GEOTECHNICAL FEASIBILITY STUDY
PROPOSED MANUFACTURING PLANT SITE
PINE BLUFF, ARKANSAS

Report

To

DANA
TOTAL FACILITY RESOURCES
SHANNON PROPERTIES GROUP
Toledo, Ohio

GRUBBS, HOSKYN, BARTON & WYATT, INC.
Little Rock, Arkansas

June 1999

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June 7, 1999
Job No. 99-207

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Attn: Mr. Keith Recknagel

REF: GEOTECHNICAL FEASIBILITY STUDY
PROPOSED MANUFACTURING PLANT SITE
PINE BLUFF, ARKANSAS

INTRODUCTION

This report presents the results of the geotechnical feasibility study performed for the proposed manufacturing plant site in Pine Bluff, Arkansas. This study was authorized on May 17, 1999 and has been performed in general accordance with our proposal dated May 15, 1999.

We understand the project will consist of a single-story, pre-engineered metal building with approximately 132,000 sq ft footprint area. The location being considered for the plant is a 13-acre tract in Pine Bluff, Arkansas. Foundation loads are anticipated to be light. Site grading plans are not available. However, some fill is anticipated to attain a dock-high plant floor. The project will also include paved drives and parking areas.

The purposes of this study were to perform a limited exploration of subsurface conditions at the subject site and to develop general information for planning regarding foundation and pavement design and construction considerations. The following report sections discuss the results of the field and laboratory studies and recommendations are presented for foundation design and construction.

SUBSURFACE INVESTIGATION

Subsurface conditions at the project site were explored by drilling four (4) borings to depths of 5.5 to 30 ft below existing grades. The borings were drilled with a truck-mounted Failing 1500 rotary drilling rig using a combination of dry-auger and rotary-wash drilling methods. The approximate boring locations are shown on Plate 1. Descriptions of the soil stratigraphy encountered in the borings, as well as results of field and laboratory tests, are presented on the boring logs, Plates 2 through 5. A key to the terms and symbols used on the logs is included as Plate 6.

Soil samples were obtained at approximately 2-ft intervals to a depth of 10 ft and at 5-ft intervals thereafter. Undisturbed samples of the cohesive soils were obtained using a 3-inch-diameter thin-walled tube hydraulically advanced into the soil. Undrained shear strength of cohesive soils was estimated in the field using a calibrated hand penetrometer. Estimated shear strength values are plotted on the log forms, in tons per sq ft, as circles enclosing an "x".

Samples of the slightly cohesive or granular soils were obtained using a 2-inch-diameter split-barrel sampler driven into the strata by blows of a 140-lb 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 inches of an 18-inch total drive, or portion thereof, is defined as the Standard Penetration Number (N). Recorded N-values are shown on the appropriate boring logs in the "Blows Per Ft" column.

All soil samples were examined, visually classified by the field technician, and placed in appropriate containers to prevent moisture loss and/or change in condition during transfer to our laboratory for further examination and testing.

Groundwater conditions were observed during and following drilling operations. Groundwater observations are noted in the lower-right portion of each log and are discussed in subsequent sections of this report.

LABORATORY TESTING

To evaluate representative soil properties, laboratory tests consisting of shear strength tests, classification, and natural water content determinations were performed. Soil shear strength was estimated in the field using hand penetrometer and SPT results. In addition, laboratory strength

testing included one (1) unconfined compression test and one (1) unconsolidated-undrained triaxial compression test. Undrained shear strength (cohesion) determined from the results of the compression tests are plotted on the boring log at the appropriate depth, in tons per sq ft, as an open circle or open triangle, for unconfined and triaxial compression tests, respectively.

Unit dry weight and natural water content were also determined as a part of each strength test. In addition, twenty (20) natural water content determinations were performed on representative samples to develop information regarding *in-situ* soil-water content conditions for each boring. Water content results are plotted on the log forms as a solid circle in accordance with the scale and symbols shown in the legend located in the upper-right corner of the log.

