

November 23, 2013  
Job No. 13-169

BES Design/Build, LLC  
766 Middle Street  
Fairhope, Alabama 36532

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Assistant Project Manager

**RESULTS of GEOTECHNICAL INVESTIGATION  
VA-LR NEW PARKING DECK  
LITTLE ROCK, ARKANSAS  
CROMWELL PROJECT No. 2013-168**

**INTRODUCTION**

Submitted herein are the final results of the geotechnical investigation performed for the new parking deck planned at the Veteran's Administration (VA) hospital facility in Little Rock, Arkansas. This geotechnical investigation was authorized by the agreement between BES Design/Build, LLC and Grubbs, Hoskyn, Barton & Wyatt, Inc. dated September 5, 2013. This study has been performed in general accordance with our proposal of August 6, 2013 (GHBW Proposal No. 13-163). Preliminary results of the borings and initial foundation recommendations were provided on September 11 and October 1, 2013 and have been discussed with the Engineer during the course of this study.

We understand that the project consists of a two- to six-level parking structure with a footprint of approximately 125 ft by 340 ft with associated new pavement areas. The new parking structure is expected to be precast or cast-in-place concrete and foundation loads are expected to be moderate to heavy. Site grading information is not currently available.

The purposes of this geotechnical investigation were to explore subsurface conditions at the planned parking deck site and to develop recommendations to guide design and construction of foundations, ground level slab, and pavements. The following report sections discuss the results of the field and laboratory studies. Recommendations for design and construction are discussed in subsequent report sections.

## **SUBSURFACE EXPLORATION**

Subsurface conditions at the parking deck site were investigated by drilling six (6) sample borings to 30- to 40-ft depth. The number and locations of the borings were specified by the Engineer. The site vicinity is included as Plate 1. The approximate boring locations are shown on the Plan of Borings, attached as Plate 2. Boring logs, presenting descriptions of the subsurface strata encountered and results of field and laboratory tests, are attached as Plates 3 through 8. The approximate ground surface elevation, as inferred from the topographic information provided by the Engineer, is also shown on the logs. It must be recognized that the elevations shown are approximate and actual elevations may vary. Keys to the terms and symbols used on the logs are shown on Plates 9 and 10.

The borings were drilled with a truck-mounted Mobile B-53 rotary-drilling rig. Boring 6 was advanced using a combination of dry-auger and rotary-drilling methods. The other borings were drilled using dry-auger drilling procedures. Samples were typically obtained using a 2-in.-diameter split-barrel sampler driven into the strata by blows of a 140-lb safety hammer dropped 30 inches, in accordance with Standard Penetration Test (SPT) procedures. The number of blows required to drive the standard split-barrel sampler the final 12 in. of an 18-in. total drive, or portion thereof, is defined as the Standard Penetration Number (N). Recorded N-values are shown on the boring logs in the "Blows Per Ft" column. Where rock hardness precluded obtaining samples via the SPT, cuttings were obtained for use in visual classification.

All samples were removed from sampling tools in the field, examined and visually classified. Samples were then placed in appropriate containers to prevent moisture loss and/or change in condition during transfer to our laboratory for further examination and testing.

The borings were advanced using dry-auger drilling procedures to the extent possible to facilitate observation of groundwater levels. The observations regarding groundwater are noted in the lower portion of each log and are discussed in subsequent sections of this report. All boreholes were backfilled after obtaining final groundwater level readings.

## **LABORATORY TESTING**

To evaluate pertinent physical and engineering characteristics of the foundation and subgrade soil and rock, laboratory tests consisting of natural water content determinations and classification tests were performed on selected representative soil and shale samples. A total of 40 natural water content determinations (ASTM D-2216) were performed. The results of these

tests are plotted on the logs as solid circles, in accordance with the scale and symbols shown in the legend located in the upper-right corner.

To verify field classification and to evaluate soil plasticity, eight (8) liquid and plastic (Atterberg) limit determinations (ASTM D-4318) and three (3) sieve analyses (ASTM D-1140) were performed on selected representative samples. The Atterberg limits are plotted on the logs as pluses inter-connected with a dashed line using the water content scale. The percent of soil passing the No. 200 Sieve is noted in the "No. 200%" column on the log forms. Classification test results, as well as soil classification by the Unified Soil Classification System, are summarized in Appendix A.

## **GENERAL SITE and SUBSURFACE CONDITIONS**

### **Site Conditions**

The existing John L. McClellan Memorial Veterans Hospital is located between Shuffield Drive and West 7<sup>th</sup> Street, bordered by Hooper Drive and Jack Stephens Drive, in Little Rock, Arkansas. The facility includes several existing buildings in the central portion of this location. Paved parking lots and drives surround the existing buildings. The new parking deck location is at the northeast corner of the hospital campus, bounded on the north by Suffield Drive and on the east by Jack Stephens Drive. This area is currently an active parking lot surfaced with asphalt concrete pavements. The existing pavements are relatively new and in visually good condition. Solar panel canopies, with underground power lines and other elements associated with the solar panels, presently cover much of this area. It is understood that a building or buildings previously occupied that area. It is also understood that these buildings were razed prior to construction of the existing parking lots. The site terrain is sloping with a fall from the west to the east. Surface drainage is considered fair to good in light of the paved ground surface.

### **Site Geology**

The site locale is within the mapped exposure of the Pennsylvanian Period Jackfork Sandstone Formation. Shale is predominant in the Jackfork, with a variable content of fine- to coarse-grained sandstone. The shale is typically argillaceous, though some carbonaceous shale is present. The shale and sandstone units are typically moderately dipping to steep and quartz veins and inclusions are relatively common. The Jackfork is conformable on the Stanley Shale and is reported to have a thickness varying from 3500 to 6000 feet.

### Seismic Conditions

The Pulaski County, Arkansas site is located in Seismic Zone 1, defined by the Arkansas Building Authority (2005) as the zone of least seismic potential. Based on the average results of the borings and the local geology, a Seismic Site Class B (rock profile) is considered fitting for the site in accordance with the criteria of IBC 2006 and 2012.

### Subsurface Conditions

Based on the results of the borings, the subsurface stratigraphy at the parking deck site may be generalized into the following primary strata.

Pavements: The ground surface is predominantly covered with asphalt concrete pavements. The results of the borings indicate that the existing pavements are comprised of about 2 to 3 in. (average 2.5 in.) of asphalt concrete surface course underlain by 3 to 5 in. (average 4 in.) of crushed stone aggregate base. The crushed stone base is locally as thick as 21 in. (see Boring 6). The existing pavements visually appear to be in good condition.

