REVISED
GEOTECHNICAL AND PAVEMENT DESIGN REPORT
LEES FERRY ACCESS ROAD IMPROVEMENTS
AZ PRA GCLA 5(2)

GLEN CANYON NATIONAL RECREATION AREA
COCONINO COUNTY, ARIZONA

January 16, 2012
YA Project No. 211-052

Prepared for:
HDR
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Denver, CO 80203-1256
and
Federal Highway Administration
Central Federal Lands Highway Division
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Lakewood, Colorado 80228

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Prepared by:

for

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Sr. Geotechnical Engineer

Reviewed by:

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APPENDICES

1.0 PURPOSE AND SCOPE OF STUDY

Yeh and Associates, Inc. was retained by HDR, to provide geotechnical pavement recommendations for preliminary and final design of improvements to the Lees Ferry Access Road in the Glen Canyon National Recreation Area (GCLA) near Page, Arizona. Lees Ferry Access Road (AZ PRA GCLA 5(2)) begins at the intersection of US 89 and proceeds northward for approximately 4.5 miles. The route is entirely within the Glen Canyon National Recreational Area in Coconino County. The road is maintained by the National Park Service. The project location is shown on Figure 1.1.

The proposed road reconstruction will consist of replacing/rehabilitating the existing roadway surface with either an asphalt overlay or pulverize and replace the existing asphalt. Erosion along the roadside and will be addressed with roadside ditch improvements, outlet and inlet protection and channel realignments. The project includes minor roadside grading, drainage structures, placement of pulverized base and asphalt pavement, minor signing, striping, and other safety-related features necessary to meet current design practice.

The No Name Wash crossing will have additional cross culverts installed and possibly a low flow crossing to reduce the impacts of flooding. These improvements will be designed and implemented in accordance with National Park Service, CFLHD, and AASHTO Highway Design Standards, in cooperation with the National Park Service, Denver Service Center and Glen Canyon National Recreation Area.

The purpose of the geotechnical investigation is to evaluate geologic and subsurface conditions in the project area and provide recommendations for design of drainage structures and pavements. This report presents the results of the geotechnical investigation along Lees Ferry Road. The design recommendations include pavements, surface and subsurface drainage, grading and corrosivity of soil materials. This report addresses potential geologic hazards and constraints for the proposed improvements, existing pavement conditions along the Lees Ferry Access Road, and includes recommendations for pavement section thickness designs.

Figure 1.1: Project Location Map

2.0 GEOLOGIC SETTING

Lees Ferry Recreational Area is on the southwest section of the Colorado Plateau, near the north end of the Grand Canyon, below the Glen Canyon Dam. The Colorado Plateau is dissected by a series of long north - south trending normal (tension) faults and monoclines, creating a series of smaller plateaus, monocline ridges, and canyons.

The road to Lees Ferry extends north, northeast from its junction with Arizona HWY 89A for approximately 4.5 miles to the Lees Ferry Boat Launch near the confluence of the Colorado and Paria Rivers. The road is located on the Marble Platform, a local geologic feature that makes up the landscape on both sides of the Colorado River Canyon (Marble Canyon) in this area. Along most of the access road alignment, the surrounding and underlying bedrock is the Moenkopi Formation, which consists of dark reddish brown siltstone and mudstone with some thin-bedded, ripple marked limestone. This formation was deposited during the lower Triassic period approximately 245 million years ago. Where the road descends to the Paria River, the bedrock is Permian age Kaibab Limestone that is overlain by alluvial terrace gravel deposits. Beyond the Paria River Bridge, the road crosses silty fluvial delta deposits that extend to the boat launch area at Lee's Ferry.

3.0 SITE CONDITIONS

3.1 Terrain

The site is located in rolling to mountainous desert terrain with sparse vegetation consisting of grasses and shrubs. Numerous rock outcrops and monument features are visible in the surrounding area and adjacent to the roadway. Lees Ferry Access Road has gentle curves and

moderate grades as it traverses the Marble Platform, a broad bench of rolling terrain. As the road descends to the Paria River, the grades steepen and the alignment winds through narrow rock cuts to the canyon floor. The paved access road continues north across the delta formed by the confluence of the Paria and Colorado Rivers for about ½ mile to the parking lot and boat ramp.

3.2 Climate

The Lees Ferry area has a high desert climate typified by low precipitation and great season ranges in temperatures. The average annual precipitation is 6.22 inches, most of which occurs from July through October in the form of summer thunderstorms. Snowfall is typically less than 1 inch per event with no long-term accumulation. High temperatures range from 48.7^{o} F to 103.4^{o} F and low temperatures range from 26.8^{o} F to 72.3^{o} F. The high temperatures are concurrent with the heaviest seasonal use of the Lees Ferry Access Road.

3.3 Pavement Condition

The surface of the two-lane asphalt-paved road is in poor condition. Observed pavement distress includes transverse thermal stress cracks spaced at about 15 to 20 feet and areas where the thermal cracking has progressed to block cracking. Blocks range in size from less than 1 foot to about 5 feet in many locations. The block cracking is most prevalent near the centerline on curves where wheel loads have produced increased lateral forces on the pavement. Figure 3.1 shows typical thermal and block cracking at a curve in the road. The majority of the observed cracks have been filled with bituminous crack sealer. The road has received several chip seal or slurry seal treatments since it was originally paved. The parking lot at the boat ramp received a micro-surfacing treatment in 2010.

Figure 3.1: Thermal and block cracking patterns at a curve.

Approximately one mile north of the intersection with SH 89A, where the road climbs and then descends a saddle south of Cathedral Rock, the pavement is very rough due to ridges and depressions in the asphalt surface. The surface unevenness extends for about ¼-mile through an area reported to have poor surface drainage during heavy seasonal precipitation events. Ditches adjacent the road in this area had been paved with asphalt but the ditch paving is displaced, broken or cracked at several locations. Figure 3.2 shows a section of the distressed ditch pavement on the northbound side about 1.4 miles from SH 89A.

Figure 3.2: Deteriorated ditch pavement, (approx Station 170 - 180)

Isolated areas of pavement settlement were observed at two locations along the access road. Approximately 1.5 miles from SH 89A, near the Cathedral Wash Trailhead, the pavement has settled about 3 inches over a distance of about 20 feet. The pavement surface has not failed but vehicles are noticeably affected when they cross this area at the posted speed. North of the Paria River Bridge is another area of pavement settlement. The asphalt surface is intact but a depression about 4 inches deep for a distance of about 10 feet was observed.

An underground utility line was recently installed beneath the roadway for about 0.75 mile beginning at approximately 3 miles north of SH 89A. The line was installed in the southbound lane and the asphalt patch for the trench is visible.

Surface drainage adjacent to the roadway was recently improved at several locations. The observed improvements include re-grading ditches at culvert inlets and reconstruction of shoulder slopes at the edges of the pavement.

4.0 SUBSURFACE INVESTIGATION

Yeh and Associates contracted with Enviro-Drill, Inc. of Phoenix, Arizona to drill exploratory borings for the geotechnical investigation at the Lees Ferry Access Road. Traffic control during drilling was provided by RoadSafe Traffic Systems of Phoenix, Arizona. The borings were drilled on May 3 and 4, 2011. The locations of the borings are shown on the aerial photo titled "Boring Location Image" in Appendix A. Logs of the borings are shown in Appendix B.

4.1 Exploratory Borings

Borings P-1 through P-22 were drilled near the center of the northbound and southbound travel lanes of the access road. Odd numbered borings were generally located in the northbound lane and even numbered borings were in the southbound lane. Boring P-18 was drilled in the northbound lane to avoid the underground utility in the southbound lane. Boring P-23 was drilled in the boat launch parking lot. The borings were drilled to evaluate subgrade conditions for pavement design and corrosivity of the soils.

The borings were drilled with a truck-mounted CME 75 drilling rig using 8-inch O.D. hollow stem augers. Samples were obtained at selected intervals using a 1.5-inch I.D. split-spoon sampler and a 2-inch I.D. California barrel sampler. The split-spoon and California samplers were driven into the subsoils with a 140-pound hammer falling 30 inches. The number of blows needed to drive the sampler 12 inches constitutes the blow count, N, reported on the Boring Logs (Appendix B). The blow count can be used as a relative measure of the material stiffness or density. Bulk samples of auger cuttings were also obtained from the borings at selected intervals. Upon completion, the borings were backfilled with auger cuttings. The pavement was patched with at least 3 inches of cold asphalt patch mix.