To verify field classification and to evaluate plasticity of the soils, seven (7) liquid and plastic (Atterberg) limit determinations and seven (7) sieve analyses were performed. The Atterberg limits are plotted on the boring logs as pluses connected with a dashed line using the water content scale. The percent of soil passing the No. 200 sieve is noted in the "Minus No. 200" column on the appropriate log forms.

SITE and SUBSURFACE CONDITIONS

Site Conditions

The project site is located on the northwest quadrant of the Jefferson Parkway and Hutchinson Street intersection in Pine Bluff, Arkansas. The site is currently vacant and wooded. Surface drainage is considered fair to poor. The site contains several low-lying areas with wet and soft surface soils.

Site Geology

The site is located in the Gulf Coastal Plain Geophysical Province. Based on the Geologic Map of Arkansas, the site is in the mapped locale of Quaternary Terrace Deposits. The terrace deposits are typically comprised of a mixture of silt, sandy silt, silty clay, sandy gravel, clayey gravel and clay with a variable mixture of sand, gravel and clay at depth.

Seismic Conditions

The Jefferson County site is located in Seismic Zone 1; the area of low anticipated seismic damage. A Soil-Profile Type S_2 and a Seismic Site Coefficient (S) value of 1.2, in accordance with

Standard Building Code criteria, are considered appropriate for use in design. Liquefaction potential of the soils encountered within the exploration depths of the borings is considered to be minor.

Subsurface Conditions

In light of the results of the borings, subsurface conditions are considered variable, both vertically and horizontally. The surficial soils to 1- to 4-ft depth are generally comprised of very soft light gray and tan clayey silt (ML and ML-CL) and silty clay (CL) to very soft to firm brown and tan fine sandy clay (CL). The surface soils exhibit low plasticity, low shear strength and high compressibility.

The surface soils are underlain by stiff to very stiff tan and gray to reddish brown and light gray fine sandy clay (CL) and clay (CH). Some discontinuous medium dense light gray and tan clayey fine sand (SC) strata are also present. The fine sandy clay and clay exhibited moderate shear strength and low compressibility. Soil plasticity varied from low to moderate.

The generalized stratigraphy described above has been inferred between discrete and relatively widely spaced boring locations. In view of the natural variations in stratigraphy and subsurface conditions, variations in soil conditions must be anticipated. Additionally, the natural transition between soil strata is typically variable, particularly in a terrace deposit geologic environment.

Groundwater Conditions

Groundwater was measured at 3-ft depth in two (2) borings and was not encountered in the remaining borings (May 1999). We believe the shallow water represents perched water in the silty upper soils. Groundwater levels will vary with seasonal precipitation, surface runoff and infiltration and stream levels in nearby waterways.

Significant Conditions

The significant site and subsurface conditions considered pertinent to design and construction of the project are:

(a) The generally flat-lying terrain of the site, often with poor surface drainage;

(b) The presence of trees across the site;

(c) The low shear strength exhibited by the surface soils to 1- to 4-ft depth;

(d) The moisture sensitivity of the surface soils to about 1 to 4 ft, with the potential for significant reduction in shear strength and increase in compressibility when saturated and/or disturbed;

(e) The increase in shear strength and decrease in compressibility of the sandy clay predominant below about 1- to 4-ft depth;

(f) The low to moderate plasticity of the near-surface soils with low potential for shrink-swell activity; and

(g) The presence of localized shallow perched groundwater at 3-ft depth in May 1999, with potential variations in groundwater levels with seasonal conditions.

The significant conditions above have been used to develop broad conclusions regarding design and construction of facilities on the subject site.

CONCLUSIONS

Foundation Design

Foundations for structures must satisfy two (2) basic and independent design criteria. First, foundations must have an acceptable factor of safety against bearing failure under maximum design loads. Secondly, movement of foundations due to consolidation or swelling of the underlying strata should not exceed tolerable limits for the structure or equipment operational requirements. Construction factors, such as installation of foundations, excavation procedures and surface and groundwater conditions, must also be considered.

