AGEC

Applied GeoTech

GEOTECHNICAL INVESTIGATION AND GEOLOGIC HAZARD STUDY

PROPOSED WATER TANK

4200 NORTH 5300 EAST

WEBER COUNTY, UTAH

PREPARED FOR:

GARDNER ENGINEERING
5150 SOUTH 375 EAST
WASHINGTON TERRACE, UTAH 84405

ATTENTION: DAN WHITE

PROJECT NO. 1160909

NOVEMBER 22, 2016

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EXECUTIVE SUMMARY

1. The subsurface soil encountered consists of approximately 1 foot of topsoil overlying clayey gravel with sand, which extends the full depth investigated, approximately 21 feet. The gravel contains cobbles and boulders up to approximately 2 feet in size.

2. No subsurface water was encountered in the test pits.

3. The proposed water reservoir may be supported on spread footings bearing on the undisturbed natural soil or on structural fill extending down to the undisturbed natural soil and may be designed for a net allowable bearing pressure 3,500 pounds per square foot.

4. Some excavation difficulties can be expected for excavation in the clayey gravel due to the cobbles and boulders.

5. Temporary unretained excavation slopes may be constructed at ½ horizontal to 1 vertical or flatter. Permanent unretained cut and fill slopes may be constructed at 2½ horizontal to 1 vertical or flatter.

6. The only geologic hazard identified during this study to potentially affect the proposed tank is seismic ground shaking. This hazard will be mitigated through structural design. In our professional opinion, landslide, rockfall, debris flow, surface fault rupture and ground subsidence are not considered hazards at this site based on our geologic hazard study.

7. Geotechnical information related to foundations, subgrade preparation and materials is included in the report.

SCOPE

This report presents the results of a geotechnical investigation and geologic hazard study for the proposed water reservoir to be constructed at approximately 4200 North 5300 East in Weber County, Utah. The report presents the subsurface conditions encountered, laboratory test results and recommendations for foundations. The study was conducted in general accordance with our proposal dated October 26, 2016 except the investigation was performed using a track-mounted excavator rather than a drill rig.

Field exploration was conducted to obtain information on the subsurface conditions and to obtain samples for laboratory testing. Information obtained from the field and laboratory was used to define the conditions at the site for our engineering analysis. Results of the field exploration and laboratory tests were analyzed to develop recommendations for the proposed foundations.

This report has been prepared to summarize the data obtained during the study and to present our conclusions and recommendations based on the proposed construction and the subsurface conditions encountered. Design parameters and a discussion of geotechnical engineering considerations related to construction are included in the report.

SITE CONDITIONS

At the time of our field study, the area for the proposed water reservoir consisted of undeveloped land. There is a buried tank to the west of the site and a pond farther to the west. The surrounding area consists of undeveloped hillside.

The ground surface at the site slopes gently down to the south.

Vegetation at the site consists of grass and brush.

FIELD STUDY

The field study was originally attempted on November 2, 2016 using a drill rig but the rig broke down. The field study was conducted on November 9, 2016. Two test pits were excavated using a tracked excavator at the approximate locations indicated on Figure 1. The test pits were logged and soil samples obtained by an engineer from AGEC. Logs of the subsurface conditions encountered in the test pits are graphically shown on Figure 2.

The test pit was backfilled without significant compaction. The backfill in the test pits should be properly compacted where it will support proposed tank, slabs or pavement.

SUBSURFACE CONDITIONS

The subsurface soil encountered consists of approximately 1 foot of topsoil overlying clayey gravel with sand, which extends the full depth investigated, approximately 21 feet. The gravel contains cobbles and boulders up to approximately 2 feet in size.

A description of the various soils encountered in the test pits follows:

> Topsoil - The topsoil consists of clayey gravel with sand, cobbles and boulders. It is moist, dark brown and contains roots and organics.
>
> Clayey Gravel with Sand - The gravel contains some cobbles and boulders up to approximately 2 feet in size. It is medium dense to dense, moist and greenish gray to reddish gray.
>
> Laboratory tests conducted on samples of the gravel indicate it has natural moisture contents ranging from 6 to 10 percent. Results of gradation tests performed on the gravel are presented on Figure 3.

