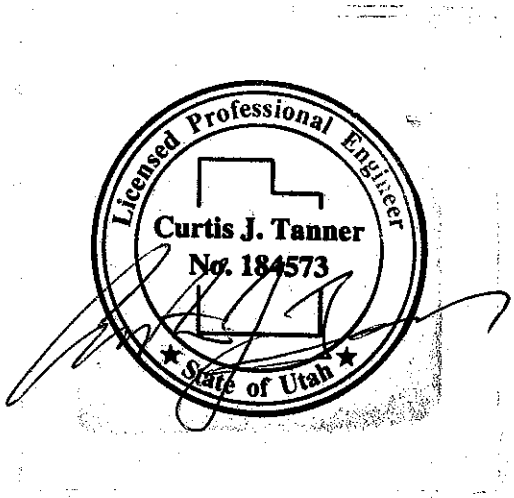
GEOTECHNICAL ENGINEERING REPORT

PROPOSED TRAFFIC SIGNAL PROJECT
1400 NORTH AND 600 WEST
LOGAN, UTAH

Terracon Project No. 61085027
May 6, 2008



Prepared for:

DMJM HARRIS
935 East South Union Avenue, Suite D-203
Midvale, UT 84047

Prepared by:

TERRACON CONSULTANTS, INC.
12217 South Lone Peak Pkwy. Suite 100
Draper, Utah 84020

Terracon

May 6, 2008

DMJM Harris
935 East South Union Avenue, Suite D-203
Midvale, UT 84047

Attention: Mr. Kelly D. Harris
Email: Kelly.Harris@dmjmharris.com

Telephone: (801) 569-2131
Facsimile: (801) 569-2149

Terracon
Consulting Engineers & Scientists
Terracon Consultants, Inc.
12217 South Lone Peak Parkway, Suite 100
Draper, Utah 84020

1550 North 320 West, Suite J
Layton, Utah 84041

Phone 801.545.8500
Fax 801.545.8600
www.terracon.com

Re: Geotechnical Engineering Report
Proposed Traffic Signal Project
Intersection of 1400 North and 600 West
Logan, Utah
Terracon Project No. 61085027

Mr. Harris:

At your request, Terracon has performed a geotechnical exploration at the proposed traffic signal project, located at the intersection of 1400 North and 600 West in Logan, Utah. This exploration was performed in general conformance with our Proposal for Geotechnical Engineering Services, dated January 24, 2008. The accompanying report describes the exploration, summarizes our findings and presents recommendations regarding site grading, pavement section thickness design, structural fill and other soil related issues.

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

Sincerely,
TERRACON CONSULTANTS

Jeff W. Gilbert
Geotechnical Staff Engineer

Reviewed By:

Rick L. Chesnut, P.E., P.G.
Principal / Utah Operations Manager

Curtis J. Tanner, P.E.
Geotechnical Department Manager

JWG/CJT/RLC/sm
Copies To: Addressee (3, Electronic)
N:\Projects\2008\61085027\61085027 Logan Traffic Signal rpt.doc

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GEOTECHNICAL ENGINEERING REPORT
PROPOSED TRAFFIC SIGNAL PROJECT
1400 NORTH AND 600 WEST
LOGAN, UTAH

Terracon Project No. 61085027
May 6, 2008

INTRODUCTION

This report presents the results of a geotechnical exploration for the site of the proposed traffic signal project; located at the intersection of 1400 North and 600 West in Logan, Utah. The general location of the site with respect to existing roads is presented on the Vicinity Map and Boring Location Plan, included in Appendix A.

The purpose of this exploration was to evaluate subsurface conditions at the site, and provide geotechnical recommendations regarding site grading, pavement section thickness design, structural fill and other soil related issues as may be appropriate. The scope of work included subsurface exploration, field and laboratory testing, engineering analysis, and the preparation of this report.

PROJECT DESCRIPTION

We understand that the project will include providing a design for intersection improvements at the intersection of 1400 North and 600 West in Logan. As part of the intersection improvements, new pavement sections will be constructed for the intersecting roadways. We understand that the new pavement sections will consist of either asphaltic or Portland cement concrete supported on untreated base course and granular subbase as appropriate. Cuts and fills are expected to be 2 feet or less.

Traffic information was made available to Terracon by DMJM Harris at the time of the preparation of this report.

If the project construction, traffic loading or site grading varies significantly from that described above, we should be notified immediately so the necessary modifications can be made to our recommendations.