In light of the results of the borings and the site conditions, light to moderate structural loads could appropriately be supported on a shallow foundation system. Alternatively, foundation loads could be supported on drilled piers. Specific foundation considerations and recommendations will depend on the particular loading characteristics of the project being planned for the site. However, general considerations for foundation alternatives are discussed in the following report sections. Geotechnical recommendations for use in final design must be developed based on a site- and project-specific study. This will require acquiring additional data on subsurface conditions via exploration and laboratory testing.

Shallow Foundations

Light to moderate structural loads may typically be supported on continuous or individual footings founded in the natural stiff to very stiff fine sandy clay. Footing depth would be anticipated to range from about 1.5 to 4.5 ft below existing grades. Footings supported in the stiff to very stiff

fine sandy clay can probably be designed with respect to net allowable soil bearing pressures of 2500 to 3500 lbs per sq ft. These values should include a factor of safety of 2.0 to 2.5 and should limit post-construction settlement to less than 1 inch for light to moderate loads. Where sustained dynamic loads are present, the net allowable bearing capacity will be reduced.

Depending on final site grading plans, footings could also be supported in compacted, high-quality fill. Individual or continuous footings founded in select fill can commonly be designed for net allowable soil bearing pressures of 1500 to 2500 lbs per sq ft. Final bearing capacity will be a function of the specific site conditions, depth of fill and the magnitude of loads.

Individual footings should typically have a minimum dimension of 24 to 30 inches and continuous footings a minimum width of 18 to 24 inches. Perimeter footings, or footings in unheated areas, should be placed a minimum of 1.5 ft below lowest adjacent grade for frost protection.

Drilled Piers

As an alternative to shallow foundations, structural loads could be supported on drilled piers. Drilled-and-underreamed (belled) or straight-shaft piers founded at a minimum depth of 10 ft below existing grade could probably be designed for net allowable end-bearing pressures on the order of 5 to 7.5 kips per sq ft, and possibly more. Groundwater is not expected to be a problem for drilled piers installed to depths on the order of 10 to 20 ft and casing is not expected to be required. However, casing should be on site during installation, in the event it is required. A minimum shaft diameter of 24 inches is recommended.

Floor Slabs

Slab-on-fill construction should be suitable for floor slabs. For design of slabs placed on a properly-prepared subgrade of the stiff natural soils, a subgrade modulus (k) value on the order of 75 to 125 lbs per cu inch is probably suitable. If grades are raised, as-built slabs may ultimately be supported on select fill. A k value of 125 to 200 lbs per cu inch may be developed for an improved subgrade comprised of a minimum of 2 ft of select fill or aggregate base. Floor slabs should be placed on a 4- to 6-inch-thick layer of clean granular material and underlain by an impervious barrier to prevent moisture transmission.

Site Grading

Positive surface drainage should be established at the start of construction, should be maintained during the work, and incorporated into final site grades. During wet seasons some seepage into shallow excavations may occur. However, such seepage is likely to be minor and can probably be controlled with a sump-and-pump system or ditching. Excavations extending below about 5 to 8 ft are more likely to encounter significant groundwater.

Site preparation should begin with clearing and grubbing of the trees and stripping the approximately 6- to 12-inch-thick zone of organic-containing surface soils. As noted, the surface soils are moisture sensitive and relatively weak. Consequently, some undercutting should be anticipated. Depending on final grading plans and seasonal site conditions, undercuts of 2 to 4 ft, more or less, could be required. Disturbance resulting from clearing and grubbing activities may mandate mass undercut. All stump holes should be properly backfilled with compacted select fill.

Depending on seasonal site conditions, use of a geotextile may be cost effective in reducing the need for undercut in areas of deeper fill. Consideration could also be given to the use of geogrids.

