RABA KISTNER INFRASTRUCTURE

Project No. AUA 13-046-00
June 26, 2013

Rick Everson
Watts Enterprises
5200 South Highland Drive, Ste. 100
Salt Lake City, Utah 84117

RE: **Powder Mountain Resort**
Earl's Peak Water Tank
Weber County, Utah

Dear Mr. Everson

Raba Kistner Infrastructure Inc. (RKI) is pleased to submit the report of our Geotechnical Engineering Study for the above-referenced project located near Powder Mountain Ski Resort in Weber County, Utah. This study was performed in accordance with the **RKI** proposal, dated June 4, 2013. The purpose of this study was to evaluate the soil conditions at the site of the proposed water tank and to develop a geotechnical report. The following report presents the findings of our subsurface exploration, results of our laboratory testing and geotechnical recommendations regarding the development of the subject site.

We appreciate the opportunity to be of service to you on this project. Should you have any questions about the information presented in this report, or if we may be of additional assistance, please call.

Very truly yours,

RABA KISTNER INFRASTRUCTURE, INC.

Aaron B. Smith, P.E.
Geotechnical Engineer

REGISTERED PROFESSIONAL ENGINEER
6-26-13
No. 7884841
AARON BRIAN SMITH
STATE OF UTAH

Newel K. White, P.E.
Geotechnical Manager

RABA KISTNER INFRASTRUCTURE

EXECUTIVE SUMMARY

The results from our 60 foot ODEX boring along with previous geotechnical exploration reports (IGES, 2012) indicate the site is suitable for development of the proposed water tank. The results of this study do not indicate any known geologic conditions that would preclude development of the site. Except for some backfill and bearing capacity precautions outlined below, the site is suitable for construction of proposed water tank.

- SPT blow counts and ODEX cuttings indicate subsurface materials consist of dense, silty gravel with cobbles and boulders. The primary foundation consideration is settlement of the subsurface soils.

    1. Mat foundations may be designed using an allowable bearing capacity of **2,500 psf** and a Modulus of Subgrade reaction of **240 psi/inch**.

    2. Conventional spread or continuous wall footings constructed on competent native soils may be designed using an allowable bearing capacity **of 4,200 psf**.

- On-site material consists of silts, sands, cobbles and boulders with an estimated maximum diameter of 5 feet. This material may be used as Backfill around perimeter of water tank as long as it is processed and reduced to 4" minus material.

- Soils encountered can be described as Type C soils per OSHA classification. Excavation walls during tank construction should be laid back to 1.5 feet horizontal to 1 foot vertical. Large boulders and cobbles should be removed from the excavation walls to prevent rock fall hazards.

GEOTECHNICAL ENGINEERING STUDY

For

POWDER MOUNTAIN RESORT
WATER TANK
WEBER COUNTY, UTAH

Prepared for

WATTS ENTERPRISES
Salt Lake City, Utah

Prepared by

RABA KISTNER INFRASTRUCTURE
Orem, Utah

PROJECT NO. AUA 13-046-00

JUNE 2013

RABA KISTNER INFRASTRUCTURE

TABLE OF CONTENTS

TABLES

RABA KISTNER INFRASTRUCTURE

TABLE OF CONTENTS

PICTURES

FIGURES

APPENDICES

INTRODUCTION

Raba Kistner Infrastructure (RKI) has completed the authorized subsurface exploration for new water tank located at the Powder Mountain Ski Resort in Weber County, Utah. This report describes the procedures utilized during this study and presents our findings along with our recommendations for the water tank design.

PROJECT DESCRIPTION

Based on conversations with you, Bowen Collins and Associates and the information provided in the IGES Geotechnical Engineering Report with drawings of site, we understand the site will be developed for the construction of a water tank. We understand the new water tank will be a reinforced concrete structure, the perimeter of the tank will be founded on a thickened slab, and the roof structure will be supported on columns founded on conventional isolated footings. The column footings will be placed directly on the tank slab on grade. The tank will have a height of about 20 feet. The tank will be completely buried, with a maximum of 2 feet cover but may have as little as 10 feet of burial. We expect the diameter of the tank to be on the order of 70 feet. Excavated material from site would like to be reused as backfill around perimeter of tank.

FIELD AND LABORATORY TESTS

Subsurface conditions at the site were evaluated by drilling one (1) standard penetration test (SPT) boring at the approximate location shown on the Boring Location Map, Figure 1. The perimeter of the water tank had previously been staked and the boring was advanced along the northern edge of the proposed water tank. The boring was accomplished with an ODEX drill rig and advanced to a depth of 60 feet below existing grade. Due to the coarse nature of the soils encountered, relatively small disturbed samples were retrieved from the SPT sampler. Additional material was collected as cuttings ejected during the boring operation. During drilling, the following samples were collected:

Table 1 – Samples Collected

Type of Sample	Number Collected
Bag/Disturbed Samples	10
Bucket Sample	1

Each sample was visually classified in the field by a member of our Geotechnical Engineering staff. The geotechnical engineering properties of the strata were evaluated by the following tests:

Table 2 – Laboratory Tests Performed

Type of Test	Number Conducted
Natural Moisture Content	8
Atterberg Limits	8
Sieve Analysis	11

The results of laboratory tests are presented in graphical or numerical form on the boring log illustrated on Figure 2. A key to classification terms and symbols used on the logs is presented on Figures 4a, b and c.

