GEO-TEST

GEOTECHNICAL
ENGINEERING SERVICES
JOB NO. 1-90801
COUNTY ROAD 54-LOS PINOS ROAD
ALL WEATHER CROSSING AT ARROYO HONDO
SANTA FE COUNTY, NEW MEXICO

PREPARED FOR:

LOUIS BERGER U.S., INC.

GEO-TEST, INC.
3204 RICHARDS LANE
SANTA FE,
NEW MEXICO
87507
(505) 471-1101
FAX (505) 471-2245

8528 CALLE ALAMEDA NE
ALBUQUERQUE,
NEW MEXICO
87113
(505) 857-0933
FAX (505) 857-0803

2805-A LAS VEGAS CT.
LAS CRUCES,
NEW MEXICO
88007
(575) 526-6260
FAX (575) 523-1660

GEO-TEST

October 14, 2019
Job No.1-90801

Louis Berger U.S., Inc.
2019 Galisteo Street, Suite M-1
Santa Fe, New Mexico 87505

ATTN: Mr. Richard Rotto, PE
Associate Vice President

RE: Geotechnical Engineering Services Report
County Road 54-Los Piños Road
All Weather Crossing at Arroyo Hondo
Santa Fe County, New Mexico

Dear Mr. Rotto:

Submitted herein is the Geotechnical Engineering Services Report for the above referenced project. The report contains the results of our field investigation, laboratory testing, and recommendations for culvert design, as well as criteria for site grading.

It has been a pleasure to serve you on this project. If you should have any questions, please contact this office.

Respectfully submitted:

GEO-TEST, INC.

Timothy Matson, Staff Engineer

Reviewed by:

Robert D Booth, P.E.

ROBERT D. BOOTH NEW MEXICO 5711 LICENSED PROFESSIONAL ENGINEER

cc: Addressee

GEO-TEST, INC.
3204 RICHARDS LANE
SANTA FE,
NEW MEXICO
87507
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FAX (505) 471-2245

8528 CALLE ALAMEDA NE
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FAX (505) 857-0803

2805-A LAS VEGAS CT.
LAS CRUCES,
NEW MEXICO
88007
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FAX (575) 523-1660

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GEO-TEST, INC.
3204 RICHARDS LANE
SANTA FE,
NEW MEXICO
87507
(505) 471-1101
FAX (505) 471-2245

8528 CALLE ALAMEDA NE
ALBUQUERQUE,
NEW MEXICO
87113
(505) 857-0933
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LAS CRUCES,
NEW MEXICO
88007
(575) 526-6260
FAX (575) 523-1660

INTRODUCTION

This report presents the results of the geotechnical engineering services investigation performed for the proposed new box culvert to be constructed under County Road 54-Los Piños Road at Arroyo Hondo in Santa Fe County, New Mexico.

The objectives of this investigation were to:

1) Evaluate the nature and engineering properties of the subsurface soils underlying the site.

2) Provide recommendations for the design of the proposed box culvert including foundation preparation, as well as criteria for site grading.

.
The investigation includes subsurface exploration, selected soil sampling, laboratory testing of the samples, performing an engineering analysis and preparation of this report.

PROPOSED CONSTRUCTION

It is understood that the project includes the removal of three existing, 30-inch diameter CMP's and replacement with a 6 barrel 12'x8'x32' cast-in-place concrete box culvert (CBC) at the Arroyo Hondo. The new box culvert will be oriented at a 30-degree skew to the roadway and headwalls will be constructed on the upstream and downstream ends of the culvert. The base of the new CBC will be founded at a depth of about 7 feet below existing site grades at the centerline of the existing roadway. A detour will be constructed on the downstream side of the existing crossing to divert traffic around the area during construction.

Should foundation loads or other project details vary significantly from those outlined above, this firm should be notified for review and possible revision of the recommendations contained herein.

FIELD EXPLORATION

Two exploratory borings were drilled at the site to depths of approximately 20½ feet below existing site grades. The locations of the borings are shown on the attached Boring Location Map, Figure 1. Drilling was accomplished with a truck mounted drill rig using 5.5-inch diameter continuous flight hollow stem auger. Subsurface materials were sampled at five-foot intervals or less in the borings utilizing an open tube split barrel sampler driven by a

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87113
(505) 857-0933
FAX (505) 857-0803

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LAS CRUCES,
NEW MEXICO
88007
(575) 526-6260
FAX (575) 523-1660

standard penetration test hammer.

