amec

Preliminary Geotechnical Investigation Report
Gila River Bank Protection Pre-Design Project
Perryville Road to Citrus Road
Maricopa County, Arizona

amec

Celebrating 50 Years of Service in Arizona

Preliminary Geotechnical Investigation Report
Gila River Bank Protection Pre-Design Project
Perryville Road to Citrus Road
Maricopa County, Arizona

Submitted to:

Stantec Consulting, Inc.
Phoenix, Arizona

Submitted by:

AMEC Earth & Environmental, Inc.
Tempe, Arizona

REGISTERED GEOLOGIST
CERTIFICATE NO.
22738
RICHARD
BANSBERG
Date Signed 4/15/09
ARIZONA, U. S. A.
Expires 03/31/2011

AMEC Job No. 08-117-01092
April 15, 2009

April 15, 2009
AMEC Job No. 08-117-01092

Stantec Consulting, Inc.
8211 South 48th Street
Phoenix, Arizona 85044

Attn: Patrick J. Ellison

Re: Preliminary Geotechnical Investigation Report
Gila River Bank Protection Pre-Design Project
Perryville Road to Citrus Road
Maricopa County, Arizona

Submitted herein are the results of a preliminary geotechnical investigation of the north bank of the Gila River between Perryville and Citrus Roads in Maricopa County. The purpose of the investigation was to characterize geotechnical conditions that should be considered during pre-design of a bank protection system. This report presents an overview of the project, results of our site investigations, descriptions of the geological and geotechnical conditions observed along the bank, results of geological and engineering analyses, and discussions of foundation design considerations.

Should you have any questions regarding this transmittal, please do not hesitate in contacting the undersigned.

Respectfully submitted,

AMEC Earth & Environmental, Inc.

Richard Bansberg, P.G.
Senior Geologist

REGISTERED GEOLOGIST
CERTIFICATE NO. 22738
RICHARD BANSBERG
Date Signed 4/15/09
ARIZONA, U.S.A.
Expires 03/31/2011

Reviewed by:

Brett A. Howey, P.E.
Senior Geotechnical Engineer

Registered Professional Engineer (Civil)
CERTIFICATE NO. 40209
BRETT A. HOWEY
Date Signed 4/15/09
ARIZONA, U.S.A.
Expires 12/31/09

Addressee (4)

G:\Engineering Department\2008 Projects\08-117-01092 Gila River Bank Protection Pre-design Project\Report\Report_Gila River Bank Protection_ver2.doc

AMEC Earth & Environmental, Inc.
1405 West Auto Drive
Tempe, Arizona 85284-1016
Tel: (480) 940-2320
Fax: (480) 785-0970
www.amec.com

TABLE OF CONTENTS

Page

1.0 INTRODUCTION 1
2.0 PROJECT DESCRIPTION 1
3.0 INVESTIGATIVE APPROACH 1
3.1 Review of Existing Data 1
3.2 Field Reconnaissance 1
3.3 Subsurface Exploration 2
3.3.1 Utility Clearance and Environmental Permitting 2
3.3.2 Borings 2
3.3.3 Test Pits 2
3.4 Laboratory Testing 3
4.0 GEOLOGICAL/GEOTECHNICAL CONDITIONS 3
4.1 Geomorphic Setting 3
4.2 Bank Conditions 3
4.2.1 Native Bank 4
4.2.2 Fill Slopes 5
4.2.3 Graded Slopes 5
4.3 Channel Conditions 6
4.4 Groundwater and Soil Moisture Conditions 6
5.0 ENGINEERING ANALYSIS AND RECOMMENDATIONS 7
5.1 Bank Slope Stability Analyses 7
5.2 Foundation Considerations 8
5.3 Excavations 8
5.4 Existing Bank Stabilization 8
5.5 Debris Mitigation 9
5.6 Recommendations 9
6.0 REFERENCES 10

LIST OF FIGURES

Figure 1 Site Map

PHOTOGRAPHIC LOG

TABLE OF CONTENTS (Cont.)

LIST OF APPENDICES

Appendix A Field Investigation
Appendix B Laboratory Test Results

LIST OF SHEETS

Sheet 1 of 2 Site Plan
Sheet 2 of 2 Site Plan

REGISTERED GEOLOGIST
CERTIFICATE NO.
22738
RICHARD
BANSBERG
Date Signed 4/15/09
ARIZONA, U. S. A.
Expires 03/31/2011

1.0 INTRODUCTION

This report presents the results of a preliminary geotechnical investigation performed by AMEC Earth & Environmental, Inc. (AMEC) of the north bank of the Gila River between Citrus Road and Perryville Road in the Town of Buckeye, the City of Goodyear, and unincorporated areas of Maricopa County. The purpose of the geotechnical investigation was to identify fatal flaws and/or other significant geotechnical conditions that should be considered during pre-design of a bank protection system. Additional geotechnical investigations are recommended for final design.

2.0 PROJECT DESCRIPTION

The Gila River Bank Protection Pre-design Project extends along the north bank of the Gila River between Citrus Road and Perryville Road. Areas adjacent to this reach of the Gila River are currently subject to floods resulting from potential bank failure and lateral migration of the river. The objective of the pre-design project is to establish the alignment, configuration, profile, aesthetic elements and associated features needed to complete the final design of a bank protection system that will mitigate historic flooding and erosion problems. The final design will be compatible with the El Rio Watercourse Master Plan (WCMP).

3.0 INVESTIGATIVE APPROACH

3.1 Review of Existing Data

Readily available geotechnical and geological data including aerial photography, geologic literature and maps, and existing reports were collected and reviewed.

3.2 Field Reconnaissance

A field reconnaissance was performed by Richard Bansberg, P.G., with AMEC, on January 19, 2009 to observe and document existing geological and geotechnical conditions along the north bank of the river. During the reconnaissance, soil and bedrock conditions exposed at the ground surface were documented, and bank armoring and surface debris located along the bank were described and mapped. General bank conditions are shown on Figure 1 and on Sheets 1 and 2 presented in the map pocket at the end of this report. Photographs showing the general condition of the river bank and areas of interest are presented in the Photographic Log section of this report. Locations of the photographs are identified on Sheets 1 and 2. During the reconnaissance, two areas in the central portion of the project site could not be accessed because right-of-entry had not been granted for these parcels (see Sheets 1 and 2).

3.3 Subsurface Exploration

3.3.1 Utility Clearance and Environmental Permitting

Boring and test pit locations were staked in the field during the site reconnaissance and Blue Stake was contacted (Ticket No. 2009012200463.000) to clear the locations of underground utilities prior to starting subsurface investigations. A dust permit (E090109) was obtained from the Maricopa County Air Quality Department, and the Flood Control District of Maricopa County (FCDMC) provided a water truck to assist with dust control during the field operations. Mr. James B. Rodgers, Principal Investigator, with Scientific Archeological Services (SAS) monitored field operations due to the presence of an archival site within close proximity to the project area.

3.3.2 Borings

Three (3) borings (BH-1 through BH-3) were advanced on the river bank to depths ranging from 31 to 41 feet below existing grades. Locations of the borings are shown on Figure 1 and Sheets 1 and 2. The borings were completed with a CME-95 truck-mounted drill rig advancing 8 5/8-inch outer diameter (OD) hollow-stem auger. The drill rig is owned and operated by Geomechanics Southwest, Inc. (GSI). Standard penetration (split-spoon) testing and sampling were performed at 5-foot intervals in all borings.

Soils encountered in the borings were continuously examined, visually classified and logged by Mark A.R. Keyes, P.G, with AMEC. The boring logs are presented in Appendix A, along with a description of the drilling technique used, a summary of the Unified Soil Classification System (USCS), and an explanation of the terminology used in describing the soils.

Because groundwater was encountered in the boreholes, GSI notified the Arizona Department of Water Resources (ADWR), filed appropriate forms, and grouted the borings with neat cement.

3.3.3 Test Pits

Four (4) test pits (TP-1 through TP-4) were excavated in portions of the bank that have been armored with rip rap. The test pits were excavated to depths ranging from 3.5 to 4 feet below existing grades using a Caterpillar 446B backhoe owned and operated by FCDMC. Soils encountered in the borings were continuously examined, visually classified and logged by Mr. Keyes; and representative soil samples were collected for laboratory analyses. Test pit logs are presented in Appendix A. The test pits were backfilled with the materials excavated from the pits, and the rip rap was replaced to match adjacent areas.

3.4 Laboratory Testing

Laboratory testing of representative soil samples collected from the borings and test pits was performed to characterize the physical properties of the soils. The following tests were performed:

- Total sieve analyses (6 samples);
- Plasticity Index and liquid limit (6 samples);
- Moisture content (6 samples);
- Density (5 samples); and
- Consolidation (3 samples).

Copies of the laboratory reports are presented in Appendix B.

