IGES

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GEOTECHNICAL INVESTIGATION
Jamie Evans
1950 North 200 East
Spanish Fork, Utah

IGES Job No. 01190-001

RECEIVED
JUL 14 2008

July 11, 2008

Prepared for:

Evans Grader & Paving
c/o Jamie Evans

TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY

This report presents the results of a geotechnical investigation conducted for the proposed approximately 16-acre light industrial/commercial subdivision located near 1950 North and 200 East in Spanish Fork, Utah. The purposes of this investigation were to assess the nature and engineering properties of the subsurface soils at the proposed site, and to provide recommendations for general site grading and the design and construction of foundations, slabs-on-grade and exterior concrete flatwork.

As a part of this investigation, subsurface soil conditions were explored by excavating 8 exploratory test pits to depths of 9 to 11 feet below the existing site grade. Soils at the site generally consisted of layers of Lean CLAY (CL), SILT (ML), Clayey SAND (SC), Silty Clayey SAND (SC-SM), Silty SAND (SM), and Poorly Graded SAND with silt (SP-SM). Representative soil samples were tested in the laboratory to assess pertinent engineering properties. Unit weight and moisture content determinations were performed to estimate the in-place moisture and density conditions of the on-site soils. Consolidation and collapse tests were performed to assess the settlement potential of the on-site soils under increased loading and moisture conditions. Atterberg Limit tests and gradation analyses were also performed to aid in developing engineering recommendations for the site. A compaction test with a California Bearing Ratio (CBR) test were completed to assess the suitability of the native soils to support a pavement section.

Based on the subsurface conditions encountered at the site, it is our opinion that the subject site is suitable for the proposed construction provided that the recommendations contained in this report are complied with. Soft soils were encountered at the site and are susceptible to settlement with increased loading. Conventional strip and spread footings may be used to support the anticipated building loads if founded on relatively undisturbed native soils or a zone of properly placed and compacted structural fill. Alternatively a deep foundation as described in the following paragraphs should be considered if a higher bearing capacity is desired.

NOTICE: The scope of services provided within this report are limited to the assessment of the subsurface conditions for the proposed light industrial/commercial subdivision. This executive summary is not intended to replace the report of which it is part and should not be used separately from the report. The executive summary is provided solely for purposes of overview. The executive summary omits a number of details, any one of which could be crucial to the proper application of this report.

3.0 METHOD OF STUDY

3.1 FIELD INVESTIGATION

As a part of this investigation, subsurface soil conditions were explored by excavating 8 exploratory test pits to depths of 9 to 11 feet below the existing site grade. The approximate locations of the explorations are shown on the Geotechnical Map, Plate A-2 in Appendix A. Exploration points were placed to provide optimum coverage of the site. Logs of the subsurface conditions, as encountered in the explorations, were recorded at the time of excavation by a qualified geotechnical engineer and are presented in Appendix A, Plates A-3 through A-10. A Key to Soil Symbols and Terminology used in the Test Pit Logs is found on Plate A-11 in Appendix A.

The test pits were advanced using a track hoe. Soil sampling occurred at varying depths, however, sampling locations were limited due to caving in of the test pits and shallow groundwater. Disturbed soil samples were obtained and placed in buckets or baggies. Relatively undisturbed samples were obtained through the use of a U-type hand sampler driven with a 2 lb. sledge hammer. The soils observed in the explorations were classified according to the Unified Soil Classification System (USCS) by the geotechnical engineer. Classifications for the individual soil units are shown on the attached Test Pit Logs.

3.2 LABORATORY INVESTIGATION

Representative soil samples were tested in the laboratory to assess pertinent engineering properties. Unit weight and moisture content determinations were performed to estimate the in-place moisture and density conditions of the on-site soils. Consolidation and collapse tests were performed to assess the settlement potential of the on-site soils under increased loading and moisture conditions. Atterberg Limit tests and gradation analyses were also performed to aid in developing engineering recommendations for the site. A compaction test with a California Bearing Ratio (CBR) test were completed to assess the suitability of the native soils to support a pavement section.

Results of the laboratory tests indicate that the in-situ soils have dry unit weights ranging between 88 and 107 pounds per cubic feet (pcf). The subsurface soils moisture content ranged from a low of 7% to a high of 31%.

4.0 GENERALIZED SITE CONDITIONS

4.1 SURFACE CONDITIONS

The site is located at an elevation of approximately 4,530 feet above mean sea level (msl). The site of the planned light subdivision is currently vacant and undeveloped. The topography of the site is generally flat and sloping slightly down to the north by northwest.

4.2 SUBSURFACE CONDITIONS

As previously mentioned, the subsurface soil conditions were explored at the subject property by excavating 8 test pits at the site to depths between 9 and 11 feet below the existing site grade. Subsurface soil conditions were logged at the time of exploration and are included in Appendix A as Plates A-3 through A-10 at the end of this report. The soil and moisture conditions encountered, during our investigation, are discussed below.

4.2.1 Soils

Soils at the site generally consisted of layers of Lean CLAY (CL), SILT (ML), Clayey SAND (SC), Silty Clayey SAND (SC-SM), Silty SAND (SM), and Poorly Graded SAND with silt (SP-SM); a relatively thin layer of Poorly Graded GRAVEL with silt (GP-GM) was observed in TP-4. The stratification lines shown on the enclosed Test Pit Logs represent the approximate boundary between soil types. The actual in situ transition may be more gradual.

4.2.2 Groundwater/Moisture Content Conditions

Groundwater was encountered in all of the test pits. Water levels were measured at the time of our subsurface explorations in June, 2008. At this time, groundwater levels were observed within 2½ to 5 feet of the existing ground surface. It is our opinion that observed groundwater levels were observed above their seasonal lows. Seasonal fluctuations in precipitation, snowmelt and runoff, surface runoff from adjacent properties, irrigation on properties in the general vicinity, or other on or offsite sources may increase moisture conditions at the site; groundwater conditions can be expected to rise several feet depending on the time of year.

marks and scour features on close inspection. This unit was deposited in relatively shallow water near shore during the regression of Lake Bonneville. Exposed thicknesses are reported to be < 10 meters.

Lacustrine silt and clay (lpm)

Sediment consists of Upper Pleistocene calcareous silt with minor clay and fine sand (Machette, 1992). The unit is thick bedded or massive in nature, which implies that it was deposited in quiet water, either in sheltered bays, lagoons, or offshore in deeper water. Some blocks of silt and clay are dense and contain conchoidal fractures. This unit also generally overlies sandy to gravelly deposits. Exposed thicknesses are reported to be <5 meters.

5.3 SEISMICITY AND FAULTING

There are no known active faults that pass under or immediately adjacent to the site (Black and others, 2003). The site is located approximately 5.07 miles west of the mapped location of the southern end of the Provo segment of the Wasatch fault. The Provo segment is one of the longest (70 km) and most active segments of the Wasatch fault zone (Machette, 1992). Analyses of ground shaking hazard along the Wasatch Front suggests that the Wasatch fault zone is the single greatest contributor to the seismic hazard in Utah Valley region.

Using the criteria outlined in the 2006 IBC, the maximum considered earthquake (MCE) ground motion is taken as that motion represented by an acceleration response spectrum having a 2% chance of exceedance within a 50-year period (Section 1613.5). This hazard was identified for the site using the Java Application Ground Motion Parameter Calculator – Version 5.0.8 developed by the USGS (http://earthquake.usgs.gov/research/hazmaps /design/), which correlates with the International Building Code (2006 IBC) seismic hazard maps. This program, as with the IBC maps, is used to develop the probabilistic spectral accelerations corresponding to MCE seismic hazard level for rock-like conditions. To account for site soil effects, site coefficients (F_a and F_v) were used to attenuate the rock-based spectral acceleration values. Based on our field exploration, we believe that the soils at this site are representative of a "Stiff Soil" profile; best described by IBC Site Class D with F_a and F_v values of 1.01 and 1.50, respectively. From these procedures the MCE PGA was level and duration of seismic ground motions; (2) soil type and consistency; and (3) depth to groundwater.

Referring to the "Surface Rupture and Liquefaction Potential Special Study Area Map for Utah County, Utah" (Jarva, 1994), the subject site is located in an area designated as "high" for liquefaction potential. Based on the field and laboratory data collected for this site, native soils appear to be susceptible to liquefaction. Additionally, a liquefaction dike was observed in native soils in TP-8 indicating that liquefaction has occurred in the past within soils underlying the site. A liquefaction assessment was beyond the scope of this geotechnical investigation. A complete liquefaction assessment typically includes a minimum of one boring to 50 feet, in some cases a CPT (cone penetration test) exploration, additional laboratory testing, and engineering analysis. IGES can complete this analysis if desired.

5.4.2 Shallow Groundwater Flooding

Shallow groundwater flooding is a hazard that can cause the flooding of excavated areas where the depth of excavation exceeds the depth of the local water table. Shallow groundwater flooding should be considered when designing habitable structures which require excavation that may exceed the depth to the shallow groundwater.

Groundwater was encountered in all of the test pits at a depth of 3 to 5 feet. It is anticipated that dewatering will be needed in excavations that extend 3 to 5 feet beneath the existing surface at the property. Additionally, site grading should take into account the current level of the water table and the potential for groundwater to rise several feet during wet seasons.

Based on the soil types observed and shallow groundwater difficulty in equipment mobility may occur during site grading and other construction activities. Localized areas of soft soils can be stabilized by pushing cobbles or angular gravel into the subgrade until a relatively firm surface is achieved. Alternatively, soft soils may be stabilized as recommended in Section 6.2.4.

An IGES representative should observe the site preparation and grading operations to observe that the recommendations presented in this report are complied with.

6.2.2 Temporary Excavations

Based on Occupational Safety and Health Administration (OSHA) guidelines for excavation safety, trenches with vertical walls up to 5 feet in depth may be occupied. However, groundwater was encountered at approximately 3 to 4 feet below existing grade across the site. When saturated or wet conditions are encountered, side slopes should be further flattened to maintain slope stability; the slopes should be flattened until caving in and sloughing in of overlying materials no longer occurs. As discussed previously, the soils in the test pits had a high tendency to cave in, therefore, we recommend that consideration be given to using shoring or trench boxes to improve working conditions in the trenches. Dewatering measures will likely be required as well as temporary shoring of excavation walls. When the trench is deeper than 5 feet, we recommend a trench-shield or shoring be used as a protective system to workers in the trench. Based on our soil observations, laboratory testing, and OSHA guidelines, native soils at the site classify as Type C soils. Deeper excavations, if required, should be constructed with side slopes no steeper than one and one-half horizontal to one vertical (1.5H:1V) and it is our opinion that deeper excavations can only be completed if dewatering is also being completed. The contractor is ultimately responsible for trench and site safety. Pertinent OSHA requirements should be met to provide a safe work environment. If site specific conditions arise that require engineering analysis in accordance with OSHA regulations, IGES can respond and provide recommendations as needed.

6.2.3 Other Excavations

All footing excavations should extend laterally a minimum of 1-foot for every foot of depth of overexcavation beneath the bottom of the footings. Excavations should extend

We recommend that an IGES representative be on-site during all excavations to assess the exposed foundation soils. We also recommend that the geotechnical engineer be allowed to review the grading plans when they are prepared in order to evaluate their compatibility with these recommendations.

6.2.5 Structural Fill and Compaction

All fill placed for the support of structures, flatwork or pavements, should consist of structural fill. Structural fill may consist of native soils, however, due to the high moisture content, native soils will likely require significant moisture conditioning and processing, therefore consideration should be given to using an imported soil as structural fill. If native soils containing pinholes observed in TP-2, TP-3, TP-4, & TP-5 are used as structural fill, they should be thoroughly processed to remove the pinhole structure prior to being placed as structural fill. If soil is imported for use as structural fill, it should be a relatively well graded granular soil with a maximum of 50 percent passing the No. 4 mesh sieve and a maximum fines content (minus No.200 mesh sieve) of 25 percent. Structural fill, whether native or imported, should be free of vegetation and debris, and contain no particles larger than 3-inches in nominal size. Structural fill should be 1-inch minus material when within 1 foot of any footings or base coarse material. All structural fill soils should be approved by the geotechnical engineer prior to placement.

Structural fill should be placed in maximum 8-inch loose lifts and compacted on a horizontal plane, unless otherwise approved by the geotechnical engineer. Structural fill should be compacted to at least 95 percent of the maximum dry density (MDD), as determined by ASTM D-1557. The moisture content should be within 3 percent of the optimum moisture content (OMC) at the time of placement and compaction. Any imported fill materials should be approved prior to importing. Also, prior to placing any fill, the excavations should be observed by the geotechnical engineer to assess whether unsuitable materials or loose soils have been removed. In addition, proper grading should precede placement of fill, as described in the **General Site Preparation and Grading** subsection of this report (Section 6.2.1).

Fill soils placed for subgrade below pavement sections and exterior flat work, should be within 3% of the OMC when placed and compacted to at least 95 percent of the MDD as determined by ASTM D-1557. All utility trenches backfilled below pavement sections, curb and gutter and sidewalks, should be backfilled with structural fill that is within 3%

Strip footings should be 2- to 4-feet wide and spread footings should have dimensions of 3- to 6-feet. All exterior footings should be embedded at least 30 inches below final grade for frost protection and confinement. Interior footings not exposed to the full effects of frost should be embedded a minimum of 12 inches for confinement.