4.2 Laboratory Testing

Samples retrieved during the field exploration were returned to our laboratory for assignment of tests by the project geotechnical engineer. An applicable program of laboratory testing was developed to determine engineering properties of the subsurface materials. Following the completion of the laboratory testing, the field descriptions were confirmed or modified as necessary and boring logs were prepared.

Laboratory tests performed included gradation (ASTM D 421, C 136 and AASHTO T 27), Atterberg limits (AASHTO T 89/T 90), one-dimensional consolidation (ASTM D 2435), moisture content (AASHTO T 265), in-situ dry density (ASTM D 2937), R-value (ASTM D 2844), sulfate content (AASHTO T290), pH (ASTM D 4972/AASHTO T 289) and chloride ion content (ASTM D

4327). Gradation and Atterberg limits test results were used to classify the soils in accordance with the AASHTO classification system and the Unified Soil Classification System (USCS). The swell and consolidation tests were used to evaluate potential settlement or expansion of the on-site soils when wetted. Moisture content and in-situ dry density provide an estimate of the degree of compaction and moisture conditions of the subgrade and underlying materials. Soil R-value is a measure of soil subgrade strength used for pavement design. Tests for soluble sulfate content, pH, resistivity and soluble chlorides are used to evaluate the potential of the soil to be aggressive to concrete and to corrode buried metal. The laboratory test results are presented in Appendix C and on the boring logs in Appendix B. Photos of the pavement conditions and boring locations along the project are presented in Appendix D.

5.0 SUBSURFACE CONDITIONS

The thickness of asphalt pavement encountered in the exploratory borings ranged from 1.5 to 3.5 inches. The measured asphalt thickness includes the Hot Asphalt Concrete Pavement (HACP) and chip seal applications that occurred before and after the HACP was placed. Accurately distinguishing individual layers of the Hot Asphalt Concrete Pavement (HACP) was not possible due to the destructive nature of the drilling process. The thickness of aggregate base course encountered below the asphalt ranged from 2 to 5 inches except in Borings P-20 and P-21 where the base course thickness was 0 inches and 1 inch, respectively. Borings B-21 and B-22 encountered a 6-inch thick layer of crushed shale and/or sandstone fill below the base course. The asphalt surface course and base course thicknesses and brief descriptions of the underlying fill and native subgrade materials are summarized in Table 5.1. Laboratory tests performed on samples of the subgrade soils and bedrock are presented in Appendix C. The relatively soft sandstone/shale bedrock of the Moenkopi Formation will have pavement support characteristics similar to a very stiff to hard soil. These bedrock materials have permeable layers and will soften when wet.

Table 5.1: Pavement and Base Course Thicknesses

Boring	Asphalt (in)	ABC (in)	Fill (ft)	Embankment Fill Description	Natural Subgrade Description
P-1	3	2			Sandstone
P-2	3	3	2.5	Silty Sand w/shale fragments	Sandstone/Shale
P-3	3	4			Sandstone/Shale
P-4	3	4	1	Silty Sand w/shale fragments	Sandstone/Shale
P-5	2.5	3.5	0.5	Silty Sand w/shale fragments	Sandstone/Shale
P-6	3	4			Silty Sand w/shale fragments
P-7	3	4.5			Sandstone/Shale
P-8	3	4			Silty Sand w/shale fragments
P-9	2	4			Silty Sand w/shale fragments
P-10	3	4			Silty Sand w/shale fragments
P-11	3.5	4.5	4.8	Silty sand w/gravel	Sandstone
P-12	3	4.5	4.4	Silty Sand w/shale fragments	
P-13	3	5	0.8	Silty Sand w/shale fragments	Sandstone/Shale
P-14	2.5	4.5	4.4	Silty Sand w/shale fragments	
P-15	3	4	4.4	Silty Sand w/shale fragments	
P-16	3.5	4.5	4.3	Silty Sand w/shale fragments	
P-17	3.5	4			Silty Sand w/ gravel & cobbles
P-18	3	4			Silty Sand w/ gravel & cobbles
P-19	2	3	4.6	Silty Sand w/ gravel & cobbles	
P-20	1.5	0			Silty Sand w/shale fragments
P-21	4	1	0.5	Silty Sand w/shale fragments	Silty Sand
P-22	3	2	0.5	Silty Sand w/shale fragments	Silty Sand
P-23	3	0	15	Sandy Gravel	Silty Sand

Subgrade materials in the south portion of Lees Ferry Road are derived from the surrounding Moenkopi Formation bedrock. The native soil materials consist of silty sand with gravel to cobble size shale fragments. Embankment fill encountered in Borings P-2, P-4, P-5 and P-12

through P-16 is composed of the native soils or fragmented sandstone/shale bedrock that is similar to the native soils. The fill encountered in Boring P-11 contained rounded alluvial gravel in addition to shale fragments. The subgrade materials in this segment of the road have 16 to 48 percent fines consisting of slightly clayey silt, plasticity indices that range from non-plastic to 9 and low expansion potential when wetted. The natural moisture contents of two relatively undisturbed samples obtained from Borings P-4 and P-5 were relatively high and were 12.9 and 13.0 percent, respectively. The natural dry densities of these samples were 128.4 pcf and 114.0 pcf, respectively. The R-value of a bulk sample of the subgrade materials obtained from Boring 4 was 42 and the R-value of the bulk sample from Boring P-10 was 35. Subgrade soils from the southern segment have AASHTO classifications of A-4, A-2-4 and A-1-b with group indices of 0 to1. Borings P-17, P-18 and P-19 encountered silty gravelly sand below the pavement section. These materials (native and embankment fill) are derived from the alluvial terrace gravel deposits that make up the surrounding low hills in this section of the alignment. The gravely sand samples from these borings had 21 to 38 percent fines. Samples from Borings P-17 and P-18 were non-plastic and the sample from Boring P-19 had a plasticity index of 6. A bulk sample form Boring 18 had an R-value of 61. The sample from Boring P-17 had an AASHTO classification of A-2-4, the P-18 sample was A-1-b and the sample from P-19 classified as A-4. These three samples had group indices of 0.

Boring P-20 was located in a narrow rock cut in the Moenkopi Formation, uphill from the Paria River Bridge. The boring encountered subgrade soil consisting of silty to clayey sand with shale fragments. The subgrade soil sample had 30 percent fines, a plasticity index of 7 and an AASHTO classification of A-2-4 with a group index of 0.

Borings P-21, P-22 and P-23 were drilled in the fluvial deposits along the Paria and Colorado Rivers. The native subgrade soils sampled in this area consist of non-plastic silty sand with 16 to 48 percent fines. Borings P-21 and P-22 encountered a 6 inch thick layer of crushed sandstone/shale fill below the asphalt and a thin layer of base course. Boring P-23, located in the boat launch parking lot, encountered about 18 inches of coarse gravel fill below the asphalt. The bulk soil sample from Boring P-21 has an R-value of 64 and an AASHTO classification of A-2-4 with a group index of 0. A relatively undisturbed sample from this boring had a natural moisture content of 3.8 percent and a natural dry density of 105.9 pcf. The silty sand soil encountered in P-22 had a natural moisture content of 13.0 percent, a natural dry density of 107.1 pcf and an AASHTO classification of A-4 with a group index of 0. The bulk sample of the subgrade soil from Boring P-23 was contaminated with the overlying gravel fill. The laboratory AASHTO classification of this soil sample was A-1-b with a group index of 0.

Swell/Consolidation tests run on the soils from this project ranged form -0.037 to -0.076% indicating that there are minimal problems from swelling or collapsing soils in the majority of the project.

6.0 GEOTECHNICAL RECOMMENDATIONS

The sandstone/shale bedrock of the Moenkopi Formation is a relatively soft sedimentary rock composed of thinly bedded sandstone, claystone and siltstone. This bedrock has pavement support characteristics similar to very stiff to hard soil of the same composition. The geotechnical recommendations presented below treat this material as a soil with respect to improvements to drainage, slope grading and pavement subgrade.

6.1 Drainage

Surface drainage adjacent to the existing road embankment is generally good with the exception of the area near Cathedral Rock (Stations 131+00 to 178+00) where the asphalt lining of the ditches has failed or cracked. The depressions and ridges in the pavement surface are probably the result of surface moisture infiltration along permeable layers in the bedrock that has wetted underlying siltstone and claystone layers, causing them to soften and lose strength.

