Attachment 7:

Exploration data from Ruby Wash Diversion Levee only, by Kleinfelder West (2009).

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FINAL GEOTECHNICAL EVALUATION REPORT
FEMA CERTIFICATION
OF RUBY WASH DIVERSION LEVEE WEST
STATION 163+80 TO 381+30
WINSLOW, ARIZONA

Prepared for:

Woodson Engineering & Surveying, Inc.
124 North Elden Street
Flagstaff, Arizona 86001

Kleinfelder Project No.: 93212 (2.4W)

Kleinfelder West, Inc.
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July 17, 2009

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KLEINFELDER
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July 17, 2009
File No.: 93212 (2.4W)

Jeff Swan, PE
Woodson Engineering & Surveying, Inc.
124 North Elden Street
Flagstaff, Arizona 86001-5262

SUBJECT: Final Geotechnical Evaluation Report
FEMA Certification of the Ruby Wash Diversion Levee West
Station 163+80 to 381+30
Winslow, Arizona

Dear Mr. Swan:

Kleinfelder is pleased to present this Final Geotechnical Evaluation Report for the Ruby Wash Diversion Levee West located in Winslow, Arizona. The purpose of this report is to summarize our findings regarding the geotechnical aspects of levee certification per 44 CFR Section 65.10. In addition, recommendations for further study are provided.

Kleinfelder appreciates the opportunity to work with you on this project. Should you wish to discuss this report or if we may be of further assistance, please contact the undersigned.

Sincerely,

KLEINFELDER WEST

Registered Geologist Certificate No. 46236 Marc Nicholas Moncilovich Date Signed 7-17-09 Arizona U.S.A.

Marc Moncilovich, RG
Geotechnical Project Manager

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1 INTRODUCTION

1.1 Location and Description

The Ruby Wash Diversion Levee (RWDL) is owned by the City of Winslow and is located approximately 1 mile south of Winslow, Arizona. Specifically, the levee is located within sections 31, 32 and 33 of Township 19 North, Range 16 East and sections 34, 35 and 36 of Township 19 North, Range 15 East of the Salt River Baseline Meridian. The site location is presented on Plate 1.

1.2 Purpose and Scope

Woodson Engineering is under contract with the City of Winslow to perform the Federal Emergency Management Agency (FEMA) certification of Ruby Wash Diversion Levee. RWDL is a provisionally accredited levee (PAL) with a FEMA PAL agreement that expires on July 22, 2009. The levee is within FEMA Region 9 jurisdiction. The RWDL has been segmented into two sections. Only one of the two sections (RWDL West) is intended to obtain FEMA certification at this time. This is discussed in greater detail in Section 2.1.

Kleinfelder has been selected to provide geotechnical engineering services in support of the FEMA certification for the RWDL West. Kleinfelder's scope is limited to geotechnical evaluations and includes investigations and documentation to satisfy current FEMA requirements B(4) and B(5) of 44CFR 65.10. Hydraulics and Hydrology (H&H) analyses were performed by JE Fuller, Inc. and Coe and Van Loo, Inc. Woodson Engineering coordinated the certification effort on behalf of the City of Winslow. Woodson Engineering also provided engineering support and survey services for the project and will prepare the final levee certification report to FEMA.

Kleinfelder's geotechnical study was divided into two phases (Phase I and II) to be completed under separate contracts. This report presents results of both the Phase I and Phase II study. The purpose of the Phase I study was to obtain subsurface information within the levee and underlying foundation materials, develop site characterization model, evaluate potential failure modes and select cross sections for engineering analyses. The Phase 1 study was completed in general accordance with

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our proposal to Woodson Engineering dated August 28, 2008. The Phase I study was limited to the levee reach from Station 165+00 to Station 381+30 as shown on Plate 1. The scope included background information review, field investigations with surface geophysical surveys and exploratory borings, soil sampling, laboratory testing and engineering evaluations of the data.

The Phase II field study was completed in general accordance with our proposal to Woodson Engineering dated April 7, 2009. The Phase II field study was limited to Station 163+80 to Station 381+30. These station limits were based upon the report titled: Segmentation Technical Memorandum for Ruby Wash Diversion Levee, by JE Fuller Inc. dated November, 2008. The study limits are shown on Plates 3 through 8. The purpose of the Phase II field study was to aid in the evaluation, from a geotechnical standpoint, whether the RWDL West levee satisfactorily meets or exceeds the current general FEMA requirements for levee certification outlined in 44 CFR Section 65.10, or if it requires further improvements to meet certification requirements.

1.3 Project Elevations

Ground surface elevations are based on existing surface topographic survey elevations provided by Woodson Engineering Inc. and 100-year water surface elevations were provided by JE Fuller and Associates. Elevation references in this report are in feet and are based on the North American Vertical Datum of 1929 (NAVD29).

1.4 Levee Performance Issues Not Addressed

This report primarily addresses levee performance issues related to operation and maintenance, seepage, slope stability and settlement. Other levee performance issues not addressed in this report include the following:

- Embankment Protection;
- Closure Devices;
- Interior Drainage; and,
- Encroachments.

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2 BACKGROUND INFORMATION

2.1 Description of the Ruby Wash Diversion Levee

The Ruby Wash Diversion Levee system is approximately 5.3 miles in length and was constructed to provide flood protection to the City of Winslow from flood waters originating from two main areas. According to the report titled: Segmentation Technical Memorandum for Ruby Wash Levee, by JE Fuller and Coe and Van Loo, dated November 2008, the levee is segmented by a ridgeline at approximately Station 163+80. Waters originating south and east of this ridgeline flow parallel to the levee and into the Little Colorado River (LCR). Similarly, waters originating south and west of this ridgeline run west and then north into Ruby Wash through a storm drain that penetrates the levee at Station 286+40. Because of this ridgeline, the Ruby Wash Diversion Levee system, can be divided into two separate levees appropriately labeled RWDL West and RWDL East with Station 163+80 serving as the division. According to JE Fuller's H&H report dated October 2008 almost the entire section of the RWDL East from approximately Station 147+34 to the confluence of the Little Colorado River at Station 99+60 would overtop under a 100-year flood. Therefore, the City of Winslow has only requested FEMA certification under 44 CFR Section 65.10 for the RWDL West Levee as defined from levee station 163+80 to 381+30.

The RWDL West provides protection from Ice House Wash, Ruby Wash and four other unnamed washes. Flow from each of these washes is characterized as intermittent. A low flow channel is located on the waterside of the levee. The channel and levee were constructed concurrently to contain and divert water generally parallel to the levee.

Previous to the design and construction of the RWDL system, the Civil Aeronautics Administration (now the Federal Aviation Agency) constructed a small diversion levee in 1944 to protect the recently completed Winslow Airport runway extension. This older levee was removed during construction of the RWDL. The only remnant of this older levee can be seen on the west bank of Ruby Wash just north (landside) of levee Station 286+40.

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2.2 Levee Design and Construction

The levee was designed by the United States Army Corps of Engineers (USACE) in 1969 and construction was competed in 1971. The USACE document titled: Winslow Flood Control Project, Winslow, Arizona and Vicinity – Design Memorandum No. 1, dated 1969, states the following:

"The levees would be constructed of soil and rock from the excavation and borrow. The fill material would be placed in layers not exceeding 12-inches. A 10-foot minimum width of compacted soil would be provided at the center of the levee to preclude an entire rock fill section. (Zone I). The outer zones would vary from soil to rock fill, with coarser (rock) materials placed toward the outer slopes (Zone II). Because of the short duration of peak flow and the imperviousness of the compacted soil, a steady seepage condition would not develop, hence piping would not occur Placement of the coarser material on the outer slopes would result in an infinite slope safety factor of 1.2, based on the assigned shear strengths."

Plate 2 illustrates a typical RWDL levee cross section with Zone I and II levee materials indicated. The assigned design strength parameters from the design memorandum are provided in Table 1-1 below:

Table 1-1 – Assigned Design Shear Strengths

	Compacted Soil	Compacted Rock Fill	Foundation Soil
Dry Weight, pcf	105	120	90
Drained Weight, pcf	121	125	105
Saturated Weight	129		120
Degrees (drained)	30	35	28

The USACE document titled: Specifications for Ruby Wash Diversion Levee, dated 1970, indicates the Zone I material is to consist of a minimum of 70% passing the No. 4 sieve with no pieces larger than 9 inches. In addition, the waterside slopes are covered with an ungrouted stone revetment ranging in weight from 5 to 500 pounds. See photograph No. 1 in Appendix G for a typical view of levee revetment.

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A low flow channel was constructed parallel to the levee to convey and channelize overland flows, which are generally oriented perpendicular to the levee alignment. The channel, as shown on Plate 2, is trapezoidal in cross section with approximately 0.5H:1V slopes. It is located approximately 30 to 100 feet from the levee toe and varies in depth from approximately 1 to 20 feet. See Appendix 3, Photograph No. 2 for a typical view of the channel.

According to the USACE design documents, the average height of the levee is approximately 12 feet with an average crown width of 16 feet. The slopes of the levee are approximately 2H:1V. A 36-inch reinforced concrete pie was constructed through the levee at Station 286+40 to provide outlet of water into Ruby Wash (Appendix G, Photograph No. 3). No As-Built information for this pipe crossing was available.

USACE specifications referenced the specifications for Ruby Wash Diversion Levee, dated 1970 indicate the following:

"*Fill material shall be compacted with rubber-tired rollers of the type hereinbefore specified to the extent that each layer of fill is transversed with four passes of a rubber-tired or vibratory roller…If from field tests made by the government, it is determined that the desired compaction of any fill is not secured by the minimum number of passes specified, additional passes shall be made over the surface area of such designated portion."*

No minimum compaction density percentages for levee fills were stated in the specification documents or in the plans. However, the moisture content of the levee fills were required to be within three percent of optimum moisture as provided by American Association of State Highway Officials Specification T 99-61 I, Moisture Density Relations of Soil Using a 5.5 pound Rammer and a 12-inch Drop.

2.3 Operation and Maintenance

An outline for procedures of operation and maintenance (O&M) of the RWDL is provided in USACE document titled: Operation and Maintenance Manual for Ruby Wash Diversion Levee Flood Control Project at Winslow, Arizona, November 1981, Revised 2007. The O&M manual indicated levee inspections are to be performed semiannually and records are to be submitted to the USACE Commander, Los Angeles

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District. The inspections are the responsibility of the Superintendant appointed by the Winslow City Council. One levee inspection report was discovered in the records search. The inspection was performed on June 20 and 21, 2007 and reported issues of erosion to the landslide embankment, encroachment and overgrown vegetation.

Kleinfelder performed an inspection of the RWDL in March, 2008. The results of the inspection are presented in the final report titled: *Levee Inspection Memorandum Letter, Ruby Wash Diversion Levee, Winslow, Arizona*, dated January 6, 2009 (Appendix K). Numerous maintenance items such as slope erosion (rilling) and animal burrows were observed and documented in the referenced report. Minor rilling and general slope erosion tended to be more pronounced on the landside levee slopes. Riling areas tended to occur intermittently along the levee length. However, some localities experienced deeper erosional gullies. No evidence of seepage, settlement, or slope failure was discovered during the inspection. The report identifies several areas along the levee that appear to have a minor reduction in levee cross section due to erosion from rainwater. Many of these problematic areas of erosion were compounded by human activities such as off-road vehicle use and burrowing animals.

2.4 Levee Survey Comparison

Woodson Engineering performed a survey along the levee control line to compare the original As-Built elevations. The survey was performed in 2008 and illustrates the As-Built levee profile compared to the 1971 As-Built plans. Selected cross section profiles from the 1971 As-Built's were also surveyed by Woodson Engineering. The surveys are presented in Appendix I.

In general, the 2008 elevation measurements along the levee control line were greater than shown on the 1971 As-Built plans. Out of 64 control line survey points only three indicated elevations less than the 1971 As-Builts. The three survey points in question ranged from 0.09 to 0.3 feet. The remaining 61 survey points that measured above the 1971 As-Builts ranged from 0.05 to 2.9 feet. The deviations in the levee profiles from the As-Built plans may be attributed to either a lack of construction control during grading, a higher level of survey accuracy when compared to the 1970's survey technology, or a combination of both.

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The 2008 survey elevations along the levee slopes indicate that the slopes are generally shallower than were originally surveyed by the Army Corps of Engineers. This may be attributed to erosional processes like hydraulic forces caused by rainfall and abrasion caused by wind in dry conditions and water in wet conditions. A lack of adequate construction survey control during construction may have also been a factor.

2.5 Historical Floods

The City of Winslow Fire Chief, Mr. Boney Candalaria, stated via a personal interview with Mr. Jeff Swan of Woodson Engineering that he could not recall flood waters being behind the subject levee within the last 40 years. Mr. Candalaria is responsible for checking the drainages around Winslow during high rain events.

One flood was briefly discussed for the Winslow area in the USACE Design Memorandum No. 1 (Appendix E). According to this document, the storm of August 25, 1957, dropped approximately 1 inch of rain within an hour. A total of 1.2 inches fell over a four hour period. Discharge estimates or damage reports were not provided and the location of flooding was not specified.

The report titled: *Data Collection and Levee Categorization Report for Ruby Wash Diversion Levee,* Winslow, Arizona, by J.E. Fuller, Inc., dated October 2008 were reviewed for historical flood data. No records of flooding against the RWDL were found. However, the 100-year flood elevation data is provided in this report. The 100-year Flood level, as provided by J.E. Fuller report, was plotted against the levee crown and toe height at specific boring locations (Plate 14). In general, the difference between the 100-year flood elevation and the top of levee increases from west to east. From Station 381+30 to 350+00, the 100-year flood height against the levee is approximately 1 foot. From Station 350+00 to approximately 270+00 the 100-year flood height is approximately 5-feet. The 100-year flood height against the levee ranges from 5 to 10 feet from Station 270+00 to 165+00.

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The document titled: *Flood Insurance Study (FIS) for Navajo County*, by the Federal Emergency Management Agency, dated November 1993 was also reviewed for historical flood information. One historical flood event was discussed in this reference. The flood occurred in 1978 within a subdivision near the Little Colorado River. Extensive property damage was reported in this subdivision. This area is not within the RWDL West floodplain and there were no references to flooding against the RWDL.

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3 GEOLOGY AND GROUNDWATER

3.1 Geology

The site is located in the Colorado Plateau physiographic province, which is one of three physiographic and structural provinces in the State of Arizona: the Colorado Plateau, Transition Zone, and Basin and Range. The Colorado Plateau is generally characterized by broad, relatively flat-lying, seismically stable mesas. Geologic mapping of the project area by Richards, Reynolds, Spencer and Pearthree (2000) indicates Triassic Moenkopi Formation (Moenkopi) as the only major rock unit exposed at the surface at the site. The Moenkopi Formation was deposited in a near-shore, braided stream environment during the mid to upper Triassic time period (230 – 245 million years ago).

The Moenkopi is generally red in color with interbedded and laterally discontinuous claystone/siltstone lenses. Gypsum and other evaporite minerals intermittently occur as thin laminations between the claystone/siltstone interbeds. In general, weathering of this rock unit has produced a relatively thin residual cover of silty and clayey sand. The Moenkopi was observed in outcroppings throughout the project area, especially within washes and the low flow channel excavation. These intermittent washes are generally subject to flash-flood conditions during infrequent rain events.

3.2 Faulting and Seismicity

According to the report titled: *Development of Seismic Acceleration Contour Maps for Arizona*, by Euge and Lam, dated September 1992, the Ruby Wash Diversion Levee is located in the Southwestern Plateau Seismic Source Zone. This seismic zone is characterized by low-activity Quaternary faults. The maximum credible earthquake for the project area is conservatively estimated at a magnitude of 6.5 (Euge, et al, 1992). The largest instrumentally recorded event was the 1959 Fredonia earthquake of a magnitude of 5.5 (Euge, et al, 1992).

There are no mapped faults within the general vicinity of the project site. The United States Geological Survey reports that there are at least four active fault zones within 50 miles of the site. The nearest Holocene faults to the site are the Horseshoe Fault Line

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and the Big Chino Fault located approximately 89 miles southwest and 103 miles west of the project area, respectively. The nearest Late Quaternary faults are the Rock Horse Faults and Lake Mary Fault Zone located approximately 34 miles northwest and 40 miles west of the project area, respectively. The nearest Mid Quaternary Faults to the site are the Leupp Faults located approximately 28 miles northwest, Vernon Fault Zone located approximately 69 miles southeast, and the Cottonwood Basin Fault located approximately 68 miles northwest of the project area. In general, the faults form am intersecting pattern of northeast and northwesterly trending faults.

Based on the seismic acceleration contour maps developed by the USGS (2005), the peak horizontal acceleration in bedrock with a 10 percent probability of exceedance in 50 years is approximately 0.04g for the subject site. The peak horizontal acceleration in bedrock with a two percent probability of exceedance in 50 years is approximately 0.11g for the subject site.

3.3 Regional Groundwater

A search of the Arizona Department of Water Resources web site indicates that two state monitored wells are located approximately 5 miles from the levee. Well No. A-19-1606CDB is located approximately 5 miles to the northwest of the levee. The depth to groundwater at this well is approximately 44 feet. However, this well is approximately 1 mile west of the Little Colorado River (LCR), within the LCR floodplain, and is likely influenced by groundwater recharge from the river. Well No. A-18-1413ABD3 is located approximately 5 miles southwest of the levee. The depth to groundwater at this well is 286 feet. We anticipate the groundwater depth beneath the levee for the project area is in excess of 100 feet below the ground surface. No groundwater was encountered during our field exploration.

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4 FIELD EXPLORATION AND LABORATORY TESTING

4.1 Previous Explorations

USACE performed a limited study during the design phase of the RWDL. The USACE information is provided on the As-Built plans (Appendix D). Exploration locations are also shown on Plates 3 through 8. Pre-construction explorations consisted of "auger probes" to refusal depths and test pits. Auger probe test results, as shown on As-Built plans, only include depth to refusal and no subsurface soil descriptions. Auger probe refusal depths ranged from 0.1 feet to 6 feet below ground surface. Four test pits (TT-5 through TT-9) are located within the study area. The test pit logs indicate silty sand and clayey sand overlying bedrock.

4.2 Phase I (2008) Exploration

Based on the review of the available background information and our site inspection results, Kleinfelder produced a detailed exploration plan for the Phase I field study. The exploration program was designed to compliment information already available and to meet the following objectives: characterize subsurface stratigraphy in view of the identified potential failure modes; collect samples for laboratory testing; estimate material properties for seepage and slope stability analyses; and to develop a subsurface stratigraphy profile along the levee crown and at the selected cross-sections. The plan included drilling details and specifications, data objectives, locations and depths of borings, locations of geophysical lines and proposed field and laboratory testing program (Kleinfelder, 2008).

The locations of the subsurface explorations are presented on Plates 3 through 8. Generally, the boring locations were selected to 1) investigate foundation conditions near linear map features crossing the levee alignment such as washes and streams; 2) validate data from old auger probes; 3) evaluate existing conditions and validate information presented on As-Built drawings; and 4) evaluate embankment material properties as compared to the design parameters.

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The subsurface exploration was performed from October 30 to November 11, 2008, and consisted of drilling and logging a total of 25 hollow stem auger borings. Borings B-1 through B-18 and B-20 through B-26 were generally advanced to auger refusal. Boring B-19 was omitted from the boring plan because the proposed location was actually a ridgeline with a very thin levee section present. The borings were advanced utilizing a CME-75 truck-mounted drill rig equipped with an 8-1/4-inch outside diameter hollow stem auger. Bedrock cores were obtained at five boring locations. At a few boring locations where bedrock cores were desired, an air-rotary drilling method using a tricone bit was used to advance the hole down to a stratum that had sufficient hardness to begin the NQ core run. Water was used as the circulating medium only for the NQ bedrock cores. The borings were advanced to depths between 2 feet and 30.5 feet below existing grade.

Relatively disturbed soil samples were obtained using a California sampler with a 2.5-inch inside diameter and a 3.0-inch outside diameter. Additional soil samples were obtained using a split-spoon sampler with a 1.5-inch inside diameter and a 2.0-inch outside diameter. The split spoon sampler with no liners was driven a maximum of 18 inches using a 140-pound “automatic” hammer falling 30 inches. Blow counts for successive 6-inch penetration intervals were recorded. This process is referred to as the standard penetration test (SPT). The SPT data is discussed in greater detail in Section 5.1.1. California samplers were driven a maximum of 12 inches with the same hammer weight and drop height. Bulk samples of auger cuttings were obtained at selected intervals. Each bore hole was backfilled with a cement/bentonite slurry mixture.

A Kleinfelder Staff Professional continuously monitored the field drilling activities; visually classified the soil and rock encountered, prepared boring and core logs, and collected samples for laboratory testing. The explorations were logged in general accordance with procedures established in ASTM D 2488, ASTM D 2487 and USACE Engineering Manual for Geotechnical Investigations (EM 1110-1-1804). Boring logs in gINT format are provided in Appendix A.

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4.3 Phase II (2009) Exploration

The phase II field program was developed based upon the findings of the Phase I study. The main objectives for the Phase II field program were to:

- Use the sonic boring method to recover more representative samples of the levee fill material to compare laboratory gradation and internal zonation against the original project specifications.
- The Phase I geophysical line S5 indicated an anomalous subsurface feature near Station 361+00. An additional, higher resolution geophysical study was performed in this area, along with additional sonic borings, to further characterize the anomaly.
- Better characterize the alluvial materials that underlie the levee where the levee intersects washes and recover undisturbed samples of the alluvial materials for laboratory testing.
- Evaluate the as-built condition of the Ruby Wash culvert levee penetration at station 286+40.

The locations of the Phase II sonic borings and geophysical lines are presented on Plates 3 through 8. The sonic borings were performed from March 30 to April 7, 2009, and consisted of drilling a total of seven bore holes (SB-1 through SB-7). The borings were advanced using a track-mounted Mini Sonic Class 100 Series drill rig equipped with 6-¼-inch outside diameter core barrel. The borings were advanced to practical refusal on hard bedrock material. The recovered samples were logged in the field and transported to Kleinfelder's Tempe laboratory.

An undisturbed sample was obtained of alluvial material from under the levee at sonic boring location SB-1 at 26.5 feet below existing ground surface as shown on Appendix A-33 A California sampler was driven a maximum of 12 inches using a 140-pound "automatic" hammer falling 30 inches. Blow counts for successive 6-inch penetration intervals were recorded. Each boring was backfilled with a cement/bentonite slurry mixture.

A Kleinfelder Registered Professional Geologist continuously monitored the field activities and supervised the Kleinfelder Staff Professional who visually classified the soil and rock, prepared boring logs, and collected samples for laboratory examination and testing. The explorations were logged in general accordance with procedures

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established in ASTM D 2488, ASTM D 2487 and USACE Engineering Manual for Geotechnical Investigations (EM 1110-1-1804). Boring logs in gINT format are provided in Appendix A. Photographs of the recovered sonic and rock core samples are presented in Appendix H.

4.4 Laboratory Testing

Geotechnical laboratory tests were performed on selected soil samples collected from the borings. The laboratory program was designed to aid in our assessment of the geotechnical engineering properties of the levee materials and subsurface soils.

The Phase I laboratory testing program consisted of the following tests:

- Ten (10) Unit Weight (ASTM Test Method D 2937);
- Ten (10) Moisture Content (ASTM Test Method D 2216);
- Twenty (20) Grain Size Analysis (ASTM Test Method D 2487);
- Twenty (20) Atterberg Limits (ASTM Test Method D 4318); and,
- Five (5) Particle Size Analyses – Hydrometer (ASTM Test Method D 422).

The Phase II laboratory testing program consisted of the following tests:

- Thirty (30) Grain Size Analysis with Hydrometer (ASTM Test Method D 2487 and D 422);
- Thirty (32) Atterberg Limits (ASTM Test Method D 4318);
- Two (2) Grain Size Analysis, 200 minus by washing (ASTM C 117); and,
- One (1) Consolidation (ASTM D 2435).

A summary of the laboratory test results are presented in Appendix B and discussed in Section 5.2. Results of the unit weight and moisture content tests are shown on the boring logs in Appendix A.

4.5 Geophysical Explorations

The Phase I geophysical survey was conducted to supplement information obtained in the Phase I borings and assist with site characterization efforts. Five Refraction Microtremor (ReMi) Seismic lines were performed by Kleinfelder's subcontractor, Mr.

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Jim O'Donnell. The ReMi method is a geophysical method that utilizes background noise to delineate the layered profile of the subsurface, and calculates the shear wave in the subsurface materials. In addition to the ReMi survey, ground penetrating radar (GPR) surveys were performed at the same five Phase I ReMi locations. GPR is a tool to detect voids and to interpret geologic structures in the subsurface.

The Phase II geophysical survey consisted of performing two (2), 235-foot, 48 channel Vp refraction tomography seismic lines at the locations specified below. In addition to the seismic lines, a GPR survey was conducted at the same locations to supplement the seismic data. The Phase II geophysical survey was conducted to:

- Provide a more accurate subsurface velocity model to better characterize the anomaly encountered in the Phase I ReMi geophysical survey in the vicinity of Station 381+00.
- Provide information regarding the backfill material that was placed over the levee culvert penetration at station 286+40.

The results of the Phase I and Phase II geophysical surveys are presented in Appendix C. The results are discussed in Sections 5.1.1 and 5.1.2.

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5 SUBSURFACE CONDITIONS

5.1 Subsurface Conditions

Subsurface conditions encountered in the exploratory borings are summarized in Table 5-1 and discussed in the following sections.

Table 5-1 - Summary of Subsurface conditions at selected boring locations

Boring No.	Station No.	Elevation of Boring	Maximum Depth of Boring (ft bgs)	Embankment Levee Fill Termination Elevation	Bedrock Elevation	100 Year Water Surface Elevation
B-1	362+49	4959	7	N/A	4954	4962
B-2	362+35	4970	17.3	4960	4960	4962
B-3	362+19	4962	14.5	N/A	4954	4962
B-4	332+00	4950	2	N/A	4949	4951
B-5	332+58	4960	12	4951	4951	4950
B-6	332+69	4950	2	N/A	4948.2	4950
B-7	295+94	4926	14	4915	4912	4920
B-8	285+50	4912	4	N/A	4911	4916
B-9	285+97	4922	21	4910.5	4902	4916
B-10	284+82	4911	14	N/A	4908	4916
B-11	275+02	4925	20.1	4910	4905	4914
B-12	253+57	4897	15	N/A	4884	4908
B-13	253+74	4921	30.5	4905	Not Encountered[1]	4908
B-14	253+72	4892	13	N/A	4882	4908
B-15	220+23	4908	2.5	N/A	4906.8	4902
B-16	207+00	4882	2	N/A	4880.8	4892
B-17	208+62	4905	25.3	4889	4881	4892
B-18	207+08	4891	14	N/A	4881	4892
B-20	172+38	4867	6.5	N/A	4863	4874
B-21	172+54	4888	30.1	4869	4858	4874

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Boring No.	Station No.	Elevation of Boring	Maximum Depth of Boring (ft bgs)	Embankment Levee Fill Termination Elevation	Bedrock Elevation	100 Year Water Surface Elevation
B-22	172+68	4865	17.5	N/A	4857.8	4870
B-23	372+20	4962	20	N/A	4945.5	4964
B-24	347+00	4956	15	N/A	Not Encountered[1]	4957
B-25	318+00	4943	12.3	N/A	4941.5	4940
B-26	244+00	4903	11	N/A	4901	4908
SB-1	209+80	4888	27.5	4864	4861.5	4894
SB-2	244+90	4920	25	N/A	4901.5	4908
SB-3	261+47	4922	25	N/A	4906	4911
SB-4	356+20	4957	12.5	N/A	4952	4966
SB-5	358+64	4969	35	4952.5	4952.5	4960
SB-6	357+80	4969	35	4956.5	4948.5	4959
SB-7	360+13	4959	15	N/A	4952.5	4960

Notes:
Not Encountered[1] Boring terminated in soil, no bedrock encountered.
N/A Not Available – no embankment fill encountered in test

The 100 Year Water Surface Elevation data was obtained from the H&H report by J.E. Fuller Hydrology and Geomorphology, Inc., "Data collection and Levee Categorization Report for the Ruby Wash Diversion Levee", Winslow, Arizona, Pages 2-6 to 2-8 100 year water surface elevation plotted as a contour against the levee topography.

5.1.1 Levee Fill

Levee embankment fill materials were encountered in borings B-2, B-5, B-7, B-9, B-11, B-13, B-17, B-21, SB-1 through SB-4, SB-5 and SB-6, which were located along the crest of the existing levee. In general, the thickness of the levee fill was observed to range from 8 to 17 feet below existing grade of the levee crown. This is consistent with information presented on the As-Built plans.

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As discussed in Section 2.2, the levee was to be constructed with an internal core approximately 10 feet in width extending up from the levee foundation to a certain distance (3 to 5 feet) below the crown of the levee (see Plate 2). The material for this core is referred to in the specifications as “Zone I” material. According to the project specifications, the Zone I material is to consist of a maximum of 70% passing the No. 4 sieve with no pieces larger than 9-inches (Appendix F). The Zone I core is capped and protected by coarser grained Zone II material. The outer Zone II materials were allowed to vary from soil to rock fill, with coarser (rock) materials placed towards the outer slopes. Each of the hollow stem auger borings performed under the Phase I study were drilled through the approximate center of the levee crown and should have encountered both Zone I and Zone II materials. However, Zone I and Zone II materials were generally indistinguishable using this drilling method because of the granular nature of the levee fill and contamination of the drill cuttings with depth caused by the rotation of the auger and subsequent mixing of the soil. As part of the Phase II field study, we performed additional borings through the levee crown using the sonic drilling method. This provided more representative bulk samples of the levee fill for testing. Levee zonation is discussed further in Section 5.2.1.

The levee fill materials were noticeably finer grained from approximately Station 381+30 to 335+00. According to the As-Built plans (Appendix D), the previously existing 1944 levee was to be removed for the construction of RWDL. The 1944 levee material was probably re-used in the construction of the new RWDL. This finer grained zone is probably the result of the old levee materials being incorporated into the new RWDL.

During the Phase I drilling, Standard Penetration Tests (SPTs) were performed approximately every 2 feet within the borings that penetrated levee fill materials. Gravel and cobbles encountered in the levee fill affected the SPT results and resulted in high SPT blow counts. Consequently, the SPT blow counts within the gravel or cobble materials should not be relied upon as estimates of soil strength. Soils encountered in Borings B-2 and B-21 contains less gravel. Accordingly, SPT data from these borings are representative of the soil matrix. Based on the SPT results from B-2 and B-21, levee fill material has uncorrected SPT blow counts greater than 20 and can be characterized as dense. SPTs were not performed under the Phase II field study. Sonic drill rigs are not tooled to perform this test efficiently.

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Phase I seismic lines S2, S4 and S5 and Phase II seismic No. line 2 were performed on the levee crown. These lines are presented in plan view on plates 3, 5, 6 and 7. In general, geophysical surveys corroborate data obtained from the borings and information presented on the As-Built plans. The thickness of the levee fill, estimated from the seismic lines is consistent with interpretation from the boring logs. However, some minor variations do occur between levee fill depths provided on the boring logs and those interpreted by the seismic models. These variations are attributed to the general difficulty discerning levee fill materials from native soils using both the hollow stem auger and geophysical seismic test methods.

According to the Phase I 2D seismic profiles shown in Appendix C, the levee fill soils have seismic shear wave velocities (Vs) ranging from 700 to 1,000 feet per second (ft/s). Using generally accepted correlations as provided in International Building Code (IBC), Table 1613.5.2, the shear wave velocities are within the expected ranges for a stiff soil profile. According to the Phase II geophysical P-wave (Vp) tomography study, the levee fill materials appeared to be well compacted based upon the similarities between the velocities observed in the native materials and the levee fill. No areas of low shear wave velocities, anomalies or voids within the levee fill were detected in the geophysical surveys.

5.1.2 Levee Soil Foundation

Levee foundation and native soils were explored with eight hollow stem auger borings and five sonic borings advanced from the levee crown. Similarly, 17 hollow stem auger borings and two sonic borings were drilled at the landside and/or riverside levee toes. In addition, geophysical surveys were conducted at the riverside levee toe at approximate station numbers 208+00, 253+00 and 362+00.

In general, RWDL foundation model includes two native soil groups. These groups consisted of soils derived from two distinct geologic processes. The most commonly encountered native soils generally consisted of sandy lean clays (CL), sandy silts (ML), clayey silty-sands (SM-SC), and clayey sands (SC) and appear to be derived from the in-situ weathering of the Moenkopi bedrock. These residual soils were encountered within most boring locations and ranged in thickness from 2 feet to 10 feet. The residual soils were of low to medium plasticity, moderately firm to very firm consistency and dry. These native soils had a strong reaction to a dilute hydrochloric acid (HCL) solution,

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which indicates the presence of calcium carbonate. The calcium carbonates within these native soils were probably derived from the gradual weathering of the bedrock material since hand samples of the bedrock also exhibited reaction to HCL. No cementation of the surficial native soils was observed. However, the native soils gradually grade into harder bedrock with increasing depth.

The second and less common native soil group was only encountered within borings performed over areas where washes appear to intercept the levee alignment. These soils were transported to their current locations within the washes by the direct action of water. This soil group is commonly referred to as alluvium. The alluvial soils generally consisted of silty sands (SM), silty gravels (GM), clayey gravels (GC) and poorly graded gravels with silt and clay (GM-GC). The thickness of the alluvial soils ranged from 2 to 10 feet. The alluvial soils were encountered at borings B-6, B-8, B-12 through B-14, B-16 through B-18, B-20, B-24, and SB-1. The alluvial soils were generally non-plastic to low plasticity, medium to very dense and contained high percentages of fine sands and gravels. Gravelly soils were encountered in borings advanced in areas that were in close proximity to washes and channels. The gravels were encountered in borings B-13, B-17, B-18 and B-24. With the exception of B-24, each of the borings were located in areas where washes appear to intersect the levee. B-24 encountered a gravelly soil yet the boring is not located next to an obvious wash or channel. The washes located approximately at Stations 208+00 and 254+00 both encountered a thickness of approximately 5 feet of gravelly alluvial soils.

Shear wave velocities within the native soils ranged from 1,700 to 2,200 f/s. These velocities correlate with IBC Table 1613.5.2 for a very dense soil and soft rock category. In general, the velocities of the native soils increased with depth. This increase in velocity may be attributed to an increase in cementation of the native soils with depth as the native soils transition into unweathered sandstone bedrock.

Phase I seismic line S5 is located within the Ice House Wash area approximately between levee Station 356+00 and 378+00. The Phase I geophysical study indicated a zone of lower shear wave velocity extending underneath the levee. This zone may be interpreted as a buried stream channel or lateral change in cementation within the sandstone. The line did not extend far enough to estimate the width of this feature. Consequently, as part of the Phase II study a seismic Vp tomography line was performed in this area. This method provided a better resolution then the ReMi seismic

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as performed under Phase I. The results of the Vp tomography seismic refraction did not indicate as an extreme velocity drop as the Remi. However, smaller buried drainages were interpreted in the Vp tomography profiles. These drainage areas appear to be dense based upon the seismic velocities. Sonic borings in these areas did not encounter loose or highly fractured rock. However, in boring SB-4 the Moenkopi was notably friable and thinly laminated. The low shear wave zone as described in seismic line S5 is probably the results of the thinly laminated and friable nature of the Moenkopi Formation in this area.

5.1.3 Moenkopi Formation

The Moenkopi Formation (bedrock) was encountered at each of the borings except B-13 and B-24, The Moenkopi formation is composed of stratified layers of sandstone, claystone and siltstone bedrock. The bedrock was encountered at depths ranging from 1 to 28 feet bgs. Outcrops of Moenkopi were observed at the surface throughout the project site. The uppermost section of the Moenkopi formation weathers into thin remnant cover of sands with variable amounts of silt, clay and gravel as described in Section 5.1.2.

Based on the information obtained from the recovered rock cores, the sandstone is red-brown and fine grained. The discontinuities observed within the sandstone were intensely to moderately fractured, thinly to moderately bedded, low in toughness and slightly rough to rough. The discontinuity aperture separations are open to open very wide (0.1 to greater than 0.4 inch) or (2.5 to 10 mm). The discontinuity spacing's are tight to wide.

In the claystone, the discontinuities are intensely to moderately fractured, very thinly to thinly bedded and slightly rough. The discontinuity aperture separations are moderately open to open (0.1 to greater than 0.4 inch) or (2.5 to 10 mm). The discontinuity spacings are tight to wide. The rock quality estimated by the Rock Quality Designation (RQD) ranged from 0% to 84%. A typical core run was 5 feet. Core Photographs are presented in Appendix H, photos 1 through 8.

Velocity inversions were detected by the geophysical survey along the seismic lines S1 and S3. A velocity inversion is defined as a material having a higher shear wave velocity, overlaying a material of lower velocity. The Moenkopi Formation typically

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consists of interbedded sandstone, claystone and mudstone layers, such as observed in rock outcroppings throughout the site and in recovered core samples. Each of these types of bedrock lithologies exhibit varying degrees of cementation. Thus, localized shear wave velocity inversions within the Moenkopi Formation as a whole, would be expected as a result of these varying degrees of cementation.

Phase I ReMi seismic line S5 encountered an anomalous area within the bedrock. This anomaly consisted of material with a high shear wave velocity (7,500 f/s) next to an area of lower shear wave velocity (3,500 f/s). This anomaly can be attributed to some lateral change in the degree of cementation with in the bedrock material or presence of an ancient buried stream channel within the Moenkopi. This area was further evaluated with the higher resolution Vp tomography seismic refraction technique. The anomaly was not as pronounced as seen in the phase I ReMi method. However, the higher resolution method did detect areas of smaller laterally discontinuous areas that may be interpreted as buried stream channels or a lateral change in the degree of cementation within the Moenkopi sandstone.

5.2 Engineering Properties

5.2.1 Levee Fill

Based on representative SPT tests and the results of the geophysical study the levee embankment materials appear to be well compacted and predominantly homogenous with little horizontal or lateral variability in the composition and properties of the soils. Laboratory testing performed by Kleinfelder indicated an average moisture content of one to three percent and fines content range from 15 to 30 percent. Liquid Limit (LL) values ranged from 0 to 29, and the plasticity index (PI) ranged from non-plastic (NP) to 12 as shown below in Figures 1 and 2, respectively. The density of the soil in place by the drive cylinder method as estimated by ASTM S 2937 ranged from 112.4 to 113.6 pounds per cubic foot (pcf). The soils were classified as silty and clayey gravels (GM,GC) and low to medium plasticity clayey sands (SC) with cobbles.

As discussed in Section 5.1.1, Zone I and Zone II materials were hard to distinguish. Twenty-two samples of what would, according to the as-built plans, be zone I materials were tested in the laboratory. According to project specifications, the Zone I materials required 70% of the sample to be passing the No. 4 screen (Appendix F, Section 3,

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Page B-2). Section 3 in the project specifications states: **"Zone I materials shall have at least 70% of the material passing the standard No. 4 sieve and no stone greater than 9 inches."** Out of the Twenty-two samples tested, six met the stated specifications for passing the No. 4 sieve as shown in Figure 4, which shows that six of the samples were larger than the No. 4 sieve. This is shown in the figures below. The distribution of the materials finer than the No. 200 sieve are shown in Figure 3 below.

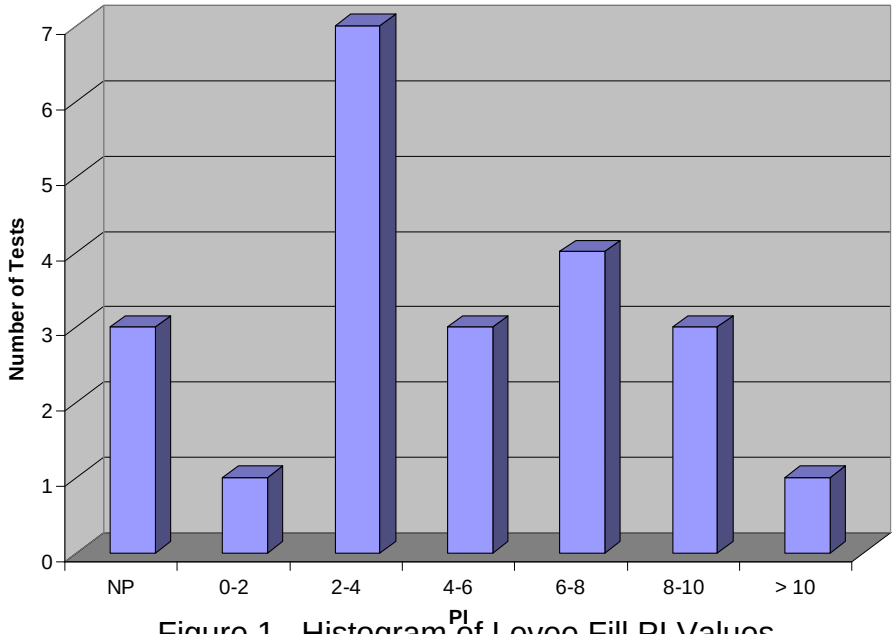

Figure 1. Histogram of Levee Fill PI Values

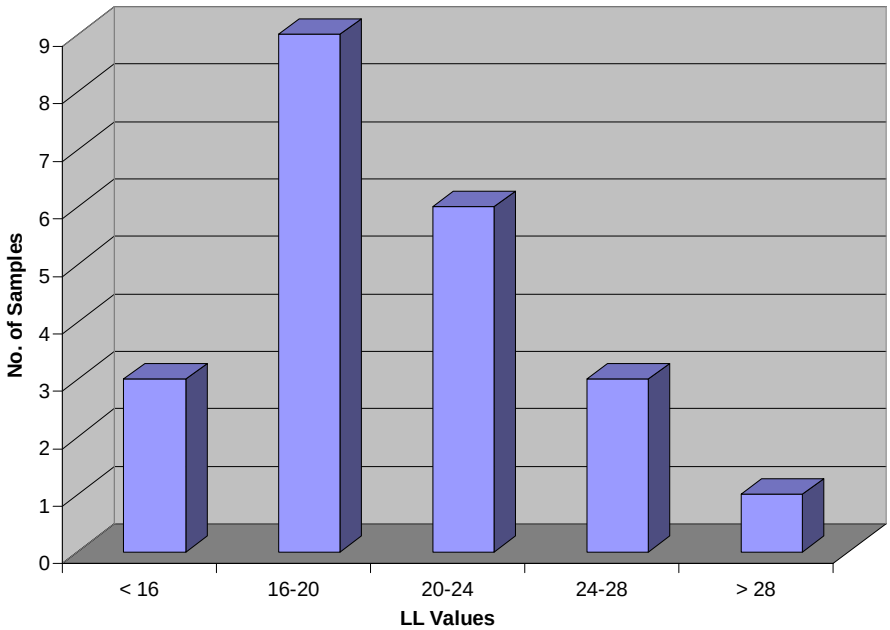

Figure 2 Histogram of Levee Fill LL Values

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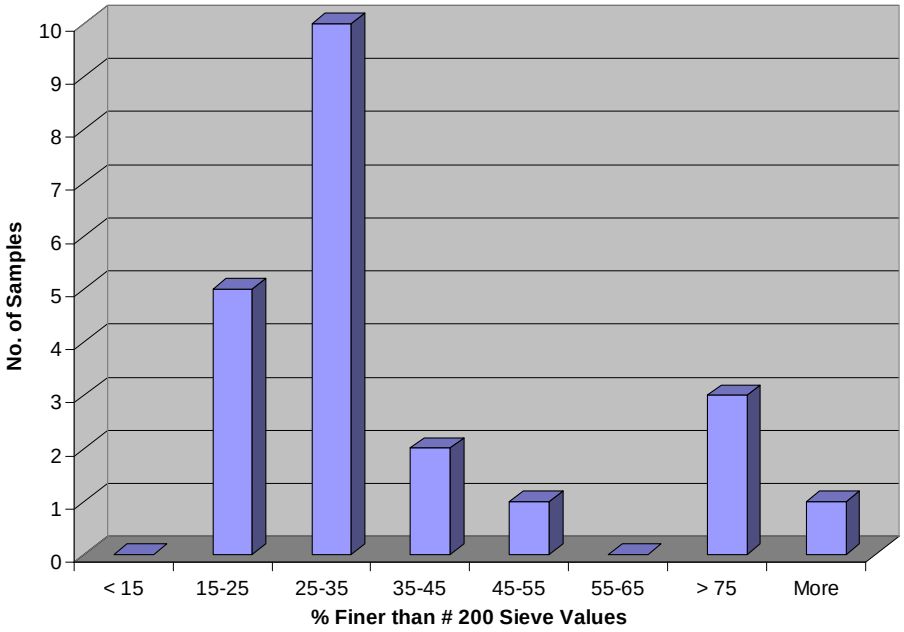

Figure 3. Histogram of % Finer than #200 Sieve Values in Levee Fil

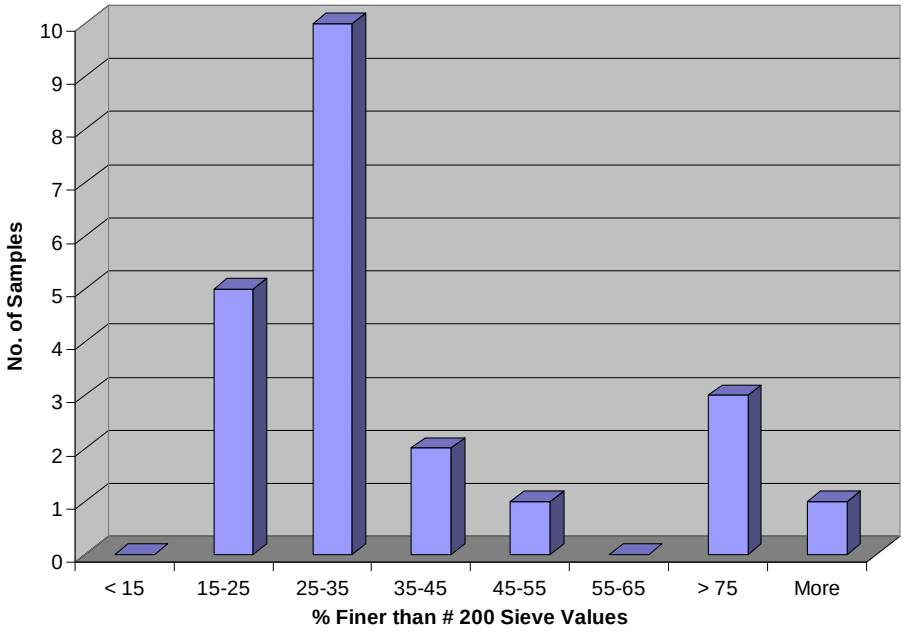

Figure 4. Histogram of Percent Larger than #4 Sieve Values in Levee

Laboratory test results for the Levee Zone I fill materials are summarized in Table 5-2. Detailed test results are presented in Appendix B.

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Table 5-2 - Summary of Laboratory Test Results of Zone I Levee Fill

					Sieve Sizes: Percent Passing by Weight								
					GRAVEL	SAND				FINES	SILT	CLAY	
					Coarse & Fine	Coarse		Medium	Fine				
Boring Num.	Sample Depth Interval (feet)	USCS	LL	PI	**1/4"**	**#4**	**#8**	**#30**	**#100**	**#200**	**0.005 mm**	**0.001 mm**	**Nat. Dry Den. (pcf)**
B-2	5	ML	29	12	97	96	94	89	82	74.8	–	–	112.4
B-7	5	GM	23	8	62	58	48	33	27	23.5	14.1	9.4	–
B-9	7	GM	24	7	49	46	40	31	27	24.3	14.8	9.5	113.6
B-11	11	GM	23	6	70	65	56	43	36	30.2	19.3	10.9	113.4
B-13	9	GM	-	NP	47	45	40	34	31	16.9	–	–	–
B-21	10	SM	18	NP	71	69	67	59	53	31.4	–	–	118.6
SB-1	5-7.5	GM	-	NP	53	51	46	42	37	19	6.8	4.2	
SB-1	10-12.5	GC-GM	20	4	56	53	49	41	37	30	9.5	5.7	
SB-1	15-17.5	GC-GM	19	5	61	58	52	44	40	29	8.9	4.6	
SB-1	17.5-20	SM	17	3	73	71	67	61	58	33	10.6	4.4	
SB-1	21-22.5	GC-GM	16	7	51	48	43	37	34	21	7.5	3.2	
SB-1	22.5-24	GM	18	3	65	62	58	53	49	37	14.4	6.8	
SB-2	5-7.5	GM	18	2	59	57	53	46	43	29	8.4	3.1	
SB-2	10-12.5	GM	19	3	63	59	56	49	47	32	9.7	3.6	
SB-2	15-17.5	SC-SM	21	5	78	77	72	60	55	46	15.5	9.8	
SB-3	5-7.5	GC	19	3	63	60	52	41	35	27	8.2	4.8	
SB-3	10-12.5	GC-GM	20	4	52	49	44	37	34	26	7.5	3.4	
SB-3	12.5-15	GC-GM	22	4	46	43	38	32	31	27	6.9	3.2	
SB-5	5-7.5	GC	25	9	56	53	50	45	41	36	14.5	9.0	
SB-5	7.5-10	CL	26	10	99	99	98	94	86	71	33.9	20.5	
SB-5	10-12.5	CL	25	8	99	99	98	97	93	84	27.7	16.2	
SB-5	12.5-15	CL	24	9	100	100	100	98	89	71	30.8	20.3	

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5.2.2 Levee Soil Foundation

Laboratory testing of the existing native soils within the upper five feet indicated plasticity indices ranging from non-plastic to 13 and the fines (portion passing the #200 sieve) contents ranging from 23 to 88 percent. The distribution of the plasticity indices and percent passing the No. 200 sieve is shown in Figures 5 and 6 below. The moisture content ranged from 1.3 to 4.1 percent. The density of the in place soil, as estimated by ASTM D 2937, ranged from 85.4 to 124.8 pcf. The distribution of the amount of gravel retained on the No. 4 sieve is shown in Figure 7 below.

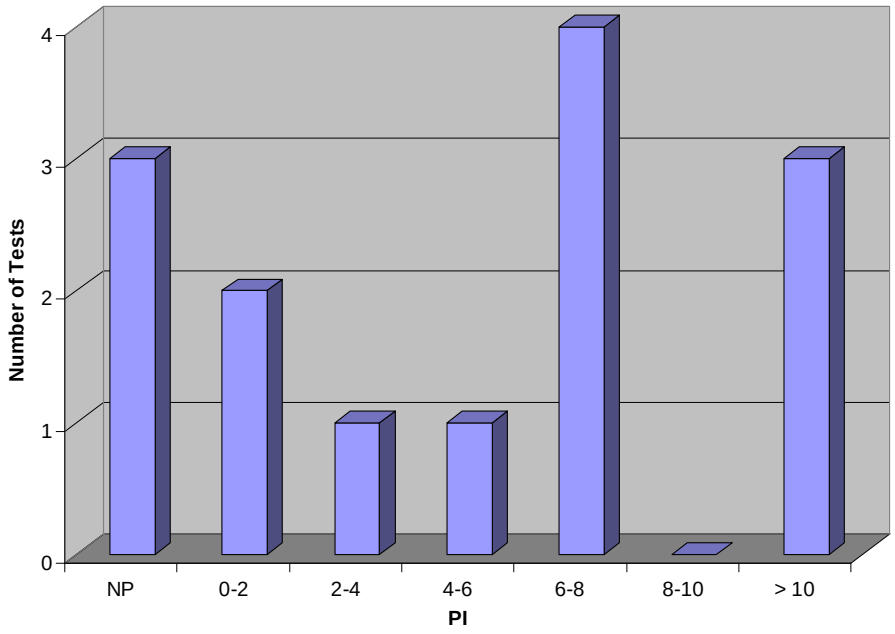

Figure 5. Histogram of Levee Fill PI Values

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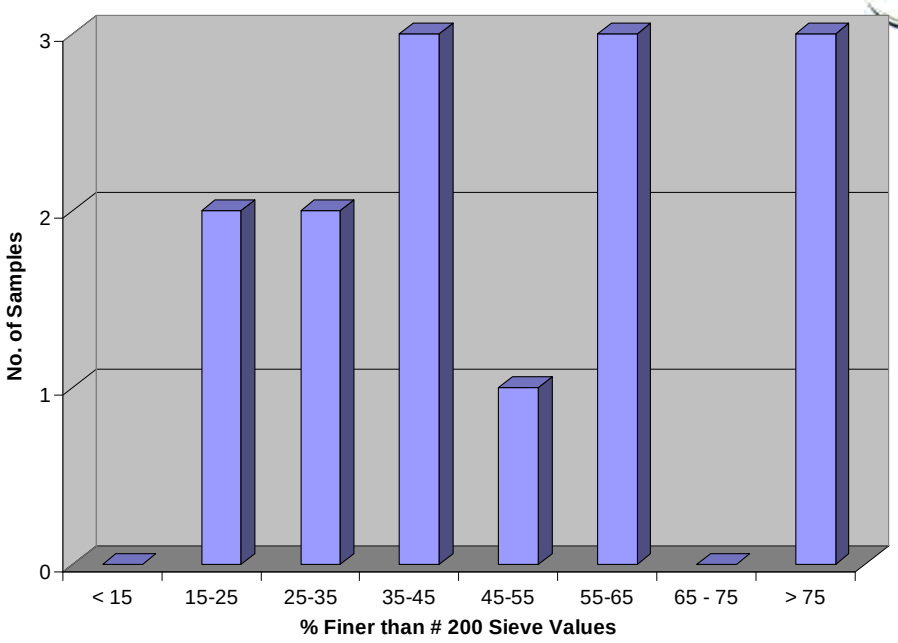

Figure 6. Histogram of % Finer than #200 Sieve Values in Levee Native Soils

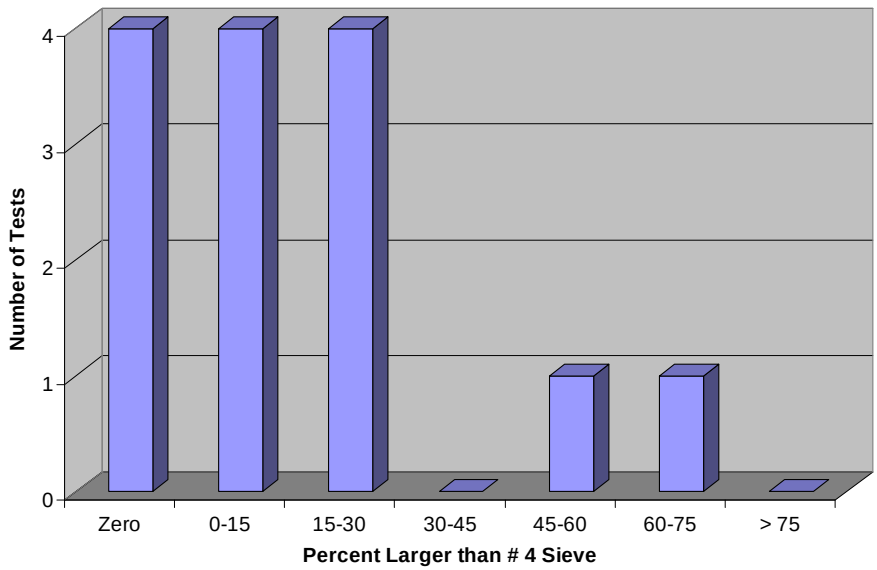

Figure 7. Histogram of Percent Larger than #4 Sieve Values in Levee Native Soils

Laboratory test results for native soils are presented in Table 5-3 below. Detailed test results are presented in Appendix B.

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Table 5-3 - Summary of Laboratory Test Results of Levee Foundation Soil

					Sieve Sizes: Percent Passing by Weight										
					GRAVEL	SAND						FINES	SILT	CLAY	
					Coarse & Fine	Coarse		Medium		Fine					
Boring Num.	**Sample Depth (feet)**	**USCS**	**LL**	**PI**	**1/4"**	**#4**	**#8**	**#10**	**#30**	**#40**	**#100**	**#200**	**0.005 mm**	**0.001 mm**	**Nat. Dry Den. (pcf)**
B-1	1	ML	29	13	100	100	100	100	100	100	97	87.7	–	–	–
B-3	1	ML	27	11	100	100	100	100	100	99	98	87.5	19.6	10.5	100.3
B-6	1	SM	20	1	100	100	99	99	91	86	60	35.9	–	–	101.3
B-12	6	ML	21	6	98	97	94	94	88	86	78	61.7	–	–	–
B-12	11	ML	25	6	100	99	99	98	95	94	91	75.6	–	–	–
B-17	19	GM	–	NP	42	40	37	36	34	33	32	20.4	–	–	124.8
B-18	1	GM	22	7	52	50	46	45	41	40	36	26.5	–	–	–
B-20	1	SM	17	1	81	79	72	70	48	45	35	22.9	–	–	104.9
B-21	21	ML	21	6	99	98	97	96	84	82	74	51.3	–	–	–
B-23	6	ML	25	5	100	100	100	100	100	99	81	64.7	–	–	–
***B-23**	**11**	**SM**	**–**	**NP**	**96**	**95**	**88**	**86**	**67**	**61**	**45**	**37.9**	**–**	**–**	**85.4**
SB-1	24-25.5	SM	17	2	77	76	73	72	65	63	57	42	15.4	9.0	
SB-1	25.5-26	SM	18	NP	80	78	72	71	55	51	42	29	9.9	5.1	
SB-5	17.5-20	CL	31	12	74	74	72	72	68	67	63	60	23.4	5.3	

*Note – sample B-23 may represent collapsible soils based upon the low natural dry density obtained during laboratory testing and may be prone to high volume changes if subjected to increased moisture conditions.

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6 GEOTECHNICAL EVALUATION

6.1 General

Formal published guidelines for levee certification analysis in Arizona have not been established. Therefore, we have used the following USACE engineering manuals (EM) and engineering technical letters (ETL) for guidance in establishing out methodology for evaluation.

- EM 1110-2-1913 “Design and Construction of Levees,“ dated April 30, 2000
- ETL 1110-2-569 “Design Guidance for Levee Underseepage,” dated May 1, 2005

Based on our review of the published engineering guidance documents, the geotechnical evaluation of the existing levee should include the following analyses: 1) Under and through seepage, 2) Slope stability, and 3) Settlement. The evaluation should be performed on levee reaches (i.e., domains), which have similar foundation conditions, embankment height and fill materials. For the purpose of our evaluation, we have divided the Ruby Wash Diversion Levee (RWDL) into two domains with different cross sections: 1) Levee Fill/Native Materials/Bedrock and 2) Levee Fill/Alluvial Materials/Bedrock.

It should be noted that other levee failure modes other than those outlined in the engineering guidance documents also may occur along the levee alignment. One such failure mode would be internal erosion resulting from flow of the retained water through cracks that have developed from drying of the soil, animal burrows or differential settlement induced by collapsible foundation soils. In addition, internal erosion can also occur along pipe penetrations. Thus, we have developed a third domain to cover the levee pipe crossing.

6.2 Site Characterization – Engineering and Geologic Domains

We divided the RWDL site into three typical reaches or “domains” to systematically assess various potential failure modes, evaluate existing subsurface information, and select appropriate cross-sections for slope stability and seepage and settlement analyses. The levee composition was estimated from our subsurface exploration and also estimated from the material properties outlined in the design documentation.

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6.2.1 Levee Domains

Domain 1 (Levee Fill/Native Materials/Bedrock Profile): This prevalent geologic domain is relatively continuous along the majority of the levee alignment, and consists of levee fill materials overlying minor amounts of weathered bedrock/soil underlain by Moenkopi bedrock at depth. The cross sections of the domain evaluated is exhibited at Station 172+53.75 (Appendix J, Page J1) and Station 253+73.79 (Appendix J, Page J7).

Domain 2 (Levee Fill/Native Materials/Bedrock Profile): This domain is localized along the levee alignment and is characterized by levee fill overlying alluvium, underlain by Moenkopi bedrock at depth. The alluvial materials typically consist of silty gravel and sand associated with ore-levee Holocene deposition within intermittent drainages (washes) in proximity to the existing levee alignment. Alluvial materials typically have higher hydraulic conductivity values, thus making levees underlain by these materials more prone to failure modes such as seepage or piping. Two of these Domain 2 reaches are located near levee Station 208+60 (Appendix J, Page J4). A more extensive Domain 2 area underlying the levee fill materials is located generally from Station 356+00 to 378+00, see typical cross section at Station 358+64.50 (Appendix J, Page J10). The alluvium in this zone is not associated with a single wash but a series of smaller washes that intersect the levee from the south. This series of wash channels is named Ice House Wash.

Domain 3 (Special Feature-Pipeline Crossing): This domain is located at Station 286+40 and includes the 36-inch diameter reinforced concrete culvert penetrating the levee. Embankment penetrations present a unique set of concerns and should be evaluated separately.

6.3 Seepage

To estimate the seepage through and under the levee, seepage analyses were performed at each of the four levee sections. The water surface elevation (WSE) for Ruby Wash Diversion Levee was developed by JE Fuller's H&H report (2008). We understand the WSE is based in 100-year hydrology combined with assumptions regarding upstream levee performance. The water surfaces used in our analyses are referred to as the 100-year WSE and were taken from JE Fuller's H&H report.

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6.3.1 Evaluation Criteria

The evaluation criteria for steady state seepage recommends:

- no seepage should exit on the face of the levee; and,
- exit gradients should be less than the allowable gradient values outlined in Table 6-1 under steady state conditions at the toe of the levee or exit face.

Table 6-1 – Allowable Exit Gradients

Location	Allowable Exit[1]
Landside toe of levee	<0.5
Bottom of empty ditch at landside toe	<0.5
Bottom of empty ditch 150 feet landward of toe	<0.8
Ditch between landside toe and 150 feet landward of Interpolate	<0.5 to <0.8

[1] Reference: Ditches Landside of Levee (EM 1110-2-1913 Section 8-16), Criteria presented in this table are based on an assumed minimum saturated unit weight soil of 110 pcf.

6.3.2 Analysis Details

To evaluate the potential for seepage under and through the levee, seepage analyses were performed on the typical cross section developed for each of the domains. Seepage analyses were conducted using "SEEP/W," which is a finite element computer program used to model two-dimensional groundwater flow. Exit gradients and the phreatic surface during steady state conditions were established for each of the typical cross sections. Generalized profiles and material parameters used in our analyses are presented in Appendix J. The selection of these values was based on previous experience and test data, in addition to the field work and laboratory tests conducted for this exploration.

Based upon the original USACE design memorandum and hydrological analysis provided to us by J.E. Fuller for the Ruby Wash Diversion Levee, we understand the 100-year water surface will have a relatively short duration against the levee. Since the levee was not designed or anticipated to retain water for long periods of time, we have performed a transient analysis assuming a 20 day period that the water will be retained by the levee (to estimate the phreatic surface for use in our stability analysis) and a steady state conditions for evaluation of seepage gradient to meet the USACE current

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engineering guidelines. We have assumed that the initial groundwater table is at the bedrock surface in our analyses.

There is currently no USACE analysis certification criteria for flash-flooding loading conditions, and no analysis guidelines or minimum required slope stability FOS have been established in the current published documents. Additionally, hydrograph data is not available for such conditions. As further certification criteria is developed, it is our opinion that further analysis of a Flash Flood Case for levees located in such areas should be performed.

6.3.3 Results

As indicated by our transient analysis during the assumed 20-day inundation period, the phreatic surface within the levee is much lower than shown for our steady state condition (i.e., long term inundation). The phreatic surfaces computed from each of the time steps (20 day and long term) were used in our transient and steady state stability analyses, respectively.

To meet the USACE guidance documentation, we computed exit gradient at the toe of the levee or berm under steady state conditions. The scenarios analyzed and results are presented in Table 6-2. Plates showing the seepage profile, total head contours and exit gradients for each of the analyses are presented in Appendix J.

Table 6-2 Summary of Seepage Analyses Results

Analysis Condition	Required Exit Gradient[1]	Calc. Exit Gradient
Station 172+53.75	< 0.5	0.29
Station 208+61.92	< 0.5	0.19
Station 253+73.79	< 0.5	0.39
Station 358+64.50	< 0.5	0.02

[1]US Corps of Engineers, EM 1110-2-1913

As indicated by the results of our seepage analyses provided in Table 6-3, the exit gradient at the landward toe is considered to be acceptable for each case, as the exit gradient estimated by the model is below that dictated by the acceptance criteria.

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6.4 Stability Analysis

To estimate the stability of the levee slopes for the different conditions for which it will be exposed, slope stability analyses were performed at each of the four levee sections.

6.4.1 Evaluation Criteria

The USACE Manual EM 1110-2-1913 identifies four types (Cases) of loading conditions for slope stability analyses: 1) End of Construction, 2) Steady State Seepage-Long Term, 3) Rapid Drawdown and 4) Seismic. A brief description of each case is outlined below. It should be noted that there are no formal published guidelines for seismic evaluation of levees as well as specific design criteria in terms of liquefaction and/or acceptable/unacceptable levee deformations under seismic conditions.

Case I: End of Construction. This case addresses slope stability at the end of construction of the levee. Since the RWDL was constructed more than 30 years ago; the End of Construction case is not applicable.

Case II: Steady Seepage from Full Flood Stage. This condition occurs when the water remains at or near flood stage elevations, fully saturating the embankment soils resulting in a steady state seepage condition.

Case III: Rapid Drawdown. This case represents a condition where the flood stage fully saturates a majority of the levee embankment, and then the water lowers faster than the soil can drain.

Case IV: Earthquake (Seismic). This case represents a condition were seismic activity results in deformation of the embankment. We understand USACE is developing a guidance document on this topic; however, no specific information is available at this time. Thus, no seismic slope stability analyses were performed as part of this study.

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6.4.2 Analysis Details

Slope stability calculations were performed using the computer program "SLOPE/W", which calculates the factor of safety of a slope using the Spencer limit equilibrium method of slices. The factor of safety (FOS), by definition, is equal to the ratio of shear strength of the soil divided by the shear stress required for equilibrium (Duncan and Wright 2005). The minimum slope stability FOS against failure as outlined by the USACE documentation for each of the cases is summarized in Table 6-3.

Table 6-3 – Minimum Factor of Safety for Existing Levee Slope Stability

Case	Minimum Factor of Safety[1]
Case I – End of Construction	NA
Case II – Rapid Drawdown	1.0 (short duration flood)
Case III – Steady State Seepage	1.4
Case IV – Seismic	Check for Liquefaction (see seismic evaluation)

[1] Factor for Safety criteria is referenced from EM 1110-2-1913

Case II-Steady State: We have estimated that it would take long term inundation to obtain steady state conditions. Since the levee was not originally designed for steady state conditions and will probably never become saturated with steady state seepage, we have also performed stability analysis at a transient condition after a relatively short term (20 day) inundation period. The phreatic surface developed during our seepage analysis at transient and steady state conditions through the levee was used in our stability analyses. The steady state stability analysis was only performed to show the FOS for a completely saturated condition and to meet the USACE guideline criteria. In our professional opinion, the FOSs estimated for the levee sections during transient (20 day inundation period) slope stability analysis are more representative of conditions that will occur during a flood event.

Case III-Rapid Drawdown: The USACE recommends a 3-stage type of analyses, but for our analyses, we chose to use a simplified analysis that uses the Simple Total Strength Method. In this analysis, rapid drawdown is assumed to occur instantaneously. With this assumption, the stabilizing force due to the upstream water is immediately reduced but the piezometric surface follows the upstream slope surface and remains unchanged from steady state within the levee embankment. In general, the simple total strength approach represents the worst case scenario since rapid drawdown seldom occurs

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instantaneously and pore water pressures in the upstream material tends to dissipate during the drawdown process. To perform this type of analyses requires approximating the saturated total stress parameters for zones of the embankment and foundation that are assumed to be saturated at the time of drawdown. Appendix J has details on the cross-sections analyzed and the assumptions used to model various zones in the cross-sections.

Shear Strength Assumptions: The shear strength parameters used in our analyses were developed from the original design memorandum, experience with local materials and published literature data. The effective shear strength of the clayey sand and gravel fill material above the phreatic surface were based on the findings presented in the U.S. Bureau of Reclamation, Earth Laboratory Report EM-577, Triaxial Shear Characteristics of Clayey Gravel Soils. This report include effective shear strength parameters for clayey and sandy gravels with varying percentage of gravel and a clay having a Plasticity Index of 28 compacted to 95 percent of standard Proctor effort. Effective shear strength parameters for the fill materials below the phreatic surfaces were assume to have ¼ the effective cohesion and the same effective friction angle. Foundation material effective shear strength parameters were taken as the original design values.

For the simplified total stress rapid drawdown analysis, we have assumed that the saturated levee embankment materials would have a total stress cohesion would be about 1 ½ times the effective and that the total stress friction angle would be about ½ of the effective friction angle. These values are based on review of triaxial data on similar clay materials. For use in our analysis we have assumed the shear strengths outlined in Table 6-4. The subsurface profile and material properties used in our analyses of each cross section are outlined in Appendix J.

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Table 6-4 – Assumed Shear Strength Parameters

		Effective-Moist		Effective -Saturated		Total -Saturated	
Material	**Unit Weight** moist/saturated (pcf)	**Cohesion** (psf)	**Friction Angle** (degrees)	**Cohesion** (psf)	**Friction Angle** (degrees)	**Cohesion** (psf)	**Friction Angle** (degrees)
Fill: GM	125/132	400	34	100	34	600	17
Fill: GC	125/132	400	32	100	32	600	16
Fill: SC/CL	120/128	200	28	50	30	300	15
CL/SC	105/120	0	28	0	28		
SM	105/120	0	30	0	30		
Bedrock	135/140	0	38	0	38		

6.4.3 Results

The computed Factors of Safety for the scenarios analyzed are presented in Table 6-5. Plates showing the slope profile and theoretical failure surface for each of the analyses are presented in Appendix J. As indicated by the results of our stability analyses provided in Table 6-5, the FOS against overall slope failure is above the minimum stated in the acceptance criteria with the exception of the steady state condition at station 253+73.70 which is discussed in Section 7.1.

Table 6-5. Summary of Stability Analyses Results

Analysis Condition	Required FOS[1]	Calc. FOS	Slope
Station 172+53.75			
End-of-Construction	NA	NA	
Steady State (Long Term) Transient (20 day) (Water Elev. 4873 feet)	1.4 --	1.5 1.9	Downstream
Rapid Drawdown	1.0 (short term)	1.4	Upstream
Station 208+61.92			
End-of-Construction	NA	NA	
Steady State (Long Term) Transient (20 day) (Water Elev. 4890 feet)	1.4 --	2.0 2.6	Downstream
Rapid Drawdown	1.0 (short term)	1.5	Upstream
Station 253+73.79			
End-of-Construction	NA	NA	
Steady State (Long Term) Transient (20 day)	1.4 --	1.1 1.5	Downstream

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Analysis Condition	Required FOS[1]	Calc. FOS	Slope
(Water Elev. 4906 feet)			
Rapid Drawdown	1.0 (short term)	1.4	Upstream
Station 358+64.50			
End-of-Construction	NA	NA	
Steady State (Long Term)	1.4	2.1	Downstream
Transient (20 day)	--	NA[2]	
(Water Elev. 4960 feet)			
Rapid Drawdown	1.0 (short term)	1.8	Upstream

[1]US Corps of Engineers, EM 1110-2-1913

[2]Phreatic surface at steady state does not saturate levee embankment and FOS>2, transient analysis not performed.

6.5 Verification of Slope Stability Results Using an Alternative Method

Based on the USACE Engineering Manual EM 1110-2-1902, Slope Stability, dated October 31, 2003, requirements include that slope stability analyses be verified by another method. UTEXAS4 was chosen as the computer program to perform additional slope stability analyses on a select cross-section to compare the results with the SLOPE/W program.

Two slope stability cases including the Steady State Case (Static Stability Analysis) and the Rapid Drawdown Case were performed on the cross-section at levee Station 253+73.79 using the UTEXAS4 program. The soil material properties in Appendix J and the levee water surface elevations in from JE Fullers H&H report were used in this analysis. Our slope stability analysis results from the UTEXAS4 program showed similar critical slip surfaces and corresponding FOSs. These results are presented in Appendix J, pages J13 and J14. For the Steady State Case, the FOS for the critical slip surfaces were 1.218 and 1.274 obtained from SLOPE/W and UTEXAS4, respectively. For the Rapid Drawdown Case, the FOS for the critical slip surfaces were 1.381 and 1.413 obtained from SLOPE/W and UTEXAS4, respectively. In general, the UTEXAS4 slope stability analysis results were consistent with the results developed from SLOPE/W.

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6.6 Settlement Analysis

The levee embankments have been in place for over 30 years; thus, we anticipate that the majority of the levee embankment settlement due to consolidation of the foundation materials under the weight of the embankment has occurred at the time of this study. Additional settlement of the levee embankment could be induced by wetting of collapsible soils during a flood event. Typically, collapse settlement of the foundation would result in longitudinal and transverse cracking in areas where the subsurface profiles vary, such as at the transitions between domains.

6.6.1 Collapsible Soils

Construction of levees on very dry foundation materials of low density may result in settlement of the levee embankment due to wetting and collapse of these materials during a flood event. Review of the original design documents indicates that no remedial measures were taken to remove potentially collapsible soils.

We estimated the collapse potential of the on site foundation materials by estimating the density ratio (in-place density/estimated standard Proctor maximum dry density) and plotting the ratio percentage versus moisture difference from optimum moisture as outlined in the United States Bureau of Reclamation, Design of Small Dams textbook (Figure 6-34, page 236). In addition, we performed a collapse potential test on a sample of silty sand (SM) with gravel obtained a depth 25 feet in Boring SB-1 (Sta. 209+80). The collapse potential test resulted in a volumetric compression due to collapse of about 6 percent under 3,000 pounds per square foot (psf) loading. For the 3-foot thick layer of silty sand (SM) encountered at this location, settlement on the order of about 2 inches could occur due to the collapse of these materials.

If the collapsible foundation materials become inundated during flooding, longitudinal and transverse cracking could result due to settlement of the collapsible material. The cracks may lead to “hydraulic fracturing” of the levee along the preferential seepage pathways. Based on the subsurface data obtained during our study, it appears that a small percentage of the native materials have a moderately severe collapse potential.

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Additional monitoring of the alluvial wash areas should be performed during flood events to identify any cracks that may occur along the levee alignment due to the collapsibility. Particular attention should be given to formation of transverse cracks at the transition from native soils to alluvial soils at the edges of the wash areas. If a transverse crack or hydraulic fracturing of the levee develops during a flood event, an internal erosion failure is possible.

6.7 Seismic Evaluation

We understand USACE is developing a guidance document on this topic; however, guidelines for seismic evaluation of levees have not been published as of this date. USACE does require that the foundation materials be evaluated for liquefaction. As noted previously, the "soft rock" peak ground accelerations for the 10%/50 year and 2%/50 year events are 0.04 and 0.11g, respectively. These motions developed by USGS represent soft rock conditions, which are assumed to be representative of the soil/rock interface that would be encountered below a depth of approximately 5 to 20 feet below the base of the levee.

Liquefaction: Since the RWDL is composed of compacted levee fill and foundation soils are not saturated (i.e., groundwater at 20 to 44 feet below existing grades) at present and are not likely to be saturated at the time of an earthquake (i.e., the probability of a simultaneous occurrence of an earthquake and design flood are remote and are not considered realistic) and the published peak ground accelerations are relatively low for this area; we conclude that liquefaction is not a concern with the levee evaluation.

6.8 Special Feature-Pipeline Crossing (Station 286+40)

This domain is located at Station 286+40 and includes the 36-inch diameter reinforced concrete pipe (RCP) culvert penetrating the levee (Appendix G, Photograph 3). According to Woodson Engineering Inc., the invert elevation of the Ruby Wash culvert at the north (outlet) side is approximately 4,907 feet and at the inlet is 4,908 feet. The pipe crossing was evaluated for potential damage that would negatively impact the integrity of the levee and could ultimately lead to catastrophic failure. During high water, seepage tends to concentrate along the outer surface of pipes resulting in piping of fill or foundation material. The presence of a discontinuity such as the culvert can also

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cause arching and low stress levels in portions of the embankment that are then subject to hydraulic fracture. If the levee is constructed of highly erosive or dispersive soils, the internal erosion could result in breaching of the levee. Based on our observations of the levee slopes, no significant evidence (i.e., severe rilling or junk holes), which are representative of dispersive soils, was noted.

No as-built construction information was available at the time of this study. In addition, an intrusive exploration into the backfill was not performed in order to not damage the existing structure. A ground penetrating radar (GPR) survey performed at this location indicated that no significant voids or major subsidence are located with the upper 8 feet (elevation 4,922 to 4,914 feet) of fill placed over the culvert. In addition, 2D Seismic Refraction Tomography was performed at the culvert location and the results of this survey indicate that the fill adjacent and around the pipe were placed in about the same manner. No anomalies were observed in the vicinity of the culvert pipe. It should be noted that the tomography survey indicates a potential filled drainage at about 25 to 50 feet east of the culvert location and extends to about an elevation of 4,892 feet.

Based on these surveys it appears that the backfill material has a similar composition to the levee fill and no distinct voids were detected in the near vicinity of the existing culvert pipe.

A visual examination was performed from within the 36-inch RCP by a Kleinfelder Geotechnical Professional during the Phase II field study. Some of the pipe segments appear to have experienced some joint separation. Approximately 3 inches of joint separation were observed at the sixth joint in from the inlet side of the culvert, or, approximately 30 feet from the inlet (see plate G-4 photograph 7). Joint separation of approximately 3 inches was also observed from outside of the RCP at the last section of the outlet side (see plate G-3 photograph 5 and 6). In addition, hairline cracking was visually observed from within the pipe along the top of most of pipe sections (see Appendix G, photographs 5 through 8). No staining was observed that would suggest infiltration of water from backfill material around the RCP.

We recommend that the noted joint separations be repaired and that regularly scheduled inspections be performed at the culvert location and that any changes in the pipe integrity and composition of the materials adjacent to culvert be evaluated and remedial measures implemented.

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7 RECOMMENDATIONS AND CERTIFICATION

7.1 General Conditions

The existing levee was designed based on the assumption that the levee would only be subjected to short duration events and that steady state seepage would not occur. The current USACE evaluation procedures require a stability analysis be performed at steady state conditions. The results of our stability analysis at steady state conditions indicate that the levee at Station 253+73 does not meet the current USACE criteria. However, we also performed a transient analysis that is more representative for the conditions anticipated during flood events. The transient analysis indicates that the levee section would have an adequate slope stability FOS. Based on the very low probability that steady state conditions will develop from the 100-year flood event, Kleinfelder recommends that section be accepted based on the transient analysis.

Based on sieve analyses test results it appears that the Zone I levee core materials were not placed in accordance with the project design specifications. Our seepage analysis indicates that for the domains analyzed the difference in Zone 1 materials did not result in steady state exit gradient exceeding certification criteria under CFR 65.10 for steady state seepage.

Based on the anticipated short term flood conditions, long term seepage and settlement as shown in our results should not control the stability of the levee. For this levee, we anticipate that levee instability or breaching would most likely occur from “hydraulic fracturing” and internal erosion resulting from flow of the retained water through cracks that have developed from drying of the soil, animal burrows or differential settlement induced by collapsible foundation soils. In addition, internal erosion can also occur along pipe penetrations. As discussed in Section 6.7, the levee penetration at Station 286+40 appears to have experienced some joint separation and cracking along the top of the pipe. The noted joint misalignments should be repaired and this condition should be carefully monitored, particularly during and after storm events.

The regular inspection schedule as provided in the O&M manual should be implemented to identify potential areas where cracking, animal burrows and other issues that may affect levee stability.

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7.2 Certification

Based on our evaluation and findings of this geotechnical study, it is our opinion that, from a geotechnical engineering standpoint, the subject levee meets the current FEMA requirements for levee certification outlined in 44 CFR Section 65.10 with regard to seepage conditions, the stability of the existing slopes, and potential for embankment settlement.

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8 LIMITATIONS

This work was performed in a manner consistent with that level of care and skill ordinarily exercised by other members of Kleinfelder's profession practicing in the same locality, under similar conditions and at the date the services are provided. Our conclusions, opinions and recommendations are based on a limited number of observations and data. It is possible that conditions could vary between or beyond the data evaluated. Kleinfelder makes no other representation, guarantee or warranty, express or implied, regarding the services, communication (oral or written), report, opinion, or instrument of service provided.

This report may be used only by the Client and the registered design professional in responsible charge and only for the purposes stated for this specific engagement within a reasonable time from its issuance, but in no event later than two (2) years from the date of the report.

The scope of services was limited to 45 borings and eight geophysical lines within the levee alignment and it should be recognized that definition and evaluation of subsurface conditions are difficult. Judgments leading to conclusions and recommendations are generally made with incomplete knowledge of the subsurface conditions present due to the limitations of data from field studies. The conclusions of this assessment are based on borings drilled to a maximum depth of approximately twice the levee height, laboratory testing of soil plasticity, gradation, and engineering analyses.

Kleinfelder offers various levels of investigative and engineering services to suit the varying needs of different clients. Although risk can never be eliminated, more detailed and extensive studies yield more information, which may help understand and manage the level of risk. Since detailed study and analysis involves greater expense, our clients participate in estimating levels of service, which provide information for their purposes at acceptable levels of risk. The client and key members of the design team should discuss the issues covered in this report with Kleinfelder, so that the issues are understood and applied in a manner consistent with the owner's budget, tolerance of risk and expectations for future performance and maintenance.

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Recommendations contained in this report are based on our field observations and subsurface explorations, limited laboratory tests, and our present knowledge of the proposed construction. It is possible that soil, rock or groundwater conditions could vary between or beyond the points explored. If soil, rock or groundwater conditions are encountered during construction that differ from those described herein, the client is responsible for ensuring that Kleinfelder is notified immediately so that we may reevaluate the recommendations of this report. If the scope of the proposed construction, including the estimated building loads, and the design depths or locations of the foundations, changes from that described in this report, the conclusions and recommendations contained in this report are not considered valid unless the changes are reviewed, and the conclusions of this report are modified or approved in writing, by Kleinfelder.

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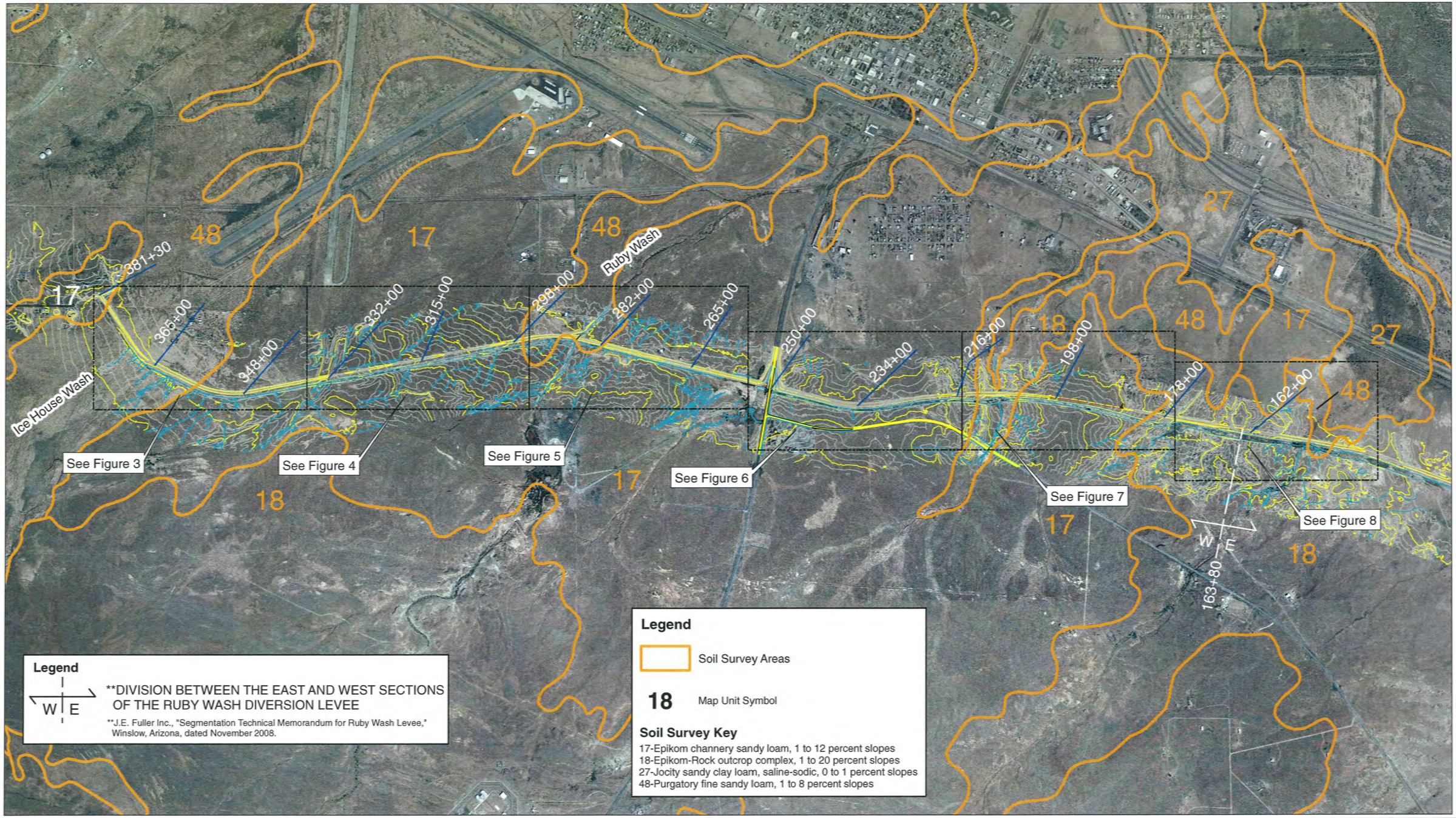
PLATES



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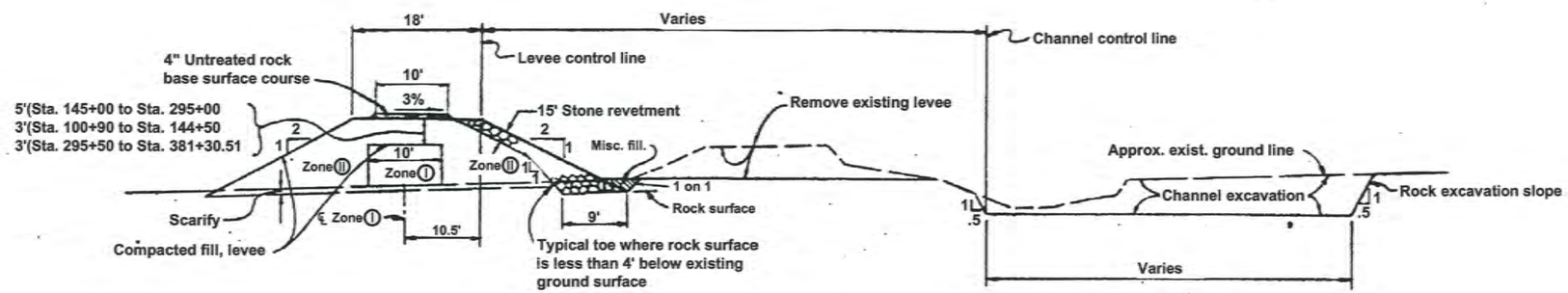
Winslow Levees General Map

Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee,Sta. 165+00 to 381+30
Winslow, Arizona

Plate 1

Cartography By: MAR | Date: MAY 2009 | Project Number: 93212 | File Name: Map1



TYPICAL SECTION
CHANNEL AND LEVEE

Legend:

Zone I: Soil from the excavation and borrow built to a 10-foot minimum width at the center of the levee.

Zone II: Soil and rock placed towards the outer slopes.

20' 10' 0 20'
APPROXIMATE SCALE (feet)

Source: U.S. Army Corps of Engineers, Winslow Flood Control Project, Project Location, Index and General Plan of Improvements, Sheet 1, March 1969, As-Builts

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DRAWN:	MAY 2009
DRAWN BY:	MAR
CHECKED BY:	RCK
FILE NAME:	Plate 2.dwg

TYPICAL SECTION OF RUBY WASH CHANNEL AND LEVEE

WINSLOW LEVEES
WOODSON ENGINEERING & SURVEYING, INC.
RUBY WASH DIVERSION LEVEE
WINSLOW, ARIZONA

PLATE
2

PLOTTED: 15 Jul 2009, 1:44pm, MRuiz
CAD FILE: L:\2009\Projects\93212\Figures\ LAYOUT: 2
ATTACHED IMAGES: Images: Plate 2 cross-section.JPG Images: profile.JPG Images: scan plate 2.JPG
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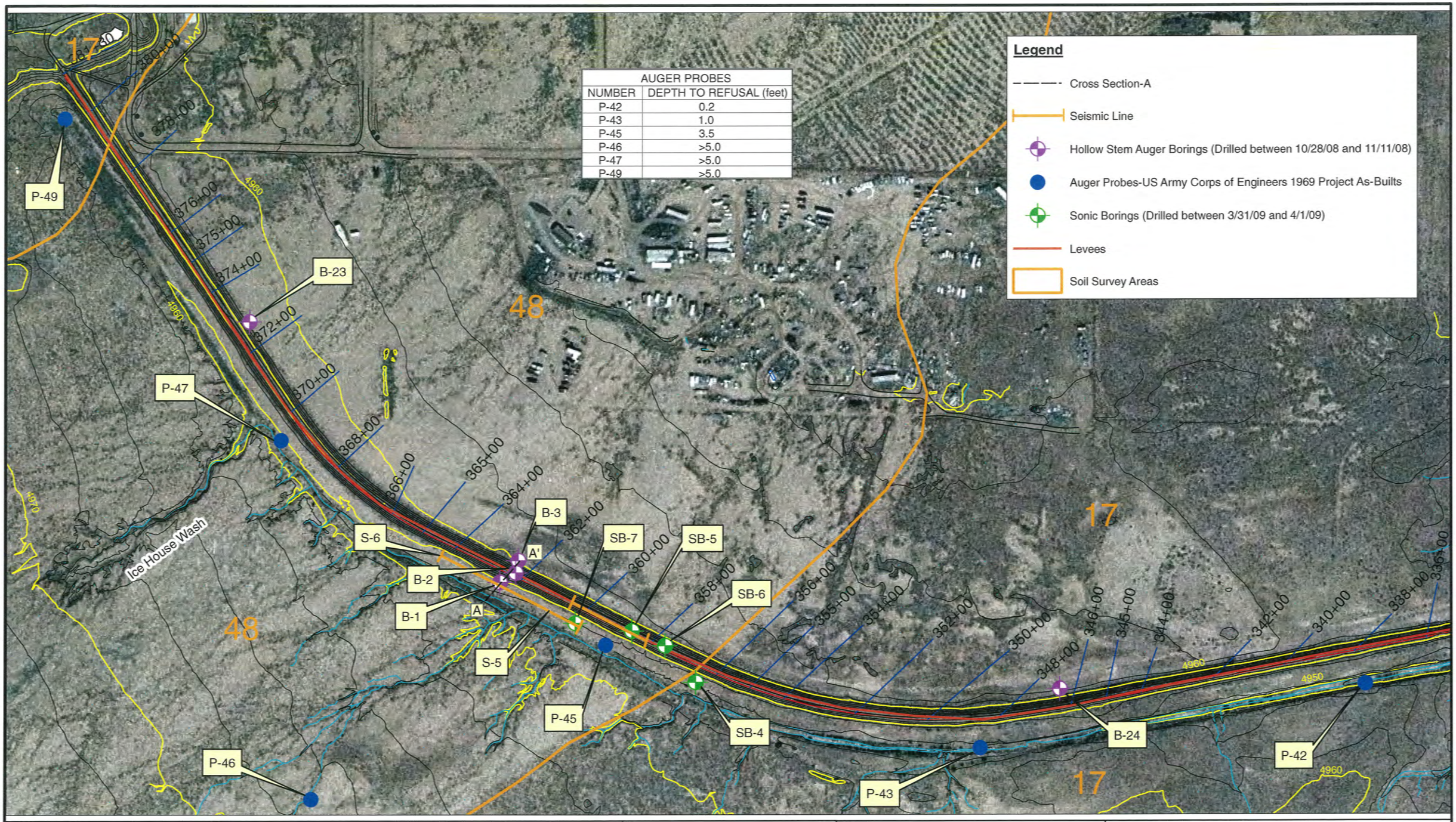
TEMPE,AZ



AUGER PROBES	
NUMBER	DEPTH TO REFUSAL (feet)
P-42	0.2
P-43	1.0
P-45	3.5
P-46	>5.0
P-47	>5.0
P-49	>5.0

N

Source: Aerial Image-GIS Data and RUBY_WASH_DIVERSION_LEVEE_KA-04142008 (JE FULLER)

0 125 250 500 750 1,000 Feet

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KLEINFELDER

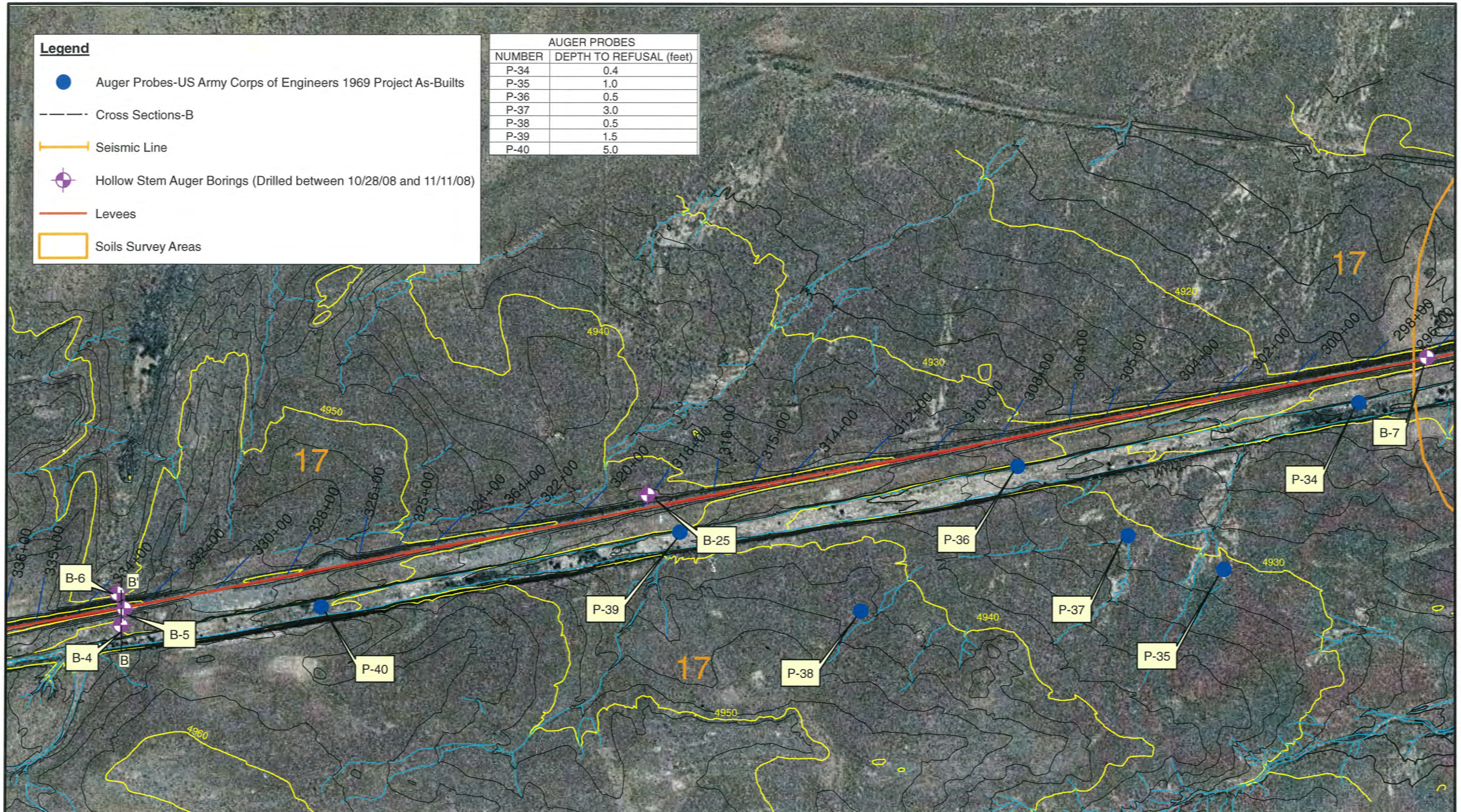
Cartography By: MAR | Date: MAY 2009

Ruby Wash Levee
Boring Location Map

Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee,Sta. 381+30 to 336+00
Winslow, Arizona

Project Number: 93212 | File Name: Map3

Plate 3



AUGER PROBES	
NUMBER	DEPTH TO REFUSAL (feet)
P-34	0.4
P-35	1.0
P-36	0.5
P-37	3.0
P-38	0.5
P-39	1.5
P-40	5.0

N

Source: Aerial Image-GIS Data and RUBY_WASH_DIVERSION_LEVEE_KA-04142008 (JE FULLER)

0 125 250 500 750 1,000 Feet

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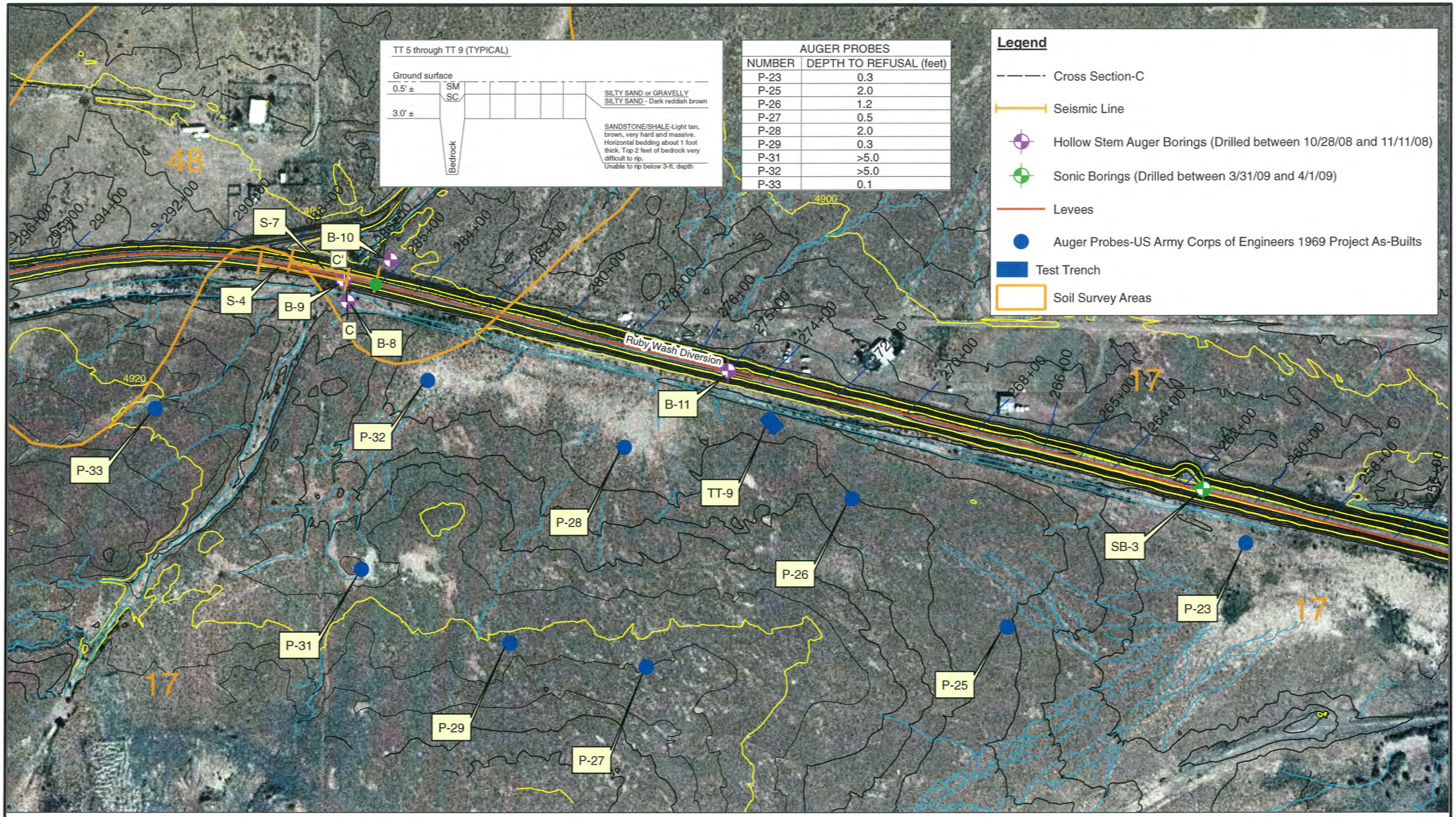
KLEINFELDER

Ruby Wash Levee
Boring Location Map

Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee,Sta. 296+00 to 336+00
Winslow, Arizona

Plate 4

Cartography By: MAR | Date: MAY 2009 | Project Number: 93212 | File Name: Map4



AUGER PROBES	
NUMBER	DEPTH TO REFUSAL (feet)
P-23	0.3
P-25	2.0
P-26	1.2
P-27	0.5
P-28	2.0
P-29	0.3
P-31	>5.0
P-32	>5.0
P-33	0.1

N

Source: Aerial Image-GIS Data and RUBY_WASH_DIVERSION_LEVEE_KA-04142008 (JE FULLER)

0 125 250 500 750 1,000 Feet

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KLEINFELDER

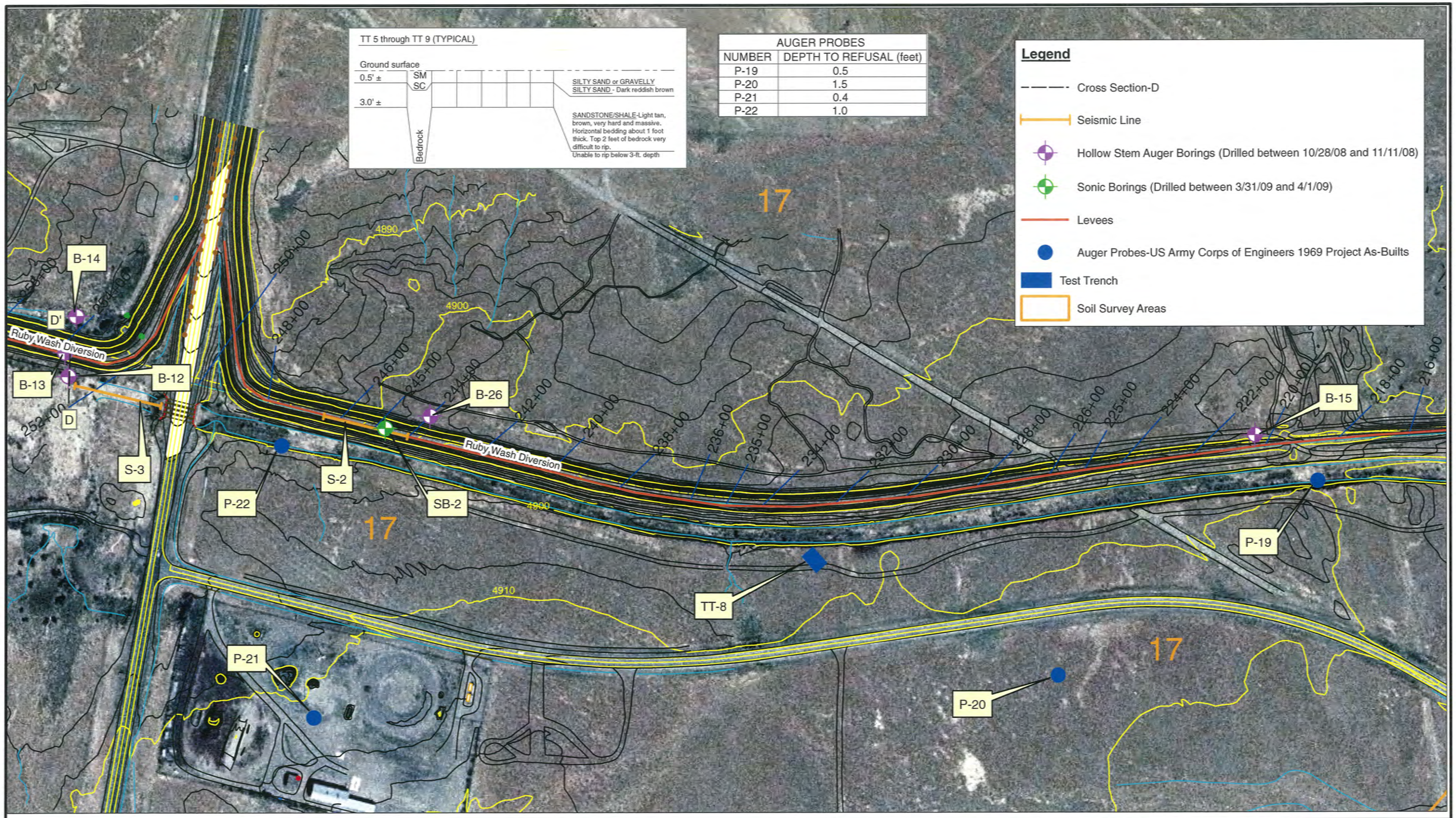
Cartography By: MAR | Date: MAY 2009

Ruby Wash Levee
Boring Location Map

Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee,Sta. 256+00 to 296+00
Winslow, Arizona

Project Number: 93212 | File Name: Map5

Plate 5



AUGER PROBES	
NUMBER	DEPTH TO REFUSAL (feet)
P-19	0.5
P-20	1.5
P-21	0.4
P-22	1.0

N

Source: Aerial Image-GIS Data and RUBY_WASH_DIVERSION_LEVEE_KA-04142008 (JE FULLER)

0 125 250 500 750 1,000 Feet

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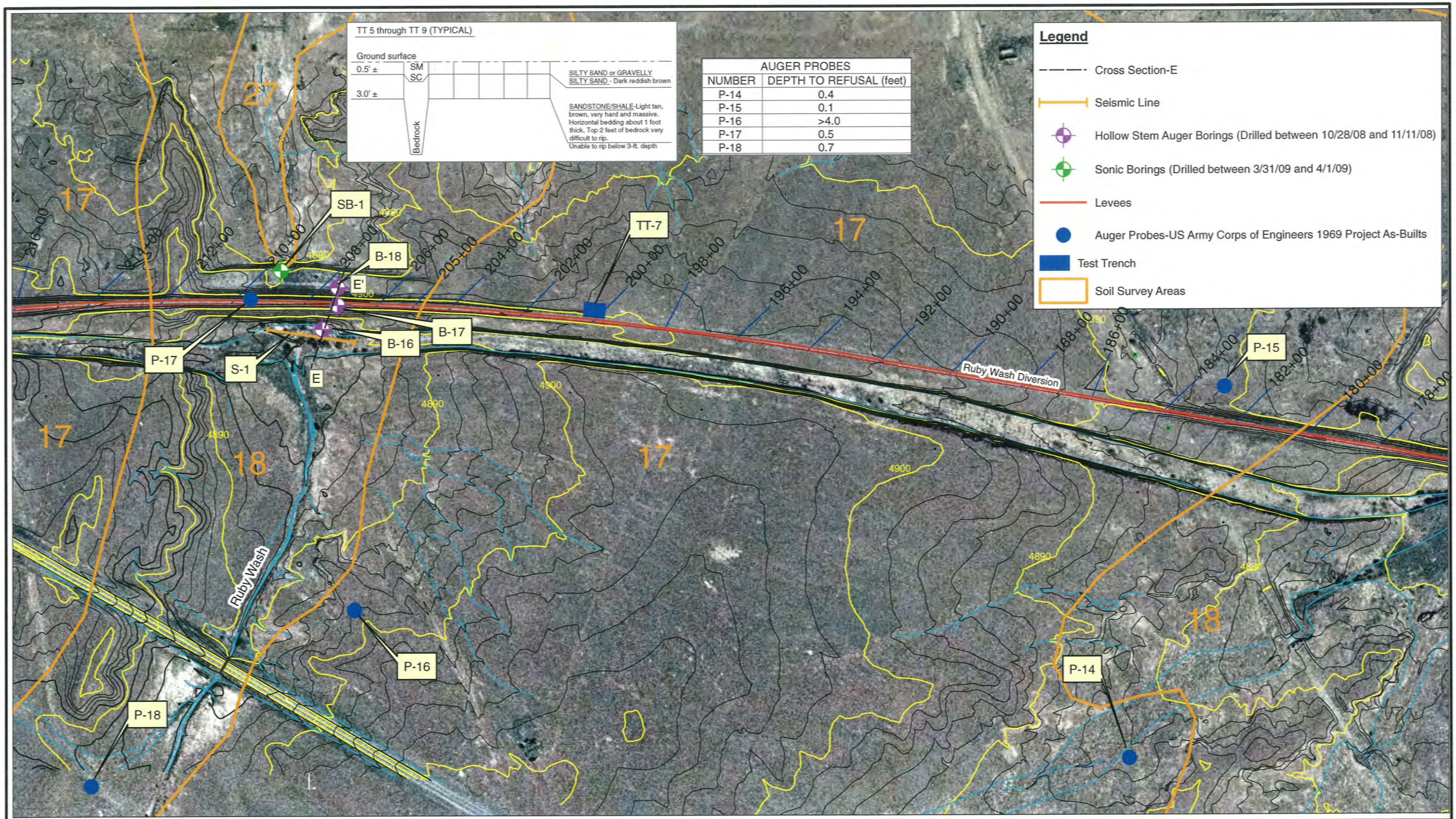
KLEINFELDER

Ruby Wash Levee
Boring Location Map

Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee,Sta. 216+00 to 256+00
Winslow, Arizona

Plate 6

Cartography By: MAR | Date: MAY 2009 | Project Number: 93212 | File Name: Map6



AUGER PROBES	
NUMBER	DEPTH TO REFUSAL (feet)
P-14	0.4
P-15	0.1
P-16	>4.0
P-17	0.5
P-18	0.7

N

Source: Aerial Image-GIS Data and RUBY_WASH_DIVERSION_LEVEE_KA-04142008 (JE FULLER)

0 125 250 500 750 1,000 Feet

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KLEINFELDER

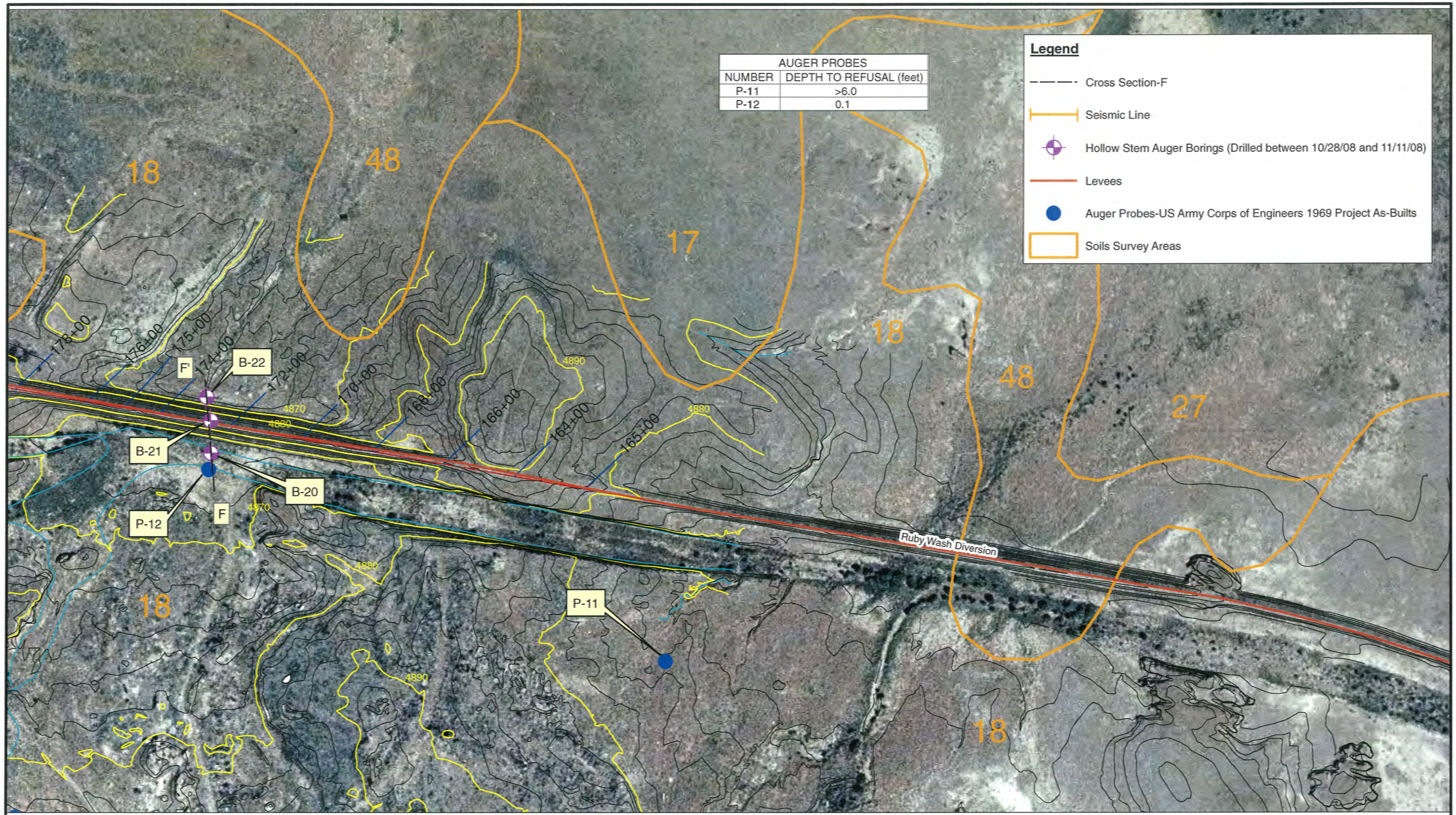
Cartography By: MAR | Date: MAY 2009

Ruby Wash Levee
Boring Location Map

Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee,Sta. 178+00 to 216+00
Winslow, Arizona

Project Number: 93212 | File Name: Map7

Plate 7



AUGER PROBES	
NUMBER	DEPTH TO REFUSAL (feet)
P-11	>6.0
P-12	0.1

N

Source: Aerial Image-GIS Data and RUBY_WASH_DIVERSION_LEVEE_KA-04142008 (JE FULLER)

0 125 250 500 750 1,000 Feet

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KLEINFELDER

Ruby Wash Levee
Boring Location Map

Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee,Sta. 165+00 to 178+00
Winslow, Arizona

Plate 8

Cartography By: MAR | Date: MAY 2009 | Project Number: 93212 | File Name: Map8

Navajo County Area, Arizona, Central Part

17—Epikom channery sandy loam, 1 to 12 percent slopes

Map Unit Setting
Elevation: 4,800 to 5,500 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 53 to 56 degrees F
Frost-free period: 150 to 180 days

Map Unit Composition
Epikom and similar soils: 65 percent

Description of Epikom

Setting
Landform: Plateaus
Landform position (two-dimensional): Summit
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Alluvium derived from mudstone and/or sandstone

Properties and qualities
Slope: 1 to 12 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Very low (about 1.9 inches)

Interpretive groups
Land capability (nonirrigated): 7e
Ecological site: Sandstone/Shale Upland 6-10" p.z. (R035XB215AZ)

Typical profile
0 to 1 inches: Channery sandy loam
1 to 10 inches: Loam
10 to 14 inches: Very flaggy loam
14 to 24 inches: Unweathered bedrock

Data Source Information

Soil Survey Area: Navajo County Area, Arizona, Central Part
Survey Area Data: Version 10, Sep 11, 2008

Navajo County Area, Arizona, Central Part

18—Epikom-Rock outcrop complex, 1 to 20 percent slopes

Map Unit Setting
Elevation: 4,800 to 5,500 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 53 to 56 degrees F
Frost-free period: 150 to 180 days

Map Unit Composition
Epikom and similar soils: 50 percent
Rock outcrop: 30 percent

Description of Epikom

Setting
Landform: Plateaus, mesas, buttes
Landform position (two-dimensional): Summit, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Alluvium derived from mudstone and/or sandstone

Properties and qualities
Slope: 1 to 20 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Very low (about 1.7 inches)

Interpretive groups
Land capability (nonirrigated): 7e
Ecological site: Sandstone/Shale Upland 6-10" p.z. (R035XB215AZ)

Typical profile
0 to 3 inches: Channery sandy loam
3 to 14 inches: Channery sandy loam
14 to 24 inches: Unweathered bedrock

Description of Rock Outcrop

Properties and qualities
Depth to restrictive feature: 0 to 1 inches to lithic bedrock

Data Source Information

Soil Survey Area: Navajo County Area, Arizona, Central Part
Survey Area Data: Version 10, Sep 11, 2008

Source: United States Department of Agriculture
http://websoilsurvey.nrcs.usda.gov

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KLEINFELDER

Ruby Wash Diversion Levee West
Physical Soil Properties

Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee,Sta. 165+00 to 381+30
Winslow, Arizona

Plate 9

Cartography By: MAR | Date: JUNE 2009 | Project Number: 93212 | File Name: Map1

Navajo County Area, Arizona, Central Part

27—Jocity sandy clay loam, saline-sodic, 0 to 1 percent slopes

Map Unit Setting
Elevation: 4,800 to 5,500 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 53 to 56 degrees F
Frost-free period: 150 to 180 days

Map Unit Composition
Jocity and similar soils: 80 percent

Description of Jocity

Setting
Landform: Flood plains
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed alluvium derived from volcanic and sedimentary rock

Properties and qualities
Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Very slightly saline to strongly saline (4.0 to 32.0 mmhos/cm)
Sodium adsorption ratio, maximum: 13.0
Available water capacity: Low (about 4.0 inches)

Interpretive groups
Land capability classification (irrigated): 4w
Land capability (nonirrigated): 7w
Ecological site: Loamy Wash 6-10" p.z. Saline (R035XB211AZ)

Typical profile
0 to 9 inches: Sandy clay loam
9 to 41 inches: Sandy clay loam
41 to 60 inches: Fine sandy loam

Data Source Information

Soil Survey Area: Navajo County Area, Arizona, Central Part
Survey Area Data: Version 10, Sep 11, 2008

Navajo County Area, Arizona, Central Part

48—Purgatory fine sandy loam, 1 to 8 percent slopes

Map Unit Setting
Elevation: 4,800 to 5,500 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 53 to 56 degrees F
Frost-free period: 150 to 180 days

Map Unit Composition
Purgatory and similar soils: 75 percent

Description of Purgatory

Setting
Landform: Plateaus
Landform position (two-dimensional): Summit
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Gypsiferous eolian sands and/or gypsiferous alluvium derived from mudstone and/or sandstone

Properties and qualities
Slope: 1 to 8 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately high (0.01 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Gypsum, maximum content: 80 percent
Maximum salinity: Nonsaline to slightly saline (2.0 to 8.0 mmhos/cm)
Available water capacity: Low (about 4.2 inches)

Interpretive groups
Land capability (nonirrigated): 7e
Ecological site: Loamy Upland 6-10" p.z. Gypsic (R035XB205AZ)

Typical profile
0 to 1 inches: Fine sandy loam
1 to 20 inches: Loam
20 to 27 inches: Clay loam
27 to 60 inches: Weathered bedrock

Data Source Information

Soil Survey Area: Navajo County Area, Arizona, Central Part
Survey Area Data: Version 10, Sep 11, 2008

Source: United States Department of Agriculture
http://websoilsurvey.nrcs.usda.gov

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KLEINFELDER

Ruby Wash Diversion Levee West
Physical Soil Properties

Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee,Sta. 165+00 to 381+30
Winslow, Arizona

Plate 10

Cartography By: MAR | Date: JUNE 2009 | Project Number: 93212 | File Name: Map10

Physical Soil Properties

This table shows estimates of some physical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at 1/3- or 1/10-bar (33kPa or 10kPa) moisture tension. Weight is determined after the soil is dried at 105 degrees C. In the table, the estimated moist bulk density of each soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute linear extensibility, shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. Depending on soil texture, a bulk density of more than 1.4 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Saturated hydraulic conductivity (Ksat) refers to the ease with which pores in a saturated soil transmit water. The estimates in the table are expressed in terms of micrometers per second. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Saturated hydraulic conductivity (Ksat) is considered in the design of soil drainage systems and septic tank absorption fields.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each soil layer. The capacity varies, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Linear extensibility refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. It is an expression of the volume change between the water content of the clod at 1/3- or 1/10-bar tension (33kPa or 10kPa tension) and oven dryness. The volume change is reported in the table as percent change for the whole soil. The amount and type of clay minerals in the soil influence volume change.

