GEOTECHNICAL INVESTIGATION REPORT

for

DIXIE STATE COLLEGE - STUDENT HOUSING PROJECT
Dixie State College Campus

St. George, Utah

Landmark Project No. 12361

November 12, 2012

Prepared for:

Dixie State College
225 South 700 East
St. George, Utah 84770

LANDMARK TESTING & ENGINEERING

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Submitted to:

Dixie State College
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1.0 INTRODUCTION

This report presents the results of Landmark Testing & Engineering's geotechnical investigation for the proposed Student Housing Project at the Dixie State College campus. Figure 1 is a Vicinity map showing the anticipated location of the project relative to surrounding features. Figure 2 is a Site Plan showing the proposed project area. Figure 2 also shows the approximate locations of the investigatory borings completed for this investigation.

This investigation was completed to assist in developing opinions and recommendations concerning site earthwork and foundation design.

2.0 PROPOSED CONSTRUCTION

Final designs have not yet been completed, however, we understand that buildings will be three stories in height with possibly precast and brick veneer. Structural loads have not been provided, however, maximum wall loads are anticipated to be on the order of 5 to 7 kips per lineal foot and maximum isolated column loads approaching 250 kips.

The grade of the buildings has not yet been determined. The existing student housing buildings step down to the south and we anticipate similar construction in order to minimize import of structural fill. We anticipate that an elevator pit will be required, however, the extent of any below-grade structures is unknown. In addition to the buildings new parking lots will be required. Any significant changes to the anticipated loads should be reviewed by Landmark to evaluate the continued applicability of the recommendations contained in this report.

3.0 SITE SETTING

3.1 SURFACE CONDITIONS

The site is located between 900 and 1000 East and immediately south of 100 South as shown on Figures 1 and 2. The site is sod covered and sprinkler irrigated with no existing development. Overall, the site slopes downward to the south with an estimated elevation difference of approximately 1.5 feet from NE to SE and

5 feet from NW to SW. Existing student housing borders the east side, 100 South borders the north side, and paved access roads for the college border the west and south sides.

3.2 SEISMICITY AND FAULTING

Seismicity at the site was determined using the United States Geological Survey, Earthquake Hazards Program website. The following values are presented to assist with seismic design:

- Latitude= 37.1059, Longitude= -113.5637
- Site Class = D - Stiff soil profile

Period (sec)	Sa (g)	Site Class
0.2	0.511 S_S	B
1.0	0.163 S_1	B
0.2	0.474 SD_S	D
1.0	0.234 SD_1	D

(2009 International Building Code Seismic Design Provisions from USGS Java Ground Motion Parameter Calculator - Version 5.1.0)

The peak ground acceleration resulting from a large earthquake at the site with a 2% probability of being exceeded in 50 years is 0.21g. The 10% probability of being exceeded in 50 years is 0.091g.

The St. George basin lies within the transitional zone between the Colorado Plateau to the east and the Basin and Range Province to the west. Southwestern Utah is located on a structural block proximate to the southern segment of the Intermountain Seismic belt, which is characterized by high-angle normal faults that tend to step down to the west (Higgins and Willis, 1995)[1]. The Hurricane fault with an offset of 6,000 to 8,000 feet forms the eastern edge of the transition zone. The Grand Wash-Reef Reservoir-Gunlock fault system with displacement of about 1,500 to 3,000 feet forms the western edge.

The projected trace of the St. George fault is located approximately 1,500 feet east of the site. The St. George fault is a north-trending, high-angle, down-to-the west normal fault. Higgins and Willis (1995)

[1]Higgins, J.M. and Willis, G.C., Interim Geologic Map of the St. George Quadrangle, Washington County, Utah, August 1995, Utah; Geological Survey Open File Report 323.

found no evidence of quaternary movement in the St. George Quadrangle. The Washington fault is located approximately 3.4 miles east of the site. Higgins and Willis (1995) indicate that the Washington fault displaces late Quaternary sediments and is considered active. Both the Washington Fault and nearby Hurricane Fault are considered capable of generating earthquakes of magnitude 7.0 to 7.5.[2]

Groundwater at the site ranges from approximately 8.5 to over 16 feet below the existing grade. Groundwater was not encountered in boring B-1. The groundwater, where encountered, is generally perched on relatively impervious siltstone bedrock or clay lenses, however, 3-6 feet of silty sand with relatively low equivalent SPT blowcounts exists below the water table in borings B-2 through B-4.

A liquefaction assessment was completed for these intervals using the Simplified Empirical Procedure developed by Seed et al.(1985)[3]. The silty sand intervals in borings B-3 at 9-15 feet and B-4 at 9-12 feet have a factor of safety less than 1.0 and could possibly liquefy under the evaluated seismic conditions.

Potential seismically-induced settlement of saturated sand in level areas was estimated using the Tokimatsu and Seed (1987[4]) procedure. Assuming a 10 feet thick layer, an $(N1)_{60}$ value of 12 (considering up to 30% fines), and a cyclic stress ratio of 0.18, a volumetric strain of 2.0% would be anticipated. Assuming that the non-liquefiable layers above the liquefiable layer do not account for any bridging effect, potential settlement of approximately 0.75 to 1.5 inches could be realized under the seismic conditions.

3.3 STRATIGRAPHY

Geologically, the site is situated within the St. George valley bordered by the Red Hills to the north, the Middleton Black Ridge to the east, the West Black Ridge to the west, and the Virgin River to the south. Near surface soils are mapped as "older alluvial and eolian deposits". These deposits are moderately to well

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[2] Christensen, Gary E., 1995, *The September 2, 1992 M_L 5.8 St. George Earthquake, Washington County, Utah*; Utah Geological Survey, Circular 88.

[3] Seed, H.B., Tokimatsu, K., Harder, L.F., and Chung, R.F., 1985, Influence of SPT Procedures in Soil Liquefaction Resistance Evaluations: Journal of Geotechnical Engineering Division, ASCE, Vol. 11, No. 12, pp 1425-1445.

[4] Tokimatsu, K. and Seed, H.B., 1987, Evaluation of Settlement in Sands Due to Earthquake Shaking; Journal of Geotechnical Engineering Division, ASCE, Vol. 113, No. 8, August

sorted and vary from clay to sand to minor gravel sized material. The older alluvial deposits have moderately well developed cemented (caliche) zones.

The near-surface soils are underlain by the Moenave Formation. The Moenave Formation consists of siltstone and mudstone with claystone and fine sandstone interbeds.

3.4 SUBSURFACE CONDITIONS

Four (4) borings were completed to characterize subsurface conditions across the site. The approximate locations of the borings are shown on Figure 2. Logs of the borings are presented on Figures 3 through 6. A key to the descriptions on the boring logs is presented on Figure 7. Subsurface conditions are summarized as follows:

Sod/topsoil- Sod and topsoil was encountered in the upper 6 inches of all borings. This material was moist to very moist. The drill rig became stuck due to wet conditions at boring B-4.

Silty sand- Silty sand and silty silt was encountered below the topsoil in all borings. This material was loose to medium dense and extended to 11 to 15 feet.

Lean clay- Lean clay lenses from 2-4 feet thick were encountered in borings B-2 and B-3. The clay had a low plasticity and was stiff.

Siltstone/claystone/mudstone - Bedrock comprised of siltstone, claystone, or mudstone was encountered in all borings at depths ranging from 11 to 18 feet. This material was moderately soft to moderately hard. Groundwater was generally perched on this material.

Groundwater ranged from approximately 8.5 to over 16 feet below the existing grade. Groundwater was not encountered in boring B-1 on the northwest corner of the site. Some fluctuation of groundwater should be expected with the highest elevation in spring and summer when runoff and irrigation occurs.

4.0 LABORATORY TESTING

Laboratory tests included mechanical gradation analyses and Atterberg limits to aid in soil classification, collapse/consolidation tests to assess volume change under wetting, unit weight, and moisture content.