Stratum I: The surface soils below the existing pavements are comprised of a relatively thin stratum of on-site fill extending up to 1.5-ft depth and to an average depth of 1 foot. The on-site fill content is variable and includes dense tan fine sand with variable amounts of concrete and brick debris and firm to stiff gray, tan, light gray, to dark gray silty clay with shale fragments. The fill appears to be generally compact with moderate shear strength. The fill is locally absent (see Boring 3). Fill content, depth, and compaction will vary across the project area.

Stratum II: The natural overburden soil below the pavements and/or the on-site fill is soft to stiff tan, gray, to dark gray silty clay with a variable content of shale fragments. The natural silty clay represents the completely weathered shale. The silty clay (completely weathered shale) exhibits low plasticity and a wide range in shear strength and compressibility. The stratum of silty clay is discontinuous and localized. The overburden soils (Strata I and II) extend to variable depths of 1 to 6.5 ft and average depth of 3.5 ft below existing grade.

Stratum III: Low hardness to moderately tan, gray, light gray, to dark gray weathered shale is present below about 1- to 6.5-ft depth, and an average depth of 3.5 ft, and extends to about 7- to 18-ft depth. The average depth of this stratum is 14 feet. Locally the upper zones of the weathered shale stratum are highly weathered (see Borings 5 and 6) which grades to moderately weathered shale at depth. The highly weathered shale and moderately weathered shale are steeply bedded with an apparent dip on the order of 60°. The weathered shale units exhibit very poor to poor rock quality but high shear strength and low compressibility. Hard sandstone seams and layers are locally interbedded in the predominant weathered shale stratum.

Stratum V: The basal stratum encountered within the 30- to 40-ft exploration depths of the borings is moderately hard dark gray shale. The basal shale is slightly weathered to fresh and is also steeply bedded. The dark gray shale exhibits fair rock quality, high shear strength and low compressibility.

#### Groundwater Conditions

Groundwater was encountered in the borings at 16- to 26-ft depth in August 2013. This is indicative of groundwater in the fractured zones of the weathered shale and shale. Groundwater levels will vary, depending on seasonal precipitation, surface runoff and infiltration, and water levels in nearby streams. In addition, seasonal surface seeps could be present as infiltrated surface water migrates through the fractured zones of the weathered shale.

#### Significant Conditions

The site and subsurface conditions considered significant to design and construction of the new parking deck project are summarized below.

- a) The solar panel canopies on the site with associated underground cables.
- b) The underground utilities and utility structures which are located in or traverse the project area.
- c) The reported prior buildings on the site with possible abandoned foundations and utilities.
- d) The gently sloping site terrain with a fall from the west to the east.
- e) The overall fair to good surface drainage.
- f) The existing 2 to 3 in. of asphalt concrete surface course underlain by 3 to 5 in. of crushed stone aggregate base of the existing pavements which are visually in good condition.
- g) The relatively thin stratum of generally compact on-site fill (Stratum I) extending to an average depth of 1 foot.
- h) The natural soft to stiff silty clay (Stratum II) below the pavements and/or on-site fill, extending to about 1- to 6.5-ft depth and exhibiting low to moderate shear strength and moderate to high compressibility.
- i) The low hardness to moderately hard highly weathered shale and moderately weathered shale (Stratum III) at 1- to 6.5-ft depth.
- j) The basal competent moderately hard dark gray shale (Stratum IV) present below about 7- to 18-ft depth.
- k) Groundwater at 16- to 26-ft depth in August 2013 and the potential for seasonal variations in groundwater levels and amounts, as well as seasonal seeps and springs.

The conditions above have been considered in developing the recommendations and conclusions discussed in the following report sections.

## **ANALYSES and RECOMMENDATIONS**

### **Foundations**

Foundations for the new parking deck must satisfy two (2) basic and independent design criteria. First, the maximum bearing pressure transmitted to the supporting strata must not exceed the allowable bearing pressure based on an allowable factor of safety with respect to bearing stratum shear strength. Secondly, foundation movements resulting from consolidation, shrinkage, or swelling of the supporting strata should be within tolerable limits for the structure. Construction factors such as installation of foundation units, fill placement, excavation procedures, and surface and groundwater conditions must also be considered.

Given the anticipated site grading including some fill, the variable depth of the overburden and weathered shale strata, and the potential for abandoned foundations and existing and abandoned utility lines, we recommend that the moderate to heavy foundation loads of the parking deck be supported on a drilled pier foundation system. Consideration may be given to supporting lightly-loaded, independent structural and architectural elements on footings. However, the potential for differential settlement between pier-supported and footing-supported elements must be considered. Recommendations for foundations are discussed in detail in the following report sections.

### **Drilled Piers**

We recommend that the structural loads of the new parking deck be supported on drilled, straight-shaft piers. Drilled straight-shaft piers should extend through the overburden soils and low hardness to moderately hard weathered shale to bear at least 5 ft or one and one-half (1.5) shaft diameters, whichever is greater, into the moderately hard dark gray shale. Drilled piers founded in the moderately hard dark gray shale as recommended may be sized using a maximum net allowable end-bearing pressure of 45 kips per sq foot. The allowable end-bearing value includes a minimum factor of safety of 2.5 with respect to competence of the shale bearing stratum. Total and differential settlement of properly installed drilled piers founded in the moderately hard shale should be negligible.

Resistance to uplift will be provided by the weight of the foundations and circumferential shaft friction. For calculation of uplift capacity, an allowable skin resistance value of 1500 lbs per sq ft may be assumed for shaft penetration into the moderately hard dark gray, gray, and tan weathered shale (Stratum III). An allowable skin resistance value of 3200 lbs per sq ft may be

utilized for shaft penetration into the moderately hard dark gray shale (Stratum IV). The allowable skin friction values include a minimum factor of safety of 2.5.

Resistance to lateral loads will be developed by the passive resistance of the weathered shale and shale bearing strata. For shaft penetration into the moderately hard weathered shale (Stratum III) and shale (Stratum IV) in excess of 5 ft below the top of piers, an allowable lateral bearing pressure of 3500 lbs per sq ft may be assumed up to a maximum penetration of four (4) shaft diameters. A point of fixity at approximately one (1) shaft diameter into the moderately hard weathered shale may be assumed for estimation purposes. The allowable lateral pressure values include a minimum factor of safety of 3.0 with respect to static loads. Where lateral loads control design or significantly impact design, performing detailed lateral load analyses will be warranted.

