GEOTECHNICAL AND
WATER RESOURCES ENGINEERING

GEOTECHNICAL TECHNICAL MEMORANDUM

NEW MEXICO UNIT PROJECT – GILA RIVER

GRANT COUNTY, NEW MEXICO

Submitted to

New Mexico Interstate Stream Commission
P.O. Box 25102
Santa Fe, New Mexico 87504

Submitted by

RJH Consultants, Inc.
9800 Mt. Pyramid Court, Suite 330
Englewood, Colorado 80112
303-225-4611
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June 2015
Project 15113

ROBERT J. HUZJAK
NEW MEXICO
13725
REGISTERED PROFESSIONAL ENGINEER
6/30/15

Robert J. Huzjak P.E.
Project Manager

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SECTION 1 - INTRODUCTION

1.1 Purpose

The New Mexico Interstate Stream Commission (ISC) retained RJH Consultants, Inc. (RJH) to provide engineering services for a potential diversion structure (Project) on the Gila River, upstream of the confluence with Brock Canyon (Site). The purpose of this Geotechnical Technical Memorandum (Memorandum) is to present data collected from our geotechnical investigation at the Site and preliminary recommendations for the diversion structure foundation. The purpose of collecting the geotechnical data is to support evaluation of the feasibility of installing a diversion structure at the Site.

1.2 Background

Storage of water in the upper Cliff-Gila valley is desired to provide water for irrigation and for replenishing the Gila River. Bohannan Huston, Inc. (BHI) (2014) previously evaluated multiple alternatives for diversion and storage of water. The alternative that was selected by the ISC for further evaluation is a diversion structure on the Gila River upstream of the confluence with Brock Canyon (Site 6 identified by BHI (2014)) (Site). This structure would divert water into a conveyance system for storage into planned new reservoirs.

The Site is located along the Gila River in the Gila National Forest, northeast of Gila, New Mexico. The Site is accessed using Turkey Creek Road off of Highway 153. A Site Vicinity Map is shown on Figure 1.1.

A geophysical seismic survey was performed at the Site by Geolines as part of the previous evaluation performed by BHI (2014). The subsurface profile interpreted from the geophysical data generally consisted of alluvium extending approximately 25 feet below the ground surface, Gila Conglomerate 25 to 105 feet below the ground surface, and bedrock located at approximately 105 feet below the ground surface.

1.3 Scope of Work

RJH performed the following services for the geotechnical investigation at the Site:

- Obtained a well permit from the New Mexico Office of the State Engineer (NM OSE).
- Drilled, sampled, logged, and backfilled one boring.

- Performed two in-situ hydraulic conductivity tests within the alluvium.
- Performed geotechnical laboratory tests on collected samples.
- Filed plugging records with the NM OSE upon completion of the field exploration.
- Developed preliminary recommendations for the diversion structure foundation.
- Prepared this Memorandum.

1.4 Site Description

A Site map is shown on Figure 1.2. The Site vicinity generally consists of undeveloped National Forest land that is covered by native vegetation ranging from grasses and small bushes to large cottonwood trees. Existing campsites are present within the Site vicinity. The Site is accessed from Turkey Creek Road using existing two-track vehicular trails.

1.5 Authorization

This work was performed in accordance with the terms and conditions of Contract Number 18345, Work Order No. GR-15-2, between the ISC and RJH dated April 22, 2015.

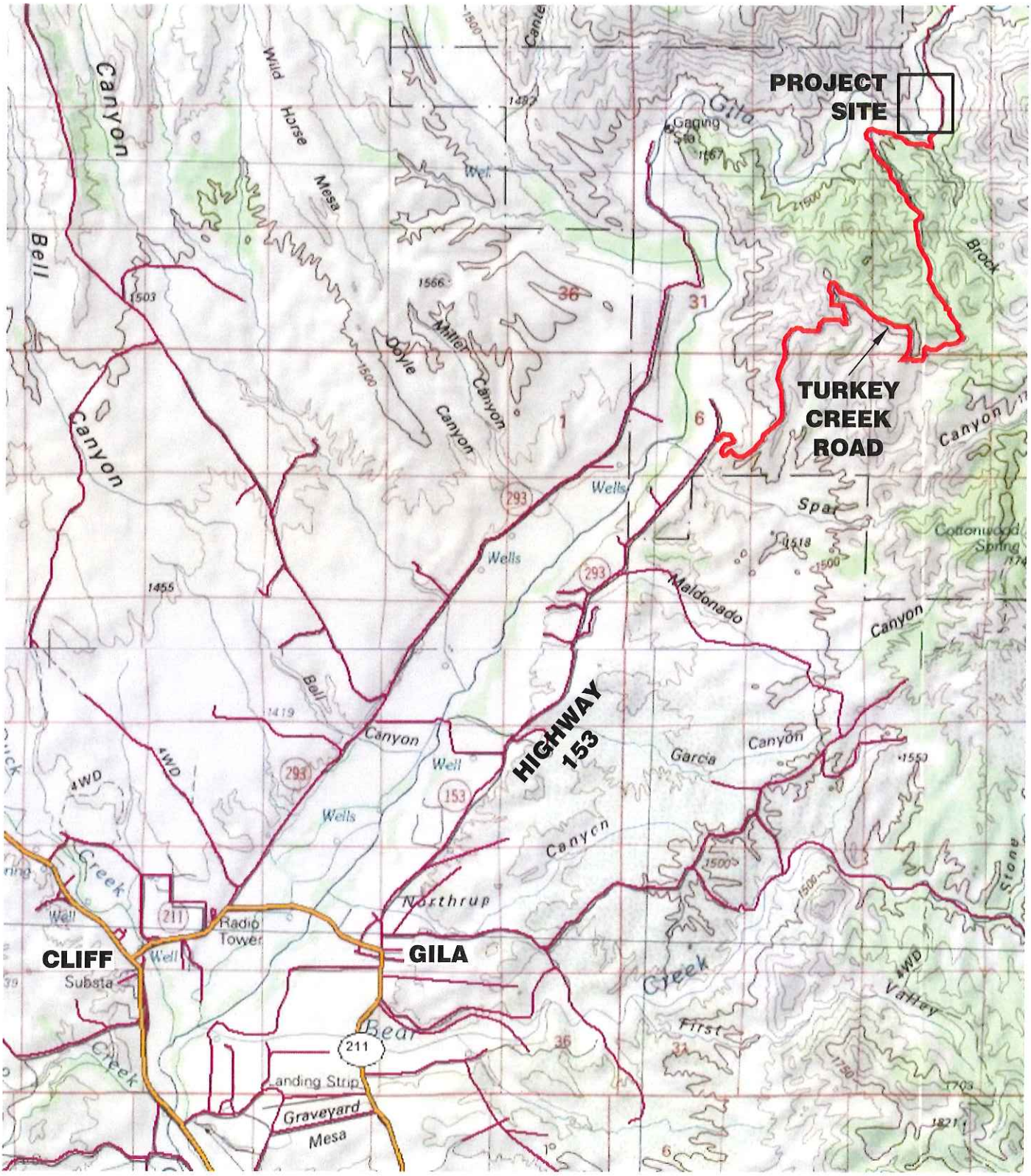
Work was also performed in accordance with Temporary Special-Use Permit SCR0205 that the ISC obtained from the U.S. Forest Service for this work.

1.6 Project Personnel

The following personnel from RJH are responsible for the work contained in this Memorandum:

Project Manager	Robert J. Huzjak, P.E.
Project Engineer	Adam B. Prochaska, Ph.D., P.E.(1), P.G.(1)
Geotechnical Engineer	Kevin T. Mininger, P.G.(1)
Geological Engineer	Andrea L. Christians

Note 1: Licensed in states other than New Mexico.



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RJH CONSULTANTS, INC.	GILA RIVER DIVERSION STRUCTURE GEOTECHNICAL TECHNICAL MEMORANDUM	SITE VICINITY MAP
	PROJECT NO. 15113	June 2015 **Figure 1.1**

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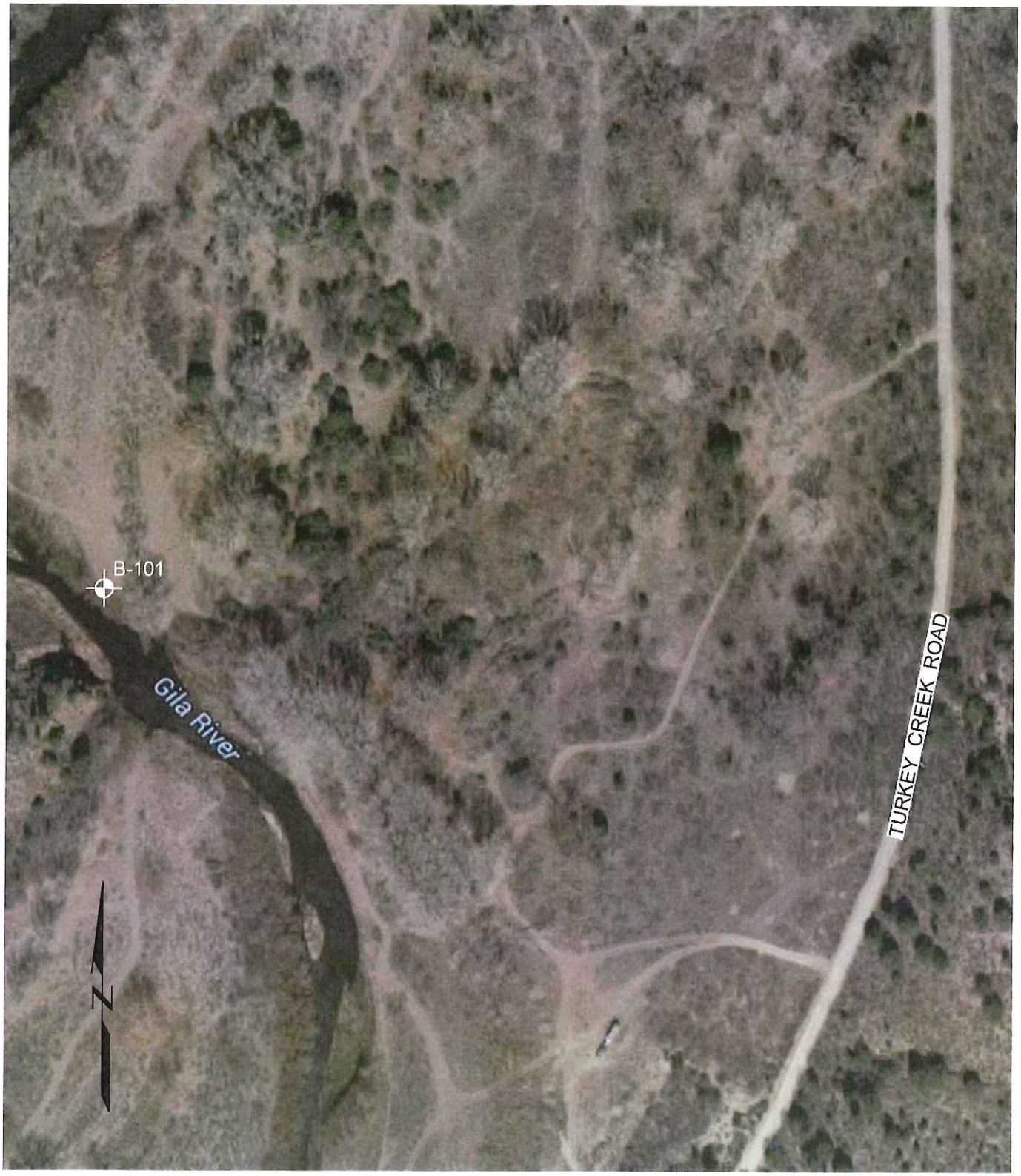

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RJH CONSULTANTS, INC.	GILA RIVER DIVERSION STRUCTURE GEOTECHNICAL TECHNICAL MEMORANDUM	SITE MAP
	PROJECT NO. 15113	June 2015 **Figure 1.2**

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SECTION 2 - SITE EXPLORATION

2.1 General

The Site exploration was performed on May 28 and 29, 2015. The Site exploration generally consisted of:

- Drilling, sampling, and logging one boring.
- Performing in-situ hydraulic conductivity tests within the boring.

Photographs of field activities are presented in Appendix A.

2.2 Boring

One boring was drilled for the Project. The approximate location of the boring is provided in Table 2.1. The boring location is shown on Figure 1.2.

TABLE 2.1
SUMMARY OF BORING

Boring	Latitude(1)	Longitude(1)	Ground Surface Elevation(2) (ft)	Depth to Bedrock(3) (ft)	Depth to Groundwater(3) (ft)	Total Depth of Boring(3) (ft)
B-101	N33° 03' 45.8"	W108° 30' 02.3"	4755	N/E(4)	3.5	49.5

Notes:
1. The boring position is approximate and was based on data obtained from GoogleEarth and field measurements using a handheld recreational-grade GPS.
2. The ground surface elevation is approximate and was obtained from Google Earth.
3. Depth below the ground surface elevation at the boring.
4. Not encountered.

RJH retained Elite Drilling Services (Elite) of Denver, Colorado to provide drilling equipment and services. The boring was advanced using a buggy-mounted CME 550 drill rig with an automatic hammer.