LABORATORY TESTING

Selected soil samples were tested in the laboratory to determine certain engineering properties of the soils. Moisture contents were determined to evaluate the various soil deposits with depth. The results of these tests are shown on the boring logs.

Sieve analysis and Atterberg limits tests were performed to aid in soil classification. Results of these tests are presented in the Summary of Laboratory Results and on the individual test reports presented in a following section of this report.

SITE CONDITIONS

A brief site reconnaissance was performed during our site exploration. The site is located where the Arroyo Hondo crossing County Road 54-Los Piños Road. The channel is well defined and flows from east to west at the crossing. Native shrubs, weeds and tumbleweeds were observed in the arroyo and on the roadway embankments. A mangled chain link fence or possibly an old gabion basket was observed on the downstream side of the crossing.

SUBSURFACE SOIL CONDITIONS

As indicated by the exploratory borings, the soils encountered in borings consist of a surface layer comprised of interbedded silty sand and relatively clean sand, both with various amounts of gravel. These soils are non-plastic and range from medium dense to loose and extend to depths ranging from 5 to 10 feet below existing site grades. Below the interbedded granular soils, sandy clay was encountered and extended depths ranging from about 12 to 17½ feet below existing site grade. These soils were generally of medium plasticity and soft. Below the sandy clay, interbedded silty sand and relatively clean sand were encountered and extended to full depth explored in boring no. 2 and to around 18 feet in boring no. 1. These soils were non-plastic and range from loose to medium dense. Below the interbedded silty sand and sand in boring no.1, sandy clay was encountered and extended to full depth explored. These soils were of medium plasticity and moderately firm.

No free groundwater was encountered in the borings and soil moisture contents were generally low in the granular soils and moderate to high in the clayey soils. After removing the auger from boring no. 1, the hole collapsed

GEO-TEST, INC.
3204 RICHARDS LANE
SANTA FE,
NEW MEXICO
87507
(505) 471-1101
FAX (505) 471-2245

8528 CALLE ALAMEDA NE
ALBUQUERQUE,
NEW MEXICO
87113
(505) 857-0933
FAX (505) 857-0803

2805-A LAS VEGAS CT.
LAS CRUCES,
NEW MEXICO
88007
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to about 13 feet below existing site grade. The boring was left open for 48 hours and groundwater was not observed in the hole. Since the site is located in an arroyo, the groundwater levels may fluctuate seasonally and could be higher or lower during certain times of the year.

CONCLUSIONS AND RECOMMENDATIONS

As indicated by the standard penetration test data, the soils near the base of the proposed box culvert are loose and soft and possess relatively high moisture contents. Foundations bearing on these soils may be susceptible to excessive differential settlements, particularly upon significant moisture increases. However, with site preparation and very careful moisture protection, as recommended in a following section of this report, the proposed CBC can be supported on a mat foundation bearing directly on properly compacted structural fill. The headwalls can be supported on shallow spread-type footings but should also be founded on properly compacted structural fill.

The site preparation would involve an overexcavation of the existing soils throughout the area to such an extent as to provide for at least 18 inches of properly compacted, non-expansive structural fill below all foundations. The limits of the overexcavation should also extend laterally from the foundation perimeters a distance equal to the depth of fill beneath their bases. The exposed native soils at the base of the excavation should be densified prior to placement of structural fill. If the bottom of the overexcavation is wet, soft and unstable and cannot be compacted, the cut surface should be stabilized as outlined in the Site Grading section of this report. Detailed recommendations for foundation design and the required site grading are presented in the following sections of this report.

FOUNDATIONS

The base of the culvert should be designed to act as a self-supporting mat-type foundation. An allowable soil bearing pressure of 1,500 pounds per square foot should not be exceeded based on the site preparation as recommended in a following section of this report. The minimum recommended depth of the mat foundation should be 2.0 feet below lowest adjacent finished grade.