Linear extensibility is used to determine the shrink-swell potential of soils. The shrink-swell potential is low if the soil has a linear extensibility of less than 3 percent; moderate if 3 to 6 percent; high if 6 to 9 percent; and very high if more than 9 percent. If the linear extensibility is more than 3, shrinking and swelling can cause damage to buildings, roads, and other structures and to plant roots. Special design commonly is needed.

Organic matter is the plant and animal residue in the soil at various stages of decomposition. In this table, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter. The content of organic matter in a soil can be maintained by returning crop residue to the soil.

Organic matter has a positive effect on available water capacity, water infiltration, soil organism activity, and tilth. It is a source of nitrogen and other nutrients for crops and soil organisms.

Erosion factors are shown in the table as the K factor (Kw and Kf) and the T factor. Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and Ksat. Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor Kw indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Erosion factor Kf indicates the erodibility of the fine-earth fraction, or the material less than 2 millimeters in size.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind and/or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their susceptibility to wind erosion in cultivated areas. The soils assigned to group 1 are the most susceptible to wind erosion, and those assigned to group 8 are the least susceptible. The groups are described in the "National Soil Survey Handbook."

Wind erodibility index is a numerical value indicating the susceptibility of soil to wind erosion, or the tons per acre per year that can be expected to be lost to wind erosion. There is a close correlation between wind erosion and the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture and frozen soil layers also influence wind erosion.

Reference:
United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. (http://soils.usda.gov)

Source: United States Department of Agriculture
http://websoilsurvey.nrcs.usda.gov

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KLEINFELDER

Ruby Wash Diversion Levee West
Physical Soil Properties

Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee,Sta. 165+00 to 381+30
Winslow, Arizona

Plate 11

Cartography By: MAR | Date: JUNE 2009 | Project Number: 93212 | File Name: Map11

Report—Physical Soil Properties

Physical Soil Properties– Navajo County Area, Arizona, Central Part

Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	Pct	Pct	Pct	g/cc	micro m/sec	In/In	Pct	Pct					
17—Epikom channery sandy loam, 1 to 12 percent slopes														
Epikom	0-1	-66-	-23-	5-12- 18	1.45-1.65	14.00-42.00	0.07-0.11	0.0-2.9	0.0-0.5	.17	.20	1	3	86
	1-10	-44-	-40-	15-17- 18	1.40-1.50	4.00-14.00	0.14-0.18	0.0-2.9	0.0-0.5	.32	.32			
	10-14	-44-	-41-	12-15- 18	1.35-1.45	4.00-14.00	0.07-0.12	0.0-2.9	0.0-0.5	.10	.32			
	14-24	—	—	—	—	0.00-0.42	—	—	—					
18—Epikom-Rock outcrop complex, 1 to 20 percent slopes														
Epikom	0-3	-66-	-23-	5-12- 18	1.45-1.65	14.00-42.00	0.07-0.11	0.0-2.9	0.0-0.5	.17	.20	1	3	86
	3-14	-66-	-19-	12-15- 18	1.35-1.45	4.00-14.00	0.10-0.15	0.0-2.9	0.0-0.5	.24	.32			
	14-24	—	—	—	—	0.00-0.42	—	—	—					
Rock outcrop														
26—Jocity sandy clay loam, saline-sodic, 0 to 1 percent slopes														
Jocity	0-9	-55-	-17-	20-28- 35	1.20-1.30	1.40-4.00	0.01-0.12	3.0-5.9	0.0-0.5	.28	.28	5	5	56
	9-41	-55-	-17-	20-28- 35	1.20-1.30	1.40-4.00	0.01-0.12	3.0-5.9	0.0-0.5	.28	.28			
	41-60	-71-	-17-	5-13- 20	1.40-1.55	14.00-42.00	0.01-0.11	0.0-2.9	0.0-0.5	.24	.24			
48—Purgatory fine sandy loam, 1 to 8 percent slopes														
Purgatory	0-1	-71-	-17-	10-13- 15	1.40-1.55	4.00-14.00	0.10-0.15	0.0-2.9	0.5-1.0	.49	.49	3	3	86
	1-20	-43-	-40-	10-18- 25	1.35-1.45	4.00-14.00	0.12-0.16	0.0-2.9	0.0-0.5	.37	.43			
	20-27	-35-	-33-	30-33- 35	1.20-1.30	4.00-14.00	0.19-0.21	3.0-5.9	0.0-0.5	.37	.37			
	27-60	—	—	—	—	0.07-4.20	—	—	—					

Physical Soil Properties– Navajo County Area, Arizona, Central Part

Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	Pct	Pct	Pct	g/cc	micro m/sec	In/In	Pct	Pct					
26—Jocity sandy clay loam, saline-sodic, 0 to 1 percent slopes														
Jocity	0-9	-55-	-17-	20-28- 35	1.20-1.30	1.40-4.00	0.01-0.12	3.0-5.9	0.0-0.5	.28	.28	5	5	56
	9-41	-55-	-17-	20-28- 35	1.20-1.30	1.40-4.00	0.01-0.12	3.0-5.9	0.0-0.5	.28	.28			
	41-60	-71-	-17-	5-13- 20	1.40-1.55	14.00-42.00	0.01-0.11	0.0-2.9	0.0-0.5	.24	.24			
27—Jocity sandy clay loam, saline-sodic, 0 to 1 percent slopes														
Jocity	0-9	-55-	-17-	20-28- 35	1.20-1.30	1.40-4.00	0.01-0.12	3.0-5.9	0.0-0.5	.28	.28	5	5	56
	9-41	-55-	-17-	20-28- 35	1.20-1.30	1.40-4.00	0.01-0.12	3.0-5.9	0.0-0.5	.28	.28			
	41-60	-71-	-17-	5-13- 20	1.40-1.55	14.00-42.00	0.01-0.11	0.0-2.9	0.0-0.5	.24	.24			
48—Purgatory fine sandy loam, 1 to 8 percent slopes														
Purgatory	0-1	-71-	-17-	10-13- 15	1.40-1.55	4.00-14.00	0.10-0.15	0.0-2.9	0.5-1.0	.49	.49	3	3	86
	1-20	-43-	-40-	10-18- 25	1.35-1.45	4.00-14.00	0.12-0.16	0.0-2.9	0.0-0.5	.37	.43			
	20-27	-35-	-33-	30-33- 35	1.20-1.30	4.00-14.00	0.19-0.21	3.0-5.9	0.0-0.5	.37	.37			
	27-60	—	—	—	—	0.07-4.20	—	—	—					

Source: United States Department of Agriculture
http://websoilsurvey.nrcs.usda.gov

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Ruby Wash Diversion Levee West
Physical Soil Properties

Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee,Sta. 165+00 to 381+30
Winslow, Arizona

Plate 12

Cartography By: MAR | Date: JUNE 2009 | Project Number: 93212 | File Name: Map12

Physical Soil Properties–Navajo County Area, Arizona, Central Part

Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	Pct	Pct	Pct	g/cc	micro m/sec	in/in	Pct	Pct					
[illegible]														
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
[illegible]														
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			

Data Source Information

Soil Survey Area: Navajo County Area, Arizona, Central Part
Survey Area Data: Version 10, Sep 11, 2008

Source: United States Department of Agriculture
http://websoilsurvey.nrcs.usda.gov

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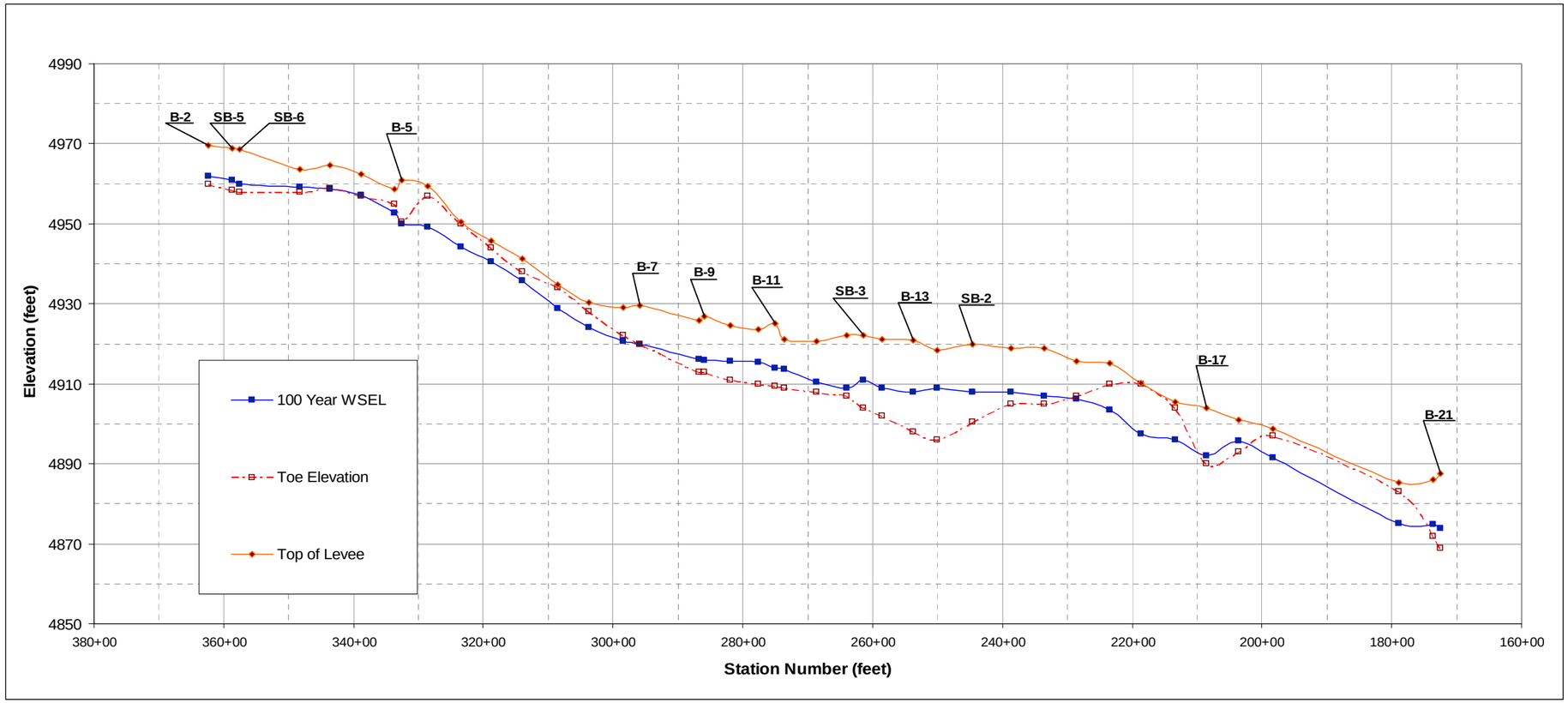
Ruby Wash Diversion Levee West
Physical Soil Properties

Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee,Sta. 165+00 to 381+30
Winslow, Arizona

Plate 13

Cartography By: MAR | Date: JUNE 2009 | Project Number: 93212 | File Name: Map13



100 Year WSEL: Data Collection and Levee Report - JE Fuller and Coe & Van Loo, October 2008.
Toe Elevation: JE Fuller
Top of Levee: Source: RUBY_WASH_DIVERSION_LEVEE_KA-04142008 (JE Fuller)

HORZ. SCALE = 1" = 20'
VERT. SCALE = 1" = 25'

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PROJECT NO.	93212
DRAWN:	JUNE 2009
DRAWN BY:	MAR
CHECKED BY:	RCK
FILE NAME:	Plate 14.dwg

RUBY WASH DIVERSION LEVEE AND DESIGN EVENT PROFILE

WINSLOW LEVEES
WOODSON ENGINEERING & SURVEYING, INC.
RUBY WASH DIVERSION LEVEE, STA. 163+84 to 381+30
WINSLOW, ARIZONA

PLATE
14

PLOTTED: 24 Jun 2009, 3:14pm, MRuiz
CAD FILE: L:\2009\Projects\93212\Figures\ LAYOUT: 13
ATTACHED IMAGES: Images: profile.JPG
ATTACHED XREFS:
TEMPE,AZ

APPENDIX A

Field Exploration Boring Logs

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			USCS SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS (More than half of material is larger than the #200 sieve)	GRAVELS (More than half of coarse fraction is larger than the #4 sieve)	CLEAN GRAVELS WITH LESS THAN 5% PASSING NO. 200 SIEVE	GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES
			GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES
		GRAVELS WITH OVER 12% PASSING NO. 200 SIEVE	GM	SILTY GRAVELS, GRAVEL-SILT-SAND MIXTURES
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SANDS (More than half of coarse fraction is smaller than the #4 sieve)	CLEAN SANDS WITH LESS THAN 5% PASSING NO. 200 SIEVE	SW	WELL-GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE OR NO FINES
			SP	POORLY-GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE OR NO FINES
		SANDS WITH OVER 12% PASSING NO. 200 SIEVE	SM	SILTY SANDS, SAND-GRAVEL-SILT MIXTURES
			SC	CLAYEY SANDS, SAND-GRAVEL-CLAY MIXTURES
FINE GRAINED SOILS (More than half of material is smaller than the #200 sieve)	SILTS AND CLAYS (Liquid limit less than 50)		ML	INORGANIC SILTS & VERY FINE SANDS, SILTY OR CLAYEY FINE SANDS, CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC SILTS & ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS (Liquid limit greater than 50)		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILT
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH	ORGANIC CLAYS & ORGANIC SILTS OF MEDIUM-TO-HIGH PLASTICITY

Note: Fine grained soils that plot within the hatched area on the Plasticity Chart, and coarse grained soils with between 5% and 12% passing No. 200 sieve require dual USCS symbols. (See KEY A-3 if provided)

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Date: June, 2009
Project Number: 93212

UNIFIED SOIL CLASSIFICATION SYSTEM
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A1

GEO-KEY A1 SOIL 93212.GPJ 6/18/2009

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LOG SYMBOLS

BULK / GRAB SAMPLE

MODIFIED CALIFORNIA SAMPLER
(2 inch inside diameter)

RING (PORTER) SAMPLER
(2.4 - inch inside diameter)

STANDARD PENETRATION
SPLIT SPOON SAMPLER
(2.0-inch O.D. X 1.4-inch I.D.)

SHELBY TUBE
(3 inch outside diameter)

NON-STANDARD PENETRATION
SPLIT SPOON SAMPLER
(1.5-inch O.D. X 0.9-inch I.D.)

BDBGM SIZE CORE BARREL
(1.65-inch I.D.)

BW44 SIZE CORE BARREL
(1.75-inch I.D.)

HQ-3 SIZE CORE BARREL
(2.4-inch I.D.)

NON-STANDARD PENETRATION
SPLIT SPOON SAMPLER
(2.5-inch O.D. X 2.0-inch I.D.)

WATER LEVEL
(level after completion)

WATER LEVEL
(level where first encountered)

GENERAL NOTES

1. Lines separating strata on the logs represent approximate boundaries only. Actual transitions may be gradual.
2. No warranty is provided as to the continuity of soil or rock conditions between individual sample locations.
3. Logs represent general soil or rock conditions observed at the point of exploration on the date indicated.
4. In general, the Unified Soil Classification designations presented on the logs were based on visual classification in the field, modified where appropriate by visual classifications in the office, and/or laboratory gradation and index testing.
5. NA = Not Analyzed

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LOG KEY
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A2

GEO-KEY A2 LOG 93212.GPJ 6/18/2009

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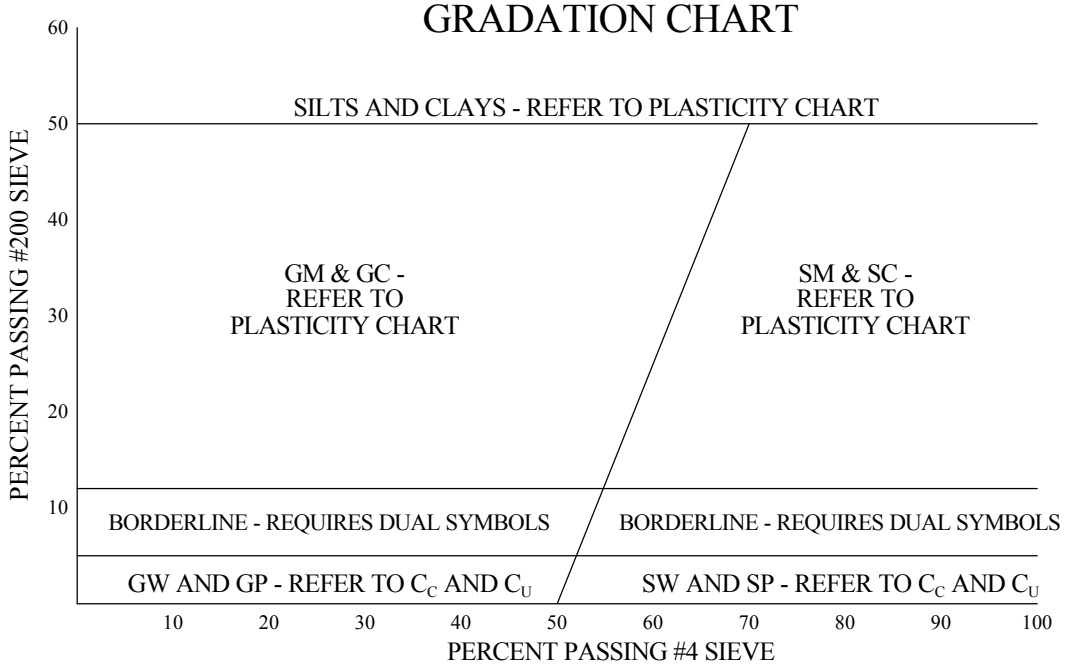
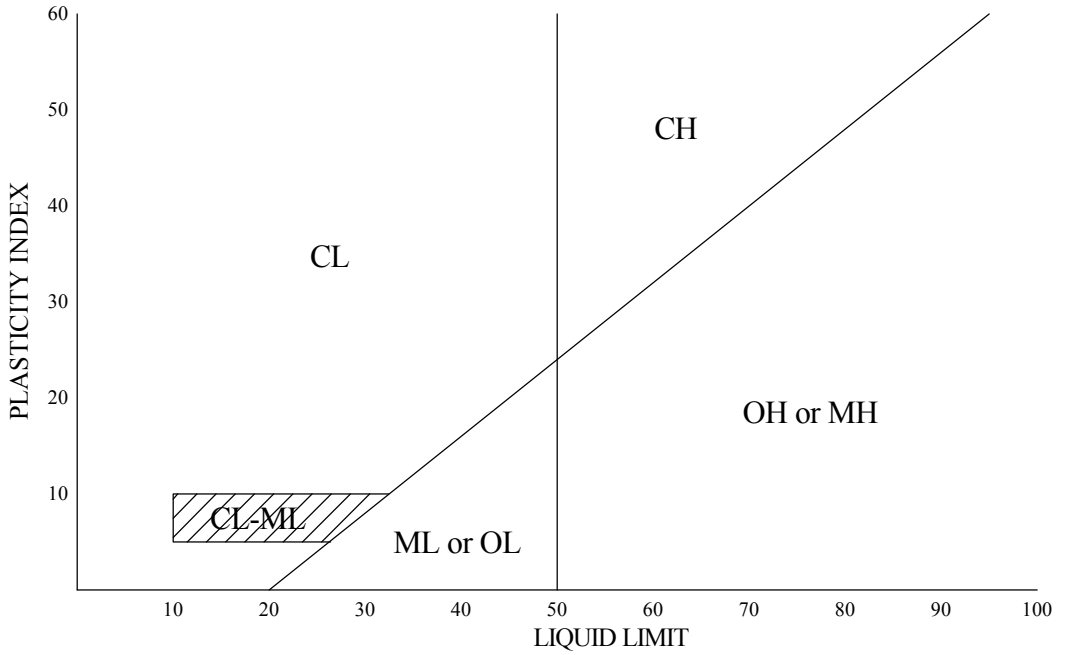
GRADATION CHART



PLASTICITY CHART



DEFINITIONS OF SOIL FRACTIONS

SOIL FRACTION	PARTICLE SIZE RANGE
Boulders	Greater than 300mm (12in.)
Cobbles	300mm to 75mm (12in. to 3in.)
Coarse Gravel	75mm to 19mm (3in. to 3/4in.)
Fine Gravel	19mm (3/4in.) to No. 4 sieve
Coarse Sand	No. 4 sieve to No. 10 sieve
Medium Sand	No. 10 sieve to No. 40 sieve
Fine Sand	No. 40 sieve to No. 200 sieve
Fines	less than No. 200 sieve

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Date: June, 2009
Project Number: 93212

CHARTS & DEFINITIONS
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A3

GEO-KEY A3 CHART 93212.GPJ 6/18/2009

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TERMINOLOGY USED ON THE BORING LOGS TO DESCRIBE THE FIRMNESS, DENSITY, OR CONSISTENCY OF SOILS

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. Terms for description of partially saturated and/or cemented soils 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
51+	Hard

2. Terms for description 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
51+	Very dense

3. Terms for description of clays which are saturated or near saturation.

N	Relative Consistency
0 - 2	Very soft
3 - 4	soft
5 - 8	Moderately stiff
9 - 15	Stiff
16 - 30	Very Stiff
31+	Hard

GEO-KEY A4 SOIL-TERMINOLOGY 93212.GPJ 6/18/2009

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Date: June, 2009
Project Number: 93212

TERMINOLOGY USED TO DESCRIBE SOILS
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Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A4

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Depth:	Distance (in feet) from the collar of the borehole.
Elevation:	Elevation (in feet) from the collar of the borehole.
Run No.:	Number of in the individual coring interval.
Box No.:	Number of the core box which contains core from the corresponding run.
Drill Rate:	Rate (in minutes per foot) of penetration of drilling.
Recovery:	Amount (in percent) of core recovered from the coring interval; calculated as the lenth of core recovered divided by the length of the run.
RQD:	(Rock Quality Designation) Amount (in percent) of intact core (pieces of sound core greater than twice the core diameter in length) in each coring interval; calculated as the sum of the lengths of intact core divided by the length of the core run.
Fracture Frequency:	The number of naturally occurring fractures in each foot of core; does not include mechanical breaks, which are considered to be induced by drilling.
Fracture Orientation:	Orientation of the naturally occurring fractures relative to the cross-sectional axis of the core. "NR" indicates no recovery.
Lithology:	A graphic log presentation using symbols to represent differing soil & rock types.
Material Description:	Lithologic description in this order: rock type, color, grain size, weathering, fracture aperture, fracture spacing, strength, and other features; descriptive terms are defined on the following page.
Field Notes:	Comments on drilling, including water loss, reasons for core loss, and use of drilling mud; also, laboratory tests performed on core.

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Date: June, 2009
Project Number: 93212

KEY TO ROCK CORE LOG
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

KEY

A-5

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SYMBOL	ROCK TYPE	SYMBOL	ROCK TYPE	SYMBOL	ROCK TYPE
	ANDESITE		GNEISS		CONGLOMERATE
	BASALT		GRANITIC		SANDSTONE, SILTSTONE
	GRANODIORITE		RHYOLITE		DIORITE

ROCK WEATHERING / ALTERATION

Designation	Criteria
Residual Soil	Original minerals of rock have been entirely decomposed to secondary minerals, and original rock fabric is not apparent; material can be easily broken by hand
Completely Weathered/Altered	Original minerals of rock have been almost entirely decomposed to secondary minerals, although original fabric may be intact; material can be granulated by hand
Highly Weathered/Altered	More than half of the rock is decomposed; rock is weakened so that a minimum 50-mm-diameter sample can be broken readily by hand across rock fabric
Moderately Weathered/Altered	Rock is discolored and noticeably weakened, but less than half is decomposed; a minimum 50-mm-diameter sample cannot be broken readily by hand across rock fabric
Slightly Weathered/Altered	Rock is slightly discolored, but not noticeably lower in strength than fresh rock
Fresh	Rock shows no discoloration, loss of strength, or other effect of weathering/alteration

FRACTURING

Discontinuity Width/Aperture (inches)		Discontinuity Spacing	
Wide	(0.5 - 2.0)	Very Widely	> 6 ft
Moderately Wide	(0.1 - 0.5)	Widely	2 - 6 ft
Narrow	(0.05 - 0.1)	Moderately	8 - 24 in
Very Narrow	(< 0.05)	Closely	2-1/2 - 8 in
Tight	(0)	Very Closely	3/4 - 2-1/2 in

ROCK STRENGTH / COMPETENCY

Description	Recognition	Approximate Uniaxial Compressive Strength (psi)
Extremely Weak	Can be indented by thumbnail	36 - 145
Very Weak	Can be peeled by pocket knife	145 - 725
Weak	Can be peeled with difficulty by pocket knife	725 - 3,600
Medium Strong	Can be indented 5 mm with sharp end of pick	3,600 - 7,250
Strong	Requires one hammer blow to fracture	7,250 - 14,500
Very Strong	Requires many hammer blows to fracture	14,500 - 36,000
Extremely Strong	Can only be chipped with hammer blows	> 36,000

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Date: June, 2009
Project Number: 93212

TERMINOLOGY USED TO DESCRIBE ROCKS
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

KEY

A-6

GEO-KEY A6 ROCK-TERM REV 93212.GPJ 6/18/2009

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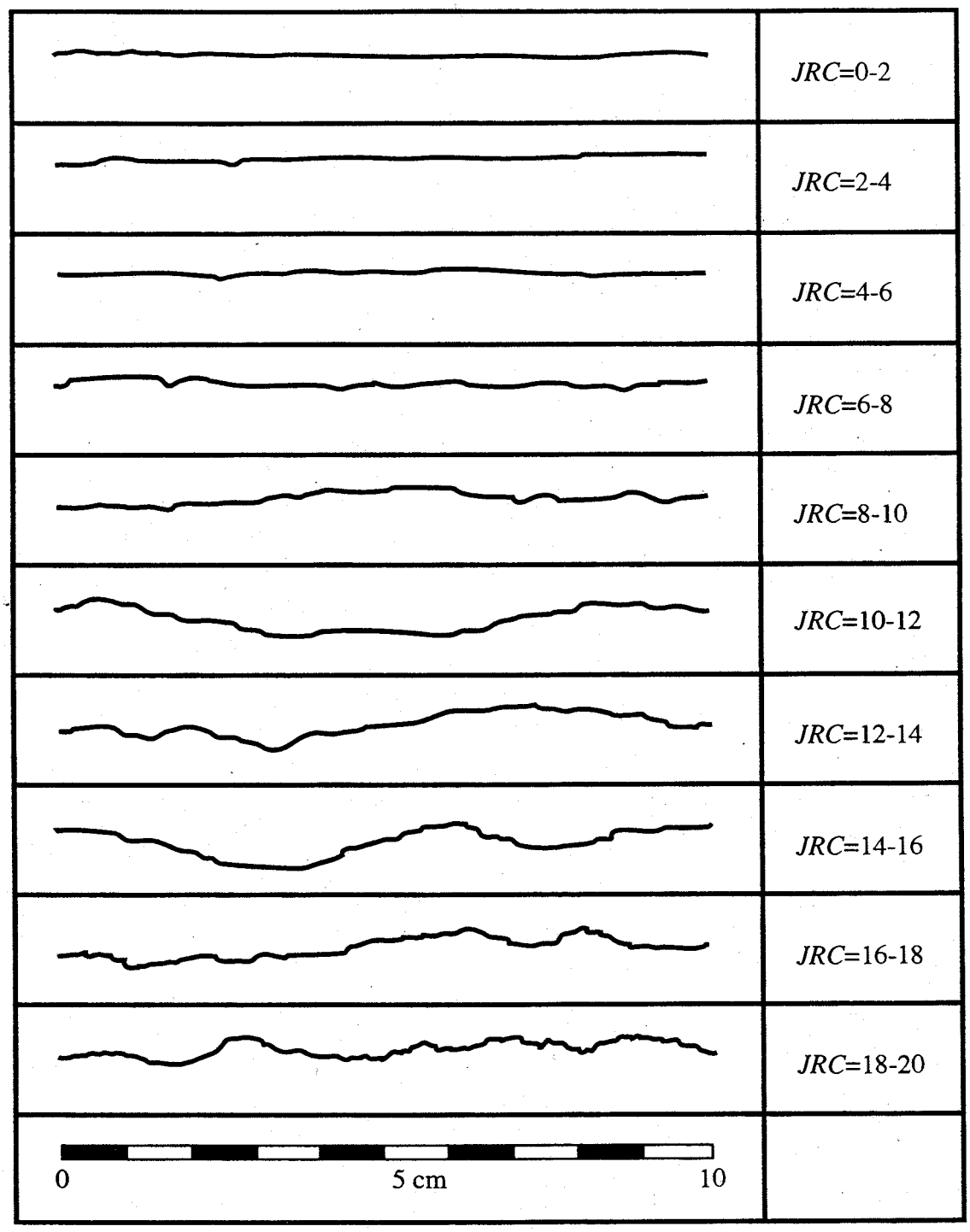

Roghness Profiles and Corresponding JRC Values. (Barton 1973; Hoek, et. al., 1995)

GEO-KEY A7 ROCK-JRC 93212.GPJ 6/18/2009

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JOINT ROUGHNESS COEFFICIENT
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

KEY

A-7

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Latitude & Longitude:	N 35° 0' 30" W 110° 44' 24"			Date Started:	10/31/2008
Groundwater Depth (ft):	No Free Groundwater Encountered			Date Completed:	10/31/2008
Drilling Company:	Yellow Jacket	Equipment:	CME-75	Logged By:	E. Everts
Hole Diameter (in):	8 1/4	Drilling Method:	Hollow Stem Auger & Coring - NWJ Rods		
Hammer Type:	Automatic			Total Depth (ft):	7.0

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 0.0 to 7.0 feet Appx. Surface Elevation (ft): 4959.26 Surface Condition: Sparse Vegetation, Station # 362+49
			10 13 16				29	13	100	88			CL	**Lean Clay with Sand,** About 12% to 13% fine to medium sand; 87.7% fines with low plasticity, no dilatancy, very high dry strength, and low to medium toughness; dry; red-brown; strong reaction to HCL Less than 15% fine sand
4955	5												CL	**Sandy Lean Clay,** About 20% fine to medium sand; about 80% fines with low plasticity, no dilatancy, high dry strength, and low to medium toughness; dry; red; strong reaction to HCL
			50/3											**Claystone, Moenkopi Formation,** yellow to light gray; claystone/sandstone bedrock, medium plasticity, gravel-sized particles crumble between hammer and hard surface
4950	10													Auger refusal at 7.0 feet on bedrock (Moenkopi Formation) Initiated HQ Wireline coring at 6.0 feet Stopped sampling at 6.25 feet
4945	15													

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Drafted By: E. Everts
Date: June, 2009
Project Number: 93212

LOG OF Test boring B-1
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A8

UPDATED GEO ADOT EW/EL 93212.GPJ 6/18/2009

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Latitude & Longitude:	N 35° 0' 30" W 110° 44' 24"	Date Started:	10/30/2008
Groundwater Depth (ft):	No Free Groundwater Encountered	Date Completed:	10/30/2008
Drilling Company:	Yellow Jacket	Equipment:	CME-75
Logged By:	E. Everts		
Hole Diameter (in):	8 1/4	Drilling Method:	Hollow Stem Auger
Hammer Type:	Automatic	Total Depth (ft):	17.3

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 0.0 to 17.0 feet Appx. Surface Elevation (ft): 4969.72 Surface Condition: Sparse Vegetation, Station # 362+35
			6 11 17										FILL	**Sandy Lean Clay, Levee Fill:** About 30% to 45% fine sand; about 55% to 70% fines with low plasticity, no dilatancy, high dry strength, and low to medium toughness; dry; red-brown; maximum size, coarse sand; strong reaction to HCL
			12 18 21											Trace angular gravel; gravel-sized particles fracture with considerable hammer blow; maximum size, 1 in.
4965	5		55/12		112	4.6	29	12	96	75			FILL	**Sandy Lean Clay, Levee Fill:** About 12% to 13% fine to medium sand; 75% fines with low plasticity, no dilatancy, very high dry strength, and low to medium toughness; dry; red-brown; strong reaction to HCL
			14 21 17											Red-brown and white; some polishing of fines visible in sample; maximum size, 1/4 in.
			6 13 20										CL	**Sandy Lean Clay, Native: Weathered Bedrock:** About 30% to 45% fine sand; about 55% to 70% fines with low plasticity, no dilatancy, high dry strength, and low to medium toughness; dry; red-brown; maximum size, coarse sand; strong reaction to HCL
4960	10													No gravel; polishing of fines visible in sample; maximum size, medium sand
			8 11 16											
			11 26 39											**Sandstone, Triassic Moenkopi Formation,** sedimentary, red-brown, moderately hard, moderately weathered, very fine grained, thin bedded, intensely fractured
4955	15		9 12 27											Note: weak cementation; low toughness, base of levee, start of native Moenkopi Formation No cementation; no polishing of fines visible in sample; maximum size, coarse sand

UPDATED GEO ADOT EW/EL 93212.GPJ 6/18/2009

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Project Number: 93212

LOG OF Test boring B-2
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A9

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ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 17.0 to 17.3 feet
			50/4											**Claystone, Moenkopi Formation** yellow to light gray, medium plasticity, gravel-sized particles crumble between hammer and hard surface
														Auger refusal at 17.0 feet on bedrock (Moenkopi Formation)
														Stopped sampling at 17.33 feet
4950	20													
4945	25													
4940	30													
4935	35													

UPDATED GEO ADOT EW/EL 93212.GPJ 6/18/2009

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Date: June. 2009
Project Number: 93212

LOG OF Test boring B-2 (Continued)
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A9

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Latitude & Longitude:	N 35° 0' 30" W 110° 44' 24"	Date Started:	11/4/2008
Groundwater Depth (ft):	No Free Groundwater Encountered	Date Completed:	11/5/2008
Drilling Company:	Yellow Jacket	Equipment:	CME-75
Logged By:	E. Everts		
Hole Diameter (in):	8 1/4	Drilling Method:	Coring - NWJ Rods
Hammer Type:	NA	Total Depth (ft):	14.5

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 0.0 to 14.5 feet Appx. Surface Elevation (ft): 4959.80 Surface Condition: Sparse Vegetation, Station # 362+19
			27/12		100	4.1	27	11	100	88			CL	**Lean Clay with Sand,** About 12% to 13% fine sand; about 87.5% fines with low plasticity, no dilatancy, very high dry strength, and low to medium toughness; dry; red-brown; strong reaction to HCL
													CL	**Sandy Lean Clay,** About 30% to 45% fine to medium sand; about 55% to 70% fines with medium plasticity, no dilatancy, very high dry strength, and low to medium toughness; dry; red-brown; strong reaction to HCL
4955	5													
			12 17 18										SC	**Clayey Sand,** About 55% to 70% fine to coarse sand; about 30% to 45% fines with low plasticity, no dilatancy, high dry strength, and low toughness; trace angular, fine gravel, gravel-sized particles fracture with considerable hammer blow; maximum size, 3/4 in.; dry; red-brown; strong reaction to HCL
4950	10													**Claystone, Triassic Moenkopi,** sedimentary, claystone, very fine grained, thin bedded, intensely fractured, weathered, yellow to light gray; claystone/sandstone bedrock, medium plasticity, gravel-sized particles crumble between hammer and hard surface Note: A wobble in the coring rods caused core diameter to vary from approximately 1 1/4 in. to 2 in. This also caused very poor recovery (less than 55% of run length) and unrepresentative run times. Due to these problems specific rock features such as RQD could not be determined.
4945	15													Auger refusal at 8.0 feet on bedrock (Moenkopi Formation) Initiated HQ Wireline coring at 8.0 feet Stopped sampling at 14.5 feet

UPDATED GEO ADOT EW/EL 93212.GPJ 6/18/2009

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Drafted By: E. Everts
Date: June, 2009
Project Number: 93212

LOG OF Test boring B-3
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A10

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Latitude & Longitude:	N 35° 0' 28" W 110° 43' 49"	Date Started:	10/31/2008
Groundwater Depth (ft):	No Free Groundwater Encountered	Date Completed:	10/31/2008
Drilling Company:	Yellow Jacket	Equipment:	CME-75
Hole Diameter (in):	8 1/4	Drilling Method:	Hollow Stem Auger
Hammer Type:	Automatic	Logged By:	E. Everts
		Total Depth (ft):	2.0

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 0.0 to 2.0 feet Appx. Surface Elevation (ft): 4949.97 Surface Condition: Sparse Vegetation, Station # 332+00
			50/5										SC	**Clayey Sand,** About 55% to 65% fine to coarse sand; about 25% to 40% fines with low plasticity, no dilatancy, high dry strength, and low to medium toughness; about 5% to 10% angular, fine gravel, gravel-sized particles fracture with considerable hammer blow; maximum size, 3/4 in.; dry; red-brown; strong reaction to HCL
														Claystone/sandstone bedrock, Moenkopi Formation, weathered, yellow to light gray; claystone/sandstone bedrock, medium plasticity, gravel-sized particles crumble between hammer and hard surface
4945	5													Auger refusal at 2.0 feet on bedrock (Moenkopi Formation) Stopped sampling at 1.4 feet
4940	10													
4935	15													

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Drafted By: E. Everts
Date: June, 2009
Project Number: 93212

LOG OF Test boring B-4
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A11

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Latitude & Longitude:	N 35° 0' 29" W 110° 43' 49"	Date Started:	10/30/2008
Groundwater Depth (ft):	No Free Groundwater Encountered	Date Completed:	10/30/2008
Drilling Company:	Yellow Jacket	Equipment:	CME-75
Logged By:	E. Everts		
Hole Diameter (in):	8 1/4	Drilling Method:	Hollow Stem Auger
Hammer Type:	Automatic	Total Depth (ft):	12.0

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 0.0 to 12.0 feet Appx. Surface Elevation (ft): 4960.84 Surface Condition: Sparse Vegetation, Station # 332+58
4960			12 37 50/1										FILL	**Clayey Sand, Levee Fill:** About 55% to 70% fine sand; about 30% to 45% fines with low plasticity, no dilatancy, high dry strength, and low to medium toughness; dry; red-brown; strong reaction to HCL Mostly sand; some fines; about 15% to 25% fine, angular gravel, gravel-sized particles fracture with considerable hammer blow; maximum size, 1 in.
			15 28 23				23	6	64	30			FILL	Mostly sand, little fines, some gravel and cobbles **Clayey Gravel, Levee Fill:** with sand, predominantly fine grained sand, 10% fine sand; about 30% fines clay and silt, low plasticity, no dilatancy, high dry strength, and low to medium toughness; dry; red-brown; strong reaction to HCL, some polishing of fines visible in sample
	5		31 24											
4955			24											
			32/12										FILL	**Clayey Gravel with Sand, Levee Fill:** About 50% fine to coarse, angular gravel; about 30% fine sand, about 20% fines with low plasticity, high dry strength, and low toughness; dry; red-brown; strong reaction to HCL
			50/3											**Sandstone bedrock, Triassic Moenkopi, Native:** sedimentary, red-brown, moderately hard, unweathered, very fine grained, thin bedded, intensely fractured Note: Base of levee, start of native Moenkopi Formation
	10													
4950			20 50/3											
														Auger refusal at 12.0 feet on bedrock (Moenkopi Formation) Stopped sampling at 11.75 feet
	15													
4945														

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Drafted By: E. Everts
Date: June, 2009
Project Number: 93212

LOG OF Test boring B-5
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A12

UPDATED GEO ADOT EW/EL 93212.GPJ 6/18/2009

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Latitude & Longitude:	N 35° 0' 29" W 110° 43' 50"	Date Started:	11/3/2008
Groundwater Depth (ft):	No Free Groundwater Encountered	Date Completed:	11/3/2008
Drilling Company:	Yellow Jacket	Equipment:	CME-75
Hole Diameter (in):	8 1/4	Drilling Method:	Coring - NWJ Rods
Hammer Type:	NA	Logged By:	E. Everts
		Total Depth (ft):	2.0

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 0.0 to 2.0 feet Appx. Surface Elevation (ft): 4949.68 Surface Condition: Sparse Vegetation, Station # 332+69
		■	63/12		101	2.6	20	1	100	36			SC	**Clayey Sand, Weathered Bedrock:** About 60% fine sand; about 36% fines with low plasticity, slow dilatancy, high dry strength, and low toughness; about 5% angular, fine gravel, gravel-sized particles fracture with considerable hammer blow; dry; red-brown; strong reaction to HCL
														Sandstone, Triassic Moenkopi Formation, sedimentary, red-brown, moderately hard, unweathered, very fine grained, thin bedded, intensely fractured
														Auger refusal at 2.0 feet on bedrock (Moenkopi Formation) Stopped sampling at 2.0 feet
4945	5													
4940	10													
4935	15													

UPDATED GEO ADOT EW/EL 93212.GPJ 6/18/2009

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Drafted By: E. Everts
Date: June, 2009
Project Number: 93212

LOG OF Test boring B-6
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A13

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Latitude & Longitude:	N 35° 0' 36" W 110° 43' 6"	Date Started:	10/30/2008
Groundwater Depth (ft):	No Free Groundwater Encountered	Date Completed:	10/30/2008
Drilling Company:	Yellow Jacket	Equipment:	CME-75
Logged By:	E. Everts		
Hole Diameter (in):	8 1/4	Drilling Method:	Hollow Stem Auger
Hammer Type:	Automatic	Total Depth (ft):	14.0

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 0.0 to 14.0 feet Appx. Surface Elevation (ft): 4929.61 Surface Condition: Sparse Vegetation, Station # 295+94
			50/6										FILL	**Clayey Sand with Gravel, Levee Fill:** About 55% fine to coarse sand; about 15% fines with low plasticity, slow dilatancy, high dry strength, and low toughness; about 30% angular, fine to coarse gravel, cobbles and boulders, gravel-sized particles fracture with considerable hammer blow; dry; red-brown; strong reaction to HCL Note: On first attempt, auger refusal at less than 1 foot on boulder; moved 5 feet west
			25 39 41											
4925	5		5 17 45				23	8	58	24			FILL	**Clayey Gravel, with sand Levee Fill:** with sand, fine grained sand, 10% fine sand; about 25% fines clay and silt, low plasticity, no dilatancy, high dry strength, and low to medium toughness; dry; red-brown; strong reaction to HCL, some polishing of fines visible in sample Some polishing of fines visible in sample
			43 50/6											
4920	10		22 50/5											
			15 40 50/1											**Sandstone, Triassic Moenkopi Formation, Native:** Weathered sandstone bedrock, Moenkopi Formation sedimentary, red-brown, moderately hard, unweathered, very fine grained, thin bedded, intensely fractured Note: Base of levee, start of native weathered sandstone bedrock,
			50/3											
4915	15													Auger refusal at 14.0 feet on bedrock (Moenkopi Formation) Stopped sampling at 13.25 feet

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Date: June, 2009
Project Number: 93212

LOG OF Test boring B-7
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A14

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UPDATED GEO ADOT EW/EL 93212.GPJ 6/18/2009

Latitude & Longitude:	N 35° 0' 35" W 110° 42' 54"	Date Started:	11/3/2008
Groundwater Depth (ft):	No Free Groundwater Encountered	Date Completed:	11/3/2008
Drilling Company:	Yellow Jacket	Equipment:	CME-75
Logged By:	E. Everts		
Hole Diameter (in):	8 1/4	Drilling Method:	Hollow Stem Auger
Hammer Type:	Automatic	Total Depth (ft):	4.0

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 0.0 to 4.0 feet Appx. Surface Elevation (ft): 4911.98 Surface Condition: Sparse Vegetation, Station # 285+50
4910			99/11										SC	**Clayey Sand with Gravel,** About 55% fine to coarse sand; about 15% fines with low plasticity, slow dilatancy, high dry strength, and low toughness; about 30% angular, fine to coarse gravel, gravel-sized particles fracture with considerable hammer blow; dry; red-brown; strong reaction to HCL
														Sandstone, Triassic Moenkopi Formation, weathered, red-brown, moderately hard, unweathered, very fine grained, thin bedded, intensely fractured
	5													Auger refusal at 4.0 feet on bedrock (Moenkopi Formation) Stopped sampling at 2.0 feet
4905														
	10													
4900														
	15													
4895														

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Date: June, 2009
Project Number: 93212

LOG OF Test boring B-8
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A15

UPDATED GEO ADOT EW/EL 93212.GPJ 6/18/2009

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Latitude & Longitude:	N 35° 0' 36" W 110° 42' 54"			Date Started:	10/30/2008
Groundwater Depth (ft):	No Free Groundwater Encountered			Date Completed:	10/30/2008
Drilling Company:	Yellow Jacket	Equipment:	CME-75	Logged By:	E. Everts
Hole Diameter (in):	8 1/4	Drilling Method:	Coring - NWJ Rods		
Hammer Type:	Automatic			Total Depth (ft):	21.0

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 0.0 to 17.0 feet Appx. Surface Elevation (ft): 4926.85 Surface Condition: Sparse Vegetation, Station # 285+97
													FILL	**Clayey Sand with Gravel, Levee Fill:** About 55% predominantly fine sand; about 15% fines with low plasticity, slow dilatancy, high dry strength, and low toughness; about 30% angular, fine to coarse gravel, gravel-sized particles fracture with considerable hammer blow; maximum size, 3 in.; dry; light red-brown; strong reaction to HCL
			11											
4925			16											
			12											
			89/12											some gravel and cobbles
	5		12											some polishing of fines visible in the sample
			22											
			46										FILL	**Clayey Gravel with Sand, Levee Fill:** About 50% to 60% fine to coarse, angular gravel and cobbles; about 25% to 35% fine sand, about 15% to 25% fines with low plasticity, slow dilatancy, high dry strength, and low toughness; dry; light red-brown; strong reaction to HCL
4920			37/12		114	3.2	24	7	46	24			FILL	
			13											**Clayey Gravel, Levee Fill:** About 25% fine to coarse sand; about 25% fines with low plasticity, slow dilatancy, high dry strength, and low toughness; about 50% angular, fine gravel, gravel-sized particles fracture with considerable hammer blow; maximum size, 1 in.; dry; light red-brown; strong reaction to HCL
			28											
	10		22											
			21											Mostly sand, little fines, some gravel
			15										SC	**Clayey Sand, Native: Weathered Bedrock:** About 55% fine to coarse sand; about 30% fines with low plasticity, slow dilatancy, high dry strength, and low toughness; about 15% angular, fine gravel, gravel-sized particles fracture with considerable hammer blow; maximum size, 1 in.; dry; light red-brown; strong reaction to HCL Note: Base of levee, start of native Moenkopi Formation
4915			13										SC	
			16											
			50/5											
	15													**Clayey Sand, with gravel Weathered Bedrock:** About 50% to 70% fine to coarse sand; about 15% to 25% fines with low plasticity, slow dilatancy, high dry strength, and low toughness; about 15% to 25% angular, fine gravel, gravel-sized particles
4910														

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Date: June, 2009
Project Number: 93212

LOG OF Test boring B-9
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A16

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ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 17.0 to 21.0 feet
			33 26 17										SC	fracture with considerable hammer blow; maximum size, 1 1/4 in.; dry; light red-brown; strong reaction to HCL
	20													**Sandstone, Triassic Moenkopi Formation,** weathered, sedimentary, red-brown, moderately hard, unweathered, very fine grained, thin bedded, intensely fractured
4905														Auger refusal at 21.0 feet on bedrock (Moenkopi Formation) Stopped sampling at 18.5 feet
	25													
4900														
	30													
4895														
	35													

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Drafted By: E. Everts
Date: June, 2009
Project Number: 93212

LOG OF Test boring B-9 (Continued)
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A16

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Latitude & Longitude:	N 35° 0' 36" W 110° 42' 53"			Date Started:	11/7/2008
Groundwater (ft.):	No Free Groundwater Encountered			Date Completed:	11/7/2008
Drilling Company:	Yellow Jacket	Equipment:	CME-75	Logged By:	E. Everts
Core Diameter (in):	8	Drilling Method:	Coring - NWJ Rods		
Hammer Type:	NA	Surface Elevation (ft):	4910.80	Total Depth (ft):	14.0

ELEVATION (ft)	DEPTH (ft)	Sample Type	Blow Counts per 6 inches	ROCK CORE Run No.	Box No.	Drilling Rate (min/ft)	Recovery (%)	RQD (%)	Fracture Frequency	Fracture Orientation (deg)	JRC	Lithology	USCS Designation	MATERIAL DESCRIPTION Surface Condition: Sparse Vegetation, Station # 284+82
4910													SC	**Clayey Sand, trace gravel** About 60% to 65% predominantly fine sand; about 30% fines with low plasticity, no dilatancy, high dry strength, and low toughness; about 5% to 10% angular, fine to coarse gravel, gravel-sized particles fracture with considerable hammer blow; maximum size, 1 1/2 in.; dry; red-brown; strong reaction to HCL Note: Advanced tri-cone drill bit to start of competent bedrock
				1	1		80	17						**Sandstone, Triassic Moenkopi Formation,** sedimentary, red-brown, moderately hard, unweathered, very fine grained, thin bedded, intensely fractured Note: Rig operated at 1900 rpm in second gear and at 125 psi
4905	5													
				2	2		100	14						
4900	10													Between 10' - 5" and 11' - 2", core broken up into coarse sand- to fine gravel-sized particles around fractures; fractures infilled with clay; maximum separation, 5 mm. Between 11' - 2" and 12' - 3", core is more sound; fracture at 11' - 8" is infilled with clay and separated 7 mm. Between 12' - 3" to 13' - 3", core broken up into coarse sand- to fine gravel-sized particles around fractures; fractures infilled with clay; maximum separation, 5 mm. Between 13' - 3", core is more sound; no fractures Yellow/light gray layer between 13' - 6" and 13' - 7"
4895	15													Auger refusal at 4.0 feet on bedrock (Moenkopi Formation) Initiated HQ Wireline coring at 4.0 feet Core terminated at 14.0 feet

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Drafted By: E. Everts
Date: June, 2009
Project Number: 93212

LOG OF Test boring B-10
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A17

UPDATED GEO CORE EW/EL 93212.GPJ 6/18/2009

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Latitude & Longitude:	N 35° 0' 33" W 110° 42' 42"	Date Started:	10/30/2008
Groundwater Depth (ft):	No Free Groundwater Encountered	Date Completed:	10/30/2008
Drilling Company:	Yellow Jacket	Equipment:	CME-75
Logged By:	E. Everts		
Hole Diameter (in):	8 1/4	Drilling Method:	Hollow Stem Auger
Hammer Type:	Automatic	Total Depth (ft):	20.1

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 0.0 to 17.0 feet Appx. Surface Elevation (ft): 4925.01 Surface Condition: Sparse Vegetation, Station # 275+02
			9 18 14										FILL	**Clayey Sand, Levee Fill:** About 60% to 65% predominantly fine sand; about 30% fines with low plasticity, no dilatancy, high dry strength, and low toughness; about 5% to 10% angular, fine to coarse gravel, gravel-sized particles fracture with considerable hammer blow; maximum size, 1 1/2 in.; dry; red-brown; strong reaction to HCL
			70/12				24	7	56	28			FILL	**Clayey Gravel with Sand, Levee Fill:** with sand, predominantly fine grained sand, 10% fine sand; about 25% to 30% gravel, fines clay and silt, low plasticity, no dilatancy, high dry strength, and low to medium toughness; dry; red-brown; strong reaction to HCL, some polishing of fines visible in sample
4920	5		19 22 50/5										FILL	**Clayey Gravel with Sand, Levee Fill:** About 50% to 55% fine to coarse, angular gravel; about 30% to 35% fine to coarse sand, about 15% fines with low plasticity, slow dilatancy, high dry strength, and low toughness; maximum size, 1 in.; dry; red-brown; strong reaction to HCL; some polishing of fines visible in sample **Note:** Drilling became more difficult between approximately 6' - 6" and 7' - 5"
			97/11											
			44 50/3										FILL	**Clayey Gravel with gravel, Levee Fill:** About 15% predominantly fine sand; about 15% to 30% fines with low to medium plasticity, no dilatancy, high dry strength, and low to medium toughness; about 30% angular, fine to coarse gravel, gravel-sized particles fracture with considerable hammer blow; dry; red-brown; strong reaction to HCL **Note:** Drilling became more difficult between approximately 9' - 6" and 10' - 6" Mostly sand, little fines, little gravel; fine to coarse sand; maximum size, 1 in.
4915	10													
			60/12		113	2.9	23	6	65	30				
			9 18 50/3											Mostly sand, little fines with low plasticity, some gravel; maximum size, 1 1/4 in.
													SC	**Clayey Sand with Gravel, Native: Weathered Bedrock:** About 50% to 55% fine sand; about 15% to 20% fines with low to medium plasticity, no dilatancy, high dry strength, and low to medium toughness; about 30% angular, fine to coarse gravel, dry; red-brown; strong reaction to HCL
4910	15		17 40 35											Note: Base of levee, start of native Moenkopi Formation; slight increase in moisture

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Drafted By: E. Everts
Date: June, 2009
Project Number: 93212

LOG OF Test boring B-11
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A18

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ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 17.0 to 20.1 feet
													SC	content; drilling became more difficult due to harder subsurface conditions
4905	20		50/1											**Sandstone, Triassic Moenkopi,** weathered, sedimentary, red-brown, moderately hard, unweathered, very fine grained, thin bedded, intensely fractured
														Auger refusal at 20.0 feet on bedrock (Moenkopi Formation) Stopped sampling at 16.5 feet
4900	25													
4895	30													
4890	35													

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Drafted By: E. Everts
Date: June. 2009
Project Number: 93212

LOG OF Test boring B-11 (Continued)
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A18

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Latitude & Longitude:	N 35° 0' 28" W 110° 42' 17"			Date Started:	11/4/2008
Groundwater Depth (ft):	No Free Groundwater Encountered			Date Completed:	11/4/2008
Drilling Company:	Yellow Jacket	Equipment:	CME-75	Logged By:	E. Everts
Hole Diameter (in):	8 1/4	Drilling Method:	Hollow Stem Auger		
Hammer Type:	Automatic			Total Depth (ft):	15.0

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 0.0 to 15.0 feet Appx. Surface Elevation (ft): 4897.19 Surface Condition: Sparse Vegetation, Station # 253+57
			50/5										SC	**Clayey Sand,** About 50% to 70% fine to coarse sand; about 30% to 45% fines with low plasticity, slow dilatancy, very high dry strength, and low toughness; trace angular, fine gravel, gravel-sized particles fracture with considerable hammer blow; maximum size, 3/4 in.; dry; red-brown; strong reaction to HCL
4895														
	5													
			30 27 25				21	6	97	62			CL	**Lean Clay,** About 65% fines with low plasticity, no dilatancy, high dry strength, and low to toughness; about 20% to 25% fine to coarse sand; dry; red-brown; maximum size, coarse sand; polishing of fines visible in sample; strong reaction to HCL Note: Mostly sand, some fines, about 5% to 10% fine gravel
4890														
	10													
			11 26 40				25	6	99	76				Note: About 75% fines and about 25% fine to coarse sand.
4885													SC	**Clayey Sand,** About 55% to 70% fine to coarse sand; about 30% to 45% fines with low plasticity, no dilatancy,high dry strength, and low toughness; maximum size, coarse sand; dry; red-brown; strong reaction to HCL
	15													**Sandstone, Triassic Moenkopi Formation,** weathered, sedimentary, red-brown, moderately hard, unweathered, very fine grained, thin bedded, intensely fractured
														Auger refusal at 15.0 feet on bedrock (Moenkopi Formation) Stopped sampling at 12.5 feet

UPDATED GEO ADOT EW/EL 93212.GPJ 6/18/2009

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Drafted By: E. Everts
Date: June. 2009
Project Number: 93212

LOG OF Test boring B-12
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
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Latitude & Longitude:	N 35° 0' 28" W 110° 42' 17"	Date Started:	10/31/2008
Groundwater Depth (ft):	No Free Groundwater Encountered	Date Completed:	10/31/2008
Drilling Company:	Yellow Jacket	Equipment:	CME-75
Logged By:	E. Everts		
Hole Diameter (in):	8 1/4	Drilling Method:	Hollow Stem Auger
Hammer Type:	Automatic	Total Depth (ft):	30.5

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 0.0 to 17.0 feet Appx. Surface Elevation (ft): 4920.81 Surface Condition: Sparse Vegetation, Station # 253+74
4920			17 33 29										FILL	**Clayey Sand with Gravel, Levee Fill:** About 50% fine to coarse sand; about 20% fines with low plasticity, slow dilatancy, high dry strength, and low toughness; about 30% angular, fine to coarse gravel, gravel-sized particles fracture with considerable hammer blow; maximum size, 1 in.; dry; light red-brown; strong reaction to HCL
			18/12										FILL	**Clayey Gravel with Sand, Levee Fill:** About 20% to 55% fine to coarse, angular gravel; about 20% fine to coarse sand, about 15% to 20% fines with low plasticity, slow dilatancy, high dry strength, and low toughness; maximum size, 1 1/2 in.; dry; red-brown; strong reaction to HCL Maximum size, 1 in.
4915	5		8 5 2											
			34/12											
			5 3 6			0.8	NV	NP	45	17				
4910	10		10 7											11' - 0" to 11' - 4" yellow/light gray silt/sandstone
			11/12											Maximum size, 2 in.
4905	15		22 17 11											

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Date: June, 2009
Project Number: 93212

LOG OF Test boring B-13
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A20

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ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 17.0 to 30.5 feet
													GC	**Clayey Gravel with Sand, Native:** About 50% to 55% fine to coarse, angular gravel; about 30% to 35% fine to coarse sand, about 15% to 20% fines with low plasticity, slow dilatancy, high dry strength, and low toughness; maximum size, 1 in.; dry; red-brown; some polishing of fines visible in sample; sample fractured into flat, horizontal gravel-sized particles; strong reaction to HCL Note: Base of levee, start of native Moenkopi Formation Moist, polishing of fines visible in sample
	20		16 21 21											
4900														
	25		23 33 36										SC	**Clayey Sand with Gravel,** About 50% to 55% fine to coarse sand; about 30% to 35% fines with low plasticity, no dilatancy, high dry strength, and low to medium toughness; about 15% to 20% angular, fine to coarse gravel, gravel-sized particles fracture with considerable hammer blow; maximum size, 1 in.; moist; red-brown; polishing of fines visible in sample; strong reaction to HCL
4895														
	30		15 12 18										CL	**Clay with Sand,** About 25% to 30% fine sand; about 70% to 75% fines with low plasticity, no dilatancy, high dry strength, and low to medium toughness; maximum size, medium sand; moist; red; strong reaction to HCL Note: Auger refusal on possible boulder at 29' - 0". However, SPT sampler was able to be driven past obstruction. Auger refusal on possible boulder at 29.0 feet Stopped sampling at 30.5 feet
4890														
	35													
4885														

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Date: June. 2009
Project Number: 93212

LOG OF Test boring B-13 (Continued)
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A20

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Latitude & Longitude:	N 35° 0' 29" W 110° 42' 16"			Date Started:	11/4/2008
Groundwater Depth (ft):	No Free Groundwater Encountered			Date Completed:	11/4/2008
Drilling Company:	Yellow Jacket	Equipment:	CME-75	Logged By:	E. Everts
Hole Diameter (in):	8 1/4	Drilling Method:	Hollow Stem Auger		
Hammer Type:	Automatic			Total Depth (ft):	13.0

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 0.0 to 13.0 feet Appx. Surface Elevation (ft): 4892.28 Surface Condition: Sparse Vegetation, Station # 253+72
			36/12										CL	**Sandy Lean Clay,** About 30% to 45% fine sand; about 55% to 70% fines with medium plasticity, no dilatancy, very high dry strength, and low to medium toughness; maximum size, medium sand; trace roots; dry; red-brown with small areas of white; strong reaction to HCL
4890														
	5													
			15 25 28											
4885														
	10													
			4 4 50/3										SC	**Clayey Sand with Gravel,** About 50% to 70% fine to coarse sand; about15% to 25% fines with low plasticity, slow dilatancy, high dry strength, and low toughness; 15% to 25% angular, fine gravel, gravel-sized particles fracture with considerable hammer blow; maximum size, 1/2 in.; dry; red-brown; strong reaction to HCL
4880														**Claystone, Moenkopi Formation** weathered, yellow to light gray; claystone/sandstone bedrock, medium plasticity, gravel-sized particles crumble between hammer and hard surface
	15													Auger refusal at 13.0 feet on bedrock (Moenkopi Formation) Stopped sampling at 12.5 feet

UPDATED GEO ADOT EW/EL 93212.GPJ 6/18/2009

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Drafted By: E. Everts
Date: June, 2009
Project Number: 93212

LOG OF Test boring B-14
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
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Latitude & Longitude:	N 35° 0' 26" W 110° 41' 37"	Date Started:	11/4/2008
Groundwater Depth (ft):	No Free Groundwater Encountered	Date Completed:	11/4/2008
Drilling Company:	Yellow Jacket	Equipment:	CME-75
Logged By:	E. Everts		
Hole Diameter (in):	8 1/4	Drilling Method:	Hollow Stem Auger
Hammer Type:	Automatic	Total Depth (ft):	2.5

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 0.0 to 2.5 feet Appx. Surface Elevation (ft): 4908.05 Surface Condition: Sparse Vegetation, Station # 220+23
		◣	50/3										SC	**Clayey Sand,** About 65% to 80% fine to coarse sand; about 15% to 25% fines with low plasticity, slow dilatancy, low dry strength, and low toughness; about 5% to 10% angular, fine gravel, gravel-sized particles fracture with considerable hammer blow; maximum size, 1/2 in.; dry; red-brown; strong reaction to HCL
4905														**Sandstone, Triassic Moenkopi Formation,** weathered, sedimentary, red-brown, moderately hard, unweathered, very fine grained, thin bedded, intensely fractured
														Auger refusal at 2.5 feet on bedrock (Moenkopi Formation) Stopped sampling at 1.25 feet
	5													
4900														
	10													
4895														
	15													

UPDATED GEO ADOT EW/EL 93212.GPJ 6/18/2009

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Drafted By: E. Everts
Date: June, 2009
Project Number: 93212

LOG OF Test boring B-15
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A22

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Latitude & Longitude:	N 35° 0' 26" W 110° 41' 22"	Date Started:	11/4/2008
Groundwater Depth (ft):	No Free Groundwater Encountered	Date Completed:	11/4/2008
Drilling Company:	Yellow Jacket	Equipment:	CME-75
Logged By:	E. Everts		
Hole Diameter (in):	8 1/4	Drilling Method:	Hollow Stem Auger
Hammer Type:	Automatic	Total Depth (ft):	2.0

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 0.0 to 2.0 feet Appx. Surface Elevation (ft): 4881.99 Surface Condition: Sparse Vegetation, Station # 207+00
			50/6										SC	**Clayey Sand,** About 70% to 80% fine to coarse sand; about 15% to 25% fines with low plasticity, slow dilatancy, high dry strength, and low toughness; about 5% angular, fine gravel, gravel-sized particles fracture with considerable hammer blow; maximum size, 1/2 in.; dry; red-brown; strong reaction to HCL
4880														**Claystone, Moenkopi Formation** weathered, yellow to light gray; claystone/sandstone bedrock, medium plasticity, gravel-sized particles crumble between hammer and hard surface
	5													Auger refusal at 2.0 feet on bedrock (Moenkopi Formation) Stopped sampling at 1.5 feet
4875														
	10													
4870														
	15													
4865														

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Drafted By: E. Everts
Date: June, 2009
Project Number: 93212

LOG OF Test boring B-16
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A23

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Latitude & Longitude:	N 35° 0' 26" W 110° 41' 21"	Date Started:	10/28/2008
Groundwater Depth (ft):	No Free Groundwater Encountered	Date Completed:	10/29/2008
Drilling Company:	Yellow Jacket	Equipment:	CME-75
Logged By:	E. Everts		
Hole Diameter (in):	8 1/4	Drilling Method:	Hollow Stem Auger
Hammer Type:	Automatic	Total Depth (ft):	25.3

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 0.0 to 17.0 feet Appx. Surface Elevation (ft): 4904.64 Surface Condition: Sparse Vegetation, Station # 208+62
			17 25 25										FILL	**Clayey Sand with Gravel, Levee Fill:** About 45% fine sand; about 20% fines with no plasticity, slow dilatancy, high dry strength, and low toughness; about 15% angular, fine gravel, gravel-sized particles fracture with considerable finger pressure; maximum size, 3/4 in.; dry; light red-brown; strong reaction to HCL
			12 8 12				NV	NP	71	21			FILL	**Clayey Sand with Gravel, Levee Fill:** 50% fine sand; 21% fines with non-plastic, slow dilatancy, high dry strength, and low toughness;, fine gravel, gravel-sized particles fracture with considerable finger pressure; maximum size, 3/4 in.; dry; light red-brown; strong reaction to HCL, Maximum size 1 1/4 in.; light red-brown with yellow-white aggregate
4900	5		15 34 50/6											Gravel-sized particles crumble with hammer blow
			6 11 23											Maximum size, 1 in.; yellow-white, orange and red-brown
4895	10		15 31 16										FILL	**Gravel with Clay, Levee Fill:** About 50% to 65% fine to coarse, angular gravel; about 30% to 40% fine to coarse sand, about 5% to 10% fines with low plasticity, slow dilatancy, low dry strength, and low toughness; maximum size, 1 1/4 in.; dry; red-brown; strong reaction to HCL
			24 7 10											
			27 21 19										FILL	**Clayey Sand with Gravel, Levee Fill:** About 50% to 55% fine to coarse sand; about 15% fines with low plasticity, slow dilatancy, high dry strength, and low toughness; about 30% to 35% angular, fine gravel, gravel-sized particles fracture with considerable hammer blow; maximum size, 1 in.; dry; red-brown; strong reaction to HCL
4890	15		10 6 18										SC	**Clayey Sand with Gravel, Native:** About 50% to 55% fine to coarse sand; about 15% fines with low plasticity, slow dilatancy, high dry strength, and low toughness; about 30% to

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Drafted By: E. Everts
Date: June. 2009
Project Number: 93212

LOG OF Test boring B-17
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
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ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 17.0 to 25.3 feet
			18										GP-GC	35% angular, fine gravel, gravel-sized particles fracture with considerable hammer blow; maximum size, 1 in.; dry; red-brown; strong reaction to HCL
			7											
			7											
			16/12		125	3.3	NV	NP	40	20			GC	Mostly sand, little fines, 15% to 25% gravel Note: Approximate base of levee, start of native Moenkopi Formation
4885	20													**Poorly Graded Gravel with Clay and Sand,** About 65% to 80% fine to coarse, angular gravel; about 15% to 25% fine to coarse sand, about 5% to 10% fines non-plastic, slow dilatancy, low dry strength, and low toughness; maximum size, 1 1/4 in.; dry; red-brown; some polishing of fines visible in sample; strong reaction to HCL
			24											
			22											
			50/5										CL	**Silty Gravel,** About 25% fine to coarse sand; about 20% fines with no plasticity, no dilatancy, high dry strength, and low toughness; about 30% to 45% angular, fine to coarse gravel, gravel-sized particles fracture with considerable hammer blow; maximum size, 1 1/2 in.; dry; red-brown; strong reaction to HCL About 50% to 65% sand, 30% to 40% fines, 5% to 10% fine gravel
			50/3											
4880	25		50/3											**Clayey Gravel with Sand,** About 30% to 45% fine sand; about 55% to 70% fines with low plasticity, no dilatancy, high dry strength, and low toughness; dry; red-brown; strong reaction to HCL
														Sandstone, Triassic Moenkopi Formation, weathered, sedimentary, red-brown, moderately hard, unweathered, very fine grained, thin bedded, intensely fractured
														Auger refusal at 25.0 feet on bedrock (Moenkopi Formation) Stopped sampling at 25.25 feet
4875	30													
4870	35													

UPDATED GEO ADOT EW/EL 93212.GPJ 6/18/2009

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Drafted By: E. Everts
Date: June. 2009
Project Number: 93212

LOG OF Test boring B-17 (Continued)
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A24

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Latitude & Longitude:	N 35° 0' 27" W 110° 41' 21"	Date Started:	11/4/2008
Groundwater Depth (ft):	No Free Groundwater Encountered	Date Completed:	11/4/2008
Drilling Company:	Yellow Jacket	Equipment:	CME-75
Logged By:	E. Everts		
Hole Diameter (in):	8 1/4	Drilling Method:	Hollow Stem Auger
Hammer Type:	Automatic	Total Depth (ft):	14.0

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 0.0 to 14.0 feet Appx. Surface Elevation (ft): 4891.38 Surface Condition: Sparse Vegetation, Station # 207+08
4890			46/12				22	7	50	27			GC	**Clayey Gravel with Sand,** About 15% to 25% fine to coarse sand; about 25% fines with low plasticity, no dilatancy, high dry strength, and low toughness; about 45% angular, fine to coarse gravel, gravel-sized particles fracture fracture with considerable hammer blow; dry; red-brown with some yellow-white to light gray aggregate; strong reaction to HCL
	5												SC	**Clayey Sand with Gravel,** About 45% to 50% fine to coarse sand; about 10% to 15% fines with low plasticity, no dilatancy, high dry strength, and low toughness; about 40% angular, fine to coarse gravel, gravel-sized particles fracture fracture with considerable hammer blow; dry; red-brown with some yellow-white to light gray aggregate; strong reaction to HCL
4885			9 10 7											
	10													
4880			50/3											**Sandstone,Triassic Moenkopi Formation,** weathered, sedimentary, red-brown, moderately hard, unweathered, very fine grained, thin bedded, intensely fractured
	15													Auger refusal at 14.0 feet on bedrock (Moenkopi Formation) Stopped sampling at 11.25 feet
4875														

UPDATED GEO ADOT EW/EL 93212.GPJ 6/18/2009

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Drafted By: E. Everts
Date: June, 2009
Project Number: 93212

LOG OF Test boring B-18
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A25

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Latitude & Longitude:	N 35° 0' 21" W 110° 40' 40"	Date Started:	11/4/2008
Groundwater Depth (ft):	No Free Groundwater Encountered	Date Completed:	11/4/2008
Drilling Company:	Yellow Jacket	Equipment:	CME-75
Logged By:	E. Everts		
Hole Diameter (in):	8 1/4	Drilling Method:	Hollow Stem Auger
Hammer Type:	Automatic	Total Depth (ft):	6.5

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 0.0 to 6.5 feet Appx. Surface Elevation (ft): 4866.52 Surface Condition: Sparse Vegetation, Station # 171+38
4865			21/12		105	1.5	17	1	79	23			SC	**Clayey Sand with Gravel, Weathered Bedrock:** About 25% to 50% fine to coarse sand; about 20% to 25% fines with low plasticity, slow dilatancy, very high dry strength, and low toughness; about 5% angular, fine gravel, gravel-sized particles fracture with considerable hammer blow; maximum size, 1/2 in.; dry; red-brown; strong reaction to HCL
	5													**Claystone, Moenkopi Formation** weathered, yellow to light gray; claystone/sandstone bedrock, medium plasticity, gravel-sized particles crumble between hammer and hard
			50/3											
4860														Auger refusal at 6.5 feet on bedrock (Moenkopi Formation) Stopped sampling at 6.25 feet
	10													
4855														
	15													
4850														

UPDATED GEO ADOT EW/EL 93212.GPJ 6/18/2009

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Drafted By: E. Everts
Date: June, 2009
Project Number: 93212

LOG OF Test boring B-20
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A26

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Latitude & Longitude:	N 35° 0' 22" W 110° 40' 40"	Date Started:	10/29/2008
Groundwater Depth (ft):	No Free Groundwater Encountered	Date Completed:	10/29/2008
Drilling Company:	Yellow Jacket — Equipment: CME-75	Logged By:	E. Everts
Hole Diameter (in):	8 1/4 — Drilling Method: Hollow Stem Auger		
Hammer Type:	Automatic	Total Depth (ft):	30.1

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 0.0 to 17.0 feet Appx. Surface Elevation (ft): 4887.56 Surface Condition: Sparse Vegetation, Station # 172+54
			11 15 14										FILL	**Clayey Gravel with Sand, Levee Fill:** About 50% to 55% fine to coarse, angular gravel; about 30% to 35% fine to coarse sand, about 15% to 20% fines with low plasticity, slow dilatancy, high dry strength, and low toughness; maximum size, 1 1/4 in.; dry; red-brown and yellow-gray; strong reaction to HCL
4885														
			21 50/6										FILL	**Clayey Sand with Gravel, Levee Fill:** About 45% to 55% fine to coarse sand; about 35% to 45% fines with low plasticity, no dilatancy, high dry strength, and low toughness; about 5% to 10% angular, fine to coarse gravel, gravel-sized particles crumble with hammer blow; maximum size, 1 1/4 in.; dry; red-brown; some polishing of fines visible in sample; strong reaction to HCL Mostly sand, some fines, 15% to 25% fine to coarse gravel
	5		18 13 10											
			21 38 33											
4880														
			7 14 11				18	18	69	31				Maximum size, 3/4 in.
	10													
			49/12		119	3.2							FILL	**Clayey Sand with Gravel, Levee Fill:** About 25% to 40% fine to coarse sand; about 30% to 35% fines with no plasticity, no dilatancy, high dry strength, and low toughness; about 20% to 30% angular, fine to coarse gravel, gravel-sized particles crumble with hammer blow; maximum size, 1 1/4 in.; dry; red-brown; some polishing of fines visible in sample; strong reaction to HCL Mostly sand, 15% to 20% fines, 30% to 35% gravel; maximum size, 1 1/2 in. Note: 1 1/2 in. gravel was fractured inside the sampler indicating that it was part of larger sized gravel
4875														
			4 8 10											Mostly fine sand, about 30% to 45% fines, about 5% to 10% gravel; maximum size, 1 in.
	15		5 45 50/4											Moist between approximately 15 feet and 15.75 feet Mostly fine sand, about 15% to 25% fines, about 25% to 35% gravel

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Drafted By: E. Everts
Date: June, 2009
Project Number: 93212

LOG OF Test boring B-21
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
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ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 17.0 to 30.1 feet
			25										SC	**Clayey Sand , Native:** About 45% to 55% fine sand; about 45% to 55% fines with low plasticity, no dilatancy, high dry strength, and low toughness; dry; red-brown; polishing of fines visible in sample; strong reaction to HCL
4870			50/5											Note: Base of levee, start of native Moenkopi Formation
			28											Maximum size, medium sand; polishing of fines visible in sample
			50/6											
	20													
			15				21	6	98	51			CL	**Lean Clay,** About 12% to 47% fine to medium sand; 55% fines with low plasticity, no dilatancy, very high dry strength, and low to medium toughness; dry; red-brown; strong reaction to HCL
			15											Moist
			19											Maximum size, fine sand
4865														
			9											
			9											
			9											
	25													
			4											
			5											
			6											
			6										SC	**Clayey Sand,** About 55% to 70% fine sand; about 30% to 45% fines with low plasticity, slow dilatancy, high dry strength, and low toughness; maximum size, fine sand; dry; red-brown; strong reaction to HCL
4860			8											
			13											**Claystone, Moenkopi Formation** weathered; yellow to light gray; claystone/sandstone bedrock, medium plasticity, gravel-sized particles crumble between hammer and hard surface; Moenkopi Formation
			25											
			21											
	30		50/1											Auger refusal at 30.0 feet on bedrock (Moenkopi Formation)
														Stopped sampling at 30.08 feet
4855														
	35													

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Date: June. 2009
Project Number: 93212

LOG OF Test boring B-21 (Continued)
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
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Latitude & Longitude:	N 35° 0' 22" W 110° 40' 40"			Date Started:	11/11/2008
Groundwater (ft.):	No Free Groundwater Encountered			Date Completed:	11/11/2008
Drilling Company:	Yellow Jacket	Equipment:	CME-75	Logged By:	E. Everts
Core Diameter (in):	8	Drilling Method:	Coring - NWJ Rods		
Hammer Type:	NA	Surface Elevation (ft):	4864.65	Total Depth (ft):	17.5

ELEVATION (ft)	DEPTH (ft)	Sample Type	Blow Counts per 6 inches	ROCK CORE Run No.	Box No.	Drilling Rate (min/ft)	Recovery (%)	RQD (%)	Fracture Frequency	Fracture Orientation (deg)	JRC	Lithology	USCS Designation	MATERIAL DESCRIPTION Surface Condition: Sparse Vegetation, Station # 172+68
														Clayey Sand, About 60% to 65% predominantly fine sand; about 30% fines with low plasticity, no dilatancy, high dry strength, and low toughness; about 5% to 10% angular, fine to coarse gravel, gravel-sized particles fracture with considerable hammer blow; maximum size, 1 1/2 in.; dry; red-brown; strong reaction to HCL Note: Advanced tri-cone drill bit to start of competent bedrock
4860	5													
				1	1		93	84						**Sandstone, Triassic Moenkopi,** sedimentary, yellow-orange, moderately hard, unweathered to slightly weathered, fine grained, thin bedded, moderately fractured Note: Rig operated at 1900 rpm at 125 psi (first gear between 7.5 feet and 10 feet; second gear between 10 feet and 12.5 feet)
4855	10													
				2	2		100	77						Highly fractured
4850	15													White to light gray and yellow-orange; intensely fractured from 15' - 8" to 16' - 7"

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Drafted By: E. Everts
Date: June, 2009
Project Number: 93212

LOG OF Test boring B-22
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
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ELEVATION (ft)	DEPTH (ft)	Sample Type	Blow Counts per 6 inches	ROCK CORE: Run No.	Box No.	Drilling Rate (min/ft)	Recovery (%)	RQD (%)	Fracture Frequency	Fracture Orientation (deg)	JRC	Lithology	USCS Designation	MATERIAL DESCRIPTION
														Auger refusal at 7.5 feet on bedrock (Moenkopi Formation) Initiated HQ Wireline coring at 7.5 feet Core terminated at 17.5 feet
4845	20													
4840	25													
4835	30													
4830	35													

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Drafted By: E. Everts
Date: June, 2009
Project Number: 93212

LOG OF Test boring B-22 (Continued)
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
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UPDATED GEO CORE EW/EL 93212.GPJ 6/18/2009

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Latitude & Longitude:	N 35° 0' 37" W 110° 44' 33"			Date Started:	11/3/2008
Groundwater Depth (ft):	No Free Groundwater Encountered			Date Completed:	11/3/2008
Drilling Company:	Yellow Jacket	Equipment:	CME-75	Logged By:	E. Everts
Hole Diameter (in):	8 1/4	Drilling Method:	Hollow Stem Auger		
Hammer Type:	Automatic			Total Depth (ft):	20.0

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 0.0 to 17.0 feet Appx. Surface Elevation (ft): 4962.35 Surface Condition: Sparse Vegetation, Station # 372+63
			34/12										CL	**Sandy Lean Clay,** About 30% to 45% predominantly fine sand; about 55% to 70% fines with low plasticity, no dilatancy, very high dry strength, and low toughness; maximum size, coarse sand; dry; red-brown; strong reaction to HCL
4960														
	5													
			10 17 20				25	5	100	65			CL	**Sandy Lean Clay,** About 30% to 45% fine sand; about 55% to 65% fines with low plasticity, slow dilatancy, high dry strength, and low toughness; maximum size, medium sand; dry; red-brown; strong reaction to HCL
4955														
	10													
			16/12		85	1.3	NV	NP	95	38			SC	**Clayey Sand,** About 55% to 60% fine to medium sand; about 25% to 40% fines; maximum size, coarse sand; no plasticity, dry; red-brown; mica present; strong reaction to HCL
4950														
	15													
			20 38											Note: About 85% to 95% fine to coarse sand; about 5% to 10% fines with no plasticity, slow dilatancy, high dry strength, and low toughness; less than 5% flat, angular fine

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Drafted By: E. Everts
Date: June, 2009
Project Number: 93212

LOG OF Test boring B-23
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
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ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 17.0 to 20.0 feet
4945			43											gravel; maximum size, 1/2 in.; dry; red-brown and yellow-light gray; strong reaction to HCL **Claystone/Siltstone, Moenkopi Formation,** red-brown. moist, weathered sandstone bedrock, sedimentary, red-brown, moderately hard, unweathered, very fine grained, thin bedded, intensely fractured
	20													Auger refusal at 20.0 feet on bedrock (Moenkopi Formation) Stopped sampling at 17.5 feet
4940														
	25													
4935														
	30													
4930														
	35													

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Date: June. 2009
Project Number: 93212

LOG OF Test boring B-23 (Continued)
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
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UPDATED GEO ADOT EW/EL 93212.GPJ 6/18/2009

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Latitude & Longitude:	N 35° 0' 27" W 110° 44' 6"	Date Started:	11/3/2008
Groundwater Depth (ft):	No Free Groundwater Encountered	Date Completed:	11/3/2008
Drilling Company:	Yellow Jacket	Equipment:	CME-75
Logged By:	E. Everts		
Hole Diameter (in):	8 1/4	Drilling Method:	Hollow Stem Auger
Hammer Type:	Automatic	Total Depth (ft):	15.0

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 0.0 to 15.0 feet Appx. Surface Elevation (ft): 4956.19 Surface Condition: Sparse Vegetation, Station # 346+19
4955			50/3										GM-GC	**Silty Gravel to Clayey Gravel, Weathered Bedrock:** About 30% predominantly fine sand, about 15% fines with low plasticity, no dilatancy, high dry strength, and low toughness; about 55% angular, fine to coarse gravel and cobbles, gravel-sized particles fracture with considerable hammer blow; dry; red-brown; strong reaction to HCL
	5													
4950			50/4											
	10													
4945			50/4											fine to coarse sand Note: some gravel-sized particles recovered in sampler can be broken with considerable finger pressure into angular pieces having a laminated structure (approximately 1 mm thick seams alternating between red-brown and dark brown)
	15													Auger refusal at 15.0 feet on bedrock (Moenkopi Formation) Stopped sampling at 11.33 feet
4940														

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Date: June, 2009
Project Number: 93212

LOG OF Test boring B-24
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
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Latitude & Longitude:	N 35° 0' 32" W 110° 43' 32"			Date Started:	11/6/2008
Groundwater (ft.):	No Free Groundwater Encountered			Date Completed:	11/6/2008
Drilling Company:	Yellow Jacket	Equipment:	CME-75	Logged By:	E. Everts
Core Diameter (in):	8	Drilling Method:	Coring - NWJ Rods		
Hammer Type:	NA	Surface Elevation (ft):	4942.54	Total Depth (ft):	12.3

ELEVATION (ft)	DEPTH (ft)	Sample Type	Blow Counts per 6 inches	ROCK CORE Run No.	Box No.	Drilling Rate (min/ft)	Recovery (%)	RQD (%)	Fracture Frequency	Fracture Orientation (deg)	JRC	Lithology	USCS Designation	MATERIAL DESCRIPTION Surface Condition: Sparse Vegetation, Station # 317+73
													SC	**Clayey Sand** Note: Advanced tri-cone drill bit to start of competent bedrock
4940				1	1		84	7						**Sandstone, Triassic Moenkopi,** sedimentary, red-brown, moderately hard, unweathered, very fine grained, thin bedded, intensely fractured Note: Rig operated at 1700 rpm at 125 psi (third gear) Note: core advanced quickly between 3' - 1" and 3' - 4"
	5													Note: between approximately 4' - 10" and 5' - 0", the drilling rods wobbled as if no longer drilling through competent bedrock
4935				2	2		98	16						
	10													Slightly weathered, core broken up into coarse sand- to fine gravel-sized particles around fractures
4930														Auger refusal at 2.0 feet on bedrock (Moenkopi Formation) Initiated HQ Wireline coring at 2.0 feet Core terminated at 12.5 feet
	15													

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Drafted By: E. Everts
Date: June, 2009
Project Number: 93212

LOG OF Test boring B-25
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
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UPDATED GEO CORE EW/EL 93212.GPJ 6/18/2009

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Latitude & Longitude:	N 35° 0' 27" W 110° 42' 5"			Date Started:	11/10/2008
Groundwater (ft.):	No Free Groundwater Encountered			Date Completed:	11/10/2008
Drilling Company:	Yellow Jacket	Equipment:	CME-75	Logged By:	E. Everts
Core Diameter (in):	8	Drilling Method:	Coring - NWJ Rods		
Hammer Type:	NA	Surface Elevation (ft):	4902.81	Total Depth (ft):	11.0

ELEVATION (ft)	DEPTH (ft)	Sample Type	Blow Counts per 6 inches	ROCK CORE Run No.	Box No.	Drilling Rate (min/ft)	Recovery (%)	RQD (%)	Fracture Frequency	Fracture Orientation (deg)	JRC	Lithology	USCS Designation	MATERIAL DESCRIPTION Surface Condition: Sparse Vegetation, Station # 243+55
													SC	**Clayey Sand,** About 60% to 65% predominantly fine sand; about 30% fines with low plasticity, no dilatancy, high dry strength, and low toughness; about 5% to 10% angular, fine to coarse gravel, gravel-sized particles fracture with considerable hammer blow; maximum size, 1 1/2 in.; dry; red-brown; strong reaction to HCL Note: Advanced tri-cone drill bit to start of competent bedrock
				1	1		98	0						**Sandstone, Triassic Moenkopi,** sedimentary, red-brown, moderately hard, unweathered, very fine grained, thin bedded, intensely fractured Note: Rig operated at 1900 rpm at 125 psi (first gear)
4900														
	5													Note: Rig operated at 1900 rpm at 125 psi (second gear) Between 5' - 6" and 5' - 11", slightly weathered; core broken up into coarse sand- to fine gravel-sized particles around fractures; fractures infilled with clay; maximum separation, 4 mm.
				2	2		100	59						Highly fractured; no infill; outer surface of core slightly pitted between 9' - 6" and 10' - 3" Note: Rig operated at 1900 rpm at 125 psi (third gear)
4895														
	10												SM	**Silty Sand,** with some clayey sand, fines with low plasticity, slow dilatancy, high dry strength, and low toughness; maximum size, fine sand; dry; red-brown; strong reaction to HCL
														Auger refusal at 1.0 feet on bedrock (Moenkopi Formation) Initiated HQ Wireline coring at 2.0 feet Core terminated at 11.0 feet
4890														
	15													

UPDATED GEO CORE EW/EL 93212.GPJ 6/18/2009

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Drafted By: E. Everts
Date: June, 2009
Project Number: 93212

LOG OF Test boring B-26
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
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Latitude & Longitude:	N 35° 0' 27.8" W 110° 41' 23.7"	Date Started:	4/1/2009
Groundwater Depth (ft):	No Free Groundwater Encountered	Date Completed:	4/1/2009
Drilling Company:	Boart Longyear	Equipment:	
Logged By:	R. Caratachea		
Hole Diameter (in):	6	Drilling Method:	Sonic
Hammer Type:	Automatic	Total Depth (ft):	27.5

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 0.0 to 17.0 feet Appx. Surface Elevation (ft): 4888.00 Surface Condition: Sparse Vegetation, Station # 209+80
													SM	**Levee Fill: Silty Sand** with gravel, fine to coarse sand, reddish gray, dry, low plasticity.
4885							16	2	59	27			GM	**Levee Fill: Silty Gravel** with fine sand and cobbles, low toughness, reddish brown, dry, low plasticity.
	5						NV	NP	51	19			GM	**Levee Fill: Silty Gravel** with fine sand and cobbles, light brown, dry, non-plastic.
4880													GC	**Levee Fill: Clayey Gravel**with fine to coarse sand and cobbles, reddish brown, dry, low plasticity.
	10						20	4	53	30			GC-GM	**Levee Fill: Silty, Clayey Gravel** with fine to coarse sand and cobbles, reddish brown, dry, low plasticity.
4875														Note: drillers added water
	15						19	5	58	29			GC-GM	**Levee Fill: Silty, Clayey Gravel** with fine sand and gravel, reddish brown, dry, low plasticity.