The boring was advanced using 7.75-inch outside diameter (O.D.) (4.25-inch inside diameter (I.D.) hollow-stem augers. Samples were generally obtained at about 2.5-foot or 5-foot intervals using a 1.375-inch I.D. (2.0-inch O.D.) standard split-spoon sampler. A standard penetration test (SPT) was performed in general accordance with ASTM D 1586 at the location of each split-spoon sample. At each SPT location, RJH obtained a

"standard penetration resistance" or SPT N-value. The SPT N-value equals the number of blows that are required from a 140-pound hammer dropped 30 inches to drive a standard split-spoon sampler from 6 to 18 inches. A blowcount of zero means the sampler advanced under the weight of the hammer. Water was poured down the hollow-stem augers while removing the center bit to reduce the potential for heaving of soil prior to sampling. At one sample location, the SPT sampler encountered refusal (50 blows for less than 6 inches of penetration) prior to advancing 18 inches; therefore, an SPT N-value could not be obtained at this location. The SPT N-values presented in this Memorandum were not adjusted to account for overburden pressures, hammer energy, etc.

The boring was backfilled with cement-bentonite grout. Potable water, obtained from Elite's office in Denver, was used for mixing grout. Well permit information and plugging records are provided in Appendix B. The boring location was covered by a cairn of boulders after backfilling.

2.3 Logging Procedures

RJH observed drilling procedures, recorded relevant drilling information, photographed and visually classified the soil samples, and prepared a field log of the boring. In the field, soil samples were classified according to ASTM D 2488 (visual-manual method).

Collected soil and rock samples were packaged and transported in general conformance with ASTM D 4220. Recovered split-spoon samples were placed in sealed Ziploc™ bags and a bulk sample was placed in a canvas sample bag.

RJH prepared final boring logs based on field and laboratory classifications, quality assurance office review of samples, and indirect observations (i.e., drill chatter, drill resistance, etc.), as appropriate. Between recovered samples, the lithology presented on the boring logs is interpreted. Explanations of the soil descriptors used on the boring log are presented in Appendix C. The boring log is presented in Appendix D.

2.4 In-situ hydraulic conductivity tests

2.4.1 General

Two in-situ hydraulic conductivity tests were performed to evaluate the hydraulic conductivity of the subsurface materials. Water used for testing was obtained from the same source as the water used for mixing grout. The test methods consisted of a rising head test and a falling head test. The test procedures and data reduction techniques are

presented in the following sections. A summary of the test results is presented in Table 2.2. Calculations are presented in Appendix E.

TABLE 2.2
IN-SITU HYDRAULIC CONDUCTIVITY TEST RESULTS

Boring	Test No.	Test Interval (feet below ground surface)	Test Type	Calculated Horizontal Hydraulic Conductivity (cm/s)
B-101	K-1	6.5 to 8.0	Rising Head	4×10^{-2}
B-101	K-2	18.0 to 18.5	Falling Head	7×10^{-3}

2.4.2 Rising Head Test

A rising head test was performed from 6.5 to 8.0 feet below the ground surface. A rising head test was selected for this interval because the test interval was too permeable to allow for reliable data collection during a falling head test. The general test procedures were as follows:

1. The augers were raised to expose a section of borehole walls at the bottom of the boring (test interval).
2. Water was pumped into the hollow stem augers. The amount of water added and the change in the depth to water within the augers was measured over time.
3. The average water level (head) between two consecutive measurements was used along with the flow rate between the same two measurements to estimate hydraulic conductivity for constant head conditions using equations published by Hvorslev (1951).

2.4.3 Falling Head Test

A falling head test was performed from 18.0 to 18.5 feet below the ground surface. The general test procedures were as follows:

1. The augers were raised to expose a section of borehole walls at the bottom of the boring (test interval).
2. Water was pumped into the hollow stem augers until the water surface was near the top of the augers.

3. The water supply was turned off and the depth to water within the augers was measured over time as the water level declined.
4. Hydraulic conductivity was estimated using equations published by Hvorslev (1951) for variable head conditions.

SECTION 3 - LABORATORY TESTING

Laboratory tests were performed on selected soil samples collected during the Site exploration. RJH engaged HP Geotech of Parker, Colorado to perform the laboratory tests. The tests consisted of two particle size analyses (ASTM D 6913) with manual analysis of particles larger than 3 inches.

Laboratory test results are summarized in Table 3.1 and are provided in Appendix F.

TABLE 3.1
LABORATORY TEST RESULTS

Boring ID	Sample ID	Depth Interval (ft)	% Cobbles (12" to 3")	% Gravel (3" to #4)	% Sand (#4 to #200)	% Fines (< #200)
B-101	BU-1	0.0-30.0	8	57	29	6
B-101	S-11	48.2-49.5	0	21	71	8

Note:
1. Laboratory test results were limited by the scale of the sampling methods. Laboratory test results likely underestimate the percentage of cobbles and boulders in the alluvium.

SECTION 4 - SITE AND SUBSURFACE CONDITIONS

4.1 Site Geology

A geologic map of the Site is presented on Figure 4.1. According to published mapping (Ratte and Gaskill, 1975), the Site is underlain by Holocene-age (less than 10,000 years old) valley alluvium and terrace gravels. These materials have been mapped across the width of the valley bottom between approximately the right bank (while looking downstream) of the Gila River and Turkey Creek Road.

Bedrock on the valley slopes adjacent to the Site has been mapped as the Oligocene-age (23 to 34 million years old) Volcanic Complex of Brock Canyon, which generally consists of fresh to intensely altered latitic and andesitic lava flows, flow breccia, and minor volcaniclastic and pyroclastic materials.

Our Site observations generally agree with the published mapping. Alluvium was present between Turkey Creek Road and the Gila River. Most of the alluvium observed on the ground surface consisted of fine sand. However, the ground surface around the location of B-101 consisted of a cobble bar. The surface of the cobble bar generally consisted of rounded to subrounded cobbles and boulders (ranging from 3 to 18 inches in size) in a matrix of fine sand. Bedrock on both valley slopes adjacent to the Site appeared to be volcanic rock that was variable in alteration and weathering, however we did not cross the Gila River to observe the outcrop on the right side of the Site. The bedrock outcrop across the river from B-101 contained high-angle fractures that appeared to be spaced every 2 to 4 feet and were generally north-south oriented (up and down the canyon).

4.2 Subsurface Conditions

Alluvium was encountered throughout the entire depth explored by B-101. Based on the collected samples and our field observations, it appears that the alluvium at the location of B-101 can be divided into an upper cobbley unit and a lower sandy unit.

A subsurface cross section is shown on Figure 4.2 and an explanation of the symbols used on the cross section is provided on Figure 4.3. The cross section is generalized from the boring log and does not include all information. Additional information is provided on the boring log in Appendix D. Descriptions of the encountered materials are presented in the following sections.

4.2.1 Cobbley Alluvium

Recovered samples of cobbley alluvium classified as well graded gravel with sand, silty sand, well graded sand with gravel, well graded gravel with silt and sand, and well graded sand with silt and gravel. Recovered split spoon samples contained 0 to 80 percent gravel, 20 to 85 percent sand, and less than 40 percent nonplastic fines. One tested bulk sample contained 8 percent cobbles, 57 percent gravel, 29 percent sand, and 6 percent fines. Boulders up to 18 inches in size were observed on the ground surface.

Characterization of the cobbley alluvium was limited by the scale of sampling methods. Based on the guidelines presented in ASTM D 5519, we estimate that an approximately 1,000-pound sample would be required to obtain a gradation result that is accurate to within about 5 percent. Based on visual observations, it is our opinion that the percentage of cobbles is greater than identified in the tested bulk sample.

The cobbley alluvium was wet and very loose to very dense. SPT N-values in the cobbley alluvium ranged from 6 to 64, and averaged 23. N-values may have been affected by the presence of cobbles.

The horizontal hydraulic conductivity of the cobbley alluvium measured by two in-situ tests ranged from 7×10^{-3} to 4×10^{-2} cm/sec.

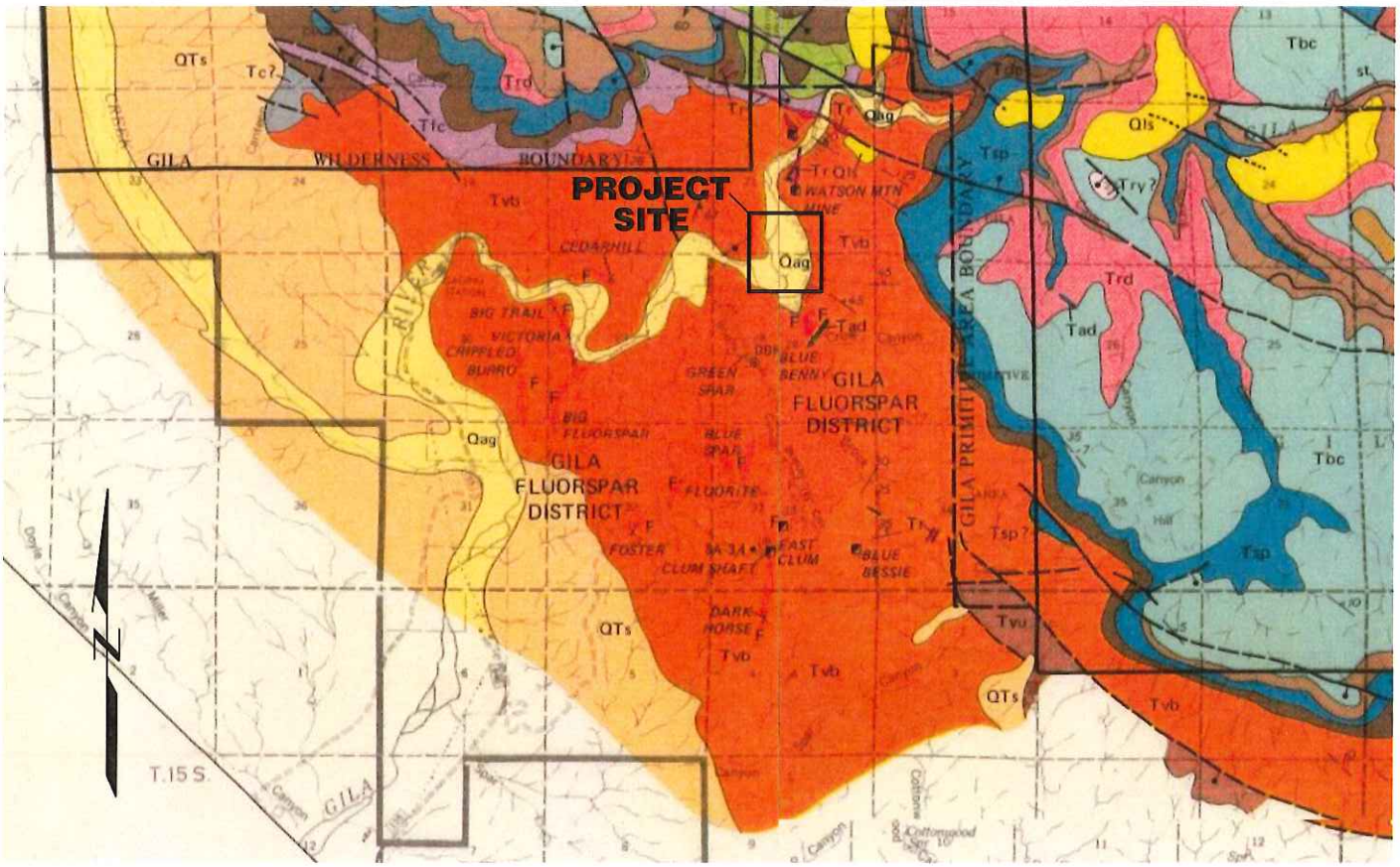
It appears that the cobbley alluvium may correspond to the material interpreted to be "alluvium" by the previous geophysical survey (BHI, 2014) (see Section 1.2).

4.2.2 Sandy Alluvium

Recovered samples of sandy alluvium classified as well graded sand with gravel, well graded sand with clay and gravel, and poorly graded sand with silt and gravel. Recovered split spoon samples contained 15 to 25 percent gravel, 65 to 85 percent sand, and less than 15 percent nonplastic to medium plasticity fines. One tested sample contained 21 percent gravel, 71 percent sand, and 8 percent fines.

The sandy alluvium was dense to very dense and wet. SPT N-values in the sandy alluvium ranged from 36 to 52, and averaged 43. Refusal (50 blows for less than 6 inches of penetration) was encountered at the location of one SPT test. The maximum recovered particle size was 1.5 inches, which may have been limited by the sampler diameter.

It appears that the sandy alluvium may correspond to the material interpreted to be Gila Conglomerate by the previous geophysical survey (BHI, 2014) (see Section 1.2). Based on our Site observations and published geologic mapping (Figure 4.1), in our opinion it is unlikely that Gila Conglomerate exists between the alluvium and the volcanic bedrock complex.



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STRIKE AND DIP OF FOLIATION

25 Inclined

Vertical

Qag — VALLEY ALLUVIUM AND TERRACE GRAVELS (HOLOCENE)

Tvb — VOLCANIC COMPLEX OF BROCK CANYON (OLIGOCENE) – Mainly fresh to intensely altered latitic and andesitic lava flows, flow breccia, and minor volcaniclastic and pyroclastic materials. Some rocks may be intrusive. Complex is host to quartz-fluorite veins of Gila fluorspar district, which probably are younger than the hydrothermally altered and mineralized rocks along Brock and Brushy Canyons and adjoining areas straddling the Gila River. K-Ar ages on biotite of 30–34 m.y. (R. F. Marvin, written commun., 1972) from unaltered quartz latite flow breccia near the Clum mine and zircon fission-track ages of 30.2 ± 5.3 m.y. (C. W. Naeser, written commun., 1973) from altered and mineralized rock in Brushy Canyon indicate that the sulfide-mineralized and altered rocks are comparable in age to the unaltered lava flows of the complex. The sulfide mineralization thus is mid-Tertiary or younger. The zircons in the altered rocks were previously reported to have a fission-track age of 49 ± 2 m.y. (Ratté and others, 1972), but new work on the zircons from these rocks (sample localities SA-3, SA-4) has shown the age reported earlier to have been in error

NOTES:

1. ONLY GEOLOGIC UNITS AND SYMBOLS NEAR THE SITE ARE INCLUDED IN THE LEGEND.
2. GEOLOGIC MAP IS FROM RATTE AND GASKILL (1975).