In order to assess the volume change in native soils due to saturation, one-dimensional collapse consolidation tests were performed on silty sand samples. The silty sand had low collapse potentials ranging from 0.2 to 0.7% when saturated under a load of 2,000 psf. Test results are shown on the boring logs and on Figure 8. The collapse consolidation test curves are shown on Figures 9-11.

5.0 FOUNDATION AND CONSTRUCTION CONSIDERATIONS

Structural loads have not been provided, however, for a potential three-story structure maximum wall loads are anticipated to be on the order of 5 to 7 kips per lineal foot and maximum isolated column loads on the order of 250 kips. Due to the relatively close water table, we do not recommend a basement. An elevator pit may require a dewatering system depending on the final depth.

Near surface soils consist of moist to very moist, loose, silty sand. We recommend that finished floor elevations of the buildings be near the existing surface elevations in order to minimize import of fill and to minimize potential settlement in loose sand from loads covering large portions of the site.

To adequately support anticipated loads we recommend that the existing silty sand be overexcavated and a combination of re-used silty sand and imported structural fill be placed below foundations to provide adequate support and to minimize excessive settlement. Overexcavation recommendations include:

Foundation Type	Depth of Imported Granular Fill	Depth of Compacted Native Soils Underlying Granular Fill
Continuous footings up to 7 kips and columns less than 75 kips	2 feet	1 foot
Isolated columns 75-150 kips	4 foot	1 foot
Columns 150-250 kips	4 feet	2 feet

Beneath exterior concrete flatwork, 1.0 foot of over-excavation and recompaction of existing soils is recommended following grubbing of surface materials. Where individual footings are overexcavated and

replaced with imported structural fill, the structural fill should extend at least six inches beyond the foundation for each foot fill depth below the foundation.

5.1 FOUNDATION DESIGN

The proposed structures may be supported on conventional spread or continuous footings established on suitable structural fill and compacted native soils as shown above. Foundation excavations should be visually observed and tested by qualified personnel prior to placement of reinforcing steel or concrete. Additional foundation recommendations are subsequently presented.

DESCRIPTION	VALUE
Foundation Type	Continuous or spread footings on structural fill
Bearing Material	Imported structural fill over compacted native soils as shown in Section 5.0
Allowable Bearing Capacity	2000 psf
Minimum embedment depth below finished grade	1.0 foot
Minimum footing width	12 inches (continuous) for single-story, 18-inches for three stories, 24-inches (isolated spread)
Friction coefficient (granular structural fill)	0.37
Total estimated settlement	1-inch
Total differential settlement	less than 3/4 inch

The allowable bearing capacity is based upon dead load plus long term live load. A one-third increase in allowable bearing capacity may be used for short duration loads, such as wind or seismic loads. Additional settlement should be expected if subgrade soils become saturated.

6.0 SITE GRADING AND EARTHWORK

Final design grades have not been provided. The site slopes downward to the south and soils within the the upper 11 feet consist of loose to medium dense silty sand. We recommend that finished floor elevations of the buildings be near the existing surface elevations in order to minimize import of fill and to minimize potential settlement in loose sand from areal loads. Alternatively, cuts may be utilized on the north side to match the south side elevations or the buildings may be stepped down to the south similar to the existing student housing buildings.

Preparation of the site for construction should include the removal of all vegetation, sod, and organic material. A grubbing depth on the order of 6-inches is anticipated. The grubbed material may be used in landscaped areas, however, due to abundant organics it should not be used in areas subjected to structural loads.

Following over-excavation to allow of placement of import and compaction of native soils below foundations as recommended in Section 5.0 the bottom of the excavation should be scarified to a depth of 8-inches, moisture conditioned to optimum or to within 2% above the optimum moisture content and compacted to 90% of the maximum dry density as determined by ASTM D-1557. Loose or soft areas detected during the scarification and compaction operation should be recompacted or removed and replaced with structural fill. If groundwater is encountered resulting in excessive pumping, scarification and recompaction may be eliminated and cobbly material may be required to stabilize the base of the excavation. Structural fill may then be placed on properly prepared subgrade. Suitable silty sand may be used as fill beneath granular, imported, structural fill.

6.1 FILL PLACEMENT AND COMPACTION

All fill to be placed for support of footings, slabs-on-grade, or exterior concrete flatwork and pavements should be considered structural fill. Foundations for the buildings or interior slabs should not be established directly on the silty sand, however, the silty sand may be used in the lower portions of structural fill provided it is overlain by granular, imported structural fill.

Imported, structural fill should be granular and consist of USCS classifications GC (clayey gravel), GM (silty gravel), or GP (well graded gravel). Granular fill should be well-graded, non-expansive, and free of organics and all deleterious materials. Soils used for granular, imported, structural fill should meet the following specifications:

GRADATION	PERCENT PASSING
6- inch	100
3-inch	80-100
No. 200 sieve	5-20
Liquid Limit	30 or less
Plasticity Index	10 or less
Maximum lift thickness	8-inch (loose)
Minimum compaction	95% ASTM D-1557
Compacted Moisture Content	within 2% of optimum

Material not meeting the above requirements may be suitable for use as structural fill at the discretion of the geotechnical engineer. Samples of structural fill should be submitted for testing prior to transporting to the site. All structural fill should be evenly spread on a horizontal plane in eight-inch loose lifts.

7.0 CUT AND FILL SLOPES

Final design grades have not been provided. We recommend that the site be stepped or the north end cut as much as possible to achieve a level pad rather than significantly raising the south end.

Mudstone and siltstone bedrock were encountered below approximately 11 feet at the site and is not expected to be encountered during construction. It is recommended that permanent cut or fill slopes be maintained at a slope of one vertical to two horizontal (1V:2H) or flatter. Grading of both cut and fill slopes should be such that surface water is directed away from the slopes and not concentrated on slopes or in unprotected channels. Construction procedures should ensure adequate compaction of slope faces.

8.0 FLOOR SLABS

We recommend that interior floor slabs for the building be established on at least 12 inches of imported structural fill overlying 12 inches of suitable native soils that have been compacted to structural fill standards. A minimum four-inch thick layer of free-draining gravel (containing less than 5% fine grained material passing the #200 sieve) should be placed immediately below the floor slabs to help distribute floor loads, break the rise of capillary water, and aid in the concrete curing process. The gravel should be adequately consolidated and placed directly below the floor slab and may count as part of the 12 inches of granular structural fill.

Concrete slabs should be designed using rebar reinforcement and frequent crack control joints to help control normal shrinkage and stress cracking. Concrete placement and curing should meet ACI[5] requirements including following hot or cold weather placement recommendations, when appropriate. If a moisture-sensitive floor covering will be installed, we recommend that a vapor barrier be installed beneath the concrete slab. The moisture sensitivity of floor finishes, anticipated project conditions, and the potential effects of slab curling and cracking should be considered in determining if the barrier should be placed directly beneath the slab or beneath the free-draining gravel (see ACI 302.IR-96 for more information regarding vapor barrier location). If the vapor barrier is installed directly beneath the slab, measures should be taken to minimize excessive slab curl such as reduced joint spacing and use of a low shrinkage (low water-cement ratio) mix.

9.0 LATERAL EARTH PRESSURES

Lateral loads imposed on foundations may be resisted by the development of passive earth pressures against the sides of footings and friction between the base of the footing and the supporting soils. Lateral earth pressure values are presented in the table on the following page.

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[5] American Concrete Institute

Case Evaluated	Soil Type	Value
Active	Granular import/suitable silty sand	37 psf/ft
		56 psf/ft (with seismic)
At-Rest	Suitable on-site	56 psf/ft
		75 psf/ft (with seismic)
Passive	Granular (import)	425 psf/ft
Coefficient of friction	Granular (import) Suitable on-site	0.37 0.33

The lateral earth pressures presented do not include any safety factors. The pressures also assume horizontal backfill behind the walls and the walls are in a drained condition with no build-up of hydrostatic pressure behind the wall. The additional effects of sloping backfill, surcharge, structural loads and groundwater conditions should be included in calculating lateral earth pressures. Backfill should be placed in accordance with the requirements of structural fill except that backfill in landscape and areas that will not be subject to structural loadings may be reduced to 90% of the maximum dry density as determined by ASTM D-1557.