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Drafted By: R. Katako
Date: June. 2009
Project Number: 93212

LOG OF Test boring SB-1
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A33

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UPDATED GEO ADOT EW/EL 93212.GPJ 6/18/2009

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 17.0 to 27.5 feet
													GC-GM	
4870							17	3	71	33			SM	**Levee Fill: Silty Sand** with fine to coarse gravel and cobbles, sand is fine grained, reddish brown, dry, low plasticity.
	20													
							16	7	48	21			GC-GM	**Levee Fill: Silty Clayey Gravel** with fine sand and cobbles, reddish brown, dry, low plasticity.
4865							18	3	62	37				**Levee Fill: Silty Gravel** with fine sand and cobbles, light brown, dry, low plasticity.
							17	2	76	42			SM	**Silty Sand** with gravel and cobbles, nominal size 5", fine to medium grained sand, dark reddish gray, moist, trace clay, no plasticity.
	25													
			62/8				NV	NP	78	29				
														Kaibab Formation, light-yellow, hard, quartzitic sandstone, quartz grains are well rounded and poorly graded, weak reaction to HCL.
4860														Note: very difficult drilling
														Stopped drilling at 27.5 feet in hard bedrock
	30													
4855														
	35													

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Date: June. 2009
Project Number: 93212

LOG OF Test boring SB-1 (Continued)
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
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Latitude & Longitude:	N 35° 0' 26.8" W 110° 42' 6.6"	Date Started:	4/1/2009
Groundwater Depth (ft):	No Free Groundwater Encountered	Date Completed:	4/1/2009
Drilling Company:	Boart Longyear	Equipment:	
Logged By:	R. Caratachea		
Hole Diameter (in):	6	Drilling Method:	Sonic
Hammer Type:	Automatic	Total Depth (ft):	25.0

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 0.0 to 17.0 feet Appx. Surface Elevation (ft): 4919.96 Surface Condition: Sparse Vegetation, Station # 244+68
													GC-GM	**Levee Fill: Silty, Clayey Gravel** with fine to coarse grained sand and cobbles, reddish brown, dry, low plasticity, weak reaction to HCL.
							19	3	56	29			GM	**Levee Fill: Silty Gravel** with fine sand and cobbles, reddish brown, dry, low plasticity, weak reaction to HCL.
4915	5						18	2	57	29				
													GC	**Levee Fill: Clayey Gravel** with fine to coarse sand and cobbles, reddish brown, dry, medium plasticity, weak reaction to HCL.
4910	10						19	3	59	32			GM	**Levee Fill: Silty Gravel** with fine to coarse sand and cobbles, reddish brown, dry, low plasticity, weak reaction to HCL.
													SC-SM	**Levee Fill: Silty, Clayey Sand** with gravel, sand is fine to coarse grained, reddish brown, dry, low plasticity, weak reaction to HCL.
4905	15						21	5	77	46				

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Drafted By: R. Katako
Date: June. 2009
Project Number: 93212

LOG OF Test boring SB-2
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
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ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 17.0 to 25.0 feet
													SC-SM	
4900	20													**Moenkopi Formation (sandstone),** light-brown, moderately hard, poorly weathered, fine grained, thin horizontal bedding, moderately fractured, weak reaction to HCL.
4895	25													Stopped drilling at 25.0 feet in hard sandstone Stopped sampling at 25.0 feet
4890	30													
4885	35													

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Drafted By: R. Katako
Date: June, 2009
Project Number: 93212

LOG OF Test boring SB-2 (Continued)
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
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Latitude & Longitude:	N 35° 0' 30.7" W 110° 42' 26.2"	Date Started:	3/31/2009
Groundwater Depth (ft):	No Free Groundwater Encountered	Date Completed:	3/31/2009
Drilling Company:	Boart Longyear	Equipment:	
Hole Diameter (in):	6	Drilling Method:	Sonic
Hammer Type:	Automatic	Logged By:	R. Caratachea
		Total Depth (ft):	25.0

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 0.0 to 17.0 feet Appx. Surface Elevation (ft): 4921.99 Surface Condition: Sparse Vegetation, Station # 261+47
													SM	**Levee Fill: Silty Sand** with gravel and cobbles, sand is fine to coarse grained, reddish brown, dry, trace clay.
4920														
							17	1	53	24			GM	**Levee Fill: Silty Gravel** with fine to coarse sand and cobbles , reddish brown, dry, low plasticity, trace clay, weak reaction to HCL.
	5						19	3	60	27			GC	**Levee Fill: Clayey Gravel** with fine to coarse sand and cobbles, reddish brown, dry, low plasticity, weak reaction to HCL. Note: driller added water
4915														
													GM	**Levee Fill: Silty Gravel** with fine to coarse sand and cobbles, reddish brown, dry, low plasticity, weak reaction to HCL.
	10						20	4	49	26			GC-GM	**Levee Fill: Silty, Clayey Gravel** with fine to coarse sand and cobbles, reddish brown, dry, low plasticity, trace clay, weak reaction to HCL. Note: driller added water to hole
4910														
							22	4	43	27				
	15												SC	**Clayey Sand,** fine to coarse, reddish brown, dry, low plasticity, low plasticity, weak reaction to HCL.
														Moenkopi Formation (sandstone), light-brown, moderately hard, poorly weathered, fine grained, thin horizontal
4905														

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Date: June. 2009
Project Number: 93212

LOG OF Test boring SB-3
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A35

UPDATED GEO ADOT EW/EL 93212.GPJ 6/18/2009

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ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 17.0 to 25.0 feet
														bedding, moderately fractured, weak reaction to HCL.
	20													
4900														
	25													Stopped drilling at 25.0 feet in hard bedrock
4895														
	30													
4890														
	35													

UPDATED GEO ADOT EW/EL 93212.GPJ 6/18/2009

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LOG OF Test boring SB-3 (Continued)
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A35

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Latitude & Longitude:	N 35° 0' 27.3" W 110° 44' 18.2"	Date Started:	3/31/2009
Groundwater Depth (ft):	No Free Groundwater Encountered	Date Completed:	3/31/2009
Drilling Company:	Boart Longyear	Equipment:	
Logged By:	R. Caratachea		
Hole Diameter (in):	6	Drilling Method:	Sonic
Hammer Type:	Automatic	Total Depth (ft):	12.5

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 0.0 to 12.5 feet Appx. Surface Elevation (ft): 4957.09 Surface Condition: Sparse Vegetation, Station # 356+48
							27	12	100	82			CL	**Sandy Lean Clay (native),** with fine grained sand, reddish-brown, dry, medium plasticity.
4955														Note: Slight increase in fine grained sand at 2.5 feet.
	5													**Moenkopi Formation (sandstone),** light-brown, moderately weathered, fine grained, bedding is thin and horizontal with interspersed mudstone laminations, moderately fractured, moderately soft and friable in hand specimen.
4950														Note: Becomes moderately hard at 7.0 feet. Rig chatter increased.
	10													Note: Very hard drilling at 10 feet.
4945														Stopped drilling at 12.5 feet in hard bedrock
	15													

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LOG OF Test boring SB-4
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A36

UPDATED GEO ADOT EW/EL 93212.GPJ 6/18/2009

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Latitude & Longitude:	N 35° 0' 28.7" W 110° 44' 20.3"	Date Started:	3/31/2009
Groundwater Depth (ft):	No Free Groundwater Encountered	Date Completed:	3/31/2009
Drilling Company:	Boart Longyear	Equipment:	
Logged By:	R. Caratachea		
Hole Diameter (in):	6	Drilling Method:	Sonic
Hammer Type:	Automatic	Total Depth (ft):	35.0

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 0.0 to 17.0 feet Appx. Surface Elevation (ft): 4968.63 Surface Condition: Sparse Vegetation, Station # 358+64
							29	11	89	71			CL	**Levee Fill : Sandy Lean Clay** some fine sand and gravel, reddish-brown, dry, medium plasticity.
4965													SC-SM	**Levee Fill: Silty, Clayey Sand** with gravel, sand is fine to coarse grained, light reddish brown, dry, low plasticity, weak reaction to HCL.
	5						25	9	53	36			GC	**Levee Fill: Clayey Gravel** with medium to coarse sand and gravel, light brown, dry, low plasticity.
4960							26	10	99	71			CL	**Levee Fill: Sandy Lean Clay** trace fine sand and gravel and cobbles, light reddish brown, dry, medium plasticity, weak reaction to HCL.
	10						25	8	99	84				Note: drillers added water
4955							24	9	100	71				
	15												CL	**Weathered Bedrock: Sandy Lean Clay,** trace sand and gravel, light brown to reddish, dry, medium plasticity, weak reaction to HCL,

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LOG OF Test boring SB-5
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A36

UPDATED GEO ADOT EW/EL 93212.GPJ 6/18/2009

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ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 17.0 to 35.0 feet
							31	12	74	60			CL	stratified with thin and horizontal laminations of silty sand. Note: Increased cobbles at 17.5 feet.
4950														
	20													**Moenkopi Formation (sandstone),** light-brown, poor to moderate weathering, fine grained, thin and horizontal bedding, moderately fractured, well cemented, strong reaction to HCL. Note: difficult drilling at 20 feet.
4945														
	25													Note: driller added water to drill hole periodically. Note: Drilling contractor indicated that the drill advance was alternating between hard and soft layers in the subsurface.
4940														
	30													Note: Reaction to HCL becomes weak at 30.5 feet
4935														
	35													Stopped drilling at 35 feet in bedrock (Moenkopi Formation)

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LOG OF Test boring SB-5 (Continued)
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A36

UPDATED GEO ADOT EW/EL 93212.GPJ 6/18/2009

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Latitude & Longitude:	N 35° 0' 28.3" W 110° 44' 19.2"	Date Started:	3/31/2009
Groundwater Depth (ft):	No Free Groundwater Encountered	Date Completed:	3/31/2009
Drilling Company:	Boart Longyear	Equipment:	
Hole Diameter (in):	6	Drilling Method:	Sonic
Hammer Type:	Automatic	Logged By:	R. Caratachea
		Total Depth (ft):	35.0

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 0.0 to 17.0 feet Appx. Surface Elevation (ft): 4968.87 Surface Condition: Sparse Vegetation, Station # 357+63
							28	12	87	57			CL	**Levee Fill: Sandy Lean Clay** some fine to medium sand and gravel, dark reddish brown, dry, medium plasticity.
							28	12	94	72				Note: Color becomes light brown.
4965														
	5													Note: Trace cobbles at 4.5, sand fraction becomes fine to coarse.
							27	10	99	79				
							23	9	100	73				
4960														
	10						23	10	100	81				
							22	7	99	81			CL-ML	**Levee Fill: Sandy Silty Clay,** trace gravel and cobbles, sand fraction is fine to medium, reddish brown, dry, low plasticity.
4955														
	15													
														Moenkopi Formation (sandstone), light-brown, moderately weathered, thinly laminated horizontal bedding, fine grained,

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LOG OF Test boring SB-6
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A37

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ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 17.0 to 35.0 feet
														weak reaction to HCL, friable in hand specimen.
4950														
	20													
														Note: Becomes moderately weathered andhard at 22 feet.
4945														
	25													
4940														
	30													
4935														
	35													Drilling Stopped at 35.0 fee in moderately hard sandstone. Stopped sampling at 35.0 feet

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LOG OF Test boring SB-6 (Continued)
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Winslow, Arizona

FIGURE
A37

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Latitude & Longitude:	N 35° 0' 28.9" W 110° 44' 22.2"	Date Started:	3/31/2009
Groundwater Depth (ft):	No Free Groundwater Encountered	Date Completed:	3/31/2009
Drilling Company:	Boart Longyear	Equipment:	
Logged By:	R. Caratachea		
Hole Diameter (in):	6	Drilling Method:	Sonic
Hammer Type:	Automatic	Total Depth (ft):	15.0

ELEVATION (ft)	DEPTH (ft)	FIELD: Sample Interval	FIELD: Blow Counts per 6" Interval	FIELD: Continuous Pen. Resistance (bpf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphical Log	USCS Classification	DESCRIPTION 0.0 to 15.0 feet Appx. Surface Elevation (ft): 4958.54 Surface Condition: Sparse Vegetation, Station # 360+14
							24	10	100	89			CL	**Silty Clay,** with fine grained sand, reddish brown, dry, low plasticity.
4955														
	5													Note: difficult drilling started at 5'.
														Sandstone, Triassic Moenkopi Formation, sedimentary, light-brown, moderately weathered, fine grained, moderately hard, thinly bedded.
4950														Note: hard
	10													Note: very difficult drilling
4945														
	15													Drilling Stopped at 15.0 feet. Stopped sampling at 15.0 feet

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Date: June. 2009
Project Number: 93212

LOG OF Test boring SB-7
Winslow Levees
Woodson Engineering & Surveying, Inc.
Ruby Wash Diversion Levee, Station 165+00 to 381+30
Winslow, Arizona

FIGURE
A38

UPDATED GEO ADOT EW/EL 93212.GPJ 6/18/2009

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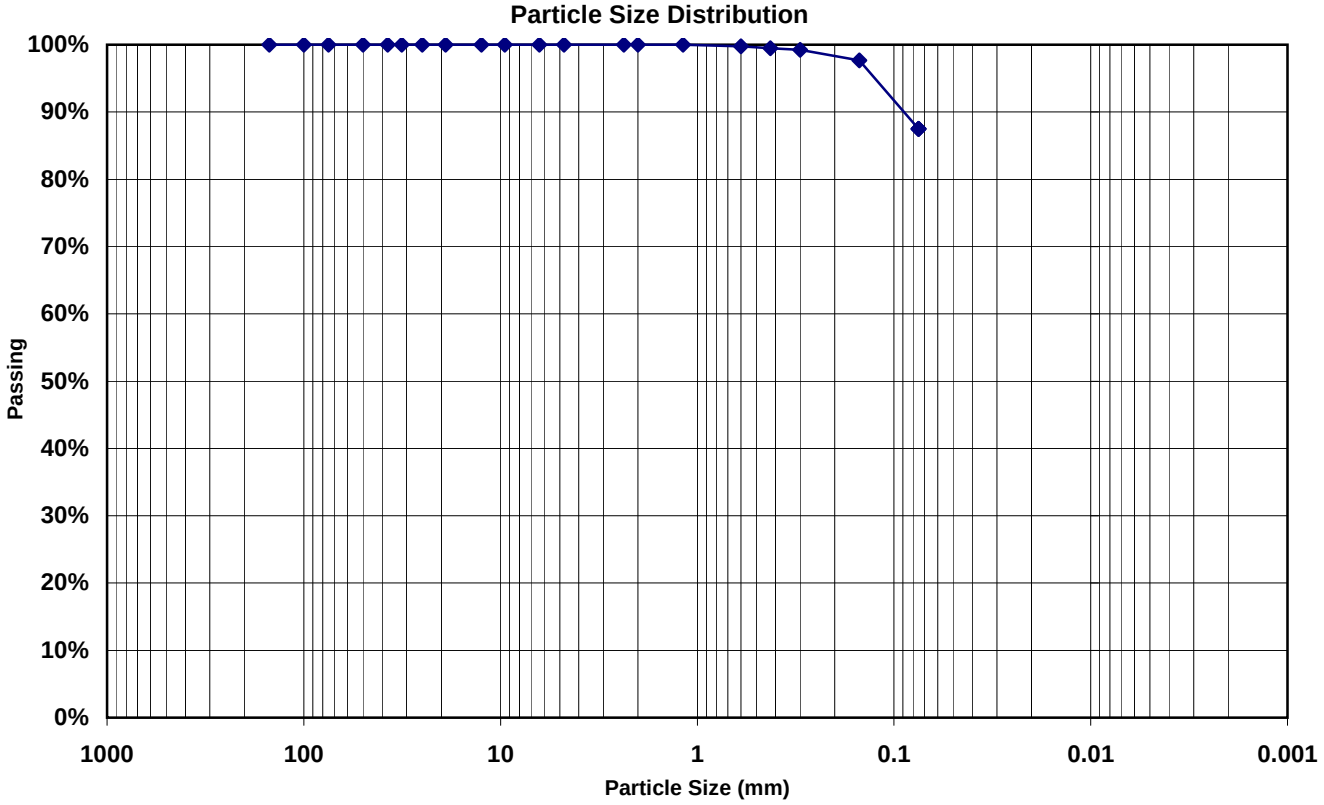
APPENDIX B

Laboratory Test Results



Cobbles	Gravel		Sand			Fines
	COARSE	FINE	COARSE	MEDIUM	FINE	
0.0%	0.0%	0.0%	0.0%	0.5%	12.0%	87.5%

SAMPLE SOURCE: **B-3 @ 1'**

ATTERBERG LIMITS
LL: 27
PL: 16
PI: 11

USCS: CL
Sandy Lean clay

AASHTO: A-6(8)
Clayey soils

NATURAL MOISTURE CONTENT: 4.12%
NATURAL DRY DENSITY: 100.3

PARTICLE SIZE	% FINER
6"	100
4"	100
3"	100
2"	100
1½"	100
1¼"	100
1"	100
3/4"	100
1/2"	100
3/8"	100
1/4"	100
#4	100
#8	100
#10	100
#16	100
#30	100
#40	99
#50	99
#100	98
#200	87

Results include summarized reporting of ASTM D2487, D2216, D2937

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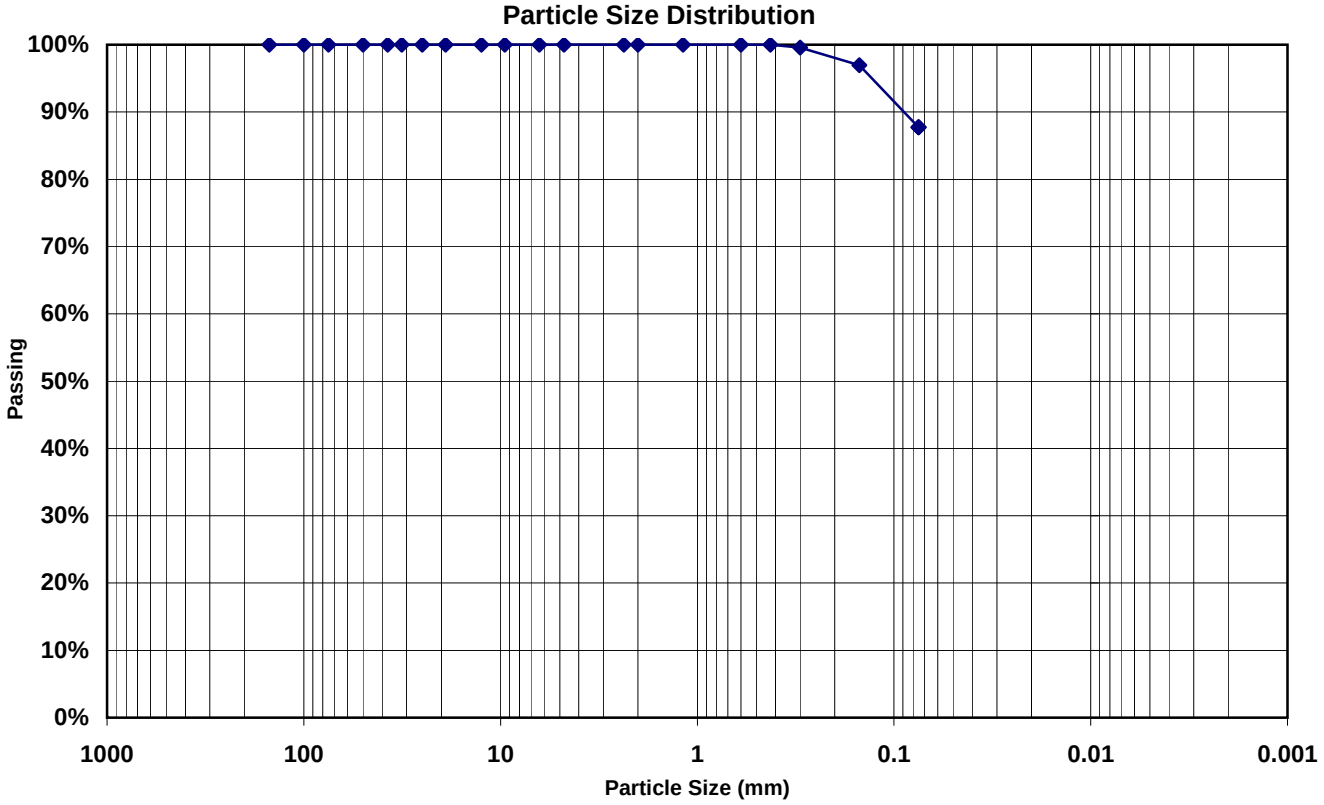
RUBY WASH DIVERSION LEVEE
STA 165+00 to 381+50

CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 10/30/08
93212(1.6w): 08706-1

APPENDIX
B.1



Cobbles	Gravel		Sand			Fines
	COARSE	FINE	COARSE	MEDIUM	FINE	
0.0%	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**12.3%**	**87.7%**

SAMPLE SOURCE: **B-1 @ 1'**

ATTERBERG LIMITS
LL: 29
PL: 16
PI: 13

USCS: CL
Lean clay

AASHTO: A-6(10)
Clayey soils

PARTICLE SIZE	% FINER
6"	100
4"	100
3"	100
2"	100
1½"	100
1¼"	100
1"	100
3/4"	100
1/2"	100
3/8"	100
1/4"	100
#4	100
#8	100
#10	100
#16	100
#30	100
#40	100
#50	100
#100	97
#200	88

Results include summarized reporting of ASTM D2487

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RUBY WASH DIVERSION LEVEE
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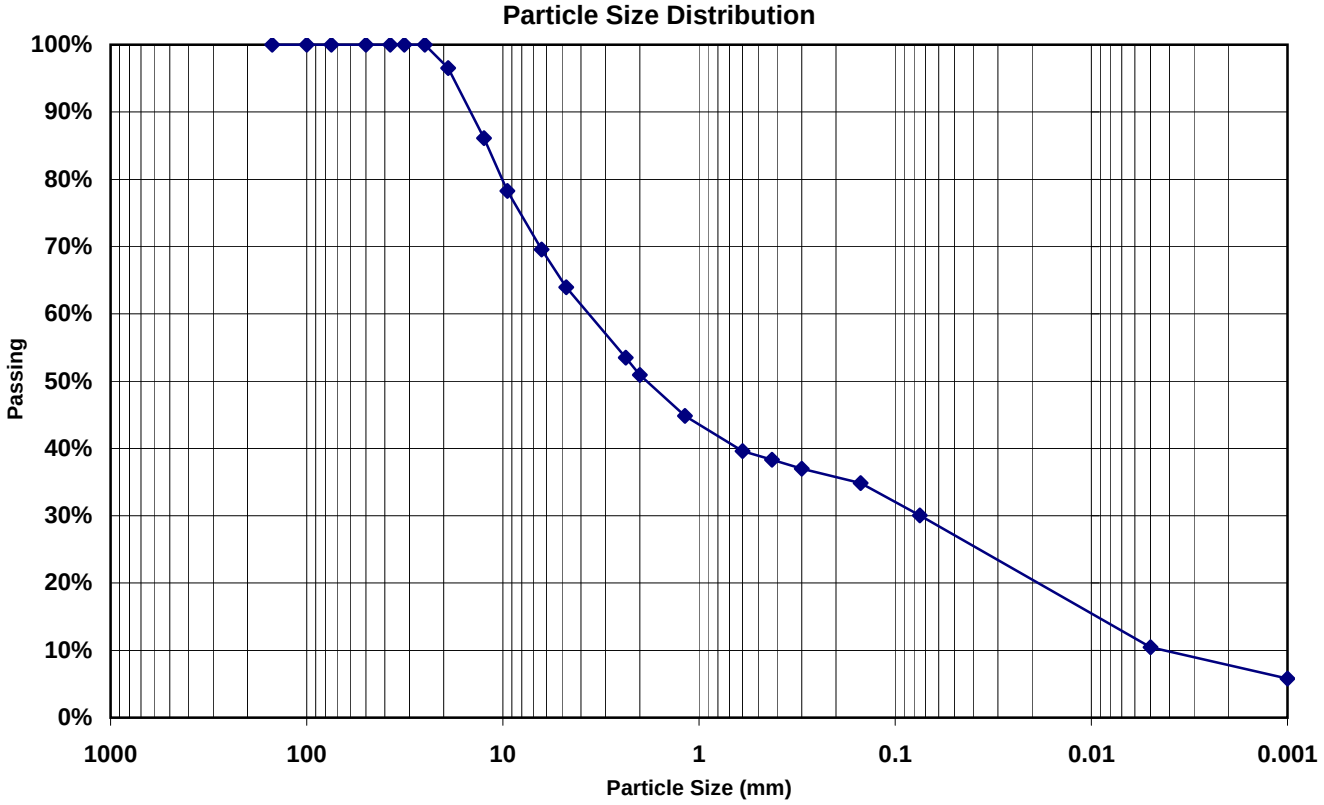
CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 10/30/08

93212(1.6w): 08706-2

APPENDIX
B.2



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
0.0%	**3.5%**	**32.6%**	**13.0%**	**12.6%**	**8.3%**	**19.6%**	**10.5%**

SAMPLE SOURCE: **B-5 @ 3'**

ATTERBERG LIMITS
LL: 23
PL: 17
PI: 6

USCS: GC-GM
Silty, clayey gravel with sand

AASHTO: A-2-4(0)
Silty gravel and sand

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	100	
2"	100	
1½"	100	
1¼"	100	
1"	100	
3/4"	97	
1/2"	86	
3/8"	78	
1/4"	70	
#4	64	
#8	54	
#10	51	
#16	45	
#30	40	
#40	38	
#50	37	
#100	35	
#200	30	
0.005 mm	10.5	
0.001 mm	5.8	(colloids)

Results include summarized reporting of ASTM D2487, D422

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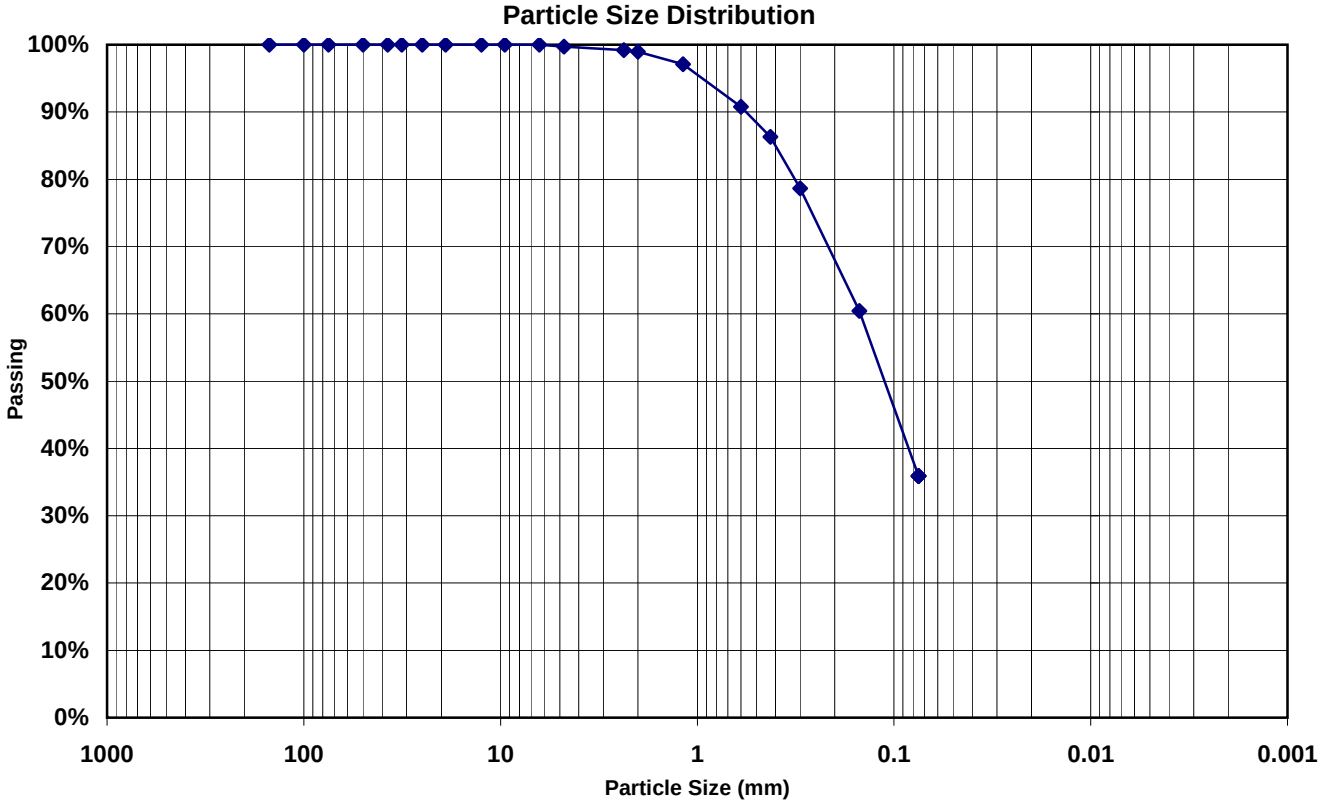
CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 10/30/08

93212(1.6w): 08706-3

APPENDIX
B.3



Cobbles	Gravel		Sand			Fines
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT
0.0%	**0.0%**	**0.3%**	**0.8%**	**12.7%**	**50.4%**	**35.9%**

SAMPLE SOURCE: **B-6 @ 1'**

ATTERBERG LIMITS
LL: 20
PL: 19
PI: 1

USCS: SC
Clayey sand

AASHTO: A-4(0)
Silty soils

NATURAL MOISTURE CONTENT: 2.63%
NATURAL DRY DENSITY: 101.3

PARTICLE SIZE	% FINER
6"	100
4"	100
3"	100
2"	100
1½"	100
1¼"	100
1"	100
3/4"	100
1/2"	100
3/8"	100
1/4"	100
#4	100
#8	99
#10	99
#16	97
#30	91
#40	86
#50	79
#100	60
#200	36

Results include summarized reporting of ASTM D2487, D2216, D2937

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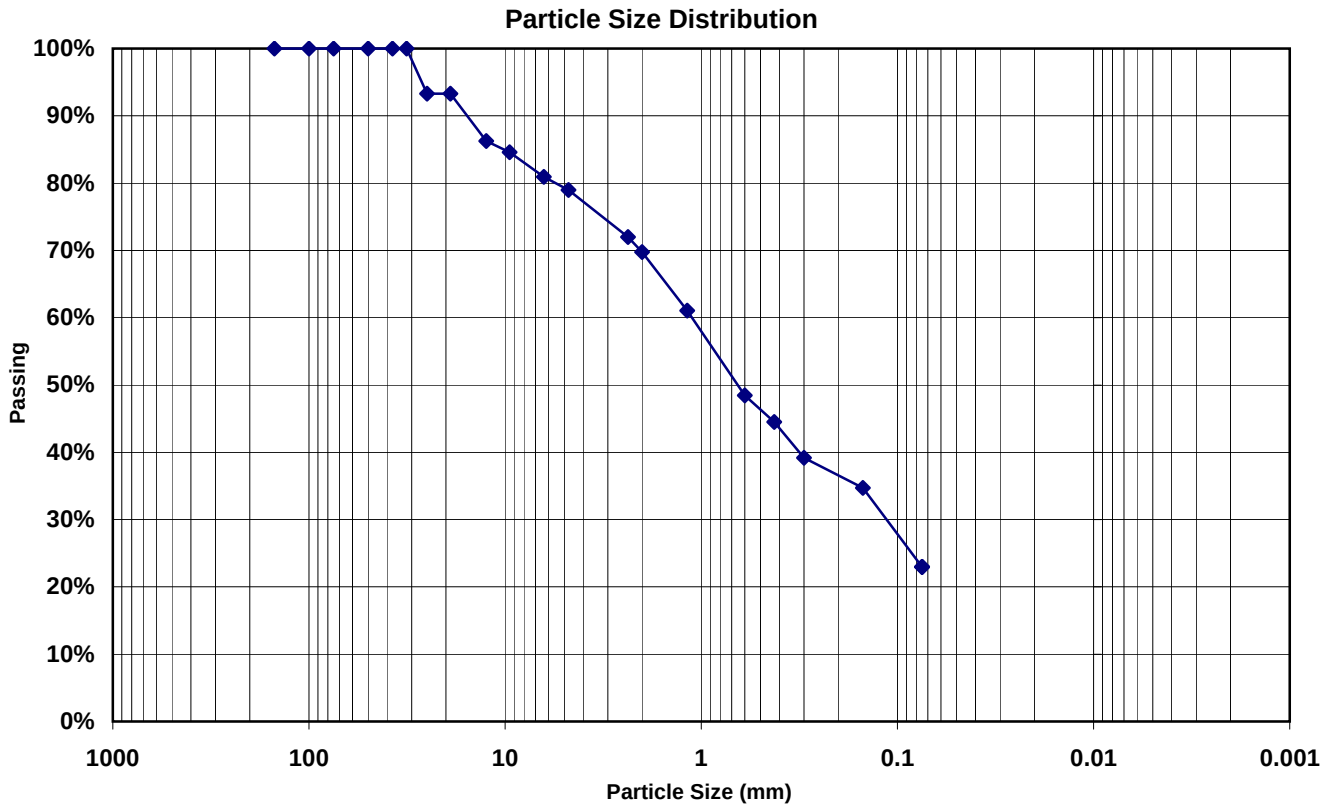
RUBY WASH DIVERSION LEVEE
STA 165+00 to 381+50

CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 10/30/08
93212(1.6w): 08706-4

APPENDIX
B.4



Cobbles	Gravel		Sand			Fines
	COARSE	FINE	COARSE	MEDIUM	FINE	
0.0%	**6.7%**	**14.3%**	**9.2%**	**25.2%**	**21.6%**	**22.9%**

SAMPLE SOURCE: **B-20 @ 1'**

ATTERBERG LIMITS
LL: 17
PL: 16
PI: 1

USCS: SC
Clayey sand with gravel

AASHTO: A-1-b(0)
Stone fragments, gravel and sand

NATURAL MOISTURE CONTENT: 1.45%
NATURAL DRY DENSITY: 104.9

PARTICLE SIZE	% FINER
6"	100
4"	100
3"	100
2"	100
1½"	100
1¼"	100
1"	93
3/4"	93
1/2"	86
3/8"	85
1/4"	81
#4	79
#8	72
#10	70
#16	61
#30	48
#40	45
#50	39
#100	35
#200	23

Results include summarized reporting of ASTM D2487, D2216, D2937

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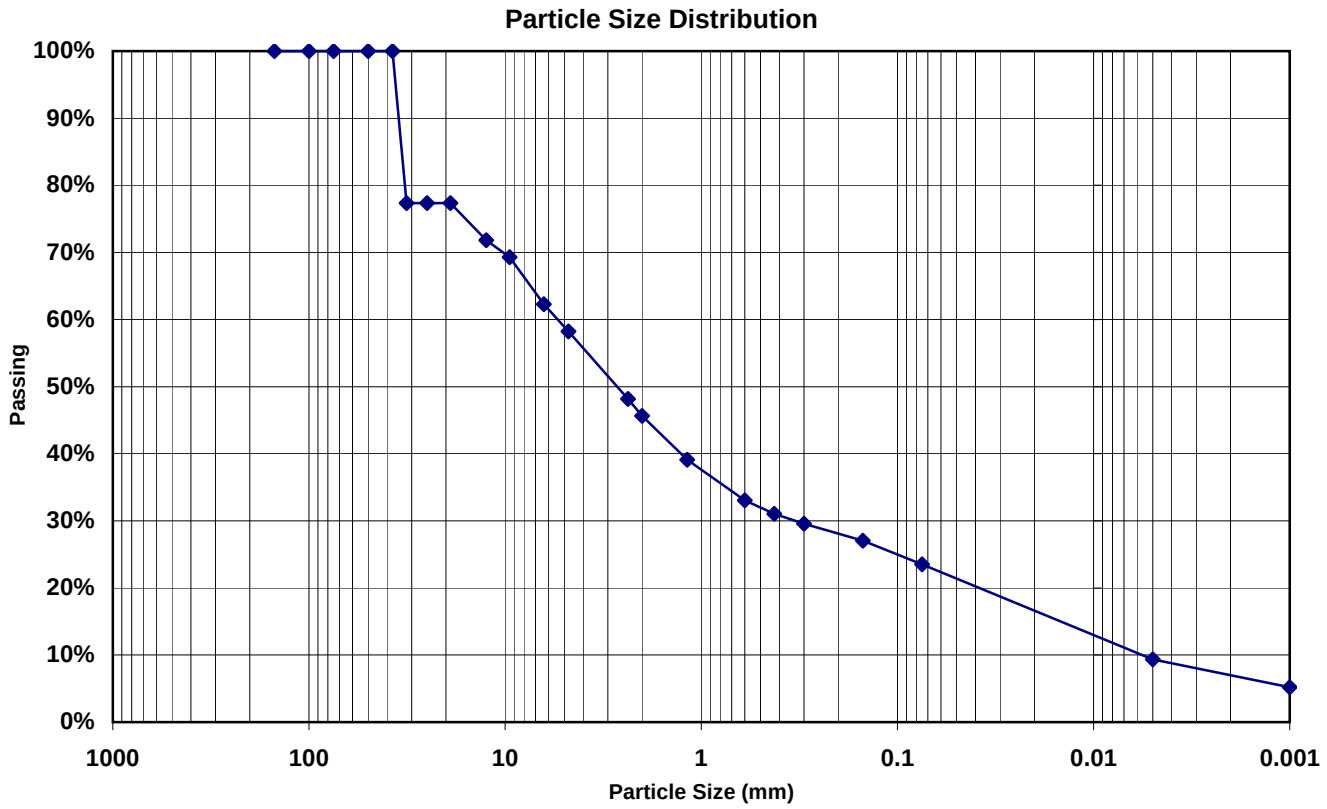
RUBY WASH DIVERSION LEVEE
STA 165+00 to 381+50

CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 10/30/08
93212(1.6w): 08706-5

APPENDIX
B.5



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
0.0%	**22.6%**	**19.1%**	**12.6%**	**14.6%**	**7.5%**	**14.1%**	**9.4%**

SAMPLE SOURCE: **B-7 @ 5'**

ATTERBERG LIMITS
LL: 23
PL: 15
PI: 8

USCS: GC
Clayey gravel with sand

AASHTO: A-2-4(0)
Silty gravel and sand

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	100	
2"	100	
1½"	100	
1¼"	77	
1"	77	
3/4"	77	
1/2"	72	
3/8"	69	
1/4"	62	
#4	58	
#8	48	
#10	46	
#16	39	
#30	33	
#40	31	
#50	30	
#100	27	
#200	24	
0.005 mm	9.4	
0.001 mm	5.2	(colloids)

Results include summarized reporting of ASTM D2487, D422

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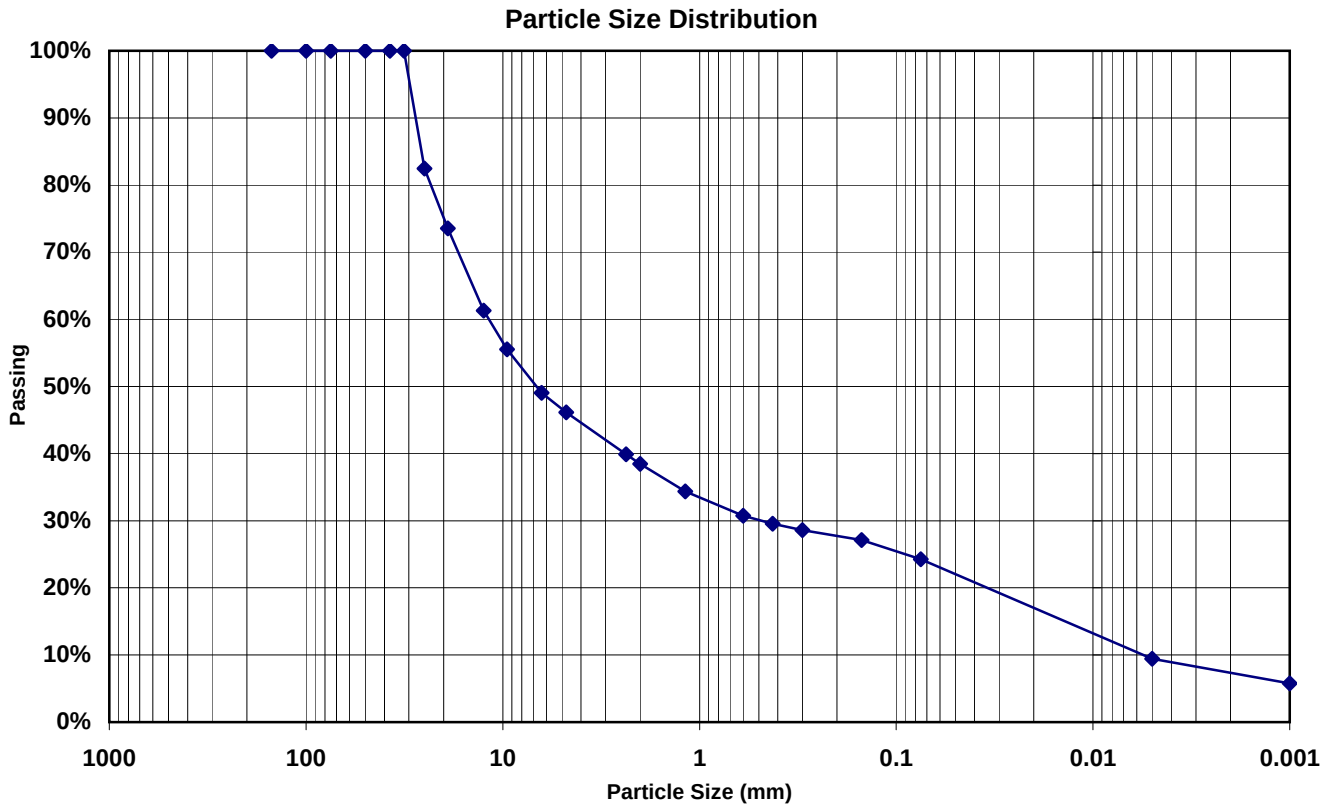
RUBY WASH DIVERSION LEVEE
STA 165+00 to 381+50

CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 10/30/08

93212(1.6w): 08706-6

APPENDIX
B.6



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
0.0%	**26.4%**	**27.4%**	**7.7%**	**8.9%**	**5.3%**	**14.8%**	**9.5%**

SAMPLE SOURCE: **B-9 @ 7'**

ATTERBERG LIMITS
LL: 24
PL: 17
PI: 7

USCS: GC-GM
Silty, clayey gravel with sand

AASHTO: A-2-4(0)
Silty gravel and sand

NATURAL MOISTURE CONTENT: 3.19%
NATURAL DRY DENSITY: 113.6

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	100	
2"	100	
1½"	100	
1¼"	100	
1"	82	
3/4"	74	
1/2"	61	
3/8"	56	
1/4"	49	
#4	46	
#8	40	
#10	38	
#16	34	
#30	31	
#40	30	
#50	29	
#100	27	
#200	24	
0.005 mm	9.5	
0.001 mm	5.8	(colloids)

Results include summarized reporting of ASTM D2487, D2216, D2937, D422

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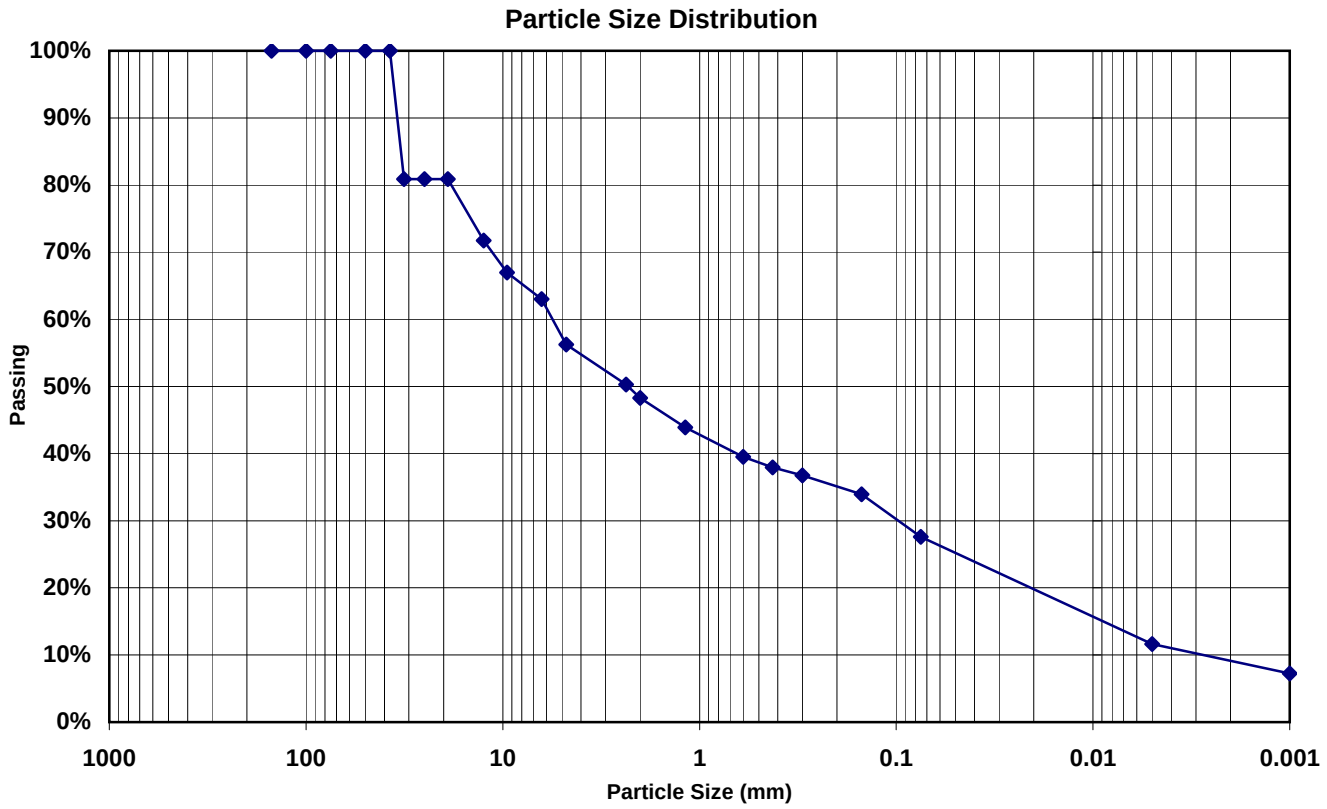
f| 480.763.1212

RUBY WASH DIVERSION LEVEE
STA 165+00 to 381+50

CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 10/30/08

93212(1.6w): 08706-7

APPENDIX
B.7



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
0.0%	**19.1%**	**24.7%**	**8.0%**	**10.3%**	**10.3%**	**15.9%**	**11.6%**

SAMPLE SOURCE: **B-11 @ 3'**

ATTERBERG LIMITS
LL: 24
PL: 17
PI: 7

USCS: GC-GM
Silty, clayey gravel with sand

AASHTO: A-2-4(0)
Silty gravel and sand

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	100	
2"	100	
1½"	100	
1¼"	81	
1"	81	
3/4"	81	
1/2"	72	
3/8"	67	
1/4"	63	
#4	56	
#8	50	
#10	48	
#16	44	
#30	40	
#40	38	
#50	37	
#100	34	
#200	28	
0.005 mm	11.6	
0.001 mm	7.3	(colloids)

Results include summarized reporting of ASTM D2487, D422

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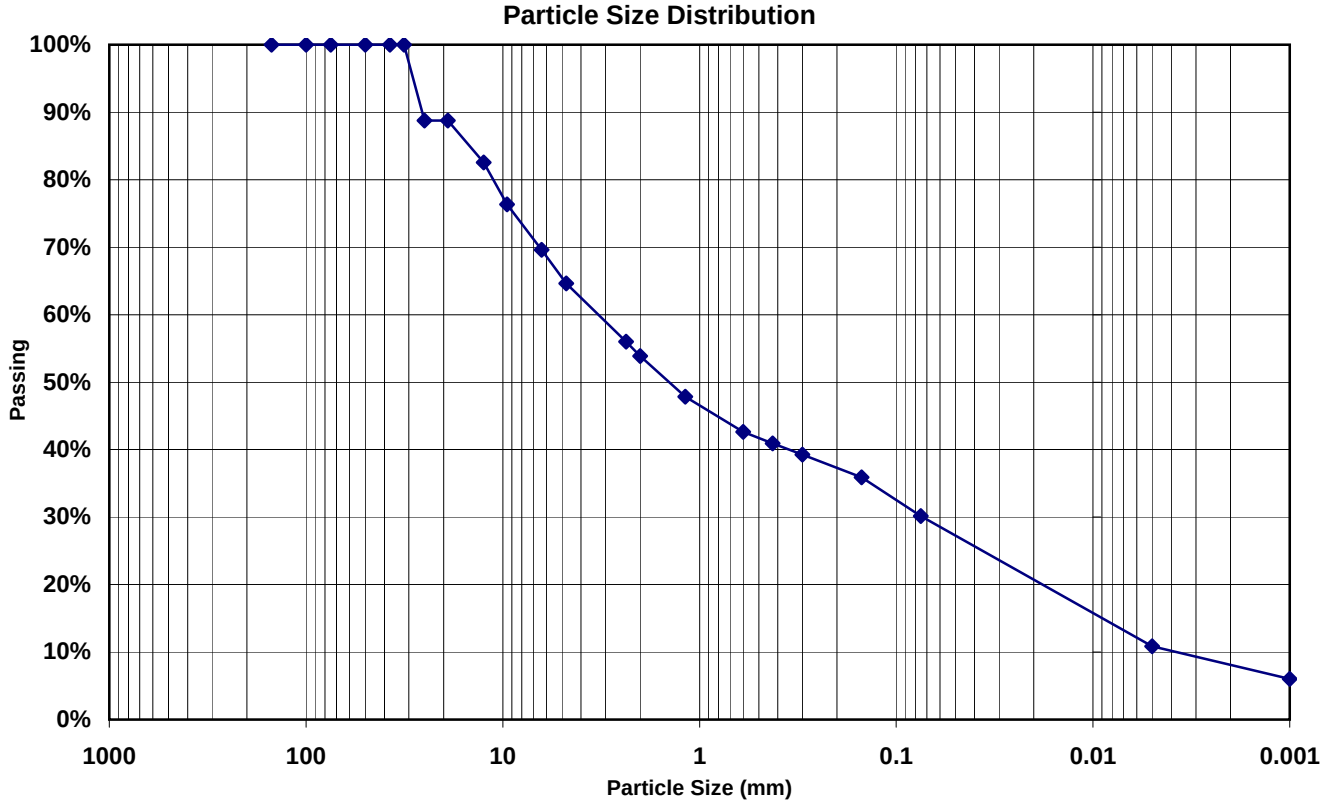
RUBY WASH DIVERSION LEVEE
STA 165+00 to 381+50

CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 10/30/08

93212(1.6w): 08706-8

APPENDIX
B.8



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
0.0%	**11.2%**	**24.2%**	**10.8%**	**12.9%**	**10.8%**	**19.3%**	**10.9%**

SAMPLE SOURCE: **B-11 @ 11'**

ATTERBERG LIMITS
LL: 23
PL: 17
PI: 6

USCS: GC-GM
Silty, clayey gravel with sand

AASHTO: A-2-4(0)
Silty gravel and sand

NATURAL MOISTURE CONTENT: 2.91%
NATURAL DRY DENSITY: 113.4

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	100	
2"	100	
1½"	100	
1¼"	100	
1"	89	
3/4"	89	
1/2"	83	
3/8"	76	
1/4"	70	
#4	65	
#8	56	
#10	54	
#16	48	
#30	43	
#40	41	
#50	39	
#100	36	
#200	30	
0.005 mm	10.9	
0.001 mm	6.0	(colloids)

Results include summarized reporting of ASTM D2487, D2216, D2937, D422

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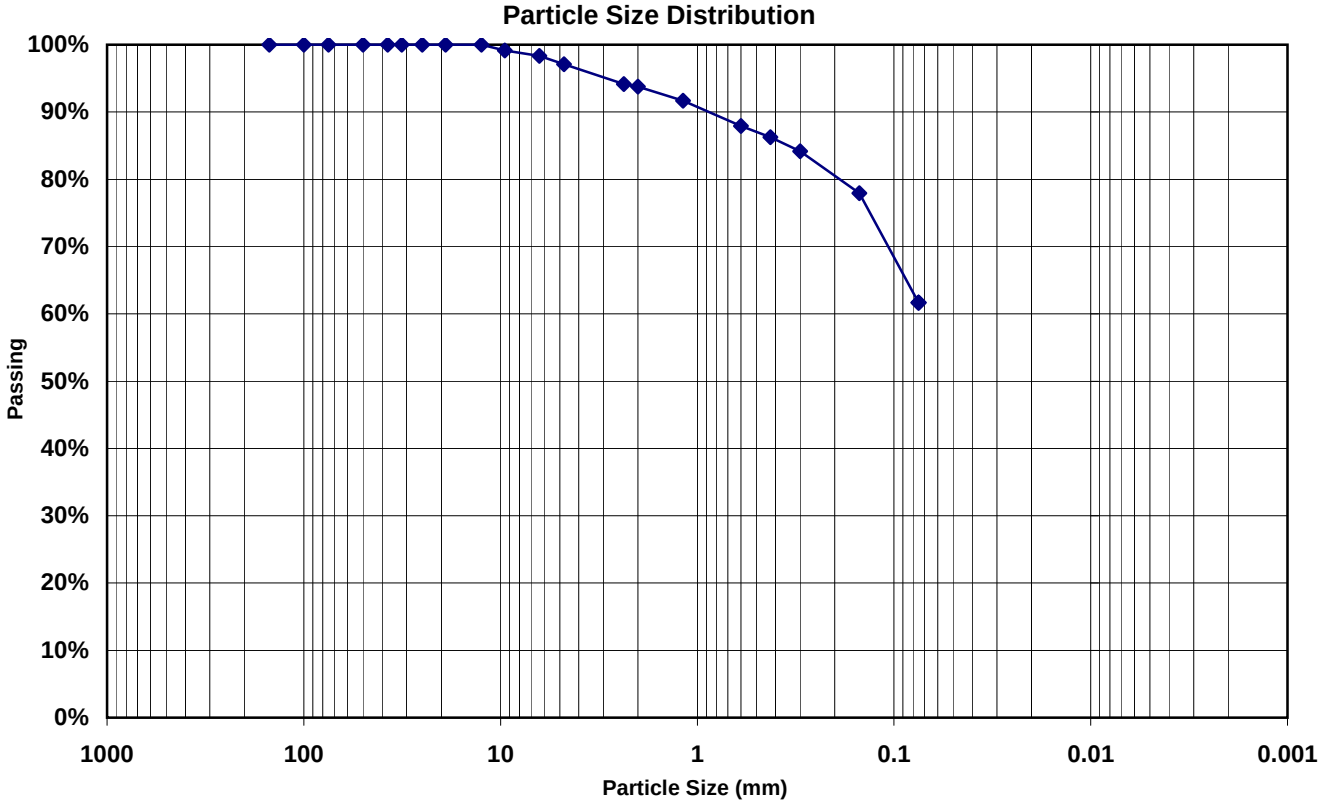
RUBY WASH DIVERSION LEVEE
STA 165+00 to 381+50

CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 10/30/08

93212(1.6w): 08706-9

APPENDIX
B.9



Cobbles	Gravel		Sand			Fines
	COARSE	FINE	COARSE	MEDIUM	FINE	
0.0%	**0.0%**	**2.9%**	**3.3%**	**7.5%**	**24.6%**	**61.7%**

SAMPLE SOURCE: **B-12 @ 6'**

ATTERBERG LIMITS
LL: 21
PL: 15
PI: 6

USCS: CL-ML
Silty clay

AASHTO: A-4(1)
Silty soils

PARTICLE SIZE	% FINER
6"	100
4"	100
3"	100
2"	100
1½"	100
1¼"	100
1"	100
3/4"	100
1/2"	100
3/8"	99
1/4"	98
#4	97
#8	94
#10	94
#16	92
#30	88
#40	86
#50	84
#100	78
#200	62

Results include summarized reporting of ASTM D2487

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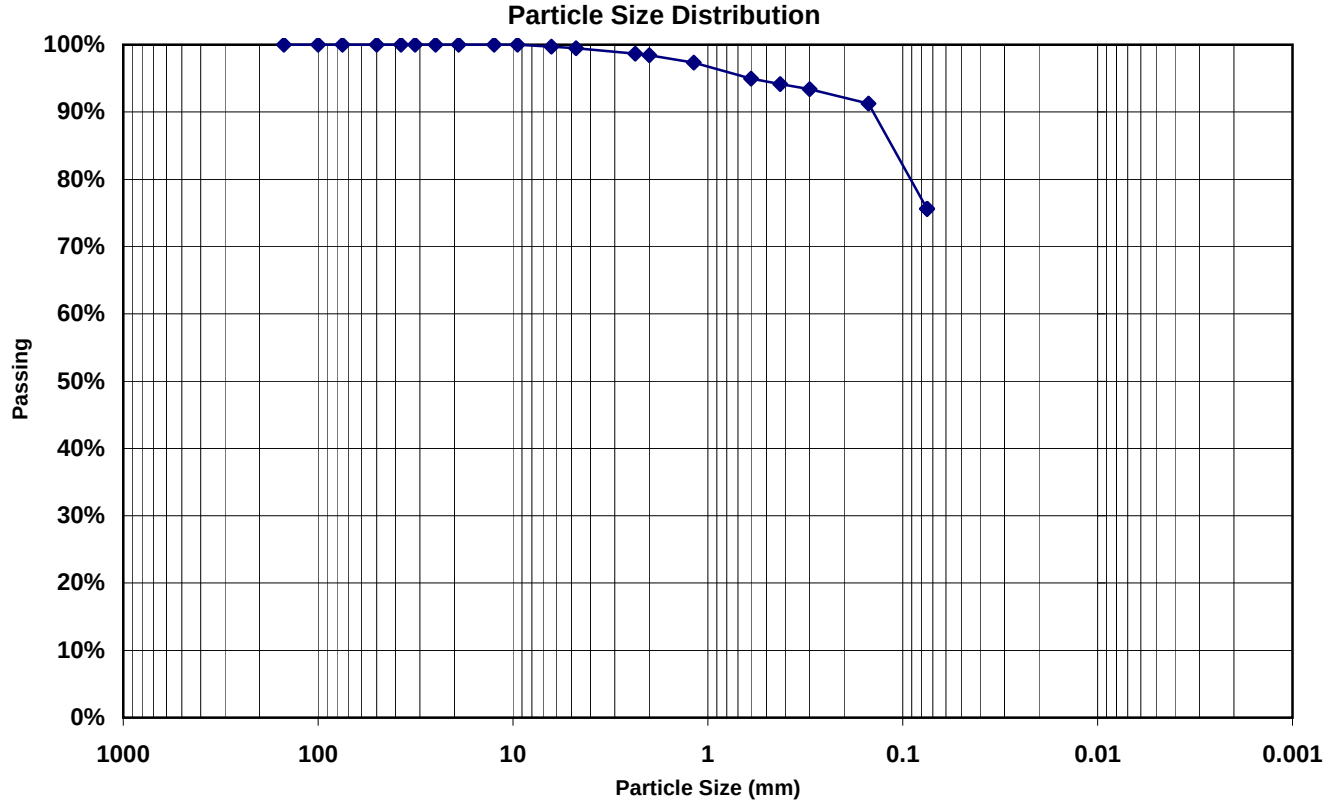
RUBY WASH DIVERSION LEVEE
STA 165+00 to 381+50

CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 10/30/08
93212(1.6w): 08706-10

APPENDIX
B.10



Cobbles	Gravel		Sand			Fines
	COARSE	FINE	COARSE	MEDIUM	FINE	
0.0%	0.0%	0.5%	1.1%	4.2%	18.6%	75.6%

SAMPLE SOURCE: **B-12 @ 10'**

ATTERBERG LIMITS
LL: 25
PL: 19
PI: 6

USCS: CL-ML
Silty clay

AASHTO: A-4(3)
Silty soils

PARTICLE SIZE	% FINER
6"	100
4"	100
3"	100
2"	100
1½"	100
1¼"	100
1"	100
3/4"	100
1/2"	100
3/8"	100
1/4"	100
#4	99
#8	99
#10	98
#16	97
#30	95
#40	94
#50	93
#100	91
#200	76

Results include summarized reporting of ASTM D2487

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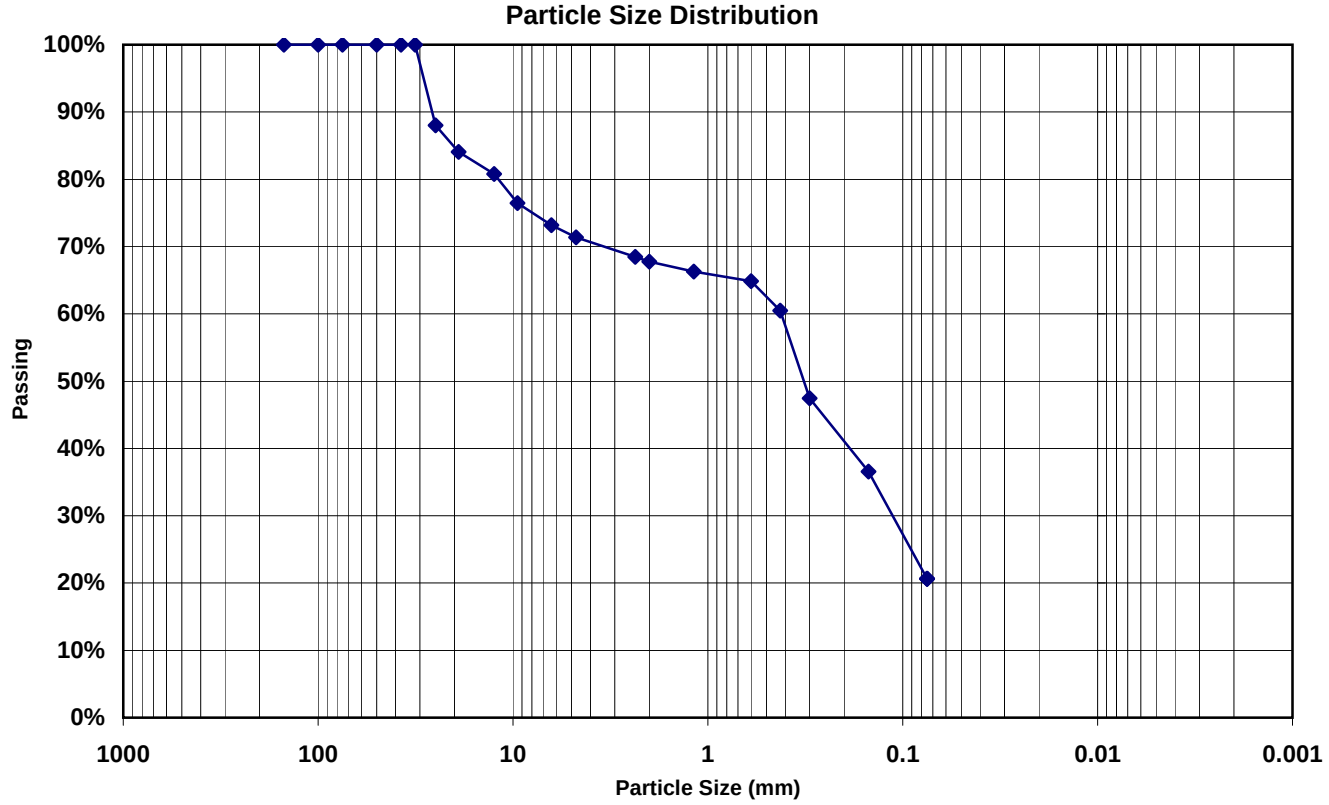
RUBY WASH DIVERSION LEVEE
STA 165+00 to 381+50

CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 10/30/08
93212(1.6w): 08706-11

APPENDIX
B.11



Cobbles	Gravel		Sand			Fines
	COARSE	FINE	COARSE	MEDIUM	FINE	
0.0%	**15.9%**	**12.7%**	**3.6%**	**7.2%**	**39.9%**	**20.6%**

SAMPLE SOURCE: **B-17 @ 3'**

ATTERBERG LIMITS
LL: NV
PL: NP
PI: NP

USCS: SC
Clayey sand with gravel

AASHTO: A-2-4(0)
Silty gravel and sand

PARTICLE SIZE	% FINER
6"	100
4"	100
3"	100
2"	100
1½"	100
1¼"	100
1"	88
3/4"	84
1/2"	81
3/8"	76
1/4"	73
#4	71
#8	68
#10	68
#16	66
#30	65
#40	60
#50	47
#100	37
#200	21

Results include summarized reporting of ASTM D2487

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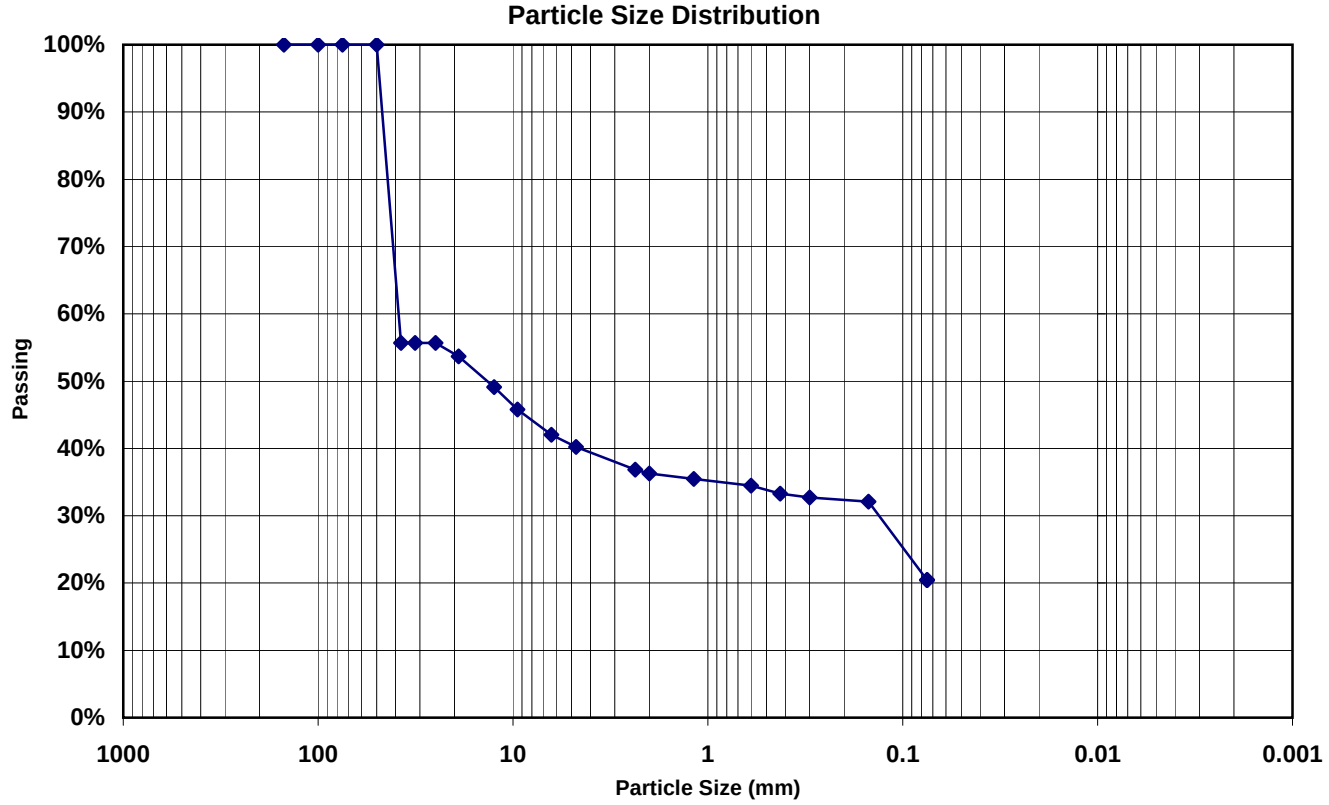
RUBY WASH DIVERSION LEVEE
STA 165+00 to 381+50

CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 10/30/08
93212(1.6w): 08706-12

APPENDIX
B.12



Cobbles	Gravel		Sand			Fines
	COARSE	FINE	COARSE	MEDIUM	FINE	
0.0%	**46.3%**	**13.5%**	**4.0%**	**3.0%**	**12.9%**	**20.4%**

SAMPLE SOURCE: **B-17 @ 19'**

ATTERBERG LIMITS
LL: NV
PL: NP
PI: NP

USCS: GC
Clayey gravel with sand

AASHTO: A-1-b(0)
Stone fragments, gravel and sand

NATURAL MOISTURE CONTENT: 3.30%
NATURAL DRY DENSITY: 124.8

PARTICLE SIZE	% FINER
6"	100
4"	100
3"	100
2"	100
1½"	56
1¼"	56
1"	56
3/4"	54
1/2"	49
3/8"	46
1/4"	42
#4	40
#8	37
#10	36
#16	35
#30	34
#40	33
#50	33
#100	32
#200	20

Results include summarized reporting of ASTM D2487, D2216, D2937

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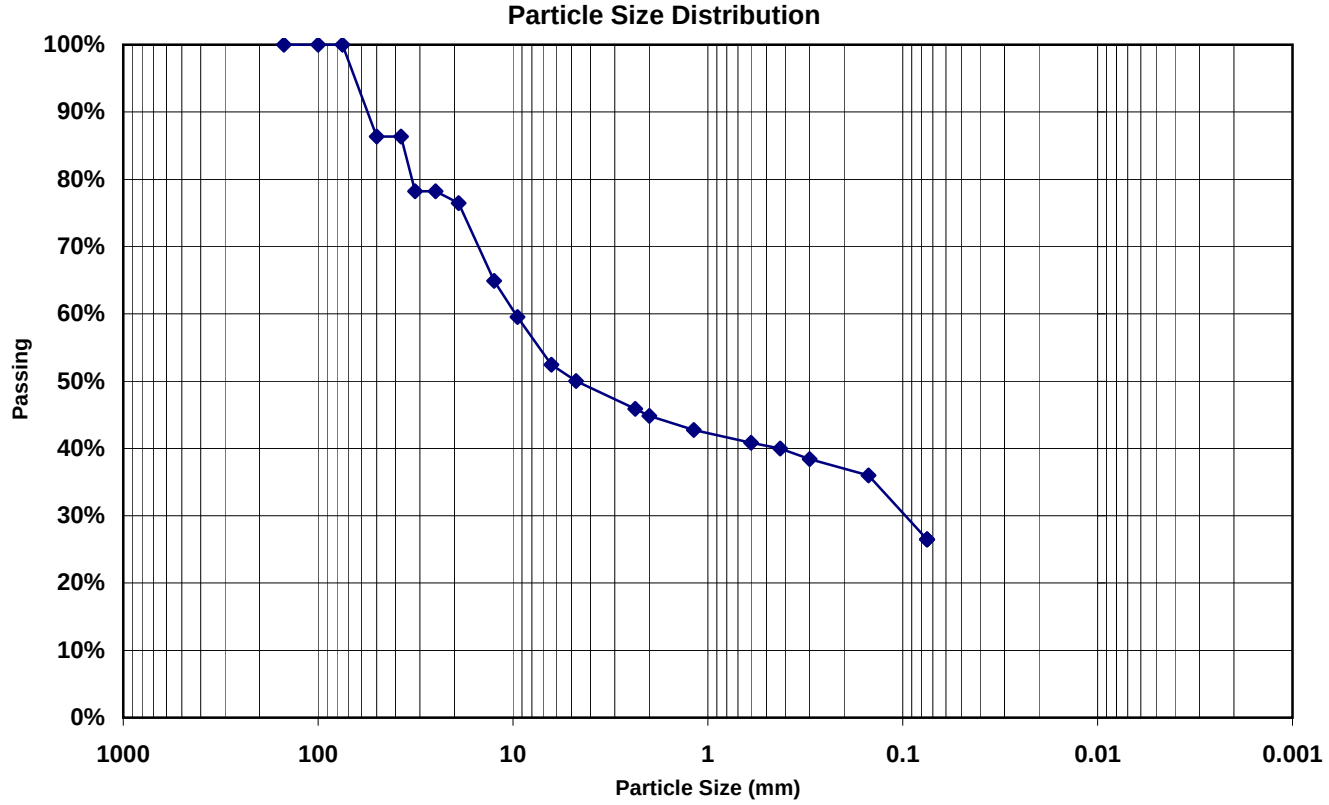
RUBY WASH DIVERSION LEVEE
STA 165+00 to 381+50

CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 10/30/08
93212(1.6w): 08706-13

APPENDIX
B.13



Cobbles	Gravel		Sand			Fines
	COARSE	FINE	COARSE	MEDIUM	FINE	
0.0%	23.5%	26.5%	5.2%	4.8%	13.5%	26.5%

SAMPLE SOURCE: **B-18 @ 1'**

ATTERBERG LIMITS
LL: 22
PL: 15
PI: 7

USCS: GC-GM
Silty, clayey gravel with sand

AASHTO: A-2-4(0)
Silty gravel and sand

PARTICLE SIZE	% FINER
6"	100
4"	100
3"	100
2"	86
1½"	86
1¼"	78
1"	78
3/4"	76
1/2"	65
3/8"	60
1/4"	52
#4	50
#8	46
#10	45
#16	43
#30	41
#40	40
#50	38
#100	36
#200	27

Results include summarized reporting of ASTM D2487

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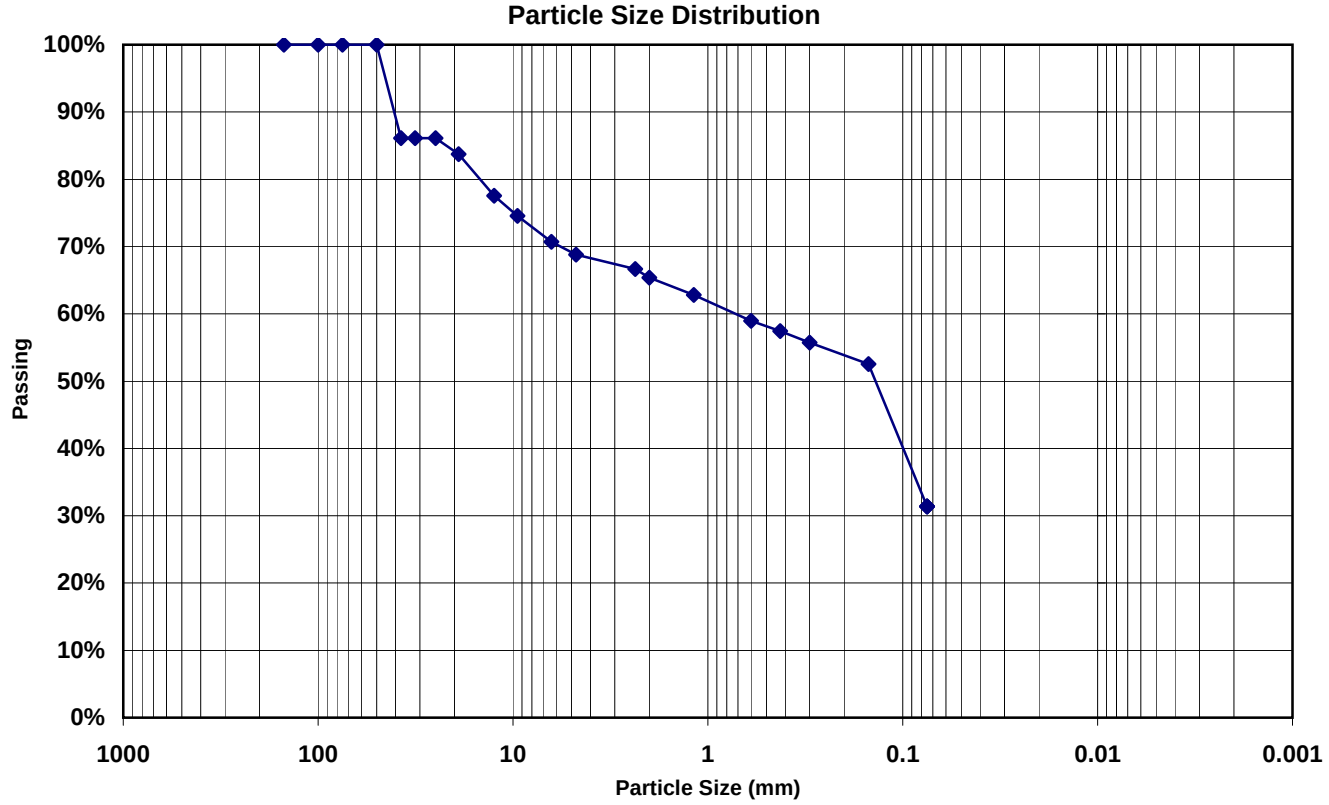
RUBY WASH DIVERSION LEVEE
STA 165+00 to 381+50

CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 10/30/08
93212(1.6w): 08706-14

APPENDIX
B.14



Cobbles	Gravel		Sand			Fines
	COARSE	FINE	COARSE	MEDIUM	FINE	
0.0%	16.2%	15.0%	3.4%	7.9%	26.1%	31.4%

SAMPLE SOURCE: **B-21 @ 10'**

ATTERBERG LIMITS
LL: 18
PL: NP
PI: NP

USCS: SC
Clayey sand with gravel

AASHTO: A-2-4(0)
Silty gravel and sand

NATURAL MOISTURE CONTENT: 3.20%
NATURAL DRY DENSITY: 118.6

PARTICLE SIZE	% FINER
6"	100
4"	100
3"	100
2"	100
1½"	86
1¼"	86
1"	86
3/4"	84
1/2"	78
3/8"	75
1/4"	71
#4	69
#8	67
#10	65
#16	63
#30	59
#40	57
#50	56
#100	53
#200	31

Results include summarized reporting of ASTM D2487, D2216, D2937

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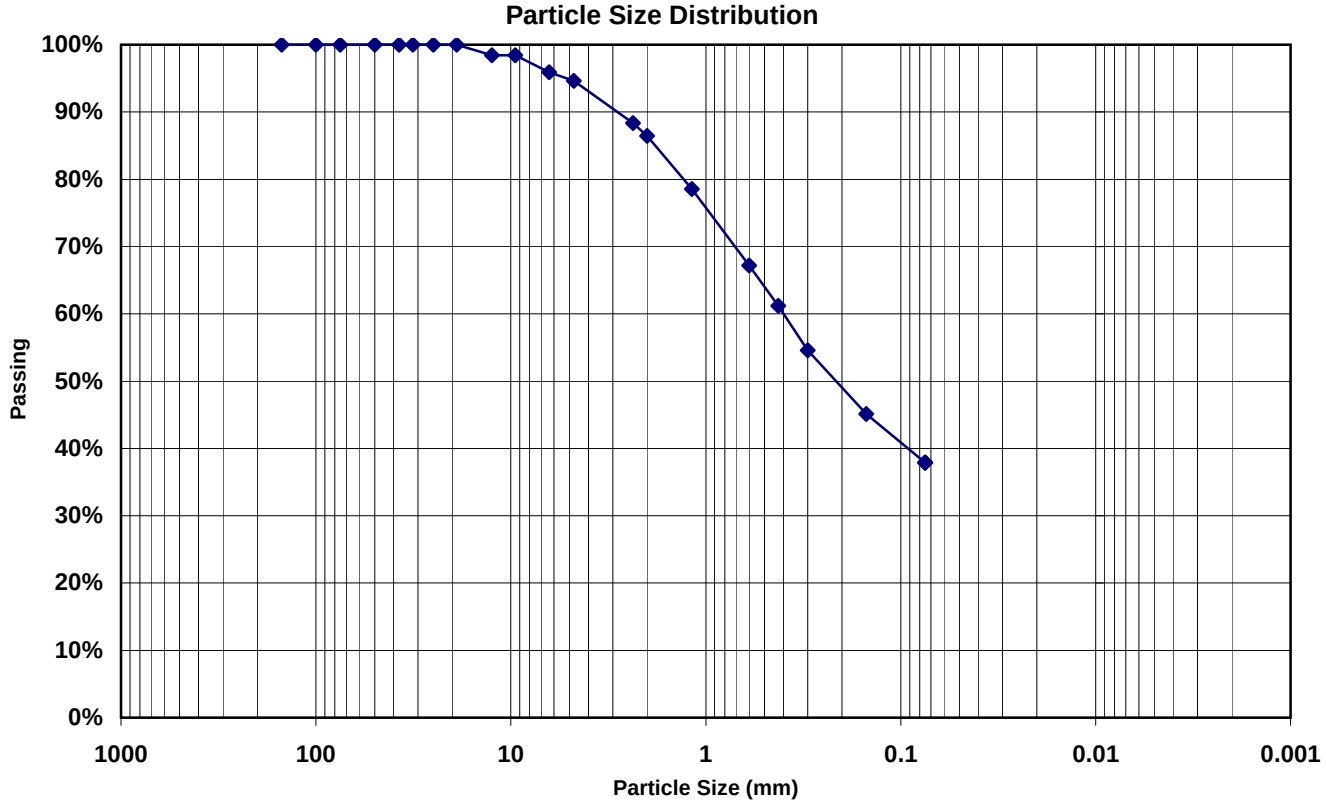
RUBY WASH DIVERSION LEVEE
STA 165+00 to 381+50

CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 10/30/08
93212(1.6w): 08706-15

APPENDIX
B.15



Cobbles	Gravel		Sand			Fines
	COARSE	FINE	COARSE	MEDIUM	FINE	
0.0%	**0.0%**	**5.4%**	**8.2%**	**25.2%**	**23.3%**	**37.9%**

SAMPLE SOURCE: **B-23 @ 11'**

ATTERBERG LIMITS
LL: NV
PL: NP
PI: NP

USCS: SC
Clayey sand

AASHTO: A-4(0)
Silty soils

NATURAL MOISTURE CONTENT: 1.29%
NATURAL DRY DENSITY: 85.4

PARTICLE SIZE	% FINER
6"	100
4"	100
3"	100
2"	100
1½"	100
1¼"	100
1"	100
3/4"	100
1/2"	98
3/8"	98
1/4"	96
#4	95
#8	88
#10	86
#16	79
#30	67
#40	61
#50	55
#100	45
#200	38

Results include summarized reporting of ASTM D2487, D2216, D2937

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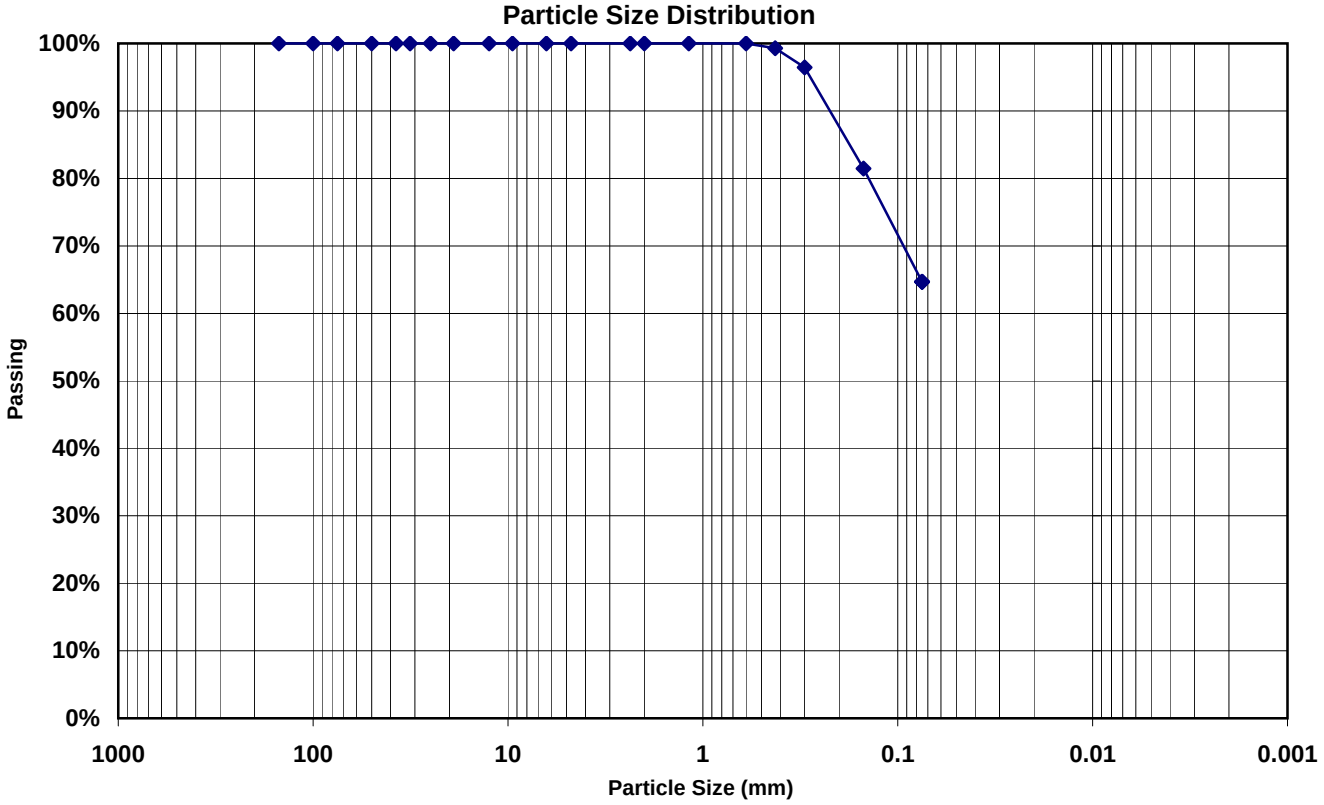
RUBY WASH DIVERSION LEVEE
STA 165+00 to 381+50

CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 10/30/08
93212(1.6w): 08706-16

APPENDIX
B.16



Cobbles	Gravel		Sand			Fines
	COARSE	FINE	COARSE	MEDIUM	FINE	
0.0%	**0.0%**	**0.0%**	**0.0%**	**0.7%**	**34.6%**	**64.7%**

SAMPLE SOURCE: **B-23 @ 6'**

ATTERBERG LIMITS
LL: 25
PL: 20
PI: 5

USCS: CL-ML
Silty clay

AASHTO: A-4(1)
Silty soils

PARTICLE SIZE	% FINER
6"	100
4"	100
3"	100
2"	100
1½"	100
1¼"	100
1"	100
3/4"	100
1/2"	100
3/8"	100
1/4"	100
#4	100
#8	100
#10	100
#16	100
#30	100
#40	99
#50	96
#100	81
#200	65

Results include summarized reporting of ASTM D2487

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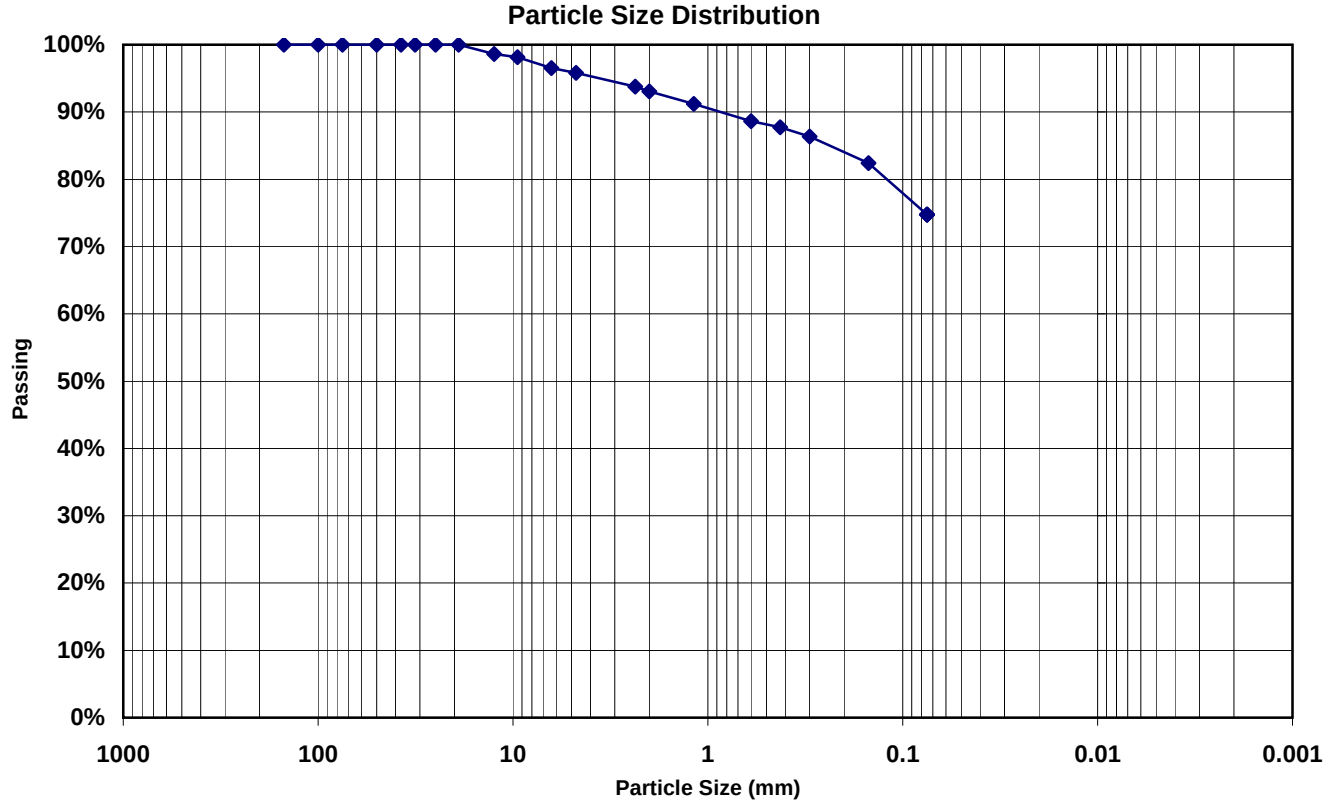
RUBY WASH DIVERSION LEVEE
STA 165+00 to 381+50

CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 10/30/08
93212(1.6w): 08706-17

APPENDIX
B.17



Cobbles	Gravel		Sand			Fines
	COARSE	FINE	COARSE	MEDIUM	FINE	
0.0%	**0.0%**	**4.2%**	**2.8%**	**5.3%**	**13.0%**	**74.8%**

SAMPLE SOURCE: **B-2 @ 5'**

ATTERBERG LIMITS
LL: 29
PL: 17
PI: 12

USCS: CL
Lean clay

AASHTO: A-6(7)
Clayey soils

NATURAL MOISTURE CONTENT: 4.61%
NATURAL DRY DENSITY: 112.4

PARTICLE SIZE	% FINER
6"	100
4"	100
3"	100
2"	100
1½"	100
1¼"	100
1"	100
3/4"	100
1/2"	99
3/8"	98
1/4"	97
#4	96
#8	94
#10	93
#16	91
#30	89
#40	88
#50	86
#100	82
#200	75

Results include summarized reporting of ASTM D2487, D2216, D2937

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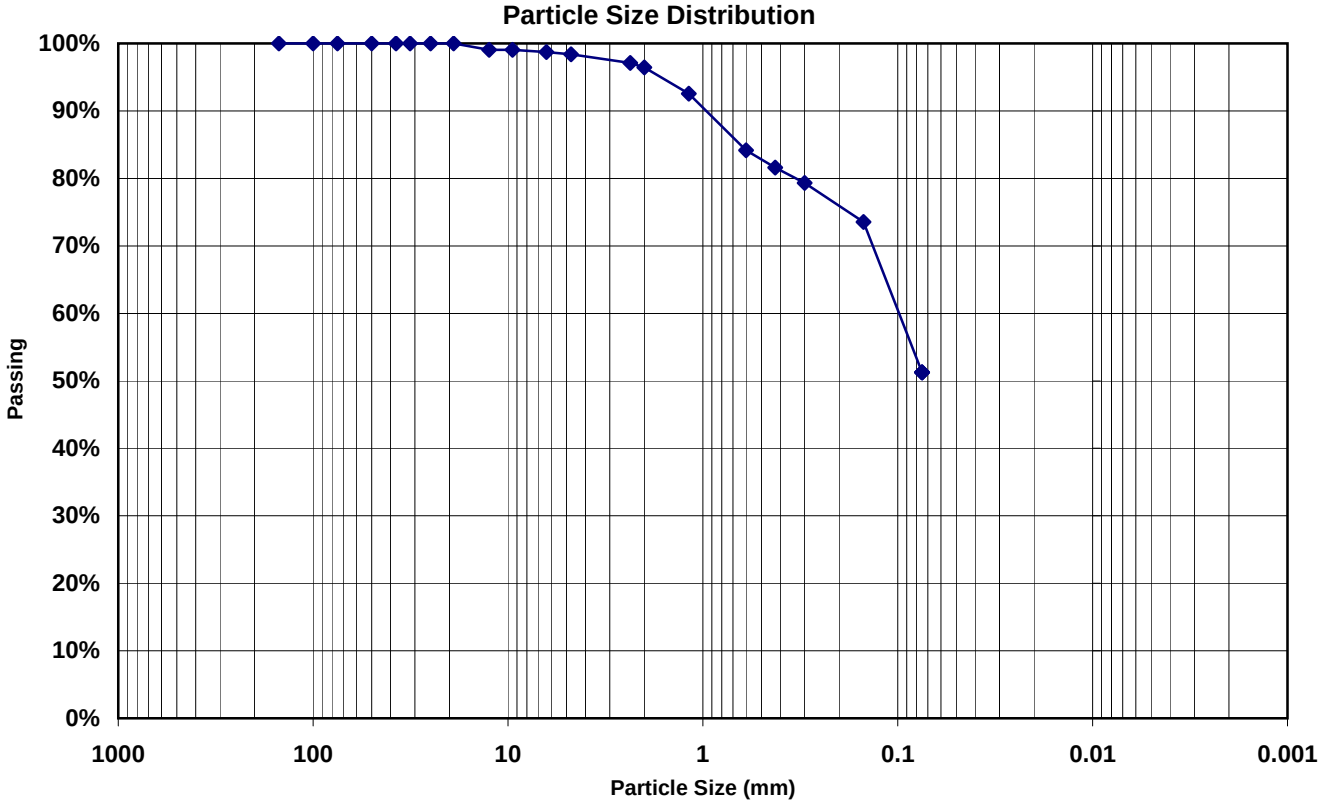
RUBY WASH DIVERSION LEVEE
STA 165+00 to 381+50

CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 10/30/08
93212(1.6w): 08706-18

APPENDIX
B.18



Cobbles	Gravel		Sand			Fines
	COARSE	FINE	COARSE	MEDIUM	FINE	
0.0%	**0.0%**	**1.6%**	**1.9%**	**14.9%**	**30.3%**	**51.3%**

SAMPLE SOURCE: **B-21 @ 21'**

ATTERBERG LIMITS
LL: 21
PL: 15
PI: 6

USCS: CL-ML
Silty clay

AASHTO: A-4(0)
Silty soils

PARTICLE SIZE	% FINER
6"	100
4"	100
3"	100
2"	100
1½"	100
1¼"	100
1"	100
3/4"	100
1/2"	99
3/8"	99
1/4"	99
#4	98
#8	97
#10	96
#16	93
#30	84
#40	82
#50	79
#100	74
#200	51

Results include summarized reporting of ASTM D2487

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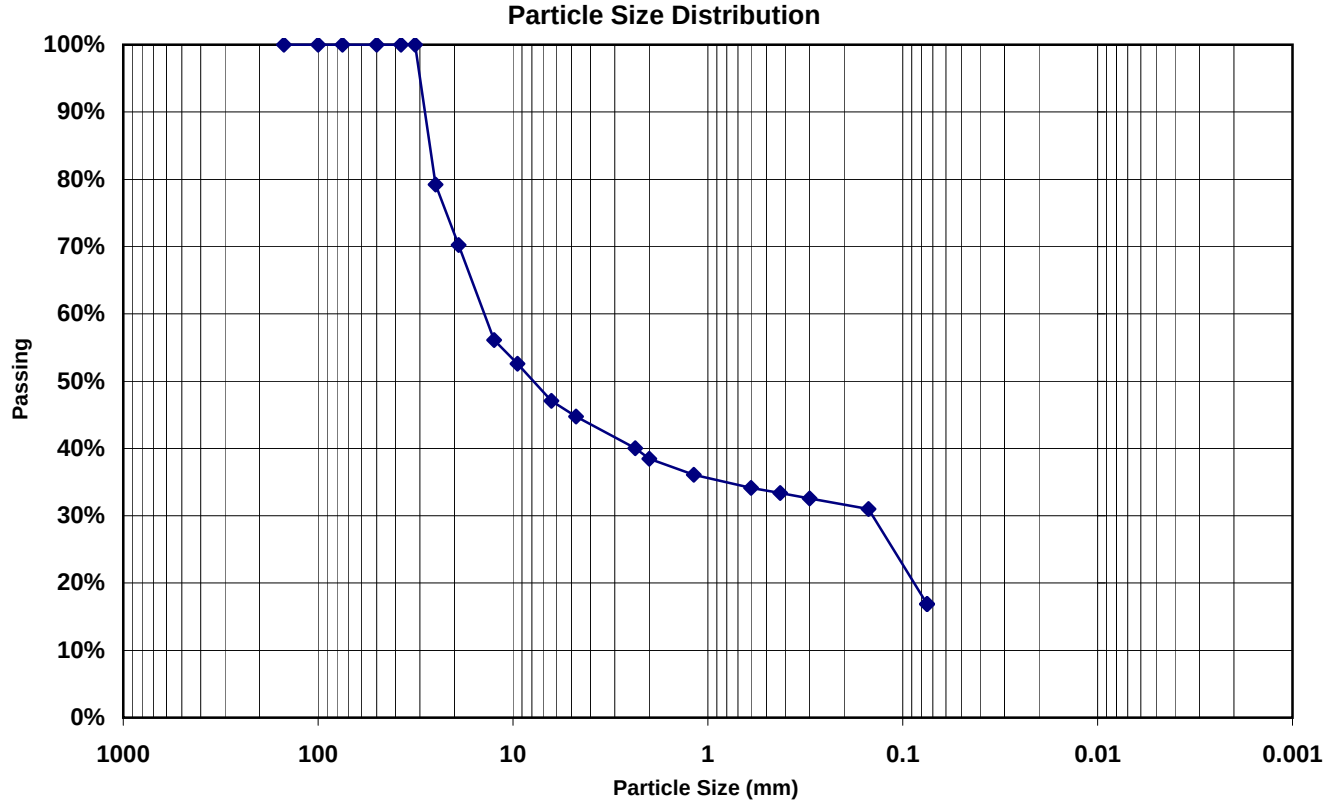
RUBY WASH DIVERSION LEVEE
STA 165+00 to 381+50

CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 10/30/08
93212(1.6w): 08706-19

APPENDIX
B.19



Cobbles	Gravel		Sand			Fines
	COARSE	FINE	COARSE	MEDIUM	FINE	
0.0%	**29.8%**	**25.5%**	**6.3%**	**5.1%**	**16.5%**	**16.9%**

SAMPLE SOURCE: **B-13 @ 9'**

ATTERBERG LIMITS
LL: NV
PL: NP
PI: NP

USCS: GC
Clayey gravel with sand

AASHTO: A-1-b(0)
Stone fragments, gravel and sand

NATURAL MOISTURE CONTENT: 0.78%

PARTICLE SIZE	% FINER
6"	100
4"	100
3"	100
2"	100
1½"	100
1¼"	100
1"	79
3/4"	70
1/2"	56
3/8"	53
1/4"	47
#4	45
#8	40
#10	38
#16	36
#30	34
#40	33
#50	33
#100	31
#200	17

Results include summarized reporting of ASTM D2487, D2216

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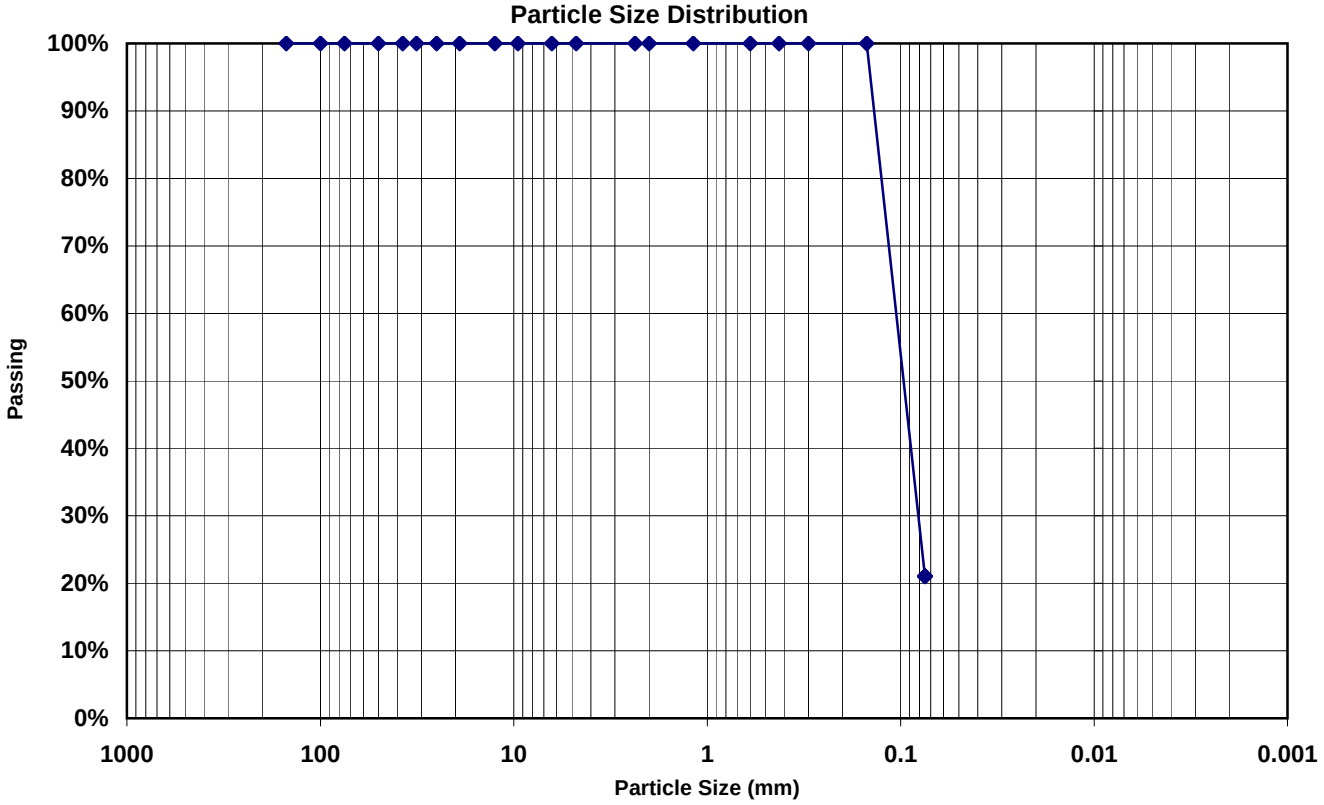
RUBY WASH DIVERSION LEVEE
STA 165+00 to 381+50

CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 10/30/08
93212(1.6w): 08706-20

APPENDIX
B.20



Retained on No. 200	Passing No. 200
78.9%	21.1%

SAMPLE SOURCE: **B-13 @ 20-21.5'**

ATTERBERG LIMITS
LL: 19
PL: 16
PI: 3

Results include summarized reporting of ASTM C117 & D4318

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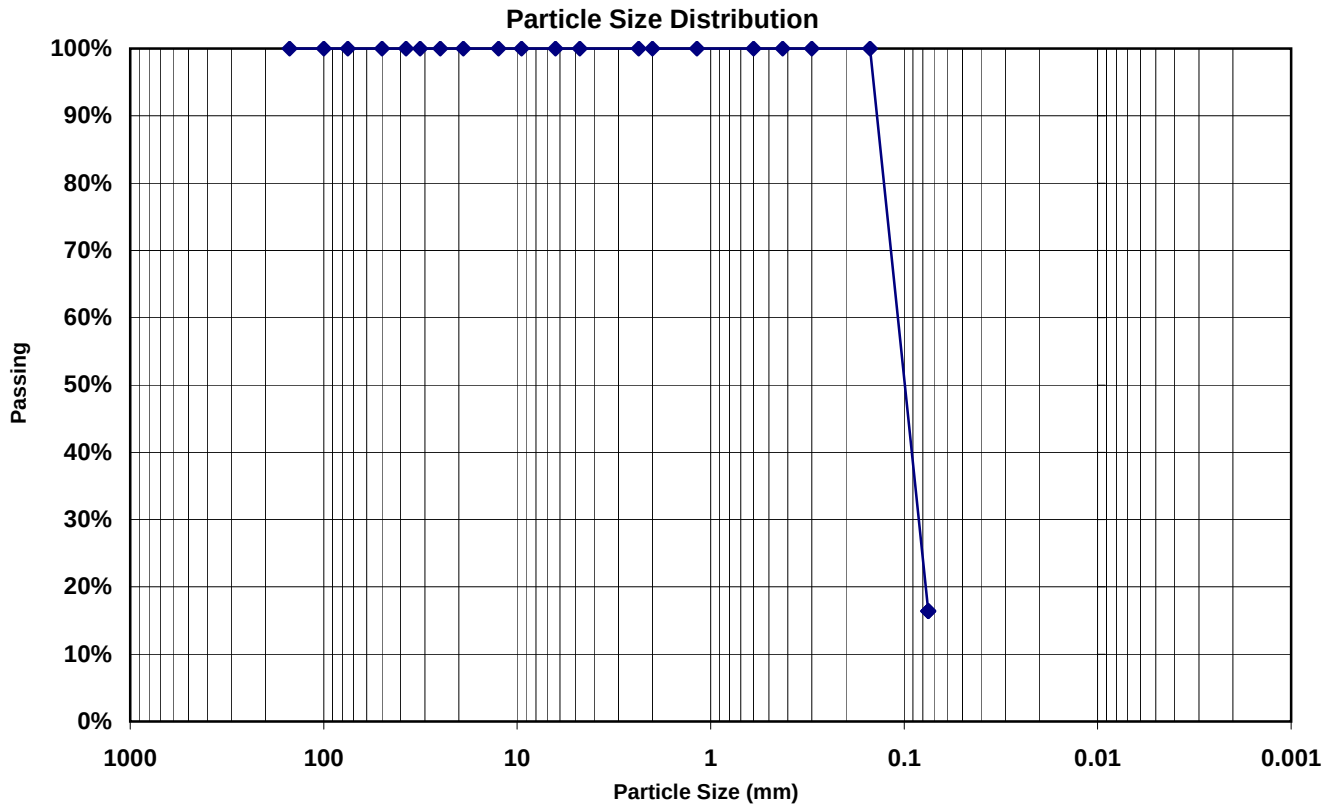
f| 480.763.1212

RUBY WASH DIVERSION LEVEE
STA 165+00 to 381+50

CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 10/30/08
93212(1.6w): 09144-1

APPENDIX
B.21



Retained on No. 200	Passing No. 200
83.6%	16.4%

SAMPLE SOURCE: **B-13 @ 15-16.5'**

ATTERBERG LIMITS
LL: NV
PL: NP
PI: NP

Results include summarized reporting of ASTM C117 & D4318

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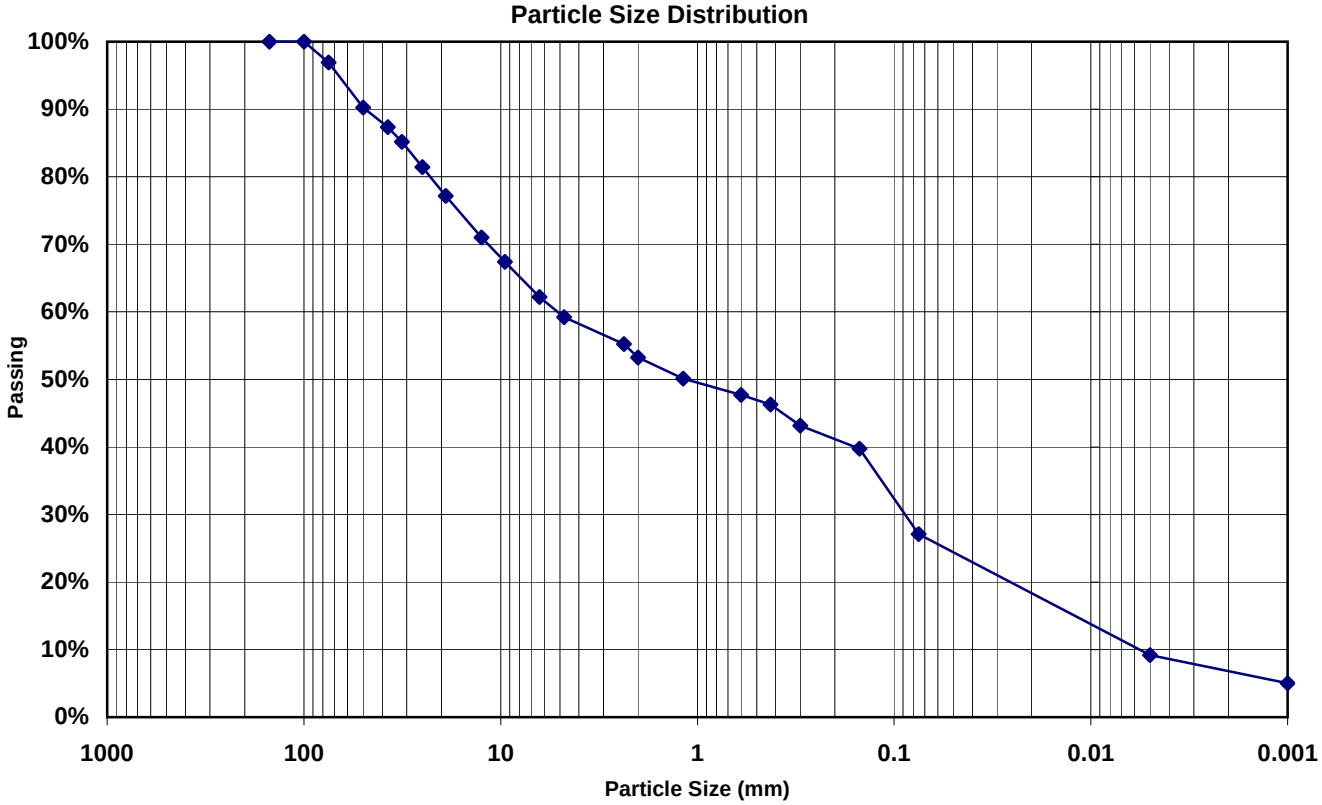
STA 165+00 to 381+50

CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 10/30/08
93212(1.6w): 09144-2

APPENDIX
B.22



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
3.1%	**19.8%**	**18.0%**	**6.0%**	**7.0%**	**19.1%**	**17.9%**	**9.2%**

SAMPLE SOURCE: **SB-1 @ 2.5-5'**

ATTERBERG LIMITS
LL: 16
PL: 14
PI: 2

USCS: GM
Silty gravel with sand

AASHTO: A-2-4(0)
Silty gravel and sand

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	97	
2"	90	
1½"	87	
1¼"	85	
1"	81	
3/4"	77	
1/2"	71	
3/8"	67	
1/4"	62	
#4	59	
#8	55	
#10	53	
#16	50	
#30	48	
#40	46	
#50	43	
#100	40	
#200	27	
0.005 mm	9.2	
0.001 mm	5.0	(colloids)

Results include summarized reporting of ASTM D2487& D422

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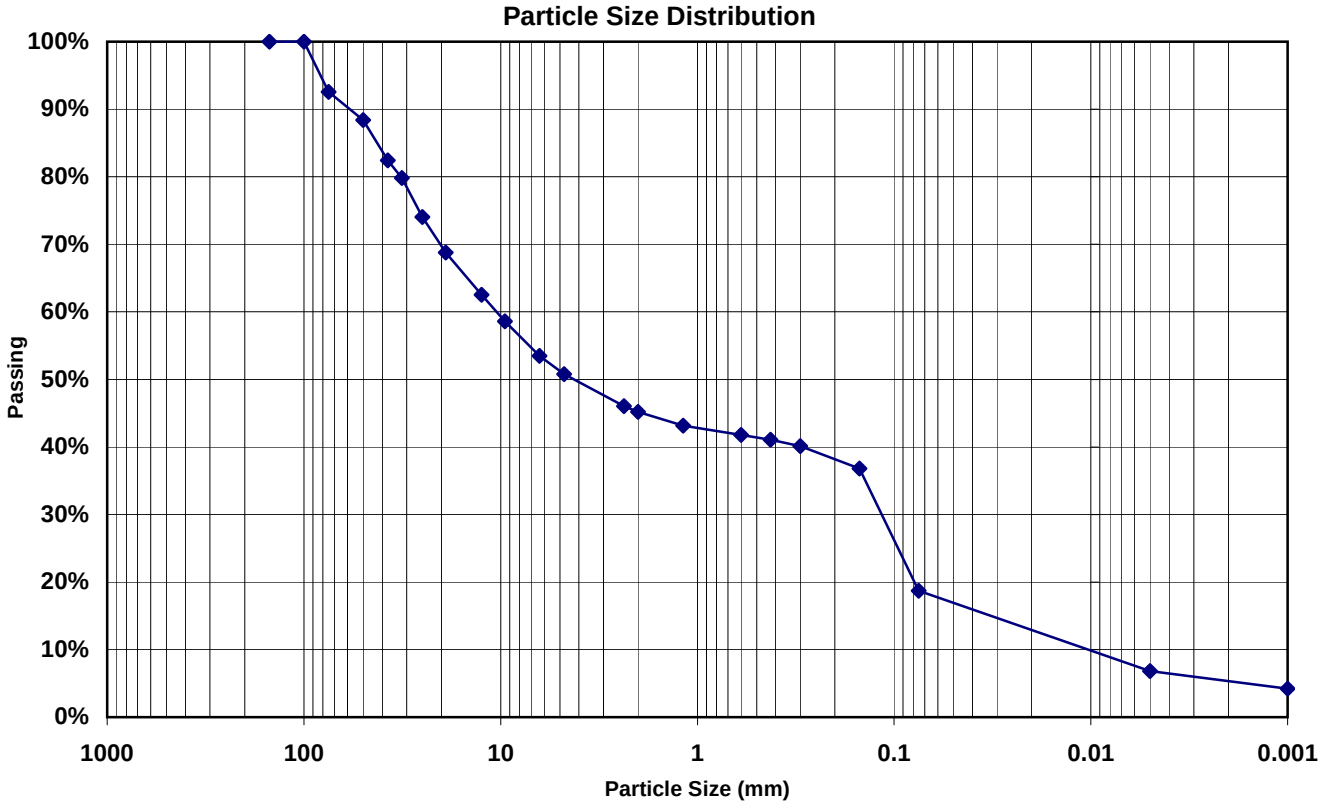
RUBY WASH DIVERSION LEVEE
STA 165+00 to 381+50

CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 04/01/09

93212(2.2w): 09113-2

APPENDIX
B.23



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
7.5%	**23.8%**	**18.0%**	**5.6%**	**4.1%**	**22.4%**	**11.9%**	**6.8%**

SAMPLE SOURCE: **SB-1 @ 5-7.5'**

ATTERBERG LIMITS
LL: NV
PL: NP
PI: NP

USCS: GM
Silty gravel with sand

AASHTO: A-1-b(0)
Stone fragments, gravel and sand

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	93	
2"	88	
1½"	82	
1¼"	80	
1"	74	
3/4"	69	
1/2"	63	
3/8"	59	
1/4"	53	
#4	51	
#8	46	
#10	45	
#16	43	
#30	42	
#40	41	
#50	40	
#100	37	
#200	19	
0.005 mm	6.8	
0.001 mm	4.2	(colloids)

Results include summarized reporting of ASTM D2487& D422

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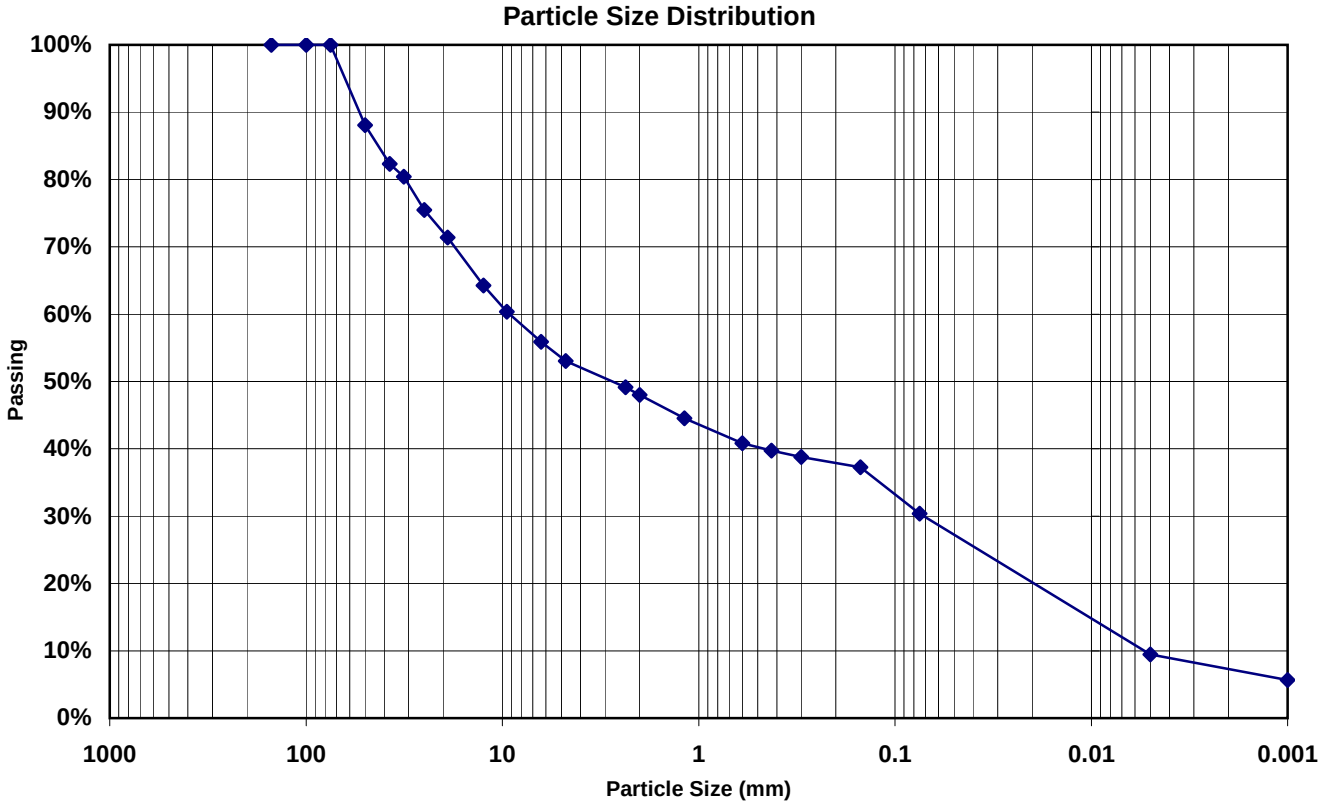
STA 165+00 to 381+50

CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 04/01/09

93212(2.2w): 09113-3

APPENDIX
B.24



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
0.0%	**28.6%**	**18.3%**	**5.0%**	**8.3%**	**9.3%**	**20.9%**	**9.5%**

SAMPLE SOURCE: **SB-1 @ 10-12.5'**

ATTERBERG LIMITS
LL: 20
PL: 16
PI: 4

USCS: GC-GM
Silty, clayey gravel with sand

AASHTO: A-2-4(0)
Silty gravel and sand

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	100	
2"	88	
1½"	82	
1¼"	80	
1"	75	
3/4"	71	
1/2"	64	
3/8"	60	
1/4"	56	
#4	53	
#8	49	
#10	48	
#16	45	
#30	41	
#40	40	
#50	39	
#100	37	
#200	30	
0.005 mm	9.5	
0.001 mm	5.7	(colloids)

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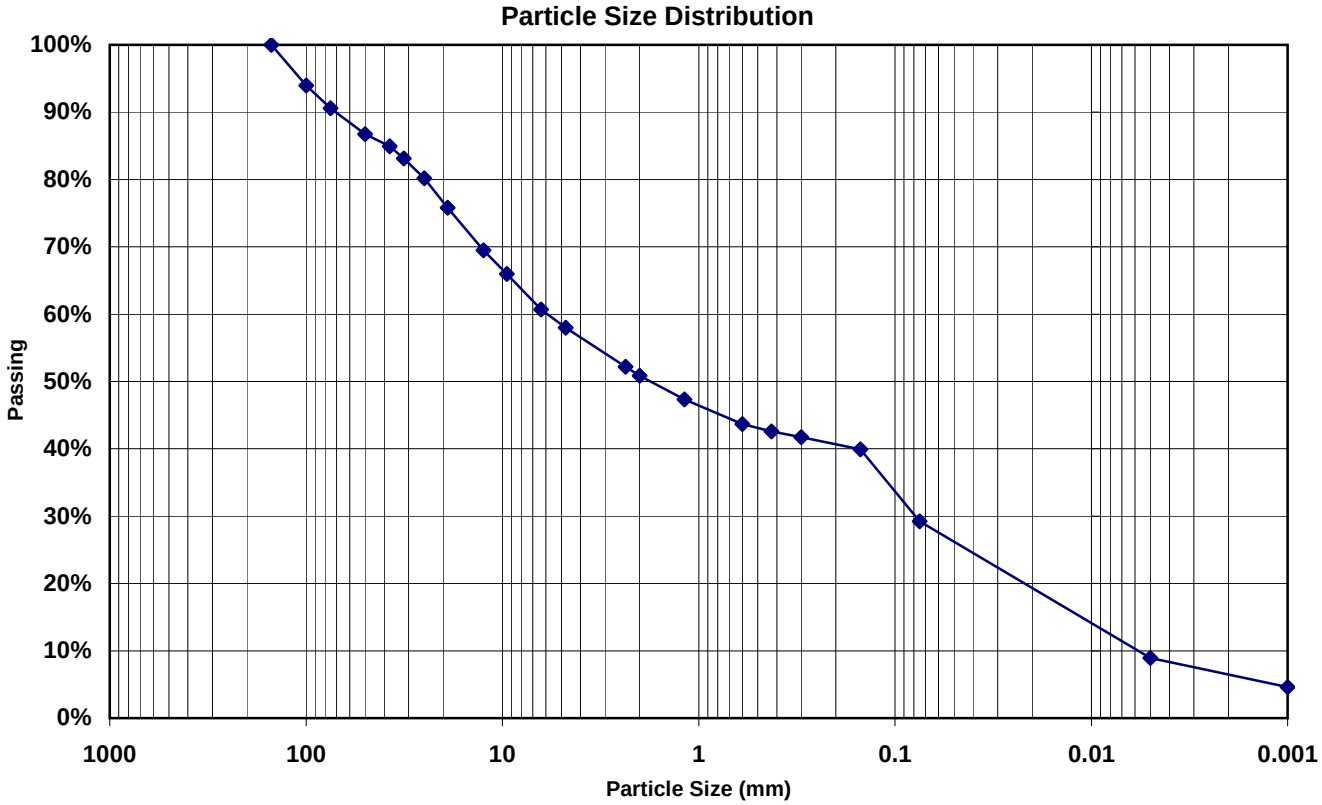
CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 04/01/09

93212(2.2w): 09113-5

APPENDIX
B.25



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
9.4%	**14.8%**	**17.8%**	**7.1%**	**8.3%**	**13.3%**	**20.3%**	**8.9%**

SAMPLE SOURCE: **SB-1 @ 15-17.5'**

ATTERBERG LIMITS
LL: 19
PL: 14
PI: 5

USCS: GC-GM
Silty, clayey gravel with sand

AASHTO: A-2-4(0)
Silty gravel and sand

PARTICLE SIZE	% FINER	
6"	100	
4"	94	
3"	91	
2"	87	
1½"	85	
1¼"	83	
1"	80	
3/4"	76	
1/2"	69	
3/8"	66	
1/4"	61	
#4	58	
#8	52	
#10	51	
#16	47	
#30	44	
#40	43	
#50	42	
#100	40	
#200	29	
0.005 mm	8.9	
0.001 mm	4.6	(colloids)

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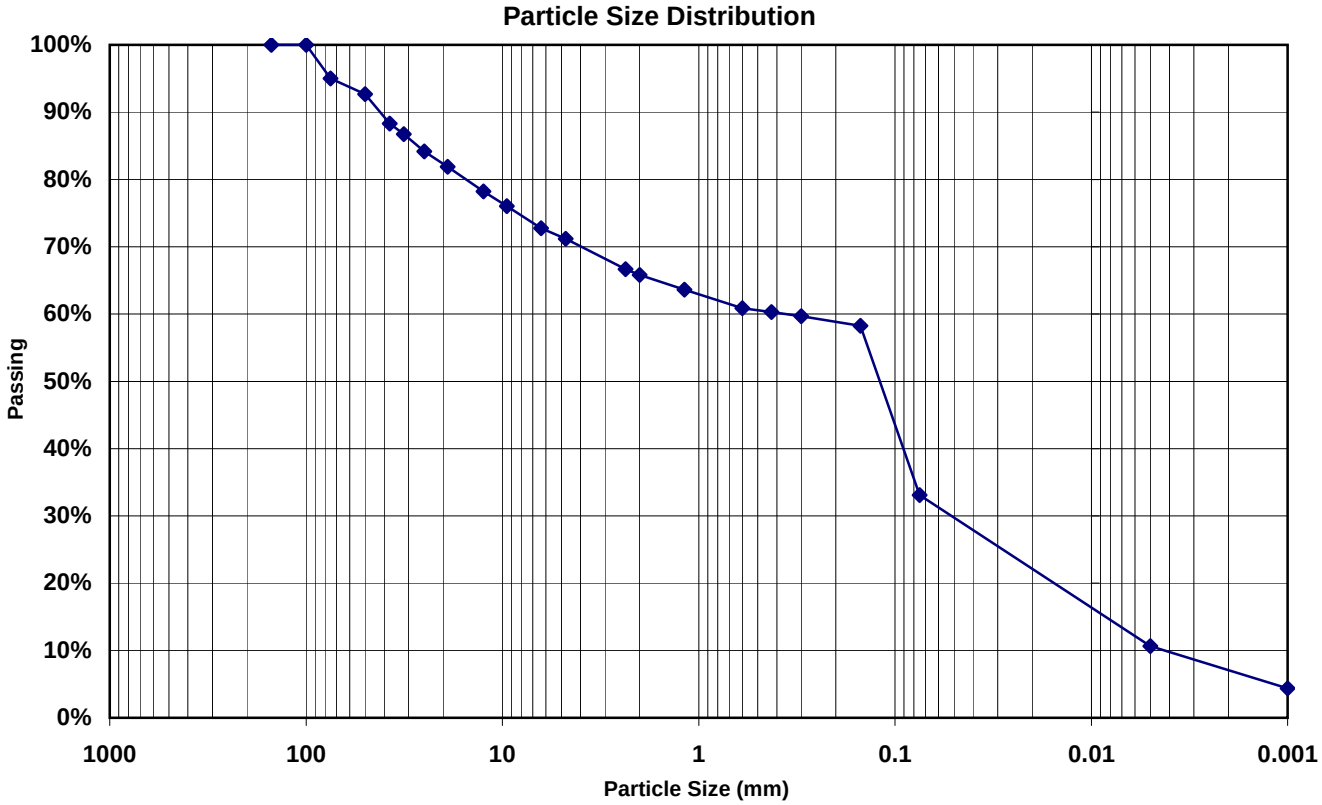
CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 04/01/09

