Salt Lake City, Utah
SHB Job No. E89-2009
February 10, 1989

Prepared for:

Davis-Weber Canal Company
c/o Jones and Associates
5670 Quincy
Ogden, Utah 84403

REPORT FOR:

SOIL AND GROUNDWATER STUDY
PROPOSED SUBDRAIN
NORTHEAST OF FERN DRIVE
CLEARFIELD, UTAH
FOR THE DAVIS-WEBER CANAL COMPANY

SERGENT, HAUSKINS & BECKWITH
CONSULTING GEOTECHNICAL ENGINEERS

SERGENT, HAUSKINS & BECKWITH CONSULTING GEOTECHNICAL ENGINEERS

APPLIED SOIL MECHANICS • ENGINEERING GEOLOGY • MATERIALS ENGINEERING • HYDROLOGY

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February 10, 1989

Davis-Weber Canal Company
c/o Jones and Associates
3670 Quincy
Ogden, Utah 84403

SHB Job No. E89-2009

Attention: Mr. Kent Jones

Re: Report
Soil and Groundwater Study
Proposed Subdrain
Northeast of Fern Drive
Clearfield, Utah
For the Davis-Weber Canal Company

Gentlemen:

1. INTRODUCTION

1.1 General

This report presents the results of our soils and groundwater study for the proposed subdrain to be installed below the existing Davis-Weber Canal northeast of Fern Drive in Clearfield, Utah. The location of the site with respect to surrounding roads and topographic features is presented on Figure 1, Site Map. The locations of the borings and piezometers drilled and installed in conjunction with this study are referenced on Figure 1. The locations of the piezometers installed in conjunction with previous studies by others are also referenced on Figure 1.

During the course of this study, conclusions and recommendations were transmitted verbally to Mr. Kent Jones of Jones and Associates, and Mr. Floyd Bayhem of the Davis-Weber Canal Company.

1.2 Objectives and Scope

The objectives and scope of this study were planned in discussions between Mr. Kent Jones of Jones and Associates and Mr. Bill Gordon of Sergent, Hauskins & Beckwith Engineers (SHB). In general, the objectives of this study were to accurately define and evaluate the subsurface soil and groundwater conditions in the vicinity of the proposed subdrain and residential structures along Fern Drive and to provide design recommendations for the proposed subdrain.

In accomplishing these objectives, our scope included: review and correlation of background and subsurface data provided by others; drilling, logging, and sampling of four borings including the installation of piezometers in each of the borings; laboratory testing; office analyses; and the preparation of this final summary report.

1.3 Authorization

Authorization to perform this study was initially granted verbally by Mr. Kent Jones of Jones and Associates. Subsequently, a signed copy of our Professional Services Agreement dated January 11, 1989 was returned to our office.

1.4 Professional Statements

Supporting data upon which our recommendations are based, are presented in subsequent sections of this report. Recommendations presented herein are governed by the physical properties of the soils encountered in the exploration borings, projected groundwater conditions, and the data discussed in Section 2 of this report. If subsurface conditions other than those described in this report are encountered and/or if design and layout changes are implemented, SHB must be informed so that our recommendations can be reviewed.

Our professional services have been performed, our findings obtained, and our recommendations prepared in accordance with generally accepted engineering principles and practices at this time.

2. BACKGROUND-PROJECT DESCRIPTION

Since construction a number of homes along the northeast side of Fern Drive have experienced problems associated with groundwater seeping into the basements. In the last few years, the problem has become more severe.

The homes are located on the northeast side of Fern Drive immediately to the west of the Davis-Weber Canal. It is our understanding that the homes are approximately 25 years old. The canal was constructed many years prior to the construction of the houses and is in operation during the irrigation season.

Interstate 15 is located several hundred feet to the east of Fern Drive and was constructed more than 15 years ago.

