurface information and preliminary geotechnical data

and shall not be used in the design of structures. A structure specific geotechnical investigation shall be conducted to supplement this report for use in final design.

This report does not address nor was intended to address any environmental issues, hazardous materials or toxic waste issues, or other subsurface situations or conditions other than those described within this report. The project geotechnical engineer declares that the findings, recommendations and/or professional advice contained herein have been made and this report prepared in accordance with generally accepted professional engineering practice in the fields of geotechnical engineering and engineering geology. No other warranties are implied or expressed.

This report is valid until site conditions change due to disturbance (cut and fill grading) or changes to nearby drainage conditions, or for 3 years from the date of this report, whichever occurs first. Beyond this validation date, Triax shall not accept any liability associated with the engineering recommendations in the report, particularly if the site conditions have changed.

This report is intended for the sole use of Mr. Nate Herman and approved agents during the construction of the above mentioned project site. This office cannot be responsible for any conclusions or recommendations made by other parties based upon the data contained herein.

Boring #	Depth (ft)
B-1	20
B-2	20
B-3	20
B-4	8
B-5	2.5
B-6	7

TRIAX ENGINEERING

Shelton Studio Ranch
850 Shelton Rd.
Golden CO

Boring Location Plan

Project No: D18G158

Not to Scale

Log of Boring:B-1

ELEVATION AND DATUM:
Lat: Long: Elev:ft.

DATE STARTED: 10/5/2018
DATE FINISHED: 10/5/2018
TOTAL DEPTH (ft.): 20
GROUND WATER (ft):
During Drilling: After 48 Hrs:

Project Name: Shelton Studio Ranch
ADDRESS: 850 Shelton Road Golden CO

Location: Shelton Road Ext.

HAMMER WEIGHT: 140 lbs **DROP:** 30 Inches
LOGGED BY: Solomon Areda

DEPTH (feet)	SAMPLES Symbol	Samples	Blows/ Foot	MATERIAL DESCRIPTION	LABORATORY TESTS Moisture Content (%)	% Fines	% Swell	Liquid Limit (LL)	Plasticity Index (PI)	RES. (ohm.cm)	USCS	pH	Water Sol. Sulfates	Moisture Content (%) 0 10 20 30
0				Top Soil / Vegetation										
		SS	14	Brown Clayey Sand — Stiff to Hard	7.6									
5		CA	32	— Medium Dense	6.4		0.5							
10		SS	16		9.5	49.8		33	15		SC			
15		SS	22		13.3									
				Reddish Brown Sandstone — Hard										
20		CA	40	— Weathered	9.8	50.3		32	15		CL			
				— End of Borehole —										
25														
30														
35														
40														
45														

Soil Stratigraphic boundaries represent approximate boundary lines between different soil / rock types. Actual transition may be gradual.

Project No.: D18G158

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Plate: 2

Log of Boring:B-2

ELEVATION AND DATUM:
Lat: Long: Elev:ft.

DATE STARTED: 10/5/2018
DATE FINISHED: 10/5/2018
TOTAL DEPTH (ft.): 20
GROUND WATER (ft):
During Drilling: After 48 Hrs:

Project Name: Shelton Studio Ranch

ADDRESS: 850 Shelton Road
Golden CO

Location: Shelton Road Ext.

HAMMER WEIGHT: 140 lbs **DROP:** 30 Inches

LOGGED BY: Solomon Areda

DEPTH (feet)	SAMPLES Symbol	Samples	Blows/ Foot	MATERIAL DESCRIPTION	Moisture Content (%)	% Fines	% Swell	Liquid Limit (LL)	Plasticity Index (PI)	RES. (ohm.cm)	USCS	pH	Water Sol. Sulfates
0				Top Soil / Vegetation									
		SS	9	Brown Silty Sand — with Gravel — Loose to Very Dense	3.2								
5		SS	50@11"		2.3	21.0		NP	NP		SM		
10		CA	50@6"		4.0								
				Brown Sandstone									
15		CA	45	— Dense — Weathered	2.4								
20		SS	39		7.8	23.9		22	2		SM		
				— End of Borehole —									
25													
30													
35													
40													
45													

LABORATORY TESTS

Moisture Content (%) 0 10 20 30

Soil Stratigraphic boundaries represent approximate boundary lines between different soil / rock types. Actual transition may be gradual.

Project No.: D18G158

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Plate: 3

Log of Boring:B-3

ELEVATION AND DATUM:
Lat: Long: Elev:ft.

DATE STARTED: 10/5/2018
DATE FINISHED: 10/5/2018
TOTAL DEPTH (ft.): 20
GROUND WATER (ft):
During Drilling: After 48 Hrs:

Project Name: Shelton Studio Ranch

ADDRESS: 850 Shelton Road
Golden CO

Location: Shelton Road Ext.

HAMMER WEIGHT: 140 lbs **DROP:** 30 Inches

LOGGED BY: Solomon Areda

DEPTH (feet)	SAMPLES Symbol	Samples	Blows/ Foot	MATERIAL DESCRIPTION	Moisture Content (%)	% Fines	% Swell	Liquid Limit (LL)	Plasticity Index (PI)	RES. (ohm.cm)	USCS	pH	Water Sol. Sulfates
0				Top Soil / Vegetation									
		SS	50@4"	Brown Silty Sand — Dense to Very Dense — Medium Stiff to Very Stiff	1.0								
5		CA	46	— Moist	1.1								
10		SS	50@5"		1.1	28.7		NP	NP		SM		
15		CA	50@4"		9.9								
				Reddish Brown Sandstone — Very Dense — Weathered									
20		SS	60		11.5								
				— End of Borehole —									
25													
30													
35													
40													
45													

Moisture Content (%) 0 10 20 30

Soil Stratigraphic boundaries represent approximate boundary lines between different soil / rock types. Actual transition may be gradual.

Project No.: D18G158

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Plate: 4

Log of Boring:B-4

ELEVATION AND DATUM:
Lat: Long: Elev:ft.

DATE STARTED: 10/5/2018
DATE FINISHED: 10/5/2018
TOTAL DEPTH (ft.): 20
GROUND WATER (ft): During Drilling: After 48 Hrs:

Project Name: Shelton Studio Ranch
ADDRESS: 850 Shelton Road Golden CO

Location: Shelton Road Ext.

HAMMER WEIGHT: 140 lbs **DROP:** 30 Inches
LOGGED BY: Solomon Areda

DEPTH (feet)	SAMPLES Symbol	Samples	Blows/ Foot	MATERIAL DESCRIPTION	LABORATORY TESTS: Moisture Content (%)	% Fines	% Swell	Liquid Limit (LL)	Plasticity Index (PI)	RES. (ohm.cm)	USCS	pH	Water Sol. Sulfates	Moisture Content (%) 0 10 20 30
0				Top Soil / Vegetation										
		SS	50@1"	Brown Clayey Sand — Very Dense	6.6									
				— with Gravel										
5		CA	50@5"	— Medium Dense	1.5	26.4	-0.1	25	9		SC			
				— Auger Refusal @ 8-ft										
				— End of Borehole —										
10														
15														
20														
25														
30														
35														
40														
45														

Soil Stratigraphic boundaries represent approximate boundary lines between different soil / rock types. Actual transition may be gradual.

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PH: 720.230.1931 FAX: 720.230.5471 Email: info@triaxgeo.com

Log of Boring:B-5

ELEVATION AND DATUM:
Lat: Long: Elev:ft.

DATE STARTED: 10/22/2018
DATE FINISHED: 10/22/2018
TOTAL DEPTH (ft.): 3
GROUND WATER (ft): During Drilling: After 48 Hrs:

Project Name: Shelton Studio Ranch

ADDRESS: 850 Shelton Road Golden CO

Location: Drive @ Lot 5

HAMMER WEIGHT: 140 lbs **DROP:** 30 Inches

LOGGED BY: Solomon Areda

DEPTH (feet)	SAMPLES Symbol	Samples	Blows/ Foot	MATERIAL DESCRIPTION	LABORATORY TESTS: Moisture Content (%)	% Fines	% Swell	Liquid Limit (LL)	Plasticity Index (PI)	RES. (ohm.cm)	USCS	pH	Water Sol. Sulfates	Moisture Content (%) 0 10 20 30
0				Top Soil / Vegetation										
		SS	50@1"	Brown Silty Sand — with Gravel, Very Dense	3.1	27.8		NP	NP		SM			
				— Auger Refusal at 2.5-ft										
				— End of Borehole —										
5														
10														
15														
20														
25														
30														
35														
40														
45														

Soil Stratigraphic boundaries represent approximate boundary lines between different soil / rock types. Actual transition may be gradual.