93212(2.2w): 09113-7

APPENDIX
B.26



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
5.0%	**13.2%**	**10.7%**	**5.4%**	**5.5%**	**27.2%**	**22.5%**	**10.6%**

SAMPLE SOURCE: **SB-1 @ 17.5-20'**

ATTERBERG LIMITS
LL: 17
PL: 14
PI: 3

USCS: SM
Silty sand with gravel

AASHTO: A-2-4(0)
Silty gravel and sand

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	95	
2"	93	
1½"	88	
1¼"	87	
1"	84	
3/4"	82	
1/2"	78	
3/8"	76	
1/4"	73	
#4	71	
#8	67	
#10	66	
#16	64	
#30	61	
#40	60	
#50	60	
#100	58	
#200	33	
0.005 mm	10.6	
0.001 mm	4.4	(colloids)

Results include summarized reporting of ASTM D2487& D422

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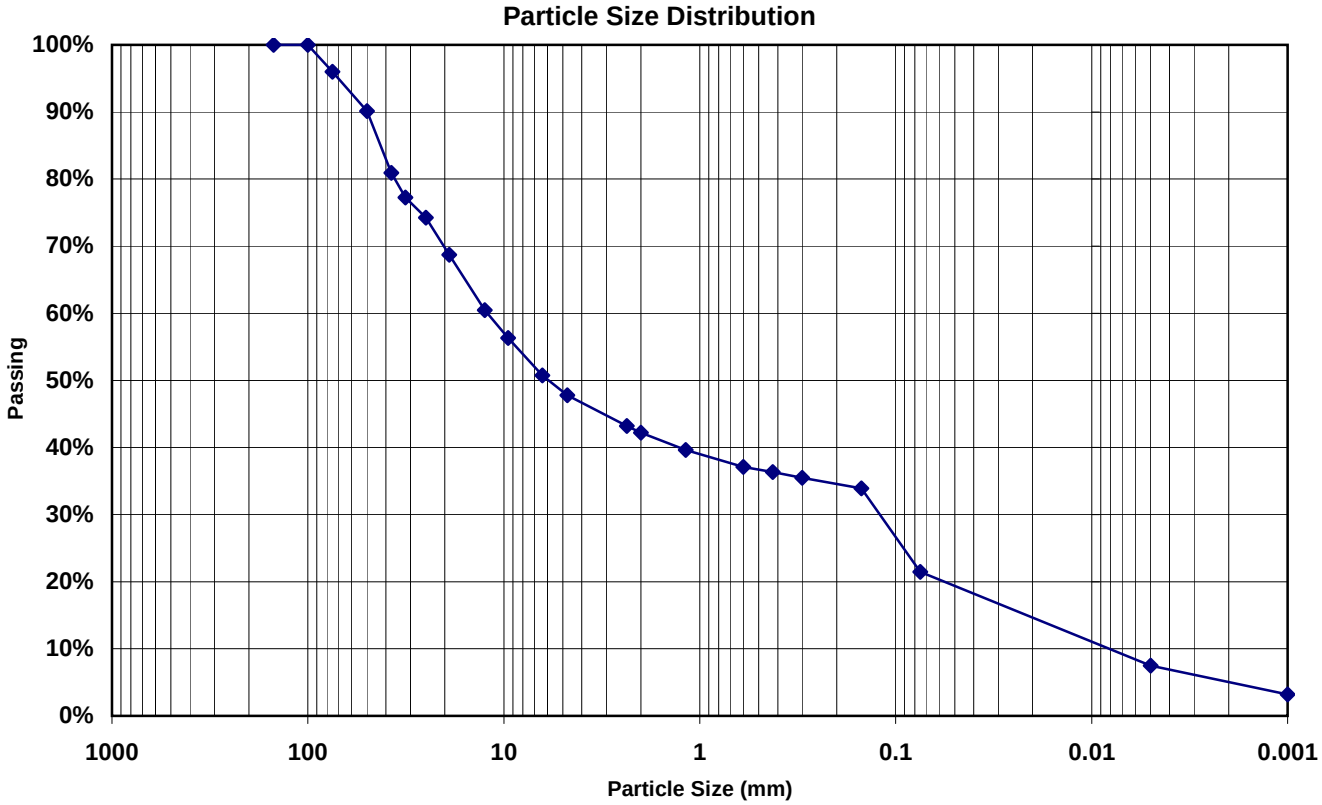
CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 04/01/09

93212(2.2w): 09113-8

APPENDIX
B.27



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
4.0%	**27.3%**	**21.0%**	**5.6%**	**5.9%**	**14.9%**	**14.0%**	**7.5%**

SAMPLE SOURCE: **SB-1 @ 21-22.5'**

ATTERBERG LIMITS
LL: 16
PL: 9
PI: 7

USCS: GC-GM
Silty, clayey gravel with sand

AASHTO: A-2-4(0)
Silty gravel and sand

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	96	
2"	90	
1½"	81	
1¼"	77	
1"	74	
3/4"	69	
1/2"	60	
3/8"	56	
1/4"	51	
#4	48	
#8	43	
#10	42	
#16	40	
#30	37	
#40	36	
#50	35	
#100	34	
#200	21	
0.005 mm	7.5	
0.001 mm	3.2	(colloids)

Results include summarized reporting of ASTM D2487& D422

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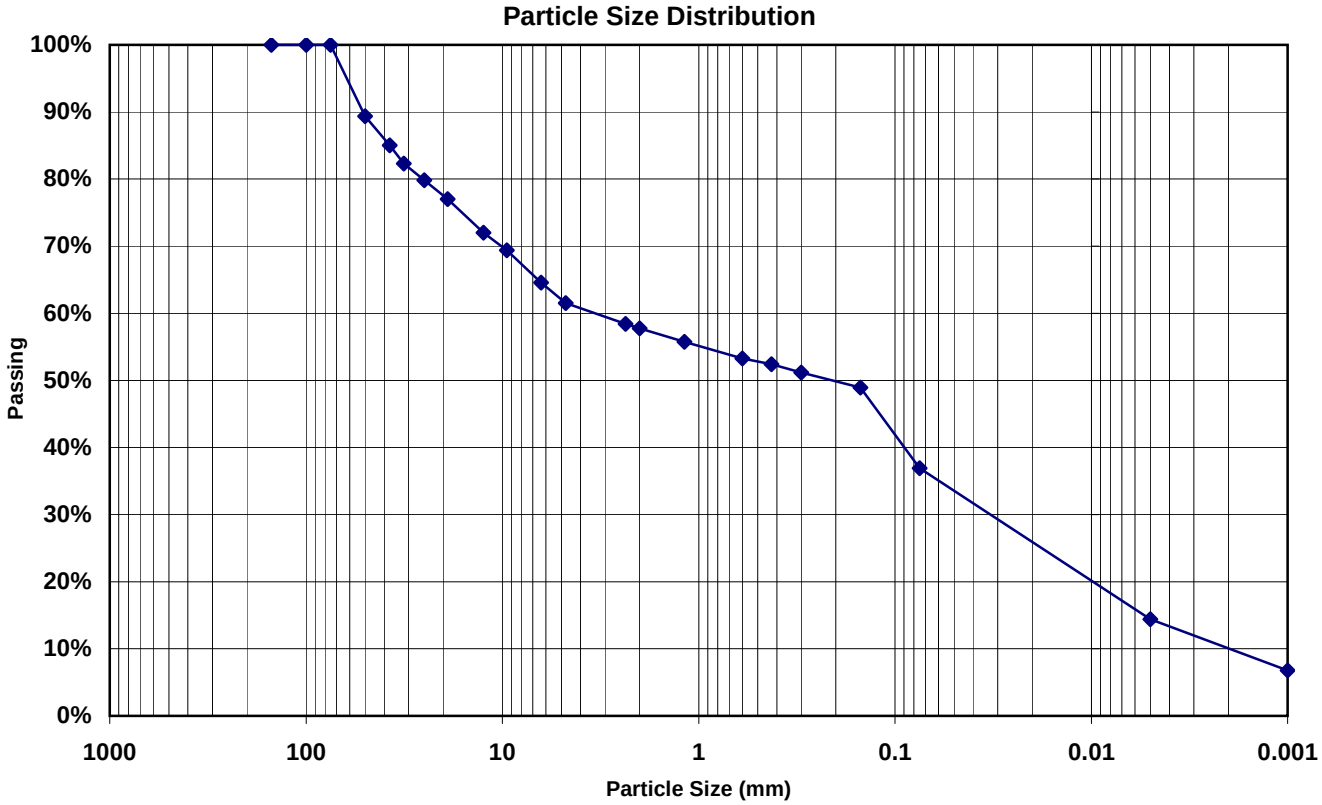
CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 04/01/09
93212(2.2w): 09113-10

APPENDIX
B.28



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
0.0%	**23.0%**	**15.5%**	**3.8%**	**5.4%**	**15.5%**	**22.5%**	**14.4%**

SAMPLE SOURCE: **SB-1 @ 22.5-24'**

ATTERBERG LIMITS
LL: 18
PL: 15
PI: 3

USCS: GM
Silty gravel with sand

AASHTO: A-4(0)
Silty soils

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	100	
2"	89	
1½"	85	
1¼"	82	
1"	80	
3/4"	77	
1/2"	72	
3/8"	69	
1/4"	65	
#4	62	
#8	58	
#10	58	
#16	56	
#30	53	
#40	52	
#50	51	
#100	49	
#200	37	
0.005 mm	14.4	
0.001 mm	6.8	(colloids)

Results include summarized reporting of ASTM D2487& D422

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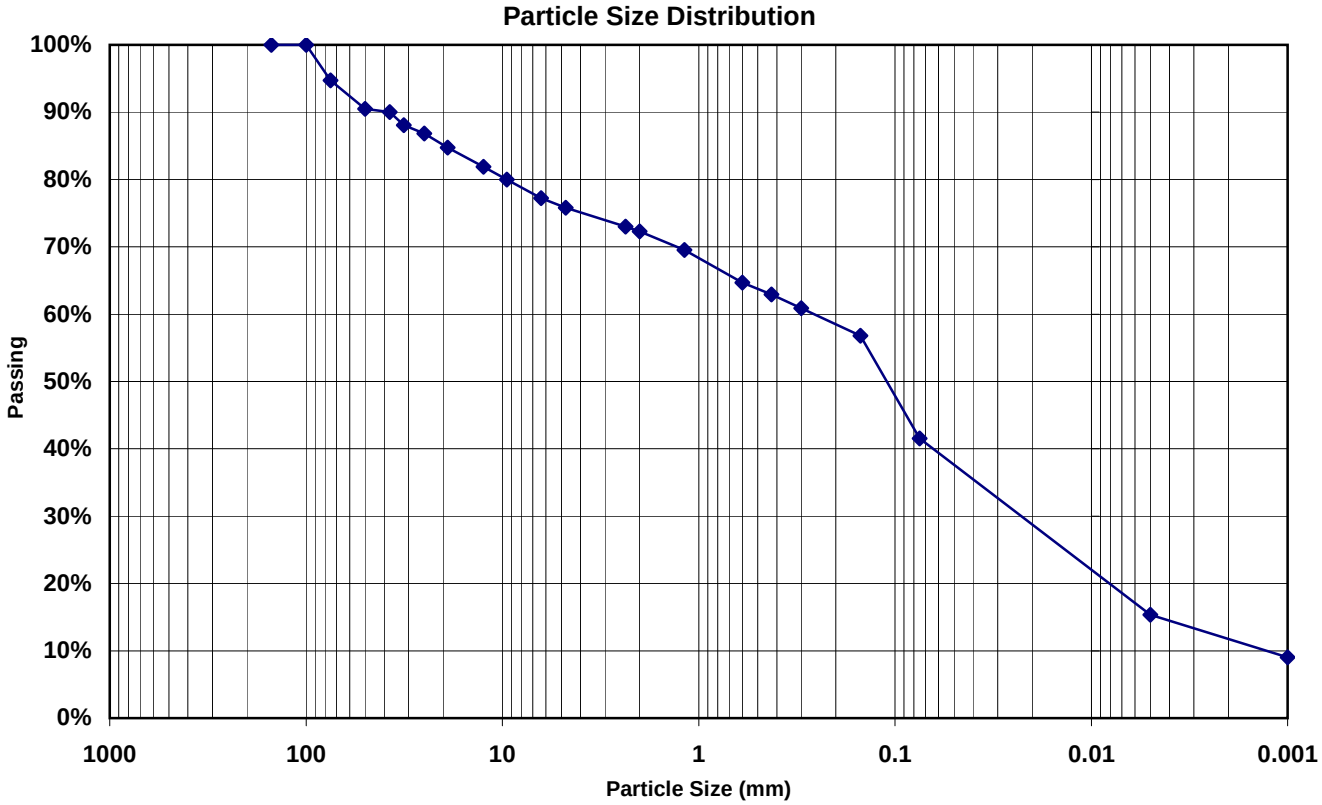
RUBY WASH DIVERSION LEVEE
STA 165+00 to 381+50

CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 04/01/09
93212(2.2w): 09113-11

APPENDIX
B.29



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
5.3%	**10.0%**	**9.0%**	**3.5%**	**9.4%**	**21.4%**	**26.2%**	**15.4%**

SAMPLE SOURCE: **SB-1 @ 24-25.5'**

ATTERBERG LIMITS
LL: 17
PL: 15
PI: 2

USCS: SM
Silty sand with gravel

AASHTO: A-4(0)
Silty soils

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	95	
2"	91	
1½"	90	
1¼"	88	
1"	87	
3/4"	85	
1/2"	82	
3/8"	80	
1/4"	77	
#4	76	
#8	73	
#10	72	
#16	70	
#30	65	
#40	63	
#50	61	
#100	57	
#200	42	
0.005 mm	15.4	
0.001 mm	9.0	(colloids)

Results include summarized reporting of ASTM D2487& D422

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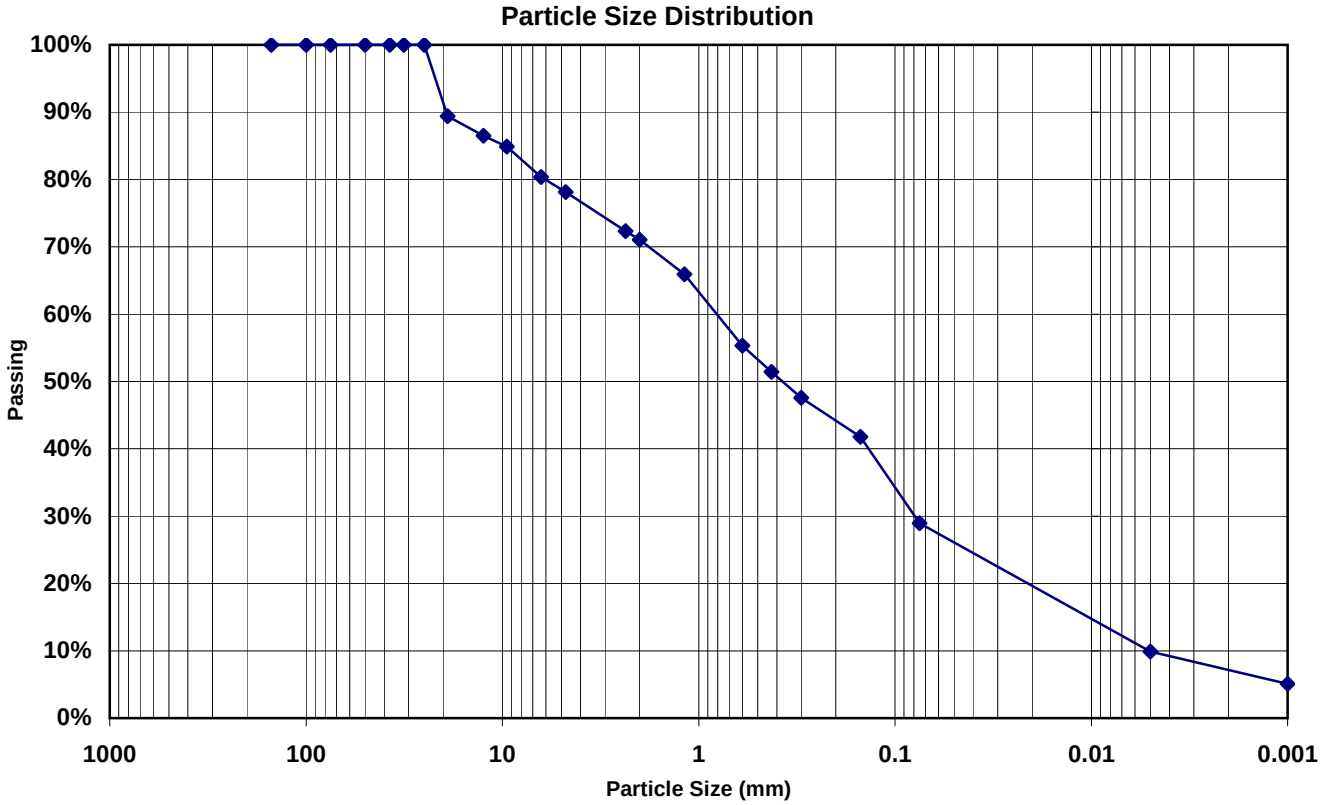
CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 04/01/09
93212(2.2w): 09113-12

APPENDIX
B.30



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
0.0%	**10.6%**	**11.3%**	**7.1%**	**19.6%**	**22.5%**	**19.1%**	**9.9%**

SAMPLE SOURCE: **SB-1 @ 25.5-26'**

ATTERBERG LIMITS
LL: 18
PL: NP
PI: NP

USCS: SM
Silty sand with gravel

AASHTO: A-2-4(0)
Silty gravel and sand

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	100	
2"	100	
1½"	100	
1¼"	100	
1"	100	
3/4"	89	
1/2"	86	
3/8"	85	
1/4"	80	
#4	78	
#8	72	
#10	71	
#16	66	
#30	55	
#40	51	
#50	48	
#100	42	
#200	29	
0.005 mm	9.9	
0.001 mm	5.1	(colloids)

Results include summarized reporting of ASTM D2487& D422

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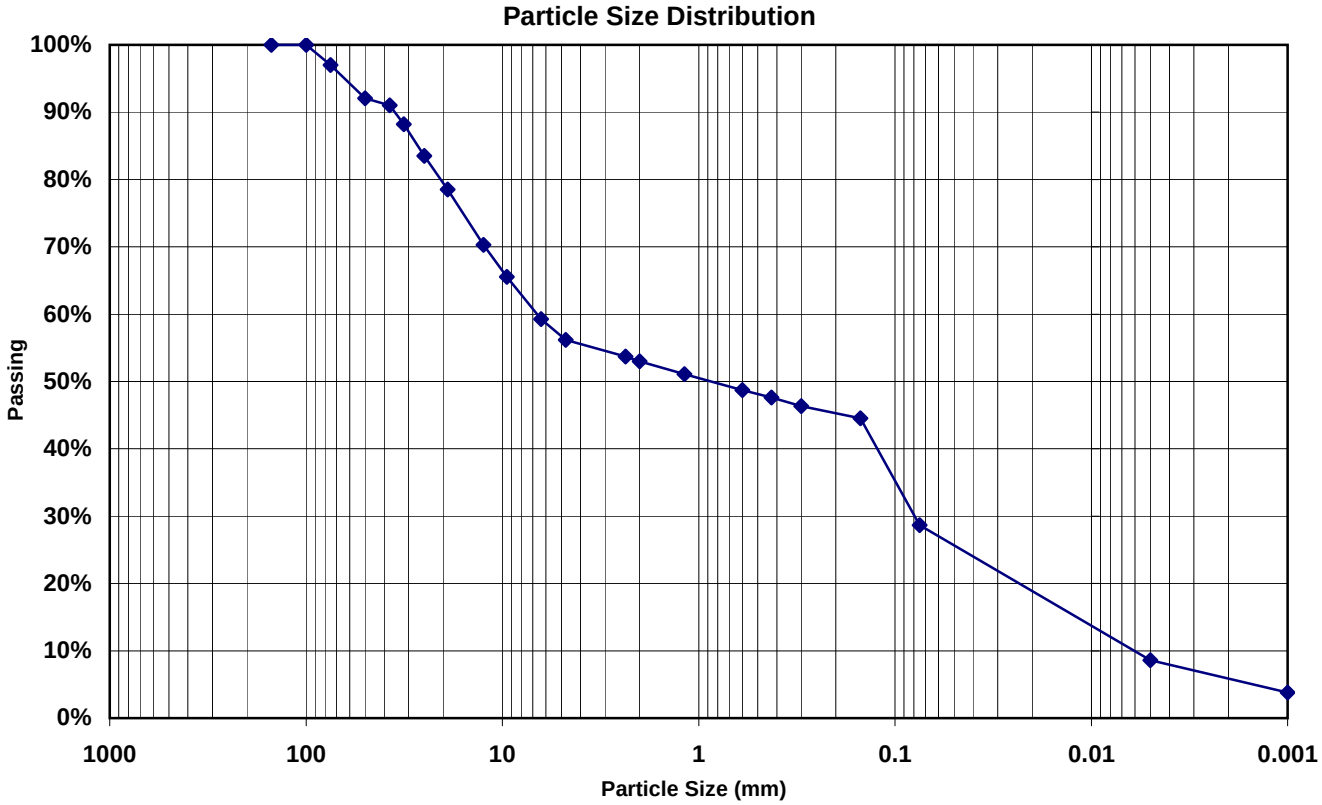
RUBY WASH DIVERSION LEVEE
STA 165+00 to 381+50

CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 04/01/09
93212(2.2w): 09113-13

APPENDIX
B.31



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
3.0%	**18.5%**	**22.3%**	**3.2%**	**5.4%**	**19.0%**	**20.0%**	**8.6%**

SAMPLE SOURCE: **SB-2 @ 2.5-5'**

ATTERBERG LIMITS
LL: 19
PL: 16
PI: 3

USCS: GM
Silty gravel with sand

AASHTO: A-2-4(0)
Silty gravel and sand

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	97	
2"	92	
1½"	91	
1¼"	88	
1"	84	
3/4"	79	
1/2"	70	
3/8"	66	
1/4"	59	
#4	56	
#8	54	
#10	53	
#16	51	
#30	49	
#40	48	
#50	46	
#100	45	
#200	29	
0.005 mm	8.6	
0.001 mm	3.8	(colloids)

Results include summarized reporting of ASTM D2487& D422

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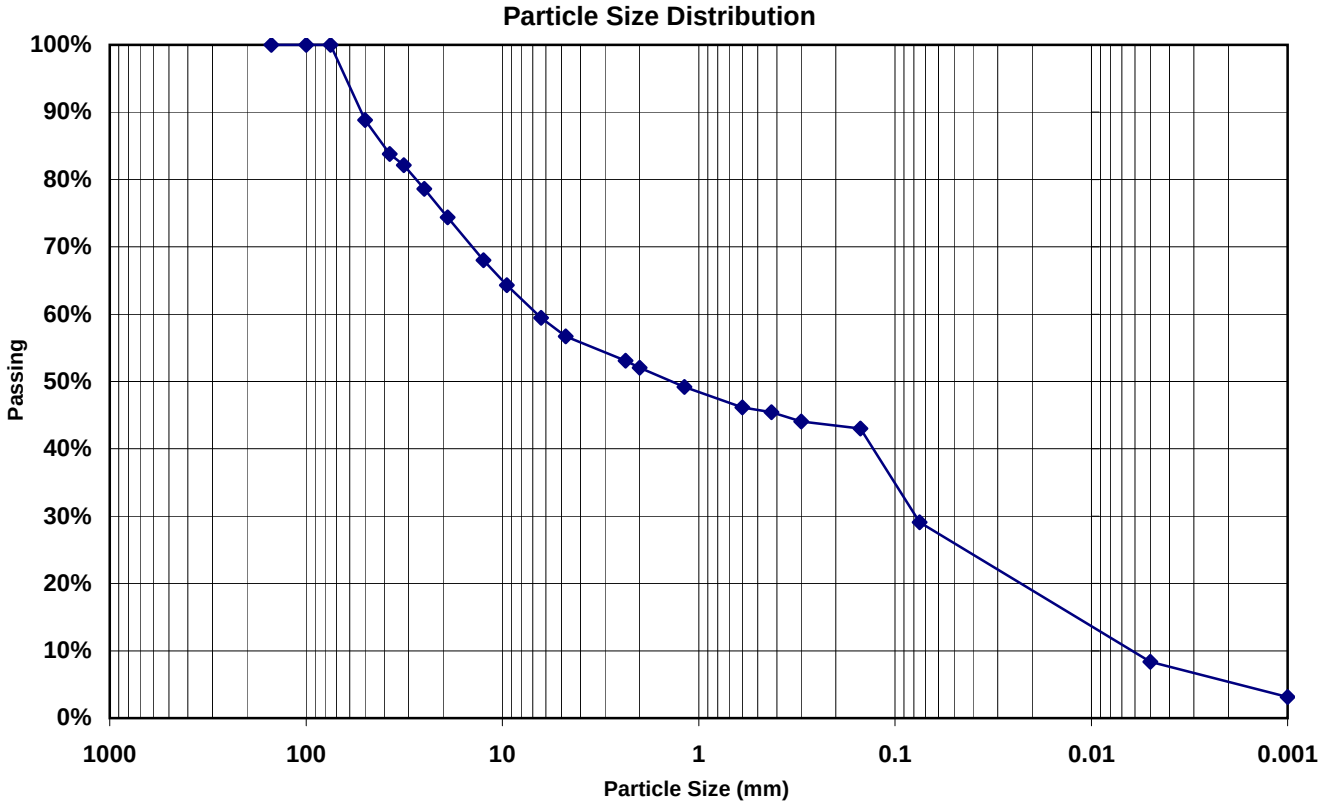
CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 04/01/09
93212(2.2w): 09113-16

APPENDIX
B.32



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
0.0%	**25.6%**	**17.7%**	**4.6%**	**6.6%**	**16.3%**	**20.7%**	**8.4%**

SAMPLE SOURCE: **SB-2 @ 5-7.5'**

ATTERBERG LIMITS
LL: 18
PL: 16
PI: 2

USCS: GM
Silty gravel with sand

AASHTO: A-2-4(0)
Silty gravel and sand

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	100	
2"	89	
1½"	84	
1¼"	82	
1"	79	
3/4"	74	
1/2"	68	
3/8"	64	
1/4"	59	
#4	57	
#8	53	
#10	52	
#16	49	
#30	46	
#40	45	
#50	44	
#100	43	
#200	29	
0.005 mm	8.4	
0.001 mm	3.1	(colloids)

Results include summarized reporting of ASTM D2487& D422

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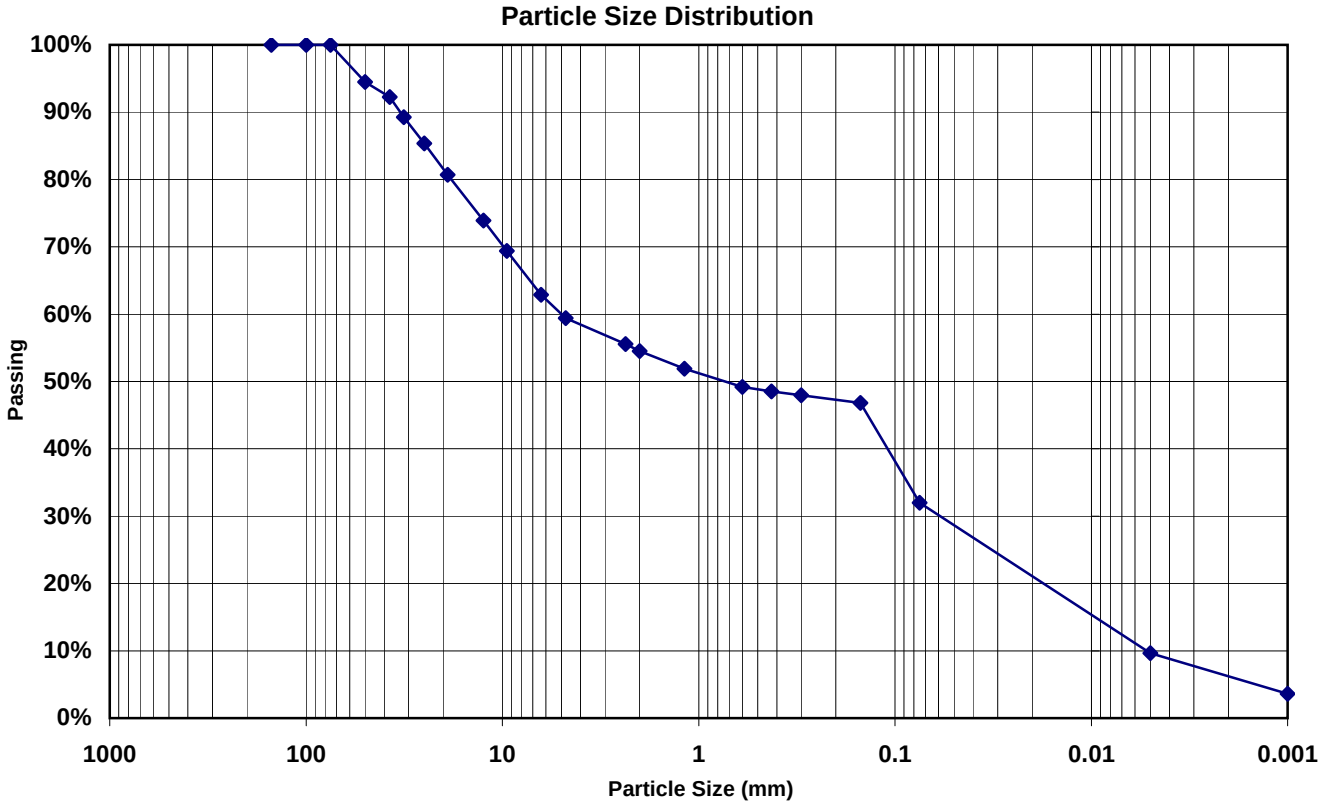
CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 04/01/09
93212(2.2w): 09113-17

APPENDIX
B.33



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
0.0%	**19.3%**	**21.3%**	**4.9%**	**6.0%**	**16.5%**	**22.3%**	**9.7%**

SAMPLE SOURCE: **SB-2 @ 10-12.5'**

ATTERBERG LIMITS
LL: 19
PL: 16
PI: 3

USCS: GM
Silty gravel with sand

AASHTO: A-2-4(0)
Silty gravel and sand

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	100	
2"	94	
1½"	92	
1¼"	89	
1"	85	
3/4"	81	
1/2"	74	
3/8"	69	
1/4"	63	
#4	59	
#8	56	
#10	55	
#16	52	
#30	49	
#40	49	
#50	48	
#100	47	
#200	32	
0.005 mm	9.7	
0.001 mm	3.6	(colloids)

Results include summarized reporting of ASTM D2487& D422

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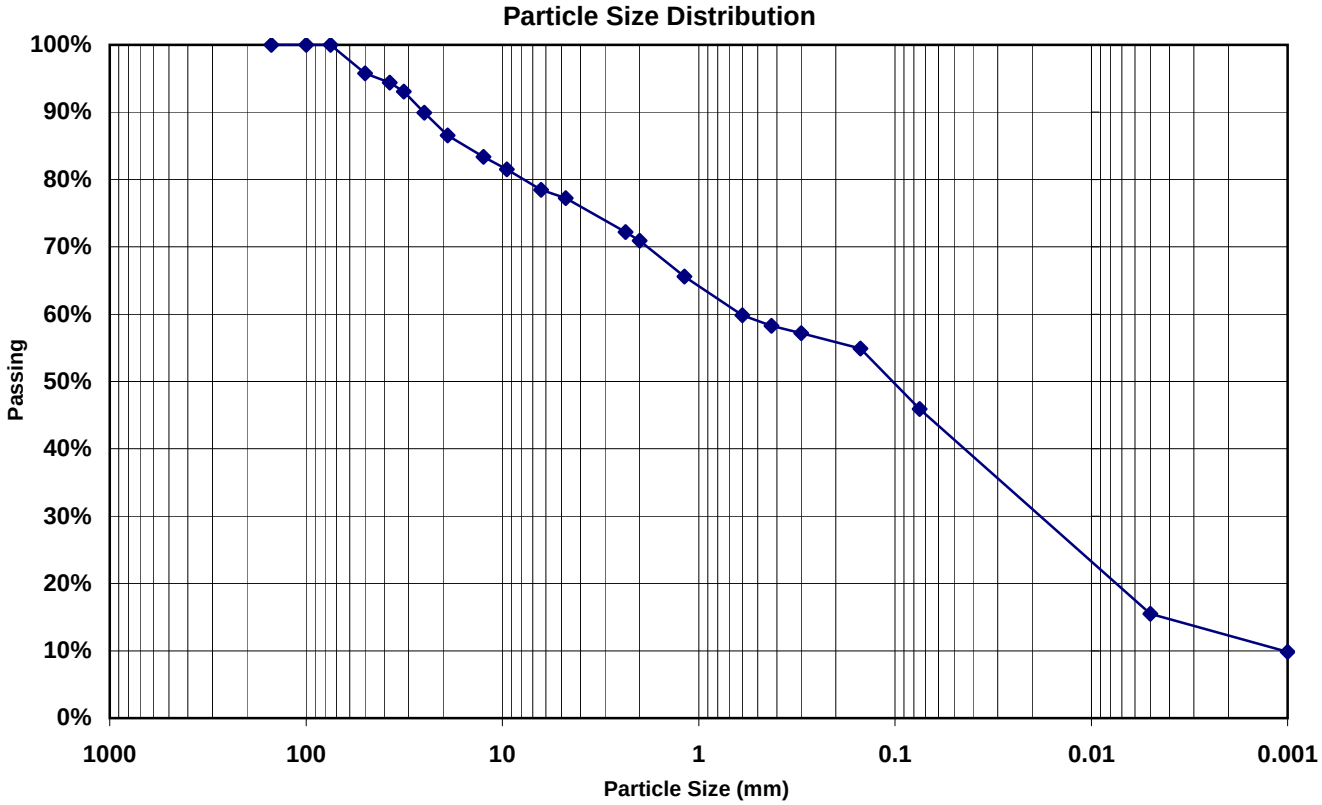
f| 480.763.1212

RUBY WASH DIVERSION LEVEE
STA 165+00 to 381+50

CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 04/01/09
93212(2.2w): 09113-19

APPENDIX
B.34



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
0.0%	**13.5%**	**9.3%**	**6.3%**	**12.6%**	**12.4%**	**30.4%**	**15.5%**

SAMPLE SOURCE: **SB-2 @ 15-17.5'**

ATTERBERG LIMITS
LL: 21
PL: 16
PI: 5

USCS: SC-SM
Silty, clayey sand with gravel

AASHTO: A-4(0)
Silty soils

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	100	
2"	96	
1½"	94	
1¼"	93	
1"	90	
3/4"	87	
1/2"	83	
3/8"	82	
1/4"	78	
#4	77	
#8	72	
#10	71	
#16	66	
#30	60	
#40	58	
#50	57	
#100	55	
#200	46	
0.005 mm	15.5	
0.001 mm	9.8	(colloids)

Results include summarized reporting of ASTM D2487& D422

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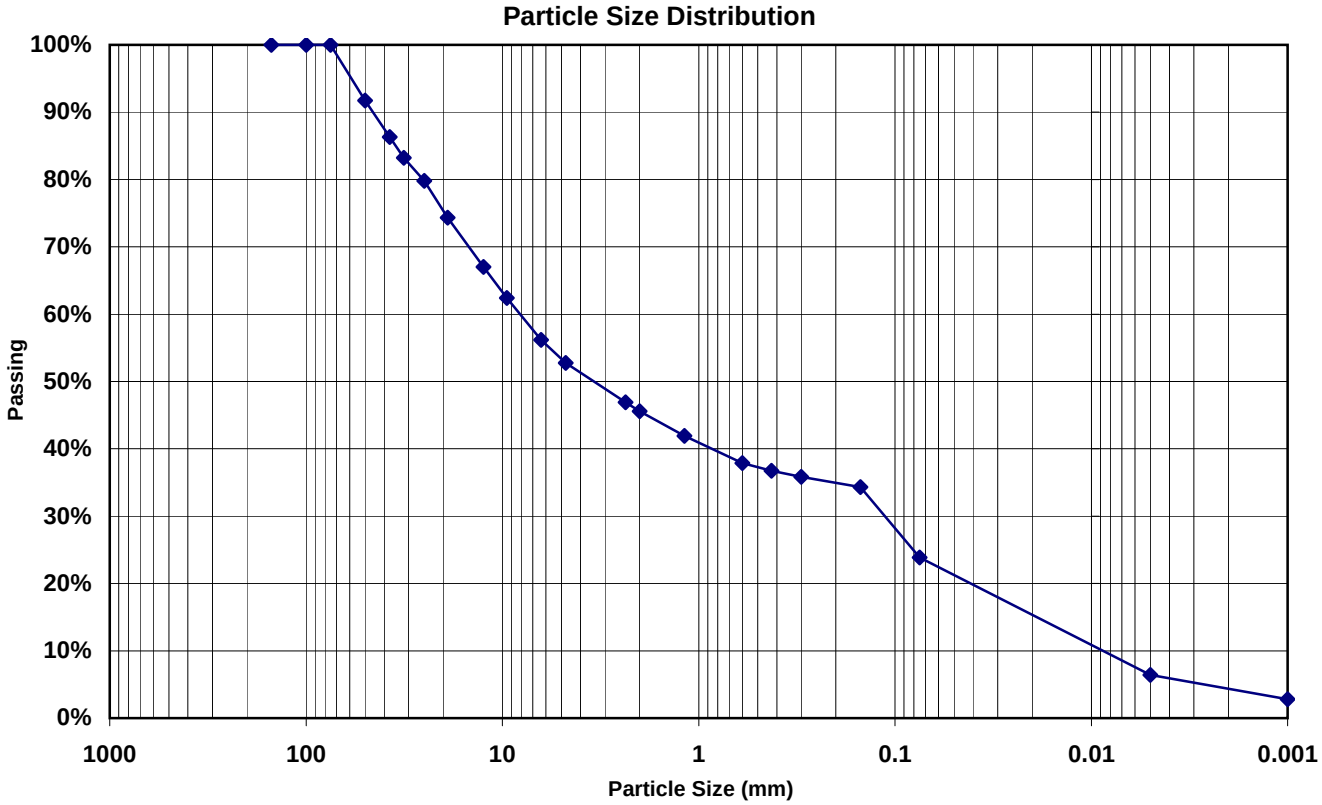
STA 165+00 to 381+50

CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 04/01/09
93212(2.2w): 09113-21

APPENDIX
B.35



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
0.0%	**25.7%**	**21.6%**	**7.2%**	**8.8%**	**12.9%**	**17.4%**	**6.4%**

SAMPLE SOURCE: **SB-3 @ 2.5-5'**

ATTERBERG LIMITS
LL: 17
PL: 16
PI: 1

USCS: GM
Silty gravel with sand

AASHTO: A-1-b(0)
Stone fragments, gravel and sand

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	100	
2"	92	
1½"	86	
1¼"	83	
1"	80	
3/4"	74	
1/2"	67	
3/8"	62	
1/4"	56	
#4	53	
#8	47	
#10	46	
#16	42	
#30	38	
#40	37	
#50	36	
#100	34	
#200	24	
0.005 mm	6.4	
0.001 mm	2.8	(colloids)

Results include summarized reporting of ASTM D2487& D422

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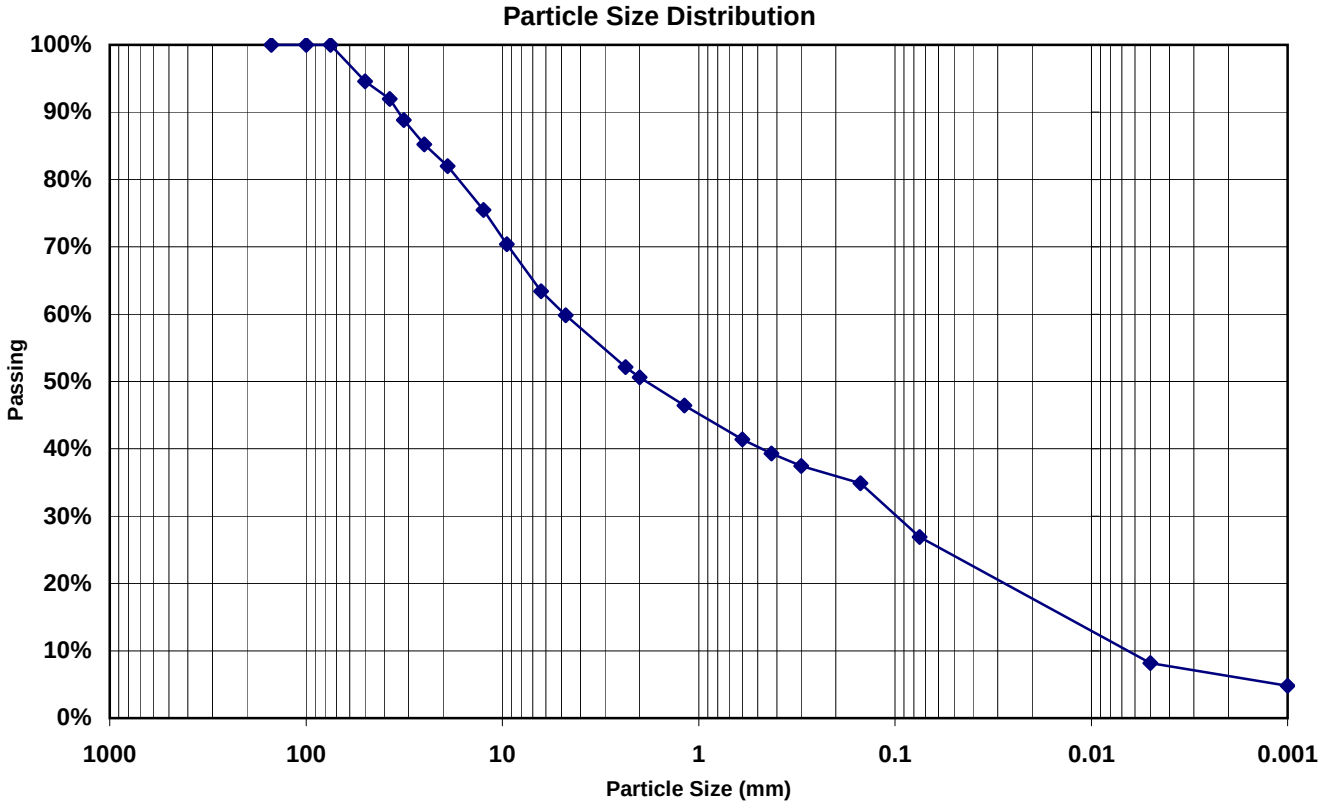
Sampled: 04/01/09
93212(2.2w): 09113-26

APPENDIX
B.36



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
0.0%	**18.0%**	**22.2%**	**9.2%**	**11.3%**	**12.4%**	**18.7%**	**8.2%**

SAMPLE SOURCE: **SB-3 @ 5-7.5'**

ATTERBERG LIMITS
LL: 19
PL: 16
PI: 3

USCS: GC
Clayey gravel with sand

AASHTO: A-2-4(0)
Silty gravel and sand

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	100	
2"	95	
1½"	92	
1¼"	89	
1"	85	
3/4"	82	
1/2"	75	
3/8"	70	
1/4"	63	
#4	60	
#8	52	
#10	51	
#16	46	
#30	41	
#40	39	
#50	37	
#100	35	
#200	27	
0.005 mm	8.2	
0.001 mm	4.8	(colloids)

Results include summarized reporting of ASTM D2487& D422

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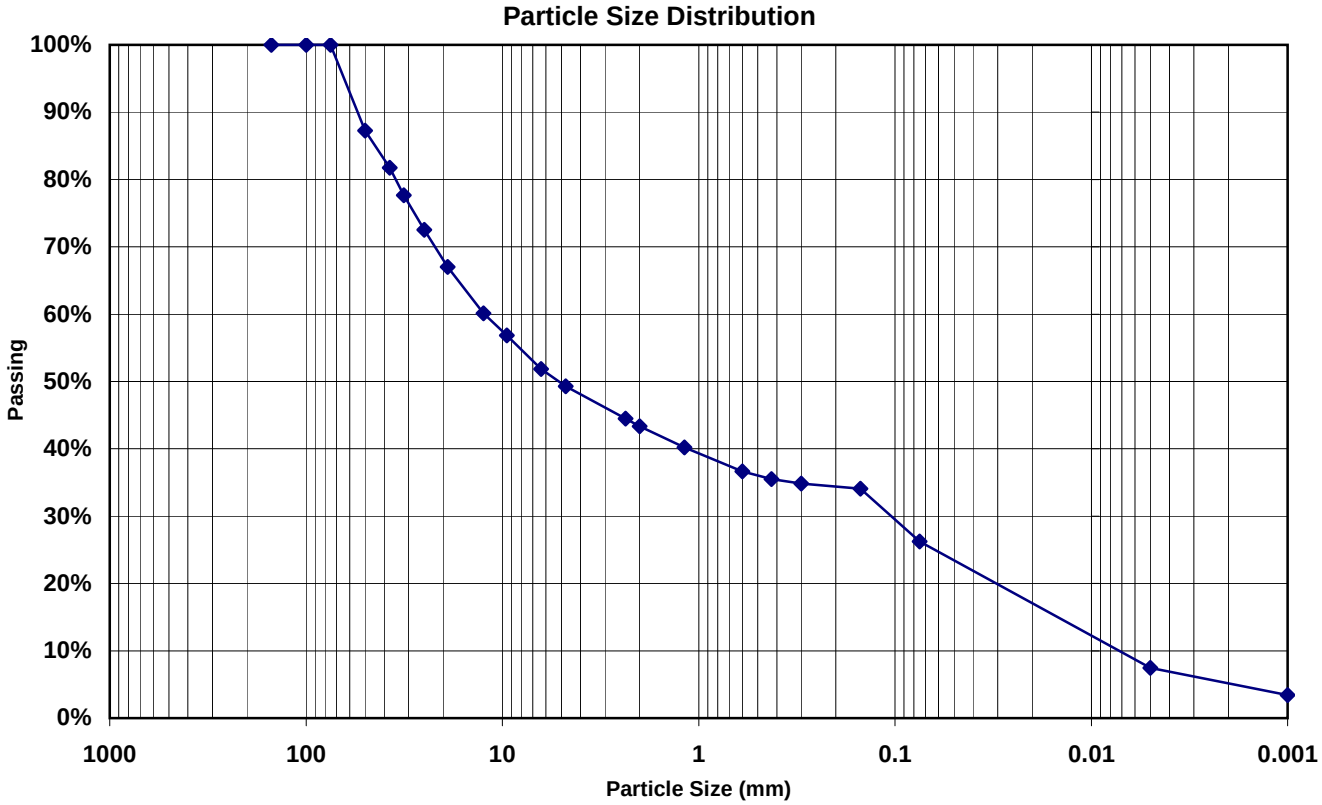
Sampled: 04/01/09
93212(2.2w): 09113-27

APPENDIX
B.37



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
0.0%	**33.0%**	**17.7%**	**6.0%**	**7.8%**	**9.3%**	**18.8%**	**7.5%**

SAMPLE SOURCE: **SB-3 @ 10-12.5'**

ATTERBERG LIMITS
LL: 20
PL: 16
PI: 4

USCS: GC-GM
Silty, clayey gravel with sand

AASHTO: A-2-4(0)
Silty gravel and sand

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	100	
2"	87	
1½"	82	
1¼"	78	
1"	73	
3/4"	67	
1/2"	60	
3/8"	57	
1/4"	52	
#4	49	
#8	44	
#10	43	
#16	40	
#30	37	
#40	36	
#50	35	
#100	34	
#200	26	
0.005 mm	7.5	
0.001 mm	3.4	(colloids)

Results include summarized reporting of ASTM D2487& D422

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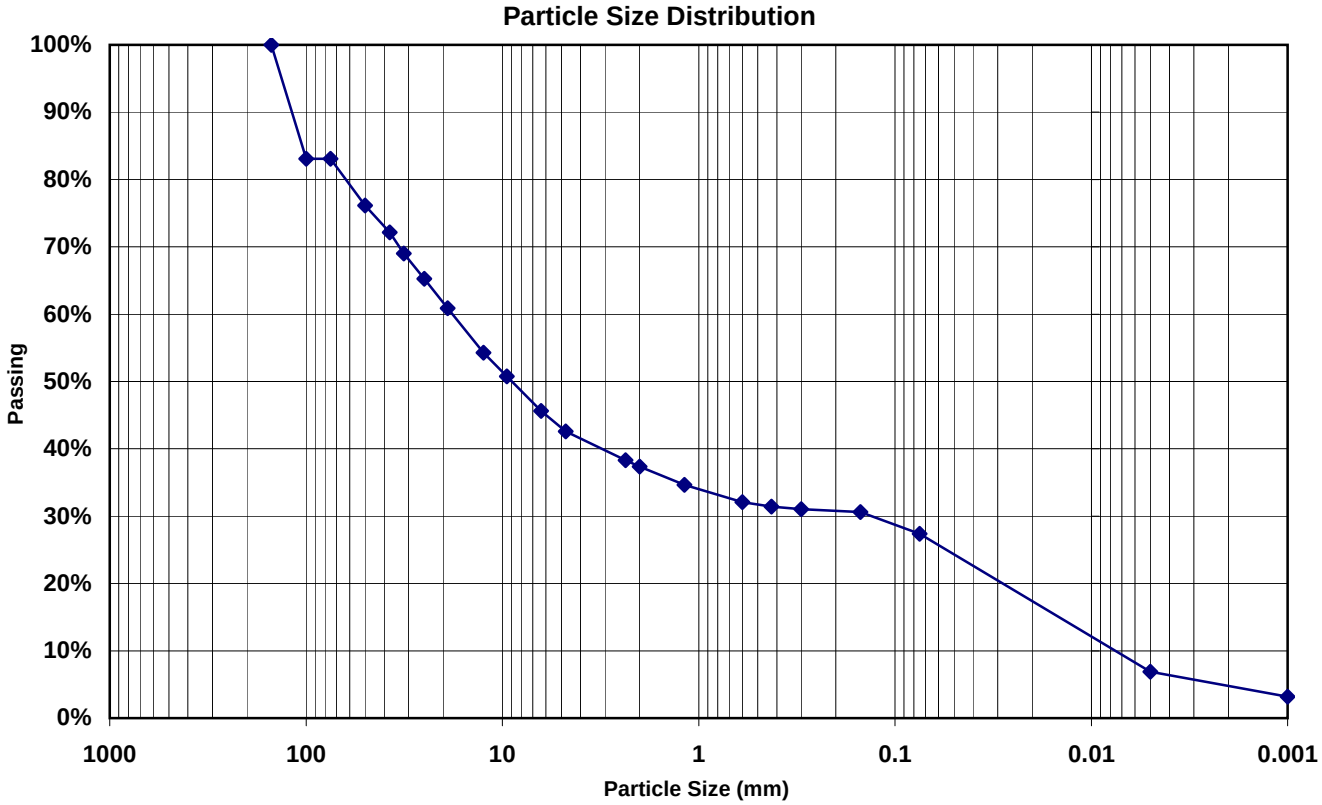
Sampled: 04/01/09
93212(2.2w): 09113-30

APPENDIX
B.38



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
16.9%	**22.2%**	**18.3%**	**5.2%**	**5.9%**	**4.0%**	**20.5%**	**6.9%**

SAMPLE SOURCE: **SB-3 @ 12.5-15'**

ATTERBERG LIMITS
LL: 22
PL: 18
PI: 4

USCS: GC-GM
Silty, clayey gravel with sand

AASHTO: A-2-4(0)
Silty gravel and sand

PARTICLE SIZE	% FINER	
6"	100	
4"	83	
3"	83	
2"	76	
1½"	72	
1¼"	69	
1"	65	
3/4"	61	
1/2"	54	
3/8"	51	
1/4"	46	
#4	43	
#8	38	
#10	37	
#16	35	
#30	32	
#40	31	
#50	31	
#100	31	
#200	27	
0.005 mm	6.9	
0.001 mm	3.2	(colloids)

Results include summarized reporting of ASTM D2487& D422

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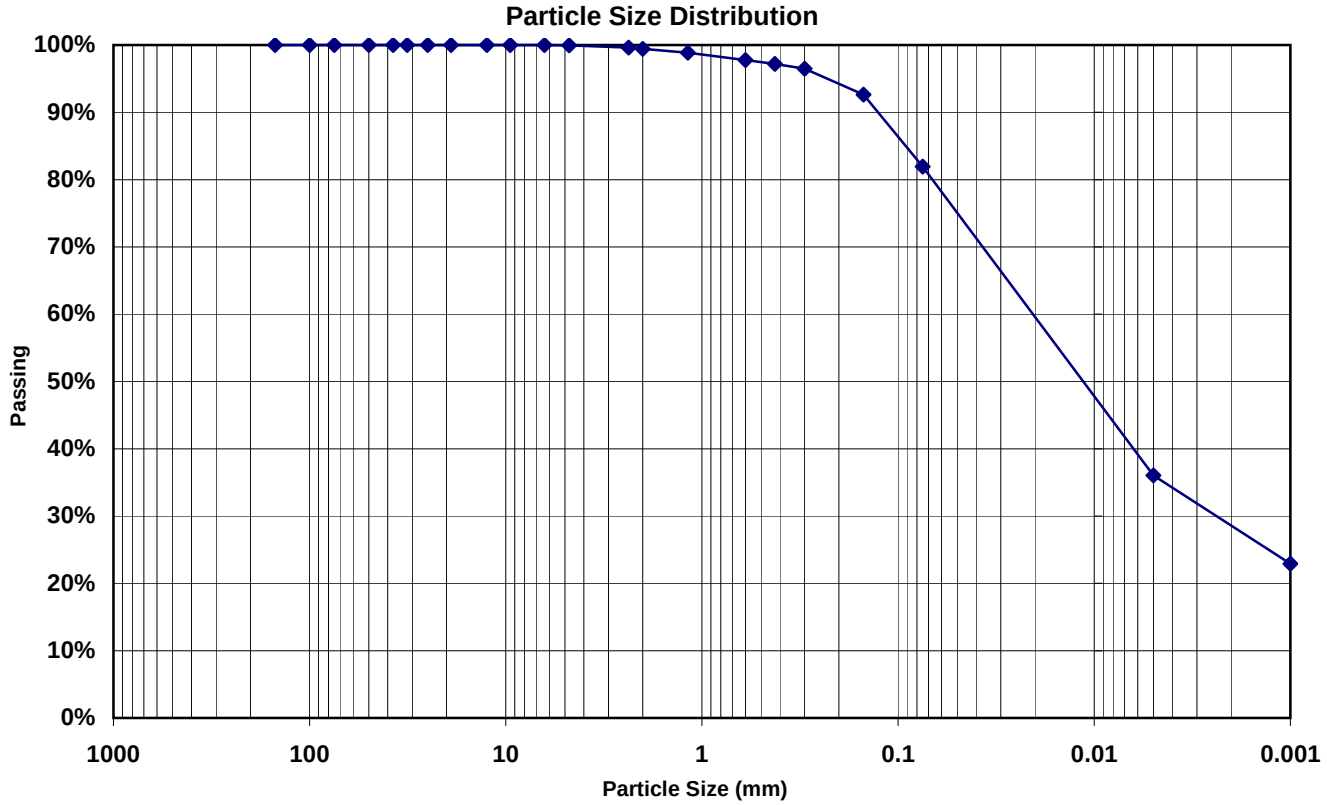
CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 04/01/09
93212(2.2w): 09113-31

APPENDIX
B.39



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
0.0%	**0.0%**	**0.0%**	**0.6%**	**2.2%**	**15.3%**	**45.9%**	**36.0%**

SAMPLE SOURCE: **SB-4 @ 0-2.5'**

ATTERBERG LIMITS
LL: 27
PL: 15
PI: 12

USCS: CL
Sandy Lean clay

AASHTO: A-6(8)
Clayey soils

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	100	
2"	100	
1½"	100	
1¼"	100	
1"	100	
3/4"	100	
1/2"	100	
3/8"	100	
1/4"	100	
#4	100	
#8	100	
#10	99	
#16	99	
#30	98	
#40	97	
#50	96	
#100	93	
#200	82	
0.005 mm	36.0	
0.001 mm	22.9	(colloids)

Results include summarized reporting of ASTM D2487& D422

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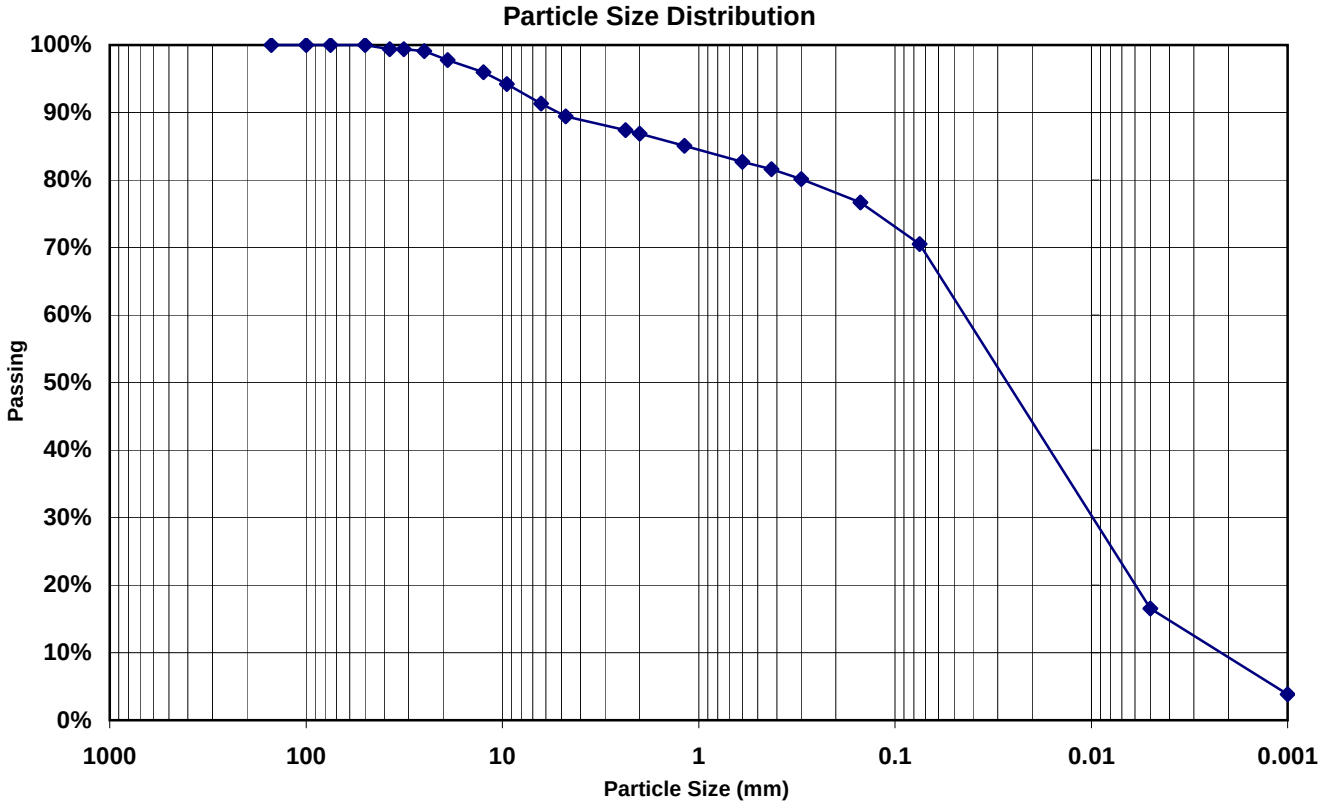
CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 04/01/09
93212(2.2w): 09113-36

APPENDIX
B.40



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
0.0%	**2.2%**	**8.3%**	**2.5%**	**5.3%**	**11.1%**	**54.0%**	**16.5%**

SAMPLE SOURCE: **SB-5 @ 0-2.5'**

ATTERBERG LIMITS
LL: 29
PL: 18
PI: 11

USCS: CL
Sandy Lean clay

AASHTO: A-6(6)
Clayey soils

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	100	
2"	100	
1½"	99	
1¼"	99	
1"	99	
3/4"	98	
1/2"	96	
3/8"	94	
1/4"	91	
#4	89	
#8	87	
#10	87	
#16	85	
#30	83	
#40	82	
#50	80	
#100	77	
#200	71	
0.005 mm	16.5	
0.001 mm	3.8	(colloids)

Results include summarized reporting of ASTM D2487& D422

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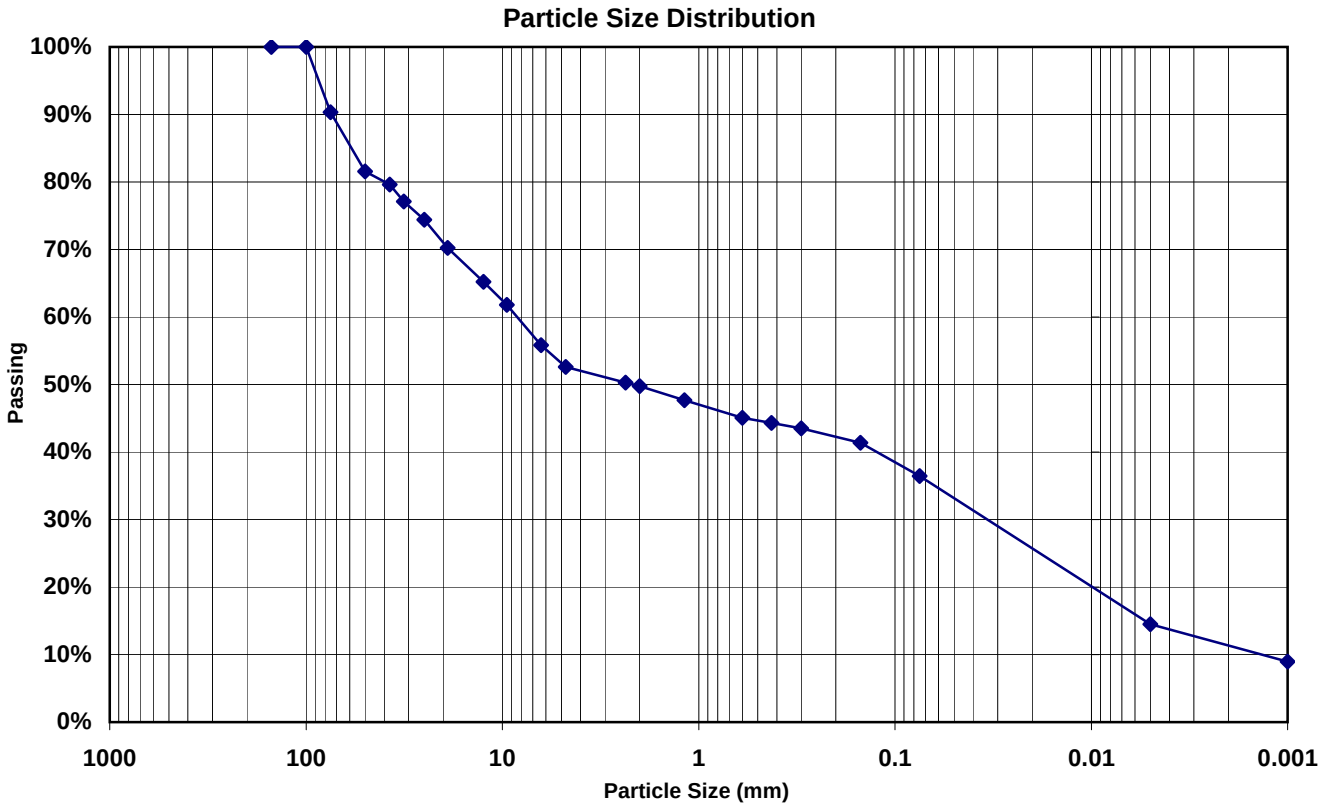
CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 04/01/09
93212(2.2w): 09113-41

APPENDIX
B.41



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
9.7%	**20.1%**	**17.6%**	**2.8%**	**5.5%**	**7.9%**	**22.0%**	**14.5%**

SAMPLE SOURCE: **SB-5 @ 5-7.5'**

ATTERBERG LIMITS
LL: 25
PL: 16
PI: 9

USCS: GC
Clayey gravel with sand

AASHTO: A-4(0)
Silty soils

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	90	
2"	82	
1½"	80	
1¼"	77	
1"	74	
3/4"	70	
1/2"	65	
3/8"	62	
1/4"	56	
#4	53	
#8	50	
#10	50	
#16	48	
#30	45	
#40	44	
#50	43	
#100	41	
#200	36	
0.005 mm	14.5	
0.001 mm	9.0	(colloids)

Results include summarized reporting of ASTM D2487& D422

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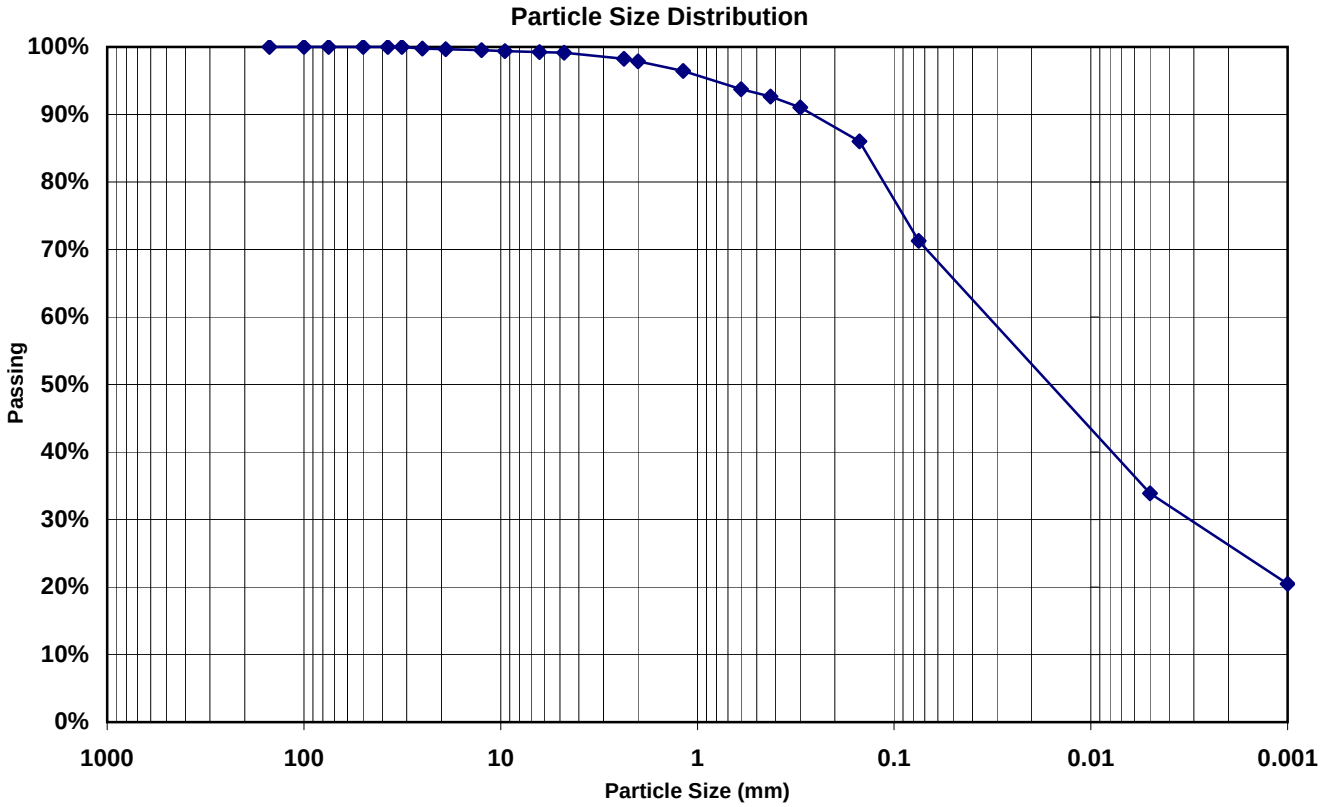
RUBY WASH DIVERSION LEVEE
STA 165+00 to 381+50

CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 04/01/09
93212(2.2w): 09113-43

APPENDIX
B.42



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
0.0%	**0.3%**	**0.6%**	**1.3%**	**5.2%**	**21.4%**	**37.4%**	**33.9%**

SAMPLE SOURCE: **SB-5 @ 7.5-10'**

ATTERBERG LIMITS
LL: 26
PL: 16
PI: 10

USCS: CL
Sandy Lean clay

AASHTO: A-4(5)
Silty soils

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	100	
2"	100	
1½"	100	
1¼"	100	
1"	100	
3/4"	100	
1/2"	100	
3/8"	99	
1/4"	99	
#4	99	
#8	98	
#10	98	
#16	96	
#30	94	
#40	93	
#50	91	
#100	86	
#200	71	
0.005 mm	33.9	
0.001 mm	20.5	(colloids)

Results include summarized reporting of ASTM D2487& D422

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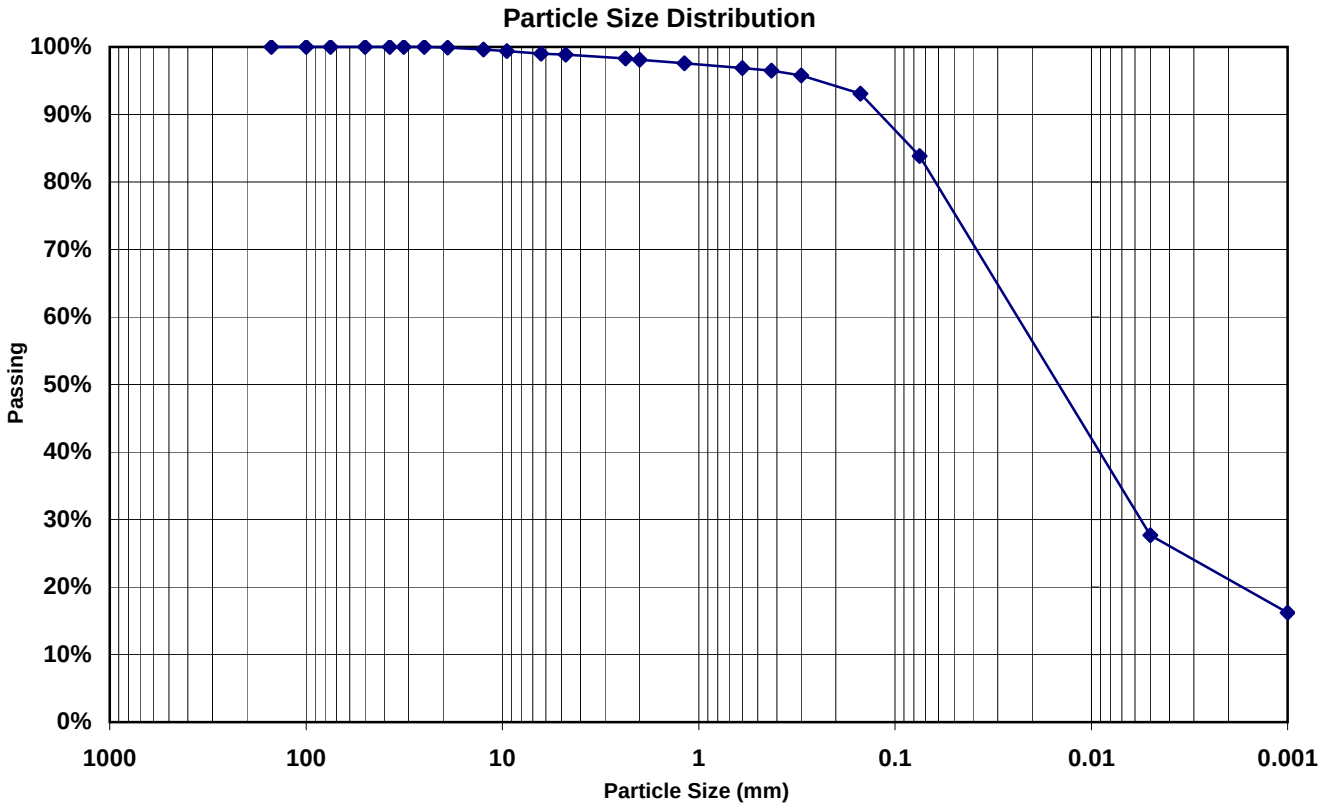
CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 04/01/09
93212(2.2w): 09113-44

APPENDIX
B.43



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
0.0%	**0.1%**	**1.1%**	**0.7%**	**1.6%**	**12.6%**	**56.2%**	**27.7%**

SAMPLE SOURCE: **SB-5 @ 10-12.5'**

ATTERBERG LIMITS
LL: 25
PL: 17
PI: 8

USCS: CL
Sandy Lean clay

AASHTO: A-4(5)
Silty soils

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	100	
2"	100	
1½"	100	
1¼"	100	
1"	100	
3/4"	100	
1/2"	100	
3/8"	99	
1/4"	99	
#4	99	
#8	98	
#10	98	
#16	98	
#30	97	
#40	96	
#50	96	
#100	93	
#200	84	
0.005 mm	27.7	
0.001 mm	16.2	(colloids)

Results include summarized reporting of ASTM D2487& D422

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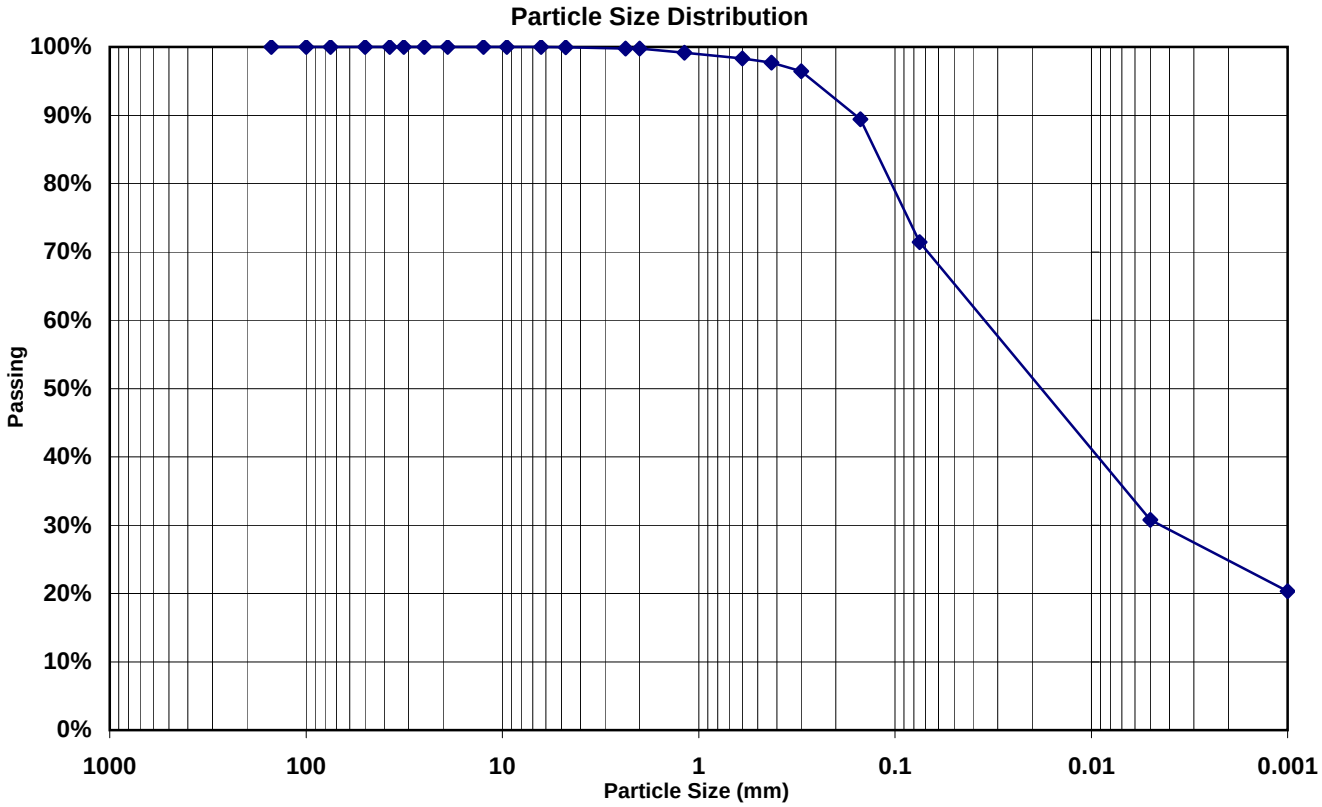
CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 04/01/09
93212(2.2w): 09113-45

APPENDIX
B.44



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
0.0%	**0.0%**	**0.0%**	**0.2%**	**2.1%**	**26.3%**	**40.6%**	**30.8%**

SAMPLE SOURCE: **SB-5 @ 12.5-15'**

ATTERBERG LIMITS
LL: 24
PL: 15
PI: 9

USCS: CL
Sandy Lean clay

AASHTO: A-4(4)
Silty soils

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	100	
2"	100	
1½"	100	
1¼"	100	
1"	100	
3/4"	100	
1/2"	100	
3/8"	100	
1/4"	100	
#4	100	
#8	100	
#10	100	
#16	99	
#30	98	
#40	98	
#50	96	
#100	89	
#200	71	
0.005 mm	30.8	
0.001 mm	20.3	(colloids)

Results include summarized reporting of ASTM D2487& D422

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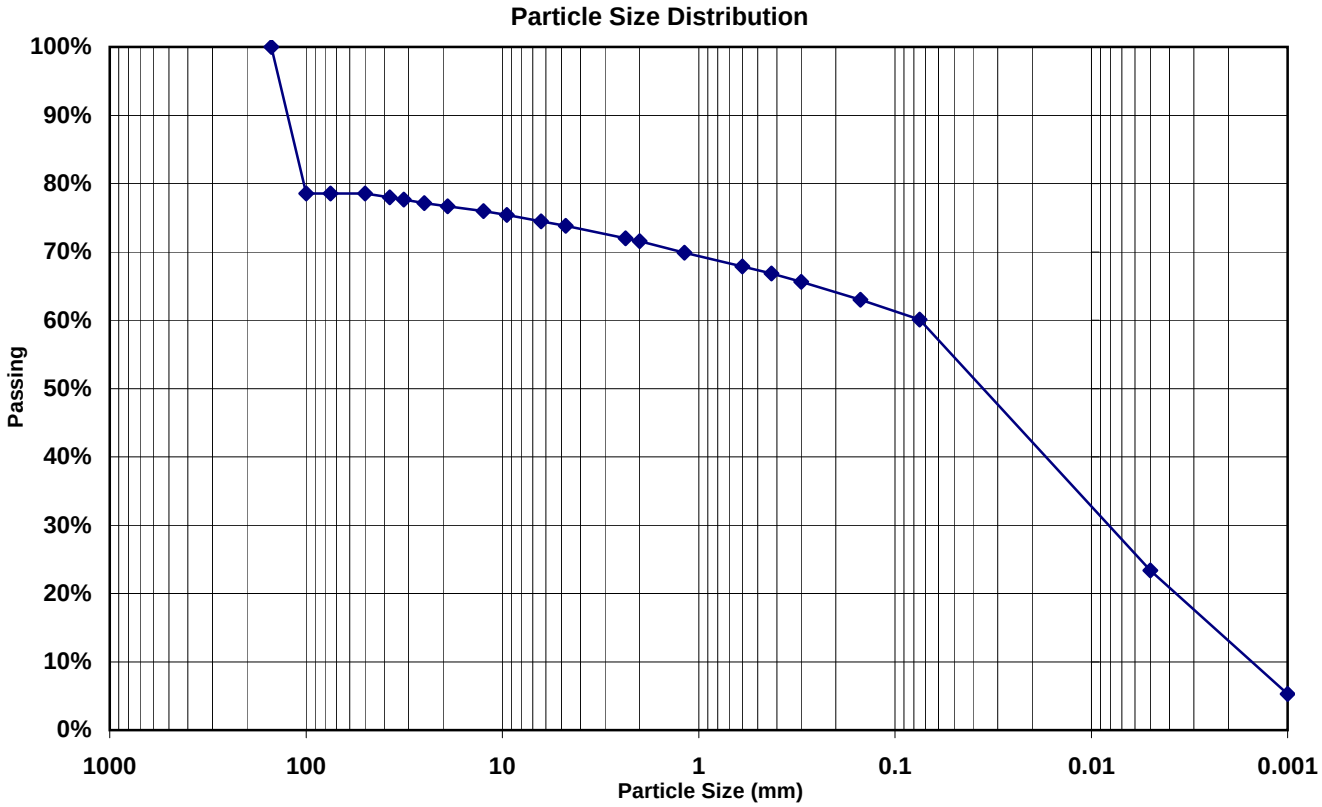
CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 04/01/09
93212(2.2w): 09113-46

APPENDIX
B.45



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
21.4%	**1.9%**	**2.8%**	**2.3%**	**4.7%**	**6.7%**	**36.7%**	**23.4%**

SAMPLE SOURCE: **SB-5 @ 17.5-20'**

ATTERBERG LIMITS
LL: 31
PL: 19
PI: 12

USCS: CL
Gravelly Lean clay

AASHTO: A-6(5)
Clayey soils

PARTICLE SIZE	% FINER	
6"	100	
4"	79	
3"	79	
2"	79	
1½"	78	
1¼"	78	
1"	77	
3/4"	77	
1/2"	76	
3/8"	75	
1/4"	74	
#4	74	
#8	72	
#10	72	
#16	70	
#30	68	
#40	67	
#50	66	
#100	63	
#200	60	
0.005 mm	23.4	
0.001 mm	5.3	(colloids)

Results include summarized reporting of ASTM D2487& D422

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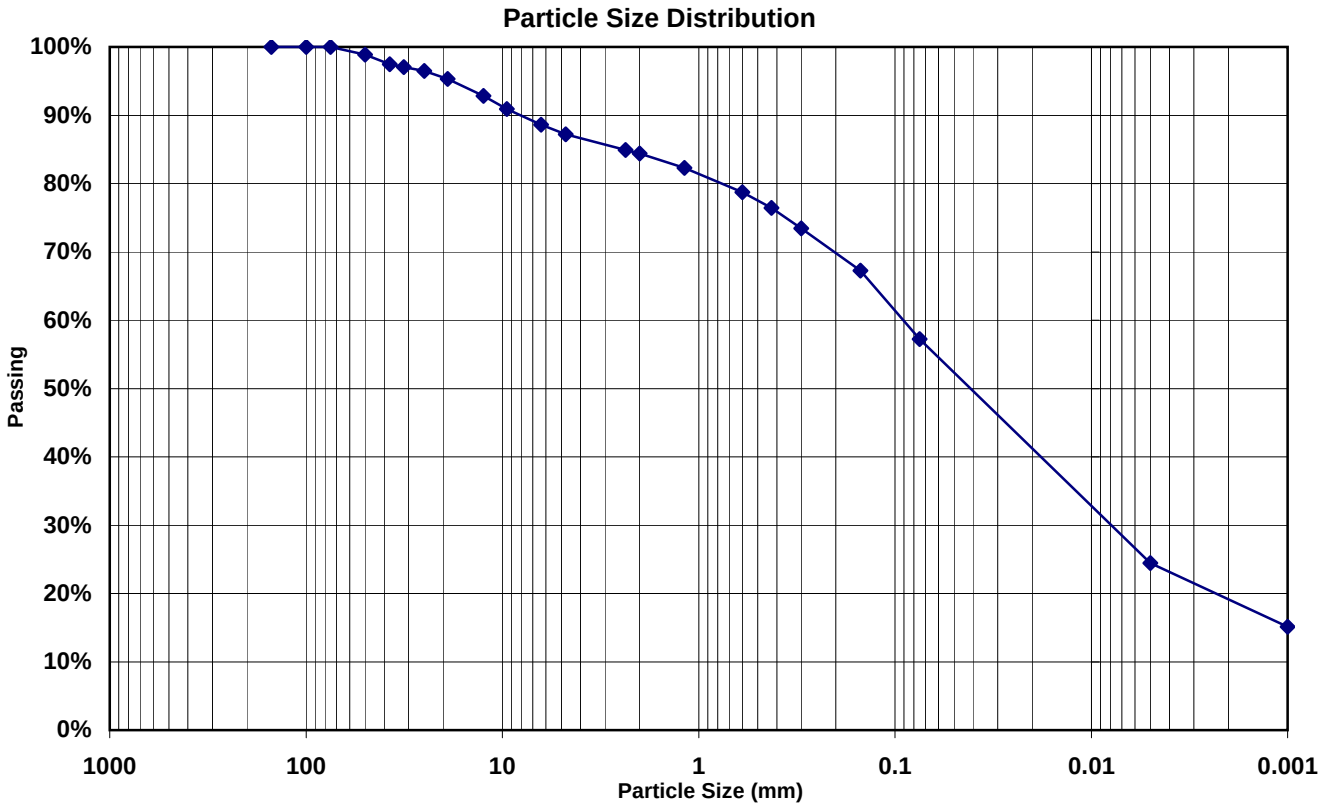
CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 04/01/09
93212(2.2w): 09113-48

APPENDIX
B.46



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
0.0%	**4.7%**	**8.1%**	**2.8%**	**7.9%**	**19.2%**	**32.8%**	**24.5%**

SAMPLE SOURCE: **SB-6 @ 1-3'**

ATTERBERG LIMITS
LL: 28
PL: 16
PI: 12

USCS: CL
Sandy Lean clay

AASHTO: A-6(4)
Clayey soils

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	100	
2"	99	
1½"	97	
1¼"	97	
1"	96	
3/4"	95	
1/2"	93	
3/8"	91	
1/4"	89	
#4	87	
#8	85	
#10	84	
#16	82	
#30	79	
#40	76	
#50	73	
#100	67	
#200	57	
0.005 mm	24.5	
0.001 mm	15.1	(colloids)

Results include summarized reporting of ASTM D2487& D422

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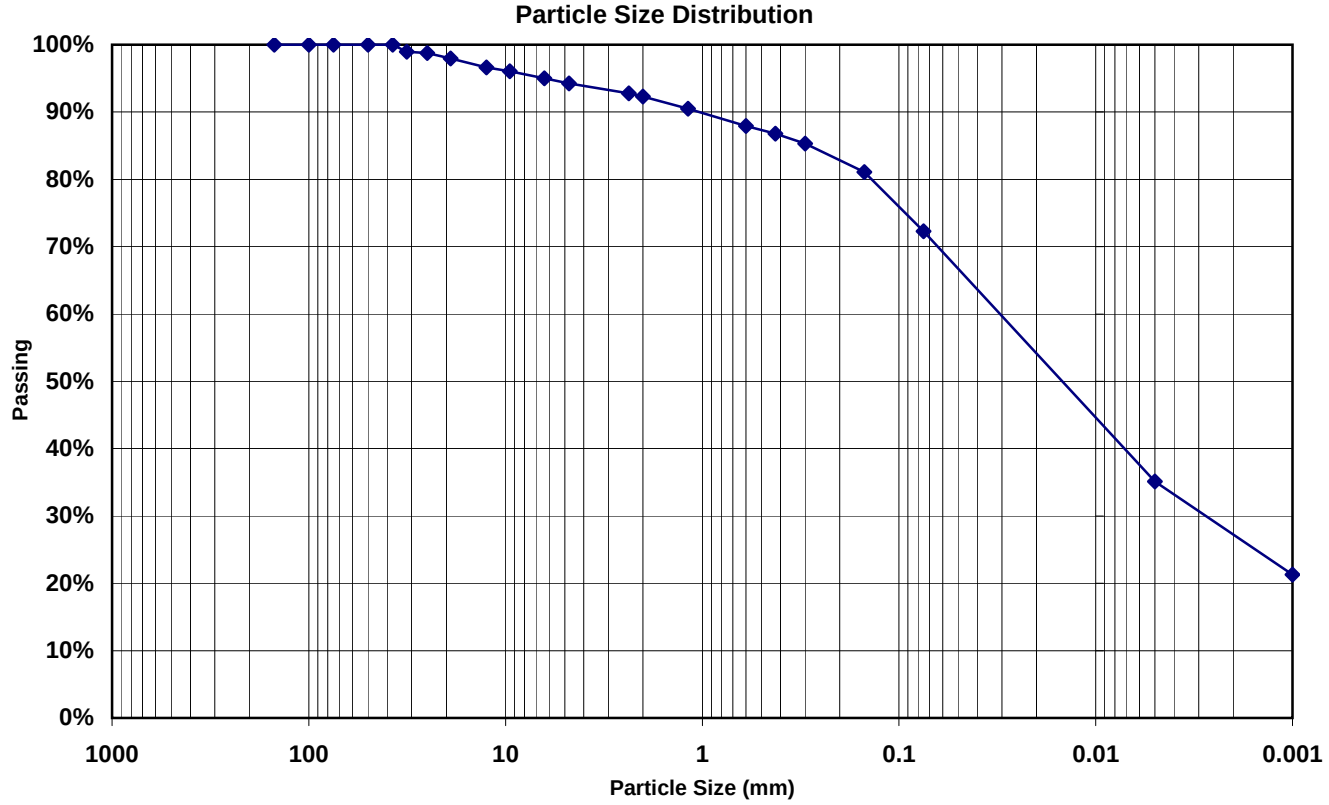
CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 04/01/09
93212(2.2w): 09113-56

APPENDIX
B.47



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
0.0%	**2.0%**	**3.7%**	**2.0%**	**5.5%**	**14.5%**	**37.2%**	**35.1%**

SAMPLE SOURCE: **SB-6 @ 3-5'**

ATTERBERG LIMITS
LL: 28
PL: 16
PI: 12

USCS: CL
Sandy Lean clay

AASHTO: A-6(6)
Clayey soils

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	100	
2"	100	
1½"	100	
1¼"	99	
1"	99	
3/4"	98	
1/2"	97	
3/8"	96	
1/4"	95	
#4	94	
#8	93	
#10	92	
#16	91	
#30	88	
#40	87	
#50	85	
#100	81	
#200	72	
0.005 mm	35.1	
0.001 mm	21.3	(colloids)

Results include summarized reporting of ASTM D2487& D422

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f| 480.763.1212

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STA 165+00 to 381+50

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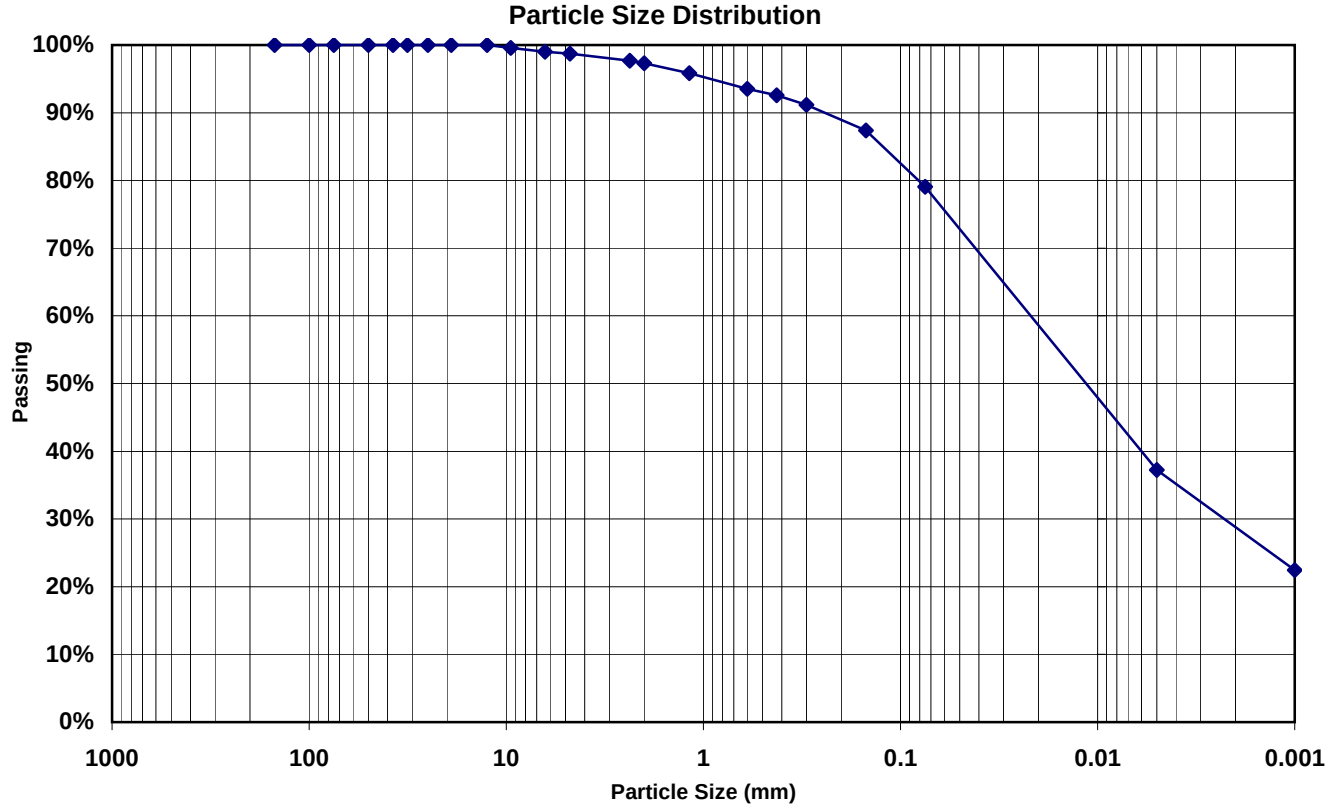
Sampled: 04/01/09

93212(2.2w): 09113-57

APPENDIX
B.48



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
0.0%	**0.0%**	**1.3%**	**1.4%**	**4.7%**	**13.6%**	**41.8%**	**37.3%**

SAMPLE SOURCE: **SB-6 @ 7-8'**

ATTERBERG LIMITS
LL: 27
PL: 17
PI: 10

USCS: CL
Sandy Lean clay

AASHTO: A-4(6)
Silty soils

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	100	
2"	100	
1½"	100	
1¼"	100	
1"	100	
3/4"	100	
1/2"	100	
3/8"	100	
1/4"	99	
#4	99	
#8	98	
#10	97	
#16	96	
#30	94	
#40	93	
#50	91	
#100	87	
#200	79	
0.005 mm	37.3	
0.001 mm	22.5	(colloids)

Results include summarized reporting of ASTM D2487& D422

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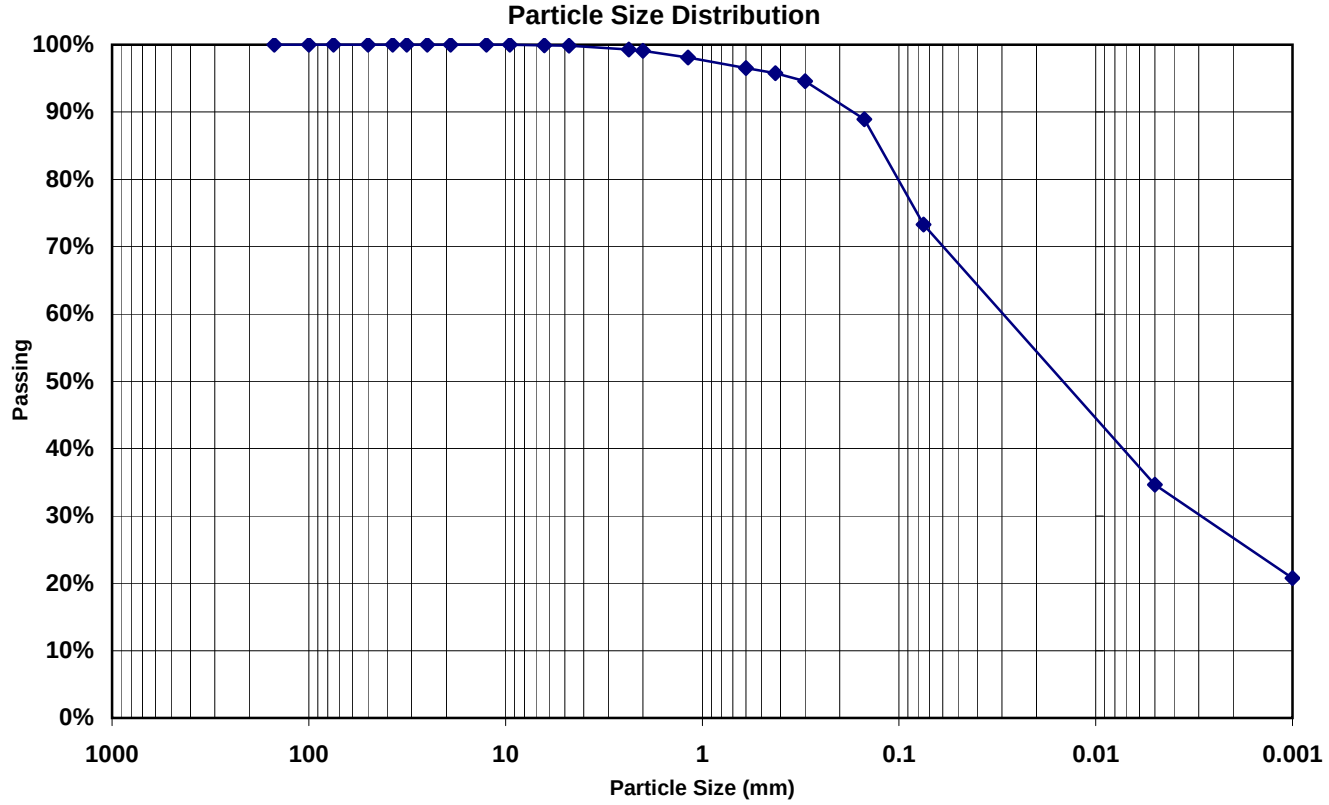
CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 04/01/09

93212(2.2w): 09113-59

APPENDIX
B.49



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
0.0%	**0.0%**	**0.1%**	**0.8%**	**3.3%**	**22.5%**	**38.6%**	**34.6%**

SAMPLE SOURCE: **SB-6 @ 8-10'**

ATTERBERG LIMITS
LL: 23
PL: 14
PI: 9

USCS: CL
Sandy Lean clay

AASHTO: A-4(4)
Silty soils

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	100	
2"	100	
1½"	100	
1¼"	100	
1"	100	
3/4"	100	
1/2"	100	
3/8"	100	
1/4"	100	
#4	100	
#8	99	
#10	99	
#16	98	
#30	97	
#40	96	
#50	95	
#100	89	
#200	73	
0.005 mm	34.6	
0.001 mm	20.8	(colloids)

Results include summarized reporting of ASTM D2487& D422

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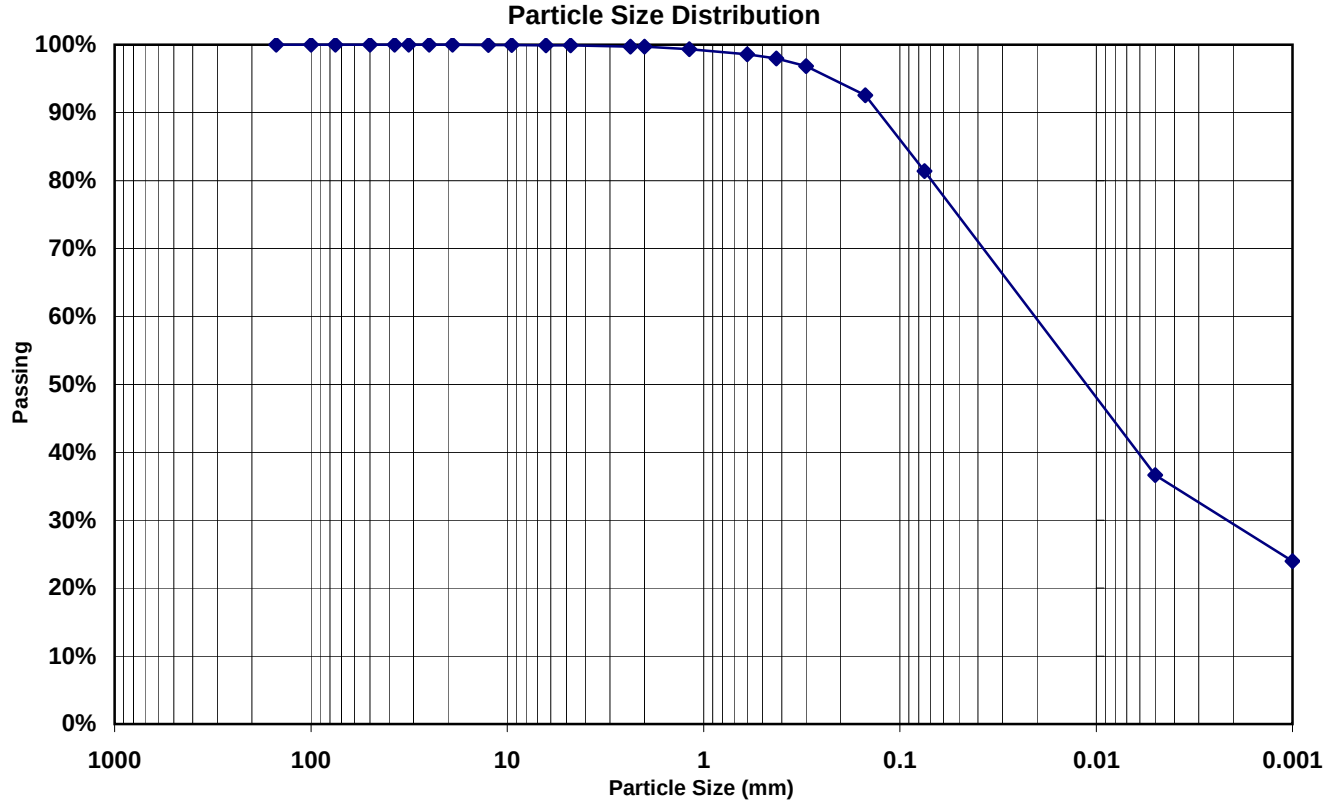
CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 04/01/09

93212(2.2w): 09113-60

APPENDIX
B.50



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
0.0%	**0.0%**	**0.1%**	**0.2%**	**1.7%**	**16.6%**	**44.7%**	**36.6%**

SAMPLE SOURCE: **SB-6 @ 10-12.5'**

ATTERBERG LIMITS
LL: 23
PL: 13
PI: 10

USCS: CL
Sandy Lean clay

AASHTO: A-4(5)
Silty soils

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	100	
2"	100	
1½"	100	
1¼"	100	
1"	100	
3/4"	100	
1/2"	100	
3/8"	100	
1/4"	100	
#4	100	
#8	100	
#10	100	
#16	99	
#30	99	
#40	98	
#50	97	
#100	93	
#200	81	
0.005 mm	36.6	
0.001 mm	24.0	(colloids)

Results include summarized reporting of ASTM D2487& D422

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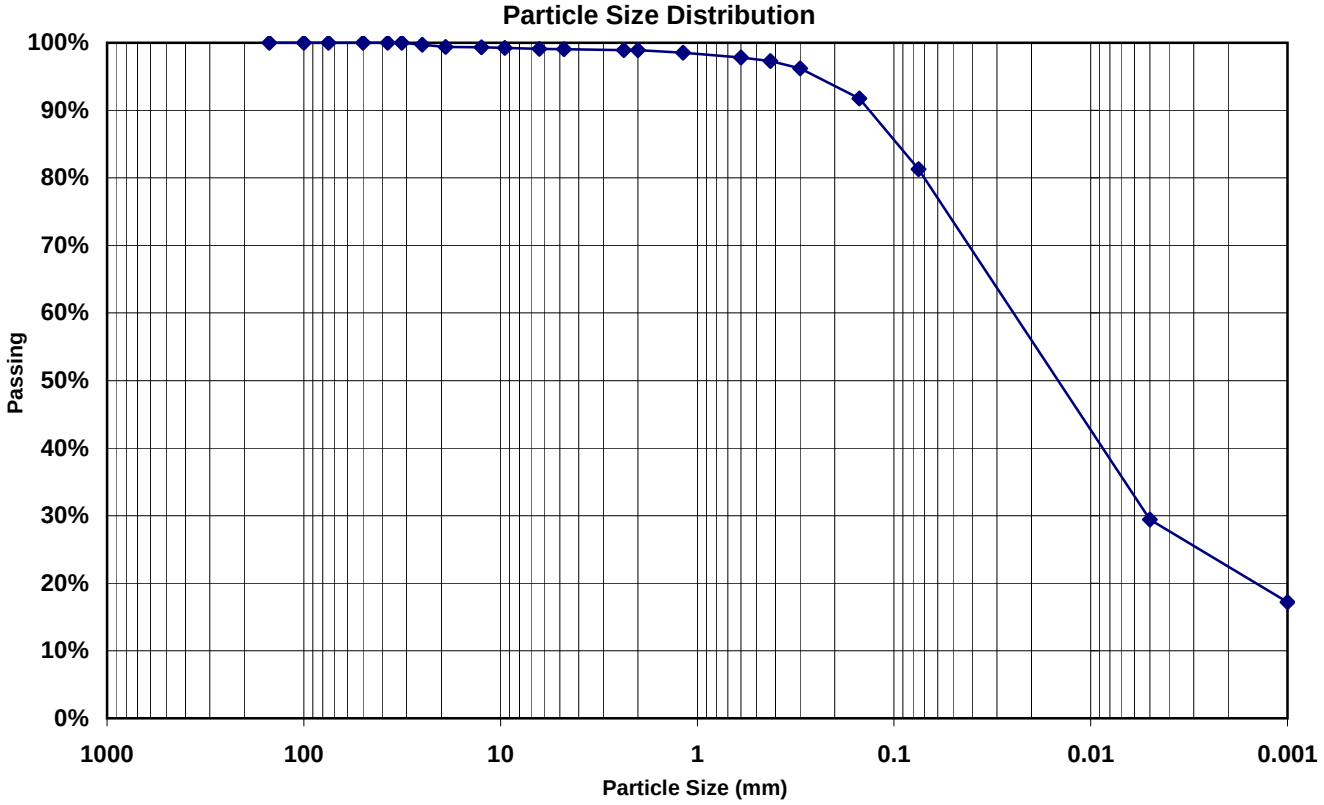
CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 04/01/09

93212(2.2w): 09113-61

APPENDIX
B.51



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
0.0%	**0.6%**	**0.3%**	**0.2%**	**1.6%**	**16.0%**	**51.9%**	**29.4%**

SAMPLE SOURCE: **SB-6 @ 12.5-15'**

ATTERBERG LIMITS
LL: 22
PL: 15
PI: 7

USCS: CL-ML
Sandy Silty clay

AASHTO: A-4(3)
Silty soils

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	100	
2"	100	
1½"	100	
1¼"	100	
1"	100	
3/4"	99	
1/2"	99	
3/8"	99	
1/4"	99	
#4	99	
#8	99	
#10	99	
#16	99	
#30	98	
#40	97	
#50	96	
#100	92	
#200	81	
0.005 mm	29.4	
0.001 mm	17.2	(colloids)

Results include summarized reporting of ASTM D2487& D422

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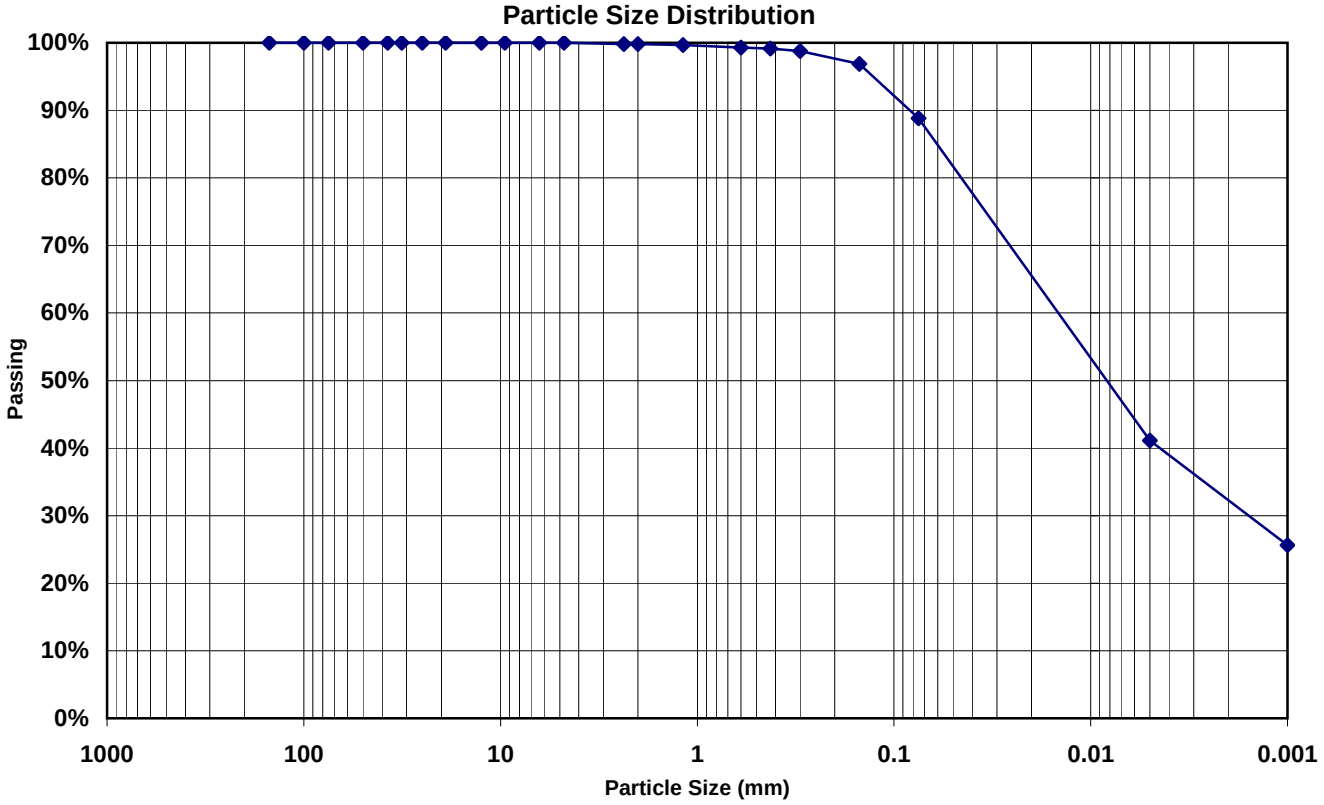
CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 04/01/09

93212(2.2w): 09113-62

APPENDIX
B.52



Cobbles	Gravel		Sand			Fines	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
0.0%	**0.0%**	**0.0%**	**0.2%**	**0.7%**	**10.3%**	**47.7%**	**41.1%**

SAMPLE SOURCE: **SB-7 @ 0-2.5'**

ATTERBERG LIMITS
LL: 24
PL: 14
PI: 10

USCS: CL
Sandy Lean clay

AASHTO: A-4(6)
Silty soils

PARTICLE SIZE	% FINER	
6"	100	
4"	100	
3"	100	
2"	100	
1½"	100	
1¼"	100	
1"	100	
3/4"	100	
1/2"	100	
3/8"	100	
1/4"	100	
#4	100	
#8	100	
#10	100	
#16	100	
#30	99	
#40	99	
#50	99	
#100	97	
#200	89	
0.005 mm	41.1	
0.001 mm	25.6	(colloids)

Results include summarized reporting of ASTM D2487& D422

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CLIENT: WOODSON ENGINEERING & SURVEYING, INC.
Sampled: 04/01/09

93212(2.2w): 09113-71

APPENDIX
B.53

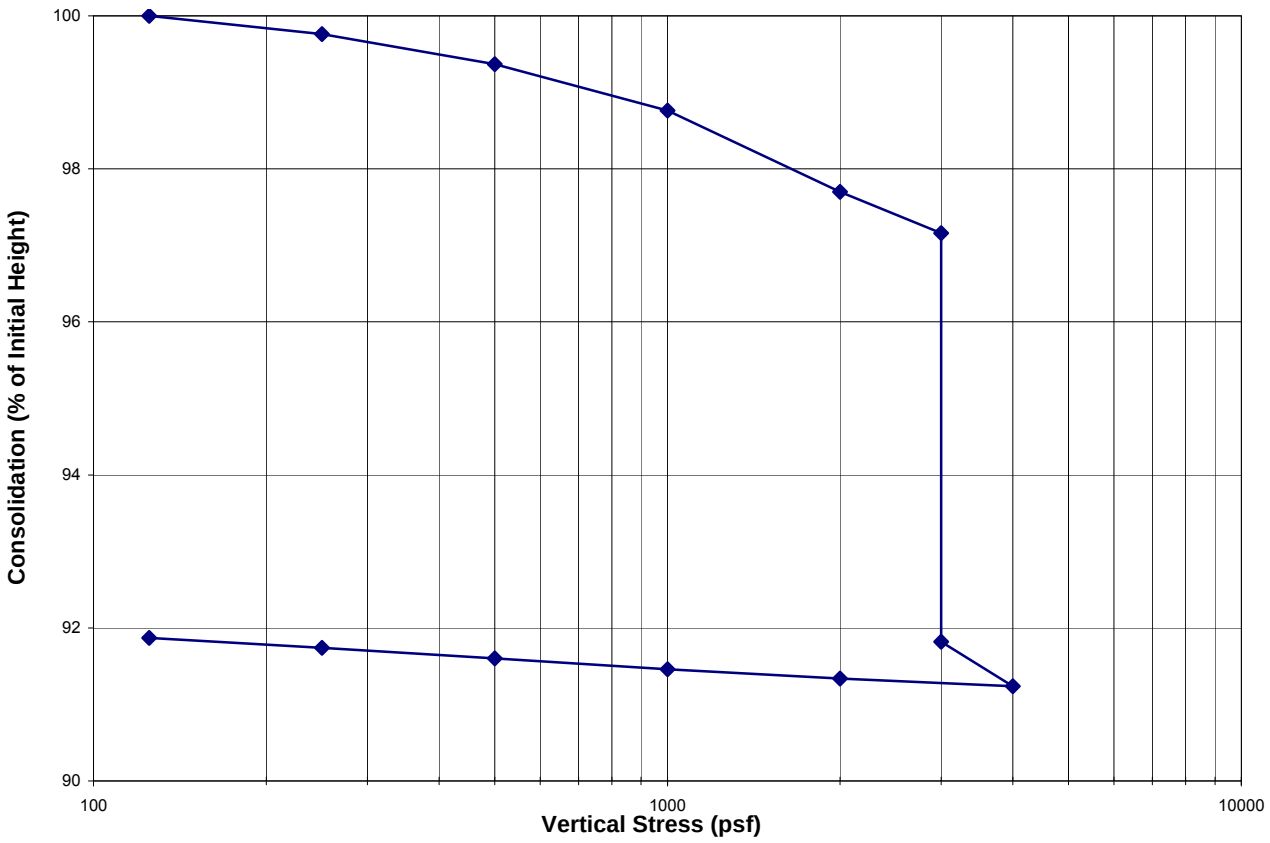
SAMPLE SOURCE: **SB-1 @ 25.5-26'**

USCS: SM "Silty sand with gravel"

SPECIFIC GRAVITY: 2.65 (estimated)

SATURATED AT: 3000 psf

	INITIAL	FINAL
Moisture Content (%)	4.7	16.4
Dry Density (pcf)	103.3	112.6
Degree of Saturation (%)	20	93
Void Ratio	0.6	0.5



Results include summarized reporting of ASTM D2435

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RUBY WASH DIVERSION LEVEE

STA 165+00 to STA 381+50

CLIENT: WOODSON ENGINEERING & SURVEYING, INC.