Following stripping and any cut or undercut, and prior to fill placement, the subgrade should be evaluated by the Geotechnical Engineer to determine suitability. Soft, wet or loose soils should be excavated and replaced with select fill. Site preparation during wet seasons will warrant modification of these recommendations.

The on-site clayey silt and highly organic surface soils are not considered suitable for use as structural fill. The low-plasticity fine sandy clay will be suitable for select fill use. Imported borrow for fill and backfill may consist of low-plasticity sandy clay (CL), clayey sand (SC), or gravelly clay (GC) with a liquid limit less than 45, or an approved alternate. All fill and backfill should be free of organics and debris and approved by the Engineer. Any granular or slightly cohesive fill materials must be protected from erosion or contained.

Fill, backfill or recompacted on-site soils in building areas should be compacted to a specified minimum value, to be determined based on specific project requirements. Fill should typically be placed in nominal 6- to 8-inch-thick loose lifts. Each lift of fill should be properly compacted, tested and approved prior to placing subsequent lifts.

Pavements

The very soft to firm surface soils typically offer poor to very poor support for pavements. However, after clearing, grubbing and stripping some subgrade will probably be suitable for pavement subgrade. The following properties are typically suitable for use in pavement design on the natural soils in a dry and firm condition:

Subgrade: Stiff fine sandy clay
California Bearing Ratio (CBR): 3 to 5
Modulus of Subgrade Reaction (k): 75 to 100 lbs per cu inch

Where the subgrade is comprised of 12 to 24 inches of high-quality select fill, fair to good subgrade support would be anticipated. The following subgrade properties would typically be suitable for pavement design on such a subgrade:

Subgrade: Select low-plasticity fill
California Bearing Ratio (CBR): 5 to 10
Modulus of Subgrade Reaction (k): 100 to 150 lbs per cu inch

We believe that suitable asphalt or concrete pavements can be designed and constructed on the site. Specific design will depend on the traffic mix, loads, and volume. 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.

CLOSURE

This report has been prepared to provide preliminary information regarding site and subsurface conditions. The conclusions and comments contained herein have been developed based on a discrete number of widely-spaced borings. This information is intended for use in planning and conceptual design only. Specific design recommendations should be based on an appropriate geotechncial study for the project, as well as site grading plans and final structure/building layout.

* * * *

The following illustrations are attached and complete this report:

Plate 1	Plan of Borings
Plates 3 through 5	Boring Logs
Plate 6	Key to Terms and Symbols

* * * *

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

Respectfully Submitted,

GRUBBS, HOSKYN,
BARTON & WYATT, INC.

Ben Simpson, E.I.