Recommended improvements to surface drainage in this area include re-shaping and relining the ditches with impermeable materials such as HACP, Portland Cement Concrete or a suitable Geosynthetic/Clay Liner. Subsurface drains to intercept infiltrated water before it reaches the pavement are also recommended. The subsurface drains should be designed and constructed similar to CFLHD Standard Detail Drawing C605-50. The depth of the drains should be to at least 1 foot below the bottom of the improved pavement subgrade (see Subgrade Improvement Recommendations below). The drains should be installed on both sides of the road, through the areas of pavement distress.

6.2 Subgrade Improvement

Areas of subgrade-related pavement distress were observed along the access road near Cathedral Rock and along the Paria River fluvial plain. The distress at Cathedral Rock has occurred because the pavement subgrade strength is not uniform through this segment of the road. The dip in the pavement observed near the Paria River is the result of differential settlement of the soft silty sand subgrade soils. To address these areas, following the placement of the edge drain, we recommend that the existing pavement and base be pulverized to a depth of 6 inches and recompacted. After compaction, we recommend that a geogrid or stabilization geotextile be placed followed by an additional 6.0 inches of aggregate base course (ABC). A new HACP pavement should then be placed and ditches lined. The raised elevation of the pavement will assist the drainage of surface water away from the pavement in this area. For ditch lining, we recommend two inches of HACP on compacted existing subgrade.

Two other spot locations were noted, one south of the Cathedral Rock area, and one in the flood plain north of the Paria River Bridge. For these spot locations, we recommend the subgrade be improved by replacing the existing soils with at least 18 inches of compacted granular materials

such as Subbase Fill, Grading A or B, or Aggregate Base Course (ABC) Grading D per Section 703 of the Standard Specifications for Construction of Roads and Bridges FP-03. We also recommend that a geogrid or stabilization geotextile be placed 6 inches below the HACP. This treatment should be included in the plans as a deep patch item so that the Project Engineer can easily address any other locations with similar subgrade problems.

6.3 Soil Corrosivity

Samples from Borings P-6, P-11 and P-22 had water soluble sulfate concentrations of 0.27, 0.26 and 0.08 percent. These are relatively high percentage of water soluble sulfates and these soils will be aggressive toward buried concrete. Sulfate resistant cement is recommended for all buried concrete in the alignment.

The pH of the sample from Boring P-6, P11 and P-22 were 8.7, 8.6 and 9.0 respectively. Chloride content of the samples from P-6, P-11 and P-22 were all to below the detection limit for the test method used.

Resistivity measurements of 777, 715, and 1124 ohm-cm were measured indicating that the soil may be aggressive to buried metal pipes.

6.4 Earthwork

The soils encountered in the exploratory borings are suitable for use as embankment fill under roadways. Embankment materials should be placed and compacted in accordance with the Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects. Cut and fill slopes should be graded at 3 horizontal to 1 vertical or flatter. Slopes should be protected from erosion by re-vegetation or other means.

Soft soils such as those encountered near the Paria River could soften and become unstable during construction if subjected to traffic loads following removal or pulverization of the existing pavement. If soft areas are encountered or develop during construction, the upper 1.5 feet of the soft material should be removed and replaced with compacted Subbase Fill, Grading A or B or ABC. The required depth of removal and replacement can be reduced if a geosynthetic reinforcement or separator fabric is used below the Subbase Fill.

7.0 PAVEMENT RECOMMENDATIONS

7.1 Subgrade Strength

The following equations are from NCHRP Study 128 and were included in the writing of the AASHTO 1993 Pavement Design Guide.

$$S_1 = [(R-5)/11.29] + 3$$

$$M_R = 10^{[S_1 + 18.72)/6.24]}$$

Where: M_R = resilient modulus (psi)
S_1 = the soil support value
R = the R-value obtained from the Hveem Stabilometer (AASHTO T190)

R-values measured in accordance with AASHTO T190 on the soils from the project, were 35, 42, and 65. Using these equations, an R-value of 35 was used to calculate a resilient modulus of 8,065 psi. The R-35 was chosen in order to be conservative and use the same pavement thickness in areas where less pulverized material will be available to meet existing curb lines. This resilient modulus value was used as one of the inputs for the DARWin Pavement Design computer program to determine recommended pavement thickness for Lee's Ferry Access Road. The DARWin pavement design computer program follows the AASHTO 1993 Pavement Design Manual.

Other structural layer coefficients used in design were found in the “FHWA CFL Project Development and Design Manual (PDDM)”, March 2008.

7.2 Traffic Loading

Traffic information for this project was obtained from the Glen Canyon National Monument traffic records for Lee's Ferry Access Road. Two types of information were obtained. Volume counts from counters in the pavement, and the vehicle classification and count of heavy vehicles associated with float trips on the Colorado River. Because the traffic counters are not believed to be continuously operating, the highest volume from each month for the data between 2006 and 2011 was used. This volume was assumed to be 75% cars and pick-up trucks and 25% camper type vehicles.

For the float trip related vehicles, the vehicle types from the classification study were assigned an 18-kip Equivalent Single Axle Loads (ESAL) factor based on Exhibit 11.2 of the PDDM Manual.

These volumes and ESAL factors were then used to develop 20-Year Design ESALs to determine the minimum HACP thickness for Lees Ferry Access Road. The design ESAL value is 88,700 ESALs. Complete traffic volume information and ESAL calculations are presented in Appendix E.

7.3 Recommended Pavement Thickness

Based on discussions with the National Recreation Area personnel, the preferred rehabilitation treatment for the existing pavement is to pulverize and place a new Hot Asphalt Concrete Pavement (HACP). Using the strength information based on the soils information and the strength coefficients from the PDDM for the treatments, the recommended treatment is to pulverize the existing pavement to a depth of 6 inches followed by placement of a 4 inch HACP pavement. Table 5.1 shows that there is adequate thickness of HACP and ABC for most of Lees Ferry Road to address the pulverization depth. Table 7.3 contains the input parameters used for the pavement thickness design as well as the recommended section thicknesses. The parameters were taken from the FHWA Project Development and Design Manual March 2008 based on the traffic loading and treatments for this pavement. The output from the DARWin Pavement Design Program is presented in Appendix F.

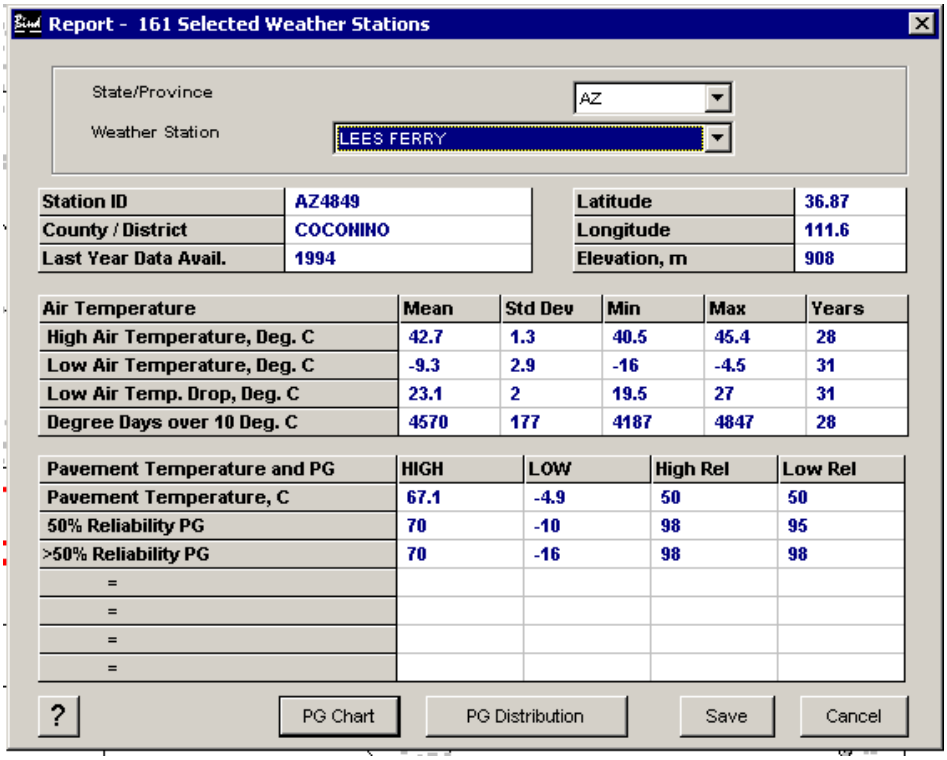
Table 7.3 Pavement Design Parameters and Section Thicknesses

Design Parameter	Parameter Value	Design Parameter	Parameter Value
18-kip ESALs	88,700	Resilient Modulus $M_{R,}$ psi	8,065
Initial Serviceability	4.2	Terminal Serviceability	2.0
Reliability	75%	Structural Number	2.03
Pulverization, in.	6	HACP thickness, in.	4

7.4 Binder and Mix Recommendations

Using the Long Term Pavement Performance binder selection program LTPPBind, the 98% reliability binder recommended for Lees Ferry Access Road is PG 70-16. Figure 7.4 shows the print-out from the program based on historic weather information from the Lee's Ferry Weather station.