SITE EXPLORATION PROCEDURES

Field Exploration

The subsurface exploration included drilling 3 borings to depths of about 6½ feet below existing site grade on road shoulders at the existing intersection. A fourth boring was planned but could not be drilled due to access issues. The approximate boring locations in relation to the existing intersection are shown on the Vicinity Map and Boring Location Plans, included in Appendix A. The borings were located by reference to existing on-site features. The locations are approximate and should be considered accurate only to the degree implied by the means and methods used to determine them.

The borings were drilled with a truck-mounted Mobile B-80 rotary drill rig with continuous flight hollow-stem augers. Disturbed soil samples were collected at various depths utilizing a 2½-inch outside-diameter split spoon sampler driven in general accordance with the standard penetration test (SPT) method. This test consists of driving the sampler into the ground with a 140-pound hammer free-falling through a distance of 30 inches. The number of blows required to advance the sampler the last 12 inches, or the interval indicated, of a typical 18-inch penetration is recorded as the standard penetration resistance value (N-value). These values are indicated on the boring logs at the respective sample depths.

The standard penetration test provides a reasonable indication of the in-place density of sandy type materials, but only provides an indication of the relative stiffness of cohesive materials since the blow count in these soils may be affected by the moisture content. In addition, considerable care should be exercised in interpreting the N-values in gravelly soils, particularly where the size of the gravel particle exceeds the inside diameter of the sampler.

Terracon personnel prepared a log of each boring during drilling. The soil samples were packaged and transported to our Draper laboratory for further observation and testing.

Laboratory Testing

Samples obtained during the field exploration were visually classified in the laboratory in general accordance with the Unified Soil Classification System (USCS). The USCS is described in Appendix C.

Selected soil samples were tested to determine physical and engineering properties and to aid in classification. Following are the laboratory tests performed and a brief description of each test:

Natural Water Content: The percentage of water in the soil at the sample location.

Percent Passing the No. 200 Sieve: Amount of combined clay and silt-sized particles in the soil sample.

Sieve Analysis: Measurement of the grain-size distribution of a soil sample as a percentage of total dry sample weight.

Atterberg Limits: Consistency and range of moisture content within which the material is workable.

Results of the laboratory tests are summarized on the boring logs in Appendix A, on the summary sheets in Appendix B and in the following sections of this report.

SITE CONDITIONS

The project site is located northwest of Logan at the intersection of 1400 North and 600 West. The site is located west of railroad tracks that parallel 600 West Street. Residential neighborhoods are located on the east side of the tracks. Open fields and some manufacturing/commercial buildings are located to the north and west of the site. Bridgerland Applied Technology College (BATC) is located to the southwest. A small irrigation ditch with some water was noted running along the north side of 1400 North Street, west of 600 West Street. Existing pavements within the project limits appeared to be in good condition.

SUBSURFACE CONDITIONS

Soil Conditions

Subsurface conditions encountered at the site are indicated on the boring logs in Appendix A. The stratification lines shown on the logs represent the approximate boundary between the soil types encountered; the actual transition may be gradual.

Fill generally consisting of clay with sand and gravel was encountered in Borings B-1 and B-3 to depths of approximately 4½ feet. Native soils encountered below the fill and below the ground surface in the remaining borings generally consisted of sandy clay and silt to the maximum depth explored of approximately 6½ feet below surface elevation.

The fill encountered had N-values ranging between 17 and 19 blows per foot of penetration. Native clay and silt with sand were generally stiff to very stiff with N-values ranging between 9 to 14 blows per foot of penetration. Laboratory test results are indicated on the attached soil boring logs in Appendix A and on the laboratory summary sheets in Appendix B.

Groundwater Conditions

At the time of our field exploration, groundwater was not encountered within the depths explored. Water was observed on the north side of 1400 North Street, west of 600 West Street in a small irrigation ditch. A previous geotechnical field investigation at BATC encountered groundwater at depths of 3 to 4 feet below the existing north parking lot surface, which we estimate is slightly lower in elevation than the intersection. It should be recognized that fluctuations of the groundwater table may occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Evaluation of these factors is beyond the scope of this exploration.

ENGINEERING ANALYSIS AND RECOMMENDATIONS

Geotechnical Considerations

Based on the results of this exploration, it is our opinion that the site is suitable for the proposed construction provided the recommendations contained in this report are followed. The proposed roadways may be supported on properly prepared subgrade as recommended in the **Earthwork** section below. Existing fill should either be removed down to native soils and replaced with properly placed and compacted structural fill, or be scarified and recompacted to meet specifications in the **Earthwork** section of this report.