Samples will be retained in our laboratory for 60 days after submittal of this report. Other arrangements may be provided at the request of the Client.

GENERAL SITE CONDITIONS

SITE DESCRIPTION

The subject site is located in the Powder Mountain Ski Resort at the top of Powder Ridge road. The proposed water tank is located south of the existing Hidden Lake Lodge and Hidden Lake ski lift, along the southern edge of the existing parking area. At the time of our field work the majority of the work area consisted of about 5 feet of leveled fill, pushed to the hillside edge and leveled to accommodate the drill rig. A gravel road runs east-west along the southern edge of the proposed water tank. The vegetation at the site consists of brush, weeds and native grasses. Cobbles and boulders (2-3 feet max diameter) protrude regularly from the surface vegetation.

Figure 1 - Looking Southeast from boring.

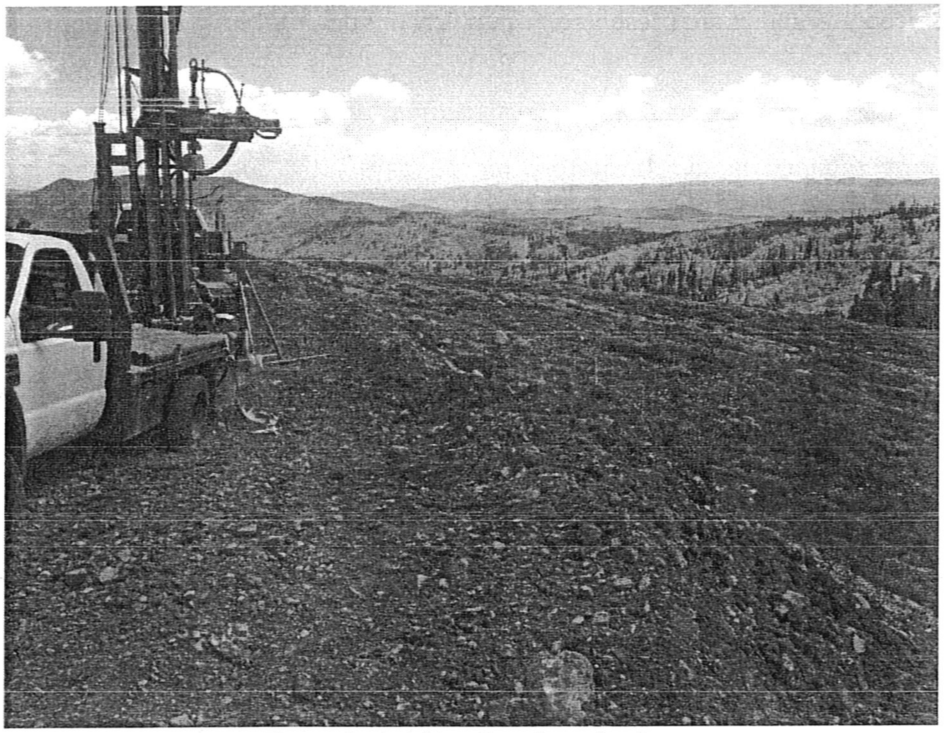

Figure 2 - Looking East from boring.

Figure 3 - Looking Northwest from southern side of proposed tank.

RABA KISTNER INFRASTRUCTURE

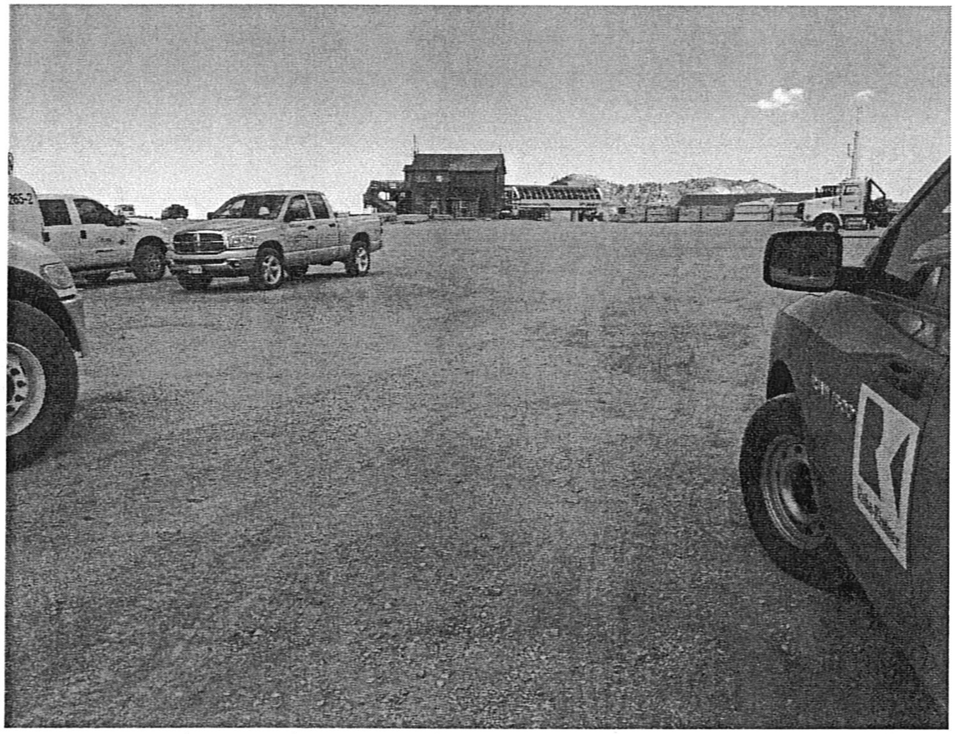

Figure 4 – Looking North across parking area to Hidden Lake Lodge and ski lift.