Shallow spread-type footings for the support of the headwalls at the ends of the culvert should also bear on a minimum thickness of 18 inches of properly compacted, non-expansive structural fill. An allowable soil bearing pressure of 1,500 pounds per square foot is recommended for the design of shallow spread-type footings. The minimum width of continuous footings

GEO-TEST, INC.
3204 RICHARDS LANE
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FAX (505) 471-2245

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ALBUQUERQUE,
NEW MEXICO
87113
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FAX (505) 857-0803

2805-A LAS VEGAS CT.
LAS CRUCES,
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88007
(575) 526-6260
FAX (575) 523-1660

should be 1.33 feet. Footings should be established a minimum 2.0 feet below the lowest adjacent grade.

In order to minimize the potential for scour of erosion beneath the foundations, concrete cut-off walls should be constructed at the upstream and downstream ends of the box culvert and at the arroyo side the spread footings supporting the headwalls. The cut-off walls should be a minimum or 12 inches wide and extend to a depth of 3 feet below the base of the foundations or to a minimum of 12 inches into the underlying sandy clay soils, whichever is the lesser depth.

The bearing values recommended above apply to full dead load plus realistic live loads and can be safely increased by one-third for loading of short durations such as wind or seismic forces.

Settlement of the box culvert or headwall foundations designed and constructed as recommended herein are estimated not to exceed 1.0 inch for the soil moisture contents encountered during test drilling or compaction moisture contents introduced during construction. Differential movements are estimated not to exceed 75 percent of total movements.

LATERAL LOADS

Resistance to lateral forces will be provided by soil friction between the base of the mat and footing supporting the headwalls and the soils and by passive earth pressure against the sides of the culvert and footings. A coefficient of friction of 0.40 should be used for computing the lateral resistance between the base of the culvert and footing and the soil. With backfill as recommended in the site grading section of this report, a passive resistance equivalent to a fluid weighing 325 pounds per square foot per foot of depth for the full height of the embankment above the box. The roof of the box should be designed to resist the full weight of the embankment above the culvert plus any surcharge loads including traffic.

Lateral earth pressures against the sides of the culvert and the headwalls at the ends of the culvert will depend on the degree of restraint. Walls which are restrained so as to limit movement at the top to less than 0.001 times the height of the wall should be designed for "at rest" earth pressures of 55 pounds per square foot per foot of depth. Walls free to move at the top should be designed for an "active" earth pressure equal to 35 pounds per square foot per foot of depth.

The recommended lateral earth pressures are applicable to a condition of horizontal backfill without surcharge loads or hydrostatic forces. Analysis of

GEO-TEST, INC.
3204 RICHARDS LANE
SANTA FE,
NEW MEXICO
87507
(505) 471-1101
FAX (505) 471-2245

8528 CALLE ALAMEDA NE
ALBUQUERQUE,
NEW MEXICO
87113
(505) 857-0933
FAX (505) 857-0803

2805-A LAS VEGAS CT.
LAS CRUCES,
NEW MEXICO
88007
(575) 526-6260
FAX (575) 523-1660

earth pressures produced by sloping backfill or surcharge loads can be provided by this firm upon request. The pressures assume no build up of hydrostatic pressures behind the walls. To prevent the buildup of hydrostatic pressures, adequate weep holes should be provided or composite drainage systems such as Miradrain or equivalent can be installed on the backside of the walls prior to backfilling. The drainage layer would be connected to a collector pipe at the base of the wall and routed to a sump or to a positive gravity drain.

Retaining wall backfill should meet the structural fill specifications outlined in the Site Grading section of this report. During backfilling, the contractor should be limited to the use of hand operated compaction equipment within a zone of about 3 feet horizontally from the back of the walls. The use of heavier equipment could apply lateral pressures well in excess of the recommended design earth pressure, particularly over the upper portions of the walls.