RJH CONSULTANTS, INC.	GILA RIVER DIVERSION STRUCTURE GEOTECHNICAL TECHNICAL MEMORANDUM	GEOLOGIC MAP
	PROJECT NO. 15113	June 2015 — **Figure 4.1**

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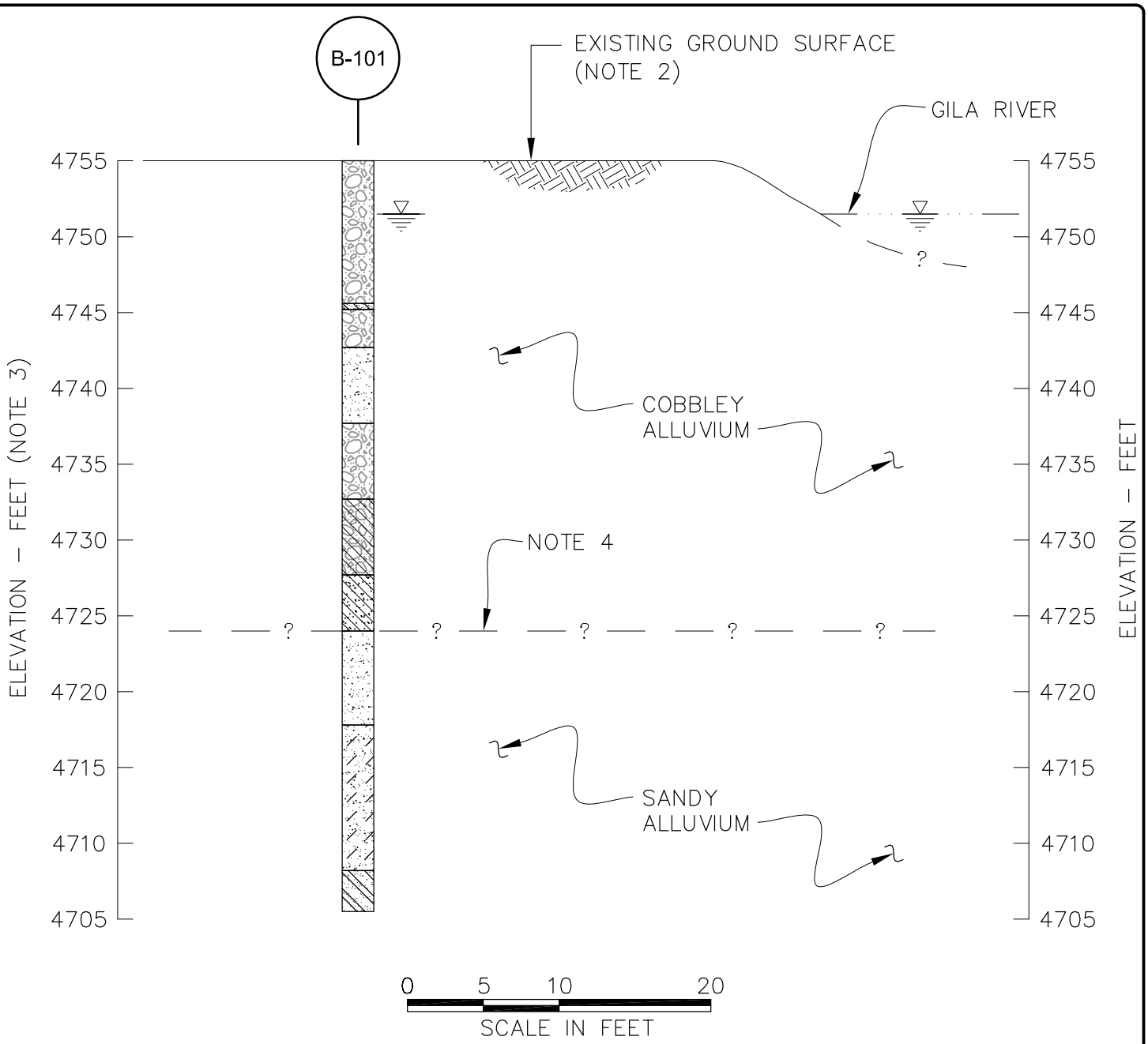

NOTES:

1. PROFILE IS LOOKING DOWNSTREAM.
2. GROUND SURFACE IS APPROXIMATE.
3. ELEVATIONS ARE APPROXIMATE.
4. CONTACT BETWEEN COBBLEY ALLUVIUM AND SANDY ALLUVIUM IS APPROXIMATE AND WAS INFERRED FROM DRILLING CONDITIONS AND RECOVERED SAMPLES.
5. SUBSURFACE INFORMATION IS ONLY KNOWN AT THE SAMPLE LOCATIONS. CONDITIONS BETWEEN SAMPLES ARE INTERPOLATED.
6. SECTION IS GENERALIZED FROM BORING LOG AND DOES NOT INCLUDE ALL INFORMATION. SEE BORING LOG IN APPENDIX D FOR ADDITIONAL INFORMATION.

RJH CONSULTANTS, INC.	GILA RIVER DIVERSION STRUCTURE GEOTECHNICAL TECHNICAL MEMORANDUM	SUBSURFACE PROFILE
	PROJECT NO. 15113	June 2015 **Figure 4.2**

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LEGEND

WELL GRADED GRAVEL WITH SAND (GW)

SILTY SAND (SM)

WELL GRADED SAND WITH GRAVEL (SW)

WELL GRADED GRAVEL WITH SILT AND SAND (GW-GM)

WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM)

WELL GRADED SAND WITH CLAY AND GRAVEL (SW-SC)

POORLY GRADED SAND WITH SILT (SP-SM)

RJH CONSULTANTS, INC.	GILA RIVER DIVERSION STRUCTURE GEOTECHNICAL TECHNICAL MEMORANDUM	SYMBOL EXPLANATION
	PROJECT NO. 15113	June 2015 **Figure 4.3**

SECTION 5 - DIVERSION STRUCTURE FOUNDATION RECOMMENDATIONS

Foundation conditions at the diversion structure location generally consist of cobbley to sandy alluvium that extends at least 50 feet below the ground surface. The foundation is anticipated to have a high hydraulic conductivity, and significant seepage is expected to occur through the alluvium beneath and around a diversion structure. Design of foundation treatment and foundations will be dependent on the type, size, and configuration of the diversion structure; however, the following should be considered in development of a diversion structure concept:

- We anticipate that a partial foundation cutoff will be required into the alluvium beneath the diversion structure to reduce seepage gradients combined with an engineered filter and scour protection system at the downstream side of the diversion structure to protect against piping and undermining of the structure.
- The diversion structure is anticipated to be relatively light and it may be possible to support the structure on a shallow foundation. However, a shallow alluvial foundation would create the potential for differential settlement with the structure's bedrock connection in the right abutment. The potential for differential settlement needs to be considered.
- The diversion structure could be supported by a deep foundation in the alluvium soils. A deep foundation would reduce the potential differential settlement of the structure; however, this lack of settlement could cause the structure to lose intimate contact with the underlying soil if material is scoured from the foundation. Cobbles within the alluvium could also complicate installation of the foundation elements.

Recommendations for the diversion structure foundation should be refined once the concept for the structure is better defined.

SECTION 6 - LIMITATIONS

This Memorandum has been prepared for the exclusive use of RJH and the ISC to support evaluation of a proposed diversion structure on the Gila River. RJH is not responsible for technical interpretations of this data by others. RJH has endeavored to conduct our professional services for this Project in a manner consistent with a level of care and skill ordinarily exercised by members of the engineering profession currently practicing in New Mexico under similar conditions as this Project. RJH makes no other warranty, expressed or implied.

The methods used in this study indicate subsurface conditions only at the specific locations where samples were obtained, only at the time they were obtained, and only to the depths penetrated. Samples cannot be relied on to accurately reflect variations in subsurface conditions that may exist between sampling locations.

The nature and extent of variations between borings may not become evident until construction. Additional explorations and geotechnical analyses need to be performed to support structural design. Also, timely and comprehensive observation and evaluation of actual subsurface conditions, supported by appropriate field and laboratory testing, will be critical during construction as variations from anticipated subsurface conditions may be encountered.

SECTION 7 - REFERENCES

Bohannan Huston, Inc. (BHI) (2014). *Preliminary Engineering Report for Phase II Engineering Evaluation of AWSA Diversion and Storage Proposals*. November 7. Available at: http://nmawsa.org/ongoing-work/diversion-and-storage-proposals/bhi-phase-ii-engineering-evaluation-of-the-2004-awsa-diversion-and-storage-proposals/cliff-gila

Hvorslev, M.J. (1951). *Time Lag and Soil Permeabilities in Groundwater Observations*, U.S. Army Corps of Engineers Waterways Experiment Station Bulletin 36.

Ratte, J.C. and Gaskill, D.L. (1975). *Reconnaissance Geologic Map of the Gila Wilderness Study Area, Southwestern New Mexico*. U.S. Geological Survey Map I-886.

APPENDIX A

SITE EXPLORATION PHOTOGRAPHS

Appendix A
Site Exploration Photos

Photo 1: Unloading equipment at staging area.

Photo 2: Access road between Turkey Creek Road and boring location prior to mobilization, looking towards Turkey Creek Road.

Photo 3: Access road between Turkey Creek Road and boring location prior to mobilization.

Photo 4: Bedrock outcrop on right abutment (looking downstream) of proposed diversion structure location, looking across the Gila River from near B-101.

Photo 5: Proposed diversion structure location, looking downstream.

Photo 6: Cobble bar prior to mobilization, looking upstream from approximate location of B-101.

Photo 7: Drill rig set up on B-101.

Photo 8: Support truck with water tank onsite.

Photo 9: Using automatic hammer to perform SPT test and collect split spoon sample.

Photo 10: Recovered sample S-2 at 6.5 feet deep, typical of cobbley alluvium.

Photo 11: Recovered sample S-11 at 48 feet deep, typical of sandy alluvium.

Photo 12: Mixing grout to backfill B-101.

Photo 13: Using tremie pipe to displace water from the augers during grouting.

Photo 14: Boring backfilled with grout.

Photo 15: Work area after demobilizing.

Photo 16: Gravel and cobbles in cuttings while augering from 0 to 4 feet. The outside diameter of the auger flights is 7.75 inches.

APPENDIX B

WELL PERMIT INFORMATION AND PLUGGING RECORD

STATE OF NEW MEXICO
OFFICE OF THE STATE ENGINEER
District 3 Office, Deming, NM

Tom Blaine, P.E.,
State Engineer

P.O. Box 844
321 W. Spruce Street
Deming, New Mexico 88031
PHONE: (575) 546-2851
FAX: (575) 546-2290

May 13, 2015

FILE: GSF-4603

New Mexico Interstate Stream Commission
c/o RJH Consultants, Inc./Adam Prochaska
9800 Mt Pyramid Court Suite 330
Englewood, CO 80112

Greetings:

Enclosed is your copy of Exploratory Well Permit GSF-4603-POD2, which has been approved.

This application is approved provided it is not exercised to the impairment of any others having existing rights prior to this application for permit for a exploratory well; further provided that all rules and regulations of the State Engineer pertaining to the drilling of shallow wells be complied with; and is not detrimental to the public welfare or contrary to the conservation of water within the state, subject to the following conditions:

1. Well GSF-4603-POD2 shall be constructed by a driller licensed in the State of New Mexico in accordance with New Mexico Statutes Annotated Section 72-12-12. (1998 Repl.)
2. Well GSF-4603-POD2 shall be drilled to a depth not to exceed 20 feet and shall be constructed with casing not to exceed 8.0 inch outside diameter.
3. Well record shall be filed with the District 3 Office of the State Engineer within 20 days after completion of well GSF-4603-POD2. Failure to timely file the well record shall result in cancellation of this permit.
4. The State Engineer retains jurisdiction to administer the conditions of this permit.
5. Well GSF-4603-POD2 shall be plugged by a licensed well driller on or before May 31, 2016, unless the applicant has received an approved permit from the State Engineer for additional use.
6. This permit shall automatically expire on May 31, 2016.

Sincerely,

Lloyd R. Valentine III
District 3 Manager

By: Priscilla Sanchez
Priscilla Sanchez
Gila-San Francisco Basin Assistant Manager

PS:tm
Cc: State Engineer

F

File No. GSF-4603

NEW MEXICO OFFICE OF THE STATE ENGINEER

APPLICATION FOR PERMIT TO DRILL A WELL WITH NO CONSUMPTIVE USE OF WATER

(check applicable box):

For fees, see State Engineer website: http://www.ose.state.nm.us/

3-20808 $500

Purpose:	☐ Pollution Control And / Or Recovery	☐ Geo-Thermal
☒ Exploratory	☐ Construction Site De-Watering	☐ Other (Describe):
☐ Monitoring	☐ Mineral De-Watering	

A separate permit will be required to apply water to beneficial use.