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Log of Boring:B-6

ELEVATION AND DATUM:
Lat: Long: Elev:ft.

DATE STARTED: 10/5/2018
DATE FINISHED: 10/5/2018
TOTAL DEPTH (ft.): 7
GROUND WATER (ft): During Drilling: After 48 Hrs:

Project Name: Shelton Studio Ranch
ADDRESS: 850 Shelton Road Golden CO

Location: Drive @ Lot 5

HAMMER WEIGHT: 140 lbs **DROP:** 30 Inches
LOGGED BY: Solomon Areda

DEPTH (feet)	SAMPLES Symbol	Samples	Blows/ Foot	MATERIAL DESCRIPTION	LABORATORY TESTS: Moisture Content (%)	% Fines	% Swell	Liquid Limit (LL)	Plasticity Index (PI)	RES. (ohm.cm)	USCS	pH	Water Sol. Sulfates	Moisture Content (%) 0 10 20 30
0				Top Soil / Vegetation										
		SS	50	Brown Silty Sand — Very Dense	4.0									
				— with Gravel										
5		SS	50@5"	— Auger Refusal @ 7-ft	2.8	21.1		NP	NP		SM			
				— End of Borehole —										
10														
15														
20														
25														
30														
35														
40														
45														

Soil Stratigraphic boundaries represent approximate boundary lines between different soil / rock types. Actual transition may be gradual.

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Client:

Mr. Nate Herman
850 Shelton Rd
Golden CO 80401

Project:

Shelton Studio Ranch
850 Shelton Road
Golden CO

Project #: D18G158

Boring No	Depth (ft)	MC (%)	LL (%)	PI (%)	% Fines	NDD (pcf)	% Swell	USCS Class.	AASHTO Class.	UCS (tsf)	pH	Su	Resistivity ohm.cm
B-1	1	7.6											
B-1	5	6.4				125.1	1.6%						
B-1	10	9.5	33	15	49.8%			SC	A-6(4)				
B-1	15	13.3											
B-1	20	9.8	32	15	50.3%	117.0		CL	A-6(4)				
B-2	1	3.2											
B-2	5	2.3	NP	NP	21.0%			SM	A-1-b(0)				
B-2	10	4				112.3							
B-2	15	2.4											
B-2	20	7.8	22	2	23.9%			SM	A-1-b(0)				
B-3	1	1											
B-3	5	1.1				135.5							
B-3	10	1.1	NP	NP	28.7%			SM	A-2-4(0)				
B-3	15	9.9				119.2				0.9			

MC= Moisture Content(%) LL= Liquid Limit (%) PI= Plasticity Index (%) pH = pH (distilled water)/pH (cacl2)
UCS = Unconfined Compressive Strength Su= water soluble sulfates, % by dry wt.

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Client:

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850 Shelton Rd
Golden CO 80401

Project:

Shelton Studio Ranch
850 Shelton Road
Golden CO

Project #: D18G158

Boring No	Depth (ft)	MC (%)	LL (%)	PI (%)	% Fines	NDD (pcf)	% Swell	USCS Class.	AASHTO Class.	UCS (tsf)	pH	Su	Resistivity ohm.cm
B-3	20	11.5											
B-4	1	6.6											
B-4	5	1.5	25	9	26.4%	115.1	-0.1%	SC	A-2-4(0)				
B-5	1	3.1	NP	NP	27.8%			SM	A-2-4(0)				
B-6	1	4											
B-6	5	2.8	NP	NP	21.1%			SM	A-2-4(0)				

MC= Moisture Content(%) LL= Liquid Limit (%) PI= Plasticity Index (%) pH = pH (distilled water)/pH (cacl2)
UCS = Unconfined Compressive Strength Su= water soluble sulfates, % by dry wt.

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Client:

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850 Shelton Rd

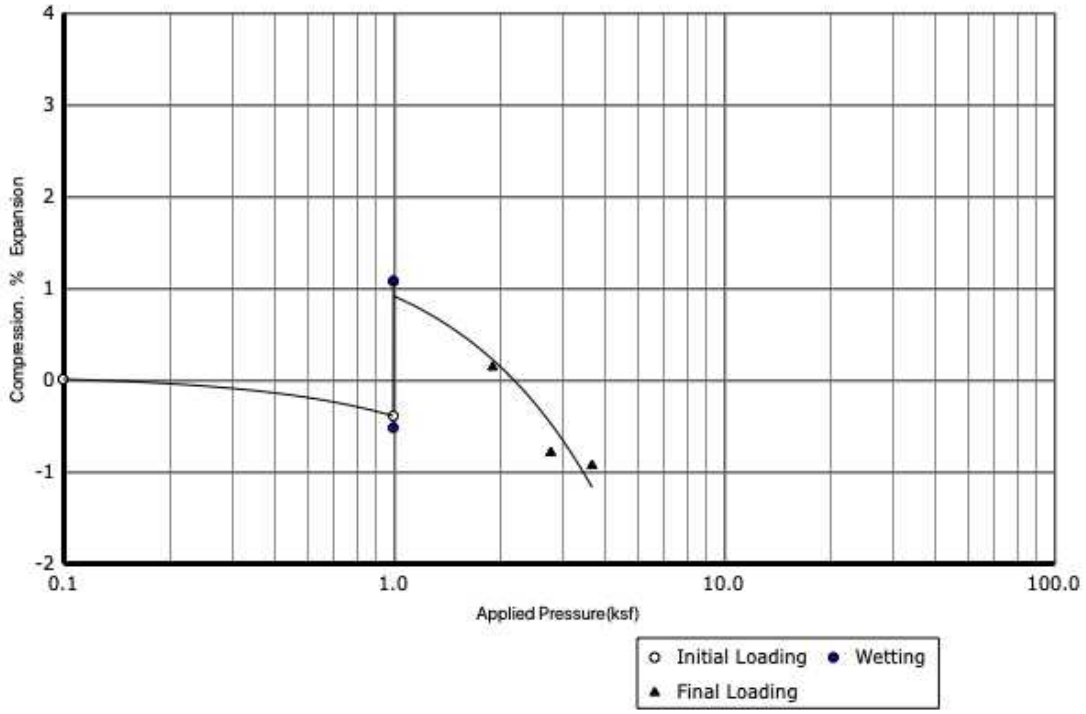
Golden CO 80401

Project:
Shelton Studio Ranch

850 Shelton Road

Golden CO
Project #: D18G158

Boring #: B-1 **Lab ID #:** 18-1173 **Depth:** 5 ft



Description:	Brown Clayey Sand

NDD (pcf)		% Moisture	% Fines	% Swell	
Dry	Wet	6.4		1.6	Swelling due to wetting under constant pressure-surcharge load:1000 psf
125.1	133.1				
LL	PI				