SITE GRADING

The following guidelines should be included in the project construction specifications to provide a basis for quality control during site grading. It is recommended that all structural fill and backfill be placed and compacted under engineering observation and in accordance with the following:

1) After demolition and removal of the existing CMP culverts, the existing site soils throughout the site should be overexcavated to such an extent as to remove all loosened or disturbed soils and to provide for at least 18 inches of properly compacted structural fill beneath the new mat foundation and footings supporting the headwalls. The overexcavation limits should extend laterally beyond the foundation perimeters equal to the depth of fill beneath their bases. After the required overexcavation, the exposed cut surface should be densified. Densification of the exposed cut surface should consist of moisture conditioning (wetting or drying) to near the optimum moisture content and compacting the subgrade to a minimum of 95 percent of maximum dry density as determined in accordance with ASTM D-698 for clay soils or ASTM D1557 for granular soils.

2) If the bottom of the overexcavation is wet, soft and unstable and cannot be compacted to the above requirements, the cut surface should be stabilized by working pit run gravel into the subgrade to create a stable surface. Stabilization could also be achieved with the

GEO-TEST, INC.
3204 RICHARDS LANE
SANTA FE,
NEW MEXICO
87507
(505) 471-1101
FAX (505) 471-2245

8528 CALLE ALAMEDA NE
ALBUQUERQUE,
NEW MEXICO
87113
(505) 857-0933
FAX (505) 857-0803

2805-A LAS VEGAS CT.
LAS CRUCES,
NEW MEXICO
88007
(575) 526-6260
FAX (575) 523-1660

use of geo-grid reinforcement.

3) The results of this investigation indicate that most of the overexcavated soils will be suitable for use as structural fill; however, some blending may be required to meet the gradation specification below. Any imported material should also meet the specification for structural fill. All structural fill or backfill material should be free of vegetation and debris and contain no rocks larger than 3 inches. Gradation of the structural fill or backfill material, as determined in accordance with ASTM D-422, should be as follows:

Size	Percent Passing
3-inch	100
No. 4	60 - 100
No. 200	15 - 50

4) The plasticity index should be no greater than 15 when tested in accordance with ASTM D-4318.

5) Fill or backfill, shall be placed in 8-inch loose lifts and compacted with approved compaction equipment. Loose lifts should be reduced to 4 inches if hand-held compaction equipment is used. Each lift should be firm and non-yielding. All compaction of fill or backfill shall be accomplished to a minimum of 95 percent of the maximum dry density as determined in accordance with ASTM D-1557. The moisture content of the structural fill during compaction should be within 2 percent of the optimum moisture content.

6) Tests for degree of compaction should be determined by the ASTM D-1556 method or ASTM D-6938. Observation and field tests should be carried on during fill and backfill placement by the geotechnical engineer to assist the contractor in obtaining the required degree of compaction. If less than 95 percent is indicated, additional compaction effort should be made with adjustment of the moisture content as necessary until 95 percent compaction is obtained.

MOISTURE PROTECTION

Precautions should be taken during and after construction to minimize moisture increase of near surface foundation soils. Accumulations of excessive moisture can weaken or cause other changes in the soils

GEO-TEST, INC.
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SANTA FE,
NEW MEXICO
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8528 CALLE ALAMEDA NE
ALBUQUERQUE,
NEW MEXICO
87113
(505) 857-0933
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2805-A LAS VEGAS CT.
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supporting the foundations. This can cause differential movement of the foundations and can result in cosmetic or structural damage to the culvert or headwalls.

Positive drainage should be established away from the culvert headwalls. A typical adequate slope is 6 inches in the first 5 feet with positive drainage being provided from those points to streets, pavement or natural water courses. If necessary, to provide positive drainage, the drainage area should be raised above adjacent grades with structural fill.

The foregoing recommendations should only be considered minimum requirements for overall site development. It is recommended that a civil/drainage engineer be consulted for more detailed grading and drainage recommendations.

FOUNDATION REVIEW AND INSPECTION

This report has been prepared to aid in the evaluation of this site and to assist in the design of this project. It is recommended that the geotechnical engineer be provided the opportunity to review the final design drawings and specifications in order to determine whether the recommendations in this report are applicable to the final design. Review of the final design drawings and specifications should be noted in writing by the geotechnical engineer.

In order to permit correlation between the conditions encountered during construction and to confirm recommendations presented herein, it is recommended that the geotechnical engineer be retained to perform continuous observations and testing during the earthwork portion of this project. Observation and testing should be performed during construction to confirm that suitable fill soils are placed upon competent materials and properly compacted and foundation elements penetrate the recommended soils.