10.0 MOISTURE CONTROL

Laboratory tests indicate that subgrade soils have a low collapse potential when allowed to become wet. The following moisture control measures are recommended:

(1) The ground surface should be graded to drain surface water away from buildings in all directions. A minimum grade of 5% (IBC 1803.3) in the first 10 feet is recommended except in ramp areas subject to ADA restrictions. If physical obstructions prohibit 10 feet of horizontal distance, a 5% slope should be provided to an approved alternate method of diverting water away from the foundation. Impervious surfaces such as concrete walkways or asphalt pavement adjacent to the structure are effective in reducing the potential for water migration beneath foundations and slabs and should be considered in design. Impervious surfaces such as asphalt or concrete within 10 feet of building foundations should be sloped a minimum of 2% away from the building.

(2) Roof runoff should be collected and discharged well outside of the backfill limits. Alternatively, roof runoff may discharge on impervious surfaces sloped away from the foundation. Water should not be allowed to pond on the site or adjacent to footings or structurally placed fill.

(3) Xeriscape (landscaping that eliminates the need for supplemental irrigation of plants) is recommended within 5 feet of the building foundation.

(4) Inadequate compaction of foundation backfill and utility trench backfill provides a conduit for water migration. All utility trenches within the building footprint and extending 5 feet beyond the footprint should be backfilled with structural fill similar to that approved for the foundations. Backfill adjacent to structures should be compacted to at least 90 percent of the maximum dry density as determined by ASTM D-1557 and the minimum slope requirements should be followed. Backfill beneath structures and pavements should be compacted to at least 95% of the maximum dry density.

(5) Grading should be such that surface water is directed away from the site to an adjacent roadway or to the south and downgradient of all structures. Water should not be allowed to pond on-site. Onsite retention is discouraged. If used, ensure that water is retained down gradient of all structures.

(6) Raingutters and downspouts are recommended for the building even if impervious surfaces are installed adjacent to the foundations. Water collected in downspouts should be piped to impervious surfaces that slope away from the building or to adjacent roads.

It should be emphasized that final grading and landscaping generally occur after construction of the structure and observation of these features is outside of normal geotechnical inspection and observation. The developer/owner is responsible to ensure that these surface drainage and moisture control recommendations are followed throughout the life of the structure.

Groundwater was encountered at 8.5 to 9.0 feet below the ground surface over the majority of the site. Depending on the final site configuration groundwater could be encountered in elevator pits or deep excavations and an under drain system should be installed to collect and transport water away from deep excavation or pits. A generic under drain system is shown on Figure 12.

11.0 PAVEMENT DESIGN

Pavement design for parking areas is based on a traffic index of 5.5, typical for heavy residential use. The following parameters were considered:

- Pavement Design Life - 20 years
- Subgrade CBR Value - 6 (assumed)
- Structural Layer Coefficients - Asphalt = 0.4
  - Type II = 0.1

Based on design parameters 2.5 inches of asphaltic concrete over 6 inches of Type II base would be adequate for automobile parking areas.

At a minimum the upper-12 inches of existing subgrade should be scarified, moisture conditioned to within 2% of the optimum moisture content, and compacted to a minimum of 90% of the maximum dry density as determined by ASTM D 1557. The compacted subgrade should extend at least two feet beyond the pavement limits. Trafficking upon silty sand subgrade soils will be extremely difficult during periods of wet weather when the subgrade becomes wet.

Base course material should be compacted to a minimum of 95% of maximum dry density (ASTM D 1557). Asphaltic concrete should be compacted to at least 96 percent of the laboratory Marshal mix design density (ASTM D 6926 and D 2726). Asphaltic concrete and base should be tested prior to site delivery and during placement for conformance with project specifications.

12.0 SOIL CORROSIVITY

Sulfate exposure for soils/bedrock in the area generally classify as "severe" due to relatively high gypsum content. Concrete mixes in contact with site soils or groundwater should be designed in accordance with ACI 318, Section 4.3 for "severe" sulfate exposure. Buried pipes should be plastic (PVC or HDPE) instead of metal, where possible.

13.0 FOUNDATION REVIEW AND TESTING

This report has been prepared to assist in project design and construction. Variations from the conditions portrayed in the exploratory investigations may occur which are sometimes sufficient to require modifications to the design. In order to incorporate recommendations provided into actual field conditions and to confirm that the project specifications are implemented, we recommend that observation and testing be performed during construction to monitor over-excavation, grading, and preparation of soils upon which foundations elements or structural loads may be established.

14.0 LIMITATIONS

The exploratory data presented in this report were collected to provide geotechnical design recommendations for this project and subsurface site descriptions represent conditions observed at the time and at the locations explored. The investigations may not be indicative of subsurface conditions beyond the investigation location and conditions may change with passage of time. If subsurface conditions are encountered that are significantly different than those reported herein, Landmark should be contacted immediately for the continued applicability of the recommendations. In the event changes to the project are made that differ from those presented in this report, Landmark should be made aware of the changes. Landmark will provide written verification that the recommendations and conclusions remain valid or that modifications are required.

This report has been prepared to assist in project design and construction. We respectfully request the opportunity to review the final design drawings and specifications in order to determine whether the assumptions and recommendations presented herein are applicable to the anticipated designs.

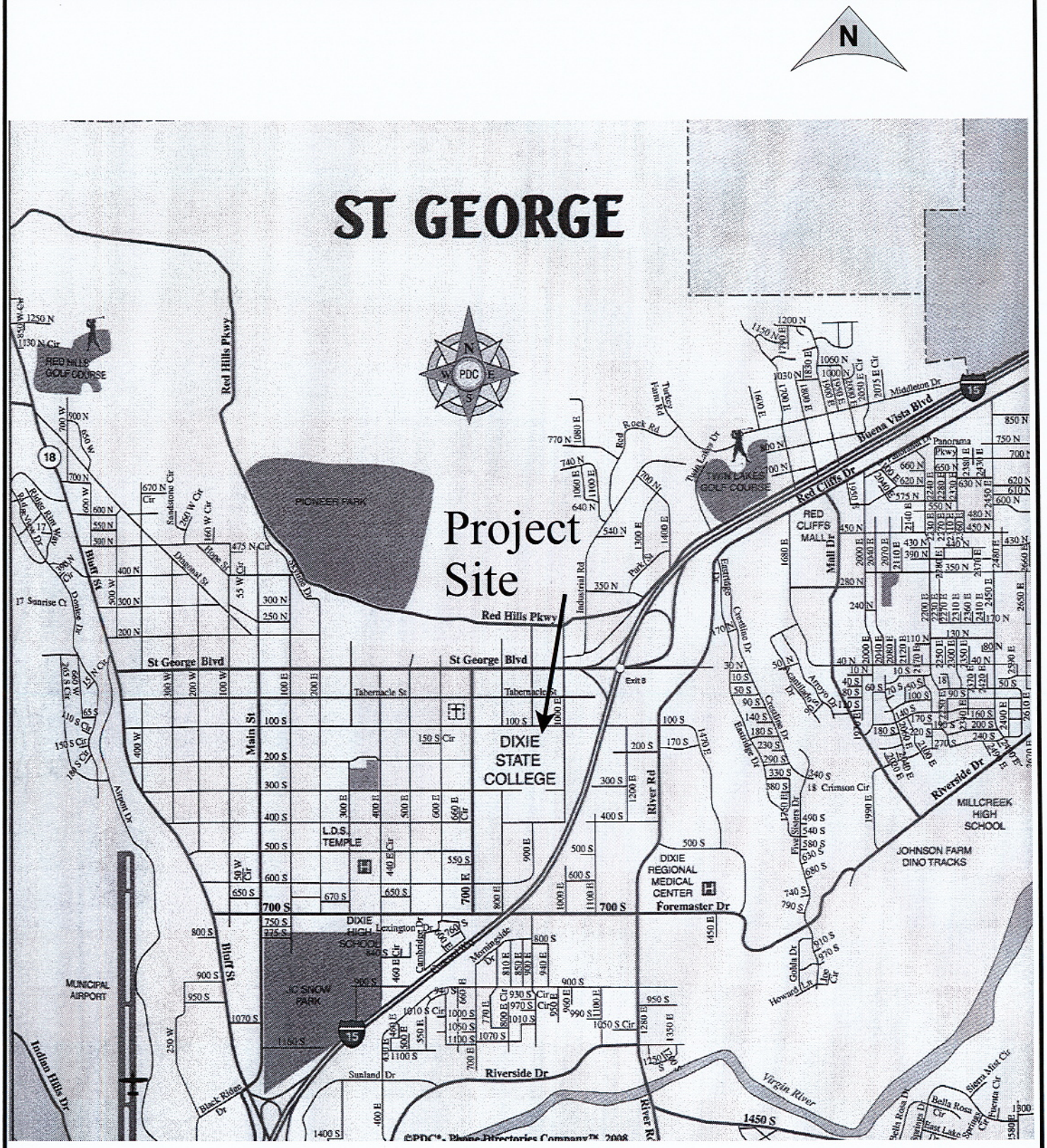
This report is not intended to be used as a bid document. Any information concerning the environmental conditions of the site is beyond the scope of this geotechnical study. This geotechnical report has been prepared to meet the specific needs of our client and may not be appropriate to satisfy the needs of other users.

