FCD – Engineering Div.

GEOTECHNICAL INVESTIGATION REPORT
EAST PAPAGO - HOHOKAM - SKY HARBOR FREEWAYS SOUTH BANK PROTECTION

Soil Nail Wall

ADOT PROJECT NO. 202L MA H 0855 01D
ARIZONA DEPARTMENT OF TRANSPORTATION
MARICOPA COUNTY, ARIZONA

AGRA
Earth & Environmental

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FCD – Engineering Div.

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MARICOPA COUNTY, ARIZONA

Soil Nail Wall

Submitted To:

DMJM
300 West Clarendon Avenue
Suite 335
Phoenix, Arizona 85013-3499

Submitted By:

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22 August 1994

AGRA Job No. E87-56
Letter No. 1205

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22 August 1994
AGRA Job No. E87-56
Letter No. 1205

DMJM
300 West Clarendon Avenue
Suite 335
Phoenix, Arizona 85013-3499

Attention: Thomas M. Monchak, P.E.

Gentlemen:

**RE: EAST PAPAGO - HOHOKAM -
SKY HARBOR FREEWAYS
SOUTH BANK PROTECTION SYSTEM
ADOT PROJECT NO. 202L MA H 0855 01D
ARIZONA DEPARTMENT OF TRANSPORTATION
MARICOPA COUNTY, ARIZONA**

Our Geotechnical Investigation Report addressing the south bank protection for the portion of the Salt River between McClintock Drive and a point approximately 3600 feet east is submitted herewith. The report includes results of our field investigation and laboratory analysis, soil nail wall design and construction information, man-made fill removal criteria and recommendations for materials to be used in construction of the south bank protection.

Should any questions arise concerning this letter, please do not hesitate to contact us.

Respectfully submitted,

AGRA Earth & Environmental, Inc.

Charles E. Reynolds
Staff Engineering Geologist
Project Manager

Reviewed by:

Registered Professional Engineer (Civil)
CERTIFICATE NO.
12176
NORMAN HAROLD
WETZ
Date Signed 8/22/94
ARIZONA, U.S.A.

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

c: Addressee (9)

njf/J5-94/8-19-94

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Sheet 2 - Site Plan & Typical Sections - Temporary Soil Nailed Wall
Sheet 3 - Vertical Views - Temporary Soil Nailed Wall

Registered Professional Engineer (Civil)
CERTIFICATE NO.
12176
NORMAN HAROLD
WETZ
Date Signed 8/22/94
ARIZONA, U.S.A.

1.0 INTRODUCTION

This report presents the results of a geotechnical investigation addressing the south bank protection in the area between McClintock Drive and a point 3600 feet east completed by AGRA Earth & Environmental, Inc. (AGRA E&E). The report provides information and recommendations for removal of man-made fill materials, construction of a temporary soil nailed wall and materials to be used for construction of the south bank protection.

2.0 PROJECT DESCRIPTION

Details related to the location of the proposed bank protection were provided by Simons Li & Associates, Inc. (SLA). The alignment for the proposed bank protection system is shown on the site map (Sheet 1) included in the map pocket. The south bank protection will provide flood protection for the properties located south of the Salt River. It is suspected that many of the properties adjacent to the Salt River contain landfill deposits.

The south bank will consist of approximately 3600 feet of embankment protected with cement stabilized alluvium (CSA) along the south bank of the Salt River. The CSA will be about 8 feet wide and will extend 15 to 20 feet below the proposed channel grade. The CSA will be placed at a slope of 1.5:1 (horizontal to vertical).

3.0 INVESTIGATION

3.1 REVIEW OF EXISTING DATA & BORING LOGS

Reports and boring logs of previous geotechnical and environmental investigations performed by this firm (SHB, 1990a, 1990b, 1991, 1993)* in the project area were reviewed as part of the present investigation. The locations of these borings are shown on the site plan presented in the map pocket (Sheet 1).

3.2 SUBSURFACE EXPLORATION

Five borings (GT-1 through GT-5, inclusive) were drilled by Layne Environmental Services to a depth of up to 49 feet below existing grade utilizing an AP-1000 percussion hammer drill rig. In addition to the test borings, two backhoe test pits (GTP-1 and GTP-2) were excavated to depths approximately 17.5 feet below existing grade along the proposed alignment for the bank protection system.

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* References are listed at the end of this report.

AGRA E&E's field engineer continuously observed drilling and test pit operations, visually classified the soils, packaged and labeled soil samples, and prepared the boring and test pit logs. Results of the field investigation are presented in Appendix A, which includes a brief description of drilling and sampling equipment and procedures, boring and test pit logs. A site plan showing boring and test pit locations is included in the map pocket (Sheet 1). Coordinates and elevations of the borings and test pits are shown on the boring and test pit logs.

3.3 LABORATORY ANALYSIS

Grain-size analysis and Atterberg limits tests were performed on selected samples. Results of these tests are presented in Appendix C.

4.0 SITE CONDITIONS & GEOTECHNICAL PROFILE

4.1 SITE CONDITIONS

The project site generally is located along the existing south bank of the Salt River. A major portion of the current study area is located within the active Salt River floodplain. The topography of the parcels extending from the Perry Lane Landfill eastward to the Old Tempe Landfill is relatively flat. The northern portions of the parcels drop off steeply to the active channel of the Salt River. The property west of the Perry Lane Landfill that extends to McClintock Drive consists of an eroded river floodplain terrace, dropping off gradually to the north into the Salt River channel. The area between McClintock Drive and the Perry Lane Landfill generally consists of undisturbed native soils.

The elevations of the land surface over the study area vary between approximately 1145 and 1185 feet above mean sea level. The flat surface of the Perry Lane Landfill, which extends east to the Old Tempe Landfill, ranges in elevation from approximately 1170 to 1185 feet. The north side of these fill deposits drops off steeply to the Salt River channel, to an elevation of about 1150 feet. Elevations for the parcel west of the Perry Lane Landfill range from about 1170 feet on the south side to about 1145 feet on the north side.

The photos presented in Appendix B depict man-made fill materials excavated from selected test pits during this and previous investigations. Photo Nos. 1 through 10, inclusive, show man-made fill materials encountered in test pits excavated in the area of the Perry Lane Landfill. Photo Nos. 11 through 15, inclusive, characterize material encountered in test pits in the area of an inactive construction debris landfill located on ADOT parcels 7-6335 and 7-6617 (see site plan).

4.2 GEOTECHNICAL PROFILE

The native soils encountered in the borings can be generalized as being sand, gravel and cobble (SGC) deposits with small amounts of clay. In the near-surface deposits (generally above elevation 1100 to 1140 feet), the SGC is relatively clean and contains little or no clay.

Below these deposits, the SGC contains varying amounts of clay and clay-coated particles. The SGC deposits typically are dense to very dense and extend to about elevation 1050 to 1062 feet. Though dominated by gravel and cobbles 6 to 12 inches in diameter, boulders as large as 30 inches in greatest dimension can be encountered.

Man-made fills encountered during this and previous investigations were predominantly composed of silty sands with gravel and cobbles, and inert construction debris, consisting but not limited to Portland cement concrete rubble, reinforced concrete pipe, glass shards, and bricks. Also included in the man-made fill deposits was rubbish which is the organic fraction of construction debris that includes but is not limited to wood reels, boards, cables, landscape rubble, grass clippings, yard trimmings, palm fronds, tree trunks and logs. Some municipal solid waste also is included in portions of the man-made fills, which includes but is not limited to household waste (clothing, plastic and paper) and wastes resulting from the processing, handling, preparation, cooking, and serving of food. Man-made fills were encountered in soil borings and test pits located in the area of the Perry Lane Landfill and inactive construction debris landfill; these fills extended to depths of up to 45 feet below the ground surface. Material quantity estimation was beyond the scope of this investigation.

4.3 GROUNDWATER CONDITIONS

Groundwater was encountered during this investigation in Borings GT-1, GT-2 and GT-3 at depths of 30 to 35 feet below existing ground surface (elevation 1109 to 1122 feet). The groundwater levels fluctuate greatly due to flows in the Salt River. The fluctuations between long periods of no flow and flow in the river channel, based on previous borings, can be as much as 70 to 80 feet.

5.0 DISCUSSION & RECOMMENDATIONS

5.1 DISCUSSION

The man-made fills will have to be removed prior to the construction of the CSA embankment. The man-made fills predominantly are located in the area from the Perry Lane Landfill east to the Old Tempe Landfill. Removal of the man-made fill will require excavating up to 45 feet below the existing surface.

Because the man-made fill deposits are located within a Superfund site, excavation should be minimized so as to remove only those materials that may affect the structural integrity of the CSA embankment. The granular material available on-site, both native and excavated fill materials, may be acceptable for use to construct a CSA embankment and fill the existing pits in the Salt River channel. However, the material will require various degrees of processing to provide a reasonably uniform and properly graded material for the CSA embankment. The cement content required for the CSA will be higher for the SGC materials that contain clay than those that are relatively clean. Recommended gradation and placement criteria for these materials are presented in Section 5.3.