Some of the near-surface native soils are fine-grained and may be susceptible to disturbance or rutting under the weight of construction equipment if they become wet. If these soils are very moist to wet during construction, dump and spread procedures, and the use of geotextiles in combination with angular granular fill may be required to reduce the potential for disturbance of the soils.

Design Assumptions And Parameters

Design traffic loading information was provided to Terracon from DMJM Harris. The functional roadway classification for 600 West Street is a collector, while 1400 North Street is a minor arterial as indicated by UDOT functional class system map for the Logan Urban area, dated February 14, 2005. Using the provided information, design Equivalent Single Axel Loads (ESAL) for a 20 year design lift for flexible pavement and a 40 year design life for rigid pavement design for each street are shown in the following table. The selected traffic distributions for each street, as well as other pavement design parameters are also shown in the following tables.

Design ESAL's

Street	UDOT Classification	ESAL's Flexible	ESAL's Rigid
1400 North	Minor Arterial	1,921,232	7,473,816
600 West	Collector	400,505	1,530,641

Vehicle Class Distribution Assumptions

Class	Description	1400 North % of Traffic	600 West % of Traffic
1-2	Motorcycles/Cars	93.64	96.88
3	Other Two Axle, Four Tire	3.98	2.25
4	Buses	1.0	0.4
5-7	Single Unit trucks	0.41	0.13
8-10	Single Trailer Trucks	0.9	0.25
11-13	Multi-Trailer trucks	0.08	0.09

Other Design Parameters

Parameter	Value
Average Annual Growth Rate	2.2%
Assumed CBR	4.0

If actual traffic or other parameters will be different than those assumed we should be notified so that we can review and if necessary revise our designs and recommendations.

Recommended Pavement Section

Pavement section thickness design was performed using the procedures outlined in the Utah Department of Transportation (UDOT) Pavement Management and Pavement Design Manual, dated November 1998 and the 1993 AASHTO "Guide for the Design of Pavement Structures". The following minimum pavement section, or an approved equivalent, should be placed on the properly prepared subgrade soils as described below.

Pavement Sections

Traffic Area	Recommended Pavement Sections (Inches)				
	Asphalt Concrete Surfacing	Portland Cement Surfacing	Aggregate Base Course	Granular Subbase	Total
1400 North	5.0	---	12.0	16.0	31
	---	10.0	6.0	---	16
600 West	4.0	---	10.0	12.0	26
	---	7.5	6.0	---	13.5

UDOT recommends that the total pavement section thickness be at least 70 percent of the frost depth in frost sensitive soils such as silt, clay and fine sand. UDOT lists a frost depth of 40 to 50 inches for Cache Valley. Using 70 percent of 40 inches, a minimum of 28 inches is recommended. Where frost susceptibility is a concern, the subbase thickness could be increased to provide a total section thickness of 28 inches.

Paved areas should have positive drainage to prevent ponding of surface water and saturation of the base course and underlying subgrade. Permanent drainage should be incorporated into the pavement grading design.

The asphaltic concrete should be placed and compacted to at least 95 percent of the maximum density as determined by ASTM D 1559 (50 blows each end). Aggregates, granular subbase, and asphaltic concrete should conform to local city or UDOT specifications.

The pavement sections provided in this report are minimums for the given design criteria and as such, periodic maintenance should be expected. A maintenance program that includes surface sealing, joint cleaning and sealing, and timely repair of cracks and deteriorated areas will increase the pavement's service life. As an option, thicker sections could be constructed to decrease future maintenance.

If actual traffic data varies from that described above Terracon should be contacted so that modifications can be made to the recommendations presented in this report.

Earthwork

Existing fill, disturbed soils and other deleterious materials should be removed from beneath pavement areas. Excavations resulting from the removal of these materials should be backfilled with structural fill. Following removal of fill material, the exposed native soils should be proof-rolled to aid in assessing subgrade condition. Soft areas encountered during proof-rolling should be excavated and replaced with structural fill properly placed and compacted as described below. Unstable or very soft subgrade may need to be stabilized using crushed angular rock underlain by a separator fabric. A geotextile placed on top of the separator fabric may also be required.

If the existing fill is left in place there is an inherent risk that compressible fill or unsuitable material within or buried by the fill will not be discovered and may adversely affect the proposed project. This risk of unforeseen conditions cannot be eliminated without completely removing the existing fill. If the owner is willing to accept this risk and the resulting consequences, the fill may be left in place. If left in place, the exposed fill subgrade should be scarified to a depth of 12 inches, moisture conditioned to within 2% of the optimum water content and compacted to a minimum of 95 percent of the maximum density as determined by ASTM D 1557 (Modified Proctor).