CLOSURE

Our conclusions, recommendations and opinions presented herein are:

1) Based upon our evaluation and interpretation of the findings of the field and laboratory program.

2) Based upon an interpolation of soil conditions between and beyond the explorations.

GEO-TEST, INC.
3204 RICHARDS LANE
SANTA FE,
NEW MEXICO
87507
(505) 471-1101
FAX (505) 471-2245

8528 CALLE ALAMEDA NE
ALBUQUERQUE,
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87113
(505) 857-0933
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2805-A LAS VEGAS CT.
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88007
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3) Subject to confirmation of the conditions encountered during construction.

4) Based upon the assumption that sufficient observation will be provided during construction.

5) Prepared in accordance with generally accepted professional geotechnical engineering principles and practice.

This report has been prepared for the sole use of WSP USA, specifically, to aid in the design of the proposed all weather crossing on County Road 54-Los Piños Road at the Arroyo Hondo crossing in Santa Fe County, New Mexico, and not for use by any third parties.

We make no other warranty, either express or implied. Any person using this report for bidding or construction purposes should perform such independent investigation as he deems necessary to satisfy himself as to the surface and subsurface conditions to be encountered and the procedures to be used in the performance of work on this project. If conditions encountered during construction appear to be different than indicated by this report, this office should be notified.

All soil samples will be discarded 60 days after the date of this report unless we receive a specific request to retain the samples for a longer period.

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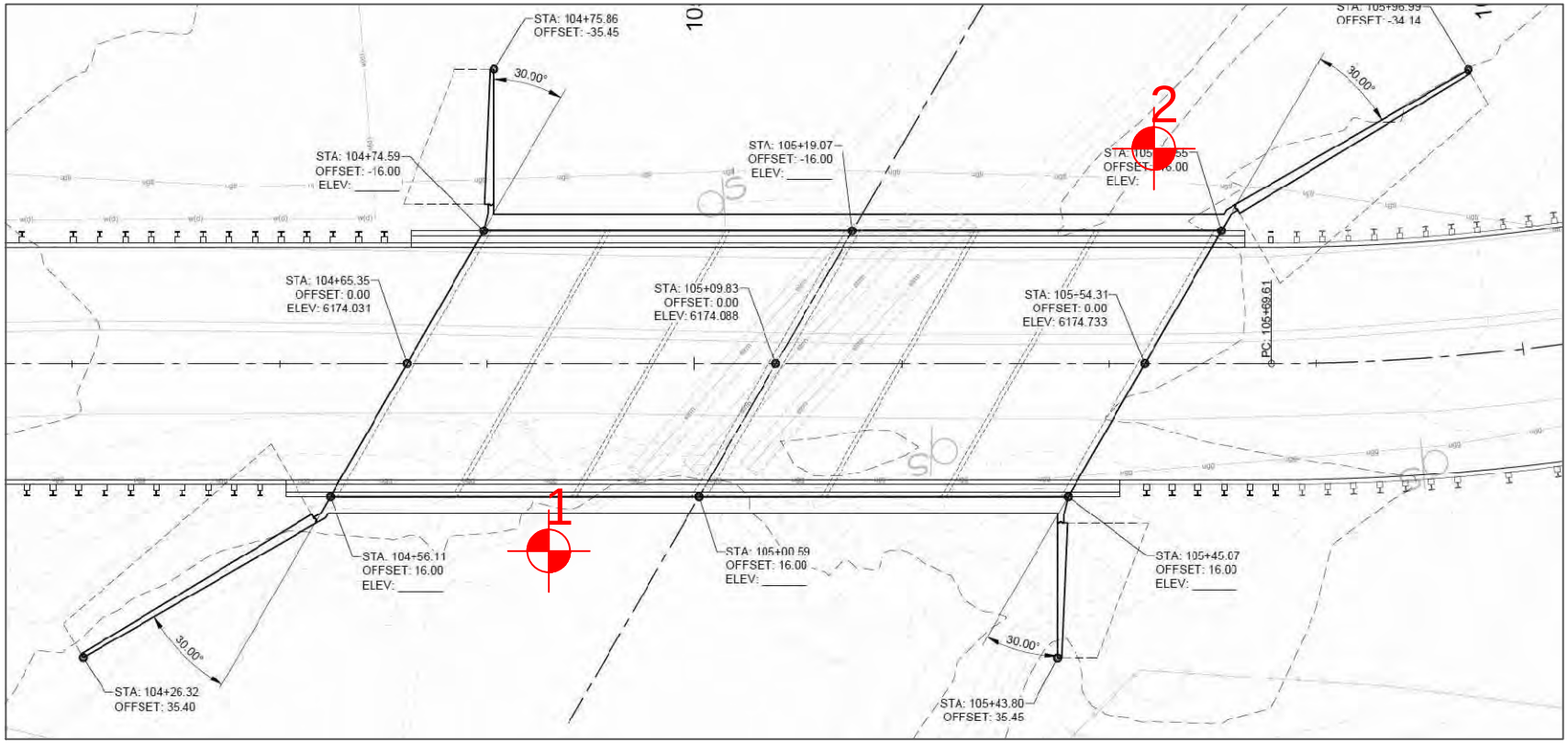
3204 RICHARDS LANE
SANTA FE,
NEW MEXICO
87507
(505) 471-1101
FAX (505) 471-2245