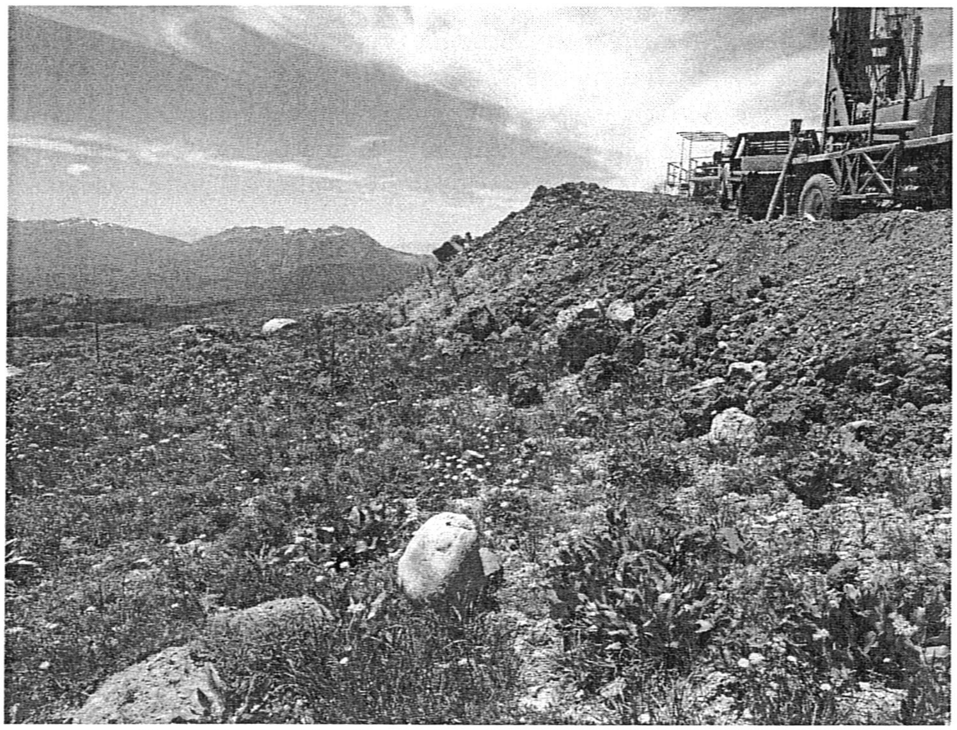

Figure 5 – Looking West through proposed center of tank.

Figure 6 – Looking East over bag samples from ongoing water well drill site.

GEOLOGY

Based on our review of the above mentioned subsurface exploration and laboratory testing the subject site is underlain primarily by the Tertiary-age Wasatch Formation (Tw), which generally consists of unconsolidated conglomerate. Surface material to the maximum depth explored of 60 feet below the surface generally consists of dense silty gravel with cobbles and boulders. The top 5 feet consist of clayey gravel with sand and cobbles. Soils classifying as clay and/or silt were encountered in limited areas between gravel and cobble layers.

SEISMIC COEFFICIENTS

Based upon a review of Section 1613 *Earthquake Loads – Site Ground Motion* of the 2009 International Building Code and the 2009 NEHRP recommended Provisions for Seismic Regulations for New Buildings and Other Structures provided by USGS Seismic Hazard Curves, the following information has been summarized for seismic considerations associated with this site. This information is preliminary and based on our limited subsurface investigation.

- Site Class Definition (Table 1613.5.2): **Class C**.
- Mapped Maximum Considered Earthquake Ground Motion for a 0.2 sec Spectral Response Acceleration (Figure 1613.5(5)): $\mathbf{S_s = 0.835g}$. Note that the value taken from Figure 1613(5) is based on Site Class B and are adjusted per Section1613.5 3 and 1613.5.4 below.

- Mapped Maximum Considered Earthquake Ground Motion for a 1 sec Spectral Response Acceleration (Figure 1613.5(6)): S_1 = **0.278g**. Note that the value taken from Figure 1613(5) is based on Site Class B and are adjusted per Section 1613.5.3 and 1613.5.4 below.
- Values of Site Coefficient (Table 1613.5.3(1)): F_a = **1.066**
- Values of Site Coefficient (Table 1613.5.3(2)): F_v = **1.522**

The Maximum Considered Earthquake Spectral Response Accelerations are as follows:

- 0.2 sec, adjusted based on equation 16-38: S_{ms} = **0.890g**
- 1 sec, adjusted based on equation 16-39: S_{m1} = **0.423g**

The Design Spectral Response Acceleration Parameters are as follows:

- 0.2 sec, based on equation 16-40: S_{DS} = **0.594g**
- 1 sec, based on equation 16-41: S_{D1} = **0.282g**

STRATIGRAPHY

Based on our field observations, subsurface exploration, and review of referenced geologic soils maps, the soil conditions encountered in the boring, to the depth explored, are relatively similar to TP-15 in the 2012 IGES report. At the ground surface, topsoil and/or fill consisting of reddish brown gravel with silt and clay with organics was encountered to approximately 5 feet below the surface. From 5 feet extending to depths of 60 feet the material is generally very dense silty gravel with cobbles and boulders up to 30 inches in diameter. Between 25 and 35 feet there was a 10 foot layer of reddish-brown clayey gravel with slightly more plasticity than the surrounding soils.

