GEOTECHNICAL INVESTIGATION REPORT

Pedestrian Bridge

47th Avenue & Arizona Canal

Glendale, Arizona

SHB Job No. E83-173

SERGENT, HAUSKINS & BECKWITH

Consulting Geotechnical Engineers

PHOENIX • ALBUQUERQUE • SANTA FE • SALT LAKE CITY

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SERGENT, HAUSKINS & BECKWITH CONSULTING GEOTECHNICAL ENGINEERS

APPLIED SOIL MECHANICS • ENGINEERING GEOLOGY • MATERIALS ENGINEERING

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January 26, 1984

Hoffman-Miller Engineers, Inc.
Consulting Engineers
3737 East Indian School Road
Suite 401
Phoenix, Arizona 85018

SHB Job No. E83-173

Attention: Lloyd W. Miller, P.E.

Re: Pedestrian Bridge
47th Avenue & Arizona Canal
Glendale, Arizona

Gentlemen,

Our Geotechnical Investigation Report on the referenced project is herewith submitted. The report includes results of test drilling, laboratory analysis and recommended criteria for foundation design.

Should any questions arise concerning this report, we would be pleased to discuss them with you.

Respectfully submitted,
Sergent, Hauskins & Beckwith Engineers

By Norman H. Wetz
Norman H. Wetz, P.E.

Reviewed by Lawrence A. Hansen
Lawrence A. Hansen, Ph.D., P.E.

Registered Professional Engineer (Civil) CERTIFICATE NO. 13872 LAWRENCE A. HANSEN Date Signed 1-26-84 ARIZONA, U.S.A.

Copies: Addressee (3)

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SHB Job No. E83-173

Pedestrian Bridge
47th Avenue & Arizona Canal
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1. INTRODUCTION

This report is submitted pursuant to a geotechnical investigation made by this firm of the site of the proposed pedestrian bridge at 47th Avenue over the Arizona Canal in Glendale, Arizona. The object of this investigation was to evaluate the physical properties of the subsoils underlying the site to provide recommendations for foundation design.

2. PROJECT DESCRIPTION

Preliminary details of the proposed construction were provided by Lloyd W. Miller, P.E., of Hoffman-Miller Engineers, Inc. Consulting Engineers.

It is understood that a single-span pedestrian bridge will cross the Arizona Canal at 47th Avenue. The approximate vertical loads at the abutments of the bridge are approximately 50 to 60 kips.

Should details involved in final design vary significantly from those as outlined, this firm should be notified for review and possible revision of recommendations.

3. INVESTIGATION

3.1 Subsurface Exploration

Two exploratory borings were drilled to depths of 25 to 30 feet below existing grade. The borings were performed using 6 5/8-inch O.D. hollow stem auger. Standard penetration testing and open-end drive sampling were performed at selected intervals in the borings. The results of the field investigation are presented in Appendix A, which includes a brief description of drilling and sampling equipment and procedures, a site plan showing the boring locations, and logs of the test borings. The field investigation was supervised by J. David Deatherage, P.E., staff engineer of this firm.

3.2 Laboratory Analysis

Moisture content determinations were made on selected drive samples recovered. The results of these tests are shown on the boring logs.

Grain-size analysis and Atterberg Limits tests were performed on selected samples. The results of these tests are presented in Appendix B.

4. SITE CONDITIONS & GEOTECHNICAL PROFILE

4.1 Site Conditions

The Arizona Canal has just been relocated in the vicinity of 47th Avenue. The pedestrian bridge will span the new portion of the Arizona Canal. The area is void of any vegetative cover due to recent construction.

4.2 Geotechnical Profile

The soils underlying the site consist of a surface layer of sandy clays and clayey sands that extend about 10 to 15 feet below existing grade. The upper 5 to 7 feet of these materials are man-made fill for the construction of the existing Arizona Canal banks. The soils vary from moderately firm to very firm. Relatively clean sand and gravel mixtures underlie the surface layer and extend the full depths of the borings. These materials vary from medium dense to very dense.

4.3 Soil Moisture & Groundwater Conditions

No free groundwater was encountered in the borings and soil moisture contents were relatively low throughout their extent, being somewhat below the plastic limit for the clayey soils.

