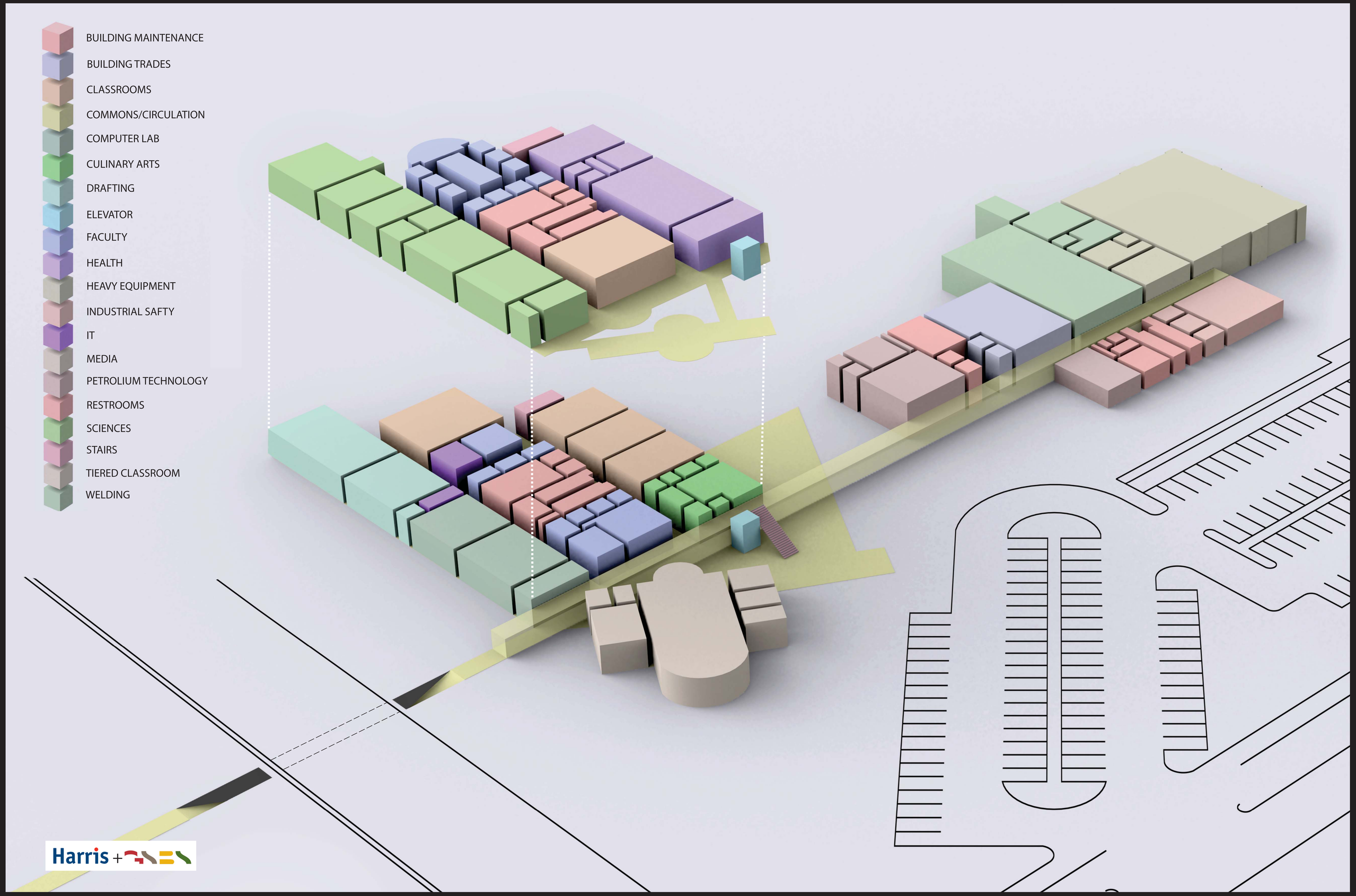
UINTAH BASIN MASTER PLAN

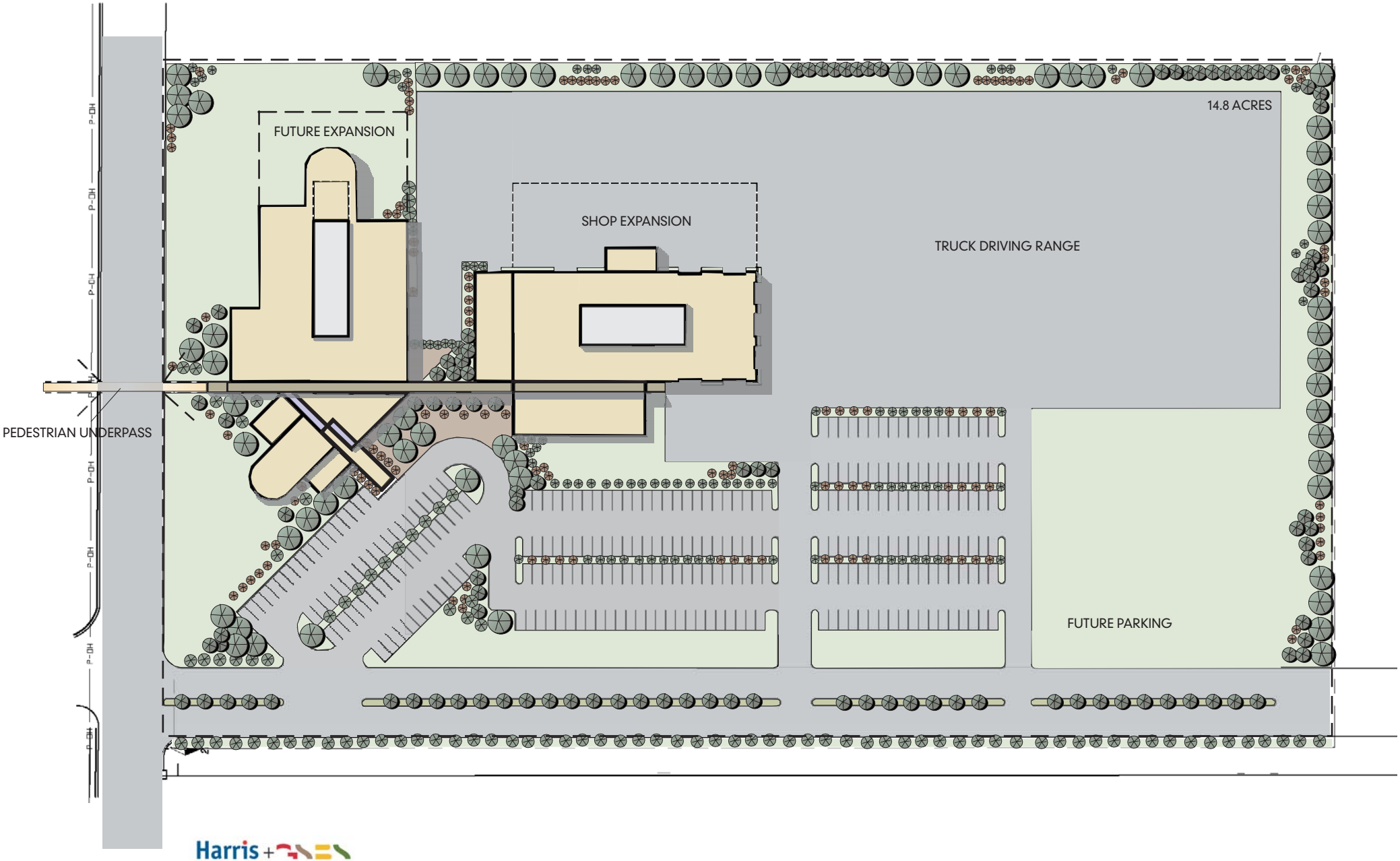
VERNAL CAMPUS

UtahState UNIVERSITY

Harris SM
Architects • Engineers • Program and Construction Managers

10.18.06


BUILDING MAINTENANCE
BUILDING TRADES
CLASSROOMS
COMMONS/CIRCULATION
COMPUTER LAB
CULINARY ARTS
DRAFTING
ELEVATOR
FACULTY
HEALTH
HEAVY EQUIPMENT
INDUSTRIAL SAFTY
IT
MEDIA
PETROLIUM TECHNOLOGY
RESTROOMS
SCIENCES
STAIRS
TIERED CLASSROOM
WELDING
Harris +



Harris +

PRELIMINARY SITE PLAN

NEW CLASSROOM BUILDING AND
INDUSTRIAL TECHNOLOGY FACILITY

DFCM NO. 05174250 DECEMBER 20th, 2006 Not to Scale

- BUILDING MAINTENANCE
- BUILDING TRADES
- CLASSROOMS
- COMMONS and STUDY AREA
- COMPUTER LABS
- CULINARY ARTS
- DRAFTING
- ELEVATOR
- FACULTY and ADMINISTRATION
- HEALTH SCIENCES
- STAIRWELL
- HEAVY EQUIPMENT
- INDUSTRIAL SAFETY
- IT
- MEDIA CENTER
- PETROLEUM TECHNOLOGY
- RESTROOMS
- SCIENCES
- STAIRS
- TIERED CLASSROOM
- WELDING