8528 CALLE ALAMEDA NE
ALBUQUERQUE,
NEW MEXICO
87113
(505) 857-0933
FAX (505) 857-0803

2805-A LAS VEGAS CT.
LAS CRUCES,
NEW MEXICO
88007
(575) 526-6260
FAX (575) 523-1660

BORING LOCATION MAP



All Weather Crossing-County Road 54
Santa Fe County, New Mexico
Job No. 1-90801

Figure 1

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GEOTECHNICAL ENGINEERING
AND MATERIAL TESTING

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Project: County Road 54 All Weather Crossing
Date: 09/24/2019 Project No: 1-90801
Elevation: 6162' Type: 5.5" OD HSA

LOG OF TEST BORINGS

GROUNDWATER DEPTH

NO: 1

During Drilling: none After 48 Hours: none

DEPTH (Ft)	LOG	SAMPLE INTERVAL	TYPE	N. BLOWS/FT	MOISTURE %	DRY DENSITY (pcf)	USC	DESCRIPTION	N blows/ft (20 40 60 80)
			SS	10-10-16 26	3		SM	SILTY SAND with GRAVEL, non-plastic, medium dense, dry, brown	26
5			SS	5-6-2 8	5 21				8
							CL	SANDY CLAY, medium plasticity, soft, moist to very moist, brown	
10			SS	3-3-3 6	29				6
							SM	SILTY SAND, fine to medium grained, non-plastic, loose, moist, brown	
15			SS	6-5-4 9	11				9
							CL	SANDY CLAY, medium plasticity, moderately firm, very moist to wet, brown	
20			SS	3-6-7 13	30				13
								Stopped Auger @ 19 feet Stopped Sampler @ 20.5 feet	
25									

LOG OF TEST BORING 1-90801 COUNTY ROAD 54 AT LOS PINOS-ALL WEATHER CROSSING AT ARROYO HONDO, SANTA FE.GPJ GEO TEST.GDT 10/8/19

LEGEND

SS - Split Spoon
AC - Auger Cuttings
UD/SL - Undisturbed Sleeve
AMSL - Above Mean Sea Level
CS - Continuous Sampler
UD - Undisturbed
ST - Shelby Tube

Stratification lines represent approximate boundaries between soil types. Transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to factors other than those present at the time measurments were made.

GEO-TEST

Project: County Road 54 All Weather Crossing
Date: 09/13/2019 Project No: 1-90801
Elevation: Type: 5.5" OD HSA

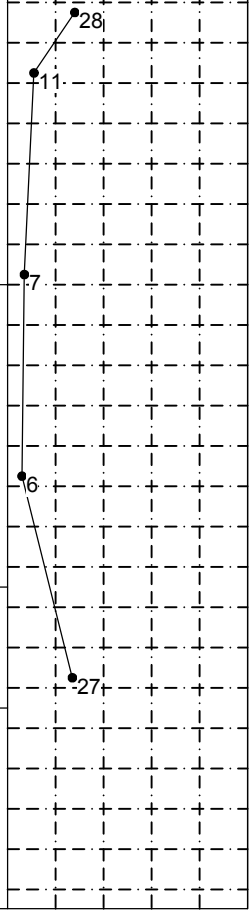
LOG OF TEST BORINGS

GROUNDWATER DEPTH

NO: 2

During Drilling: none After 24 Hours:

DEPTH (Ft)	LOG	SAMPLE INTERVAL	TYPE	N. BLOWS/FT	MOISTURE %	DRY DENSITY (pcf)	USC	DESCRIPTION
5			SS	6-12-16 28	3		SW-SM	SAND with SILT, fine to coarse grained, some gravel, non-plastic, medium dense, dry, brown
			SS	6-6-5 11	3			
10			SS	12-4-3 7	4 27		CL	SANDY CLAY, medium plasticity, soft, moist to very moist, brown
15			SS	4-3-3 6	24			
20			SS	10-10-17 27	2		SW-SM	SAND with SILT, fine to medium grained, non-plastic, medium dense, dry, brown
25								Stopped Auger @ 19 feet Stopped Sampler @ 20.5 feet



LOG OF TEST BORING 1-90801 COUNTY ROAD 54 AT LOS PINOS-ALL WEATHER CROSSING AT ARROYO HONDO, SANTA FE.GPJ GEO TEST.GDT 10/8/19

LEGEND

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AC - Auger Cuttings
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SUMMARY OF LABORATORY RESULTS

						SIEVE ANALYSIS PERCENT PASSING											
TEST HOLE	DEPTH (FEET)	UNIFIED CLASS	(%) MOIST	LL	PI	NO 200	NO 100	NO 40	NO 10	NO 4	3/8"	1/2"	3/4"	1"	1 1/2"	2"	4"
1	3.0		3.4														
1	4.5	SM	5.5	NP	NP	16	26	47	76	83	87	88	88	100			
1	5.3		21.3														
1	10.0	CL	28.7	37	16	61	74	90	98	100							
1	15.0		10.5														
1	20.0		30.0														
2	2.5		3.4														
2	5.0	SW-SM	3.4	NP	NP	6	9	25	73	93	98	99	100				
2	9.5		4.1														
2	10.3		27.0														
2	15.0	CL	24.3	37	14	60	71	81	92	97	100						
2	20.0	SW-SM	2.3	NP	NP	6	10	28	76	90	98	100					