The required pier length will vary with site grading plans and the specific subsurface conditions. The minimum as-built pier bottoms are anticipated to be about 20 ft below existing grades, on average. A minimum pier length of 10 ft and a minimum shaft diameter of 24 in. are recommended. Depending on the degree and extent of weathering, rock quality and final grading plans, localized deepening or shortening of pier depths will be warranted. Drilled pier excavations should be observed by the Geotechnical Engineer to verify suitable bearing and adequate penetration.

#### Footings - Independent Elements

Structural or architectural elements which have light foundation loads and are independent of pier-supported elements could be supported on footings. Continuous or individual footings should be founded in the natural stiff tan, gray, to dark gray silty clay (Stratum II), the low hardness to moderately hard tan, gray, light gray, to dark gray weathered shale (Stratum III), or in compacted select fill. Footings founded as recommended may be sized based on maximum net allowable bearing pressures of 2000 and 2500 lbs per sq ft for continuous and individual footings, respectively. The recommended bearing values are based on a minimum factor of safety of 2.5 with respect to the measured shear strength of the natural stiff silty clay (Stratum II), the competence of the weathered shale (Stratum III), and anticipated shear strength of properly compacted fill.

Post-construction settlement of foundations supported as recommended and underlain by less than 6 ft of fill should be less than 1 inch. Differential settlement of footings founded in the same bearing stratum should be less than one-half of the total value. Differential settlement

between footing-supported elements and pier-supported elements will be equal to the total settlement of footings. Consequently, differential settlement of 1 in., more or less, could occur between footing-supported elements and pier-supported elements. We recommend a flexible joint be utilized between any footing-supported elements and pier-supported elements.

Footing excavations or footing undercuts must extend through the on-site fill (Stratum I) and any compressible zones of the silty clay (Stratum II) to suitable bearing strata. Where the on-site fill and/or compressible silty clay are encountered at the plan footing depth, the footings should be undercut to suitable bearing strata. Footing undercuts should be backfilled with select fill, approved flowable fill (minimum compressive strength of 300 psi), or lean concrete. Based on the results of the borings, undercuts of weak soils on the order of 2 to 6 ft, more or less, could be required. Care must be taken not to undermine existing structures, utilities, and pavements with deep undercuts.

Undercuts of footings backfilled with select fill should have a minimum width determined by a 1-horizontal to 2-vertical (1H:2V) projection from the footing edges to the undercut bottom to the extent possible. Footing undercuts backfilled with flowable fill or concrete may be excavated neat to the plan footing dimensions. Where mass undercuts are warranted, the undercut should extend at least 8 ft outside the footing limits to the extent possible.

Uplift resistance of footings will be developed by the weight of the structure and the foundation units. Resistance to lateral forces will be developed by the passive resistance of the foundation soils and sliding resistance at the footing bottom. The passive resistance of the soil and weathered rock within the upper 2 ft should be neglected. Below 2-ft depth, an ultimate passive resistance value of 750 lbs per sq ft may be assumed for the stable overburden soils, weathered shale, and compacted select fill. Resistance to sliding may also be evaluated using an ultimate friction value ( $\tan \delta$ ) of 0.35 for concrete on suitable bearing strata. Where foundation undercuts are backfilled with flowable fill or concrete, these should be rough finished to enhance friction resistance. Alternatively, short dowels may be utilized to mobilize shear resistance between foundation bottoms and cementitious backfill. An appropriate factor of safety must be included in analysis of sliding.

Perimeter footings and footings in unheated areas should extend a minimum of 2 ft below final grade for footing embedment and frost protection. Continuous footings should have a



minimum width of 18 in. and individual footings a minimum dimension of 24 inches. All footing excavations and foundation undercuts should be observed by the Geotechnical Engineer to verify suitable bearing and adequate undercut.

#### Parking Deck Bottom Slab

Slab-on-grade construction is expected to be suitable for the parking deck ground level slab. Subgrade preparation for the ground level slab must include thorough proof-rolling of the subgrade. Localized undercuts of 2 to 6 ft below existing grades, more or less, depending on final grading plans and specific seasonal site conditions, could be needed for subgrade preparation.

For a properly prepared subgrade of stable on-site soils or compacted select fill, a modulus of subgrade reaction (k) value of 100 lbs per sq in. per in. may be utilized for design of the ground level slab. The modulus of subgrade reaction (k) may be increased to 140 lbs per sq in. per in. if the ground level slab is underlain by 6 in. of crushed stone base (AHTD Standard Specifications Section 303, Class 7). The modulus of subgrade reaction (k) may be increased to 200 lbs per sq in. per in. if the ground level is underlain by at least 12 in. of crushed stone base.

The ground level slab thickness must be determined based on structural requirements. However, we recommend the minimum ground level slab thickness comply with the pavement section below based on vehicle traffic considerations.

- 6 in. Portland Cement Concrete ( $f'_c = 4000$  psi @ 28 days)
- 6 in. Crushed Stone Base (AHTD Standard Specifications Section 303, Class 7)

#### Pavements

We understand that some incidental replacement pavements may be required around the parking deck area after the new parking deck is constructed. Asphalt concrete pavements are expected for these replacement pavements. Traffic in these new pavement areas is expected to primarily be automobile and light utility vehicle traffic with occasional and infrequent delivery trucks.

The subgrade in the new pavement areas is expected to be comprised of the compact on-site fill (Stratum I), the stable silty clay (Stratum II), the weathered shale (Stratum III), or compacted select fill. These soils will provide fair subgrade support in conjunction with proper subgrade preparation and positive surface drainage.

Recommended pavement section alternatives are summarized below.

Parking Areas – light duty for automobile parking

- 3 in. Asphalt Concrete Hot Mix Surface Course (AHTD Standard Specifications, Section 407, ½ inch,  $N_{max} = 115$ )
- 6 in. Crushed Stone Base (AHTD Standard Specifications Section 303, Class 7)

Vehicle Drives – medium duty for automobiles, service vehicles, and infrequent trucks

- 3 in. Asphalt Concrete Hot Mix Surface Course (AHTD Standard Specifications, Section 407, ½ inch,  $N_{max} = 115$ )
- 9 in. Crushed Stone Base (AHTD Standard Specifications Section 303, Class 7)

Subgrade preparation recommendations are discussed in the Site Grading section of this report. We recommend that all subgrade be proof-rolled immediately prior to placing base course to verify stable subgrade conditions prior to base placement. Aggregate base should be compacted to a minimum of 98 percent of the AASHTO T-180 maximum dry density as per AHTD criteria.