OFFICE OF THE STATE ENGINEER DEMING, NM 2015 MAY -4 PM 1:08

☒ Temporary Request - Requested Start Date: 5/11/15 Requested End Date: 6/30/15

Plugging Plan of Operations Submitted? ☒ Yes ☐ No

1. APPLICANT(S): New Mexico Interstate Stream Commission

~~Name:~~ c/o RJH Consultants, Inc.	Name:
Contact or Agent: check here if Agent ☐ Adam Prochaska	Contact or Agent: check here if Agent ☐
Mailing Address: 9800 Mt Pyramid Court Suite 330	Mailing Address:
City: Englewood	City:
State: CO Zip Code: 80112	State: Zip Code:
Phone: 303-501-4550 ☐ Home ☒ Cell Phone (Work): 303-225-4611	Phone: ☐ Home ☐ Cell Phone (Work):
E-mail (optional): aprochaska@rjh-consultants.com	E-mail (optional):

FOR OSE INTERNAL USE

Application for Permit, Form wr-07, Rev 4/12/12

File Number: GSF-4603	Tm Number:
Trans Description (optional): GSF-4603-POD2-Expl	
Sub-Basin: GSCG	
PCW/LOG Due Date: 5/31/2016	

2. WELL(S) Describe the well(s) applicable to this application.

Location Required: Coordinate location must be reported in NM State Plane (NAD 83), UTM (NAD 83), or Latitude/Longitude (Lat/Long - WGS84).
District II (Roswell) and District VII (Cimarron) customers. provide a PLSS location in addition to above.

☐ NM State Plane (NAD83) (Feet)
☐ NM West Zone
☐ NM East Zone
☐ NM Central Zone

☐ UTM (NAD83) (Meters)
☐ Zone 12N
☐ Zone 13N

☒ Lat/Long (WGS84) (to the nearest 1/10th of second)

Well Number (if known):	X or Easting or Longitude:	Y or Northing or Latitude:	Provide if known: -Public Land Survey System (PLSS) (*Quarters or Halves , Section, Township, Range*) OR - Hydrographic Survey Map & Tract; OR - Lot, Block & Subdivision; OR - Land Grant Name
GSF-4603-POD2 B-101	108° 30' 1.3" W	33° 3' 47.1" N	NE¼NE¼NW¼, Section 28, Township 14 South, Range 16 West, NMPM

NOTE: If more well locations need to be described, complete form WR-08 (Attachment 1 – POD Descriptions)

Additional well descriptions are attached: ☐ Yes ☒ No **If yes, how many** _____

Other description relating well to common landmarks, streets, or other:

Well is on land owned by: U.S. Forest Service

Well Information: NOTE: If more than one (1) well needs to be described, provide attachment. **Attached?** ☐ Yes ☒ No
If yes, how many_____

Approximate depth of well (feet): 20'	Outside diameter of well casing (inches): 8" HSA
Driller Name: Rod Hammer	Driller License Number: WD1186

3. ADDITIONAL STATEMENTS OR EXPLANATIONS

Attached is copy of permit from USFS for this work. Boring location is approximate and may be adjusted in the field for access considerations.

Boring will be advanced through soil using hollow stem augers and insitu hydraulic conductivity tests (constant head or falling head) will be performed through the augers. If bedrock is encountered the boring will be advanced by rock coring and pressure (Packer) testing will be performed in the bedrock.

Boring will be grouted and no casing will be installed.

FOR OSE INTERNAL USE

Application for Permit, Form wr-07

File Number: GSF-4603	Tm Number:

4. SPECIFIC REQUIREMENTS: The applicant must include the following, as applicable to each well type. Please check the appropriate boxes, to indicate the information has been included and/or attached to this application:

Exploratory: ☒ Include a description of any proposed pump test, if applicable.	**Pollution Control and/or Recovery:** ☐ Include a plan for pollution control/recovery, that includes the following: ☐ A description of the need for the pollution control or recovery operation. ☐ The estimated maximum period of time for completion of the operation. ☐ The annual diversion amount. ☐ The annual consumptive use amount. ☐ The maximum amount of water to be diverted and injected for the duration of the operation. ☐ The method and place of discharge. ☐ The method of measurement of water produced and discharged. ☐ The source of water to be injected. ☐ The method of measurement of water injected. ☐ The characteristics of the aquifer. ☐ The method of determining the resulting annual consumptive use of water and depletion from any related stream system. ☐ Proof of any permit required from the New Mexico Environment Department. ☐ An access agreement if the applicant is not the owner of the land on which the pollution plume control or recovery well is to be located.	**Construction De-Watering:** ☐ Include a description of the proposed dewatering operation, ☐ The estimated duration of the operation, ☐ The maximum amount of water to be diverted, ☐ A description of the need for the dewatering operation, and, ☐ A description of how the diverted water will be disposed of.	**Mine De-Watering:** ☐ Include a plan for pollution control/recovery, that includes the following: ☐ A description of the need for mine dewatering. ☐ The estimated maximum period of time for completion of the operation. ☐ The source(s) of the water to be diverted. ☐ The geohydrologic characteristics of the aquifer(s). ☐ The maximum amount of water to be diverted per annum. ☐ The maximum amount of water to be diverted for the duration of the operation. ☐ The quality of the water. ☐ The method of measurement of water diverted. ☐ The recharge of water to the aquifer. ☐ Description of the estimated area of hydrologic effect of the project. ☐ The method and place of discharge. ☐ An estimation of the effects on surface water rights and underground water rights from the mine dewatering project. ☐ A description of the methods employed to estimate effects on surface water rights and underground water rights. ☐ Information on existing wells, rivers, springs, and wetlands within the area of hydrologic effect.
Monitoring: ☐ Include the reason for the monitoring well, and, ☐ The duration of the planned monitoring.		**Geo-Thermal:** ☐ Include a description of the geothermal heat exchange project, ☐ The amount of water to be diverted and re-injected for the project, ☐ The time frame for constructing the geothermal heat exchange project, and, ☐ The duration of the project. ☐ Preliminary surveys, design data, and additional information shall be included to provide all essential facts relating to the request.	

ACKNOWLEDGEMENT

I, We (name of applicant(s)), Adam Prochaska
Print Name(s)

affirm that the foregoing statements are true to the best of (my, our) knowledge and belief.

Adam Prochaska
Applicant Signature

Applicant Signature

2015 MAY -4 PM 1:06
OFFICE OF THE STATE ENGINEER DEMING, NM

ACTION OF THE STATE ENGINEER

This application is:

☒ approved ☐ partially approved ☐ denied

provided it is not exercised to the detriment of any others having existing rights, and is not contrary to the conservation of water in New Mexico nor detrimental to the public welfare and further subject to the attached conditions of approval.

Witness my hand and seal this 13th day of May 20 15, for the State Engineer,

Tom Blaine, P.E., State Engineer

By: Signature

Lloyd R. Valentine III
Print

Title: District 3 Manager
Print

FOR OSE INTERNAL USE

Application for Permit, Form wr-07

File Number: GSF-4603	Trn Number:

ATTACHMENT
STATE ENGINEER CONDITIONS OF APPROVAL

FILE: GSF-4603

APPLICATION: GSF-4603-POD2-EXPL

APPLICANTS: New Mexico Interstate Stream Commission

1. Well GSF-4603-POD2 shall be constructed by a driller licensed in the State of New Mexico in accordance with New Mexico Statutes Annotated Section 72-12-12. (1998 Repl.)
2. Well GSF-4603-POD2 shall be drilled to a depth not to exceed 20 feet and shall be constructed with casing not to exceed 8.0 inch outside diameter.
3. Well record shall be filed with the District 3 Office of the State Engineer within 20 days after completion of well GSF-4603-POD2. Failure to timely file the well record shall result in cancellation of this permit.
4. The State Engineer retains jurisdiction to administer the conditions of this permit.
5. Well GSF-4603-POD2 shall be plugged by a licensed well driller on or before May 31, 2016, unless the applicant has received an approved permit from the State Engineer for additional use.
6. This permit shall automatically expire on May 31, 2016.

Witness my hand and seal this 13th day of May, 2015.

Tom Blaine, P.E., State Engineer

Lloyd R. Valentine III
District 3 Manager

STATE OF NEW MEXICO
OFFICE OF THE STATE ENGINEER
District 3 Office, Deming, NM

Tom Blaine, P.E.,
State Engineer

P.O. Box 844
321 W. Spruce Street
Deming, New Mexico 88031
PHONE: (575) 546-2851
FAX: (575) 546-2290

May 13, 2015

File: GSF-4603

Enviro-Drill, Inc.
c/o Rodney Hammer
8305 Washington Place, NE
Albuquerque, NM 87113

Greetings:

Enclosed is your copy of Well Plugging Plan of Operations for GSF-4603-POD2-Exploratory, which has been approved and accepted for filing.

Sincerely,

Lloyd R. Valentine III
District 3 Manager

By: Priscilla Sanchez
Priscilla Sanchez
Assistant Manager
Gila-San Francisco Basin

PS:tm
Encl:Well Plugging Plan of Operations
cc: State Engineer
New Mexico Interstate Stream Commission
c/o RJH Consultants, Inc./Adam Prochaska
9800 Mt Pyramid Court Suite 330
Englewood, CO 80112

034

WELL PLUGGING PLAN OF OPERATIONS

NOTE: A Well Plugging Plan of Operations shall be filed with and accepted by the Office of the State Engineer prior to plugging.

I. FILING FEE: There is no filing fee for this form.

II. GENERAL / WELL OWNERSHIP:

Existing Office of the State Engineer POD Number (Well Number) for well to be plugged: GSF-4603-POD2

Name of well owner: RJH Consultants / New Mexico Interstate Stream Commission

Mailing address: 9800 Mt Pyramid Court Suite 330

City: Englewood State: CO Zip code: 80112

Phone number: 303-225-4611 E-mail: aprochaska@rjh-consultants.com

III. WELL DRILLER INFORMATION:

Well Driller contracted to provide plugging services: Rod Hammer

New Mexico Well Driller License No.: WD 1186 Expiration Date: 3/31/16

IV. WELL INFORMATION:

Note: A copy of the existing Well Record for the well to be plugged should be attached to this plan.

1) GPS Well Location: Latitude: 33 deg, 3 min, 47.1 sec
Longitude: 108 deg, 30 min, 1.3 sec, NAD 83

2) Reason(s) for plugging well: well will be a geotechnical boring that will be back filled upon completion.

3) Was well used for any type of monitoring program? no If yes, please use section VII of this form to detail what hydrogeologic parameters were monitored. If the well was used to monitor contaminated or poor quality water, authorization from the New Mexico Environment Department may be required prior to plugging.

4) Does the well tap brackish, saline, or otherwise poor quality water? no If yes, provide additional detail, including analytical results and/or laboratory report(s):

5) Static water level: Not drilled yet feet below land surface / feet above land surface (circle one)

6) Depth of the well: 20 feet maximum

2015 MAY -4 PM 1:0
OFFICE OF THE STATE ENGINEER DEMING NM

7) Inside diameter of innermost casing: N/A inches.

8) Casing material: No casing installed

9) The well was constructed with: auger boring and possibly rock coring

X an open-hole production interval, state the open interval: _____

_____ a well screen or perforated pipe, state the screened interval(s): _____

10) What annular interval surrounding the artesian casing of this well is cement-grouted? N/A

11) Was the well built with surface casing? no If yes, is the annulus surrounding the surface casing grouted or otherwise sealed? _____ If yes, please describe: _____

12) Has all pumping equipment and associated piping been removed from the well? N/A If not, describe remaining equipment and intentions to remove prior to plugging in Section VII of this form.

V. DESCRIPTION OF PLANNED WELL PLUGGING:

Note: If this plan proposes to plug an artesian well in a way other than with cement grout, placed bottom to top with a tremie pipe, a detailed diagram of the well showing proposed final plugged configuration shall be attached, as well as any additional technical information, such as geophysical logs, that are necessary to adequately describe the proposal.

1) Describe the method by which cement grout shall be placed in the well, or describe requested plugging methodology proposed for the well: tremied from bottom up using drill rig pump

2) Will well head be cut-off below land surface after plugging? N/A

VI. PLUGGING AND SEALING MATERIALS:

Note: The plugging of a well that taps poor quality water may require the use of a specialty cement or specialty sealant

1) For plugging intervals that employ cement grout, complete and attach Table A.

2) For plugging intervals that will employ approved non-cement based sealant(s), complete and attach Table B.

3) Theoretical volume of grout required to plug the well to land surface: 0.35 ft^3 per foot for 8" auger

4) Type of Cement proposed: Holcim Type I/II Portland Cement

5) Proposed cement grout mix: 2.5 gallons of water per ~~94~~ 40 pound sack of Portland cement

6) Will the grout be: _____ batch-mixed and delivered to the site

X mixed on site

7) Grout additives requested, and percent by dry weight relative to cement:

5% CETCO Supergel Powdered Bentonite

8) Additional notes and calculations:

VII. ADDITIONAL INFORMATION: List additional information below, or on separate sheet(s):

2015 MAY 14 PM 1:01
OFFICE OF THE STATE ENGINEER
DEPUTY

VIII. SIGNATURE:

I, Adam Prochaska, say that I have carefully read the foregoing Well Plugging Plan of Operations and any attachments, which are a part hereof; that I am familiar with the rules and regulations of the State Engineer pertaining to the plugging of wells and will comply with them, and that each and all of the statements in the Well Plugging Plan of Operations and attachments are true to the best of my knowledge and belief.

Adam Prochaska — Signature of Applicant

4-28-15 — Date

IX. ACTION OF THE STATE ENGINEER:

This Well Plugging Plan of Operations is:

X Approved subject to the attached conditions.
____ Not approved for the reasons provided on the attached letter.

Witness my hand and official seal this 13th day of May, 2015

Tom Blaine, P.E., ~~State Engineer~~

By: _____

Lloyd R. Valentine III
District 3 Manager

TABLE A - For plugging intervals that employ cement grout. Start with deepest interval.