Sampled: 04/01/09

93212(2.2w): 09113-13

APPENDIX

B.54

APPENDIX C

Geophysical Reports

Geophysical Survey Tests at the Winslow, AZ Levee

Jim O'Donnell- Geophysical Contractor- January 12, 2008

Seismic Refraction Microtremor, ReMi (Vs), tests which measure Shear wave velocities –Vs, were run to aid in the chacterization of the Winslow Levee. Soil and rock strength is often determined by Vs, the higher the Vs the stronger or more competent the material is. Voids or loose/unpacked soils give lower Vs values. The Shear Modulus which is a measure of strength of soil/rock material is given by the product of the density and the square of (Vs). Ground Penetrating Radar, GPR, tests were also made in an effort to correlate the very shallow section with the seismic surveys and evaluate GPR for Levee chacterization.

Both methods rely on high frequencies to sense shallow and low frequencies to sense deep. GPR is an electro-magnetic radio wave, active source reflection method, and used 500 MHz bistatic antennas (Transmitter and Receiver) to sense shallow (~5 ft) and 200 MHz bistatic antennas to sense deeper (~10ft), both having very short wave lengths on the order of a few inches and less. The Levee area surveyed had built up soil/rock to heights between 10 to 20 ft. The combination of compacted soil and rock built into the Levee causes multiple reflections/diffractions which appear as clutter on the GPR profile as a result GPR interpretation becomes more of an art than a science. On the other hand a line off the Levee was able to track a shallow dipping layer quite well. In other words, experience in seeing such clutter before and sorting it out is very important, as in general pseudo (false) anomalies are numerous in GPR profiles.

The seismic method uses elastic waves, which utilized both active and passive sources, and measured frequencies from ~5 to 100 Hz. The 100 Hz yielded the shallow depths and the 5 Hz the deeper depths, both giving wave lengths on the order of ~1.0 ft to 200 ft. For the 1D model the Velocities were an average over the line length of 230ft and for the 2D models the Velocities were an average of a 110ft line length. These longer seismic wave lengths are averaging the geology over the line length which gives smooth looking results compared to the GPR scans which have such high resolution on very short wave lengths but are depth limited.

In my opinion the Seismic surveys did not detect any significant areas of weakness in the Levees which could be caused by buried washouts/voids or not having used adequate construction material. In order to see the complete Levee depth with the GPR, three (3) different sized antennas would be required (500, 200 & 100 MHz). Since we used the 500 MHz we were limited to a depth of ~4 ft. The one time we used the 200 MHz antenna we sensed ~10 ft, but lost resolution on the first ~5 ft. Consequently, all 3 sized antennas would be recommended to cover a depth of ~20ft. with adequate resolution.

ReMi Method:

In spite of its name ReMi is not a refraction method, but becomes extremely useful in ascertaining Vs from both passive and active sources. Both shallow and deep Vs can be determined by changing the geophone spacing (controls resolution) and lengthening the line (controls depth).
The ReMi method uses background noise for signal, Rayleigh waves, which are generated from wind, nearby traffic, and nearby hammer pounding. A big part of the Rayleigh waves are formed from Shear waves and the Shear wave velocities can be obtained from analysis of the ReMi data. Actually, the ReMi method is one of three Surface Wave methods used to compute average Vs down to a 100 foot depth which is required by the International Building Code for Geotechnical work (IBC-2006). The other two methods are the better known Spectral Analysis of Surface Waves

(SASW) and Multiple Analysis of Surface Waves (MASW). The MASW method has recently been used for evaluation of Levees in New Orleans, New Mexico, and N. Texas (see Ivanov, J., et al, 2006 & 2007). All three methods can be used to compute a 1D model as the Vs changes with depth. The big difference between the three methods is ReMi routinely uses Passive Rayleigh waves (background noise) while the other two prefer an Active source such as hammer hits which limit the depth of investigation. Quasi 2D Vs models can also be calculated from the data, which allows for seeing changes along the surface (horizontal direction).

The five seismic lines (S1 to S5) were recorded using 4.5 Hz geophones with spikes, consisting of 24 geophones with 10ft spacing, giving a line length of 230ft. In addition, the seismic data was collected utilizing Seismic Sources Co., 24 channel, DAQLink II digital seismograph and data acquisition software Vibroscope V2.3.35. Multiple Vs data sets, ten to thirty, were collected at a sample rate of two milliseconds for intervals of 30 seconds for each site. The Thunderbolt II (a sleeve hammer) was used to generate the higher frequency signals.

In general seismic methods are much more global in nature than borehole measurements, which only measure rock properties in the borehole or very close to it. Furthermore, the ReMi method is more global than the GPR method which has very good resolution due to the high frequencies used. Consequently, when we measure the ReMi data over a line length, in our case L=230 ft (1D) or 110 ft (2D), we are getting an average Vs over the entire length of the line. The measured depth is proportional to the line length, the wave length of the Rayleigh wave recorded, and the velocity of the rock material. The longer wave lengths penetrate deeper and measure to deeper depths than the shorter wave lengths (higher frequencies) which are limited to shallower depths. The wave lengths we encountered were on the order of 2 to 200ft which is an indication of the geology we are able to sample.

The ReMi data was analyzed using Optim software which computed the Velocity Spectra (p-f domain) from the field data, stacking the Spectra, and then picking the Dispersion Curve (DC). The DC was then modeled to give a 1D model with changing Vs layers with depth. Good references for the ReMi method are: John Louie's original paper on ReMi (2001), and a recent ReMi case-study by Pullammanappallil (2006).

Results:

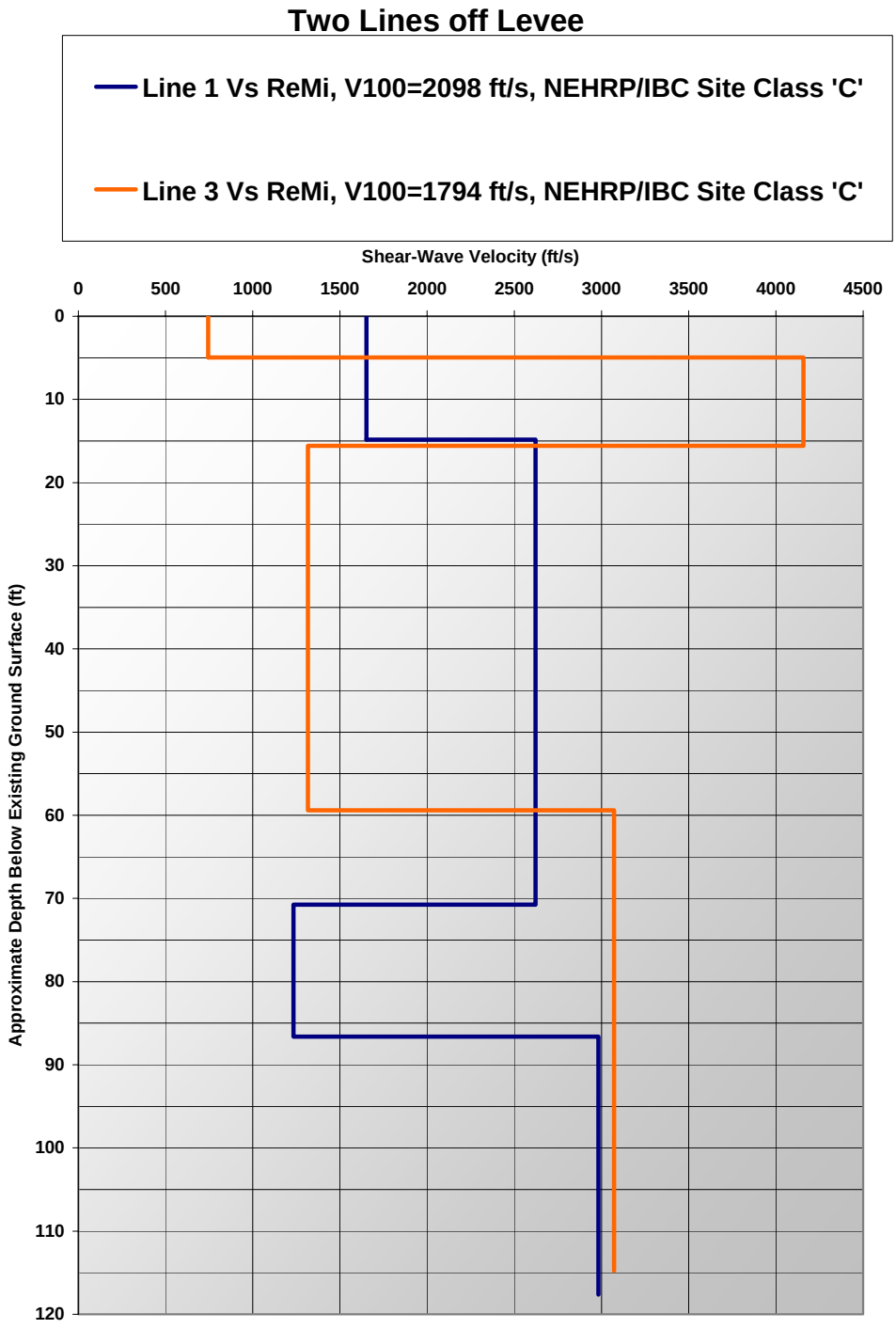
The Vs 1D models: See Levee 1D Vs Models

The five (5) models show that the Levee lines (S2,S4 & S5) have similar Vs values down to ~15 ft with S4 and S5 having the most similar models overall; these 2 lines are separated by a distance of ~3,000 ft. Lines S2 (on Levee) and S3 (off Levee), are only ~ 500 ft apart but yet they show the greatest difference in their models. In order to account for their large difference in the High and Low velocity layers- consider the following geologic model:
The native rock becomes fractured which lowers the rock Vs considerably, and some of it eventually gets recemented causing a considerable increase in the original Vs.

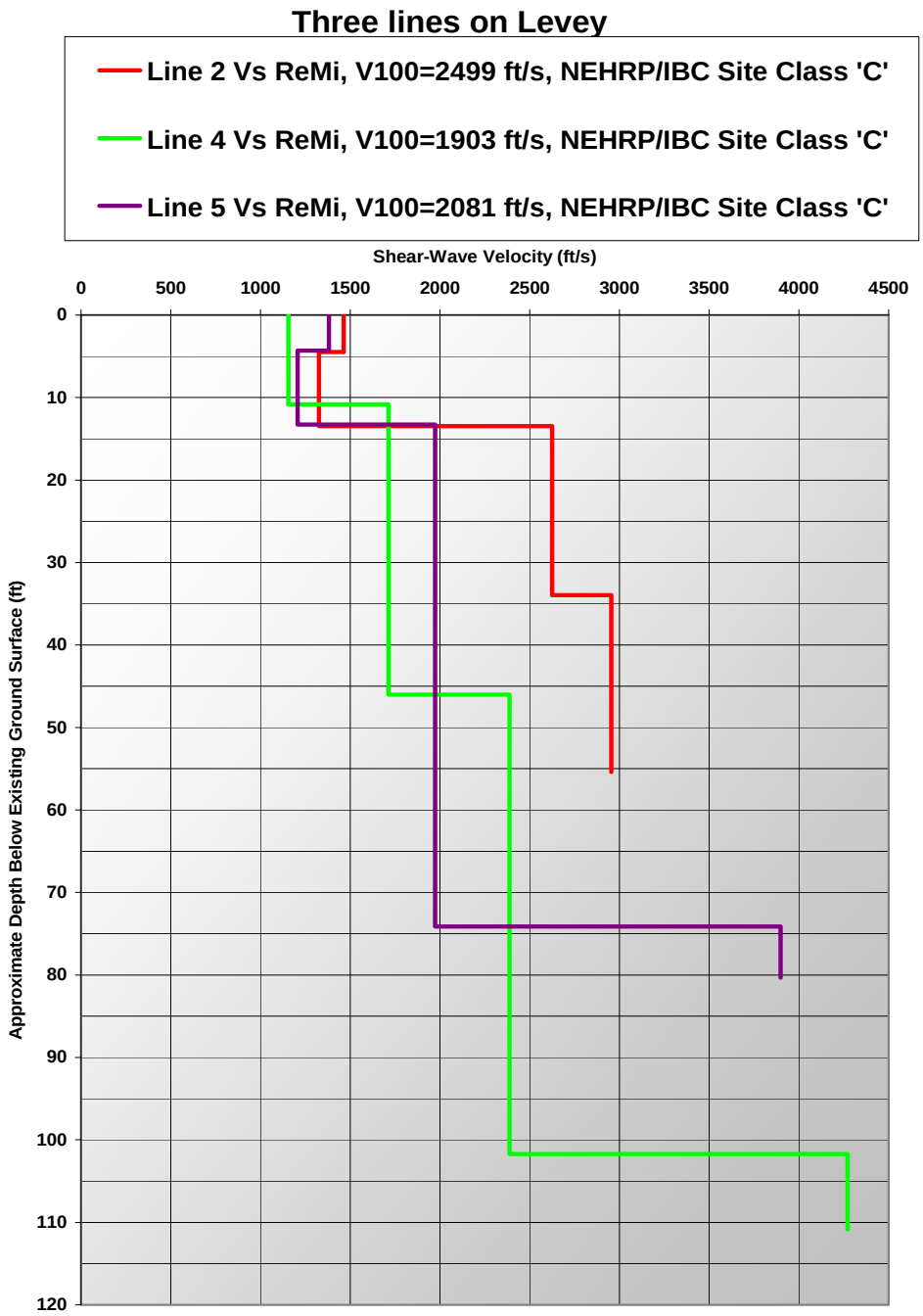
The 2 Lines off the Levee show 1D Vs model differences all the way down to 85 ft where they approach the same Vs. They both have velocity inversions but at different depths. The lines are only ~1 mile apart so the Vs profiles indicate significant geologic changes such as a ~40 ft vertical

displacement to align the 2 profiles.

1D Vs Models:



The 3 lines on the Levee show low 1D Vs models down to ~12ft where they all increase significantly are indicating a much stiffer soil/rock at depth. L4 & 5 are more similar than L2 and are located at the West end of Levee, ~3/4 mile apart.



You can expect the 1D & 2D models to differ when the geology changes along the line, as the 1D model is an average of the Vs along the total line length which is 230 ft. The 2D models are calculated from a Line length of 110ft, and moved 30 ft then recalculated to give 5 models which are merged together to give a 2D profile. The 2D models are averaged over 110 ft before merging together.

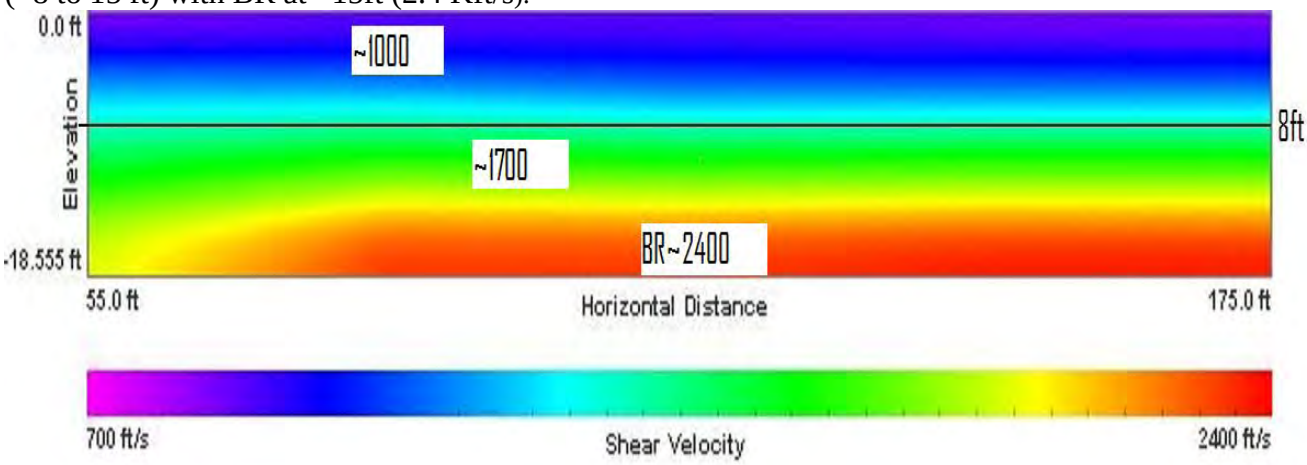
<u>The Vs 2D models</u>: See Seismic 2D Vs Profiles

The Levee profiles, S2, S4, S5, are the most similar and show model depths to 18, 25 and 33 ft respectively. They show uniformity along the line with an increasing Vs with depth to the bottom of the Levees.

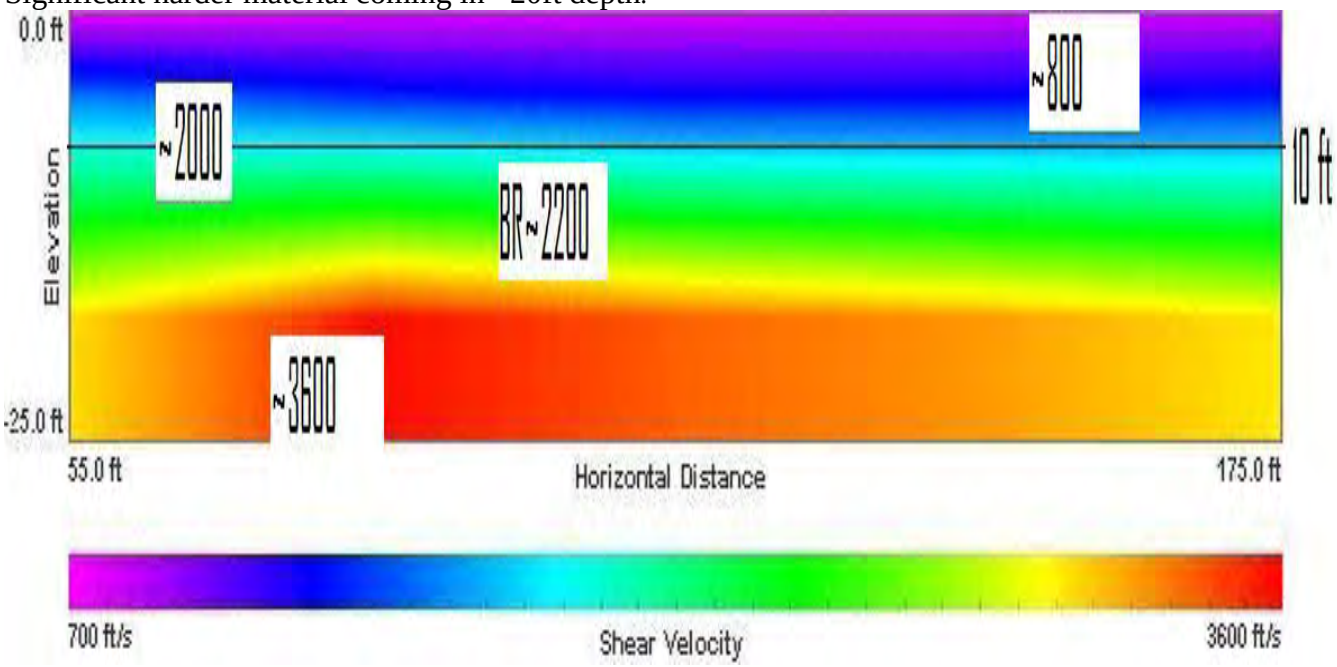
The two lines not on the Levee (S1 & S3) show a much more complex Vs model- with Low and High Vs material as well as going much deeper. The higher Vs allows for longer wave lengths and deeper penetration than found on the Levees.

Geologic interpretations of 2D Vs Seismic Profiles from ReMi method: Assume Bed Rock (BR) velocity is <u>Vs~2-3Kf/s, which would give a Vp ~4-6Kf/s;</u> higher velocities represent harder rocks which can come from stronger cementation, where fracturing lowers the velocity. (West, NW is to the left & East, SE is to the right.)

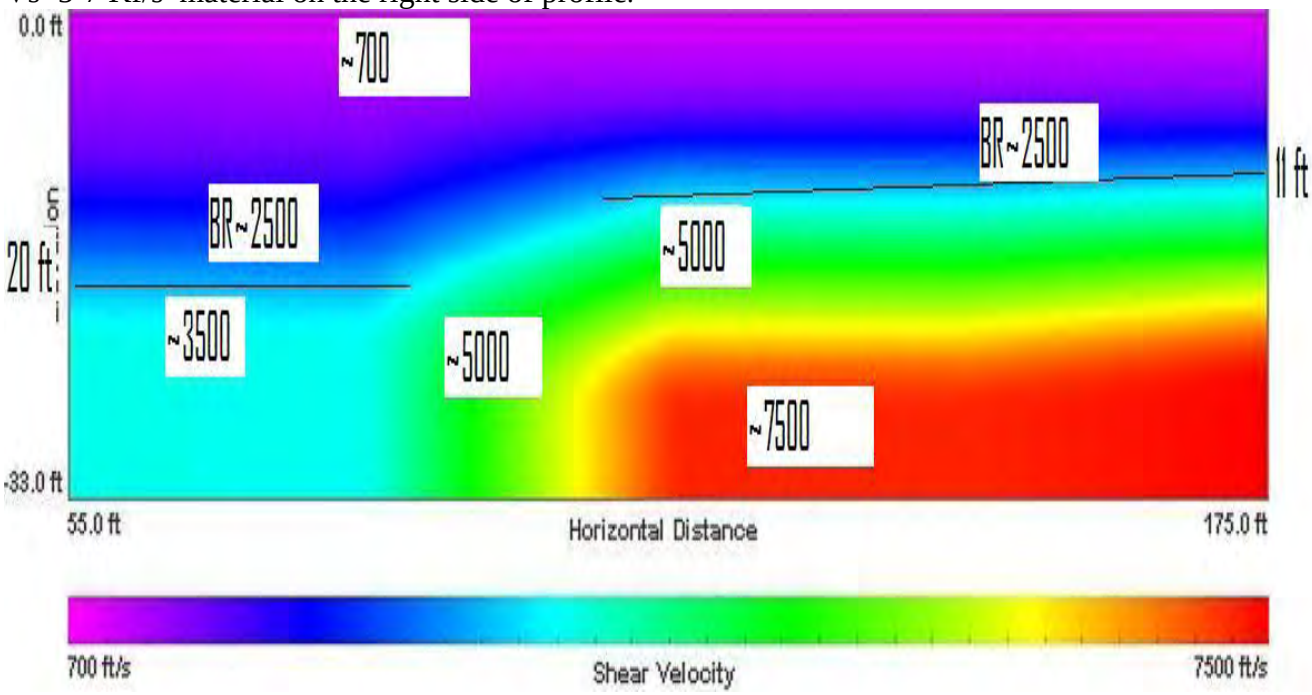
S2 on Levee- (Near B26) Levee soil stiffness increasing with depth (0 to ~8ft), then native soil/rock (~8 to 15 ft) with BR at ~15ft (2.4 Kft/s).



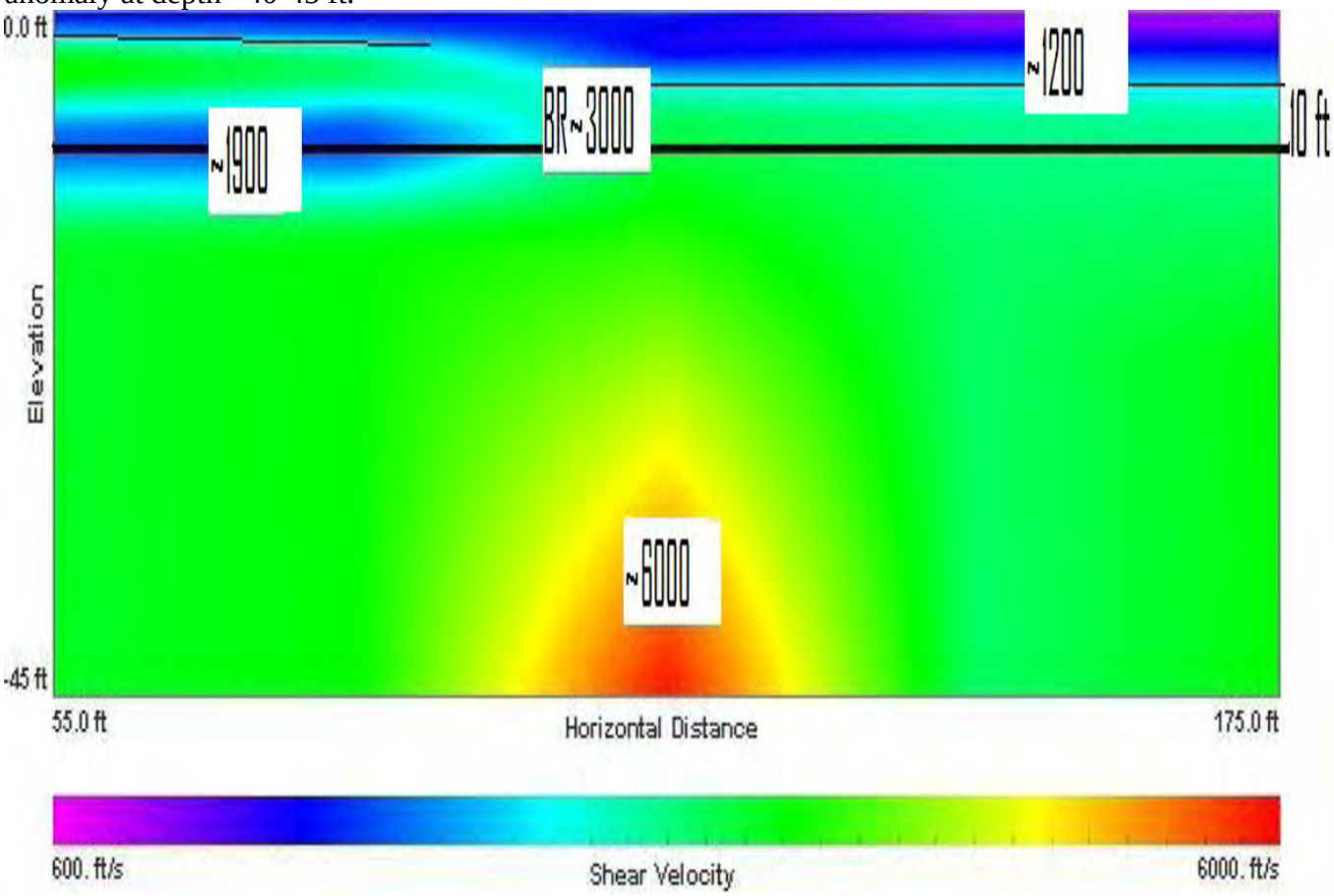
S4 on Levee- (near B9) Levee soil increasing stiffness with depth to ~10ft, BR starting ~11ft. Significant harder material coming in ~20ft depth.



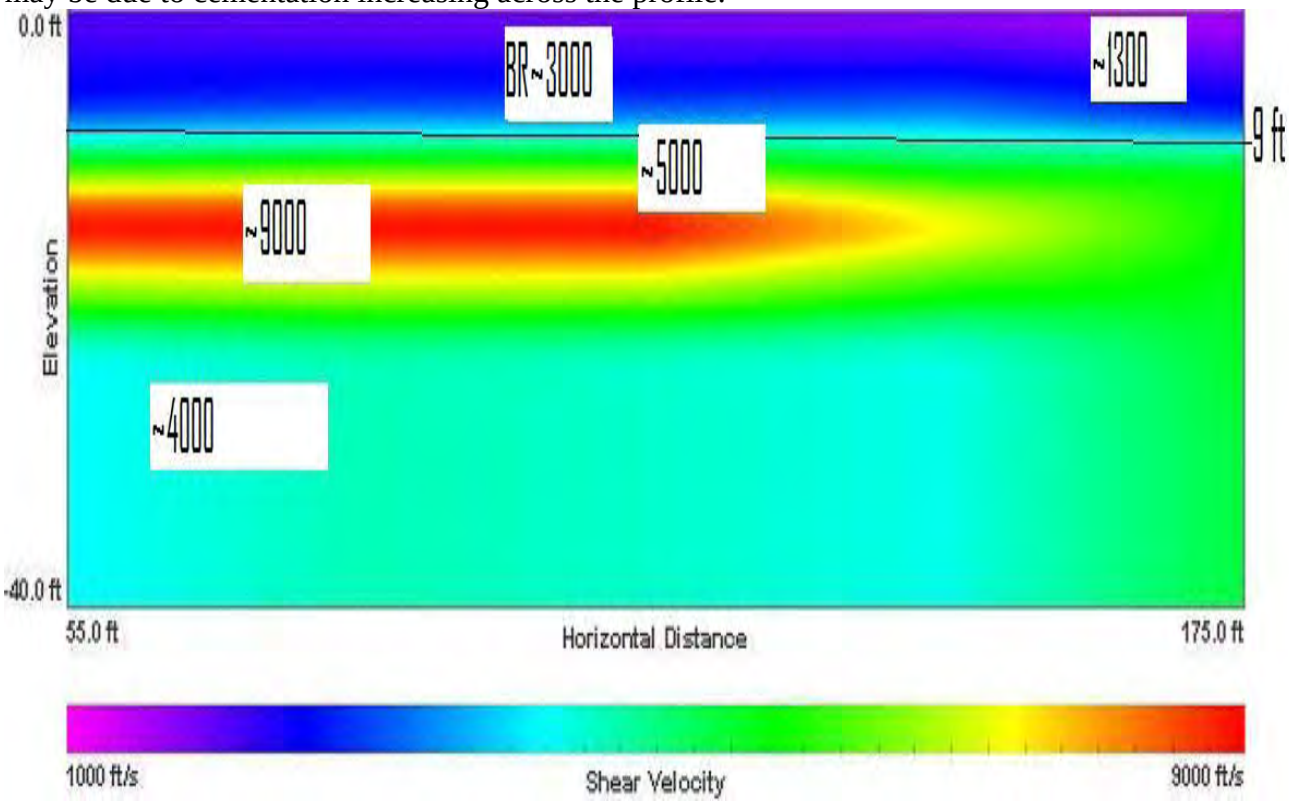
S5 on Levee- (near B2) shows increase in stiffness of soil on Levee with depth to ~10ft, with BR (Vs~2.5 Kf/s) at ~11ft. A possible buried stream channel can be seen on the left and higher Vs~5-7 Kf/s material on the right side of profile.



S3 off Levee (near B2) shows thinning & dipping soil to the East, with BR (Vs~3Kft/s) at 5 ft and less. A lower Vs Lens (Vs<2Kft/s) can be seen at ~10ft on the left side; and a higher Vs~6 Kft/s anomaly at depth ~40-45 ft.



S1 off Levee- (near B16) shows soil increasing velocity with shallow depth and BR starting ~8ft (Vs~2-3Kft/s) and hard possible Caliche lenses (Vs~9Kft/s) at ~15ft. Vs variation of Vs below lens may be due to cementation increasing across the profile.



GPR Profiles/Scans

The GPR system used was the Canadian Sensors & Software Inc. "pulseEKKO PRO" for data collection utilizing a SmartCart, and the "EKKO View Deluxe" analysis program.
See http://www.sensoft.ca/products/pulseekko/pulseekkopro.html
The data was stacked in the field using ~30 records with a WOW filter.
All the lines were done using the 500 MHz bistatic antennas- On & off the Levee. One Line near S1, on the Levee, used both 500 MHz and 200 MHz bistatic antennas for comparison to see shallow & deep respectively. The method measures reflected time and is converted to depth by assuming a velocity. The usual way to obtain GPR velocities is to measure the sides of a hyperbole in the profile. The value obtained using this calibration scheme was 0.60 ft/nanosecond-ns, (Velocity in air is 1ft/ns and all rocks are slower). Dry rocks are usually on the order of 0.5ft/ns.

The GPR Scans showed no indication of voids being present.

F1. S1- is off the Levee and shows a dipping layer (probably in the Moenkopi formation) to the West and is able to track the bed to a depth of ~5ft. The line was run in both directions W to E and then E to W, and repeats itself rather nicely. **The dipping bed only has ~2 degree dip, but the dip is exaggerated due to the Vertical to Horizontal scales used.**

F2. Line BH16, which is off the Levee was centered on BH16, and was run in a SW to NE

direction, starting by geophone #16. It shows some disturbed beds but they too are exaggerated due to the scaling involved.

F3. Line BH17, was on the Levee, and is the only line which used the 500 & 200 MHz antennas: it clearly shows both antennas are needed to see the high resolution shallow (~5ft) and deeper depths (~10ft). I actually have a 100 MHz antenna which could have possibly see down to the bottom of the Levee assuming ~20ft height.

F4. Line S2 was run on the Levee W to E with BH26 located to the E. It appears not to see as deep probably due to more attenuation caused by more moisture in the rocks.

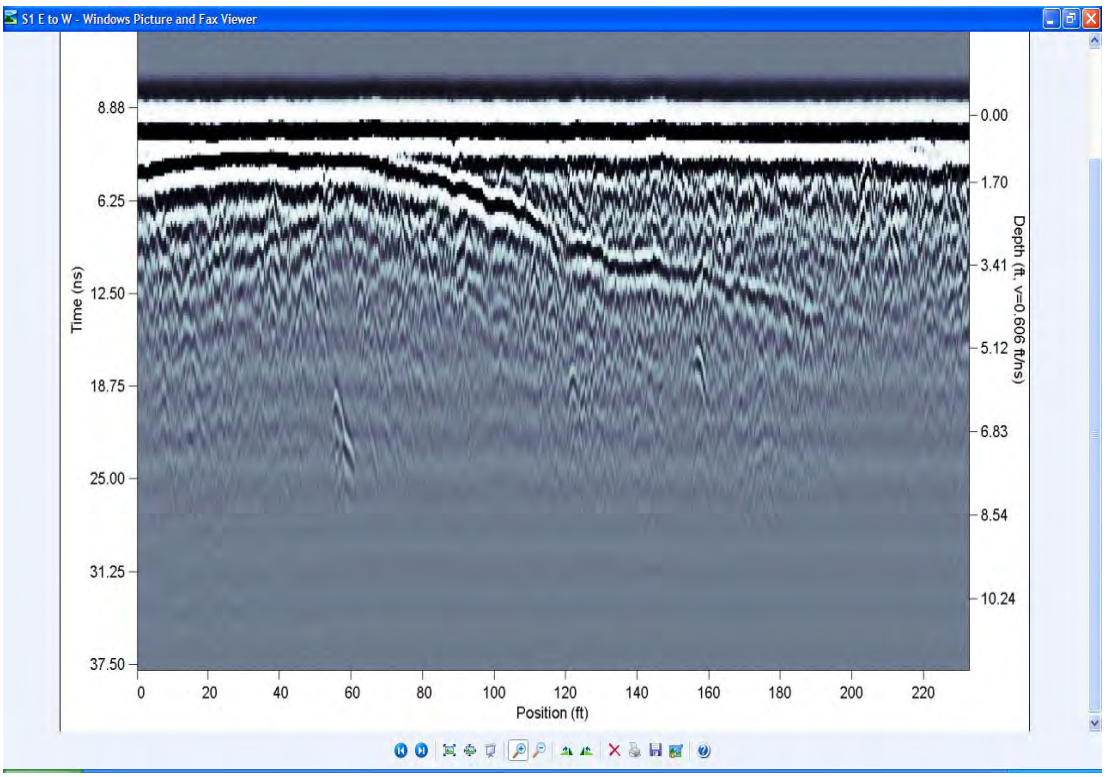
F5a. S3 is off the Levee, near BH12, running W to E for a distance of only 60 ft. It was a short line due to the vegetation/brush which allowed using geophones but would be required to be removed to run GPR. At ~40ft distance a layer seems to disappear, at ~3.5ft depth. There are several hyperbolas present indicating reflections off boulder like rocks.

F5b & 5c. The 2 short lines (18ft) are very similar and were run very close to the BH2 in a W to E and N to S direction. They did not get much penetration probably due to moisture in soil.

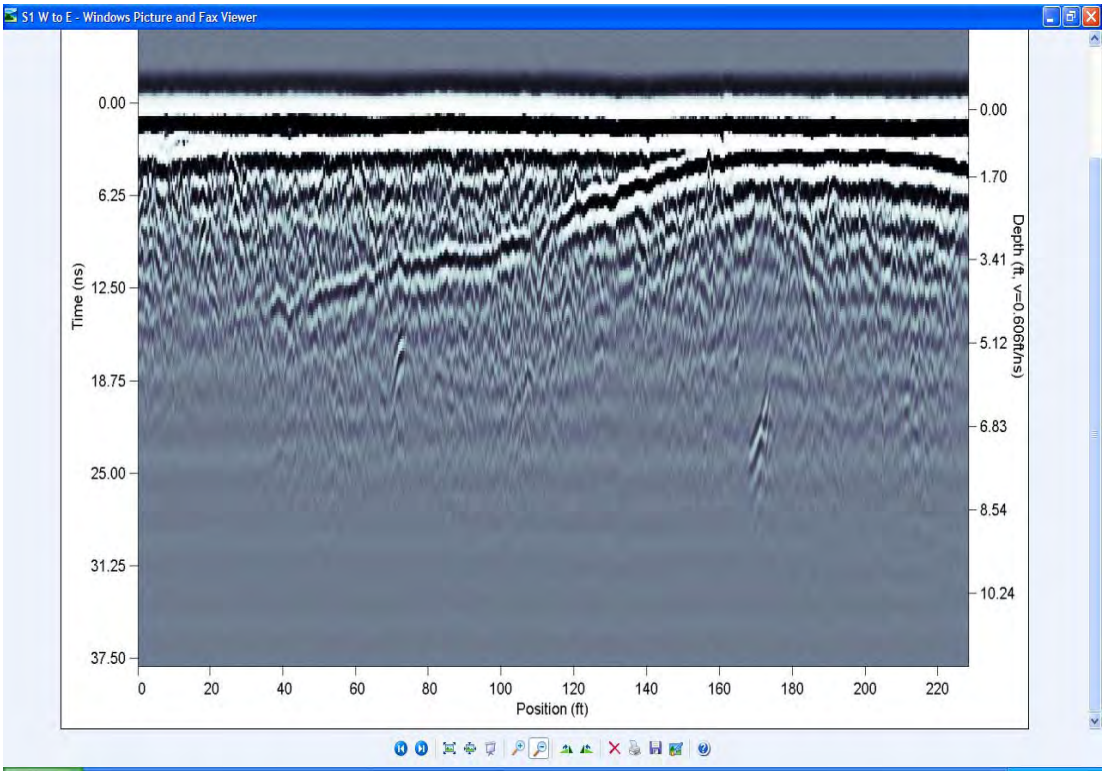
Fig 6. S4 is on the Levee for a length of 140ft and is short due to a vehicle parked on the Levee.

<u>No GPR profile for S5.</u>

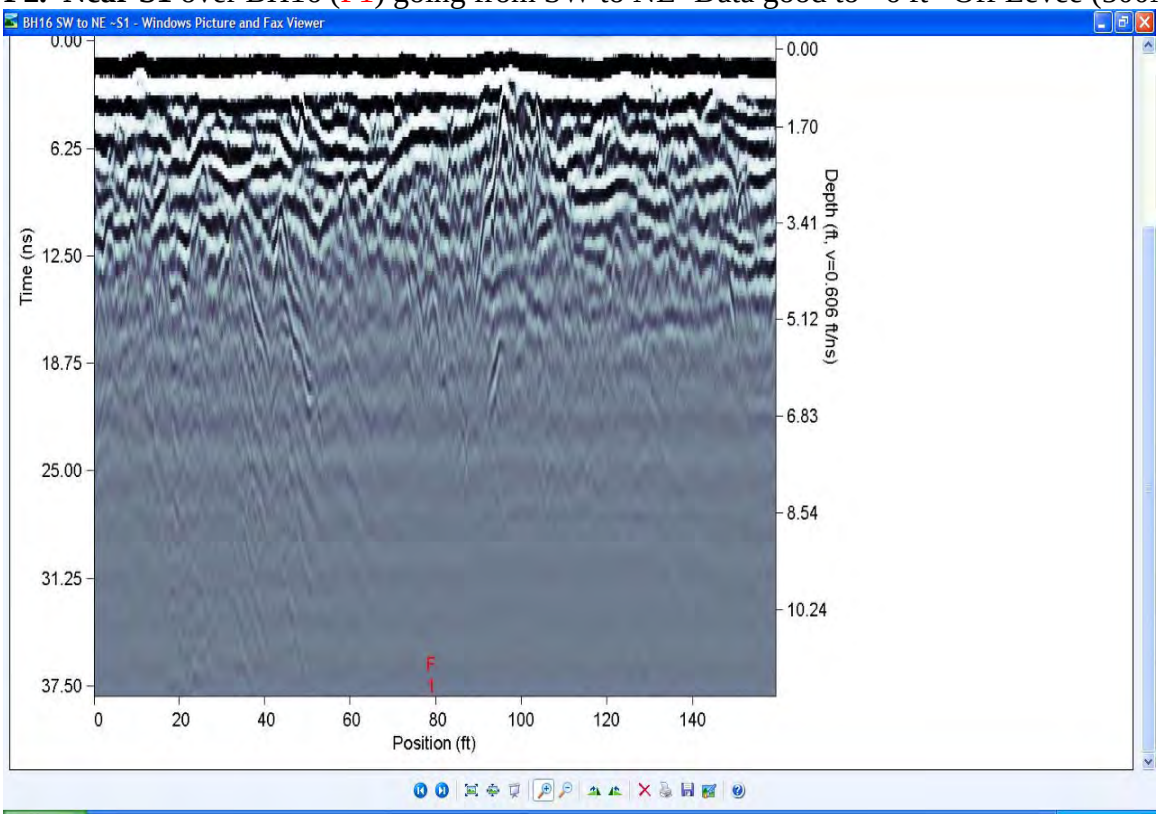
GPR Profile Scans- F1. Line S1 GPR 500 MHz antennas going E to W- covers geophone 24 to 1 (230 ft)-Data interpretable to ~6ft. The dip angle is only ~2 degrees as horizontal & vertical scales are so different.



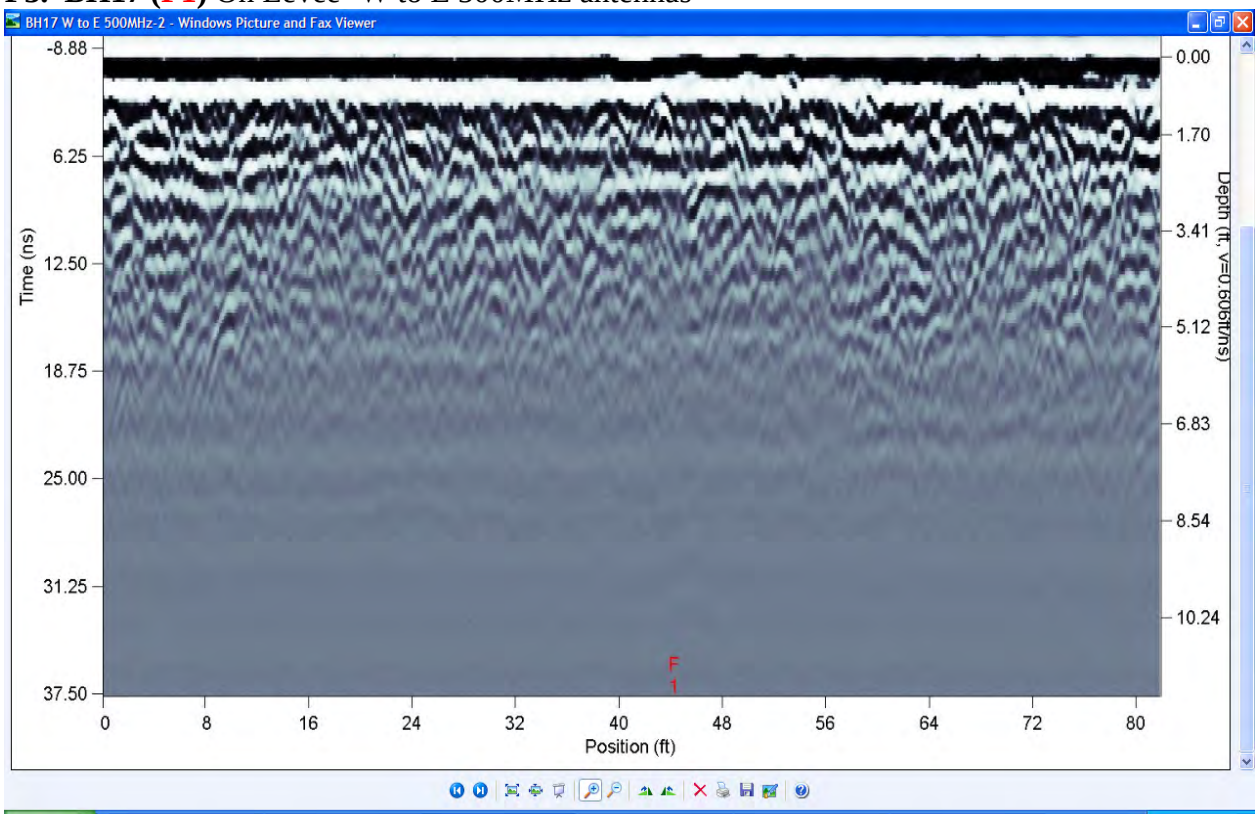
Line S1 GPR 500 MHz antennas going W to E covers geophone 1 to 24 (230 ft) Data interpretable to ~6ft. Note by running the profile in the reverse direction- we see the same features.



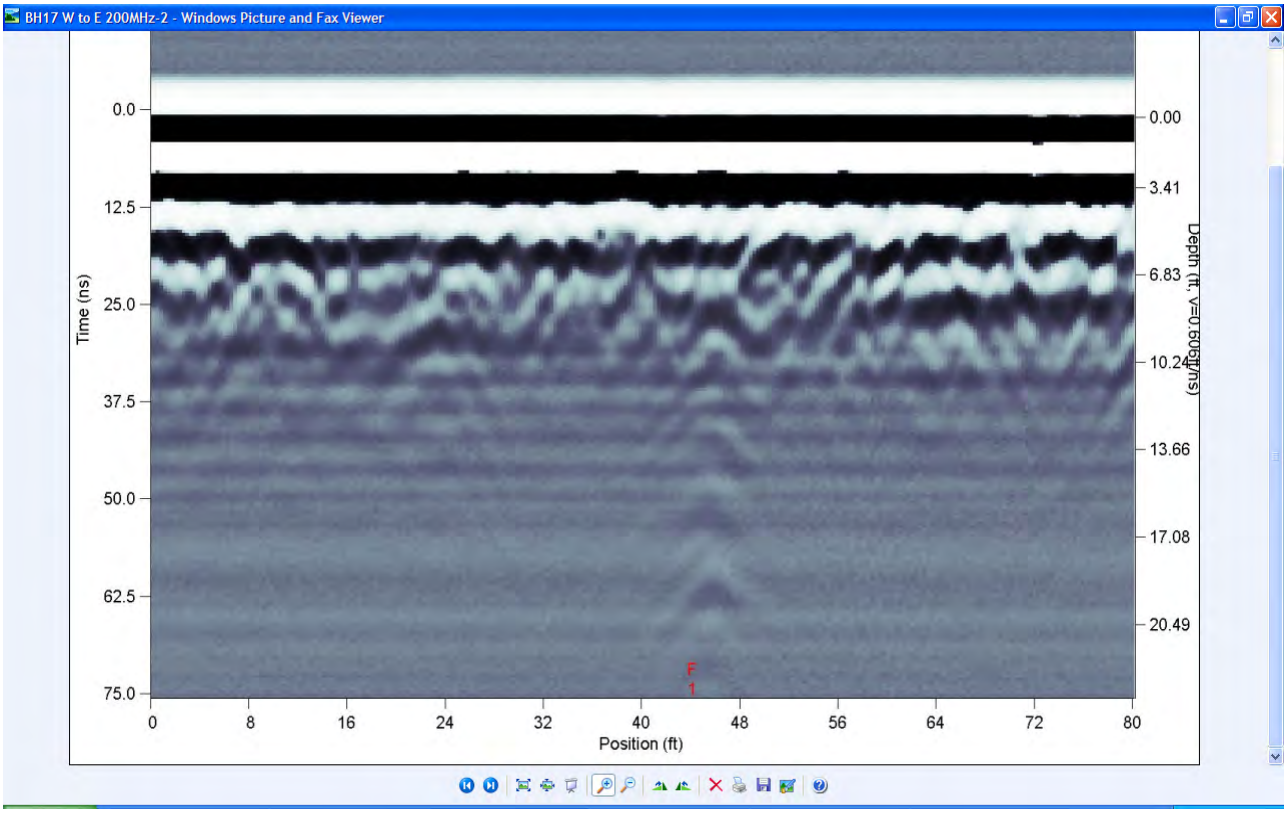
F2. Near S1 over BH16 (F1) going from SW to NE- Data good to ~6 ft Off Levee (500MHz)



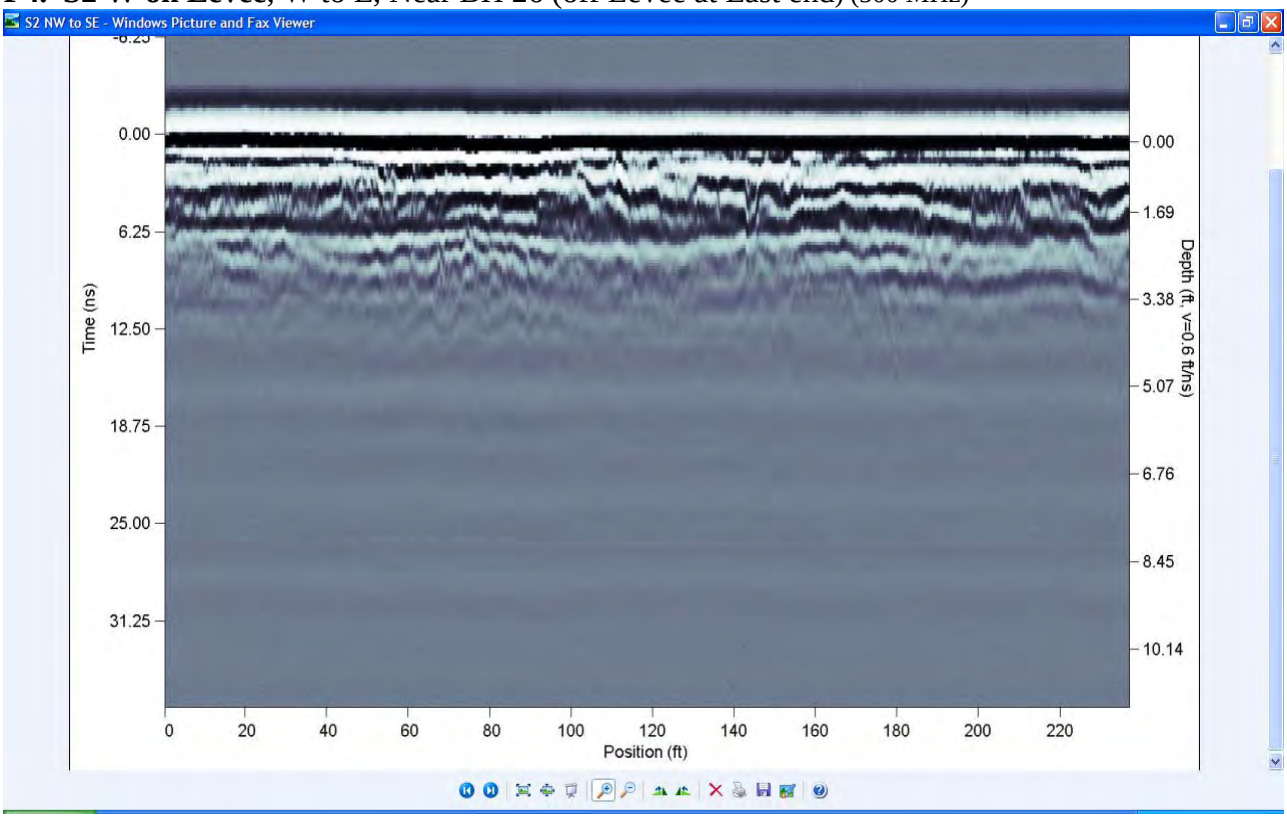
F3. BH17 (F1) On Levee- W to E 500MHz antennas



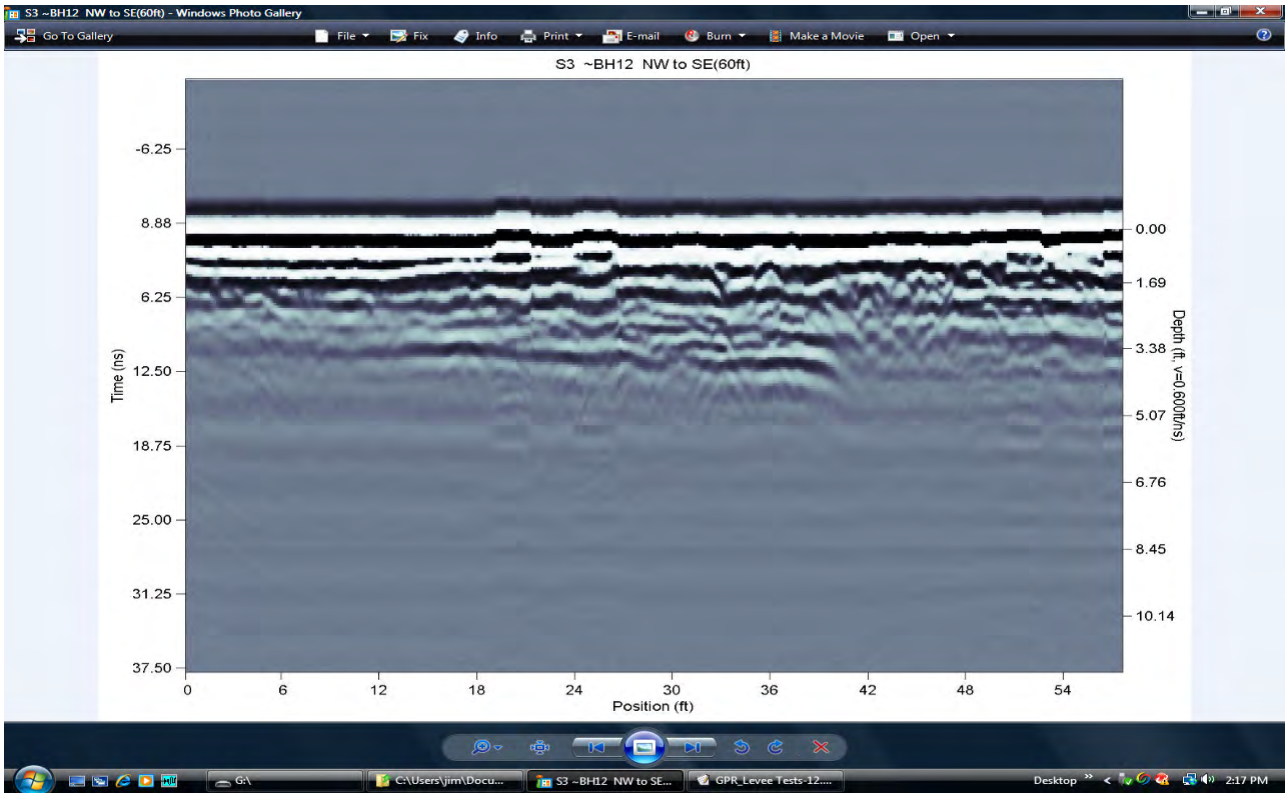
BH17 (F1) On Levee- W to E 200MHz antennas- Notice poor resolution in 0 to 5 ft, but go to ~11ft.



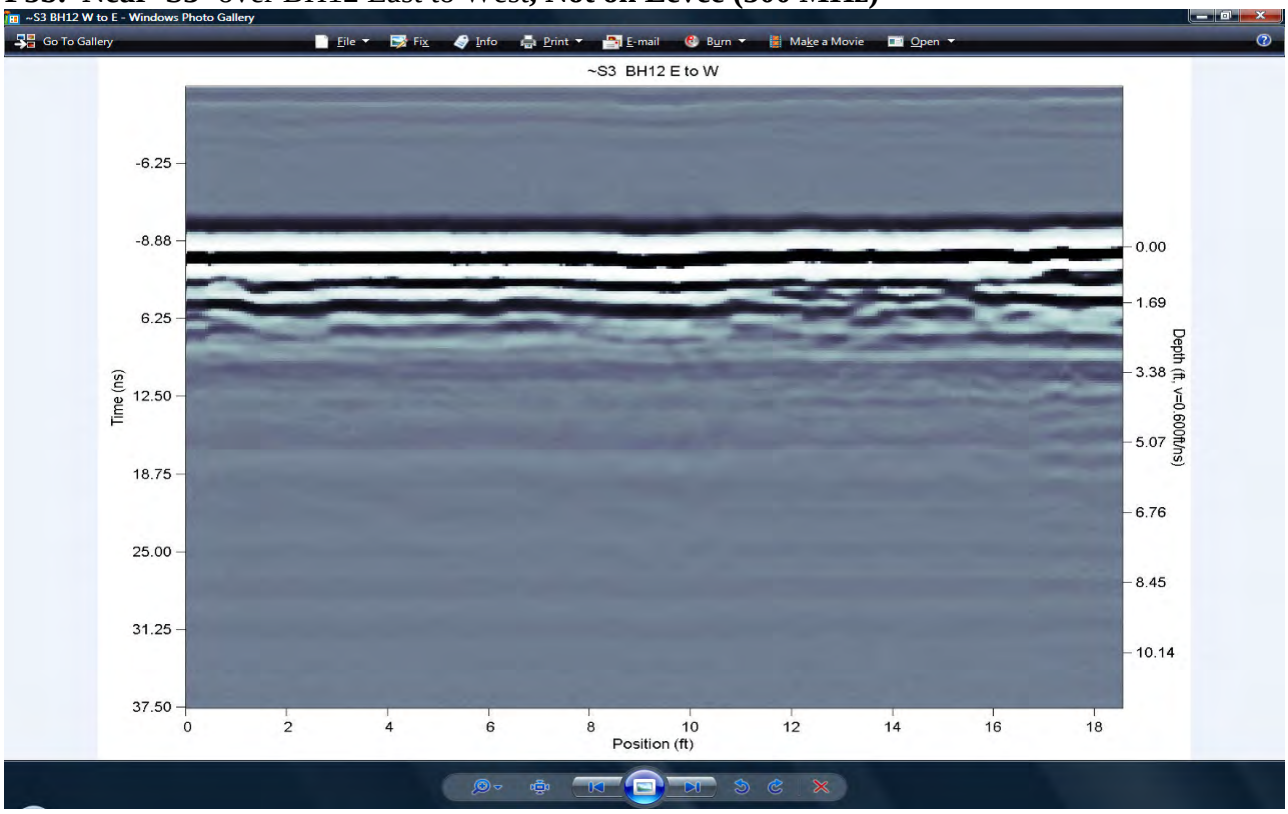
F4. S2 W on Levee, W to E, Near BH 26 (off Levee at East end) (500 MHz)



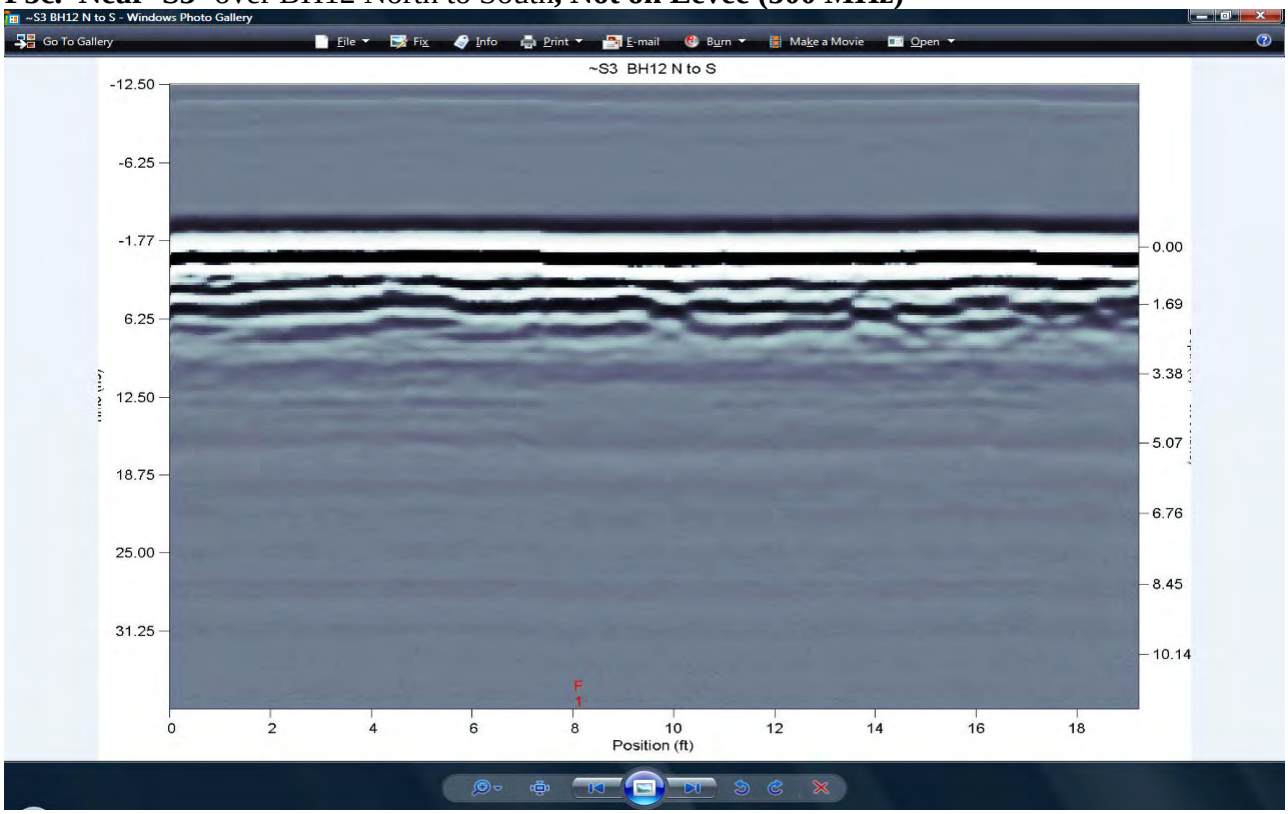
F5a. S3 W to E, Not on Levee, ~ 50ft E of BH 12- Only 60ft of GPR line due to Brush/Vegetation obstruction (500MHz)



F5b. Near S3- over BH12 East to West**, Not on Levee (500 MHz)**

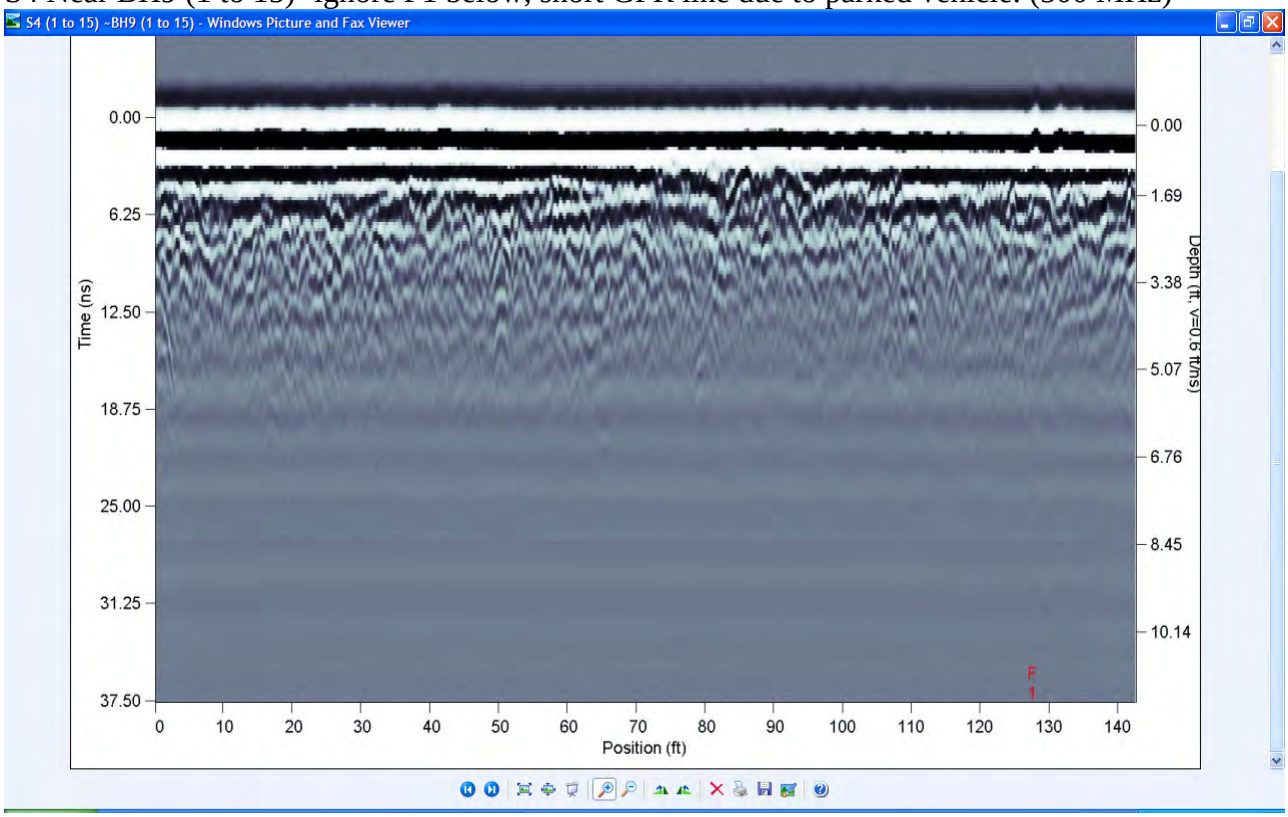


F5c. Near S3- over BH12 North to South**, Not on Levee (500 MHz)**



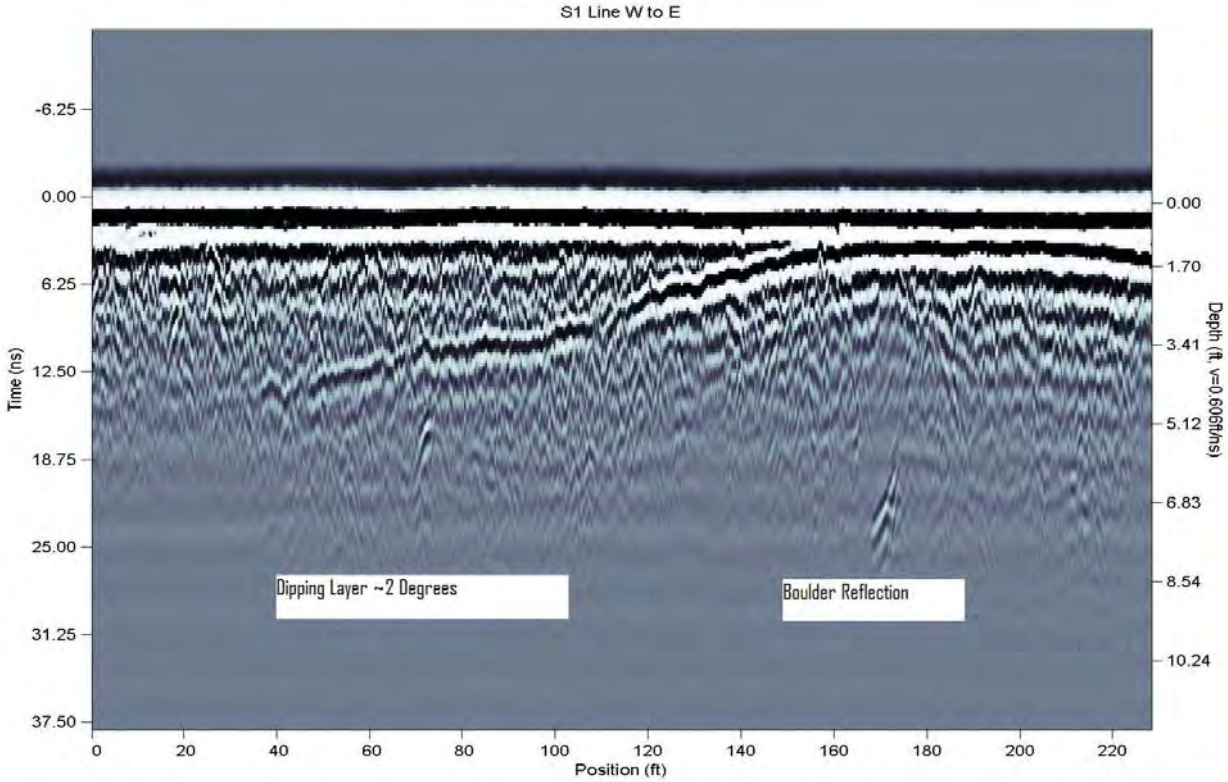
F6.

S4 Near BH9 (1 to 15)- ignore F1 below, short GPR line due to parked vehicle: (500 MHz)

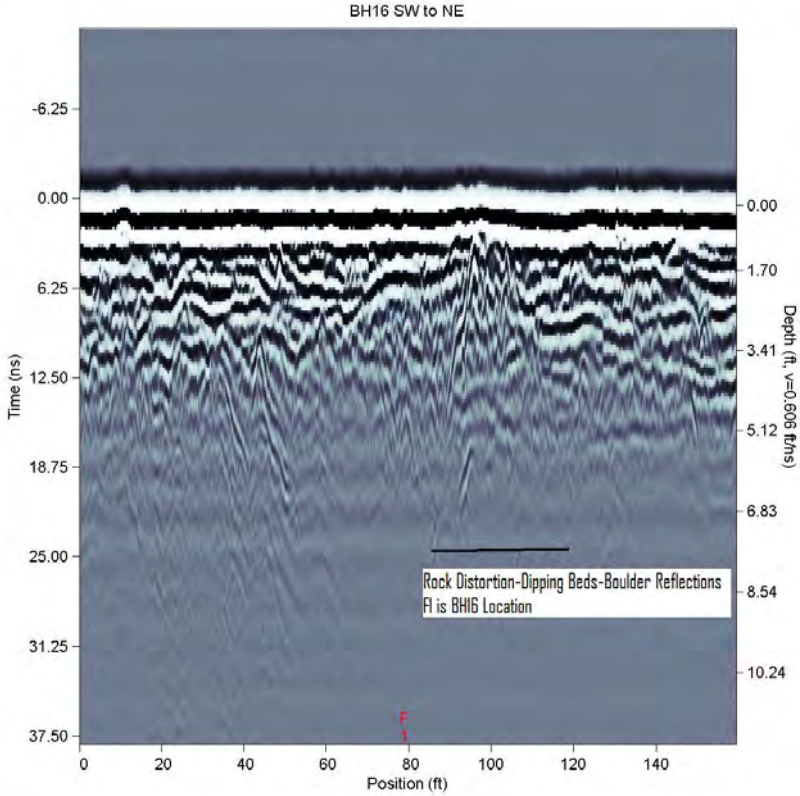


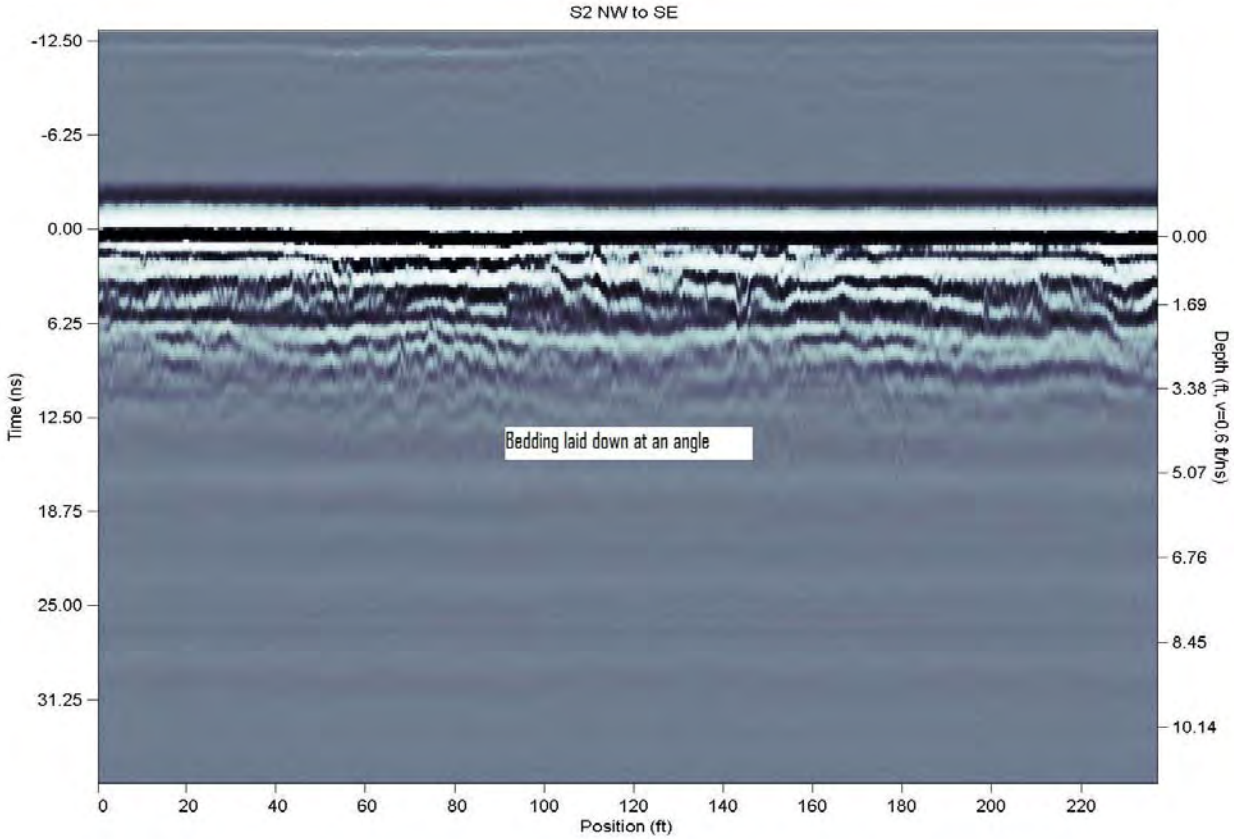
S5 W to E ~BH2 on W end, No GPR Profile

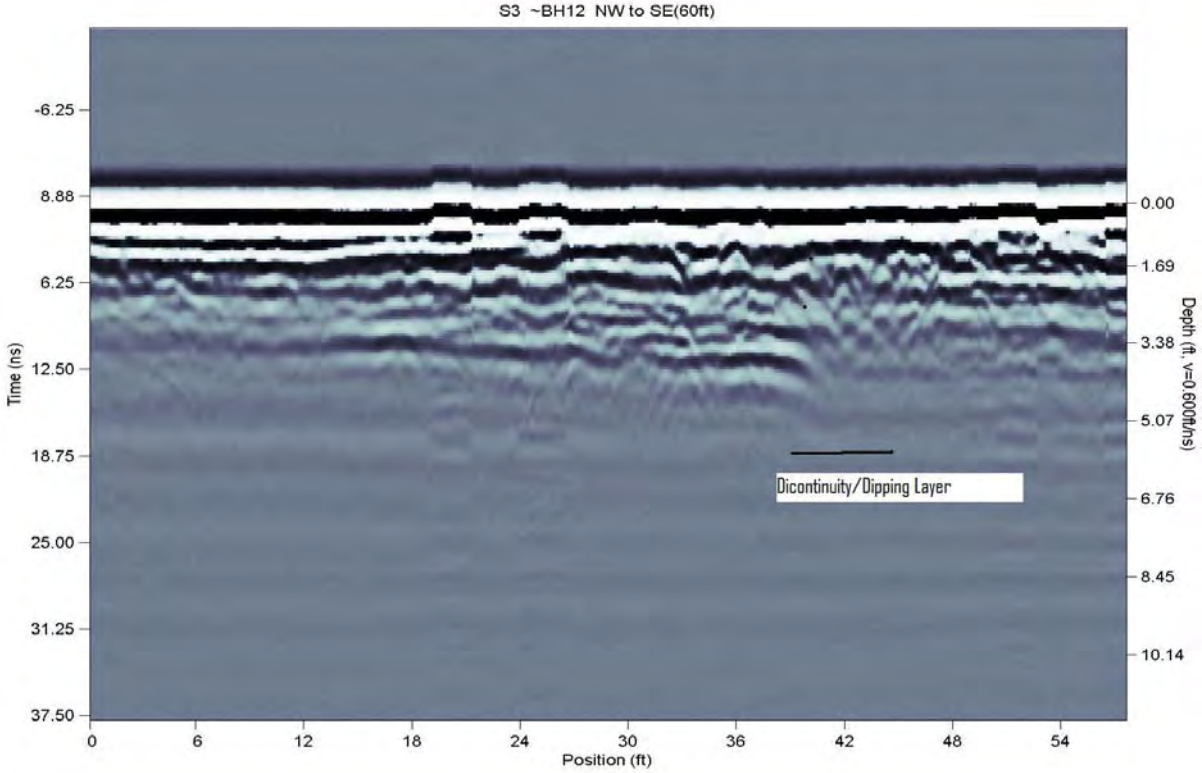
Identifying features on Scans- GPR Stratigraphy can be applied to the scans.



Line close to S1 by BH16




S2 NW to SE
Time (ns)
-12.50
-6.25
0.00
6.25
12.50
18.75
25.00
31.25
Depth (ft, v=0.6 ft/ns)
0.00
1.69
3.38
5.07
6.76
8.45
10.14
Bedding laid down at an angle
0
20
40
60
80
100
120
140
160
180
200
220
Position (ft)


S3 ~BH12 NW to SE(60ft)
Time (ns)
-6.25
8.88
6.25
12.50
18.75
25.00
31.25
37.50
Depth (ft, v=0.600ft/ns)
0.00
1.69
3.38
5.07
6.76
8.45
10.14
Dicontinuity/Dipping Layer
0
6
12
18
24
30
36
42
48
54
Position (ft)

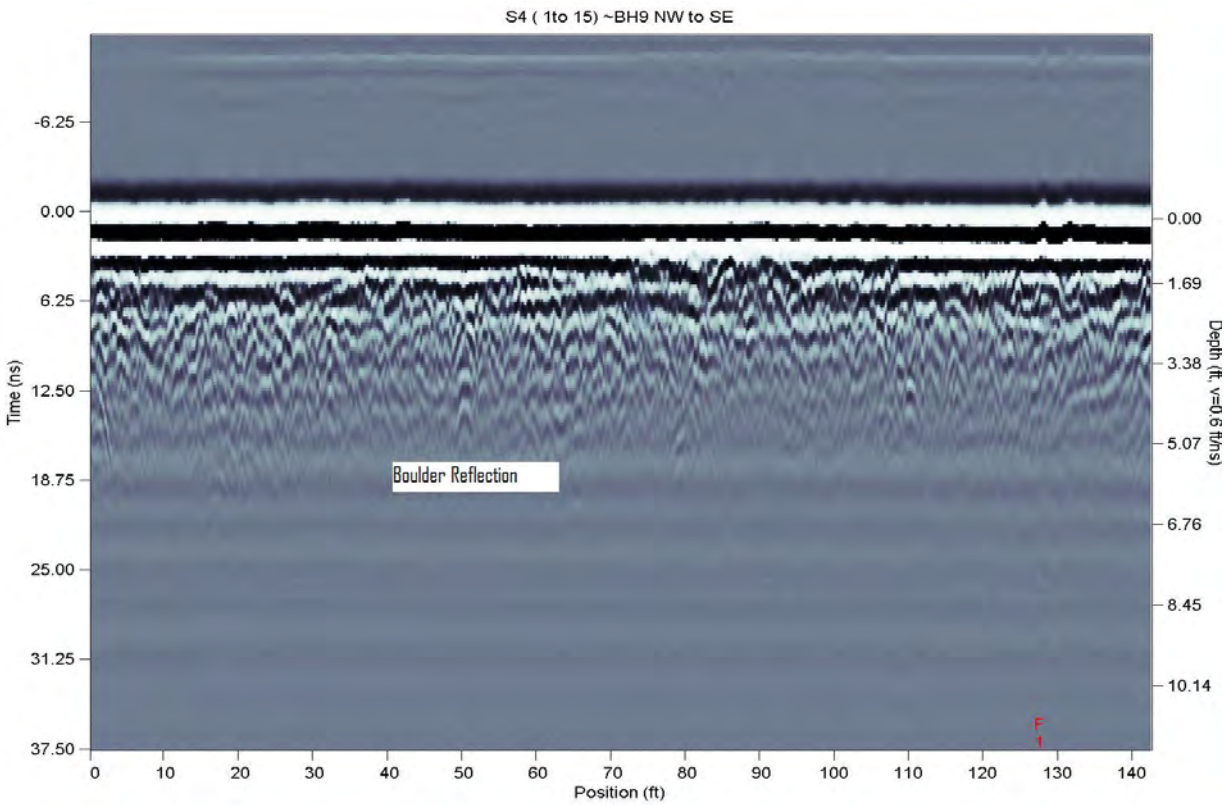


Figure 1.

Andrew Alvaro - Running GPR test along seismic line on Levee-with 500 MHz antennas.

GPR System collecting Data along ReMi Line

Seismic system-

<u>REFERENCES:</u>

Burger, H. Roberts, 1992, Exploration Geophysics of the Shallow Subsurface: Prentice Hall, Inc. (GPR section good)

IBC 2006, International Building Code®, International Code Council,

See Table 1613.5.2 and Table 1613.5.5 for Shear wave velocity site class , ISBN-10: 1-58001-302-3 (e-document)

Ivanov, J., R. D. Miller, and J. Xia, 2007, Applications of the JARS method to study levee sites in southern Texas and southern New Mexico: 77th Annual International Meeting, SEG, Expanded Abstracts, 1725–1729.

Ivanov, J., R. D. Miller, J. Xia, D. Steeples, and C. B. Park, 2006, Joint analysis of refractions with surface waves: An inverse refraction-traveltime solution: Geophysics, **71**, R131–R138.

Louie, John N., 2001, Faster, better: shear-wave velocity to 100 meters depth from refraction microtremor arrays: Bull. Seismol. Soc. Amer., 91, no. 2 (April), 347-364. http://optimsoftware.com/white_papers/images/remi.pdf

Derive one-and two-dimensional S-wave velocity from ambient (passive) and or active source using a typical seismograph and standard refraction geophones. See http://optimsoftware.com/products/

Pullammanappallil, 2006, Highway Geophysics NDE, Conference Proceedings, St. Louis, MO, Geotechnical and Geophysical case studies involving the refraction microtremor (ReMi) method for shear wave profiling.

Seismic Source Company is a manufacturer of seismic instruments and data acquisition systems, See http://seismicsource.com/phpnuke/html/index.phphttp://seismicsource.com/phpnuke/html/index.php

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Boulder City, NV

Geophysical Survey Tests at the Winslow, AZ Levee

Jim O'Donnell- Geophysical Consultant/Contractor- May 11, 2009
Field work performed by Jim O'Donnell, Jim Houda; and Andrew Alvaro-Kleinfelder

Seismic P-wave (Vp) refraction tomography lines were run on and near the Winslow Levee to aid in characterizing the Levee. Line 1 was made off the Levee to better define an anomaly seen on a previous seismic survey using the Seismic Refraction Microtremor (ReMi) method, S-wave (Vs). The Vs test interpretation was a possible buried stream channel cutting below the Levee. The ReMi method was used in the first survey as it works when there is a velocity inversion with depth but the refraction method does not. It was determined from the ReMi tests that only minor velocity inversions were encountered so the Vp refraction tomography method was employed as it gives much better resolution and more accurate velocity models than the ReMi method. A second Vp line, Line 2, was run on the Levee where a buried Culvert goes through the bottom of the Levee. (See Site Location maps-attached.)

Ground Penetrating Radar, GPR, tests were run on both Lines 1 and 2, to look for a correlation between the seismic and GPR measurements, as well as zones of weakness or voids in the subsurface. A GPR line was also run on top of the Levee next to Line 1 for detection of voids or zones of weakness in the Levee.

Field Parameters:

The two seismic lines (Line1 & Line2) were recorded using 4.5 Hz geophones with spikes, consisting of 48 geophones with 5ft spacing, giving a geophone spread of 235ft. A Hammer source was utilized for a seismic source using ten (10) Shot Points (SP) with each SP having 5 hits, which were stacked later. The SP's were located evenly along the line with 2 Shot Points being 10 ft off each end of the line; this essentially makes the Lines 255ft. To extend Line 1 even further another Line was set up with overlapping geophones (9) to increase the length to 455ft. Data sampling was done at 1/4ms with a time record of 0.3s. In addition, the seismic data was collected utilizing Seismic Sources Co., 48 channel, DAQLink II digital seismograph and data acquisition software Vibroscope V2.3.35. See http://seismicsource.com/phpnuke/html/daq.php

The GPR system used was the Canadian Sensors & Software Inc. "pulseEKKO PRO" for data collection utilizing a SmartCart. See http://www.sensoft.ca/products/pulseekko/pulseekkopro.html The GPR system utilized three (3) different antennas- 100, 200, 500 MHz; and the data was stacked in the field using ~10-30 records.

Processing Parameters:

The First Break (FB) picks and the geometry of the lines are all that is required to process the Vp Tomography data. Jim O'Donnell made the First Break picks and formulated the geometry- SP and geophone locations. With 48 geophones and 10 SP's, we have a possible 480 FB picks or Raypaths to calculate a Vp model. For Line 1 where we essentially joined 2 lines together we have a possible 960 Raypaths to define the subsurface. The modeling was done by Dr. Satish Pullammanappallil, of Optim Software in Reno, NV, using their **SeisOpt® @2D**™; program which derives 2D subsurface velocity structure from surface acquired seismic data.

The GPR data was analyzed by Jim O'Donnell using EKKO_View, a program from Sensors & Software, Inc. The method measures reflected time and converts to depth by assuming a velocity. The usual way to obtain GPR velocities is to measure the sides of a hyperbole in the profile. The value obtained using this calibration scheme was 0.30-0.50 ft/nanosecond-ns, velocity in air is ~1ft/ns (0.98ft/ns) and all rocks are slower; dry rocks are usually on the order of 0.4-0.5ft/ns and wet rocks are ~0.2-0.3ft/s. See **Typical GPR Velocities for Common Materials** in GPR Scans.

RESULTS:

Seismic- Vp 2D Tomographic Profiles

Line 1- The Vp seismic Line shows essentially 3 layers with increasing Vp with depth. Bedrock, BR, is assumed to be the bottom layer which has a high velocity, (Vp~9 to 13,000 ft/s) and starts between depths of 10ft (East side) to 18ft (West side). The top of the BR is ~8-9,000ft/s and could be due to weathering which lowers the Vp. This surface does show some signs of irregularity, which can be interpreted as a stream channel around ~200ft and ~350ft mark.

Line 2- The Vp seismic Line shows essentially the same 3 layers with increasing Vp with depth, except this line was taken on the Levee, by the Culvert. The top layer is ~16ft thick and consists of mostly Levee material. I am a bit surprised that the Levee material appears to be about the same velocity as the first ground layer seen in Line 1. I assume the Levee Material (rock) has been dug out of the ground nearby and then compacted to make the Levee. A case for a stream channel could be made for the area between 70 to 100 ft and at a depth of about 25-30ft. A "Goggle Blowup" does show surface expressions of depressions (possible previous drainage-lines) crossing the Levee at Line 2, but not in this area-See Fig 4. As expected, this is a bit deeper than the interpreted stream channels on Line 1 which is not setting under the Levee so would measure shallower. The Culvert is located in the middle of the line at 125ft and was estimated in the field to be at a depth of 16ft. This also is where the seismic indicated a second layer is coming in with a Vp~6,000ft/s, which is hard material so the Culvert probably is buried in the first layer of lower Vp~2-3,000ft/s, which is material that is not as stiff. We did not see the buried Culvert with the seismic survey. The Vp profile for both Line 1 (Off Levee-undisturbed ground) and Line 2 (on the Levee consisting of engineered soil/rock) look very much alike, indicating the Levee is strong. In other words, the Levee fill has the same Vp as the undisturbed ground.

GPR- Scans/Profiles

Line 1- 500, 200, 100 MHz- OFF Levee

The dark and white zones represent rock layering, and you can see disturbed layering from 130 to 230ft. The expanded scale shows subsidence structure (slumping beds) at 153ft and a hyperbola at 190ft. The hyperbola looks like an upside down U and can be used to compute the rock velocity by measuring the slope steepness; steeper slopes are slower velocities or shallower slopes (dist/time=ft/ns) are higher velocities. The quasi-hyperboles seen here are probably from buried boulders. The 500MHz antenna shows the subsidence best as it is at a shallow depth.

Line 1a- 200, 100 MHz- ON Levee (500 MHz not used)

The Levee scans show more irregularities, and quasi-hyperboles which are probably buried boulders or pieces of rock (sandstone) that were used in the Levee construction.

Line 2- 500, 200, 100 MHz- ON Levee

This line had a Culvert in the middle of the line buried at the bottom of the Levee (14-16ft), which we were not able to see. It also had a wire fence with metal posts just east of the middle (marked as F1) as well as a single metal sign (near F2) just west of middle. Both of these surface metal objects can be good GPR reflectors and seen in the profile. F1 and F2 are marks we put on the profile as we pass over the wire fence location, and the middle of the line which is where the Culvert is buried. You can see the metal sign best on the 200MHz and even measure hyperbole slope which approaches a velocity of ~1ft/ns which indicates it is a surface reflection. Ignoring these artifacts from the surface we are able to see the layering disturbed in several areas which is a consequence on how the Levee was constructed. In spite of these minor irregularities the integrity of the Levee seems to be good. No signs of voids or major subsidence are seen in the first 8 ft, which is as deep as we were able to see.

Winslow Levee Site Location for Geophysical Tests on 4/6 & 4/7/2009

Fig 1: **Overview for Line1, Line1a & Line2**

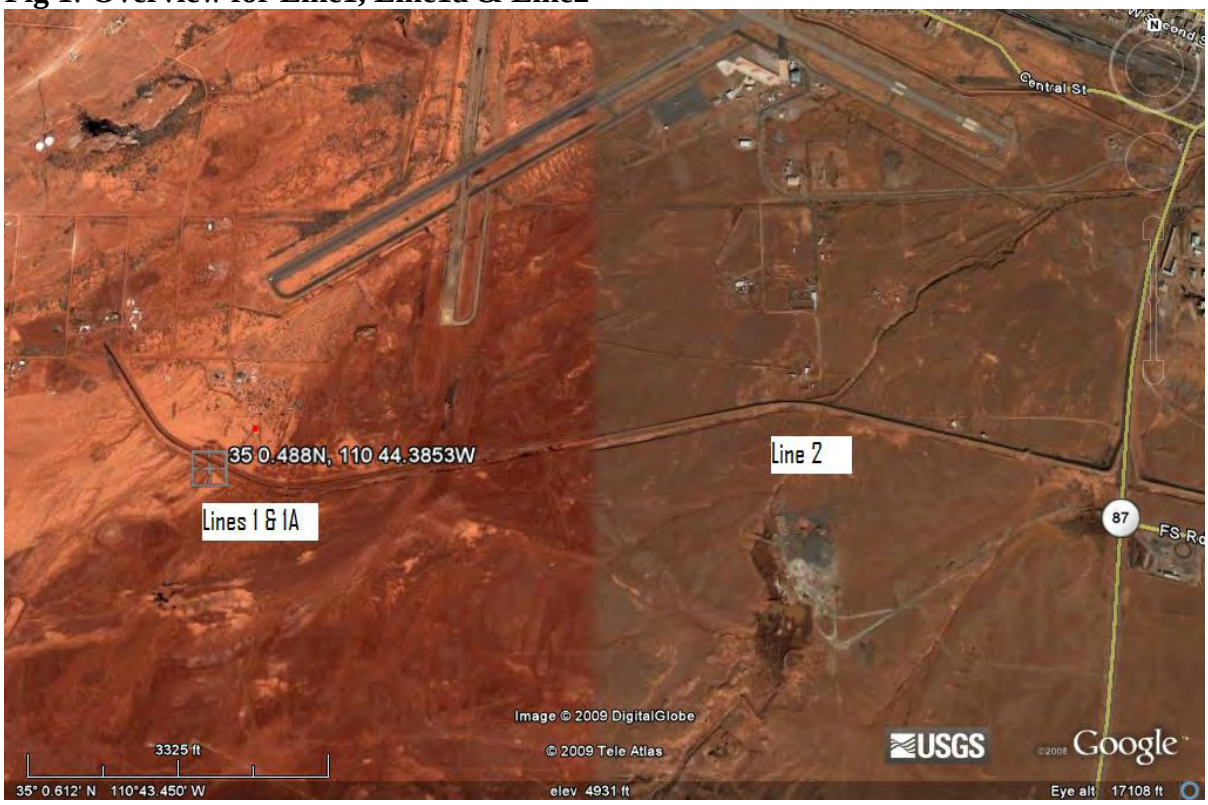


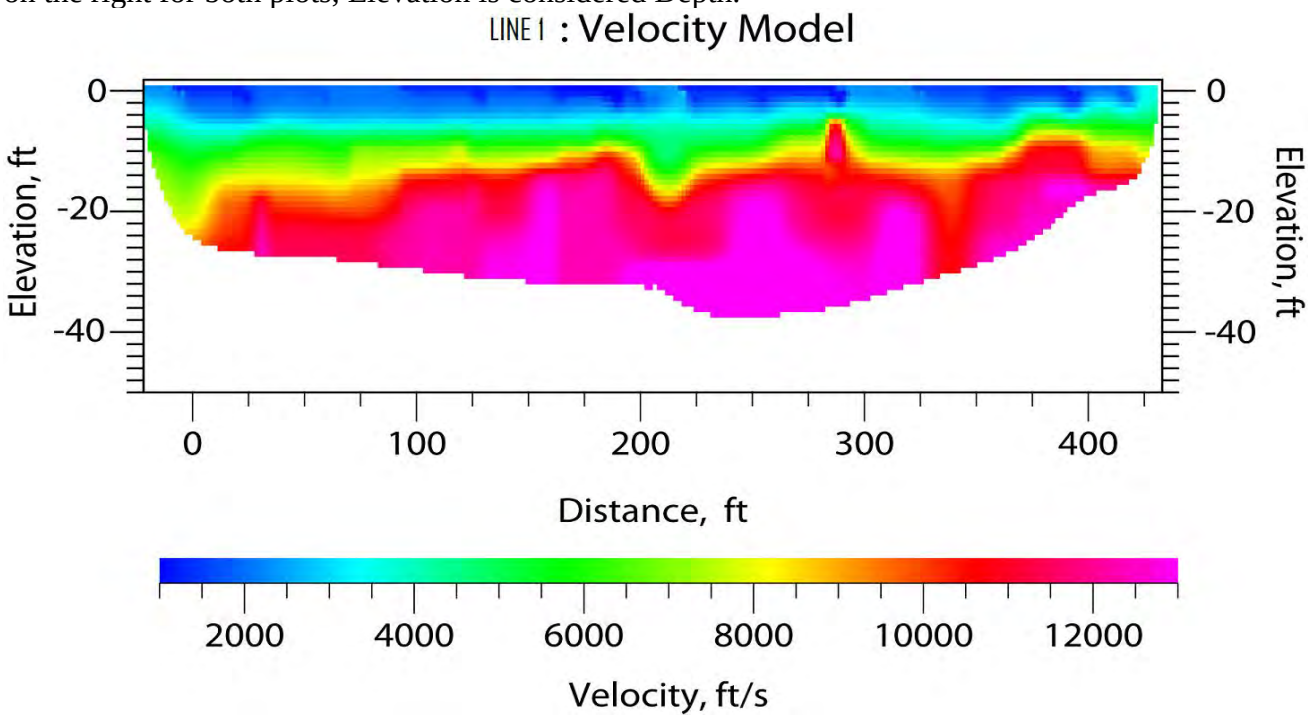
Fig 2: GPR lines Lines1 (Off Levee) & Lines1a (On Levee) 255ft Lines

Fig 3: Line 1 has been extended 200ft - a 455ft Vp Tomography Line- Off Levee

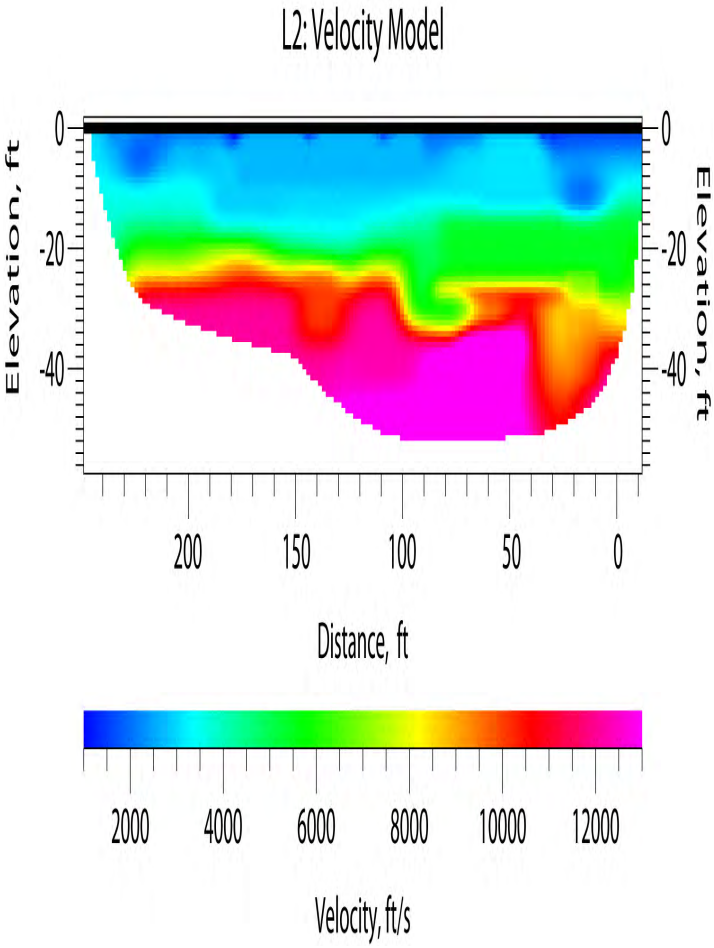
Fig 4: L2 255ft line with both GPR & Vp Tomography

Vp Tomography Lines:

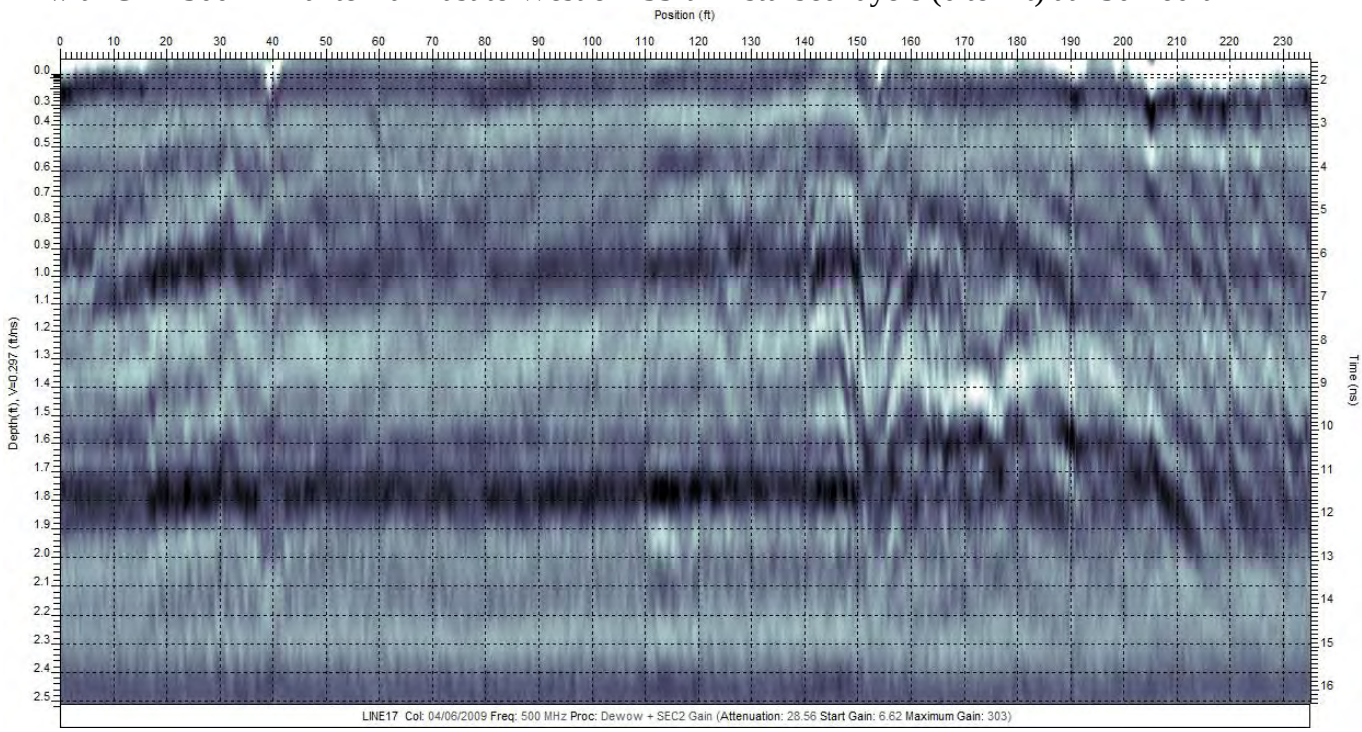
Line 1: (OFF LEVEE): Scales approximately the same for both plots- Vp color the same and East is on the right for both plots, Elevation is considered Depth.