SECOND FLOOR
SCALE = 1/16′ = 1′

FIRST FLOOR
SCALE = 1/16′ = 1′

DIESEL SHOP
SCALE = 1/16′ = 1′

CLASSROOM COMPONET ~ SCHEMATIC DESIGN

NEW CLASSROOM BUILDING AND INDUSTRIAL TECHNOLOGY FACILITY

DFCM NO. 05174250

Harris +

Geotechnical Engineering Study

Uintah Basin Applied Technology School
Proposed Classroom, Shop, and Library Buildings
Vernal, Utah 84078

Prepared for:

Division of Facilities and Construction Management
Salt Lake City, UT

Harris & Associates

December 20, 2006

DFCM
Attn: Lyle Knudsen
4110 State Office Building
Salt Lake City, UT 84114

RE: Geotechnical Engineering Study
Uintah Basin Applied Technology Center
Classroom, Shop, and Administration Buildings
Vernal, Utah 84078

Dear Mr. Knudsen:

This report presents our geotechnical findings for the proposed buildings at approximately 1855 West 500 North in Vernal, Utah. The location of the site and proposed building location is shown on Figures 1 and 2, respectively. The objectives of this study were to define subsurface soil and groundwater conditions and then prepare recommendations regarding site grading and foundations. A summary of our findings include:

- The site soils will not adequately support conventional spread footings. Highly compressible soft clay soils were encountered from 3.5 to 10 feet below the surface.
- Options include using soil improvement technology, deep foundations, or over-excavating compressible soils (10 to 13-feet) and replacing with structural fill. We recommend conventional spread footings placed over a rammed aggregate rock pier system (Geopier).
- At the Uintah High School, north of site, all soft soils were over-excavated and replaced with granular fill.
- Native soil consisted of the following typical sequence: 8 to 12-inches of organic silty clay (topsoil), then a medium stiff clay to 4-feet, below which is a highly compressible sandy clay to 8.5-feet below the surface. Beneath the sandy clay is a two feet layer of medium stiff clay then a gravelly cobble layer to full depth explored (14.5-feet).
- Additional investigations are needed for future buildings and to address ground and surface water concerns.

If you have questions regarding this report or desire additional information, please contact me at (801) 521-8564.

Sincerely,

REGISTERED PROFESSIONAL ENGINEER
No. 343891
TODD LANGE
TOUCHARD
LICENSED
STATE OF UTAH

Todd Touchard, P.E.
HARRIS & ASSOCIATES

265 East 100 South, Suite 350 Salt Lake City, Utah 84111 (801) 521-8564 FAX: (801) 355-2938
www. harris-assoc.com

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1.0 INTRODUCTION

This report presents our findings for the proposed campus building located at approximately 1855 West 500 North in Vernal, Utah. The location of the site and proposed building locations are shown on **Figure 1 and 2**, respectively. The objectives of this study were to define subsurface soil and groundwater conditions then give recommendations regarding site grading, foundation, and pavements.

To accomplish the objectives, a field investigation program and laboratory analysis of soil was conducted. The field investigation included ten boreholes using a hollow stem auger drill rig. Borehole locations are presented in **Figure 2**. The borehole logs are shown in **Figure 3A-3J**. A legend to log symbols and additional soil information is provided in **Figure 4**. Individual laboratory tests (**Figure 5A to 5D**) and lab summary (**Figure 6A to 6B**) are attached.

If the proposed structure, location of structures, or proposed use of pavements changes, our office shall be notified to review and potentially change recommendations contained in this report.

2.0 PROPOSED CONSTRUCTION

Three buildings consisting of standard masonry, concrete, and steel construction. Buildings will be two story with anticipated loads of 2.0 to 5.0 kips/lf and moderate column loads on the order of 150 to 200 kips.

3.0 FIELD AND LABORATORY INVESTIGATION

3.1 Field Investigation

To define the subsurface soil and groundwater conditions, we conducted ten boreholes (BH-1 through BH-10) shown on **Figure 2**, in the Appendix. Boreholes were completed to required depth or auger refusal. Groundwater was encountered in all excavations.

The boreholes were located within the areas of the proposed building lots to best illustrate the general subsurface conditions. Soil samples were obtained from the boreholes at a minimum depth of two feet below grade and then at the five foot intervals or at significant change in soil strata. Soils were classified in the field and later verified with laboratory testing. The sampling was done in general accordance with ASTM D-420. The subsurface conditions disclosed by the field investigation are discussed in Section 4.0.

The descriptions of soil encountered in the excavations are presented in **Figures 3A to 3J** in the Appendix. Sampling information and other pertinent field data and observations are also included on the Borehole Logs. A Soil Classification Chart defining the terms and symbols used on the logs, is provided as **Figure 4** in the Appendix.

3.2 Laboratory Investigation

For soil classification and engineering properties, the samples obtained from exploratory borings were laboratory tested. The tests include:

- Moisture Content
- Soil Density
- Partial Sieve Analysis
- Torvane Shear Test
- Atterberg Limits
- Consolidation Tests

Laboratory test data is shown on the individual Logs and is attached.

4.0 SITE CONDITIONS

The site slopes moderately downward to the south and east. The site is being used for agricultural purposes and is planted in alfalfa.

4.1 Surficial Soils

The surficial soil consists of a dark brown silty clay with organics (Topsoil). These clays will exhibit very poor engineering properties. The depth of topsoil ranges from 8 to 12-inches thick.

4.2 Subsoils

The subsoils soils at the site were found to be relatively consistent across the site. Beneath the surface topsoil, a medium stiff silty clay layer extends from 3 to 5 feet. Beneath which is a highly compressible sandy clay layer that ranges to depths of 8 to 10 feet below the surface. Below the sandy clay, a medium stiff clay layer (1 to 2 feet thick) typically occurs then a gravel cobble layer was observed to full depth explored (14.5-feet). Water well logs in the area show that the cobble layer extends to at least 25 feet below the surface.

4.3 Groundwater

Groundwater was encountered in all of the boreholes. Groundwater elevations at the time of the field exploration are shown on borehole logs and **Table 1** below. The groundwater elevation is controlled by field drains installed by the Bureau of Reclamation.

Subsurface drains were constructed with open ended concrete pipes or perforated plastic tubing two to three feet below the surface. Drains were installed to lower groundwater to allow farming and daylights in the Steinaker Canal at the southeast corner of the property. The determination of the suitability and existing condition of these drains are beyond the scope of this investigation. At a minimum, these drains need to be inspected and maintained in order to prevent high groundwater related problems form occurring. We recommend a groundwater drainage system evaluation study.

Approximately midway along the west boundary of the entire property, surface water flows across the property to the southeast. A shallow groundwater gravel aquifer daylights in this area. The surface water typically only flows during the spring. A drainage system will need to be designed to remediate this problem.

Seasonal fluctuation of groundwater levels is anticipated to occur in this area. Depending on site grading and time of construction, groundwater and soft soils may be encountered at footing and pavement subgrades. It is beyond the scope of this report to monitor and determine depth of potential highest groundwater levels. Subgrade Stabilization is discussed in **Section 5.8**.

Table 1. Groundwater Elevation (depth below surface)

Borehole	BH-1	BH-2	BH-3	BH-4	BH-5	BH-6
Groundwater Elevation	**6’2”**	**6’3”**	**4’11”**	**4’7”**	**7’0”**	**4’**

5.0 DESIGN RECOMMENDATIONS

The following recommendations have been developed on the basis of the previously described project characteristics and subsurface conditions. A technical design review should be made by this office if actual loads are greater than anticipated or if there is any change in project criteria, including building location on the site.

5.1 Foundations

A conventional shallow spread foundation system can not be used without soil improvement. The in-situ compressible sandy clay layer is estimated to settle on the order of 4-inches under typical foundation loads. This sandy clay layer exists 3 to 5 feet beneath the surface and extends to depths of 8.5 to 13.5 feet below the surface.

Options include removing the clay layer to underlying gravelly cobble and replacing with structural fill, conducting a soil improvement technology, or installing a deep foundation system.

We researched different systems and recommend placing rammed aggregate piers beneath conventional spread footings.

Intermediate Foundation Recommendations

Rammed aggregate piers, or *Geopier* elements, may be used as an alternative to massive over-excavation and recompaction or deep foundations. Geopier-reinforced soils improve the subgrade below conventional spread footings and reduce the compressibility of the underlying soil.

Geopier soil reinforcement elements are constructed by drilling a 24 or 30-inch diameter hole, removing a volume of soil, and then building a bottom bulb of clean, open-graded stone using a beveled, high-energy tamper. The Geopier shaft is constructed on top of the bottom bulb using well-graded highway base course stone placed in thin lifts (12 inches compacted thickness). Geopier shaft lengths typically range between 8 and 20 feet as measured from footing subgrade. The result of construction is a reinforced zone of soil directly under footings that allows for the construction of shallow spread footings proportioned for a relatively high bearing pressure.

Geopier elements are spaced singly or in close groups beneath interior footings to support concentrated column loads. Beneath continuous footings, Geopier elements typically are spaced at 6 to 12 feet on center depending on loads, soil conditions, and other design requirements.