Soils located west of the Perry Lane Landfill (west of approximate project Station 15+00) appear to be native soils, based on the blow counts recorded during drilling and visual inspection of the material. It is possible that some of these soils in the upper 10 feet have been the result of scour and redeposition. Thus, some minor amounts of debris may be encountered in the upper 10 feet. Any deleterious materials or man-made fills encountered during excavation for construction of the CSA embankment should be removed prior to placement of the CSA.

5.2 MAN-MADE FILLS

Man-made fills are present along the proposed alignment for the south bank protection system. The man-made fill deposits extend from the Perry Lane Landfill at the western limit, approximately Station 15+00, to the Old Tempe Landfill at the eastern limit, approximately Station 30+00. The man-made fill materials encountered are described in Section 4.2 of this report and are detailed in the test pit and boring logs presented in Appendix A. Photos 1 through 15 in Appendix B show materials excavated during this and previous investigations from test pits located on ADOT Parcels 7-6341, 7-6614, 7-6615, and 7-6616.

5.2.1 Construction Considerations for Excavating Man-Made Fills

The vertical extent of man-made fills within the structural foundation of the CSA embankment should be completely removed to the contact with the native SGC unit. The lateral limits of the man-made fill should be completely removed, to the extent possible, within the established project right of way.

We recommend that the Plan for Controlled Removal of Man-Made Fills and the Contractor's Work Plan, approved by the United States Environmental Protection Agency (EPA), for ADOT Project RAM 600-5-507 be implemented for removal of the man-made fills described above.

5.3 SOIL NAILED WALL

A soil nailed wall is proposed to minimize excavation of man-made fills between approximately Stations 15+00 and 24+20. The wall will be located along the southern right of way boundary between the noted stations. The computer program SOILNAIL, developed by Suang S. Cheng, P.E., of this firm, was utilized for the design analysis. The program is based on Shen and others (1981) with slight modifications.

It was assumed for analysis that the soil nailed wall will be installed vertically. The design bond stress of the man-made fill is based on a friction angle of 28° and a cohesion of 150 psf, recommended by Mitchell (1992). The bond stress of the SGC is based on a friction angle of 38° and a cohesion of 100 psf. Details of the analysis for the proposed wall design are presented in Appendix D for various wall heights. Construction plans are presented on Sheets Nos. 2 and 3 in the map pocket and construction specifications are presented in Appendix D.

5.4 CEMENT STABILIZED ALLUVIUM

Soil-cement or roller-compacted-concrete (RCC) can be used for bank protection. However, availability of the required type of aggregate for these two alternatives governs construction costs. The fines content (defined as percent finer than the no. 40 sieve) of the SGC does not meet the conventional requirements for either soil-cement or RCC construction. If either of these alternatives are to be used, fines will have to be imported from a borrow source to achieve a conventional mix.

It is our opinion that the Salt River alluvium can provide adequate bank protection without the addition of fines if the embankment material is plant mixed on the site. Based on previous studies, the following guidelines for gradation are recommended:

Sieve Size (Square Openings)	Percent Passing by Weight
3 Inch	100
No. 4	30-65
No. 200	0-8

The materials should be free of organic or other deleterious material and contain no clay lumps larger than 1 inch in diameter. The plasticity index should be no greater than 25 when tested in accordance with the requirements of AASHTO T-90.

Where materials are nonplastic, a cement content of 6 to 7 percent is estimated to be required to achieve a 7-day compressive strength of 750 psi. Where the SGC materials are clayey and have a plasticity index of 10 to 25, a cement content of 8 to 10 percent is estimated to be required. The clay will have an adverse effect on the strength of the proposed cemented embankment materials. It is recommended that a mix design be performed using the specific materials proposed for construction. Where possible, the clayey SGC should be avoided in the production of CSA bank protection.

5.5 EMBANKMENT FILL & BACKFILL OF LOW AREAS IN SALT RIVER CHANNEL

It is understood that the proposed south bank will be constructed with materials available on-site, and that these materials also may be used to fill the low areas in the Salt River channel. The back slope of the embankment may be as steep as 2:1 (horizontal to vertical). No structures or paved roadways are planned for areas where fills will be placed in accordance with the specifications presented herein.

The recommended gradation for embankment fills to be located behind the CSA are as follows:

Sieve Size (Square Openings)	Percent Passing by Weight
12 Inch	100
6 Inch	80-100
No. 4	25-60
No. 200	0-15

The fill should be free of organic or other deleterious material. The plasticity index should not exceed 15 when tested in accordance with the requirements of AASHTO T-90. This material should be placed in accordance with Section 203-5.03 of ADOT Standard Specifications for Road and Bridge Construction (1990), with the exception that layer thickness can be increased from 8 inches to 12 inches. Embankment fills should be compacted to at least 95 percent of maximum density in accordance with Arizona Test Methods 225, 226, 227, 230 or 231 and 232.

The recommended gradation specification for materials to be used in backfilling of low areas within the Salt River channel are given as follows:

Sieve Size (Square Openings)	Percent Passing by Weight
24 Inch	100
No. 4	20-60
No. 200	0-30

The fill should be free of organic or other deleterious materials. The placement of these materials should be in accordance with Section 203-10.03 of ADOT Standard Specifications for Road and Bridge Construction (1990). The material should be compacted to at least 85 percent of maximum density as determined by Arizona Test Methods 225, 226, 227, 230 or 231 and 232.

It is likely that the backfill and embankment materials cannot be tested for density using conventional test methods because of the presence of large size particles. Thus, a minimum roller specification is recommended as follows for those materials that are to coarse for conventional compaction testing:

- A minimum of four passes of a 50-ton vibratory roller having a minimum frequency of vibration during operation of 1,000 cycles per minute, and minimum dynamic force of 40,000 pounds at the operating frequency; or

- A minimum of eight passes of a 10-ton vibratory roller having a minimum frequency of vibration during operation of 1,000 cycles per minute, and minimum dynamic force of 30,000 pounds at the operating frequency.

The maximum roller speed during operation should be no greater than 2.5 miles per hour.

The type and size of roller should be verified and approved by the Engineer prior to construction.

5.6 ESTIMATED STRENGTH PARAMETERS

The estimated strength parameters for properly compacted granular embankment fill, as specified herein, and native undisturbed SGC are as follows:

Material	ϕ°	c, psf	γ_T, pcf
Embankment Fill	36	0	130
Native SGC	40	0	135

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Arizona Department of Transportation (ADOT), 1990, Standard Specifications for Road and Bridge Construction, ADOT, Phoenix, Arizona.

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Shen, C.K. and others, 1981, An In-Situ Earth Reinforcement Lateral Support System, Report No. 81-03, Department of Civil Engineering, University of California, Davis, March.

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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.

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.

TEST DRILLING EQUIPMENT & PROCEDURES (CONT.)

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.

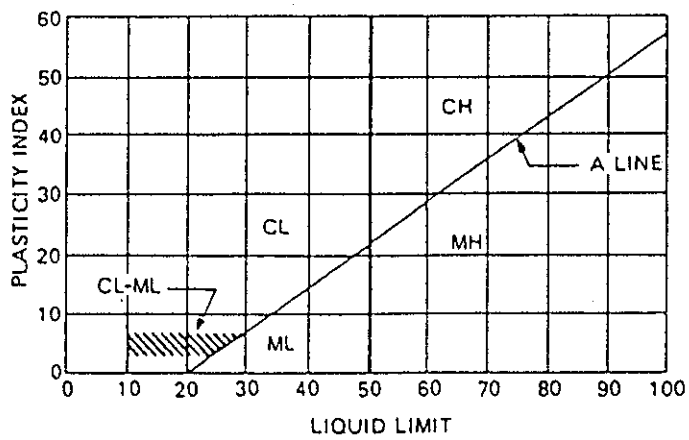
UNIFIED SOIL CLASSIFICATION SYSTEM

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 0.3 meter (foot) is obtained by the ASTM D1586 procedure using 5.1 centimeter (2-inch) O.D., 3.5 centimeter (1 3/8-inch) 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 centimeters with fist.
3-4	Soft	Easily penetrated several centimeters with thumb.
5-8	Medium stiff	Can be penetrated several centimeters 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

PROJECT East Papago Freeway 215,000 CFS
Conceptual Alignment South Hardbank

LOG OF TEST BORING NO. GT-1

JOB NO. E87-56 DATE 6-27-94

Location: N885765 E503513

RIG TYPE AP-1000
BORING TYPE 9" Dual Percussion
SURFACE ELEV. 1144.1'
DATUM Anderson Nelson Survey (ADOT)