5. DISCUSSION & RECOMMENDATIONS

5.1 Analysis of Results

Based on our experience with similar soil deposits, it is our judgement that the upper clayey soils would be weakened by moisture increases. The likelihood of moisture increases due to the adjacent Arizona Canal is quite high. In the event of substantial moisture increases in the supporting clayey soils, excessive settlements of footings would result. Thus, it is recommended that footings extend to the granular sand and gravel deposits present at 10 to 15 feet below existing grade. It appears that the most efficient foundation system would be cast-in-place concrete piers extending to the clean sand and gravel mixtures. These could either be straight or drilled-and-belled piers. Design criteria for straight, drilled, cast-in-place concrete piers are given in Section 5.2.

5.2 Straight, Drilled, Cast-in-Place Concrete Piers

5.2.1 Downward Loads

Straight, drilled, cast-in-place concrete piers are recommended. These piers should extend at least 1.0 foot into the clean sand and gravel mixtures. With this criteria, depths will range from about 11 to 16 feet. Recommended capacities are as follows:

Diameter (feet)	Safe Downward Capacity (kips)
1.5	29
2.0	52
2.5	82

Capacities apply to full dead plus live loads. A one-third increase is recommended when considering wind or seismic forces. A minimum shaft diameter of 1.5 feet is recommended for drilled foundations.

5.2.2 Estimated Settlements

It is estimated that settlements of pier foundations designed and constructed in accordance with the criteria presented herein will not exceed ½ inch. Settlements can be expected to occur rapidly, with a major portion being complete at the end of construction.

5.2.3 Resistance to Lateral Loads

Lateral resistance of drilled piers can be analyzed by methods outlined by Broms (1964)*. The materials can be assumed to be cohesive for the length that would provide lateral support, with a cohesion value (c_u) of 500 psf. The value of K_hD can be taken as 300 pounds per square inch, where k_h is the coefficient of horizontal subgrade reaction and D is the pier diameter.

Criteria given above apply to isolated piers spaced no closer than 3 diameters on center perpendicular to the line of thrust and 6 diameters on center parallel to the line of thrust.

5.2.4 Cleaning of Drilled Pier Excavations

Straight, drilled pier excavations should be advanced with a single flight auger, or bucket auger bits, to the design depth. It should be verified by inspection and measurement that excavations are open to that depth. The auger should be placed back in the holes and additional passes made to clean all loose material present in the bottom of the holes.

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*Broms, B.B., 1964, "Lateral Resistance of Piles in Cohesive Soils", ASCE, JSMFD, Volume 90, No. SM2, March, pp. 27-63.

5.2.5 Placement of Concrete

Concrete should be placed through a hopper or other device approved by the geotechnical engineer so that it is channeled in such a manner to free fall and clear the walls of the excavation and reinforcing steel until it strikes the bottom. Adequate compaction will be achieved by free fall of the concrete up to the top 5.0 feet. The top 5.0 feet of concrete should be vibrated in order to achieve proper compaction. The concrete should be designed, from a strength standpoint, so that the slump during placement is in the range of 4 to 6 inches.

5.2.5 Inspection & Construction

Continuous inspection of the construction of drilled piers should be carried out by the geotechnical engineer.

The inspector should verify proper diameter, depth and cleaning, and should also verify the nature of the materials encountered in the pier excavations. Concrete placement should be continuously observed by the inspector to ensure that it meets requirements. An inspection report should be submitted on each pier stating, in writing, that all details have been inspected and meet requirements.

It appears that drilled pier excavations can be advanced to the depths recommended with little or no caving. Caving is expected to be minimal, so that concrete quantities may be very near the neat volume indicated by the plans. Should piers extend into the clean sand and gravel mixtures, some to considerable caving and sloughing is anticipated.