GROUNDWATER

Groundwater was not encountered in the exploration. Seasonal and yearly fluctuations in groundwater levels may occur depending on topography, subsurface geologic conditions, precipitation and other factors. Evaluation of factors associated with groundwater fluctuations was beyond the scope of this study.

LIQUEFACTION

Liquefaction is a phenomenon in which loose, saturated soils lose shear strength under short-term (dynamic) loading conditions. Ground shaking of sufficient duration results in loss of grain-to-grain contact in potentially liquefiable soils due to a rapid increase in pore water pressure. This causes the soil to behave as a fluid for a short period of time. To be potentially liquefiable, a soil is typically cohesionless with a grain-size distribution generally consisting of sand and silt. It is generally loose to medium dense, saturated, and subjected to sufficient magnitude and duration of ground shaking. Liquefaction can induce ground settlement and lateral spreading, which can result in damage to structures. The Weber County liquefaction potential map identifies this area as having very low liquefaction potential.

Lateral spread displacement is a liquefaction-induced phenomena that occurs where a non-liquefiable soil mass underlain by a continuous liquefiable layer experiences permanent lateral displacement down-slope, or towards a free face such as a river bluff or edge. The evaluation of the lateral spread potential is a function of the ground slope, thickness of the continuous liquefiable layer, the fines content and mean grain size of that continuous layer, and the seismic energy applied as defined by the earthquake magnitude and location of the site relative to the seismic energy source. Based on our evaluation and review of the subsurface data collected for the site, it is our opinion that the potential for lateral spread to occur at the site is very low.

EARTHWORK AND SITE GRADING

SITE PREPRATION

Prior to construction, the ground surface in proposed water tank area should be cleared of any surface and subsurface obstructions, debris, organics (including vegetation), and other deleterious material. In general a stripping depth of 6-18 inches will be required across the site. Topsoil can be stockpiled on-site and used in landscape areas. Areas of undocumented fill may be encountered up to 5 feet in depth along the northern edge of proposed water tank. All topsoil, undocumented fill, or other unsuitable material should be completely removed. Where large cobbles or boulders are encountered and removed, over excavation and backfilling may be required to level the working surface. Backfilling and leveling should comply with the "Backfill" section of this report.

The Geotechnical Engineer should observe the exposed subgrade soils to evaluate if removals down to more competent soils are needed. Proof rolling with construction equipment may be used for this evaluation. Soft, saturated, or otherwise unsuitable native soils should be removed from proposed improvement areas and replaced with granular material.

SITE GRADING

We understand that the proposed water tank columns founded on conventional isolated footings will sit near the elevation of 8883. If there is a design change to finish floor elevation by more than plus or minus 5 feet, RKI should be retained to review the site grading plans prior to bidding the project for construction.

BACKFILL

On site material consists of sand, silt, cobbles and boulders with a maximum diameter of up to 5 feet. This material may be used as Backfill around perimeter of the water tank as long as it is processed and reduced to 4" minus material. This may be accomplished by crushing or screening the on-site soils.

Backfill should be moisture conditioned and compacted to a density of 92% of Maximum Dry Density (MDD) as determined by ASTM D1557. Regions of the water tank that will be below the future parking area should be compacted to a relative density of an average of 95% of MDD as determined by ASTM D1557. All fills should be free of organic, frozen, or other deleterious material or garbage.

OVERSIZE MATERIAL

Based on our observations at the site, there is significant potential for the presence of oversize material (larger than 6 inches in greatest dimension). Large rocks may require special handling, such as segregation from structural fill, crushing or disposal. Large boulders, up to 2.5 feet in diameter were observed during exploration and adjacent subsurface exploration conducted by IGES indicate that boulders as large as 5 feet in diameter may be encountered.

EXCAVATION SLOPING AND BENCHING

For excavations that extend below a depth of 5 ft., the contractor shall be required to develop an excavation safety plan in accordance with OSHA guidelines. The soils encountered during our subsurface exploration program can generally be described as Type C soils. These soils allow a maximum cut slope of 1.5 H:1 V. Large cobbles and boulders should be removed from excavated slopes to reduce rockfall hazard into the work zone.

If steeper slopes are contemplated for the project, they may be evaluated on a case by case basis by a licensed Geotechnical Engineer and will require field inspection and evaluation to determine their suitability.

FOUNDATION ANALYSIS

FOUNDATIONS

Based on subsurface conditions encountered in our borings, it is our opinion that the project site is suitable for development of the water tank, provided the following recommendations are adhered to:

ALLOWABLE BEARING CAPACITY

The native silty gravel with cobbles is suitable for the support of the proposed water tank. For design purposes our analyses indicate that spread or continuous wall footings constructed on competent native soils may be designed using an allowable bearing capacity **of 4,200 psf**. Mat or continuous foundations may be designed using an allowable bearing capacity of 2,500 psf and a modulus of subgrade reaction of 240 psi/in. The allowable bearing capacity may be increased by 1/3 for wind or seismic loads.