Even though there have been long-term seepage problems in the basements of the homes, this problem appears to have increased significantly after the construction of the apartments located on both sides of Bruce Street east of the Davis-Weber Canal. In conjunction with construction of the apartments, there was a considerable amount of landscaping. It is our understanding that the landscaping is irrigated very heavily and regularly during the spring, summer, and fall months.

Because the seepage problems have become more prevalent in the past few years, sumps and subdrains have been installed below basement floorslabs and adjacent to foundations at some of the homes on the east side of Fern Drive. The subdrains have been only marginally effective.

It is not within the scope of this study to determine exactly the reason(s) why the groundwater seepage problems along Fern Drive have increased during the last few years. However, representatives of Clearfield City, the Davis-Weber Canal Company, and local homeowners have speculated that the rise in the groundwater could possibly be attributed to: seepage losses from the canal, infiltration of irrigation water at the apartment complex property to the east, construction of the freeway also to the east, or a combination of these and other factors.

Regardless of the cause, the Davis-Weber Canal Company has elected to install a subdrain below the bottom of the canal in the vicinity of Fern Drive for the purpose of lowering the groundwater table to the immediate west. The location of the proposed subdrain is shown on Figure 1. The near-surface groundwater within the vicinity of Fern Drive flows from the northeast to the southwest.

Other subdrain alignments were also considered; however, because of obstructions and difficulty of access, the present alignment has been chosen.

In conjunction with installation of the subdrain system, a new concrete liner will be installed along the canal.

3. INVESTIGATIONS

3.1 Subsurface

The subsurface soil and groundwater conditions within the vicinity of the proposed subdrain and Fern Drive were explored in conjunction with this study by drilling 4 borings to depths ranging from 21.5 to 26.5 feet below existing grade. The locations of the borings are referenced on Figure 1. In addition, previous soils and groundwater studies dated August 16, 1988; September 6, 1988; and December 1, 1988, which were conducted by Mr. Mike Lowe, Davis County Geologist, were also reviewed. The locations of the test pits, borings, and piezometers installed in conjunction with Mr. Lowe's studies are also referenced on Figure 1.

The field portion of our study was under the direct control and continuous supervision of an experienced member of our geotechnical staff. During the course of the drilling operations, a continuous log of the subsurface conditions encountered was maintained. In addition, samples of the typical soils penetrated were obtained for subsequent laboratory testing and examination. The soils were classified in the field based upon visual and textural examination. These classifications were later supplemented by subsequent inspection and testing in our laboratory. Detailed graphical representation of the subsurface conditions encountered is presented on Figures 2A through 2D, Log of Borings. The nomenclature utilized to describe the soil types is presented on Figure 3, Unified Soil Classification System.

Following completion of the drilling operations, one and one-quarter inch diameter slotted PVC pipe was installed to depths ranging from 20 to 25.5 feet in all our borings.

3.2 Laboratory Testing

3.2.1 General

A laboratory testing program was conducted to provide data for our engineering analyses. The program included moisture and gradation tests. The following paragraphs describe the tests and summarize the test data.

3.2.2 Moisture Tests

Moisture tests were conducted to aid in determining the quantity of moisture in the soils which is an indicator of the level of the groundwater table. The result of the moisture tests are presented on the Boring Logs on Figures 2A through 2D.

3.2.3 Gradation Tests

To aid in classifying the soils and to aid in determining filter fabric recommendations, gradational tests were performed on selected samples. The results of these tests are as follows:

Boring Number	Depth (feet)	Percent Passing by Weight					Soil Classification
		No. 10	No. 16	No. 40	No. 100	No. 200	
B-2	5.0	99.9	99.9	98.4	77.9	38.6	SM
B-3	5.0	99.6	98.8	95.8	77.7	55.3	SM/ML
B-3	20.0	100	100	99.9	94.9	50.3	SM/ML

4. SITE CONDITIONS AND GEOTECHNICAL PROFILE

4.1 Site Conditions

Fern Drive is located at approximately 400 North and approximately 250 East in the northeast portion of Clearfield, Utah. The portion of Fern Drive included in this study is approximately 1,300 feet in length and runs in a northwest-southeast direction. As stated previously, a number of the homes along the east side of Fern Drive have and are experiencing water seepage problems in the basements. The homes are mostly one-level, above-grade, and of timber-frame construction with full-depth basements consisting of concrete foundation walls, footings, and concrete slabs. The depth to the basement floor slabs is estimated to be on the order of six and one-half to seven and one-half feet below existing surrounding grade.