The near-surface native soils encountered may be susceptible to disturbance or rutting under the weight of construction equipment. In order to reduce the potential for disturbance or rutting, excessive water should not be applied to the surface during earthwork operations and construction should occur during dryer weather. Construction traffic should be closely monitored so that native subgrade does not become unstable. This may require rerouting construction traffic, reducing loads or using track equipment. Soils that become excessively rutted, are pumping or otherwise disturbed are not suitable for support of pavements and should be removed and replaced with structural fill. The use of crushed angular rock in combination with separator fabric and/or geogrid may be required.

Structural fill used for site grading below pavement sections should consist of well graded, granular soil with a maximum particle size of 3 inches, 25 to 60 percent passing the No. 4 sieve and having less than 15 percent fines. Rock used for stabilization should be 1 to 3 inches, with angular edges and little to no fines.

All fill should be approved by the geotechnical engineer, should be moisture conditioned to near optimum water content, placed in uniform lifts not exceeding 8 inches in loose thickness, and be compacted to a minimum of 95 percent of the maximum density as determined by ASTM D 1557 (Modified Proctor). Stabilization rock should be placed and compacted with several passes of compaction equipment to seat the rock.

Positive drainage away from the subgrade should be provided during construction and maintained throughout the life of the proposed project. Infiltration of water into subgrade excavations should be prevented during construction. Surface drainage should be collected and discharged away from the pavement surface.

It is the responsibility of the contractor to provide safe working conditions in connection with underground excavations. Temporary construction excavations should be properly sloped or shored. All excavations should be accomplished in accordance with applicable federal, state, and local standards.

GENERAL COMMENTS

Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications for the project. Terracon also should be retained to provide testing and observation during subgrade preparation and construction phases of the project.

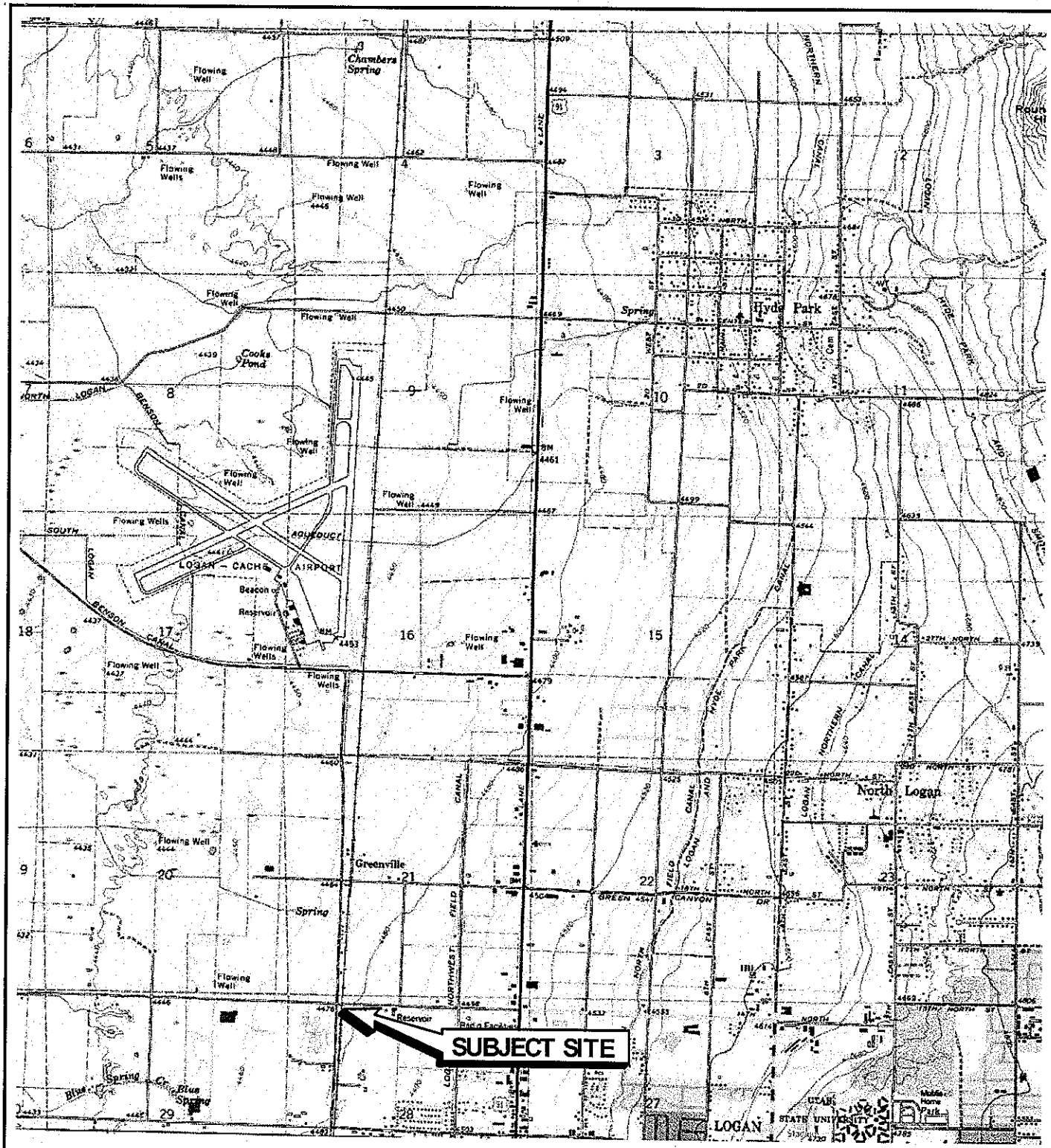
The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the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