Geopier Foundation Company was contacted to provide preliminary recommendations for the design of foundations at this site. Their preliminary recommendations include a maximum allowable bearing pressure of 5,000 pounds per square foot for spread footings bearing on a Geopier-reinforced subgrade. This pressure is a composite pressure, applicable across the entire area of the footing. The allowable pressure may be increased by 1/3 for consideration of short-term seismic loading. Geopier elements would be 30 inches in diameter and would extend through the upper clay to the underlying gravel to limit total and differential settlement to 1 inch and ½ inch, respectively.

Geopier soil reinforcement should be designed and constructed by an installer licensed by the Geopier Foundation Company, Inc. The installer should provide a Geopier layout and detailed design calculations sealed by a professional engineer licensed in the State of Utah. The design calculations should demonstrate that Geopier soil reinforcement is designed to control long-term settlement to magnitudes within the criteria for this project. The licensed Geopier installer for the State of Utah is Geopier Northwest. They can be contacted at 801-269-8012.

The design parameters should be verified by a full-scale Geopier modulus test (similar to a pile load test) performed in the field. The Geotechnical Consultant should be retained to monitor the modulus test and subsequent installation of production Geopier elements.

5.2 Estimated Settlement

Settlement is based on the contractor following the recommendations provided in this report and by Geopier Foundation Company. The anticipated total settlement of the foundation will be on the order of 1-inch, assuming light to moderate loads. Differential settlement is not expected to exceed 1/2-inch. This is assuming the design recommendations are followed.

5.3 Lateral Resistance and Earth Pressure

For the determination of lateral resistance for footings placed on a rammed aggregate piers, a friction value of 0.35 may be used for ultimate lateral resistance.

The follow equivalent fluid pressures are based on using granular soil backfill (135 pcf). Backfill depth is not expected to exceed 3-feet in depth next to classroom. Compact backfill to 90% of relative maximum density (ASTM D1557) within 3-feet of basement walls.

	Equivalent Fluid Density (pcf)		
	Active	At-Rest	Passive
Static	35	60	300
Seismic	50	70	250

5.4 Site Soil Classification & Coefficient

The site is classified as "E", according to the International Building Code (IBC) 2006 edition. Site coefficients provided by the USGS web page for 2006 IBC are provided in **Table 2** below.

Table 2. Design Acceleration Coefficients

Design acceleration of short periods (0.2 sec)				**Design acceleration for 1 second period**			
S_s	F_a	S_{MS}	S_{DS}	S_1	F_v	S_{M1}	S_{D1}
0.338	2.271	0.750	0.500	0.092	3.5	0.316	0.211

5.5 Liquefaction & Faults

Liquefaction of a soil is defined as the condition when, a saturated, loose, cohesion-less, (fine sand-type) soils have a sudden, large decrease, in their ability to support. This is because of excessive pore water pressure, which develops during a seismic event. Cohesive (clay type) soils and dry soils typically do not liquefy during a seismic event. If the buildings were to be placed on conventional spread footings, the saturated soft sandy clay is expected to have a moderate to low potential for settlement. The rammed aggregate piers will lessen the liquefaction settlement potential.

The site is located approximately 16 to 18 miles southwest of a suspected section of the Diamond Gulch faults, as depicted on the Utah Quaternary Fault and Fold Map (Utah

Geological Survey, 2003). This 20 km fault has a dip direction of NE and SW. The faulted deposits are from the Tertiary age and the slip rate is <0.2 mm/yr.

5.6 Pavement Design

The following pavement designs are recommended:

Roadway Areas (medium to light truck traffic):

- Asphalt: 4-inches
- Base: 6-inches roadbase
- Subbase 12-inches granular fill
- Geogrid BX1100
- Over: Native undisturbed granular soil or properly prepared granular fill

Parking Areas:

- Asphalt: 3-inches
- Base: 6-inches roadbase
- Subbase 12-inches of granular fill
- Over: Native undisturbed granular soil or properly prepared granular fill

A geogrid, such as Tensar BX1100 (or equivalent), shall be placed between granular fill and native undisturbed soil in roadway traffic areas. Geogrid is to be placed as per manufacturer's recommendations.

Compaction should be done in 8-inch loose lifts and tested to 95% relative to laboratory maximum density (ASTM D1557). If the native soils are soft or if groundwater is encountered follow recommendation in **Section 5.8**.

Native soils below the pavement section shall be proof rolled with heavy equipment to tighten any loose soil at the surface and identify soft spots before placing any portion of the pavement section. If soft spots are encountered they shall be addressed as per **Section 6.0** below.

5.7 Concrete Slabs on Grade

It is anticipated that fill will be used to create level building floor elevations. Due to high groundwater and soft soils, is not recommended to place floor slabs lower than existing elevations. The additional loads of bookshelves, maintenance equipment, trucks, and up to six feet of fill will cause the floor slab to settle as much as 1-inch.

We recommend placing all floor slabs over a geopier grid system that will limit settlement below ½-inch. A Geogrid will be required such as Tensar BX1100 to be placed between geopiers and floor slabs. The spacing and depths of rammed aggregate piers can be provided by Geopier Northwest (801-269-8012).

Interior and exterior concrete slabs on grade should be placed over 4" minimum, of ½" to 1" diameter, poorly graded, clean, free-draining gravel. Below the 4" gravel layer shall be properly

compacted granular fill or natural undisturbed native soil. For moisture sensitive floor coverings, a plastic vapor barrier should be installed beneath the concrete slab.

5.8 Subgrade Stabilization

If construction practices or weather conditions during the placement of the fill caused the native fine grain soils to become soft in floor slab or footings areas one of the following should be done:

- Remove areas where soils are disturbed and place an additional 18-inches of granular fill (crushed or pit-run gravel), gradation requirements are shown in **Section 6.4**, then place footings or begin placing subbase for pavements.

- Or place Geotextile grid between the undisturbed native soil and fill material to achieve proper compaction of the fill layers. Follow manufacture's recommendations for lap length and installation. Manufacturer, type, and properties of geotextile grid used shall submitted to geotechnical engineer for approval prior to construction.

If soft spots or disturbed soils are encountered, contact our office to verify the appropriate corrective action to be used.

5.9 Soil Chemistry

Soil was tested for pH and sulfates levels to determine corrosion potential of concrete and buried utilities. The Sulfate and pH levels tested are considered to not be injurious to concrete. Lab tests are shown in **Table 3** below.

Table 3. Soil Chemical Testing

Sample Location	Sulfates (mg/L)	pH
B-2 at 2.5' below surface	2	7.7

6.0 GENERAL CONSTRUCTION PROCEDURES AND RECOMMENDATIONS

The guidelines outlined below address the geotechnically-related construction concerns for this project.

6.1 Foundation Excavations

Prior to placement of the foundations and floor sections, all areas that will support foundation loads or pavements should be inspected to insure that all loose, soft or otherwise undesirable material is removed and that the structures will bear on satisfactory material. All topsoil, fill and other deleterious materials underneath the proposed structure and pavement should be removed.

Harris & Associates or an approved geotechnical engineer must be contacted to inspect each excavation before the placement piers, footings, or foundations.

If unsatisfactory material pockets are encountered in the excavation, the undesirable material should be removed and the elevation re-established by backfilling, which can be done with lean concrete or a properly compacted granular fill.

All foundation excavations should be protected against any detrimental change in condition such as disturbance, rain and freezing. Surface runoff should be directed away from the excavation and not allowed to pond. If possible, all footing concrete should be poured the same day as the excavation is made. If this is not practical, the foundation excavation should be adequately protected and foundation placement should take place as soon as possible.

6.2 Soil Special Inspection, Fill Compaction & Installation

Soil Special Inspections are required for all fill placed greater than 12-inches. A Special Inspector shall provide the following inspections as outlined in the 2006 IBC:

1. Verify materials below footings are adequate to achieve design bearing capacity (periodic).
2. Verify excavations are extended to proper depth and have reached proper material (periodic).
3. Perform classification and testing of controlled fill materials (periodic).
4. Verify use of proper materials, densities, and lift thickness during placement and compaction of controlled fill (continuous).
5. Prior to placement of controlled fill, observe subgrade and verify site has been prepared properly (periodic).
6. Additional Special Inspections will be required to verify rammed aggregate piers are properly installed to correct depth, spacing, and compaction (continuous).

All fill beneath load bearing areas should be compacted to at least 95 percent of the Modified Proctor maximum density (ASTM D 1557). Fill placed in rammed aggregate piers will be verified using a cone penetration test (ASTM D 6951).

Compaction tests by a qualified testing agency should be taken on each lift to insure the required compaction is being achieved. The compaction should be accomplished by placing the fill in 8-inch loose lifts and mechanically compacting each lift to the specified minimum density. Field density tests should be performed on each lift as necessary to insure that compaction is being achieved.

Table 3. Recommend Minimum Frequency of Soil Testing During Construction.