LANDMARK TESTING & ENGINEERING

Russell Owens, P.E.
Geotechnical Manager

Reviewed by:

Riley Champneys, PE
Project Engineer



LANDMARK TESTING & ENGINEERING	VICINITY MAP LANDMARK PROJECT 12361	Figure 1

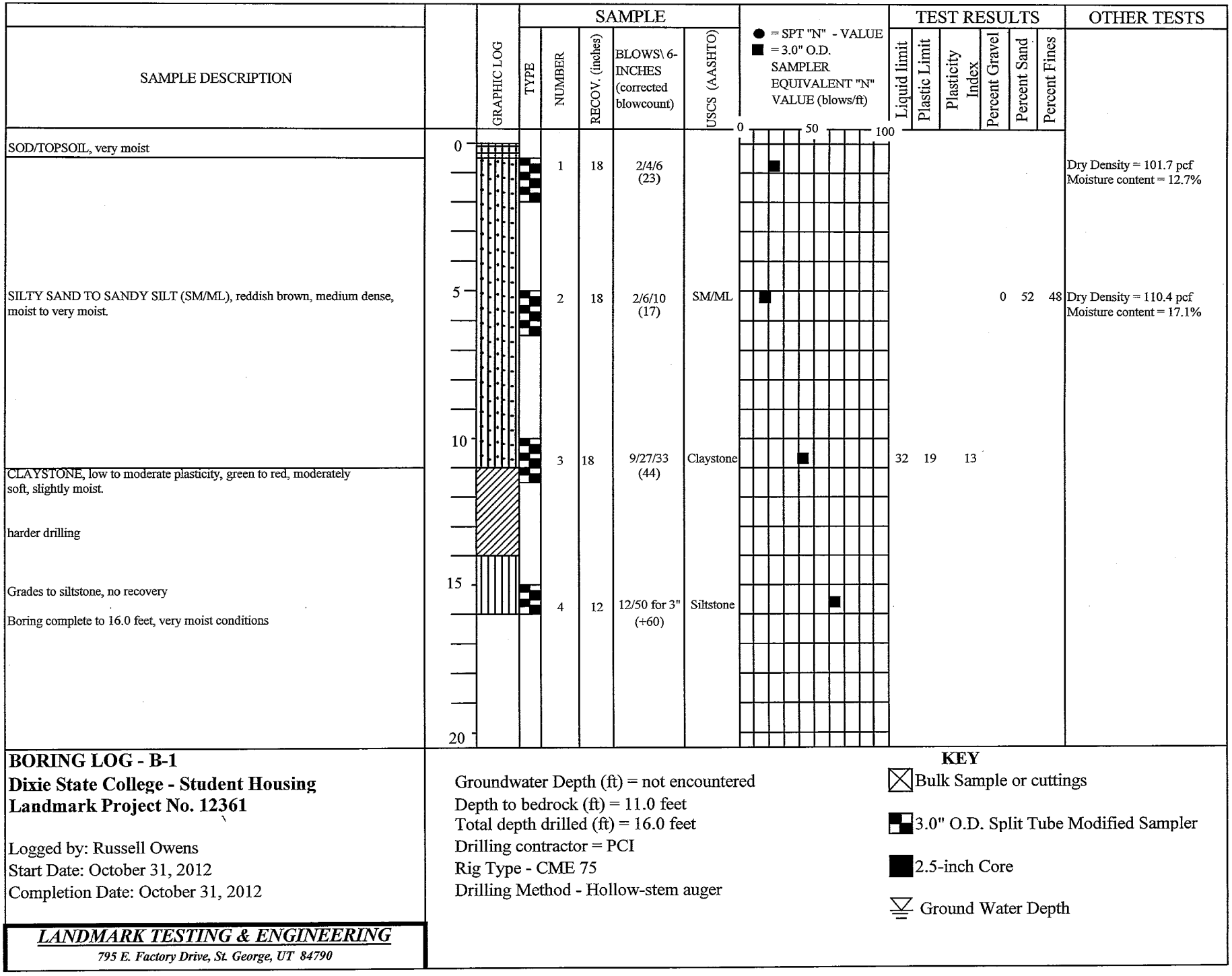
● Approximate Boring Location

LANDMARK TESTING & ENGINEERING

SITE PLAN

LANDMARK PROJECT 12361

FIGURE 2



BORING LOG - B-1
Dixie State College - Student Housing
Landmark Project No. 12361

Logged by: Russell Owens
Start Date: October 31, 2012
Completion Date: October 31, 2012