Positive surface drainage must be incorporated into pavement design. The importance of positive drainage for satisfactory pavement performance cannot be overemphasized. Grades should direct water off paved areas and ditches or storm drains should be used to develop positive flow away from pavement edges. Periodic maintenance of pavements should include sealing of all joints and cracks to prevent surface water infiltration.

It should be recognized that some periodic maintenance of pavements will be required. As a minimum, this should include periodic sealing of all joints and cracks to prevent surface water infiltration.

Site Grading

Specific information on site grading has not been provided. However, site grading is expected to include some fill. The project site is presently paved with asphalt concrete and much of the project area is currently occupied by solar panel canopies. Site preparation is expected to begin with removal of the solar panels, demolition of the existing canopies and pavements, and stripping all loose surface materials and debris.

Where grades to the plan subgrade elevation will be raised more than about 12 in., consideration may be given to leaving the existing asphalt concrete pavements in place. This can facilitate site preparation and reduce the undercut potential. If left in place, the existing pavements should be randomly perforated to prevent trapping infiltrated surface water. The

initial lift of fill placed on pavements will probably need to be about 10 in. thick to allow compaction on the relatively hard pavements.

We recommend that all abandoned foundations and underground utilities in the project area be completely excavated unless specifically accepted by the Engineer. After the required demolition, stripping, and completing any required cut, but prior to any fill placement, the subgrade should be proof-rolled with a loaded tandem-wheel dump truck or similar equipment. Areas identified to be soft or that exhibit pumping should be undercut and processed and re-compacted or replaced, whichever is appropriate. Depending on specific site conditions and final grading plans, undercuts on the order of 2 to 6 ft below existing grades, more or less, could be required. Mass undercuts in areas where footings will be used should extend at least 8 ft outside the footing lines to the extent possible. Care must be taken not to undermine existing structures, utilities, and pavements with deep undercuts or other excavations.

The on-site silty clay and weathered shale, free of organics and debris and properly processed, are suitable for use as select fill and backfill. Water content adjustment will likely be required to achieve compaction of the on-site soils and weathered shale. Processing and water addition will be required for use of the on-site weathered shale as fill or backfill.

Imported borrow for use as fill or backfill should consist of an approved silty clay/shale fragment blend or low-plasticity clayey sand (SC), sandy clay (CL), or clayey gravel (GC) with a liquid limit less than 40 and a maximum plasticity index (PI) of 20 or an approved alternate. All fill and backfill should be free of organics and durable rock fragments in excess of about 3-in. dimension and a maximum PI of 20. The top 18 in. of fills should have a maximum particle size limited to about 1.5 inches. The Geotechnical Engineer should approve all fill and backfill.

Fill, backfill, and recompacted soil and weathered shale should be compacted to a minimum of 95 percent of the maximum Modified Proctor (ASTM D-1557) dry density within a water content range of minus 2 to plus 3 percent of optimum. Shale fragment/silty clay blend fill should be compacted at a water content of optimum to about 3 percent above optimum. A vibrating sheepsfoot or padfoot compactor should be used to facilitate breakdown of shale fragments.

Fill and backfill should be placed in horizontal, nominal 6- to 8-in.-thick loose lifts. Each lift of backfill and fill should be tested and approved prior to placing subsequent lifts.

## **CONSTRUCTION CONSIDERATIONS**

### **Groundwater and Seepage Control**

Positive surface drainage should be established at the start of work, be maintained during construction and following completion of the project to prevent surface water ponding and subsequent saturation of subgrade soils. Density and water content of all earthwork should be maintained until the foundations, lower-level slabs and pavements are completed. Subgrade soils that become saturated by ponding water or runoff, should be excavated to suitable soils.

Groundwater was encountered at 16- to 26-ft depth in August 2013. Though not found in the borings, some seasonal shallow perched water could be present at shallow depth. Seasonal surface seeps or wet weather springs could also be present or may be encountered during the work. Limited seepage into shallow excavations, if encountered, can probably be controlled by ditching or sump-and-pump methods. If seepage infiltration cannot be controlled, construction of drains and/or the use of stone backfill (i.e., "B" stone) will be warranted. Stone backfill should be vented to positive discharge into storm lines or to daylight. Care should be taken to avoid using stone backfill in areas where drilled piers will be constructed.

### **Drilled Piers**

Groundwater may be encountered in drilled pier excavations. Limited seepage into drilled pier excavations can probably be controlled by close coordination of drilling, cleanup and concrete placement. However, casing may be needed to control localized caving and/or seepage into pier excavations. We recommend that casing be on site during pier construction.

All drilled pier excavations should be observed by the Geotechnical Engineer to verify suitable bearing. Drilled pier excavations should essentially be dry at the time of concrete placement. Where more than about 3 in. of water is present in pier excavations, the excavation should be dewatered or approved underwater concrete placement methods should be used. Pier excavation, steel placement and concreting should be completed expeditiously to reduce the possibility of changes in foundation conditions.

### **Footings**

All footing excavations and footing undercuts should be observed by the Geotechnical Engineer to verify suitable bearing and adequate undercut. Footing excavations should be clean and dry at the time of concrete placement. Where footing excavations will remain open for

extended periods, we recommend that the bearing stratum be protected with a thin layer of seal concrete.

#### Rock Excavation

Shallow cuts in the overburden soils (Strata I and II) and low hardness highly weathered shale and weathered shale (Stratum III) can typically be performed with conventional heavy-duty excavation equipment. The moderately hard weathered shale (Stratum III) is relatively competent and resistant. Though generally rippable with conventional heavy-duty equipment, more resistant zones could locally be encountered which will be difficult to excavate. In addition, some localized and discontinuous layers and zones of hard sandstone could also be encountered. Use of a hoeram, jackhammer or similar rock excavation methods will be warranted where these more resistant materials are encountered.

The potential for rock excavation should be anticipated. We recommend that contract documents include a unit price for removal and disposal of materials and obstructions that cannot be excavated with conventional heavy-duty excavating equipment. Conventional heavy-duty excavating equipment may be defined as a Caterpillar D-8 bulldozer with single tooth ripper, a Caterpillar 320 track excavator equipped with rock teeth, or equipment of similar power and capability. Rock excavation volumes should be determined based on in-place measurements via cross sectioning. If excavation is to be unclassified, the Contractor must be responsible for assessing rock excavation requirements.