4.0 GEOLOGICAL/GEOTECHNICAL CONDITIONS

4.1 Geomorphic Setting

The headwaters of the Gila River originate in the Mogollon Mountains of western New Mexico. The Gila River crosses the southern portion of Arizona from east to west before joining the Colorado River near Yuma. The project site is located southwest of Phoenix at the northwest end of the Estrella Mountains approximately eight miles downstream of the confluence of the Gila and Salt Rivers. This reach of the Gila River is ephemeral, only flowing in response to precipitation events or water releases from upstream dams.

The Gila River is more than a mile wide within the project limits. The southern side of the river is generally defined by the Estrella Mountains, whereas the northern side of the river is defined by an approximately 15-foot high bank of fine-grained floodplain deposits. Access to the river bottom by vehicles is limited. There is a road at the western limit of the project that allows access to the river (Photograph 1), and it is possible to access the river (with difficulty) at the eastern end of the project where the bank has been graded and armored with rip rap. Travel within the river bottom, either by foot or vehicle, is limited due to thick stands of salt cedar. Vehicular travel within the river bottom was not required for this investigation.

4.2 Bank Conditions

The general condition of the bank can be categorized into three (3) zones:

- Native bank (locally disturbed);
- Fill slopes (generally covered with debris and litter); and
- Graded slopes (armored with rip rap).

The general locations of these three zones are shown on Figure 1. Sheets 1 and 2 depict the limits of these zones in greater detail.

4.2.1 Native Bank

The native bank (shown in green on Figure 1) is relatively steep and generally covered with a dense growth of salt cedar. Conditions along the native bank are relatively consistent, except near the western limit of the project where a broad bench has been cut into the bank (Sheet 1 and Photograph 2). Otherwise, the native bank consists of a continuous relatively steep, approximately 15-foot high slope. Soils exposed in the bank generally consist of mixtures of clay, silt and sand with some well graded gravel. In general, the exposed deposits are uncemented to weakly lime cemented, nonplastic to low in plasticity, and light to medium brown.

Results of the test borings revealed a two-layer system: an approximately 15-foot thick layer of fine grained soils (clay, silt and sand) underlain by coarse grained soils (sand, gravel and cobbles). The fine-grained materials are floodplain deposits and the coarse-grained materials are channel deposits.

In Boring BH-1, advanced at the western portion of the project, the upper layer consists of silty medium- to coarse-grained sand with some gravel. The materials are slightly moist, loose, uncemented, nonplastic, and grayish brown. In Borings BH-2 and BH-3, advanced in the central and eastern portions of the project, respectively, the upper layer consists of clayey silt to silty clay with a trace of gravel. The materials are slightly moist to moist, weakly lime cemented, medium in plasticity, and medium to dark brown. There is some indication that the materials in the upper portion of Boring BH-1 is fill, since the materials differ from the floodplain deposits encountered in the upper portions of Borings BH-2 and BH-3 and the ground surface in the vicinity of Boring BH-1 has been disturbed.

N-values (the summation of the second and third 6-inch intervals of the standard penetration tests {SPTs}) in the silty sand deposits encountered in Boring BH-1 ranged from 6 to 8, which correlates to a relative density of loose. N-values in the silty clay to sandy clay deposits encountered in Borings BH-2 and BH-3 ranged from 7 to 36, which correlates to a relative consistency of soft to very firm. The dry density of five samples ranged from 91.6 to 100.4 pounds per cubic foot (pcf) and averaged 95.5 pcf.

The floodplain deposits are underlain by channel deposits consisting of sand and gravel with occasional cobbles. The sand is predominantly medium to coarse grained, and the gravel is predominantly subrounded and coarse grained. The channel deposits are slightly moist to wet, uncemented, nonplastic and grayish brown. N-values were variable, ranging from 7 to 68, which correlates to a relative density of loose to very dense.

4.2.2 Fill Slopes

As shown on Figure 1 (in red) and on Sheets 1 and 2, there are several locations along the bank where fill materials have been pushed over the edge of the bank (Photographs 3 and 6). Much of this material appears to consist of locally-derived silt and sand. However, in at least one area the materials appear to have been imported. The area of imported fill is located in the central portion of the project and consists of low to medium plasticity clayey sand and gravel (Photograph 7). These soils are darker brown than the adjacent native soils.

Most of the fill slopes are covered with construction debris and household litter. As shown in Photographs 5 and 6, much of the construction debris consists of concrete, cinder blocks, roof tiles, wood, and metal. In some areas, the slopes are covered with palm fronds and other vegetative debris (Photographs 7 and 8) or littered with household debris (Photographs 9 and 10). No subsurface investigations were performed in the fill slopes, so it is not known if the debris and litter are limited to the surface of the slopes or are buried within the fill materials. Not all of the fill slopes could be accessed during the reconnaissance. In general, it appears that the debris and litter are typical construction and household materials, although a stained area of soil (approximately 5 feet by 10 feet) was observed in the central portion of the project area near Photograph 8. The type of staining is not known, although it appears to be oil. It is understood that the soil staining will be assessed during a Phase I Environmental Assessment of the project site.

4.2.3 Graded Slopes

The eastern portion of the bank (shown in blue on Figure 1) has been graded and is generally armored with cobbles (Photographs 13), except for a short section which is armored with rock (Photograph 14). The cobbles are well rounded and generally range from 6 to 12 inches in diameter, although there are occasional boulders ranging up to 3 feet in diameter. The cobble armoring to the west of the rock rip rap is generally limited to the upper part of the slope. Soil exposed in the lower portion of the slope in this area consists of silt and fine-grained sand, with a trace of well graded gravel and some concrete rubble. A minor amount of rilling is locally present along the lower portion of the slope. The rip rap located in the central portion of the armored area generally consists of 0.5 to 4 foot diameter fragments of hard, angular granite gneiss. Essentially the entire slope is armored with cobbles to the east of the rock rip rap (Photograph 15).

All four of the test pits were excavated in the armored portion of the bank. Test Pits TP-1 through TP-3 were excavated in the middle portion of the slope, whereas TP-4 was excavated at the toe of the slope. The cobble armoring is generally about 1½ feet thick and underlain by woven geotextile. Test Pit TP-4 excavated at the toe of the slope uncovered gabion baskets filled with cobbles. The geotextile appears to extend beneath the gabion baskets. Results of the preliminary investigation suggest that there may be a single row of gabion baskets at the toe of the slope and that the baskets are about 6 to 8 inches thick.

Soils encountered below the cobble armoring and geotextile are variable, consisting of sand with gravel in TP-1, sandy silt in TP-2, silty clay in TP-3, and sand and gravel in TP-4. In general, the soils are moist, uncemented, nonplastic, and brown. However, the silty clay encountered in TP-2 has medium plasticity and is dark brown. There is some concrete rubble mixed in with the soils.

4.3 Channel Conditions

In general, channel deposits exposed in the river adjacent to the north bank consist of fine- to medium-grained, subangular to subrounded sand with some well-graded gravel (Photographs 3 and 12). In a few areas, the channel deposits consist of sand and well graded, rounded to well rounded gravel with occasional cobbles (Photograph 5). The channel deposits are uncemented, nonplastic and light grayish brown. As described in Section 4.2.2, the drilling results indicate that the channel deposits extend beneath the fine-grained floodplain deposits exposed in the bank.

Several bedrock outcrops occur in the river bottom adjacent to the bank in the western portion of the project site (see Sheet 1). Two small outcrops of conglomerate were observed (Photograph 3). The conglomerate consists of moderately to strongly lime cemented, well graded sand and gravel and small cobbles. Several larger outcrops of fine-grained granite gneiss are present immediately upstream of the conglomerate. These outcrops are slightly weathered, hard to very hard, and light greenish gray (Photograph 4). Fractures are closely to moderately closely spaced (0.2 to 3 feet), but poorly developed and discontinuous. These outcrops probably represent the presence of a large mass of bedrock, possibly an extension of the Estrella Mountains, buried beneath the river channel.

4.4 Groundwater and Soil Moisture Conditions

The soil moisture content of samples obtained from the borings and test pits ranged from 1.8 to 20.7 percent. Deposits dominated by clay and silt had moisture contents ranging from 10.3 to 20.7 percent, whereas deposits dominated by sand and gravel had moisture contents ranging from 1.8 to 6.9 percent.

Groundwater was encountered in all three of the borings at depths ranging from 23 to 25 feet below existing grades, or approximately 8 to 10 feet below the river bottom adjacent to the north bank.

5.0 ENGINEERING ANALYSIS AND RECOMMENDATIONS

5.1 Bank Slope Stability Analyses

A conventional static stability analysis of a representative native channel bank slope geometry was performed using the computer program SLOPE/W. The comprehensive formulation of SLOPE/W makes it possible to easily analyze both simple and complex slope stability problems using a variety of methods to calculate the factor of safety.

The soil parameters utilized in the analyses were conservatively developed based on the results of the field investigation completed by AMEC, published parameters, and AMEC's experience with similar materials. A two-layer system was selected to represent a typical geotechnical profile, including Layer 1, an approximately 15-foot thick layer of fine grained soils (clay, silt and sand) underlain by Layer 2, coarse grained soils (sand, gravel and cobbles). The soil strength parameters utilized in the analysis are summarized in the following two tables.