Depth in Feet	Drill Rate Min/Ft.	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	60.0								slightly moist to moist	**SANDY GRAVEL TO CLAYEY GRAVEL**, some cobbles, trace of small boulders, predominantly coarse grained, subangular to subrounded gravel, fine to medium grained sand, weakly lime cemented, medium plasticity, brown
	94.0									
	70.0									
	69.0									
	129.0							GP-	dense	
5	35.0			A			5	GC		
	106.0									
	67.0									
	105.0									
	90.0									
10	125.0									
	79.0									
	71.0									
	70.0									**SANDY GRAVEL & COBBLES**, some silt, well graded sand, predominantly coarse grained subangular to subrounded gravel, nonplastic to low plasticity, brown
	53.0			A			2		moist to very moist to wet below 35'	
15	71.0									
	36.0									
	91.0									
	73.0									
	74.0								medium dense to dense	note: 1'6" thick clay lense at 28'
20	62.0									
	37.0									
	60.0									
	51.0									
	39.0									
25	51.0							GP		
	41.0									
	50.0									
	26.0									
	40.0									
30	72.0									
	78.0									
	55.0									
	50.0									
	89.0									
▽ 35	76.0									
	112.0									**SAND, GRAVEL & COBBLES**, trace of silt & clay, predominantly medium grained sand, predominantly coarse grained subrounded to subangular gravel, nonplastic, brown
	98.0									
	78.0									
	75.0									
40	91.0									
	58.0									
	91.0									
	50.0								wet	
	67.0									
45	63.0							GP	dense to very dense	
	140.0									Stopped Casing bit at 49' grouted hole from 0 to 49'
	110.0									
	88.0									
50										

GROUNDWATER

	DEPTH	HOUR	DATE
▽	35.0	8:22a	6-27-94
▼			

SAMPLE TYPE

C - California tube Sample
A - Drill cuttings
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
NR - No Recovery

AGRA EARTH & ENVIRONMENTAL INC.

PROJECT East Papago Freeway 215,000 CFS
Conceptual Alignment South Hardbank

LOG OF TEST BORING NO. GT-2

JOB NO. E87-56 DATE 6-27-94 Location: N885404 E503017

RIG TYPE AP-1000
BORING TYPE 9" Dual Percussion
SURFACE ELEV. 1152.2'
DATUM Anderson Nelson Survey (ADOT)

Depth in Feet	Drill Rate Min/Ft.	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									slightly moist medium dense	**SAND & GRAVEL**, trace of silt, some cobbles, predominantly medium to coarse grained sand, poorly graded, subrounded to rounded gravel, weakly lime cemented, nonplastic, brown note: sand lense from 11' to 13'
	38.0									
	38.0									
	111.0									
	62.0									
5	89.0							GP		
	89.0									
	48.0									
	139.0									
	48.0									
10	25.0									
	16.0									
	87.0			A			2			
	51.0									
	61.0									
15	91.0									
	88.0									
	94.0									
	63.0									
	43.0									
20	49.0								moist to very moist medium dense to very dense	**SAND, GRAVEL & COBBLES**, trace of silt & clay, predominantly medium grained sand, poorly graded gravel, subrounded to rounded, nonplastic to low plasticity, brown note: some interbedded sand lense (1' thick) from 20' to 30' note: sand lense from 32' to 35' note: possible small boulder at 36'
	55.0									
	36.0									
	47.0									
	29.0									
25	34.0									
	78.0									
	42.0							GP		
	57.0									
▽ 30	62.0									
	47.0									
	51.0									
	28.0									
	34.0									
35	29.0									
	50.0									
	206.0									
40										Stopped Casing bit at 37' grouted hole from 0 to 37'
45										
50										

GROUNDWATER

	DEPTH	HOUR	DATE
▽	30.0	11:20a	6-27-94
▼			

SAMPLE TYPE
C - California tube Sample
A - Drill cuttings
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
NR - No Recovery

AGRA EARTH & ENVIRONMENTAL INC.

PROJECT East Papago Freeway 215,000 CFS
Conceptual Alignment South Hardbank

LOG OF TEST BORING NO. GT-3

JOB NO. E87-56 DATE 6-27-94 Location: N886028 E504121

RIG TYPE AP-1000
BORING TYPE 9" Dual Percussion
SURFACE ELEV. 1152.2'
DATUM Anderson Nelson Survey (ADOT)

Depth in Feet	Drill Rate Min/Ft.	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	23.0								slightly moist	Man-made FILL
	30.0									**SILTY SAND TO SAND**, some gravel, cobbles & small boulders,
	24.0									
	40.0								loose to medium dense	predominantly fine to medium grained sand, subangular to subrounded,
	45.0									nonplastic, brown
5	83.0									
	60.0									note: considerable boulders from 0 to 10'
	43.0									
	72.0									
	94.0			A						
10	26.0							SW-		note: clayey sand & gravel lense at 14'
	26.0							SM		
	19.0									note: sand lense at 20'
	17.0									
	8.0									
15	5.0			A						
	7.0									
	8.0									
20	9.0									
	10.0			A			11			
	9.0									
	9.0									
	9.0									
25	9.0									
	14.0									
	59.0									
	79.0									**SAND, GRAVEL & COBBLES**, trace
	79.0								moist to wet	of silt, predominantly medium grained
30	105.0									sand, poorly graded gravel, subrounded
	72.0							GP		to rounded, nonplastic, brown
	73.0								dense to very dense	
	82.0									note: large cobbles or small boulders
	46.0									at 32'
35										Stopped Casing bit at 35' grouted hole from 0 to 35'
										note: moved hole 10' east due to encountering boulders or concrete block in 1st hole at 3'
40										
45										
50										

GROUNDWATER

DEPTH	HOUR	DATE
34.0	2:25p	6-27-94

SAMPLE TYPE
C - California tube Sample
A - Drill cuttings
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
NR - No Recovery

AGRA EARTH & ENVIRONMENTAL INC.

PROJECT East Papago Freeway 215,000 CFS
Conceptual Alignment South Hardbank

LOG OF TEST BORING NO. GT-4

JOB NO. E87-56 DATE 6-27-94

Location: N885803 E504434

RIG TYPE AP-1000
BORING TYPE 9" Dual Percussion
SURFACE ELEV. 1175.1'
DATUM Anderson Nelson Survey (ADOT)

Depth in Feet	Drill Rate Min/Ft.	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	29.0								slightly moist to moist	Man-made FILL **CLAYEY SAND**, some silt, gravel & cobbles, predominantly medium grained sand, subrounded, medium plasticity, brown
	19.0									
	27.0									
	23.0									
	17.0								loose	
5	20.0			A						note: sand lense at 10'
	26.0									
	28.0									
	36.0									note: increase in plasticity in lens at 12'
	26.0									
10	20.0			A			4	SC		note: decrease in amount of clay grading to silty sand below 28'
	18.0									
	20.0									
	21.0									note: increase in amount of gravel in lens at 23'
	7.0									
15	16.0									
	5.0									
	10.0									
	10.0									
	14.0									
20	11.0			A			4			
	45.0									
	58.0									
	65.0									
	16.0									
25	61.0								moist	**SAND, GRAVEL & COBBLES**, trace of silt & clay, predominantly medium to coarse grained sand, poorly graded gravel, subrounded to rounded, nonplastic to low plasticity, brown
	79.0									
	105.0									
	147.0								dense to very dense	
	77.0							GP		
30	93.0									
	77.0									
	125.0									
	168.0									
	139.0									
35										Stopped Casing bit at 35' grouted hole from 0 to 35'
40										
45										
50										

GROUNDWATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

C - California tube Sample
A - Drill cuttings
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
NR - No Recovery

AGRA EARTH & ENVIRONMENTAL INC.