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

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

APPENDIX A

VICINITY MAP
BORING LOCATION PLAN
BORING LOGS



PROJECT VICINTY MAP
LOGAN TRAFFIC SIGNAL PROJECT
1400 NORTH 600 WEST
LOGAN, UTAH
DMJM HARRIS

USGS 7.5 MINUTE SERIES TOPOGRAPHIC MAP
SMITHFIELD, UTAH QUADRANGLE

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES.

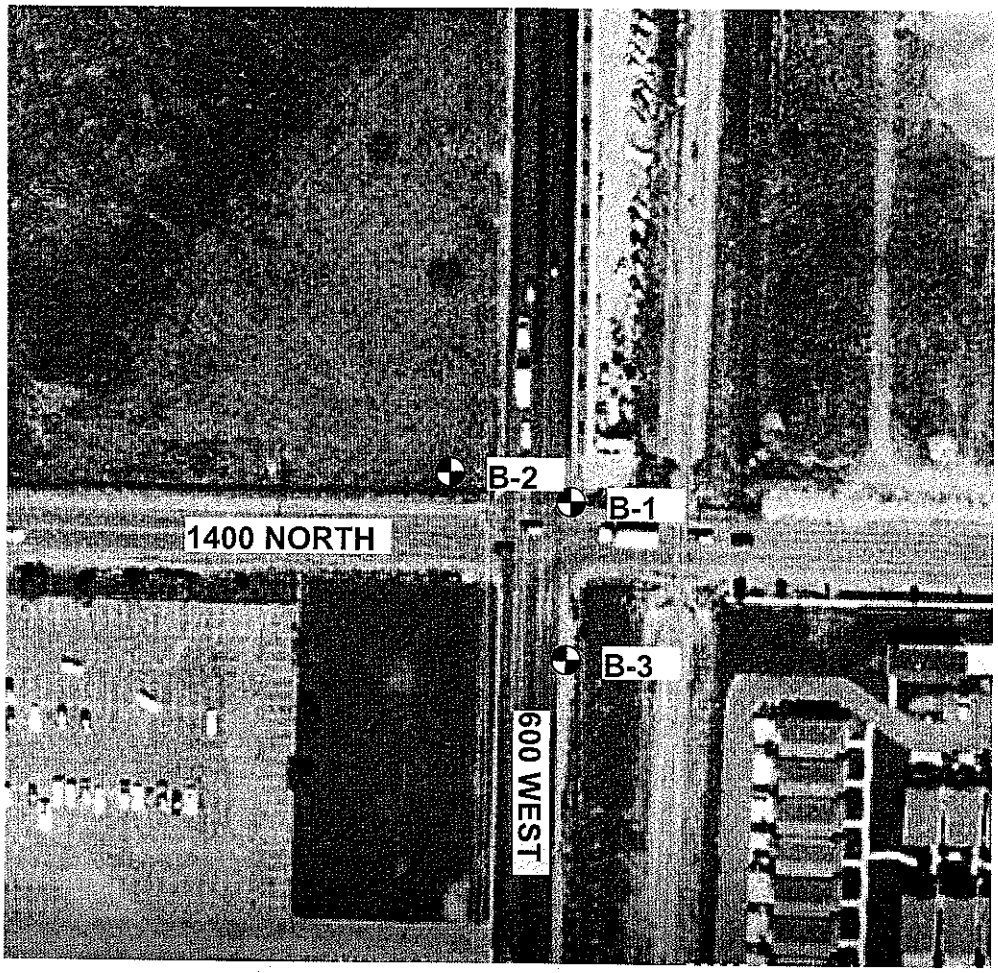
N

Project Mngr:	CJT
Designed By:	USGS
Checked By:	JWG
Approved By:	CJT

Terracon
12217 S. Lone Peak Pkwy. Ste. 100
Draper, Utah 84020
801.545.8500 fax: 801.545.8600

Project No.	61085027
Scale:	NTS
Date:	5-5-08
Drawn By:	JWG (61)
Figure No.	1

File Path: N:\Projects\2008\61085027\61085027 Vic Map.ppt



BORING LOCATION MAP
LOGAN TRAFFIC SIGNAL PROJECT
1400 NORTH AND 600 WEST
LOGAN, UTAH
DMJM HARRIS

N

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES.

Project Mngr:	CJT	Terracon	Project No. 61085027
Designed By:	OTHER		Scale: NTS
Checked By:	JWG	12217 S. Lone Peak Pkwy. Ste. 100 Draper, Utah 84020 801.545.8500 fax: 801.545.8600	Date: 5-5-08
Approved By:	CJT		Drawn By: JWG (61)
File Path: N:\Projects\2008\61085027\61085027 Boring Loc.			Figure No. 2

LOG OF BORING NO. B-1

OTHER **DMJM Harris**

SITE **1400 N 600 W Logan, UT**

PROJECT **Logan Traffic Signal**

Boring Location: **Northeast corner of intersection**

GRAPHIC LOG	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, in.	SAMPLES PENETRATION RESISTANCE BLOWS / ft.	TESTS WATER CONTENT, %	TESTS DRY UNIT WEIGHT, PCF	TESTS LIQUID LIMIT	TESTS PLASTICITY INDEX	TESTS % PASSING NO. 200 SIEVE	OTHER
	1											
	2											
	3		1	SS	6	17	23				92	Sieve
	4											
	5											
	6	CL	2	SS	13	9	29		37	19	82	

FILL:
clay with trace of sand and gravel, brown

4.5

CLAY:
with sand, stiff, brown with white mottling

6.5