Test Method	Frequency
ASTM D 1557 Modified Moisture Density Relationship (proctor)	Start of project for each type of soil being compacted and when material appears to change in color or particle size distribution.
ASTM D 422 Particle Size Analysis	Before import fill is delivered to project.
ASTM D 2922 Nuclear Density Compaction Testing	Every 100 linear feet of backfill, each lift, or a minimum of 8 tests for project.
ASTM D 2922 Nuclear Density Compaction Testing Roadways.	One test per 800 s.f. of roadway subbase and roadbase placed.
ASTM D 6951 Dynamic Cone Penetration Test	Each rammed aggregate pier to verify compaction of aggregates and depth of piers.

6.3 Granular Fill

Granular soils free of organics, debris, or other deleterious materials are recommended for use as granular fill at this site. Granular fill is defined as a well graded sand and gravel material (pitrun or crushed gravel), with less than 15 percent passing the #200 sieve and no particles greater than 4 inches in maximum dimension. Granular fill should not exhibit plasticity characteristics. Approved soil types as defined using the Unified Soil Classification are considered to be GW, GP, or GM or combinations thereof. See **Figure 4** for soil type definitions. Granular fill to have a minimum CBR value of 60%. Contractor is to provide soil classification and sieve analysis submittal for final approval to Geotechnical Engineer.

6.4 Road base

For the base material directly below pavement, we recommend a granular soil free of organic or other deleterious material. We recommend a sand and fractured gravel material with between 5 and 12 percent passing the #200 sieve and no particles greater than approximately ¾ -inches in maximum dimension. Roadbase should have a minimum CBR value of 80%. Contractor is to provide soil classification and sieve analysis submittal for final approval to Geotechnical Engineer.

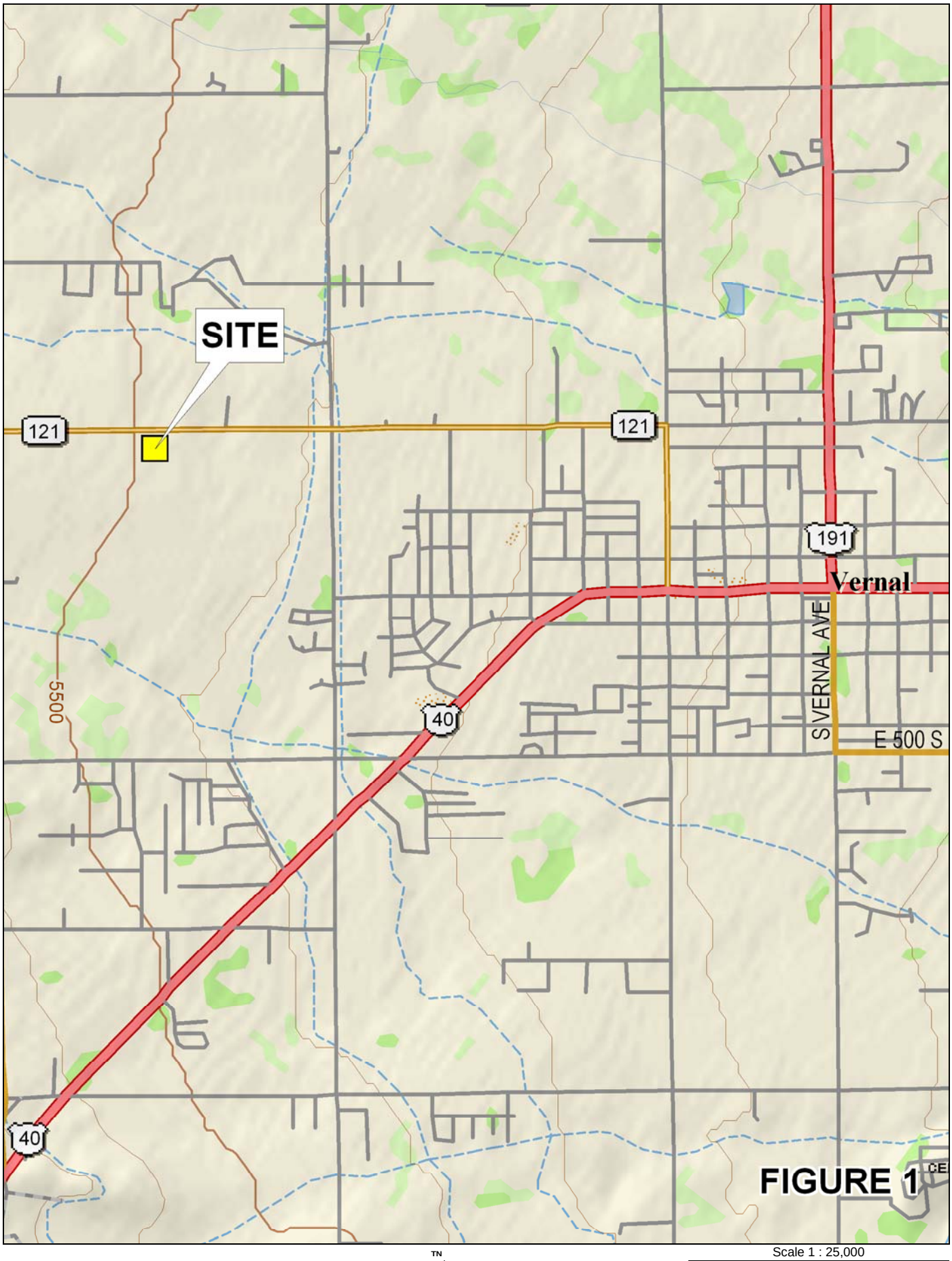
7.0 LIMITATIONS

The recommendations provided herein were developed by evaluating the information obtained from the boreholes. The borehole data reflects the subsurface conditions only at the specific location at the particular time designated on the borehole log. Soil and ground water conditions may differ from conditions encountered at the actual borehole locations. The nature and extent of any variation in the borehole may not become evident until during the course of construction. If variations do appear, it may become necessary to re-evaluate the recommendations of this report after we have observed the variation.

Our professional services have been performed, our findings obtained, and our recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices. This warranty is in lieu of all other warranties, either expressed or implied.

Enclosures: Appendix :

Figure 1 - Project Location Map
Figure 2 - Location Boreholes Site Map
Figure 3A-3B - Logs of Boreholes
Figure 4 - Soil Classification Chart
Laboratory Analysis Data



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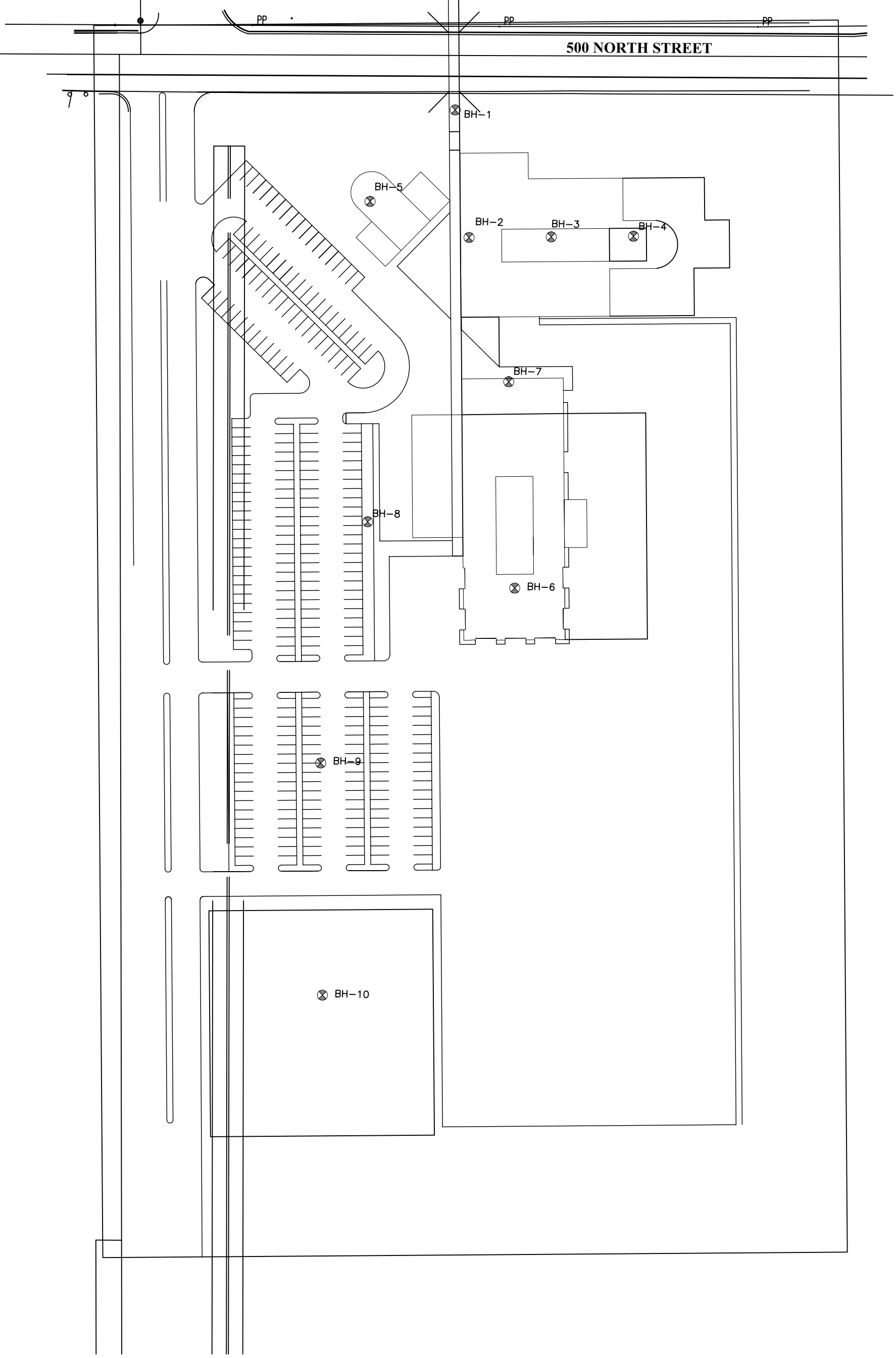

BOREHOLE LOCATIONS

NOT TO SCALE

Harris & Associates

LEGEND:

⊗ – BOREHOLE LOCATIONS

PROJECT:

UBATC–USU VERNAL FACILITY

JOB NO.