PROJECT East Papago Freeway 215,000 CFS
Conceptual Alignment South Hardbank

LOG OF TEST BORING NO. GT-5

JOB NO. E87-56 DATE 6-28-94 Location: N885755 E503922

RIG TYPE AP-1000
BORING TYPE 9" Dual Percussion
SURFACE ELEV. 1173.6'
DATUM Anderson Nelson Survey (ADOT)

Depth in Feet	Drill Rate Min/Ft.	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	76.0								slightly moist	Man-made FILL **SILTY SAND & GRAVEL**, trace of clay & cobbles, predominantly coarse grained sand, subrounded to rounded, low plasticity, brown
	47.0									
	64.0									
	24.0								medium dense to dense	
	25.0									
5	30.0									
	124.0									note: concrete fragments at 7'
	127.0			A				GM		
	104.0									note: asphaltic fragments at 9' & rubber at 10'
	79.0									
10	52.0									note: possible void from 12' to 13'
	8.0									
	50.0									
	98.0									
	45.0									
15	48.0			A						
	41.0									
	36.0									
	35.0									
	24.0									
20	13.0			A			4		moist	Man-made FILL **SAND**, trace of silt, fine to medium grained, subangular to subrounded, nonplastic, reddish brown
	12.0									
	10.0								loose	
	12.0									
	13.0									
25	12.0									note: some gravel & cobbles at 27'
	19.0									
	22.0									
	24.0									
	18.0							SP		
30	21.0			S	6-12-12					
	23.0									
	19.0									
	23.0									
	16.0									
35	14.0									
	16.0									
	27.0									
	86.0									
	69.0									
40	105.0			A			7		moist	**CLAYEY SAND, GRAVEL & COBBLES**, some silt, predominantly medium grained, subrounded to rounded, medium plasticity, brown
	86.0									
	76.0									
	55.0								dense to very dense	
	96.0							GP-		
45	84.0							GC		
	108.0									Stopped Casing bit at 49' grouted hole from 0 to 49'
	11.0									
	92.0									
50										

GROUNDWATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE
C - California tube Sample
A - Drill cuttings
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
NR - No Recovery

AGRA EARTH & ENVIRONMENTAL INC.

PROJECT East Papago Freeway 215,000 CFS
Conceptual Alignment South Hardbank

LOG OF TEST PIT NO. GTP-1

JOB NO. E87-56 DATE 7-13-94

GROUNDWATER		
DEPTH	HOUR	DATE
	none	

BACKHOE TYPE Link-belt LS 2650
LOCATION N885811 E504424
ELEVATION 1175.5'
DATUM Anderson Nelson Survey (ADOT)

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0						slightly moist to moist	Man-made FILL **CLAYEY SAND**, some to considerable silt, gravel & cobbles & construction debris, predominantly medium grained, subrounded to subangular, low to medium plasticity, light brown to brown note: construction debris comprised of reinforced concrete fragments up to 6' in maximum dimension, some culverts 3' in diamter, plastic sheeting, bricks, PVC & steel pipe, lumber & galvanized steel sheeting
5					SC		note: tree stump (4' diameter) at 11' note: some organic vapors
10							
15							
					SP	moist	Man-made FILL **GRAVELLY SAND**, predominantly fine grained, subrounded to subangular, nonplastic, light brown
20							Stopped Trackhoe at 17'6"
25							

SAMPLE TYPE
B - Undisturbed Block Sample.
D - Disturbed Bulk Sample.
U - 3" O.D. 2.42" I.D. Tube Sample

AGRA EARTH & ENVIRONMENTAL, INC

PROJECT East Papago Freeway 215,000 CFS
Conceptual Alignment South Hardbank

LOG OF TEST PIT NO. GTP-2

JOB NO. E87-56 DATE 7-13-94

GROUNDWATER		
DEPTH	HOUR	DATE
	none	

BACKHOE TYPE Link-belt LS 2650
LOCATION N885797 E504258
ELEVATION 1176.2'
DATUM Anderson Nelson Survey (ADOT)

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0						slightly moist to moist	Man-made FILL **SILTY GRAVEL**, some cobbles, considerable sand, some construction debris, predominantly fine grained, subrounded to subangular, low plasticity, brown note: construction debris consists of reinforced concrete fragments, some plastic strapping, rebar, plastic bags, lumber & tree branches, electrical wiring & scrap metal
5					GM		
10							
15							
					SP	moist	**GRAVELLY SAND**, predominantly fine grained, subrounded to subangular, nonplastic, light brown
							Stopped Trackhoe at 18'
20							
25							

SAMPLE TYPE
B - Undisturbed Block Sample.
D - Disturbed Bulk Sample.
U - 3" O.D. 2.42" I.D. Tube Sample

AGRA EARTH & ENVIRONMENTAL, INC

APPENDIX B

SELECTED SITE PHOTOGRAPHS

Photo 1. Clayey sand with silt, gravel and cobbles excavated from GTP-1. Other components include construction debris.

Photo 2. Tree stump and reinforced concrete pipe excavated from GTP-1.

Photo 3. Silty gravel and cobbles excavated from GTP-2. Note well-distributed construction debris.

Photo 4. Construction debris excavated from GTP-2.

Photo 5. Silty sand, gravel and cobbles excavated from THB-14. Minor components include construction debris.

Photo 6. Clayey sand and gravel excavated from THB-12.

Photo 7. Silty sand and gravel excavated from THB-11. Note concrete rubble upper left and lower right portions of the photo.

Photo 8. Sand, gravel and cobbles excavated from THB-10.

Photo 9. Silty gravel and concrete excavated from THB-9.

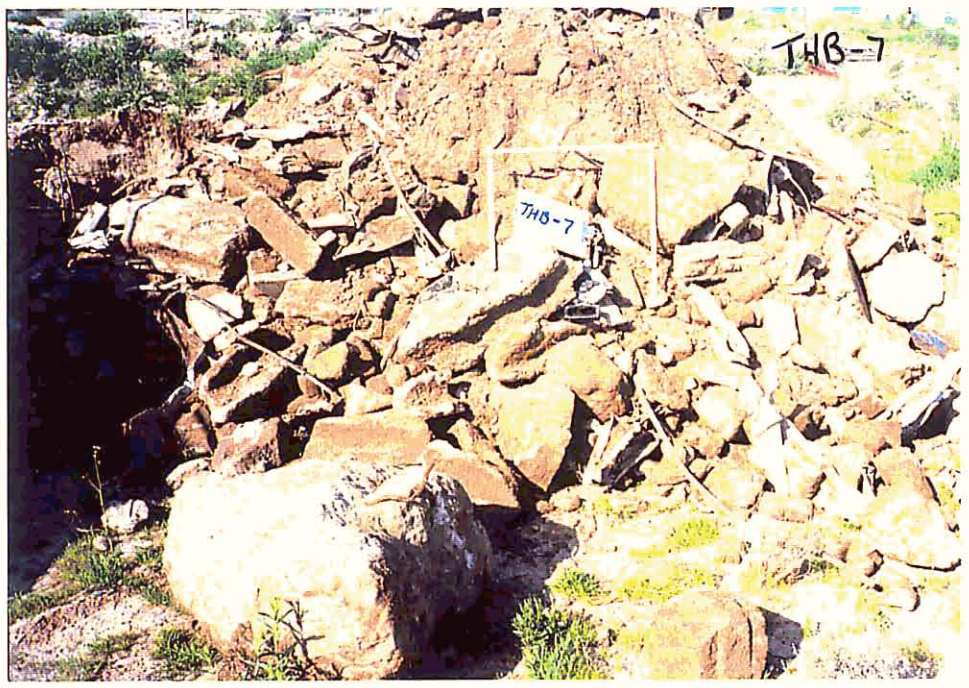


Photo 10. Construction debris and silty sand and gravel excavated from THB-7.

Photo 11. Test Pit THB-6.
Note considerable reinforcing rods, cable and concrete.

Photo 12. Silty sand and gravel excavated from THB-5.
Note large concrete block in the foreground.

Photo 13. Silty sand and gravel with construction debris excavated from THB-2.

Photo 14. Test pit THB-2. Note considerable concrete and assorted construction debris.

Photo 15. Construction debris and rubbish with sand, gravel and cobbles excavated from THB-1. Note considerable amount of wood and organic material.

APPENDIX C

LABORATORY TESTING

AGRA Earth & Environmental

TABULATION OF TEST RESULTS

Job No. E87-56
W/O 77

HOLE NO	DEPTH	UNIFIED CLASS	L.L.	P.I.	SIEVE ANALYSIS-ACCUM % PASSING #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
GT-1	5'-12'	GP-GC	34	20	6.5	9	13	16	19	22	24	24	28	31	36	42	
					54	64	79	100									7-56-1507
GT-1	14'-19'	GP	NV	NP	4.4	7	11	13	15	19	22	23	30	33	40	47	
					60	69	80	93	100								7-56-1508
GT-2	12'-18'	GP	NV	NP	4.1	7	13	18	24	36	42	42	47	55	60	67	
					75	81	88	93	100								7-56-1509
GT-3	21'-26'	SW-SM	NV	NP	10	13	25	41	58	73	77	77	80	82	85	86	
					88	90	91	92	96	100							7-56-1512
GT-4	10'-20'	SC	35	15	19	22	28	32	39	57	64	65	71	73	77	80	
					90	93	95	96	100								7-56-1514
GT-4	20'-25'	SM	NV	NP	13	26	50	61	69	79	81	81	84	88	93	95	
					98	99	100										7-56-1515
GT-5	20'-28'	SP	NV	NP	4.9	11	43	62	75	92	96	96	98	98	99	99	
					99	100											7-56-1518
GT-5	40'-45'	GP-GC	38	18	9.1	12	15	17	21	31	35	36	41	44	50	54	
					65	76	87	87	100								7-56-1519

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APPENDIX D

TECHNICAL SPECIFICATIONS

TECHNICAL SPECIFICATIONS FOR TEMPORARY SOIL NAILED WALLS

1.0 QUALIFICATIONS

1.1 The Contractor shall submit a reference list of at least four successfully completed soil nailed or ground anchor retaining wall projects during the last five years. The reference list shall include a brief description of each project with Owner's name and project location.