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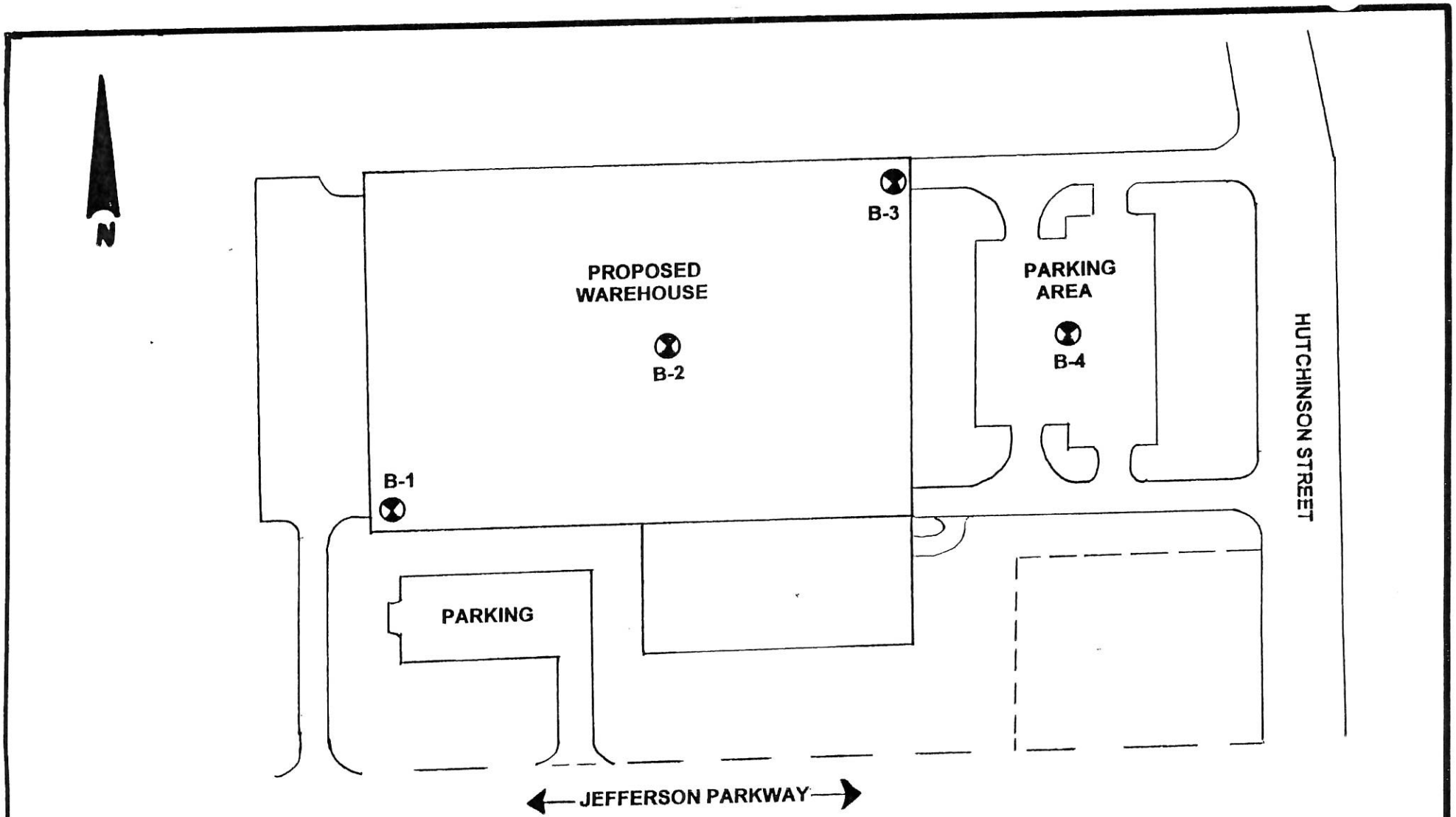
BMS/MEW/caa

Copies submitted: Dana, Total Facility Resources, Shannon Properties Group
Attn: Mr. Keith Recknagel (3+fax)



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Barton & Wyatt, Inc.
Consulting Engineers

PLAN OF BORINGS
Feasibility Study - Manufacturing Plant
Pine Bluff, Arkansas

SCALE: N.T.S.	JOB NO.: 99-207	PLATE 1 OF 6

99-207

Grubbs, Hoskyn, Barton & Wyatt, Inc.
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LOG OF BORING NO. 1

Feasibility Study - Manufacturing Plant
Pine Bluff, Arkansas

TYPE: Auger to 10 ft /Wash

LOCATION: See Plate 1

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200 %
			SURF. EL:				
			Very soft light gray and tan clayey silt w/ferrous stains, wet	1			80
5			Stiff tan and light gray fine sandy clay w/ferrous stains				77
10			Medium dense tan and light gray silty clay w/ferrous staining and light gray sand pockets	31			
15			Stiff reddish brown and light gray clay w/ferrous staining, seams and pockets and some fine sand	31			81
20			Medium dense light gray and tan clayey fine sand w/tan light gray clay seams and layers				
25			Stiff gray and brown silty clay w/ferrous staining and nodules				
30							