Results of the laboratory tests are summarized on Table I and are included on logs of the test pits.

SUBSURFACE WATER

No subsurface water was encountered in the test pits. Fluctuations in the water level and possible development of a perched water condition should be expected over time.

GEOLOGIC HAZARDS

Geologic conditions at the site were evaluated by a review of geologic literature, aerial photographs and Lidar data. Aerial photographs used during the investigation were downloaded from the Utah Geological Survey website. They have photograph numbers of ELK-2-169 and 170 and a photograph date of June 25, 1963. The Lidar data has a date of 2011 and was obtained from the Open Topography website.

A. Geologic Literature Review

The site is located in Ogden Valley, which is a northwest trending valley within the Wasatch Mountains of north/central Utah. The valley is filled with an accumulation of lacustrine, alluvial and colluvial sediments from deposition during the past 15 million years (Sorensen and Crittenden, 1979). The surface deposits across the site consist of Quaternary-age colluvium consisting of clayey gravel with cobbles and boulders. These sediments are underlain by bedrock consisting of Precambrian metamorphic rock or possibly Tertiary-aged Norwood Tuff.

Ogden Valley is a down-dropped structure with the Ogden Valley Northeast margin fault along the northeast side of the valley and the Ogden Valley Southwest margin fault and the Ogden Valley North Fork fault along the southwest side of the valley. These faults are oriented in a general northwest/southeast direction with the two western faults estimated to have moved in the last 750,000 years and the east fault having evidence of movement in the last 2.6 million years. The faults are considered normal faults with dip direction down to the northeast on the two west fault systems and down to the southwest for the Ogden Valley Northeast margin fault. The faults are considered relatively old structures and do not represent a significant surface-fault-rupture hazard for development within the Ogden Valley area. Tectonic subsidence associated with fault movement would similarly not be a significant hazard at this site.

The Utah Fault and Fold database shows the Ogden Valley North Fork fault located along the north fork of the Ogden River approximately 2 miles to the southwest and the Ogden Valley Northeast margin fault located on the hillside to the northeast, approximately 1 mile from the site. No active faults are mapped through or near the site. The closest active fault to the site based on the Utah Geological Survey database is the Wasatch fault located approximately 6 miles to the west.

The geologic map by Sorensen and Crittenden (1979) shows the site to be underlain by colluvium and slope wash of Holocene age.

Mapping by Coogan and King (2001) shows the area underlain by alluvium and colluvium of Quaternary age.

The Elliott and Harty (2010) landslide map does not show the site as landslide deposits.

The King and others (2014) geologic map, which is a map in progress and currently has no legend, shows the site mapped as "Qmc". This mapping would suggest that the site is underlain by undivided landslide, slump and colluvial deposits. Gravel deposits were encountered in the test pits excavated at the site and with the relatively gentle slopes at the site, landslide would not be considered a hazard.

B. Aerial Photograph and Lidar Review

The geologic literature indicates that there may be landslide deposits in the area of the site. Review of aerial photographs and Lidar data finds evidence of potential geomorphology consistent with landslide deposits in the area but no evidence of landslide geomorphology at the site.

Based on the topography of the site and surrounding area, rockfall and debris flow are not potential geologic hazards at the site.

C. Seismicity

The property is located in the Intermountain Seismic Zone, which consists of an area of relatively high historical seismic activity. The most intense seismic ground shaking at the site is expected to originate from the Wasatch fault zone. The Wasatch fault zone is considered capable of producing earthquakes on the order of 7 to 7.5 magnitude and can result in significant seismic ground shaking at the site. The US Geological Survey data indicate that a peak ground acceleration of 0.37g can be expected to have a 2 percent probability of being exceeded in a 50-year time period at this site (IBC, 2012).

D. Liquefaction

Liquefaction is not a hazard at this site because of the type of sediments encountered and the expected depth to groundwater of greater than 30 feet.

E. Conclusions

Seismic ground shaking is considered the only significant geologic hazard at the site. This hazard will be mitigated through structural design. It is our professional opinion that landslide, debris flow, rockfall, surface fault rupture, tectonic subsidence and liquefaction are not significant hazards at the site.