Conventional footings founded on native soil may be proportioned for a maximum allowable bearing capacity of **1,800 psf**. If a higher bearing capacity is desired, footings placed on a minimum of 12 inches of structural fill that has been properly placed and compacted as described above (Section 6.2.5) may be proportioned for a maximum allowable bearing capacity of **2,300 psf**. Due to shallow groundwater and fine-grained soils, soft soils may be encountered at the bottom of the footing excavations, especially if they are overexcavated for a higher bearing capacity. These soils may be stabilized in accordance with the recommendations in Section 6.2.4. These bearing capacities apply only to the use of conventional footings.

Settlements of properly designed and constructed conventional footings, founded as described above, are anticipated to be less than 1.0 inch. Differential settlements should be on the order of ½ the total settlement over 30 feet.

6.4 CONCRETE SLAB-ON-GRADE CONSTRUCTION

Concrete slab-on-grade construction may be constructed over at least 6-inches of compacted free-draining gravel over native soil or granular structural fill that has been prepared or placed in accordance with the recommendations in Sections 6.2.1, 6.2.4, and 6.2.5 of this report. The gravel should consist of road base with a 3/4-inch maximum particle size and no more than 12 percent fines passing the No. 200 mesh sieve. The gravel layer should be compacted to at least 95 percent of the MDD as determined by ASTM D-1557. It should be noted that heavily loaded floor slabs may experience excessive settlement. Therefore, we recommend that floor slabs be designed for a maximum floor load of 400psf. If a higher floor load is needed IGES can provide additional recommendations. All concrete slabs should be designed to minimize cracking as a result of shrinkage. Consideration should be given to reinforcing the slab with a welded wire fabric, re-bar, or fiber mesh.

Ultimate lateral earth pressures for native soils or structural fill acting against retaining walls and buried structures may be computed from the lateral pressure coefficients or equivalent fluid densities presented in the following table:

Condition	Lateral Pressure Coefficient	Equivalent Fluid Density (pounds per cubic foot)
Active	0.31	40
At-rest	0.47	55
Passive	3.25	375

These coefficients and densities assume level, granular backfill with no buildup of hydrostatic pressures. The force of the water should be added to the presented values if hydrostatic pressures are anticipated. Additionally, if sloping backfill is present, the additional surcharge created by the wedge of soil should be added to the presented values. If sloping backfill is present, we recommend the geotechnical engineer be consulted to provide more accurate lateral pressure parameters once the design geometry is established.

Walls and structures allowed to rotate slightly should use the active condition. If the element is constrained against rotation, the at-rest condition should be used. These values should be used with an appropriate factor of safety against overturning and sliding. A value of 1.5 is typically used.

6.7 MOISTURE PROTECTION AND SURFACE DRAINAGE

Precautions should be taken during and after construction to reduce saturation of foundation soils and structural fill. Over wetting the soils prior to or during construction may result in increased softening and pumping, causing equipment mobility problems and difficulty in achieving compaction.

Moisture should not be allowed to infiltrate the soils in the vicinity of, or upslope from, the structures. We recommend that roof runoff devices be installed to direct all runoff a minimum of 10 feet away from structures. The grade within 15 feet of the structures should be sloped a minimum of 2% away from the structure.

It is our experience that pavement in areas where trucks frequently turn around, backup, or load and unload experience more distress. If the owner wishes to prolong the life of the pavement in these areas, Portland cement concrete should be considered. If a Portland cement concrete pavement section is desired, IGES recommends the following for an ESAL count of approximately 1.7 million.

Area	Portland Cement Concrete (in.)	Untreated Base Course (in.)	Granular Borrow (in.)	Non-Woven Filter Fabric
General	**6**	**8**	**-**	**Propex Geotex® 601**

As discussed previously, unsuitable soils beneath roadway alignments should be stabilized or removed and replaced with structural fill in accordance with the recommendations in Section 6.2.5. Asphalt has been assumed to be a high stability plant mix, base course material should be composed of crushed stone with a minimum CBR of 70. Granular borrow material should consist of a pit run gravel, with a minimum CBR value of 30. Subgrade preparation should include reworking and compacting the uppermost 12-inches of native soils to a minimum of 95 percent of the MDD as determined by ASTM D-1557 as discussed previously. The granular borrow material may be comprised of imported granular soils provided material larger than 6-inches has been removed and the minimum CBR value of 30 is confirmed.

If traffic conditions vary significantly from our stated assumptions, IGES should be contacted so we can modify our pavement design parameters accordingly. Specifically if the traffic counts are significantly higher or lower, we should be contacted to revise the pavement section design if necessary.

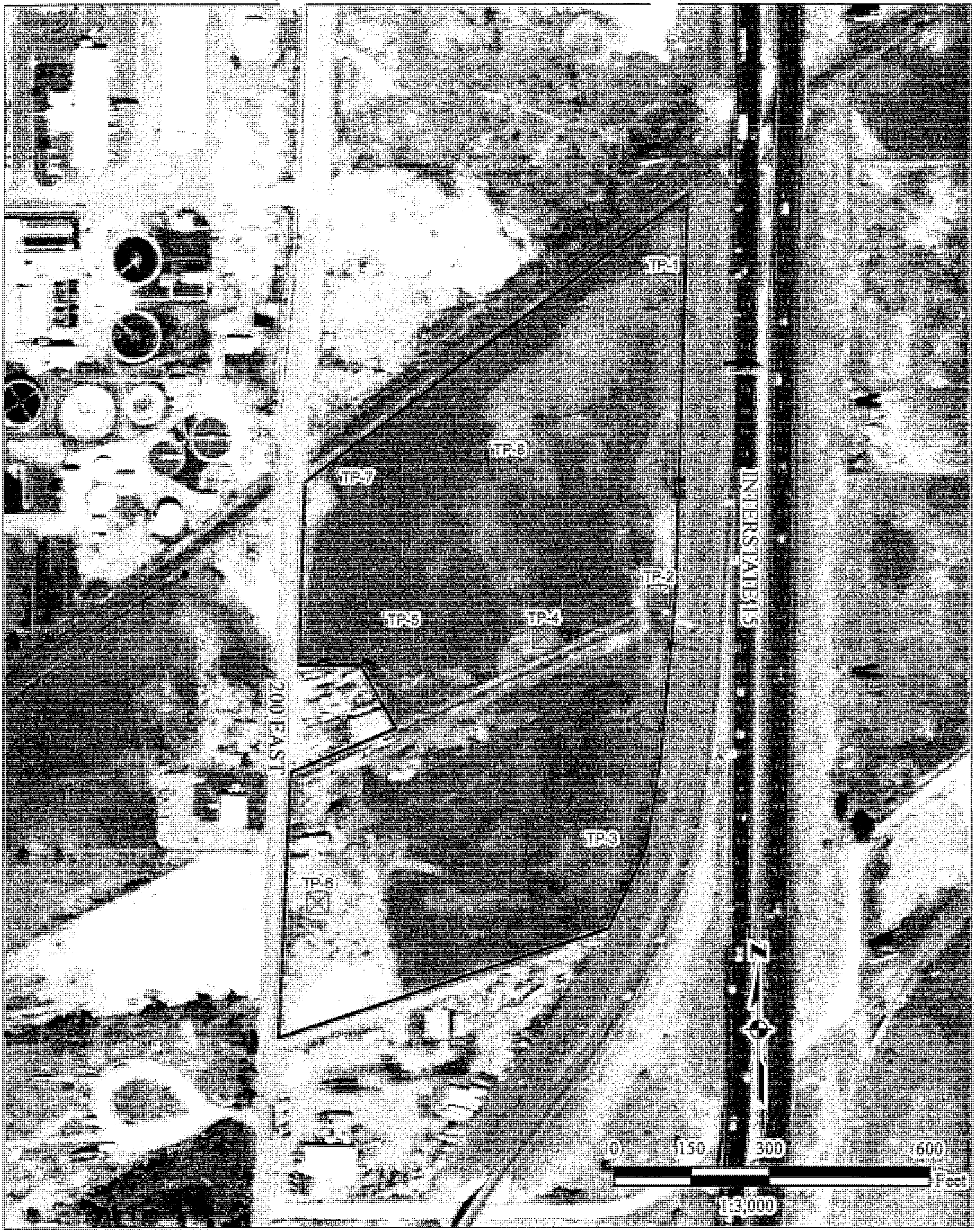
6.9 SOIL CORROSIVITY

No chemical testing was completed as a part of this investigation. However, based on our experience in this area, we expect that the corrosion potential of native soils on site will be high. We recommend that a corrosion engineer be consulted to design cathodic protection or sacrificial thicknesses. We expect that the sulfate content is <50 ppm and that the pH will be relatively neutral which indicate a low potential for sulfate attack on concrete. We recommend that at a minimum conventional Type II cement be used for all concrete for this project if founded on native soils.

We also recommend that project plans and specifications be reviewed by us to verify compatibility with our conclusions and recommendations. Additional information concerning the scope and cost of these services can be obtained from our office.

We appreciate the opportunity to be of service on this project. Should you have any questions regarding the report or wish to discuss additional services, please do not hesitate to contact us at your convenience (801) 748-4044.

APPENDIX A



IGES

Project Number - 01190-001

Geotechnical Investigation
Jamie Evans
1950 North 200 East
Spanish Fork, Utah

GEOTECHNICAL MAP

Plate

A - 2

DATE	
STARTED:	6/12/08
COMPLETED:	6/12/08
BACKFILLED:	6/12/08

Geotechnical Investigation
Jamie Evans
1950 North 200 East
Spanish Fork, Utah
Project Number 01190-001

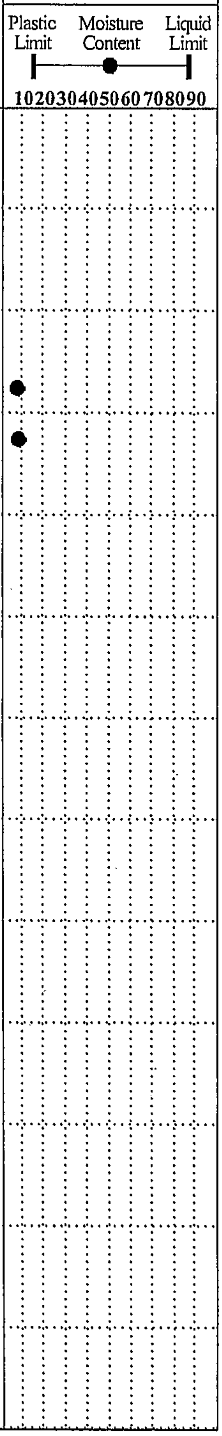
IGES Rep: dap
Rig Type: Track Hoe

TEST PIT NO: TP- 2
Sheet 1 of 1

LOCATION
NORTHING EASTING ELEVATION

DEPTH METERS	DEPTH FEET	SAMPLES	WATER LEVEL	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
0	0				Topsoil - Sandy Lean CLAY with trace gravel - very stiff, moist, dark brown, with dense roots					
				SM	Silty SAND with gravel - medium dense, moist, medium brown -some fine pinholes					
		⧗		SP-SM	Poorly Graded SAND with silt - loose to medium dense, moist, gray, some fine-grained gravel		6.9	6.3		
1		▯				87.8	7.5			
					-lense of gravel - 1 to 1.5 inches in diameter					
	5		▼							
2										
3	10									
					Bottom of Test Pit @ 11 Feet					

Moisture Content and Atterberg Limits



LOG OF TEST PITS (A) - (4 LINE HEADER) 01190-001.GPJ IGES.GDT 7/10/08

IGES

SAMPLE TYPE
▯ - GRAB SAMPLE
⧗ - 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
▼- MEASURED
▽- ESTIMATED

NOTES:

Plate

A - 4

DATE	
STARTED:	6/12/08
COMPLETED:	6/12/08
BACKFILLED:	6/12/08

Geotechnical Investigation
Jamie Evans
1950 North 200 East
Spanish Fork, Utah

Project Number 01190-001

IGES Rep: dap

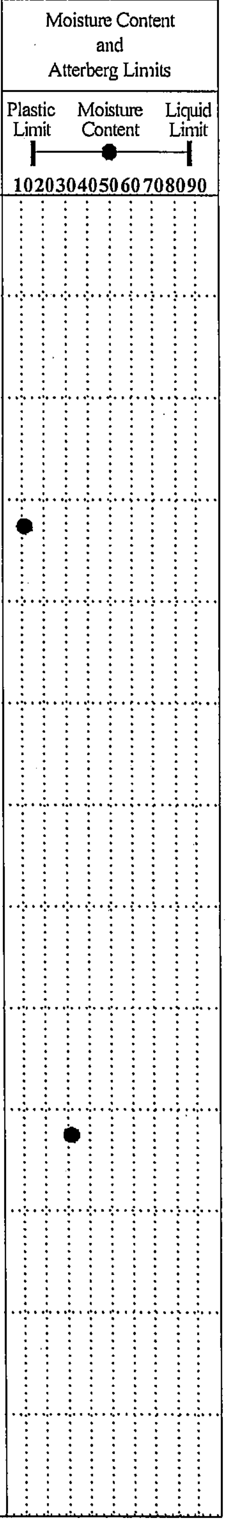
Rig Type: Track Hoe

TEST PIT NO:
TP- 4
Sheet 1 of 1

LOCATION

NORTHING EASTING ELEVATION

DEPTH METERS	DEPTH FEET	SAMPLES	WATER LEVEL	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
0	0				Topsoil - Sandy Lean CLAY - stiff, moist, dark brown, with roots pinholes, trace gravel					
				SP-SM	Poorly Graded SAND with silt - medium dense, moist, tan, frequent fine pinholes, and up to 3/8 inch diameter root holes, and worm holes					
1		▯		GP-GM	Layer of Poorly Graded GRAVEL with silt and sand		10.2			
				SM	Silty SAND - medium dense, wet, brown					
			▼							
	5									
2										
		▯					31.0	15.8		
3	10				Bottom of Test Pit @ 10 Feet					