Approximately 100 feet to the northeast of the homes, located on the northeast side of Fern Drive, is the Davis-Weber Canal which runs northwest-southeast. The canal has a bottom width on the order of 20 feet and is approximately 6 feet deep. Because of the slope of the ground surface in the vicinity of the site, the bottom of the canal is up to 10 feet higher than some of the basement floor slabs in the homes on the east side of Fern Drive. Immediately to the northeast of the canal is an apartment complex which has approximately two dozen two- to three-level multi-unit structures. Further to the northeast is Interstate 15 and Hill Air Force Base. To the west of the site is mostly residential areas.

The ground surface in the vicinity of the site slopes downward to the southwest with an average slope on the order of five percent. However, because of recent development, some terracing and steeper areas exist.

The area within the vicinity of the site is fully developed with residential structures and landscaping consisting of grass, trees, occasional flowers and vegetable gardens.

4.2 Geotechnical Profile

4.2.1 Previous Studies

Previous soil and groundwater studies have been performed by Mr. Mike Lowe, Davis County Geologist. Mr. Lowe's studies included excavation of test pits and drilling of borings in the vicinity of the Davis-Weber Canal. Most of this previous exploration was performed on the upgradient side of the canal to the northeast encountered sand and silty sand soils to a depth of approximately 12 feet with occasional layers of silt. Below a depth of approximately 12 feet, the sand grades more silty and clayey. At a depth ranging from approximately 18 to 27 feet in these borings, a layer described as sandy and silty clay was encountered.

Groundwater was encountered in all of the test pits and borings drilled in conjunction with the previous studies. Depths to groundwater and the dates measured are tabulated below:

	Depth to Groundwater (feet)	
Piezometer No.	Sept 1988	Oct 1988
P-1	13	--
P-2	11	--
P-3	--	18
P-4	--	29
P-5	--	13
P-6	--	15
TP-1	10	--
TP-2	11	--

4.2.2 This Study

The soil conditions encountered in the borings drilled in conjunction with this study are fairly consistent.

At the ground surface and extending to the maximum depth of the borings, brown silty fine sand and brown silty fine sand-fine sandy silt were encountered. Generally the soils become more silty with depth with the silty fine sand-fine sandy silty soils becoming more prevalent below a depth of approximately 10 to 20 feet. Interspersed in these soils are occasional approximately one-quarter inch to eight-inch layers of clayey silt, silt, and fine sand with some silt. One approximately five-foot layer of fine sand with some silt was encountered at a depth of approximately eight feet in Boring 3. These soils range from loose to medium dense in consistency.

Based upon gradational analysis, the soils are relatively permeable within the upper 10 to 12 feet and become less permeable with depth.

Groundwater was encountered in all of the borings. Depths to groundwater are tabulated below:

Boring No.	Depth to Groundwater January 1989 (feet)
B-1	9.4
B-2	8.0
B-3	7.6
B-4	10.0

5. DISCUSSIONS AND RECOMMENDATIONS

5.1 Discussion of Findings

The results of this study indicate that the proposed subdrain, if properly designed and installed, should control and lower the groundwater in the vicinity of the subdrain to a point where a significant decrease in the basement seepage problems along Fern Drive should be realized. Presently, the subdrain invert is designed to be approximately three feet below the lowest basement floor slab on the east side of Fern Drive, which is experiencing seepage problems. It is our opinion that based upon the relatively homogeneous silty sand soil conditions that the subdrain as proposed should lower and maintain the groundwater table after a sufficient period of time, below the majority of if not all of the basement floor slabs experiencing seepage problems. It must be realized that even with the subdrain that some basement seepage problems may continue. In our opinion, heavy irrigation around the immediate perimeter of many of the homes is also a source of seepage into basements. The new subdrain will not control this seepage.