	Interval 1 – deepest	Interval 2	Interval 3 – most shallow
			Note: if the well is non-artesian and breaches only one aquifer, use only this column.
Top of proposed interval of grout placement (ft bgl)			0
Bottom of proposed interval of grout placement (ft bgl)			bottom of boring (20' maximum)
Theoretical volume of grout required per interval (gallons)			2.6 gallons per foot for 8" auger
Proposed cement grout mix gallons of water per 94-lb. sack of Portland cement			2.5 gallons per 40 lbs cement
Mixed on-site or batch-mixed and delivered?			onsite
Grout additive 1 requested			CETCO Supergel Powdered Bentonite
Additive 1 percent by dry weight relative to cement			5%
Grout additive 2 requested			—
Additive 2 percent by dry weight relative to cement			—

ATTACHMENT
STATE ENGINEER CONDITIONS OF APPROVAL

FILE: GSF-4603

APPLICATION: GSF-4603

APPLICANTS: New Mexico Interstate Stream Commission

1. Well GSF-4063-POD2 shall be drilled and plugged by a driller licensed in the State of New Mexico in accordance with Section 72-12-1 New Mexico Statutes Annotated.

2. Plugging operations shall conform stringently to the conditions and descriptives as detailed in the submitted and approved plugging plan of operations for GSF-4063-POD2. Adherence to specific cementitious or other approved sealant quantities and types and maximum quantities of mix water in the proposed mix design(s) shall be maintained without deviation to achieve the maximum sealant and plugging performance capabilities for the approved components and mix. Placement of all plugging components and sealants shall be done in strict compliance to the plugging plan of operations and to meet or exceed New Mexico State Engineers' standards and regulations for plugging of wells.

3. The State Engineer retains jurisdiction to administer the conditions of this permit.

4. Approval of this Plugging Plan of Operations by the Office of the State Engineer does not relieve the permittee from compliance to requirements of other governing agencies. Permittee shall comply with any and all local, state, or federal laws and/or regulations.

5. Well plugging record shall be filed within 20 days after completion of plugging operations but in any event no later than on or before May 31, 2015.

Witness my hand and seal this 13th day of May, 2015.

Tom Blaine, P.E., State Engineer

Lloyd R. Valentine III
District 3 Manager

Adam Prochaska

From: Sanchez, Priscilla A., OSE <priscilla.sanchez@state.nm.us>
Sent: Wednesday, May 20, 2015 8:16 AM
To: Adam Prochaska
Subject: RE: Exploratory Well Permit

Hello
No so far that should be ok any deeper would require a permit to deepen. Did you get your permit in the mail already?

From: Adam Prochaska [mailto:aprochaska@rjh-consultants.com]
Sent: Wednesday, May 20, 2015 8:11 AM
To: Sanchez, Priscilla A., OSE
Subject: RE: Exploratory Well Permit

Priscilla,

We have adjusted our work plan for our boring near Gila. The maximum depth will now be 50 feet instead of 20 feet. No other aspects of our drilling and plugging plug have changed. Let me know if this change in the maximum depth will be a problem with our well permit.

Thank you

Adam B. Prochaska, Ph.D., P.E., P.G.
RJH Consultants, Inc.
9800 Mt. Pyramid Court, Suite 330
Englewood, CO 80112
303-225-4611 Phone
303-501-4550 Cell
303-225-4615 Fax
www.rjh-consultants.com

From: Sanchez, Priscilla A., OSE [mailto:priscilla.sanchez@state.nm.us]
Sent: Monday, May 18, 2015 9:08 AM
To: Adam Prochaska
Subject: RE: Exploratory Well Permit

Hello
I had completed this application early last week, but it has been held up in my District Manager's office waiting for final signatures because he was out in the field most of last week. He just advised me that he will sign it this morning and it should be going out in the mail to you today or tomorrow.
Please let me know if you do not receive it by end of this week and I will just email you an approved copy.
Thank you
Priscilla

PLUGGING RECORD

NOTE: A Well Plugging Plan of Operations shall be approved by the State Engineer prior to plugging - 19.27.4 NMAC

I. GENERAL / WELL OWNERSHIP:

State Engineer Well Number: GSF-4603 POD-2

Well owner: New Mexico ISC c/o RJH Consultants Phone No.: 303-225-4611

Mailing address: 9800 Mt Pyramid Court Suite 330

City: Englewood State: CO Zip code: 80112

II. WELL PLUGGING INFORMATION:

1) Name of well drilling company that plugged well: _____

2) New Mexico Well Driller License No.: _____ Expiration Date: _____

3) Well plugging activities were supervised by the following well driller(s)/rig supervisor(s): _____

4) Date well plugging began: 5-29-15 Date well plugging concluded: 5-29-15

5) GPS Well Location: Latitude: 33 deg, 3 min, 45.8 sec
Longitude: 108 deg, 30 min, 2.3 sec, WGS 84

6) Depth of well confirmed at initiation of plugging as: 49.5 ft below ground level (bgl), by the following manner: drill rod and split spoon sampler

7) Static water level measured at initiation of plugging: 3.5 ft bgl

8) Date well plugging plan of operations was approved by the State Engineer: 5-13-15

9) Were all plugging activities consistent with an approved plugging plan? yes If not, please describe differences between the approved plugging plan and the well as it was plugged (attach additional pages as needed):

Well was advanced beyond the 20 feet maximam listed on the plugging plan. This was authorized by NM OSE via email on May 20, 2015.

Well was drilled approximately 150 feet southwest of the location listed on the plugging plan. As-built coordinates are provided on this plugging record.

10) Log of Plugging Activities - Label vertical scale with depths, and indicate separate plugging intervals with horizontal lines as necessary to illustrate material or methodology changes. Attach additional pages if necessary.

For each interval plugged, describe within the following columns:

Depth (ft bgl)	Plugging Material Used (include any additives used)	Volume of Material Placed (gallons)	Theoretical Volume of Borehole/ Casing (gallons)	Placement Method (tremie pipe, other)	Comments ("casing perforated first", "open annular space also plugged", etc.)
0 to 49.5	cement-bentonite grout	150	121	tremie pipe	
	Portland cement and 5% bentonite gel				

MULTIPLY		BY		AND OBTAIN
cubic feet	x	7.4805	=	gallons
cubic yards	x	201.97	=	gallons

III. SIGNATURE:

I, _____ , say that I am familiar with the rules of the Office of the State Engineer pertaining to the plugging of wells and that each and all of the statements in this Plugging Record and attachments are true to the best of my knowledge and belief.

_____ _____

Signature of Well Driller Date

APPENDIX C

SOIL DESCRIPTORS

COARSE GRAINED SOILS
(< 50% FINES)

A) FLOWCHART APPLIED TO LABORATORY TESTED SOIL SAMPLES.
ADAPTED FROM ASTM D 2487 *CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES (USCS)*.

				GROUP SYMBOL		GROUP NAME
GRAVEL %GRAVEL > %SAND	< 5% FINES	(Cu≥4 and 1≤Cc≤3)		GW	<15% SAND	WELL GRADED GRAVEL
					≥15% SAND	WELL GRADED GRAVEL WITH SAND
		(Cu<4 and/or 1>Cc>3)		GP	<15% SAND	POORLY GRADED GRAVEL
					≥15% SAND	POORLY GRADED GRAVEL WITH SAND
	5-12% FINES	(Cu≥4 and 1≤Cc≤3)	FINES = ML or MH	GW-GM	<15% SAND	WELL GRADED GRAVEL WITH SILT
					≥15% SAND	WELL GRADED GRAVEL WITH SILT AND SAND
			FINES = CL or CH (or CL-ML)	GW-GC	<15% SAND	WELL GRADED GRAVEL WITH CLAY (OR SILTY CLAY)
					≥15% SAND	WELL GRADED GRAVEL WITH CLAY AND SAND (OR SILTY CLAY AND SAND)
		(Cu<4 and/or 1>Cc>3)	FINES = ML or MH	GP-GM	<15% SAND	POORLY GRADED GRAVEL WITH SILT
					≥15% SAND	POORLY GRADED GRAVEL WITH SILT AND SAND
			FINES = CL or CH (or CL-ML)	GP-GC	<15% SAND	POORLY GRADED GRAVEL WITH CLAY (OR SILTY CLAY)
					≥15% SAND	POORLY GRADED GRAVEL WITH CLAY AND SAND (OR SILTY CLAY AND SAND)
	>12% FINES		FINES = ML or MH	GM	<15% SAND	SILTY GRAVEL
					≥15% SAND	SILTY GRAVEL WITH SAND
			FINES = CL or CH	GC	<15% SAND	CLAYEY GRAVEL
					≥15% SAND	CLAYEY GRAVEL WITH SAND
			FINES = CL - ML	GC-GM	<15% SAND	SILTY, CLAYEY GRAVEL
					≥15% SAND	SILTY, CLAYEY GRAVEL WITH SAND
SAND %SAND > %GRAVEL	< 5% FINES	(Cu≥6 and 1≤Cc≤3)		SW	<15% GRAVEL	WELL GRADED SAND
					≥15% GRAVEL	WELL GRADED SAND WITH GRAVEL
		(Cu<6 and/or 1>Cc>3)		SP	<15% GRAVEL	POORLY GRADED SAND
					≥15% GRAVEL	POORLY GRADED SAND WITH GRAVEL
	5-12% FINES	(Cu≥6 and 1≤Cc≤3)	FINES = ML or MH	SW-SM	<15% GRAVEL	WELL GRADED SAND WITH SILT
					≥15% GRAVEL	WELL GRADED SAND WITH SILT AND GRAVEL
			FINES = CL or CH (or CL-ML)	SW-SC	<15% GRAVEL	WELL GRADED SAND WITH CLAY (OR SILTY CLAY)
					≥15% GRAVEL	WELL GRADED SAND WITH CLAY AND GRAVEL (OR SILTY CLAY AND GRAVEL)
		(Cu<6 and/or 1>Cc>3)	FINES = ML or MH	SP-SM	<15% GRAVEL	POORLY GRADED SAND WITH SILT
					≥15% GRAVEL	POORLY GRADED SAND WITH SILT AND GRAVEL
			FINES = CL or CH (or CL-ML)	SP-SC	<15% GRAVEL	POORLY GRADED SAND WITH CLAY (OR SILTY CLAY)
					≥15% GRAVEL	POORLY GRADED SAND WITH CLAY AND GRAVEL (OR SILTY CLAY AND GRAVEL)
	>12% FINES		FINES = ML or MH	SM	<15% GRAVEL	SILTY SAND
					≥15% GRAVEL	SILTY SAND WITH GRAVEL
			FINES = CL or CH	SC	<15% GRAVEL	CLAYEY SAND
					≥15% GRAVEL	CLAYEY SAND WITH GRAVEL
			FINES = CL - ML	SC-SM	<15% GRAVEL	SILTY, CLAYEY SAND
					≥15% GRAVEL	SILTY, CLAYEY SAND WITH GRAVEL

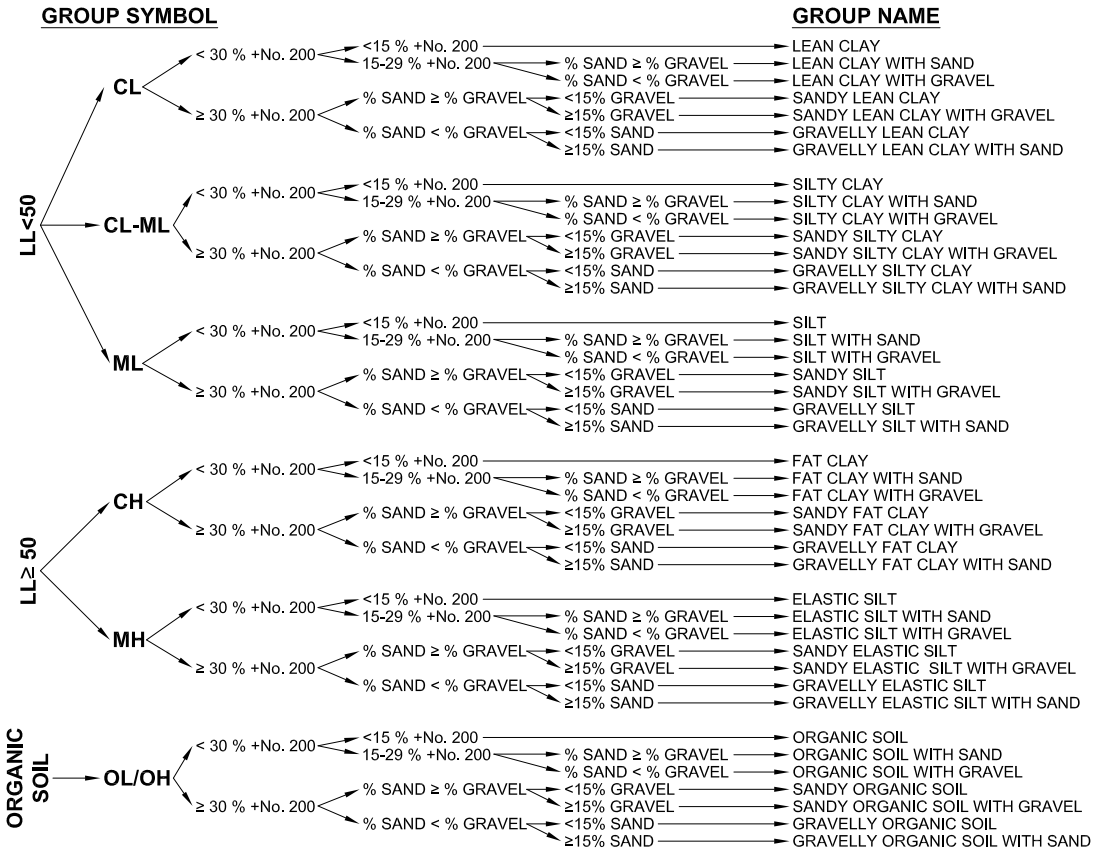
B) FLOWCHART APPLIED TO FIELD CLASSIFIED SOIL SAMPLES.
ADAPTED FROM ASTM D 2488 *DESCRIPTION AND IDENTIFICATION OF SOILS (VISUAL-MANUAL PROCEDURE)*.