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Golden CO 80401

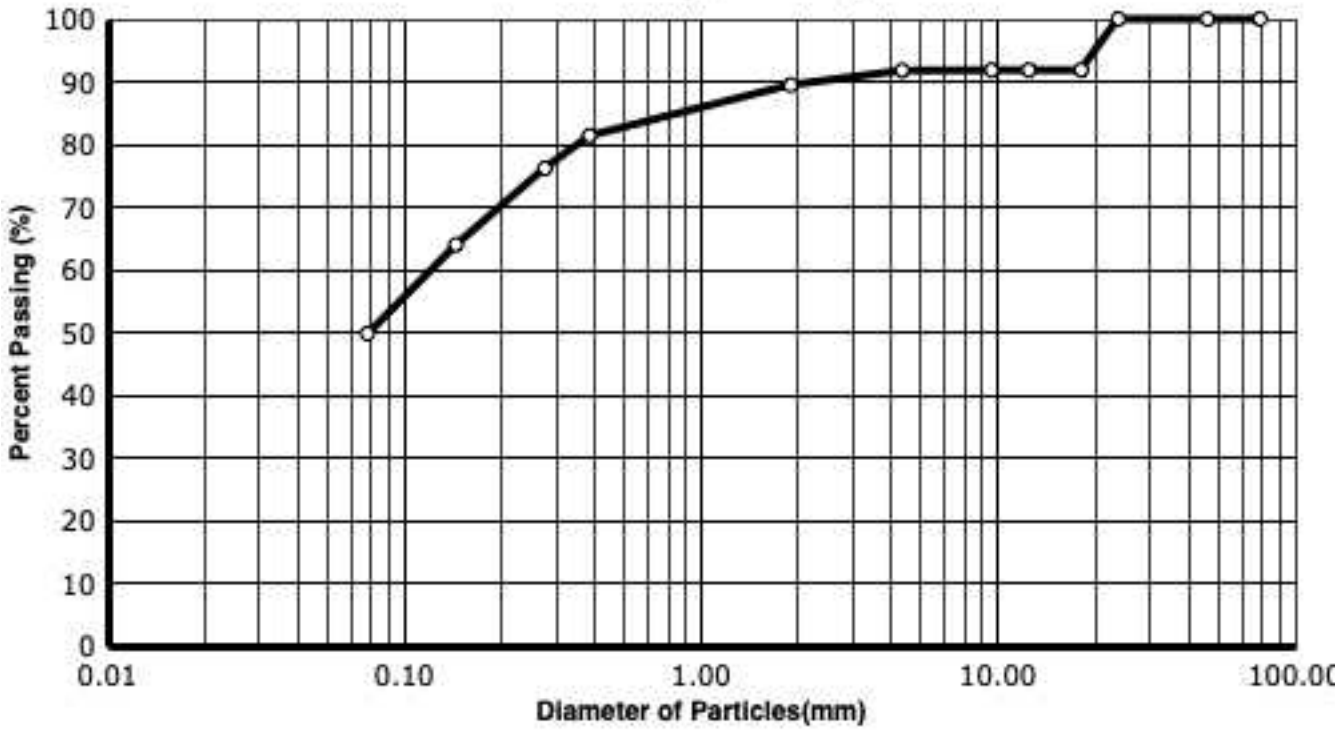
Project:
Shelton Studio Ranch
850 Shelton Road

Golden CO
Project #: D18G158

Boring #/Location: B-1

Depth: 10 ft
Lab ID #: 18-1174

Sieve Analysis Report



Silt or Clay	Sand			Gravel		Cobbles
	Fine	Medium	Coarse	Fine	Coarse	

Description:	Brown Clayey Sand

% Gravel	8.2%
% Sand	42.0%
% Fines	49.8%

Atterberg Limits	
LL	33
PI	15

Classification	
AASHTO	A-6(4)
USCS	SC

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Golden CO 80401

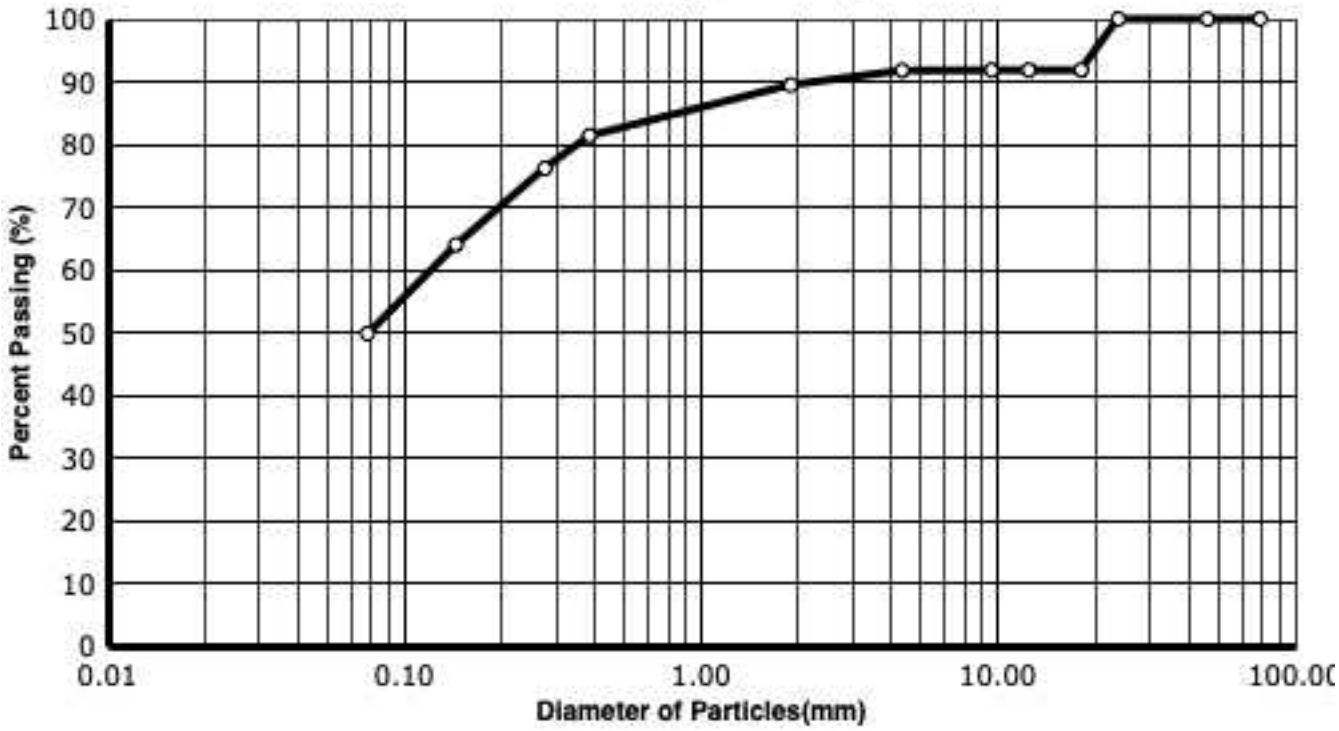
Project:
Shelton Studio Ranch
850 Shelton Road

Golden CO
Project #: D18G158

Boring #/Location: B-1

Depth: 20 ft
Lab ID #: 18-1176

Sieve Analysis Report



Silt or Clay	Sand			Gravel		Cobbles
	Fine	Medium	Coarse	Fine	Coarse	

Description:	Reddish Brown Sandstone, Weathered

% Gravel	3.1%
% Sand	46.6%
% Fines	50.3%

Atterberg Limits	
LL	32
PI	15

Classification	
AASHTO	A-6(4)
USCS	CL

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Client:
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850 Shelton Rd
Golden CO 80401

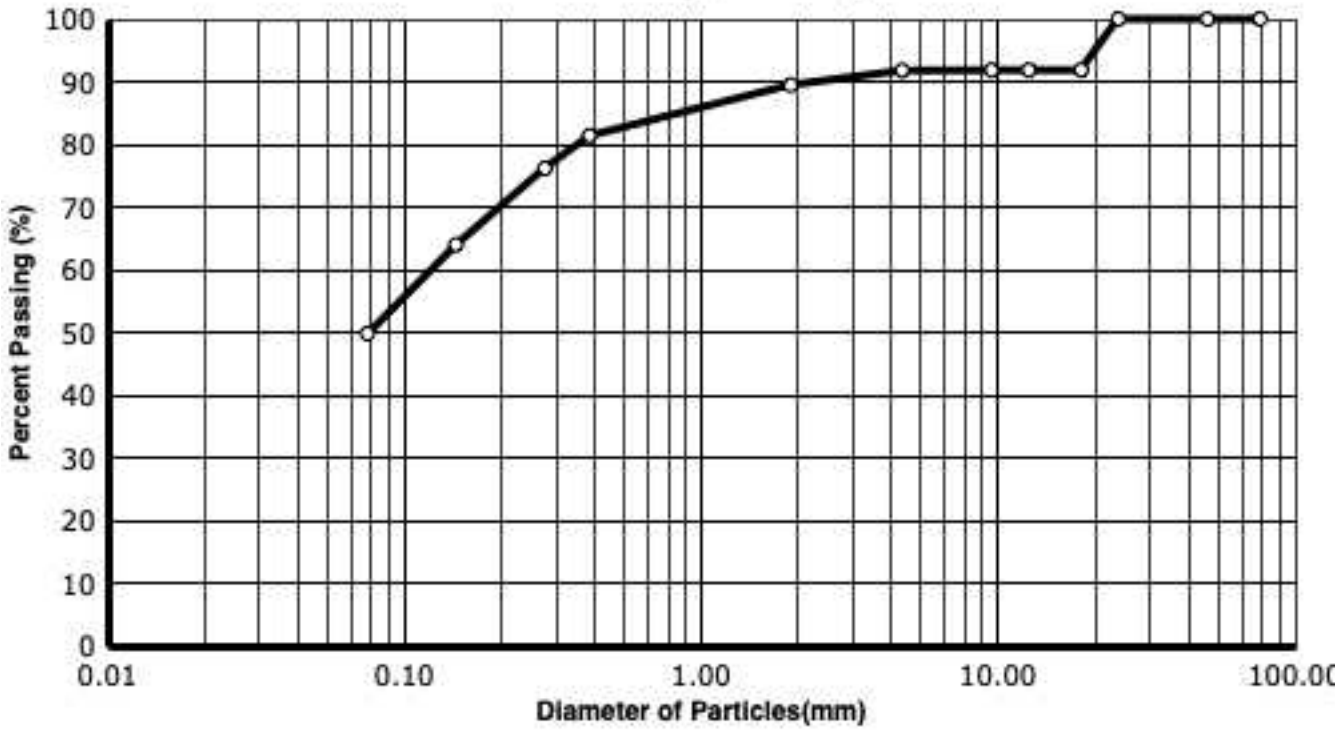
Project:
Shelton Studio Ranch
850 Shelton Road