Drilled piers will be advanced through the overburden soils (Strata I and II) and the weathered shale (Stratum III) into the moderately hard dark gray shale (Stratum IV). It is expected that drilled piers can be drilled with conventional heavy-duty drilling equipment and rock augers. However, more resistant shale units or localized sandstone beds could require the use of rock coring tools in order to obtain the required pier penetration. In addition, drilled pier excavations could locally encounter sandstone boulders or sandstone beds which are particularly difficult to penetrate. Rock drilling methods will likely be required where the localized sandstone is encountered.

It is recommended that Contract Documents include an allowance for drilling intervals of hard rock that cannot be drilled with conventional augers fitted with rock teeth. We also recommend that hard rock should be delineated as intervals that require the use of core barrels or percussion tools to advance the shaft excavation. Intervals of hard rock should be classified by

the Geotechnical Engineer and approved by the Architect. In addition, rock excavation quantities should be verified by the Geotechnical Engineer and approved by the Engineer.

### **CLOSURE**

The Engineer or a designated representative should monitor site preparation, grading work, and foundation and pavement construction. Subsurface conditions significantly at variance with those encountered in the borings should be brought to the attention of the Geotechnical Engineer. The conclusions and recommendations of this report should then be reviewed in light of the new information.

The following illustrations are attached and complete this final report.

Plate 1	Site Vicinity
Plate 2	Plan of Borings
Plates 3 through 8	Boring Logs
Plates 9 and 10	Keys to Terms and Symbols
Appendix A	Classification Test Results


\* \* \* \*

We appreciate the opportunity to be of service to you during this phase of the project. Should you have any questions regarding this report, or if we may be of additional assistance during final design or construction, please call on us.

Sincerely,

**GRUBBS, HOSKYN,  
BARTON & WYATT, INC.**

Yongsheng Zhao, Ph.D., P.E.  
Project Engineer

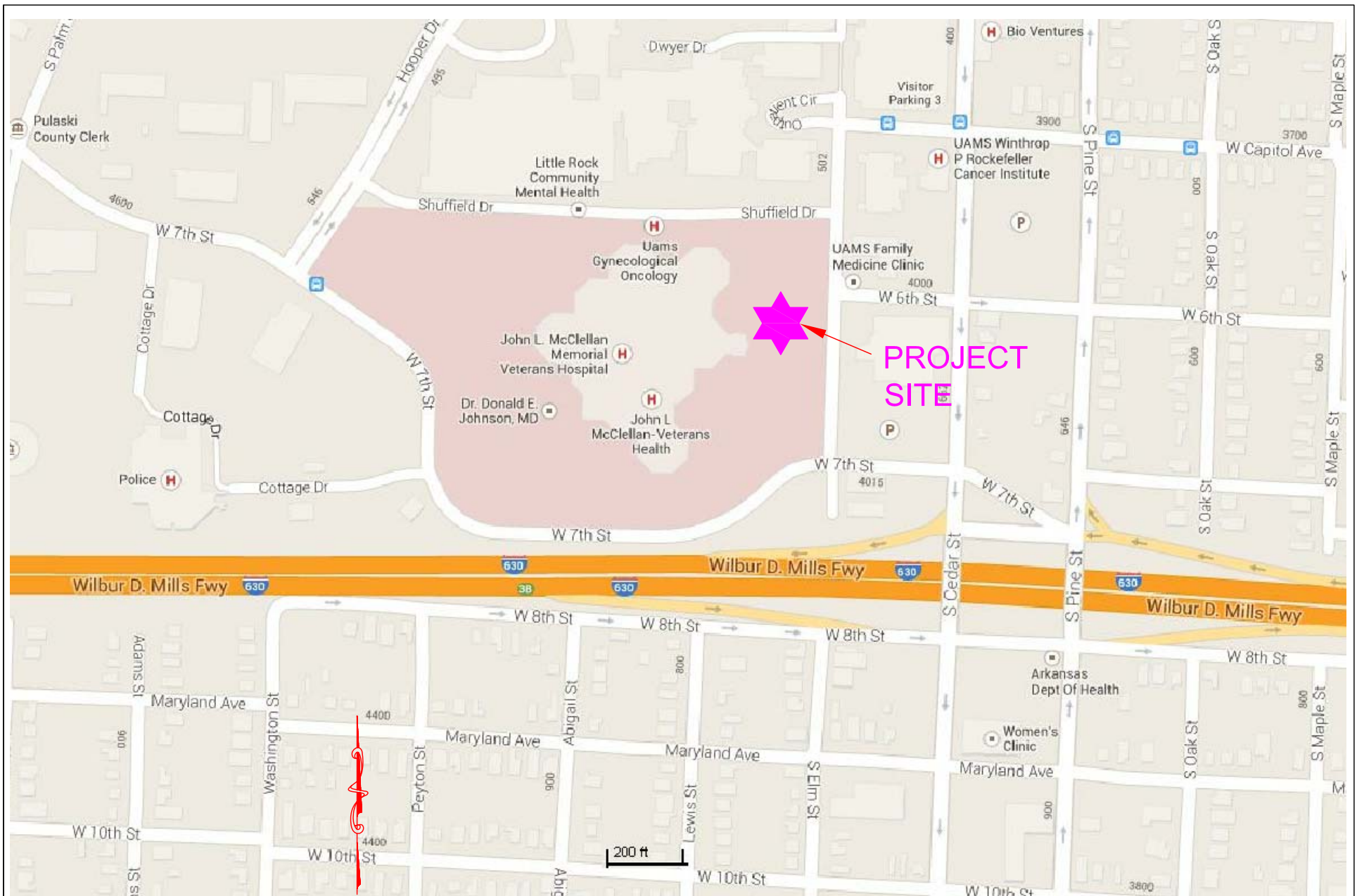
  
Mark E. Wyatt, P.E.  
President



YZ/MEW:jw

Copies submitted:    BES Design/Build, LLC  
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                              Attn: Mr. Greg Sellers, P.E    (1-email)