1.2 Prior to the start of work, the Contractor shall submit a project personnel list, identifying the Engineer or Superintendent, drill rig operators and on-site supervisors assigned to the project. The Superintendent shall have a minimum of two years experience and the drill operators and on-site supervisors shall have a minimum one year experience installing soil nails or ground anchors.

2.0 GENERAL

2.1 The major elements of the work include a 920-foot long soil nailed wall system along the south bank of Salt River as shown in the plans. The soil nailed wall system will consist of removing soil in front of the wall, drilling auger holes to the lengths specified in the construction plans, installing the nails, placing grouts, installing wire mesh and applying the shotcrete on the wall facing.

2.2 The soil nailed wall location and elevations, shown on the construction plans, are based on the topo map provided by Arizona Department of Transportation (ADOT) and shall be verified by the Contractor on-site before proceeding with the work. The nailed wall location and elevation will be adjusted according to the verified stations and elevations.

2.3 The nailed wall system shall be completed in accordance with these specifications and in reasonably close conformity to the lines and details shown on the construction plans or established by the Engineer.

2.4 The Contractor shall submit a construction plan to the Engineer for approval. The submittal shall include:

- The proposed schedule and construction sequence.
- Method of staged excavation and excavation equipment.
- Drilling methods and equipment.

- Certified grout and shotcrete mix design.
- Soil nail testing equipment including jacking frame, bracing and calibration records of jack pressure gauges.

2.5 All nail testing and excavation work shall be performed after the approval of the submittal outlined in Section 2.4. All excavation shall be carried out in accordance with the construction sequence plan approved by the Engineer.

3.0 SOIL CONDITIONS & DESIGN ASSUMPTION

3.1 The general soil profile present at the site includes man-made fill extending to depths of 20 to 40 feet from the ground surface overlying the native sand, gravel and cobbles (SGC). The soil nailed wall will extend to at least the top of the SGC.

3.2 The man-made fills consist of silty sands with gravel and cobbles, and construction debris. Construction debris may include concrete rubble, landscape rubble, wood reels, glass shards and bricks. One piece of reinforced concrete pipe and a tree trunk were encountered in the test pits. Details of the items encountered are described in SHB's investigation report (SHB Job No. E87-56, Letter No. 1056). It is anticipated that the soil nails can be installed with conventional augers. Casing or augercast installation may be required. Temporary battered face or flash coat the face to temporarily stabilize the exposed man-made fill shall be anticipated.

3.3 The native SGC is medium dense to dense with a trace of silt and generally is uncemented. A combination of rotary-percussive drilling and casing shall be anticipated for the native SGC.

3.4 The regional water table is assumed to be below the bottom of excavation. A fluctuating water level shall be anticipated, especially when the Salt River is flooded.

3.5 A nominal soil unit weight of 115 pcf, and a general surcharge of 200 psf for spoil materials or light construction equipment have been used for the design. Heavy construction equipment closer than 15 feet to the wall facing is considered unacceptable.

3.6 Soil reinforcement has been designed for the following factors of safety:

Nail Adhesion F.S. = 1.5
General Shear Failure F.S. = 1.25
Reinforced Steel Failure F.S. = 1.5

4.0 MATERIALS

4.1 NAILS

4.1.1 No. 8 and 10 nail bars shall be Grade 60 steel conforming to ASTM A617 and 1-inch threadbar shall be Grade 150 threadbar conforming to ASTM A722, as specified in the construction plans. Alternative nail bar schedules may be used based on the design loads, specified in the construction plans, with the approval of the Engineer. If alternative nail bars are used, all nail bars shall be sized such that the design load does not exceed 67 percent of yield strength of the steel. All bars shall be clean and free of excessive rust and mill scale at the time of installation. Bars shall not be welded.

4.1.2 Grout shall comply to all applicable requirements of ACI 318 and ADOT specifications. Grout shall be a pumpable mixture with a minimum 28-day compressive strength of 3,000 psi. The Contractor shall submit the mix design to ADOT for approval.

4.2 WELDED WIRE FABRIC & WALER STEELS

Welded wire mesh to be used in the shotcrete shall be 6" x 6" 2.5W/2.5W and shall confirm to ASTM A82 and A185, or approved equivalent. Steel bars shall be no. 4 deformed steel bars conforming to ASTM A615, or approved equivalent.

4.3 SHOTCRETE

Shotcrete applied to the facing of the nailed wall shall be a pumpable mixture with a minimum 28-day compressive strength of 3,000 psi. The Contractor shall submit the mix design to ADOT for approval.

4.4 STRAIN GAUGE

Strain gauges shall be weldable vibrating wire gauges. The Contractor shall submit the selected strain gauge part number and indicator for approval.

5.0 INSTALLATION

5.1 Nails shall be installed at the locations, and to the lengths and inclinations shown on the construction plans. The nail pattern may be modified by the Contractor with approval by the Design Engineer. Welded wire mesh and the steel waler bars shall be installed at the locations shown on the construction plans. Shotcrete shall be applied to the lines and thickness shown on the construction plans. The allowable tolerances shall be:

Nail Position	± 1 foot in any direction
Nail Length	- 0 feet
Nail Inclination	± 5 degrees
Shotcrete Thickness	- 0 inch
Auger Hole Diameter	- 0 inch

5.2 The nail position may be modified with the approval of the Engineer, when large concrete rubble are encountered.

5.3 Nails shall be installed in a horizontal sequence, with the ground elevation on the excavated side no more than 3 feet below the level of the nail to be installed.

5.4 Nail bars shall be placed in the predrilled holes to the length shown on the construction plans. Auger holes shall be drilled without loss of ground, which may require casing or augercast installation methods. Auger holes shall not be drilled with bentonite or water without the approval of the Engineer. As soon as drilling is completed, clean bars, centered in the middle third of the hole by centralizers, shall be placed in the hole. The hole shall be tremie grouted. The space between the top of grout and the top of hole shall be filled with shotcrete.

5.5 If water is encountered in the hole, the hole shall be flushed with air, and the nail shall be proof tested as specified in Section 6.0.

5.6 Welded wire mesh shall be placed over exposed soil, using spacers to keep mesh 2 inches from the exposed soil face. Waler bars shall be attached to the mesh as shown on the construction plans.

5.7 Welded wire mesh laps shall be 12 inches minimum. Waler bars shall be lapped a minimum of 18 inches with laps staggered of 3 feet from laps on adjacent bars.

5.8 Shotcrete shall be applied in the same work shift as the soil is trimmed to final line. The Engineer may extend the open time to 24 hours, if site conditions permit.

5.9 Soil below the level from which nails are installed may be excavated two days after nail installation or after the shotcrete on the preceding lift has reached 25 percent of its 28-day strength and the nail grout has reached 50 percent of its 28-day strength.

6.0 NAIL TESTING

6.1 SACRIFICIAL NAILS

6.1.1 Before production nailing begins, sacrificial nails shall be installed with the same equipment and methods to be used for the production work. The sacrificial nails shall be tested such that the soil/nail bond stress will reach the assumed ultimate value at the maximum test load. Any change in equipment or methods including but not limited to drill rigs, drill tools, and drilling and grouting sequences, shall required re-validation by installing one additional test nail. The sacrificial nails shall have a free length of 6 feet minimum or direct by the Engineer. Steel bars for the sacrificial nails shall be sized such that the test load does not exceed 80 percent of the yield strength of the steel. A total five sacrificial nails shall be installed as indicated below:

Maximum Depth of Nail Head (feet)	Design Adhesion (kips/foot)	Bond Length (feet)	Free Length (feet)	Test Load (kips)	No. of Test Nails
10	1.5	10	10	25.0	2
20	2.0	10	15	30.0	2
30	3.0	10	25	45.0	1

6.1.2 The sacrificial nails at 10-foot depth shall be installed on the wall at an inclination of 15 degrees, between the location of the production nails, if applicable. The locations of the tests will be decided by the Engineer such that they are representative of the field conditions. Validation tests may be performed at shallower depths than indicated or at steeper drilled angle, at the Contractor's option. However, the additional overburden may be required to achieve the indicated adhesion.

6.1.3 The sacrificial nails deeper than 10 feet shall be installed vertically. The locations of these sacrificial nails will be directed by the Engineer.

6.1.4 Production nail length, diameter and/or spacing will be adjusted on the basis of the above test results so there is a minimum factor of safety of 1.5 against pullout and 1.25 against shear failure. Minimum hole diameter shall be 6 inches.