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SAMPLE TYPE
▯ - GRAB SAMPLE
⧗ - 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
▼- MEASURED
▽- ESTIMATED

NOTES:

Plate A - 6

DATE	
STARTED:	6/12/08
COMPLETED:	6/12/08
BACKFILLED:	6/12/08

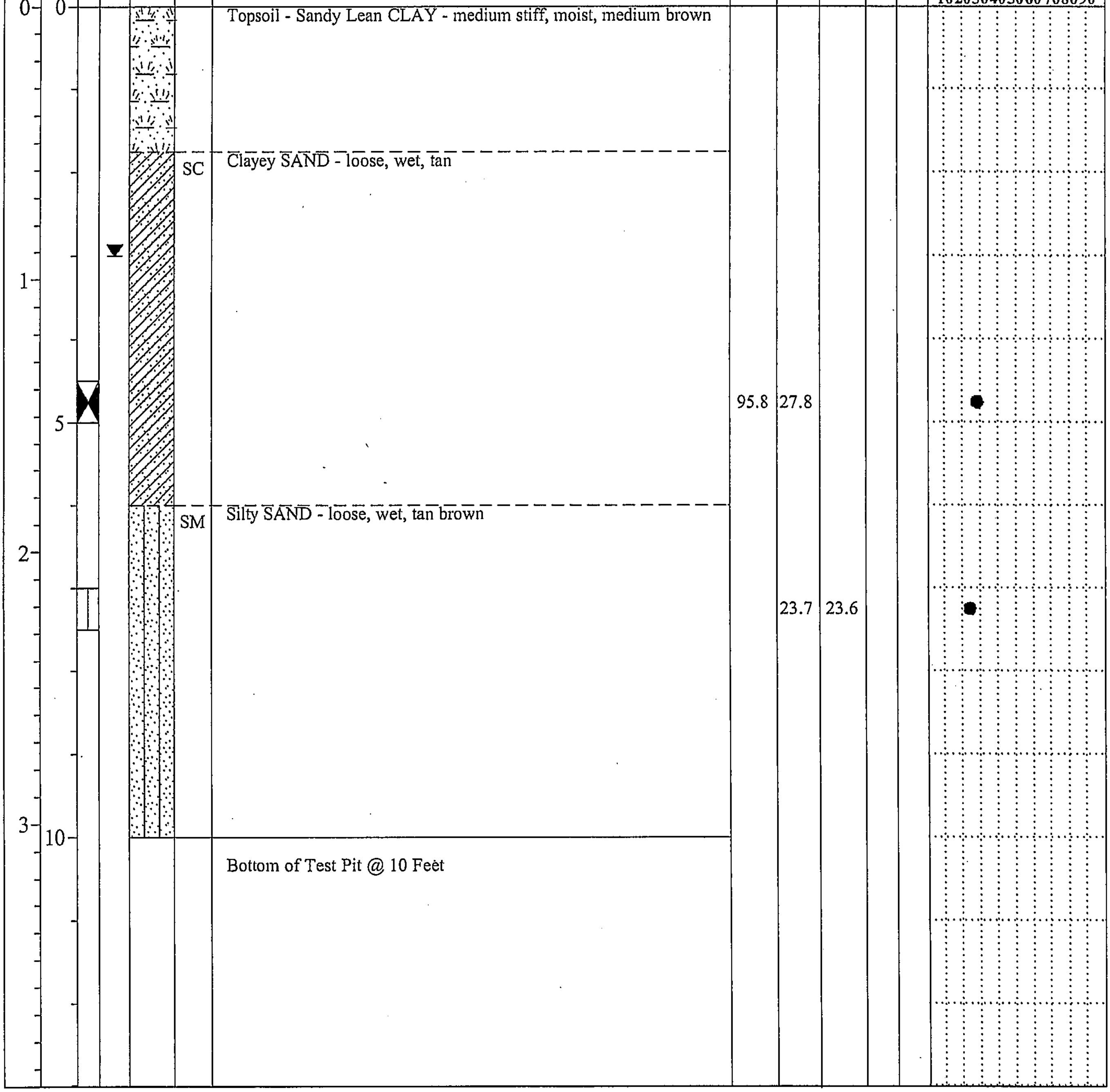
Geotechnical Investigation
Jamie Evans
1950 North 200 East
Spanish Fork, Utah

Project Number 01190-001

IGES Rep: dap
Rig Type: Track Hoe

TEST PIT NO: **TP- 6**
Sheet 1 of 1

LOCATION
NORTHING EASTING ELEVATION



UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
	Topsoil - Sandy Lean CLAY - medium stiff, moist, medium brown					
SC	Clayey SAND - loose, wet, tan					
		95.8	27.8			
SM	Silty SAND - loose, wet, tan brown					
			23.7	23.6		
	Bottom of Test Pit @ 10 Feet					

IGES

SAMPLE TYPE
▯ - GRAB SAMPLE
⧗ - 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
▼ - MEASURED
▽ - ESTIMATED

NOTES:

Plate
A - 8

DATE	
STARTED:	6/12/08
COMPLETED:	6/12/08
BACKFILLED:	6/12/08

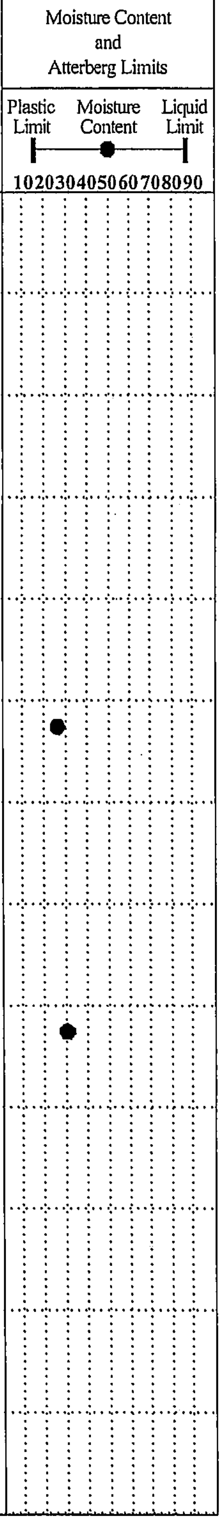
Geotechnical Investigation
Jamie Evans
1950 North 200 East
Spanish Fork, Utah
Project Number 01190-001

IGES Rep: dap
Rig Type: Track Hoe

TEST PIT NO:
TP- 8
Sheet 1 of 1

LOCATION
NORTHING EASTING ELEVATION

DEPTH (FEET)	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
0		Topsoil - Sandy Lean CLAY - medium stiff, moist, brown					
	SC	Clay SAND - loose, moist, red brown, with roots					
	SM	Silty SAND - loose to very loose, wet, tan					
		-medium dense					
		-dense					
5		-liquefaction dike	97.1	25.6			
		-olive					
		-gray					
		-orange brown		29.9	23.7		
10		Bottom of Test Pit @ 10 Feet					



IGES

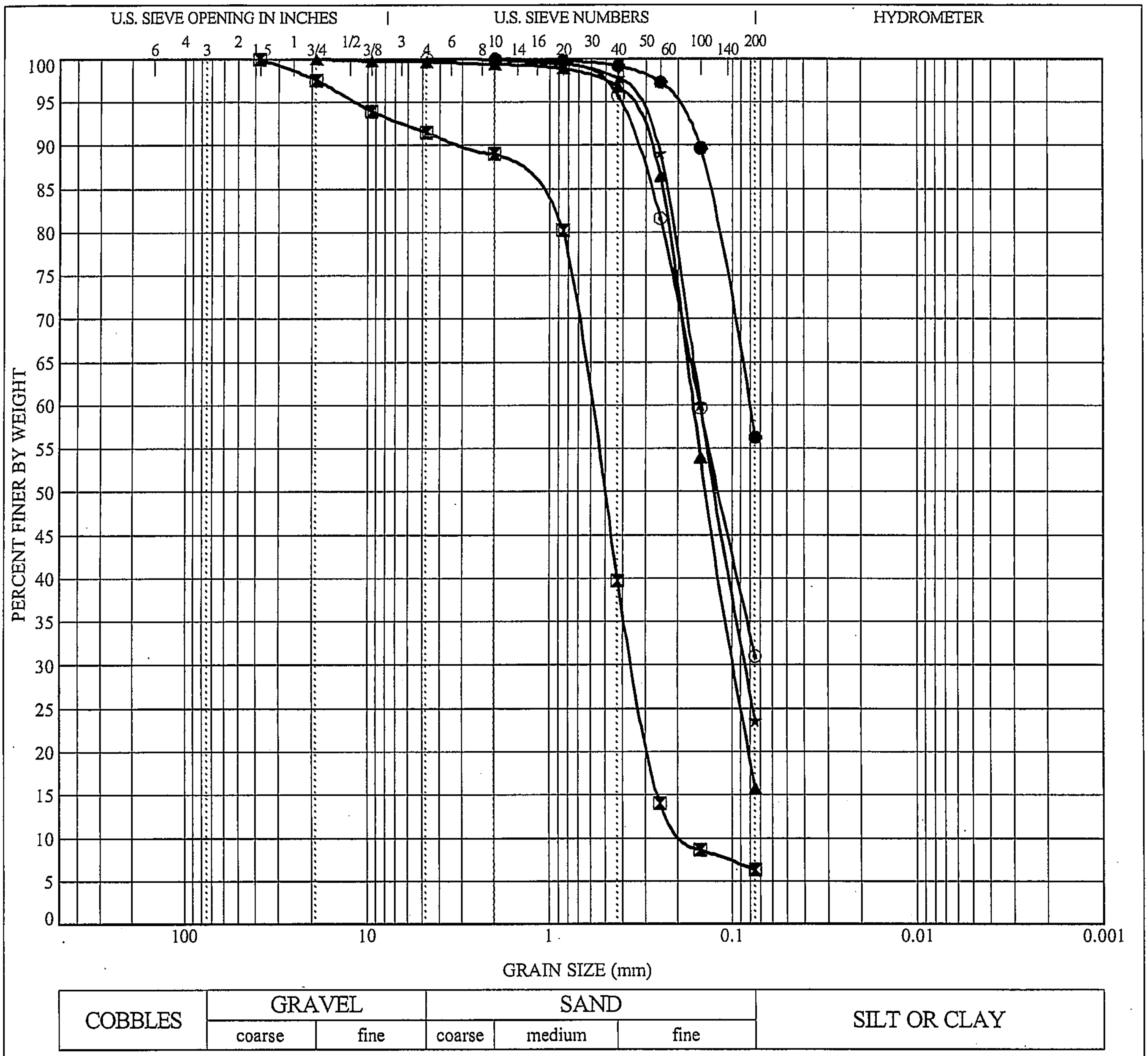
SAMPLE TYPE
- ▯ - GRAB SAMPLE
- ⧗ - 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
- ▼ - MEASURED
- ▽ - ESTIMATED

NOTES:

Plate A - 10

APPENDIX B



Sample Location	Depth	Classification	LL	PL	PI	Cc	Cu
● TP- 1	7.5	**Sandy SILT (ML)**					
☒ TP- 2	2.5	**Poorly Graded SAND with silt (SP-SM)**				1.18	3.52
▲ TP- 4	9.0	**Silty SAND (SM)**					
★ TP- 6	7.0	**Silty SAND (SM)**					
⊙ TP- 7	2.5	**Silty SAND (SM)**	19	16	3		

Sample Loctaion	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● TP- 1	7.5	2	0.081			0.0	43.7	56.3	
☒ TP- 2	2.5	38.1	0.601	0.348	0.171	8.5	85.2	6.3	
▲ TP- 4	9.0	19.05	0.165	0.097		0.3	83.9	15.8	
★ TP- 6	7.0	2	0.15	0.085		0.0	76.4	23.6	
⊙ TP- 7	2.5	4.75	0.151			0.0	69.0	31.0	