Golden CO
Project #: D18G158

Boring #/Location: B-2

Depth: 5 ft
Lab ID #: 18-1178

Sieve Analysis Report



Silt or Clay	Sand			Gravel		Cobbles
	Fine	Medium	Coarse	Fine	Coarse	

Description:	Brown Silty Sand with Gravel

% Gravel	24.8%
% Sand	54.2%
% Fines	21.0%

Atterberg Limits	
LL	NP
PI	NP

Classification	
AASHTO	A-1-b(0)
USCS	SM

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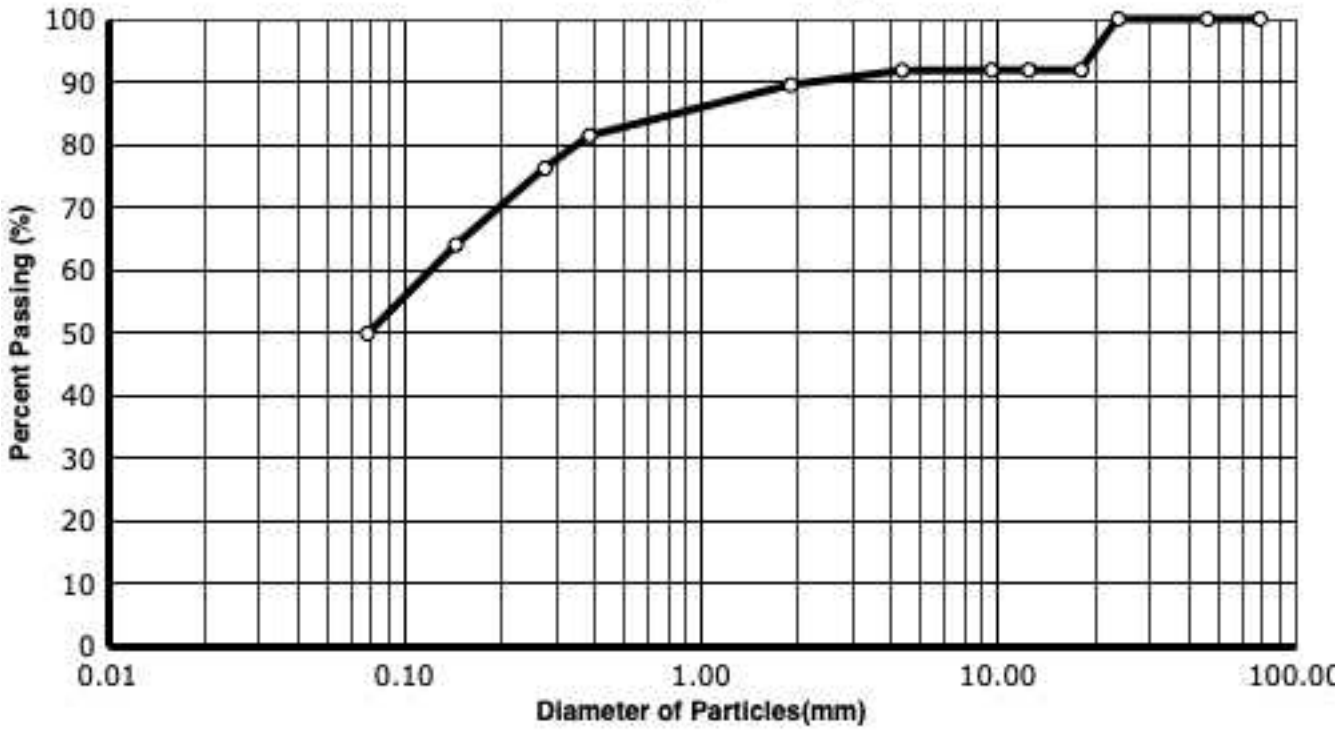
Project:
Shelton Studio Ranch
850 Shelton Road

Golden CO
Project #: D18G158

Boring #/Location: B-2

Depth: 20 ft
Lab ID #: 18-1181

Sieve Analysis Report



Silt or Clay	Sand			Gravel		Cobbles
	Fine	Medium	Coarse	Fine	Coarse	

Description:	Brown Silty Sand with Gravel

% Gravel	24.6%
% Sand	51.5%
% Fines	23.9%

Atterberg Limits	
LL	22
PI	2

Classification	
AASHTO	A-1-b(0)
USCS	SM

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Client:
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Golden CO 80401

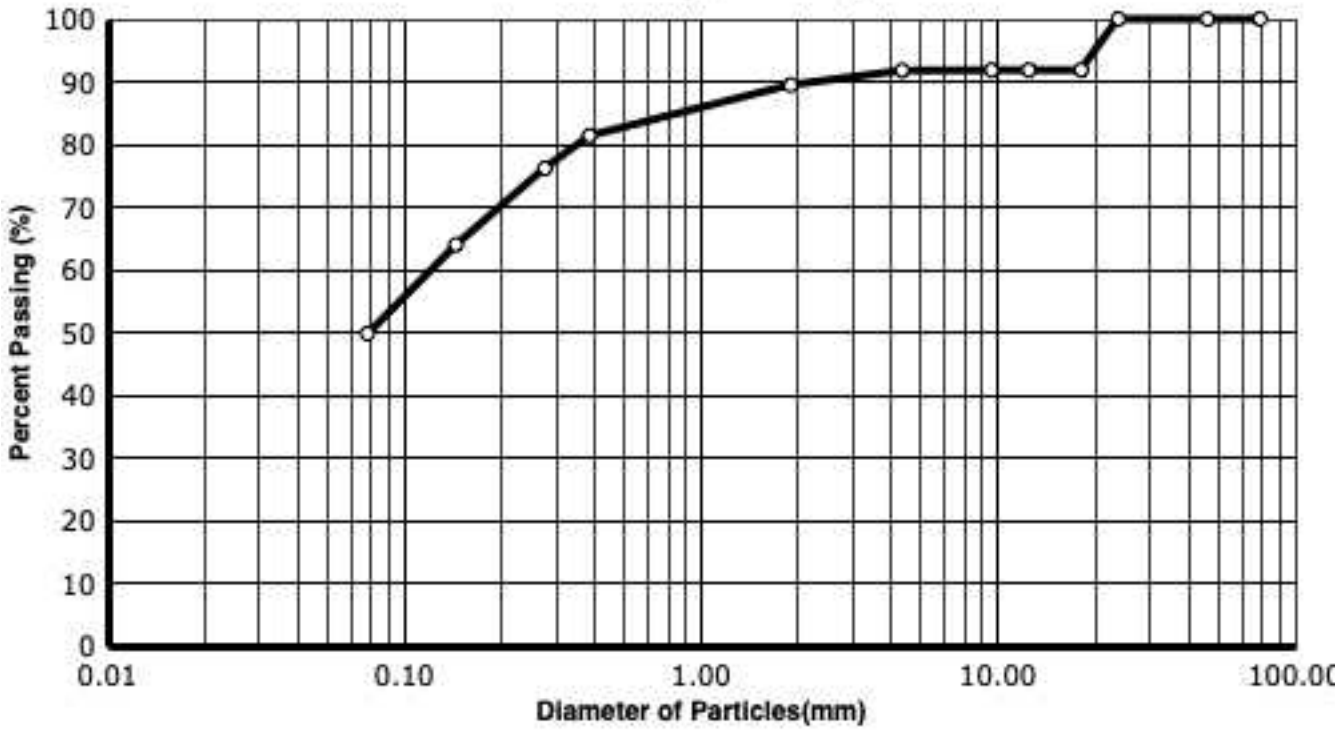
Project:
Shelton Studio Ranch
850 Shelton Road