SETTLEMENT

Based on the subsoil conditions encountered and the assumed building loads we estimate that for foundations bearing on native soils total settlement will be on the order of ½ to ¾ of an inch. We estimate that differential settlement will be less than ½ of an inch.

LATERAL EARTH PRESSURES

Lateral loads on conventional spread and continuous wall foundations may be resisted by the development of passive earth pressures and friction between the base of the footings and the supporting soils. Over native soils or granular structural fill a coefficient of friction of 0.40 can be used in determining frictional resistance.

FROST CONSIDERATION

Frost depth in the vicinity of this site is approximately 42 inches. Footings should extend a minimum depth of 42 inches below adjacent grades for frost protection.

LIMITATIONS

This engineering report has been prepared in accordance with accepted Geotechnical Engineering practices in the region of Weber County, Utah and for the use of Watts Enterprises and its representatives for design purposes. This report may not contain sufficient information for purposes of other parties or other uses. This report is not intended for use in determining construction means and methods.

This report may not reflect the actual variations of the subsurface conditions across the site. The nature and extent of variations across the site may not become evident until construction commences. The construction process itself may also alter subsurface conditions. If variations appear evident at the time of construction, it may be necessary to reevaluate our recommendations after performing on-site observations and tests to establish the engineering impact of the variations.

The scope of our Geotechnical Engineering Study does not include an environmental assessment of the air, soil, rock, or water conditions either on or adjacent to the site. No environmental opinions are presented in this report.

* * * * * * * * * * * * * * * * * *

The following figures are attached and complete this report:

Figure 1	Boring Location Map
Figure 1a, 1b	Log of Boring
Figures 2a, b, c, d	Key to Terms and Symbols
Figure 3	Soil Classification Chart
Figure 4	Results of Soil Sample Analysis
Figures 5	Lab Testing Data

APPENDIX 1

RABA KISTNER

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BORING LOCATION MAP

Powder Mountain
Water Storage Tank
Powder Mountain Resort
Utah

REVISIONS

No.	Date	Description

PROJECT NO.: AUA-13-046-00

ISSUE DATE:	6/25/2013
DRAWN BY:	TRG
CHECKED BY:	
REVIEWED BY:	AS

FIGURE 1

NOTE: This Drawing is Provided for Illustration Only. May Not be to Scale and is Not Suitable for Design or Construction Purposes

LOG OF BORING NO. B-1

Water Storage Tank
Powder Mountain
Utah

RABA KISTNER
TBPE Firm Registration No. F-3257

DRILLING METHOD: Air Rotary

LOCATION: See Figure 1

SHEAR STRENGTH, TONS/FT²: 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT: 10 20 30 40 50 60 70 80

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
0	Fill - clayey gravel with cobble boulders, 2' diameter			9	46
5	Silty Gravel with Clay - very dense, moist, red-brown	13			
10	-2' diameter rock encountered with 6" gap between boulders	50/4"			
15	-decrease in cobbles/boulders/increase in angular gravel, yellowish color change	98/10"		NP	10
20		88/9"		NP	21
	-encountered boulder - softened up between 24' - 25'				
25	Silty Gravel with Clay - very dense, moist, red-brown	98		NP	27
	-decrease in gravels - @29' hit large rock, 12" diameter			4	
30	-sample of cuttings taken at 28'				
		94/7"		6	32
	- @33' hit large rock for 1.5' followed by 8" sandstone followed by another boulder @ 34' for 10" - Interchanging between boulder/sandstone/boulder				

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	60.0 ft	DEPTH TO WATER:	
DATE DRILLED:	6/13/2013	DATE MEASURED:	6/13/2013
PROJ. No.:	AUA-13-046-00	FIGURE:	1a

LOG OF BORING NO. B-1

Water Storage Tank
Powder Mountain
Utah

RABA KISTNER
TBPE Firm Registration No. F-3257

DRILLING METHOD: Air Rotary

LOCATION: See Figure 1

SHEAR STRENGTH, TONS/FT^2: 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT: 10 20 30 40 50 60 70 80

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
	Silty Gravel with Clay - very dense, moist, red-brown	50/5"			
	-dense drilling			NP	
	-sample of cuttings taken at 38'				
40		50/3"			
	-cutting sample taken at 42' - 44'			NP	
45	-cobbles and boulders interchanging - 2' -3' max diameter, 2" - 6" clay layers between cobbles	50/3"			
	-sample of cuttings taken at 48'			NP	
50		50/2"			
55	-cobbles end ~ 56' - gravels increase	50/4"			
	-sample of cuttings taken between 50' - 55'				
60	Boring Terminated	50/3"			
65					

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED: 60.0 ft
DATE DRILLED: 6/13/2013
DEPTH TO WATER:
DATE MEASURED: 6/13/2013
PROJ. No.: AUA-13-046-00
FIGURE: 1b