Details pertaining to subdrain recommendations are presented later in this report; however, proper installation of the subdrain system cannot be over emphasized. It is proposed that the subdrain line be encased in a free-draining gravel which in turn will be wrapped in a filter fabric. The filter fabric is a critical component since it reduces the possibility of migration of the fine sand and silt sized particles into the inner subdrain system. The soils encountered at the site are particularly prone to "piping"; therefore, any punctures, holes. etc., in the filter fabric could lead to catastrophic results such as sink holes and plugging of the subdrain system which may temporarily or permanently render the subdrain system ineffective. Therefore, utmost care must be taken during the installation and long-term operation of the subdrain system to prevent punctures, gaps, etc., from occurring in the filter fabric.

Detailed discussions and recommendations pertaining to subdrain design and earthwork are presented in the following sections.

5.2 Subdrain

5.2.1 General

The proposed subdrain (alignment shown on Figure 1) if installed as proposed, should control and lower the groundwater in the vicinity of the subdrain. In addition, the subdrain should intercept possible surface water infiltrations on the upgradient side of the subdrain.

Because the subdrain is approximately 100 feet northeast of the homes experiencing seepage problems, the effectiveness of the proposed subdrain will be reduced by infiltration of precipitation or irrigation water applied between the downgradient side of the subdrain and the homes. Irrigation should be kept to a minimum in this area.

5.2.2 Subdrain Design Data

The proposed subdrain design appears to be suitable. The design includes a perforated 10-inch diameter PVC pipe encased in three-quarter inch minus washed free-draining gravel. The free-draining gravel is to extend 6 inches below and above the pipe and laterally 10 inches from each edge of the pipe. To reduce the possibility of plugging, the gravel will be wrapped in a filter fabric. To reduce the possibility of damage during construction, we recommend that Mirafi 180N, Amoco 4551, Phillips Supac 10 NP, or equivalent be utilized. The consequences of puncturing the filter fabric was discussed earlier.

Above the gravel and extending to final grade, the backfill may consist of the excavated silty sand soil. We recommend that the cleaner more permeable excavated soils be placed in the lower portion of the backfill sequence. The slope and diameter of the subdrain pipe should be sufficient to discharge 700 to 1,000 gallons per minute.

5.3 Earthwork

5.3.1 Excavation

Excavation depths for the subdrain are anticipated to be on the order of 11 to 13 feet below the bottom of the canal. Excavation below the groundwater table must be anticipated. Excavation sideslopes below the groundwater table will be extremely unstable. Proper shoring and/or bracing of the excavation side walls must be provided in the working area. In addition, the excavation must be dewatered during installation of the subdrain. A sump and pump system in the bottom of the excavation should be considered. Relatively large volume pumps will be required. If the sump and pump system is only marginally effective, well points on other systems in conjunction with the sump and pump system should be considered.

The excavation sideslopes and bracing system should be inspected periodically by qualified personnel. If any signs of instability are noted, immediate remedial action must be initiated.

5.4 Fill Material

Backfill placed over the filter fabric wrapped gravel subdrain system, may consist of the on-site sand and silty sand soils. Care should be taken as to not allowing pieces of trash, coarse gravel, cobbles, or pieces of broken-up concrete to be placed in the backfill particularly near the filter fabric where the filter fabric may be punctured. We recommend that during the excavation operations, the cleaner near-surface sands be isolated so that it can be utilized first as backfill in the zone five feet directly above the filter fabric wrapped subdrain component. The cleaner sand soils are more permeable and will render the subdrain more efficient than if the silty sand or sandy silt soils were to be used in the same zone. Above the previous referenced zone, the on-site silty sand and sandy silt soils may be utilized up to finished subgrade elevation.