Golden CO
Project #: D18G158

Boring #/Location: B-3

Depth: 10 ft
Lab ID #: 18-1184

Sieve Analysis Report



Silt or Clay	Sand			Gravel		Cobbles
	Fine	Medium	Coarse	Fine	Coarse	

Description:	Brown Silty Sand

% Gravel	7.6%
% Sand	63.7%
% Fines	28.7%

Atterberg Limits	
LL	NP
PI	NP

Classification	
AASHTO	A-2-4(0)
USCS	SM

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Golden CO 80401

Project:

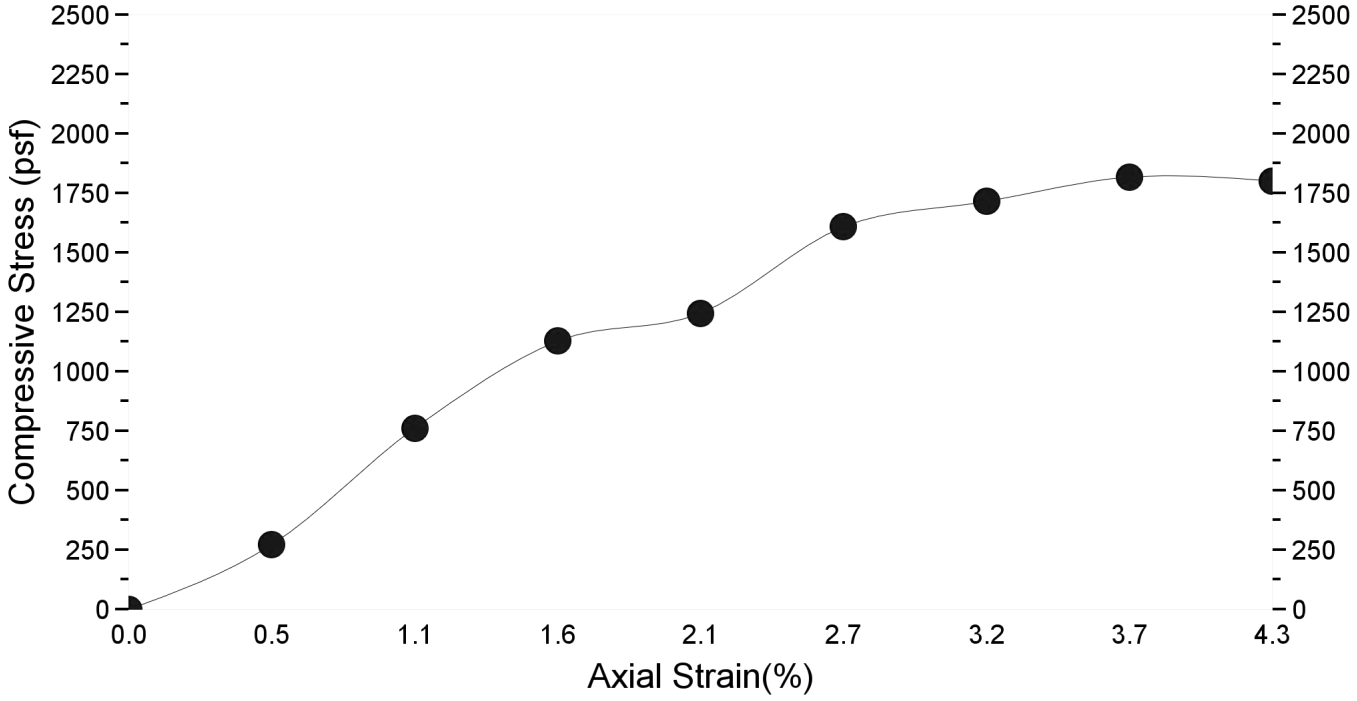
Shelton Studio Ranch
850 Shelton Road

Golden CO

Project #: D18G158

Boring #: B-3	**Lab ID #:** 18-1185	**Depth:** 15 ft

Unconfined Compressive Strength



Description:	Brown Silty Sand

	psf.	tsf.	psi
Unconfined Compressive Strength	1818	0.9	12.6
Undrained Shear Strength	909	0.5	6.3

Strain at Failure 3.7%

StrainRate 0.8%/Min

Wet Density	124.0	pcf
Dry Density	112.8	pcf
Moisture Content(%)	9.9	
Wt of Specimen	353.7	g
Length/Diameter	2.0	
Average Specimen Diameter	1.9	in.
Average Specimen Height	3.8	in.

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Project:
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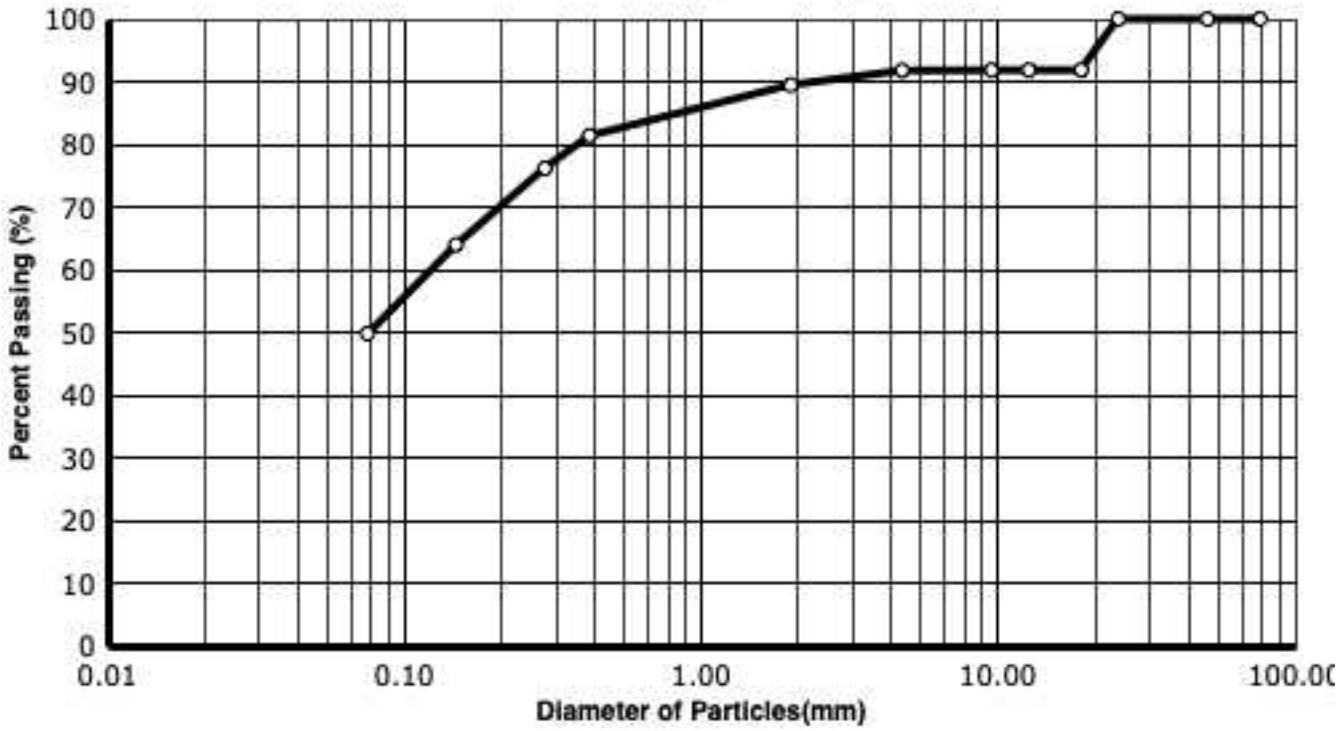
850 Shelton Road

