GEOTECHNICAL INVESTIGATION REPORT
ASSIGNMENT NO. 2
CHANNEL IMPROVEMENT
BROADWAY ROAD TO EMF CHANNEL
CONTRACT NO. FCD 96-13
MESA, ARIZONA

AGRA
Earth & Environmental

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Submitted To:

Maricopa County Flood Control District
2801 West Durango Street
Phoenix, Arizona 85009

Submitted By:

AGRA Earth & Environmental, Inc.
3232 West Virginia Avenue
Phoenix, Arizona 85009-1502

20 March 1997

AEE Job No. 7-117-000023

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20 March 1997
AEE Job No. 7-117-000023

Maricopa County Flood Control District
2801 West Durango Street
Phoenix, Arizona 85009

Attention: **Warren Rosebraugh, P.E.**
Project Manager

Gentlemen:

RE: **GEOTECHNICAL INVESTIGATION REPORT**
ASSIGNMENT NO. 2
CHANNEL IMPROVEMENT
BROADWAY ROAD TO EMF CHANNEL
CONTRACT NO. FCD 96-13
MESA, ARIZONA

Our Geotechnical Investigation Report for the above referenced project is herewith submitted. The following sections provide the results of exploratory drilling and laboratory analysis, and present recommended criteria for the design of rigid channel liners and recommendations for channel slopes, excavation and site grading.

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

Respectfully submitted,

AGRA Earth & Environmental, Inc.

Elizabeth A. Judd, E.I.T.

Reviewed by:

Norman H. Wetz, P.E.
Senior Geotechnical Engineer

Registered Professional Engineer (Civil) CERTIFICATE NO. 12176 NORMAN HAROLD WETZ Date Signed 3/20/97 ARIZONA, U.S.A.

c: Addressee (3)
pm/J5-97/03-19-97

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APPENDICES

1.0 INTRODUCTION

This report presents the results of a geotechnical investigation by AGRA Earth & Environmental, Inc. (AEE) of the site of a proposed drainage channel, located in Mesa, Arizona. The purpose of this investigation was to evaluate the physical properties of the soils underlying the channel alignment. Based on this evaluation, recommendations are presented for rigid channel liners, site grading and channel design.

2.0 PROJECT DESCRIPTION

Details of the project were provided by Warren Rosebraugh, P.E., of Maricopa County Flood Control District. It is understood that a trapezoidal channel about 50 feet in width and about 5 to 19 feet in height is planned. The channel is located adjacent to Broadway and Higley Roads in Maricopa County, Arizona. The channel will be lined with concrete or gunite.

3.0 INVESTIGATION

3.1 SUBSURFACE EXPLORATION

Two exploratory borings were drilled to respective depths of 10 to 15 feet below existing site grades along the channel alignment. The borings were advanced using a CME-75 drill rig equipped with 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. During drilling, the encountered soils were continuously examined, visually classified and logged. The field investigation was supervised by Elizabeth A. Judd, E.I.T., of this firm.

Results of the field investigation are presented in Appendix A, including a brief description of drilling and sampling equipment and procedures, and logs of the test borings. A site plan showing the locations of the test borings is also included in Appendix A.

3.2 LABORATORY ANALYSIS

The moisture contents of selected samples recovered were determined. The results of these tests are shown on the boring logs. Grain-size analysis, Atterberg limits and density tests were performed on selected samples. The results of these tests are presented in Appendix B.

4.0 SITE CONDITIONS & GEOTECHNICAL PROFILE

4.1 SITE CONDITIONS

The site is bordered on the west side by the Roosevelt Conservation District Canal, on the north side by Broadway Road, to the east by residences, and on the south side by a golf

course. The general area is undeveloped except to the west, where a narrow band of landscaped vegetation is located between the site and the canal. This vegetation consists of small desert trees including palo verde and mesquite and is maintained by Leisure World. A moderate growth of smaller brush and wild grasses is present across the remainder of the site.

4.2 GEOTECHNICAL PROFILE

Based on the test borings, the soils underlying the channel alignment consist predominantly of clayey sand with lesser deposits of sandy silt. The clayey sands are of medium plasticity in the upper 11 feet, increasing to high plasticity below 11 feet. The sandy silt layer encountered in Boring No. 1 at a depth of 1 1/2 to 8 feet is of a low plasticity. Man-made fill consisting of clayey sand with construction debris was encountered in Boring No. 2 from the surface to a depth of 7 feet below existing grade. The relative firmness of the soils varies from moderately firm to hard.