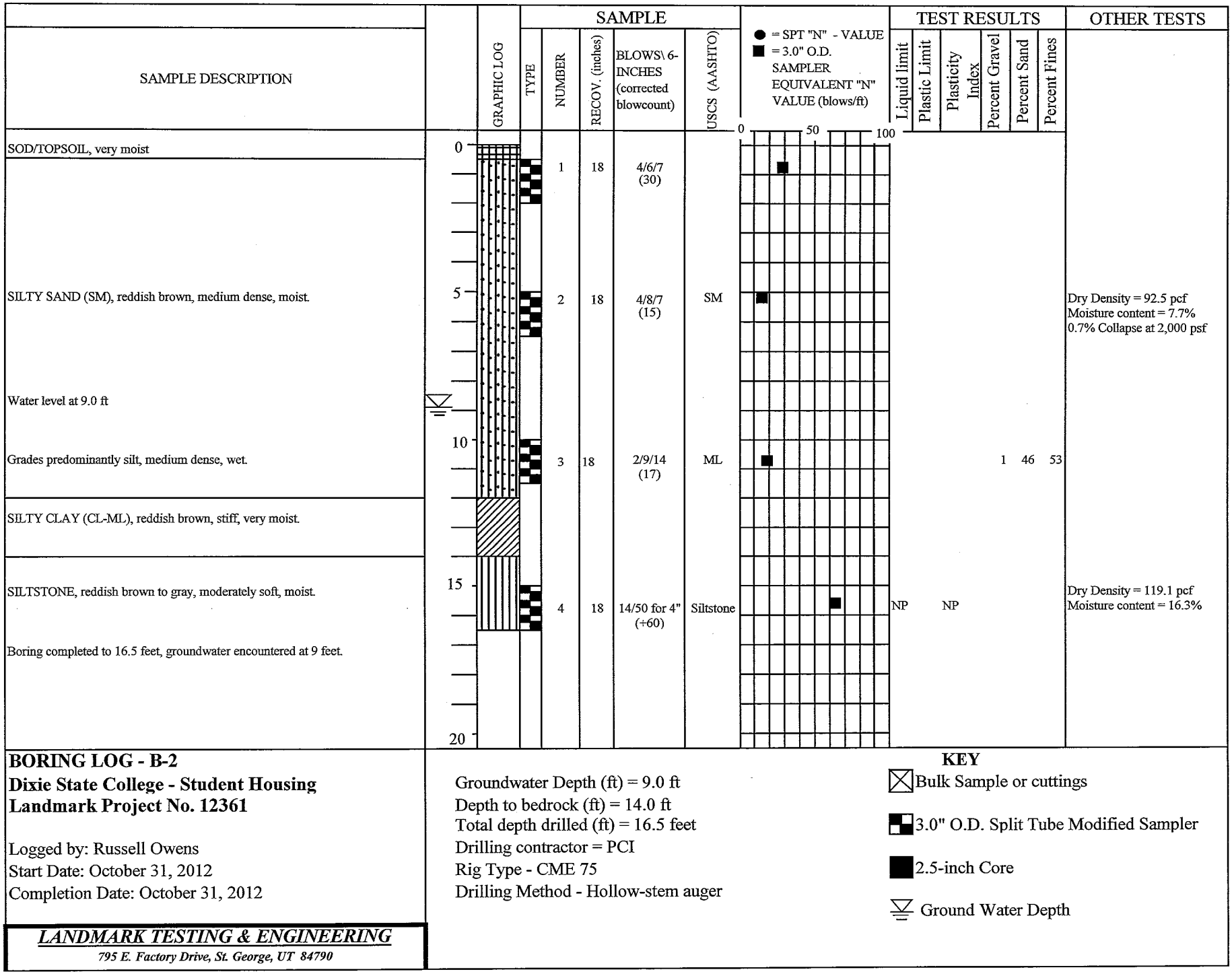
LANDMARK TESTING & ENGINEERING
795 E. Factory Drive, St. George, UT 84790

Groundwater Depth (ft) = not encountered
Depth to bedrock (ft) = 11.0 feet
Total depth drilled (ft) = 16.0 feet
Drilling contractor = PCI
Rig Type - CME 75
Drilling Method - Hollow-stem auger

KEY
- Bulk Sample or cuttings
- 3.0" O.D. Split Tube Modified Sampler
- 2.5-inch Core
- Ground Water Depth

BORING B-1

FIGURE 3



BORING LOG - B-2
Dixie State College - Student Housing
Landmark Project No. 12361

Logged by: Russell Owens
Start Date: October 31, 2012
Completion Date: October 31, 2012

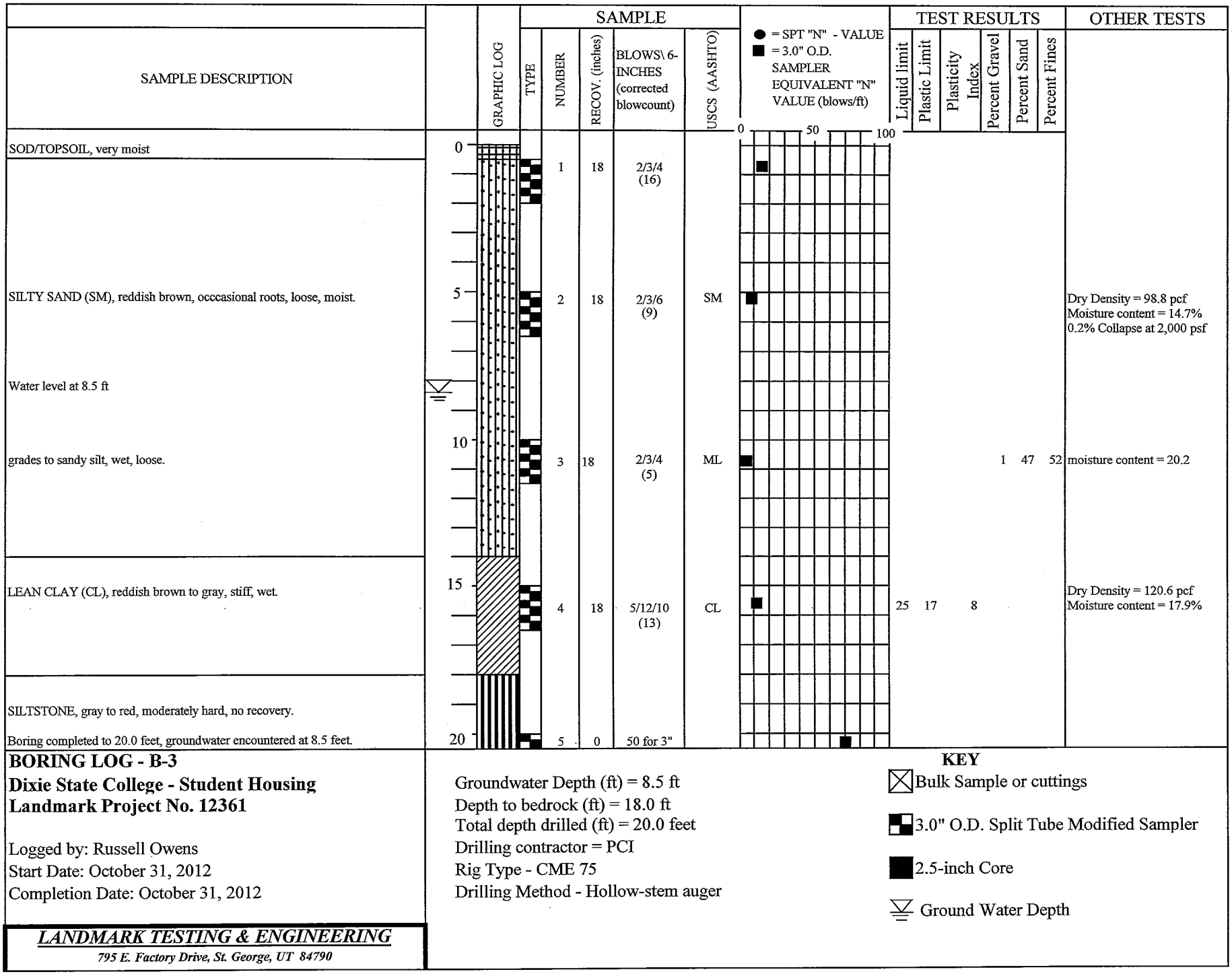
LANDMARK TESTING & ENGINEERING
795 E. Factory Drive, St. George, UT 84790

Groundwater Depth (ft) = 9.0 ft
Depth to bedrock (ft) = 14.0 ft
Total depth drilled (ft) = 16.5 feet
Drilling contractor = PCI
Rig Type - CME 75
Drilling Method - Hollow-stem auger

KEY
- Bulk Sample or cuttings
- 3.0" O.D. Split Tube Modified Sampler
- 2.5-inch Core
- Ground Water Depth

BORING B-2

FIGURE 4



BORING LOG - B-3
Dixie State College - Student Housing
Landmark Project No. 12361

Logged by: Russell Owens
Start Date: October 31, 2012
Completion Date: October 31, 2012