BOTTOM OF BORING AT APPROXIMATELY 6.5 FEET

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

WATER LEVEL OBSERVATIONS, ft			
WL	▽ NE	WD	▼
WL	▽		▼
WL			

Terracon

BORING STARTED			4-4-08
BORING COMPLETED			4-4-08
RIG	B-80	FOREMAN	SCD
LOGGED	SCD	JOB #	61085027

BOREHOLE 99 61085027.GPJ TERRACON.GDT 5/6/08

LOG OF BORING NO. B-2

OTHER **DMJM Harris**

SITE **1400 N 600 W Logan, UT**

PROJECT **Logan Traffic Signal**

Boring Location: **Northwest corner of intersection**

GRAPHIC LOG		DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, in.	SAMPLES PENETRATION RESISTANCE BLOWS / ft.	TESTS WATER CONTENT, %	TESTS DRY UNIT WEIGHT, PCF	TESTS LIQUID LIMIT	TESTS PLASTICITY INDEX	TESTS % PASSING NO. 200 SIEVE	OTHER
	0.17 **TOPSOIL:** approximately 2 inches thick: silty loam												
	CLAY: with some sand, stiff to very stiff, brown with orange mottling, with organics	1											
		2											
		3		1	SS	13	14						
		4											
		5											
	with gravel	6		2	SS	10	11	24				89	
	6.5 BOTTOM OF BORING AT APPROXIMATELY 6.5 FEET												

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

WATER LEVEL OBSERVATIONS, ft			
WL	▽ NE	WD	▽
WL	▽		▽
WL			

Terracon

BORING STARTED			4-4-08
BORING COMPLETED			4-4-08
RIG	B-80	FOREMAN	SCD
LOGGED	SCD	JOB #	61085027

BOREHOLE 99 61085027.GPJ TERRACON.GDT 5/6/08

LOG OF BORING NO. B-3

OTHER **DMJM Harris**

SITE **1400 N 600 W Logan, UT**

PROJECT **Logan Traffic Signal**

Boring Location: **Southeast corner of intersection**

GRAPHIC LOG	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, in.	SAMPLES PENETRATION RESISTANCE BLOWS / ft.	TESTS WATER CONTENT, %	TESTS DRY UNIT WEIGHT, PCF	TESTS LIQUID LIMIT	TESTS PLASTICITY INDEX	TESTS % PASSING NO. 200 SIEVE	OTHER
	1											
	2											
	3		1	SS	3	19						
	4											
	5	ML	2	SS	10	10	33		NP	NP	88	
	6											