Layer 1 Soil Strength Parameters

Moist Unit Weight (pcf)	95
Phi (degrees)	31
Cohesion (psf)	100

Layer 2 Strength Parameters

Moist Unit Weight (pcf)	110
Phi (degrees)	37
Cohesion (psf)	0

The purpose of the stability evaluation was to estimate the current global slope stability of the existing channel bank. The slope geometry analyzed was a 16-foot high 1.6H:1V (horizontal to vertical) cut with a 250 psf surcharge applied to the top of the slope, 10 feet from the edge of the slope, to account for potential Operation and Maintenance vehicle traffic adjacent to the channel. The minimum factors of safety for the most critical failure surfaces were determined for static conditions using the program's search features. The analyses indicate that an adequate factor of safety (FS = 1.67) currently exists. Based on our slope stability estimation, cut slopes at or flatter than 1.6H:1V are acceptable; however, a maximum slope inclination of 2H:1V is recommended to allow easier slope maintenance. Severe raveling and rilling of the slopes may occur at this inclination and should be considered during final design.

5.2 Foundation Considerations

The foundation footprint of the area to be occupied by any bank protection should be stripped or over excavated to sufficient depth to remove all vegetation, roots, debris, loose rock, and other objectionable material. The required excavations for the Native Slope foundation areas will be in the range of approximately 2 to 3 feet. For the more extensive Fill Slope areas over excavation may be required to remove debris and man-made fill. Graded Slopes, which consist primarily of existing rock riprap armoring, have what visually appears to be an acceptable sub-grade foundation condition. Final limits and methods of foundation preparation should be established through a comprehensive final design geotechnical investigation.

Three (3) consolidation/collapse tests were completed on samples from each of the three (3) borings. The test results indicate the native soils below the site have a low to moderately low collapse potential upon wetting. The testing indicated a range in collapse potential of 0.5 to 2.5 percent for samples having dry densities of 92 to 103 pcf, and in situ moisture contents of 8 to 23 percent. Low density soils may be encountered within the shallow geotechnical profile which may require recompaction.

5.3 Excavations

It is estimated that typical earthwork equipment can be used for excavation of the site soils. Trenches can be excavated by typical tractor-mounted backhoes to depths of 10 feet, or deeper with an extension boom. Trenches at depths below 15 feet may require track-mounted backhoes. Two types of bedrock were observed at the site: conglomerate and granite gneiss. Based on observations of two small outcrops of the conglomerate, the conglomerate can probably be ripped with conventional equipment. The granite gneiss is hard to very hard and excavation would be very difficult with mechanical equipment.

Temporary excavation slopes to depths of 5 feet should be maintained no steeper than H1:V1. All construction loads, such as spoils piles and equipment, should be maintained a distance of at least 10 feet from the edge of the excavation. Cut slopes should be observed by a qualified geotechnical engineer during excavation. Shoring will be required for vertical cuts. The perimeter of the excavation should be protected against surface water runoff with berms at the top of the slope or other measures. Severe raveling and rilling of the slopes could occur if impacted by runoff.

5.4 Existing Bank Stabilization

In general, the 1983 (with 1988 Revisions) Perryville Bank Stabilization construction plans show a design slope of 2.5H:1V with cobble riprap extending from Stations 1000+00 to 1009+50 and from Stations 1015+00 to 1022+00 on either side the existing larger rock riprap (FCDMC, 1988). The plans show filter fabric overlain by 6 inches of bedding material overlain by 12 inches of riprap with the bank protection extending 10 feet below the ground surface. Adjacent to the

existing rock riprap, the construction plans show 9-inch thick gabion baskets underlain by filter fabric extend between 24 to 36 feet from the edge of the rock riprap. The plans indicate the gabion is 36 feet wide from Stations 1009+50 to 1012+75 and 24 feet wide from Stations 1012+75 to 1015+00.

Stationing provided on the construction plans was not observed in the field, although it is assumed that the existing rock riprap identified on the plans correlates to the large rock riprap lining a portion of the bank. Test pits excavated along the bank protection during this phase of the geotechnical investigation locally encountered conditions that match the construction plans, although additional investigations would be necessary to confirm some aspects of the construction plans. The cobble riprap was found to be approximately 18 inches thick and underlain by filter fabric where excavated, although the lower portion of the slope to the west of the existing (larger) riprap was not covered with cobble riprap. Gabion baskets were identified in TP-4 excavated at the toe of the bank east of the large rock riprap, and the baskets were estimated to be 6 to 8 inches thick and underlain by filter fabric. However, the plans only show gabion adjacent to the large rock riprap, not the remainder of the bank protection. As discussed in Section 5.5., additional investigations are recommended to fully verify the construction plans.

5.5 Debris Mitigation

Site preparation will include grubbing and clearing of trees, brush, roots, vegetative debris and deleterious debris, and litter within the limits of construction. Inert solid waste such as concrete, bricks, cinder blocks, and roof tiles will require removal with proper disposal. Vegetative debris, wood, plastic, scrap metal, cardboard, paper, and similar materials should be disposed of at permitted construction and/or municipal solid waste landfills. Stained soils, containers with residual liquids, materials suspected of containing lead paint or asbestos, and other potentially hazardous materials should be isolated, tested by qualified personnel, and disposed of at a properly licensed hazardous waste disposal facility.

5.6 Recommendations

The following investigations are recommended for final design:

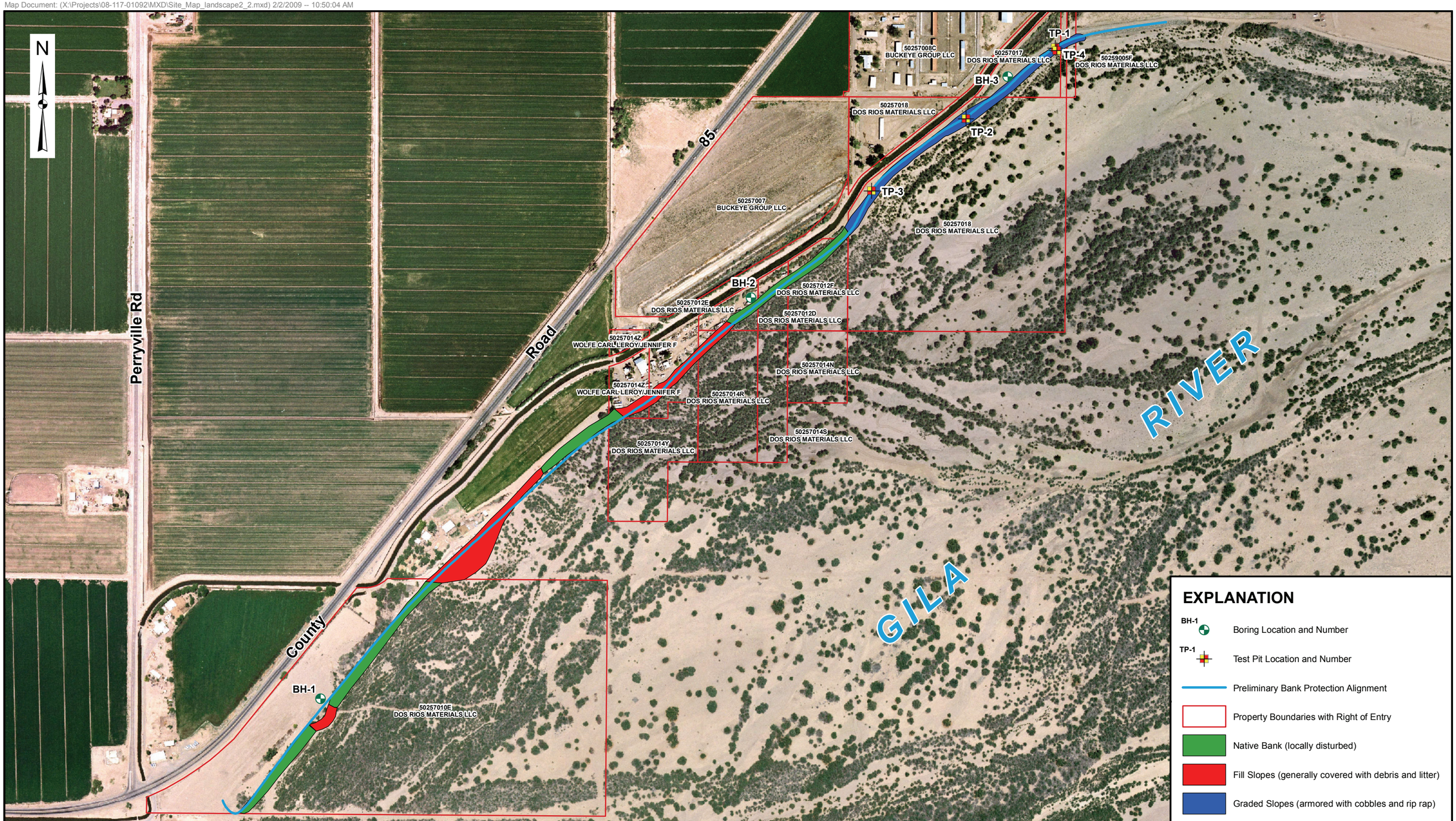
- Install a minimum of three (3) piezometers to monitor groundwater levels. These borings could also be used to investigate geotechnical conditions at these locations. Geotechnical borings should be advanced a minimum of 5 feet below anticipated bank protection toe-down depths;
- Drill borings in large areas of fill to characterize the depth and condition of the fill;
- Excavate several test pits in areas of significant fill to evaluate the types and extent of debris; and
- Excavate additional test pits along the toe of the existing bank stabilization to verify the1983 bank stabilization plans (FCDMC, 1988).