**VICINITY MAP**  
 Parking Deck  
 VA Hospital  
 Little Rock, Arkansas

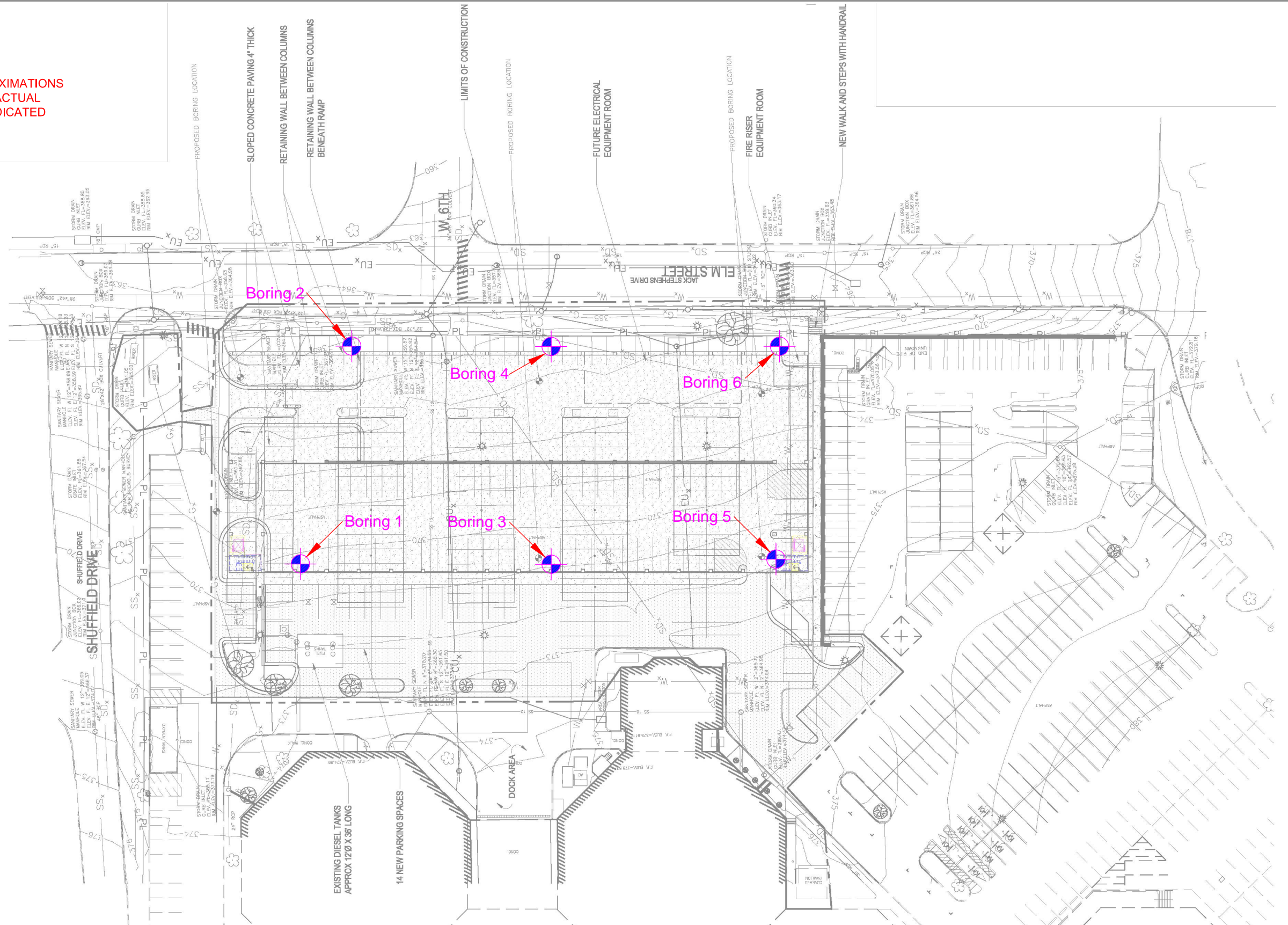
**Scale: AS SHOWN**  
**Date: August, 2013**

**Job No. 13-169 PLATE 1**





NOTE: BORING LOCATIONS ARE APPROXIMATIONS  
BASED ON FIELD DIMENSIONS. ACTUAL  
LOCATIONS MAY VARY FROM INDICATED  
POSITIONS.





**Grubbs, Hoskyn,  
Barton & Wyatt, Inc.**  
Consulting Engineers

# LOG OF BORING NO. 1

VA - New Parking Deck  
Little Rock, Arkansas

TYPE: Auger

LOCATION: See Plate 2

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT							- No. 200 %						
						0.2	0.4	0.6	0.8	1.0	1.2	1.4							
			SURF. EL: 370±			PLASTIC LIMIT +			WATER CONTENT ●										
							10	20	30	40	50	60	70						
			3 inches: Asphalt Concrete			●													
			4 inches: Crushed Stone Base	35		●													
			Dense tan fine sand (fill)	13		●													
5			Stiff dark gray silty clay w/weathered shale fragments	50/6"		●		+	-	+									
			Moderately hard gray, tan and light gray weathered shale, 60° dip ±	50/5"		●													
			- tan and dark gray below 8.5 ft	50/1"		●													
10																			
				30/0"		●													
15																			
			Moderately hard dark gray shale, 60° dip ±	30/0"		●													
20																			
				30/0"		●													
25																			
				30/0"															
30																			
				30/0"															
35																			
				30/0"															
40																			
			NOTE: Water at 10.1 ft at 24 hours after drilling.																
COMPLETION DEPTH: 40.0 ft				DEPTH TO WATER															
DATE: 8-21-13				IN BORING: 26 ft				DATE: 8/21/2013											

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**Grubbs, Hoskyn,  
Barton & Wyatt, Inc.**  
Consulting Engineers

## LOG OF BORING NO. 2

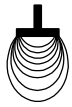
VA - New Parking Deck  
Little Rock, Arkansas

TYPE: Auger

LOCATION: See Plate 2

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT							- No. 200 %
						0.2	0.4	0.6	0.8	1.0	1.2	1.4	
			SURF. EL: 365±										
			2 inches: Asphalt Concrete										
			4 inches: Crushed Stone Base										
			Stiff tan and light gray silty clay										
			w/some sandstone and shale										
			fragments (fill)										
5			Low hardness light gray and tan										
			highly weathered shale										
			- moderately hard, dark gray, gray										
			and tan below 2 ft										
				20									
				50/9"									
				50/5"									
				50/5"									
				50/5"									
			Moderately hard dark gray shale,										
			60° dip ±										
10				30/0"									
				30/0"									
				30/0"									
15				30/0"									
			- water at 16 ft										
				30/0"									
20				30/0"									
				30/0"									
25				30/0"									
				30/0"									
30				30/0"									
			- auger refusal at 31 ft										
			NOTE: Water at 5.2 ft at 24 hours										
			after drilling.										
COMPLETION DEPTH: 31.0 ft				DEPTH TO WATER				DATE: 8/21/2013					
DATE: 8-21-13				IN BORING: 16 ft									

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**Grubbs, Hoskyn,  
Barton & Wyatt, Inc.**  
Consulting Engineers