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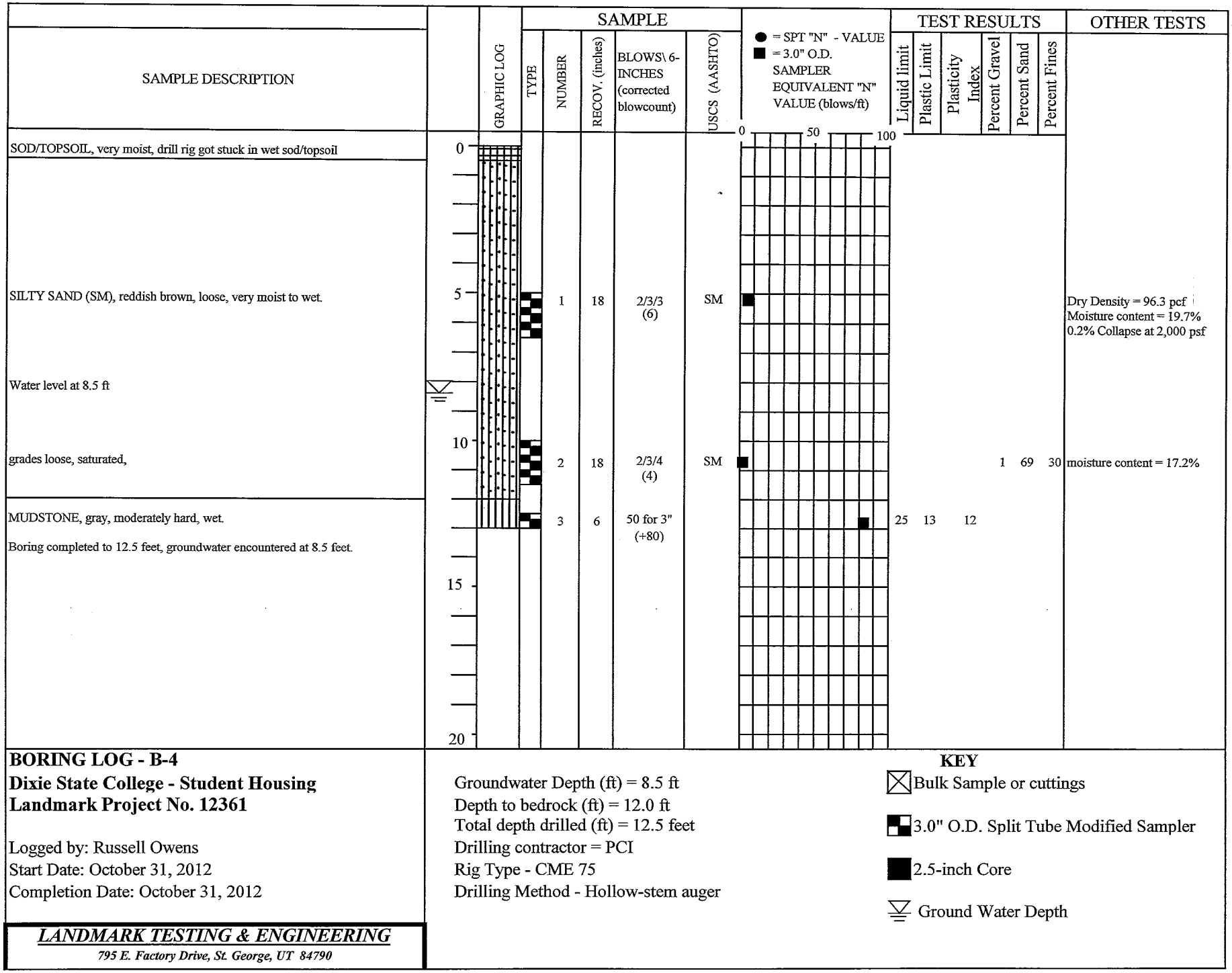
795 E. Factory Drive, St. George, UT 84790

Groundwater Depth (ft) = 8.5 ft
Depth to bedrock (ft) = 18.0 ft
Total depth drilled (ft) = 20.0 feet
Drilling contractor = PCI
Rig Type - CME 75
Drilling Method - Hollow-stem auger

KEY
- Bulk Sample or cuttings
- 3.0" O.D. Split Tube Modified Sampler
- 2.5-inch Core
- Ground Water Depth



BORING LOG - B-4
Dixie State College - Student Housing
Landmark Project No. 12361

Logged by: Russell Owens
Start Date: October 31, 2012
Completion Date: October 31, 2012

LANDMARK TESTING & ENGINEERING
795 E. Factory Drive, St. George, UT 84790

Groundwater Depth (ft) = 8.5 ft
Depth to bedrock (ft) = 12.0 ft
Total depth drilled (ft) = 12.5 feet
Drilling contractor = PCI
Rig Type - CME 75
Drilling Method - Hollow-stem auger

KEY
- Bulk Sample or cuttings
- 3.0" O.D. Split Tube Modified Sampler
- 2.5-inch Core
- Ground Water Depth

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS		SYMBOL	TYPICAL NAMES
COARSE-GRAINED SOILS (More than 1/2 of soil > No.200 sieve size)	**GRAVELS** (More than 1/2 of coarse fraction > No. 4 sieve size)	GW	Well graded gravels or gravel-sand mixtures little or no fines
		GP	Poorly graded gravels or gravel-sand mixtures, little or no fines
		GM	Silty gravels, gravel-sand-silt mixtures
		GC	Clayey gravels, gravel-sand-clay mixtures
	SANDS (More than 1/2 of coarse fraction < No. 4 sieve size)	SW	Well graded sands or gravelly sands, little or no fines
		SP	Poorly graded sands or gravelly sands, little or no fines
		SM	Silty sands, sand-silt mixtures
		SC	Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS (More than 1/2 of soil < No.200 sieve size)	**SILTS & CLAYS** Liquid Limit <50	ML	Inorganic silts and very fine sands, rock flour, silty fine sands or clayey silts with slight plasticity
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandys clays, silty clays, lean clays
		OL	Organic silts and organic silty clays of low plasticity
	SILTS & CLAYS Liquid Limit >50	MH	Inorganic silts, micaceous or diatomaceous fine sand or silty soils, elastic silts
		CH	Inorganic clays of high plasticity, fat clays
		OH	Organic clays of medium to high plasticity, organic silty clays, organic silts
HIGHLY ORGANIC SOILS		PT	Peat and other highly organic soils

GRAIN SIZE CHART

CLASSIFICATION	RANGE OF GRAIN SIZE	
	U.S. Standard Sieve Size	**Grain Size in Millimeters**
BOULDERS	Above 12"	Above 305
COBBLES	12" to 3"	305 to 76.2
GRAVEL	3" to No.4	76.2 to 4.76
Coarse	3" to ¾"	76.2 to 19.1
Fine	¾" to No.4	19.1 to 4.76
SAND	No.4 to No.200	4.76 to 0.074
Coarse	No.4 to No.10	4.76 to 2.00
Medium	No.10 to No.40	2.00 to 0.420
Fine	No.40 to No.200	0.420 to 0.074
SILT & CLAY	Below No.200	Below 0.074

Hardness of Rock

Descriptive Term	Characteristics
Moderately Hard	Can be scratched with a knife with light to moderate pressure; breaks with moderate hammer blow.
Hard	Can be scratched with a knife with difficulty; can be broken with heavy hammer blow.
Very Hard	Cannot be scratched with a knife; can only be broken with repeated heavy hammer blows.