We anticipate that the bottom of the excavation will be unstable and in order to stabilize the bottom of the excavation prior to placement of the subdrain, an initial lift of coarse gravel and cobbles may be utilized. The coarse gravels and cobbles should be compacted by passing the hand operated, flat plate vibratory compactor over the surface continuously at least twice. As an alternative method, the coarse gravels and cobbles may be compacted by dropping a backhoe bucket uniformly over the surface at least twice. A minimum of six inches of on-site sand, or bankrun sand backfill should be placed above the coarse gravel and cobbles, again to reduce the possibility of puncturing the filter fabric.

Backfill other than the stabilizing coarse gravels and cobbles should be placed in lifts not exceeding eight inches in loose thickness, and compacted to a minimum of 90 percent of the maximum dry density as determined by the AASHTO T-180* (ASTM D-1557**) method of compaction.

oOo

We appreciate the opportunity of providing this service for you. If you have any questions regarding this report, or require additional information, please contact the undersigned.

Respectfully submitted,
Sergent, Hauskins & Beckwith Engineers

By Jon E. Bischoff
Jon E. Bischoff
Professional Engineer No. 8155
State of Utah

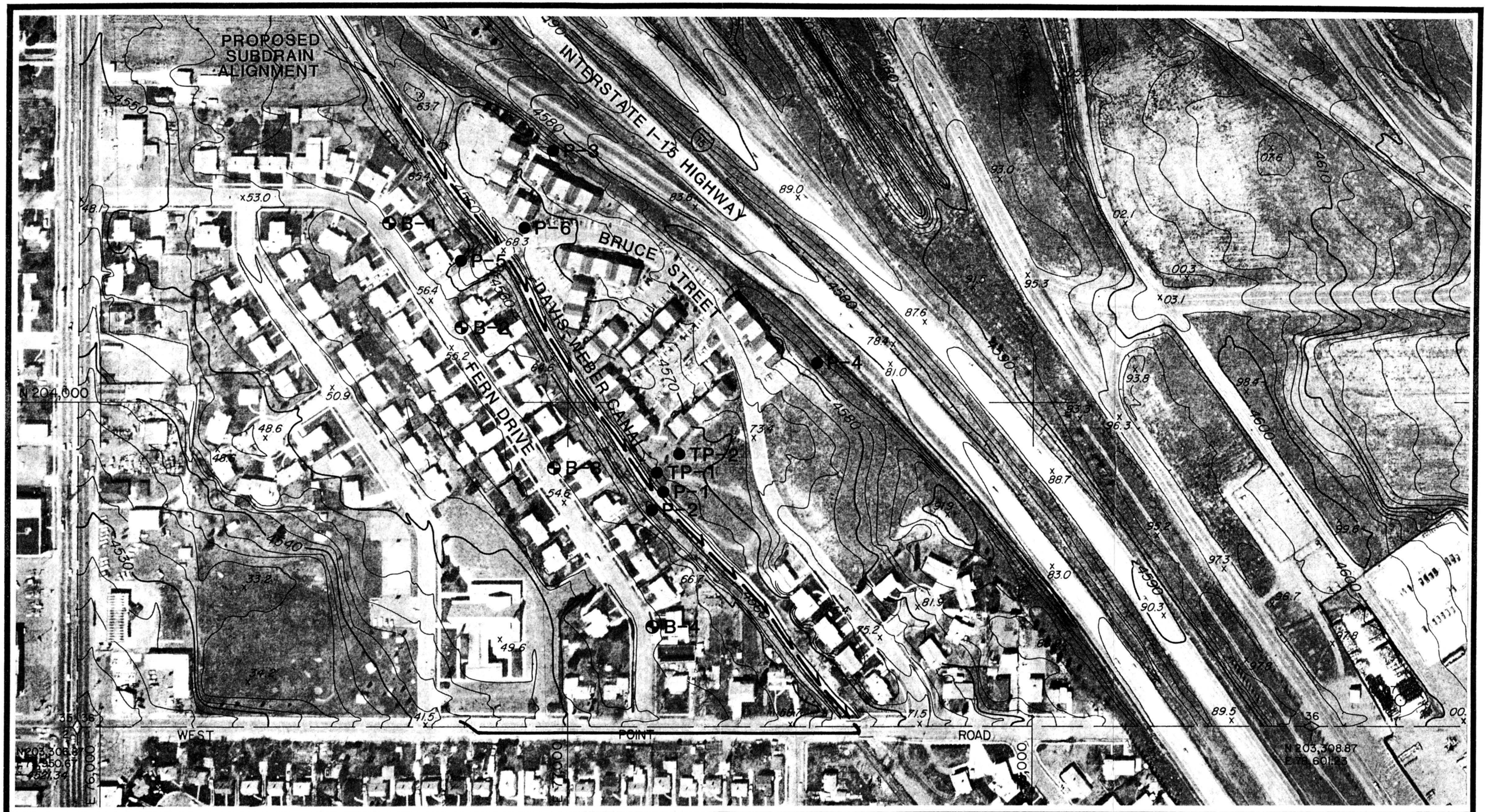
Reviewed by
William J. Gordon
Professional Engineer No. 3457
State of Utah