KEY TO TERMS AND SYMBOLS

MATERIAL TYPES

SOIL TERMS

- CALCAREOUS
- CALICHE
- CLAY
- CLAYEY
- GRAVEL
- GRAVELLY
- PEAT
- SAND
- SANDY
- SILT
- SILTY
- FILL

ROCK TERMS

- CHALK
- CLAYSTONE
- CLAY-SHALE
- CONGLOMERATE
- DOLOMITE
- IGNEOUS
- LIMESTONE
- MARL
- METAMORPHIC
- SANDSTONE
- SHALE
- SILTSTONE

OTHER

- ASPHALT
- BASE
- CONCRETE/CEMENT
- BRICKS / PAVERS
- WASTE
- NO INFORMATION

WELL CONSTRUCTION AND PLUGGING MATERIALS

- BLANK PIPE
- SCREEN
- BENTONITE
- CEMENT GROUT
- BENTONITE & CUTTINGS
- CONCRETE/CEMENT
- CUTTINGS
- GRAVEL
- SAND
- VOLCLAY

SAMPLE TYPES

- AIR ROTARY
- GRAB SAMPLE
- CORE
- GEOPROBE SAMPLER
- ROTOSONIC -DAMAGED
- MUD ROTARY
- NO RECOVERY
- NX CORE
- PITCHER
- ROTOSONIC -INTACT
- SHELBY TUBE
- SPLIT BARREL
- SPLIT SPOON
- TEXAS CONE PENETROMETER
- DISTURBED

STRENGTH TEST TYPES

- POCKET PENETROMETER
- TORVANE
- UNCONFINED COMPRESSION
- TRIAXIAL COMPRESSION UNCONSOLIDATED-UNDRAINED
- TRIAXIAL COMPRESSION CONSOLIDATED-UNDRAINED

NOTE: VALUES SYMBOLIZED ON BORING LOGS REPRESENT SHEAR STRENGTHS UNLESS OTHERWISE NOTED

PROJECT NO. AUA-13-046-00

KEY TO TERMS AND SYMBOLS (CONT'D)

TERMINOLOGY

Terms used in this report to describe soils with regard to their consistency or conditions are in general accordance with the discussion presented in Article 45 of SOILS MECHANICS IN ENGINEERING PRACTICE, Terzaghi and Peck, John Wiley & Sons, Inc., 1967, using the most reliable information available from the field and laboratory investigations. Terms used for describing soils according to their texture or grain size distribution are in accordance with the UNIFIED SOIL CLASSIFICATION SYSTEM, as described in American Society for Testing and Materials D2487-06 and D2488-00, Volume 04.08, Soil and Rock; Dimension Stone; Geosynthetics; 2005.

The depths shown on the boring logs are not exact, and have been estimated to the nearest half-foot. Depth measurements may be presented in a manner that implies greater precision in depth measurement, i.e 6.71 meters. The reader should understand and interpret this information only within the stated half-foot tolerance on depth measurements.

RELATIVE DENSITY

Penetration Resistance Blows per ft	Relative Density
0 - 4	Very Loose
4 - 10	Loose
10 - 30	Medium Dense
30 - 50	Dense
> 50	Very Dense

COHESIVE STRENGTH

Resistance Blows per ft	Consistency	Cohesion TSF
0 - 2	Very Soft	0 - 0.125
2 - 4	Soft	0.125 - 0.25
4 - 8	Firm	0.25 - 0.5
8 - 15	Stiff	0.5 - 1.0
15 - 30	Very Stiff	1.0 - 2.0
> 30	Hard	> 2.0

PLASTICITY

Plasticity Index	Degree of Plasticity
0 - 5	None
5 - 10	Low
10 - 20	Moderate
20 - 40	Plastic
> 40	Highly Plastic

ABBREVIATIONS

B = Benzene
T = Toluene
E = Ethylbenzene
X = Total Xylenes
BTEX = Total BTEX
TPH = Total Petroleum Hydrocarbons
ND = Not Detected
NA = Not Analyzed
NR = Not Recorded/No Recovery
OVA = Organic Vapor Analyzer
ppm = Parts Per Million

Qam, Qas, Qal = Quaternary Alluvium
Qat = Low Terrace Deposits
Qbc = Beaumont Formation
Qt = Fluviatile Terrace Deposits
Qao = Seymour Formation
Qle = Leona Formation
Q-Tu = Uvalde Gravel
Ewi = Wilcox Formation
Emi = Midway Group
Mc = Catahoula Formation
El = Laredo Formation
Kknm = Navarro Group and Marlbrook Marl
Kpg = Pecan Gap Chalk
Kau = Austin Chalk

Kef = Eagle Ford Shale
Kbu = Buda Limestone
Kdr = Del Rio Clay
Kft = Fort Terrett Member
Kgt = Georgetown Formation
Kep = Person Formation
Kek = Kainer Formation
Kes = Escondido Formation
Kew = Walnut Formation
Kgr = Glen Rose Formation
Kgru = Upper Glen Rose Formation
Kgrl = Lower Glen Rose Formation
Kh = Hensell Sand

PROJECT NO. AUA-13-046-00

KEY TO TERMS AND SYMBOLS (CONT'D)

TERMINOLOGY

SOIL STRUCTURE

Slickensided	Having planes of weakness that appear slick and glossy.
Fissured	Containing shrinkage or relief cracks, often filled with fine sand or silt; usually more or less vertical.
Pocket	Inclusion of material of different texture that is smaller than the diameter of the sample.
Parting	Inclusion less than 1/8 inch thick extending through the sample.
Seam	Inclusion 1/8 inch to 3 inches thick extending through the sample.
Layer	Inclusion greater than 3 inches thick extending through the sample.
Laminated	Soil sample composed of alternating partings or seams of different soil type.
Interlayered	Soil sample composed of alternating layers of different soil type.
Intermixed	Soil sample composed of pockets of different soil type and layered or laminated structure is not evident.
Calcareous	Having appreciable quantities of carbonate.
Carbonate	Having more than 50% carbonate content.