SHEET OF

Harris & Associates
265 East 100 South
Salt Lake City, UT 84111

BOREHOLE -1

Project Name: Vernal UBATC
Project No.: 063-3021
Location: 1900 West 500 North, Vernal, Utah
Client: DFCM
Drilling Method: Hollow Stem Auger Drill Rig
Date Drilled: 10/24/2006
Elevation: Existing
Water Level: 6'-2"
Remarks: Slotted PVC installed

Graphical Log	Water Level	DESCRIPTION	DEPTH FT.	SAMPLE TYPE	BLOWS/6-inch	MOISTURE (%)	% PASSING #200	DRY DENSITY (PCF)	Liquid Limit (%)	Plastic Limit (%)	REMARKS
		Ground Surface	0								
		Topsoil 0' to 1' soft, moist, dark-brown/black									
		Silty Clay (CL): 1' to 4.5' medium stiff, moist, brown w/rust color mottling									
				SPT	3,2,2						
		Silty Clay (CL): 8.5' to 10' very soft, fine to medium sand, saturated, light brown	5	SPT	1,1,1	30	91		31	21	
		Grades to: **Sandy Clay (CL)**									
				MC	1,1,4	27	65				
		Silty Clay (CL): 8.5' to 10' medium stiff, saturated, brown									
		Cobbles and Gravel w/Trace Silt and Sand (GP): 10' to 14' very dense, fine to coarse sand, fine to coarse gravel, cobbles to 6", saturated, brown	10								
				SPT	68,50-2"						
			15								Auger Refusal at 14' SPT=Stanard Split Spoon CAL=2"ID California MC=Modified California
			20								

FIGURE 3A

Harris & Associates
265 East 100 South
Salt Lake City, UT 84111

BOREHOLE -2

Project Name: Vernal UBATC
Project No.: 063-3021
Location: 1900 West 500 North, Vernal, Utah
Client: DFCM
Drilling Method: Hollow Stem Auger Drill Rig
Date Drilled: 10/24/2006
Elevation: Existing
Water Level: 6'-3"
Remarks: Slotted PVC installed

Graphical Log	Water Level	DESCRIPTION	DEPTH FT.	SAMPLE TYPE	BLOWS/6-inch	MOISTURE (%)	% PASSING #200	DRY DENSITY (PCF)	Liquid Limit (%)	Plastic Limit (%)	REMARKS
		Ground Surface	0								
		Topsoil 0' to 1' soft, moist, dark-brown/black									
		Silty Clay (CL): 1' to 4' medium stiff, moist, brown w/rust color mottling									
				MC	4,4,6	21		96			
		Silty Clay w/trace Sand (CL): 4' to 8' very soft, fine to medium sand, saturated, light brown									
			5								
		Grades to:		MC	1,1,1	28		92			
		Sandy Clay (CL)									
		Silty Clay w/trace Gravel (CL): 8' to 12' medium stiff,fine gravel, saturated, reddish brown									
				MC	5,7,7						
			10								
		Cobbles and Gravel w/Trace Silt .Sand (GP): 12' to 15' very dense, fine to coarse sand, fine to coarse gravel, cobbles to 6", saturated, brown									
				CAL	18,75						
			15								Auger Refusal at 15' SPT=Standard Split Spoon CAL=2"ID California MC=Modified California
			20								

FIGURE 3B

Harris & Associates
265 East 100 South
Salt Lake City, UT 84111

BOREHOLE -3

Project Name: Vernal UBATC
Project No.: 063-3021
Location: 1900 West 500 North, Vernal, Utah
Client: DFCM
Drilling Method: Hollow Stem Auger Drill Rig
Date Drilled: 10/24/2006
Elevation: Existing
Water Level: 4'-11"
Remarks: Slotted PVC installed

Graphical Log	Water Level	DESCRIPTION	DEPTH FT.	SAMPLE TYPE	BLOWS/6-inch	MOISTURE (%)	% PASSING #200	DRY DENSITY (PCF)	Liquid Limit (%)	Plastic Limit (%)	REMARKS
		Ground Surface	0								
		Topsoil 0' to 1' soft, moist, dark-brown/black									
		Silty Clay (CL): 1' to 5' medium stiff, moist, brown w/rust color mottling									
				MC	2,2,2	25	95				
		Silty Clay w/trace Sand (CL): 5' to 10' very soft, fine to medium sand, saturated, light brown	5	MC	1,1,2	32		87			
		Grades to: **Sandy Clay (CL)**									
				MC	1,1,1						
		Sandy Clay w/some Gravel (SC): 10' to 13' fine to coarse sand, fine to coarse gravel, soft, saturated, light brown	10	CAL	2,3,4	30	42		26	17	
		Cobbles and Gravel w/Trace Silt Sand (GP): 13' to 13.5' very dense, fine to coarse sand, fine to coarse gravel, cobbles to 6", saturated, brown		CAL	2"-50						
			15								Auger Refusal at 13.5' SPT=Standard Split Spoon CAL=2"ID California MC=Modified California
			20								

FIGURE 3C

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BOREHOLE -4

Project Name: Vernal UBATC
Project No.: 063-3021
Location: 1900 West 500 North, Vernal, Utah
Client: DFCM
Drilling Method: Hollow Stem Auger Drill Rig
Date Drilled: 10/24/2006
Elevation: Existing
Water Level: 4'7"
Remarks: Slotted PVC installed

Graphical Log	Water Level	DESCRIPTION	DEPTH FT.	SAMPLE TYPE	BLOWS/6-inch	MOISTURE (%)	% PASSING #200	DRY DENSITY (PCF)	Liquid Limit (%)	Plastic Limit (%)	REMARKS
		Ground Surface	0								
		Topsoil 0' to 1' soft, moist, dark-brown									
		Silty Clay (CL): 1' to 3.5' medium stiff, moist, brown w/rust color mottling		MC	3,3,4	25		94			
		Silty Clay w/trace Sand (CL): 3.5' to 8.5' very soft, fine to medium sand, saturated, light brown									
		Grades to: **Sandy Clay (CL)**	5	MC	1,2,1	31	88		30	15	
		Silty Clay w/trace Gravel (CL): 8.5' to 9.5' medium stiff,fine gravel, saturated, reddish brown		MC	7,10, 50-4"						
		Cobbles and Gravel w/Trace Silt .Sand (GP): 9.5' to 10' very dense, fine to coarse sand, fine to coarse gravel, cobbles to 6", saturated, brown	10								Auger Refusal at 10'
			15								
			20								SPT=Standard Split Spoon CAL=2"ID California MC=Modified California

FIGURE 3D

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BOREHOLE -5

Project Name: Vernal UBATC
Project No.: 063-3021
Location: 1900 West 500 North, Vernal, Utah
Client: DFCM
Drilling Method: Hollow Stem Auger Drill Rig
Date Drilled: 10/24/2006
Elevation: Existing
Water Level: 7'
Remarks: Slotted PVC installed

Graphical Log	Water Level	DESCRIPTION	DEPTH FT.	SAMPLE TYPE	BLOWS/6-inch	MOISTURE (%)	% PASSING #200	DRY DENSITY (PCF)	Liquid Limit (%)	Plastic Limit (%)	REMARKS
		Ground Surface	0								
		Topsoil 0' to 1' soft, moist, dark-brown									
		Silty Clay (CL): 1' to 4.5' medium stiff, moist, brown w/rust color mottling									
				MC	3,3,4	24		96			
		Silty Clay w/some Sand (CL): 4.5' to 8.5' very soft, fine to medium sand, saturated, light brown	5								
				MC	1,1,1						
		Silty Clay(CL): 8.5' to 12' medium stiff, saturated, reddish brown									
			10	MC	4,9,6	24		101			
		Cobbles and Gravel w/Trace Silt .Sand (GP): 12' to 13' very dense, fine to coarse sand, fine to coarse gravel, cobbles to 6", saturated, brown									Auger Refusal at 13'
			15								
											SPT=Standard Split Spoon CAL=2"ID California MC=Modified California
			20								