Figure 7.4 - Recommended Mix Binder



The new HACP overlay should be a nominal ½-inch mix with the above recommended binder. Grading Designation E mix is recommended (as per FP-03). The Superpave Mix Design system and a 75-gyration mix design using a ½ inch nominal mix is recommended. The quantity of binder can be estimated at 6% by weight of the mix and the unit weight can be estimated at 145 lbs/ft^3.

This project is in a relatively remote location and the asphalt batch plant may be several miles from the construction site. Loss of temperature and segregation of the hot asphalt mix can occur during long distance transport. We recommend the project specifications require the use of a material transfer device at the point of placement to insure uniform temperatures and prevent segregation of the mix during placement. Use of a material transfer device is especially important if the mix is placed in cool weather.

The application of tack coat (at 0.10 gallons/ yd^2) is required on the pulverized base material prior to paving. The tack coat material should be CSS-1, CSS-1h, SS-1, or SS-1h. A tack coat at the above rate should be included between each lift of HACP.

Pulverized material or aggregate base course should receive a prime coat of an emulsion blended as a penetrating prime at a rate of 0.33 gallons/yd^2. If an emulsion such as CSS-1 is used for prime coat, it should be disked into the top 2-3 inches of base course and re-compacted prior to placement to the new HACP.

8.0 REFERENCES

Federal Highway Administration (FHWA), 2003, *Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects*, FP-03.

United States Geological Survey (USGS) Map, *Geologic Map and Sections of the Lee's Ferry Area*, *Coconino County*, *Arizona*, D.A. Phoenix, 1956

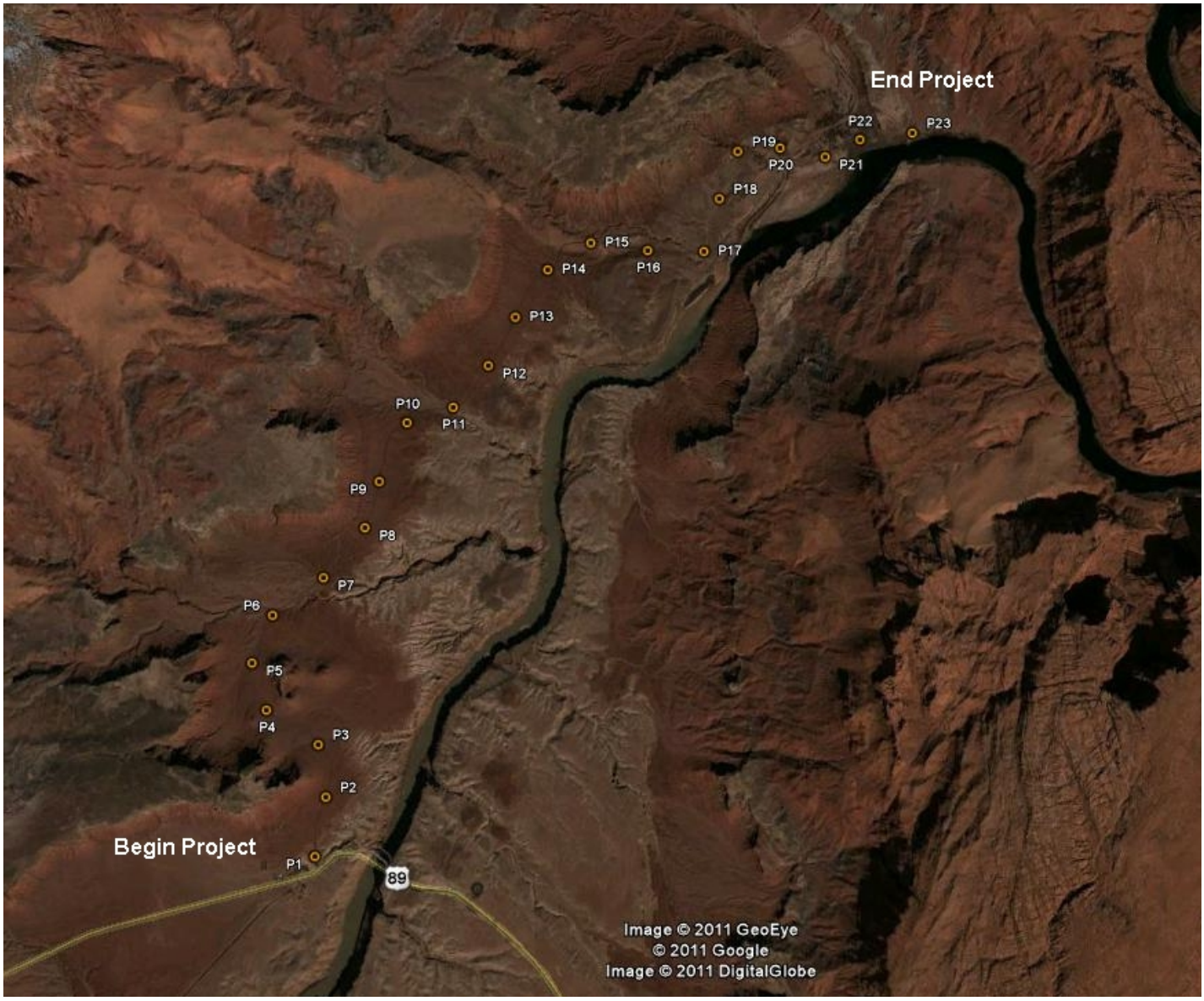
Google Earth, 2011

NCHRP Report No. 128, 1972.

9.0 LIMITATIONS

This study was conducted in accordance with generally accepted geotechnical engineering practices in this area for use by the client for design and construction purposes. The conclusions and recommendations submitted in this report are based upon the data obtained from exploratory borings and field review and the proposed type of construction. Subsurface variations across the site are likely and may not become evident until excavation is performed. If during construction, fill, soil, rock or water conditions appear to be different from those described herein, this office should be advised at once so reevaluation of the recommendations may be made. We recommend on-site observation of excavations and pavement subgrade conditions by a representative of the geotechnical engineer.

Appendix A – Site Map



Boring Location Image

Appendix B – Exploratory Boring Logs

YEH AND ASSOCIATES, INC.
GEOTECHNICAL ENGINEERING CONSULTANTS

Project: Lees Ferry Access Road
Project Number: 211-052 Date: 5/3/11

Boring: **P-1**
Sheet 1 of 1

Boring Began: 5/3/2011
Drilling Method: Hollow-Stem Auger
Drill: CME 75
Driller: Enviro-Drill - Jeff
Logged By: T. Allen
Final By: T. Allen
Inclination: Vertical

Completed: 5/3/2011
Drill Bit:
Casing:
Weather:

Total Depth: 3.0 ft
Ground Elevation:
Location:
Coordinates: N: E:

Ground Water Notes:

Depth	-	-	-	-
Date	-	-	-	-
Time	-	-	-	-

Elevation (feet)	Depth (feet)	Run / Sample Type	Recovery (%)	Rock RQD	Soil Samples Blows per 6 in	Soil Samples N	Lithology	Material Description	Field Notes and Lab Tests
								0.0 - 0.3 ft. 3" ASPHALT.	
								0.3 - 0.4 ft. 2" ABC.	
								0.4 - 1.0 ft. silty SAND, SM, tan, no plasticity, dry.	
					18/50			**1.0 - 3.0 ft.** Sandstone Bedrock, tan, very hard, (Kaibab Formation).	#4= 27% #200= 39% LL= NV PL= NP
								Bottom of Hole at 3.0 ft.	Refusal at 3 feet on bedrock