FOR SOILS WITH < 50% FINES

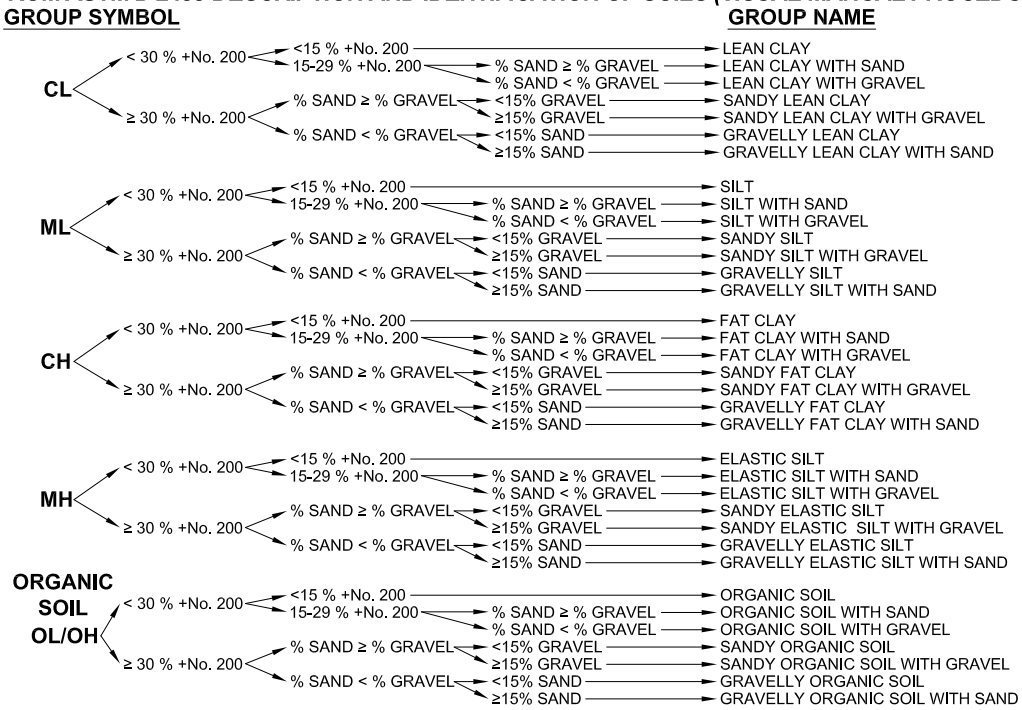
				GROUP SYMBOL		GROUP NAME
GRAVEL %GRAVEL > %SAND	≤ 5% FINES	WELL GRADED		GW	<15% SAND	WELL GRADED GRAVEL
					≥15% SAND	WELL GRADED GRAVEL WITH SAND
		POORLY GRADED		GP	<15% SAND	POORLY GRADED GRAVEL
					≥15% SAND	POORLY GRADED GRAVEL WITH SAND
	5-15% FINES	WELL GRADED	FINES = ML or MH	GW-GM	<15% SAND	WELL GRADED GRAVEL WITH SILT
					≥15% SAND	WELL GRADED GRAVEL WITH SILT AND SAND
			FINES = CL or CH	GW-GC	<15% SAND	WELL GRADED GRAVEL WITH CLAY
					≥15% SAND	WELL GRADED GRAVEL WITH CLAY AND SAND
		POORLY GRADED	FINES = ML or MH	GP-GM	<15% SAND	POORLY GRADED GRAVEL WITH SILT
					≥15% SAND	POORLY GRADED GRAVEL WITH SILT AND SAND
			FINES = CL or CH	GP-GC	<15% SAND	POORLY GRADED GRAVEL WITH CLAY
					≥15% SAND	POORLY GRADED GRAVEL WITH CLAY AND SAND
	≥15% FINES		FINES = ML or MH	GM	<15% SAND	SILTY GRAVEL
					≥15% SAND	SILTY GRAVEL WITH SAND
			FINES = CL or CH	GC	<15% SAND	CLAYEY GRAVEL
					≥15% SAND	CLAYEY GRAVEL WITH SAND
SAND %SAND > %GRAVEL	≤ 5% FINES	WELL GRADED		SW	<15% GRAVEL	WELL GRADED SAND
					≥15% GRAVEL	WELL GRADED SAND WITH GRAVEL
		POORLY GRADED		SP	<15% GRAVEL	POORLY GRADED SAND
					≥15% GRAVEL	POORLY GRADED SAND WITH GRAVEL
	5-15% FINES	WELL GRADED	FINES = ML or MH	SW-SM	<15% GRAVEL	WELL GRADED SAND WITH SILT
					≥15% GRAVEL	WELL GRADED SAND WITH SILT AND GRAVEL
			FINES = CL or CH	SW-SC	<15% GRAVEL	WELL GRADED SAND WITH CLAY
					≥15% GRAVEL	WELL GRADED SAND WITH CLAY AND GRAVEL
		POORLY GRADED	FINES = ML or MH	SP-SM	<15% GRAVEL	POORLY GRADED SAND WITH SILT
					≥15% GRAVEL	POORLY GRADED SAND WITH SILT AND GRAVEL
			FINES = CL or CH	SP-SC	<15% GRAVEL	POORLY GRADED SAND WITH CLAY
					≥15% GRAVEL	POORLY GRADED SAND WITH CLAY AND GRAVEL
	≥15% FINES		FINES = ML or MH	SM	<15% GRAVEL	SILTY SAND
					≥15% GRAVEL	SILTY SAND WITH GRAVEL
			FINES = CL or CH	SC	<15% GRAVEL	CLAYEY SAND
					≥15% GRAVEL	CLAYEY SAND WITH GRAVEL

FINE GRAINED SOILS
(≥ 50% FINES)

A) FLOWCHART APPLIED TO LABORATORY TESTED SOIL SAMPLES.
ADAPTED FROM ASTM D 2487 *CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES (USCS)*.



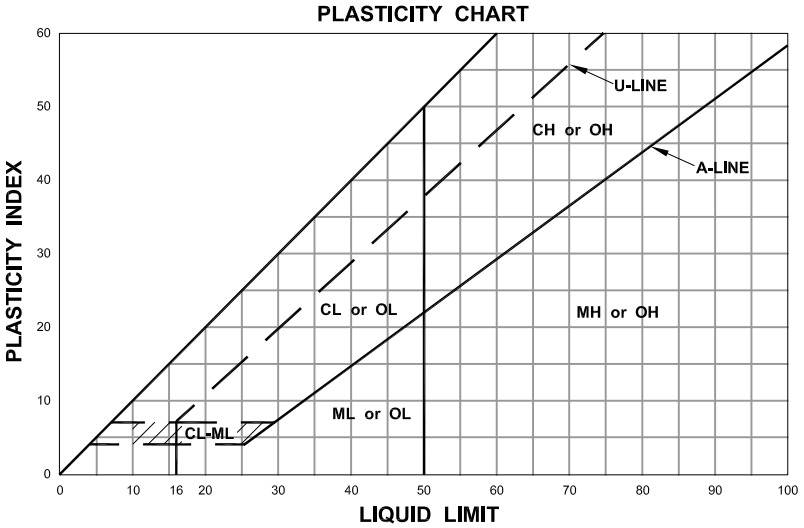
B) FLOWCHART APPLIED TO FIELD CLASSIFIED SOIL SAMPLES.
ADAPTED FROM ASTM D 2488 *DESCRIPTION AND IDENTIFICATION OF SOILS (VISUAL-MANUAL PROCEDURE)*.



NOTE:

1. **THE PLASTICITY CHART ON THE FOLLOWING PAGE WAS USED TO IDENTIFY THE GROUP SYMBOL FOR FLOWCHART A. A COMBINATION OF THE VISUAL MANUAL CRITERIA ON THE FOLLOWING PAGE WERE USED TO IDENTIFY THE GROUP SYMBOL FOR FLOWCHART B.**

SOIL PLASTICITY CHARACTERISTICS



A) IDENTIFICATION OF FINES GROUP SYMBOL FROM LABORATORY TESTS.
REPRODUCED FROM ASTM D 2487 *CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES (USCS)*.

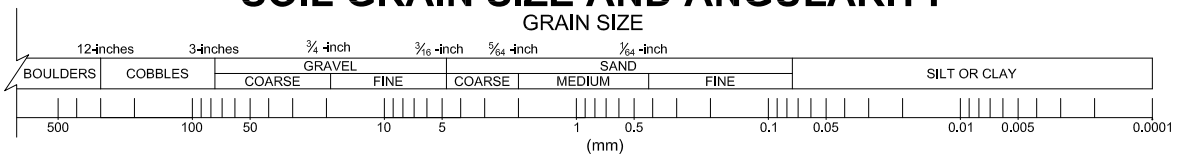
B) IDENTIFICATION OF FINES GROUP SYMBOL FROM VISUAL-MANUAL CRITERIA.
REPRODUCED FROM ASTM D 2488 *DESCRIPTION AND IDENTIFICATION OF SOILS (VISUAL-MANUAL PROCEDURE).*

DRY STRENGTH	
DESCRIPTION	CRITERIA
NONE	CRUMBLES TO POWDER WHILE HANDLING.
LOW	CRUMBLES TO POWDER WITH SOME FINGER PRESSURE.
MEDIUM	BREAKS INTO PIECES OR CRUMBLES WITH CONSIDERABLE FINGER PRESSURE.
HIGH	CANNOT BE BROKEN WITH FINGER PRESSURE. BREAKS INTO PIECES BETWEEN THUMB AND HARD SURFACE.
VERY HIGH	CANNOT BE BROKEN BETWEEN THUMB AND HARD SURFACE.
DILATANCY (RESISTANCE TO SHAKING)	
DESCRIPTION	CRITERIA
NONE	NO VISIBLE CHANGE IN SPECIMEN.
SLOW	WATER APPEARS SLOWLY ON THE SURFACE OF THE SPECIMEN DURING SHAKING AND DOES NOT DISAPPEAR OR DISAPPEARS SLOWLY UPON SQUEEZING.
RAPID	WATER APPEARS QUICKLY ON THE SURFACE OF THE SPECIMEN DURING SHAKING AND DISAPPEARS QUICKLY UPON SQUEEZING.

TOUGHNESS (CONSISTENCY NEAR PLASTIC LIMIT)	
DESCRIPTION	CRITERIA
LOW	ONLY SLIGHT PRESSURE IS REQUIRED TO ROLL THE THREAD. THREAD AND LUMP ARE WEAK AND SOFT.
MEDIUM	MEDIUM PRESSURE IS REQUIRED TO ROLL THE THREAD. THREAD AND LUMP HAVE MEDIUM STIFFNESS.
HIGH	CONSIDERABLE EFFORT IS REQUIRED TO ROLL THE THREAD. THREAD AND LUMP HAVE HIGH STIFFNESS.
PLASTICITY	
DESCRIPTION	CRITERIA FOR A 1/8-INCH (3 mm) THREAD.
NON-PLASTIC	THREAD CANNOT BE ROLLED.
LOW	THREAD CAN BARELY BE ROLLED AND THE LUMP CANNOT BE FORMED WHEN DRIER THAN THE PLASTIC LIMIT.
MEDIUM	THREAD IS EASY TO ROLL AND NOT MUCH TIME IS REQUIRED TO REACH THE PLASTIC LIMIT. THE THREAD CANNOT BE RE-ROLLED SEVERAL TIMES AFTER REACHING THE PLASTIC LIMIT. THE LUMP CRUMBLES WHEN DRIER THAN THE PLASTIC LIMIT.
HIGH	IT TAKES CONSIDERABLE TIME ROLLING AND KNEADING TO REACH THE PLASTIC LIMIT. THE THREAD CAN BE RE-ROLLED SEVERAL TIMES AFTER REACHING THE PLASTIC LIMIT. THE LUMP CAN BE FORMED WITHOUT CRUMBLING WHEN DRIER THAN THE PLASTIC LIMIT.

SYMBOL	DRY STRENGTH	DILATANCY	TOUGHNESS AND PLASTICITY	PLASTICITY
ML	NONE - LOW	SLOW - RAPID	LOW	LOW TO NON-PLASTIC
CL	MEDIUM - HIGH	NONE - SLOW	MEDIUM	LOW TO MEDIUM
MH	LOW - MEDIUM	NONE - SLOW	LOW TO MEDIUM	LOW TO MEDIUM
CH	HIGH - VERY HIGH	NONE	HIGH	HIGH

SOIL GRAIN SIZE AND ANGULARITY



PARTICLE ANGULARITY

UPDATED 03-2014

H: _ADMIN \ OFFICEMANUALS \ DRILLING \ 13-10-07_LOGGINGAIDS.DWG 9/25/2014 3:11 PM

TABLE 1.1
CRITERIA FOR DESCRIBING SOIL STRUCTURE[1]

Description	Criteria
Stratified	Alternating layers of varying material or color with layers greater than or equal to 1/4 inch thick (6 mm)
Laminated	Alternating layers of varying material or color with layers less than 1/4 inch thick (6 mm)
Fissured	Breaks along definite plates of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay
Homogeneous	Same color and appearance throughout

Note:
1. Modified from ASTM D 2488 *Description and Identification of Soils (Visual-Manual Procedure)* and differ from the U.S. Bureau of Reclamation *Engineering Geology Field Manual* (2001).