TEST DRILLING EQUIPMENT & PROCEDURES

Drilling Equipment Truck-mounted CME-55 drill rigs powered with 4 or 6 cylinder Ford industrial engines are used in advancing test borings. The 4 cylinder and 6 cylinder engines are capable of delivering about 4,350 and 6,500 foot/pounds torque to the drill spindle, respectively. The spindle is advanced with twin hydraulic rams capable of exerting 12,000 pounds downward force. Drilling through soil or softer rock is performed with 6 1/2 O.D., 3 1/4 I.D. hollow stem auger or 4 1/2 inch continuous flight auger. Carbide insert teeth are normally used on the auger bits so they can often penetrate rock or very strongly cemented soils which require blasting or very heavy equipment for excavation. Where refusal is experienced in auger drilling, the holes are sometimes advanced with tricone gear bits and NX rods using water or air as a drilling fluid. Where auger and tricone gear bits cannot be used to advance the hole due to cobbles or caving conditions, the ODEX (overburden drilling with the eccentric method) is used. A percussion down-the-hole hammer underreams the hole and 5 inch steel casing is introduced into the hole during drilling. The drill bit is eccentric and can be removed from the center of the casing to allow sampling of the material below the bit penetration depth.

Sampling Procedures Dynamically driven tube samples are usually obtained at selected intervals in the borings by the ASTM D1586 procedure. In many cases, 2" O.D., 1 3/8" I.D. samplers are used to obtain the standard penetration resistance. "Undisturbed" samples of firmer soils are often obtained with 3" O.D. samplers lined with 2.42" I.D. brass rings. The driving energy is generally recorded as the number of blows of a 140 pound 30 inch free fall drop hammer required to advance the samplers in 6 inch increments. However, in stratified soils, driving resistance is sometimes recorded in 2 or 3 inch increments so that soil changes and the presence of scattered gravel or cemented layers can be readily detected and the realistic penetration values obtained for consideration in design. These values are expressed in blows per foot on the logs. "Undisturbed" sampling of softer soils is sometimes performed with thin walled Shelby tubes (ASTM D1587). Where samples of rock are required, they are obtained by NX diamond core drilling (ASTM D2113). Tube samples are labeled and placed in watertight containers to maintain field moisture contents for testing. When necessary for testing, larger bulk samples are taken from auger cuttings.

Continuous Penetration Tests Continuous penetration tests are performed by driving a 2" O.D. blunt nosed penetrometer adjacent to or in the bottom of borings. The penetrometer is attached to 1 5/8" O.D. drill rods to provide clearance to minimize side friction so that penetration values are as nearly as possible a measure of end resistance. Penetration values are recorded as the number of blows of a 140 pound 30 inch free fall drop hammer required to advance the penetrometer in one foot increments or less.

Boring Records Drilling operations are directed by our field engineer or geologist who examines soil recovery and prepares boring logs. Soils are visually classified in accordance with the Unified Soil Classification System (ASTM D2487) with appropriate group symbols being shown on the logs.

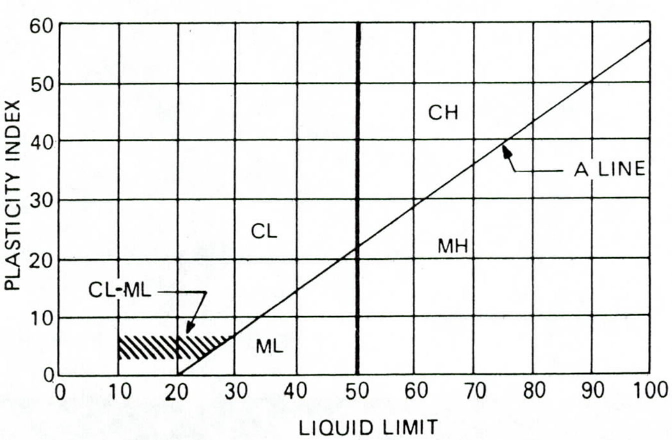
UNIFIED SOIL CLASSIFICATION SYSTEM

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

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

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

PLASTICITY CHART



DEFINITIONS OF SOIL FRACTIONS

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

TERMINOLOGY USED TO DESCRIBE THE RELATIVE DENSITY, CONSISTENCY OR FIRMNESS OF SOILS

The terminology used on the boring logs to describe the relative density, consistency or firmness of soils relative to the standard penetration resistance is presented below. The standard penetration resistance (N) in blows per foot is obtained by the ASTM D1586 procedure using 2" O.D., 1 3/8" I.D. samplers.