FIGURE 3E

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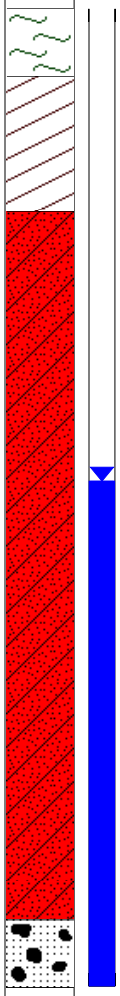
BOREHOLE -6

Project Name: Vernal UBATC
Project No.: 063-3021
Location: 1900 West 500 North, Vernal, Utah
Client: DFCM
Drilling Method: Hollow Stem Auger Drill Rig
Date Drilled: 10/25/2006
Elevation: Existing
Water Level: 4'
Remarks: Slotted PVC installed



Graphical Log	Water Level	DESCRIPTION	DEPTH FT.	SAMPLE TYPE	BLOWS/6-inch	MOISTURE (%)	% PASSING #200	DRY DENSITY (PCF)	Liquid Limit (%)	Plastic Limit (%)	REMARKS
		Ground Surface	0								
		Topsoil 0' to 1' soft, moist, dark-brown									
		Silty Clay (CL): 1' to 3' medium stiff, moist, brown w/rust color mottling									
		Silty Clay w/trace Sand (CL): 3' to 13.5' very soft, fine to medium sand, saturated, light brown		MC	1,2,2	30		89	29	15	
			5	MC	1,1,1	31	89				
		Grades to: **Sandy Clay** with depth									
			10	MC	0,1,1	26	55				
		Cobbles and Gravel w/Trace Silt Sand (GP): 13.5' to 14.5' very dense, fine to coarse sand, fine to coarse gravel, cobbles to 6", saturated, brown	15	CAL	50-4"						Auger Refusal at 14.5'
			20								SPT=Standard Split Spoon CAL=2"ID California MC=Modified California

FIGURE 3F

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BOREHOLE -7

Project Name: Vernal UBATC
Project No.: 063-3021
Location: 1900 West 500 North, Vernal, Utah
Client: DFCM
Drilling Method: Hollow Stem Auger Drill Rig
Date Drilled: 10/25/2006
Elevation: Existing
Water Level: Initial Water Level at 6'
Remarks:

Graphical Log	Water Level	DESCRIPTION	DEPTH FT.	SAMPLE TYPE	BLOWS/6-inch	MOISTURE (%)	% PASSING #200	DRY DENSITY (PCF)	Liquid Limit (%)	Plastic Limit (%)	REMARKS
		Ground Surface	0								
		Topsoil 0' to 1' soft, moist, dark-brown									
		Silty Clay (CL): 1' to 8' medium stiff, saturated, brown									
				MC	3,3,3						
			5								
		color changes to brown with dark grey mottling		MC	5,9,9						
		Silty Clay w/some Sand (CL): 8' to 10' very soft, fine to medium sand, saturated, light brown									
			10	MC	1,2,4						
		Cobbles and Gravel w/Trace Silt Sand (GP): 10.5' to 11' very dense, fine to coarse sand, fine to coarse gravel, cobbles to 6", saturated, brown									Auger Refusal at 11'
			15								SPT=Standard Split Spoon CAL=2"ID California MC=Modified California
			20								

FIGURE 3G

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BOREHOLE -8

Project Name: Vernal UBATC
Project No.: 063-3021
Location: 1900 West 500 North, Vernal, Utah
Client: DFCM
Drilling Method: Hollow Stem Auger Drill Rig
Date Drilled: 10/25/2006
Elevation: Existing
Water Level: Initial Water Level at 4'
Remarks:

Graphical Log	Water Level	DESCRIPTION	DEPTH FT.	SAMPLE TYPE	BLOWS/6-inch	MOISTURE (%)	% PASSING #200	DRY DENSITY (PCF)	Liquid Limit (%)	Plastic Limit (%)	REMARKS
		Ground Surface	0								
		Topsoil 0' to 1' soft, moist, dark-brown									
		Silty Clay (CL): 1' to 4.5' medium stiff, saturated, brown		MC	3,4,3	27		94			
		Silty Clay w/trace Sand (CL): 4.5' to 8.5' very soft, organics and roots, fine to medium sand, saturated, light brown	5	MC	1,1,1	58	89		33	13	
		Silty Clay (CL): 8.5' to 11.5' medium stiff, saturated, brown	10	MC	2,5,3						
											End of Sampling and Drilling at 11.5'
			15								SPT=Standard Split Spoon CAL=2"ID California MC=Modified California
			20								

FIGURE 3H

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BOREHOLE -9

Project Name: Vernal UBATC
Project No.: 063-3021
Location: 1900 West 500 North, Vernal, Utah
Client: DFCM
Drilling Method: Hollow Stem Auger Drill Rig
Date Drilled: 10/25/2006
Elevation: Existing
Water Level:
Remarks: Parking lot

Graphical Log	Water Level	DESCRIPTION	DEPTH FT.	SAMPLE TYPE	BLOWS/6-inch	MOISTURE (%)	% PASSING #200	DRY DENSITY (PCF)	Liquid Limit (%)	Plastic Limit (%)	REMARKS
		Ground Surface	0								
		Topsoil 0' to 1' soft, moist, dark-brown									
		Silty Clay (CL): 1' to 4.5' medium stiff, moist, brown		SPT	4,4,5,7	22					
				SPT	2,3,5	22					
			5								End Sampling and Drilling at 4.5'
			10								
			15								
			20								SPT=Standard Split Spoon CAL=2"ID California MC=Modified California

FIGURE 3I

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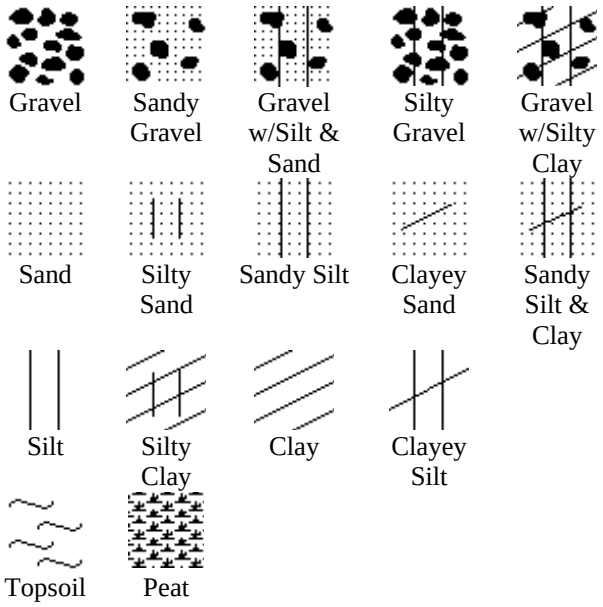
BOREHOLE -10

Project Name: Vernal UBATC
Project No.: 063-3021
Location: 1900 West 500 North, Vernal, Utah
Client: DFCM
Drilling Method: Hollow Stem Auger Drill Rig
Date Drilled: 10/25/2006
Elevation: Existing
Water Level:
Remarks: Parking Lot

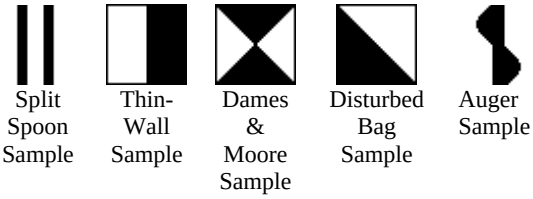
Graphical Log	Water Level	DESCRIPTION	DEPTH FT.	SAMPLE TYPE	BLOWS/6-inch	MOISTURE (%)	% PASSING #200	DRY DENSITY (PCF)	Liquid Limit (%)	Plastic Limit (%)	REMARKS
		Ground Surface	0								
		Topsoil 0' to 1' soft, moist, dark-brown									
		Silty Clay (CL): 1' to 4.5' medium stiff, saturated, brown		SPT	2,1,2,3						
				SPT	3,2,2,1	30					
		Silty Clay w/some Sand (CL): 4.5' to 5' very soft, fine to medium sand, saturated, light brown	5								End Sampling and Drilling at 5'
			10								
			15								
			20								SPT=Standard Split Spoon CAL=2"ID California MC=Modified California

FIGURE 3J

Graphical Log Legend



Sample Symbol Legend



Moisture Content

Description	Field Test
Dry	Absence of moisture, dusty
Moisture	Damp but no visible water
Wet	Saturated, free water, typically below water table

Coarse Grain Soil Modifiers

Description	%
Trace	< 15
Some	15 to 30
Modifier (y)	30 to 40

Fine Grain Soil Modifiers

Description	%
Trace	< 5
Some	5 to 12
Modifier (y)	12 to 40

Stratification

Description	Thickness
Seam	1/16 ”- ½”
Layer	½” to 12”

Description	Thickness
Occasional	One or less per foot of thickness
Frequent	More than one per foot of thickness

Apparent Density- Coarse Grain, Cohesionless

Apparent Density	SPT blows/ft	D&M blows/ft	Field Test
Very Loose	< 4	< 10	Easily penetrate w/1/2” reinforcing rod pushed by hand.
Loose	4 – 10	10 – 26	Difficult to penetrate rod pushed by hand.
Medium Density	10 – 30	26 – 72	Easily penetrate rod 1ft, driven w/5-lb hammer.
Dense	30 – 50	72 – 104	Difficult to penetrate rod 1ft, driven w/5-lb hammer.
Very Dense	> 50	> 104	Only able to penetrate rod couple inches, driven w/5-lb hammer.