# LOG OF BORING NO. 3

VA - New Parking Deck  
Little Rock, Arkansas

TYPE: Auger

LOCATION: See Plate 2

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT							- No. 200 %
						<div><div></div><div>0.20.40.60.81.01.21.4</div></div>							
						PLASTIC LIMIT	WATER CONTENT					LIQUID LIMIT	
			SURF. EL: 370±			10	20	30	40	50	60	70	
			2 inches: Asphalt Concrete										
			5 inches: Crushed Stone Base	44			+	-	+				
			Stiff gray, tan and dark gray silty clay	50/6"									
5			Low hardness gray, tan and dark gray weathered shale, 60° dip ±	50/5"									
			- moderately hard below 3 ft	50/4"									
			- dark gray and tan below 7 ft	30/0"									
10													
				30/0"									
15													
20			Moderately hard dark gray shale, 60° dip ±	30/0"									
				30/0"									
25													
				30/0"									
30													
				30/0"									
35													
				30/0"									
40													
			NOTE: Water at 9.5 ft at 5 hours after drilling.										
COMPLETION DEPTH: 40.0 ft				DEPTH TO WATER				DATE: 8/22/2013					
DATE: 8-22-13				IN BORING: 19 ft									

LGBNEW 13-169.GPJ 9-6-13



**Grubbs, Hoskyn,  
Barton & Wyatt, Inc.**  
Consulting Engineers

# LOG OF BORING NO. 4

VA - New Parking Deck  
Little Rock, Arkansas

TYPE: Auger

LOCATION: See Plate 2

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT							- No. 200 %
						0.2	0.4	0.6	0.8	1.0	1.2	1.4	
			SURF. EL: 366±			PLASTIC LIMIT +	WATER CONTENT ●				LIQUID LIMIT +		
						10	20	30	40	50	60	70	
			3 inches: Asphalt Concrete	50/5"		●							
			3 inches: Crushed Stone Base										
			Dense tan fine sand w/some concrete and brick debris (fill)										
			Moderately hard dark gray, gray and tan weathered shale, 60° dip ±	50/9"		●	+	-	+				
5				50/9"		●							
				50/5"		●							
			Moderately hard dark gray shale, 60° dip ±	30/0"		●							
10													
				30/0"		●							
15													
				30/0"		●							
20			- water at 20 ft										
				30/0"		●							
25													
				30/0"									
30													
				30/0"									
			NOTE: Water at 9.1 ft at 8 hours after drilling.										
COMPLETION DEPTH: 30.0 ft				DEPTH TO WATER				DATE: 8/21/2013					
DATE: 8-21-13				IN BORING: 20 ft									

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**Grubbs, Hoskyn,  
Barton & Wyatt, Inc.**  
Consulting Engineers

# LOG OF BORING NO. 5

VA - New Parking Deck  
Little Rock, Arkansas

TYPE: Auger

LOCATION: See Plate 2

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT							- No. 200 %
						0.2	0.4	0.6	0.8	1.0	1.2	1.4	
			SURF. EL: 371±										
			2 inches: Asphalt Concrete										
			5 inches: Crushed Stone Base	14		●	+	---	+				31
			Stiff gray and tan silty clay w/sandstone and shale fragments (fill)	6		●	---	+					63
5			Soft tan silty clay w/occasional sandstone fragments and trace organics	9		●							
			- firm, tan and gray with weathered shale seams below 4 ft	25		●							
			Low hardness tan and gray highly weathered shale, 60° dip ±	50/2"		●							
10			Moderately hard dark gray and tan weathered shale, 60° dip ±	30/0"		●							
15													
20			Moderately hard dark gray shale, 60° dip ±	30/0"		●							
			- water at 20 ft										
25				30/0"									
30				30/0"									
35				30/0"									
40				30/0"									
			NOTE: Water at 11.7 ft at 24 hours after drilling.										
COMPLETION DEPTH: 40.0 ft				DEPTH TO WATER				DATE: 8/22/2013					
DATE: 8-22-13				IN BORING: 20 ft									

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**Grubbs, Hoskyn,  
Barton & Wyatt, Inc.**  
Consulting Engineers

# LOG OF BORING NO. 6

VA - New Parking Deck  
Little Rock, Arkansas

TYPE: Auger to 15.5 ft /Wash

LOCATION: See Plate 2

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT			- No. 200 %				
						PLASTIC LIMIT	WATER CONTENT	LIQUID LIMIT					
SURF. EL: 366±						0.2	0.4	0.6	0.8	1.0	1.2	1.4	
						10	20	30	40	50	60	70	
			3 inches: Asphalt Concrete										
			21 inches: Crushed Stone Base (fill)	14									
			Firm gray and tan silty clay and shale fragments (fill)	9									
5			Firm gray silty clay w/trace fine gravel	6									
			- soft, tan and gray below 4 ft										
			Moderately hard gray and tan highly weathered shale w/silty clay seams	50/9"									
			- dark gray below 8 ft	50/1"									
10			Moderately hard tan and dark gray weathered shale										
				30/0"									
15			- hard gray sandstone layer at 15 - 16 ft										
			- auger refusal at 15.6 ft										
			Moderately hard dark gray shale	30/0"									
20													
				30/0"									
25													
				30/0"									
30													
				30/0"									

COMPLETION DEPTH: 30.0 ft  
DATE: 8-20-13

DEPTH TO WATER  
IN BORING: Dry to 15.6 ft

DATE: 8/20/2013



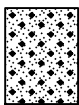
## SYMBOLS AND TERMS USED ON BORING LOGS

### SOIL TYPES

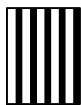
(SHOWN IN SYMBOLS COLUMN)



Gravel



Sand



Silt

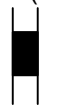


Clay

Predominant type shown heavy

### SAMPLER TYPES

(SHOWN ON SAMPLES COLUMN)



Shelby  
Tube



Rock  
Core



Split  
Spoon



No  
Recovery



Cutting

### TERMS DESCRIBING CONSISTENCY OR CONDITION

**COARSE GRAINED SOILS** (major portion retained on No. 200 sieve): Includes (1) Clean gravels and sands, and (2) silty or clayey gravels and sands. Condition is rated according to relative density, as determined by laboratory tests.

#### DESCRIPTIVE TERM

VERY LOOSE

LOOSE

MEDIUM DENSE

DENSE

VERY DENSE

#### N-VALUE

0-4

4-10

10-30

30-50

50 and above

#### RELATIVE DENSITY

0-15%

15-35%

35-65%

65-85%

85-100%

**FINE GRAINED SOILS** (major portion passing No. 200 sieve): Includes (1) Inorganic and organic silts and clays, (2) gravelly, sandy, or silty clays, and (3) clayey silts. Consistency is rated according to shearing strength, as indicated by penetrometer readings or by unconfined compression tests.