Golden CO
Project #: D18G158

Boring #/Location: B-4

Depth: 5 ft
Lab ID #: 18-1188

Sieve Analysis Report



Silt or Clay	Sand			Gravel		Cobbles
	Fine	Medium	Coarse	Fine	Coarse	

Description:	Brown Clayey Sand with Gravel

% Gravel	29.7%
% Sand	43.9%
% Fines	26.4%

Atterberg Limits	
LL	25
PI	9

Classification	
AASHTO	A-2-4(0)
USCS	SC

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Golden CO 80401

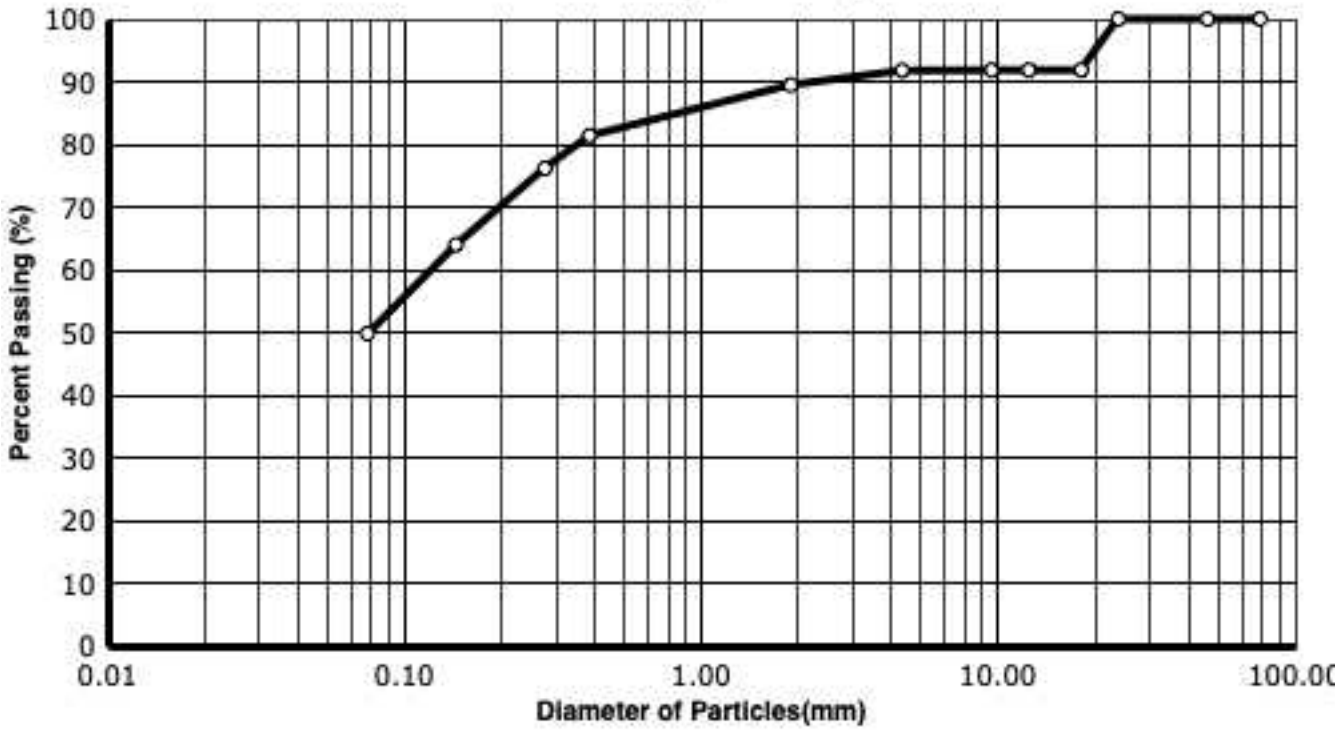
Project:
Shelton Studio Ranch
850 Shelton Road

Golden CO
Project #: D18G158

Boring #/Location: B-5

Depth: 1 ft
Lab ID #: 18-1189

Sieve Analysis Report



Silt or Clay	Sand			Gravel		Cobbles
	Fine	Medium	Coarse	Fine	Coarse	

Description:	Brown Silty Sand with Gravel

% Gravel	18.9%
% Sand	53.3%
% Fines	27.8%

Atterberg Limits	
LL	NP
PI	NP

Classification	
AASHTO	A-2-4(0)
USCS	SM

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Golden CO 80401

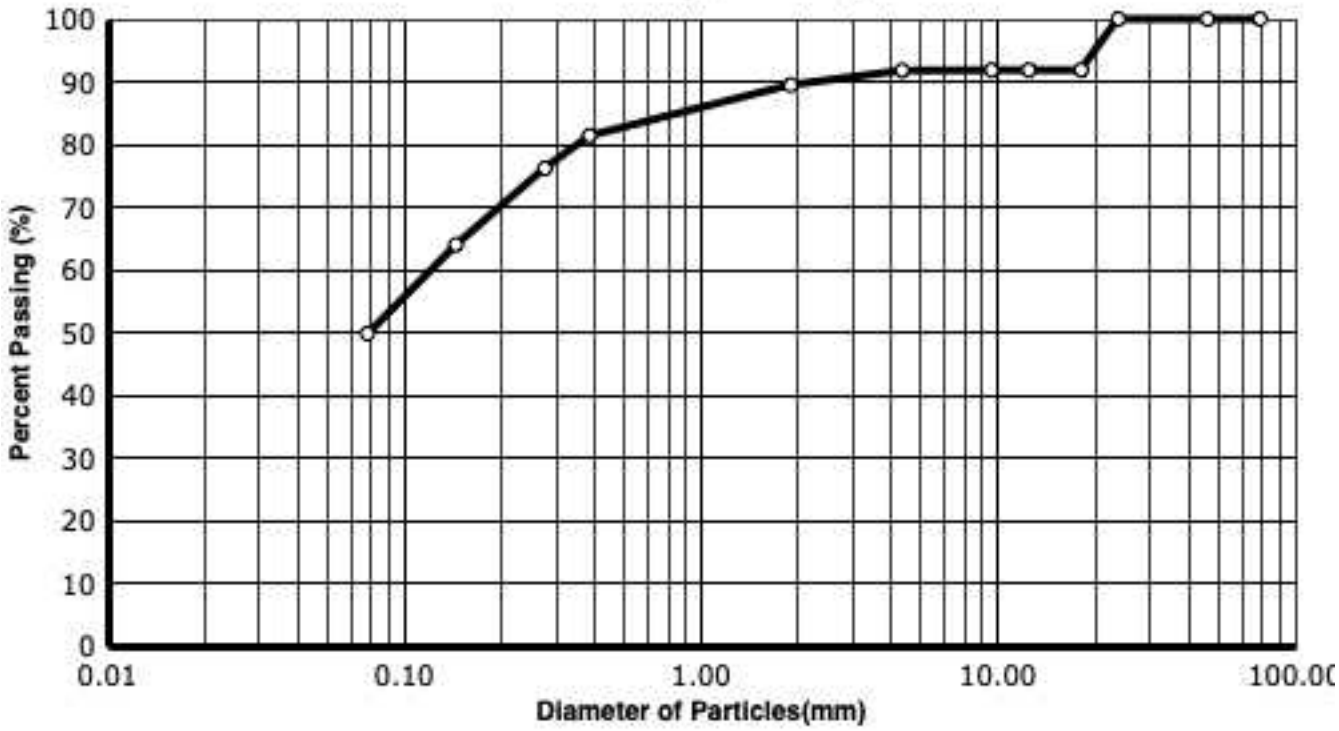
Project:
Shelton Studio Ranch
850 Shelton Road