FILL:
sandy clay with gravel, dark brown

4.5

SILT:
with some sand, stiff, brown ▽

6.5

BOTTOM OF BORING AT APPROXIMATELY 6.5 FEET

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

WATER LEVEL OBSERVATIONS, ft			
WL	▽ 5	WD	▽
WL	▽		▽
WL			

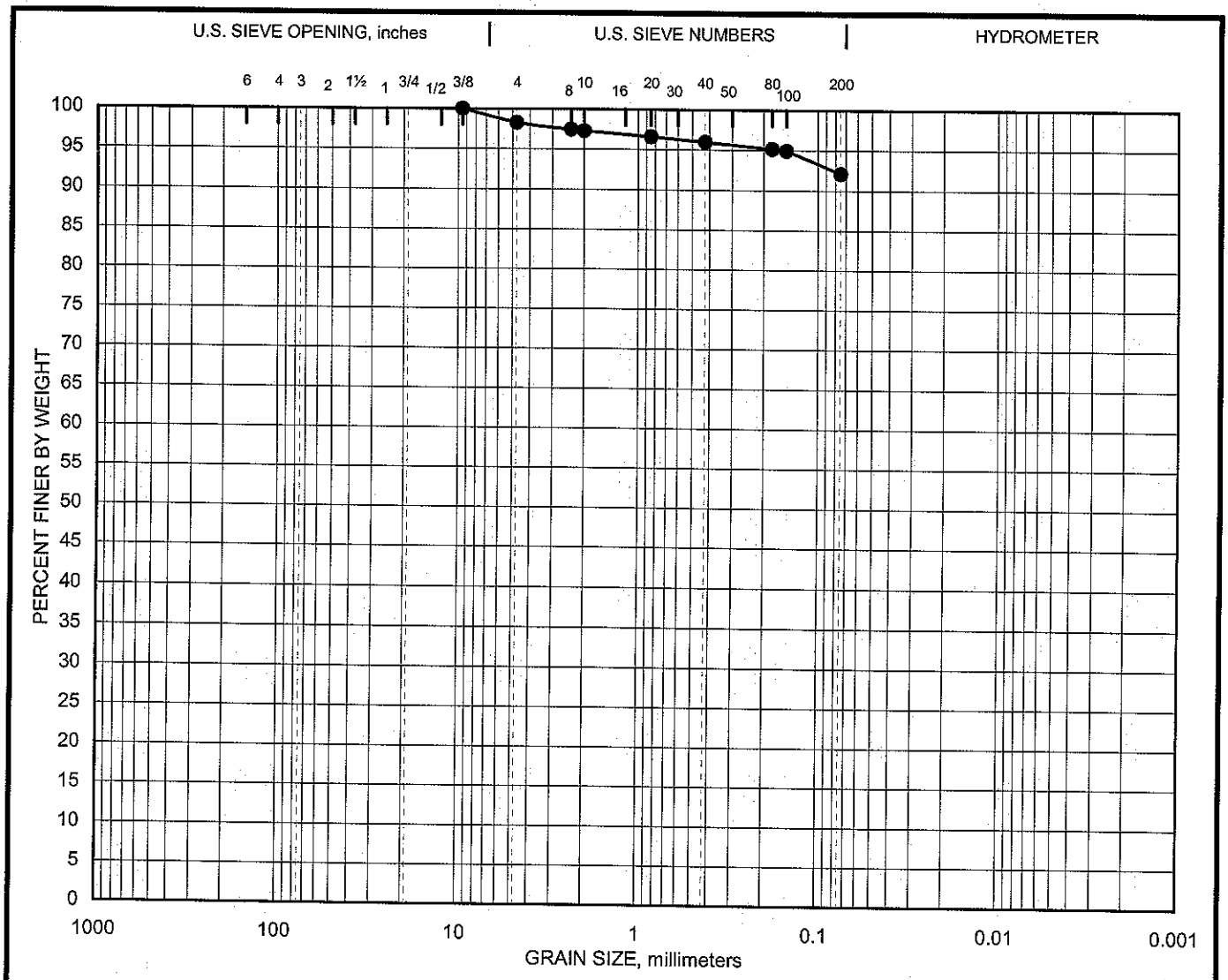
Terracon

BORING STARTED			4-4-08
BORING COMPLETED			4-4-08
RIG	B-80	FOREMAN	SCD
LOGGED	SCD	JOB #	61085027

BOREHOLE 99 61085027.GPJ TERRACON.GDT 5/6/08

APPENDIX B

LABORATORY TEST RESULTS



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	MC%	LL	PL	PI	Cc	Cu
●	**B-1 @ 2.5**	**Clay**	**23**				--	--
■								
▲								
◆								
X								