BORING LOG 211-052 LOGS.GPJ YEH ASSOCIATES.GDT 7/8/11

YEH AND ASSOCIATES, INC.
GEOTECHNICAL ENGINEERING CONSULTANTS

Project: Lees Ferry Access Road
Project Number: 211-052 Date: 5/3/11

Boring: **P-2**
Sheet 1 of 1

Boring Began: 5/3/2011
Drilling Method: Hollow-Stem Auger
Drill: CME 75
Driller: Enviro-Drill - Jeff
Logged By: T. Allen
Final By: T. Allen
Inclination: Vertical

Completed: 5/3/2011
Drill Bit:
Casing:
Weather:

Total Depth: 5.0 ft
Ground Elevation:
Location:
Coordinates: N: E:

Ground Water Notes:

Depth	-	-	-	-
Date	-	-	-	-
Time	-	-	-	-

Elevation (feet)	Depth (feet)	Run / Sample Type	Recovery (%)	Rock RQD	Soil Samples Blows per 6 in	Soil Samples N	Lithology	Material Description	Field Notes and Lab Tests
								0.0 - 0.3 ft. 3 " ASPHALT.	
								0.3 - 0.5 ft. 3 " ABC.	
								0.5 - 3.0 ft. silty SAND FILL with gravel size shale fragments, SM, red-brown, low plasticity, dry, very dense.	
					14/20/18	38			#4= 24% #200= 37% LL= 24 PL= 21 PI= 3 AASHTO: A-4 (0)
								3.0 - 5.0 ft. Sandstone/Shale Bedrock, red-brown, dry, very hard, slightly calcareous, (Moenkopi Formation).	
	5							Bottom of Hole at 5.0 ft.	

BORING LOG 211-052 LOGS.GPJ YEH ASSOCIATES.GDT 7/8/11

YEH AND ASSOCIATES, INC.
GEOTECHNICAL ENGINEERING CONSULTANTS

Project: Lees Ferry Access Road
Project Number: 211-052 Date: 5/3/11

Boring: **P-3**
Sheet 1 of 1

Boring Began: 5/3/2011
Drilling Method: Hollow-Stem Auger
Drill: CME 75
Driller: Enviro-Drill - Jeff
Logged By: T. Allen
Final By: T. Allen
Inclination: Vertical

Completed: 5/3/2011
Drill Bit:
Casing:
Weather:

Total Depth: 5.0 ft
Ground Elevation:
Location:
Coordinates: N: E:

Ground Water Notes:

Depth	-	-	-	-
Date	-	-	-	-
Time	-	-	-	-

Elevation (feet)	Depth (feet)	Run / Sample Type	Recovery (%)	Rock RQD	Soil Samples Blows per 6 in	Soil Samples N	Lithology	Material Description	Field Notes and Lab Tests
								0.0 - 0.3 ft. 3 " Asphalt.	
								0.3 - 0.6 ft. 4 " ABC.	
								0.6 - 1.0 ft. silty SAND with shale fragments, SM, red-brown, low plasticity, damp, medium dense.	
								1.0 - 5.0 ft. weathered sandstone/shale, red-brown, moist, hard to very hard, thinly bedded, calcareous, (Moenkopi Formation).	MC= 6.7% #4= 17% #200= 43.5% LL= 24 PL= 21 PI= 3 AASHTO: A-4 USCS: SM
	5							Bottom of Hole at 5.0 ft.	

BORING LOG 211-052 LOGS.GPJ YEH ASSOCIATES.GDT 7/8/11

YEH AND ASSOCIATES, INC.
GEOTECHNICAL ENGINEERING CONSULTANTS

Project: Lees Ferry Access Road
Project Number: 211-052 Date: 5/3/11

Boring: **P-4**
Sheet 1 of 1

Boring Began: 5/3/2011
Drilling Method: Hollow-Stem Auger
Drill: CME 75
Driller: Enviro-Drill - Jeff
Logged By: T. Allen
Final By: T. Allen
Inclination: Vertical

Completed: 5/3/2011
Drill Bit:
Casing:
Weather:

Total Depth: 5.0 ft
Ground Elevation:
Location:
Coordinates: N: E:

Ground Water Notes:

Depth	-	-	-	-
Date	-	-	-	-
Time	-	-	-	-

Elevation (feet)	Depth (feet)	Run / Sample Type	Recovery (%)	Rock RQD	Soil Samples Blows per 6 in	Soil Samples N	Lithology	Material Description	Field Notes and Lab Tests
								0.0 - 0.3 ft. 3" Asphalt.	
								0.3 - 0.6 ft. 4" ABC.	
					15/13/26	39		**0.6 - 1.1 ft. silty SAND** with shale fragments, red-brown, low plasticity, moist to wet, medium dense to dense, Fill.	MC= 12.9% DD= 128.4pcf S/C= -0.061%
								1.1 - 5.0 ft. Weathered Claystone.	Water in bedding below 1.5' #4= 18% #200= 38% LL= 26 PL= 21 PI= 5 R-Value= 42 AASHTO: A-4 USCS: SM-SC
	5							Bottom of Hole at 5.0 ft.	

BORING LOG 211-052 LOGS.GPJ YEH ASSOCIATES.GDT 7/8/11

YEH AND ASSOCIATES, INC.
GEOTECHNICAL ENGINEERING CONSULTANTS

Project: Lees Ferry Access Road
Project Number: 211-052 Date: 5/3/11

Boring: **P-5**
Sheet 1 of 1

Boring Began: 5/3/2011
Drilling Method: Hollow-Stem Auger
Drill: CME 75
Driller: Enviro-Drill - Jeff
Logged By: T. Allen
Final By: T. Allen
Inclination: Vertical

Completed: 5/3/2011
Drill Bit:
Casing:
Weather:

Total Depth: 3.0 ft
Ground Elevation:
Location:
Coordinates: N: E:

Ground Water Notes:

Depth	-	-	-	-
Date	-	-	-	-
Time	-	-	-	-

Elevation (feet)	Depth (feet)	Run / Sample Type	Recovery (%)	Rock RQD	Soil Samples Blows per 6 in	Soil Samples N	Lithology	Material Description	Field Notes and Lab Tests
								0.0 - 0.2 ft. 2.5" Asphalt.	
								0.2 - 0.5 ft. 3.5" ABC.	
					9/20			**0.5 - 1.0 ft. silty SAND**.	MC= 13% DD= 114.0pcf S/C= -0.037%
								1.0 - 3.0 ft. Interbedded Sandstone and Claystone, red-brown, moist, hard.	
								Bottom of Hole at 3.0 ft.	Refusal on Sandstone at 3 Feet

BORING LOG 211-052 LOGS.GPJ YEH ASSOCIATES.GDT 7/8/11

YEH AND ASSOCIATES, INC.
GEOTECHNICAL ENGINEERING CONSULTANTS

Project: Lees Ferry Access Road
Project Number: 211-052 Date: 5/3/11

Boring: **P-6**
Sheet 1 of 1

Boring Began: 5/3/2011
Drilling Method: Hollow-Stem Auger
Drill: CME 75
Driller: Enviro-Drill - Jeff
Logged By: T. Allen
Final By: T. Allen
Inclination: Vertical

Completed: 5/3/2011
Drill Bit:
Casing:
Weather:

Total Depth: 5.0 ft
Ground Elevation:
Location:
Coordinates: N: E:

Ground Water Notes:

Depth	-	-	-	-
Date	-	-	-	-
Time	-	-	-	-

Elevation (feet)	Depth (feet)	Run / Sample Type	Recovery (%)	Rock RQD	Soil Samples Blows per 6 in	Soil Samples N	Lithology	Material Description	Field Notes and Lab Tests
								0.0 - 0.3 ft. 3" Asphalt.	
								0.3 - 0.6 ft. 4" ABC.	
								0.6 - 2.0 ft. silty SAND.	
					9/13/27	40			
								2.0 - 5.0 ft. Weathered Claystone and Shale.	MC= 3.9% #4= 20% #200= 37.3% LL= 23 PL= 17 PI= 6 pH= 8.69 S= .265% Cl= 0% AASHTO: A-4 USCS: SM-SC
	5							Bottom of Hole at 5.0 ft.	