COMPLETION DEPTH: 30.0 ft
DATE: 5-20-99

DEPTH TO WATER IN BORING: 3 ft

DATE: 5/20/99

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PLATE 2

99-207

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LOG OF BORING NO. 2

Feasibility Study - Manufacturing Plant
Pine Bluff, Arkansas

TYPE: Auger to 10 ft /Wash

LOCATION: See Plate 1

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT / WATER CONTENT / LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200 %
			SURF. EL:				
			Firm tan silty clay w/roots				
			Very stiff tan and gray fine sandy clay w/ferrous stains and nodules - w/dark gray clay laminations to 3 ft		113		66
5							
			- more sandy, dry below 9 ft				
10							
			Very stiff reddish brown and light gray fine sandy clay w/ferrous stains and some gravel, slightly blocky				
15							
			Very stiff light gray and tan fine sandy clay w/ferrous stains				
20							
25							
			Stiff brown clay w/some fine sand and ferrous stains				
30							

LGBNEW 99-207.GPJ 6-7-99

COMPLETION DEPTH: 30.0 ft
DATE: 5-20-99

DEPTH TO WATER IN BORING: Dry

DATE: 5/20/99

PLATE 3

99-207

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LOG OF BORING NO. 3

Feasibility Study - Manufacturing Plant
Pine Bluff, Arkansas

TYPE: Auger to 10 ft /Wash

LOCATION: See Plate 1

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT / WATER CONTENT / LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200 %
			SURF. EL:				
			Firm brown fine sandy clay				
			Stiff to very stiff tan sandy clay w/ferrous stains - tan and light gray below 2 ft		107		84 81
5			- w/dark gray laminations below 6.5 ft				
10							
			Very stiff gray and brown fine sandy clay w/ferrous staining and dark gray clay laminations				
15							
20							
			Very stiff gray and dark brown clay w/ferrous staining				
25							
30			- reddish brown and gray, w/trace clay below 29 ft				

COMPLETION DEPTH: 30.0 ft
DATE: 5-20-99

DEPTH TO WATER IN BORING: Dry

DATE: 5/20/99

LGBNEW 99-207.GPJ 6-7-99

PLATE 4

99-207

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LOG OF BORING NO. 4

Feasibility Study - Manufacturing Plant
Pine Bluff, Arkansas

TYPE: Auger

LOCATION: See Plate 1

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200 %
			SURF. EL:				
			Very soft brown and tan fine sandy clay, silty w/ferrous stains				76
			- tan and light gray below 2 ft				
5			Stiff tan and light gray silty clay w/ferrous stains and little fine sand				
10							
15							
20							
25							
30							

COMPLETION DEPTH: 5.5 ft
DATE: 5-20-99

DEPTH TO WATER IN BORING: 3 ft

DATE: 5/20/99

PLATE 5

LGBNEW: 99-207.GPJ 6-7-99

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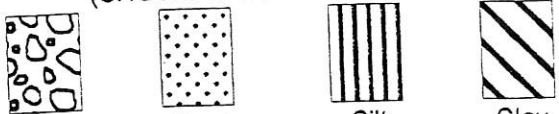
SYMBOLS AND TERMS USED ON BORING LOGS

SOIL TYPES

(SHOWN IN SYMBOLS COLUMN)

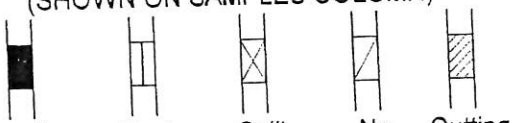


Gravel Sand Silt Clay

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 (I) 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	N-VALUE	RELATIVE DENSITY
VERY LOOSE	0-4	0-15%
LOOSE	4-10	15-35%
MEDIUM DENSE	10-30	35-65%
DENSE	30-50	65-85%
VERY DENSE	50 and above	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	UNCONFINED COMPRESSIVE STRENGTH TON/SQ. FT.
VERY SOFT	Less than 0.25
SOFT	0.25-0.50
FIRM	0.50-1.00
STIFF	1.00-2.00
VERY STIFF	2.00-4.00
HARD	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