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SOIL CLASSIFICATION

FIGURE 7

Table 1
LABORATORY TEST SUMMARY

PROJECT DSC Student Housing Project **PROJECT NO.** 12361

CLIENT Dixie State College

BORING /TEST PIT NO.	DEPTH BELOW GROUND SURFACE (ft.)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	% COLLAPSE 2000 psf load	MOISTURE DENSITY RELATIONSHIP		ATTERBERG LIMITS			MECHANICAL ANALYSIS			USCS GROUP SYMBOL
					Maximum Density (PCF)	Optimum Moisture (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	GRAVEL (%)	SAND (%)	SILT & CLAY (%)	
B-1	1.0	12.7	101.7										SM
	5.0	17.1	110.4							0	52	48	SM
	10.0						32	19	13				Claystone
B-2	5.0	7.7	92.5	0.7%									SM
	10.0									1	46	53	ML
	15.0	16.3	119.1				NP		NP				Siltstone
B-3	5.0	14.7	98.8	0.2%									SM
	10.0	20.2								1	47	52	ML
	15.0	17.9	120.6							25	17	8	CL
B-4	5.0	19.7	96.3	0.2%									SM
	10.0	17.2											SM
	12.5						25	13	12				Mudstone

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FIGURE 8

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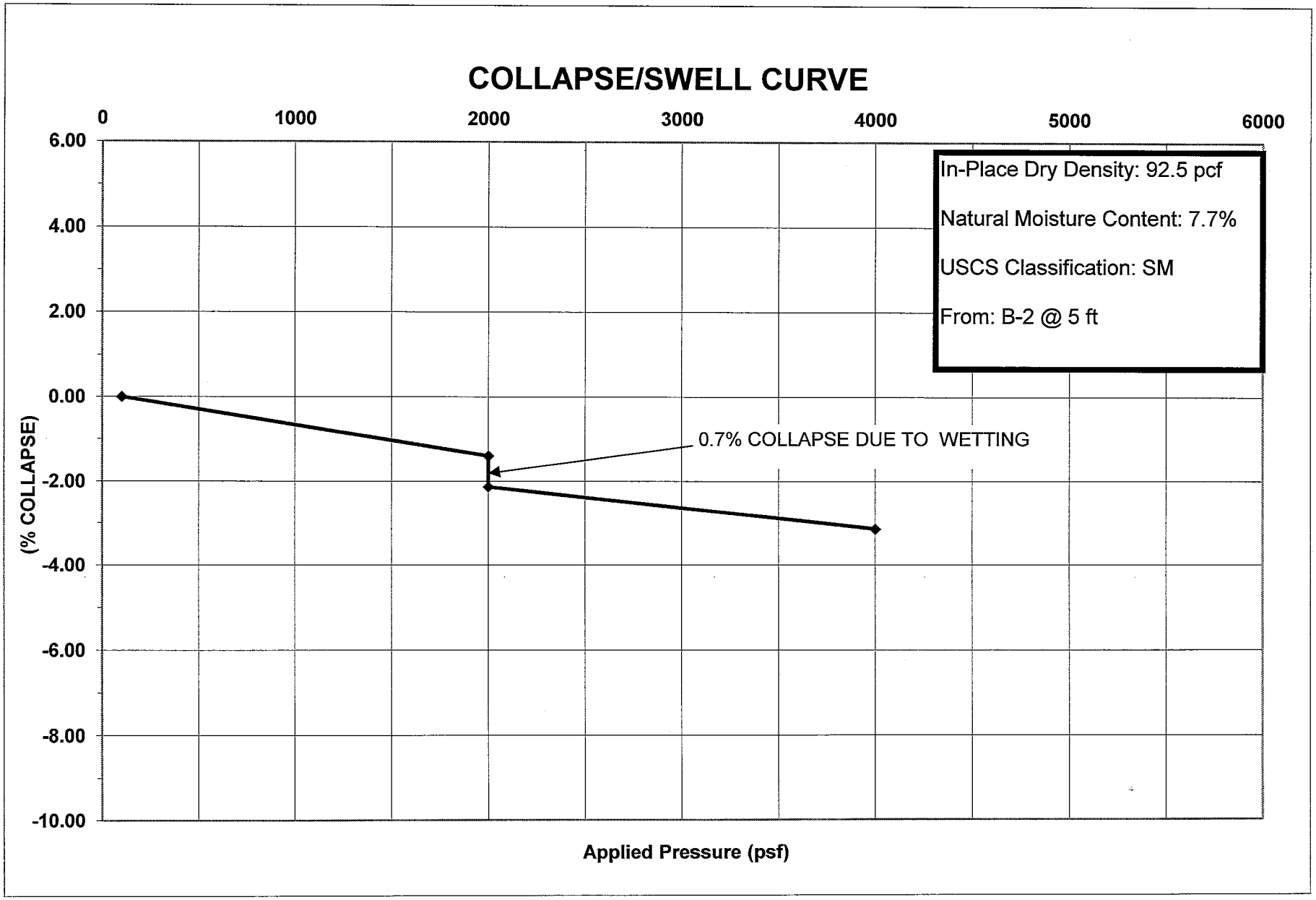

FIGURE 9

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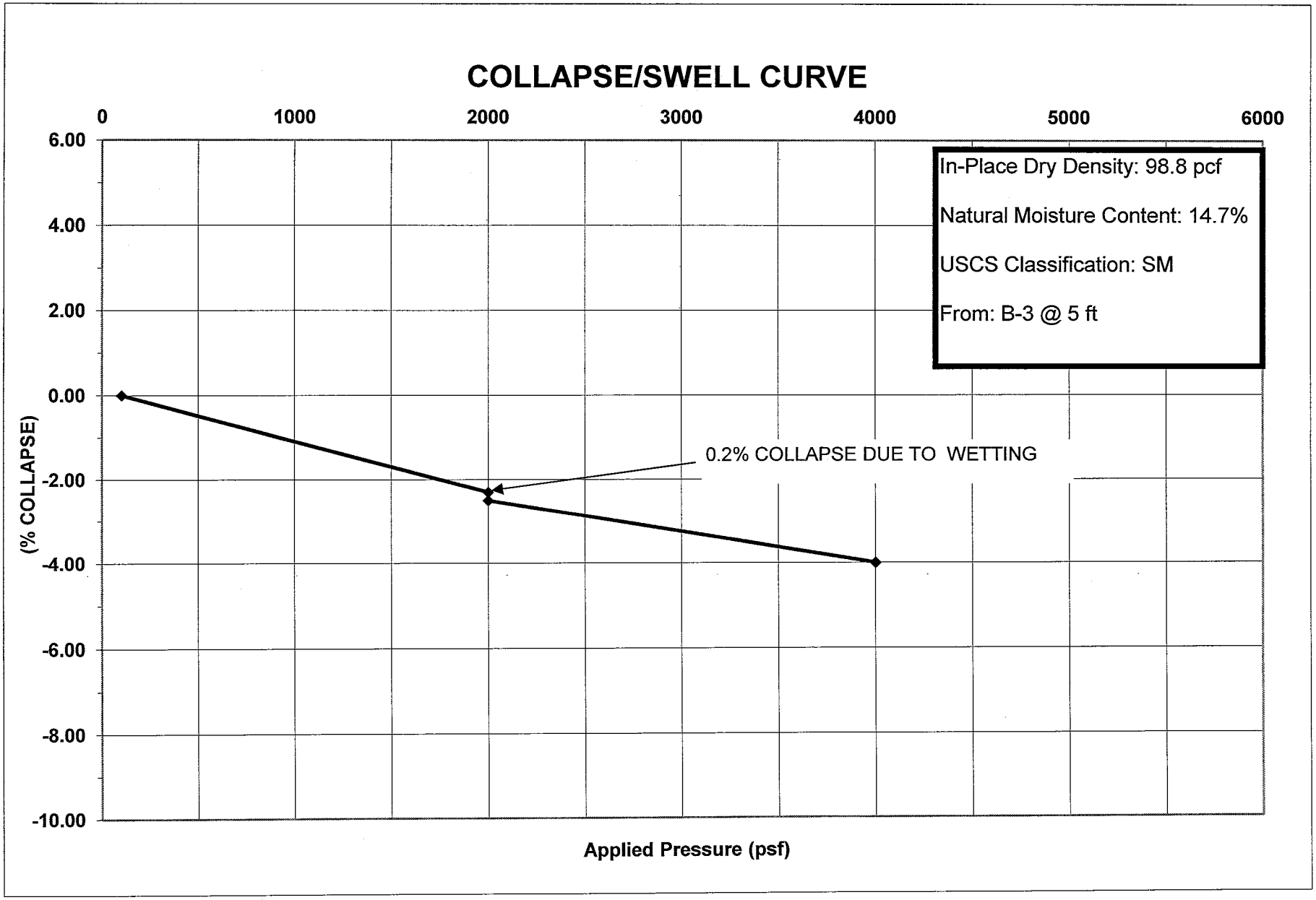