BORING LOG 211-052 LOGS.GPJ YEH ASSOCIATES.GDT 7/8/11

YEH AND ASSOCIATES, INC.
GEOTECHNICAL ENGINEERING CONSULTANTS

Project: Lees Ferry Access Road
Project Number: 211-052 Date: 5/3/11

Boring: **P-7**
Sheet 1 of 1

Boring Began: 5/3/2011
Drilling Method: Hollow-Stem Auger
Drill: CME 75
Driller: Enviro-Drill - Jeff
Logged By: T. Allen
Final By: T. Allen
Inclination: Vertical

Completed: 5/3/2011
Drill Bit:
Casing:
Weather:

Total Depth: 3.0 ft
Ground Elevation:
Location:
Coordinates: N: E:

Ground Water Notes:

Depth	-	-	-	-
Date	-	-	-	-
Time	-	-	-	-

Elevation (feet)	Depth (feet)	Run / Sample Type	Recovery (%)	Rock RQD	Soil Samples Blows per 6 in	Soil Samples N	Lithology	Material Description	Field Notes and Lab Tests
								0.0 - 0.3 ft. Asphalt.	
								0.3 - 0.6 ft. 4.5" ABC.	
								0.6 - 1.0 ft. silty SAND.	
					10/17/38	55		**1.0 - 3.0 ft.** Weathered Shale, red-brown, moist to damp, hard.	MC= 5.5% #4= 16% #200= 23.2% LL= 22 PL= 17 PI= 5 AASHTO: A-1-b USCS: SM-SC
								Bottom of Hole at 3.0 ft.	Refusal on Sandstone at 3 feet

BORING LOG 211-052 LOGS.GPJ YEH ASSOCIATES.GDT 7/8/11

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GEOTECHNICAL ENGINEERING CONSULTANTS

Project: Lees Ferry Access Road
Project Number: 211-052 Date: 5/3/11

Boring: **P-8**
Sheet 1 of 1

Boring Began: 5/3/2011
Drilling Method: Hollow-Stem Auger
Drill: CME 75
Driller: Enviro-Drill - Jeff
Logged By: T. Allen
Final By: T. Allen
Inclination: Vertical

Completed: 5/3/2011
Drill Bit:
Casing:
Weather:

Total Depth: 5.0 ft
Ground Elevation:
Location:
Coordinates: N: E:

Ground Water Notes:

Depth	-	-	-	-
Date	-	-	-	-
Time	-	-	-	-

Elevation (feet)	Depth (feet)	Run / Sample Type	Recovery (%)	Rock RQD	Soil Samples Blows per 6 in	Soil Samples N	Lithology	Material Description	Field Notes and Lab Tests
								0.0 - 0.3 ft. 3" Asphalt.	
								0.3 - 0.6 ft. 4" ABC.	MC= 2.9% #4= 37% #200= 9.4% LL= NV PL= NV PI= NP AASHTO: A-1-b USCS: SP-SM
								0.6 - 5.0 ft. silty SAND Shale and Sandstone Fragnents, red-brown, low plasticity, damp, medium dense.	
					5/13/12	25			MC= 9.6% #4= 30% #200= 30.1% LL= 25 PL= 22 PI= 3 AASHTO: A-2-4 USCS: SM
	5							Bottom of Hole at 5.0 ft.	

BORING LOG 211-052 LOGS.GPJ YEH ASSOCIATES.GDT 7/8/11

YEH AND ASSOCIATES, INC.
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Project: Lees Ferry Access Road
Project Number: 211-052 Date: 5/3/11

Boring: **P-9**
Sheet 1 of 1

Boring Began: 5/4/2011
Completed: 5/4/2011
Total Depth: 5.0 ft
Drilling Method: Hollow-Stem Auger
Drill Bit:
Ground Elevation:
Drill: CME 75
Casing:
Location:
Driller: Enviro-Drill - Jeff
Weather:
Coordinates: N: E:
Logged By: T. Allen
Final By: T. Allen
Inclination: Vertical

Ground Water Notes:

Depth	-	-	-	-
Date	-	-	-	-
Time	-	-	-	-

Elevation (feet)	Depth (feet)	Run / Sample Type	Recovery (%)	Rock RQD	Soil Samples Blows per 6 in	Soil Samples N	Lithology	Material Description	Field Notes and Lab Tests
								0.0 - 0.2 ft. 2" Asphalt.	
								0.2 - 0.5 ft. 4" ABC.	
					50			**0.5 - 0.8 ft. silty SAND**.	MC= 5.5% #4= 56% #200= 15.6% LL= NV PL= NV PI= NP AASHTO: A-1-b USCS: GM
								0.8 - 2.5 ft. Sandstone with Calcareous Layers.	
								2.5 - 5.0 ft. Sandstone.	
	5							Bottom of Hole at 5.0 ft.	Refusal in Sandstone at 5 Feet

BORING LOG 211-052 LOGS.GPJ YEH ASSOCIATES.GDT 7/8/11

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Project: Lees Ferry Access Road
Project Number: 211-052 Date: 5/3/11

Boring: **P-10**
Sheet 1 of 1

Boring Began: 5/4/2011
Completed: 5/4/2011
Total Depth: 5.0 ft
Drilling Method: Hollow-Stem Auger
Drill Bit:
Ground Elevation:
Drill: CME 75
Casing:
Location:
Driller: Enviro-Drill - Jeff
Weather:
Coordinates: N: E:
Logged By: T. Allen
Final By: T. Allen
Inclination: Vertical

Ground Water Notes:

Depth	-	-	-	-
Date	-	-	-	-
Time	-	-	-	-

Elevation (feet)	Depth (feet)	Run / Sample Type	Recovery (%)	Rock RQD	Soil Samples Blows per 6 in	Soil Samples N	Lithology	Material Description	Field Notes and Lab Tests
								0.0 - 0.3 ft. 3" Asphalt.	
								0.3 - 0.6 ft. 4" ABC.	
					13/10/9	19		**0.6 - 4.5 ft. silty SAND**, red-brown, low plasticity, medium dense.	#4= 20% #200= 45% LL= NV PL= NP PI= NP R-Value= 35 AASHTO: A-4 USCS: SM
	5							**4.5 - 5.0 ft.** Sandstone.	
								Bottom of Hole at 5.0 ft.	

BORING LOG 211-052 LOGS.GPJ YEH ASSOCIATES.GDT 7/8/11

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Project: Lees Ferry Access Road
Project Number: 211-052 Date: 5/3/11

Boring: **P-11**
Sheet 1 of 2

Boring Began: 5/4/2011
Completed: 5/4/2011
Total Depth: 5.0 ft
Drilling Method: Hollow-Stem Auger
Drill Bit:
Ground Elevation:
Drill: CME 75
Casing:
Location:
Driller: Enviro-Drill - Jeff
Weather:
Coordinates: N: E:
Logged By: T. Allen
Final By: T. Allen
Inclination: Vertical

Ground Water Notes:

Depth	-	-	-	-
Date	-	-	-	-
Time	-	-	-	-

Elevation (feet)	Depth (feet)	Run / Sample Type	Recovery (%)	Rock RQD	Soil Samples Blows per 6 in	Soil Samples N	Lithology	Material Description	Field Notes and Lab Tests
								0.0 - 0.3 ft. 3.5" Asphalt.	
								0.3 - 0.7 ft. 4.5" ABC.	
								0.7 - 5.5 ft. silty SAND Gravelly, brown to red-brown, low plasticity, damp, medium dense to dense, Fill.	
					14/22/18	40			#4= 19% #200= 47.7% LL= 24 PL= 18 PI= 6 pH= 8.58 S= .23% Cl= 0% AASHTO: A-4 USCS: SM-SC
	5				50			**5.5 - 6.0 ft.** Sandstone, yellow, dry, hard.	

Bottom of Hole at 5.0 ft.