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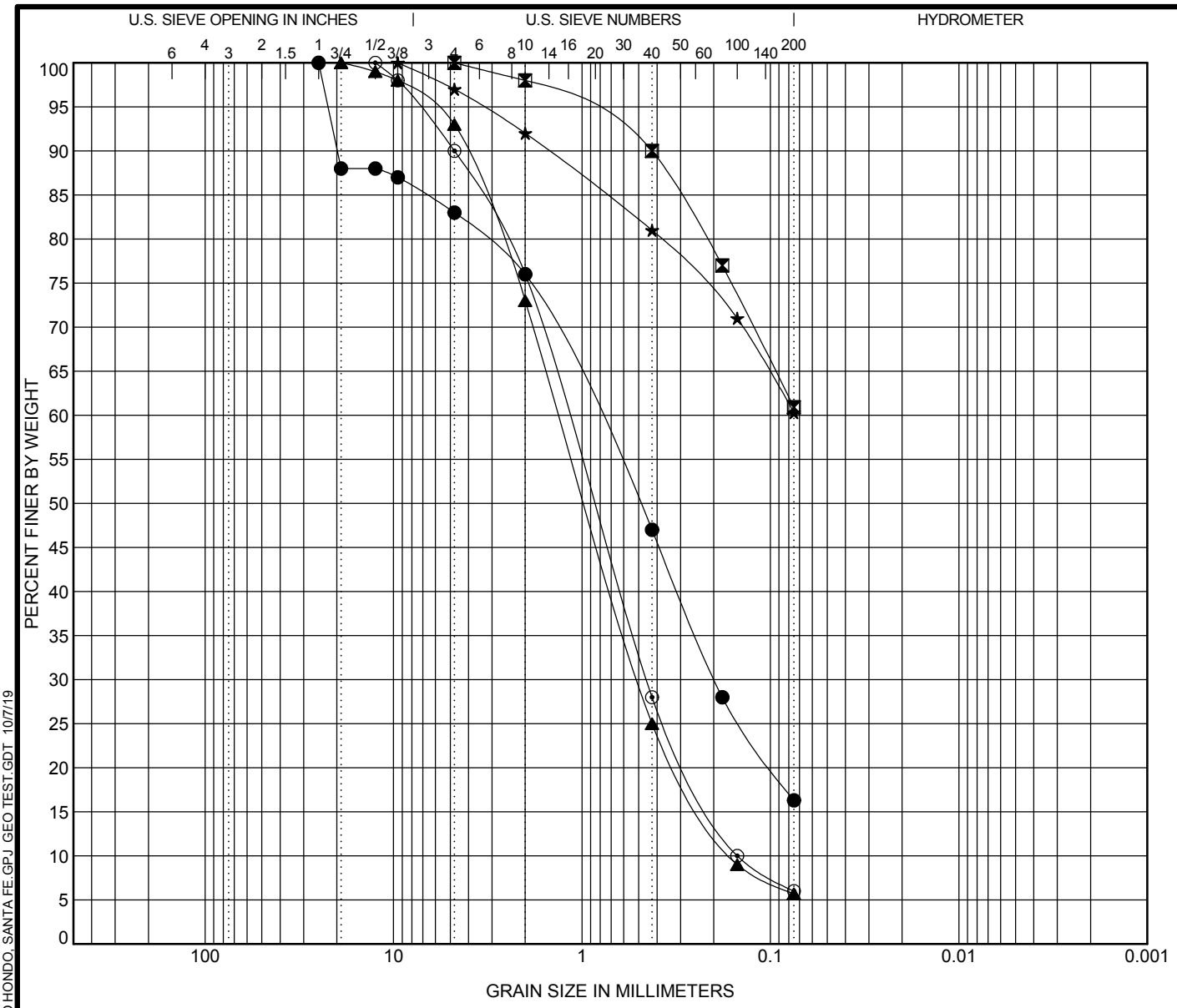
LL = LIQUID LIMIT
PI = PLASTICITY INDEX
NP = NON PLASTIC or NO VALUE

Project: County Road 54 All Weather Crossing

Location: Santa Fe County, New Mexico

Number: 1-90801

SUMMARY OF LABORATORY RESULTS 1-90801 COUNTY ROAD 54 AT LOS PINOS-ALL WEATHER CROSSING AT ARROYO HONDO, SANTA FE.GPJ GEO TEST.GDT 10/7/19



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	1	4.5	**SILTY SAND with GRAVEL(SM)**	**NP**	**NP**	**NP**		
⊠	1	10.0	**SANDY LEAN CLAY(CL)**	**37**	**21**	**16**		
▲	2	5.0	**WELL-GRADED SAND with SILT(SW-SM)**	**NP**	**NP**	**NP**	**1.18**	**8.21**
★	2	15.0	**SANDY LEAN CLAY(CL)**	**37**	**23**	**14**		
⊙	2	20.0	**WELL-GRADED SAND with SILT(SW-SM)**	**NP**	**NP**	**NP**	**1.15**	**7.96**

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	1	4.5	**25**	**0.851**	**0.197**		**17.0**	**66.7**	**16.3**	
⊠	1	10.0	**4.75**				**0.0**	**39.1**	**60.9**	
▲	2	5.0	**19**	**1.315**	**0.499**	**0.16**	**7.0**	**87.3**	**5.7**	
★	2	15.0	**9.5**				**3.0**	**36.7**	**60.3**	
⊙	2	20.0	**12.5**	**1.193**	**0.453**	**0.15**	**10.0**	**84.0**	**6.0**	

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GRAIN SIZE DISTRIBUTION

Project: County Road 54 All Weather Crossing

Location: Santa Fe County , New Mexico

Number: 1-90801

US GRAIN SIZE 1-90801 COUNTY ROAD 54 AT LOS PINOS-ALL WEATHER CROSSING AT ARROYO HONDO, SANTA FE.GPJ GEO TEST.GDT 10/7/19