FIGURE 10

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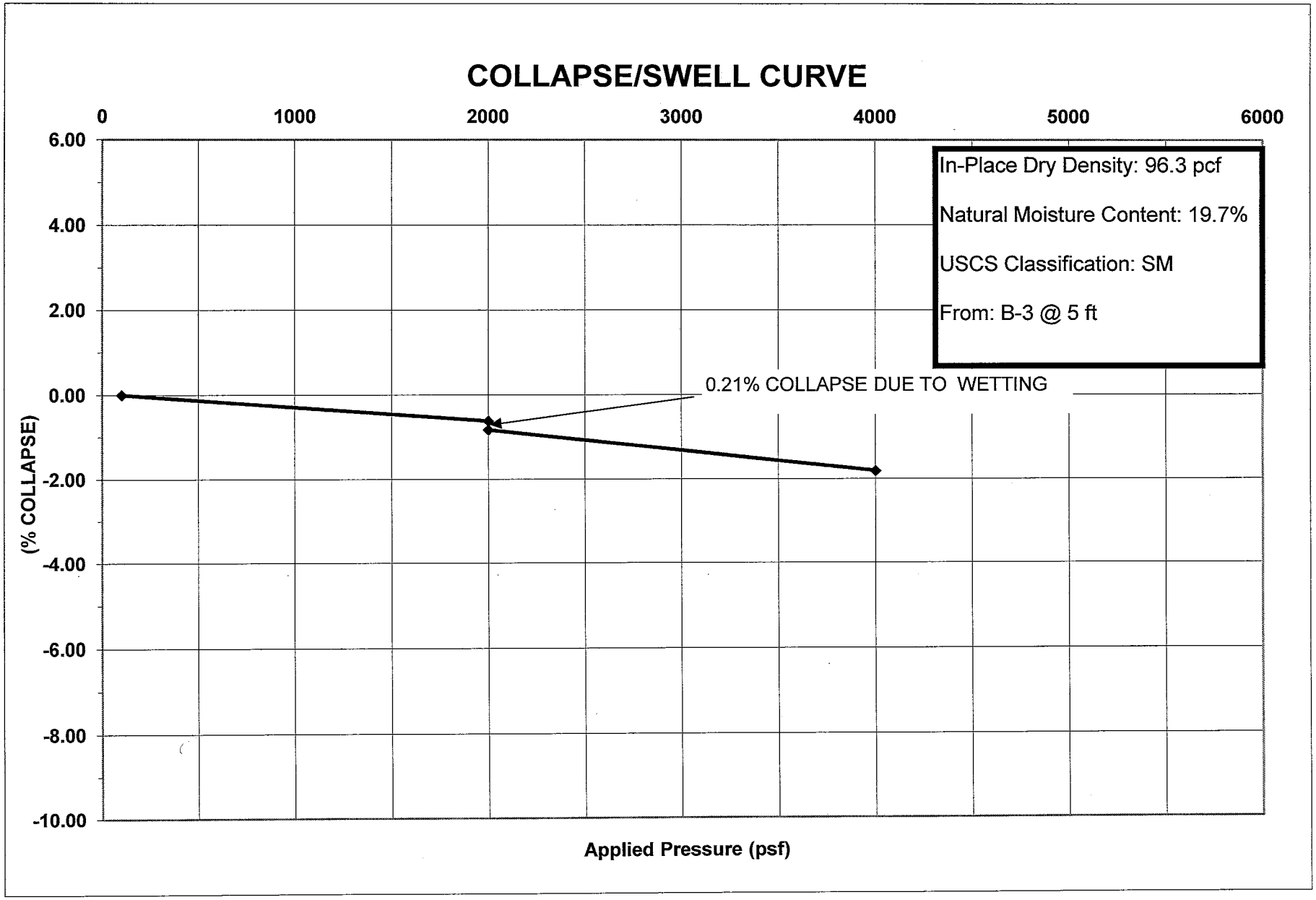
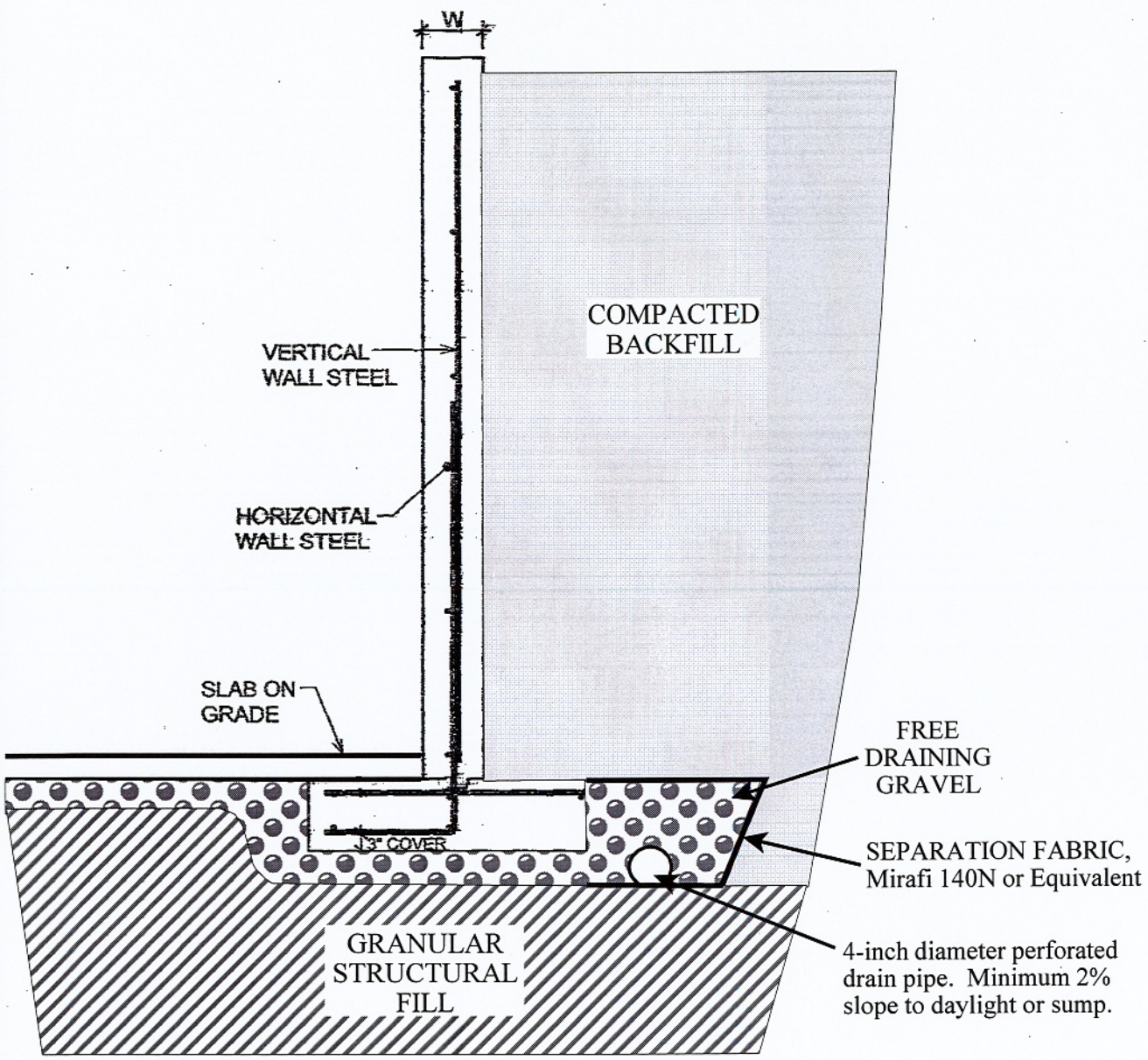


FIGURE 11



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UNDERDRAIN DETAILS

Figure 12