BORING LOG 211-052 LOGS.GPJ YEH ASSOCIATES.GDT 7/8/11

YEH AND ASSOCIATES, INC.
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Project: Lees Ferry Access Road
Project Number: 211-052 Date: 5/3/11

Boring: **P-12**
Sheet 1 of 1

Boring Began: 5/4/2011
Completed: 5/4/2011
Total Depth: 5.0 ft
Drilling Method: Hollow-Stem Auger
Drill Bit:
Ground Elevation:
Drill: CME 75
Casing:
Location:
Driller: Enviro-Drill - Jeff
Weather:
Coordinates: N: E:
Logged By: T. Allen
Final By: T. Allen
Inclination: Vertical

Ground Water Notes:

Depth	-	-	-	-
Date	-	-	-	-
Time	-	-	-	-

Elevation (feet)	Depth (feet)	Run / Sample Type	Recovery (%)	Rock RQD	Soil Samples Blows per 6 in	Soil Samples N	Lithology	Material Description	Field Notes and Lab Tests
								0.0 - 0.3 ft. 3" Asphalt.	
								0.3 - 0.6 ft. 4.5" ABC.	
								0.6 - 5.0 ft. silty SAND Cobble to Gravel sized Shale Fragments, red-brown, moist, medium dense, Fill.	
					23/10/11	21			#4= 21% #200= 40% LL= 24 PL= 19 PI= 5 AASHTO: A-4 USCS: SM-SC
	5							Bottom of Hole at 5.0 ft.	

BORING LOG 211-052 LOGS.GPJ YEH ASSOCIATES.GDT 7/8/11

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GEOTECHNICAL ENGINEERING CONSULTANTS

Project: Lees Ferry Access Road
Project Number: 211-052 Date: 5/3/11

Boring: **P-13**
Sheet 1 of 1

Boring Began: 5/4/2011
Completed: 5/4/2011
Total Depth: 5.0 ft
Drilling Method: Hollow-Stem Auger
Drill Bit:
Ground Elevation:
Drill: CME 75
Casing:
Location:
Driller: Enviro-Drill - Jeff
Weather:
Coordinates: N: E:
Logged By: T. Allen
Final By: T. Allen
Inclination: Vertical

Ground Water Notes:

Depth	-	-	-	-
Date	-	-	-	-
Time	-	-	-	-

Elevation (feet)	Depth (feet)	Run / Sample Type	Recovery (%)	Rock RQD	Soil Samples Blows per 6 in	Soil Samples N	Lithology	Material Description	Field Notes and Lab Tests
								0.0 - 0.3 ft. 3" Asphalt.	
								0.3 - 0.7 ft. 5" ABC.	
								0.7 - 1.5 ft. silty SAND, Fill.	
					6/26/27	53		**1.5 - 5.0 ft.** Weathered Claystone and Shale, red-brown, moist, Sandy Lenses with Calcarious seams, Hard to Very Hard at 4.5 feet.	#4= 20% #200= 48% LL= 24 PL= 20 PI= 4 AASHTO: A-4 USCS: SM-SC
	5							Bottom of Hole at 5.0 ft.	

BORING LOG 211-052 LOGS.GPJ YEH ASSOCIATES.GDT 7/8/11

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Project: Lees Ferry Access Road
Project Number: 211-052 Date: 5/3/11

Boring: **P-14**
Sheet 1 of 1

Boring Began: 5/4/2011
Completed: 5/4/2011
Total Depth: 5.0 ft
Drilling Method: Hollow-Stem Auger
Drill Bit:
Ground Elevation:
Drill: CME 75
Casing:
Location:
Driller: Enviro-Drill - Jeff
Weather:
Coordinates: N: E:
Logged By: T. Allen
Final By: T. Allen
Inclination: Vertical

Ground Water Notes:

Depth	-	-	-	-
Date	-	-	-	-
Time	-	-	-	-

Elevation (feet)	Depth (feet)	Run / Sample Type	Recovery (%)	Rock RQD	Soil Samples Blows per 6 in	Soil Samples N	Lithology	Material Description	Field Notes and Lab Tests
								0.0 - 0.2 ft. 2.5" Asphalt.	
								0.2 - 0.6 ft. 4.5" ABC.	
								0.6 - 5.0 ft. clayey SAND with Gravel and Shale Fragments, red-brown, medium plasticity, moist, loose, Fill.	
					8/11/12	23			#4= 13% #200= 46.2% LL= 26 PL= 17 PI= 9 AASHTO: A-4 USCS: SC
	5							Bottom of Hole at 5.0 ft.	

BORING LOG 211-052 LOGS.GPJ YEH ASSOCIATES.GDT 7/8/11

YEH AND ASSOCIATES, INC.
GEOTECHNICAL ENGINEERING CONSULTANTS

Project: Lees Ferry Access Road
Project Number: 211-052 Date: 5/3/11

Boring: **P-15**
Sheet 1 of 1

Boring Began: 5/4/2011
Completed: 5/4/2011
Total Depth: 5.0 ft
Drilling Method: Hollow-Stem Auger
Drill Bit:
Ground Elevation:
Drill: CME 75
Casing:
Location:
Driller: Enviro-Drill - Jeff
Weather:
Coordinates: N: E:
Logged By: T. Allen
Final By: T. Allen
Inclination: Vertical

Ground Water Notes:

Depth	-	-	-	-
Date	-	-	-	-
Time	-	-	-	-

Elevation (feet)	Depth (feet)	Run / Sample Type	Recovery (%)	Rock RQD	Soil Samples Blows per 6 in	Soil Samples N	Lithology	Material Description	Field Notes and Lab Tests
								0.0 - 0.3 ft. 3" Asphalt.	
								0.3 - 0.6 ft. 4" ABC.	
								0.6 - 5.0 ft. clayey SAND with gravel and Shale Fragments, brown to red-brown, medium plasticity, moist, medium dense, Fill.	
					6/7/12	19			#4= 6% #200= 40.4% LL= 18 PL= 12 PI= 6 AASHTO: A-4 USCS: SM-SC
	5							Bottom of Hole at 5.0 ft.	

BORING LOG 211-052 LOGS.GPJ YEH ASSOCIATES.GDT 7/8/11

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Project: Lees Ferry Access Road
Project Number: 211-052 Date: 5/3/11

Boring: **P-16**
Sheet 1 of 1

Boring Began: 5/4/2011
Completed: 5/4/2011
Total Depth: 5.0 ft
Drilling Method: Hollow-Stem Auger
Drill Bit:
Ground Elevation:
Drill: CME 75
Casing:
Location:
Driller: Enviro-Drill - Jeff
Weather:
Coordinates: N: E:
Logged By: T. Allen
Final By: T. Allen
Inclination: Vertical

Ground Water Notes:

Depth	-	-	-	-
Date	-	-	-	-
Time	-	-	-	-

Elevation (feet)	Depth (feet)	Run / Sample Type	Recovery (%)	Rock RQD	Soil Samples Blows per 6 in	Soil Samples N	Lithology	Material Description	Field Notes and Lab Tests
								0.0 - 0.3 ft. 3.5" Asphalt.	
								0.3 - 0.7 ft. 4.5" ABC.	
								0.7 - 5.0 ft. clayey SAND Gravelly with Shale and Sandstone Fragments, brown to red-brown, low plasticity, moist, dense, Fill.	
					28/19/18	37			#4= 20% #200= 33.1% LL= 20 PL= 15 PI= 5 AASHTO: A--2-4 USCS: SM-SC
	5							Bottom of Hole at 5.0 ft.	

BORING LOG 211-052 LOGS.GPJ YEH ASSOCIATES.GDT 7/8/11

YEH AND ASSOCIATES, INC.
GEOTECHNICAL ENGINEERING CONSULTANTS

Project: Lees Ferry Access Road
Project Number: 211-052 Date: 5/3/11

Boring: **P-17**
Sheet 1 of 1

Boring Began: 5/4/2011
Completed: 5/4/2011
Total Depth: 3.0 ft
Drilling Method: Hollow-Stem Auger
Drill Bit:
Ground Elevation:
Drill: CME 75
Casing:
Location:
Driller: Enviro-Drill - Jeff
Weather:
Coordinates: N: E:
Logged By: T. Allen
Final By: T. Allen
Inclination: Vertical

Ground Water Notes:

Depth	-	-	-	-
Date	-	-	-	-
Time	-	-	-	-

Elevation (feet)	Depth (feet)	Run / Sample Type	Recovery (%)	Rock RQD	Soil Samples Blows per 6 in	Soil Samples N	Lithology	Material Description	Field Notes and Lab Tests
								0.0 - 0.3 ft. 3.5" Asphalt.	
								0.3 - 0.6 ft. 4" ABC.	
								0.6 - 3.0 ft. silty SAND with Gravel, light brown, no plasticity, dry to moist, very dense.	
					35/18/13	31			#4= 34% #200= 20.6% LL= NV PL= NV PI= NP AASHTO: A-2-4 USCS: SM
								Bottom of Hole at 3.0 ft.	Refusal on cobbles and Boulders at 3 feet