PROPOSED CONSTRUCTION

We understand that the proposed water tank will consist of a 500,000-gallon, reinforced-concrete structure constructed partially below grade with backfill placed around and above the tank. We understand that the tank will extend to depths on the order of 8 to 20 feet below the existing ground surface. We have assumed loads for the proposed reservoir consisting of wall loads up to 5 kips per lineal foot and column loads up to 200 kips.

If the proposed construction or loads are significantly different from those described above, we should be notified so that we can reevaluate the recommendations given.

RECOMMENDATIONS

Based on the subsurface conditions encountered, laboratory test results and the proposed construction, the following recommendations are given:

A. Site Grading

We anticipate that excavation for the proposed tank will extend to depths of approximately 8 to 20 feet below the existing ground surface. We anticipate that soil will be placed around the perimeter and a soil cover provided over the top of the reservoir.

1. Excavation

We anticipate that excavation for the structure may be difficult due to the cobbles and boulders. Heavy-duty excavation equipment will likely be needed.

2. Cut and Fill Slopes

Temporary, unretained cut slopes may be constructed at ½ horizontal to 1 vertical or flatter. Permanent unretained cut and fill slopes may be constructed at 2½ horizontal to 1 vertical or flatter. Fill slopes should be protected from erosion by revegetation or other methods.

3. Subgrade Preparation

Topsoil, organics and other deleterious materials should be removed from the proposed reservoir area.

Prior to placing structural fill or concrete, loose or disturbed soil should be removed and replaced with compacted structural fill or should be properly compacted.

4. Compaction

Compaction of fill placed at the site should equal or exceed the minimum densities as indicated below when compared to the maximum dry density as determined by ASTM D 1557.

Fill To Support	Compaction
Foundations and slab	≥ 95%
Landscaping	≥ 85%
Tank Wall Backfill	85 - 90%

The fill should be compacted at a moisture content within 2 percent of the optimum moisture content to facilitate the compaction process.

Fill placed for the project should be frequently tested for compaction.

5. Materials

Materials placed as structural fill should consist of nonexpansive granular soil. The clayey gravel exclusive of oversize particles may be used as structural fill placed below and around the proposed tank.

The following recommendations are given for imported structural fill:

Fill to Support	Recommendations
Footings and Slabs	Non-expansive granular soil Passing No. 200 Sieve < 35% Liquid Limit < 30% Maximum size 4 inches
Floor Slab (Upper 4 inches)	Sand and/or Gravel Passing No. 200 Sieve < 5% Maximum size 2 inches

The moisture of the soil should be adjusted to within 2 percent of optimum to facilitate compaction. This may require wetting or drying of the soil depending of the soil moisture at the time of construction. Drying of the soil may not be practical during cold or wet times of the year.

6. Drainage

The ground surface surrounding the proposed tank should be planned to direct the surface run off away from the structure.

B. Foundations

1. Bearing Material

   With the proposed construction and the subsurface conditions encountered, the proposed water tank may be supported on spread footings bearing on the undisturbed natural soil or on compacted structural fill extending down to the undisturbed natural soil.

2. Bearing Pressure

   Spread footings bearing on the undisturbed natural soil or on compacted structural fill may be designed using an allowable net bearing pressure of 3,500 pounds per square foot. Footings should have a minimum width of 2 feet and a minimum depth of embedment of 1 foot.

3. Temporary Loading Conditions

   The allowable bearing pressure may be increased by one-half for temporary loading conditions such as wind and seismic loads.

4. Settlement

   We estimate that total and differential settlement will be less than ½ inch.

5. Lateral Resistance

   Lateral resistance for spread footings placed on the natural soil, or on structural fill is controlled by sliding resistance between the footing and the foundation soil. A friction value of 0.45 may be used in design for ultimate lateral resistance.

6. Frost Depth

   Footings below unheated areas should extend at least 36 inches below grade for frost protection.

7. Foundation Base

The base of foundation excavations should be cleared of loose or deleterious material or the loose material should be compacted.

8. Construction Observation

A representative of the geotechnical engineer should observe footing excavations prior to structural fill and concrete placement.