SAMPLING METHODS

RELATIVELY UNDISTURBED SAMPLING

Cohesive soil samples are to be collected using three-inch thin-walled tubes in general accordance with the Standard Practice for Thin-Walled Tube Sampling of Soils (ASTM D1587) and granular soil samples are to be collected using two-inch split-barrel samplers in general accordance with the Standard Method for Penetration Test and Split-Barrel Sampling of Soils (ASTM D1586). Cohesive soil samples may be extruded on-site when appropriate handling and storage techniques maintain sample integrity and moisture content.

STANDARD PENETRATION TEST (SPT)

A 2-in.-OD, 1-3/8-in.-ID split spoon sampler is driven 1.5 ft into undisturbed soil with a 140-pound hammer free falling 30 in. After the sampler is seated 6 in. into undisturbed soil, the number of blows required to drive the sampler the last 12 in. is the Standard Penetration Resistance or "N" value, which is recorded as blows per foot as described below.

SPLIT-BARREL SAMPLER DRIVING RECORD

Blows Per Foot	Description
25	25 blows drove sampler 12 inches, after initial 6 inches of seating.
50/7"	50 blows drove sampler 7 inches, after initial 6 inches of seating.
Ref/3"	50 blows drove sampler 3 inches during initial 6-inch seating interval

NOTE: To avoid damage to sampling tools, driving is limited to 50 blows during or after seating interval.

KEY TO TERMS AND SYMBOLS (CONT'D)

ROCK TERMINOLOGY

ROCK TYPE

"Rock type refers to the general geologic classification of the rock (e.g. basalt, sandstone, limestone, etc.). Certain physical characteristics are ascribed to a particular rock type with a geological name given according to the rocks mode of origin. Although the rock type is used primarily for identification and correlation, the type is often an important preliminary indication of rock mass behavior."

WEATHERING

Fresh	- No evidence of any chemical or mechanical alteration.
Slightly Weathered	- Slight discoloration on surface, slight alteration along discontinuities, less than 10 percent of the rock volume altered.
Moderately Weathered	- Discoloring evident, surface pitted and altered with alteration penetrating well below rock surfaces, weathering "halos" evident, 10 to 50 percent of the rock altered.
Highly Weathered	- Entire mass discolored, alteracation pervading nearly all of the rock with some pockets of slightly weathered rock noticeable, some minerals leached away.
Decomposed	- Rock reduced to a soil with relicit rock texture, generally molded and crumbled by hand.

HARDNESS

Very soft	- Can be deformed by hand.
Soft	- Can be scratched with a fingernail.
Moderately hard	- Can be scratched easily with a knife.
Hard	- Can be scratched with difficulty with a knife.
Very hard	- Cannot be scratched with a knife.

ROCK QUALITY DESIGNATION

	<	25	Very Poor
25	<	50	Poor
50	<	75	Fair
75	<	90	Good
90	<	100	Excellent

TEXTURE

Sedimentary

Texture	Grain Diameter	Particle Name	Rock Name
*	80 mm	Cobble	Conglomerate
*	5 - 80 mm	Gravel	-
Coarse Grained	2 - 5 mm	-	-
Medium Grained	0.4 - 2 mm	Sand	Sandstone
Fine Grained	0.1 - 0.4 mm	-	-
Very Fine Grained	0.1 mm	Clay, Silt	Shale, Claystone Siltstone

Igneous and Metamorphic

Texture	Grain Diameter
Coarse Grained	5 mm
Medium Grained	1 - 5 mm
Fine Grained	0.1 - 1 mm
Aphanite	0.1 mm

ROCK STRUCTURE

Massive	- 3-ft thick or greater
Thickly Bedded	- beds from 1- to 3-ft thick
Medium Bedded	- beds from 4 in. to 1-ft thick
Thinly Bedded	- 4-in. thick or less

Unfractured	- 6 ft or more
Slightly Fractured	- 2 to 6 ft
Moderately Fractured	- 8 in. to 2 ft
Highly Fractured	- 2 in. to 8 in.
Intensely Fractured	- 2 in. or less

Flat	- 0 to 20 degrees
Dipping	- 20 to 45 degrees
Steeply Dipping	- 45 to 90 degrees

DISCONTINUITIES

Describe the type of joint (i.e. bedding, cleavage, foliation, schistocity, or extension), the degree of weathering, joint wall separations (filled or clean), roughness, and any infilling (source, type, and thickness).