6.1.5 The test nails shall be tested as follows:

- Measurements of the nail head position shall be taken to 0.001 inch using a minimum of two independent, calibrated dial gages, with the top of ram as the position being measured. Gages to measure nail deformation shall use a tripod or similar reference point standing on the ground in front of the test nail and independent of jack and the reaction block.

- The nail shall be seated using a small load, which shall be released. The loading jack shall use a reaction frame to distribute the load over the soil face.

- The nail shall be loaded in increments of approximately 25 percent of the design load, with each load held for 5 minutes, up to test load presented in Section 6.1.1. The nail deflection shall be noted at 0, 1 and 5 minutes. The deflection shall be noted at 0, 1, 2, 3, 5, 10, 20 and 30 minutes once the final test load is reached, for creep measurements. Creep measurements can be terminated by the Engineer if the deflection rate recedes.

- The plot of creep against log time shall be linear or show a decreasing rate of creep at the ultimate soil bond stress used in the design of production nails. In addition, the creep rate shall be less than 0.08 inch per log cycle at the final test load.

- The nail shall be unloaded and reloaded to the test load in increments of 25 percent of design load. The deflection shall be noted.

- The maximum total nail displacement at the ultimate test load shall not exceed 0.5 inch beyond the elastic deformation of free length plus one half of the bond length.

6.1.6 The testing procedure may be modified if necessary by the Engineer, in order to obtain more meaningful results.

6.2 PRODUCTION NAILS

6.2.1 Three percent of production nails shall be proof tested to 133 percent of design load as shown on the construction plans. Nail to be proof tested shall be grouted only in the anchor zone and shall have un-grouted free zone. Upon completion of testing, the free zone shall be tremie grouted with grout, as specified in Section 4.0. Temporary casing, such as PVC, shall be provided as necessary to prevent caving of the open portion of the drilled holes during testing.

6.2.2 For the proof test, the nails shall be loaded in increments of approximately 25 percent of the design load with each load held for 2 minutes. The nail deflection shall be noted at 0, 1 and 2 minutes.

6.2.3 Additional tests shall be performed for nails where water is encountered in the drilled hole.

6.2.4 In any case, the test results of nails failing the proof test shall be evaluated by the Engineer for remediation.

7.0 MONITORING

7.1 Surface settlement points shall be installed at ground level along the wall. In addition, survey points on the wall face shall be installed in two rows, one at the top row of nails and the second at the mid-height of the wall. The surface settlement points and survey points on the wall shall have a horizontal spacing of 50 feet. Initial readings shall be obtained by a licensed surveyor or by ADOT at least one week prior to the start of excavation. All points shall be monitored by the Contractor, based on the initial readings, no less than once weekly during excavation and twice a month thereafter until the construction of the bank protection is completed.

7.2 Nails in each row at Stations 19+20 and 21+70 shall be instrumented with strain gauges at the Contractor's expense. The Contractor shall provide a strain gauge indicator during the construction of the soil nailed wall. The strain gauge indicator shall be available for the Engineer in the construction site during the project period.

7.3 The strain gauges shall be mounted to the bar in pairs at each 7-foot spacing throughout the entire length of the nails. The first strain gauge for each nail shall be located 2 feet from the wall facing. The nails used for the strain gauges shall be 1-inch Grade 150 threadbar conforming to ASTM A722. Alternative nail bars for the strain gauges can be only used with approval of the Engineer. The gauge pairs shall be mounted on opposite sides of the bar. The gauges shall be microwelded to the bar and the complete gauge, sensor, and wire assembly protected from moisture. All wire connections shall be of an approved water-proof type. Installation and protection of the strain gauges and connections shall be in accordance with the manufacturer's specifications.

7.4 One control panel shall be located at the instrumentation sections. The control panel shall be attached to a steel or wooden post which is firmly secured in the soil. The control panel shall be located a distance of 3 to 5 feet behind the top of the nailed wall. All instrumentation wiring to the control panel shall be done in accordance with the manufacturer's specifications. The control panel shall be sealed and waterproof. All above-ground wiring shall be enclosed in a conduit which is firmly attached to the control panel. All instrumentation control panel wiring shall be done during instrument installation.

7.5 Inclinometers will be installed by ADOT within 3 feet of the instrumented nails prior to excavation, if possible, or prior to the second row of nails being installed. The nails adjacent to the inclinometer shall be drilled at a skew of 5 degrees away from inclinometers. The Contractor shall prevent damage of the inclinometers during nail installation. If the inclinometer is damaged during construction of the nailed wall, a replacement inclinometer will be installed at the Contractor's expense. The cost of installation and measurement of the inclinometer will be borne by ADOT.

7.6 All monitoring reports for both survey and strain gauges measurement, shall be sent directly to Engineer the day following the measurement.

7.7 The control panel and inclinometer shall be left on the project site intact after construction of nailed wall is completed.

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C.OP. | CONTRACT
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FINANCE | FILE
C.&.M.
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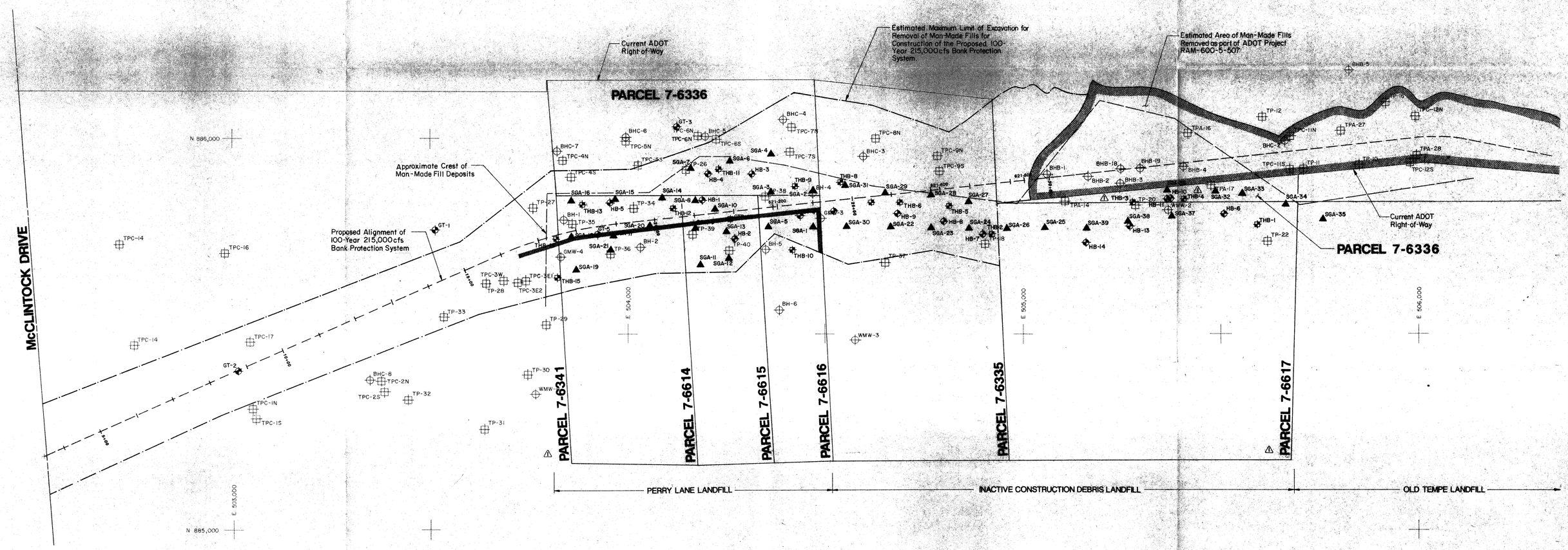

LEGEND

SPECIAL SYMBOLS

- CURRENT HARDBANK INVESTIGATION BORING LOCATION
- CURRENT HARDBANK INVESTIGATION TEST PIT LOCATION
- CURRENT HARDBANK INVESTIGATION SHALLOW SOIL GAS TEST LOCATION
- PREVIOUS INVESTIGATION BORING LOCATION
- PREVIOUS INVESTIGATION TEST PIT LOCATION

SPECIAL ABBREVIATIONS

GT–	TEST BORING
HB–	TEST BORING, SHB LETTER No. 1119
THB–	TEST PIT, SHB LETTER No. 1119
SGA–	SHALLOW SOIL GAS, SHB LETTER No. 1119
GTP–	TEST PIT
BH–, BHA–, BHB–, BHC–	PREVIOUS INVESTIGATION TEST BORING
TP–, TPA–, TPC–	PREVIOUS INVESTIGATION TEST PIT
WMW–	WATER MONITOR WELL INSTALLED DURING PREVIOUS INVESTIGATION
GMW–	GAS MONITOR WELL INSTALLED DURING PREVIOUS INVESTIGATION

- PROPERTY BOUNDARY
- ADOT RIGHT-OF-WAY
- APPROXIMATE CREST OF MAN-MADE FILLS
- PROPOSED ALIGNMENT OF 100-YEAR 215,000CFS BANK PROTECTION SYSTEM
- ESTIMATED MAXIMUM LIMIT OF MAN-MADE FILL REMOVAL
- ESTIMATED LOCATION OF PROPOSED SOIL NAILED WALL
- 5+00 APPROXIMATE HARDBANK STATIONING

NOTE: BASE MAP PREPARED WITH INFORMATION PROVIDED BY SIMONS LI & ASSOCIATES, GMTS CONSULTING ENGINEERS, DMJM AND THE ARIZONA DEPARTMENT OF TRANSPORTATION.