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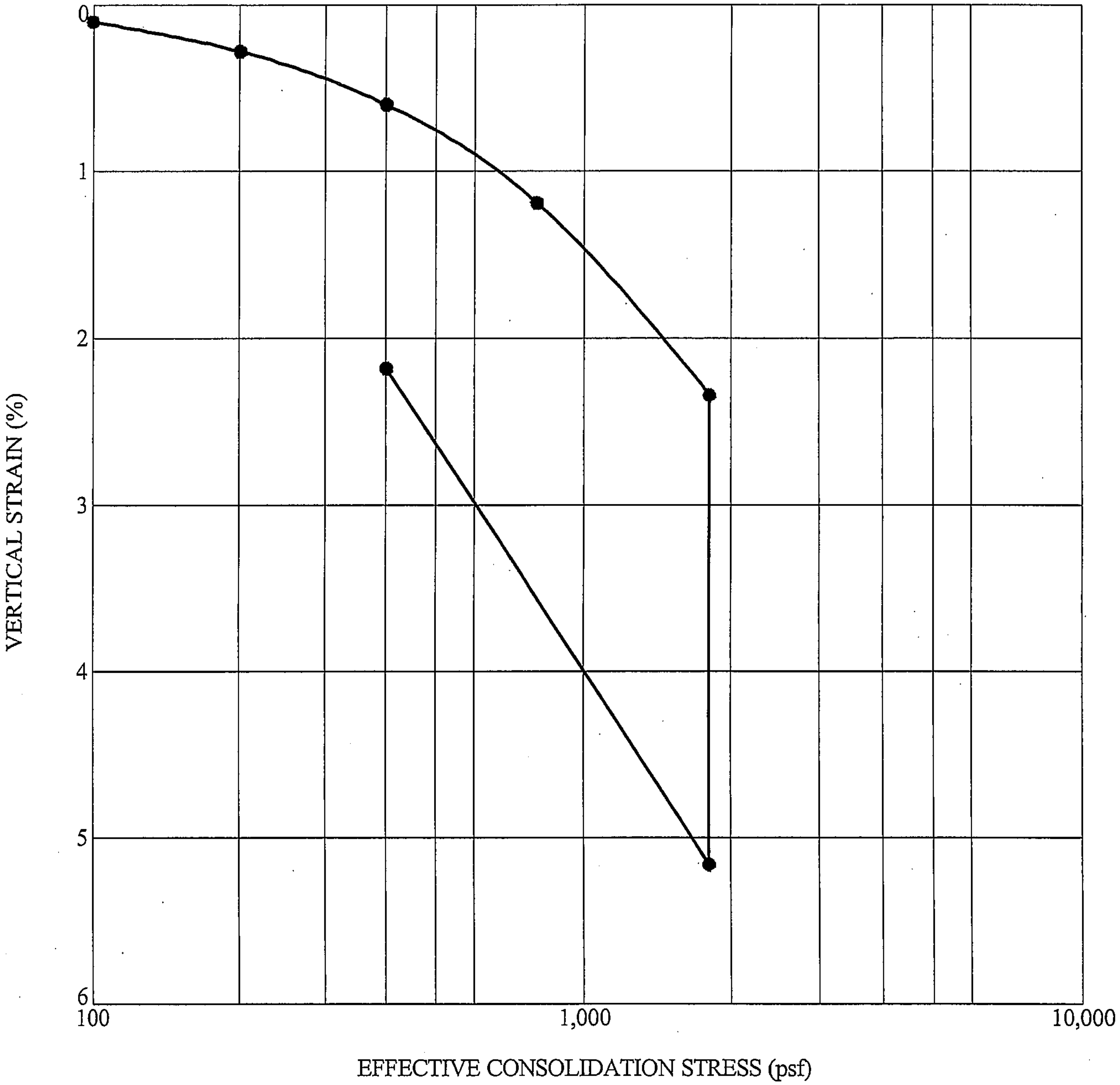
GRAIN SIZE DISTRIBUTION

Geotechnical Investigation
Jamie Evans
1950 North 200 East
Spanish Fork, Utah
Project Number: 01190-001

Plate

B - 2

B GSD 01190-001.GPJ IGES.GDT 7/10/08



	Sample Location	Depth (ft)	Classification	γ_d (pcf)	MC (%)	Inundation Load (psf)	Swell (%)	Collapse (%)
●	**TP- 7**	**2.5**	**Silty SAND (SM)**	**103**	**21**	**1800**		**2.82**

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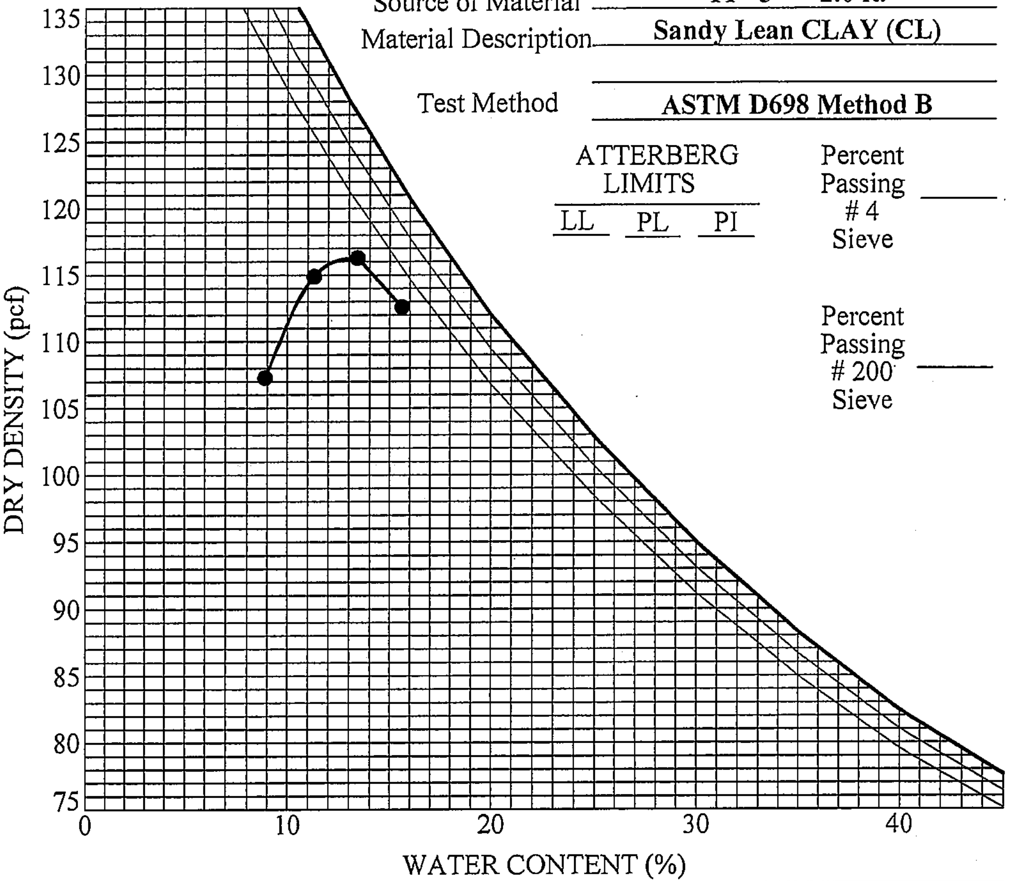
1-D SWELL/COLLAPSE TEST

Geotechnical Investigation
Jamie Evans
1950 North 200 East
Spanish Fork, Utah
Project Number: 01190-001

Plate

B - 4



Source of Material TP- 5 2.0 ft.

Material Description Sandy Lean CLAY (CL)

Test Method ASTM D698 Method B

ATTERBERG LIMITS

LL	PL	PI

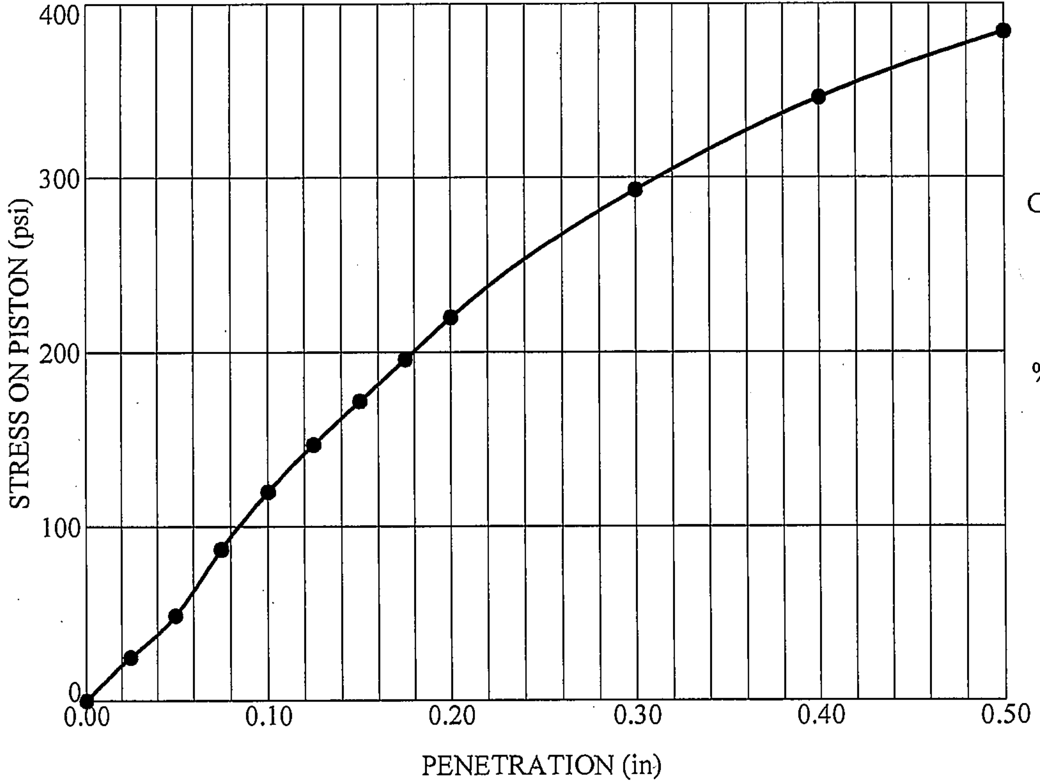
Percent Passing # 4 Sieve ______

Percent Passing # 200 Sieve ______

TEST RESULTS	
Maximum Dry Density	116.8 (pcf)
Optimum Water Content	12.4 (%)
Percent Rock	6.7 (%)
Corrected Maximum Dry Density	119.1 (pcf)
Corrected Optimum Water Content	11.7 (%)

Curves of 100% Saturation for Specific Gravity Equal to:

2.60, 2.70, 2.80



Dry Density	117.1 (pcf)
Relative Compaction	100 (%)
Surcharge	50 (psf)
% Standard CBR	12.00
Swell	0.02 (%)

IGES

COMPACTION AND CBR TEST

Geotechnical Investigation
Jamie Evans
1950 North 200 East
Spanish Fork, Utah
Project Number: 01190-001

Plate

B - 6

APPENDIX C

SUMMARY OF GEOLOGIC HAZARDS

Jamie Evans Property, Spanish Fork, Utah **Project Number 01190-001**

Hazard	Hazard Rating*				Further Study Recommended**
	Not Assessed	Probable	Possible	Unlikely	
Earthquake					
Ground Shaking		X			See Geotechnical Report
Surface Faulting				X	
Tectonic Subsidence				X	
Liquefaction	X		X		See Geotechnical Report
Slope Stability				X	
Flooding (Including Seiche)				X	
Slope Failure					
Rock Fall				X	
Landslide				X	
Debris Flow				X	
Avalanche				X	
Problem Soils					
Collapsible				X	
Soluble				X	
Expansive				X	
Organic				X	
Piping				X	
Non-Engineered Fill		X			See Geotechnical Report
Erosion				X	
Active Sand Dune				X	
Mine Subsidence				X	
Shallow Bedrock				X	
Shallow Groundwater		X			See Geotechnical Report
Flooding					
Streams			X		See Geotechnical Report
Alluvial Fans				X	
Lakes				X	
Dam Failure				X	
Canals/Ditches				X	
Radon	X				

* Hazard Rating :
Not assessed - report does not consider this hazard and no inference is made as to the presence or absence of the hazard at the site
Probable -Evidence is strong that the hazard exists and mitigation measures should be taken
Possible - hazard may exist, but the evidence is equivocal, based only on theoretical studies, or was not observed and furthes study is necessary as noted
Unlikely - no evidence was found to indicate that the hazard is present, hazard not known or suspected to be present

Further Study :
E - geotechnical/engineering, H - hydrologic, A - Avalanche, G - Additional detailed geologic hazard study out of the scope of this study

SITE GROUND MOTION [IBC SECTION 1613]