From United States Army Corps of Engineers, EM 1110-1-2908 Rock Foundations, November 1994

PROJECT NO. AUA-13-046-00

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				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 ≥ 4 and 3[E] ≥ Cc ≥ 1	GW	Well-graded gravel[F]
			Cu < 4 and/or 1 > Cc > 3[E]	GP	Poorly graded gravel[F]
		Gravels with Fines More than 12% fines[C]	Fines classify as ML or MH	GM	Silty gravel[F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel[F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[D]	Cu ≥ 6 and 3[E] ≥ Cc ≥ 1	SW	Well-graded sand[I]
			Cu < 6 and/or 1 > Cc > 3[E]	SP	Poorly graded sand[I]
		Sands with Fines More than 12% fines[D]	Fines classify as ML or MH	SM	Silty sand[G,H,I]
			Fines classify as CL or CH	SC	Clayey sand[G,H,I]
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	Inorganic	PI > 7 and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			PI < 4 or plots below "A" line[J]	ML	Silt[K,L,M]
		Organic	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OL	Organic clay[K,L,M,N]
					Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	Inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI plots below "A" line	MH	Elastic Silt[K,L,M]
		Organic	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OH	Organic clay[K,L,M,P]
					Organic silt[K,L,M,Q]
Highly organic soils		Primarily organic matter, dark in color, and organic odor		PT	Peat

[A]Based on the material passing the 3-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]$Cu = D_{60}/D_{10}$ $Cc = (D_{30})^2 / (D_{10} \times D_{60})$

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

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

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

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

[J]If Atterberg limits 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 ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

[M]If soil contains ≥ 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.

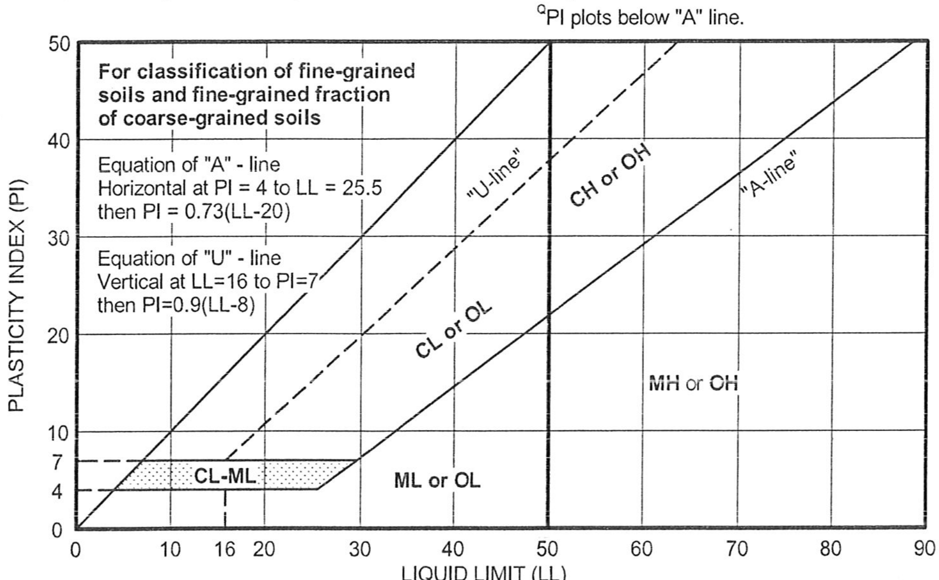

FIGURE 3

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UNIFIED SOIL CLASSIFICATION SYSTEM

Water Storage Tank
Powder Mountain
Utah

RESULTS OF SOIL SAMPLE ANALYSES

PROJECT NAME: Water Storage Tank
Powder Mountain
Utah

FILE NAME: POWDERMOUNTAIN.GPJ 6/25/2013

Boring No.	Sample Depth (ft)	Blows per ft	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	USCS	Dry Unit Weight (pcf)	% -200 Sieve	Shear Strength (tsf)	Strength Test
B-1	1.0		2	24	15	9	CL		46		
	5.0 to 6.5	13					CL				
	10.0 to 11.5	50/4"					GM				
	15.0 to 16.5	98/10"	2			NP	GW-GM		10		
	20.0 to 21.5	88/9"	5			NP	GM		21		
	25.0 to 26.5	98	6			NP	GM		27		
	28.0		9	21	17	4					
	30.0 to 31.5	94/7"	6	23	17	6	SC-SM		32		
	35.0 to 36.5	50/5"					GC				
	38.0		5			NP					
	40.0 to 41.5	50/3"					GM				
	44.0		3			NP					
	45.0 to 46.5	50/3"					GM				
	48.0		2			NP					
	50.0 to 51.5	50/2"					GM				
	55.0 to 56.5	50/4"	2				GM				
	60.0 to 61.5	50/3"	5				GM				

PP = Pocket Penetrometer TV = Torvane UC = Unconfined Compression FV = Field Vane UU = Unconsolidated Undrained Triaxial

CU = Consolidated Undrained Triaxial

PROJECT NO. AUA-13-046-00

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FIGURE 3

Important Information about Your

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.

Geotechnical 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 civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- 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,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- 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. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of 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 equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, a number of mold prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; ***none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.***

Rely, on Your ASFE-Member Geotechncial Engineer for Additional Assistance

Membership in ASFE/The Best People on Earth exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with your ASFE-member geotechnical engineer for more information.

ASFE

THE BEST PEOPLE ON EARTH

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