C. Concrete Slab-on-Grade

1. Slab Support

Floor slabs may be supported on the natural undisturbed soil, or on compacted structural fill extending down to the natural undisturbed soil.

2. Underslab Sand and/or Gravel

A minimum thickness of 4 inches of free draining sand and/or gravel should be placed beneath floor slabs. If columns are supported by thickened and reinforced sections of the floor slab, the sand and/or gravel need not be placed below the thickened portion of the slab.

D. Subgrade Walls

For the at-rest condition, where no lateral movement of the wall is permitted, the lateral load from the backfill may be calculated using an equivalent fluid weight of 65 pcf for a horizontal ground surface above the wall. An equivalent fluid weight for passive pressure of 250 pcf may be used assuming a horizontal ground surface on the passive side of the wall.

Under seismic conditions the equivalent fluid weight should be increased by 7 pcf for the at-rest condition and decreased by 22 pcf for the passive condition. This assumes a peak horizontal ground acceleration of 0.37g for a 2 percent probability of exceedance in a 50-year period (IBC 2015).

The values given above assume free-draining conditions in the wall backfill and the backfill used is similar to the soil encountered in the borings.

E. Subsurface Drains

A subsurface drain should be provided around the tank or the tank walls designed for hydrostatic pressure should the water rise to near the ground surface. The perimeter drain system should consist of at least the following items:

1. The underdrain system should consist of a perforated pipe installed in a gravel filled trench around the perimeter of the subgrade floor of the tank.

2. The flow line of the pipe should be placed at least 18 inches below the finished floor level and should slope to a sump or outlet where water can be removed by pumping or by gravity flow.

3. If placing the gravel and drain pipe requires excavation below the bearing level of the footing, the excavation for the drain pipe and gravel should have a slope no steeper than 1 horizontal to 1 vertical so as not to disturb the soil below the footing.

4. A filter fabric should be placed between the natural soil and the drain gravel. This will help reduce the potential for fine-grained material filling in the void spaces of the gravel.

5. The subgrade floor slab should have at least 6 inches of free-draining gravel placed below it and the underslab gravel should connect to the perimeter drain.

6. Consideration should be given to installing cleanouts to allow access into the perimeter drain should cleaning of the pipe be required in the future.

F. Pipe Support

The soil encountered is suitable for support of piping at the reservoir site.

1. <u>Settlement</u>
The soil at the pipe bearing elevation will experience little, if any, increase in stress due to the proposed construction. Thus, settlement of the proposed pipeline will be a function of disturbance of the soil beneath the pipe. Disturbance may result from excavation or construction activities. Care should be taken to minimize disturbance of the soil below the pipeline so that settlement can be maintained within tolerable limits.

2. <u>Pipe Bedding</u>
Pipe bedding requirements will depend on the type of pipe selected and design criteria based on the manufacture's recommendations. Pipe bedding material should be placed on undisturbed natural soil. If bearing soil is disturbed, it should be removed and replaced with compacted bedding material. Pipe bedding should meet the criteria given by the pipe manufacturer.

G. Thrust Blocks

Thrust block resistance may be calculated using the passive earth pressure condition with an equivalent fluid weight of 250 pcf. This assumes a ratio of horizontal displacement to height of thrust block of 0.01. A lower equivalent fluid weight should be used if less displacement is needed. An equivalent fluid weight of 170 pcf may be used if negligible horizontal displacement is desired. Thrust blocks should bear on the undisturbed natural soil or on compacted granular fill. A friction coefficient of 0.45 may be used between the concrete and bearing soil. This is an ultimate value and a suitable factor of safety should be applied.

H. Seismicity

Listed below is a summary of the site parameters for the 2015 International Building Code.

a.	Site Class	C
b.	Short Period Spectral Response Acceleration, S_S	0.92g
c.	One Second Period Spectral Response Acceleration, S_1	0.31g
d.	Peak Horizontal Ground Acceleration	0.37g

I. Water Soluble Sulfates

One sample of the natural soil was tested in the laboratory for water soluble sulfate content. The sample tested was found to have less than 0.1 percent water soluble sulfates. Based on the results of the test and our experience in the area, the natural soil does not contain significant water soluble sulfates. No special cement type is needed for concrete placed in contact with the natural soil.