TABLE 1.2
RELATIVE DENSITY OF SANDS ACCORDING TO RESULTS OF STANDARD PENETRATION TEST[1]

Number of Blows N	Relative Density
0-4	Very Loose
5-10	Loose
11-30	Medium
31-50	Dense
Over 50	Very Dense

Note:
1. Modified from Terzaghi, Peck, and Mesri (1996).

TABLE 1.3
GUIDE FOR STIFFNESS OF FINE-GRAINED SOILS[1]

Description	Criteria	Estimated Unconfined Compressive Strength (TSF)
Very Soft	Extrudes between fingers when squeezed	<0.25
Soft	Molded by light finger pressure	0.25-0.50
Medium	Molded by strong finger pressure	0.50-1.00
Stiff	Readily indented by thumb or penetrated with great effort	1.00-2.00
Very Stiff	Readily indented by thumbnail	2.00-4.00
Hard	Indented with difficulty by thumbnail	>4.00

Note:
1. Reproduced from NAVFAC (1986).

TABLE 1.4
CRITERIA FOR DESCRIBING SOIL MOISTURE CONDITION[1]

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below the water table

Note:
1. Reproduced from ASTM 2488 *Description and Identification of Soils (Visual-Manual Procedure)*.

TABLE 1.5
CRITERIA FOR DESCRIBING SOIL CEMENTATION[1][2]

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

Notes:
1. Reproduced from ASTM 2488 *Description and Identification of Soils (Visual-Manual Procedure)*.
2. The absence of cementation was not recorded on boring logs.

TABLE 1.6
CRITERIA FOR DESCRIBING SOIL REACTION WITH HCL[1]

Description	Criteria
None[2]	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

Notes:
1. Reproduced from ASTM 2488 Description and Identification of Soils (Visual-Manual Procedure).
2. The absence of a reaction was not recorded on boring logs.

REFERENCES

ASTM D 2487 (2011). *Standard Classification of Soils for Engineering Purposes (USCS)*. June.

ASTM D 2488 (2009). *Standard Practice for Description and Identification of Soils (Visual-Manual Method*). July.

Bates, Robert C. and Jackson, Julia A. (1984). *Dictionary of Geologic Terms*, 3rd Edition.

Hunt, Roy E. (Hunt) (2005). *Geotechnical Investigation Handbook*.

Terzaghi, Karl, Peck, Ralph B., and Mesri, Gholamreza. (Terzaghi, Peck, and Mesri). (1996). *Soil Mechanics in Engineering Practice*.

U.S. Bureau of Reclamation (USBR) (2001). *Engineering Geology Field Manual*.

APPENDIX D

BORING LOGS

LOG OF SOIL BORING

Project name: Gila River Diversion Project
Project No: 15113
Boring Location: N 33°3'45.8'' W 108°30'2.3''
Ground El: 4755.0 ft Total Depth: 49.5 ft
Groundwater El: 4751.5 ft On Date: 05-28-2015

Start Date: 05-28-2015 End Date: 05-29-2015
Driller: Elite-Dan Logged By: ABP
Bedrock Depth: Not encountered Checked By: KTM

Drilling Rig: Buggy CME 550
Equipment: HSA 4.25 inch ID and 7.75 inch OD

Borehole ID: **B-101**
Sheet 1 of 5

Elevation	Depth (ft)	Type - No	Blows per 6 inch	Penetration (ft)	Recovery (ft)	Remarks	Graphic Lithology	Description and Classification of Materials
						Augers grinding 0.0-3.0'. Hard Drilling. Cobbles and gravel in cuttings, cuttings become finer with depth.		S-1, S-2, S-3: Well Graded Gravel with Sand Mostly gravel, fine to coarse grained, subangular to rounded; 20-30% sand, fine to coarse grained, angular to subrounded; less than 5% fines; maximum particle size = 1.5 inches; medium dense; wet; brown and tan; (GW); [Qag - Valley Alluvium and Terrace Gravels]
	1							
	2							
	3					Groundwater at 3.5'.		
	4	S - 1	5/8/9	1.5	1.0			
	5							
	6							
	7	S - 2	4/5/4	1.5	0.7	Gravel in shoe 6.5-8.0' Test K-1.		*Similar to S-1 Except: loose;*
	8							
	9							*Similar to S-1 Except: loose;*
4745.6		S - 3	WOH/1/5	1.5	1.2			S-3: Silty Sand Mostly sand, fine to medium grained; 30-40% fines, nonplastic; loose; wet; brown ; (SM); [Qag - Valley Alluvium and Terrace Gravels]
4745.2	10							

Continued on next sheet

Notes Maximum particle size limited by diameter of sampler. Boring location and elevation are approximate. Lithology between recovered samples is interpreted, contacts are approximate. Boring was backfilled with grout.

LOG OF SOIL BORING

Project name: Gila River Diversion Project
Project No: 15113
Boring Location: N 33°3'45.8'' W 108°30'2.3''
Ground El: 4755.0 ft Total Depth: 49.5 ft
Groundwater El: 4751.5 ft On Date: 05-28-2015

Start Date: 05-28-2015 End Date: 05-29-2015
Driller: Elite-Dan Logged By: ABP
Bedrock Depth: Not encountered Checked By: KTM

Drilling Rig: Buggy CME 550
Equipment: HSA 4.25 inch ID and 7.75 inch OD

Borehole ID: **B-101**

Elevation	Depth (ft)	Type - No	Blows per 6 inch	Penetration (ft)	Recovery (ft)	Remarks	Graphic Lithology	Description and Classification of Materials
								S-3: Well Graded Gravel with Sand Similar to S-1 Except: loose; (GW); [Qag - Valley Alluvium and Terrace Gravels]
	11							
	12							
4742.7								S-4: Well Graded Sand with Gravel Mostly sand, fine to coarse grained, angular to subrounded; 15-25% gravel, fine to coarse grained, subangular to rounded; less than 5% fines; maximum particle size = 1.5 inches; medium dense; wet; brown; (SW); [Qag - Valley Alluvium and Terrace Gravels]
	13							
	14							
		S - 4	11/16/11	1.5	1.3			
	15							
	16							
	17							
4737.7								S-5: Well Graded Gravel with Sand Similar to S-1 Except: (GW); [Qag - Valley Alluvium and Terrace Gravels]
	18					18.0-18.5' Test K-2.		
	19							
		S - 5	18/9/6	1.5	0.4	Gravel in shoe.		
	20							

Continued on next sheet

Notes Maximum particle size limited by diameter of sampler. Boring location and elevation are approximate. Lithology between recovered samples is interpreted, contacts are approximate. Boring was backfilled with grout.

LOG OF SOIL BORING

Project name: Gila River Diversion Project
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Start Date: 05-28-2015 End Date: 05-29-2015
Driller: Elite-Dan Logged By: ABP
Bedrock Depth: Not encountered Checked By: KTM

Borehole ID: **B-101**

Drilling Rig: Buggy CME 550
Equipment: HSA 4.25 inch ID and 7.75 inch OD

Elevation	Depth (ft)	Type - No	Blows per 6 inch	Penetration (ft)	Recovery (ft)	Remarks	Graphic Lithology	Description and Classification of Materials
	21					Augers grinding 19.0-24.0'.		
	22							
4732.7								S-6: Well Graded Gravel with Silt and Sand Mostly gravel, fine to coarse grained, subangular to rounded; 20-30% sand, fine to coarse grained, angular to subrounded; 5-10% fines, nonplastic; maximum particle size = 1.5 inches; very dense; wet; brown; Gravel appears to be cobble fragments; (GW-GM); [Qag - Valley Alluvium and Terrace Gravels]
	23							
	24	S - 6	46/44/20	1.5	0.8			
	25							
	26							
	27							
4727.7								S-7: Well Graded Sand with Silt and Gravel Mostly sand, fine to coarse grained, angular to subrounded; 20-30% gravel, fine to coarse grained, subangular to rounded; 5-10% fines, nonplastic; maximum particle size = 1.5 inches; medium dense; wet; brown ; (SW-SM); [Qag - Valley Alluvium and Terrace Gravels]
	28							
	29	S - 7	12/14/11	1.5	1.2			
	30							

Continued on next sheet

Notes Maximum particle size limited by diameter of sampler. Boring location and elevation are approximate. Lithology between recovered samples is interpreted, contacts are approximate. Boring was backfilled with grout.

LOG OF SOIL BORING

Project name: Gila River Diversion Project
Project No: 15113
Boring Location: N 33°3'45.8'' W 108°30'2.3''
Ground El: 4755.0 ft Total Depth: 49.5 ft
Groundwater El: 4751.5 ft On Date: 05-28-2015

Start Date: 05-28-2015 End Date: 05-29-2015
Driller: Elite-Dan Logged By: ABP
Bedrock Depth: Not encountered Checked By: KTM

Drilling Rig: Buggy CME 550
Equipment: HSA 4.25 inch ID and 7.75 inch OD

Borehole ID: **B-101**
Sheet 4 of 5

Elevation	Depth (ft)	Type - No	Blows per 6 inch	Penetration (ft)	Recovery (ft)	Remarks	Graphic Lithology	Description and Classification of Materials
4724.0	31					Approx. 31': Inferred contact between cobbley alluvium and sandy alluvium.		S-8: Well Graded Sand with Gravel Similar to S-4 Except: Sand is fine to medium grained; maximum particle size = 1 inch; very dense; (SW); [Qag - Valley Alluvium and Terrace Gravels]
	32					Easy drilling 29.0-34.0'.		
	33							
	34	S - 8	5/11/50 for 5 inches	1.4	1.0	Andesite Cobble Fragment in shoe.		
	35							
	36					34.0-39.0' smooth hard drillng.		
	37							
4717.8								S-9, S-10: Well Graded Sand with Clay and Gravel Mostly sand, fine to coarse grained, angular to subrounded; 15-20% gravel, fine grained, subangular to rounded; 5-15% fines, low to medium plasticity; maximum particle size = 0.75 inches; very dense; moist; green-gray; (SW-SC); [Qag - Valley Alluvium and Terrace Gravels]
	38							
	39	S - 9	24/24/28	1.5	1.5			
	40							

Continued on next sheet

Notes Maximum particle size limited by diameter of sampler. Boring location and elevation are approximate. Lithology between recovered samples is interpreted, contacts are approximate. Boring was backfilled with grout.

LOG OF SOIL BORING

Project name: Gila River Diversion Project
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Groundwater El: 4751.5 ft On Date: 05-28-2015

Start Date: 05-28-2015 End Date: 05-29-2015
Driller: Elite-Dan Logged By: ABP
Bedrock Depth: Not encountered Checked By: KTM

Drilling Rig: Buggy CME 550
Equipment: HSA 4.25 inch ID and 7.75 inch OD

Borehole ID: **B-101**
Sheet 5 of 5

Elevation	Depth (ft)	Type - No	Blows per 6 inch	Penetration (ft)	Recovery (ft)	Remarks	Graphic Lithology	Description and Classification of Materials
	41							
	42							
	43							
	44	S - 10	15/20/20	1.5	1.5			*Similar to S-9 Except: dense; alternating intervals of angular gravel and sand with rounded gravel ;*
	45							
	46							
4708.2	47							S-11: Poorly Graded Sand with Silt and Gravel Lensed; mostly sand, fine to coarse grained, angular to subrounded; 15-25% gravel, fine to coarse grained, subangular to rounded; 5-12% fines, nonplastic; maximum particle size = 1.5 inches; dense; wet; brown; (SP-SM); [Qag - Valley Alluvium and Terrace Gravels]
	48	S - 11	21/21/15	1.5	1.3			
	49							
4705.5								End of boring log at 49.50 ft
	50							

Notes Maximum particle size limited by diameter of sampler. Boring location and elevation are approximate. Lithology between recovered samples is interpreted, contacts are approximate. Boring was backfilled with grout.