Project: **Jamie Evans**
Latitude = **40.1357**
Logitude = **-111.649**

Number: **01190-001**
Date: 7/10/08
By: CE/BJ

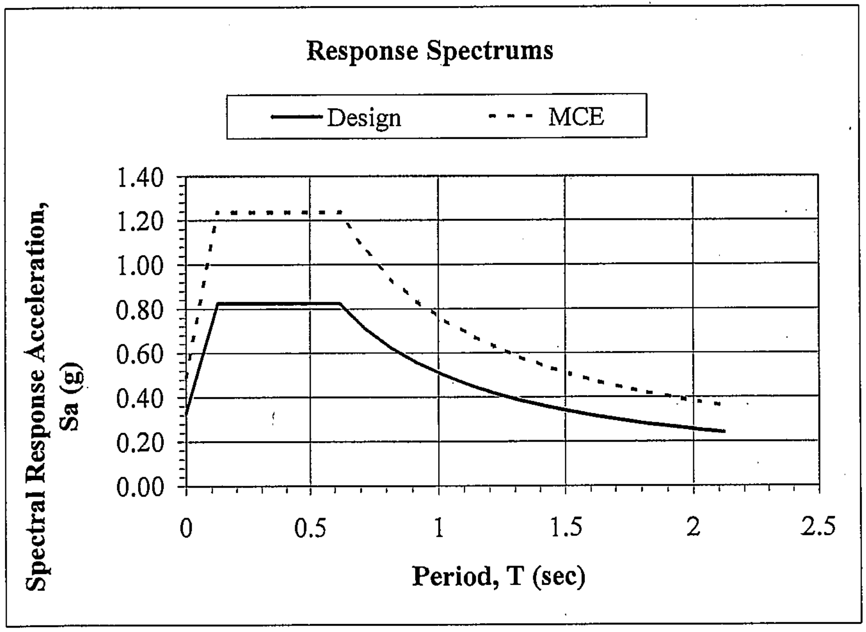
S_s = 1.222 (g) The mapped spectral accleration for short periods [1613.5]
S_1 = 0.511 (g) The mapped spectral accleration for a 1-second period

Site Class = D Table 16.13.5.2
Fa = 1.01 Table 1613.5.3(1)
Fv = 1.50 Table 1613.5.3(2)

S_{MS} = 1.236 $S_{MS} = Fa*Ss$ *The maximum considered E.Q. spectral resonse accelerations
S_{M1} = 0.767 $S_{M1} = Fv*S_1$ for short and 1-second periods [1613.5.3]
MCE/PGA = **0.494** **$0.4*S_{MS}$ [In accordance with 1802.2.7]**

S_{DS} = 0.824 $S_{DS} = 2/3*S_{MS}$ *The design spectral response acceleration
S_{D1} = 0.511 $S_{D1} = 2/3*S_{M1}$ at short and 1-second periods

T_0 = 0.124 $T_0 = 0.2*S_{D1}/S_{DS}$
T_s = 0.620 $T_s = S_{D1}/S_{DS}$
ΔT = 0.1 Time step for diagram



T (sec)	Sa (g)	Sa (MCE) (g)
0	0.33	0.49
0.12	0.82	1.24
0.62	0.82	1.24
0.72	0.71	1.06
0.82	0.62	0.93
0.92	0.56	0.83
1.02	0.50	0.75
1.12	0.46	0.68
1.22	0.42	0.63
1.32	0.39	0.58
1.42	0.36	0.54
1.52	0.34	0.50
1.62	0.32	0.47
1.72	0.30	0.45
1.82	0.28	0.42
1.92	0.27	0.40
2.02	0.25	0.38
2.12	0.24	0.36

SUMMARY OF LABORATORY TEST RESULTS TABLE

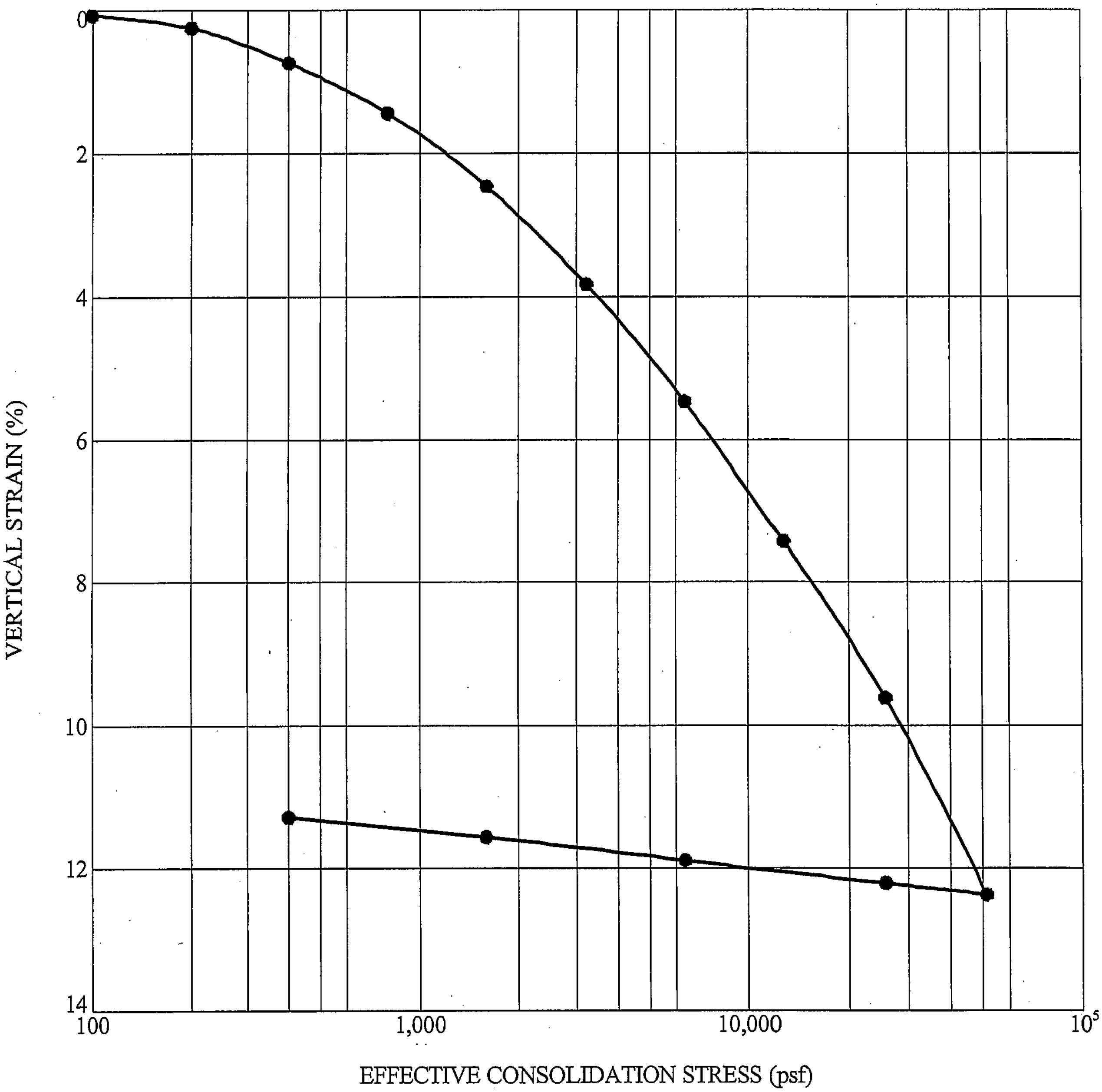
Jamie Evans

1950 North 200 East, Spanish Fork, Utah

Project Number 01190-001

SAMPLE LOCATION		NATURAL DRY DENSITY (pcf)	NATURAL MOISTURE CONTENT %	GRADATION (%)			ATTERBERG LIMITS		COLLAPSE POTENTIAL		CONSOLIDATION			PROCTOR		CBR (%)	UNIFIED SOILS CLASSIFICATION
Point No	Depth (ft)			Gravel >#4	Sand	Silt and Clay <#200	Liquid Limit	Plasticity index	Collapse (%)	Pressure (psf)	Compression Ratio	Recompression Ratio	Over Consolidation Ratio	Maximum Dry Density (pcf) STD	Optimum Moisture (%) STD		
TP-1	3.5		22.8														Sandy SILT (ML)
	4	97.6	26								0.09	0.01	3				Sandy SILT (ML)
	7.5		25.9		44	56											Sandy SILT (ML)
TP-2	2.5		6.9	8.5	85	6.3											Poorly Graded SAND with silt (SP-SM)
	3	87.8	7.5														Poorly Graded SAND with silt (SP-SM)
TP-3	3	95	26				NP	NP									Silty SAND (SM)
TP-4	3		10.2														Poorly Graded GRAVEL with silt and sand (GP-GM)
	9		31	0.3	84	16											Silty SAND (SM)
TP-5	2													119.1	11.7	12	Sandy Lean CLAY (CL)
	3	106.8	17.4														Sandy Lean CLAY (CL)
	3.5		19.9				21	6									Silty Clayey SAND (SC-SM)
TP-6	4.5	95.8	27.8														Clayey SAND (SC)
	7		23.7		76	24											Silty SAND (SM)
TP-7	2.5	102.6	21.1		69	31	19	3	2.82	1800							Silty SAND (SM)
TP-8	5	97.1	25.6														Silty SAND (SM)
	8		29.9		76	24											Silty SAND (SM)

Plate B-7



Sample Location	Depth (ft)	Classification	γ_d (pcf)	MC (%)	C'_c	C'_r	OCR
● **TP- 1**	**4.0**	**Sandy SILT (ML)**	**97.6**	**26**	**0.09**	**0.01**	**3**

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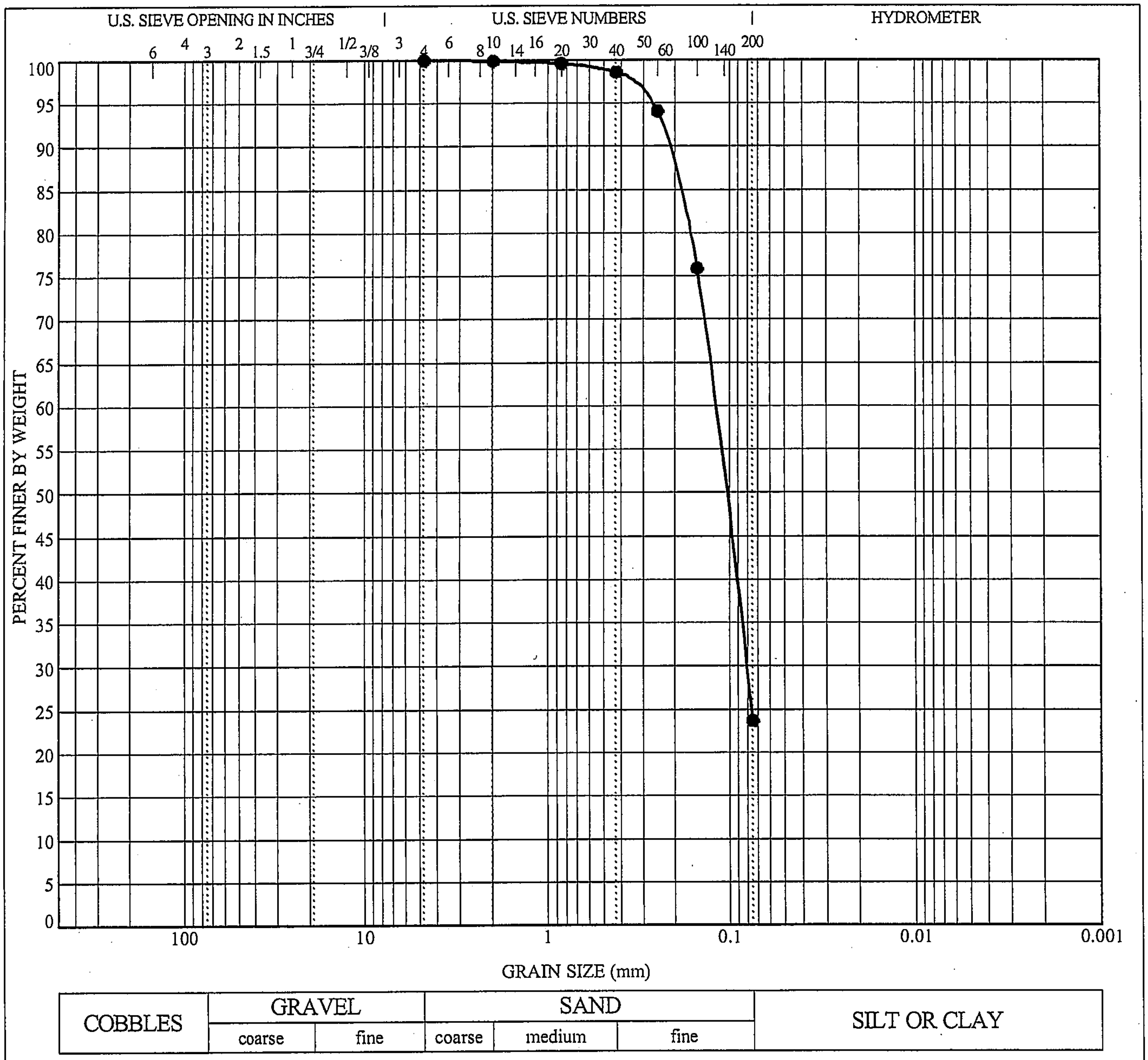
1-D CONSOLIDATION TEST

Geotechnical Investigation
Jamie Evans
1950 North 200 East
Spanish Fork, Utah
Project Number: 01190-001