4.3 GROUNDWATER & SOIL MOISTURE CONDITIONS

No free groundwater was encountered in the test borings and soil moisture contents were relatively low, ranging from 7 to 15 percent.

5.0 DISCUSSION & RECOMMENDATIONS

The clayey sands underlying the site have a low to moderate expansive potential and could cause damage to concrete or gunite liners if these soils experience substantial moisture increases. Removal of the more plastic soils and replacement with non-expansive soils would minimize the potential for damage. It is recommended that a minimum of 5 feet of soil (both vertically and laterally) beyond the rigid liners be removed and replaced. The greater the volume of removal and replacement of the clayey soils, the lower the risk there will be of damage. In any case, it is recommended that the existing man-made fill be removed to at least 5 feet beyond the limits of the proposed rigid liner.

As an alternative, building on the existing soils and accepting an increased risk of future maintenance of rigid liners is feasible. There will be lower initial cost with this alternative, but higher future maintenance costs. Since the channel will convey stormwater flows, the potential for moisture infiltration is reduced. Careful attention should be paid to providing sealed joints and other measures to minimize leakage.

5.1 EXCAVATIONS & SLOPES

It appears that mass excavation for the channel can be accomplished with conventional earthmoving equipment. Permanent cut slopes for channel excavations should be made no steeper than 1 1/2H:1V (horizontal to vertical). Temporary cut slopes should be made no steeper than 1H:1V.

5.2 SITE GRADING

5.2.1 Surface Preparation

All vegetation, debris and any man-made fill should be removed from areas designated for the channel alignment. The lateral extent of excavation should be to at least 5 feet laterally from the proposed finished grades.

The exposed surfaces upon which fill is to be placed should be scarified in the upper 6 inches, brought to within the range of optimum moisture content to plus 3 percent of optimum moisture content, and compacted to at least 90 percent of maximum dry density as determined by ASTM D698.

5.2.2 Structural Fill

All fill required to raise the site to subgrade elevation should be free of vegetation, debris and other deleterious materials, and should contain no particles larger than 6 inches in dimension. The plasticity index, as determined by ASTM D4318, should not exceed 15. The percentage of the structural fill finer than the no. 200 sieve should not exceed 65 percent. It appears that many of the existing site soils will not meet the above described criteria for reuse as structural fill.

All structural fill should be compacted to at least 95 percent of maximum dry density as determined by ASTM D698. The moisture content during compaction should be maintained within minus 1 to plus 3 percent of the optimum moisture content.

5.2.3 Granular Base

Granular base, where used, should meet the following grading requirements as determined by ASTM D422:

Sieve Size (Square Openings)	Percent Passing by Weight
1 1/8-inch	100
1/4-inch	38-70
no. 200	0-12

The plasticity index of the fraction of material passing the no. 40 sieve should be nonplastic when tested by ASTM D4318. Coarse aggregate should have a percent of wear, when subjected to the Los Angeles abrasion test (ASTM C131), of no greater than 45.

All granular base should be compacted to at least 95 percent of maximum dry density, as determined by ASTM D698.

APPENDIX A

FIELD INVESTIGATION

TEST DRILLING EQUIPMENT & PROCEDURES

Description of Subsurface Exploration Methods

Auger Boring Drilling through overburden soils is performed with 6 5/8" O.D., 3 1/4" I.D. hollow stem auger or 4 1/2" solid stem continuous flight auger. Carbide insert teeth are normally used on bits so they can penetrate soft rock or very strongly cemented soils. A CME-55 or CME-75 truck-mounted drill rig is used to advance the auger. The drill rigs are powered with six-cylinder Ford industrial engines capable of delivering about 7,000 to 8,400 foot-pounds torque to the drill spindle. The spindle is advanced with twin hydraulic rams capable of exerting 16,000 to 20,000 pounds downward force.

Generally, refusal to penetration of the auger is adopted as top of the SGC or river-run material, which normally requires other techniques for penetration. Grab samples or auger cuttings may be taken as necessary. Standard penetration tests or 2.42" diameter ring samples are taken in conjunction with the auger borings as needed, with the sampling interval and type being indicated on the boring logs.

Hammer Drill Drilling with the Hammer drill is accomplished with a Drill Systems AP1000 drill rig advancing a double-walled drive casing with a link-belt 180 diesel pile driving hammer, having a rated energy of 8,100 foot-pounds per blow. Where noted on the boring log, the hammer is equipped with a supercharger which can boost the energy to approximately 12,000 foot-pounds per blow. The supercharger is used only in portions of the boring where blow counts are relatively high. Cuttings are removed with compressed air by a reverse circulation process, and are collected in a cyclone from which grab samples are obtained. The drive casing is either 9" O.D. by 6" I.D. or 6 5/8" O.D. by 4" I.D. and employs an expendable bit of slightly larger diameter than the O.D. of the casing. Hammer blows required to advance the drive casing are recorded in 1' increments, as noted on the boring logs. Standard penetration tests or 2.42" diameter ring samples taken are noted on the boring logs.