J. Preconstruction Meeting

A preconstruction meeting should be held with representatives of the owner, project architect, geotechnical engineer, general contractor, earthwork contractor and other members of the design team to review construction plans, specifications, methods and schedule.

LIMITATIONS

This report has been prepared in accordance with generally accepted soil and foundation engineering practices in the area for the use of the client for design purposes. The conclusions and recommendations included within the report are based on the information obtained from the test pits excavated and data obtained from laboratory testing. Variations in the subsurface conditions may not become evident until additional exploration or excavation is conducted. If the subsurface soil or groundwater conditions are found to be different from those described in this report, we should be notified to reevaluate the recommendations.

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

Douglas R. Hawkes, P.E., P.G.

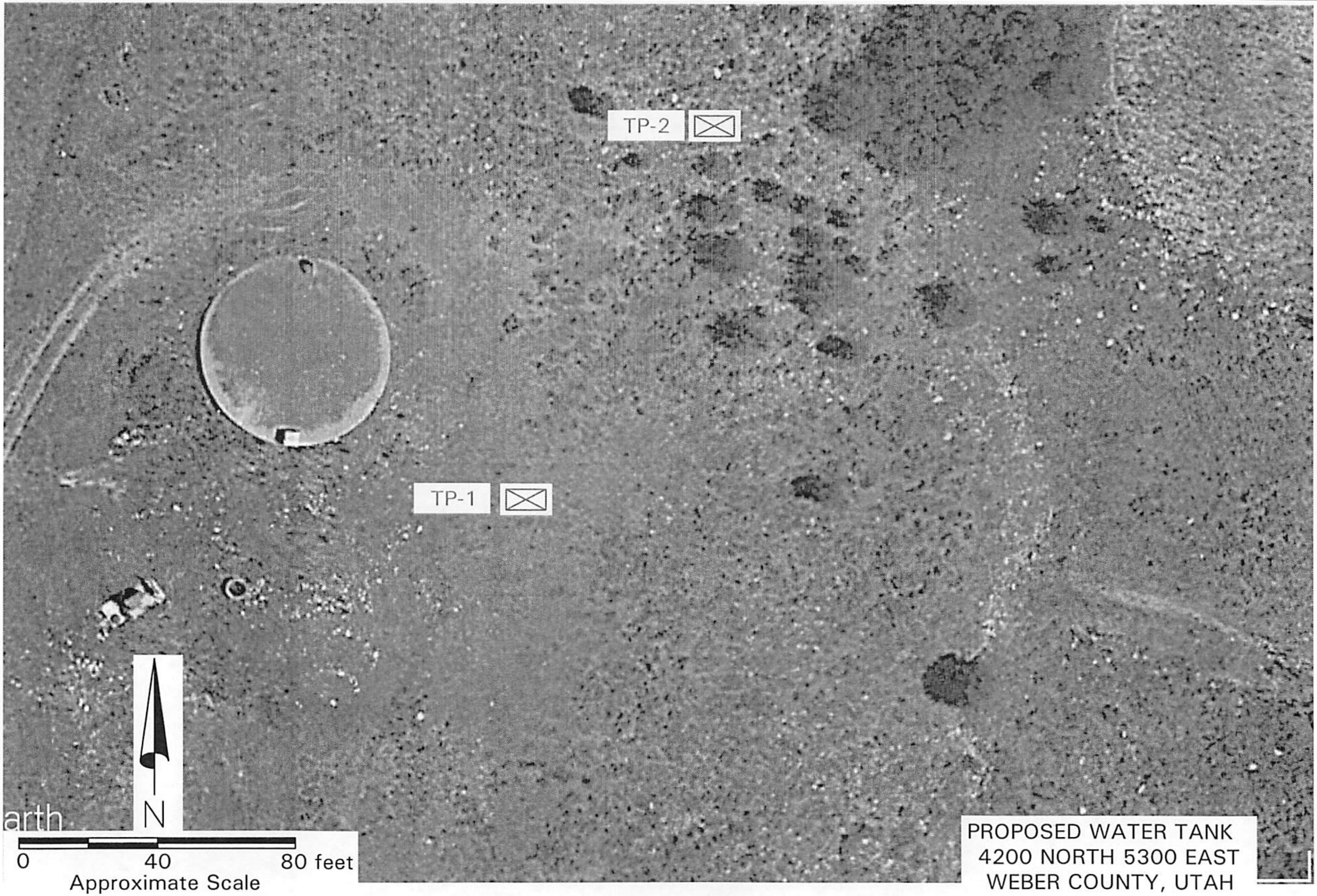
Reviewed by Jay R. McQuivey, P.E.