Copies: Addressee (3)

Attachments: Figure 1 - Site Map
Figures 2A through 2D - Log of Borings
Figure 3 - Unified Soil Classification System

* American Association of State Highway and Transportation Officials
** American Society for Testing and Materials

FILE NO. ______ BY ______ DATE ______ CHECKED BY ______ DATE ______



KEY

⊕ LOCATION OF BORINGS DRILLED IN CONJUNCTION WITH THIS STUDY, WITH PIEZOMETER

● LOCATION OF BORINGS AND TEST PITS EXCAVATED IN CONJUCTION WITH STUDIES BY OTHERS DATED 8-16-88, 9-6-88, 12-1-88

N

SCALE 1"=200'

0 200 FEET

CONTOUR INTERVAL: 2'

REFERENCE: DAVIS COUNTY AIR PHOTO BASE MAP, PHOTOGRAPHY DATE, APRIL 1982

SITE MAP

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N26013

FIGURE 1

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Clearfield, Utah

LOG OF TEST BORING NO. B-1

JOB NO. E89-2009 DATE 01-20-89

RIG TYPE CME-55
BORING TYPE 3 3/4" I.D. Hollow Stem Auger
SURFACE ELEV. 4558.0' +/-
DATUM *

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SM	medium dense	**SILTY SAND**, fine grained sand, nonplastic, brown note: grades with occasional 3" to 8" fine sand with some silt layers
			▨	S	22					
5			▨	S	14					
▽										
10			▨	S	16		29.0	SM-ML	medium dense	**SILTY SAND-SANDY SILT**, interlayered, fine grained, nonplastic, brown
15			▨	S	21					
20			▨	S	17		26.0			
25			▨	S	13					note: grades with occasional 1" clayey silt layers
30										Stopped auger at 25' Stopped sampler at 26.5' note: 1 1/4" diameter slotted PVC pipe installed to 25' *Ground surface elevation interpolated from the topographic data presented on Figure 1.
35										
40										
45										
50										

GROUNDWATER

	DEPTH	HOUR	DATE
▽	9.4		1-20-89
▼			

SAMPLE TYPE
A - Auger cuttings.
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" O.D. thin-walled Shelby tube.