#### DESCRIPTIVE TERM

VERY SOFT

SOFT

FIRM

STIFF

VERY STIFF

HARD

#### UNCONFINED COMPRESSIVE STRENGTH TON/SQ. FT.

Less than 0.25

0.25-0.50

0.50-1.00

1.00-2.00

2.00-4.00

4.00 and higher

NOTE: Slickensided and fissured clays may have lower unconfined compressive strengths than shown above, because of planes of weakness or cracks in the soil. The consistency ratings of such soils are based on penetrometer readings.

### TERMS CHARACTERIZING SOIL STRUCTURE

**SLICKENSIDED** - having inclined planes of weakness that are slick and glossy in appearance.

**FISSURED** - containing shrinkage cracks, frequently filled with fine sand or silt; usually more or less vertical.

**LAMINATED** - composed of thin layers of varying color and texture.

**INTERBEDDED** - composed of alternate layers of different soil types.

**CALCAREOUS** - containing appreciable quantities of calcium carbonate.

**WELL GRADED** - having a wide range in grain sizes and substantial amounts of all intermediate particle sizes.

**POORLY GRADED** - predominantly of one grain size, or having a range of sizes with some intermediate sizes missing.

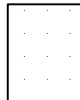
Terms used on this report for describing soils according to their texture or grain size distribution are in accordance with the UNIFIED SOIL CLASSIFICATION SYSTEM, as described in Technical Memorandum No.3-357, Waterways Experiment Station, March 1953



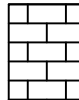


## BORING LOG TERMS – ROCK

### ROCK TYPES (SHOWN IN SYMBOLS COLUMN)



Sandstone



Limestone



Siltstone



Coal



Shale

Joint Characteristics –	<u>Spacing</u> Very Close Close Moderately Close Wide Very Wide	0.75 to 2.5 in. 2.5 to 8 in. 8 to 24 in. 2 to 6 ft More than 6 ft	Degree of Weathering –	Fresh – No visible signs of decomposition or discoloration. Rings under hammer impact.												
Bedding Characteristics –	Very Thin Thin Medium Thick Massive	0.75 to 2.5 in. 2.5 to 8 in. 8 to 24 in. 2 to 6 ft More than 6 ft		Slightly Weathered – Slight discoloration inwards from open fractures, otherwise similar to fresh.												
Lithologic Characteristics –	Clayey Shaly Calcareous (limy) Siliceous Sandy (Arenaceous) Silty Plastic Seams			Moderately Weathered – Discoloration throughout. Weaker minerals such as feldspar decomposed. Strength somewhat less than fresh rock, but cores cannot be broken by hand or scraped by knife. Texture preserved.												
Parting –	Less than 1/16 inch			Highly Weathered – Most minerals somewhat decomposed. Specimens can be broken by hand with effort or shaved with knife. Core stones present in rock mass. Texture becoming indistinct but fabric												
Seam –	1/16 to 1/2 inch															
Layer –	1/2 to 12 inches															
Stratum –	Greater than 12 inches															
Hardness–	Soft (S) – Reserved for plastic material alone.  Friable (F) – Easily crumbled by hand, pulverized or reduced to powder and is too soft to be cut with a pocket knife.  Low Hardness (LH) – Can be gouged deeply or carved with a pocket knife.  Moderately Hard (MH) – Can be readily scratched by a knife blade; scratch leaves a heavy trace of dust and scratch is readily visible after the powder has been blown away.  Hard (H) – Can be scratched with difficulty; scratch produces little powder and is often faintly visible; traces of the knife steel may be visible.  Very hard (VH) – Cannot be scratched with a pocket knife. Knife steel marks left on surface.		Solution and Void Conditions –	Completely Weathered – Minerals decomposed to soil but fabric and structure preserved (Saprolite). Specimens easily crumbled or penetrated.  Residual Soil – Advanced state of decomposition resulting in plastic soils. Rock fabric and structure completely destroyed. Large volume change.												
			Swelling Properties –	Solid, contains no voids Vuggy (pitted) Vesicular (igneous) Porous Cavities Cavernous												
			Slaking Properties –	Nonswelling Swelling												
Texture –	Fine – Barely seen with naked eye Medium – Barely seen up to 1/8 in. Coarse – 1/8 in. to 1/4 in.			Nonslaking Slakes slowly on exposure Slakes readily on exposure												
Structure –	Bedding Flat – 0° – 5° Gently Dipping – 5° – 35° Moderately Dipping – 55° – 85° Steeply Dipping – 55° – 85° Fractures, scattered Open Cemented or Tight Fractures, closely spaced Open Cemented or Tight Brecciated (Sheared and Fragmented) Open Cemented or Tight Joints Faulted Slickensides		Rock Quality Designation (RQD) –	<table><tr><th>RQD (Percent)</th><th>Diagnostic Description</th></tr><tr><td>Greater than 90</td><td>Excellent</td></tr><tr><td>75 – 90</td><td>Good</td></tr><tr><td>50 – 75</td><td>Fair</td></tr><tr><td>25 – 50</td><td>Poor</td></tr><tr><td>Less than 25</td><td>Very Poor</td></tr></table>	RQD (Percent)	Diagnostic Description	Greater than 90	Excellent	75 – 90	Good	50 – 75	Fair	25 – 50	Poor	Less than 25	Very Poor
RQD (Percent)	Diagnostic Description															
Greater than 90	Excellent															
75 – 90	Good															
50 – 75	Fair															
25 – 50	Poor															
Less than 25	Very Poor															

## **APPENDIX A**

## SUMMARY OF CLASSIFICATION TEST RESULTS

PROJECT: VA Parking Deck  
LOCATION: Little Rock, Arkansas  
JOB No.: 13-169

Boring No.	Sample Depth, ft	Water Content, %	ATTERBERG LIMITS			Percent Passing No. 200, %	UNIFIED CLASS.
			Liquid Limit	Plastic Limit	Plasticity Index		
1	4.5-5	4	26	18	8	----	Shale
2	2.5-3.5	5	27	19	8	----	Shale
3	1-2	5	28	19	9	----	Shale
4	2.5-3.5	6	29	20	9	----	Shale
5	1-2	9	30	17	13	31	GC
5	2.5-3.5	18	29	18	11	63	CL
6	4.5-5.5	22	51	21	30	71	CH
6	6.5-7.5	6	33	20	13	----	Shale