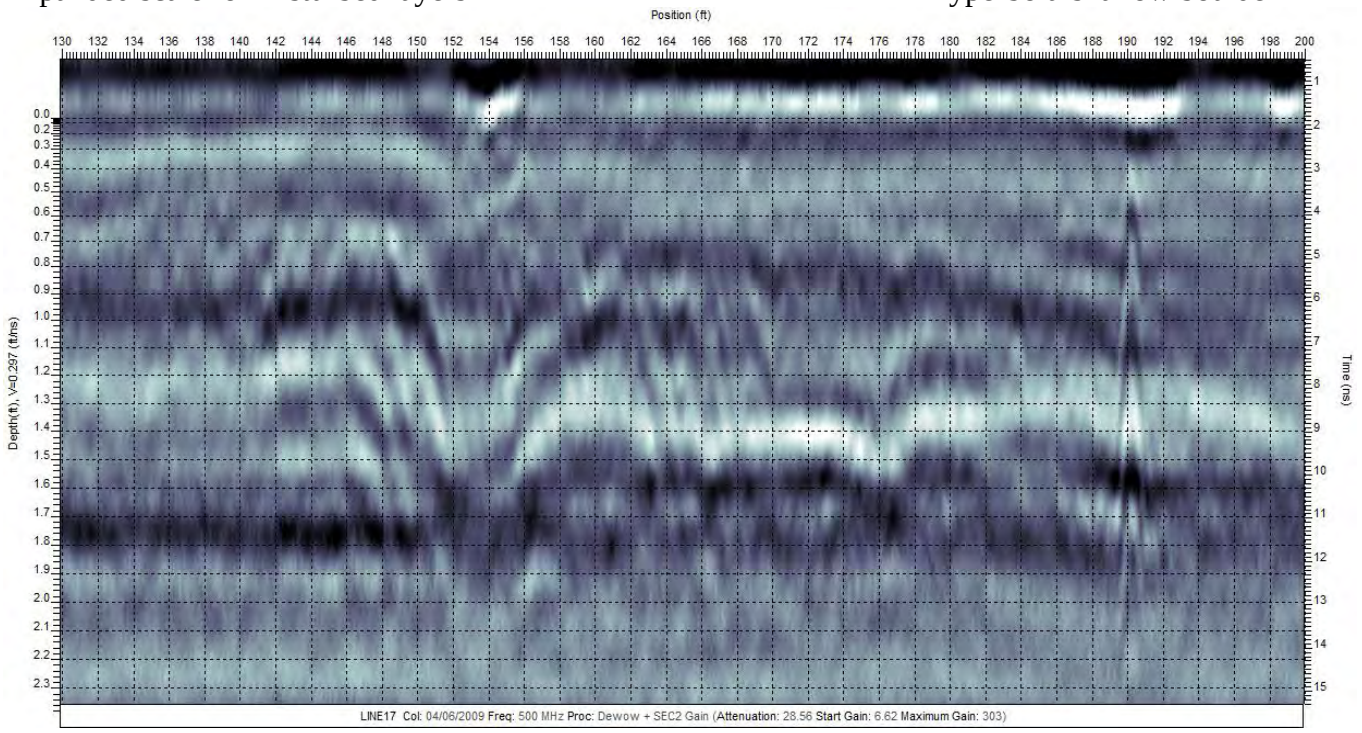
Line 2: (ON LEVEE):



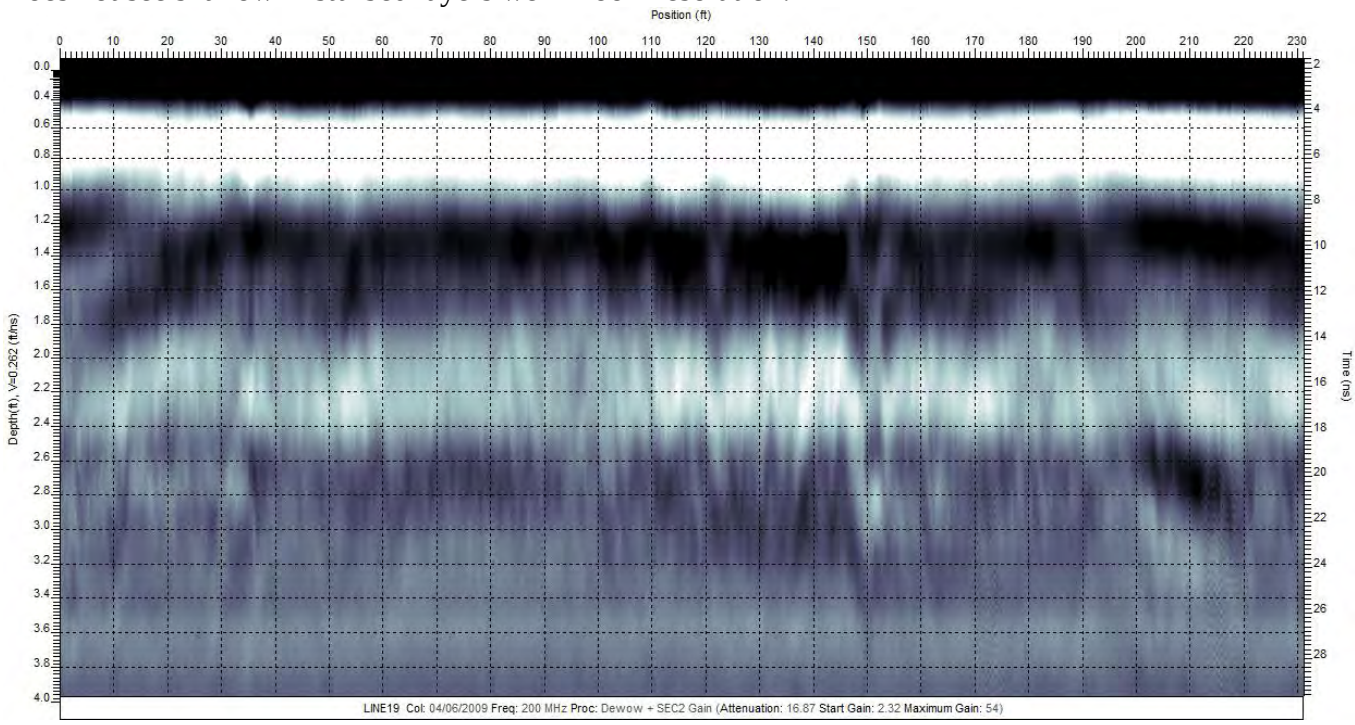
L1 with GPR 500MHz antenna- East to West of 235ft- Disturbed layers (0 to 2ft) at 150-160ft



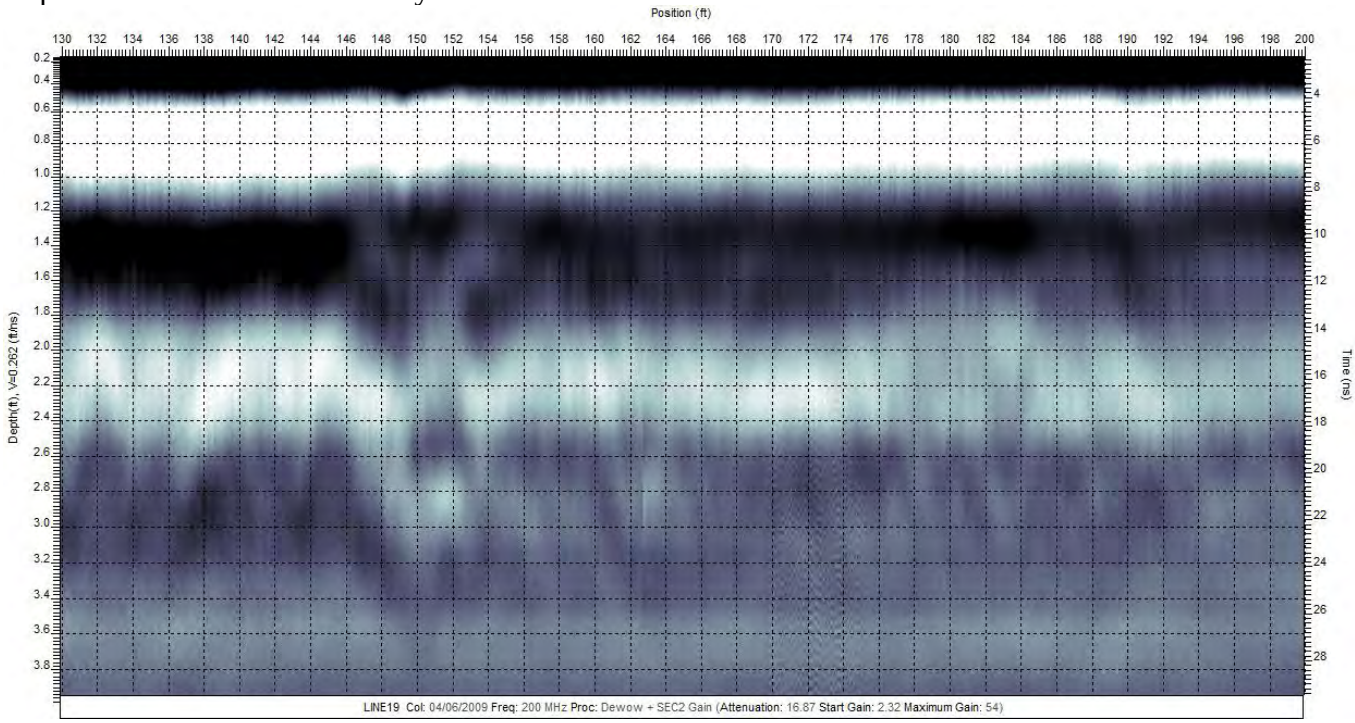
Expanded scale for Disturbed layers- Hyperbola-shallow boulder-



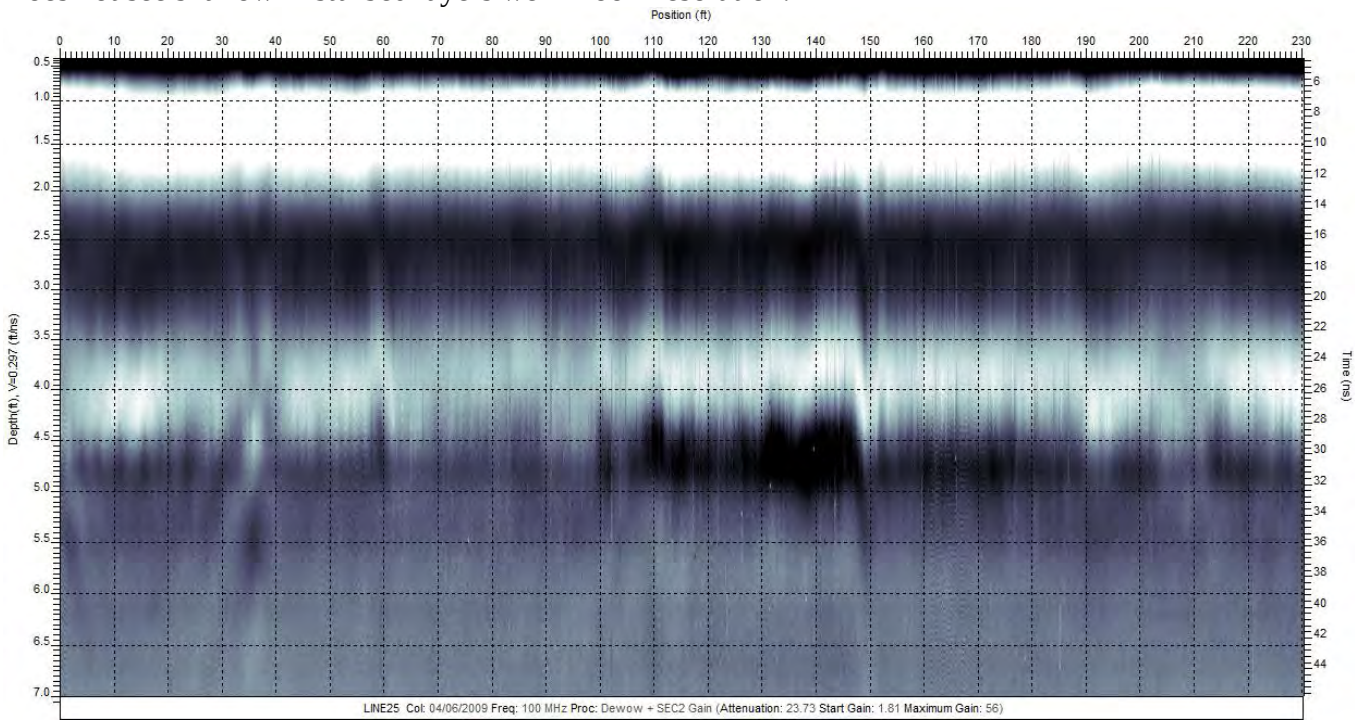
L1 with GPR 200MHz antenna- East to West of 235ft- Disturbed layers at 150-160ft
Does not see shallow Disturbed layers well- Poor Resolution.



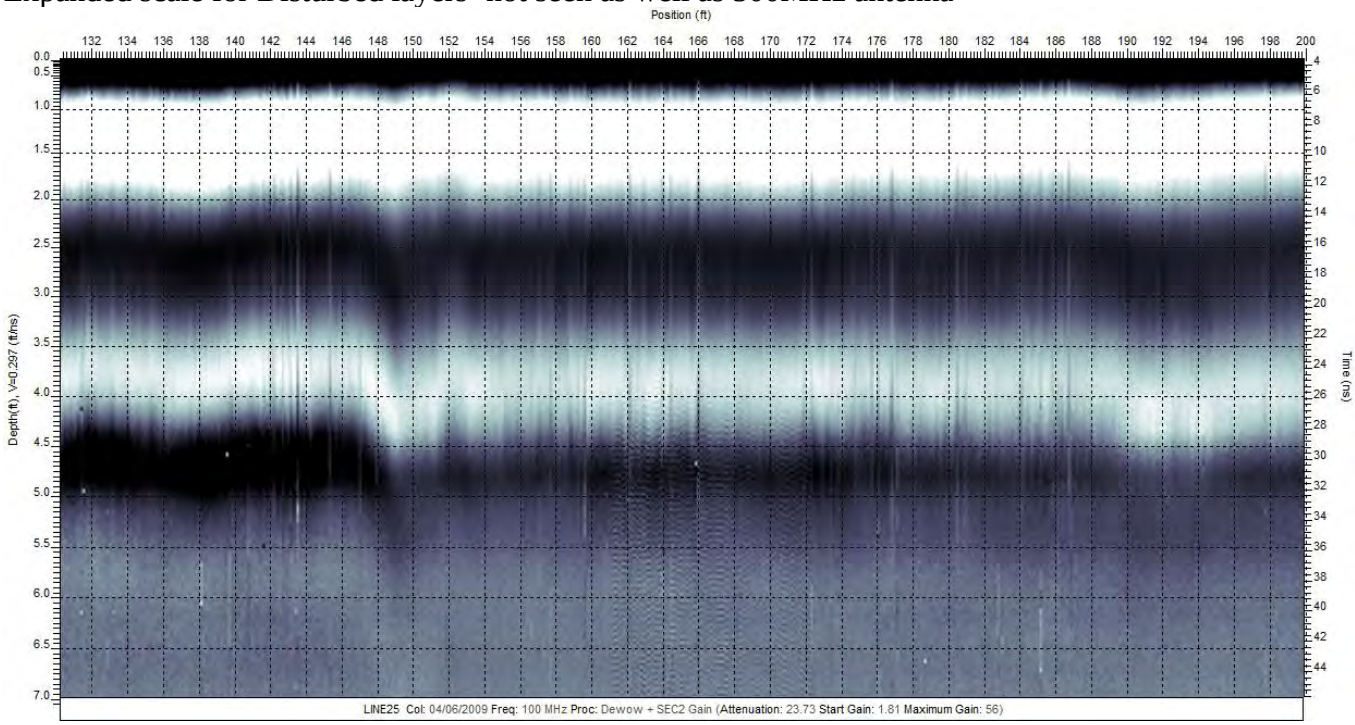
Expanded scale for Disturbed layers- not seen as well as 500MHz antenna



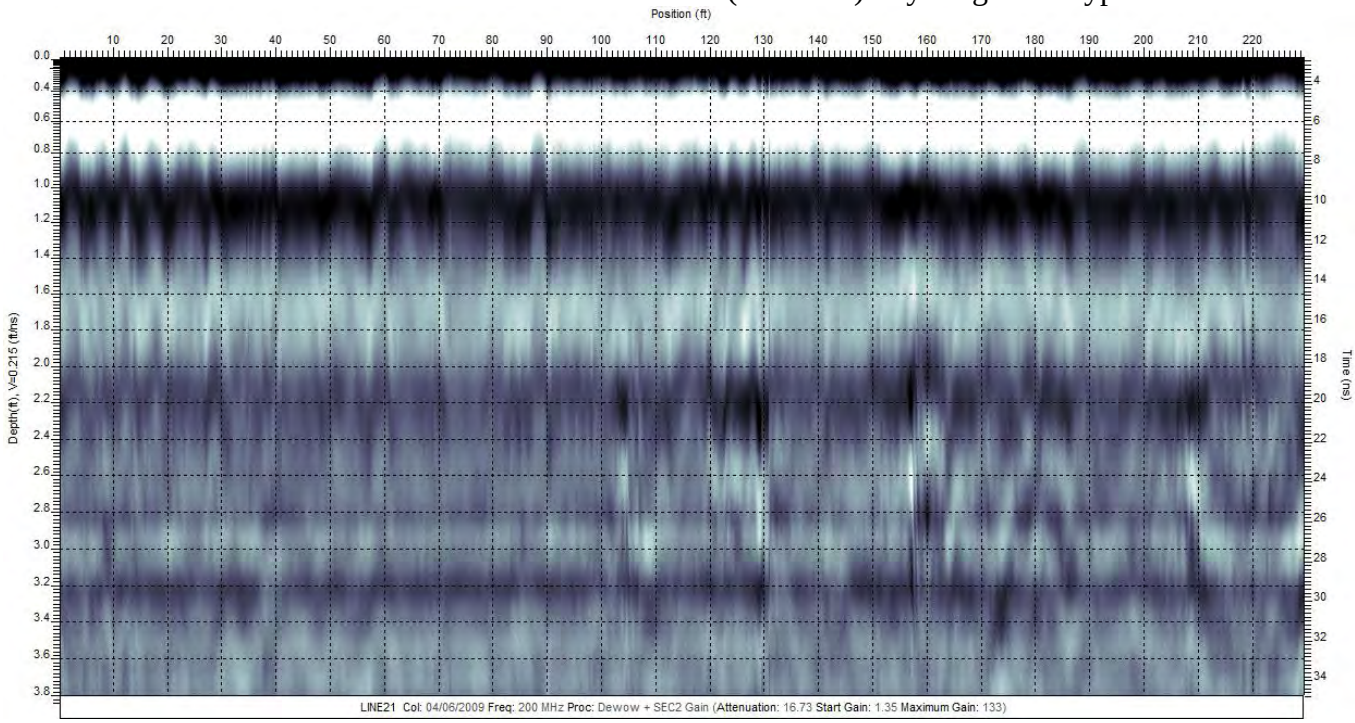
L1 with GPR 100MHz antenna- East to West of 235ft- Disturbed layers at 150-160ft
Does not see shallow Disturbed layers well- Poor Resolution.



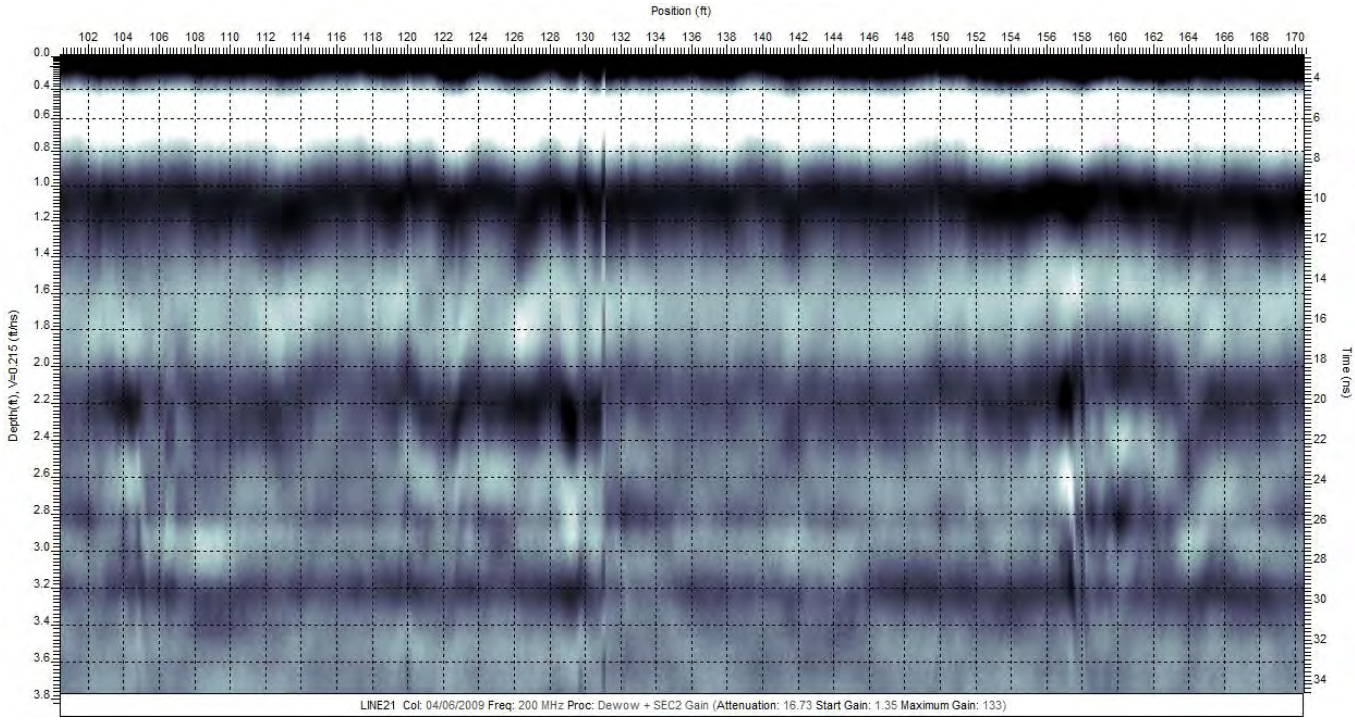
Expanded scale for Disturbed layers- not seen as well as 500MHz antenna



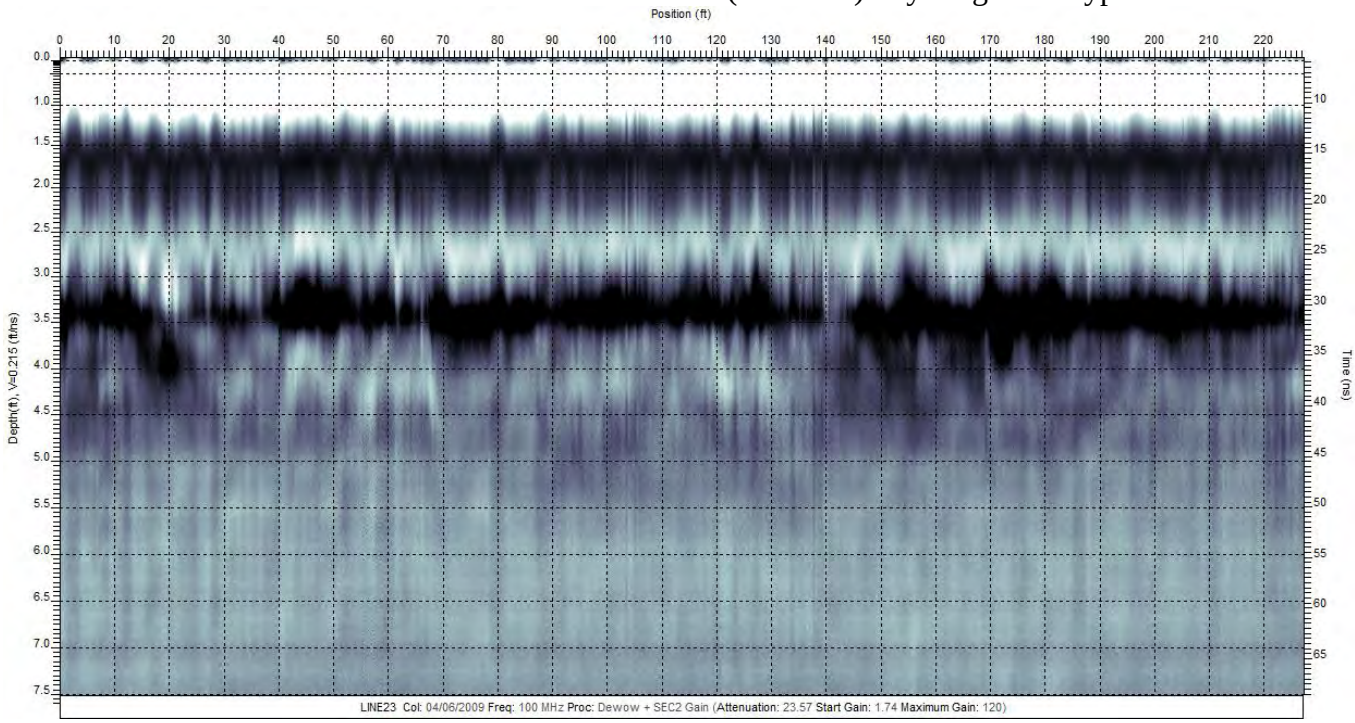
L1a with GPR 200MHz antenna- East to West of 235ft- (0 to 3.8ft) Layering with Hyperbolas



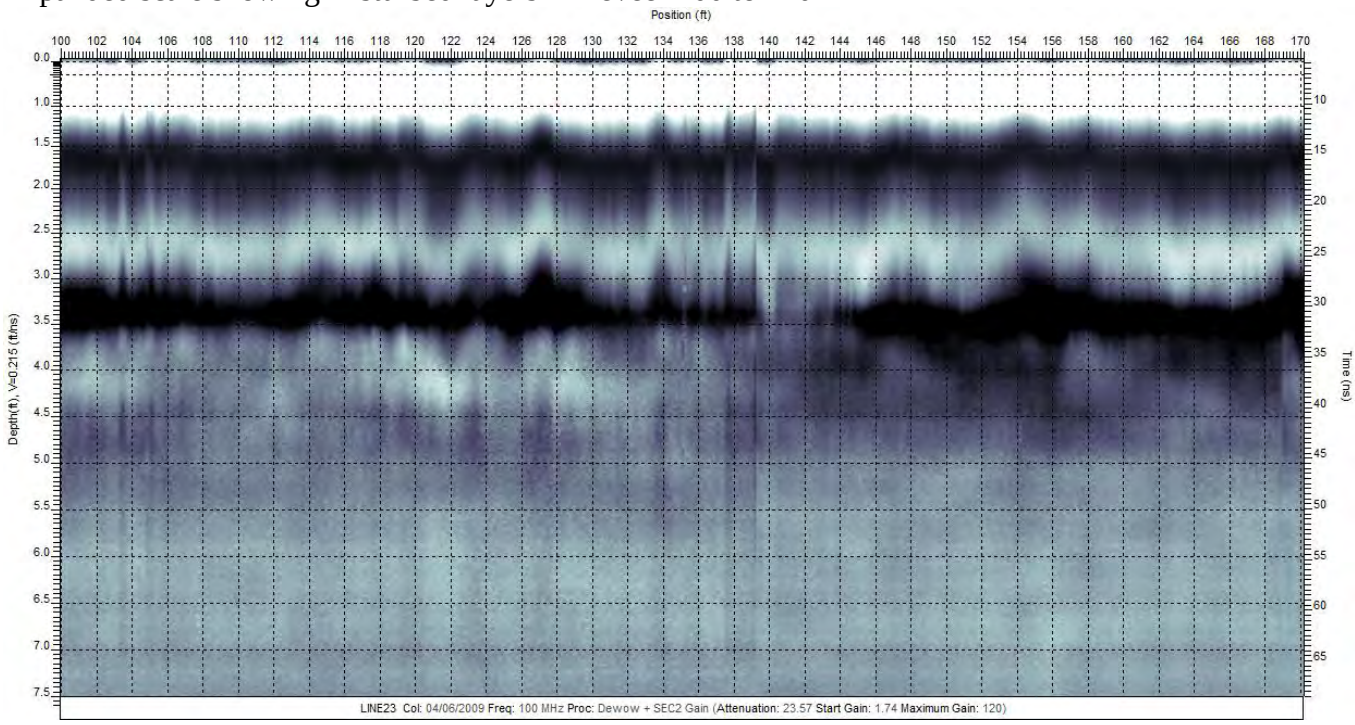
Expanded scale showing Disturbed layers in Levee- 100 to 170 ft



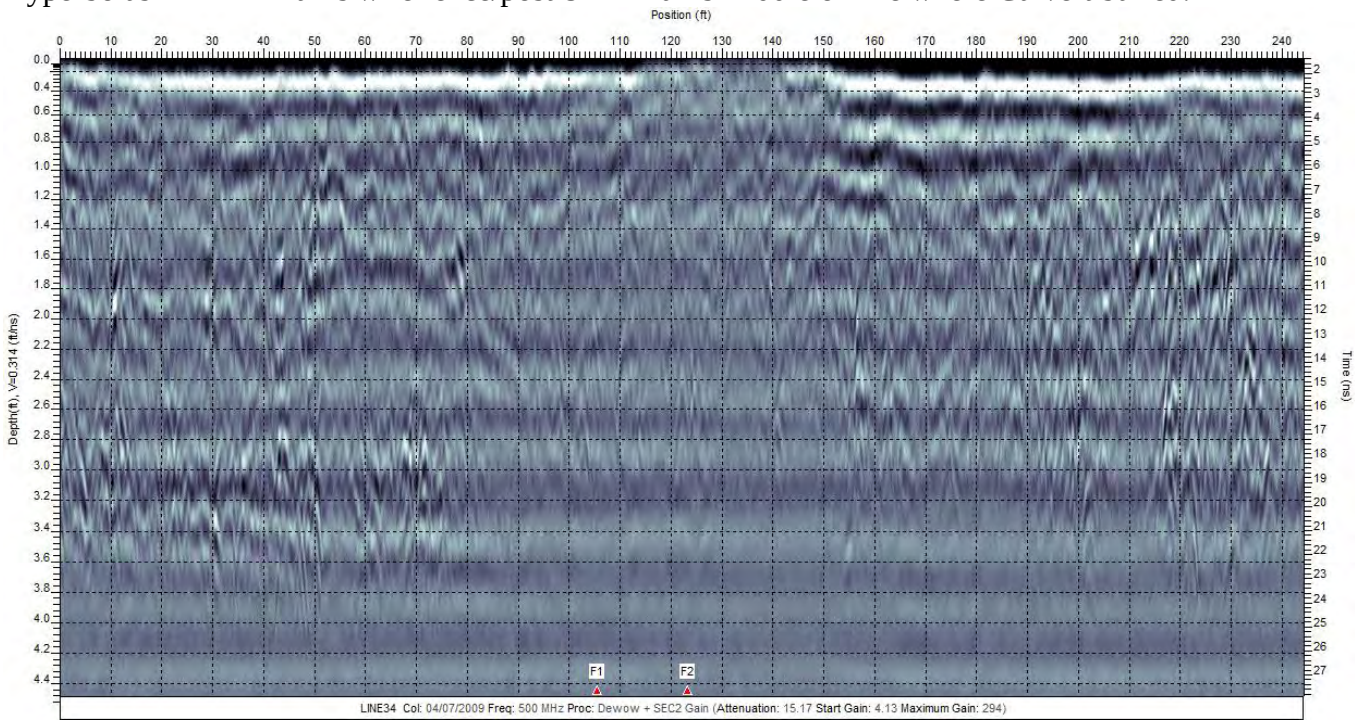
L1a with GPR 100MHz antenna- East to West of 235ft- (0 to 3.8ft) Layering with Hyperbolas



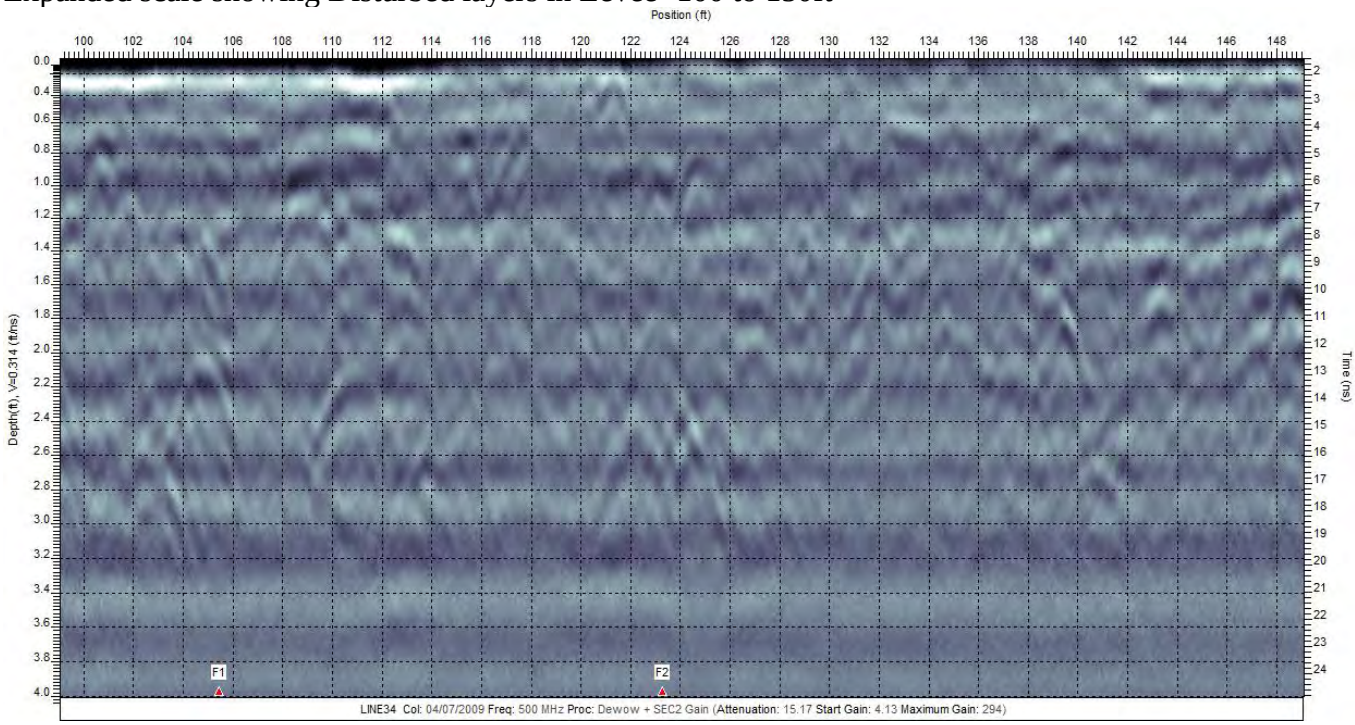
Expanded scale showing Disturbed layers in Levee- 100 to 170



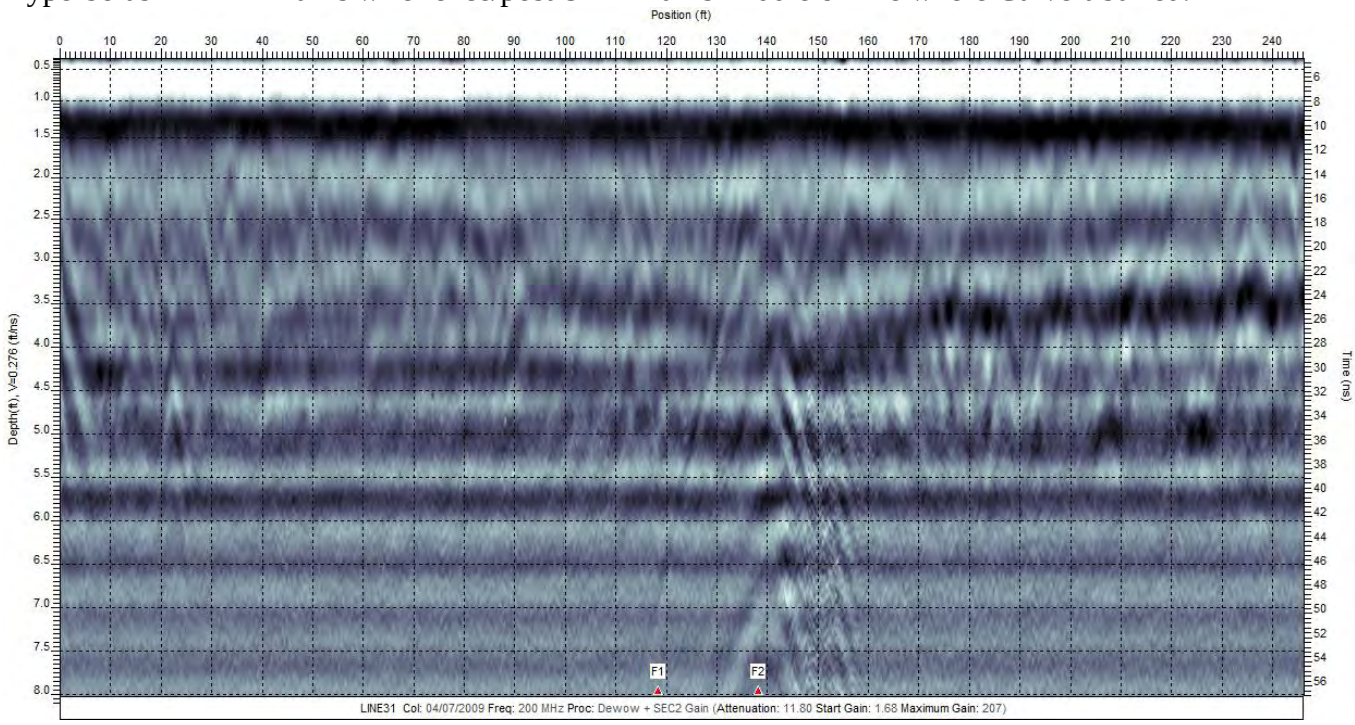
L2 with GPR 500MHz antenna- East to West of 235ft- (0 to 4.4ft) Disturbed Layering with Hyperbolas <<< F1 marks wire fence/post & F2 marks middle of line where Culvert buried.



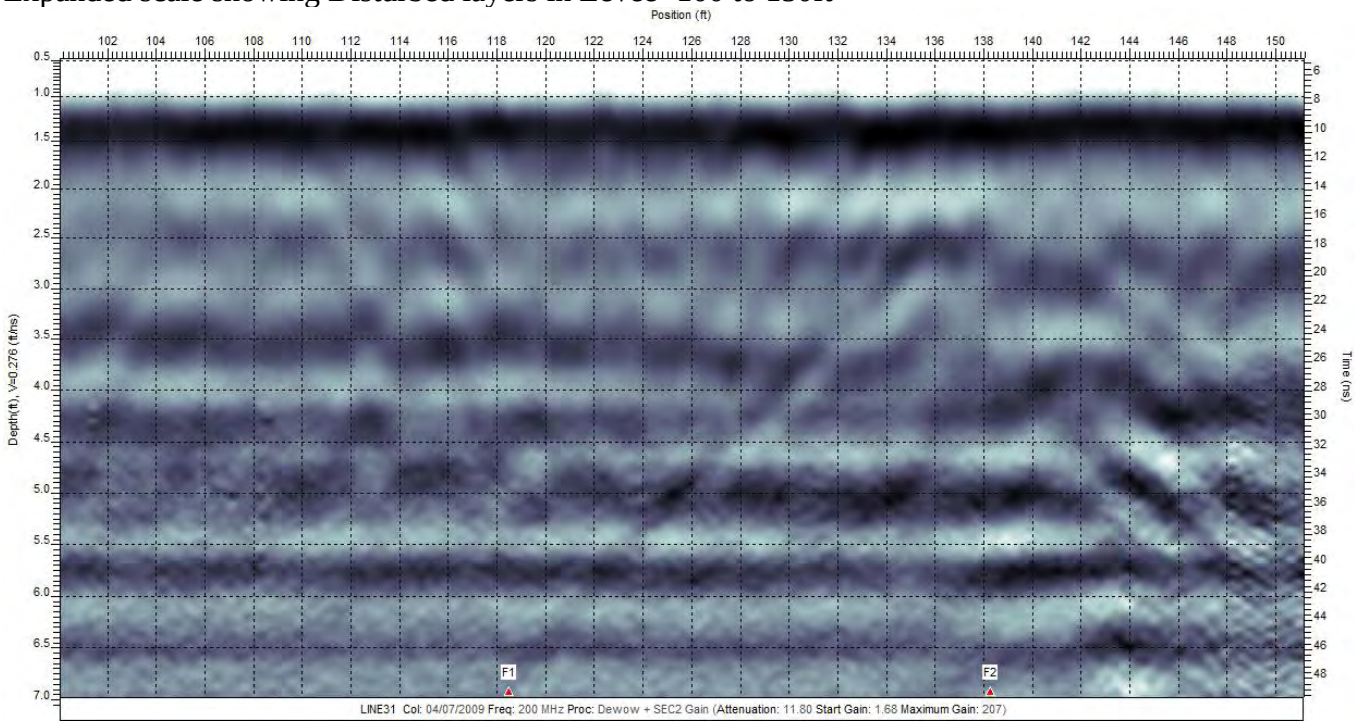
Expanded scale showing Disturbed layers in Levee- 100 to 150ft



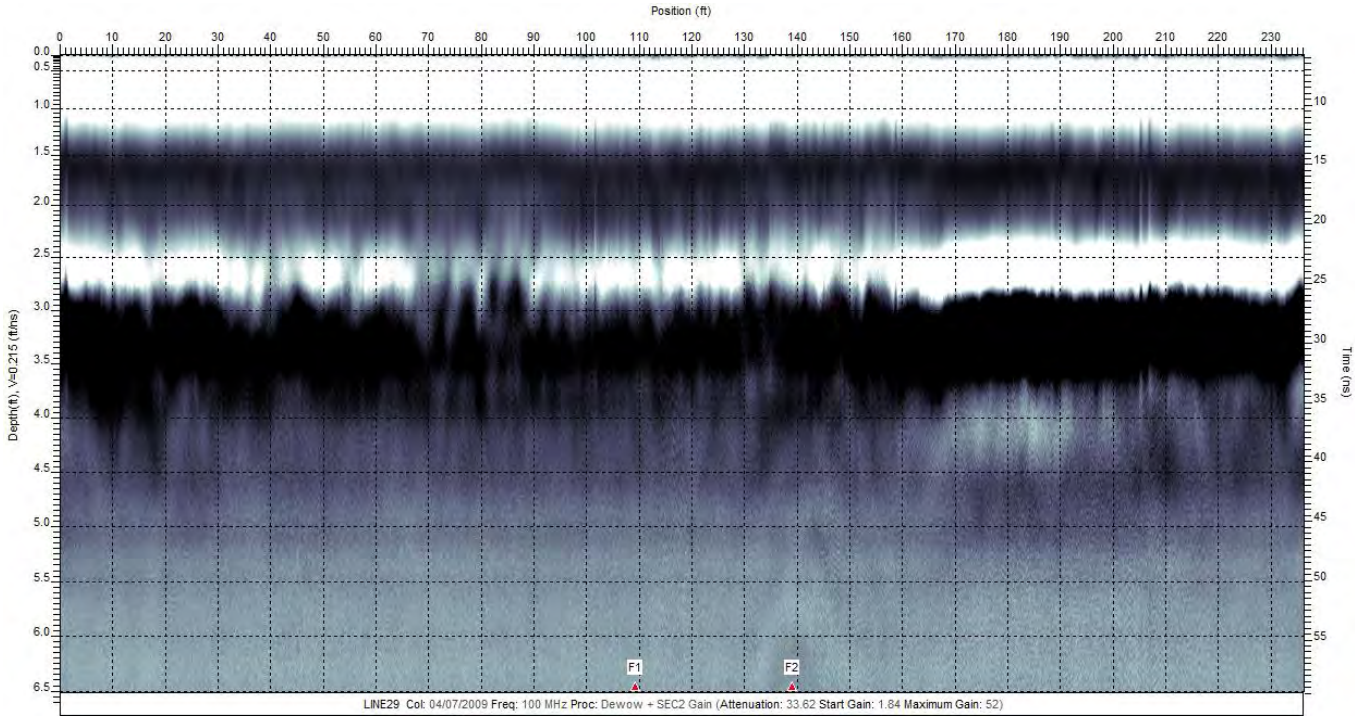
L2 with GPR 200MHz antenna- East to West of 235ft- (0 to 4.4ft) Disturbed Layering with Hyperbolas <<< F1 marks wire fence/post & F2 marks middle of line where Culvert buried.



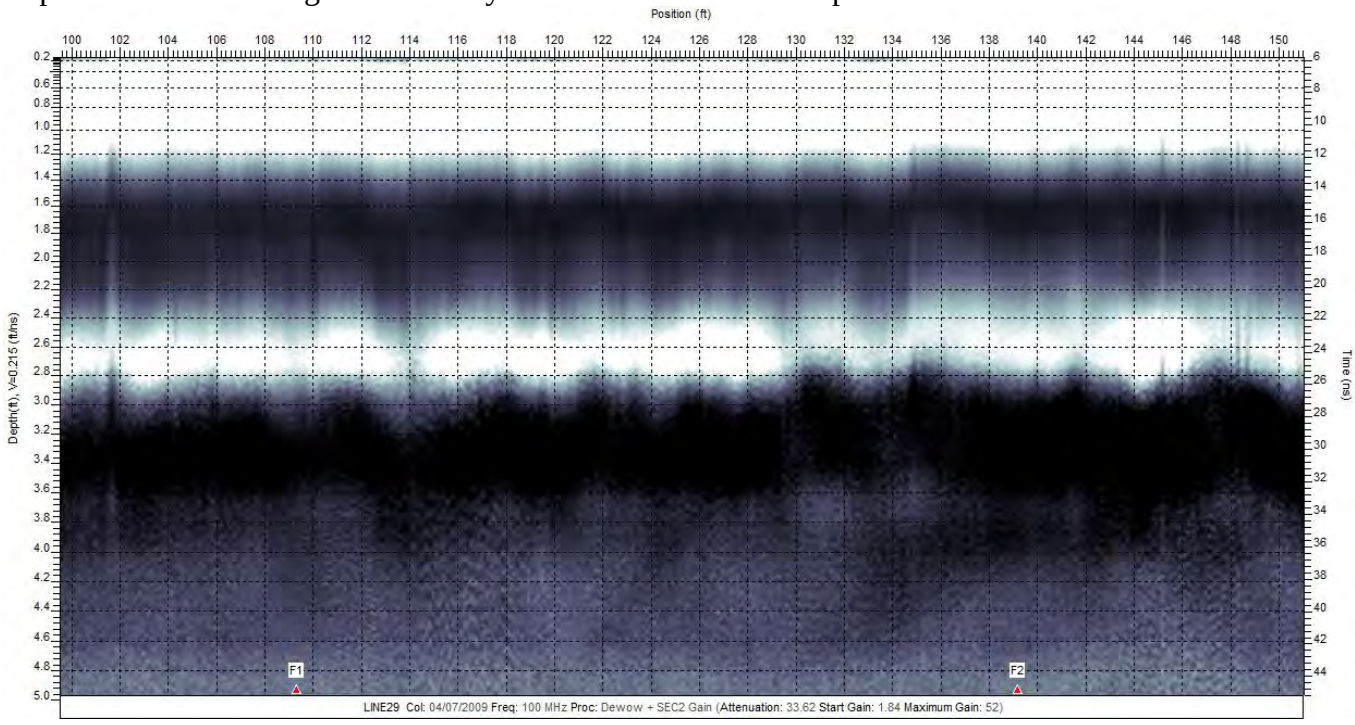
Expanded scale showing Disturbed layers in Levee- 100 to 150ft



L2 with GPR 100MHz antenna- East to West of 235ft- (0 to 6.5ft) Disturbed Layering with Hyperbolas <<< F1 marks wire fence/post & F2 marks middle of line where Culvert buried.



Expanded scale showing Disturbed layers in Levee- 100 to 150- poor resolution

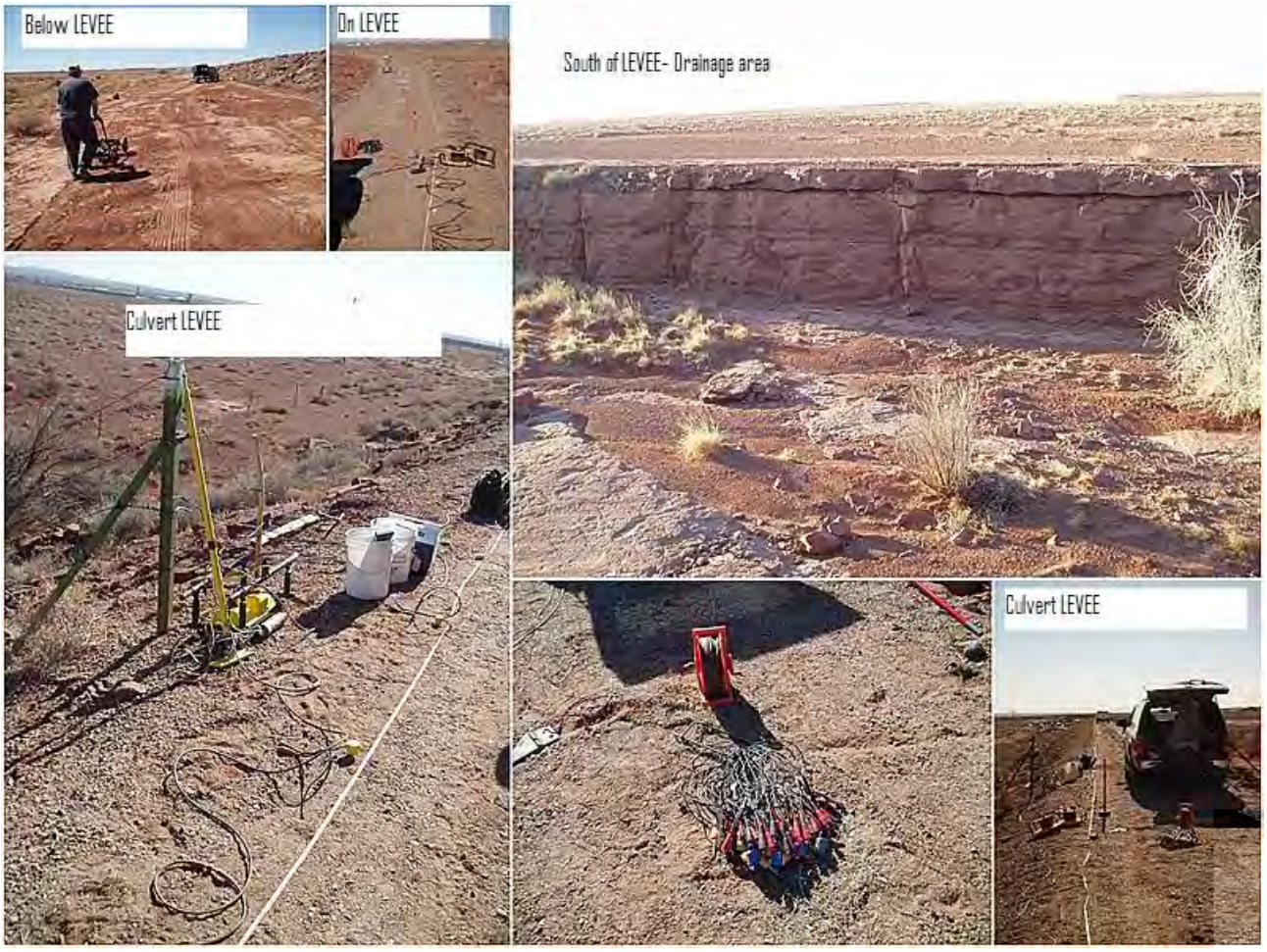


The GPR Scans showed no indication of voids being present.

Typical GPR Velocities for Common Materials

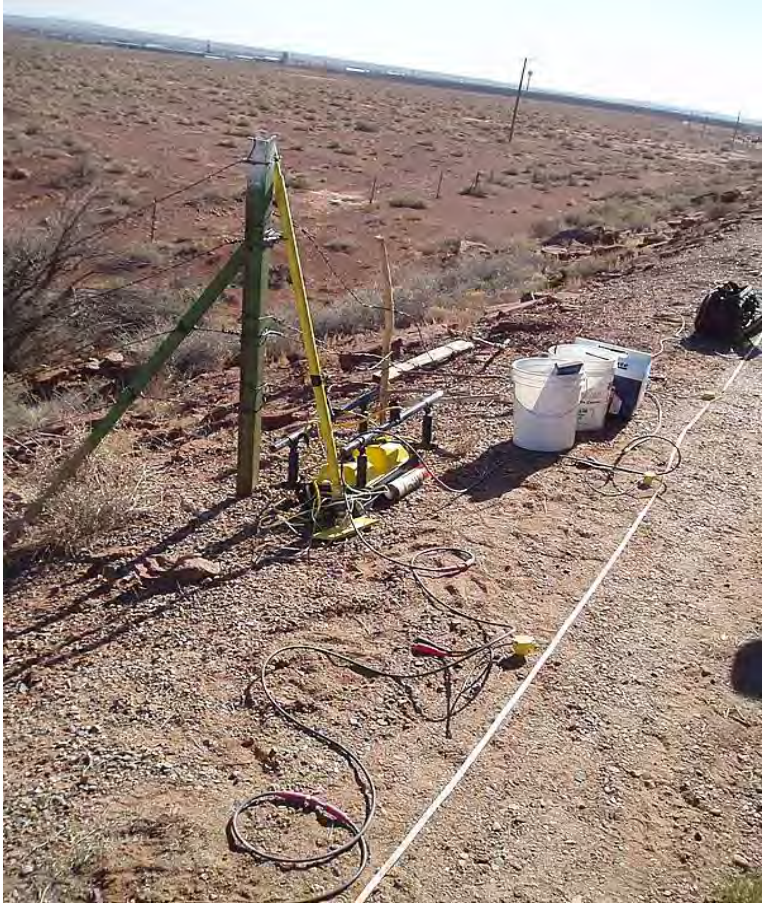
Material	Velocity (ft/ns)
Air	0.98
Ice	0.53
Dry Soil	0.49
Granite	0.49
Dry Salt	0.43
Dry Rock	0.39
Limestone	0.39
Wet Rock	0.33
Concrete	0.26-0.39
Pavement	0.33
Shale	0.30
Silt	0.23
Wet Soil	0.20
Clay	0.20
Fresh Water	0.11

Field Photos:



Line1 below Levee- Seismic & GPR Line

Line2 Metal Fence on Levee



Line2 showing Culvert under Levee on both sides

APPENDIX D

As-Built Plans

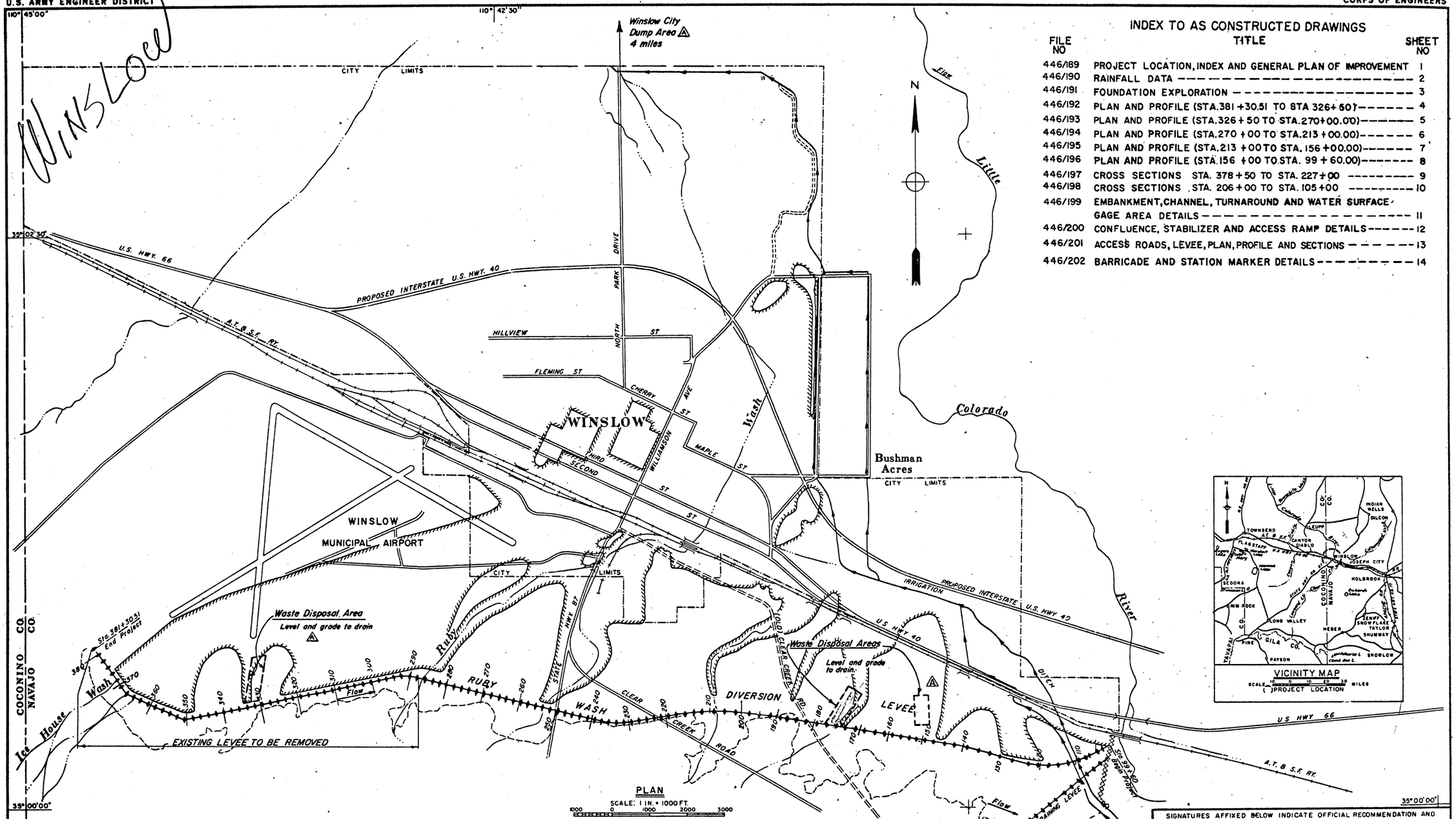
U.S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS

Winslow

INDEX TO AS CONSTRUCTED DRAWINGS

FILE NO	TITLE	SHEET NO
446/189	PROJECT LOCATION, INDEX AND GENERAL PLAN OF IMPROVEMENT	1
446/190	RAINFALL DATA	2
446/191	FOUNDATION EXPLORATION	3
446/192	PLAN AND PROFILE (STA.381+30.51 TO STA 326+50)	4
446/193	PLAN AND PROFILE (STA.326+50 TO STA.270+00.00)	5
446/194	PLAN AND PROFILE (STA.270+00 TO STA.213+00.00)	6
446/195	PLAN AND PROFILE (STA.213+00 TO STA.156+00.00)	7
446/196	PLAN AND PROFILE (STA.156+00 TO STA. 99+60.00)	8
446/197	CROSS SECTIONS STA. 378+50 TO STA. 227+00	9
446/198	CROSS SECTIONS STA. 206+00 TO STA. 105+00	10
446/199	EMBANKMENT, CHANNEL, TURNAROUND AND WATER SURFACE GAGE AREA DETAILS	11
446/200	CONFLUENCE, STABILIZER AND ACCESS RAMP DETAILS	12
446/201	ACCESS ROADS, LEVEE, PLAN, PROFILE AND SECTIONS	13
446/202	BARRICADE AND STATION MARKER DETAILS	14



PLAN

SCALE: 1 IN. = 1000 FT.

1000 0 1000 2000 3000

VICINITY MAP

SCALE 10 0 10 20 30 MILES

( ) PROJECT LOCATION

LEGEND

- BOUNDARY OF AREA SUBJECT TO OVERFLOW BY STANDARD PROJECT FLOOD
- EXISTING WASH
- LEVEE TO BE CONSTRUCTED
- RESTRICTIVE EASEMENT
- EXISTING REVETTED LEVEE

RECORD DRAWING - AS CONSTRUCTED

CONT. NO. 70-C-0092 REV. "A" DATE 17 JUN 71 BY No Change

SIGNATURES AFFIXED BELOW INDICATE OFFICIAL RECOMMENDATION AND APPROVAL OF ALL DRAWINGS IN THIS SET AS INDEXED ON THIS SHEET

DATUM IS MEAN SEA LEVEL

REVISION	DATE	DESCRIPTION	BY
A	4-27-70	Add waste disposal areas.	

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: W.B.M.
DRAWN BY: E.A.B.
CHECKED BY: J.R.N.
SUBMITTED: CHIEF, DESIGN SECTION
RECOMMENDED: CHIEF, ENGINEERING DIVISION
APPROVED: COL., CORPS OF ENGINEERS, DISTRICT ENGINEER

LITTLE COLORADO RIVER BASIN, ARIZONA AND NEW MEXICO
WINSLOW, ARIZONA AND VICINITY

WINSLOW FLOOD CONTROL PROJECT
PROJECT LOCATION, INDEX AND GENERAL PLAN OF IMPROVEMENTS

CCE CATEGORY:	SCALE: AS SHOWN	SPEC. NO. DACW09-70-B-0059	SHEET NO 1 OF 14
REFERENCE SHEET NO:	DATE: MARCH 1969	SHEET FILE NO. 446/189 REV A	

	1921		1922		1923		1924		1925		1926		1927		1928		1929		1930		1931		1932		1933		1934		1935		1936		1937		1938		1939		1940		1941		
	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	
JANUARY																							4	.23	3	.25	2	.27	5	1.62	3	.43	5	.50	1	.04	5	.41	4	.16	7	.41	JANUARY
FEBRUARY																							6	.72	2	.66	4	.42	8	1.19	7	.54	4	.46	7	.52	4	.47	6	.68	8	.53	FEBRUARY
MARCH																							3	.30	0	0	3	.12	5	.23	2	.45	8	1.00	8	1.05	7	.66	0	0	6	.95	MARCH
APRIL																							2	.34	2	.40	4	1.59	3	.21	1	.03	2	.14	2	.31	3	.77	5	.50	10	1.31	APRIL
MAY																							2	.15	3	.10	4	1.35	9	.84	2	.10	1	.03	2	.31	1	.01	6	.54	7	.74	MAY
JUNE																							2	.17	2	.07	3	.12	1	.08	4	.37	3	.15	2	.36	1	.05	3	.10	4	.14	JUNE
JULY																							9	1.01	10	.76	6	.20	7	.52	10	.66	9	.79	4	1.03	6	.21	3	.25	5	.85	JULY
AUGUST																							8	1.23	11	2.29	10	.89	12	1.50	12	1.25	9	.33	10	2.08	6	1.49	8	.77	11	1.32	AUGUST
SEPTEMBER																							3	.46	3	2.31	3	.22	6	1.01	6	1.20	3	.47	0	0	10	.72	12	2.41	5	1.95	SEPTEMBER
OCTOBER																							5	1.34	7	2.04	0	0	0	0	3	.22	1	.11	0	0	1	.06	6	1.44	10	.96	OCTOBER
NOVEMBER																							0	0	1	.58	3	.23	4	.48	0	0	1	.13	1	.04	4	1.10	6	.65	3	.25	NOVEMBER
DECEMBER																							7	.76	4	.26	4	.27	3	.35	4	.67	7	.49	6	.49	2	.23	12	1.97	8	1.13	DECEMBER
TOTAL																							51	6.71	48	9.72	46	5.68	63	8.03	54	5.92	53	4.60	43	6.23	50	6.18	71	9.47	84	10.54	TOTAL

	1942		1943		1944		1945		1946		1947		1948		1949		1950		1951		1952		1953		1954		1955		1956		1957		1958		1959		1960		1961		1962		
	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	
JANUARY	2	.31	2	.54	3	.22	4	.37	5	.47	4	.28	3	.58	6	1.10	1	.01	3	.45	4	.82	0	0	2	.28	7	.34	5	.64	6	1.06	3	.04	2	.09	4	.64	0	0	5	.83	JANUARY
FEBRUARY	6	.59	4	.40	6	.34	2	.14	1	.15	0	0	8	.58	5	.52	5	.55	2	.03	2	.31	2	.14	1	.24	1	.01	5	1.01	3	.66	8	.59	6	.42	5	.33	3	.40	8	.58	FEBRUARY
MARCH	2	.03	7	.46	4	.28	10	.41	5	.23	0	0	6	.56	4	.34	3	.15	3	.29	7	.85	1	.07	5	.58	2	.14	2	.21	8	1.13	9	.87	0	0	4	.36	6	.86	6	.48	MARCH
APRIL	5	1.16	4	.14	2	.70	2	.02	4	.16	0	0	2	.02	3	.16	0	0	6	1.18	9	.97	5	.76	3	.12	1	.20	6	.42	4	.17	6	.56	3	.28	1	.23	3	.18	0	0	APRIL
MAY	0	0	2	.23	2	.59	2	.03	1	.14	3	.79	1	.03	5	.31	1	.06	3	.47	0	0	1	.01	3	.13	5	.30	2	.20	7	.48	5	.26	1	.62	5	.50	1	.04	3	.08	MAY
JUNE	0	0	0	0	0	0	1	.15	1	.06	3	.07	2	.27	6	1.54	0	0	0	0	2	.06	0	0	3	.51	2	2.12	3	.37	2	.22	4	.23	6	.36	1	.09	0	0	3	.14	JUNE
JULY	6	.33	4	.31	6	.56	5	1.60	9	2.81	5	.71	6	.43	7	.77	11	2.72	4	.86	9	1.50	11	1.99	11	2.50	9	1.05	8	1.55	11	2.26	4	.17	7	.98	3	.94	10	.65	4	.05	JULY
AUGUST	8	1.20	8	1.38	6	.19	10	2.12	12	1.63	6	2.69	10	1.99	8	.58	6	.59	9	1.79	10	2.20	10	2.31	2	.60	12	2.30	11	1.04	14	2.18	11	1.24	9	1.08	5	.53	12	2.29	4	.74	AUGUST
SEPTEMBER	2	.20	5	1.39	5	2.18	2	.04	7	1.94	3	.38	4	.17	11	2.02	7	.72	1	.15	4	1.06	0	0	8	1.45	0	0	1	.01	0	0	11	2.40	3	.23	6	.44	6	1.49	8	.87	SEPTEMBER
OCTOBER	7	1.54	5	.74	5	.50	4	.14	0	0	6	2.11	6	.37	4	.63	0	0	4	.69	0	0	0	0	2	.35	2	.02	4	.21	11	2.45	4	.32	7	1.83	8	1.55	4	.85	5	1.66	OCTOBER
NOVEMBER	1	.14	0	0	9	.73	0	0	5	.40	2	.51	0	0	1	.27	1	.04	3	.41	10	1.67	3	.32	1	.06	2	.08	1	.09	5	.26	5	.35	3	.39	4	.17	7	.41	4	1.07	NOVEMBER
DECEMBER	3	.31	7	1.13	6	.28	2	.87	1	.02	4	.28	8	.66	3	.60	1	.07	5	.64	5	.19	6	.54	2	.13	1	.38	0	0	1	.01	1	.02	9	1.50	7	1.12	8	.76	2	.05	DECEMBER
TOTAL	42	5.81	48	6.72	54	6.57	44	5.89	51	8.01	36	7.82	56	5.66	63	8.84	36	4.91	43	6.96	62	9.63	39	6.14	43	6.95	44	6.94	48	5.75	72	10.88	71	7.05	56	7.78	53	6.90	60	7.93	52	6.55	TOTAL

	1963		1964		1965		1966		1967		1968		1969		1970																												
	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	
JANUARY	3	.52	1	.03	6	1.42	5	.68	1	.10																																	JANUARY
FEBRUARY	4	.75	3	.14	5	.45	6	.66	1	.01																																	FEBRUARY
MARCH	4	.38	5	.49	5	.97	3	.26	3	.24																																	MARCH
APRIL	1	.30	6	.27	5	.44	1	.12	3	.10																																	APRIL
MAY	0	0	1	.04	5	.92	0	0	3	.27																																	MAY
JUNE	1	.02	2	.17	4	.33	4	.32	3	1.06																																	JUNE
JULY	4	.15	6	1.63	12	1.47	10	1.34	11	2.67																																	JULY
AUGUST	16	4.80	9	2.81	8	.70	10	.96	9	1.09																																	AUGUST
SEPTEMBER	6	1.16	11	1.36	4	.91	6	.98	7	.49																																	SEPTEMBER
OCTOBER	6	1.05	2	.04	2	.16	5	.97	1	.11																																	OCTOBER
NOVEMBER	3	.36	5	.33	4	.30	2	.75	3	.36																																	NOVEMBER
DECEMBER	2	.31	4	.37	13	1.45	4	.26	6	3.73																																	DECEMBER
TOTAL	50	9.90	55	7.68	73	9.52	56	7.30	51	10.23																																	TOTAL

																																					TOTAL 36 YEARS		MEAN 36 YEARS		
	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL	NO OF RAINY DAYS	TOTAL RAIN FALL			
JANUARY																																					126	16.14	126	.13	JANUARY
FEBRUARY																																					158	16.19	158	.10	FEBRUARY
MARCH																																					156	15.40	156	.10	MARCH
APRIL																																					119	14.26	119	.12	APRIL
MAY																																					99	10.67	99	.11	MAY
JUNE																																					78	9.70	78	.12	JUNE
JULY																																					262	38.28	262	.15	JULY
AUGUST																																					332	54.18	332	.16	AUGUST
SEPTEMBER																																					179	32.79	179	.18	SEPTEMBER
OCTOBER																																					137	24.46	137	.18	OCTOBER
NOVEMBER																																					107	12.93	107	.12	NOVEMBER
DECEMBER																																					168	22.30	168	.13	DECEMBER
TOTAL																																					1921	267.30	1921	.14	TOTAL

NOTE: This tabulation compiled from published records of rainfall station at Superior, Arizona. Number of rainy days does not include days with only trace of rainfall recorded.

RECORD DRAWING - AS CONSTRUCTED

CONT. NO. 70 - C - 0092 REV. — DATE JUN. 71 BY NO CHANGE

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DISTRICT ENGINEER
LOS ANGELES, CALIFORNIA

ENGINEER: F. A. M.
DRAWN BY: S.M.B.
CHECKED BY: J. S. B.
SUBMITTED BY:
CHIEF DESIGN BR.

LITTLE COLORADO RIVER BASIN, ARIZONA AND NEW MEXICO
WINSLOW ARIZONA AND VICINITY
WINSLOW FLOOD CONTROL PROJECT
RUBY WASH DIVERSION LEVEE
RAINFALL DATA

SCALE: NONE
DATE: APRIL 1969
TO ACCOMPANY SPECIFICATIONS DACW09-70-B-0059
SHEET 2 OF 14
FILE NO. (D. O. SERIES) 446/190

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS More than half of material is larger than no. 200 sieve size.	GRAVELS More than half of coarse fraction is larger than no. 4 sieve size.	Clean gravels	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.
		Gravels with fines	GM	Silty gravels, gravel-sand-silt mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS More than half of coarse fraction is smaller than no. 4 sieve size.	Clean sands	SW	Well-graded sands, gravelly sands, little or no fines.
			SP	Poorly-graded sands, gravelly sands, little or no fines.
		Sands with fines	SM	Silty sands, sand-silt mixtures.
			SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS More than half of material is smaller than no. 200 sieve size.	SILTS AND CLAYS	Low liquid limit.	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts, with slight plasticity.
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
			OL	Organic silts and organic silty clays of low plasticity.
		High liquid limit.	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
			CH	Inorganic clays of high plasticity, fat clays.
			OH	Organic clays of medium to high plasticity, organic silts.
Highly organic soils			Pt	Peat and other highly organic soils.

NOTES:

1. Boundary Classification: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example, GW-GC, well-graded gravel-sand mixture with clay binder.
2. All sieve sizes on this chart are U. S. Standard.
3. The terms "silt" and "clay" are used respectively to distinguish materials exhibiting lower plasticity from those with higher plasticity. The minus no. 200 sieve material is silt if the liquid limit and plasticity index plot below the "A" line on the plasticity chart (Table VI, Military Standard 619A), and is clay if the liquid limit and plasticity index plot above the "A" line on the chart.
4. For a complete description of the Unified Soil Classification System, see "Military Standard 619A" dated 20 March 1962

TT 4

El 4856 ±

	MC	LL	PI	-16	-200	
ML	10		NP	100	53	SANDY SILT - Dark brown.
3.0'						
SM	19		NP	100	29	SILTY SAND - Dark brown
	28		NP	100	21	
10.0' G.W.						Very unstable due to water

TT 5 through TT 9 (TYPICAL)

Ground surface

0.5' ± SM SC — SILTY SAND or GRAVELLY SILTY SAND - Dark reddish brown

3.0' ± Bedrock — SANDSTONE/SHALE - Light tan, brown, very hard and massive. Horizontal bedding about 1 foot thick. Top 2 feet of bedrock very difficult to rip.

Unable to rip below 3-ft. depth

LEGEND

TT 4	TEST TRENCH NUMBER
MC	FIELD MOISTURE CONTENT IN PERCENT OF DRY WEIGHT.
LL	LIQUID LIMIT.
PI	PLASTICITY INDEX (LIQUID LIMIT MINUS PLASTIC LIMIT).
NP	NONPLASTIC
-4	PERCENT OF MATERIAL BY WEIGHT PASSING NO. 4 SIEVE.
-200	PERCENT OF MATERIAL BY WEIGHT PASSING NO. 200 SIEVE.
G.W.	DEPTH TO WATER.
P-1	AUGER PROBE NUMBER

GENERAL NOTES

1. All test trenches were excavated during July and August 1967.
2. Test trenches 4 through 9 were excavated with a Caterpillar D-8 Dozer with ripper.
3. For additional description of conditions encountered, see detailed logs on file in the Los Angeles District Office.
4. Probes for Ruby Wash were made in October 1968 using a 3" diameter auger.
5. Location of test trenches and auger probes are shown on sheets 4 through 8.

AUGER PROBES	
NUMBER	DEPTH TO REFUSAL (feet)
P-1	>4.0
P-2	>4.0
P-3	2.5
P-4	2.0
P-5	>4.0
P-6	0.2
P-7	3.0
P-8	2.5
P-9	0.5
P-10	3.5
P-11	>6.0
P-12	0.1
P-13	0.7

AUGER PROBES	
NUMBER	DEPTH TO REFUSAL (feet)
P-14	0.4
P-15	0.1
P-16	>4.0
P-17	0.5
P-18	0.7
P-19	0.5
P-20	1.5
P-21	0.4
P-22	1.0
P-23	0.3
P-24	>4.0
P-25	2.0
P-26	1.2

AUGER PROBES	
NUMBER	DEPTH TO REFUSAL (feet)
P-27	0.5
P-28	2.0
P-29	0.3
P-30	3.0
P-31	> 5.0
P-32	> 5.0
P-33	0.1
P-34	0.4
P-35	1.0
P-36	0.5
P-37	3.0
P-38	0.5
P-39	1.5

AUGER PROBES	
NUMBER	DEPTH TO REFUSAL (feet)
P-40	5.0
P-41	1.0
P-42	0.2
P-43	1.0
P-44	3.0
P-45	3.5
P-46	>5.0
P-47	>5.0
P-48	>5.0
P-49	>5.0
P-50	4.0
P-51	>4.0
P-52	>4.0

RECORD DRAWING - AS CONSTRUCTED
CONT. NO. 70-C-0092 REV. — DATE JUN. 71 BY NO CHANGE
DATUM IS MEAN SEA LEVEL

REVISION	DATE	DESCRIPTION	BY

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY: H.A.B. B.O.H.
CHECKED BY:
SUBMITTED BY: John H. Bird
CHIEF FOR: A. DIV. L.E. DIV.

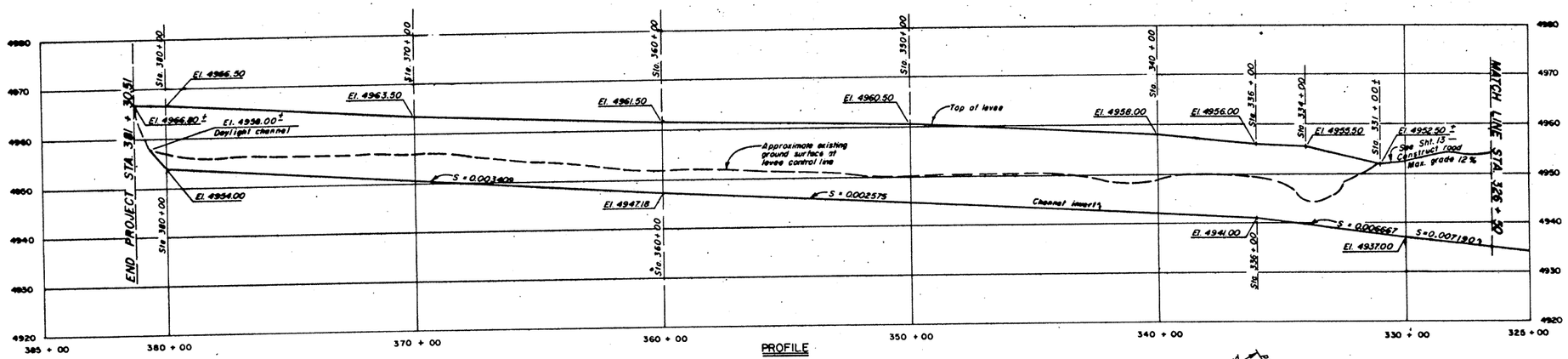
LITTLE COLORADO RIVER BASIN, ARIZONA AND NEW MEXICO
WINSLOW ARIZONA AND VICINITY

RUBY WASH DIVERSION LEVEE
FOUNDATION EXPLORATION

SUB. CONTRACTOR	SCALE: AS SHOWN	SPEC. NO. DACW 09-70-B-0059	SHEET NO. 3 OF 14
REFERENCE SHEET NO.	DATE: JUNE 1968	CHIEF FILE NO. 446/194 REV	

U. S. ARMY ENGINEER DISTRICT

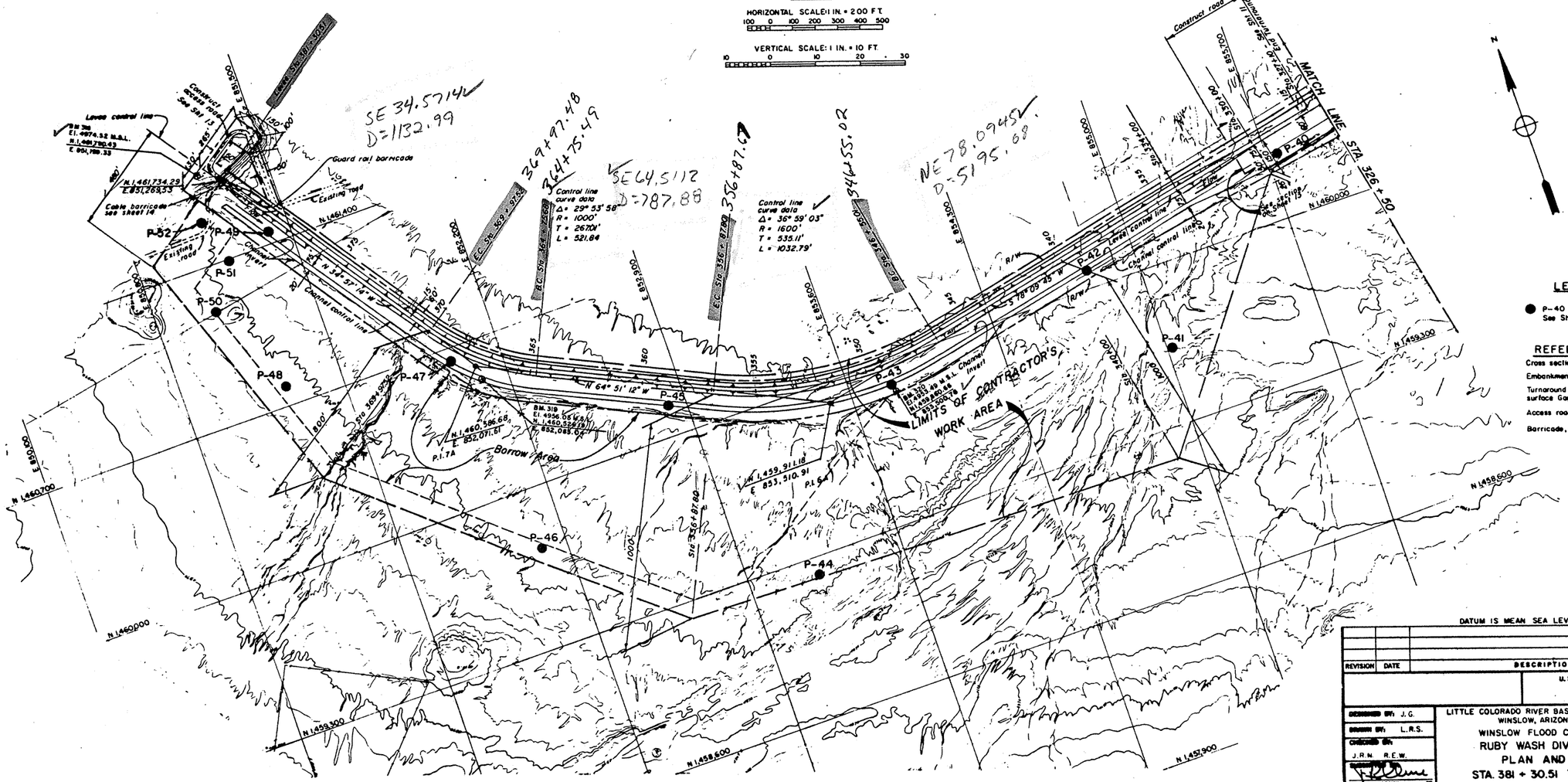
CORPS OF ENGINEERS



PROFILE

HORIZONTAL SCALE: 1 IN. = 200 FT.

VERTICAL SCALE: 1 IN. = 10 FT.



PLAN

SCALE: 1 IN. = 200 FT.

LEGEND

● P-40 Auger probe See Sheet 3.

REFERENCE DRAWINGS

Cross sections, ... Sheet 9

Embankment, channel ..... Sheet 11

Turnaround and water surface Gage Area Details ..... Sheet 11

Access road ..... Sheet 13

Barricade, Details ..... Sheet 14

DATUM IS MEAN SEA LEVEL

REVISION	DATE	DESCRIPTION	BY

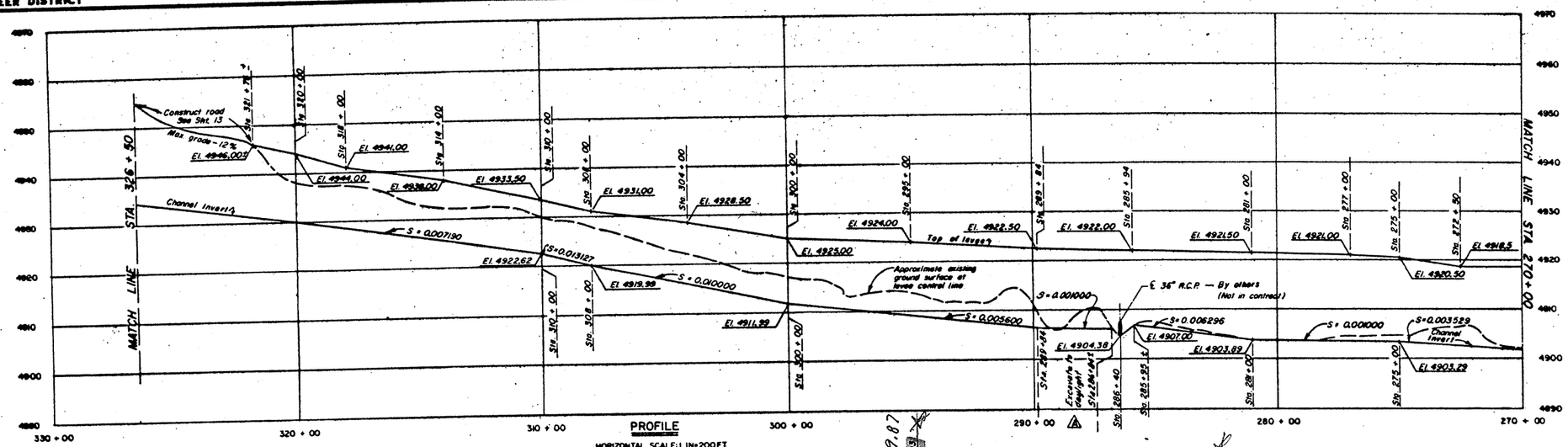
U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

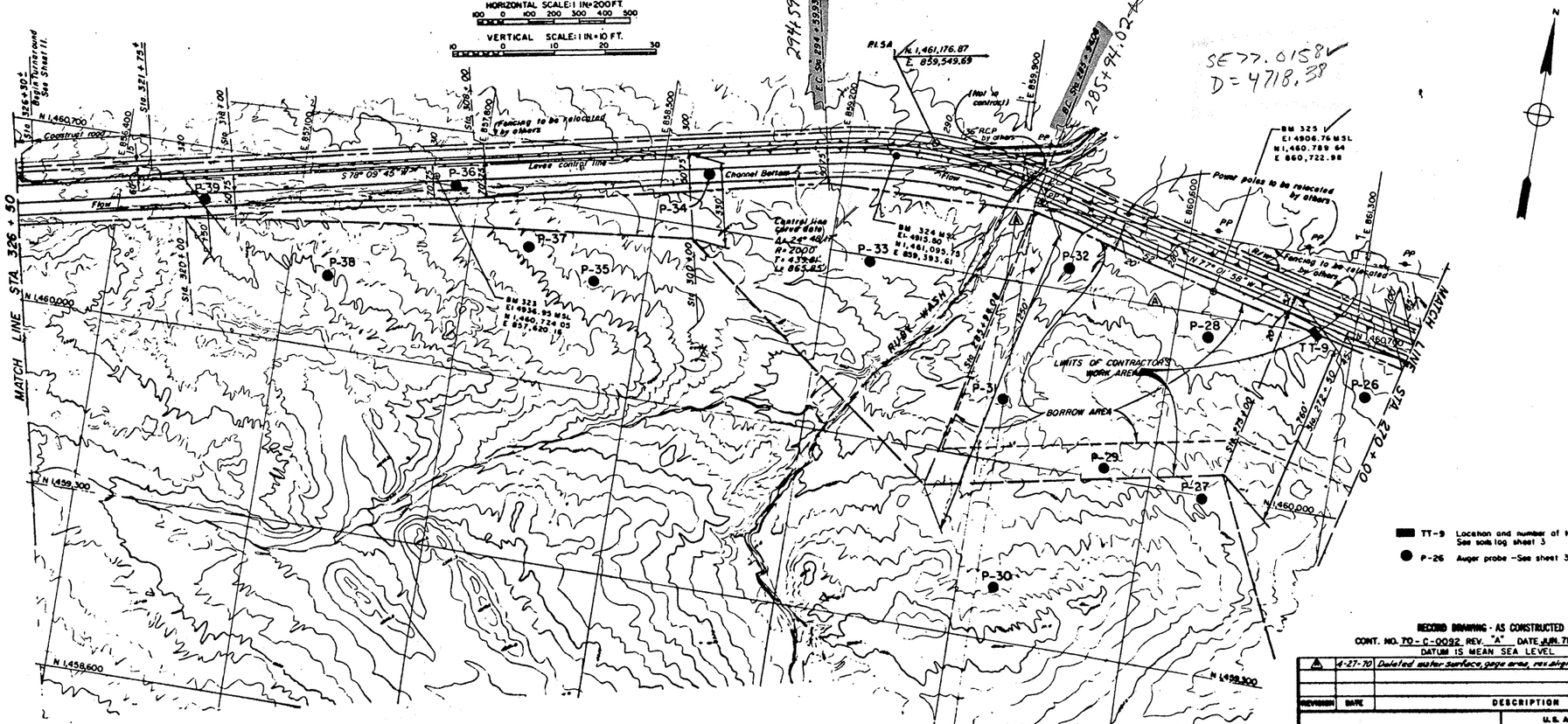
DESIGNED BY: J.G.
DRAWN BY: L.R.S.
CHECKED BY: J.R.N. R.E.W.

LITTLE COLORADO RIVER BASIN, ARIZONA AND NEW MEXICO
WINSLOW, ARIZONA AND VICINITY
WINSLOW FLOOD CONTROL PROJECT
RUBY WASH DIVERSION LEVEE
PLAN AND PROFILE
STA. 381 + 30.51 TO STA. 326 + 50

SCALE: AS SHOWN
DATE: MARCH 1969
SPEC. NO. DACW-70-B-0059
DWG FILE NO. 446/192
SHEET NO. 4 OF 14

RECORD DRAWING - AS CONSTRUCTED
CONT. NO. 70-C-0092 REV. — DATE JUN. 71 BY NO CHANGE





REFERENCE DRAWINGS

Cross-sections	Sheet 9
Embankment, channel, Turnaround and water surface Gage Area Details.	Sheet 11
Access Road	Sheet 13

PLAN
SCALE: 1 IN.=200 FT.

RECORD DRAWING - AS CONSTRUCTED
CONT. NO. 70-C-0092 REV. "A" DATE JAN. 71 BY NO CHANGE
DATUM IS MEAN SEA LEVEL

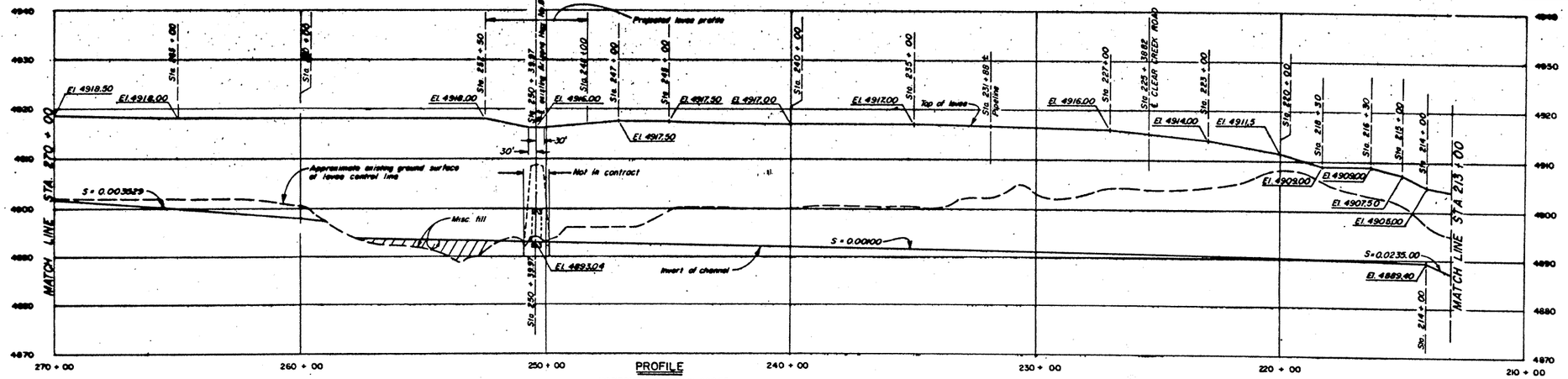
REVISION	DATE	DESCRIPTION	BY
4	4-27-70	Deleted water surface, gage area, revised grade of channel	

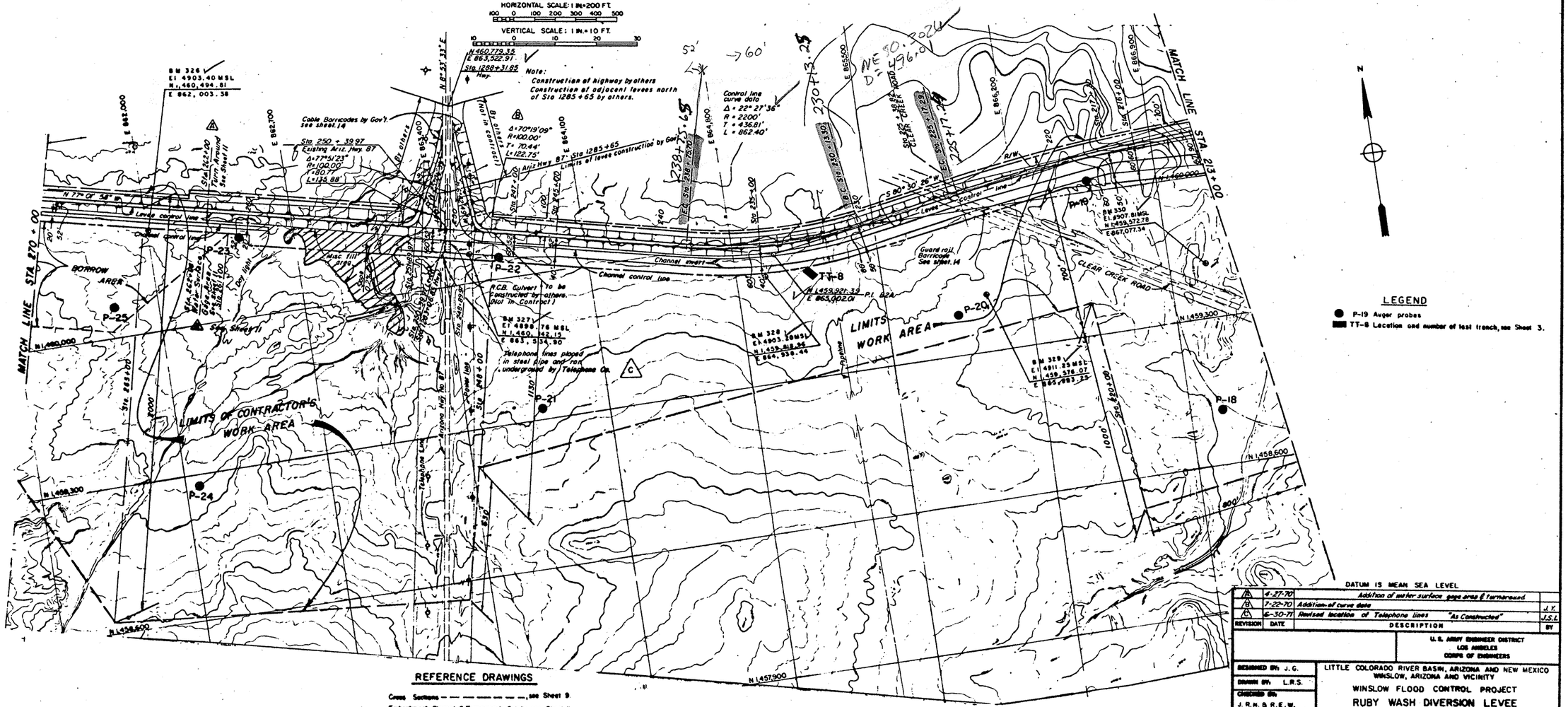
U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: J. G.
DRAWN BY: L.R.S. H.A.B.
CHECKED BY: J.R.N.

LITTLE COLORADO RIVER BASIN, ARIZONA AND NEW MEXICO
WINSLOW, ARIZONA AND VICINITY
WINSLOW FLOOD CONTROL PROJECT
RUBY WASH DIVERSION LEVEE
PLAN AND PROFILE
STA. 326 + 50 TO STA. 270+00

SCALE: AS SHOWN	SPEC. NO. DACW 09-70-B-0059		SHEET NO. 5 OF 14
DATE: MARCH 1969	DIST FILE NO. 446/193	REV. A	





LEGEND

- ● P-19 Auger probes
- ■ TT-8 Location and number of test trench, see Sheet 3.

DATUM IS MEAN SEA LEVEL

REVISION	DATE	DESCRIPTION	BY
A	4-27-70	Addition of water surface gage area & turnaround	
B	7-22-70	Addition of curve data	J.Y.
C	6-30-71	Revised location of Telephone lines "As Constructed"	J.S.L.

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: J. G.
DRAWN BY: L.R.S.
CHECKED BY: J. R.N. & R.E.W.

LITTLE COLORADO RIVER BASIN, ARIZONA AND NEW MEXICO
WINSLOW, ARIZONA AND VICINITY
WINSLOW FLOOD CONTROL PROJECT
RUBY WASH DIVERSION LEVEE
PLAN AND PROFILE
STA. 270 + 00 TO STA. 213 + 00

SCALE: AS SHOWN
DATE: MARCH 1969
CONTR. NO. DACW 09-70-B-0059
DWG. FILE NO. 446/194
REV. "C"
SHEET NO. 6 OF 14

REFERENCE DRAWINGS

Cross Sections — — — — — — — — —, see Sheet 9.
Embankment, Channel & Turnaround Details, see Sheet 11.
Barricade and Station Marker Details — — — — see Sheet 14.

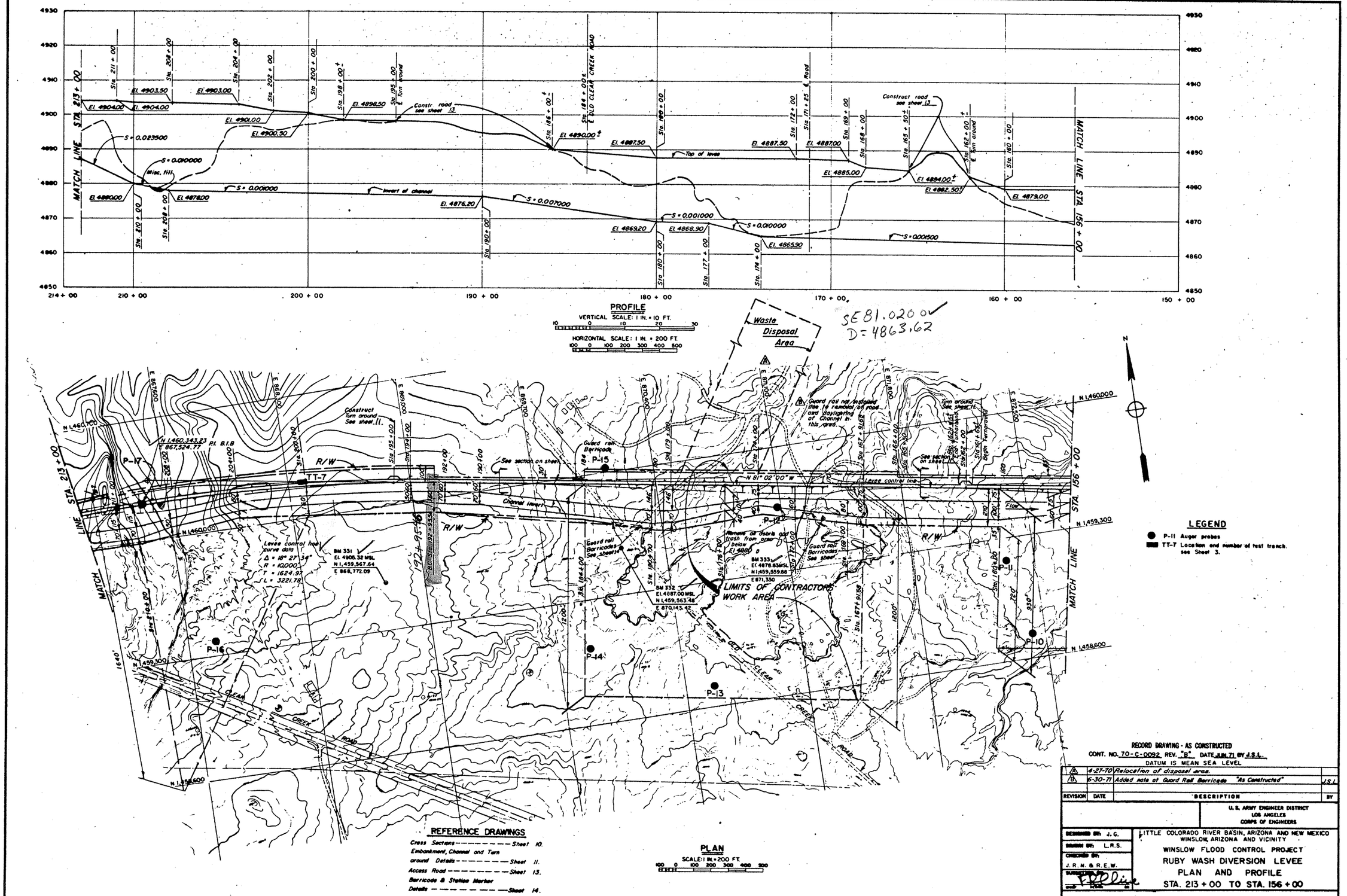
PLAN

SCALE: 1 IN. = 200 FT.

RECORD DRAWING - AS CONSTRUCTED
CONT. NO. 70-C-0092 REV. "C" DATE JUL 71 BY J.S.L.

U. S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS



LEGEND

- P-11 Auger probes
- TT-7 Location and number of test trench, see Sheet 3.

REFERENCE DRAWINGS

Cross Sections ---------- Sheet 10.
Embankment, Channel and Turn around Details ---------- Sheet 11.
Access Road ---------- Sheet 13.
Barricade & Station Marker Details ---------- Sheet 14.

RECORD DRAWING - AS CONSTRUCTED
CONT. NO. 70-C-0092 REV. "B" DATE JUN. 71 BY J.S.L.
DATUM IS MEAN SEA LEVEL

REVISION	DATE	DESCRIPTION	BY
A	4-27-70	Relocation of disposal area.	
B	6-30-71	Added note of Guard Rail Barricade "As Constructed"	J.S.L.

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

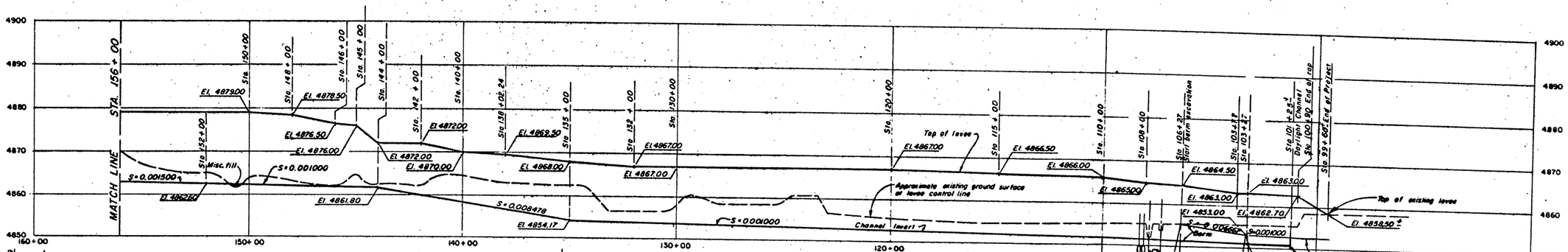
DESIGNED BY: J. G.
DRAWN BY: L.R.S.
CHECKED BY: J. R. N. & R. E. W.
SUBMITTED BY: F. R. Cline

LITTLE COLORADO RIVER BASIN, ARIZONA AND NEW MEXICO
WINSLOW, ARIZONA AND VICINITY
WINSLOW FLOOD CONTROL PROJECT
RUBY WASH DIVERSION LEVEE
PLAN AND PROFILE
STA. 213 + 00 TO STA. 156 + 00

SCALE: AS SHOWN
SPEC. NO. DACW09-70-B-0059
DATE: MARCH 1969
DWG FILE NO. 446/195
REV. "B"
SHEET NO. 7 OF 14

U. S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS

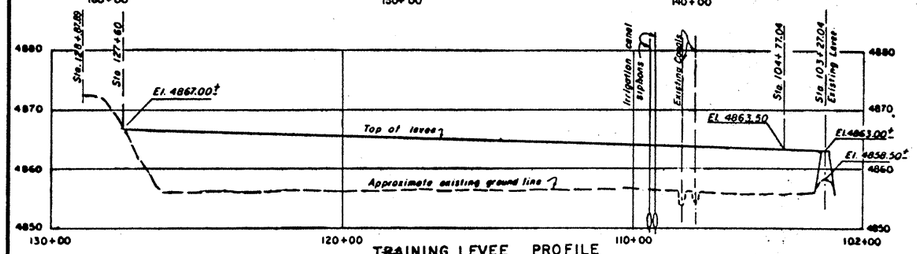


DIVERSION LEVEE

PROFILE

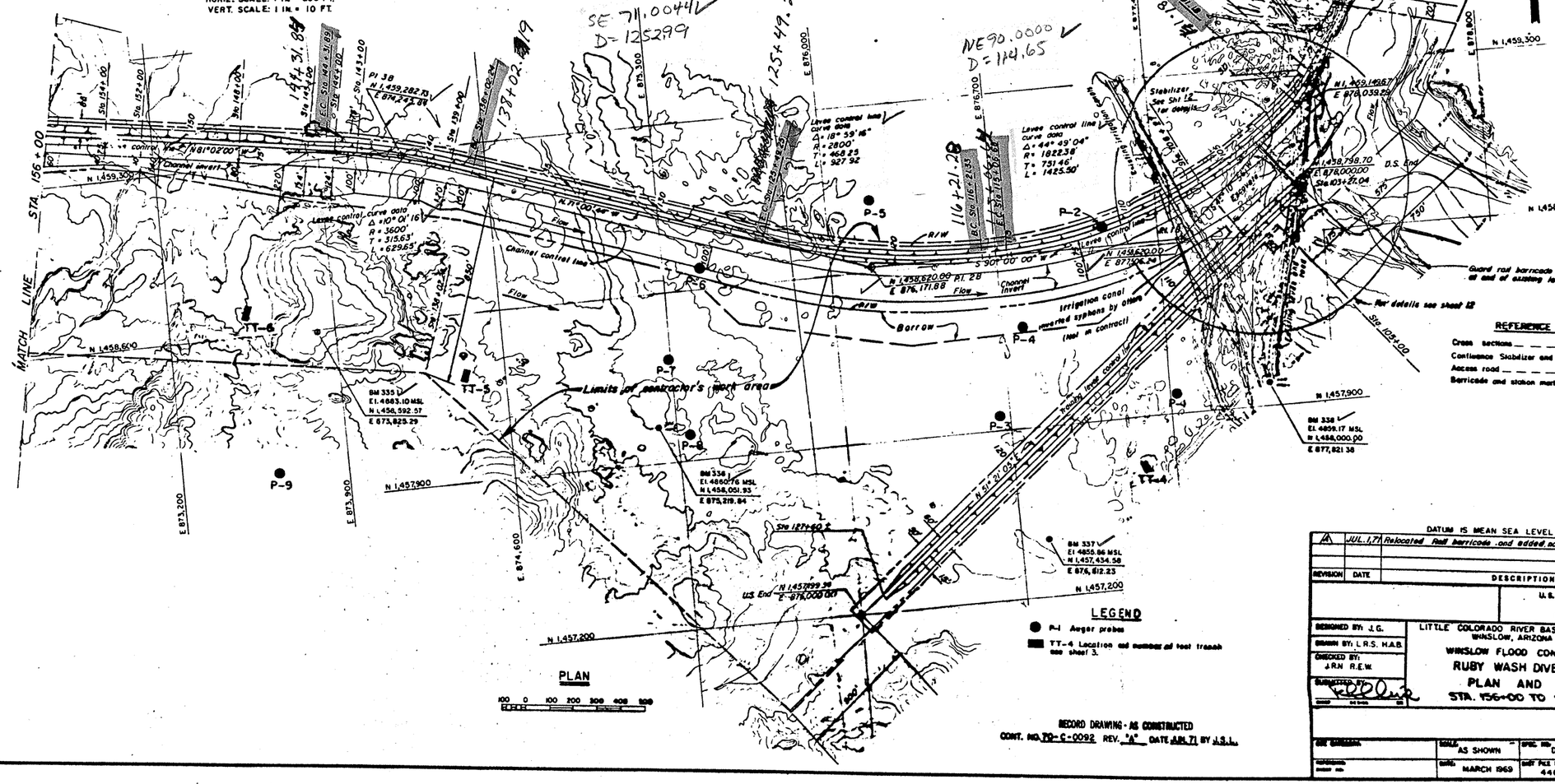
HORIZ. SCALE 1 IN. = 200 FT

VERT. SCALE: 1 IN. = 10 FT.



TRAINING LEVEE PROFILE

HORIZ. SCALE. 1 IN = 200 FT.
VERT. SCALE: 1 IN. = 10 FT.



PLAN

LEGEND

- P-1 Auger probes
- TT-4 Location and number of test trench see sheet 3.

REFERENCE DRAWINGS

Cross sections	Sheet 10
Confluence Stabilizer and Access ramp details	Sheet 12
Access road	Sheet 13
Barricade and station marker details	Sheet 14

DATUM IS MEAN SEA LEVEL

REVISION	DATE	DESCRIPTION	BY
A	JUL. 1, 71	Relocated Rail barricade and added note "As Constructed"	J.S.L.

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: J.G.
DRAWN BY: L.R.S. H.A.B.
CHECKED BY: J.R.N. R.E.W.
SUBMITTED BY: [illegible]

LITTLE COLORADO RIVER BASIN, ARIZONA AND NEW MEXICO
WINSLOW, ARIZONA AND VICINITY

WINSLOW FLOOD CONTROL PROJECT

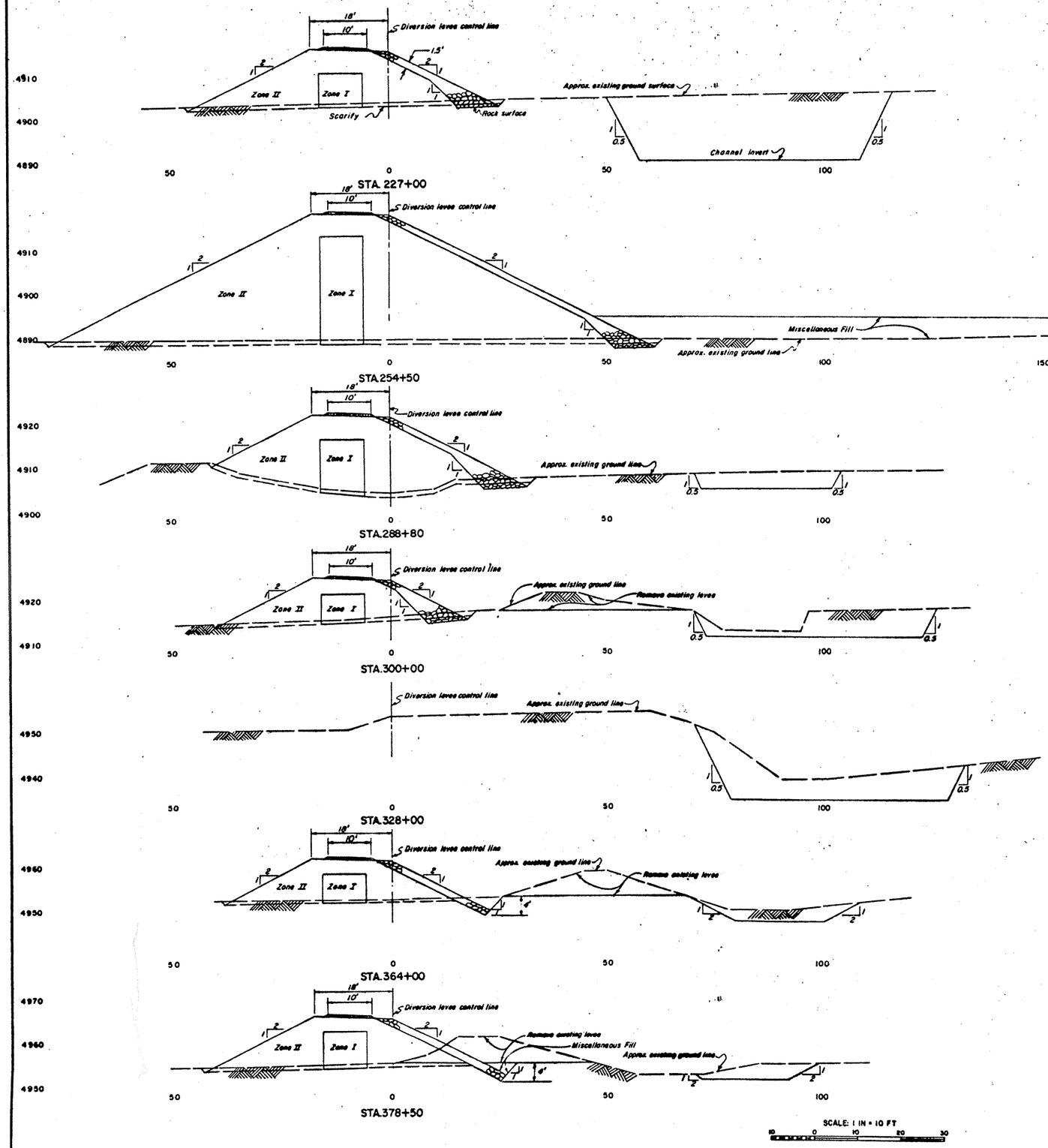
RUBY WASH DIVERSION LEVEE

PLAN AND PROFILE

STA. 156+00 TO STA. 99+60

SCALE: AS SHOWN
DATE: MARCH 1969
SPEC. NO. DACW09-70-B-0089
DWG. FILE NO. 446/196
REV. "A"
SHEET NO. 8 OF 14

RECORD DRAWING - AS CONSTRUCTED
CONT. NO. 70-C-0092 REV. "A" DATE JUL 71 BY J.S.L.



SCALE: 1 IN = 10 FT

RECORD DRAWING - AS CONSTRUCTED

CONT. NO. 70 - C - 0092 REV. — DATE JUL. 71 BY NO CHANGE

DATUM IS MEAN SEA LEVEL

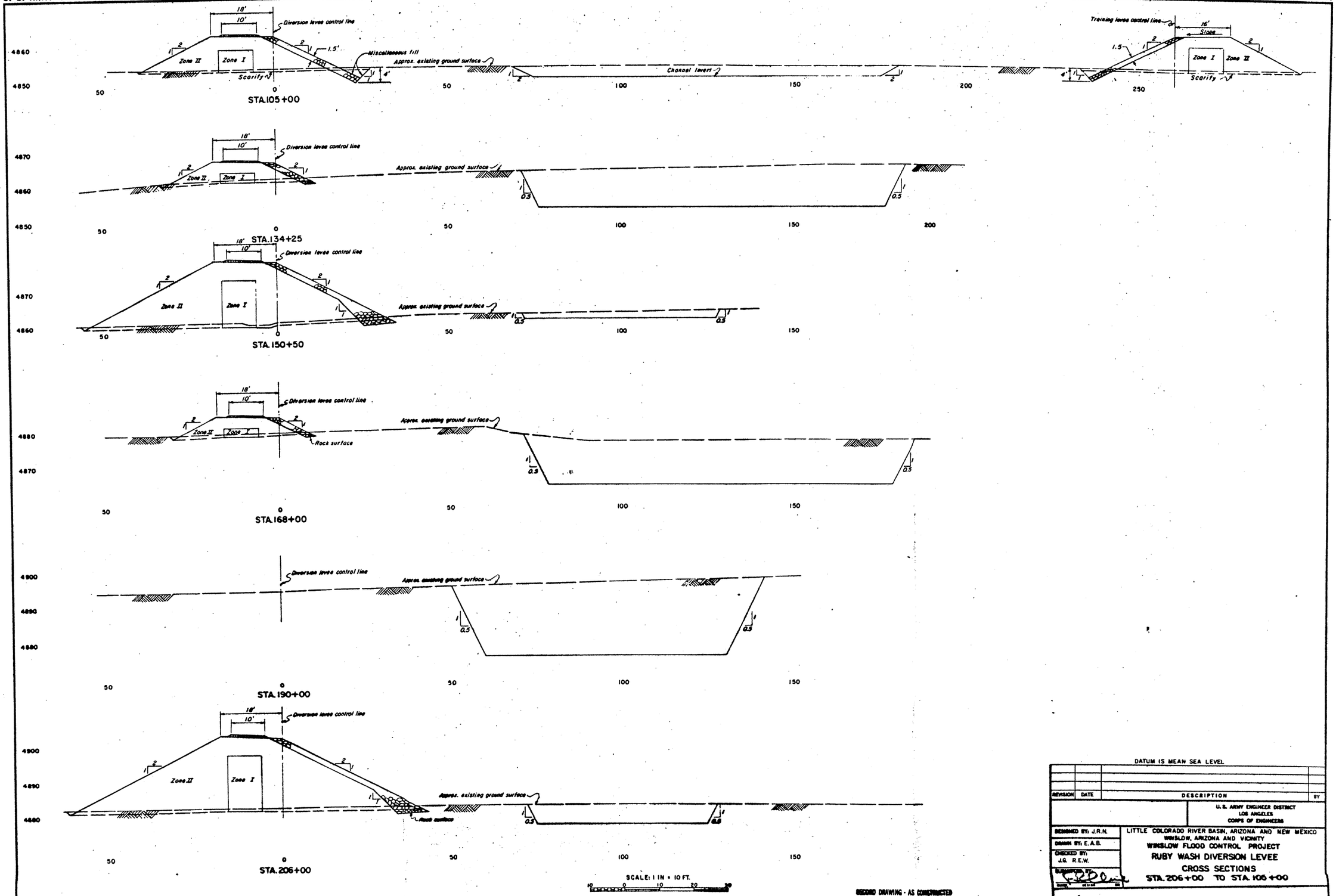
REVISION	DATE	DESCRIPTION	BY

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: J.R.N.
DRAWN BY: E.A.B.
CHECKED BY: J.G. R.E.W.
SUBMITTED BY:

LITTLE COLORADO RIVER BASIN, ARIZONA AND NEW MEXICO
WINSLOW, ARIZONA AND VICINITY
WINSLOW FLOOD CONTROL PROJECT
RUBY WASH DIVERSION LEVEE
CROSS SECTIONS
STA.378+50 TO STA.227+00

CCE CATEGORY	SCALE: AS SHOWN	SPEC. NO: DACW09-70-B-0059	SHEET NO 9 OF 14
REFERENCE SHEET NO.	DATE: MARCH 1969	DIST FILE NO. 446/197 REV	



RECORD DRAWING - AS CONSTRUCTED
CONT. NO. 70 - C - 0092 REV. — DATE JUL 71 BY NO CHANGE

DATUM IS MEAN SEA LEVEL

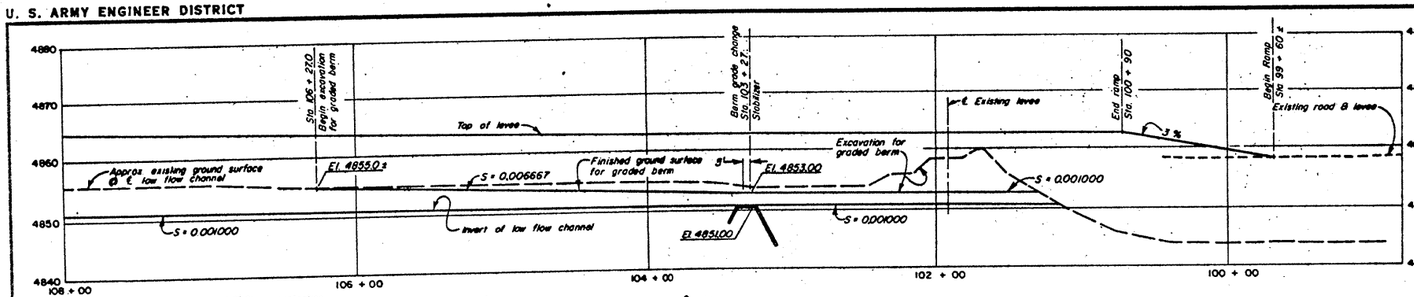
REVISION	DATE	DESCRIPTION	BY

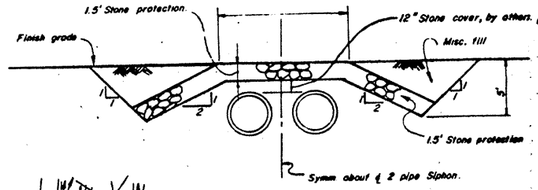
U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: J.R.N.
DRAWN BY: E.A.B.
CHECKED BY: J.G. R.E.W.