6.0 REFERENCES

Flood Control District of Maricopa County (FCDMC), 1988, Construction Plans for Bank Stabilization, Perryville Area, F.C.D. Contract 83-9, Revised on July 13, 1988.

FIGURES

Map Document: (X:\Projects\08-117-01092\MXD\Site_Map_landscape2_2.mxd) 2/2/2009 -- 10:50:04 AM



0 500 1,000 1,500 2,000 Feet

Basemap provided by Stantec. Parcel T01N R02W Sec 24, January, 2009.

JOB NO. ---	08-117-01092
DESIGN: ---	RB
DRAWN: ---	AMEC GIS
DATE: ---	2/2/2009
SCALE: ---	1" - 500'

SITE MAP

Gila River Bank Protection Pre-Design
Perryville Road to Citrus Road
Maricopa County, Arizona

FIGURE 1

amec

PHOTOGRAPHIC LOG

Photograph No. 1. Looking at bank at west end of project (the road marks the project boundary). The bank deposits at this location consist of silty fine to medium grained sand with some well graded gravel.

Photograph No. 2. A broad bench has been cut into the bank at this location (see Sheet 1). The lower portion of the bank is shown in this photograph. The soils exposed in the bank consist of silt and fine-grained sand.

Photograph No. 3. Materials in the center of the photograph consist of gravelly fine- to medium-grained sand that has been pushed over the edge of the bank. Native bank deposits generally consist of silt and fine-grained sand. Deposits exposed in the river floor generally consist of medium- to fine-grained sand. Note the outcrop of conglomerate at right edge of photograph. The conglomerate consists of moderately to strongly cemented sand, gravel and small cobbles.

Photograph No. 4. Looking northeast at outcrops of granite gneiss in floor of Gila River. The gneiss is slightly weathered and hard to very hard. Bank deposits generally consist of silt and fine-grained sand.

Photograph No. 5. Looking northwest at bank of Gila River littered with construction debris consisting of cinder blocks, roof tiles, concrete rubble, wood and wire. Deposits in the riverbed at this location vary from sand and gravel to fine- to medium-grained sand.

Photograph No. 6. Looking northwest at bank littered with construction debris; mostly concrete. Bank deposits generally appear to consist of locally-derived silt and fine-grained sand that have been pushed into the river.

Photograph No. 7. Looking north at bank covered with debris, mostly concrete and palm fronds. Most of the soil appears to be imported soil consisting of low to medium clayey sand and gravel.

Photograph No. 8. Looking east along edge of bank. The bank is covered with debris, mostly concrete, palm fronds, vegetation, wood and metal.

Photograph No. 9. Looking southwest along bank. The bank is littered with debris (mostly concrete, roof tiles and wood) and household trash. Fill consisting of gravelly silt and sand appears to have been pushed over the bank into the river channel.

Photograph No. 10. Looking northeast along top of bank. The bank is littered with debris and household trash. Fill consisting of gravelly silt and sand appears to have been pushed over the bank into the river channel.

Photograph No. 11. Looking north at “old” 10-foot deep test pit excavated at toe of bank. Soil exposed in the upper portion of the pit consists of silt with some fine-grained sand. Fine-grained sand is exposed in the bottom several feet of the pit.

Photograph No. 12. Looking west at typical section of riverbank covered with vegetation (mostly saltcedar). The bank deposits generally consist of silt and fine-grained sand. Channel deposits at this location consist of fine- to medium-grained sand.

Photograph No. 13. Looking southwest at bank. The bank has been graded and the upper portion of the bank has been armored with medium to large cobbles and small boulders. Deposits exposed in the lower portion of the bank consist of sandy silt. The lower portion of the bank contains some concrete debris.

Photograph No. 14. Looking north at rip rap along a portion of the bank. The rip rap consists of angular fragments of granite gneiss ranging from 0.5 to 5 feet in diameter.

Photograph No. 15. Looking northeast at bank located at the eastern end of the project (east of the rip rap). The slope has been graded and the entire slope has been armored with well rounded medium to large cobbles and some small boulders.

APPENDIX A

FIELD INVESTIGATION

TEST DRILLING EQUIPMENT AND PROCEDURES

Description of Subsurface Exploration Methods

Auger Boring Drilling through overburden soils is performed with 6 5/8-inch O.D., 3 1/4-inch I.D. hollow stem auger or 4 1/2-inch 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-75 truck-mounted drill rig is used to advance the auger. The drill rigs are powered with six-cylinder Cummins diesel engines capable of delivering about 11.4 kN-m torque to the drill spindle. The spindle is advanced with twin hydraulic rams capable of exerting 90 kN (20,000 pounds) downward force.

Generally, refusal to penetration of the auger is adopted as top of the SGC or “river-run” material or harder bedrock, which require other techniques for penetration. Grab samples or auger cuttings may be taken as necessary. Standard penetration tests or 2.42-inch 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 AP-1000 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-inch O.D. by 6-inch I.D. or 6 5/8-inch O.D. by 4-inch 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-foot increments, as noted on the boring logs. Standard penetration tests or 2.42-inch diameter ring samples taken are noted on the boring logs.

Core Boring Rock core samples are retrieved using a CME-75 drill rig, SAITECH GH 3 rig or Burley 2500, 4500 or 4000. The GH 3 is a portable hydraulic core drill. The GH 3 is powered by a Kohler two-cylinder 25-horsepower engine. The hydraulics motor which feeds a two-speed transmission and powers the BW spindle. This unit has a 3-foot stroke and is hand-fed with a 2,000 pound push-pull capability. The GH 3 has the capability of drilling with either B- or N-size core steel using standard or wireline systems. N-size core is the preferred size and it has a nominal O.D. of about 2 inches. The Burley 2500 and 4500 series are portable hydraulic core drills. The 4500 series is capable of a track-mounted or skid-type chassis. The Burley 2500 and 4500 series are powered by 44 and 75 HP power units, respectively, provide up to 2,000 foot-pounds (ft.-lbs.) of torque and in excess of 1,000 revolutions per minute (RPM) of spindle speed. Both rigs are capable of retrieving either N- or H-sized core using wireline systems. The N-size core has a nominal O.D. of about 2 inches and the H-size of about 2.4 inches. The Burley 4000 is a track-mounted core drill.

The CME-75 utilizes a wireline core drilling system that takes N-size cores. Using the NQ wireline system, core is recovered quickly by retrieving the core-laden inner tube through the drill string.

TEST DRILLING EQUIPMENT AND 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-inch O.D., 1 3/8-inch I.D. samples are used to obtain the standard penetration resistance. “Undisturbed” samples of firmer soils are often obtained with 3-inch O.D. samples lined with 2.42-inch 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 samples 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.

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

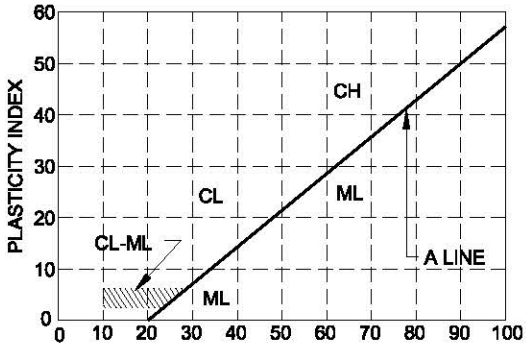
UNIFIED CLASSIFICATION SYSTEM FOR SOILS

Soils are visually classified by the United 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-sized mixtures or sand-gravel-cobble mixture.
					GP	Poorly graded gravels, gravel-sized mixtures or sand-gravel-cobble mixture.
		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 mixture.
			Limits plot below "A" line & hatched zone on plasticity chart		GC	Clayey gravels, gravel-sand-clay mixture.
	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 below "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 BELOW "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% to 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