Golden CO
Project #: D18G158

Boring #/Location: B-6

Depth: 5 ft
Lab ID #: 18-1191

Sieve Analysis Report



Silt or Clay	Sand			Gravel		Cobbles
	Fine	Medium	Coarse	Fine	Coarse	

Description:	Brown Silty Sand

% Gravel	12.2%
% Sand	66.7%
% Fines	21.1%

Atterberg Limits	
LL	NP
PI	NP

Classification	
AASHTO	A-2-4(0)
USCS	SM

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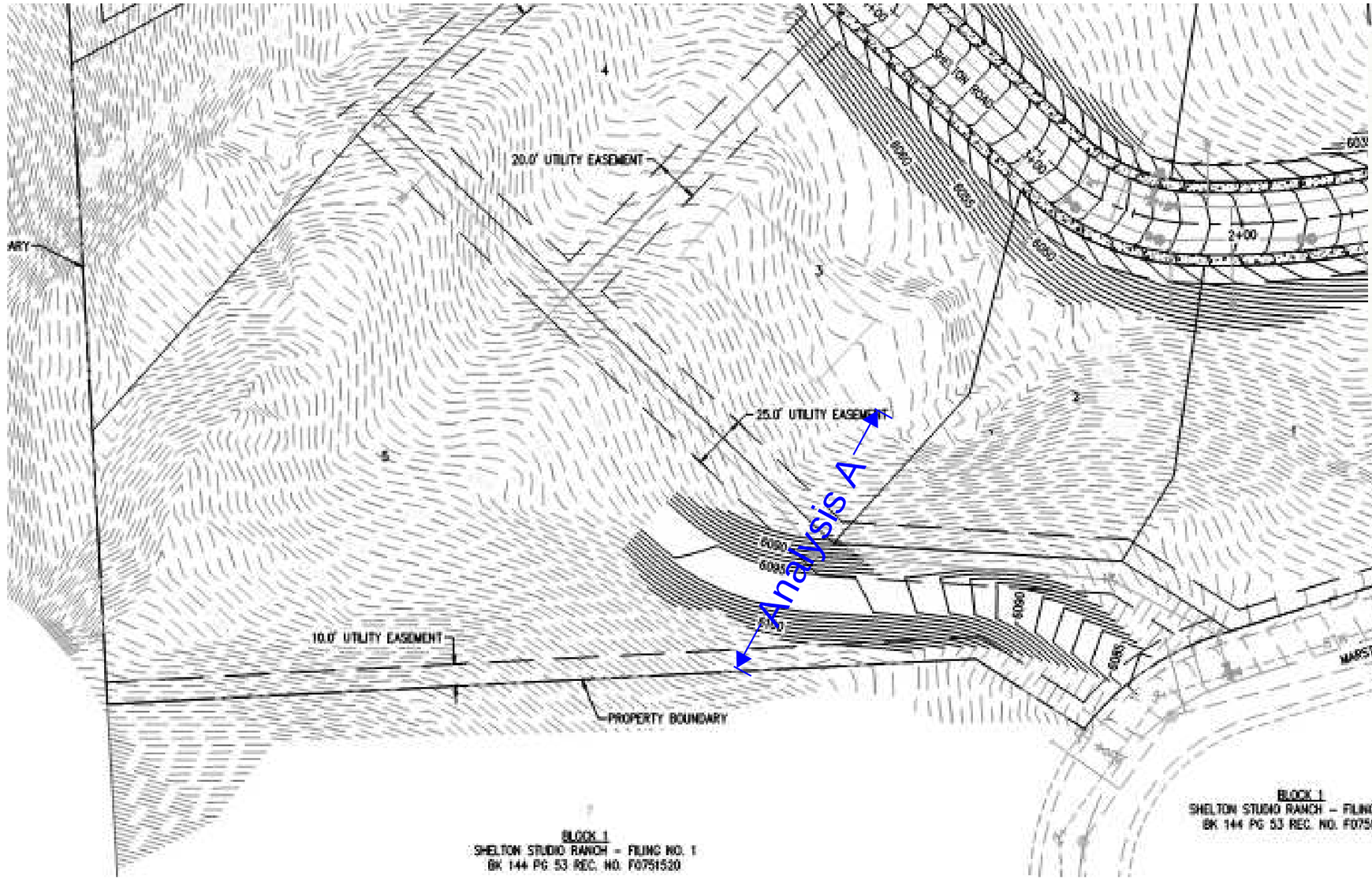

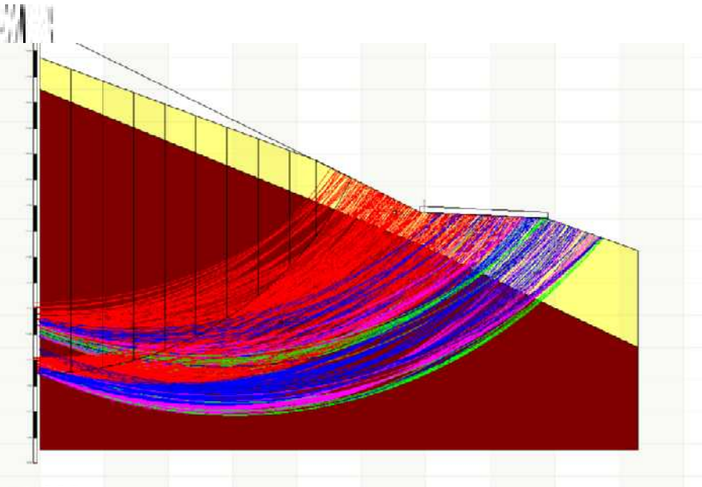

Analysis A

TRIAX ENGINEERING

Shelton Studio Ranch
850 Shelton Rd.
Golden CO

Slope Stability Analysis

Project No: D18G158

Not to Scale

Location	Shelton Studio Ranch					
20-year Equivalent Single Axle Load Applications (ESAL)					18,500	

Soil Sample Information:

Boring	B-1 to B-6			Depth	1 to 7	feet
Sample description	Brown / Dark Brown Silty Sand					
USCS	SM	AASHTO Group Number		AASHTO Group Index:		

Pavement Thickness Calculation Input Parameters:

Reliability Level (%)	70.0	Standard Normal Deviate, Zr	-0.524
Overall Standard Deviation, S_o	0.44	Sevicability Loss, DPSI	2.0
Design R-value, R	7	Equiv. Daily Load App. (EDLA)	--
M_R =	3230		

Calculated Design Structural Number: 2.16

OPTION A - Parking and Driveways

Layer	Material Desc.	Structural Coeff.	Drain Coeff.	Thickness (in.)	Calculated SN
1	Hot Mix Asphalt (HMA)	0.44	1	5	2.20
					2.20

OPTION B - Parking and Driveways

Layer	Material Desc.	Structural Coeff.	Drain Coeff.	Thickness (in.)	Calculated SN
1	Hot Mix Asphalt (HMA)	0.44	1	4	1.76
2	Aggregate Base with 77 <= R-value <83	0.12	1	4	0.48
					2.24

TRIAX ENGINEERING	FLEXIBLE PAVEMENT THICKNESS CALCULATIONS	JOB NO. D18G158
	Shelton Studio Ranch	FIGURE NO. P-1A

Location	Shelton Studio Ranch					
20-year Equivalent Single Axle Load Applications (ESAL)					18500	

Soil Sample Information:

Boring	B-1 to B-6			Depth	1 to 7	feet
Sample description	Brown / Dark Brown Silty Sand					
USCS	SM	AASHTO Group Number		AASHTO Group Index:		

Pavement Thickness Calculation Input Parameters:

Terminal Serviceability, Pt	2.0	Modulus of Rupture, S'c (psi)	650.000
Modulus of Elasticity, Ec (psi)	3400000.00	Modulus of Subgrade Reaction,k	50.0
Reliability Level (%)	70.0	Overall Standard Deviation, So	0.340
Load Transfer Coefficient, J	4.2	Loss of Support, LS	2.0
Standard Normal Deviate, Zr	-0.524	Drainage Coefficient, Cd	0.9
Design Serviceablity Loss, ΔPSI	2.5		

Calculated Design Structural Number: 4.27

OPTION A - Parking and Driveways

Layer	Material Desc.	Thickness (in.)	Calculated SN
1	Rigid Pavement	5	4.79
			4.79

TRIAX ENGINEERING	FLEXIBLE PAVEMENT THICKNESS CALCULATIONS	JOB NO.	D18G158
	Shelton Studio Ranch	FIGURE NO.	P-1B

Location	Shelton Studio Ranch
20-year Equivalent Single Axle Load Applications (ESAL)	18500

Soil Sample Information:

Boring	B-1 to B-6			Depth	1 to 7	feet
Sample description	Brown / Dark Brown Silty Sand					
USCS	SM	AASHTO Group Number		AASHTO Group Index:		

Pavement Thickness Calculation Input Parameters:

Reliability Level (%)	70.0	Standard Normal Deviate, Zr	-0.524
Overall Standard Deviation, S_o	0.44	Sevicability Loss, DPSI	2.0
Design R-value, R	7	Equiv. Daily Load App. (EDLA)	--

Resilient Modulus Calculation:

$S_1 = [(R - 5) / 11.29 + 3]$ = 3.177

$M_R = 10^{[(S_1 + 18.72) / 6.24]}$

M_R = 3230

Design R-value based on removal and replacement. If proof rolling cannot be achieved, stabilization may be required.