1. Relative Density. Terms for description of relative density of cohesionless, uncemented sands and sand-gravel mixtures.

N	Relative Density
0-4	Very loose
5-10	Loose
11-30	Medium dense
31-50	Dense
50+	Very dense

2. Relative Consistency. Terms for description of clays which are saturated or near saturation.

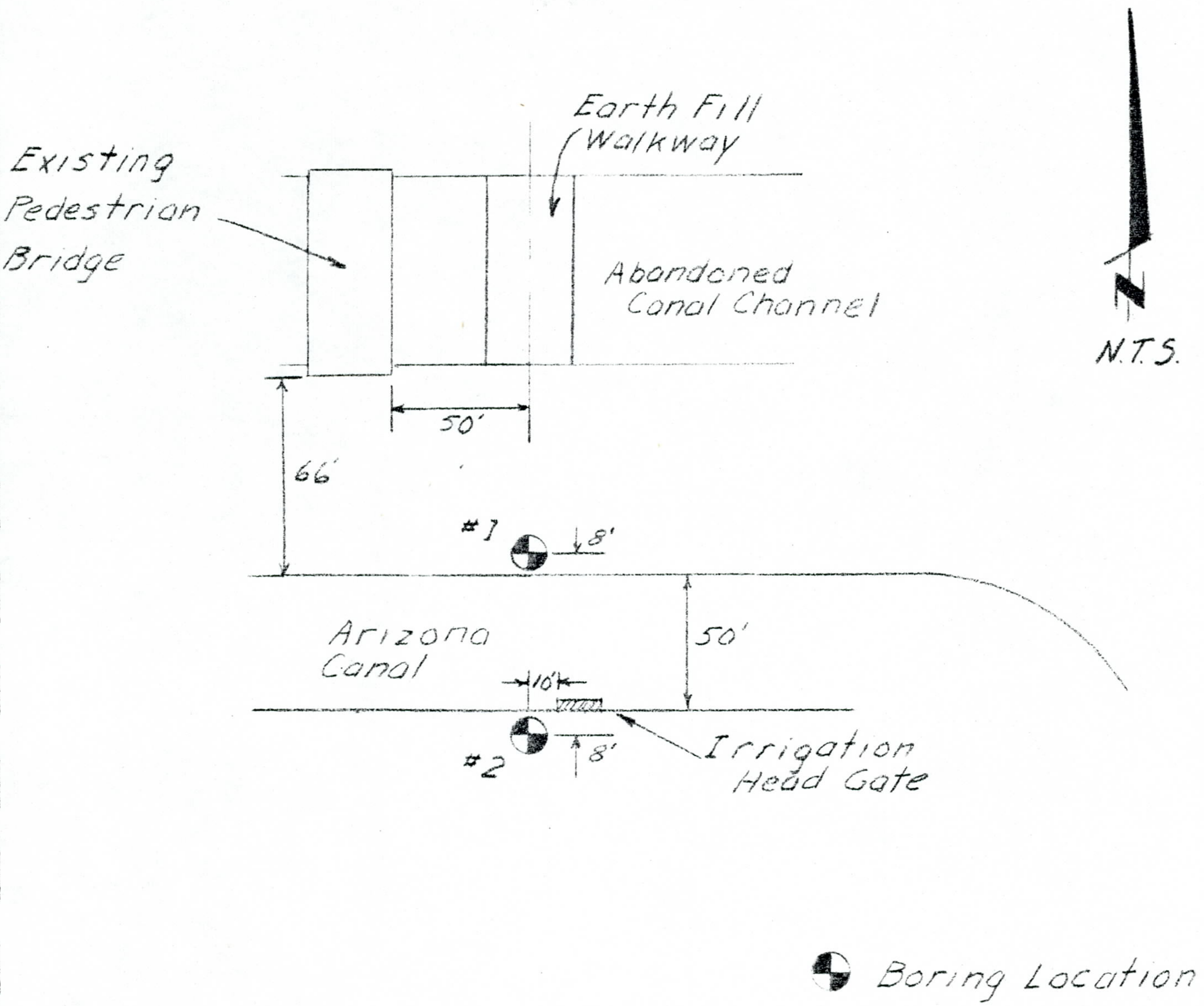
N	Relative Consistency	Remarks
0-2	Very soft	Easily penetrated several inches with fist.
3-4	Soft	Easily penetrated several inches with thumb.
5-8	Medium stiff	Can be penetrated several inches with thumb with moderate effort.
9-15	Stiff	Readily indented with thumb, but penetrated only with great effort.
16-30	Very stiff	Readily indented with thumbnail.
30+	Hard	Indented only with difficulty by thumbnail.