APPENDIX E

IN-SITU HYDRAULIC CONDUCTIVITY TESTS

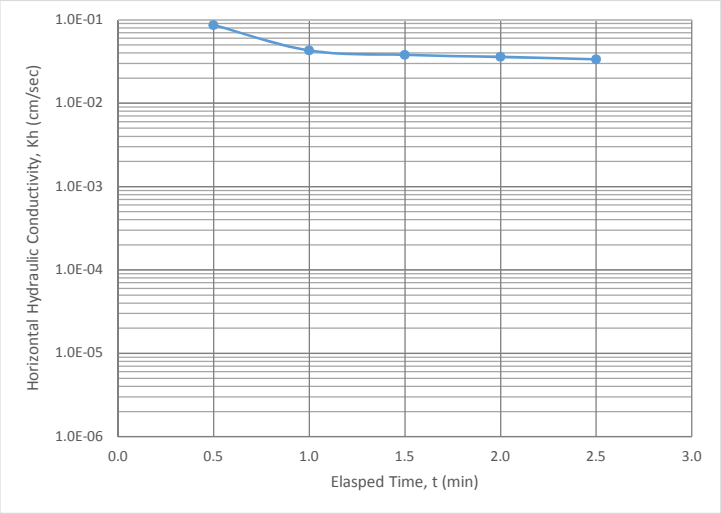
Rising Head Test - Data Reduction Calculation Sheet

Project Name	Gila River Diversion Project
Project No.	15113

Field Engineer/Geologist:	ABP	5/29/2015
Calculated By:	ALC	6/4/2015
Checked By:	ABP	6/5/2015
Approved By:		

Project Number:	**15113**
Boring:	**B-101**
Test Number:	**K-1**

Depth to top of Ground Water	3.5	ft bgs
Casing Stickup	3.8	ft
Top Depth of Test Interval	6.5	ft bgs
Bottom Depth of Test Interval	8.0	ft bgs
Inside Diameter Pipe	4.25	in
D = Diameter, intake, sample	7.75	in
L = Length, intake, sample	1.5	ft
M = Transformation Ratio	1.00	--



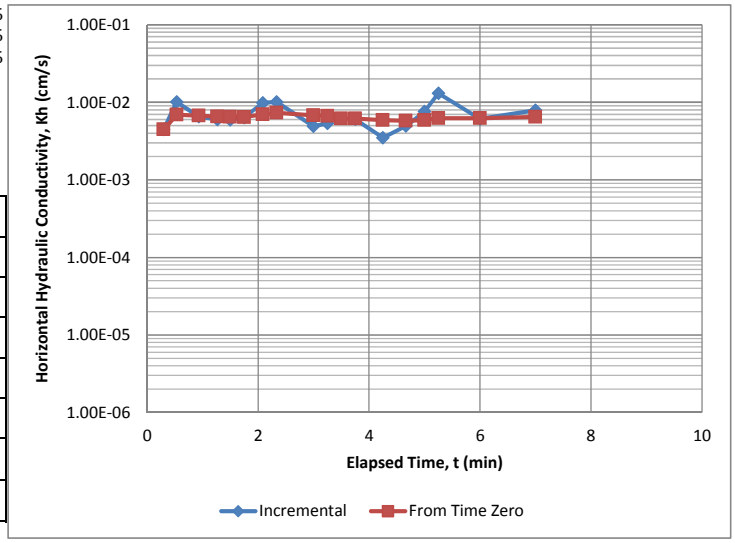
Depth to Water Surface In Pipe From Top of Casing Stickup	Elapsed Time, t	Average Head (H)		Time Between Measurements	Volume in Meter Reading	Change in Volume In	Flow Rate		Horizontal Hydraulic Conductivity (Kh)
(ft)	(min)	(ft)	(cm)	(min)	(gal)	(gal)	(gal/min)	(cm^3/sec)	(cm/sec)
7.3	0.0	-	-	-	8036.2	-	-	-	-
3.6	0.5	1.9	56.4	0.5	8043.2	7.0	14.0	883.3	8.6E-02
3.0	1.0	4.0	121.9	0.5	8050.7	7.5	15.0	946.4	4.3E-02
2.8	1.5	4.4	134.1	0.5	8058.0	7.3	14.6	921.1	3.8E-02
2.5	2.0	4.7	141.7	0.5	8065.3	7.3	14.6	921.1	3.6E-02
2.0	2.5	5.1	153.9	0.5	8072.7	7.4	14.8	933.7	3.3E-02
								Maximum Computed Hydraulic Conductivity	8.6E-02
								Geometric Mean of Hydraulic Conductivity	4.4E-02

Falling Head Test - Data Reduction Calculation Sheet

Field Engineer/Geologist:	ABP	5/29/2015
Calculated By:	ALC	6/3/2015
Checked By:	ABP	6/5/2015
Approved By:		

Project Number:	**15113**
Boring:	**B-101**
Test Number:	**K-2**

Depth to top of Ground Water	3.4	ft bgs
Casing Stickup	2.3	ft
Top Depth of Test Interval	18.0	ft bgs
Bottom Depth of Test Interval	18.5	ft bgs
Inside Diameter Pipe	4.25	in
D = Diameter, intake, sample	7.75	in
L = Length, intake, sample	0.5	ft
M = Transformation Ratio	1.00	--



Depth to Water Surface In Pipe From Top of Casing Stickup	Time, t	Time, t	Piezometric head at time, H	Incremental		From Time Zero	
				Permeability	Permeability	Permeability	Permeability
(ft)	(min)	(sec)	(ft)	(ft/s)	(cm/s)	(ft/s)	(cm/s)
0.30	0.0	0	5.4	--	--	--	--
0.90	0.3	18	4.8	1.46E-04	4.46E-03	1.46E-04	4.46E-03
1.80	0.5	32	3.9	3.31E-04	1.01E-02	2.27E-04	6.92E-03
2.60	0.9	56	3.1	2.14E-04	6.51E-03	2.21E-04	6.75E-03
3.10	1.3	76	2.6	1.96E-04	5.99E-03	2.15E-04	6.55E-03
3.40	1.5	90	2.3	1.96E-04	5.96E-03	2.12E-04	6.46E-03
3.70	1.8	105	2.0	2.08E-04	6.34E-03	2.11E-04	6.44E-03
4.20	2.1	125	1.5	3.21E-04	9.79E-03	2.29E-04	6.98E-03
4.50	2.3	140	1.2	3.32E-04	1.01E-02	2.40E-04	7.32E-03
4.80	3.0	180	0.9	1.61E-04	4.90E-03	2.22E-04	6.78E-03
4.90	3.3	195	0.8	1.75E-04	5.35E-03	2.19E-04	6.67E-03
4.90	3.5	210	0.8	0.00E+00	0.00E+00	2.03E-04	6.19E-03
5.00	3.8	225	0.7	1.99E-04	6.06E-03	2.03E-04	6.18E-03
5.10	4.3	255	0.6	1.15E-04	3.50E-03	1.92E-04	5.87E-03
5.20	4.7	280	0.5	1.63E-04	4.97E-03	1.90E-04	5.79E-03
5.30	5.0	300	0.4	2.49E-04	7.60E-03	1.94E-04	5.91E-03
5.40	5.3	315	0.3	4.28E-04	1.31E-02	2.05E-04	6.25E-03
5.50	6.0	360	0.2	2.01E-04	6.14E-03	2.05E-04	6.23E-03
5.60	7.0	420	0.1	2.58E-04	7.87E-03	2.12E-04	6.47E-03
5.70	7.5	450	0.0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
5.70	8.7	520	0.0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Estimated Permeability				**3.5E-03**	**to**	**1.3E-02**	**(cm/sec)**
Geometric Mean of Incremental Permeability (0 min to 9 min)					**6.6.E-03**	**(cm/sec)**	

(1) The boring caved at 18.5 feet below the ground surface.
(2) Calculations are from Hvorslev printed in Lambe & Whitman, Soil Mechanics, 1969, pp 285, case G.

APPENDIX F

LABORATORY TEST RESULTS

HP Geotech

Hepworth-Pawlak Geotechnical, Inc.
10302 South Progress Way
Parker, Colorado 80134
Phone: 303-841-7119

Fax: 303-841-7556
email: hpgeo2@hpgeotech.com

June 9, 2015

Andrea Christians
RJH Consultants, Inc.
9800 Mt. Pyramid Court, Suite 330
Englewood, Colorado 80112

215153B

Subject: Laboratory Tests Results for Gila River Diversion
Project 15113

Ms. Christians:

This letter presents the results of laboratory tests performed on samples submitted for the subject project. The test results are presented on the attached Figure.

If there are any questions, please feel free to contact us.

Sincerely,

HEPWORTH-PAWLAK GEOTECHNICAL, Inc.

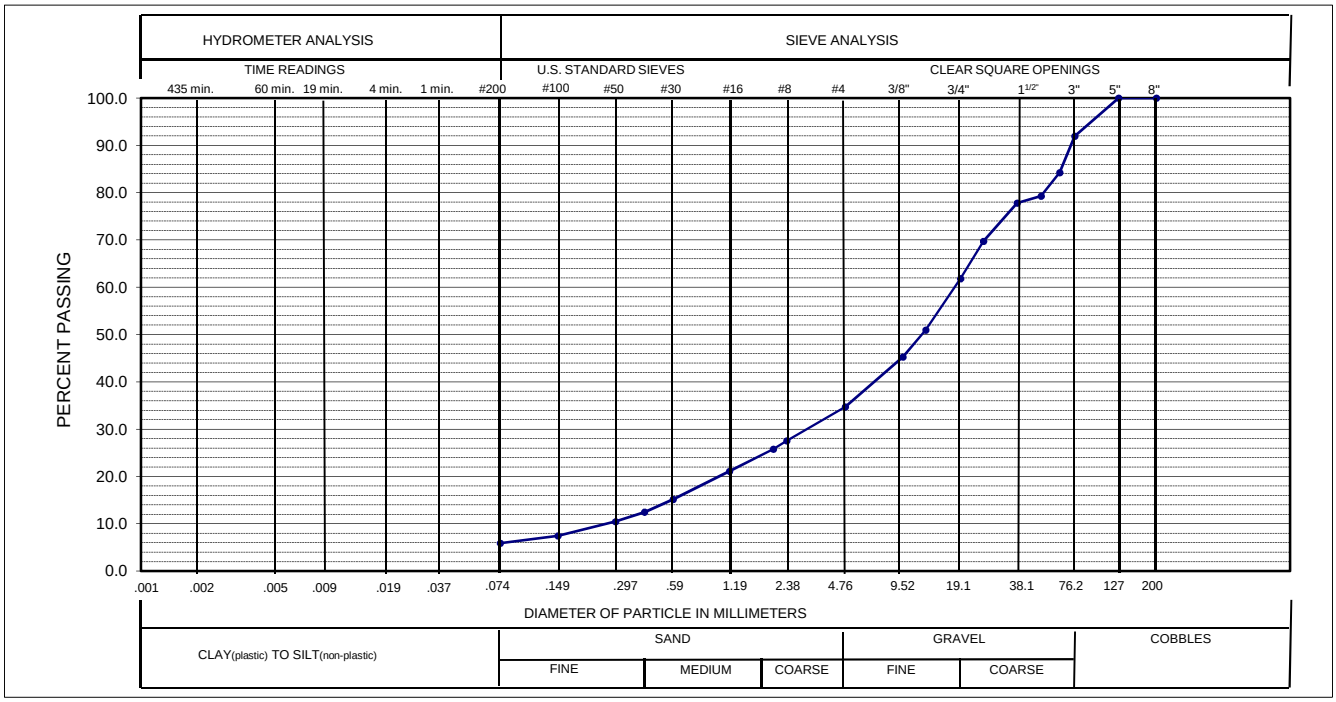
Corynne Cromwell

Reviewed by:

Arben Kalaveshi, P.E.

Attachments: Figure 1 Gradation Analysis

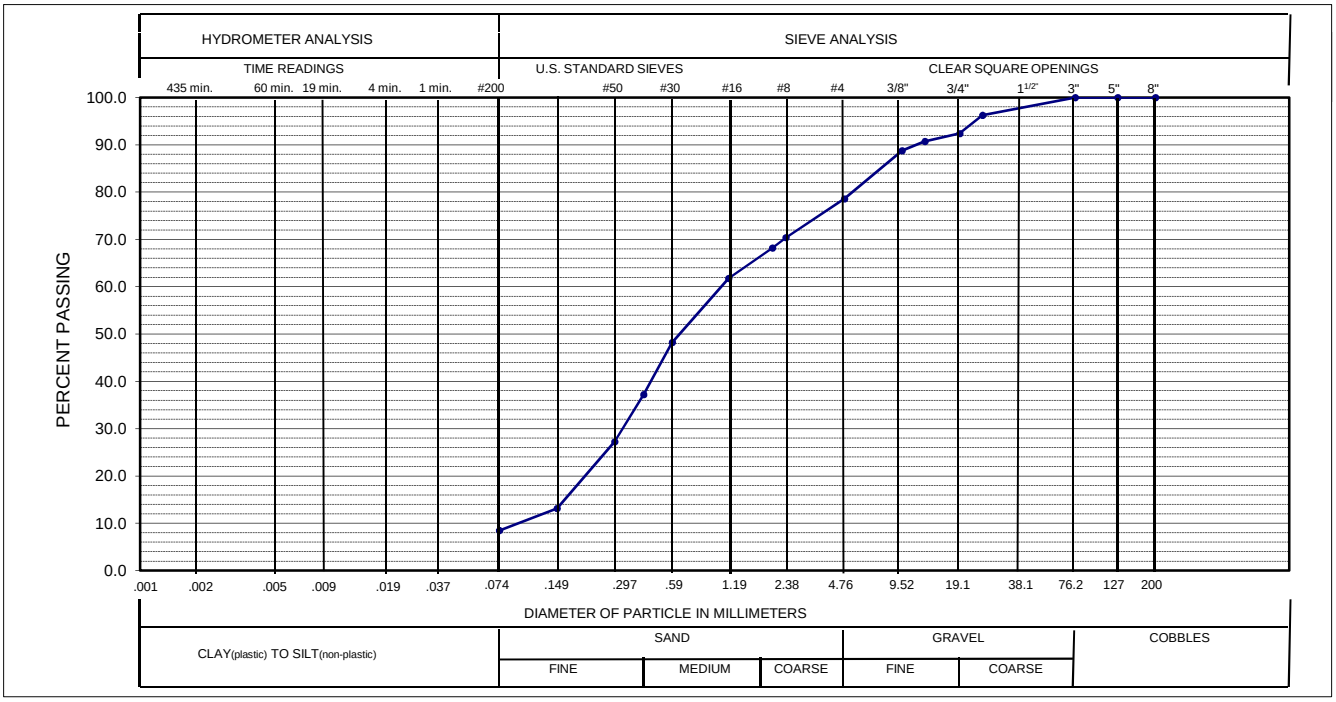
215153B xmittal.doc



COBBLE: 8% GRAVEL: 57% SAND: 29% SILT AND CLAY: 6%

LIQUID LIMIT: ~ PLASTICITY INDEX: ~

SAMPLE OF: Well Graded Gravels (GW) BORING: at 0-30' feet



GRAVEL: 21% SAND: 71% SILT AND CLAY: 8%

LIQUID LIMIT: ~ PLASTICITY INDEX: ~

SAMPLE OF: Poorly Graded Sand With Silts (SP-SM) BORING: 48.2-49.5 feet

215153B	HEPWORTH-PAWLAK GEOTECHNICAL, Inc.	Gila River Diversion Project GRADATION ANALYSIS	FIG. 1