N

0 100' 200'
SCALE: 1" = 100'

No.	DESCRIPTION	DATE
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SITE PLAN
SHOWING SAMPLING LOCATIONS INVESTIGATION OF CONCEPTUAL ALIGNMENT OF 100-YEAR 215,000 CFS HARDBANK

EAST PAPAGO - HOHOKAM - SKY HARBOR FREEWAYS TEMPE ARIZONA

JOB No.	DATE	DESIGNED BY	DRAWN BY	CHECK BY	SHEET No.
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ADMIN | LMGT
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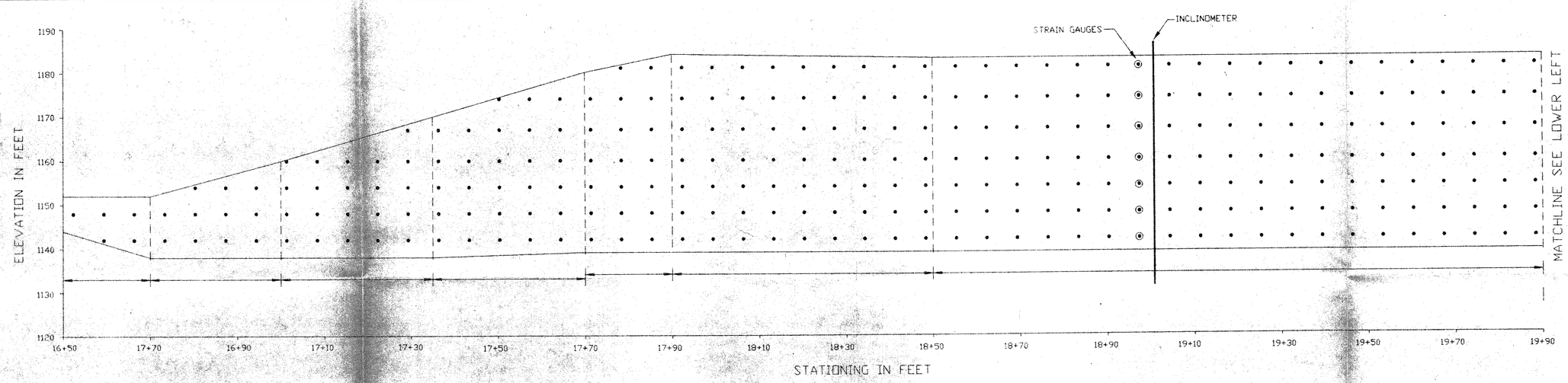

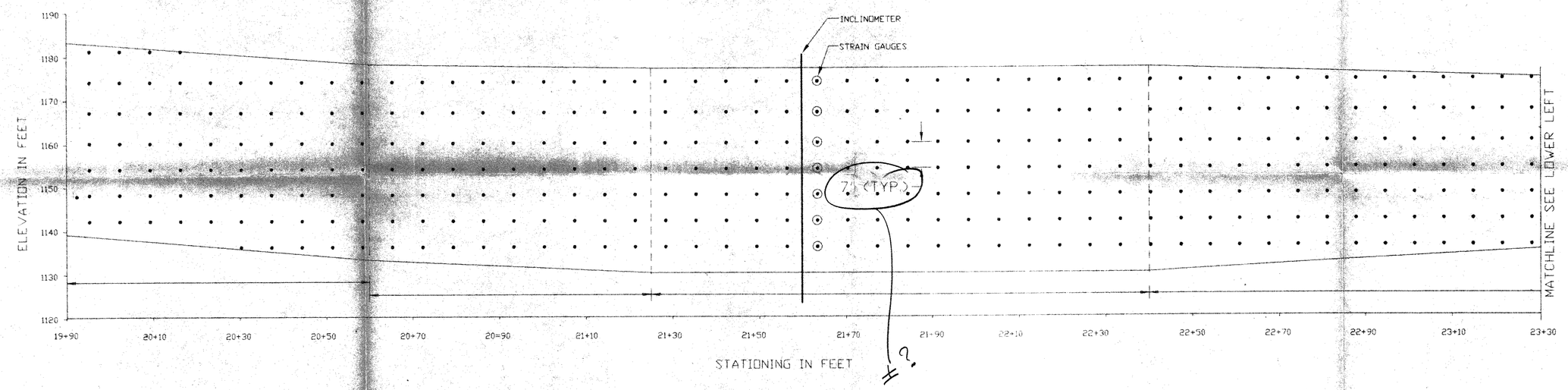

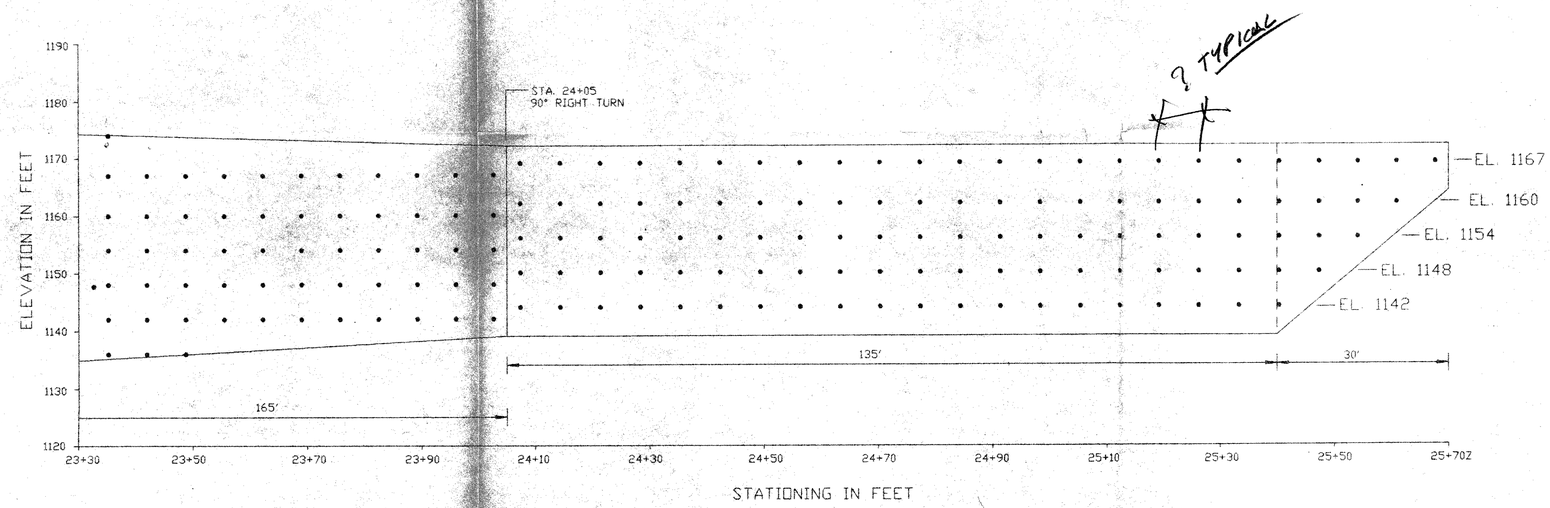

SCALE:
HORIZONTAL 1" = 12'
VERTICAL 1" = 10'