Figure 2A

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PROJECT Davis - Weber Canal Company
Clearfield, Utah
JOB NO. E89-2009 DATE 01-20-89

LOG OF TEST BORING NO. B-2

RIG TYPE CME-55
BORING TYPE 3 3/4" I.D. Hollow Stem Auger
SURFACE ELEV. 4557.0' +/-
DATUM *

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		▨						SM	loose	**SILTY SAND**, fine grained with major roots (topsoil) to 3", nonplastic, dark brown
5		▨	▨	S	5					note: grades to brown in color note: grades with occasional 1/4" to 3" layers of silt
∇		▨								
10		▨	▨	S	15		28.0		medium dense	
15		▨	▨	S	18		28.0			
20		▨	▨	S	14					note: grades with occasional layers of fine sandy silt
25										Stopped auger at 20' Stopped sampler at 21.5' note: 1 1/4" diameter slotted PVC pipe installed to 20' *Ground surface elevation interpolated from the topographic data presented on Figure 1.
30										
35										
40										
45										
50										

GROUNDWATER

	DEPTH	HOUR	DATE
∇	8.0		1-24-89
▼			

SAMPLE TYPE

A - Auger cuttings.
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" O.D. thin-walled Shelby tube.

Figure 2B

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JOB NO. E89-2009 DATE 01-20-89

LOG OF TEST BORING NO. B-3

RIG TYPE CME-55
BORING TYPE 3 3/4" I.D. Hollow Stem Auger
SURFACE ELEV. 4556.0' +/-
DATUM *

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		▥						SM	loose	**SILTY SAND**, fine grained sand with major roots (topsoil) to 3", nonplastic, dark brown
		▥						SM-ML		
5		▥	▨	S	5				loose	**SILTY SAND-SANDY SILT**, fine grained sand, nonplastic, brown
▽										
		░						SP-SM	medium dense	**SAND**, with some silty fine sand, nonplastic, brown
10		░	▨	S	21					
		▥						SM	medium dense	**SILTY SAND**, fine grained, nonplastic, brown
15		▥	▨	S	18					
20		▥	▨	S	22			SM-ML	medium dense	**SILTY SAND-SANDY SILT**, fine grained sand, nonplastic, brown
25		▥	▨	S	18					
30										Stopped auger at 25' Stopped sampler at 26.5' note: 1 1/4" diameter slotted PVC pipe installed to 25.5' *Ground surface elevation interpolated from the topographic data presented on Figure 1.
35										
40										
45										
50										

GROUNDWATER

	DEPTH	HOUR	DATE
▽	7.6		1-24-89
▼			

SAMPLE TYPE
A - Auger cuttings.
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" O.D. thin-walled Shelby tube.

Figure 2C

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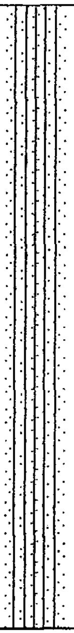
Clearfield, Utah
JOB NO. E89-2009 DATE 01-20-89

LOG OF TEST BORING NO. B-4

RIG TYPE CME-55
BORING TYPE 3 3/4" I.D. Hollow Stem Auger
SURFACE ELEV. 4555.3' +/-
DATUM *

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SM	medium dense	**SILTY SAND**, fine grained sand with major roots (topsoil) to 3", nonplastic, dark brown
5			▨	S	10		12.0			note: grades brown in color
▽ 10			▨	S	9		27.0			
15			▨	S	13					
20			▨	S	16		29.0			note: grades with occasional 5" layers of silt and fine sandy silt
25										Stopped auger at 20' Stopped sampler at 21.5' note: 1 1/4" diameter slotted PVC pipe installed to 20' *Ground surface elevation interpolated from the topographic data presented on Figure 1.
30										
35										
40										
45										
50										

GROUNDWATER

	DEPTH	HOUR	DATE
▽	10.0		1-24-89
▼			

SAMPLE TYPE

A - Auger cuttings.
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" O.D. thin-walled Shelby tube.