Specimen Identification		D100	D85	D60	D30	D15	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-1 @ 2.5**	**9.50**						**2**	**6**	**92**	
■											
▲											
◆											
X											

Terracon

GRAIN SIZE DISTRIBUTION

Project Name: **Logan Traffic Signal Project**
Location: **1400 North 600 West, Logan, Utah**
Project No.: **61085027**
Date: **5/6/2008**

APPENDIX C

GENERAL NOTES
UNIFIED CLASSIFICATION SYSTEM

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

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

The number of blows required to advance a standard 2-inch O.D. split-spoon sampler (SS) the last 12 inches of the total 18-inch penetration with a 140-pound hammer falling 30 inches is considered the "Standard Penetration" or "N-value". For 3" O.D. ring samplers (RS) the penetration value is reported as the number of blows required to advance the sampler 12 inches using a 140-pound hammer falling 30 inches, reported as "blows per foot," and is not considered equivalent to the "Standard Penetration"or "N-value".

WATER LEVEL MEASUREMENT SYMBOLS:

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

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

DESCRIPTIVE SOIL CLASSIFICATION: Soil classification is based on the Unified Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

CONSISTENCY OF FINE-GRAINED SOILS

Unconfined Compressive Strength, Qu, psf	Standard Penetration or N-value (SS) Blows/Ft.	Consistency
< 500	<2	Very Soft
500 – 1,000	2-3	Soft
1,001 – 2,000	4-6	Medium Stiff
2,001 – 4,000	7-12	Stiff
4,001 – 8,000	13-26	Very Stiff
8,000+	26+	Hard

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Standard Penetration or N-value (SS) Blows/Ft.	Ring Sampler (RS) Blows/Ft.	Relative Density
0 – 3	0-6	Very Loose
4 – 9	7-18	Loose
10 – 29	19-58	Medium Dense
30 – 49	59-98	Dense
50+	99+	Very Dense

RELATIVE PROPORTIONS OF SAND AND GRAVEL

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

GRAIN SIZE TERMINOLOGY

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

RELATIVE PROPORTIONS OF FINES

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

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1-10
Medium	11-30
High	30+

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UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]					Soil Classification	
					Group Symbol	Group Name[B]
Coarse Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[E]		GW	Well-graded gravel[F]
			$Cu < 4$ 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]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[E]		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	< 0.75	OL	Organic clay[K,L,M,N]
			Liquid limit - not dried			Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line		CH	Fat clay[K,L,M]
			PI lots below "A" line		MH	Elastic Silt[K,L,M]
		organic	Liquid limit - oven dried	< 0.75	OH	Organic clay[K,L,M,P]
			Liquid limit - not dried			Organic silt[K,L,M,Q]
Highly organic soils	Primarily organic matter, dark in color, and organic odor				PT	Peat

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

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

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

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

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[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.

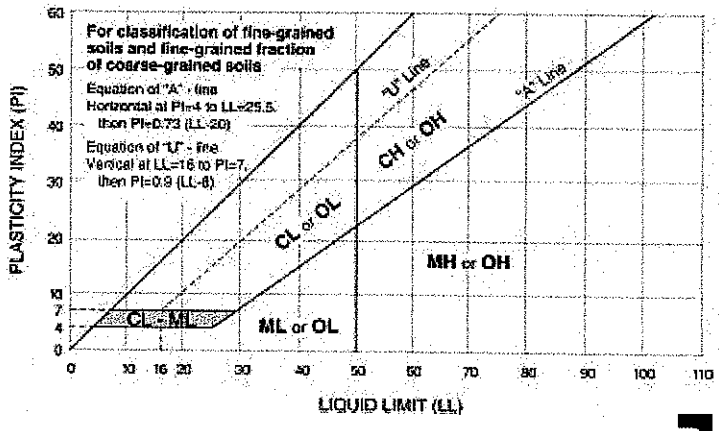
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[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.



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