LITTLE COLORADO RIVER BASIN, ARIZONA AND NEW MEXICO
WINSLOW, ARIZONA AND VICINITY
WINSLOW FLOOD CONTROL PROJECT
RUBY WASH DIVERSION LEVEE
CROSS SECTIONS
STA. 206+00 TO STA. 105+00

SCALE: AS SHOWN
DATE: MARCH 1969
SPEC. NO. DACW09-70-B-0059
SHEET FILE NO. 446/198
SHEET NO. 10 OF 14



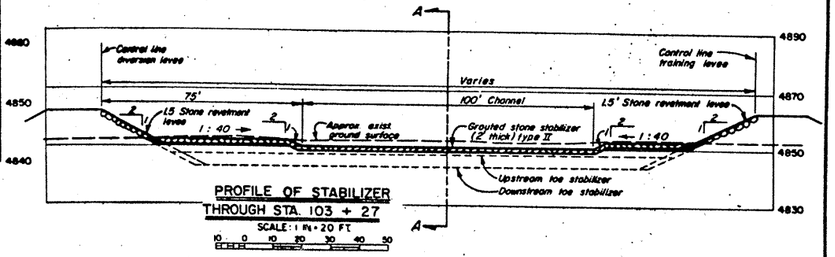


SECTION B-B
SIPHON PROTECTION BY OTHERS

NOT TO SCALE
(Not in contract)

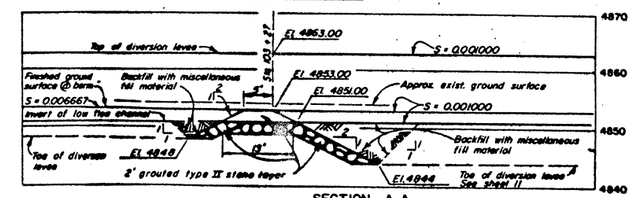
PROFILE

HORIZ. SCALE: 1 IN. = 40 FT.
VERT. SCALE: 1 IN. = 10 FT.



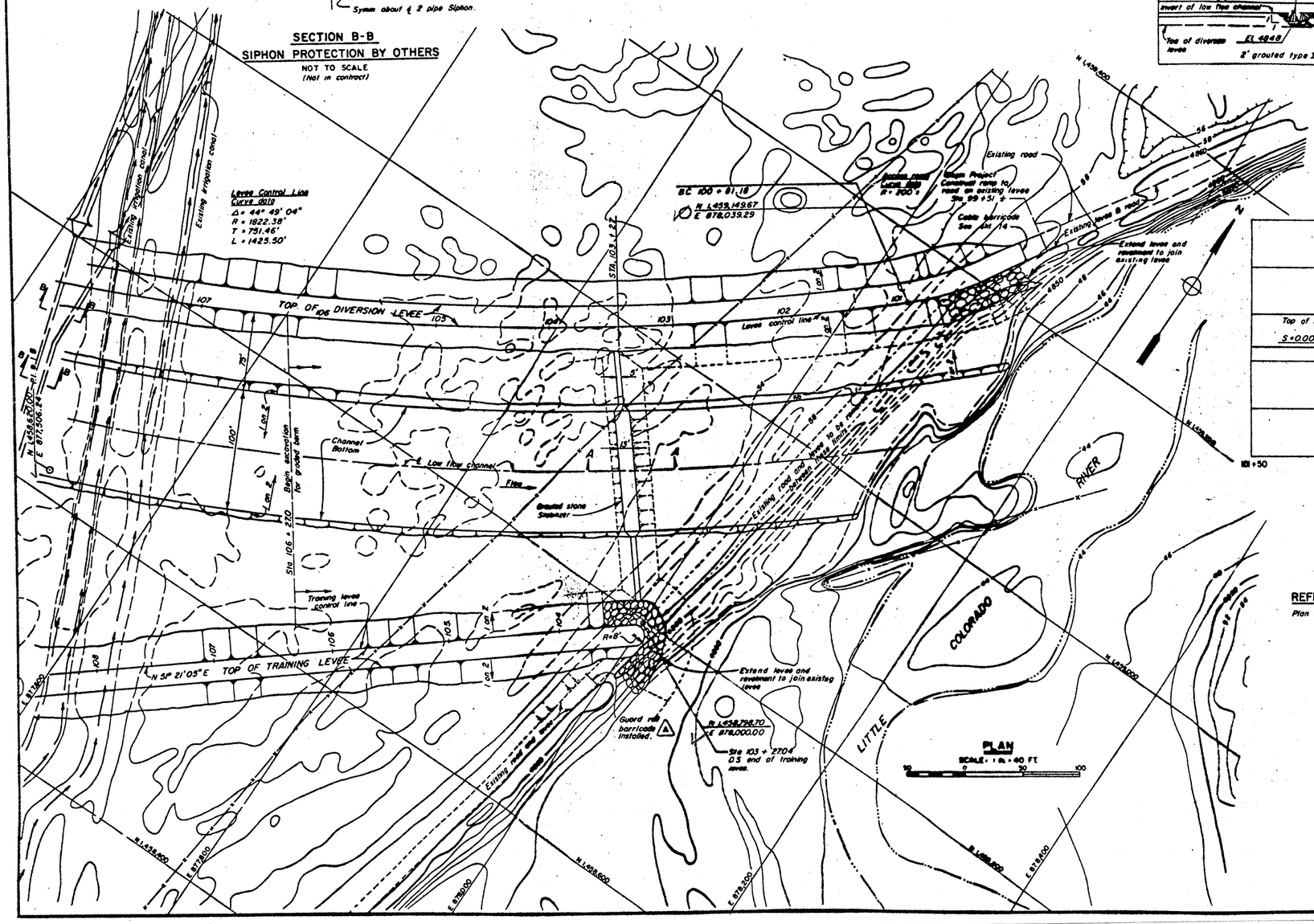
PROFILE OF STABILIZER THROUGH STA. 103 + 27

SCALE: 1 IN. = 20 FT.



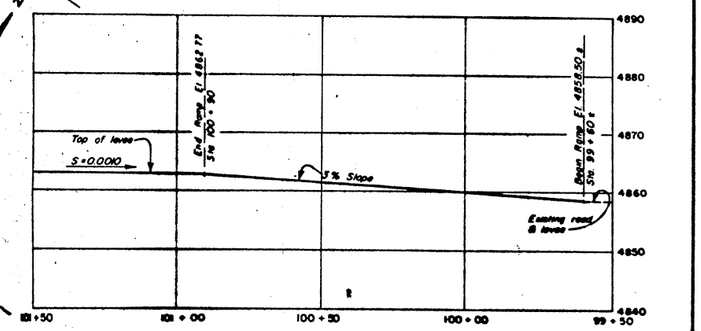
SECTION A-A

SCALE: 1 IN. = 10 FT.



PLAN

SCALE: 1 IN. = 60 FT.



PROFILE—ACCESS RAMP FROM EXISTING LEVEE ROAD

HORIZ. SCALE: 1 IN. = 20 FT.
VERT. SCALE: 1 IN. = 10 FT.

REFERENCE DRAWINGS

Plan and profile — Sheet 8

RECORD DRAWING - AS CONSTRUCTED
CONT. NO. 70-C-0092 REV. "A" DATE JUL. 71 BY J.S.L.

DATUM IS MEAN SEA LEVEL

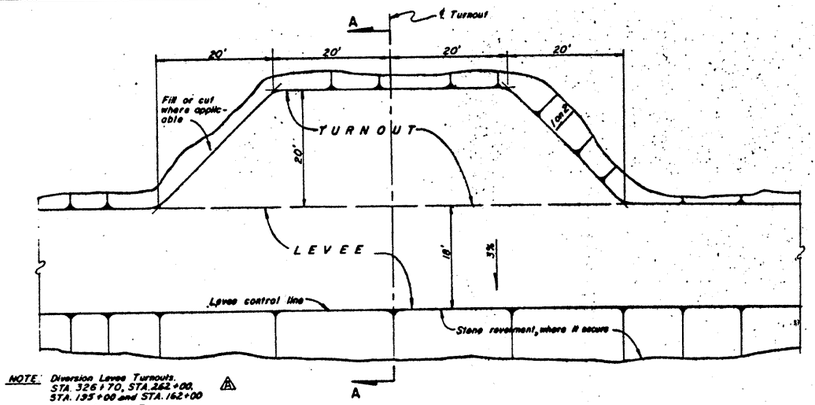
REVISION	DATE	DESCRIPTION	BY
A	JUL. 71	Added Guard rail barricade location and revised Siphon detail "As Constructed"	J.S.L.

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: L.S.
DRAWN BY: L.R.S.
CHECKED BY: J.G. J.R.N.
SUBMITTED: CHIEF, DESIGN SEC.

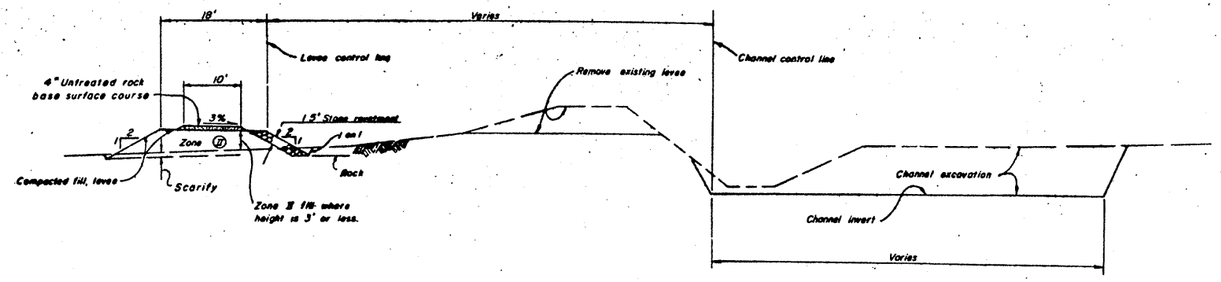
LITTLE COLORADO RIVER BASIN, ARIZONA AND NEW MEXICO
WINSLOW, ARIZONA AND VICINITY
WINSLOW FLOOD CONTROL PROJECT
RUBY WASH DIVERSION LEVEE
CONFLUENCE, STABILIZER AND ACCESS RAMP
DETAILS

CCE CATEGORY:	SCALE: AS SHOWN	SPEC. NO. DACW09-70-B-0059	SHEET NO. 12 OF 14
REFERENCE: SHEET NO.	DATE: MARCH 1969	SHEET FILE NO. 446/200 REV. "A"	

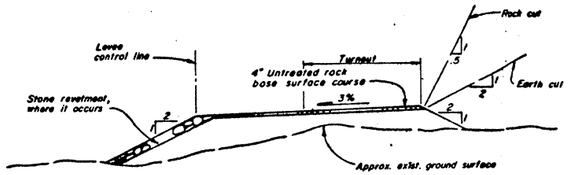


NOTE: Diversion Levee Turnouts, STA. 326+70, STA. 262+00, STA. 195+00 and STA. 162+00 See sheets 4 and 7

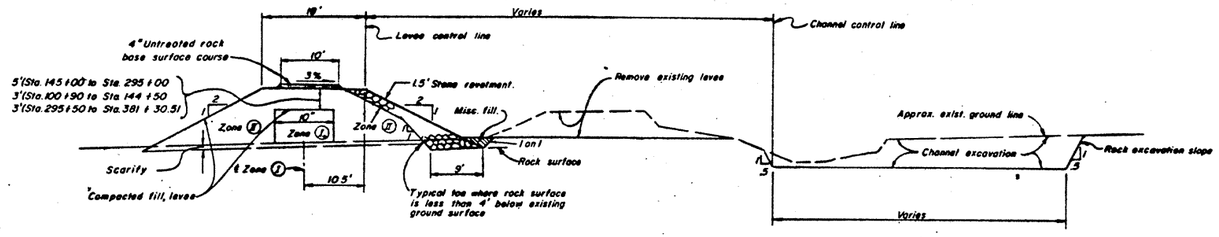
TYPICAL TURNOUT
SCALE 1 IN. = 10 FT.



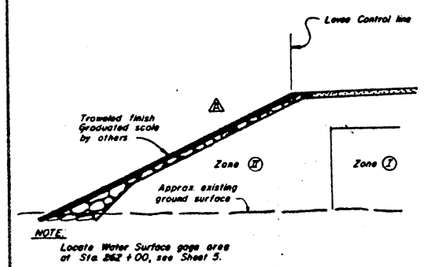
TYPICAL SECTION
CHANNEL AND LEVEE



TYPICAL TURNAROUND SECTION A-A
SCALE 1 IN = 10 FT

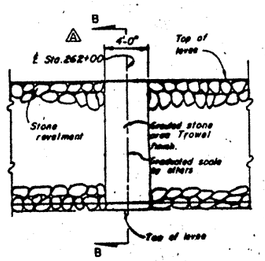


TYPICAL SECTION
CHANNEL AND LEVEE



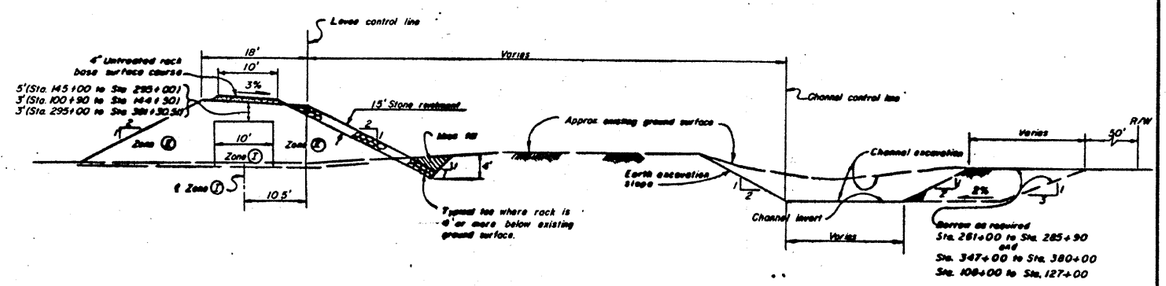
NOTE:
Locate Water Surface gage area at Sta. 262+00, see Sheet 5.

SECTION B-B

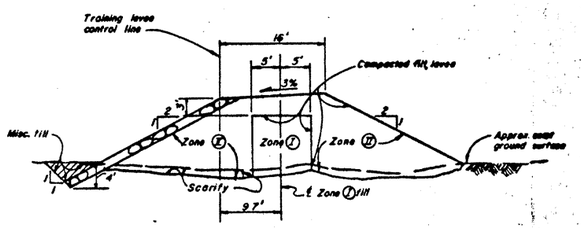


ELEVATION

WATER SURFACE GAGE AREA
NOT TO SCALE



TYPICAL SECTION
CHANNEL AND LEVEE



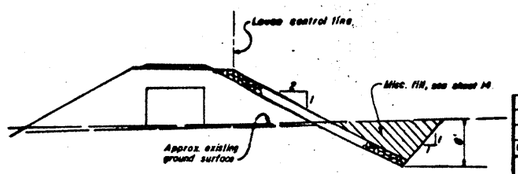
TYPICAL TRAINING LEVEE
SCALE: 1 IN. = 10 FT.

STONE REVETMENT
TYPE II (See specifications)

Sta. 108+00	to	Sta. 103+50		
" 139+00	"	" 140+00		
" 143+00	"	" 145+00		
" 157+00	"	" 164+00		
" 178+00	"	" 200+00		
" 212+00	"	" 221+00		
" 305+00	"	" 330+50		

TYPE I.
Remainder of diversion levee and training levee

LEGEND
Zone I and II Compacted fill, levee



TYPICAL TOE DETAIL
DIVERSION AND TRAINING LEVEE
STA. 103+27 to STA. 99+60
NOT TO SCALE

REFERENCE DRAWINGS
Plan and Profile sht. 4 to 8

RECORD DRAWING - AS CONSTRUCTED
CONT. NO. 70-C-0092 REV. "A" DATE JUL. 71 BY NO CHANGE

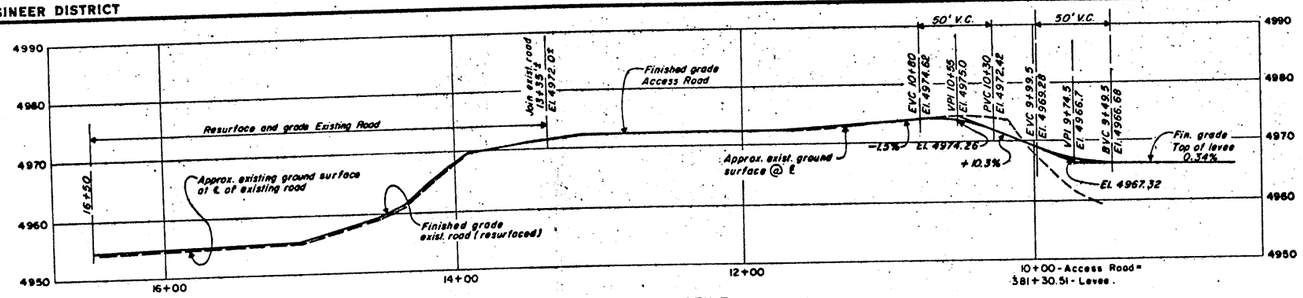
REVISION	DATE	DESCRIPTION	BY
4	4-27-70	Add turnaround station, revise water surface gage area station, grouting to depth of stonework	

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: J. G.
DRAWN BY: J. S. L.
CHECKED BY: J. R. N.
SUBMITTED BY: F. R. Olsen, CHIEF DESIGN

LITTLE COLORADO RIVER BASIN, ARIZONA AND NEW MEXICO
WINSLOW ARIZONA AND VICINITY
WINSLOW FLOOD CONTROL PROJECT
RUBY WASH DIVERSION LEVEE
EMBANKMENT, CHANNEL, TURNAROUND
WATERSURFACE GAGE AREA DETAILS

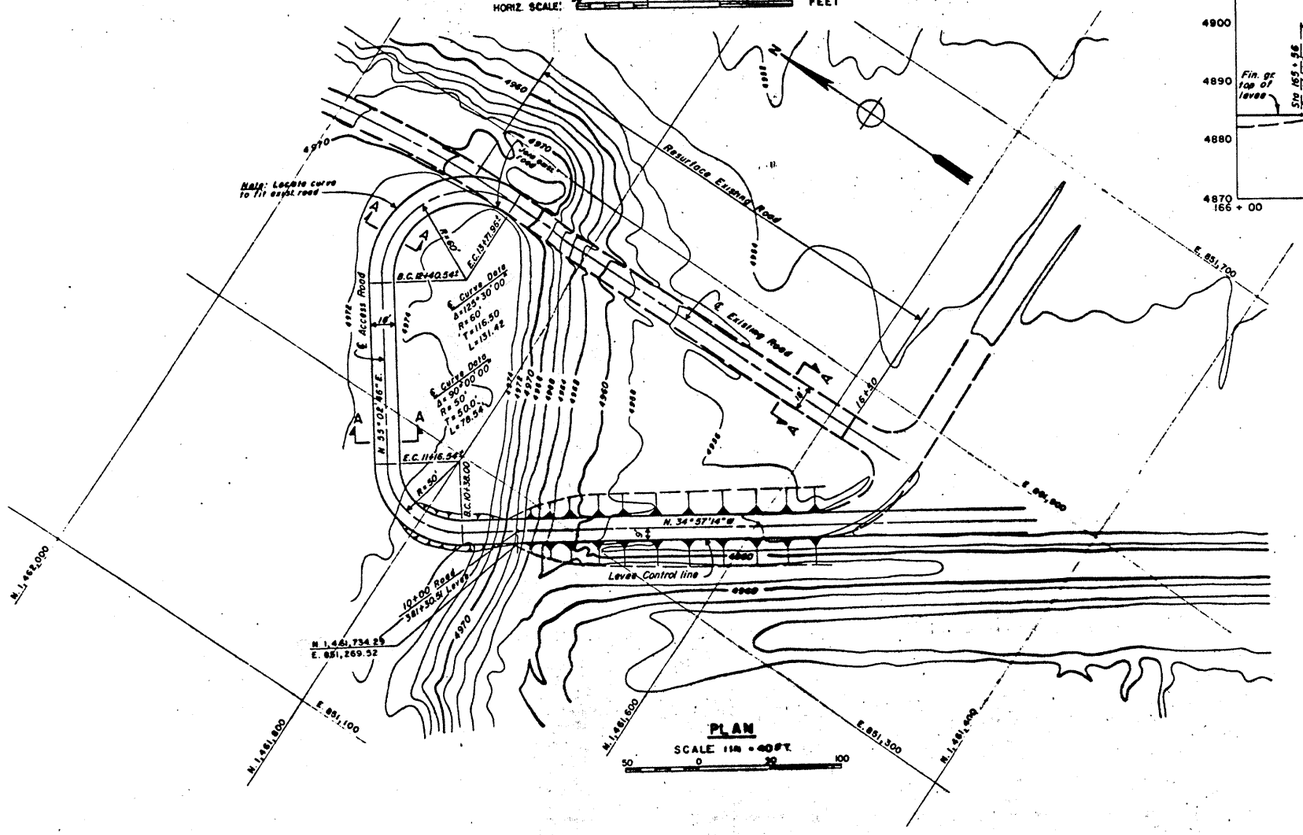
OCE CATEGORY:	SCALE:	SPEC. NO. DACW09-70-B-0059	SHEET NO. 11 OF 14
REFERENCE SHEET NO.	DATE:	DWG FILE NO. 446/199 REV. A	



PROFILE

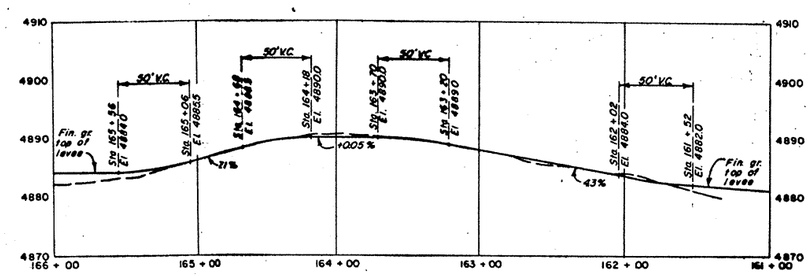
VERT. SCALE: 10 0 10 20 30 FEET

HORIZ. SCALE: 50 0 50 100 FEET



PLAN

SCALE 1 IN. = 40 FT.



STA. 162 + 00 TO STA. 165 + 50

PROFILE - ACCESS ROAD

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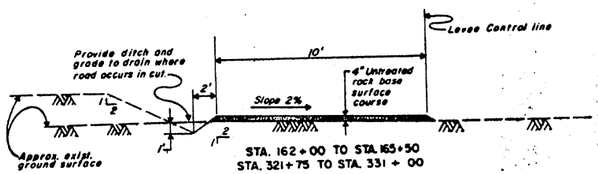
HORIZ. SCALE: 1 IN. = 40 FT.

Note: For plan, see Sheet 7



STA. 162 + 00 TO STA. 165+50

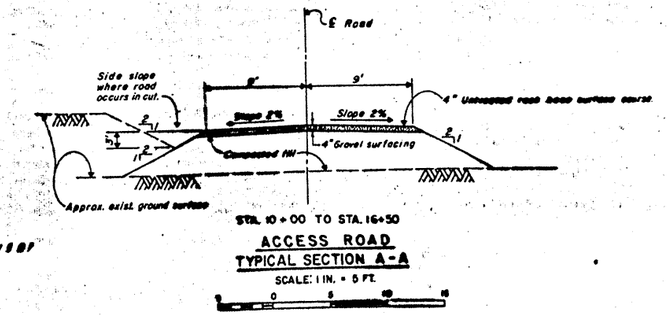
STA. 321+75 TO STA. 331 + 00

GRADED ROAD

TYPICAL SECTION

NO SCALE

Note: See sheet 8 of 7



STA. 10 + 00 TO STA. 16+50

ACCESS ROAD

TYPICAL SECTION A-A

SCALE: 1 IN. = 5 FT.

RECORD DRAWING - AS CONSTRUCTED

CONT. NO. 70-C-0082 REV. — DATE JUL. 71 BY NO CHANGE

DATUM IS MEAN SEA LEVEL

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

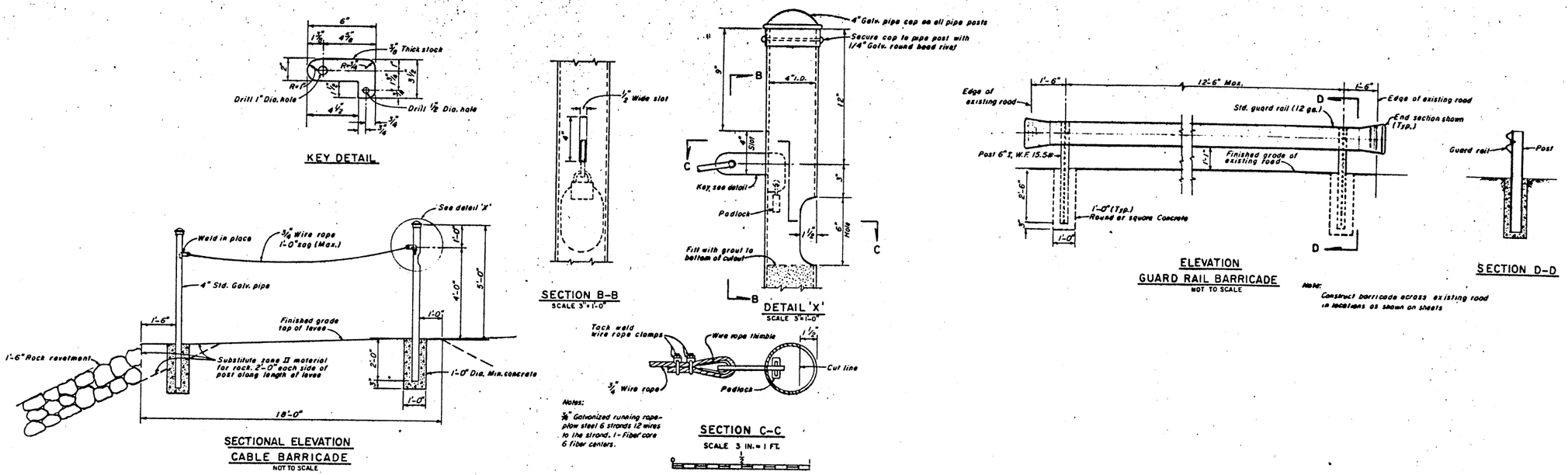
DESIGNED BY:
DRAWN BY: R.L.A
CHECKED BY:
SUBMITTED BY:
SHOP DESIGN BR

LITTLE COLORADO RIVER BASIN, ARIZONA AND NEW MEXICO
WINSLOW, ARIZONA AND VICINITY
WINSLOW FLOOD CONTROL PROJECT

ACCESS ROADS - LEVEE

PLAN, PROFILE AND SECTIONS

OCE CATEGORY:	SCALE: AS SHOWN	SPEC. NO. DACW09-70-B-0059	SHEET NO. 13 OF 14
REFERENCED SHEET NO.:	DATE: APRIL 1969	SHOP FILE NO. 446/201 REV	



RECORD DRAWING - AS CONSTRUCTED
CONT. NO. 70-C-0092 REV. — DATE JUL. 71 BY NO CHANGE

REVISION	DATE	DESCRIPTION	BY

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: J. G.
DRAWN BY: S. M. B.
CHECKED BY: J. R. N.
SUBMITTED BY: F. D. Cline
CHIEF DESIGN DIV.

LITTLE COLORADO RIVER BASIN, ARIZONA AND NEW MEXICO
WINSLOW ARIZONA AND VICINITY
WINSLOW FLOOD CONTROL PROJECT
RUBY WASH DIVERSION LEVEE
BARRICADE AND STATION MARKER
DETAILS

OCE CATEGORY:	SCALE: AS SHOWN	SPEC. NO. DACW09-70-B-0059	SHEET NO. 14 OF 14
REFERENCE: SHEET NO.	DATE: MARCH 1969	DIST FILE NO. 446/202 REV	

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APPENDIX E

Selected Sections from USACE Design Memorandum No. 1

2.08

DEPARTMENT OF THE ARMY
LOS ANGELES DISTRICT, CORPS OF ENGINEERS
P. O. BOX 2711
LOS ANGELES, CALIFORNIA 90053

IN REPLY REFER TO SPLED-DD

3 March 1969

SUBJECT: Winslow Flood Control Project, Winslow, Arizona and Vicinity - Design Memorandum No. 1 (General Design)

Division Engineer
South Pacific Division

1. Inclosed for approval in final form are 17 copies of subject report. This design memorandum is submitted in accordance with ER 1110-2-1150.

2. Work on contract plans and specifications for the Ruby Wash diversion levee has been initiated and is about 60 percent complete.

3. Expedited processing in your office and by Office, Chief of Engineers, is requested, inasmuch as initiation of construction during FY-69 is programed.

4. Inclosure 2 is in reply to SPD comments concerning draft of this report.

Norman E. Pehrson
NORMAN E. PEHRSON
Colonel, CE
District Engineer

2 Incl
1. Report (17 cys)
2. Comments

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Other Design Memorandum

No design memorandums have been issued previously for the Winslow Flood Control Project at Winslow Arizona, and no design memorandums are presently scheduled for future issuance.

Scheduled for Future Issuance

2--Ice House Wash Channel Winslow, Arizona & Vicinity

Revisions

Date	Revised Pages
20 Nov 1969	Pages i, ii, iii, iv, v, vi & vii
	Page 2, paragraph 7a
	Page 5, paragraph 23
	Page 10, paragraph 30
	Page 11, paragraph 33
	Page 12, paragraph 38
	paragraph 39 deleted
	Page 13, paragraphs 41 & 42
	Page 19, paragraph 61d
	Page 23, paragraphs 67 & 68
	Page 25, paragraph 81
	Page 26, paragraph 82
	Pages 27, 28
	Page 29 paragraph 3
	Pages 30, 31 & 32 tabulation
	Page 33 paragraph 89
	Page 45 tabulation

Additions

Appendix 2, Hydrology

Revised Drawings

Ruby Wash Diversion Levee

Plates, 16, 17, 18, 19, 20, 21, 23, 24 & 30

Additional Drawings

Plates 22 & 25

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	Page 45 tabulation
	Page 47 project cost

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DESIGN MEMORANDUM NO. 1, GENERAL DESIGN

WINSLOW FLOOD CONTROL PROJECT

WINSLOW, ARIZONA

SYLLABUS

The Winslow Flood Control project was authorized by Act of Congress, Public Law 89 - 298 89th Congress First session approved 27 October 1965, in accordance with the plan published in Senate Document 89-63.

The District Engineer now submits a recommended plan for construction of a diversion levee and a flood control channel that would provide the measure of flood-protection set forth in the Review Report For Flood Control, Winslow Arizona and vicinity, dated December 15, 1961, and included in Senate Document 89-67. The improvement would consist of (a) a diversion levee and low flow channel south of Winslow that would divert flows up to a maximum of 23,000 cfs from six main washes away from Winslow and east to Little Colorado River, and (b) improvement of the existing Ice House Wash ditch to convey flows up to a maximum of 2200 c.f.s. through the city of Winslow to a point of discharge north of the city.

The total first cost of the improvement is estimated at $4,110,000 ($3,420,000 Federal and $690,000 non-Federal). The time required to construct the project is estimated at 2 years.

The recommended plan described in this design memorandum except for minor alterations agrees with the one described in the project document plan. Local interests would provide without cost to the United States all lands, easements and rights-of-way necessary for construction of the project; bear the expense of all utility, bridge and road relocations; hold and save the United States free from all claims for damages resulting from construction, operation and maintenance of the works; maintain and operate the works after completion in accordance with regulations to be prescribed by the Secretary of the Army, prevent any encroachment upon the provements that would interfere with their operation or reduce their flood carrying capacity, and at least annually notify interests affected that the Ice House Wash Channel will not provide complete flood protection.

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WINSLOW FLOOD CONTROL PROJECT

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The District Engineer now submits a recommended plan for construction of a diversion levee and a flood control channel that would provide the measure of flood-protection set forth in the Review Report For Flood Control, Winslow Arizona and vicinity, dated December 15, 1961, and included in Senate Document 89-67. The improvement would consist of (a) a diversion levee and low flow channel south of Winslow that would divert flows up to a maximum of 23,000 cfs from six main washes away from Winslow and east to Little Colorado River, and (b) improvement of the existing Ice House Wash ditch to convey flows up to a maximum of 2200 c.f.s. through the city of Winslow to a point of discharge north of the city.

The total first cost of the improvement is estimated at $4,110,000 ($3,420,000 Federal and $690,000 non-Federal). The time required to construct the project is estimated at 2 years.

The recommended plan described in this design memorandum except for minor alterations agrees with the one described in the project document plan. Local interests would provide without cost to the United States all lands, easements and rights-of-way necessary for construction of the project; bear the expense of all utility, bridge and road relocations; hold and save the United States free from all claims for damages resulting from construction, operation and maintenance of the works; maintain and operate the works after completion in accordance with regulations to be prescribed by the Secretary of the Army, prevent any encroachment upon the provements that would interfere with their operation or reduce their flood carrying capacity, and at least annually notify interests affected that the Ice House Wash Channel will not provide complete flood protection.

DESIGN MEMORANDUM NO. 1 GENERAL DESIGN

WINSLOW FLOOD CONTROL PROJECT

WINSLOW, ARIZONA

Pertinent Data

Ruby Wash Diversion Levee

.ainage area	sq. miles	24
Design Discharge	c.f.s	8500 to 23,000
Levee and channel	ft.	28,170
Height of levee	ft.	12 to 14
Depth of channel	ft.	1 to 20

Ice House Wash Channel

Drainage area	sq. miles	2.2
Design discharge	c.f.s	2,200
Rectangular concrete channel	lin. ft.	3,645
Height of rectangular channel	ft.	10
Width of rectangular channel	ft.	20 to 40
Trapezoidal earth channel	lin. ft.	8,560
Trapezoidal channel, base width	ft.	40 to 100
Trapezoidal channel, height	ft.	7 to 12

Total Estimated Costs and Benefit Cost Ratio

Federal total first costs	$4,110,000
Non-Federal total first costs	$690,000
Annual cost for operation and maintenance	$16,500
Benefit-cost ratio	1.9

DESIGN MEMORANDUM NO. 1 GENERAL DESIGN

WINSLOW FLOOD CONTROL PROJECT

WINSLOW, ARIZONA

Pertinent Data

Ruby Wash Diversion Levee

Drainage area	sq. miles	24
Design Discharge	c.f.s	8500 to 23,000
Levee and channel	ft.	28,170
Height of levee	ft.	12 to 14
Depth of channel	ft.	1 to 20

Ice House Wash Channel

Drainage area	sq. miles	2.2
Design discharge	c.f.s	2,200
Rectangular concrete channel	lin. ft.	3,350
Height of rectangular channel	ft.	10
Width of rectangular channel	ft.	20
Trapezoidal earth channel	lin. ft.	8,860
Trapezoidal channel, base width	ft.	40 to 100
Trapezoidal channel, height	ft.	7 to 12

Total Estimated Costs and Benefit Cost Ratio

Federal total first costs	$4,191,000
Non-Federal total first costs	$641,000
Annual cost for operation and maintenance	$16,500
Benefit-cost ratio	1.7

DESIGN MEMORANDUM NO. 1 GENERAL DESIGN

WINSLOW PROJECT

LITTLE COLORADO RIVER, ARIZONA AND NEW MEXICO

Project Authorization

1. This design memorandum is submitted to present detailed information on the results of the definite-project studies of the Winslow Flood control project at Winslow Arizona, that were made since authorization of this flood-control project.

2. The project was authorized by Act of Congress, Public Law 89-298 Eighty ninth Congress, first session approved 27 October 1965.

PROJECT AS DESCRIBED IN PROJECT DOCUMENT

3. The Winslow project is a flood control project for the protection of Winslow, Arizona. The project was recommended for approval in the Chief of Engineer's report dated 11 July 1963 and published as part of Senate Document 63, Eighty-eighth Congress second session. Senate Document 89-63 will be referred to in this design memorandum as the project document.

4. The project document plan provided for (a) construction of a diversion levee which would encompass the existing diversion levee and channel south of the Winslow Airport and then continue eastward to the Little Colorado River and (b) Improvement of the Ice House Wash from the Santa Fe Railroad to a point 8,100 feet north of Hillview Street. The improvement would include 3,300 feet of rectangular reinforced-concrete channel. The channel would be 20 feet wide with an average depth of 10.5 feet. The walls would be at or below the ground surface. Northward from Hillview Street for a distance of 2,700 feet the improvement would consist of an earth bottom trapezoidal channel with a base width of 40 feet. From a point where the channel would cross the proposed Interstate Highway 40 to a point approximately 6,200 feet north of the highway the improvement would consist of a 25 foot pilot channel between parallel levees 100 feet apart. Other features of the plan would include an earth levee along and south of the railroad and a levee extending the east limit of the inlet to convey flows into the channel. A concrete box structure would replace the existing railroad bridge carrying 18 tracks over the channel. The project would require replacement of six existing street bridges which cross the existing Ice House Wash ditch, and a bridge crossing for the proposed U.S. Interstate Highway 40.

5. Waterfowl-habitant development- The Arizona Game and Fish Department indicated abandonment of waterfowl habitat development considered earlier during project studies due to lack of available water rights.

6. Recreational development- Consideration was given to the possibility of recreational development that might result within the easement lines of the floodway above the recommended diversion levee. However, because of the limited width and area of the easement lands, such development is not considered practical.

DEPARTURES FROM THE PROJECT-DOCUMENT PLAN

7. The differences between the project document plan and the plan proposed in this design memorandum are described in the following sub-paragraphs:

a. Ruby Wash Diversion levee- The length of the diversion levee would be decreased by 1,300 feet. Disposal of suitable excess material from required minimum excavation for the low-flow channel would be utilized to provide 2 feet of additional freeboard between stations 300+00 and 144+00 where flow from five main washes impinge directly on the levee. A training levee has been provided to minimize the length of the proposed siphon relocation for two existing irrigation ditches crossing the levee alinement near the Little Colorado River. Studies made during preparation of this report indicated that because of the flat slope adjacent to the river, to preclude interruption of irrigation facilities by diverted flood flow, an excessively long and difficult to maintain siphon would be required. Comparative cost estimates indicate a lower total project cost with the training levee.

b. Ice House Wash Channel- The recommended plan is approximately the same as the project-document plan with the following exceptions: the length of the rectangular channel would be decreased by 800 feet and the length of trapezoidal channel would be increased by 900 feet.

PURPOSE OF THE PROJECT

8. Construction of the improvements recommended in this report would provide protection to the city of Winslow and property outside the city from damages resulting from floods originating upstream of the recommended improvements.

9. The Ruby Wash levee would intercept and divert all flood flows up to the standard project flood magnitude away from the developed area to the Little Colorado River. The recommended improvement, by controlling floods originating upstream from the improvement, would permit local interests to develope an adequate storm-drain system to accommodate flows originating downstream from the improvement.

10. The Ice House Wash Channel improvement would protect residential and commercial areas in Winslow subject to damage from Ice House Wash flows equivalent to 48% of the standard project flood. This is larger than any known flood of record. The frequency of the design flood would be once in about 50 years.

PREVIOUS PROJECTS

11. No previous flood-control project under the jurisdication of the Corps of Engineers, U.S. Army has been adopted for the Winslow Flood Control Project. During World War II in 1944, the airport runways at the Winslow airport were extended and a diversion levee and channel improvement, upstream from the enlarged airport were constructed by the Civil Aeronautics Adminstration (now the Federal Aviation Agency).

SCOPE OF DEFINITE-PROJECT STUDIES

12. The studies described in this memorandum were made to establish the general and coordinated design of the proposed improvement. Field investigations of the drainage area were made by the District Engineer and by personnel preparing this report. Foundation conditions were also investigated. The studies were coordinated with Federal and local agencies. Economic investigations included studies of estimated project costs and field investigation of the overflow areas.

13. A topographic survey was accomplished by aerial photography along the Ruby Wash diversion levee and by plane table along the Ice House Wash. The surveys were completed in May 1967 and furnish the basic information for culture and topography used in this design memorandum.

LOCAL COOPERATION

14. Local cooperation specified in the project document- In accordance with Chief of Engineers' report dated 11 July 1963 and published as part of Senate Document No. 89-63, Eighty-eighth Congress, second session, local interests would give assurances satisfactory to the Secretary of the Army that they will: (a) Provide without cost to the United States all lands, easements, and rights-of-way necessary for construction of the project; (b) Perform without cost to the United States all necessary relocations or modifications of highways and bridges (except railroad), utilities, irrigation facilities, and drainage works; (c) Hold and save the United States free from damages due to the construction works; (d) Maintain and operate all the works after completion in accordance with regulations prescribed by the Secretary of the Army; and (e) Prevent any encroachment upon the improved channels and within the restrictive easement area upstream from the diversion levee that would reduce their flood-carrying capacities.

15. Local cooperation required by this report-- Local cooperation would fulfill the requirements stated in the paragraph titled "Local cooperation specified in the project document." Additionally thereto local interests would "At least annually notify interests affected that the Ice House Wash Channel improvements will not provide for complete flood protection.

16. Public hearings and views of local interests-- No public hearings have been held by the District Engineer since publication of the review report. Navajo County, which is the local agency responsible for fulfillment of local cooperation has concurred in the features of the general plan of improvement recommended in this memorandum by correspondence and conferences during the definite-project studies.

Principal officer responsible-- The name, title and address of the principal officer responsible for local cooperation follows:

Name	Title	Address
Max E. Taylor	Chairman, Navajo County Board of Supervisors	Holbrook, Arizona

LOCAL COOPERATION PROFFERED

17. Local interests compliance with requirements of local cooperation-- Compliance with the requirements of local cooperation prescribed by the authorizing legislation is expected from the Navajo County Board of Supervisors because that agency (a) Passed a resolution assuring the United States that this cooperation will be provided and (b) assumed the responsibility of representing local interests.

LOCATION OF PROJECT AND DESCRIPTION OF DRAINAGE AREA

18. Project works--The project is located approximately 200 miles northeast of Phoenix, Arizona and consists of two features: (a) The proposed diversion levee would be located about one mile south of the city of Winslow and would extend eastward to the Little Colorado River, (b) The proposed improvement of Ice House Wash would extend northward through the city to a point of discharge north of Winslow.

19. Drainage area-- That part of the Little Colorado River basin that would be drained by the proposed improvements comprises a drainage area of 26 square miles in Coconino and Navajo Counties in the vicinity of Winslow. The total drainage area at the railroad track is divided into an area of 2.2 square miles tributary to the existing Ice House Wash Channel, 12.8 square miles tributary to Ruby Wash, and an area of 10.7 square miles tributary to four unnamed washes. Ice House Wash and Ruby Wash pass through the present developed area of Winslow. Ruby Wash has its origin in the plateau area about 5 miles southwest of Winslow.

Ice House Wash, adjacent to and westerly of Ruby Wash originates 8 miles southwest of Winslow. An existing levee protecting the city airport diverts the flow from Ice House Wash to Ruby Wash. Only a small part of the original Ice House Wash drainage area now contributes to the flood problem along the wash downstream from the Santa Fe Railroad. Both Ruby Wash and Ice House Wash flow generally northward through Winslow and join the Little Colorado River about 7 miles north of Winslow. The four unnamed washes to the east of Ruby Wash which flow generally northward and join the Ruby Wash flow downstream of the railroad adding to the flood damage in the area. Surface flow in all these washes is intermittent.

20. Topography-- The Winslow region (El. 4850) is in the drainage basin of the Little Colorado River. In its upper portion, the Little Colorado is perennial but is intermittent at Winslow. The topography of the Winslow region consists essentially of a plateau which has been dissected by the Little Colorado River and its tributaries. In the vicinity of Winslow, the Little Colorado flows in a shifting channel through a broad valley several hundred feet wide Ruby Wash and Ice House Wash are the principal units in the Winslow region.

PROJECT RECOMMENDED IN THIS MEMORANDUM

21. General--The recommended plan of improvements would consist of two units (a) the Ruby Wash diversion levee and (b) the Ice House Wash Channel improvement.

22. Ruby Wash diversion Levee--The Ruby Wash diversion levee about 5.3 miles long would start from high ground about one mile south of Winslow and extend eastward to the Little Colorado River. The first 1200 feet of the proposed levee would follow the alinement of the existing levee and the suitable material of the existing embankment would be used in construction of the proposed new levee. Though the existing levee appears to be in satisfactory condition, it does not meet the present Corps of Engineers design standards. The proposed levee would include a low-flow channel with an established invert grade and variable widths. The diversion plan would include a training levee generally parallel to the diversion levee and extending upstream from the Little Colorado River a distance of about 2,400 feet to high ground. Its purpose would be to channelize flows over a proposed siphon for two irrigation ditches which cross the proposed plan of improvement.

23. Road relocations--A crossing would be provided for Arizona Highway 87 by relocating it over the top of the levee. Four 10 foot diameter CMPs would be provided for draining minor flows in the low flow channel (up to a maximum of 1650 cfs) under the highway. Greater flows would pass over the roadway. The existing Clear Creek Road which crosses the levee alinement at station 225+38 would be relocated to join Highway 87 at a point south of the levee. The section of this highway north of the levee would be abandoned. The Arizona Highway Department would design and construct both relocations since the Clear Creek Road is now a state highway. The old Clear Creek Road crossing at station 184+00 would be abandoned since it serves the same area as the new Clear Creek Road.

24. Utilities-- Power and telephone lines which cross the alinement of the proposed levee and are within the construction area would have to be relocated. A water line crossing the proposed levee at station 208+00 would be abandoned. Two irrigation ditches cross the levee alinement at approximately station 103+50 near its confluence with the river. The ditch flow would be carried under the levee by a two barrel inverted siphon. One 12- inch drain through the levee would be installed at Ruby Wash for downstream water rights. The utilities are summarized in Table 1.

TABLE 1

UTILITIES

RUBY WASH DIVERSION LEVEE

Location Station	Description	Owner	Proposed Treatment
288+00	12" R.C.P.	City of Winslow	To be constructed
208+00	Water line 8" C.I. Pipe		To be abandoned
208+20	Power line	Arizona Public Service	Relocate poles as necessary
103+00	Irrigation ditch	Winslow Irrigation Co.	Inverted Siphon
102+00	Irrigation	City of Winslow	Inverted Siphon

25. The Ice House Wash Channel--The Ice House Wash Channel would extend from the south side of the Santa Fe Railroad, northerly, downstream to Winslow Lake. In order to contain the design flow a levee would be constructed along the south side of the railroad from a point near Charlton Street. A training levee would extend southward from the east side of the railroad bridge at the right inlet wall to direct flow into the channel. An inlet basin would be excavated upstream from the concrete inlet structure. The channel improvement would start from the railroad bridge with 3,600 linear feet of rectangular concrete channel, then continue with 2,280 feet of earth bottom trapezoidal channel with 1 vertical on 2 horizontal sideslopes to the proposed Interstate Highway 40 and from this point about 6,200 feet of pilot channel between parallel levees 100 feet apart to confine flood flows to the outlet at Winslow Lake. Detailed descriptions of the proposed flood control improvements are given under section "Bases For Design."

26. Railroad bridge-- Eighteen tracks of the Santa Fe Railroad cross Ice House Wash on an existing bridge supported by two piers and abutments. This bridge would be removed and a new concrete box structure would be constructed to support the railroad. Detailed description of the new bridge is given in paragraph 67 in section titled "Structural Design."

27. Utilities-- Sewer, water, gas and power lines cross the existing Ice House Wash ditch. The sewer line would be relocated outside the channel. The water and gas lines would be relocated to pass under the channel invert. The power poles would be relocated away from the channel where necessary. Description of these utilities is given in Table 2.

TABLE 2

UTILITIES
ICE HOUSE WASH CHANNEL
WATER LINES

Description	Station	Description of Utility	Owner	Depth Feet	Proposed Treatment
A.T. & S.F. R.R. to 2nd St.	118+75	10" asbestos cement pipe	City of Winslow	2.5	Relocate under channel invert
N. of 2nd St.	117+20	4" steel pipe	DO	2.5	DO
DO	117+16	8" steel pipe	DO	2.5	DO
DO	117+15	12" steel pipe	DO	2.5	DO
N. edge of 2nd St.	115+90	12" asbestos cement pipe	DO	2.5	DO
Between 2nd & 3rd Sts.	112+41	8" steel pipe	DO	1.75	DO
N. of 3rd St.	110+62	3-2" steel pipes	DO	2.5	DO
W. edge, Aspinwall St.	105+19	10" asbestos cement pipe	DO	2.5	DO
N. of Aspinwall St.	101+68	6" asbestos	DO	2.5	Relocate Under channel invert
N. edge, Fleming Ave.	94+70	10" asbestos cement pipe	DO	2.5	DO

Description	Station	Description of Utility	Owner	Depth Feet	Proposed Treatment
N. edge, Mahoney St.	91+20	6" asbestos cement pipe	DO	2.5	DO
N. edge Hillview St.	84+15	6" asbestos cement pipe	DO	2.5	DO
		SEWER LINES			
S. of 2nd St.	117+28	8" vitrified clay pipe	City of Winslow	2'	Abandon @ channel & connect to new interceptor sewer
Between Fleming & Mahoney St.	93+04	8" v.c. pipe	DO	2'	DO
Between Mahoney & Hillview Sts.	89+55	8" v.c. pipe	DO	2'	DO
S. of Hillview St.	86+04	6" v.c. pipe	DO	2'	DO
		GAS LINES			
Between 2nd & 3rd Sts.	114+20	4" steel pipe	Union Gas Co.	1.5'	Relocated under channel invert
N. of 3rd St.	110+62	4" steel pipe	DO	1.5	DO
Between Fleming & Mahoney Sts.	93+07	2" steel pipe	DO	1.5	DO
N. of Mahoney St.	89+52	2" steel	DO	1.5	DO
S. of Hillview St.	85+75	2" steel pipe	DO	1.5	Relocate under channel invert
N. of Hillview St.	82+50	2" steel pipe	DO	1.5	DO

POWER LINES

Description	Station	Utility	Owner	Proposed Treatment
S. of 2nd St.	116+85	Overhead	Ariz. Public Service Co.	None
N. of 3rd St.	110+73	Overhead	DO	None-Overhead
	105+00	Pole in channel excavation limits	DO	Relocate pole
	103+90	ditto	DO	ditto
	103+58	ditto	DO	ditto
	101+65	ditto	DO	ditto
	100+15	ditto	DO	ditto
	98 25	ditto	DO	ditto
	96+62	ditto	DO	ditto
	95+25	ditto	DO	ditto
	93+00	Overhead	DO	None
	89+48	Pole in levee fill	DO	ditto
	87+65	Pole in levee fill	DO	ditto
S. of Hill-view St.	85+95	Pole in rt. levee	DO	ditto
N. of Hill-view St.	82+42	Overhead	DO	None
S. of Pro-posed U.S. Interstate Hwy 40	68+00	Overhead	DO	None
DO	67+90	Overhead	DO	None
	15+00	Overhead	DO	None

TELEPHONE LINES

Description	Station	Utility	Owner	Proposed Treatment
N. Edge of Second St.	115+76	Overhead	Mountain States Telephone & Telegraph Co.	None
N. Edge of Third St.	112+20	Underground Cable 3 Ft. depth	DO	Relocate under channel

28. Highway and Street crossings-- Bridges at Second and Third Streets (U.S. Highway 66), Fleming Aspinwall, Mahoney and Hillview Streets would be replaced over the improved channel. The rectangular channel wall sections would be designed to function as bridge abutments for all bridges except the bridge at Hillview Street which would cross a reach of trapezoidal channel and would require separate abutments. The highway bridges would be designed and constructed by the Arizona Highway Department and the street bridges (excluding 2nd and 3rd Streets, U.S. Highway 66) would be designed and constructed by local interests. A single span timber bridge for vehicular traffic on the Santa Fe Railway Company property presently crossing Ice House Wash at station 120+82 would be replaced by a new clear span timber bridge. The two existing timber bridges that cross at stations 120+00 and 117+66 would be abandoned.

29. In accordance with the requirements of the authorizing legislation local interests would be responsible for the relocation of all utilities, roads, irrigation ditches, and replacement of all highway bridges.

30. Waste disposal-

(a) Ruby Wash diversion levee--All excavated material suitable for embankment would be used for levee construction. Because there would be a surplus of suitable material from the required minimum excavation of the low-flow channel, rather than waste the material, the levee freeboard height would be increased 2 feet (total height 5 feet) between stations 300+00 and 144+00 to provide for probable impingement and wave action from tributary flows. Unsuitable material would be wasted behind the levee.

(b) Ice House Wash channel--Excavated material unsuitable for embankment would be wasted in the present Winslow city dump area northeast of the city limits. Material suitable for fill but in excess of that required for backfill and levees would be wasted within the rights of way along the land side of the levees that extend downstream of Interstate Highway 40.

MISCELLANEOUS CONSTRUCTION

31.

(a) Fencing-- The rectangular portion of the Ice House Wash channel improvement would pass through residential development and would be adjacent to an Indian School. Fencing of the chain link type, 6 feet high, would be provided on top of the walls of the open rectangular channel for safety of personnel. The fencing would be gated as necessary to allow maintenance and inspection of the channel.

32. Access for maintenance

(a) Ice House Wash Channel-- Berms would be provided along the banks of the proposed rectangular channel. The berms and crest of levees would be used for maintenance and inspection patrol roads. Access ramps to the patrol roads from the existing streets, would be provided. Turnarounds would be constructed, at 500 foot intervals, on the levees north of the proposed Interstate Highway 40.

(b) Ruby Wash diversion levee. The crest of the levee would be used as a maintenance and inspection road. An existing road at the upstream end, a state highway crossing at Station 252+80, and an existing road at the confluence with the Little Colorado River would provide access to the levee crest.

BASES FOR DESIGN

HYDROLOGY

33. General--Hydrologic data pertaining to the design of the proposed improvements are given in appendix 2 Hydrology.

BASES FOR DESIGN

RUBY WASH DIVERSION LEVEE

Hydraulic Design

34. General-- The hydraulic design of the proposed improvements is based on theoretical analyses and conforms to applicable criteria set forth in published and unpublished Engineering Manuals,"Engineering and Design," and to design practices previously approved for similar projects. It is also based on the requirements to intercept and divert flows of the standard project flood, which would range from a flow of 8,500 to 23,000 cubic feet per second.

35. Levee alinement--The proposed levee would extend from high ground generally eastward for a distance of 5.3 miles (sta. 381+30 to sta. 99+60) There would be seven curves in the alinement with deflection angles ranging from 10° 01' 16" to 44° 49' 04" and radii ranging from a minimum of 1,000 to a maximum of 10,000 feet.

36. Levee and low flow channel--The levee would have side slopes of 1 vertical to 2 horizontal and a top width of 18 feet. There would be a berm of variable width between the levee and low flow channel. The excavated low flow channel would have base widths ranging from 20 to 300 feet and would be trapezoidal in cross-section with side slopes of 1 vertical to 2 horizontal where excavated in soil and 1 vertical to 0.5 horizontal where excavated in sandstone and shale. The excavation for the low flow channel would provide material for construction of the levee. The low flow channel would provide an enlarged waterway through the ridges, which separate the tributaries and would reduce the velocities adjacent to the levee toe.

37. Invert grades--The low flow channel would have invert grades ranging from 0.001000 to 0.023500.

38. Training levee--A training levee 2,400 feet long extending from station 24+88.00 to station 3+00 on the right side of the floodway would be provided to prevent inundation and silt deposition in the irrigation ditches upstream of the siphon inlets. The levee would be approximately 12 feet in height including 3 feet of freeboard.

39. Confluence with the Little Colorado River-- The existing revetted levee which extends upstream from the Santa Fe Railroad bridge would be breached to allow flows from the proposed improvement to enter the Little Colorado River. (See plates 1 and 20). The proposed diversion levee would tie into this existing levee. The floodway would be 210 feet in width between the diversion levee and the training levee at the downstream end. A rock stabilizer would be provided to prevent scouring and degradation of the streambed upstream. Flows would pass from greater than critical to less than critical depth due to the sudden transition to a larger cross sectional area at the end of the levees. Depth of lfow in the Little Colorado River coincident with the peak flow in Ruby Wash would not cause backwater in Ruby Wash.

40. Water surface computations-- The standard project flood water surface was determined by the reach method. The friction losses were calculated by means of the Manning formula with "n" values ranging from 0.030 to 0.040. The flow would have subcritical velocities which would range from 0.7 to 17.8 feet per second, except for the reach from station 214+00 to 212+00 where the flow would have supercritical velocities ranging from 17.4 to 20.9 feet per second.

41. Freeboard-- The height of the diversion levee is designed to provide a minimum of 3 feet of freeboard above the computed water surface. Based on engineering judgement and recent experiences in performance of diversion levees an additional 2 feet of freeboard would be provided by judicious use of excess excavation between stations 300+00 and 144+00. In this reach high velocity flows from numerous existing and future washes may develope which would cause either direct impingement or wave action and ride up on the levee. The total freeboard would be 5 feet in the reach, with the exception of the Highway 87 crossing of the levee where the freeboard would be 3 feet.

BASES FOR DESIGN

ICE HOUSE WASH CHANNEL IMPROVEMENT

Hydraulic Design

42. General-- The hydraulic design of the proposed improvements is based on theoretical analyses, using applicable criteria set forth in the unpublished chapters on high-velocity flow channels of the Engineering and Design, Manual, and in the published chapters of that manual. It is also based on the following requirements: (a) an inlet structure to control a 50-year frequency flood peak of 2,200 cubic feet per second; and (b) approximately 2 miles of channel improvement to convey the flow to an appropriate disposal area.

43. Inlet structure-- The inlet would be a reinforced concrete structure with a 70-foot crest at station 124+45 and elevation at 4,855.22 feet mean sea level. In a length of 25 feet, the width of the inlet would converge from 70 feet at the crest to 20 feet at the downstream end. The hydraulic control would be at the downstream end of the inlet, station 124+20, with an invert elevation of 4,849.09 feet mean sea level and a critical depth of 7.22 feet. The wall heights would vary from 7.78 feet to 14.00 feet with a minimum freeboard of 4.27 feet. The velocity would vary from 5.24 feet per second at the control station to 8.98 feet per second at the crest.

44. Channel alinement-- The proposed channel would be along the alinement of the existing wash. However, in the downstream reach, the centerline, for about 4,000 feet of channel, would be offset 500 feet to the right (east) of the existing wash centerline in order to maintain a straight alinement downstream of the proposed Highway Interstate 40. This reduced the length of channel and eliminated two curves. There are seven curves with deflection angles ranging from 1°-18'-17" to 26°-01'-16"; and with centerline radii ranging from 800 feet to 5,000 feet. Spiral transitions would be provided on each curve, except at the 1500 feet radius curve with I=2° at Aspinwall Street.

45. Invert grades-- From the inlet crest, station 124+45 to the hydraulic control, station 124+20, the slope would be 0.245200. Downstream from this station to station 90+00, the invert slope would be 0.004332, and the flow would be of supercritical velocity. From station 90+00 to the downstream end at station 10+00, the slope would vary from 0.000107 to 0.000100, and the flow would be of subcritical velocity.

46. Rectangular channel-- The rectangular channel begins as a covered box, at station 124+00 with a width of 20 feet. The covered box bridges under 18 railroad tracks for a distance of approximately 295 feet and thense as an open rectangular channel of the same width extends from that point to station 91+00. The vertical walls in this reach vary from 14 feet to 8.50 feet. A second reach of rectangular channel is that portion where the proposed Interstate Highway 40 would cross the channel alinement between stations 64+70 and 67+70, with a width of 40 feet and wall heights of 9.00 feet.

47. Trapezoidal channel-- The upstream reach of the trapezoidal earth bottom channel begins at station 89+00 and is connected to the 20-foot rectangular channel by a 200-foot transition. This portion of trapezoidal channel extends downstream to station 68+60 and would have a base width of 40 feet, side slopes of 1 vertical on 2 horizontal and leveed banks ranging in height from 10 feet to 12 feet. The downstream end of this trapezoidal channel is connected to the 40-foot rectangular channel by a 40-foot, trapezoidal rectangular composite transition. The second reach of trapezoidal channel begins abruptly at station 64+70 without a transition. This portion of trapezoidal channel is extended to the downstream end of this improvement at station 10+00 and would have a base width of 100 feet, side slopes of 1 vertical on 2 horizontal and leveed banks ranging in height from 7 to 10 feet. The excavated invert and the cut slopes of good erosion-resistant material would be unlined.

48. Bridges-- There are five bridges at street crossings in the lined channel that would be clear-span structures. There will be one bridge in the 40-foot trapezoidal channel that would have one pier as an obstruction.

49. Water-surface computations-- The water-surface profile in the channel was determined by the reach method, using Manning's formula. A roughness coefficient of 0.014 was used in computing friction losses for the concrete, rectangular channels and 0.035 was used in the unlined, trapezoidal channels. An "n" value of 0.025 was also used in the trapezoidal channel to determine the maximum velocity and required protection. An undulating hydraulic jump would occur in the vicinity upstream from the grade change at station 90+95. Class "A" flow condition would occur at the Hillview Street crossing in the unlined channel. Yarnell's formula for Class "A" flow was used to determine hydraulic losses caused by the obstruction (width of pier plus 4-foot width of debris). The amount of entrained air in the flow was determined from curves on plate 20 of EM 1110-2-1603. The depth of flow, including entrained air, in the lined channel would range from 6.31 to 7.26 feet and would range from 2.44 to 9.48 feet in the unlined channel. Velocities would range from 8.33 to 17.20 feet per second in the lined channel and would range from 2.63 to 5.82 feet per second in the unlined channel.

50. Freeboard-- The wall heights are designed to provide a minimum freeboard of 2 feet above the computed water surface in the rectangular channel and 2.5 feet in the trapezoidal channel.

51. Superelevation-- The channel would not be superelevated inasmuch as the computed superelevation of the water surface would only range from 0.01 to 0.11 of a foot.

52. Side drainage-- Side-drainage discharges that would contribute to the flows in Ice House Wash Channel under existing or future conditions would be insignificant. The small flows from the areas adjacent to the channel would be drained through the Interstate Highway 40 embankment at locations other than Ice House Channel.

Geology and Soils

53. Topography. The Winslow region is in the drainage basin of the Little Colorado River. In its upper portion, the Little Colorado is perennial but at Winslow, Arizona, it is intermittent. The topography of the Winslow region consists essentially of a plateau which has been dissected by the Little Colorado River and its tributaries. In the vicinity of Winslow, the Little Colorado flows through a broad valley several hundred feet wide in a shifting channel. Ruby Wash and Ice House Wash are the principal units in the Winslow region.

54. Regional geology. Northeastern Arizona occupies a portion of the Colorado plateau province of the great intermountain plateaus of the western United States. The distinguishing features of the Colorado Plateau is the approximate horizontality of its rocks; the great altitude above the sea; and the remarkable development of canyons. The rocks of the region include unconsolidated and consolidated sedimentary strata and igneous rocks, chiefly of the extrusive type. The unconsolidated rocks are stream-terrace, alluvial-flat, lacustrine and channel deposits of Quaternary and Tertiary age. The consolidated sedimentary rocks include limestone, sandstone and shale and minor amounts of interbedded gypsum and coal. The sedimentary rocks exposed at the surface range from Permian to Recent in age, but the sequence is broken by disconformities and major unconformities. The igneous rocks of the region cover wide areas. They consist of lava flows, cinder cones, ash beds and intrusive dikes and plugs. These igneous formations have never been studied in detail, though it is known that some are definitely Tertiary, some are perhaps older, and some are of Quaternary age.

55. Geology. The rocks of the Winslow region consist of Moenkopi shale of lower Triassic age and Coconino sandstone of Permian Age. The Moenkopi shale occurs in the upper reach of the Winslow project. In the reach, weathering of the shale near the surface has produced a residual cover of gravelly sandy silts which are slightly plastic. The

deeper unweathered shale consists of alternating, thin, nearly horizontal layers of soft to hard sandy shale and very hard, fine-grained sandstone. The Coconino sandstone, with little or no surface cover, extends from about midway to the project reach to the flood plain of the Little Colorado River. The Coconino sandstone is white or buff, moderately hard to hard, fine-grained, cross bedded sandstone. The flood plain of the Little Colorado River consists of recent alluvium composed of silty sand and gravel in various proportions. The Kaibab limestone, which is farther to the south and east and which separates the Moenkopi and Coconino formation, apparently is phased out in the project areas. Faults are rare throughout the region, and all the known faults have small displacement.

56. Exploration, sampling, and testing. The foundation exploration along Ruby Wash diversion levee consisted of six exploration trenches excavated using a Caterpillar D-8 dozer equipped with a hydraulic ripper. The foundation exploration along the Ice House Wash Channel consisted of three exploration trenches excavated with a backhoe equipped with an 18-inch bucket. The explorations were conducted during July and August of 1967. Disturbed soil samples were obtained at three foot intervals or less if the type of soil changed. Tests were conducted on the samples to obtain moisture content, Atterberg limits, and mechanical analysis. The soils were classified from laboratory data in accordance with the Unified Soil Classification System. The bedrock was visually classified by an engineering geologist in the field and the resistance of the rock to excavation was noted. Auger probes were made in July and October 1968 to determine the depth of overburden. These probes were made to obtain data for use in cost reduction analyses of utilizing soil borrow for embankment construction with a planned reduction of required excavation in rock. The locations and logs of the trenches and auger probes are shown on plates 2 through 6 and 16 through 20.

57. Foundation conditions.

a. Ruby Wash Diversion Levee. Upstream of station 120+00 the foundation material consists of a thin mantle of silty sand overlying the shale or sandstone bedrock. Downstream of station 120+00 the materials are clayey sands and silty sands with bedrock below the depth of excavation.

b. Ice House Wash Channel. The foundation materials consist of a mantle of sandy clay overlying the shale or sandstone bedrock. Upstream of Henderson Street the mantle varies in thickness from 0 to 10 feet. The rectangular channel would be founded on rock. Downstream of Henderson Street the rock surface slopes below invert elevation and the channel would be founded on clay.

58. Ground water conditions.

a. Ruby Wash Diversion Channel. Ground water was encountered at a depth of ten feet in the flood plain of the Little Colorado River (test trench No.4). Upstream of station 120+00 no ground water was encountered during the investigation.

b. Ice House Wash Channel. Perched water was encountered in the three test trenches above invert level.

59. Design values. The following design soil values are based on testing of similar materials.

	Compacted Soil	Compacted Rock Fill	Foundation Soil
Dry weight, pcf	105	120	90
Drained weight, pcf	121	125	105
Saturated weight	129		120
Degrees (drained)	30	35	28

60. Design applications. The design applications for the proposed project are given in the following subparagraphs.

a. Foundation preparation. The foundation beneath the levees would be prepared by grubbing and stripping to remove all vegetation. The foundation beneath the rectangular channel would be rock and preparation would be limited to leveling in areas of overbreak. Areas of overbreak would be backfilled with soil from the required excavation compacted to 95 percent of maximum density as determined by standard AASHO test Method T99-57.

b. Excavation. Excavation of the soil could be accomplished by conventional equipment. Excavation of the rock could not be accomplished with conventional equipment and the rock would have to be blasted for almost the entire length of levee and channel. Temporary excavation slopes in soil would be 0.50 horizontal to 1 vertical and in rock would be 0.25 horizontal to 1 vertical. Permanent excavation slopes in soil of 2 horizontal to 1 vertical and in rock of 0.50 horizontal to 1 vertical would be stable.

c. Ground water considerations.

(1) Ruby Wash Diversion Levee. Although during the investigation ground water was encountered below invert elevation, a rise in the ground water level in the flood plain (downstream of station 120+00) would require dewatering of the construction area.

(2) Ice House Wash Channel. During construction of the rectangular channel a minor amount of perched water can be expected. The water could be controlled by sumping.

d. Levee fills. The levees would be constructed of soil and rock from the excavation and borrow. The fill material would be placed in layers not exceeding 12 inches. A 10 foot minimum width of compacted soil would be provided at the center of the levee to preclude an entire rock fill section. The outer zones would vary from soil to rock fill, with the coarser (rock) materials placed toward the outer slopes. Because of the short duration of peak flow and the imperviousness of the compacted soil, a steady seepage condition would not develope, hence piping would not occur. The compaction would be controlled by a procedural specification. The specified compactive effort would be 4 passes of a 50-ton rubber tired roller. Placement of the coarser material on the outer slopes would result in an infinite slope safety factor of 1.2, based on the assigned shear strengths.

e. Rectangular channel backfill. The rectangular channel would be founded in rock. In order to minimize pressures against the walls which would be developed by the wedging of compacted fill between the rock face and wall, compaction would be limited to hand operated compactors. The backfill would be minus 4-inch material (soil) from the excavation. Backfill would be placed in layers not exceeding 6 inches. Channel excavation would yield adequate quantities of minus 4-inch material for backfill.

f. Subdrainage. A minimal subdrainage system would be provided for the rectangular channel wall to reduce the hydrostatic pressures on the channel invert and walls. The water would be collected by perforated pipes located in the gravel and directed into the manholes. The manholes would be at approximately 1000 foot intervals. The system would be sized to reduce pressures caused by seepage from the thin overburden mantle and infiltration into the backfill. Due to the low permeability and limited infiltration capacity of the thin overburden and backfill material the unit seepage would be very small. Theoretically the gravel drain would have sufficient capacity to convey the accumulated water to the manholes without an excessive buildup of head. A 300 foot length of 6-inch perforated pipe would be supplied on each side of the channel at the manholes as a collector. With the collector pipes the safety factor against uplift would be approximately 1.6.

g. Stone revetment. Stone revetment would be stone obtained from the required excavation. Stone facing for the levees would consist of a minimum thickness of 18 inches of stone. The 18-inch minimum thickness would accommodate a 500 pound slabal stone. The stone revetment would terminate four feet below the invert or at the top of bedrock, whichever is less. Where the stone revetment terminates on bedrock a thickened section would be provided. In areas where channel velocities are less than 12 feet per second, the gradation for the stonework would be such that rippable or blasted rock could provide the desired results with little or no processing. In areas where channel velocities are greater than 12 feet per second, the gradation for the stonework would be such that selection and minor processing could provide the desired results. The degree of processing required is largely

a function of the excavation procedures and could be minimized by the contractor's excavation operations. As the stone facing would be placed on random rock fill no filter layer would be required. The gradations are as follows.

	Revetment	
	Zone I	Zone II
	V 12 ft/sec.	V 12 ft/sec.
Weight of Pieces	Percent smaller by weight	
500 pound	100	100
250	-	50-90
100	40-100	30-60
25	10-50	0-30
5	-	0-5
1	0-10	

Stone for grounted stone would be zone II revetment.

h. Sources of construction material. The levees would be constructed of rock and soil from the required excavation and borrow. The distribution of material estimates are shown on plates 29 and 30. Concrete aggregate would be obtained from Flagstaff (60 miles from the project) or Gray Mountain (45 miles north of Flagstaff) or from Phoenix. Portland cement would be available from commercial plants at Clarkdale (100 miles from the project.)

STRUCTURAL DESIGN

61. General-- The structural design of the proposed improvements would be in accordance with the following applicable provisions of EM 1110-1-2101 dated 1 Nov. 1963 titled "Working Stresses for Structural Design;" and EM 1110-2-2502 dated 29 May 1961 titled, Retaining Walls;" and EM 1110-2-2902 Draft titled "Design of Miscellaneous Structures-Conduits, Culverts and Pipes." Pertinent information on unit design stresses and on weights and properties of materials to be used in design are:

a- Ultimate compressive stress concrete f'c=	3,000 p.s.i
b- Reinforcing steel, intermediate grade fs=	20,000 p.s.i
c- Structural steel, A-36 fs=	22,000 p.s.i
d- Ratio Es/Ec = n= 9.2	
e- The weights and properties of soils are given under subheading, titled Geology & Soils.	

62. Rectangular channel-- The walls and invert would have a minimum thickness of 10 inches and would be designed as "L" walls or "U" walls depending on the height to width ratio. Where the width of channel is equal to or greater than two times the height of wall; the design would be for an L wall. With this design it is assumed that the pressure distribution under the base is a straight line with soil bearing values computed in accordance with the interaction formula P/A [Mc/I. For the case where the width of channel is equal to or less than the height of wall, then the channel is treated as a "U" wall design with uniform pressure across the base. In the case where the channel falls between the "L" and "U" wall concept, the soil pressure on the base slab would be adjusted. The earth pressure on vertical stem wall of the "L" or "U" section would be computed by using Coulomb's equation. An additional 200 p.s.f. starting at the top of wall and continuing downward to its intersection with the triangular Coulomb pressure diagram would be used to account for the effect of equipment surcharge loading. The different conditions of loading on the wall would be: Condition I with saturated backfill and an empty channel with a 1/3 increase in allowable stresses (rapid drawdown). Condition II with drained backfill, an empty channel and normal stresses. Condition III with drained backfill plus equipment surcharge load with an empty channel. Allowable stresses of 25% above normal would be permissible. Condition IV channel full with backfill counteracting the hydrostatic force.

63. Highway bridges-- These bridges would be designed by local interests in accordance with applicable standards of AASHO. In the rectangular channel reach the bridge abutments would form the channel wall and therefore compliance with Corp of Engineer's standards is also required.

65. Railroad bridge-- The proposed 18 track railroad bridge over Ice House Wash would have a clear span of 20 feet and would be placed within the area occupied by the three existing span bridge. The two center concrete piers of the existing bridge would be removed while the existing abutments would remain. The new poured in place wall abutments would be constructed within and contiguous to the existing concrete abutments. Preliminary soils data indicates the rock line is very close to the present invert and therefore a concrete rigid frame is considered best costwise and structurally. That is, an integral roof slab and abutment wall based and keyed into the rock with a thin invert slab. The bridge would be built in four parts and a tentative construction sequence has been developed in cooperation with the railroad company. Design would be in accordance with AREA and ACI standards. E-72 loading with diesel locative impact would be used for all 18 tracks.

66. Diversion & control of water during construction.

a. Ice House Wash Channel-- Ground water above the invert level would be present during most of the construction season and pumping would be required to maintain the construction area free of water. Studies indicate that the discharge from a 5 year frequency summer thunder storm would vary from 25 to 250 cubic feet per second. Flow up to 200 cubic feet per second would be controlled by construction of a coffer dam at the upstream edge of the railroad bridge and conveying them in a temporary ditch to natural drainage in Ruby Wash, east of the proposed channel improvement. Due to the natural slope of ground surface it is not anticipated that surface flow would enter the channel downstream of the railroad bridge.

b. Ruby Wash diversion levee-- The construction area would be subject to runoff from summer storms of high intensity and short duration. Assuming construction of the levee and low flow channel to proceed upstream, the channel could be used to convey runoff to the river. If construction is performed at various reaches throughout the length of the levee, the existing washes would remain open until the levee between adjacent washes is completed. Ground water could be encountered for a distance of 2,000 feet upstream from the river and excavation would be performed underwater.

Beautification

67. Ruby Wash diversion levee-- The area traversed by the proposed levee is quite distant from human habitation and outside the city limits. See plate 1. The thin soil overburden is underlain by bedded sandstone that outcrops in many places. The vegetation is extremely sparse, consisting of widely scattered shrubs of salt brush and growths of bunch grass. For these reasons and because the rock obtained from the required excavation would be placed toward the outer slopes of the levee to prevent surface erosion, landscaping or seeding is not proposed. The levee as constructed would blend in well with the surrounding terrain. Construction and borrow areas would not be visible because they would be on the waterside and screened by the levee.

68. Ice House Wash Channel-- Trees and shrubbery suitable to the climate would be planted along the channel within the rights of way. The trees would consist of Arizona Ash, Arizona Cypress, Red Gum and Palo Verde. The shrubs would include Pyracantha, Yucca Tesas sage, and

H Y D R O L O G Y

LITTLE COLORADO RIVER AND TRIBUTARIES AT AND IN THE VICINITY OF WINSLOW, ARIZ.

INTRODUCTION

1. General-- Hydrologic data pertaining to the design of the proposed improvements are given in Appendix 1: Hydrology, accompanying the district engineer's report dated 15 December 1961, titled "Review Report for Flood Control, Winslow, Arizona, and Vicinity." The standard-project-flood peak discharges were approved by the Chief of Engineers on 12 June 1961. That report will be referred to in this design memorandum as the review report. Since preparation of the review report, minor changes have been made in the alignment of the Ruby Wash diversion levee. No changes have been made in the standard-project-flood peak discharge values for the project levee and channel since publication of the review report. Information on the design values and drainage areas is summarized on the pertinent data sheet. The boundary of the project drainage area and the location of the levee and channel improvements are shown on plate 1. The standard-project-flood peak discharges are shown on plate 2.

GENERAL DESCRIPTION OF DRAINAGE AREA

2. Physiographic characteristics.-- The drainage area consists of low desert valleys traversed by shallow ravines with elevations ranging from about 4,880 feet to 5,250 feet above mean sea level.

3. Ice House Wash, the largest tributary, originates about 8 miles southwest of Winslow at an elevation of about 5,250 feet above mean sea level. Originally it flowed northeastward through the area now occupied by the Winslow Municipal Airport, entering the western part of the city through a culvert under the railroad. Since 1944 the runoff from the area upstream of the airport has been diverted eastward to Ruby Wash. The average gradient of the stream channel is about 50 feet per mile. Ruby Wash, the tributary east of Ice House Wash, rises at an elevation of about 5,150 feet. It flows northeastward and enters the eastern part of the city through a bridge under the railroad. The average gradient of the stream channel is about 54 feet per mile. The other tributaries flow generally northeastward toward the Little Colorado River east of Winslow. These tributaries have average gradients of from about 40 feet per mile to about 60 feet per mile.

4. The drainage area is underlain by thin-bedded sandstone that outcrops in many places. Over most of the area, the soil is a fine sandy loam derived from the parent rock. The soil of the Ice House Wash drainage area is clay loam covered with a surface layer of sandy loam. In a comparatively small area south of the railroad the soils are silty clay loam.

5. The vegetation is extremely sparse, consisting of scattered shrubs of salt bush and growths of bunch grass. Short-lived annuals that spring up after winter rains are the only vegetation in large parts of the area.

6. Hydrometeorological characteristics.-- Winslow is located in the Little Colorado River Valley at an elevation of about 4,850 feet above mean sea level. The adjacent terrain rises gradually in all directions except to the north-northwest along the river. The Continental Divide, of the Rocky Mountains, roughly 130 miles to the east, rises to over 9,000 feet at several points; the White Mountain area 100 miles to the southeast rises to over 11,000 feet. The Mogollon Rim, about 50 miles to the south and west, averages very close to 8,000 feet above mean sea level, while 60 miles to the northwest the San Francisco Peaks rise to 12,655 feet, the highest points in Arizona.

7. The surrounding high terrain has a considerable effect upon the climate and weather of the Winslow area. It acts as a barrier to the movement of low-level moist air currents from southwest and southeast and to the cold wintertime continental airmasses from the north and northeast. As a consequence, the semiarid climate is relatively mild for the latitude and elevation. During the late fall and winter months the prevailing wind direction is from southeast; in the spring and summer months the winds blow primarily from the southwest.

8. The elevation of Winslow and the generally clear skies tend to create a large diurnal temperature variation during all seasons. Below-zero readings occur during the winter months about one year in three, on the average. Daytime temperatures over 70° have been recorded during all winter months. Summer days are warm, with maximum temperatures of 90° or higher occurring frequently from late May to mid-September. The monthly average temperature data for Winslow are given in Table 1.

9. Monthly and annual precipitation is extremely variable in amount. Annual recorded rainfall has varied from 4.60 inches in 1937 to 17.17 inches in 1923 and averages about 7.3 inches. The monthly mean, maximum, and minimum precipitation data are given in Table 1. Most of the precipitation occurs during the summer and early fall (July-September) when moist tropical air enters from the Gulf of Mexico or from the Pacific Ocean. General summer storms occasionally occur; however, most summer storms are of the thunderstorm type. These thunderstorms are characterized by high intensities and limited areal extent. The duration of critical rainfall intensity during thunderstorms ranges from a few minutes to about 3 hours. During the months of December-March, inclusive, most of the precipitation results from general winter storms that are associated with extratropical cyclones of North Pacific origin. Intensities are light to moderate. Snowfall during the winter is generally light, and because of warm daytime temperatures soon melts away. The annual average snowfall is about 8 inches, but occasionaly a winter season will pass with only a trace being recorded.

10. Runoff characteristics.-- Streamflow is negligible except during and immediately after the heavier rains because climatic and drainage-area characteristics are not conducive to continuous runoff. In general the drainage area slopes are gentle at all elevations. However, flood flows in the comparatively flat area south of the railroad and in the city of Winslow have resulted from the high intensities of local storm rainfall. The effect of snow on runoff is negligible.

11. Existing structures affecting runoff.-- Several diversion channels have been constructed for the protection of the Winslow Municipal Airport from floods. The most important of these, which diverts runoff from Ice House Wash to Ruby Wash was constructed in 1944 by the U. S. Civil Aeronautics Authority. It has a capacity of about 4,000 cubic feet per second at the upstream end.

PRECIPITATION AND RUNOFF

12. Precipitation records.-- Precipitation records are now obtained at only one station in the vicinity; namely, Winslow Municipal Airport (15-N-5, pl. 1). The station has been operating as a recording rainfall station since January 1932. Previous to that, rainfall amounts were recorded from a standard rainfall gage at various locations in and near Winslow. A sporadic record goes back to 1888 with 26 years of record before 1932.

13. Runoff records.-- No runoff records are available for the drainage area.

14. Storms and floods of record.-- Little or no hydrologic information is available concerning the storms and floods in the Winslow area. A study of the Winslow rainfall records indicates that no very severe storms have occurred in the immediate area of the gage locations. Maximum 24-hour and maximum monthly rainfall of 2.43 and 4.80 inches, respectively, were recorded at the Winslow rainfall station for the period of record. However, this station does not necessarily reflect the true rainfall picture for this region. Severe damaging thunderstorms have occurred in this and other parts of Arizona with little or no rainfall having been recorded at the nearby stations. Records indicate that an average of 37 thunderstorms of various sizes occur annually in the Winslow region. Numerous damaging floods have occurred but storm and rainfall data are scarce. The storms of 10 September 1933 and 5 August 1939 in the Parker Creek, Arizona area (Sierra Ancha Experimental Forest) were, in several important details, the most severe ever recorded in Arizona. The storm and flood of 25 August 1957, at Winslow was the largest in recent years for which accurate damage data are available. Brief descriptions of the three storms are given in the following subparagraphs.

(a) Storm of 10 September 1933. -- The 10 September 1933 thunderstorm, which occurred in the Parker Creek, Arizona area, had the highest short-time intensities ever recorded in Arizona (see Plate 3). The total 1-, 2-hour rainfall amounts were 3.88 and 4.28 inches, respectively. The mass curve of precipitation is shown on plate 4.* Available data are insufficient for area-depth curve determination. No data on runoff are available.

(b) Storm of 5 August 1939. -- Rainfall of 2.62, 4.96, and 5.02 inches was recorded in the 1-, 2-, and 3-hour periods, respectively, of the 5 August 1939 thunderstorm, in the Parker Creek, Arizona area. The mass curve of precipitation is shown on plate 4.* The area covered by this storm was small compared to that of other storms of record (see Plate 3). No runoff data are available.

(c) Storm and flood of 25 August 1957. -- The storm and flood of 25 August 1957 is the only one of consequence in the Winslow area for which data of some hydrologic value are available. Total precipitation for the storm, which lasted 4 hours, was 1.20 inches at Winslow. Of this amount, 0.93 inch (over 77%) fell in 2 hours. The short-time intensities are not available, but a mass curve of precipitation based on hourly amounts is shown on plate 4. Location of storm center is unknown. Estimates of discharges are not available.

15. Relative magnitude of local thunderstorms.-- The 4-hour rainfall of 1.20 inches for the thunderstorm of 25 August 1957, is the largest recorded at the Winslow precipitation station. The maximum 1-hour rainfall recorded at Winslow was 1.08 inches in a storm on 26 August 1947. With respect to overall magnitude, the greatest thunderstorm of record for Arizona was that which occurred on 19 August 1954 in the Queen Creek drainage area about 60 miles east of Phoenix (see plate 3). That storm produced at its center about 5.3 inches in 6 hours, and its area-depth characteristics were unusually severe. However, that storm is not considered to be representative of thunderstorms in the Winslow region, nor to be directly transposable to it without modification. The storm of 10 September 1933, in the Parker Creek area, had the highest short-time intensities ever recorded in Arizona. The relationship of the intensity-duration curve for this storm to the curves established for four other thunderstorms is shown on plate 3. The 5.02 inches of rainfall recorded in the Parker Creek, Arizona area for the 5 August 1939 thunderstorm, is the highest 3-hour amount ever recorded in Arizona. The relationship of the area-depth curve for this storm to the curves established for four other thunderstorms is shown on plate 3.

SYNTHESIS OF STANDARD PROJECT FLOOD

16. General.-- The standard project flood discharges were developed according to criteria given in EM 1110-2-1411.

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* Data from recording gages in the Sierra Ancha Experimental Forest.

17. Determination of standard project storm.-- The standard project storm for the area was determined by evaluation of the assumed occurrence of the most severe regional storms, considered reasonably characteristic of the region, critically centered over the area. Precipitation occurring as shown was not considered to be a factor during the standard project storm for the drainage area.

18. Standard project storm.-- A period of 3 hours was selected as the maximum duration of the storm because records indicate that duration of critical rainfall intensity during thunderstorms is rarely more than 3 hours. The 5.02-inch total rainfall recorded for the 5 August 1939 Parker Creek area storm was considered reasonable as an average depth for an area of 1.0 square mile in the Winslow vicinity. For the standard project storm, an area-depth curve was then based on this area-depth relationship and the general shape of the curves for other thunderstorms (see plate 3).

(a) Precipitation.-- The average 3-hour precipitation for any drainage area tributary to a pertinent concentration point is based on the area-depth relationship established by the standard project storm curve shown on plate 3.

(b) Rainfall-intensity pattern.-- The rainfall-intensity pattern was based on the mass curves of rainfall for the severe Arizona thunderstorms for which adequate data are available. A time interval of 15 minutes was selected as the smallest time interval for which rainfall intensities would be required. Based on recording gage observations, the greatest intensity would occur about 15 minutes after the beginning of the storm. A typical rainfall-intensity pattern is shown on plate 5.

19. Rainfall-runoff relationships.-- In the absence of useful runoff records for the Winslow area, the rainfall-runoff relationships that were adopted for this study were determined by the application of unit hydrographs and rainfall-loss rates based on information from hydrologic investigations made for other flood-control reports for streams in southwestern United States.

(a) Unit hydrographs.-- The synthetic unit hydrographs used in this report were based on a lag curve (see Plate 6) and an S-graph (see Plate 7) developed by the U. S. Bureau of Reclamation for streams in the Colorado River basin above Bridge Canyon damsite.* The lag curve used for the Winslow area (see Plate 6) was drawn parallel to the lag curve developed by the U. S. Bureau of Reclamation, midway between the points indicated by the lag for Clear Creek near Winslow, Arizona, and the lag for Moenkopi Wash near Tuba City, Arizona. This position was considered more representative of conditions of the drainage area in the vicinity of Winslow. The S-graph developed by the U. S. Bureau of Reclamation for

* Lag curve and S-graph were published in the report of the U. S. Department of Interior, Bureau of Reclamation, titled "Spillway Design Flood Studies, Bridge Canyon, Colorado River Storage (Glen Canyon Unit) and Coconino Projects," and dated September 1951. The method used for deriving unit hydrographs and distribution graphs for that report is similar to the method used by the Los Angeles District.

Clear Creek near Winslow, Arizona, was considered most representative for the area. The lag curve and S-graph compare very well with similar curves developed by the Los Angeles District. For verification of the applicability of the S-graph used, a discharge computation was made with a unit graph based on an average of 8 S-graphs (see Plate 7) derived for drainage areas in Arizona. The difference in discharge was minor. The values of lag and pertinent elements for the subareas tributary to the selected concentration points in the project area are given in Table 2.

(b) Rainfall-loss rates.-- Rainfall-loss rates for the Winslow area cannot be accurately determined because of lack of rainfall and runoff data. The rainfall-loss rates were estimated by evaluation of information in the U. S. Department of Agriculture report titled "Soil Survey of the Winslow Area, Arizona" and by comparison of topographic, vegetal, and soils characteristics of the area with those of similar areas eleswhere in the southwestern United States where loss rates had been determined. A 3-hour rain prior to the standard project storm was assumed to have satisfied the expected initial loss, and a constant loss rate of 0.20 inch per hour was considered applicable for the area. Loss-rate studies show that runoff occurs during periods when average rainfall-intensity rates are less than indicated loss rates. Such runoff is attributable to high-intensity rainfall in part of the area and to imperviousness of part of the area. Consequently, the loss rate was assumed at 90% of the rainfall intensity for the periods having an average rainfall-intensity rate of less than the indicated loss rate.

(c) Base flow.-- Base flow was considered a negligible factor in the standard project flood for this area.

20. Determination of standard project flood.-- The standard project flood was determined for each of the selected concentration points by the following procedure: (a) determination of unit-time increments of rainfall for each subarea; (b) determination of effective rainfall by subtraction of loss rate; (c) determination of subarea surface-runoff hydrograph by application of subarea synthetic unit-hydrograph values to the effective unit-period rainfall; and (d) determination of total flood hydrograph for the concentration points by channel routing and by combining subarea hydrographs as required. Development of the standard project flood is indicated by the example shown on plate 8.

21. The routing of floods through river channels was accomplished by the successive average-lag method that is described in EM 1110-2-1408. Travel time between concentration points is given in Table 3.

22. Standard-project-flood peak discharges.-- Estimates of the standard-project-flood peak discharges for the selected concentration points are shown on plate 2. Estimates of discharge along the proposed diversion structure were approved by the Office of the Chief of Engineers on 12 June 1961. Other discharges were determined in a similar manner.

ADEQUACY OF STANDARD PROJECT FLOOD

23. Because of lack of runoff data for the Winslow area, the adequacy of the standard-project-flood peak discharges is difficult to determine. However, the use of a storm of the magnitude of the 5 August 1939 (Parker Creek) storm, as well as the use of (a) a more intense rainfall pattern, (b) more conservative area-depth relationships, and (c) conservative loss rates, will produce a flood that will be exceeded only on rare occasions. The estimates of peak discharges are considered reasonable for the standard project flood.

24. The adequacy of the standard-project-flood peak discharges is further indicated by comparison with major flood peak discharges (a) in Arizona and New Mexico, (b) on the Colorado River and tributaries above Lee Ferry, Arizona, and (c) with a Creager enveloping curve of peak discharges shown on Plate 9.

Table 1

Summary of climatological data at Winslow, Ariz., Little Colorado River, Ariz. and N. Mex., at and in the vicinity of Winslow, Ariz.

Month	Average temperature			Total precipitation		
	Mean monthly	Maximum monthly	Minimum monthly	Mean monthly	Maximum monthly	Minimum monthly
	Degrees Fahrenheit	Degrees Fahrenheit	Degrees Fahrenheit	Inches	Inches	Inches
Jan.	31.9	44.9	18.9	0.44	1.62	T
Feb.	38.8	52.7	24.8	.44	1.32	T
Mar.	45.3	60.8	29.7	.43	1.13	T
Apr.	53.9	70.2	37.5	.40	1.59	T
May	62.5	79.7	45.3	.29	1.35	T
June	71.9	89.8	53.9	.27	2.12	0
July	78.2	93.5	62.8	1.00	2.81	.05
Aug.	76.0	90.5	61.4	1.47	4.80	.15
Sept.	69.3	84.9	53.6	.92	2.41	0
Oct.	57.3	73.3	41.3	.68	2.45	0
Nov.	43.0	57.9	28.0	.37	1.67	0
Dec.	33.9	46.7	21.1	.61	3.73	T
Period of record	55.2	70.4	39.9	7.32	4.80	0

Note.--Period of record of above data: 1931-68, inclusive. Previous periods of record (not complete): 1888-93, 1898-1900, 1908-12, and 1913-14.

TABLE 2

Subarea lags and pertinent elements, Winslow, Ariz. diversion levee, Little Colorado River, Ariz. and N. Mex., at and in the vicinity of Winslow, Arizona.

Subarea designation*	Drainage area	L	L_{ca}	S	$\frac{L \cdot L_{ca}}{S^{\frac{1}{2}}}$	$\bar{n}$	Lag**
	Square miles	Miles	Miles	Feet per mile			Hours
A	3.2	4.4	1.7	48	1.08	0.057	1.3
B	5.3	6.3	3.1	46	2.90	.053	1.8
C	1.8	3.3	1.5	52	.69	.055	1.2
D	1.2	2.7	.91	61	.32	.057	.90
E	3.8	4.3	1.9	65	1.01	.055	1.3
F	4.8	5.6	2.7	51	2.14	.054	1.7
G	2.7	4.4	2.1	46	1.37	.052	1.5

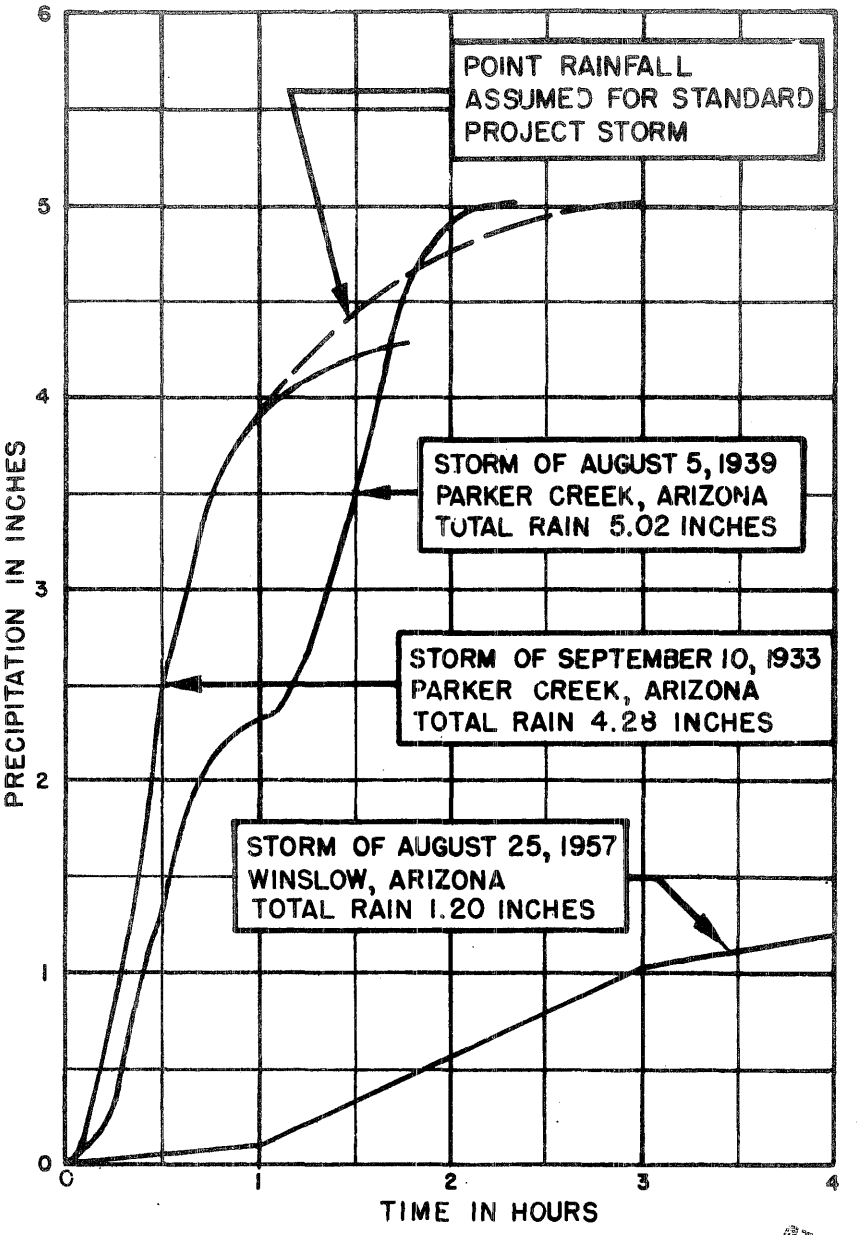
* See pl. 1 for location of subareas.
** See pl. 6 for lag curve and explanation of terms.

TABLE 3

Travel time Winslow, Ariz., diversion levee, Little Colorado River, Arizona and N. Mex., at and in the vicinity of Winslow, Ariz.

Flood discharge travel		Travel time
From concentration point number*	To concentration point number*	
		Minutes
6	5	13
5	4	9
4	3	10
3	2	12
2	1	16

* See pl. 1 for location of concentration points.



CITY OF WINSLOW
Winslow, Arizona

LITTLE COLORADO RIVER BASIN, ARIZONA AND NEW MEXICO WINSLOW ARIZONA AND VICINITY

MASS CURVES OF PRECIPITATION

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS

APPENDIX F

Selected Sections from USACE Project Specifications

Reference
DACW09-70-B-0059

SPECIFICATIONS

for

RUBY WASH DIVERSION LEVEE

WINSLOW, ARIZONA

Appropriation: 96x3122 Construction General
Corps of Engineers, Civil

Authority: This project is authorized by
Public Law 89-298

U S Army Engineer District
Los Angeles
Corps of Engineers

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PART I

SPECIAL PROVISIONS

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1. COMMENCEMENT, PROSECUTION, AND COMPLETION OF WORK. (JAN. 1965) The Contractor will be required to commence work under this contract within 10 calendar days after the date of receipt by him of notice to proceed, to prosecute said work diligently, and to complete the entire work ready for use not later than 550 calendar days after the date of receipt of notice to proceed. The time stated for completion shall include final clean-up of the premises.

1.1 Completion of Levee, Channel and Appurtenent Work. Subject to the provisions of the paragraph entitled "Public Utilities, Notices, and Restrictions," of the section entitled "General Requirements," the Contractor shall complete pertinent parts of the entire work as specified below.

1.1.1 Levee and Channel Construction. The Contractor shall complete the Levee and Channel ready for flood flow use not later than 420 calendar days after the date of receipt of notice to proceed. Flood control use is defined as having completed all work within the channel and below the top of the channel ready for flood flows.

2. LIQUIDATED DAMAGES. (JAN. 1965) In case of failure on the part of the Contractor to complete the work within the time fixed in the contract or any extensions thereof, the Contractor shall pay the Government as liquidated damages, pursuant to the clause of this contract entitled "Terminations for Default-Damages for Delay-Time Extensions," the sum of $300 for each day of delay.

3. CONTRACT DRAWINGS, MAPS AND SPECIFICATIONS. (JAN. 1965)

3.1 Ten sets of large scale contract drawings, maps and specifications will be furnished the Contractor without charge, except for applicable publications incorporated into the "Technical Provisions by reference. Additional sets will be furnished on request at the cost of reproduction. The work shall conform to the following contract drawings and maps, all of which form a part of these specifications and are available in the office of the U. S. Army Engineer District, Los Angeles, 300 North Los Angeles Street, Los Angeles, California.

Drawing No.	Title
446/189	Project Location, Index and General Plan of Improvements
446/190	Rainfall Data
446/191	Foundation Exploration
446/192	Plan and Profile (Sta. 381 + 30.51 to Sta. 326 + 50)
446/193	Plan and Profile (Sta. 326 + 50 to Sta. 270 + 00)
446/194	Plan and Profile (Sta. 270 + 00 to Sta. 213 + 00)
446/195	Plan and Profile (Sta. 213 + 00 to Sta. 156 + 00)
446/196	Plan and Profile (Sta. 156 + 00 to Sta. 99+60
446/197	Cross Sections
446/198	Cross Sections
446/199	Embankment, Channel, Turn around and Water Surface Gage Area Details
446/200	Confluence, Stabilizer and Access Ramp Details
446/201	Access Roads, Levee Plan, Profile and Sections,
446/202	Barricade & Station Marker Details

3.2 Omissions from the drawings or specifications or the misdescription of details of work which are manifestly necessary to carry out the intent of the drawings and specifications, or which are customarily performed, shall not relieve the Contractor from performing such omitted or misdescribed details of the work but they shall be performed as if fully and correctly set forth and described in the drawings and specifications.

3.3 The Contractor shall check all drawings furnished him immediately upon their receipt and shall promptly notify the Contracting Officer of any discrepancies. Figures marked on drawings shall in general be followed in preference to scale measurements. Large scale drawings shall in general govern small scale drawings. The Contractor shall compare all drawings and verify the figures before laying out the work and will be responsible for any errors which might have been avoided thereby.

4. CONTRACTOR SUBMITTALS.

4.1 General. The Contractor shall submit for approval all shop drawings, certificates of compliance, and/or equipment lists called for under the various headings of these specifications. These drawings, certificates and lists shall be complete and detailed. If approved by the Contracting Officer, each copy of the drawings, certificates, or lists will be identified as having received such approval by being so stamped and dated. The Contractor shall make any corrections required by the Contracting Officer. Unless otherwise specified in the Technical Provisions, the number of copies to be submitted shall be as stated herein. The Contractor shall complete ENG Form 4025, "Transmittal of Shop Drawings, Equipment Data, Material Samples, or Manufacturer's Certificates of Compliance for Approval" and forward 6 copies of same with each set of shop drawings, certificates of compliance, or equipment lists submitted. Blank ENG Forms 4025 will be furnished by the Contracting Officer on request. Each shop drawing submitted for approval shall have, in the lower right hand corner just above the title, a white space 3 inches x 4 inches in which the Contracting Officer can indicate the action taken. Shop drawings for submittal shall be either blue line or black line prints on a white background. Blueprints are not acceptable. Each shop drawing, certificate of compliance, and/or equipment list shall be identified with the following information as applicable:

Contract Number
Project Title and Location
Subcontractor's Name
Supplier's Name
Manufacturer's Name
Contract Specification and Paragraph Number
Contract Drawing File Number

4.2 Shop Drawings and Materials Submittal Register. Within 30 calendar days after commencement of work under this contract, the Contractor shall submit a preliminary register showing all shop drawings, certificates of compliance, equipment lists, samples, and other data required to be submitted under the various headings of these specifications. The register shall be similar to the attached sample register and shall be submitted in duplicate. The preliminary register shall show the submittal identification number, the type of submittal, and the description for all items to be submitted under this contract and, for all items needed prior to submittal of the Project Progress Schedule, the scheduled submittal date, approval need date, and the material/equipment need date shall also be included. The register shall be expanded to include all Contractor scheduled dates and shall be resubmitted within 15 calendar days after submittal of the project progress schedule. After original approval the register shall be updated to indicate actual dates, actions completed, and any additional submittals or resubmittals required, and two copies of all updated sheets shall be submitted on or before the fifteenth of each month. The register shall provide adequate time for review and approval of the submitted material and shall be coordinated with the construction progress schedule to assure that all equipment and materials will be available for incorporation into the work in accordance with approved schedule of construction operations. Payment for materials incorporated into the work will not be allowed until required approvals have been obtained.

4.3 Shop Drawings (JAN. 1965). The Contractor shall submit to the Contracting Officer for approval 10 copies of all shop drawings as called for under the various headings of these specifications. These drawings shall be complete and detailed. If approved by the Contracting Officer, each copy of the drawings will be identified as having received such approval by being so stamped and dated. The Contractor shall make any corrections required by the Contracting Officer. If the Contractor considers any correction indicated on the drawings to constitute a change to the contract drawings or specifications, notice as required under the clause entitled "Changes" will be given to the Contracting Officer. Eight sets of all shop drawings will be retained by the Contracting Officer and one set will be returned to the Contractor. The approval of the drawings by the Contracting Officer shall not be construed as a complete check, but will indicate only that the general method of construction and detailing is satisfactory. Approval of such drawings will not relieve the Contractor of the responsibility for any error which may exist as the Contractor shall be responsible for the dimensions and design of adequate connections, details, and satisfactory construction of all work.

4.4 Certificates of Compliance. Any certificates required for demonstrating proof of compliance of materials with specification requirements shall be executed in 6 copies. Each certificate shall be signed by an authorized officer of the manufacturing company and shall contain the name and address of the Contractor, the project name and location, and the quantity and date or dates of shipment or delivery to which the certificates apply. Copies of laboratory test reports submitted with certificates shall contain the name and address of the testing laboratory and the date or dates of the tests to which the report applies. Certification shall not be construed as relieving the Contractor from furnishing satisfactory material, if, after tests are performed on selected samples, the material is found not to meet the specific requirements.

4.5 Material and Equipment Schedules. As soon as practicable and within 30 calendar days after the date of commencement of work under this contract and before any material or equipment is purchased, the Contractor shall submit to the Contracting Officer for approval a complete list in sextuplicate of materials, fixtures and equipment to be incorporated in the work. With the material and equipment lists the Contractor shall submit 6 sets of applicable brochures, technical data, catalogs, cuts, diagrams, drawings, samples when required, and such other descriptive data as will give a complete description, including trade name, model number, type, size, rating and auxiliary equipment to be included.

4.6 Resubmittals. If a submittal is returned for correction or is not satisfactory and is disapproved by the Contracting Officer, the Contractor shall resubmit the corrected material in the same quantity, including reproducibles, as specified for the original submittal, for approval within 14 calendar days after receipt by him of the disapproved material.

5. PHYSICAL DATA. (JAN. 1965).

5.1 General. Information and data furnished or referred to below are furnished for the Contractor's information. However, it is expressly understood that the Government will not be responsible for any interpretation or conclusion drawn therefrom by the Contractor.

5.2 The physical conditions indicated on the drawings and in the specifications are the result of site investigations by surveys, auger borings, and laboratory Testing.

5.3 Transportation Facilities. The Atchison, Topeka, & Santa Fe Railway Co. serves the area adjacent to the site of the work. The Contractor shall investigate the availability of sidings and shall make all arrangements with the railroad company for any siding, spurs, or other facilities necessary for the delivery of materials to be used on the work. The Contractor shall make his own investigation of the condition of available public and private roads and of clearances, restrictions, bridge load limits, and other limitations affecting transportation and ingress and egress at the site of the work. It shall be the Contractor's responsibility to construct and maintain at his own expense, any haul roads required for construction operations.

5.4 Additional Information, including but not necessarily limited to, results of laboratory tests of material encountered in test holes or other explorations and field logs is available for inspection and study in the office of the District Engineer at 300 No. Los Angeles Street, Los Angeles, California.

5.5 Optional Project Office Facilities. The commissioner of the Parks and Recreation Department of the City of Winslow has stated that existing facilities may be available for rent or lease to the Contractor during construction. The Contractor may furnish suitable leased facilities for the Project Engineers Office and Laboratory in lieu of trailer and laboratory building specified in section: GENERAL REQUIREMENTS. Leased facilities shall meet all other requirements specified for Project Engineers Office and Laboratory.

6. SALVAGE MATERIALS AND EQUIPMENT. (JAN. 1965). The Contractor shall maintain adequate property control records for all materials or equipment specified to be salvaged. These records may be in accordance with the Contractor's system of property control, if approved by the property administrator. The Contractor shall be responsible for the adequate storage and protection of all salvaged materials and equipment and shall replace, at no cost to the Government, all salvage materials and equipment which are broken or damaged during salvage operations as the result of his negligence, or while in his care.

7. LAYOUT OF WORK.

7.1 The Government will establish the following base lines and bench marks at the site of the work:

7.1.1 Base Line. Control line of the levee and channel offset line thereto.

7.1.2 All necessary information relating to lines and grades will be made available to the Contractor.

7.1.3 Bench Marks.

7.1.3.1 B.M. 318 Elevation 4974.56 MSL.

Horizontal Control Third Order
Description

To reach station from the Post Office at Winslow, go south 0.4 mile along State Highway 87 to a paved road on the right leading to Winslow Airport. Go 1.0 mile Westerly along this road to a curve in the road at the Arizona National Guard Bldg. Leave paved road and go westerly along graded road, crossing two abandoned runways, 1.4 miles to a gate in a fence line. Go through gate and follow road 0.3 mile to end of earth diversion levee and station on top of small hill, a copper clad steel rod with brass cap stamped "USCE, 1967, 318" and set 0.3 foot above ground.

7.1.3.2 B.M. 319 Elevation 4956.03 MSL.

Horizontal Control Third Order

To reach station from the post office at Winslow, go south 0.4 mile along State Highway 87 to a paved road on the right leading to Winslow Airport. Go 1.0 mile westerly along road to a curve in the road at the Arizona National Guard Bldg. Leave paved road and go westerly along graded road, crossing two abandoned runways, 1.4 miles to a gate in a fence line. Go through gate and follow road 0.3 mile to end of earth diversion levee, follow the levee in a southeasterly direction 1500± to the first angle point in the levee. The station is a 1-1/2 inch iron pipe with brass cap stamped "USCE, 1967, 319" and set in the southerly toe of the levee.

7.1.3.3 B.M. 320 Elevation 4953.49 MSL.

Horizontal Control Third Order

To reach station from the Post Office at Winslow, go south 0.4 mile along State Highway 87 to a paved road on the right leading to Winslow Airport. Go 1.0 mile westerly along road to a curve in the road at the Arizona National Guard Bldg. Leave paved road and go westerly along graded road, crossing two abandoned runways, 1.4 miles to a gate in a fence line. Go through gate and follow road 0.3 mile to end of earth diversion levee. Follow the levee in a southeasterly direction .6 mile to the second bend in the levee. The station is on an angle point in the levee traverse line and is a copper clad steel rod with brass cap stamped "USCE 1967, 320" and set in the southerly slope of the levee.