DRH/rs

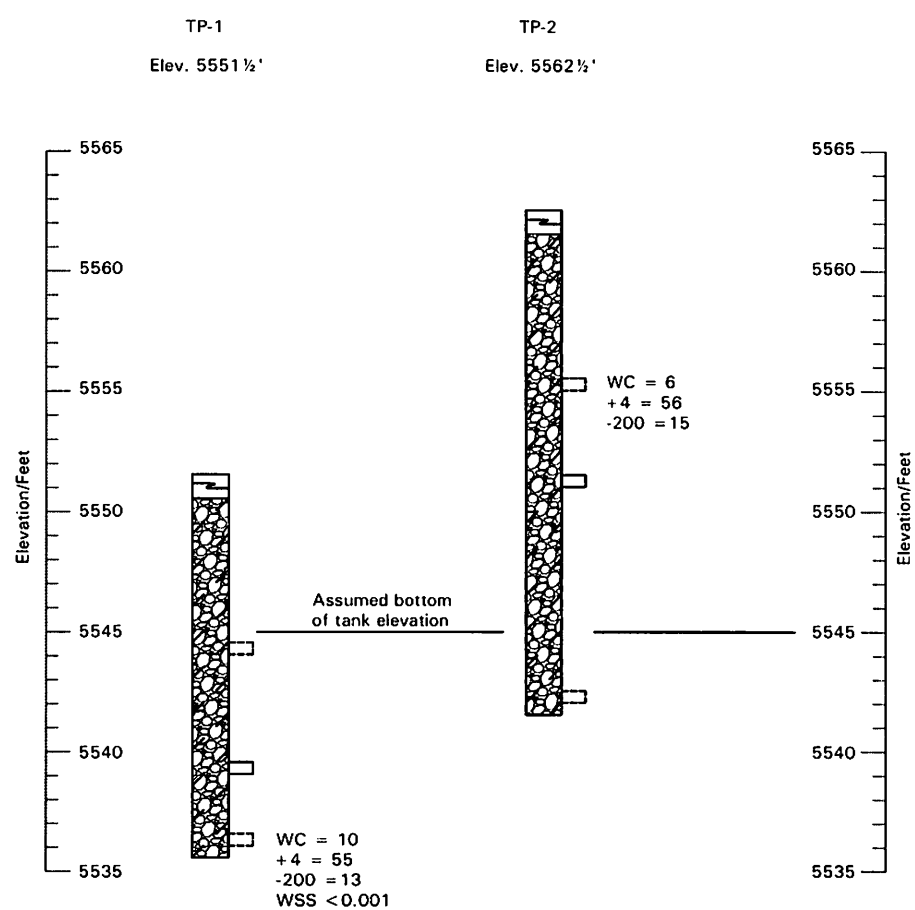
REFERENCES

Black, B.D., Hecker, S., Hylland, M.D., Christenson, G.E., and McDonald, G.N., 2003; Quaternary fault and fold database and map of Utah; Utah Geological Survey Map 193DM.

International Building Code, 2015; International Code Council, Inc., Falls Church, Virginia.



1160909	AGEC	Test Pit Locations	Figure 1



LEGEND:

- Topsoil; clayey gravel with sand, cobbles, boulders, moist, dark brown, roots, organics.
- Clayey Gravel with Sand (GC); cobbles, boulders up to approximately 2 feet in size, medium dense to dense, moist, greenish gray to reddish gray.
- Indicates disturbed sample taken.
- Indicates relatively undisturbed block sample taken.