Pavement Thickness Calculation:

$$Log_{10}(18kESAL) = [Z_R \times S_o] + [9.36 \times \log_{10}(SN + 1) - 0.20 + \frac{\log_{10}(DPSI/(4.2 - 1.5))}{(0.4+1094/(SN+1)^{5.19})}$$

$$+ [2.32 \times \log_{10}(MR)] - 8.07$$

select Structural layer coeff: Hot Mix Asphalt (HMA)
Structural layer coeff: 0.44
select Base layer1 coeff:
select Base layer 1 coeff:
select Base layer2 coeff:
select Base layer 2 coeff:

"A"		"B"
4.267172	<	4.27741

SN= 2.16 (Choose SN such that "A" is less than "B")

Pavement Thickness:

5			inches of Hot Mix Asphalt (HMA)SC=0.44
			inches of SC=
			inches of SC=
2.2	0	0	

TRIAX ENGINEERING	FLEXIBLE PAVEMENT THICKNESS CALCULATIONS - FULL DEPTH	JOB NO. D18G158
	Shelton Studio Ranch	FIGURE NO. P-1B

Location	Shelton Studio Ranch
20-year Equivalent Single Axle Load Applications (ESAL)	18500

Soil Sample Information:

Boring	B-1 to B-6			Depth	1 to 7	feet
Sample description	Brown / Dark Brown Silty Sand					
USCS	SM	AASHTO Group Number		AASHTO Group Index:		

Pavement Thickness Calculation Input Parameters:

Reliability Level (%)	70.0	Standard Normal Deviate, Zr	-0.524
Overall Standard Deviation, S_o	0.44	Sevicability Loss, DPSI	2.0
Design R-value, R	7	Equiv. Daily Load App. (EDLA)	--

Resilient Modulus Calculation:

$S_1 = [(R - 5) / 11.29 + 3]$ = 3.177

$M_R = 10^{[(S_1 + 18.72) / 6.24]}$

M_R = 3230

Design R-value based on removal and replacement. If proof rolling cannot be achieved, stabilization may be required.

Pavement Thickness Calculation:

$$Log_{10}(18kESAL) = [Z_R \times S_o] + [9.36 \times \log_{10}(SN + 1) - 0.20 + \frac{\log_{10}(DPSI/(4.2 - 1.5))}{(0.4+1094/(SN+1)^{5.19})}$$

$$+ [2.32 \times \log_{10}(MR)] - 8.07$$

select Structural layer coeff: Hot Mix Asphalt (HMA)
Structural layer coeff: 0.44
select Base layer1 coeff: Aggregate Base with 77 <= R-value <83
select Base layer 1 coeff: 0.12
select Base layer2 coeff:
select Base layer 2 coeff:

"A"		"B"
4.267172	<	4.27741

SN= 2.16 (Choose SN such that "A" is less than "B")

Pavement Thickness:

4		
4		
2.24	0	0

inches of Hot Mix Asphalt (HMA)SC=0.44
inches of Aggregate Base with 77 <= R-value <83SC=0.12

inches of SC=

TRIAX ENGINEERING	FLEXIBLE PAVEMENT THICKNESS CALCULATIONS - FULL DEPTH	JOB NO. D18G158
	Shelton Studio Ranch	FIGURE NO. P-1C

Location	Shelton Studio Ranch				
20-year Equivalent Single Axle Load Applications (ESAL)			18500		

Soil Sample Information:

Boring	B-1 to B-6			Depth	1 to 7	feet
Sample description	Brown / Dark Brown Silty Sand					
USCS	SM	AASHTO Group Number		AASHTO Group Index:		

Pavement Thickness Calculation Input Parameters:

Terminal Serviceability, P_t	2.0	Modulus of Rupture, S'_c (psi)	650
Modulus of Elasticity, E_c (psi)	3,400,000	Modulus of Subgrade Reaction,k	50
Reliability Level (%)	70.0	Overall Standard Deviation, S_o	0.34
Load Transfer Coefficient, J	4.2	Drainage Coefficient, C_d	0.9
Standard Normal Deviate, Z_r	-0.524	Loss of Support, LS	2.0
Design Serviceablity Loss, DPSI	2.5		

Pavement Thickness Calculation:

$$Log_{10}(18kESAL) = Z_R \times S_o + 7.35 \times \log_{10}(D + 1) - 0.06 + \frac{\log_{10}(DPSI/(4.5 - 1.5))}{(1+1.624x10^7/(D+1)^{8.46})}$$

$$+(4.22-0.32xp_t)x\log_{10}(S_c'xC_Dx(D^{0.75}-1.132)/(215.63xJx(D^{0.75}-18.42/(E_c/k)0.25)))$$

"A"		"B"
4.267172	<	4.79276

D= 5 (Choose D such that "A" is less than "B")

Pavement Thickness:

5 inches of portland cement concre (Min used)

TRIAX ENGINEERING	FLEXIBLE PAVEMENT THICKNESS CALCULATIONS	JOB NO. D18G158
	Shelton Studio Ranch	FIGURE NO. P-1

GENERAL NOTES

Consistency of Fine – Grained Soils

Unconfined Compressive Strength, Qu, psf	Standard Penetration Blow Counts (N-Value)	Consistency
<500	0-1	Very Soft
500-1000	2-4	Soft
1000-2000	4-8	Medium Stiff
2000-4000	8-15	Stiff
4000-8000	15-30	Very Stiff
8000+	>30	Hard

Relative Density of Coarse Grained Soils

Standard Penetration Blow Counts (N-Value)	Consistency
0-3	Very Loose
4-9	Loose
10-29	Medium Dense
30-49	Dense
>50	Very Dense

Grain Size Terminology

Terminology	Nominal Particle Size
Boulders	Over 12 inch (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 mm to 0.075 mm)
Silt/Clay	Passing #200 Sieve (<0.075mm)

Plasticity Description

Term	PI Range
Non Plastic	0
Low Plasticity	1-10
Medium Plasticity	11-30
High Plasticity	>30

Slab Performance Risk

Slab Performance Risk Category	Representative % Swell (500 psf Surcharge)	Representative % Swell (1000 psf Surcharge)
Low	0 to <3	0 to <2
Moderate	3 to <5	2 to <4
High	5 to <8	4 to <6
Very High	≥8	≥6

The data collected by Triax Engineering, LLC during this investigation was used to provide geotechnical information and recommendations regarding subsurface conditions on the site investigated, the effect of those conditions on the proposed construction, and the foundation type for the named client. The stratification lines indicated on the boring log are approximate, and subsurface conditions encountered during construction may differ from those presented herein. This uncertainty cannot be eliminated because of the many variability's associated with geology. For example material and engineering characteristics of soil and bedrock may change more gradually or more quickly indicated in this report and the actual engineering properties of non-sampled soil or rock may differ from interpretations. Quantitative conclusions regarding the performance of geotechnical structures prior to construction are not possible because of the complexity of subsurface conditions. Rather, engineering judgments and experience are used to estimate likely geotechnical performance and provide the necessary recommendations. Put another way, we cannot be sure about what is not visible, so the collected data and our training and experience are used to develop predictions and recommendations. There are no guarantees or warranties implied or expressed.

The owner and/or client must understand that uncertainties are associated with geotechnical engineering, and they, the owner and/or client, must determine the level of risk they are willing to accept for the proposed construction. The risks can be reduced, but not eliminated, through more detailed investigation, which costs more money and takes more time, and through any appropriate construction, which might be recommended as a result of that, more detailed investigation. To reduce the level of uncertainty, this report was prepared only for the referenced client and for the proposed construction indicated in the report. Unless authorized by us in writing, the owner will assume additional geotechnical risk if this report is used for any construction that differs from that indicated in the report. Our firm should be consulted well before changes in the proposed construction occur, such as the nature, size, configuration, orientation, or location of any improvements. Additionally, the knowledge and experience of the local geotechnical practice is continually expanding and it must be understood the presented recommendations were made according to the standard of practice at the time of report issuance. If the construction occurs 1 or more years after issuance of the report, the owner and/or client should contact our firm to determine if additional investigation or revised recommendations would be advisable.

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.***

GEOPROFESSIONAL BUSINESS ASSOCIATION

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