PROJECT Gila River Bank Protection Pre Design Project

JOB NO. 08-117-01092 **DATE** 2/3/09

LOCATION

RIG TYPE CME-95
BORING TYPE 8 5/8" Hollow Stem Auger
SURFACE ELEV.
DATUM

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				S	2-3-5			SP-SM	slightly moist to moist loose	**SAND TO SILTY SAND WITH GRAVEL,** rare cobble up to 6" to 7" in diameter, predominantly medium to coarse grained, subangular to subrounded sand & coarse grained, subrounded gravel, uncemented, nonplastic, grayish-brown note: possible fill material
				U	6	100.4				
5										
				U	7	97.7	7			
10										
										note: silty fine grained sand zones up to 1' thick below 13'
								SM		
				S	2-2-4			zones		
15										
								SP/GP	wet below 24' medium dense to very dense	**SAND & GRAVEL WITH COBBLES,** cobbles up to 4" to 6" in diameter, predominantly coarse grained, subrounded gravel & medium to coarse grained, subangular to subrounded sand, uncemented, nonplastic, brown
				S	26-27-28					
20										
					5-5-11					
25				S						

GROUNDWATER

DEPTH(ft)	HOUR	DATE
24.0	10:30	2-3-09

SAMPLE TYPE

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

LOG OF TEST BORING NO. BH-1

PROJECT Gila River Bank Protection Pre Design Project

JOB NO. 08-117-01092 **DATE** 2/3/09

LOCATION

RIG TYPE CME-95
BORING TYPE 8 5/8" Hollow Stem Auger
SURFACE ELEV.
DATUM

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
25								SP/GP		**SAND & GRAVEL WITH COBBLES,** continued
30				S	11-5-7					
										Stopped Auger at 29'6" Stopped Sampler at 31' note: grouted boring with neat cement to ground surface
35										
40										
45										
50										

GROUNDWATER

	DEPTH(ft)	HOUR	DATE
▽	24.0	10:30	2-3-09
▼			
▼			
▼			

SAMPLE TYPE

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

LOG OF TEST BORING NO. BH-1

PROJECT Gila River Bank Protection Pre Design Project

JOB NO. 08-117-01092 **DATE** 2/3/09

LOCATION

RIG TYPE CME-95
BORING TYPE 8 5/8" Hollow Stem Auger
SURFACE ELEV.
DATUM

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				S	2-4-4			ML	slightly moist soft to firm	**CLAYEY SILT,** sand zones up to 2" to 3" thick, low plasticity, brown
5				U	10	96.1				note: some 1/2" long calcium carbonate filaments & nodules below 6'
10				U	22	91.7	10			
								SP	slightly moist medium dense to very dense	**SAND WITH GRAVEL,** some cobbles below 22', predominantly medium to coarse grained, subangular to subrouonded sand & coarse grained, subrounded to rounded gravel, uncemented, nonplastic, grayish-brown
15				S	12-9-6					
20				S	5-9-16		2			
25				S	12-12-8					

GROUNDWATER

DEPTH(ft)	HOUR	DATE
25.0	12:30	2-3-09

SAMPLE TYPE

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

LOG OF TEST BORING NO. BH-2

PROJECT Gila River Bank Protection Pre Design Project

JOB NO. 08-117-01092 **DATE** 2/3/09

LOCATION

RIG TYPE CME-95
BORING TYPE 8 5/8" Hollow Stem Auger
SURFACE ELEV.
DATUM

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
25								SP		**SAND WITH GRAVEL,** continued
30				S	26-33-35					
35				S	7-7-35					
40										Stopped Auger at 34'6" Stopped Sampler at 36' note: grouted boring with neat cement to ground surface
45										
50										

GROUNDWATER

	DEPTH(ft)	HOUR	DATE
▽	25.0	12:30	2-3-09
▼			
▼			
▼			

SAMPLE TYPE

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

LOG OF TEST BORING NO. BH-2

PROJECT Gila River Bank Protection Pre Design Project

JOB NO. 08-117-01092 **DATE** 2/3/09

LOCATION

RIG TYPE CME-95
BORING TYPE 8 5/8" Hollow Stem Auger
SURFACE ELEV.
DATUM

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				S	3-3-4			CL	moist	**SILTY CLAY,** considerable fine grained sand, medium plasticity, dark brown
									soft to very firm	note: trace 1/8" to 1/4" long calcium carbonate filaments
										note: trace subrounded gravel below 4'
5				U	36 NR					
								ML to CL		
10				U	27	91.6	21			
									very moist at 14'	
15				S	3-3-4					
								SP/GP		**SAND & GRAVEL,** rare small cobble, predominantly medium to coarse grained, subangular to subrounded sand, predominantly coarse grained, subrounded gravel, uncemented, nonplastic, grayish-brown
									slightly moist	
20				S	8-14-18					note: medium to coarse grained sand zones up to 1'6" thick
									wet below 23'	
25				S	10-13-23					

GROUNDWATER

DEPTH(ft)	HOUR	DATE
23.0	08:00	2-3-09

SAMPLE TYPE

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

LOG OF TEST BORING NO. BH-3

PROJECT Gila River Bank Protection Pre Design Project

JOB NO. 08-117-01092 **DATE** 2/3/09

LOCATION

RIG TYPE CME-95
BORING TYPE 8 5/8" Hollow Stem Auger
SURFACE ELEV.
DATUM

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
25								SP/GP		**SAND & GRAVEL,** continued
30				S	2-3-4					
35				S	17-12-12				loose to dense	
40				S	12-14-18					
45										Stopped Auger at 39'6" Stopped Sampler at 41' note: grouted boring with neat cement to ground surface
50										

GROUNDWATER

	DEPTH(ft)	HOUR	DATE
▽	23.0	08:00	2-3-09
▼			
▼			
▼			

SAMPLE TYPE

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

LOG OF TEST BORING NO. BH-3

PROJECT Gila River Bank Protection Pre Design Project

JOB NO. 08-117-01092 DATE 2/2/09

BACKHOE TYPE CAT 446B
LOCATION Mid-slope
N3695153, E365720
SURFACE ELEV.
DATUM

GROUNDWATER

	DEPTH	HOUR	DATE
▽		none	
▼			

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture Content Percent of Dry Weight	Unified Soil Classification or Rock Unit	REMARKS	SOIL DESCRIPTION
0					GP	slightly moist	Fill (Rip Rap) COBBLES, BOULDERS & GRAVEL, predominantly coarse grained, subrounded to rounded gravel, rounded cobbles, uncemented, nonplastic, grayish-brown note: wooven geotextile at base of rip rap note: cobbles average 9" in diameter
1							
2					SP	slightly moist	SAND WITH GRAVEL, predominantly medium to coarse grained, subangular to subrounded sand & coarse grained, subrounded gravel, uncemented, nonplastic, brown
3							
4							Stopped Bucket at 3'6"
5							
6							
7							
8							
9							
10							
11							
12							

SAMPLE TYPE
B - Undisturbed Bulk Sample
D - Disturbed Bulk Sample
U - 3" O.D. 2.42" I.D. tube sample
A - Drill Cuttings
G - Grab sample

LOG OF TEST PIT NO. TP-01

PROJECT Gila River Bank Protection Pre Design Project

JOB NO. 08-117-01092 DATE 2/2/09

BACKHOE TYPE CAT 446B
LOCATION Mid-slope
N3695037, E365578
SURFACE ELEV.
DATUM

GROUNDWATER

	DEPTH	HOUR	DATE
▽		none	
▼			

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture Content Percent of Dry Weight	Unified Soil Classification or Rock Unit	REMARKS	SOIL DESCRIPTION
0					GP	slightly moist	Fill (Rip Rap) COBBLES WITH GRAVEL & SAND, rounded to subrounded, coarse grained gravel & cobbles, predominantly medium to coarse grained sand, uncemented, nonplastic, grayish-brown note: some concrete fragments note: woven geotextile at base of rip rap note: cobbles average 9" in diameter
1							
					CL		
2			D	19		slightly moist to moist	Silty clay mixed with concrete fragments
					CL	slightly moist to moist	SILTY CLAY, some sand, medium plasticity, dark brown
3							
							Stopped Bucket at 3'6"
4							
5							
6							
7							
8							
9							
10							
11							
12							

SAMPLE TYPE
B - Undisturbed Bulk Sample
D - Disturbed Bulk Sample
U - 3" O.D. 2.42" I.D. tube sample
A - Drill Cuttings
G - Grab sample

LOG OF TEST PIT NO. TP-02

PROJECT Gila River Bank Protection Pre Design Project

JOB NO. 08-117-01092 DATE 2/2/09

BACKHOE TYPE CAT 446B
LOCATION Mid-slope
N3694925, E365424
SURFACE ELEV.
DATUM

GROUNDWATER

DEPTH	HOUR	DATE
	none	

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture Content Percent of Dry Weight	Unified Soil Classification or Rock Unit	REMARKS	SOIL DESCRIPTION
0					GP	slightly moist	Fill (Rip Rap) COBBLES WITH SANDY SILT, rare boulder up to 14" in diameter, trace gravel, uncemented, nonplastic, brown note: woven geotextile at base of rip rap note: cobbles average 9" in diameter
1							
2			D	15	ML	slightly moist to moist	SANDY SILT, trace gravel, predominantly fine grained sand, uncemented, nonplastic, brown
3							
4							Stopped Bucket at 4'
5							
6							
7							
8							
9							
10							
11							
12							