Odex System The Odex (overburden drilling with the eccentric method) system, also referred to as the DTH (down-the-hole hammer) system, consists of a pneumatic-rotary percussion down-the-hole hammer operating at the bottom being drilled through a 5" diameter steel casing. The eccentric button percussion bit overreams the boreholes and allows advancement of the casing. The same compressed air or air-detergent (foam) mixture that operates the hammer also serves to expel the cuttings from the borehole, where they can be collected as grab samples. Retraction of the eccentric drill bit allows removal of the hammer from the center of the casing to facilitate standard penetration testing (ASTM D1586) where noted on the boring logs.

TEST DRILLING EQUIPMENT & PROCEDURES (CONT.)

Schramm Rotadrill The Schramm T64H truck-mounted drill rig is a top drive rotary rig capable of up to 85,500 inches/pounds of torque with a pulldown capacity of 35,000 lbs. Drilling is performed with either 4", or larger, diameter Tricone roller bits or 4" to 6" diameter down-the-hole hammer. Cutting removal is facilitated by compressed air or air/water mixtures and collected in a cyclone. Where noted on the boring logs, grab samples of the cuttings were collected. When casing is required to stabilize the borehole, an Aardvark drill through casing hammer is utilized, permitting simultaneous drilling and driving of the casing. Casing penetration is recorded on the boring logs in feet per minute. Standard penetration, 2.42" diameter ring samples, Shelby tubes, pitcher tube or Denison samples taken are noted on the boring logs.

Sampling Procedures Dynamically driven tube samples are usually obtained at selected intervals in the borings by the ASTM D1586 test 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 6 inches on the boring logs. "Undisturbed" sampling of softer soils is sometimes performed with thin walled Shelby tubes (ASTM D1587), pitcher samplers, Denison samplers or continuous CME samplers. Where samples of rock are required, they are obtained by NQ 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. Also, representative samples are obtained from the cuttings from the hammer and Schramm drill rig.

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

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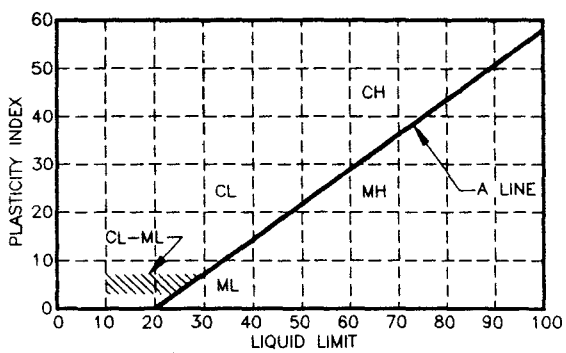
UNIFIED CLASSIFICATION SYSTEM FOR SOILS

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" ASTM Designation: D2487.

MAJOR DIVISION				GRAPH SYMBOL	GROUP SYMBOL	TYPICAL DESCRIPTION
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 sieve)			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 & HATCH 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 of high plasticity, silty soils, elastic silts.
	CLAYS (LIMITS PLOT ABOVE "A" LINE & HATCH 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, silty and 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 dual symbol.

PLASTICITY CHART



DEFINITIONS OF SOIL FRACTIONS

SOIL COMPONENT	PARTICLE SIZE RANGE
Boulders	Above 300mm (12in.)
Cobbles	300mm to 75mm (12in. to 3in.)
Gravel	75mm (3in.) to No. 4 sieve
Coarse gravel	75mm to 19mm (3in. to 3/4in.)
Fine gravel	19mm (3/4in.) 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

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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