7.1.3.4 B.M. 321 Elevation 4953.27 MSL.

Horizontal Control Third Order

To reach station from the Post Office at Winslow, go south 0.4 mile along State Highway 87 to a paved road on the right leading to Winslow Airport. Go 1.0 mile westerly along road to a curve in the road at the Arizona National Guard Bldg. Leave paved road and go westerly along graded road, crossing two abandoned runways, 1.4 miles to a gate in a fence line. Go through gate and follow road 0.3 mile to end of earth diversion levee. Follow the levee in a southeasterly direction 0.9 mile. The station is a point on tangent between Station 320 and 324 and is on top of the earth levee, a copper clad steel rod with brass cap stamped "USCE 1967, 321" set 0.1 foot above the top of the levee.

7.1.3.5 B.M. 322 Elevation 4952.81 MSL.

Horizontal Control Third Order

To reach station from the Post Office at Winslow, go south 0.4 mile along State Highway 87 is a paved road on the right leading to Winslow Airport. Go 1.0 mile westerly along road to a curve in the road at the Arizona National Guard Bldg. Leave paved road and go westerly along graded road, crossing two abandoned runways, 1.4 miles to a gate in a fence line. Go through gate and follow road 0.3 mile to end of diversion levee, follow the levee in a southeasterly direction about 1.1 miles. The station is a point on tangent in the levee traverse line between Station 320 and 324 and is in the middle of the earth levee, a lead and tack set in a drill hole in rock.

7.1.3.6 B.M. 323 Elevation 4936.95 MSL.

Horizontal Control Third Order

To reach station from the Post Office at Winslow, go south 0.4 mile along State Highway 87 to a paved road on the right leading to Winslow Airport. Go 1.0 mile westerly along road to a curve in the road at the Arizona National Guard Bldg. Leave paved road and go westerly along graded road, crossing two abandoned runways 1.4 miles to a gate in a fence line. Go through gate and follow road 0.3 mile to end of diversion levee, follow the levee easterly 1.5 miles to the station which is a point on tangent in the levee traverse line between Stations 320 and 324, a lead and tack in drill hole set in a rock on top of the levee.

7.1.3.7 B.M. 324 Elevation 4915.80 MSL.

Horizontal Control Third Order

To reach station from the Post Office at Winslow, go south along Highway 87, 0.4 mile to a paved road on the right leading to Winslow Airport. Take this road 1.0 mile west to dirt road to left (south). Go along this dirt road 0.5 mile through a gate in the fence to an earthen levee. Walk along top of levee 480'± westerly from fence crossing levee to station. A 1-1/2 inch iron pipe with brass cap stamped "USCE, 1967, 324" and set 0.3 foot above ground.

7.1.3.8 BM 325 Elevation 4906.76 MSL.

Horizontal Control Third Order
To reach station from the Post Office at Winslow, Arizona, go south 1.0 mile along Highway 87 to a fence and pole line bearing west. Go through gate and along dirt road on the north side of the fence 0.5 mile to a power pole. Cross fence and walk south 200' to Station. A 1-1/2 inch iron pipe with brass cap stamped "USCE, 1967, 325" and set 0.3 foot above ground.

7.1.3.9 B.M. 326 Elevation 4903.40 MSL.

Horizontal Control Third Order

To reach station from the Post Office in Winslow, Arizona, go south 1.0 mile along Highway 87 to a fence and pole line running west. Go through gate and along dirt road on north side of fence 0.3 mile. Cross fence and walk 490± south to station. A copper clad steel rod with brass cap stamped "USCE, 1967, 326" and driven to within 0.3 foot above the surface.

7.1.3.10 B.M. 327 Elevation 4898.76 MSL.

Horizontal Control Third Order

To reach the station from Winslow, Arizona, go south from east bound on Highway 66, 1.1 mile along Highway 87 to the northerly end of a cut in the road bed, 100 feet east of the road, 50 feet south of a telephone pole and 15 feet west of a fence and in line with the telephone line. A 1-1/2 inch iron pipe with brass cap stamped "USCE, 1967 327" and set 0.3 foot above ground.

7.1.3.11 B.M. 328 Elevation 4903.20 MSL.

Horizontal Control Third Order

To reach the station from the Post Office at Winslow, go south along Arizona Highway 87, 0.9 mile to a "Y" Junction with Clear Creek Rd, then southeasterly along Clear Creek Rd. 0.4 mile. Station is a 600 foot walk south to station. A copper clad steel rod with brass cap stamped "USCE, 1967 328" and driven to within 0.5 foot above ground.

7.1.3.12 B.M. 329 Elevation 4911.25 MSL.

Horizontal Control Third Order

To reach the station from the Post Office at Winslow, go south along State Highway 87, 0.9 mile to Clear Creek Road on the left. Follow this road 0.6 mile. Station is 360' southwesterly from the center line of the road. A 1-1/2 inch iron pipe with brass cap stamped "USCE, 1967 329" and set 0.5 foot above ground.

7.1.3.13 B.M. 330 Elevation 4907.81 MSL.

Horizontal Control Third Order

To reach the station from the Post Office at Winslow, go south along Highway 87, 0.9 mile to the intersection of Clear Creek Road on the left. Follow Clear Creek Road 0.8 mile. Station is 130 feet ± Northeasterly from the north edge of road, a 1-1/2 inch iron pipe with brass cap stamped "USCE, 1967, 330" and set 0.3 foot above ground.

7.1.3.14 B.M. 331 Elevation 4905.32 MSL.

Horizontal Control Third Order

To reach the station from the Post Office at Winslow, go south on Highway 87, 0.9 mile to the intersection of Clear Creek Road on the left. Follow Clear Creek Road 0.8 mile. Cross fence and walk 1900 feet east to station, a 1-1/2 inch iron pipe with brass cap stamped "USCE, 1967, 331" and set 0.3 foot above ground.

7.1.3.15 B.M. 332 Elevation 4887.00 MSL.

Horizontal Control Third Order

From the Post Office at Winslow, go south on Arizona State Highway 87, 0.3 mile to a paved road to the left which is the first road beyond the underpass of the AT & SF Ry. Turn left, cross the railroad track and bear left on a gravel road 1.5 miles to a small hill opposite a junk yard, and 30 feet west of a fence line, a steel rod with brass cap stamped "USCE, 1967, 332" and driven to 0.3 foot above the surface.

7.1.3.16 B.M. 333 Elevation 4878.63 MSL.

Horizontal Control Third Order

From the Post Office at Winslow, go south along Arizona State Highway 87, 0.3 mile through the underpass to the first paved road to the east. Turn left across the railroad track and bear to the left on gravel road 1.5 miles to a gate in the fence on left side of road leading into dump.

Go through gate, continue easterly through dump on dim track road 0.2 mile to station on top of small prominent hill. A standard Corps of Engineers bronze tablet stamped "LADIST, 1967, 333" set in concrete flush with ground.

7.1.3.17 B.M. 334 Elevation 4872.70 MSL.

Horizontal Control Third Order

To reach the station from the Post Office at Winslow, go south on Arizona State Highway 87, 0.3 mile through the underpass of the AT & SF Ry to a paved road to the left. Take this road and cross tracks to a gravel road bearing left. Go 1.5 miles along this road to a dump and an opening in fence. Go through opening and follow track road winding through the dump 0.3 mile to fence. Cross fence and walk 700 feet southeasterly to a wash. Station is on west side of wash. A 1-1/2 inch iron pipe with brass cap stamped "USCE, 1967, 334" projecting 0.3 foot above ground.

7.1.3.18 B.M. 335 Elevation 4883.10 MSL.

Horizontal Control Third Order

To reach the station from the Post Office at Winslow, go south along Arizona State Highway 87, 0.8 mile to "Y" Junction with Clear Creek Road. Go southeasterly along Clear Creek Road 2.2 miles to a gate on the left. Go through gate and proceed along trail 0.5 mile to a fork in the road about 200' before coming to a fence. Take left track road 0.3 mile, turn northeasterly and go cross country to top of small hill and station. A 1-1/2 inch iron pipe with brass cap stamped "USCE, 1967, 335" projecting 0.4 foot above ground.

7.1.3.19 B.M. 336 Elevation 4860.76 MSL.

Horizontal Control Third Order

To reach the station from the Post Office at Winslow, go south along Arizona State Highway 87, 0.8 mile to Junction with Clear Creek Road. Take this road 2.2 miles to a gate on left. Go through gate and proceed along track road 0.5 mile to a fork in road about 200 feet before reaching a fence. Take left fork and go 0.3 mile to station on right side of road. A 1-1/2 inch iron pipe with brass cap stamped "USCE, 1967, 336" projecting 0.4 foot above ground.

7.1.3.20 B.M. 337 Elevation 4855.86 MSL.

Horizontal Control Third Order

To reach the station from the Post Office of Winslow, go east on U.S. Highway 66, 2.5 miles to a roadside park on the right. Enter park and go easterly along bladed road to a cattle guard. Turn right and go under a railroad bridge and along top of dirt levee 0.5 mile to a point where the road leaves the levee. From here walk southwesterly cross a fence and two irrigation ditches and go 1200'± cross country to station. A 1-1/2 inch iron pipe with brass cap stamped "USCE, 1967, 337" projecting 0.3 foot above the surface.

7.1.3.21 B.M. 338 Elevation 4859.17 MSL.

Horizontal Control Third Order

To reach the station from the Post Office at Winslow, go one block south to Highway 66 eastbound, then 2.5 miles east on Highway 66 to a roadside park on the right. Enter park and go east on a graded road 0.3 mile to a cattle guard. Turn right, go under a railroad bridge and along top of dirt levee 0.5 mile to angle point in telephone line. Station is on west shoulder of levee, 16 feet ± northwest from angle pole in telephone line. A 1-1/2 inch iron pipe with brass cap stamped "USCE, 1967, 338" projecting 0.2 foot above the surface.

7.2 From the base lines and bench marks established by the Government, the Contractor shall complete the layout of the work and shall be responsible for all measurements that may be required for the execution of the work to the location and limit marks prescribed in the specifications or on the contract drawings, subject to such modifications as the Contracting Officer may require to meet changed conditions or as a result of necessary modifications to the contract work.

7.3 The Contractor shall furnish, at his own expense, such stakes, templates, platforms, equipment, tools and material, and all labor as may be required in laying out any part of the work from the base lines and bench marks established by the Government. It shall be the responsibility of the Contractor to maintain and preserve all stakes and other marks established by the Contracting Officer until authorized to remove them, and if such marks are destroyed, by the Contractor or through his negligence prior to their authorized removal they may be replaced by the Contracting Officer, at his discretion, and the expense of replacement will be deducted from any amounts due or to become due the Contractor. The Contracting Officer may require that work be suspended at any time when location and limit marks established by the Contractor are not reasonably adequate to permit checking of the work.

8. QUALITY SURVEYS.

8.1 The Contractor shall furnish all personnel, equipment and material required to make necessary original and final surveys. The Government will make such computations as are necessary to determine the quantities of work performed or finally in place.

8.2 For surveys necessary to determine the amount of progress payments, the Contractor will be required to furnish all personnel, equipment and material required to make such surveys as are necessary to determine the quantities of work performed or placed during the period covered by the progress payments. All original field notes, field computations, and other records taken in the field by the Contractor for the purpose of layout, progress, original and final surveys shall be recorded in duplicating field books, the original pages of which shall be furnished promptly in ring binders to the representative of the Contracting Officer at the site of the work, and shall be used by the Contracting Officer to the extent necessary in determining the proper amount of progress payments due to the Contractor. Unless waived in each specific case, quantity surveys made by the Contractor shall be made under the direction of a representative of the Contracting Officer.

9. DAMAGE TO WORK. The responsibility for damage to any part of the permanent work shall be as set forth in the clause of the contract entitled "Permits and Responsibilities." However, if, in the judgment of the Contracting Officer, any part of the permanent work performed by the Contractor is damaged by flood or earthquake, which damage is not due to the failure of the Contractor to take reasonable precautions or to exercise sound engineering and construction practices in the conduct of the work, the Contractor will make the repairs as ordered by the Contracting Officer and full compensation for such repairs will be made at the applicable contract unit or lump sum prices as fixed and established in the contract. If, in the opinion of the Contracting Officer, there are no contract unit or lump sum prices applicable to any part of such work an equitable adjustment pursuant to Clause 3, Changes, of the contract, will be made as full compensation for the repairs of that part of the permanent work for which there are no applicable contract unit or lump sum prices. Except as herein provided, damage to all work (including temporary construction), utilities, materials, equipment and plant shall be repaired to the satisfaction of the Contracting Officer at the Contractor's expense, regardless of the cause of such damage.

10. FUNDS AVAILABLE FOR PAYMENTS.

10.1 Such work as may be done under this contract in excess of the amount for which funds are available for payment as herein set forth, will be continued with funds hereafter appropriated and allotted for this work.

10.2 From funds heretofore appropriated by the Public Works Act of 1970 (83 Stat 325) for Construction General the sum of $70,000 is available for payments to the Contractor for work performed under this contract.

10.3 If at any time it becomes apparent to the Contracting Officer that the balance of this allocation is in excess of the amount required to meet all payments due and to become due the Contractor because of work performed and to be performed pursuant to his approved progress schedule, the right is reserved after due notice to the Contractor to reduce said allocation by the amount of such excess.

10.4 If the rate of progress of the work is such that it becomes apparent to the Contracting Officer that the balance of this allocation and any allocation for this and any subsequent fiscal years during the period of this contract is less than that required to meet all payments due and to become due the Contractor because of work performed or to be performed under this contract, the Contracting Officer may provide additional funds for such payments if there be funds available for such purpose. The Contractor will be notified in writing of any additional funds so made available. However, it is distinctly understood and agreed that the amount of funds stated in paragraph 10.2 is the maximum amount the Government insures will be available during the cur-

rent fiscal year and the Government is in no case liable for payments to the Contractor beyond this amount prior to having notified the Contractor in writing of any additional funds that can be made available. Accordingly, no progress schedule will be approved (see paragraph (a) of clause of the contract entitled "Progress Charts and Requirements for Overtime Work") which contemplates progress requiring funds in excess of the amount stated to be available in paragraph 10.2 for the current fiscal year and no progress schedule will be approved for any ensuing fiscal year which contemplates progress requiring funds in excess of the amount allocated by the Contracting Officer from funds subsequently made available, except as set forth and subject to the conditions in paragraph 10.9.

10.5 It is expected that, during subsequent fiscal years over the period of this contract, Congress will make additional appropriations for expenditure on work under this contract. The Contracting Officer will notify the Contractor of any additional allocation of funds to this contract when such funds become available. It is understood and agreed that the Government is in no case liable for damages in connection with this contract on account of delay in payments to the Contractor due to lack of available funds. Should it become apparent to the Contracting Officer that the available funds will be exhausted before additional funds can be made available, the Contracting Officer will give at least 30 days written notice to the Contractor that the work may be suspended. If the Contractor so elects, after receipt of such notice, he may continue work under the conditions and restrictions under the specifications, so long as there are funds for inspection and superintendence, with the understanding; however, that no payment will be made for such work unless additional funds shall become available in sufficient amount. When funds again become available, the Contractor will be notified accordingly. Should work be thus suspened, additional time for completion will be allowed equal to the period during which work is necessarily so suspended, as determined by the dates specified in the above-mentioned notices.

10.6 So long as funds are available, payments will be made monthly in accordance with the clause of the contract entitled "Payments to Contractor." The unit prices or lump sum price or prices stated in the contract will be used in determining the amount to be paid for work performed by the Contractor.

10.7 The procedure above described will be repeated as often as may be necessary on account of the exhaustion of available funds and the necessity of awaiting the appropriation of additional funds by Congress.

10.8 Should Congress fail to provide additional funds the contract may be terminated and considered to be completed, at the option of the Contractor, without prejudice to him or liability to the Government, at any time subsequent to 30 days after payments are discontinued, or at any time subsequent to 30 days after the passage of the Act which would have but did not carry an appropriation for continuing the work or after the adjournment of the Congress which failed to make the necessary appropriations. However, if the funds cited in the contract are enough to extend the work beyond the end of the fiscal year and no new funds are allocated to this contract for the ensuing fiscal year, the Contractor must first exhaust all the cited funds and thereafter he may, at his option, exercise the right provided in this paragraph any time after payments are discontinued.

10.9 The progress chart prepared in accordance with paragraph (a) of the clause of the contract entitled "Progress Charts and Requirements for Overtime Work" will be consistent with the amount of funds stated in paragraph 10.2 as being currently available for the period of time from the date of contract award to the end of the fiscal year in which the contract was awarded, or at the option of the Contractor, the chart may be prepared on the basis of accomplishment of work at a greater rate of progress for the period of time applicable to currently available funds. Any chart initially submitted for approval which contemplates progress at a greater rate than can be paid for with currently available funds will be approved only under the condition that such approval will in no way obligate the Government to make additional funds available for the work. That part of the chart which covers the work for which funds are not currently available will be prepared on the basis of a schedule considered to be practicable by the Contractor for accomplishment of the work at such rate of progress as he may desire for completion within the terms of the contract. The progress chart will be revised each time the Contractor is notified that additional funds are made available. Each revision will conform with the criteria stated above. With reference to the responsibilities for future funding of the work in accordance with the progress chart, attention is called to the preceding subparagraphs wherein the responsibilities of the Government are set forth for the furnishing of funds for the work. The approval of that part of the schedule covering work for which funds are not currently available will in no way obligate the Government to provide funds to accomplish work at the rate of progress indicated in the schedule.

11. PERFORMANCE OF WORK BY CONTRACTOR. (JAN. 1965). The Contractor shall perform on the site, and with his own organization, work equivalent to at least 35% of the total amount of work to be performed under the contract. If during the progress of the work hereunder the Contractor requests a reduction in such percentage; and the Contracting Officer determines that it would be to the Government's advantage, the percentage of the work required to be performed by the Contractor may be reduced; provided, written approval of such reduction is obtained by the Contractor from the Contracting Officer.

12. STATEMENT OF WORK BY CONTRACTOR. A statement in the following form shall be furnished by the Contractor, which will describe the work his own organization will perform (e.g., earthwork, paving, etc.), give the percentage of work he performs to the total amount of work, and give the estimated cost thereof. Unless this statement is furnished with the Contractor's bid, he shall submit it not later than 5 calendar days after award of contract.

"The organization of the undersigned will perform the following work:

This work represents _____% of the total work and its estimated cost is $_____."

13. OPERATIONS. The plan of operations in the waste disposal areas, shall be subject to approval, but approval of the plan will not in any way relieve the Contractor of the responsibility to operate in the waste disposal areas in a safe and systematic manner.

14. PROGRESS SCHEDULE.

14.1 Reference is made to the General Provision entitled "Progress Charts and Requirements for Overtime Work."

14.2 The Progress schedule shall provide for a uniform rate of progress throughout the entire construction period. Actual progress shall be entered on the schedule weekly. The determination of whether or not the work is behind schedule will be based upon a uniform rate of production in each feature of the work. Falling more than 5 calendar days behind the approved progress schedule in any feature of the work shall constitute sufficient grounds for a determination that the Contractor has fallen behind the progress schedule. Failure of the Contracting Officer to act under this provision shall in no way relieve the Contractor of the responsibility for completion of the work on schedule.

15. CONTRACTOR QUALITY CONTROL. The Contractor shall provide and maintain an effective quality control program that complies with General Provision 23 of the contract entitled "Contractor Inspection System."

15.1 The Contractor shall establish a quality control system to perform sufficient inspection and tests of all items of work, including that of his subcontractors, to ensure conformance to applicable specifications and drawings with respect to the materials, workmanship, construction, finish, functional performance, and identification. This control will be established for all construction except where the Technical Provisions of the contract provide for specific Government control by inspections, tests or other means. The Contractor's control system will specifically include the surveillance and tests required in the Technical Provisions of the contract specifications.

15.2 The Contractor's quality control system is the means by which he assures himself that his construction complies with the requirements of the contract plans and specifications. The controls shall be adequate to cover all construction operations and should be keyed to the proposed construction sequence.

15.3 The Contractor's job supervisory staff may be used for quality control, supplemented as necessary by additional personnel for surveillance, special technicians, or testing facilities to provide capability for the controls required by the Technical Provisions of the specifications.

15.4 After the contract is awarded and before construction operations are started, the Contractor shall meet with the Contracting Officer, or his representative, and discuss quality control requirements. The meeting shall develop mutual understanding relative to details of the system, including the forms to be used for recording the quality control operations, inspections, administration of the system, and the interrelationship of Contractor and Government inspection.

15.5 The Contractor shall submit for approval within 15 days after the receipt of the Notice to Proceed a quality control plan which shall include the procedures, instructions, and reports to be used. This document will include as a minimum:

(1) The quality control organization.

(2) Number and qualifications of personnel to be used for this purpose.

(3) Authority and responsibilities of quality control personnel.

(4) Methods of quality control including that for his subcontractor's work.

(5) Test methods including, as specified, name of qualified testing laboratory to be used.

(6) Method of documenting quality control operation, inspection, and testing.

(7) A copy of a letter of direction to the Contractor's representative responsible for the quality control, outlining his duties and responsibilities, and signed by a responsible officer of the firm.

15.6 Unless specifically authorized in writing, no construction shall be started until the Contractor's quality control plan is approved.

15.7 All compliance inspections will be recorded on an approved form, including but not limited to the specific items required in the Technical Section of the specifications entitled "General Requirements." This form, to include records of corrective action taken, will be furnished to the Government as required by the Contracting Officer.

15.8 If recurring deficiencies in an item or items indicate that the quality control system is not adequate, such corrective actions will be taken as directed by the Contracting Officer.

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DATE	SHOP DRAWINGS AND MATERIALS SUBMITTAL REGISTER					CONTRACT NO. CONTRACTOR		
			CONTRACTOR SCHEDULED DATES			CORPS ACTION DATES		
SUBMITTAL IDENT. NO.	TYPE OF SUBMITTAL	DESCRIPTION OF MATERIAL SUBMITTED	SCHEDULED SUBMIT DATE	APPROVAL NEEDED BY	MATERIAL EQUIP NEEDED BY	SUBMITTED	APPROVAL CODE & DATE	REMARKS

SECTION NO.

PART II

TECHNICAL PROVISIONS

SECTION 1 A

GENERAL REQUIREMENTS

Index

1. Applicable Publications
2. Project Facilities
3. Construction Signs
4. Project Engineer's Office and Laboratory
5. Bulletin Board
6. Maintenance and Disposal
7. Scrap Material
8. Salvage Materials
9. Dust Control
10. Archaeological Findings During Construction
11. Permits
12. Public Utilities, Notices, and Restrictions
13. Public Safety
14. Water Contamination
15. Quality Control

1. APPLICABLE PUBLICATIONS. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto.

1.1 Federal Specifications.

FF-B-571a & Am-1	Bolts, Nuts, Studs, and Tap Rivets (and Material for Same)
FF-N-105a & Int. Am-2	Nails, Wire, Brads, and Staples
MM-L-00751g	Lumber; Softwood
TT-E-529b & Am-1	Enamel, Alkyd, Semigloss
TT-P-25c	Primer Coating, Exterior (Undercoat for Wood, Ready-Mixed, White and Tints)

1.2 U. S. Department of Commerce Commercial Standards.

PS 1-66	Softwood Plywood, Construction and Industrial

2. PROJECT FACILITIES. The Contractor shall construct and/or erect the following project facilities.

2.1 Construction Signs.

2.1.1 2 Project Signs and 1 Safety Sign at locations designated by the Contracting Officer.

2.1.2 Warning Signs facing approaching traffic on all haul roads crossing under overhead power transmission lines.

2.2 Project Engineer's Office and Laboratory, including a fenced parking area and a flagpole.

2.3 Bulletin Board at the Contractor's office.

2.4 Sanitary Facilities.

3. CONSTRUCTION SIGNS.

3.1 Materials.

3.1.1 Lumber shall conform to Federal Specification MM-L-751, and shall be clear Douglas Fir, kiln-dried, S4S, except as otherwise specified.

3.1.2 Plywood shall conform to Product Standard PS 1, Grade AA, Group 1, Exterior Type.

3.1.3 Bolts, Nuts and Nails. Bolts and nuts shall conform to Federal Specifications FF-B-571, and nails shall conform to Federal Specification FF-N-105.

3.1.4 Paints and Oils. Paints shall conform to Federal Specifications TT-P-25 for primer and TT-E-529 for finish paint and lettering.

3.2 Construction.

3.2.1 Project Sign and Safety Sign shall be constructed as detailed on Figures 1, 2, and 3. Decals of the Corps of Engineers' Castle will be furnished by the Contracting Officer.

3.2.2 Warning Signs shall be constructed of plywood not less than 1/2 inch thick and shall be securely bolted to the supports with the bottom of the sign face 3 feet above the ground. The sign face shall be 2 x 4 feet, all letters shall be 4 inches in height, and the wording shall be: "WARNING: OVERHEAD TRANSMISSION LINES."

3.3 Painting. All exposed surfaces and edges of plywood shall be given one coat of linseed oil and be wiped prior to applying primer. All exposed surfaces of signs and supports shall be given one coat of primer and 2 finish coats of white paint. Lettering on all signs shall be black and sized as indicated.

4. PROJECT ENGINEER'S OFFICE AND LABORATORY.

4.1 General. The Contractor shall provide a suitable office trailer and a laboratory building for the Project Engineer. The exact site will require the Contracting Officer's approval. Both the trailer and the building shall be adequately heated, well lighted, suitably ventilated, and cooled with an exterior mounted, 1,000 cubic feet per minute minimum size, pad-type evaporative cooler, complete, with all piping and electrical connections. An adequate supply of cooled drinking water shall be furnished and maintained. Open parking space for 6 vehicles and water and sanitary facilities shall be located convenient to the office and laboratory. The combined parking and building area shall be enclosed with a woven wire fence approximately 6 feet high with a 10-foot wide lockable gate accessible from a road or street. The fenced area shall be of sufficient size to permit ease in the parking of vehicles. Materials for the facilities need not be new provided they are adequate for the intended use.

4.2 Office Trailer shall be approximately 10 feet wide by 40 feet in length.

4.3 Laboratory Building shall be weathertight and shall have a 6-inch concrete slab floor and contain not less than 400 square feet of floor area. The laboratory shall be equipped with water supply, a sink approximately 20 x 35 x 8 inches, and the usual utilities.

4.4 Flagpole. The Contractor shall furnish and erect a flagpole at the Project Engineer's Office. The flagpole shall be either wood or sectional steel type, a product of a reputable manufacturer who has been regularly engaged in the manufacture of flagpoles. The flagpole shall be complete with standard fittings and equipment, including pulley, cleats, ground protector, halyards, and snap hooks. The pole shall have 20 feet exposed height and be set in concrete foundation in conformance with the manufacturer's recommendation. Painting of the wooden pole shall conform to the applicable requirements for the safety sign. Steel pole shall be galvanized.

5. BULLETIN BOARD. A weatherproof bulletin board, approximately 36 inches wide and 30 inches high, with hinged glass door shall be provided adjacent to or mounted on the Contractor's project office. If adjacent to the office, the bulletin board shall be securely mounted on not less than 2 posts. Bulletin board and posts shall be painted or have other approved factory finish. The bulletin board shall be easily accessible at all times and shall contain wage rates, equal opportunity notice, and such other items required to be posted.

6. MAINTENANCE AND DISPOSAL. The Contractor shall maintain all above specified facilities in good condition throughout the life of the project. Upon completion of work under this contract, all facilities covered under this section will remain the property of the Contractor and shall be removed from the site at his expense.

7. SCRAP MATERIAL. Materials indicated to be removed and not indicated to be salvaged, stored or reinstalled as designated as scrap and shall become the property of the Contractor and be removed from the site of the work. The Contractor by signing this contract hereby acknowledges that he made due allowance for value, if any, of such scrap in the contract price.

8. SALVAGE MATERIALS. All materials and/or equipment removed and indicated to be either stored or reinstalled are designated as salvaged materials and/or equipment. Any salvaged materials and equipment which are excess upon completion of the work shall become the property of the Contractor.

9. DUST CONTROL. The Contractor shall provide an acceptable plan for preventing the gener-

ation of dust due to his operation in construction zones, along haul routes, in equipment parking areas, and in waste areas located on the Base. This plan may consist of water sprinkling or an equivalent service.

10. ARCHAEOLOGICAL FINDINGS DURING CONSTRUCTION. Should the Contractor or any of his employees in the performance of this contract find or uncover any archaeological remains, he shall notify the Project Engineer immediately. Such notification will be a brief statement in writing giving the location and the nature of the findings. Should the discovery site require archeological studies resulting in delays and/or additional work, the Contractor will be compensated by an equitable adjustment under the General Provisions of the contract.

11. PERMITS.

11.1 General. Reference is made to the article of the contract entitled "Permits and Responsibilities," which obligates the Contractor to obtain all required licenses and permits.

12. PUBLIC UTILITIES, NOTICES, AND RESTRICTIONS.

12.1 General. The approximate location of all pipe lines, power and communication lines, and other utilities known to exist within the limits of the work are indicated on the drawings. The sizes, locations, and names of owners of such utilities are given from available information, but their accuracy is not guaranteed. Except as otherwise indicated on the drawings, all existing utilities will be left in place and the Contractor shall conduct his operations in such a manner that the utilities will be protected from damage at all times, or arrangements shall be made by the Contractor for their relocation at the Contractor's own expense. The Contractor shall be responsible for any damage to utilities known to exist and shall reimburse the owners for such damage caused by his operations.

12.2 Relocation or Removal. Utilities to be relocated or removed not as part of this contract are designated "To be Relocated by Others" or "To be Removed by Others," respectively. Utilities shown on the plans and not so designated will be left in place and shall be subject to the provisions of paragraph: PROTECTION OF EXISTING STRUCTURES, UTILITIES, WORK AND VEGETATION of the General Provisions and other contract provisions. The Contractor, without cost to the Government, may make arrangements with the owner for the temporary relocation and restoration of utilities not designated to be relocated, or for additional work in excess of the work needed to relocate utilities designated for relocation.

12.3 Utilities Not Shown. If the Contractor encounters, within the construction limits of the entire project, utilities not shown on the plans and not visible as of the date of this contract and if such utilities will interfere with construction operations, he shall immediately notify the Contracting Officer in writing to enable a determination by the Contracting Officer as to the necessity for removal or relocation. If such utilities are left in place, removed or relocated, as directed by the Contracting Officer, the Contractor shall be entitled to an equitable adjustment for any additional work or delay.

12.4 Notices.

12.4.1 Traffic Routing. The Contractor shall notify the Contracting Officer 7 days in advance of the time work will be started in areas requiring the rerouting of traffic, traffic lane striping, and removal of road signs. The foregoing shall apply to progressive modifications of traffic routings within an area in which work is in progress. Additional requirements regarding traffic are included in section: DETOURS AND TRAFFIC CONTROL FACILITIES.

12.4.2 The Highway Patrol, and County Sheriff shall be notified by the Contractor whenever a road is to be closed to traffic. If the closing is to be of long duration, a single notification to each department 7 days before closing will be sufficient. A single notification shall then be made at the time the road is again opened to traffic. If the closing is to be of short duration or if different sections of the road are to be closed at different times, notifications shall be made on a day-to-day basis.

12.4.3 Existing Bench Marks and R/W Markers. The Contractor shall notify the Contracting Officer, in writing, 7 days in advance of the time he proposes to remove any bench mark or right-of-way marker.

12.4.4 Optional Disposal Areas. The Contractor shall notify the Contracting Officer within 30 days after receipt of "Notice to Proceed," as to which optional disposal areas he proposes to use or whether the areas will not be used for disposal. Should the Contractor elect to use any of the disposal areas, he shall indicate the approximate quantities of material he proposes to place in each area. In addition to the above requirements, the Contractor shall notify the Contracting Officer 24 hours in advance of the time he proposes to start operations in the optional disposal area, and 48 hours in advance of any work which he proposes to do in the disposal areas on Saturday, Sunday or legal holidays.

12.5 Restrictions.

12.5.1 Representatives of Other Agencies. Personnel representing owners and agencies may be present for various portions of the work. However, the Contractor will be responsible only to the Contracting Officer.

13. PUBLIC SAFETY. Attention is invited to the General Provision entitled "Permits and Responsibilities." The Contractor shall provide temporary fencing, barricades, and/or guards, as required, to provide protection in the interest of public safety. Whenever the Contractor's operations create a condition hazardous to the public, he shall furnish at his own expense and without cost to the Government, such flagmen and guards as are necessary to give adequate warning to the public of any dangerous conditions to be encountered and he shall furnish, erect, or maintain such fences, barricades, lights, signs and other devices as are necessary to prevent accidents and avoid damage or injury to the public. Flagmen and guards, while on duty and assigned to give warning to the public that the project is under construction and of any dangerous conditions to be encountered as a result thereof, shall be equipped with red wearing apparel and a red flag. Signs, flags, lights, and other warning and safety devices shall conform to applicable city, county, and state requirements. Should the Contractor appear to be neglectful or negligent in furnishing adequate warning and protection measures, the Contracting Officer may direct attention to the existence of a hazard and the necessary warning and protective measures shall be furnished and installed by the Contractor without additional cost to the Government. Should the Contracting Officer point out the inadequacy of warning and protective measures, such action of the Contracting Officer shall not relieve the Contractor from any responsibility for public safety or abrogate his obligation to furnish and pay for those devices. The installation of any general illumination shall not relieve the Contractor of his responsibility for furnishing and maintaining any protective facility.

14. WATER CONTAMINATION. In order to prevent contamination of water along beaches and waterways, all refuse, oil, greases, and other petroleum products; all toxic materials; all cement or concrete; or water containing such materials shall be disposed of in a manner to prevent their entry into waters along beaches and waterways.

15. QUALITY CONTROL. The Contractor shall inspect the work of his own forces and the work of all subcontractors for compliance with the contract requirements and record the results of the inspections. The inspections shall include all materials and equipment delivered to the site as well as work accomplished. Legible copies of the daily inspection reports shall be maintained by the Contractor at the project site at all times and the original copies of the "Construction Quality Control Report" covering the preceding week shall be delivered to the Contracting Officer on the last work day of each calendar week. A sample form of a minimum "Construction Quality Control Report" is attached at the end of this section. In addition to performing such general inspections as are required to assure adequate quality control the daily inspections shall specifically include the following operations.

* * * * *

DAILY CONSTRUCTION QUALITY CONTROL REPORT

PROJECT RUBY WASH DIVERSION LEVEE	LOCATION WINSLOW, ARIZONA	REPORT NO. DATE
CONTRACTOR	ADDRESS	CONTRACT NO.

	(1)	(2)	(3)		(4)		(5)
ITEM	IN PROCESS	LOCATION/DESCRIPTION	CONFORMS TO CONTR RQRMT		TEST REPORTS		REMARKS
			YES	NO	ATCH'D	TO FOL	
GENERAL CONDITIONS (REPORT DAILY) Manpower Adequacy							
Layout of Work							
Suitability of Construction Equipment							
Safety Condition Diversion and Control of Water ~~Clearing Site and Removing~~ Obstruction							

SPL FORM SEP 69 522

INSTRUCTIONS

(1) Enter check in column (1) to indicate (i) delivery of materials and equipment for installation in the work; (ii) delivery or use of construction equipment; and (iii) items of construction in process.

(2) Identify location and/or description of each activity checked in column (1).

(3) Enter check under either Yes or No for each activity checked in column (1).

(4) Check if appropriate.

(5) Enter appropriate comment and explain each "NO" checked in column (3). Attach additional pages if more space is required.

DAILY CONSTRUCTION QUALITY CONTROL REPORT (Cont'd)

REPORT NO.

ITEM	(1)	(2) LOCATION/DESCRIPTION	(3) CONFORMS TO CONTR RQRMT		(4) TEST REPORTS		(5) REMARKS
			YES	NO	ATCH'D	TO FOL	
3A EXCAVATION Blasting Grade Control							
Disposal of Materials							
3B FILLS AND SUBGRADE PREPARATION Materials							
Foundation & Subgrade Preparation, Placement Grade Control							
Compaction							
4A CONCRETE Materials Certificates							
Mix Control Placement							
4H GROUTING STONEWORK Materials Certificates							
Mix Control Placing Finish							
5A STONEWORK Materials ~~Foundation Preparation~~							
Placement Grade Control							

DAILY CONSTRUCTION QUALITY CONTROL REPORT (Cont'd)

REPORT NO.

ITEM	(1)	(2) LOCATION/DESCRIPTION	(3) CONFORMS TO CONTR RQRMT		(4) TEST REPORTS		(5) REMARKS
			YES	NO	ATCH'D	TO FOL	
6A MISCELLANEOUS METALWORK AND MATERIALS Materials							
Fabrication Finish Coatings or Paint Installation							
9A UNTREATED ROCK BASE Materials Placement							
Grade Control Compaction							
11A STATION MARKING Location Marking							

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DAILY CONSTRUCTION QUALITY CONTROL REPORT (Cont'd)

REPORT NO.

VERBAL INSTRUCTIONS RECEIVED

GENERAL REMARKS *(Delays, conflicts, etc.)*

THIS REPORT IS COMPLETE AND CORRECT TO THE BEST OF MY KNOWLEDGE

QUALITY CONTROL OFFICER *(Signature)*

SPL FORM SEP 69 522b

SECTION 1 B

MEASUREMENT AND PAYMENT

Index

1. Diversion and Control of Water
2. Clearing Site and Removal of Obstructions
3. Grading Access Road
4. Excavation
5. Fills
6. Additional Rolling
7. Stonework
8. Grouting Stonework
9. Portland Cement
10. Untreated Rock Base (Surface Course)
11. Barricades
12. Station Markers

1. PAYMENT FOR DIVERSION AND CONTROL OF WATER will be made at the applicable contract price, which payment shall constitute full compensation for diversion and control of water, complete.

2. PAYMENT FOR CLEARING SITE AND REMOVAL OF OBSTRUCTIONS will be made at the applicable contract price, which payment shall constitute full compensation for all clearing and removal work including disposal of cleared and removed materials, complete.

3. PAYMENT FOR GRADING ACCESS ROAD will be made at the applicable contract price, which payment shall constitute full compensation for all access road grading and subgrade preparation between access road station 9+49.5 and 16+50, complete.

4. EXCAVATION.

4.1 Measurement. A survey of the site shall be made prior to commencement of work, and all measurement will be based on this survey without regard to any changes in the site that may occur during the prosecution of the work. Measurement for excavation will be made between the excavation lines and grades indicated on the drawings or staked in the field and the ground surfaces as indicated by the above mentioned survey. The temporary slopes as excavated may vary from those indicated or staked, depending on the materials excavated and methods used in performing the work, but such alterations will not change the measurement for payment from the original lines as specified herein. Quantities will be computed by the average end area method and the planimeter will be considered a precise instrument for measuring plotted cross sections. All excavation outside of excavation lines shown on the drawings will be considered as being for the convenience of the Contractor and such will not be measured for payment. No deduction will be made from excavation for the volume occupied by pipes and drains. Excluded from measurement is excavation outside the limits of channel excavation required for lump sum items and excavation specifically included in other pay items.

4.2 Payment.

4.2.1 Payment for Excavation Channel will be made at the applicable contract price, which payment shall constitute full compensation for excavating and disposing of all materials encountered, including excavation for stonework and removal of existing levee, complete.

5. FILLS.

5.1 Measurement for payment for compacted fill will be made between the excavation and structure lines and the fill limit lines, or between the ground lines and fill lines, as indicated or staked in the field. Quantities will be computed by the average end area method and the planimeter will be considered a precise instrument for measuring plotted cross sections.

5.2 Payment.

5.2.1 Payment for Compacted Fill Levee, Zone I will be made at the applicable contract price, which payment shall constitute full compensation for obtaining, placing, and compacting fill material, including foundation preparation, complete.

5.2.2 Payment for Compacted Fill Levee, Zone II will be made at the applicable contract price, which payment shall constitute full compensation for obtaining placing and compacting fill material, including subgrade and foundation preparation, complete.

5.2.3 Payment for Fill, Miscellaneous will be made at the applicable contract price, which payment shall constitute full compensation for obtaining and placing fill material, complete.

6. ADDITIONAL ROLLING.

6.1 Measurement. Fill compaction required in addition to the number of passes specified, will be measured on the basis of the number of hours the rolling equipment approved for this job is operated in making the additional required passes. In computing the number of hours worked by the rolling equipment, only the time of actual operation will be included. Time lost by rolling equipment for refueling, greasing, oiling, breakdowns or replacement of parts will not be measured.

6.2 Payment for Additional Rolling will be made at the applicable contract price, which payment shall constitute full compensation for additional rolling, complete.

7. STONEWORK.

7.2 Measurement. The quantity of stone of the various types will be the number of cubic yards of material acceptably placed in the completed and accepted work, measured in place.

7.3 Payment for Stonework will be made at the applicable contract price, which payment shall constitute full compensation for obtaining and placing the stone, complete.

8. GROUTING STONEWORK.

8.1 Measurement of grout will be made to the nearest cubic yard by weighing all ingredients in trial batches of grout and converting each batch to absolute volume; the volume thus determined and the number of batches of grout of corresponding proportions acceptably placed in the work shall be used to determine the quantity of grout.

8.2 Payment for Grouting Stonework will be made at the applicable contract price, which payment shall constitute full compensation for grouting stonework, except portland cement, including placing and curing, complete.

9. PORTLAND CEMENT.

9.1 Measurement. The quantity of portland cement for grout to be paid for will be determined by the actual weight of cement used in the batches divided by 376.

9.2 Payment for Portland Cement will be made at the applicable contract unit price per barrel, which payment shall constitute full compensation for the cement including transporting, handling and storage of all portland cement used in grout for stonework, complete.

10. UNTREATED ROCK BASE (SURFACE COURSE).

10.1 Measurement of the untreated rock base will be the number of cubic yards of material obtained and acceptably placed within the lines indicated. Untreated rock base material used for the convenience of the Contractor will not be measured for payment.

10.2 Payment for Untreated Rock Base (Surface Course) will be made at the applicable contract price, which payment shall constitute full compensation for the untreated rock base surface course, complete.

11. PAYMENT FOR BARRICADES will be made at the applicable contract price, which payment shall constitute full compensation for furnishing and installing materials required for the construction of each of the various types of barricades, complete.

12. PAYMENT FOR STATION MARKERS will be made at the applicable contract price, which payment shall constitute full compensation for obtaining and fabrication of materials required for the construction of each of the station markers, complete.

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SECTION 2 A

DIVERSION AND CONTROL OF WATER

1. REQUIREMENTS.

1.1 General. All permanent construction shall be carried on in areas free of water. Runoff from the water sheds is rapid and, during periods of rain, intermittant freshets may be expected in the existing washes which cross the levee alinement. The responsibility of the Contractor for protection of work against water flows is specified in paragraph: DAMAGE TO WORK of the Special Provisions of these specifications. Within 10 days of receipt of the notice to proceed the Contractor shall submit plans showing the methods he proposes to use to control surface flows. The plans shall show the scheme of operations and complete layout of drainage ditches and coffer dams, dikes, pipes and pumps, etc. The plans shall also take into consideration the following specific requirements:

1.2 Bypass Capacities.

1.2.1 General. The Contractor shall provide for diversion of channel flows as hereinafter specified. The channel flows will include water originating upstream of the work, water flowing in existing washes crossing work areas, runoff from areas adjacent to the work in addition to any and all ground water originating within the work. Surface flows in excess of 2000 cfs will be regarded as flood flows.

1.3 Ponding. The diversion of both the peak flows and the continuous low flow shall be accomplished in such a manner that no ponding of the flows shall occur within the limits of construction or in the existing washes upstream of the limits of construction.

1.4 Drainage Ditches. The location and depth of any drainage ditches shall be subject to approval of the Contracting Officer. Special precautions shall be taken to avoid impairing the permanent subgrade, and any excavation below invert subgrade shall be refilled with compacted fill in accordance with the section: FILLS AND SUBGRADE PREPARATION by and at the expense of the Contractor.

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SECTION 2 B

CLEARING SITE AND REMOVAL OF EXISTING OBSTRUCTIONS

Index

1. Requirements
2. Disposal of Materials
3. Optional Disposal Areas

1. REQUIREMENTS.

1.1 General. Except as otherwise specified and/or indicated areas to be cleared and grubbed will be limited to the actual excavation area or areas on which fills and/or structures are to be placed and areas within the limits of the Contractor's work area. The removal of shrubs and other vegetation outside these areas shall be held to a minimum and care shall be exercised not to damage any shrubs or other vegetation which can be left in place.

1.2 Existing Structures and Obstructions. The Contractor shall clear the site, including existing dump area, all fill and excavation areas, and remove and dispose of all existing structures and obstructions for channel and embankment construction except as otherwise noted on the drawings. Obstructions which are designated or specified to be removed but which are not designated or specified to be removed by others shall be removed by the Contractor. Except as otherwise specified, obstructions designated to be removed by others will be removed in sufficient time to preclude interference with the Contractor's operations. Utility relocations are not considered obstructions.

Except as otherwise specified, incombustible waste material, such as broken concrete, pavement, and other like materials shall be considered scrap and shall not be used in fills. Structures, portions of structures and obstructions to be removed include but are not limited to the following:

1.2.1 Rubbish, trash, waste and debris.

1.2.2 Car bodies, and miscellaneous waste in existing dump area south of levee alinement between stations 166+00 and 184+00.

1.2.3 Fences.

1.2.4 Pipe, steel, and other material.

1.2.5 A.C. pavement.

1.3 Clearing. Vegetation shall be cut off flush or slightly below the original ground surface. Clearing operations shall be conducted so as to prevent damage to structures to remain in place and to provide for the safety of employees and others.

1.4 Grubbing shall consist of removing all objectionable vegetable matter in the required fills, foundation areas, and all excavation areas including root balls and roots larger than 3 inches.

1.6 Filling of Holes. Holes made by removal of obstructions and grubbing operations shall be refilled to subgrade with compacted fill material as specified in the section: FILLS AND SUBGRADE PREPARATION.

1.7 Pipe. Abandoned pipe to be removed shall be plugged or capped at the limit of removal.

2. DISPOSAL OF MATERIALS. All materials to be removed are designated as scrap and shall be removed as specified in section: GENERAL REQUIREMENTS.

3. OPTIONAL DISPOSAL AREAS

3.1 All materials removed in accordance with the requirements herein may be disposed in the available disposal areas.

3.2 Winslow City Dump Area. All broken pipe, scrap metal, etc. indicated as unacceptable for disposal in the section: EXCAVATION may be disposed of in the City Dump Area. This area is located approximately 5 miles northeast of Winslow.

3.3 Other Disposal Areas. The Contractor may dispose of material in other areas wherein he has acquired appropriate approval.

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SECTION 3 A

EXCAVATION

Index

1. Requirements
2. Removal of Unsuitable Soils
3. Disposal of Excavated Materials
4. Excavation for Borrow
5. Overcut

1.REQUIREMENTS.

1.1 General. Excavation shall consist of the removal of any class of material encountered except materials covered by the provisions of the section: CLEARING SITE AND REMOVING EXISTING OBSTRUCTIONS in the designated areas or from areas staked in the field. The material to be removed may include but is not limited to earth, hardpan, silt, clay, sand, gravel, cemented sand and gravel, shale, sandstone, rock, detached pieces of stone and concrete, rock fills, existing fills of miscellaneous debris and rubbish, and other unsuitable materials. Excavation for permanent cuts shall be made to the slope lines indicated.

1.2 Blasting. Where explosives are used in rock excavation, the charges shall be so proportioned and placed that they will not loosen the rock outside of the excavation lines shown on the plans or as specified herein. The Contractor shall remove, at no expense to the Government, any material outside the authorized cross section that may be shattered or loosened by blasting.

1.3 Channel Excavation will include excavation for surfaces which will form the channel and shall be performed to the lines and grades indicated on the drawings. The finish surface of the channel invert and side slopes shall be smooth and shall not vary more than 1/2 inch from indicated grade except in rock excavation. Surfaces in rock excavation shall not vary more than plus or minus 6 inches.

2. REMOVAL OF UNSUITABLE SOILS. The removal of soils which are unsuitable for foundations of the embankment may be required in certain areas. The Contractor will be required to excavate any such areas to the depth authorized and backfill the areas with compacted fill conforming to the requirements of the section: FILLS AND SUBGRADE PREPARATION.

3. DISPOSAL OF EXCAVATED MATERIALS. Excavated materials suitable for compacted fill and other required fills, shall be placed in temporary stock piles or used directly in the work. The miscellaneous fill areas are required disposal areas and shall be filled in accordance with the requirements of the section: FILLS AND SUBGRADE PREPARATION. All excess material suitable for fills and stonework shall be placed in the indicated disposal areas. Excavated material not suitable for fills and stonework shall become the property of the Contractor and shall be removed from the site. No excavated material or waste of any kind shall be disposed of at any place beyond the limits of the work under this contract without express authority. Prior to placing material, the disposal and stock pile areas shall be cleared of trash and vegetation. Vegetation shall be cut off at the existing ground line. Clearing shall conform to the applicable requirements of the section: CLEARING SITE AND REMOVING EXISTING OBSTRUCTIONS. The stockpiles and disposal fills shall be placed in a manner to preclude ponding of water. Contractor shall furnish notice of his intentions in connection with the use of indicated disposal areas in accordance with the requirements of the paragraph: PUBLIC UTILITIES, NOTICES, AND RESTRICTIONS of the Special Provisions.

4. EXCAVATION FOR BORROW consists of excavation from the designated borrow areas shown on the drawings. In general, suitable material from required excavation shall be exhausted before using borrow excavation. Suitable material from borrow excavation may be used prior to completing the required excavations provided that, in completing the work, all suitable material from required excavation is used for required fills. The width of the low flow channel may be increased to obtain borrow material outside the areas designated, subject to approval by the Contracting Officer. Upon completion of the excavation in the borrow areas, the areas shall be rough graded and sloped to drain as shown on the drawings.

5. OVERCUT. Except as otherwise specified or as may be ordered in writing, any overcut or excavation made below the channel invert grades indicated on the drawings or staked in the field shall be backfilled with compacted fill and all excavating, backfilling, compacting of backfill occasioned thereby shall be by and at the expense of the Contractor.

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SECTION 3B

FILLS AND SUBGRADE PREPARATION

Index

1. Applicable Publications
2. Compaction Equipment
3. General Requirements for Compacted Fills and Compacted Backfills
4. Compacted Fill Levee
5. Backfill
6. Miscellaneous Fill
7. Subgrade Preparation for Roadways

1. APPLICABLE PUBLICATIONS. The following publication of the issue listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto.

1.1 American Association of State Highway Officials.

T 99-61 I	Moisture-Density Relations of Soils Using a 5.5 Lb. Rammer and a 12-Inch Drop

2. COMPACTION EQUIPMENT.

2.1 General. All equipment, tools, and machines shall be maintained in satisfactory working condition at all times.

2.2 Rubber-Tired Rollers shall have a minimum of 4 wheels equipped with pneumatic tires. The tires shall be of such size and ply as to be capable of being operated at tire pressures between 80 and 100 pounds per square inch at a 25,000-pound wheel load. The roller wheels shall be located abreast and be so designed that each wheel will carry approximately equal load in traversing uneven ground. The spacing of the wheels will be such that the distance between the nearest edges of adjacent tires will not be greater than 50% of the rated tire width of a single tire. The roller shall have a rigid steel frame provided with a body suitable for such ballast loading that the load per wheel may be varied as directed by the Contracting Officer from 18,000 to 25,000 pounds. The roller shall be towed at speeds of between 4.5 and 5 miles per hour.

2.3 Vibratory Rollers shall have a total static weight of not less than 20,000 pounds with at least 90% of the weight transmitted to the ground through a single smooth drum when the roller is standing in a level position hitched to the towing vehicle. The diameter of the drum shall be at least 5 feet, and the width at least 6 feet. The unsprung weight of the drum, shaft, and internal mechanism shall not be less than 12,000 pounds. The frequency of vibration during operation shall be between 1,100 and 1,500 v.p.m., and the dynamic force shall be not less than 40,000 pounds at 1,400 v.p.m. The roller shall be towed at speeds not to exceed 1.5 miles per hour by a crawler tractor with a minimum drawbar rating of 50 horsepower. The Contractor shall submit to the Contracting Officer, from the equipment manufacturer, sufficient data, drawings and computations proving the conformance with the above requirements. The type and efficiency of this equipment will be subject to the approval of the Contracting Officer.

2.4 Mechanical Tampers. Compaction of material, in areas where it is impracticable to use a roller, shall be performed by the use of approved mechanical tampers.

3. GENERAL REQUIREMENTS FOR COMPACTED FILLS AND COMPACTED BACKFILLS.

3.1 Control. During the course of construction, fills and backfills will be regularly and continuously inspected and tested by the Government, and the Contractor shall vary his operations to secure the results specified. The moisture-density relationship, the maximum density, and the optimum moisture content will be determined in accordance with the American Association of State Highway Officials (AASHO) T-99 Publication.

3.1.1 The In-Place Density and the test method of obtaining the field density will be determined by the Contracting Officer. The Contractor shall cease or vary his operations to permit the inspector to obtain a test when directed.

3.2 Settling of Fills or Backfills with Water will not be permitted.

3.3 Material shall be free from sod, roots, brush, debris, trash or other objectionable material, and shall contain no stone whose greatest dimension is more than 3/4 of the layer thickness.

3.4 Placement. Fill material shall not be placed against concrete which has not been in place at least 14 days. Heavy equipment shall not be operated over pipes and buried structures until at least 2 feet of fill material has been placed and compacted over pipes or structures. Compacted fill and backfill shall be placed with suitable equipment in horizontal layers which after compaction, shall not exceed 12 inches in depth for rubber-tired or vibratory rollers, and 4 inches in depth when mechanical tampers are used. The Contractor may vary the layer thickness within these limits for most efficient operations. Material containing stones shall be placed in a manner to prevent the stones from striking the concrete structures and to prevent the formation of voids.

3.5 Moisture Content. Material shall have a uniform moisture content while being placed and compacted. Water shall be added at the source, if required, or by sprinkling each layer of material during placement. Uniform distribution of moisture shall be obtained by disking, harrowing, or otherwise manipulating the soil during and after the time water is added. Material containing an excess of moisture shall be manipulated with suitable implements to facilitate maximum aeration and shall be permitted to dry to the proper consistency before being compacted. Fill shall have a maximum moisture content of not more than 3% above optimum and a minimum moisture content of not less than 3% below optimum.

3.6 Compaction. No layer of fill shall be compacted before the practicable uniform moisture content has been obtained. Scarified areas are considered as a layer of fill and shall be compacted. Rollers will not be permitted to operate over buried structures until the compacted fill over the top of the structures has reached a depth of 2 feet. Compaction equipment shall be so operated that structures are not damaged nor overstressed during compaction operations.

4. COMPACTED FILL LEVEE.

4.1 Preparation for Placing. Before placing material for compacted fill, the foundation surface shall be cleared of all existing obstructions, vegetation, and debris. Unsuitable material not meeting the requirements for fill material shall be removed where indicated or directed, and the existing surfaces, except bedrock, scarified to a depth of 6 inches before placing the fill. Sloped ground surfaces steeper than one vertical to 4 horizontal, on which fill or compacted backfill is to be placed, shall be stepped in such a manner that the compaction equipment will bear on the full depth of the fill layer.

4.2 Material shall be placed in the levee section as indicated on the drawings. Zone I material shall have at least 70% of the material passing the standard No. 4 sieve and no stone larger than 9 inches. Stone larger than 9 inches may be placed in uniform layers on the outer slopes of the Zone II levee fill.

4.3 Compaction. Fill material shall be compacted with rubber-tired rollers of the type hereinbefore specified to the extent that each layer of fill is traversed with 4 passes of a rubber-tired or vibratory roller. A pass shall consist of one movement of the equipment specified over the area to be compacted. Rolling shall be done in such manner that the rollers overlap at least one foot over the fill strip previously rolled. Overlapping of previously rolled areas by one foot will not be considered as an extra pass over the fill area overlapped. If from field tests made by the Government, it is determined that the desired compaction of any fill is not secured by the minimum number of passes specified, additional passes shall be made over the surface area of such designated portion. This procedure shall be repeated until the desired compaction is obtained. The Contractor shall have all additional rolling time certified at time of performance by the Contracting Officer.

4.4 Trimming. The channel side and top of levees shall be trimmed to the lines indicated on the drawings with a tolerance of plus or minus three inches, as measured perpendicular to the slope. Any material loosened by trimming shall be recompacted. The land side of levees shall be trimmed to a uniform alignment at top of levee and to a reasonably uniform slope at or outside the lines shown on the drawings.

5. BACKFILL.

5.1 Backfill, Toe and Stabilizer shall consist of material suitable for compacted fill placed in horizontal layers not more than 24 inches in thickness, smoothed and dressed to the lines and grades indicated. Compaction other than that obtained by the controlled movement of

equipment will not be required. Broken concrete, rock, and boulders to be wasted may be buried in the toe backfill areas, provided such material is placed in a manner that will prevent the formation of voids and provided it is placed a minimum of one foot below finished grade. No depressions shall be left in toe backfill areas.

6. MISCELLANEOUS FILL is a required fill and shall consist of material from the required excavation, placed in the section indicated as "Miscellaneous Fill" and shall be placed with suitable equipment in layers which shall not exceed 24 inches in depth before consolidation. Broken concrete, rock, and bituminous paving to be wasted may be buried in the larger miscellaneous fill areas, provided such material is placed in a manner that will prevent the formation of voids and provided it is placed not less than 2 feet below finished grade. No depressions in which water might pond shall be left in miscellaneous fill areas. The finished areas shall be sloped to drain. Compaction other than that obtained by the controlled movemenr of the construction equipment will not be required.

7. SUBGRADE PREPARATION FOR ROADWAYS. The subgrade shall be alternately watered and scarifie until the material is uniformly moistened throughout for a depth of not less than 4 inches. All stones larger than 4 inches in diameter, and hard ribs of earth shall be removed. The amount of water to be applied shall be that which is required to provide optimum results in compaction under rolling. Following the above operations, the roadbed shall be shaped to a true cross section sufficiently higher than the specified grade to allow for subsequent compaction and then be thoroughly compacted to not less than 95% of maximum density. After the subgrade has been prepared and completed, the surface shall be firm, hard, and unyielding, with a true, even, and uniform surface conforming to the grade and cross section indicated on the drawings. All points of the finished subgrade shall be not more than 1/4 inch below or above true subgrade.

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SECTION 4A

CONCRETE

Index

1. Applicable Publications
2. General
3. Embedded Items

1. APPLICABLE PUBLICATIONS. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto.

1.1 Federal Specifications.

SS-A-281b & Am-1	Aggregate; (for) Portland-Cement-Concrete
SS-C-192g & Am-1	Cement, Portland

1.2 American Society for Testing and Materials Standards.

C 39-68	Compressive Strength of Molded Concrete Cylinders
C 94-68	Ready-Mixed Concrete

2. GENERAL. Concrete shall be mixed to provide a minimum compressive strength of 2,500 pounds per square inch at 28 days. Concrete shall consist of Portland cement, coarse and fine aggregate and water. Portland cement shall conform to Federal Specification SS-C-192, Type I or II low alkali Aggregate shall conform to Federal Specification SS-A-281. Coarse aggregate shall be well graded between the nominal sizes of one inch to No. 4. Water shall be potable. Concrete shall be mixed to provide a homogenous mixture, using only sufficient water to provide compressive strength hereinbefore specified. The slump shall be within 2 to 3 inches, provided the requisite compressive strength is obtained. Ready-mixed concrete may be used. Ready-mixed concrete shall conform to ASTM Standard C 94. Ready-mixed concrete will be accepted on the basis of the mixing plant certificate of compliance with these specifications and on the condition that strength test requirements are met.

3. EMBEDDED ITEMS. Before placing concrete, embedded items including posts shall be secured in place as indicated. Embedded items shall be free of oil, loose coatings of rust or paint, or scale and other matter that will reduce the bond.

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SECTION 4 H

GROUTING STONEWORK

Index

1. Applicable Publications
2. Materials
3. Mixing
4. Placing

1. APPLICABLE PUBLICATIONS. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto.

1.1 Federal Specifications.

SS-A-281b & Am-1	Aggregate: (for) Portland-Cement-Concrete
SS-C-192g & Am-1	Cement, Portland

1.2 U. S. Department of the Army, Corps of Engineers Handbook for Concrete and Cement.

CRD-C 300-68A	Membrane-Forming Compounds for Curing Concrete

2. MATERIALS.

2.1 Aggregate.

2.1.1 General. Aggregate as delivered to the mixers, shall consist of clean, hard, and uncoated particles. Aggregate shall conform to Federal Specification SS-A-281 and may be furnished from any source proposed by the Contractor and approved by the Contracting Officer. The Contractor shall designate in writing within 15 days after date of notice to proceed the source or sources from which he proposes to furnish the aggregate. Suitable samples of material which the Contractor proposes to use shall be taken by the Contractor and delivered at the Contractor's expense to the project Engineer's office at least 60 days prior to the time grouting is expected to begin. The Contractor shall not deliver any of the proposed material to the site of the work until approval of the test samples by the Contracting Officer has been received. Results of tests will be furnished the Contractor within 10 calendar days after receipt by the Contracting Officer of notification by the Contractor of the source or sources from which he proposes to obtain aggregate.

2.1.2 Gradation. The aggregate shall conform to the following specific requirements:

Sieve Designation, U. S. Standard Square Mesh	Percentage by Weight Passing
No. 4	95-100
No. 8	80-90
No. 16	55-75
No. 30	30-60
No. 50	12-30
No. 100	3-10

In addition to the grading limits shown above, the aggregate, as delivered to the mixer, shall have a fineness modulus of not less than 2.40 or more than 2.90. The grading of the aggregate shall also be controlled so that the fineness moduli of at least 9 of 10 test samples of the aggregate as delivered to the mixer shall not vary more than 0.15 from the average fineness modulus of all samples previously taken. The fineness modulus shall be determined by dividing by 100, the sum of the cumulative percentages retained on U. S. Standard Sieves Nos. 4, 8, 16, 30, 50, and 100. At the option of the Contractor, aggregate may be separated into 2 or more sizes or classifications, but the resulting combined sand shall be of uniform grading within the limits specified above.

2.2 Portland Cement shall conform to the requirements of Federal Specification SS-C-192, Type I or Type II, low alkali.

2.3 Water shall be fresh, clean, and potable.

3. MIXING. Grout shall be composed of cement, sand, and water mixed in the proportions as directed. The estimated cement content requirement per cubic yard of grout is 7-1/2 sacks. The water content of the mix shall not exceed 8-1/2 gallons per sack of cement. In calculating total water content of the mix, the amount of moisture carried on the surfaces of aggregate particles shall be included. Slump of grout mix shall be between 9 and 10 inches for the first course and between 7 and 8 inches for the second course or where one course is placed. The grout shall be mixed in a concrete mixer. The time of mixing shall be as long as is required to produce a satisfactory mixture, and the grout shall be used in the work within a period of 30 minutes after mixing. Retempering of grout will not be permitted. The consistency of the grout shall be such as to permit gravity flow into the interstices of the stones with the help of spading, rodding, and brooming. Grout batches in the same course shall be uniform in mix, size, and consistency.

4. PLACING. Prior to grouting, the stone shall be flushed with water to wash down the fines and to prevent absorption of water from grout. The stone shall be kept wet just ahead of the actual placing of grout. The grout shall be placed in one course. Grout shall be placed full width or in successive lateral strips approximately 10 feet in width, as applicable. The grout shall be brought to the place of final deposit by approved means and discharged directly on the stones using a splash plate of metal or wood to prevent displacement of stone directly under the discharge. The flow of grout shall be directed with brooms or other approved baffles to cover the entire area and to assure that all crevices are filled. Sufficient barring shall be done to loosen tight pockets of stone and otherwise aid the penetration of grout. The grout shall fully penetrate the stone blanket. On side slopes, all brooming shall be uphill, and after the grout has stiffened the entire surface shall be rebroomed to eliminate runs and to fill voids caused by sloughing. Where a steel-trowel finish is indicated, troweling shall be performed as soon as the floated surface has hardened sufficiently to prevent an excess of fine material from being drawn to the surface. Steel troweling shall be performed with firm pressure to produce a dense, uniform surface, free from blemishes and trowel marks. Surface irregularities of troweled finish shall not exceed 1/4-inch as measured with a 10-foot template. After completion of any strip or panel, no workmen or other load shall be permitted on the grouted surface for a period of 24 hours. The grouted surface shall be protected from injurious action of the sun; shall be protected from rain, flowing water, and mechanical injury; and shall be moist cured or membrane cured at the Contractor's option. Moist curing shall consist of covering the grout with a uniform thickness of 2 inches of sand which shall be kept continuously saturated for a period of 14 days. Membrane curing shall consist of a pigmented curing compound, conforming to Corps of Engineers Handbook No. CRD-C 300. The curing compound shall be applied as soon as the free water disappears and shall be applied in a 2-coat continuous operation by approved power-spraying equipment at a rate of not to exceed 200 square feet per gallon for the combined coats. The second coat shall be applied to overlap the first coat in a direction approximately at right angles to the direction of the first application.

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SECTION 5A

STONEWORK

1. MATERIAL.

1.1 General. All stone shall be processed from the stone obtained from the required excavation. Stone shall be clean and free from earth, clay, refuse, and adherent coating. The Contractor shall not place any stone until approval of the production samples and placement methods by the Contracting Officer has been received. Any tests will be made by the Government at its expense. Approval of the production samples shall not be construed as a waiver of the right of the Government to require the Contractor to furnish stone which complies with these specifications.

1.2 Gradation. All points on individual grading curves obtained from representative samples of stone shall lie between the boundary limits as defined by smooth curves drawn through the tabulated grading limits plotted on a mechanical analysis diagram. The individual grading curves within these limits shall not exhibit abrupt changes in slope denoting skip grading, scalping of certain sizes or other irregularities. All material shall be made to the required grading at the source, and individual loads as delivered to the project shall meet the required grading.

1.3 Stone shall be reasonably well graded within the limits specified below:

Weight of Pieces	Percent Smaller by Weight	
	Type I	Type II
500 pounds	100	100
250 pounds	--	50-90
100 pounds	40-100	30-60
25 pounds	10-50	0-30
5 pounds	--	0-5
1 pound	0-10	--

2. PLACEMENT.

2.1 Stone shall be placed in a manner to produce a reasonably well graded mass with the minimum practicable percentage of voids, and shall be constructed to the lines and grades shown on the drawings or as staked in the field. Stone shall be placed to its full course thickness in one operation and in a manner to avoid displacing the underlying material. Method of placement shall be submitted to Contracting Officer for approval prior to commencement of placement operations. The Contractor shall maintain the stone protection until accepted and any material displaced by any cause shall be replaced at his expense to the lines and grades shown on the drawings. Self propelled equipment shall not be used on the levee slopes and/or toe slopes. Hand placing, barring, or placing by crane will be required only to the extent necessary to secure the results specified. Placing stone by dumping into chutes or by similar methods likely to cause segregation will not be permitted. A tolerance of plus 3 inches or minus 1 inch from the indicated slope lines and grades will be allowed in the finished surface, except that either extreme of such tolerance shall not be continuous over an area greater than 200 square feet.

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MISCELLANEOUS METALWORK AND MATERIALS

Index

1. Applicable Publications
2. Materials
3. Installation of Barricades and Markers
4. Workmanship
5. Welding
6. Finishing
7. Zinc Coating (Galvanizing)
8. Castings
9. Painting Metalwork

1. APPLICABLE PUBLICATIONS. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto.

1.1 Federal Specifications.

FF-B-575b	Bolts, Hexagon and Square
FF-N-836b & Am-2	Nut, Plain: (Hexagon, Square Cap and Welding) Nut, Slotted, and Castellated, Hexagon
FF-W-84a & Am-2	Washers, Lock (Spring)
FF-W-92d & Am-1	Washers, Metal, Flat (Plain)
QQ-S-741d	Steel, Carbon: Structural Shapes, Plates, and Bars
QQ-S-775d	Steel Sheets, Carbon, Zinc-Coated
TT-D-643d	Drier, Paint, Naphthenate, Liquid, Concentrated
TT-L-215c	Linseed Oil, Raw (For Use in Organic Coatings)
TT-P-61d & Am-1	Paint, Exterior, Black, Ready Mixed
TT-P-115c	Paint, Traffic, Highway, White and Yellow
TT-P-00641e	Primer Coating; Zinc Dust-Zinc Oxide (For Galvanized Surface)
TT-R-191d	Red Lead, Dry and Paste-in-Oil
TT-R-266c	Resin, Alkyd; Solutions
TT-T-291c	Thinner; Paint, Volatile Spirits (Petroleum-Spirits)
WW-P-406b & Am-1	Pipe; Steel (Seamless and Welded)(For Ordinary Use)
WW-P-471a & Am-2	Pipe Fittings: Bushings, Locknuts, and Plugs; Brass or Bronze, Iron or Steel, and Aluminum; (Screwed); 125-150 Pound
RR-F-183 & Am-4	Fence-Posts, Gates, and Accessories
RR-W-410c	Wire Rope and Strand

1.2 American Society for Testing and Materials.

A 36-68	Structural Steel
A 123-68	Zinc (Hot Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars and Strip
A 283-67	Low and Intermediate Tensile Strength Carbon-Steel Plates of Structural Quality
A 245-64	Flat-Rolled Carbon Steel Sheets of Structural Quality

1.3 Military Specifications.

MIL-S-15191B	Silica, Diatomaceous (Flatting-Extender Pigment)
MIL-A-15206A	Aluminum Stearate
MIL-C-18480A	Coating Compound, Bituminous, Solvent, Coal Tar Base
MIL-C-15328C	Primer (Wash) Pretreatment, Blue (Formula 117-B for Metals)

1.4 American Welding Society.

AWS Standards

B3.0-41T	Standard Qualification Procedure (Reprinted September 1967)
D1.0-69	Code for Welding in Building Construction - Ninth Edition

2. MATERIALS

2.1 General. Materials indicated on the drawings or required in the work and not covered elsewhere by detailed requirements shall conform to the requirements of this section. In all cases not specifically covered in these specifications, the Contractor shall furnish approved highest grade commercial materials or products.

2.2 Structural Steel.

2.2.1 Structural Steel for Riveted and Bolted Structures shall conform to Federal Specification QQ-S-741, Grade A or B; ASTM Standards A-283, or A-36. Welding of Grade A steel will not be permitted except for minor and incidental members not over 3/8 inch thick.

2.2.2 Structural steel for Welded Structures shall conform to Federal Specification QQ-S-741, Grade B, or ASTM A 36.

2.3 Sheet Steel shall conform to QQ-S-775, type I, class d and e, except zinc coated surface shall withstand a 180° bend on itself at room temperature without flaking the coating.

2.4 Washers.

2.4.1 Plain Washers shall conform to Federal Specification FF-W-92, Type A, Grade 1, Class A.

2.4.2 Lock Washers shall conform to Federal Specification FF-W-84, class and style as required to fit the bolts.

2.5 Bolts shall conform to Federal Specification FF-B-575.

2.6 Nuts shall conform to Federal Specification FF-N-836.

2.7 Red Lead Paint shall be semiquick drying and shall conform to the following specifications:

Ingredient	Pigment Lbs./100 Gal.	Specification
Red Lead (97% grade)	1,568	TT-R-191, Type I
Aluminum Stearate	6.3	MIL-A-15206
Diatomaceous Silica	25	MIL-S-15191
	Vehicle	
Raw Linseed Oil	150	TT-L-215
Alkyd Solution	307	TT-R-266, Type III, except that the oil content shall be linseed oil fatty acid
Drier	Total thinner and driers 114	TT-D-643
Thinner		TT-T-291, Grade I

2.7.1 The Characteristics of the Red Lead paint shall be as follows:

Minimum weight per gallon	21.7 Pounds
Minimum pigment by weight of paint	73.5%
Maximum Volatiles by weight of paint	12.1%
Viscosity	82 to 88 KU
Drying time set to touch not more than hours	4
Dry for recoating not more than hours	18
Coarse particles	1.0% max.
Water	0.5% max.
Fineness of grind, Hegman	4 min

The working properties shall be satisfactory for brush and spray application. There shall be no objectionable odor.

2.8 Metal Guardrail. Steel for guardrail shall be open hearth, oxygen furnace or electric furnace steel having an elongation of not less than 12% in 2 inches and shall withstand a cold bend, without cracking, of 180° around a mandrel of a diameter equal to 2-1/2 times the thickness of the plate. The rail element shall consist of a corrugated beam with corrugations symmetrical about the horizontal axis and shall be not less than No. 12 gage U. S. Standard. Rail elements shall be fabricated to provide a lap of at least 12-1/2 inches when bolted in place. The rail element shall not deflect more than 5-1/2 inches when tested as a simple beam with the traffic face up and with a 2,000-pound load applied at the center of a 12-foot span through a 3-inch wide, flat bearing. The bolted connection of the rail element to the post shall withstand a 5,000-pound pull at right angles to the line of the railing. Terminal section, bolts, nuts, washers, and other fittings shall be standard with the manufacturer of the guardrail. Guardrail shall be galvanized. Guardrail may be galvanized before or after fabrication and the weight of zinc coating shall be not less than 1-1/2 ounces per square foot of sheet based upon the total weight of coating on both sides of sheet. Guardrail brackets and other items shall be galvanized after fabrication and the weight of zinc coating shall be not less than 2 ounces per square foot of actual surface.

2.9 Paint.

2.9.1 Exterior Finish Paint for wood and metal shall conform to Federal Specification TT-P-104.

2.9.2 Metal Primer Paint shall conform to Federal Specification TT-P-641.

2.9.3 Vinyl-Type Wash Coat shall conform to Military Specification MIL-C-15328.

2.10 Galvanizing (Zinc Coatings) shall conform to ASTM Standard A 123.

2.11 Pipe Post and Accessories shall conform to Federal Specification RR-F-183. Galvanized posts shall be standard weight pipe, galvanized before or after fabrication. If galvanized before fabrication, posts shall be painted. Post caps shall be drilled for rivet.

2.12 Steel Marker Posts shall conform to Federal Specification RR-F-221, type IV, style 13, galvanized. Posts may be fabricated with steel conforming to the requirements of ASTM Standard A 245, grade C, galvanized.

2.13 Cable shall conform to Federal Specification RR-W-410, type III, class 2 (6x12x3/4 inch), plow steel.

2.14 Grout for post fill shall be composed of one part cement and two parts of sand.

2.15 Padlocks will be furnished and installed by others.

3. INSTALLATION OF BARRICADES AND MARKERS.

3.1 Posts shall be fabricated and set in concrete as indicated. Concrete shall conform to the applicable requirements of the section: CONCRETE. Exposed concrete shall be crowned around posts and sloped to drain.

3.2 Guardrails shall be installed with the bottom of the rail 13 inches above the finish grounds. Brackets shall be the manufacturer's standard for the type of guardrail installed and shall be attached to posts in accordance with the instructions of the manufacturer. Ends of all rails shall be turned away from the roadway and shall be fitted with manufacturer's standard curved end sections or provided with end wings. Joint design shall be in accordance with the manufacturer's standards. The rail at joints shall have full bearing. Rail element joints shall be lapped not less than 12-1/2 inches.

3.3 Marker Plates shall be fabricated of zinc coated carbon steel sheet, size and gage indicated. Plates shall be attached to the posts as indicated.

4. WORKMANSHIP. Steel with welds will not be accepted, except where welding is definitely specified or called for on the drawings. All bolts, nuts, and screws shall be tight. All exposed ferrous metalwork shall be galvanized. Metalwork shall be galvanized after fabrication. Complete shop drawings for fabrication of all miscellaneous metalwork shall be submitted for approval, in accordance with the requirements for shop drawings of the Special Provisions.

5. WELDING shall conform to the provisions of the American Welding Society Standard D1.0. Welders who have not been certified within 2 years of the date of commencement of work under this contract shall be required to pass successfully the qualification tests as prescribed by the American Welding Society Standard B3.0.

6. FINISHING. In general, tolerances for machine-finished surfaces designated by non-decimal dimensions shall be within 1/64 inch. Sufficient machining stock shall be allowed on placing pads to insure true surfaces of solid material. Finished contract or bearing surfaces shall be true and exact to secure full contact. All drilled holes for bolts shall be accurately located and drilled from templates.

7. ZINC COATING (GALVANIZING). Zinc coatings shall be applied in a manner and of a thickness and quality conforming to ASTM Standard A 123. In the event that any portion of galvanized metalwork is abraded or otherwise damaged to the extent that the base metal is exposed, such damaged or abraded portions shall be neatly covered with Grade 50B solder conforming to the requirements of ASTM Standard B 32.

8. CASTINGS. Each casting shall have the mark number and heat number cast or stamped upon it. Dimensions of castings shown on the approved shop drawings will be the finish dimensions. Before leaving the foundry, all castings shall be thoroughly cleaned and subjected to hammer inspection after which they shall be treated.

9. PAINTING METALWORK.

9.1 Cleaning. All oil and grease shall be removed. Where required, welds shall be neutralized by the use of ammonia or other suitable agent. All surfaces to be painted shall be cleaned in the shop to remove all rust, scale, dirt, and other foreign matter. "Tight" mill scale, that cannot be lifted by applying a sharp knife to any edge, will be permitted. The cleaning shall be accomplished by scraping, wire brushing and wiping or other approved methods. The cleaning and painting operations shall be carried on in such a manner that the time between cleaning and the application of the paint will not exceed 24 hours.

9.2 Painting. All exposed surfaces shall be painted except galvanized posts and cables.

9.2.1 Ferrous Metal Surfaces shall be given 3 coats of paint; first and second coat shall be red-lead paint and the third coat shall be aluminum paint. The second red-lead coat shall contain 1/4 pound of lampblack paste per gallon of paint. No paint shall be applied in the field in rainy or misty weather. All rust spots and all places where a paint coat has been rubbed off or damaged shall be thoroughly cleaned and repainted before subsequent paint coat is applied.

9.2.2 Galvanized Surfaces. Before painting, surfaces shall be thoroughly cleaned of all dirt, oil or other deleterious material by approved means. Surface preparation shall be accomplished without damaging or removing the galvanized coating from the steel base metal and treated with a vinyl-type wash coat. Vinyl-type wash coat shall be mixed by adding one volume of acid component to 4 volumes of resin component. The acid component shall be added slowly with constant stirring to the resin component. After mixing, the wash coat shall be used within 8 hours. If additional thinning is required to maintain a wet spray, reduction shall be made with normal butyl alcohol or 99% isopropyl alcohol. After the vinyl-type wash coat treatment the guardrail shall receive one prime coat and two finish coats of white paint. Painting of numbers and letters shall be done with stencils and brush or spray. Markings on steel target or marker plates shall be uniform capital block letters and numbers 2-1/2 inches high, 1-1/2 inches wide and 3/8-inch width of lines. The sizes of letters and numbers may be reduced on steel markers if there is not enough space on the marker for using the specified sizes possible within the specified marker dimensions. Paint for use on steel markers shall be white and letters and numbers shall be black. Markings shall be vertical with the bottom of the numbers to the left. Station markings and locations shall conform to section: STATION MARKINGS.

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SECTION 9A

UNTREATED ROCK BASE

Index

1. Applicable Publications
2. Description
3. Aggregate
4. Control
5. Equipment
6. Weather Limitations
7. Preparation of Subgrade
8. Grade Control
9. Placing, Shaping, and Compacting
10. Smoothness Test

1. APPLICABLE PUBLICATIONS. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto.

1.1 American Society for Testing and Materials.

C 131-66	Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine
C 136-67	Sieve or Screen Analysis of Fine and Coarse Aggregates
D 75-59	Sampling Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Materials

1.2 American Association of State Highway Officials.

T 4-35	Abrasion of Gravel by Use of the Deval Machine
T 180-61 T	Moisture-Density Relations of Soils Using a 10-lb. Rammer and an 18-in. Drop

1.3 State of California, Department of Public Works, Division of Highways, Materials Manual, Testing and Control Procedures.

217-F	Method of Test for Sand Equivalent
301-F	Method of Test for Determination of the Resistance "R" Value of Treated and Untreated Bases, Subbases and Basement Soils by the Stabilometer

2. DESCRIPTION. The untreated rock base course material shall consist of the aggregate hereinafter specified, deposited, spread, processed, and compacted on a prepared subgrade.

3. AGGREGATE.

3.1 General. Aggregate shall consist of crushed gravel or crushed stone. The aggregate shall consist of angular fragments reasonably uniform in density and quality, and reasonably free from thin and elongated, pieces, lumps of clay, or other objectionable material.

3.2 Gradation. The mixture shall conform to the gradation shown in the following table.

Sieve Designation	Percentage by Weight Passing Square Mesh Sieves
1 Inch	100
3/4 Inch	95-100
1/4 Inch	50-65
No. 200	3-8

The method of test used shall be ASTM Standard C 136.

3.3 Quality. The material shall conform to all of the following requirements.

3.3.1 Loss in the Wet Shot Rattler Test shall not exceed 55% when tested in accordance with AASHO Standard T 4, except that sufficient water to cover the sample shall be added when the specimen is placed in the machine.

3.3.2 Loss in the Los Angeles Rattler Test, after 500 revolutions, shall not exceed 50% when tested in accordance with ASTM Standard C 131.

3.3.3 Resistance Value (R-Value) shall not be less than 78 when tested on the stabilometer in accordance with Method 301 in use by the Laboratory of the Division of Highways, State of California.

3.3.4 Sand Equivalent shall not be less than 30 when tested in accordance with Method 217 in use by the Laboratory of the Division of Highways, State of California.

3.4 Sampling and Testing. All samples of aggregate shall be supplied by the Contractor at his expense; all tests necessary to determine the requirements specified herein will be performed under the supervision of the Contracting Officer without cost to the Contractor. All materials shall be approved prior to use in the work. The source of the materials to be used for producing the aggregate mixture shall be selected well in advance of the time when they will be required in the work, and samples of the size required shall be submitted to the Contracting Officer not less than 30 days before commencing the work. Additional samples of the aggregate materials shall be furnished during the construction as required by the Contracting Officer. Field testing for the compacted gravel surfacing will be performed by the Contracting Officer without cost to the Contractor. Unless otherwise directed, ASTM Standard D 75 shall be used for sampling of materials. When deemed necessary, the sampling of materials will be observed and supervised by the Contracting Officer.

4. CONTROL.

4.1 General. During the course of construction, the gravel surfacing will be regularly and continuously inspected and tested by the Government, and the Contractor shall vary his operations to secure the results specified. The moisture-density relationship, the maximum density, and the optimum moisture content will be determined in accordance with American Association of State Highway Officials (AASHO) Test Method Standard T 180, Method D, modified as follows.

4.1.1 The mold will be 6 inches in diameter and 7 inches high. A metal spacer disk 5-5/16 inches in diameter and 2-1/2 inches high will be used as a false bottom in the mold during compaction, and the correction factor shall be adjusted accordingly.

4.1.2 All material over 3/4 inch in size will be removed and replaced with an equal portion of material between 0.187 inch (No. 4 sieve) and 3/4 inch in size.

4.1.3 A separate batch of material will be used for each compaction test specimen. No materials will be re-used.

4.1.4 The desired amount of mixing water will be added for each compaction test specimen, mixed well, and the mixture will be placed in a container with an airtight cover and allowed to cure for 24 hours. A shorter curing time may be allowed where tests show that shortening the curing time will not affect the results.

4.2 The In-Place Density and the test method of obtaining the field density will be determined by the Contracting Officer. The Contractor shall cease or vary his operations to permit the inspector to obtain a test when directed.

5. EQUIPMENT.

5.1 General. All plant, equipment, tools, and machines used in the performance of the work covered by this section shall be subject to approval, and shall be maintained in satisfactory working condition at all times.

5.2 Smooth-Wheeled Rollers shall be self-propelled, weighing not less than 10 tons. The wheels shall be equipped with adjustable scrapers.

5.3 Blade Graders shall have a wheel base of not less than 15 feet, a blade of not less than 10 feet, and shall be self-propelled.

5.4 Hauling Equipment shall consist of pneumatic-tired vehicles having dump bodies suitable for dumping materials in layers on the subgrade.

5.5 Tampers. Hand tampers shall weigh not less than 50 pounds and shall have a face area of not more than 100 square inches. Mechanical tampers shall be of an approved type.

5.6 Rubber-Tired Rollers shall consist of 2 axles on which are mounted not less than 9 pneumatic-tired wheels in such manner that the rear group of tires will not follow in the tracts of the forward group. The axles shall be mounted in a rigid frame provided with a loading platform or body suitable for ballast loading. The tires shall be uniformly inflated. The roller shall be weighted as directed by the Contracting Officer. If not self-propelled, the tractor or other towing equipment shall also be pneumatic tired.

5.7 Miscellaneous Equipment. Scarifiers, tractors, spreaders, and other equipment shall be of approved types, suitable for constructing untreated rock base course.

6. WEATHER LIMITATIONS. Untreated rock base course shall be constructed only when the weather conditions do not detrimentally affect the quality of the finished course. Any areas that are damaged by the effects of weather conditions during any phase of the construction, shall be reshaped, and recompacted to conform with the requirements of the specifications, as part of the work.

7. PREPARATION OF SUBGRADE. Prior to constructing the base course, the subgrade shall be leveled and all voids shall be filled with minus No. 4 material from excavation or borrow. The surface will be inspected by the Contracting Officer for adequate compaction and surface tolerances. Any ruts or soft-yielding spots that may appear in the subgrade, any areas having inadequate compaction, and any deviations of the surface from the requirements set forth therein shall be corrected by loosening, removing, and adding approved material, reshaping and recompacting the affected areas to line and grade, and to the specified density requirements.

8. GRADE CONTROL. The lines and grades shall be established by the Contractor from the basic horizontal and vertical controls provided by the Contracting Officer, and shall be maintained by means of grade stakes.

9. PLACING, SHAPING, AND COMPACTING. The material shall be uniformly spread in a single layer, as directed. The loose thickness of the layer to be rolled shall be such that the thickness shown on the drawings and the compaction requirements hereinafter specified will be obtained with the equipment to be used. Moisture and density shall be determined and controlled in accordance with the requirements of AASHO Standard T 180, Method D, modified. The layer shall then be bladed, moistened as applicable, shaped, and smoothed to the grades or levels required, and the entire roadway shall be compacted to not less than 100% of maximum density at optimum moisture content. Ridges or humps shall be regraded, depressions filled, the surface reworked and rolled with a smooth-wheeled roller to the tolerance specified. Where the rock surface meets an existing pavement, the large rocks shall be raked out and the surfacing feathered to the existing pavement.

10. SMOOTHNESS TEST. The surface shall not show any deviations in excess of 1/2 inch when tested with a 10-foot straightedge applied with and at right angles to the center line of the paved area. Any deviation in excess of this amount shall be corrected by loosening, adding or removing material, reshaping, watering, and compacting as directed.

* * * * *

APPENDIX G

General Site Photographs

PHOTOGRAPH 1: Typical view of levee channel.

PHOTOGRAPH 2: Typical levee riprap revetment.

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SITE PHOTOGRAPHS

WINSLOW LEVEES
WOODSON ENGINEERING & SURVEYING INC.
RUBY WASH DIVERSION LEVEE, STA. 165+00 to 381+30
WINSLOW, ARIZONA

APPENDIX

G-1

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PHOTOGRAPH 3: Culvert outlet at Station 286+40.

PHOTOGRAPH 4: View of landslide levee looking west from approximate station 252+00.

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APPENDIX

G-2

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PHOTOGRAPH 5: Outlet joint seperation looking to the east.

PHOTOGRAPH 6: Outlet joint seperation looking to the north and veiw of scour pond at outlet.

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PLATE
G-3

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OFFICE_NAME
CAD FILE: L:\2009\Projects\93212\Figures\ LAYOUT: Model
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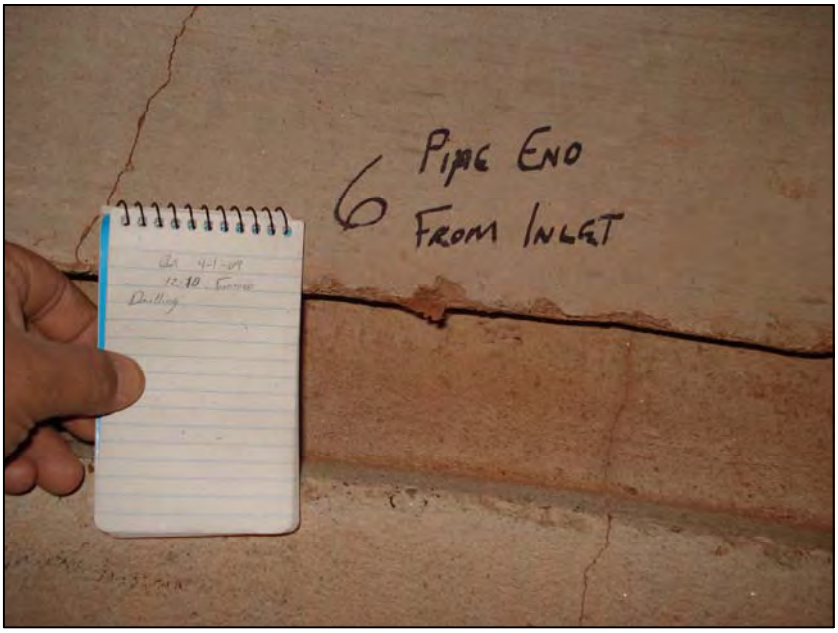

PHOTOGRAPH 7: Top of pipe seperation at south end of the sixth section of pipe in from the inlet side.

PHOTOGRAPH 8: Typical cracking observed along the top of the pipe sections.

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PLATE
G4

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APPENDIX H

Sonic Boring and Rock Coring Photographs

PHOTOGRAPH 1: B-10 from 4' to 9'

PHOTOGRAPH 2: B-10 from 9' to 14'

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APPENDIX

H-1

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PHOTOGRAPH 1: B-10 from 4' to 9'

PHOTOGRAPH 2: B-10 from 9' to 14'

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PHOTOGRAPH 3: B-22 from 7.5' to 12.5'

PHOTOGRAPH 4: B-22 from 12.5' to 17.5'

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H-2

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PHOTOGRAPH 5: B-25 from 2.3' to 7.3'

PHOTOGRAPH 6: B-25 from 7.3' to 12.3'

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H-3

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PHOTOGRAPH 7: B-26 from 1' to 6'

PHOTOGRAPH 8: B-26 from 6' to 11'

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H-4

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TEMPE,AZ

SB-1 (0'-2.5')

SB-1 (2.5'-5')

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H-5

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SB-1 (5'-7.5')

SB-1 (7.5'-10')

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H-6

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SB-1 (10'-12.5')

SB-1 (12.5'-15')

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SB-1 (17.5'-20')

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SB-1 (20'-21')

SB-1 (21'-22.5')

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H-9

TEMPE,AZ

SB-1 (22.5'-24')

SB-1 (24'-25.5')

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H-10

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SB-2 (0'-2.5')

SB-2 (2.5'-5')

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SONIC BORING PHOTOGRAPHS
SB-2

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APPENDIX
H-11

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SB- (5'-7.5')

SB-2 (7.5'-10')

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SONIC BORING PHOTOGRAPHS
SB-2

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ATTACHED IMAGES: Images: Levee Pics from 4 30 to 4 31 2009 151.jpg Images: Levee Pics from 4 30 to 4 31 2009 153.jpg Images: Levee Pics from 4 30 to 4 31 2009 154.jpg Images: Levee Pics from 4 30 to 4 3
ATTACHED XREFS:
TEMPE,AZ CAD FILE: L:\2009\Projects\93212\Figures\ LAYOUT: 1 (3) PLOTTED: 23 Jun 2009, 10:44am, MRuiz

SB-2 (10'-12.5')

SB-2 (12.5'-15')

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PROJECT NO.	93212
DRAWN:	JUNE 2009
DRAWN BY:	MAR
CHECKED BY:	MM
FILE NAME:	SBoring Site Photos SB-2.dwg

SONIC BORING PHOTOGRAPHS
SB-2

WINSLOW LEVEES
WOODSON ENGINEERING & SURVEYING INC.
RUBY WASH DIVERSION LEVEE, STA. 165+00 to 244+90
WINSLOW, ARIZONA

APPENDIX
H-13

ATTACHED IMAGES: Images: Levee Pics from 4 30 to 4 31 2009 151.jpg Images: Levee Pics from 4 30 to 4 31 2009 153.jpg Images: Levee Pics from 4 30 to 4 31 2009 154.jpg Images: Levee Pics from 4 30 to 4 3
ATTACHED XREFS:
TEMPE,AZ CAD FILE: L:\2009\Projects\93212\Figures\ LAYOUT: 1 (4) PLOTTED: 23 Jun 2009, 10:44am, MRuiz

SB-2 (15'-17.5')

SB-2 (17.5'-20')

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FILE NAME:	SBoring Site Photos SB-2.dwg

SONIC BORING PHOTOGRAPHS
SB-2

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APPENDIX
H14

ATTACHED IMAGES: Images: Levee Pics from 4 30 to 4 31 2009 151.jpg Images: Levee Pics from 4 30 to 4 31 2009 153.jpg Images: Levee Pics from 4 30 to 4 31 2009 154.jpg Images: Levee Pics from 4 30 to 4 3
ATTACHED XREFS:
TEMPE,AZ CAD FILE: L:\2009\Projects\93212\Figures\ LAYOUT: 1 (5) PLOTTED: 23 Jun 2009, 10:44am, MRuiz

SB-2 (20'-22.5')

SB-2 (22.5'-25')

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SONIC BORING PHOTOGRAPHS
SB-2

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APPENDIX
H15

ATTACHED IMAGES: Images: Levee Pics from 4 30 to 4 31 2009 076.jpg Images: Levee Pics from 4 30 to 4 31 2009 078.jpg Images: Levee Pics from 4 30 to 4 31 2009 080.jpg Images: Levee Pics from 4 30 to 4 3
ATTACHED XREFS:
TEMPE,AZ CAD FILE: L:\2009\Projects\93212\Figures\ LAYOUT: 1 PLOTTED: 23 Jun 2009, 10:46am, MRuiz

SB-3 (0'-2.5')

SB-3 (2.5'-5')

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FILE NAME:	SBoring Site Photos SB-3.dwg

CORE PHOTOGRAPHS AND SONIC BORING PHOTOGRAPHS

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WINSLOW, ARIZONA

APPENDIX
H16

ATTACHED IMAGES: Images: Levee Pics from 4 30 to 4 31 2009 076.jpg Images: Levee Pics from 4 30 to 4 31 2009 078.jpg Images: Levee Pics from 4 30 to 4 31 2009 080.jpg Images: Levee Pics from 4 30 to 4 3
ATTACHED XREFS:
TEMPE,AZ CAD FILE: L:\2009\Projects\93212\Figures\ LAYOUT: 1 (2) PLOTTED: 23 Jun 2009, 10:46am, MRuiz

SB-3 (5'-7.5')

SB-3 (7.5'-9')

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FILE NAME:	SBoring Site Photos SB-3.dwg

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APPENDIX
H17

ATTACHED IMAGES: Images: Levee Pics from 4 30 to 4 31 2009 076.jpg Images: Levee Pics from 4 30 to 4 31 2009 078.jpg Images: Levee Pics from 4 30 to 4 31 2009 080.jpg Images: Levee Pics from 4 30 to 4 3
ATTACHED XREFS:
TEMPE,AZ CAD FILE: L:\2009\Projects\93212\Figures\ LAYOUT: 1 (3) PLOTTED: 23 Jun 2009, 10:47am, MRuiz

SB-3 (9'-10')

SB-3 (10'-12.5')

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FILE NAME:	SBoring Site Photos SB-3.dwg

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APPENDIX
H18

ATTACHED IMAGES: Images: Levee Pics from 4 30 to 4 31 2009 076.jpg Images: Levee Pics from 4 30 to 4 31 2009 078.jpg Images: Levee Pics from 4 30 to 4 31 2009 080.jpg Images: Levee Pics from 4 30 to 4 3
ATTACHED XREFS:
TEMPE,AZ CAD FILE: L:\2009\Projects\93212\Figures\ LAYOUT: 1 (4) PLOTTED: 23 Jun 2009, 10:47am, MRuiz

SB-3 (12.5'-15')

SB-3 (15'-17.5')

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APPENDIX
H19

ATTACHED IMAGES: Images: Levee Pics from 4 30 to 4 31 2009 076.jpg Images: Levee Pics from 4 30 to 4 31 2009 078.jpg Images: Levee Pics from 4 30 to 4 31 2009 080.jpg Images: Levee Pics from 4 30 to 4 3
ATTACHED XREFS:
TEMPE,AZ CAD FILE: L:\2009\Projects\93212\Figures\ LAYOUT: 1 (5) PLOTTED: 23 Jun 2009, 10:48am, MRuiz

SB-3 (17.5'-20')

SB-3 (20'-22.5')

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APPENDIX
H20

ATTACHED IMAGES: Images: Levee Pics from 4 30 to 4 31 2009 076.jpg Images: Levee Pics from 4 30 to 4 31 2009 078.jpg Images: Levee Pics from 4 30 to 4 31 2009 080.jpg Images: Levee Pics from 4 30 to 4 3
ATTACHED XREFS:
TEMPE,AZ CAD FILE: L:\2009\Projects\93212\Figures\ LAYOUT: 1 (6) PLOTTED: 23 Jun 2009, 10:48am, MRuiz

SB-3 (22.5'-25')

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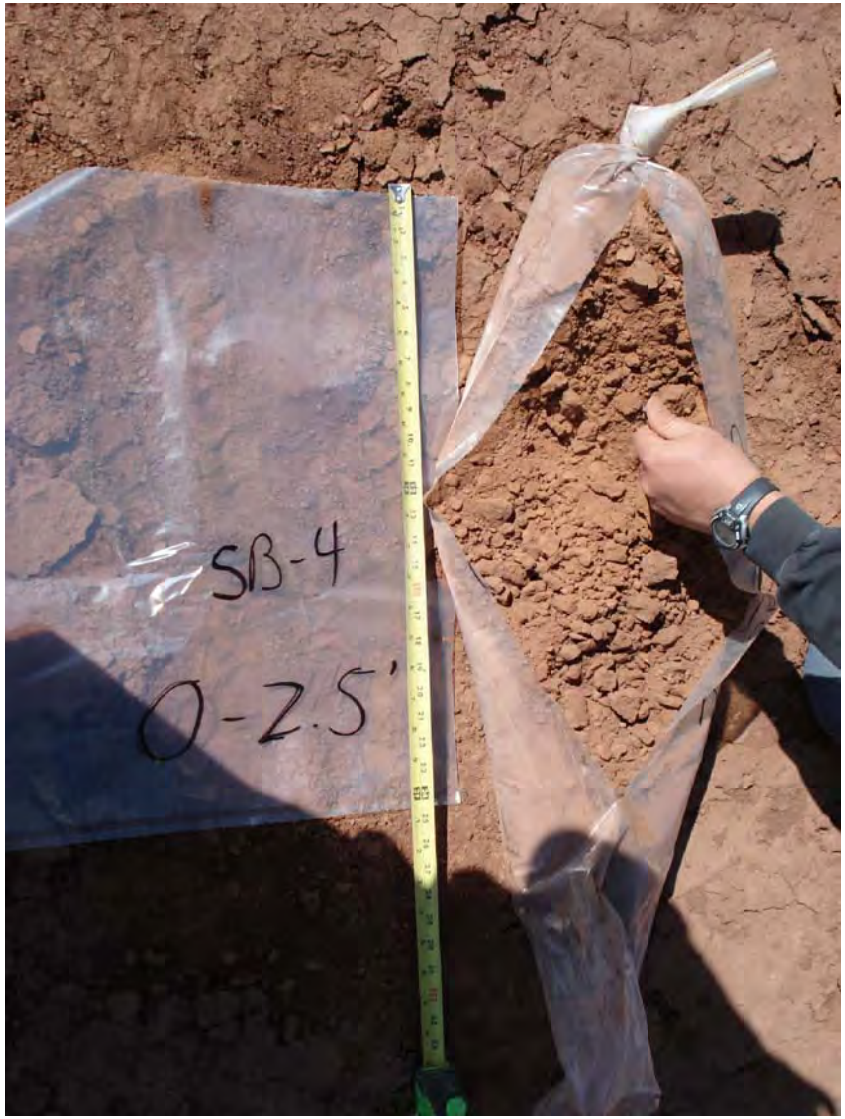
APPENDIX
H21

ATTACHED IMAGES: Images: Levee Pics from 4 30 to 4 31 2009 098.jpg Images: Levee Pics from 4 30 to 4 31 2009 101.jpg Images: Levee Pics from 4 30 to 4 31 2009 103.jpg Images: Levee Pics from 4 30 to 4 3
ATTACHED XREFS:
TEMPE,AZ CAD FILE: L:\2009\Projects\93212\Figures\ LAYOUT: 1 PLOTTED: 23 Jun 2009, 10:49am, MRuiz



SB-4 (0'-2.5')

SB-4 (2.5'-5')

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APPENDIX
H22

ATTACHED IMAGES: Images: Levee Pics from 4 30 to 4 31 2009 098.jpg Images: Levee Pics from 4 30 to 4 31 2009 101.jpg Images: Levee Pics from 4 30 to 4 31 2009 103.jpg Images: Levee Pics from 4 30 to 4 3
ATTACHED XREFS:
TEMPE,AZ CAD FILE: L:\2009\Projects\93212\Figures\ LAYOUT: 1 (2) PLOTTED: 23 Jun 2009, 10:50am, MRuiz

SB-4 (5'-7.5')

SB-4 (7.5'-10')

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DRAWN BY:	MAR
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FILE NAME:	SBoring Site Photos SB-4.dwg

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APPENDIX
H23

SB-4 (10'-12.5')

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FILE NAME:	SBoring Site Photos SB-4.dwg

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WINSLOW, ARIZONA

APPENDIX

H24

TEMPE,AZ

SB-5 (0'-2.5')

SB-5 (2.5'-5')

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WINSLOW, ARIZONA

APPENDIX

H25

TEMPE,AZ

SB-5 (5'-7.5')

SB-5 (7.5'-10')

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APPENDIX

H26

TEMPE,AZ

SB-5 (10'-12.5')

SB-5 (12.5'-15')

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FILE NAME:	

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WINSLOW, ARIZONA

APPENDIX

H27

ATTACHED IMAGES: Images: Levee Pics from 4 30 to 4 31 2009 006.jpg Images: Levee Pics from 4 30 to 4 31 2009 009.jpg Images: Levee Pics from 4 30 to 4 31 2009 012.jpg Images: Levee Pics from 4 30 to 4 3
ATTACHED XREFS:
TEMPE,AZ CAD FILE: L:\2009\Projects\93212\Figures\ LAYOUT: 1 (4) PLOTTED: 23 Jun 2009, 10:53am, MRuiz

SB-5 (15'-17.5')

SB-5 (17.5'-20')

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DRAWN:	JUNE 2009
DRAWN BY:	MAR
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FILE NAME:	SBoring Site Photos SB-5.dwg

CORE PHOTOGRAPHS AND SONIC BORING PHOTOGRAPHS

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APPENDIX
H28

ATTACHED IMAGES: Images: Levee Pics from 4 30 to 4 31 2009 006.jpg Images: Levee Pics from 4 30 to 4 31 2009 009.jpg Images: Levee Pics from 4 30 to 4 31 2009 012.jpg Images: Levee Pics from 4 30 to 4 3
ATTACHED XREFS:
TEMPE,AZ CAD FILE: L:\2009\Projects\93212\Figures\ LAYOUT: 1 (5) PLOTTED: 23 Jun 2009, 10:53am, MRuiz

SB-5 (20'-22.5')

SB-5 (22.5'-25')

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APPENDIX
H29

ATTACHED IMAGES: Images: Levee Pics from 4 30 to 4 31 2009 006.jpg Images: Levee Pics from 4 30 to 4 31 2009 009.jpg Images: Levee Pics from 4 30 to 4 31 2009 012.jpg Images: Levee Pics from 4 30 to 4 3
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TEMPE,AZ CAD FILE: L:\2009\Projects\93212\Figures\ LAYOUT: 1 (6) PLOTTED: 23 Jun 2009, 10:54am, MRuiz

SB-5 (25'-27.5')

SB-5 (27.5'-30')

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DRAWN BY:	MAR
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FILE NAME:	SBoring Site Photos SB-5.dwg

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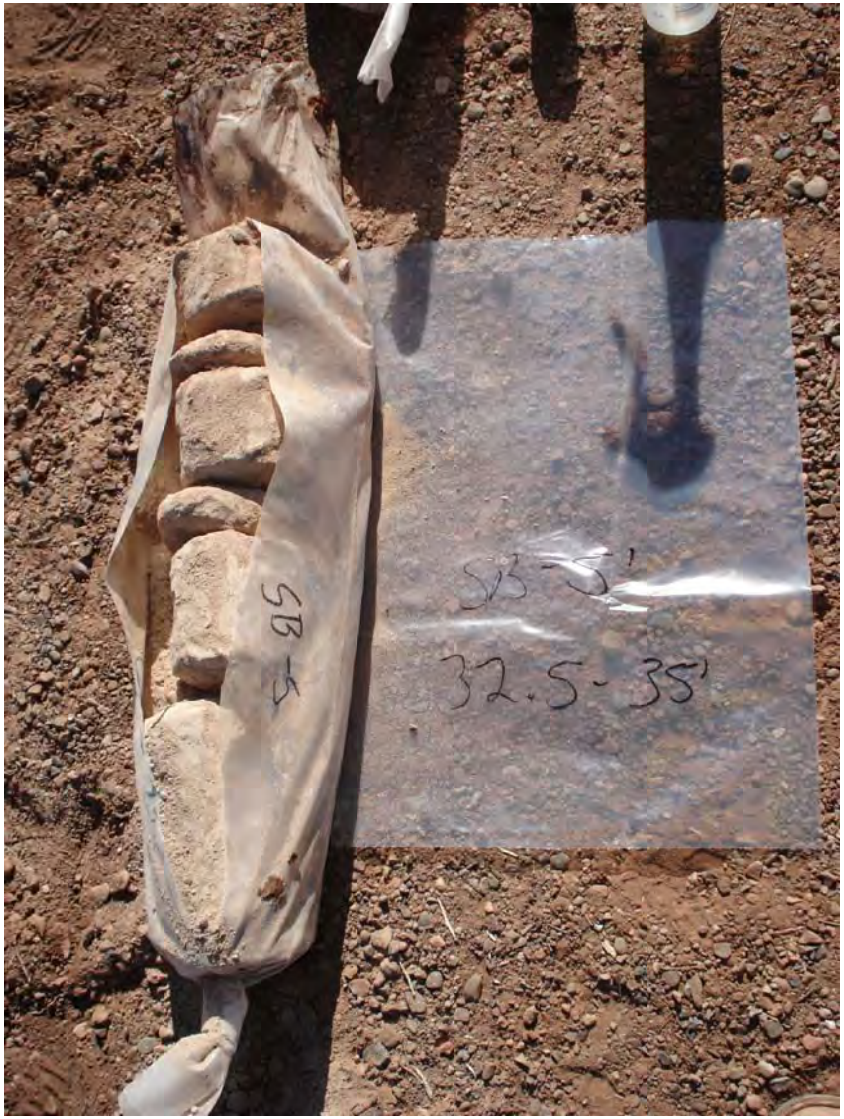
APPENDIX
H30

ATTACHED IMAGES: Images: Levee Pics from 4 30 to 4 31 2009 006.jpg Images: Levee Pics from 4 30 to 4 31 2009 009.jpg Images: Levee Pics from 4 30 to 4 31 2009 012.jpg Images: Levee Pics from 4 30 to 4 3
ATTACHED XREFS:
TEMPE,AZ CAD FILE: L:\2009\Projects\93212\Figures\ LAYOUT: 1 (7) PLOTTED: 23 Jun 2009, 10:54am, MRuiz

SB-5 (30'-32.5')



SB-5 (32.5'-35')

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DRAWN BY:	MAR
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FILE NAME:	SBoring Site Photos SB-5.dwg

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APPENDIX
H31

ATTACHED IMAGES: Images: Levee Pics from 4 30 to 4 31 2009 045.jpg Images: Levee Pics from 4 30 to 4 31 2009 047.jpg Images: Levee Pics from 4 30 to 4 31 2009 049.jpg Images: Levee Pics from 4 30 to 4 3
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TEMPE,AZ CAD FILE: L:\2009\Projects\93212\Figures\ LAYOUT: 1 PLOTTED: 23 Jun 2009, 10:56am, MRuiz

SB-6 (1'-3')

SB-6 (3'-5')

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FILE NAME:	SBoring Site Photos SB-6.dwg

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WINSLOW, ARIZONA

APPENDIX
H32

ATTACHED IMAGES: Images: Levee Pics from 4 30 to 4 31 2009 045.jpg Images: Levee Pics from 4 30 to 4 31 2009 047.jpg Images: Levee Pics from 4 30 to 4 31 2009 049.jpg Images: Levee Pics from 4 30 to 4 3
ATTACHED XREFS:
TEMPE,AZ CAD FILE: L:\2009\Projects\93212\Figures\ LAYOUT: 1 (2) PLOTTED: 23 Jun 2009, 10:56am, MRuiz

SB-6 (5'-7')

SB-6 (7'-8')

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PROJECT NO.	93212
DRAWN:	JUNE 2009
DRAWN BY:	MAR
CHECKED BY:	MM
FILE NAME:	SBoring Site Photos SB-6.dwg

CORE PHOTOGRAPHS AND SONIC BORING PHOTOGRAPHS

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WINSLOW, ARIZONA

APPENDIX
H33

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TEMPE,AZ CAD FILE: L:\2009\Projects\93212\Figures\ LAYOUT: 1 (3) PLOTTED: 23 Jun 2009, 10:57am, MRuiz

SB-6 (8'-10')

SB-6 (10'-12.5')

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APPENDIX
H34

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TEMPE,AZ CAD FILE: L:\2009\Projects\93212\Figures\ LAYOUT: 1 (4) PLOTTED: 23 Jun 2009, 10:57am, MRuiz

SB-6 (12.5'-15')

SB-6 (15'-17.5')

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APPENDIX
H35

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ATTACHED XREFS:
TEMPE,AZ CAD FILE: L:\2009\Projects\93212\Figures\ LAYOUT: 1 (5) PLOTTED: 23 Jun 2009, 10:58am, MRuiz

SB-6 (17.5'-20')

SB-6 (20'-22.5')

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APPENDIX
H36

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ATTACHED XREFS:
TEMPE,AZ CAD FILE: L:\2009\Projects\93212\Figures\ LAYOUT: 1 (6) PLOTTED: 23 Jun 2009, 10:58am, MRuiz

SB-6 (22.5'-25')

SB-6 (25'-27.5')

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H37

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SB-6 (27.5'-30')

SB-6 (30'-32.5')

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APPENDIX
H38

ATTACHED IMAGES: Images: Levee Pics from 4 30 to 4 31 2009 110.jpg Images: Levee Pics from 4 30 to 4 31 2009 112.jpg Images: Levee Pics from 4 30 to 4 31 2009 114.jpg Images: Levee Pics from 4 30 to 4 3
ATTACHED XREFS:
TEMPE,AZ CAD FILE: L:\2009\Projects\93212\Figures\ LAYOUT: 1 PLOTTED: 23 Jun 2009, 11:00am, MRuiz

SB-7 (0'-2.5')

SB-7 (2.5'-5')

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FILE NAME:	SBoring Site Photos SB-7.dwg

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ATTACHED XREFS:
TEMPE,AZ CAD FILE: L:\2009\Projects\93212\Figures\ LAYOUT: 1 (2) PLOTTED: 23 Jun 2009, 11:00am, MRuiz

SB-7 (5'-7')

SB-7 (7'-9')

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H40

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TEMPE,AZ CAD FILE: L:\2009\Projects\93212\Figures\ LAYOUT: 1 (3) PLOTTED: 23 Jun 2009, 11:01am, MRuiz

SB-7 (9'-10')

SB-7 (10'-12.5')

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SB-7 (12.5'-15')

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