SAMPLE TYPE
B - Undisturbed Bulk Sample
D - Disturbed Bulk Sample
U - 3" O.D. 2.42" I.D. tube sample
A - Drill Cuttings
G - Grab sample

LOG OF TEST PIT NO. TP-03

PROJECT Gila River Bank Protection Pre Design Project

JOB NO. 08-117-01092 DATE 2/2/09

BACKHOE TYPE CAT 446B
LOCATION Toe of slope
N3695151, E365725
SURFACE ELEV.
DATUM

GROUNDWATER

DEPTH	HOUR	DATE
	none	

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture Content Percent of Dry Weight	Unified Soil Classification or Rock Unit	REMARKS	SOIL DESCRIPTION
0					GP	slightly moist	Fill (Rip Rap) COBBLES, GRAVEL & BOULDERS, boulders up to 3' in diameter, predominantly coarse grained, subrounded gravel, subrounded to rounded cobbles, uncemented, nonplastic, grayish-brown note: woven geotextile overlain by gabion basket at 2', gabion basket appears to be 6" to 8" high
2					SP/GP	moist	SAND & GRAVEL, predominantly medium to coarse grained sand & coarse grained, subrounded gravel, uncemented, nonplastic, brown
3							Stopped Bucket at 3'

SAMPLE TYPE
B - Undisturbed Bulk Sample
D - Disturbed Bulk Sample
U - 3" O.D. 2.42" I.D. tube sample
A - Drill Cuttings
G - Grab sample

LOG OF TEST PIT NO. TP-04

APPENDIX B

LABORATORY TEST RESULTS

LABORATORY TESTING PROCEDURES

Consolidation Tests Soiltest or Clockhouse apparatus of the "floating-ring" type are employed for the one-dimensional consolidation tests. They are designed to receive 1-inch high 2.5-inch O.D. brass liner rings with soil specimens as secured in the field. Procedures for the tests generally are those outlined in ASTM D2435. Loads are applied in several increments to the upper surface of the test specimen and the resulting deformations are recorded at selected time intervals for each increment. For soils which are essentially saturated, each increment of load is maintained until the deformation versus log of time curve indicates completion of primary consolidation. For partially saturated soils, each increment of load is maintained until the rate of deformation is equal or less than 1/10,000 inch per hour. Applied loads are such that each new increment is equal to the total previously applied loading. Porous stones are placed in contact with the top and bottom of the specimens to permit free addition or expulsion of water. For partially saturated soils, the tests are normally performed at in situ moisture conditions until consolidation is complete under stresses approximately equal to those which will be imposed by the combined overburden and foundation loads. The samples are then submerged to show the effect of moisture increase and the tests continued under higher loadings. Generally, the tests are continued to about twice the anticipated curve due to overburden and structural loads with a rebound curve then being established by releasing loads.

Expansion Tests The same type of consolidometer apparatus described above is used in expansion testing. Undisturbed samples contained in brass liner rings are placed in the consolidometers, subjected to appropriate surcharge loads and submerged. The loads are maintained until the expansion versus log of time curve indicates the completion of "primary swell".

Direct Shear Tests Direct shear tests are run using a Clockhouse or Soiltest apparatus of the strain-control of approximately 0.05 inch per minute. The machine is designed to receive one of the 1-inch high 2.42-inch diameter specimens obtained by tube sampling. Generally, each sample is sheared under a normal load equivalent to the effective overburden pressure at the point of sampling. In some instances, samples are sheared at several normal loads to obtain the cohesion and angle of internal friction. When necessary, samples are saturated and/or consolidated before shearing in order to approximate the anticipated controlling field loading conditions.

PROJECT:	Gila River Bank Protection Pre-Design	**JOB NO:**	08-117-01092
LOCATION:	Arizona	**WORK ORDER NO:**	1
SAMPLE SOURCE:	SEE BELOW	**DATE ASSIGNED:**	2/6/09

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

PERCENT PASSING BY WEIGHT

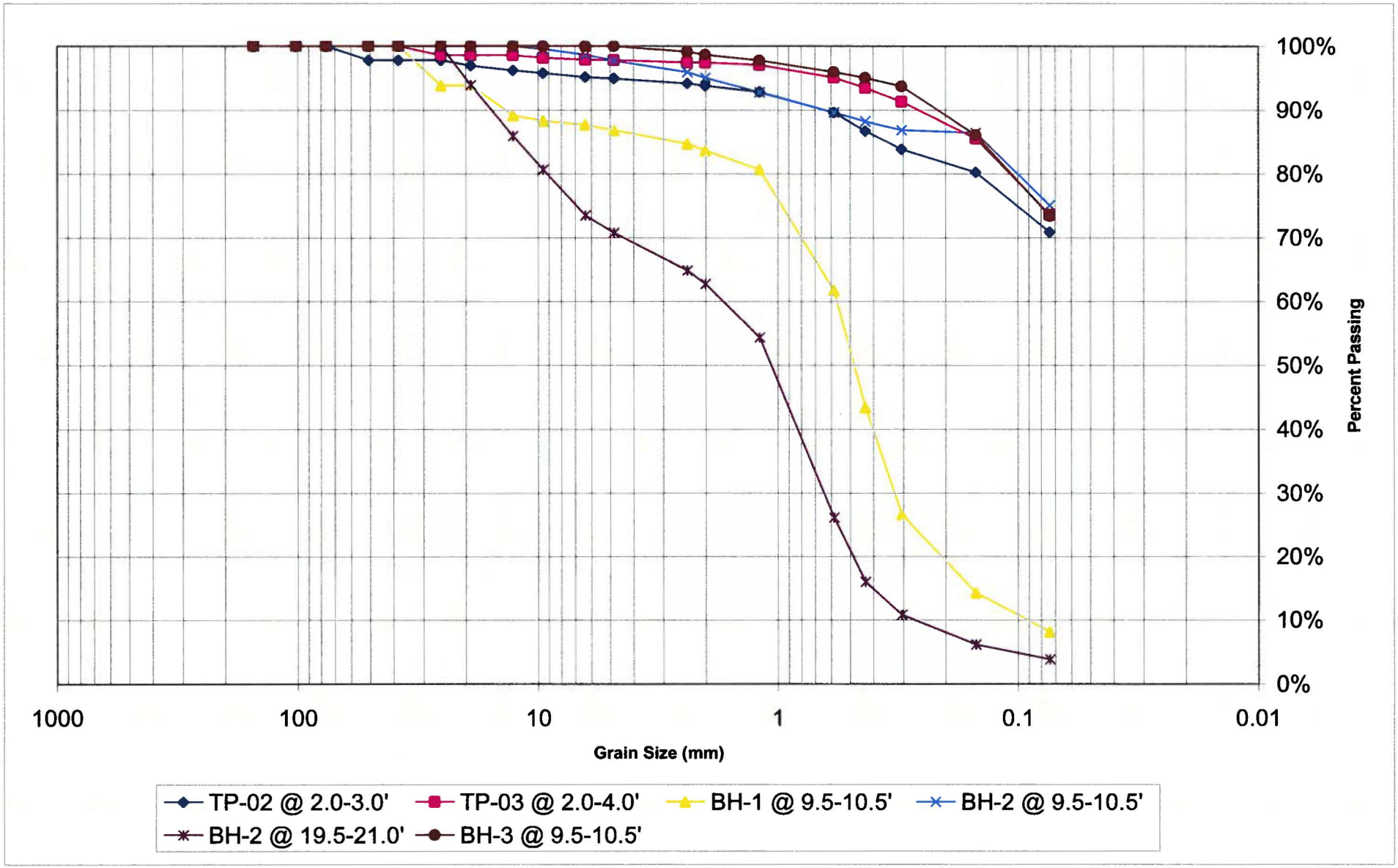
				Silt or	SAND								GRAVEL									COBBLES	
				Clay	Fine			Medium			Coarse		Fine				Coarse						
Location & Depth	**USCS**	**LL**	**PI**	**#200**	**#100**	**#50**	**#40**	**#30**	**#16**	**#10**	**#8**	**#4**	**1/4"**	**3/8"**	**1/2"**	**3/4"**	**1"**	**1 1/4"**	**1 1/2"**	**2"**	**3"**	**6"**	**Lab #**
TP-02 @ 2.0-3.0'	CL	34	16	71	80	84	87	90	93	94	94	95	95	96	96	97	98	98	98	100	100	100	1
TP-03 @ 2.0-4.0'	ML	NV	NP	74	86	91	93	95	97	97	97	98	98	98	99	99	99	100	100	100	100	100	2
BH-1 @ 9.5-10.5'	SP-SM	NV	NP	8.1	14	27	43	62	81	84	85	87	88	88	89	94	94	100	100	100	100	100	5
BH-2 @ 9.5-10.5'	ML	28	4	75	86	87	88	90	93	95	96	98	99	100	100	100	100	100	100	100	100	100	12
BH-2 @ 19.5-21.0'	SP	NV	NP	3.8	6	11	16	26	54	63	65	71	73	81	86	94	100	100	100	100	100	100	14
BH-3 @ 9.5-10.5'	CL	47	27	73	86	94	95	96	98	99	99	100	100	100	100	100	100	100	100	100	100	100	19