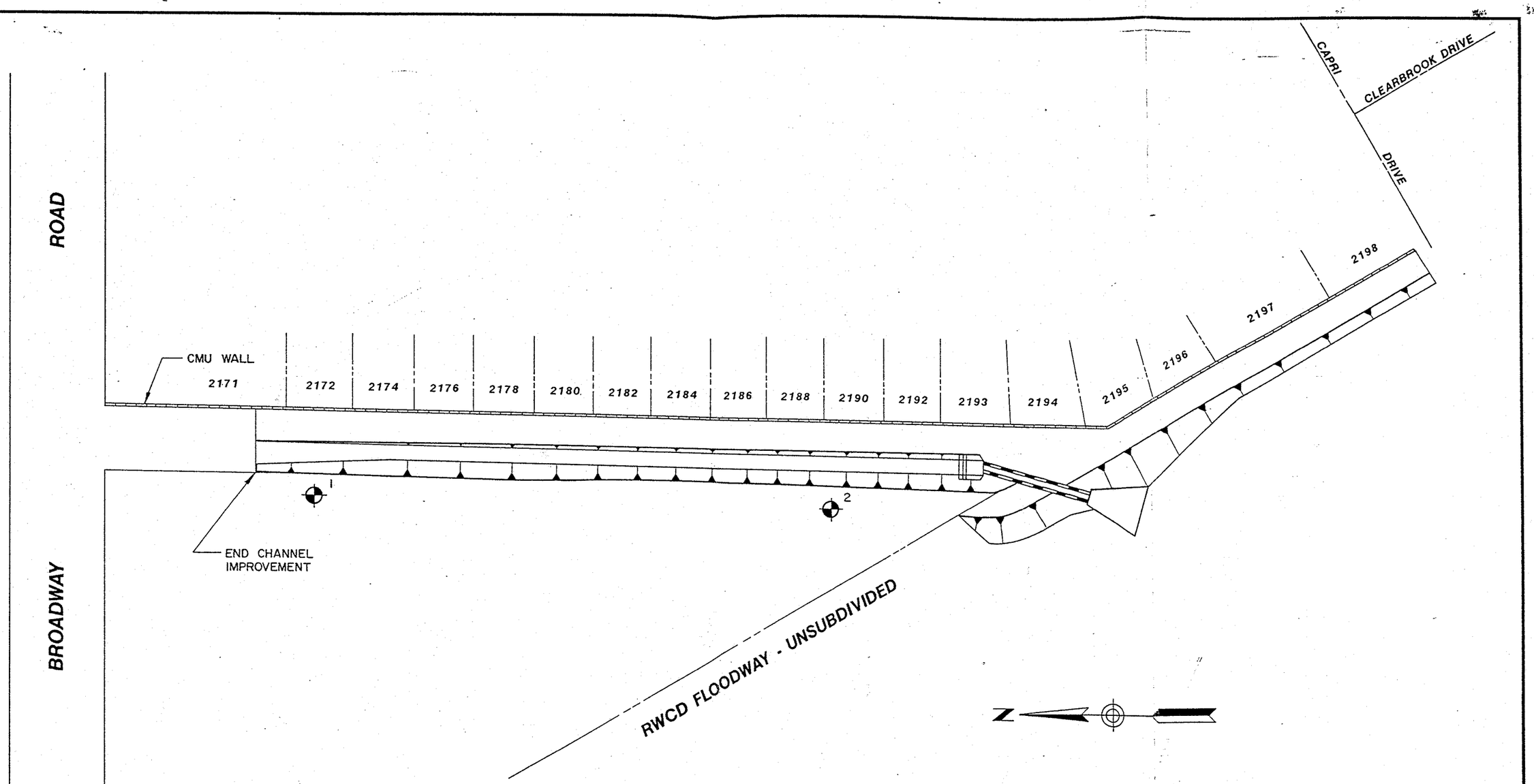
2. Relative Consistency. Terms for description of clays which are saturated or near saturation.

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

njf/M1-95/7-11-95



LEGEND

⊕ BORING LOCATION

AGRA
Earth & Environmental
3232 WEST VIRGINIA AVENUE
PHOENIX, ARIZONA, U.S.A.
85009-1502

JOB No. 7-117-000023
DESIGN BAJ
DRAWN SPG
DATE 2/97
SCALE 1"= 80'

SITE PLAN

A-5

PROJECT Assignment #2 Channel Improvements

LOG OF TEST BORING NO. 1

JOB NO. 7-117-000023 DATE 1-30-97

LOCATION See Site Plan
RIG TYPE CME-75
BORING TYPE 6 5/8" Hollow Stem Auger
SURFACE ELEV. 1246.0'
DATUM PRC Engineering

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Count	Dry Density lbs. per Cubic ft.	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	8-13-13		10	SC	slightly moist to moist, firm	**CLAYEY SAND**, trace of gravel, predominantly medium to fine grained sand, subangular to angular, medium plasticity, light brown to brown
				S	8-7-9		7		moist	**SANDY SILT**, low plasticity, brown
5				U	39	90	10	ML	moderately firm to firm	
				A						
10				S	17-21-27			SC	slightly moist, very firm	**CLAYEY SAND**, some fine grained gravel, poorly graded, subrounded to subangular, weakly lime cemented, medium plasticity, light brown
										Stopped Auger at 10' Stopped Sampler at 11'6"
15										
20										
25										