Plate

B - 5



	Sample Location	Depth	Classification	LL	PL	PI	Cc	Cu
●	**TP- 8**	**8.0**	**Silty SAND (SM)**					

	Sample Loctaion	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**TP- 8**	**8.0**	**4.75**	**0.121**	**0.082**		**0.0**	**76.3**	**23.7**	

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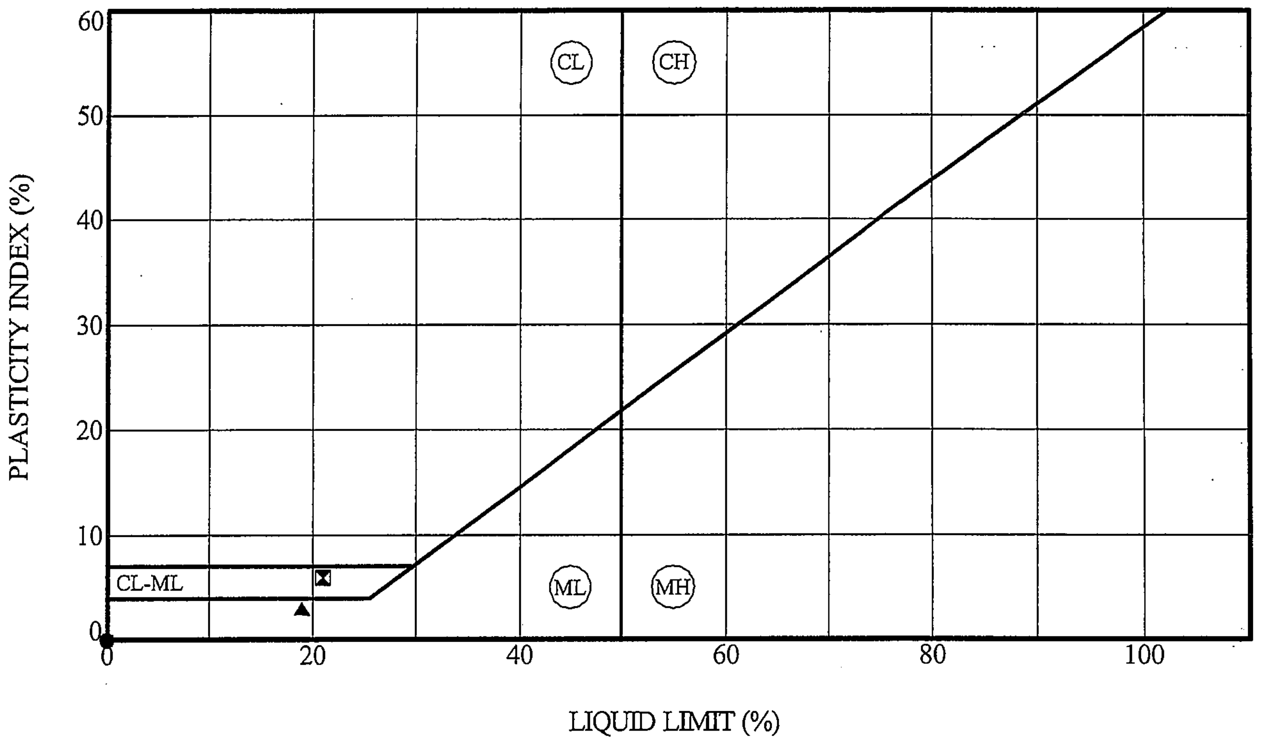
GRAIN SIZE DISTRIBUTION

Geotechnical Investigation
Jamie Evans
1950 North 200 East
Spanish Fork, Utah
Project Number: 01190-001

Plate

B - 3



Sample Location		Depth (ft)	LL (%)	PL (%)	PI (%)	Classification
●	**TP- 3**	**3.0**	**NP**	**NP**	**NP**	**Silty SAND (SM)**
☒	**TP- 5**	**3.5**	**21**	**15**	**6**	**Silty Clayey SAND (SC-SM)**
▲	**TP- 7**	**2.5**	**19**	**16**	**3**	**Silty SAND (SM)**

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ATTERBERG LIMITS' RESULTS

Geotechnical Investigation
Jamie Evans
1950 North 200 East
Spanish Fork, Utah
Project Number: 01190-001

Plate

B - 1

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			USCS SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS (More than half of material is larger than the #200 sieve)	GRAVELS (More than half of coarse fraction is larger than the #4 sieve)	CLEAN GRAVELS WITH LITTLE OR NO FINES	GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES
			GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES
		GRAVELS WITH OVER 12% FINES	GM	SILTY GRAVELS, GRAVEL-SILT-SAND MIXTURES
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SANDS (More than half of coarse fraction is smaller than the #4 sieve)	CLEAN SANDS WITH LITTLE OR NO FINES	SW	WELL-GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE OR NO FINES
			SP	POORLY-GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE OR NO FINES
		SANDS WITH OVER 12% FINES	SM	SILTY SANDS, SAND-GRAVEL-SILT MIXTURES
			SC	CLAYEY SANDS SAND-GRAVEL-CLAY MIXTURES
FINE GRAINED SOILS (More than half of material is smaller than the #200 sieve)	SILTS AND CLAYS (Liquid limit less than 50)		ML	INORGANIC SILTS & VERY FINE SANDS, SILTY OR CLAYEY FINE SANDS, CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC SILTS & ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS (Liquid limit greater than 50)		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILT
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH	ORGANIC CLAYS & ORGANIC SILTS OF MEDIUM-TO-HIGH PLASTICITY
HIGHLY ORGANIC SOILS			PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

LOG KEY SYMBOLS

⊕	BORING SAMPLE LOCATION	⧗	TEST-PIT SAMPLE LOCATION
▼	WATER LEVEL (level after completion)	▽	WATER LEVEL (level where first encountered)

CEMENTATION

DESCRIPTION	DESCRIPTION
WEAKELY	CRUMBLES OR BREAKS WITH HANDLING OR SLIGHT FINGER PRESSURE
MODERATELY	CRUMBLES OR BREAKS WITH CONSIDERABLE FINGER PRESSURE
STRONGLY	WILL NOT CRUMBLE OR BREAK WITH FINGER PRESSURE

OTHER TESTS KEY

C	CONSOLIDATION	SA	SIEVE ANALYSIS
AL	ATTERBERG LIMITS	DS	DIRECT SHEAR
UC	UNCONFINED COMPRESSION	T	TRIAXIAL
S	SOLUBILITY	R	RESISTIVITY
O	ORGANIC CONTENT	RV	R-VALUE
CBR	CALIFORNIA BEARING RATIO	SU	SOLUBLE SULFATES
COMP	MOISTURE/DENSITY RELATIONSHIP	PM	PERMEABILITY
CI	CALIFORNIA IMPACT	-200	% FINER THAN #200
COL	COLLAPSE POTENTIAL	Gs	SPECIFIC GRAVITY
SS	SHRINK SWELL	SL	SWELL LOAD

MODIFIERS

DESCRIPTION	%
TRACE	<5
SOME	5 - 12
WITH	>12

MOISTURE CONTENT

DESCRIPTION	FIELD TEST
DRY	ABSENCE OF MOISTURE, DUSTY, DRY TO THE TOUCH
MOIST	DAMP BUT NO VISIBLE WATER
WET	VISIBLE FREE WATER, USUALLY SOIL BELOW WATER TABLE

GENERAL NOTES

1. Lines separating strata on the logs represent approximate boundaries only. Actual transitions may be gradual.
2. No warranty is provided as to the continuity of soil conditions between individual sample locations.
3. Logs represent general soil conditions observed at the point of exploration on the date indicated.
4. In general, Unified Soil Classification designations presented on the logs were evaluated by visual methods only. Therefore, actual designations (based on laboratory tests) may vary.

STRATIFICATION

DESCRIPTION	THICKNESS
SEAM	1/16 - 1/2"
LAYER	1/2 - 12"

DESCRIPTION	THICKNESS
OCCASIONAL	ONE OR LESS PER FOOT OF THICKNESS
FREQUENT	MORE THAN ONE PER FOOT OF THICKNESS

APPARENT / RELATIVE DENSITY - COARSE-GRAINED SOIL

APPARENT DENSITY	SPT (blows/ft)	MODIFIED CA. SAMPLER (blows/ft)	CALIFORNIA SAMPLER (blows/ft)	RELATIVE DENSITY (%)	FIELD TEST
VERY LOOSE	<4	<4	<5	0 - 15	EASILY PENETRATED WITH 1/2-INCH REINFORCING ROD PUSHED BY HAND
LOOSE	4 - 10	5 - 12	5 - 15	15 - 35	DIFFICULT TO PENETRATE WITH 1/2-INCH REINFORCING ROD PUSHED BY HAND
MEDIUM DENSE	10 - 30	12 - 35	15 - 40	35 - 65	EASILY PENETRATED A FOOT WITH 1/2-INCH REINFORCING ROD DRIVEN WITH 5-LB HAMMER
DENSE	30 - 50	35 - 60	40 - 70	65 - 85	DIFFICULT TO PENETRATED A FOOT WITH 1/2-INCH REINFORCING ROD DRIVEN WITH 5-LB HAMMER
VERY DENSE	>50	>60	>70	85 - 100	PENETRATED ONLY A FEW INCHES WITH 1/2-INCH REINFORCING ROD DRIVEN WITH 5-LB HAMMER

CONSISTENCY - FINE-GRAINED SOIL

		TORVANE	POCKET PENETROMETER	FIELD TEST
CONSISTENCY	SPT (blows/ft)	UNTRAINED SHEAR STRENGTH (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	
VERY SOFT	<2	<0.125	<0.25	EASILY PENETRATED SEVERAL INCHES BY THUMB. EXUDES BETWEEN THUMB AND FINGERS WHEN SQUEEZED BY HAND.
SOFT	2 - 4	0.125 - 0.25	0.25 - 0.5	EASILY PENETRATED ONE INCH BY THUMB. MOLDED BY LIGHT FINGER PRESSURE.
MEDIUM STIFF	4 - 8	0.25 - 0.5	0.5 - 1.0	PENETRATED OVER 1/2 INCH BY THUMB WITH MODERATE EFFORT. MOLDED BY STRONG FINGER PRESSURE.
STIFF	8 - 15	0.5 - 1.0	1.0 - 2.0	INDENTED ABOUT 1/2 INCH BY THUMB BUT PENETRATED ONLY WITH GREAT EFFORT.
VERY STIFF	15 - 30	1.0 - 2.0	2.0 - 4.0	READILY INDENTED BY THUMBNAIL.
HARD	>30	>2.0	>4.0	INDENTED WITH DIFFICULTY BY THUMBNAIL.

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Key to Soil Symbols and Terminology

Plate
A-11

IGES, Inc. Project No.: 01190-001

DATE		
	STARTED:	6/12/08
	COMPLETED:	6/12/08
	BACKFILLED:	6/12/08

Geotechnical Investigation
Jamie Evans
1950 North 200 East
Spanish Fork, Utah

Project Number 01190-001

IGES Rep: dap
Rig Type: Track Hoe

TEST PIT NO:
TP- 7
Sheet 1 of 1

LOCATION
NORTHING EASTING ELEVATION

MATERIAL DESCRIPTION

DEPTH FEET	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
0		Topsoil - Sandy Lean CLAY - stiff, moist, brown, dense fine roots to 12 to 18 inches					
	SC	Clayey SAND - loose, moist, tan					
	SM	Silty SAND - very moist, light tan, fine to medium pinholes, some fine roots	102.6	21.7	31.0	19	3
		Bottom of Test Pit @ 9 Feet					

Depth scale: METERS 0, 1, 2, 3; FEET 0, 5, 10. Sample (grab) at approx. 2.5 ft; water level measured ▼ at approx. 4 ft.