AASHTO R18

REVIEWED BY

PROJECT:	Gila River Bank Protection Pre-Design	**JOB NO:**	08-117-01092
LOCATION:	Arizona	**WORK ORDER NO:**	1
SAMPLE SOURCE:	SEE BELOW	**DATE ASSIGNED:**	2/6/09

MECHANICAL SIEVE ANALYSIS



AASHTO R18

PROJECT:	Gila River Bank Protection Pre-Design	**JOB NO:**	08-117-01092
LOCATION:	Arizona	**WORK ORDER NO:**	1
MATERIAL:	Soil	**LAB NO:**	See Below
SAMPLE SOURCE:	See Below	**DATE ASSIGNED:**	2/6/09

MOISTURE CONTENT OF SOIL (ASTM D2216)

LAB #	BORING & DEPTH	WET WT. (gram)	DRY WT. (gram)	MOISTURE CONTENT
1	TP-02 @ 2.0-3.0'	584.2	492.4	18.6%
2	TP-03 @ 2.0-4.0'	659.0	575.2	14.6%
5	BH-1 @ 9.5-10.5'	504.8	472.0	6.9%
12	BH-2 @ 9.5-10.5'	244.3	221.4	10.3%
14	BH-2 @ 19.5-21.0'	485.5	476.7	1.8%
19	BH-3 @ 9.5-10.5'	258.0	213.7	20.7%

AASHTO R18

REVIEWED BY

amec

PROJECT:	Gila River Bank Protection Pre-Design	**JOB NO:**	08-117-01092
LOCATION:	Arizona	**WORK ORDER NO:**	1
MATERIAL:	Soil	**LAB NO:**	SEE BELOW
SAMPLE SOURCE:	SEE BORING	**DATE ASSIGNED:**	2/6/09

DENSITY OF SOIL IN PLACE BY THE DRIVE-CYLINDER METHOD(ASTM D2937)

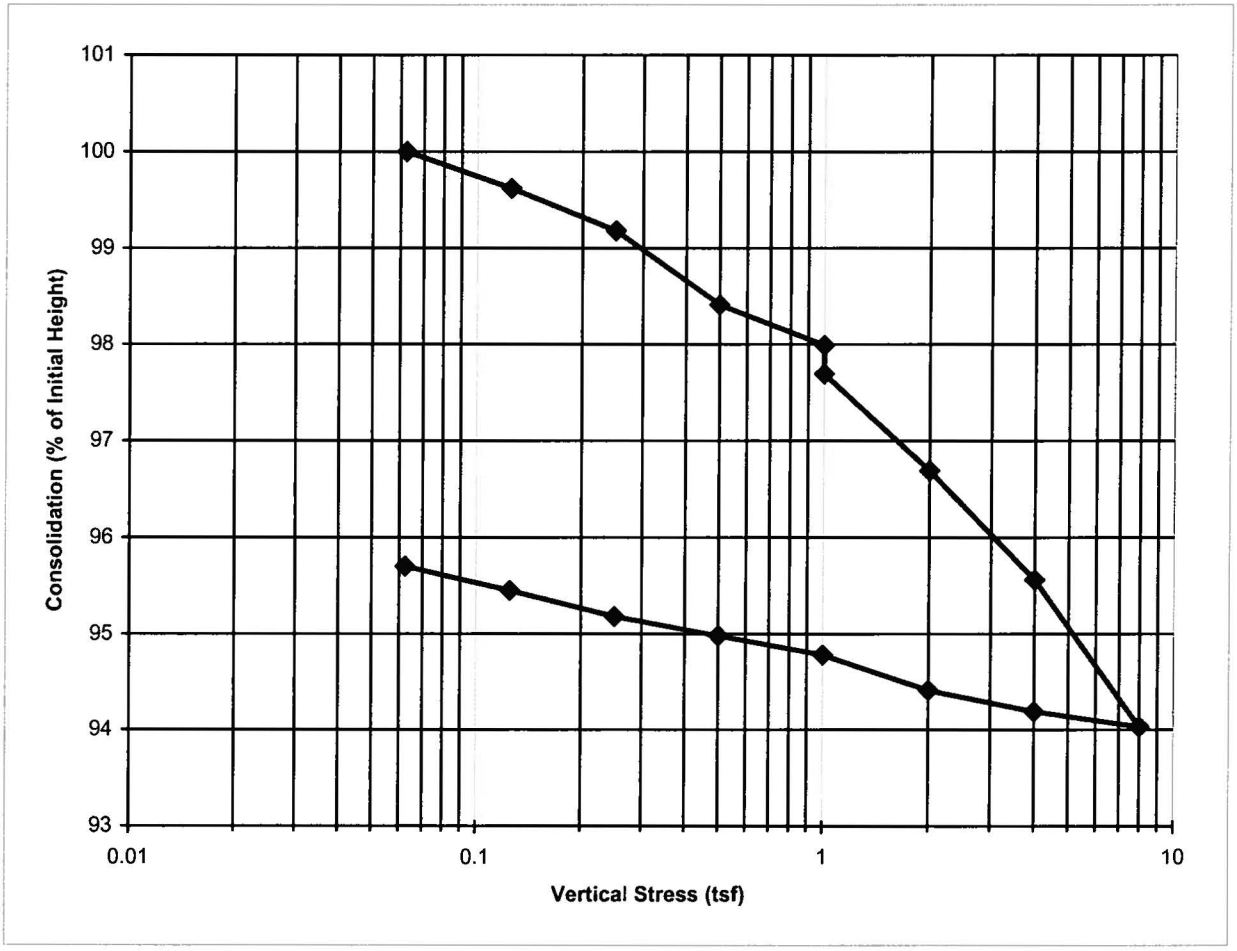
LAB #	BORING	MOISTURE WET WT. (g)	MOISTURE DRY WT. (g)	MOISTURE MOISTURE CONTENT	NUMBER OF RINGS	WET WEIGHT & RINGS (g)	WEIGHT OF RINGS (g)	DRY DENSITY (pcf)
4	BH-1 @ 4.5-5.5'	643.2	606.0	6.1%	5.0	855.8	212.1	100.4
5	BH-1 @ 9.5-10.5'	504.8	472.0	6.9%	4.0	677.7	172.8	97.7
11	BH-2 @ 4.5-5.5'	755.2	695.4	8.6%	6.0	1,012.0	256.1	96.1
12	BH-2 @ 9.5-10.5'	244.3	221.4	10.3%	4.0	671.5	182.6	91.7
19	BH-3 @ 9.5-10.5'	258.0	213.7	20.7%	3.0	529.9	129.3	91.6

REVIEWED BY _____

PROJECT:	Gila River Bank Protection Pre-Design	**JOB NO:**	08-117-01092
LOCATION:	Arizona	**WORK ORDER NO:**	1
MATERIAL:	Soil	**LAB NO:**	5
SAMPLE SOURCE:	BH-1 @ 9.5-10.5'	**DATE ASSIGNED:**	2/6/09
SAMPLE PREP:	Insitu		

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF SOILS (ASTM D2435)

INITIAL VOLUME (cu.in)	4.60	FINAL VOLUME (cu.in)	4.33
INITIAL MOISTURE CONTENT	8.0%	FINAL MOISTURE CONTENT	22.1%
INITIAL DRY DENSITY(pcf)	103.4	FINAL DRY DENSITY(pcf)	109.6
INITIAL DEGREE OF SATURATION	32%	FINAL DEGREE OF SATURATION	101%
INITIAL VOID RATIO	0.73	FINAL VOID RATIO	0.62
		SATURATED AT	1 tsf