7-117-000023.GWH 03/07/97

GROUNDWATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A - Drill cuttings.
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.
C - 6" O.D. Continuous Core

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PROJECT Assignment #2 Channel Improvements

LOG OF TEST BORING NO. 2

JOB NO. 7-117-000023 DATE 1-30-97

LOCATION See Site Plan
RIG TYPE CME-75
BORING TYPE 6 5/8" Hollow Stem Auger
SURFACE ELEV. 1246.0'
DATUM PRC Engineering

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Count	Dry Density lbs. per Cubic ft.	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	17-19-15				slightly moist to moist	Man-made FILL **CLAYEY SAND**, trace of gravel, predominantly fine to medium grained, medium plasticity, light brown to brown
				A						
				U	39	115	10	SC	very firm to moderately firm	note: some concrete particles from 0 to 1', some styrofoam particles from 3' to 4'
5				S	5-7-7					
				U	51	111	12	SC	slightly moist	**CLAYEY SAND**, some fine grained gravel, poorly graded, subrounded to subangular, weakly lime cemented, medium plasticity, light brown
10				S	10-13-11				very firm to firm	
								SC	slightly moist	**CLAYEY SAND**, trace of gravel, predominantly medium to fine grained sand, weakly lime cemented, high plasticity, light brown
15				S	15-29-30		15		firm to hard	
										Stopped Auger at 15' Stopped Sampler at 16'6"
20										
25										

7-117-000023.GWH 03/07/97

GROUNDWATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A - Drill cuttings.
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.
C - 6" O.D. Continuous Core

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APPENDIX B

LABORATORY TESTING

AGRA Earth & Environmental, Inc.

PROJECT: ASSIGNMENT #2 CHANNEL IMPROVEMENT
LOCATION: BROADWAY RD TO EMF CHANNEL

JOB NO: 7-117-000023
WORK ORDER NO: 1
DATE SAMPLED: 01-30-97

MECHANICAL SIEVE ANALYSIS
GROUP SYMBOL, USCS (ASTM D-2487)

SIEVE SIZES

				Silt or	SAND								GRAVEL								COBBLES		
				Clay	Fine			Medium			Coarse		Fine				Coarse						
Location & Depth	USCS	LL	PI	#200	#100	#50	#40	#30	#16	#10	#8	#4	1/4"	3/8"	1/2"	3/4"	1"	1 1/2"	2"	3"	4"	6"	Lab #

PERCENT PASSING BY WEIGHT

#1 @ 0.0 - 1.5'	SC	34	19	46	58	66	68	71	77	83	85	92	94	97	98	100	100	100	100	100	100	100	1
#1 @ 2.5 - 4.0'	ML	20	1	51	72	85	88	89	93	96	96	98	99	100	100	100	100	100	100	100	100	100	2
#2 @ 0.0 - 2.5'	SC	35	19	48	62	69	71	74	81	87	89	95	97	99	99	100	100	100	100	100	100	100	6
#2 @ 15.0 - 16.5'	SC	68	39	39	47	53	57	60	70	81	85	94	97	99	100	100	100	100	100	100	100	100	12

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PROJECT:	ASSIGNMENT #2 CHANNEL IMPROVEMENT	**JOB NO:**	7-117-000023
LOCATION:	BROADWAY RD TO EMF CHANNEL	**WORK ORDER NO:**	1
MATERIAL:	SEE BELOW	**LAB NO:**	SEE BELOW
SAMPLE SOURCE:	SEE BORING	**DATE SAMPLED:**	01-30-97

UNDISTURBED DENSITY (ASTM D-2937 SECT. 8.0)

RING DIAM.	6.15	cm
RING HT.	2.54	cm
VOL. OF RING	4.60	cu.in

LAB #	MAT'L	BORING	WET WT. (gr)	DRY WT. (gr)	MOISTURE	RINGS (#)	WW + RINGS (gr)	WT. RINGS (gr)	DRY DENSITY (pcf)
3	----	#1 @ 5.0-6.0'	676.0	616.6	9.6%	4	656.6	181.7	89.6
8	----	#2 @ 2.5-3.5'	934.0	850.9	9.8%	6	1184.3	271.4	114.7
10	----	#2 @ 7.5-8.5'	892.0	794.0	12.3%	5	983.9	227.8	111.4