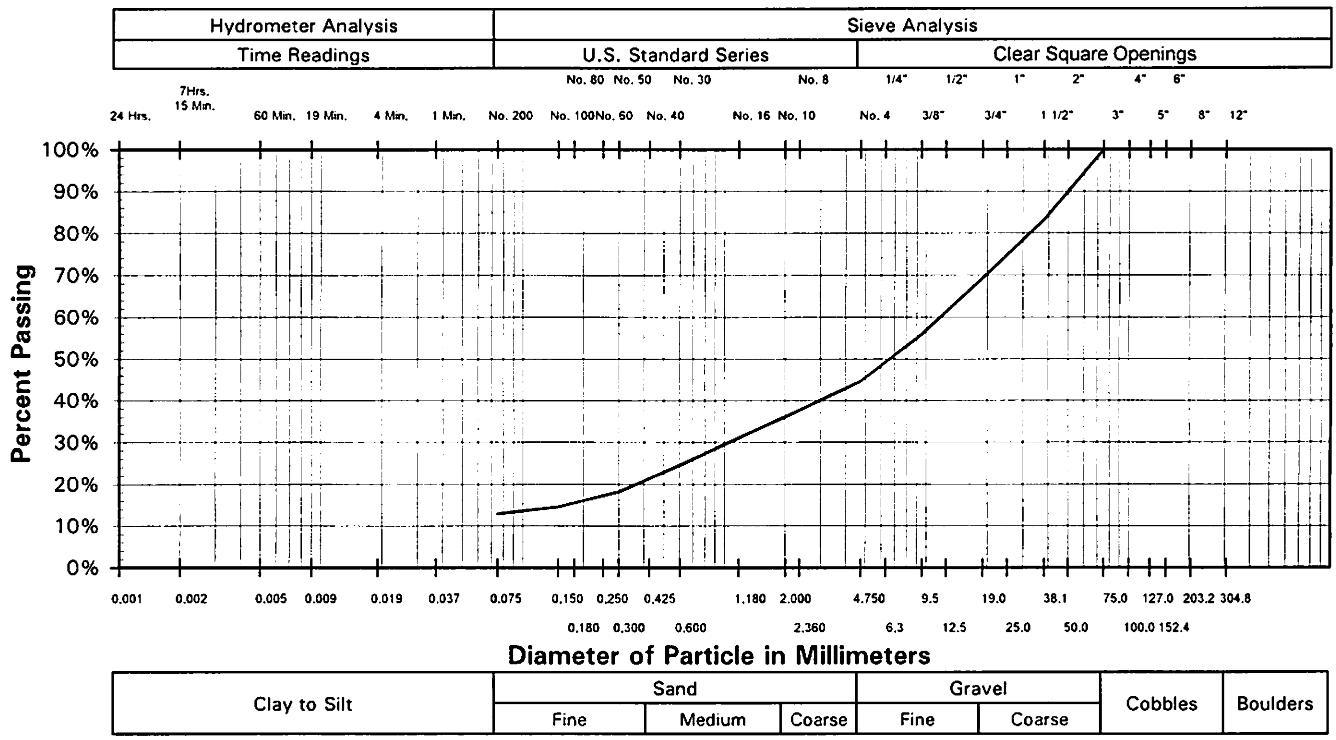
NOTES :

1. The test pits were excavated on November 9, 2016 with a tracked excavator.
2. The locations of the test pits were measured by pacing from features shown on the site plan provided.
3. The elevations of the test pits were determined by interpolating between contours shown on the site plan provided.
4. The test pit locations and elevations should be considered accurate only to the degree implied by the method used.
5. The lines between materials shown on the test pit logs represent the approximate boundaries between materials and the transitions may be gradual.
6. No free water was encountered in the test pits at the time of excavation.
7. WC = Water Content (%);
   +4 = Percent Retained on the No. 4 Sieve;
   -200 = Percent Passing the No. 200 Sieve;
   WSS = Water Soluble Sulfates (%).