Consistency-Fine Grain, Cohesive

Consist-ency	SPT blows/ft	D&M blows/ft	Field Test
Very Soft	< 2	< 2	Easily penetrated several inches by Thumb. Squeezes through fingers.
Soft	2 – 4	2 – 5	Easily penetrated 1 " by thumb. Molded by light finger pressure.
Medium Stiff	4 – 8	5 – 11	Penetrated over 1/2 " by thumb with moderate effort. Molded by strong finger pressure.
Stiff	8 – 15	11 – 22	Indented about 1/2 " by thumb but penetrated only with great effort.
Very Stiff	15 – 30	22 – 60	Readily indented by thumbnail
Hard	> 30	> 60	Indented with difficulty by thumbnail

1. In general, Unified Soil Classification Designations presented on the logs were evaluated by visual methods only. Therefore, actual designations (based on laboratory testing) may differ.

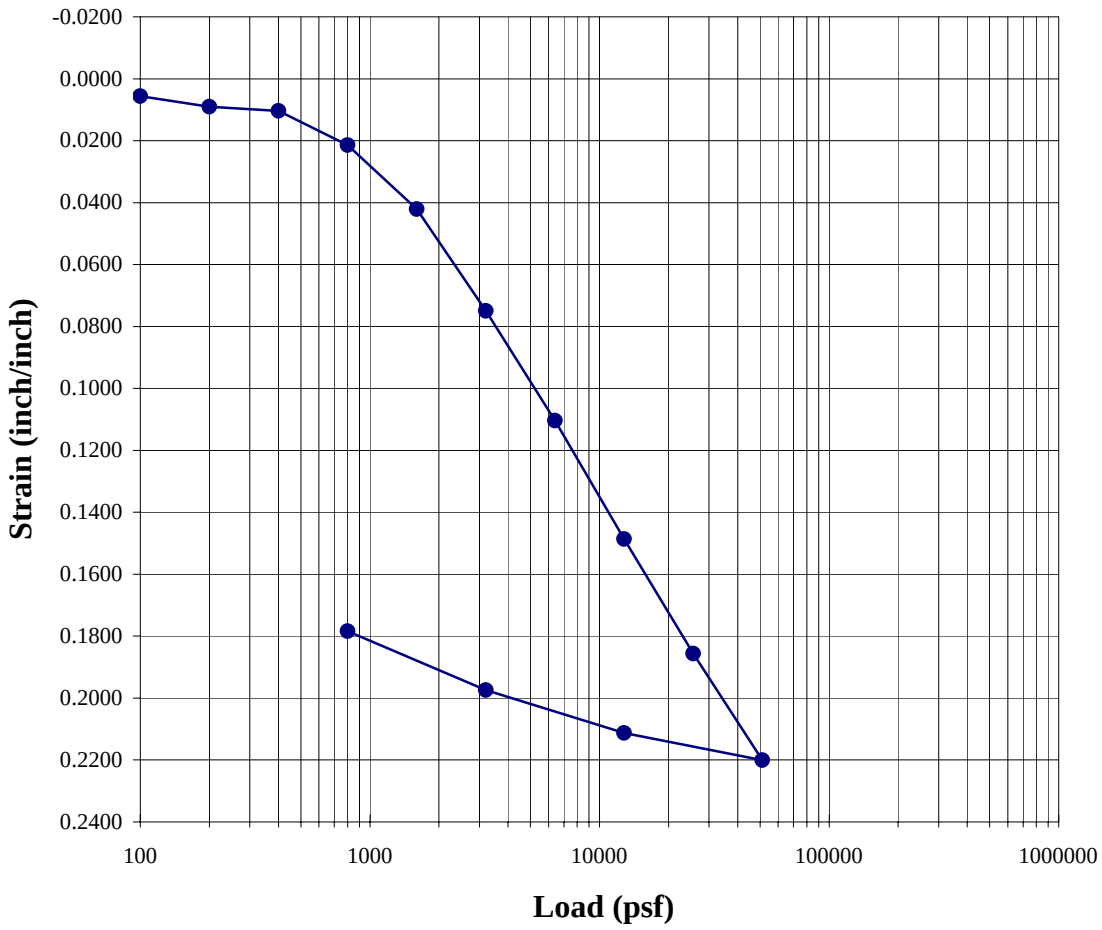
2. Lines separating strata on the logs represent approximate boundaries only Actual transitions may be gradual.

3. Logs represent general soil conditions observed at the point of exploration on the date indicated.

4. No warranty is provided as to the continuity of soil conditions between individual sample locations.

Soil Log Legend Figure 4

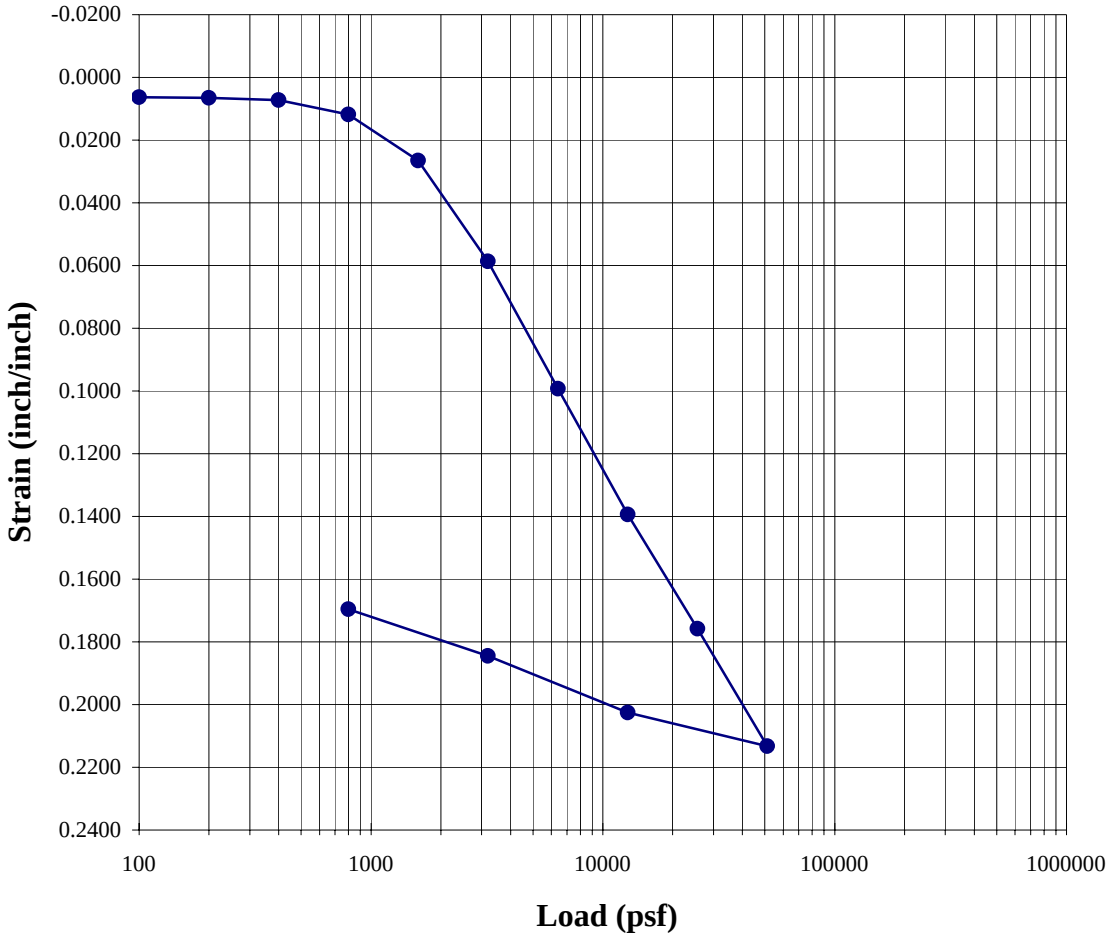
CONSOLIDATION TEST RESULTS BH-4 1.5'



Sample Type: D&M Ring
Sample Diameter, Inches: 2.416
Initial Dry Density: 96 pcf
Initial Moisture Content: 24 %
Condition of Test: Saturated @ 200 psf
Initial Void Ratio(e):