Moisture Content and Atterberg Limits
Plastic Limit — Moisture Content ● — Liquid Limit
10 20 30 40 50 60 70 80 90

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SAMPLE TYPE
▯ - GRAB SAMPLE
⧗ - 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
▼ - MEASURED
▽ - ESTIMATED

NOTES:

Plate
A - 9

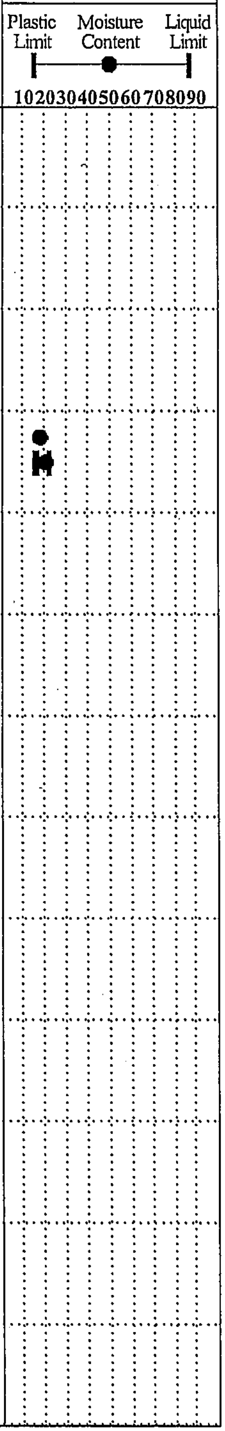
DATE		Geotechnical Investigation Jamie Evans 1950 North 200 East Spanish Fork, Utah	IGES Rep: dap	TEST PIT NO:
STARTED:	6/12/08		Rig Type: Track Hoe	TP- 5
COMPLETED:	6/12/08			Sheet 1 of 1
BACKFILLED:	6/12/08	Project Number 01190-001		

LOCATION

NORTHING EASTING ELEVATION

DEPTH METERS	DEPTH FEET	SAMPLES	WATER LEVEL	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
0	0				Topsoil - Sandy Lean CLAY - stiff, moist, brown, frequent fine roots, frequent fine to medium pinholes					
		▯		CL	Sandy Lean CLAY - medium stiff, moist, brown, frequent fine pinholes, with trace of gravel -increasing moisture at 18 inches					
1		⧗				106.8	17.4			
			▼	SC-SM	Silty Clayey SAND - medium dense, moist, tan, pinholes		19.9		21	6
	5									
2										
					Bottom of Test Pit @ 9 Feet					
3	10									

Moisture Content and Atterberg Limits



IGES

SAMPLE TYPE
▯ - GRAB SAMPLE
⧗ - 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
▼- MEASURED
▽- ESTIMATED

NOTES:

Plate

A - 7

DATE	
STARTED:	6/12/08
COMPLETED:	6/12/08
BACKFILLED:	6/12/08

Geotechnical Investigation
Jamie Evans
1950 North 200 East
Spanish Fork, Utah
Project Number 01190-001

IGES Rep: dap
Rig Type: Track Hoe

TEST PIT NO:
TP- 3
Sheet 1 of 1

LOCATION
NORTHING EASTING ELEVATION

DEPTH METERS	DEPTH FEET	SAMPLES	WATER LEVEL	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index	Moisture Content and Atterberg Limits (Plastic Limit ├─●─┤ Liquid Limit; Moisture Content) 10 20 30 40 50 60 70 80 90
0	0					Topsoil - Sandy Lean CLAY - very stiff, moist, dark brown -significant pinholes at 24 inches, wet						
					SM	Silty SAND - loose to medium dense, wet, brown -from 30 to 36 inches has fine pinholes						
1		⧗	▼				95.0	26.0		NP	NP	●
	5											
2					SP-SM	Poorly Graded SAND with silt - loose, wet, gray						
		▯				-test pit caves in, and water fills in very fast						
						Bottom of Test Pit @ 9 Feet						
3	10											

IGES

SAMPLE TYPE
▯ - GRAB SAMPLE
⧗ - 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
▼- MEASURED
▽- ESTIMATED

NOTES:

Plate
A - 5

DATE	
STARTED:	6/12/08
COMPLETED:	6/12/08
BACKFILLED:	6/12/08

Geotechnical Investigation
Jamie Evans
1950 North 200 East
Spanish Fork, Utah

Project Number 01190-001

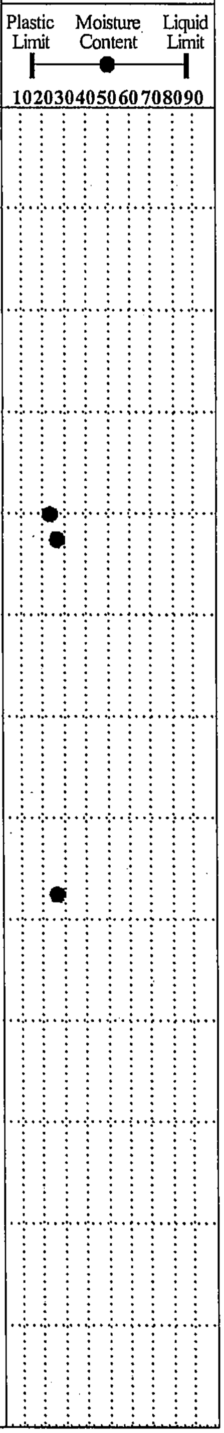
IGES Rep: dap
Rig Type: Track Hoe

TEST PIT NO:
TP- 1
Sheet 1 of 1

LOCATION
NORTHING EASTING ELEVATION

METERS	FEET	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
0	0		Topsoil - Sandy Lean CLAY, medium stiff, moist, dark brown					
		ML	Sandy SILT - soft, wet, tan					
1					22.8			
				97.6	26.0			
	5							
			-gray					
2			-brown					
					25.9	56.3		
3	10		Bottom of Test Pit @ 10 Feet					

Moisture Content and Atterberg Limits



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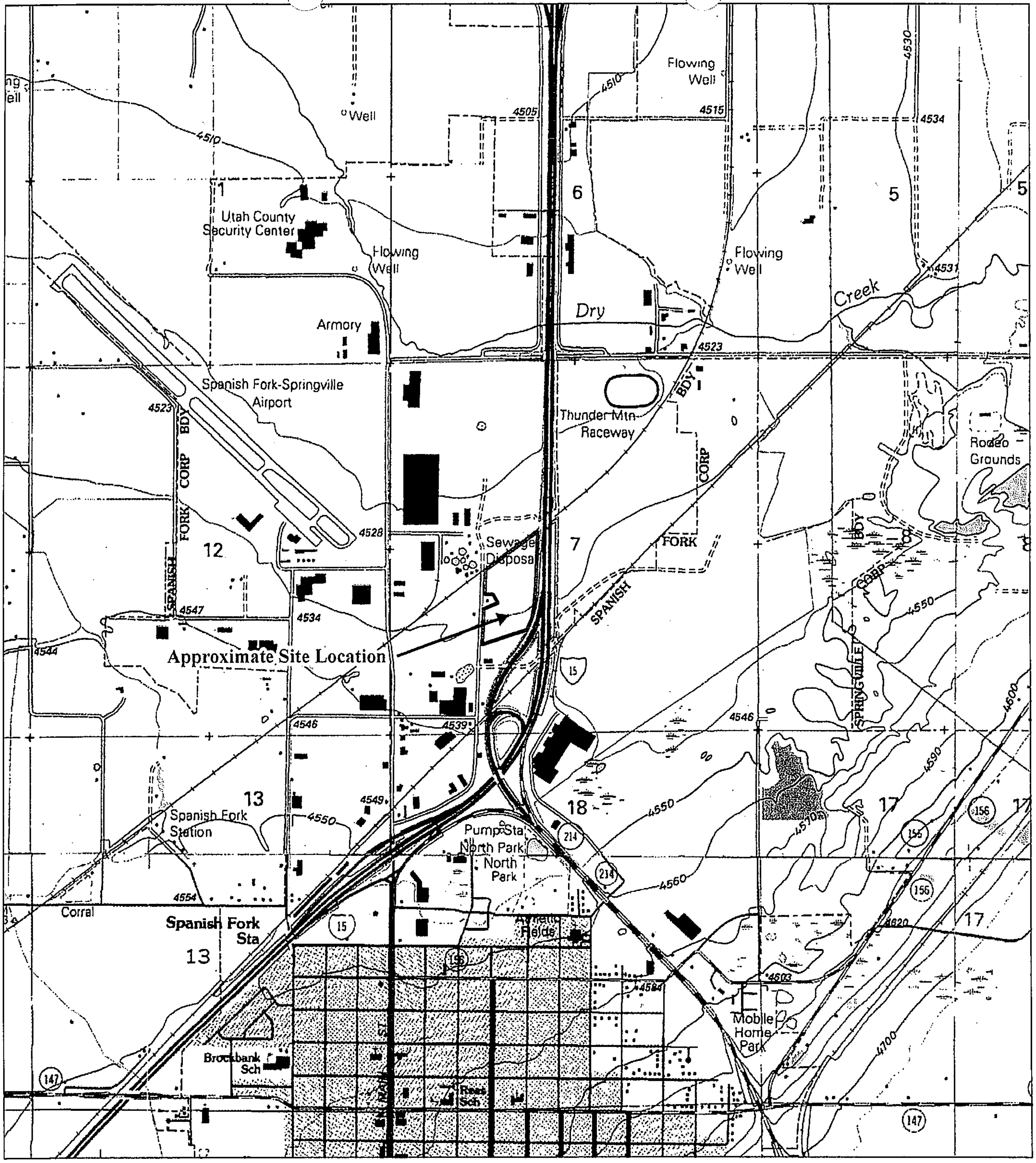
SAMPLE TYPE
▯ - GRAB SAMPLE
⧗ - 3" O.D. THIN-WALLED HAND SAMPLER

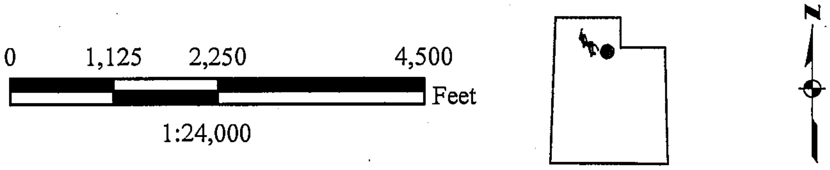
WATER LEVEL
▼- MEASURED
▽- ESTIMATED

NOTES:

Plate
A - 3



BASE MAPS:
PROVO, UTAH
SPANISH FORK, UTAH
SPANISH FORK PEAK, UTAH
SPRINGVILLE, UTAH
U.S.G.S. 7.5 MINUTE QUADRANGLES



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Project Number - 01190-001

Geotechnical Investigation
Jamie Evans
1950 North 200 East
Spanish Fork, Utah

SITE VICINITY MAP

Plate
A - 1

8.0 REFERENCES CITED

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.

Hintze, L.F. 1993, Geologic History of Utah: Brigham Young University Studies, Special Publication 7, 202 p.

Hintze, L. F., 1980, Geologic Map of Utah: Utah Geological and Mineral Survey Map-A-1, scale 1:500,000.

International Building Code [IBC], 2006, International Code Council, Inc.

Jarva, J. L., 1994, Liquefaction-potential map for a part of Utah county: Utah Geological Survey Public Information Series 28, scale 1:365,000.

Machette, M.N., 1992, Surficial geologic map of Wasatch fault zone, eastern part of the Utah Valley, Utah County and parts of Salt Lake and Juab Counties, Utah: U.S. Geological Survey Miscellaneous Investigations Series Map I-2095, scale 1:50,000.

Scott, W.E., McCoy, W.D., Shorba, R.R., and Rubin, Meyer, 1983, Reinterpretation of the Exposed Record of the Last Two Cycles of Lake Bonneville, Western United States: Quaternary Research, v.20, p. 261-285.

USGS, 2007, Java Application Ground Motion Parameter Calculator – Version 5.0.8 (http://earthquake.usgs.gov/research/hazmaps/design/), uses the International Building Code (2006 IBC) seismic hazard maps.

7.0 CLOSURE

7.1 LIMITATIONS

The recommendations contained in this report are based on our limited field exploration, laboratory testing, and understanding of the proposed construction. The subsurface data used in the preparation of this report were obtained from the explorations made for this investigation. It is possible and likely that variations in the soil and groundwater conditions could exist between and beyond the points explored. The nature and extent of variations may not be evident until construction occurs. If any conditions are encountered that differ from those described in this report, we should be immediately notified so that we may make any necessary revisions to recommendations contained in this report. In addition, if the scope of the proposed construction changes from that described in this report, we should be notified. We recommend that this report be used in its entirety; we do not recommend that sections be removed from the report and used to represent the remainder of the report.

This report was prepared in accordance with the generally accepted standard of practice at the time the report was written. No warranty, expressed or implied, is made.

It is the Client's responsibility to see that all parties to the project including the Designer, Contractor, Subcontractors, etc. are made aware of this report in its entirety. The use of information contained in this report for bidding purposes should be done at the Contractor's option and risk.

7.2 ADDITIONAL SERVICES

The recommendations made in this report are based on the assumption that an adequate program of tests and observations will be made during the construction. IGES staff should be on site to verify compliance with these recommendations. These tests and observations should include, but not necessarily be limited to, the following:

- Observations and testing during site preparation, earthwork and structural fill placement.
- Observation of footing excavations.
- Consultation as may be required during construction.
- Quality control on concrete placement to verify slump, air content, and strength.

6.8 ASPHALT CONCRETE PAVEMENT DESIGN

Based on soil classifications and an assumed CBR value of 12, near surface soils are expected to provide relatively good pavement support when properly compacted. No traffic information was available at the time this report was prepared. For this pavement section design we have assumed 3,000 passenger vehicles/day, 25 light duty trucks/day, 25 medium duty trucks/day, 25 heavy duty trucks/day and 15 single-trailer semi-trucks/day. The following pavement design alternatives have been developed for a 20-year design life assuming a 1% annual growth rate, and our assumed equivalent single axle load (ESAL) of approximately 1.7 million ESALs. In addition to the traditional pavement design, we are providing an alternative pavement design using Tensar BX1100 Geogrid reinforcement to reduce the road base and/or granular borrow thicknesses. Based on the information obtained and the above mentioned assumptions, we recommend one of the pavement sections in the table below be constructed on properly prepared subgrade. It should be noted that in order for a pavement section to perform as designed, it should be constructed over a filter fabric to separate two different soil types and reduce the amount of migration of fines from the subgrade into the granular borrow or base course.