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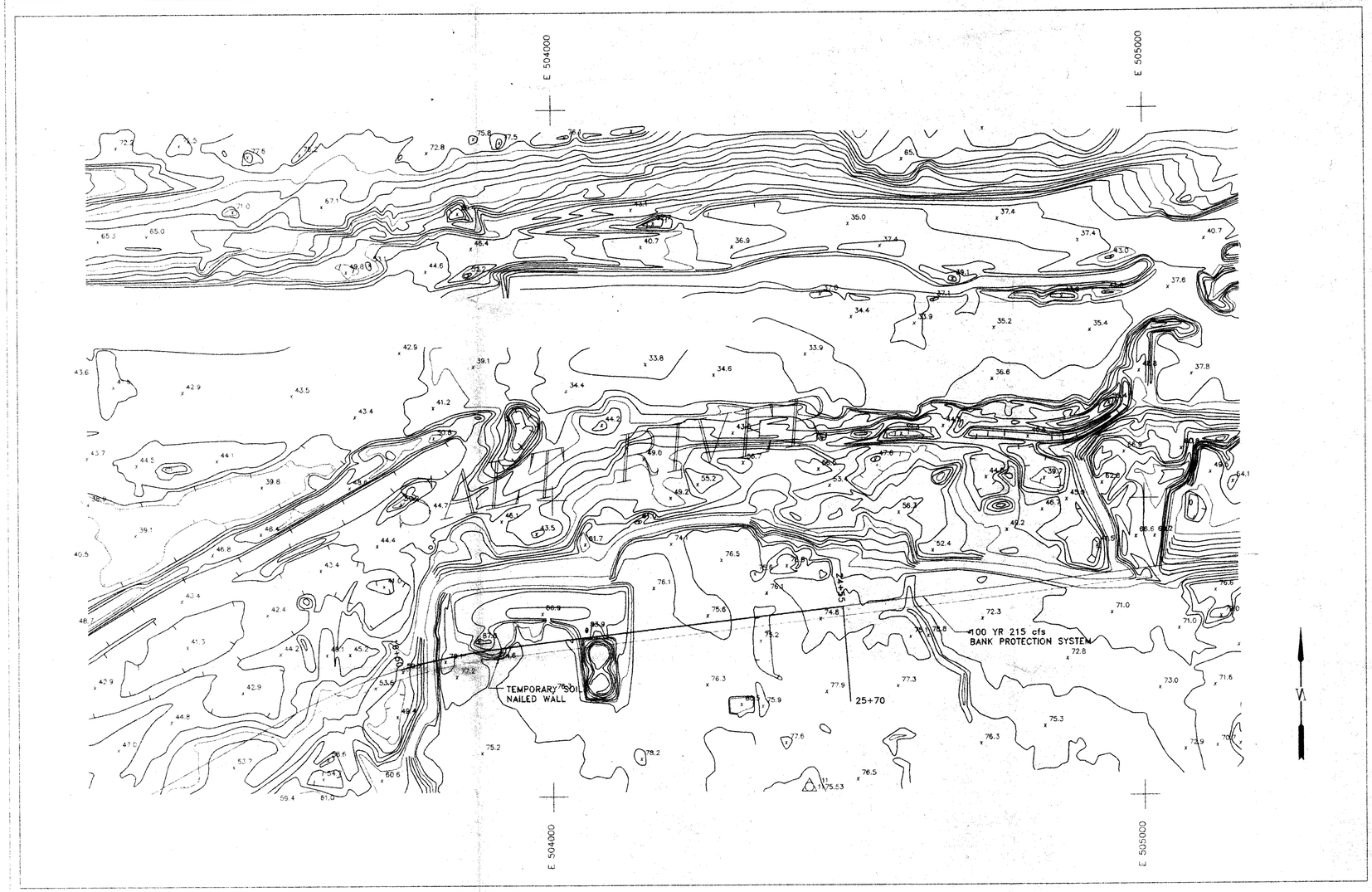
VERTICAL VIEWS
TEMPORARY SOIL NAILED WALL

JOB NO.	DATE	DESIGNED BY	DRAWN BY	CHECKED BY	SHEET NO.
E87-56	8/94	SCC	TMP	LAH	3



SITE PLAN

SCALE : 1" = 100'

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ENGINEER
C&O
FEMGR
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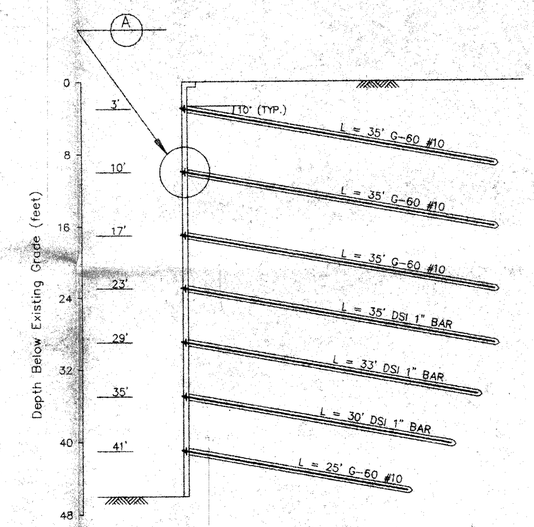
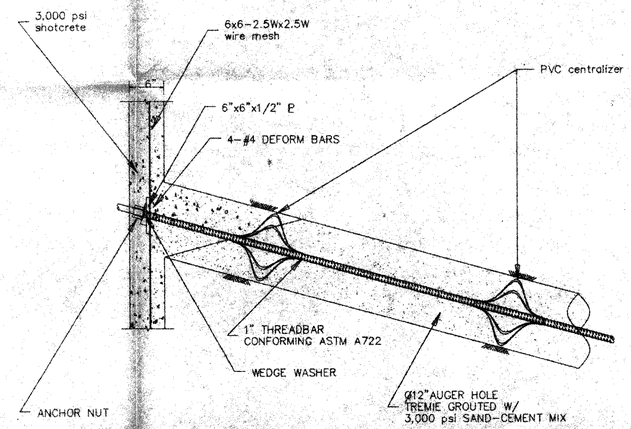
EAST PAPAGO – SALT RIVER SOUTH BANK PROTECTION





DETAIL A

Table 1 - Minimum Nail Length

Station \ Nail Elevation	Row 1 EL 4436	Row 2 EL 4432	Row 3 EL 4426	Row 4 EL 4420	Row 5 EL 4414	Row 6 EL 4408	Row 7 EL 4402	Row 8 EL 4396
0+01	-	20'	20'	-	-	-	-	-
0+07	-	25'	25'	20'	-	-	-	-
0+13 - 0+19	-	30'	30'	25'	20'	-	-	-
0+25	-	35'	35'	30'	25'	20'	-	-
0+31	-	40'	40'	40'	35'	30	25'	-
0+37 - 1+27	-	45'	45'	40'	40'	40	30	25'
1+33 - 1+57	-	45'	45'	40'	40'	40	30	-
1+63	40'	40'	40'	35'	30'	25	-	-
1+69 - 1+75	35'	35'	30'	25'	20'	-	-	-
1+81	30'	30'	25'	20'	-	-	-	-
1+87 - 1+93	25'	25'	20'	-	-	-	-	-
1+99	20'	20'	-	-	-	-	-	-

Table 2- Design Loads

Station \ Nail Elevation	Row 1 EL 4436	Row 2 EL 4432	Row 3 EL 4426	Row 4 EL 4420	Row 5 EL 4414	Row 6 EL 4408	Row 7 EL 4402	Row 8 EL 4396
0+01	-	19	25	-	-	-	-	-
0+07	-	19	26	22	-	-	-	-
0+13 - 0+19	-	24	29	36	25	-	-	-
0+25	-	28	32	41	47	31	-	-
0+31	-	29	33	41	50	49	32	-
0+37 - 1+27	-	37	42	51	61	73	73	56
1+33 - 1+57	-	36	40	50	60	70	70	-
1+63	28	33	41	50	49	32	-	-
1+69 - 1+75	28	32	41	47	31	-	-	-
1+81	24	29	35	25	-	-	-	-
1+87 - 1+93	19	26	22	-	-	-	-	-
1+99	19	25	-	-	-	-	-	-

Note: Design loads are in kips.

Table 3- Minimum Nail Bars Schedule

Station \ Nail Elevation	Row 1 EL 4436	Row 2 EL 4432	Row 3 EL 4426	Row 4 EL 4420	Row 5 EL 4414	Row 6 EL 4408	Row 7 EL 4402	Row 8 EL 4396
0+01	-	#8	#8	-	-	-	-	-
0+07	-	#8	#8	#8	-	-	-	-
0+13 - 0+19	-	#8	#8	#10	#8	-	-	-
0+25	-	#8	#10	#10	#10	#10	-	-
0+31	-	#8	#10	#10	1"	1"	#10	-
0+37 - 1+27	-	#10	#10	1"	1"	1"	1"	1"
1+33 - 1+57	-	#10	#10	1"	1"	1"	1"	-
1+63	#8	#10	#10	1"	1"	#10	-	-
1+69 - 1+75	#8	#10	#10	#10	#10	-	-	-
1+81	#8	#8	#10	#8	-	-	-	-
1+87 - 1+93	#8	#8	#8	-	-	-	-	-
1+99	#8	#8	-	-	-	-	-	-

Note: All #8 & #10 bars shall be Grade 60 conforming to ASTM A615.

All 1" bars shall be threadbar conforming to ASTM A722

PRELIMINARY

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SITE PLAN & TYPICAL SECTION
TEMPORARY SOIL NAILED WALL

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