Figure 5A

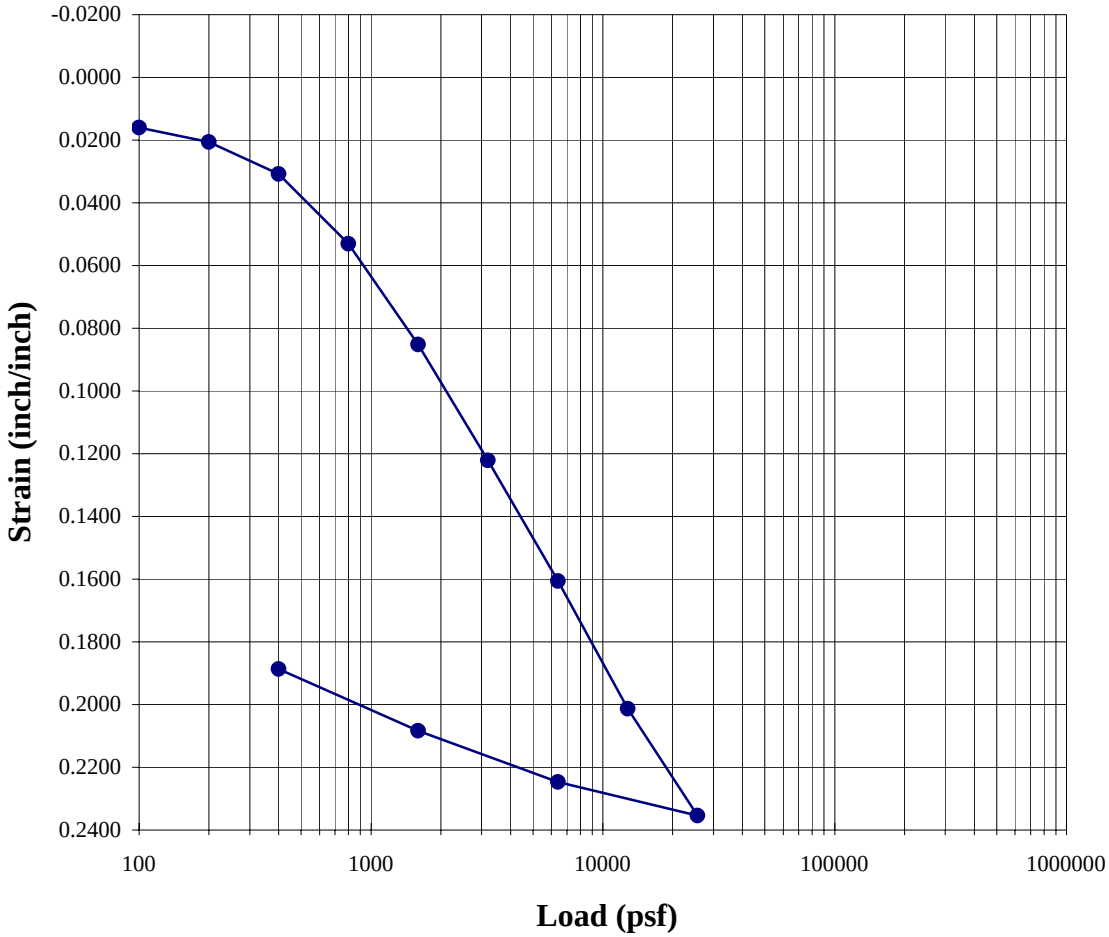
CONSOLIDATION TEST RESULTS BH-5 3.5'



Sample Type: D&M Ring
Sample Diameter, Inches: 2.416
Initial Dry Density: 96 pcf
Initial Moisture Content: 24 %
Condition of Test: Saturated @ 200 psf
Initial Void Ratio(e):

Figure 5B

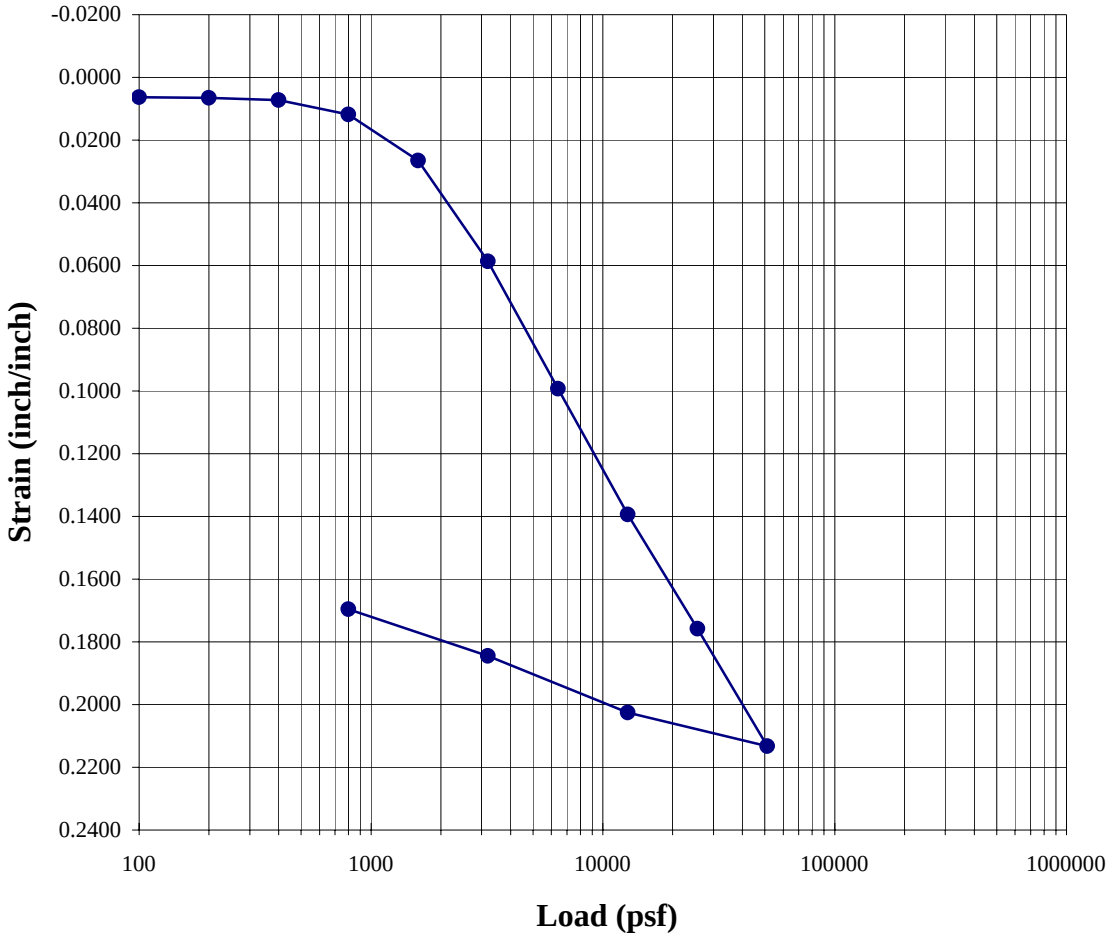
CONSOLIDATION TEST RESULTS BH-6 4'



Sample Type: D&M Ring
Sample Diameter, Inches: 2.416
Initial Dry Density: 89 pcf
Initial Moisture Content: 30 %
Condition of Test: Saturated @ 100 psf
Initial Void Ratio(e):

Figure 5C

CONSOLIDATION TEST RESULTS BH-8 2'



Sample Type: D&M Ring
Sample Diameter, Inches: 2.416
Initial Dry Density: 94 pcf
Initial Moisture Content: 27 %
Condition of Test: Saturated @ 100 psf
Initial Void Ratio(e):

Figure 5D

SUMMARY OF LAB TEST DATA

HOLE NO./ SAMPLE NO.	DEPTH BELOW GROUND SURFACE	STANDARD PENETRATION BLOWS PER FOOT	DRY UNIT WEIGHT LB./FT.3	MOISTURE PERCENT	GRADATION			TORVANE SHEAR TONS/FT.2	ATTERBERG LIMITS			SOIL CLASSIFICATION UNIFIED SYSTEM
					% SAND	% GRAVEL	% PASSING NO. 200 SIEVE		L.L.	P.L.	P.I.	
BH-1	4.5	2		30	9		91		31	21	9	CL
BH-1	6.5	2		27	35		65					SC
BH-2	2.5	10	96	21								CL
BH-2	5	2	93	28								CL
BH-3	4.5	4		25	5		95					CL
BH-3	5	3	87	32								CL
BH-3	10	7		30	58		42					SM
BH-4	1.5	7	94	25								CL
BH-4	4.5	3		31	12		88		30	15	15	CL
BH-5	3	7	96	24								CL
BH-5	9	15	101	24								CL

Figure 6A

SUMMARY OF LAB TEST DATA

HOLE NO./ SAMPLE NO.	DEPTH BELOW GROUND SURFACE	STANDARD PENETRATION BLOWS PER FOOT	DRY UNIT WEIGHT LB./FT.3	MOISTURE PERCENT	GRADATION			TORVANE SHEAR TONS/FT.2	ATTERBERG LIMITS			SOIL CLASSIFICATION UNIFIED SYSTEM
					% SAND	% GRAVEL	% PASSING NO. 200 SIEVE		L.L.	P.L.	P.I.	
BH-6	3.5	4	89	30					29	15	14	CL
BH-6	5	2		31	11		89					CL
BH-6	9.5	2		26	45		55					SC
BH-8	1.5	7	94	27								CL
BH-8	5	2		58	11		89		33	13	20	CL
BH-9	1	12		22								CL
BH-9	3	8		22								CL
BH-10	3	3		30								CL

Figure 6B