3. Relative Firmness. Terms for description of partially saturated and/or cemented soils which commonly occur in the Southwest including clays, cemented granular materials, silts and silty and clayey granular soils.

N	Relative Firmness
0-4	Very soft
5-8	Soft
9-15	Moderately firm
16-30	Firm
31-50	Very firm
50+	Hard

SITE PLAN

SHOWING LOCATIONS OF TEST BORINGS



Reference Drawing: "Sketch" by SHB field engineer, undated

Pedestrian Bridge
47th Avenue & Arizona Canal
Glendale, Arizona
SHB Job No. E83-173

SERGENT, HAUSKINS & BECKWITH
CONSULTING SOIL AND FOUNDATION ENGINEERS
PHOENIX • TUCSON • ALBUQUERQUE

PROJECT Pedestrian Bridge

JOB NO. E83-173 DATE 12-30-83

LOG OF TEST BORING NO. 1

RIG TYPE CME-55

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV.

DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			X	S	37		12			Man-made FILL
								CL	slightly moist very firm	SANDY CLAY, medium plasticity, light brown
5			X	S	21		16			
								CL	moist firm	SANDY CLAY, low plasticity, light brown
10			X	S	19		3			
								SW-SM	slightly moist medium dense to very dense	SAND & GRAVEL, some silt, well graded, subrounded, nonplastic, brown
15			X	S	63		3			
20			X	S	34		2	SW	slightly moist dense to very dense	SAND & GRAVEL, well graded, subrounded, nonplastic, light brown
25				S	50/5½"		4			
										Stopped auger at 24'6" Sampler refused at 24'11½"

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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PROJECT Pedestrian Bridge

LOG OF TEST BORING NO. 2

JOB NO. E83-173 DATE 12-30-83

RIG TYPE CME-55

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV.

DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			⊠	S	33		10	CL	very slightly moist; very firm to moderately firm	Man-made FILL; SANDY CLAY, low to medium plasticity, light brown
5			⊠	S	13					
10			⊠	U	19		6	SC	very slightly moist; moderately firm	CLAYEY SAND, well graded, low plasticity, light brown
15			⊠	S	54			SM-SP	slightly moist; very dense	SAND & GRAVEL, some silt, poorly graded, subrounded, weakly cemented, nonplastic, light brown to brown
20			⊠	S	37			SP	slightly moist	SAND, predominantly fine, nonplastic, light brown
25			⊠	S	58			SW	slightly moist; dense to very dense	SAND & GRAVEL, some silt, well graded, subrounded, nonplastic, light brown
30				S	50/4"					
										Stopped auger at 29'6" Sampler refused at 29'10"

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

A-6

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TABULATION OF TEST RESULTS

Job No. E83-173
W/O 1

HOLE NO	DEPTH	UNIFIED CLASS	L.L.	P.I.	#200 .75"	#100 1"	#50 1.5"	#40 2"	#30 2.5"	#16 3"	#10 3.5"	#8 4"	#4 6"	.25" 8"	.375" 10"	.5" 12"	LAB NO
1	4.5'-6'	CL	46	29	64.5	74	82	86	90	94	97	98	99	100			3-173-2
1	14.5'-16'		NA	-	8.3	10	14	17	20	31	44	50	66	72	80	89	
					100												3-173-4
2	0'-1.5'	CL	40	22	62	70	78	81	84	89	93	94	99	100			3-173-7
2	9.5'-11'	SC	26	9	17.5	22	29	34	39	51	65	70	86	91	97	99	
					100												3-173-9