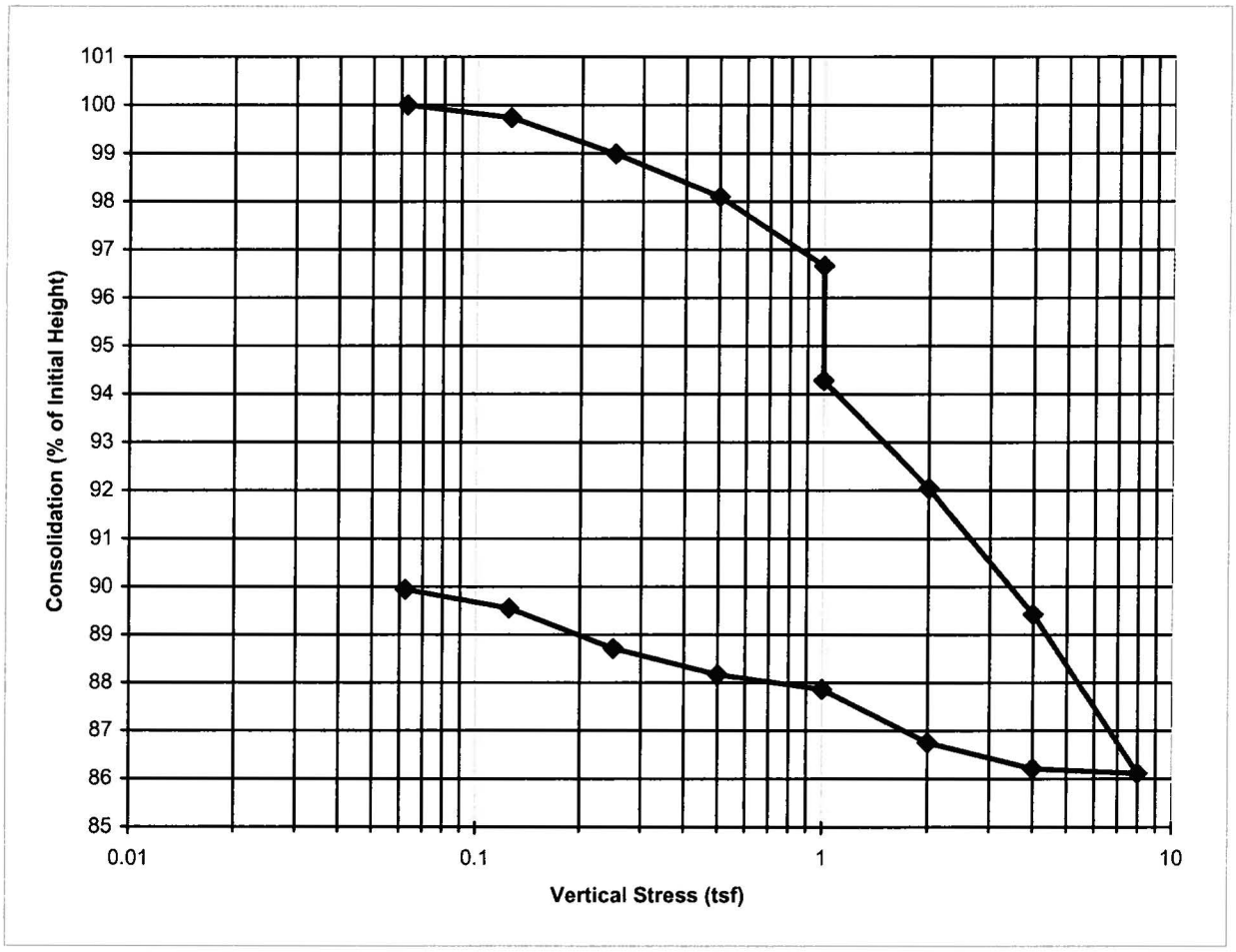
AASHTO R18

REVIEWED BY

PROJECT:	Gila River Bank Protection Pre-Design	**JOB NO:**	08-117-01092
LOCATION:	Arizona	**WORK ORDER NO:**	1
MATERIAL:	Soil	**LAB NO:**	12
SAMPLE SOURCE:	BH-2 @ 9.5-10.5'	**DATE ASSIGNED:**	2/6/09
SAMPLE PREP:	Insitu		

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF SOILS (ASTM D2435)

INITIAL VOLUME (cu.in)	4.60	FINAL VOLUME (cu.in)	3.96
INITIAL MOISTURE CONTENT	10.9%	FINAL MOISTURE CONTENT	24.6%
INITIAL DRY DENSITY(pcf)	91.1	FINAL DRY DENSITY(pcf)	105.3
INITIAL DEGREE OF SATURATION	33%	FINAL DEGREE OF SATURATION	102%
INITIAL VOID RATIO	0.96	FINAL VOID RATIO	0.69
		SATURATED AT	1 tsf



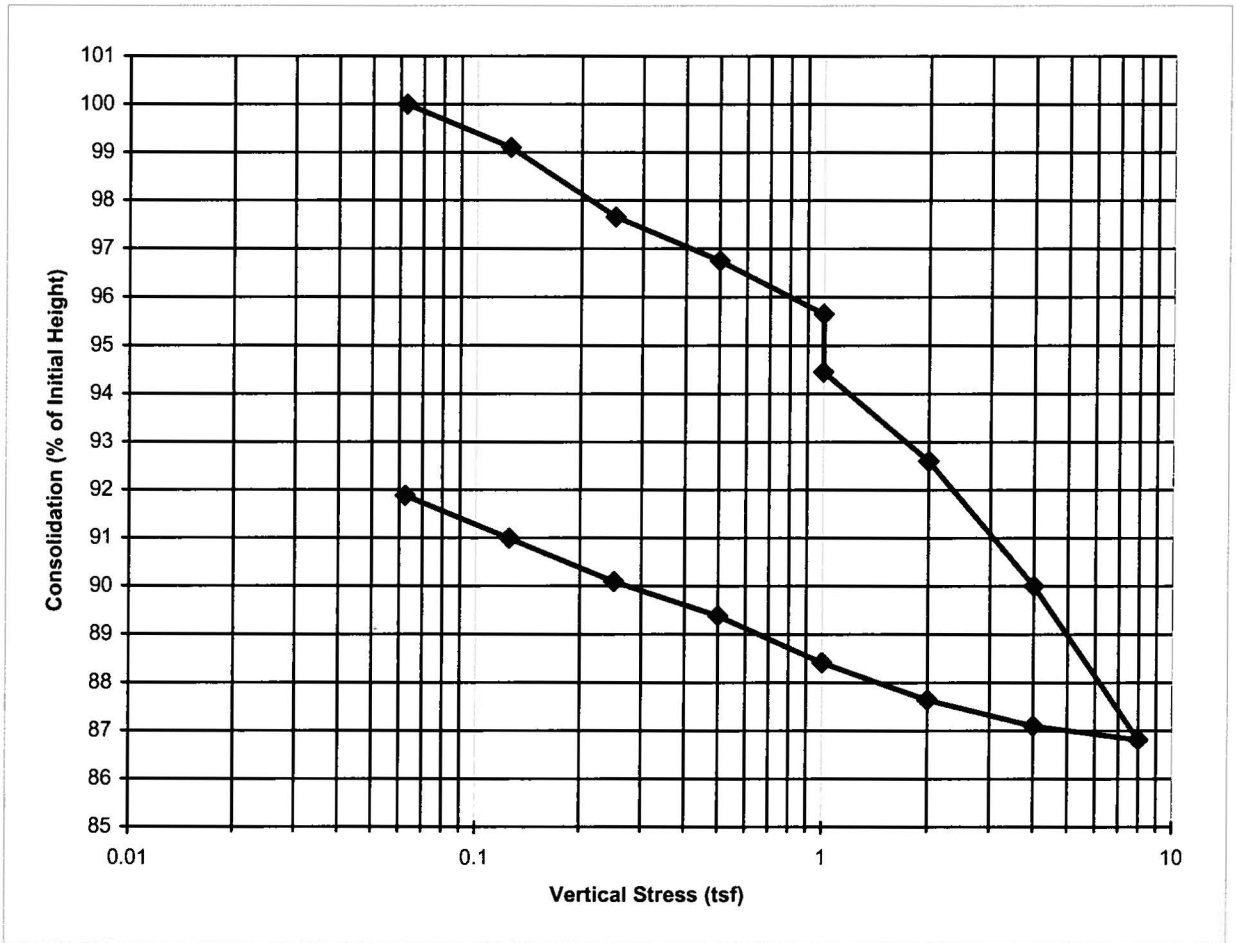
AASHTO R18

REVIEWED BY

PROJECT:	Gila River Bank Protection Pre-Design	**JOB NO:**	08-117-01092
LOCATION:	Arizona	**WORK ORDER NO:**	1
MATERIAL:	Soil	**LAB NO:**	19
SAMPLE SOURCE:	BH-3 @ 9.5-10.5'	**DATE ASSIGNED:**	2/6/09
SAMPLE PREP:	Insitu		

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF SOILS (ASTM D2435)

INITIAL VOLUME (cu.in)	4.60	FINAL VOLUME (cu.in)	3.99
INITIAL MOISTURE CONTENT	23.2%	FINAL MOISTURE CONTENT	26.3%
INITIAL DRY DENSITY(pcf)	97.0	FINAL DRY DENSITY(pcf)	111.3
INITIAL DEGREE OF SATURATION	69%	FINAL DEGREE OF SATURATION	104%
INITIAL VOID RATIO	1.10	FINAL VOID RATIO	0.82
		SATURATED AT	1 tsf



AASHTO R18

REVIEWED BY

SHEETS

0 50 100 200 300 400 Feet

Project: 08-117-01092
Scale: 1"= 100'
Design: RB

SITE PLAN

Gila River Bank Protection Pre-Design
Perryville Road to Citrus Road
Maricopa County, Arizona

SHEET
2 of 2

amec

Project: 08-117-01092
Scale: 1"= 100'
Design: RB

SITE PLAN

Gila River Bank Protection Pre-Design
Perryville Road to Citrus Road
Maricopa County, Arizona

SHEET
1 of 2

amec