Area	Asphalt Concrete (in.)	Untreated Base Course (in.)	Granular Borrow (in.)	Non-Woven Filter Fabric
General	**4**	7	**8**	**Propex Geotex® 601**

If the Tensar® Geogrid reinforcement is used, it should consist of Tensar® BX-1100 or equivalent and should be placed on top of the granular borrow layer or over properly prepared subgrade (Alternative 5) prior to placing the aggregate base course material. A cost replacement analysis should be performed by the Civil Engineer to evaluate the economic savings (if any) in using the geogrid reinforcement. IGES can assist in obtaining costs for the geogrid. If the Tensar® Geogrid is used, it will be most effective if placed as near to the base of the asphalt as possible, but should be covered by at least 4 inches of base course.

Area	Asphalt Concrete (in.)	Untreated Base Course (in.)	Tensar BX1100 Geogrid
General	**4**	**10**	**Single Layer**

6.5 DEEP FOUNDATIONS

As an alternative to overexcavation and replacement with granular structural fill, or if a higher bearing capacity is desired, a deep foundation system may be utilized to support foundation loads beneath either conventional strip and spread footings or heavily loaded floor slabs.

Geopiers ®

As an alternative to overexcavation of the soft soils the existing subgrade could be reinforced using rammed aggregate piers, or Geopier® elements, installed on a grid pattern. This option would eliminate the need for overexcavation and would allow for the placement of new fill, base course, and/or floor slab directly atop the Geopier®-reinforced subgrade.

The use of Geopiers® would significantly increase the net allowable bearing capacity such that footing dimensions could be adjusted to minimize the cost of concrete for the project and the overexcavation could be significantly reduced or eliminated reducing the need to stabilize soft soils beneath the footings.

Geopier® is a proprietary technology and is generally provided on a turnkey basis. Final analysis and costing for this approach would be provided directly by the Geopier® Foundation Company.

Auger Cast Piles, Drilled Shafts, and Helical Piers®

Auger cast piles, drilled shafts, and Helical Piers® also have the potential to substantially increase the net allowable bearing capacity. The use of these methods can also reduce the need for overexcavation and replacement of soft soils, improve the soft foundation soils, increase the net allowable bearing capacity, and significantly reduce the footing size or replace the footing with grade beams. If desired, IGES can provide recommendations for these alternatives.

6.6 EARTH PRESSURE AND LATERAL RESISTANCE

Lateral forces imposed upon conventional foundations due to wind or seismic forces may be resisted by the development of passive earth pressures and friction between the base of the footing and the supporting soils. In determining the frictional resistance, a coefficient of friction of 0.41 for native soils or structural fill against concrete should be used.

of the OMC when placed and compacted to at least 95 percent of the MDD as determined by ASTM D-1557. All other trenches that are in landscape areas should be backfilled and compacted to at least 90 percent of the MDD (ASTM D-1557).

The gradation, placement, moisture, and compaction recommendations contained in this section meet our minimum requirements, but may not meet the requirements of other governing agencies such as city, county, or state entities. If their requirements exceed IGES's recommendations, their specifications should be used instead of those presented in this report.

6.2.6 Construction Dewatering

Depending on the maximum depth of the excavation, advanced dewatering of the proposed building areas may be required to maintain work conditions suitable for excavation and construction. Pumps may need to be placed in the trenches and dewatering wells may need to be installed prior to and pumped during construction. Groundwater flow into the excavations should be controlled using a system of small pumps, grading, and a sump within the excavation. Water recovered during dewatering operations should be appropriately discharged away from the site so that it does not run back into open excavations or infiltrate and return though subsurface soils.

6.3 CONVENTIONAL FOUNDATIONS

We recommend that the proposed structures be supported with a foundation system consisting of conventional strip and/or spread footings founded entirely on relatively undisturbed native soils or on a zone of imported structural fill as recommended in Section 6.2.5. As discussed previously in this report, structural fill at a minimum, should extend beyond all edges of the supported structure a distance equal to the thickness of the structural fill beneath the structure, or 2 feet, whichever is greater. During the excavation of our explorations, the soils were observed to be sensitive and became loose once disturbed. Therefore, we recommend that the footing excavations be completed with caution in order to minimize disturbance to the native soils.

A minor hydro-collapse potential was observed; we recommend that if these soils exist beneath footings they be removed and replaced with structural fill as described in Section 6.2.5.

laterally at least two feet beyond flatwork, pavements, and slabs-on-grade and backfilled with structural fill as recommended in this report.

During excavation, it is likely that moderate to high moisture conditions will be encountered and result in soft or pumping soils. Once exposed, all subgrade surfaces beneath footings, structures, areas of concrete flatwork, and pavement should be proof rolled with a loaded 10-wheel dump truck or other heavy wheeled construction equipment. If soft or pumping soils are encountered, these soils should be stabilized as recommended in the following section (Section 6.2.4).

6.2.4 Soft Soil Stabilization

If soft or pumping soils are encountered, they should be stabilized prior to construction of the pavement section or footings or placement of structural fill. Stabilization of the subgrade soils can be accomplished using a clean, coarse angular material worked into the soft subgrade. We recommend the material be greater than 2 inches in nominal diameter, but less than 6 inches. A locally available pit-run gravel may be suitable but should contain a high percentage of particles larger than 2 inches and have less than 7 percent fines (material passing the No. 200 sieve). A pit-run gravel may not be as effective as a coarse, angular material in stabilizing the soft soils. The stabilization material should be worked (pushed) into the soft subgrade soils until a relatively firm surface is established. Once a relatively firm surface is achieved, the area may be brought to final design grade using structural fill.

In large areas of soft subgrade soils, or where any soft soils are encountered beneath a paved area such as a roadway or parking lot, stabilization of the subgrade may not be practical using the method outlined above. In these areas it may be more economical to place a woven geotextile fabric against the soft soils covered by 18 inches of coarse, sub-rounded to rounded material over the woven geotextile. An inexpensive non-woven geotextile "filter" fabric should be placed over the top of the coarse, sub-rounded to rounded fill prior to placing structural fill or pavement section soils to reduce infiltration of fines from above. The woven geotextile should consist of Propex Geotex 315ST or approved equivalent. The filter fabric should consist of Propex Geotex 601 or approved equivalent.

6.0 ENGINEERING ANALYSIS AND RECOMMENDATIONS

6.1 GENERAL CONCLUSIONS

Based on the subsurface conditions encountered at the site, it is our opinion that the subject site is suitable for the proposed construction provided that the recommendations contained in this report are complied with. Soft soils were encountered at the site and are susceptible to settlement with increased loading. Conventional strip and spread footings may be used to support the anticipated building loads if founded on relatively undisturbed native soils or a zone of properly placed and compacted structural fill. Alternatively a deep foundation as described in the following paragraphs should be considered if a higher bearing capacity is desired.

The following sub-sections present our recommendations for general site grading, design of foundations, slabs-on-grade, moisture protection and soil corrosivity.

6.2 EARTHWORK

Prior to the placement of foundations, general site grading is recommended to provide proper support for foundations, exterior concrete flatwork, concrete slabs-on-grade, and asphalt pavement sections. Site grading is also recommended to provide proper drainage and moisture control on the subject property and to aid in preventing differential movement in foundation soils as a result of variations in moisture conditions.

6.2.1 General Site Preparation and Grading

Within the areas to be graded (below proposed structures, fill sections, concrete flatwork, or pavement sections), any existing surface vegetation, debris, asphalt and concrete should be removed. Additionally, we recommend that all collapsible soils be removed beneath footings and roadways and replaced with structural fill or foundations should be founded beneath this material. The collapsible soils were typically limited to the upper 3 feet. If collapsible soils are left in place beneath footings or roadways and become saturated, they may have the potential to settle and cause distress to structures and pavement sections. Any loose, disturbed or undocumented fill soils should also be removed. Following the removal of vegetation, debris, loose or disturbed soils, as described above, site grading may be conducted to bring the site to grade.

established to be 0.49g. The MCE and Design response spectrum are presented in Appendix C on Plate C-1. The following table presents response accelerations for 0.2 and 1.0 second periods.

MCE Seismic Response Spectrum Spectral Acceleration Values for IBC Site Class D [a]

Site Location: **Latitude = 40.1357° N** **Longitude = -111.6494° W**	**Site Class D Site Coefficients:** **Fa = 1.01** **Fv = 1.50**
Spectral Period (sec)	**Response Spectrum Spectral Acceleration (g)**
0.2	1.222xFa = 1.235
1.0	0.511xFv = 0.767

[a] IBC 1615.1.3 recommends scaling the MCE values by 2/3 to obtain the design spectral response acceleration values.

5.4 OTHER GEOLOGIC HAZARDS

Geologic hazards can be defined as naturally occurring geologic conditions or processes that could present a danger to human life and property. These hazards must be considered before development of the site. There are several hazards in addition to seismicity and faulting that may be present at the site, and which should be considered in the design of roads and critical and essential facilities such as water tanks and structures designed for human habitation. The other geologic hazards considered significant at the subject site are liquefaction and shallow groundwater. A complete list of potential geologic hazards is included in the Summary of Geologic Hazards Table in Appendix C of this report (Plate C-2).

5.4.1 Liquefaction

Certain areas within the Intermountain seismic region also possess a potential to liquefy during seismic events. Liquefaction is a phenomenon whereby loose, saturated, granular soil deposits lose a significant portion of their shear strength due to excess pore water pressure buildup resulting from dynamic loading, such as that caused by an earthquake. Among other effects, liquefaction can result in densification of such deposits causing settlements of overlying layers after an earthquake as excess pore water pressures are dissipated. The primary factors affecting liquefaction potential of a soil deposit are: (1)

5.0 GEOLOGIC CONDITIONS

5.1 GEOLOGIC SETTING

The site is located in the northern portion of Spanish Fork, Utah at an elevation of approximately 4,530 to 4,540 feet, within the southeast portion of the Utah Valley. This valley represents a deep, sediment-filled structural basin of Cenozoic age flanked by uplifted blocks, the Wasatch Range on the east, and the Lake Mountains, West Mountain, the Goshen Hills, and Warm Springs Mountain (the northern end of Long Ridge) to the west (Machette, 1992 and Hintze, 1980). The Wasatch Range is the easternmost expression of pronounced Basin and Range extension in north-central Utah.

The near-surface geology of the Utah Valley is dominated by lacustrine sediments, which were deposited within the last 30,000 years by Lake Bonneville (Scott and others, 1983; Hintze, 1993; Machette, 1992). As the lake receded, streams began to incise large deltas formed at the mouths of major canyons along the Wasatch Range, and the eroded material was deposited in shallow lakes and marshes in the basin and in a series of recessional deltas and alluvial fans. Sediments toward the center of the valley are predominately deep-water deposits of clay, silt, and fine grained sand. However, these deep-water deposits are in places covered by a thin post-Bonneville alluvial cover. Most surficial deposits along the Wasatch fault zone were deposited during the Bonneville Lake Cycle that was the last cycle of Lake Bonneville between approximately 32 to 10 ka (thousands of years ago) and in the Holocene (< 10 ka). Surface sediments at the project site are discussed in the stratigraphy section below.

5.2 Stratigraphy

Geologic units exposed in the study area consist of Upper Pleistocene age lacustrine CLAY, SILT, and SAND related to the Provo (regressive) phase of the Bonneville Lake Cycle (Machette, 1992). The following paragraphs provide more detailed descriptions of geologic units found at and near the subject site.

5.2.1 Quaternary

Lacustrine sand (lps)

Sediment consists of Upper Pleistocene sand with minor pebbly gravel and silt (Machette, 1992). The bedding in this unit is thick to massive and also has ripple

Atterberg Limit tests indicate that the soils plasticity index ranged from 3 to 6; one soil sample tested was non-plastic. One sample tested collapsed approximately 3%. The results of the laboratory tests are presented on the attached Test Pit Logs (Plates A-3 to A-10 Appendix A) and in Appendix B.

2.0 INTRODUCTION

2.1 PURPOSE AND SCOPE OF WORK

This report presents the results of a geotechnical investigation conducted for the proposed approximately 16-acre light industrial/commercial subdivision located near 1950 North and 200 East in Spanish Fork, Utah. The purposes of this investigation were to assess the nature and engineering properties of the subsurface soils at the proposed site, and to provide recommendations for general site grading and the design and construction of foundations, slabs-on-grade and exterior concrete flatwork.

The scope of work completed for this study included a site reconnaissance, subsurface exploration, soil sampling, laboratory testing, engineering analyses, and preparation of this report. Our services were performed in accordance with our proposal and signed authorization, dated March 8, 2008.

The recommendations contained in this report are subject to the limitations presented in the **Limitations** section of this report (Section 7.1).

2.2 PROJECT DESCRIPTION

The project site is located on the east side of 200 East near 1950 North in Spanish Fork, Utah as shown on the Site Vicinity Map (Plate A-1). Based on our understanding of the proposed project, the facility as planned will include a light industrial/commercial subdivision.

APPENDIX

IGES

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