Approximate Vertical Scale 1" = 8'

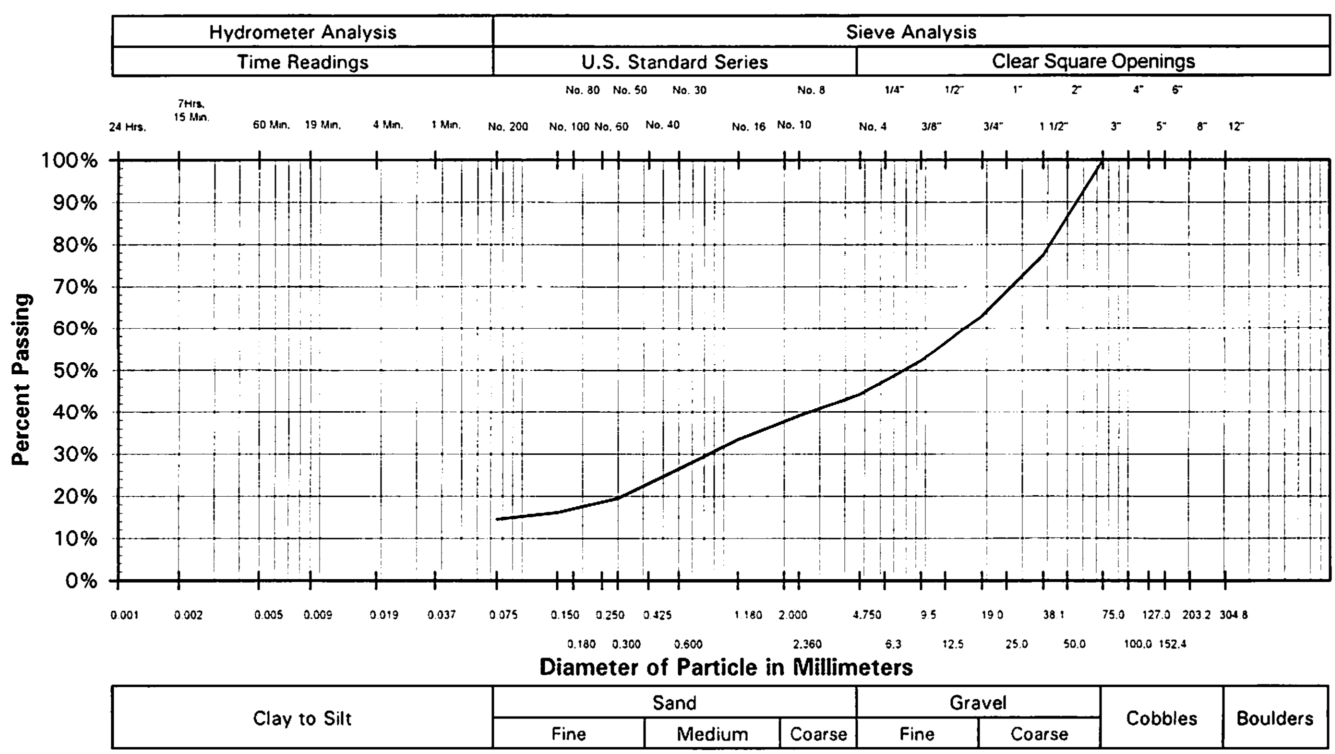
1160909	AGEC	Test Pit Logs, Legend and Notes	Figure 2

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.



Gravel	55%	Liquid Limit	-
Sand	32%	Plasticity Index	-
Silt and Clay	13%	Sample Location	TP-1 @15 feet

Sample Description Clayey Gravel with Sand (GC)



Gravel	56%	Liquid Limit	-
Sand	29%	Plasticity Index	-
Silt and Clay	15%	Sample Location	TP-2 @ 7 feet

Sample Description Clayey Gravel with Sand (GC)

TABLE I
SUMMARY OF LABORATORY TEST RESULTS

PROJECT NUMBER 1160909

SAMPLE LOCATION		NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (PCF)	GRADATION			ATTERBERG LIMITS		UNCONFINED COMPRESSIVE STRENGTH (PSF)	WATER SOLUBLE SULFATE (%)	SAMPLE CLASSIFICATION
TEST PIT	DEPTH (FEET)			GRAVEL (%)	SAND (%)	SILT/ CLAY (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)			
TP-1	15	10		55	32	13				<0.001	Clayey Gravel with Sand
TP-2	7	6		56	29	15					Clayey Gravel with Sand