Figure 2D

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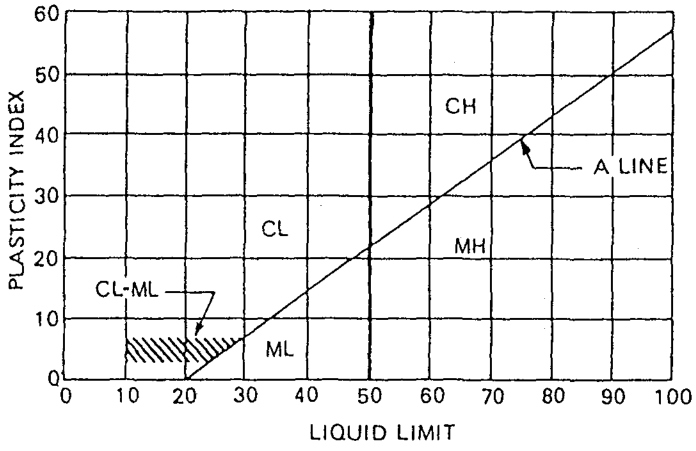
UNIFIED SOIL CLASSIFICATION SYSTEM

Soils are visually classified by the Unified Soil Classification system on the boring logs presented in this report. Grain-size analysis and Atterberg Limits Tests are often performed on selected samples to aid in classification. The classification system is briefly outlined on this chart. For a more detailed description of the system, see "The Unified Soil Classification System" Corp of Engineers, US Army Technical Memorandum No. 3-357 (Revised April 1960) or ASTM Designation: D2487-66T.

MAJOR DIVISIONS				GRAPHIC SYMBOL	GROUP SYMBOL	TYPICAL NAMES
COARSE-GRAINED SOILS (Less than 50% passes No. 200 sieve)	GRAVELS (50% or less of coarse fraction passes No. 4 sieve)	CLEAN GRAVELS (Less than 5% passes No. 200 sieve)		▨	GW	Well graded gravels, gravel-sand mixtures, or sand-gravel-cobble mixtures.
				▨	GP	Poorly graded gravels, gravel-sand mixtures, or sand-gravel-cobble mixtures.
		GRAVELS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart	▨	GM	Silty gravels, gravel-sand-silt mixtures.
			Limits plot above "A" line & hatched zone on plasticity chart	▨	GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS (More than 50% of coarse fraction passes No. 4 sieve)	CLEAN SANDS (Less than 5% passes No. 200 seive)		▨	SW	Well graded sands, gravelly sands.
				▨	SP	Poorly graded sands, gravelly sands.
		SANDS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart	▨	SM	Silty sands, sand-silt mixtures.
			Limits plot above "A" line & hatched zone on plasticity chart	▨	SC	Clayey sands, sand-clay mixtures.
FINE-GRAINED SOILS (50% or more passes No. 200 sieve)	SILTS	LIMITS PLOT BELOW "A" LINE & HATCHED ZONE ON PLASTICITY CHART	SILTS OF LOW PLASTICITY (Liquid Limit Less Than 50)	▨	ML	Inorganic silts, clayey silts with slight plasticity.
			SILTS OF HIGH PLASTICITY (Liquid Limit More Than 50)	▨	MH	Inorganic silts, micaceous or diatomaceous silty soils, elastic silts.
	CLAYS	LIMITS PLOT ABOVE "A" LINE & HATCHED ZONE ON PLASTICITY CHART	CLAYS OF LOW PLASTICITY (Liquid Limit Less Than 50)	▨	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
			CLAYS OF HIGH PLASTICITY (Liquid Limit More Than 50)	▨	CH	Inorganic clays of high plasticity, fat clays, sandy clays of high plasticity.

NOTE: Coarse grained soils with between 5% & 12% passing the No. 200 sieve and fine grained soils with limits plotting in the hatched zone on the plasticity chart to have double symbol.

PLASTICITY CHART



DEFINITIONS OF SOIL FRACTIONS

SOIL COMPONENT	PARTICLE SIZE RANGE
Cobbles	Above 3 in.
Gravel	3 in. to No. 4 sieve
Coarse gravel	3 in. to ¾ in.
Fine gravel	¾ in. to No. 4 sieve
Sand	No. 4 to No. 200
Coarse	No. 4 to No. 10
Medium	No. 10 to No. 40
Fine	No. 40 to No. 200
Fines (silt or clay)	Below No. 200 sieve

Figure 3