BORING LOG 211-052 LOGS.GPJ YEH ASSOCIATES.GDT 7/8/11

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Project: Lees Ferry Access Road
Project Number: 211-052 Date: 5/3/11

Boring: **P-18**
Sheet 1 of 1

Boring Began: 5/4/2011
Completed: 5/4/2011
Total Depth: 5.0 ft
Drilling Method: Hollow-Stem Auger
Drill Bit:
Ground Elevation:
Drill: CME 75
Casing:
Location:
Driller: Enviro-Drill - Jeff
Weather:
Coordinates: N: E:
Logged By: T. Allen
Final By: T. Allen
Inclination: Vertical

Ground Water Notes:

Depth	-	-	-	-
Date	-	-	-	-
Time	-	-	-	-

Elevation (feet)	Depth (feet)	Run / Sample Type	Recovery (%)	Rock RQD	Soil Samples Blows per 6 in	Soil Samples N	Lithology	Material Description	Field Notes and Lab Tests
								0.0 - 0.3 ft. 3" Asphalt.	
								0.3 - 0.6 ft. 4" ABC.	
								0.6 - 5.0 ft. silty SAND with Gravel and Cobbles, light brown, dry to moist, very dense.	
					38/42/32	74			#4= 40% #200= 16% LL= NV PL= NP PI= NP R-Value= 61 AASHTO: A-1-b (0) USCS: SM
	5							Bottom of Hole at 5.0 ft.	Boulder at 4 Feet. Possible Bedrock Drilling Terminated at 5 Feet

BORING LOG 211-052 LOGS.GPJ YEH ASSOCIATES.GDT 7/8/11

YEH AND ASSOCIATES, INC.
GEOTECHNICAL ENGINEERING CONSULTANTS

Project: Lees Ferry Access Road
Project Number: 211-052 Date: 5/3/11

Boring: **P-19**
Sheet 1 of 1

Boring Began: 5/4/2011
Completed: 5/4/2011
Total Depth: 5.0 ft
Drilling Method: Hollow-Stem Auger
Drill Bit:
Ground Elevation:
Drill: CME 75
Casing:
Location:
Driller: Enviro-Drill - Jeff
Weather:
Coordinates: N: E:
Logged By: T. Allen
Final By: T. Allen
Inclination: Vertical

Ground Water Notes:

Depth	-	-	-	-
Date	-	-	-	-
Time	-	-	-	-

Elevation (feet)	Depth (feet)	Run / Sample Type	Recovery (%)	Rock RQD	Soil Samples Blows per 6 in	Soil Samples N	Lithology	Material Description	Field Notes and Lab Tests
								0.0 - 0.2 ft. 2" Asphalt.	
								0.2 - 0.4 ft. 3" ABC.	
								0.4 - 5.0 ft. silty SAND Gravelly, Scattered Cobbles, light brown, low plasticity, dry to moist, medium dense to dense, Fill.	
					14/17/10	27			#4= 17% #200= 38.2% LL= 21 PL= 15 PI= 6 AASHTO: A-4 USCS: SM-SC
	5							Bottom of Hole at 5.0 ft.	

BORING LOG 211-052 LOGS.GPJ YEH ASSOCIATES.GDT 7/8/11

YEH AND ASSOCIATES, INC.
GEOTECHNICAL ENGINEERING CONSULTANTS

Project: Lees Ferry Access Road
Project Number: 211-052 Date: 5/3/11

Boring: **P-20**
Sheet 1 of 1

Boring Began: 5/4/2011
Completed: 5/4/2011
Total Depth: 5.0 ft
Drilling Method: Hollow-Stem Auger
Drill Bit:
Ground Elevation:
Drill: CME 75
Casing:
Location:
Driller: Enviro-Drill - Jeff
Weather:
Coordinates: N: E:
Logged By: T. Allen
Final By: T. Allen
Inclination: Vertical

Ground Water Notes:

Depth	-	-	-	-
Date	-	-	-	-
Time	-	-	-	-

Elevation (feet)	Depth (feet)	Run / Sample Type	Recovery (%)	Rock RQD	Soil Samples Blows per 6 in	Soil Samples N	Lithology	Material Description	Field Notes and Lab Tests
								0.0 - 0.1 ft. 1.5" Asphalt.	
								0.1 - 5.0 ft. silty SAND Shale Fragments, red-brown, medium plasticity, moist, medium dense.	
					9/10/9	19			#4= 28% #200= 29.7% LL= 22 PL= 15 PI= 7 AASHTO: A-2-4 USCS: SM-SC
	5							Bottom of Hole at 5.0 ft.	

BORING LOG 211-052 LOGS.GPJ YEH ASSOCIATES.GDT 7/8/11

YEH AND ASSOCIATES, INC.
GEOTECHNICAL ENGINEERING CONSULTANTS

Project: Lees Ferry Access Road
Project Number: 211-052 Date: 5/3/11

Boring: **P-21**
Sheet 1 of 1

Boring Began: 5/4/2011
Completed: 5/4/2011
Total Depth: 5.0 ft
Drilling Method: Hollow-Stem Auger
Drill Bit:
Ground Elevation:
Drill: CME 75
Casing:
Location:
Driller: Enviro-Drill - Jeff
Weather:
Coordinates: N: E:
Logged By: T. Allen
Final By: T. Allen
Inclination: Vertical

Ground Water Notes:

Depth	-	-	-	-
Date	-	-	-	-
Time	-	-	-	-

Elevation (feet)	Depth (feet)	Run / Sample Type	Recovery (%)	Rock RQD	Soil Samples Blows per 6 in	Soil Samples N	Lithology	Material Description	Field Notes and Lab Tests
								0.0 - 0.3 ft. 4" Asphalt.	
								0.3 - 0.4 ft. 1" ABC.	
								0.4 - 1.0 ft. Crushed Shale Fragments, Fill.	
								1.0 - 5.0 ft. silty SAND, tan, no plasticity, moist to damp, loose.	
					3/5				MC= 3.8% DD= 109.2pcf S/C= -0.0756%
									#4= 2% #200= 16% LL= NV PL= NP PI= NP R-Value= 64 AASHTO: A-2-4 (0) USCS: SM
	5							Bottom of Hole at 5.0 ft.	

BORING LOG 211-052 LOGS.GPJ YEH ASSOCIATES.GDT 7/8/11

YEH AND ASSOCIATES, INC.
GEOTECHNICAL ENGINEERING CONSULTANTS

Project: Lees Ferry Access Road
Project Number: 211-052 Date: 5/3/11

Boring: **P-22**
Sheet 1 of 1

Boring Began: 5/4/2011
Completed: 5/4/2011
Total Depth: 5.0 ft
Drilling Method: Hollow-Stem Auger
Drill Bit:
Ground Elevation:
Drill: CME 75
Casing:
Location:
Driller: Enviro-Drill - Jeff
Weather:
Coordinates: N: E:
Logged By: T. Allen
Final By: T. Allen
Inclination: Vertical

Ground Water Notes:

Depth	-	-	-	-
Date	-	-	-	-
Time	-	-	-	-

Elevation (feet)	Depth (feet)	Run / Sample Type	Recovery (%)	Rock RQD	Soil Samples Blows per 6 in	Soil Samples N	Lithology	Material Description	Field Notes and Lab Tests
								0.0 - 0.3 ft. 3" Asphalt.	
								0.3 - 0.4 ft. 2" ABC.	
								0.4 - 1.0 ft. Crushed Shale Fragments, Fill.	
								1.0 - 5.0 ft. silty SAND, tan, no plasticity, moist to damp, medium dense.	
					4/7				MC= 6.2% DD= 107.1pcf
									#4= 6% #200= 48% LL= NV PL= NP PI= NP pH= 9 S= .084% Cl= 0% AASHTO: A-4 USCS: SM
	5							Bottom of Hole at 5.0 ft.	

BORING LOG 211-052 LOGS.GPJ YEH ASSOCIATES.GDT 7/8/11

YEH AND ASSOCIATES, INC.
GEOTECHNICAL ENGINEERING CONSULTANTS

Project: Lees Ferry Access Road
Project Number: 211-052 Date: 5/3/11

Boring: **P-23**
Sheet 1 of 1

Boring Began: 5/4/2011
Completed: 5/4/2011
Total Depth: 5.0 ft
Drilling Method: Hollow-Stem Auger
Drill Bit:
Ground Elevation:
Drill: CME 75
Casing:
Location:
Driller: Enviro-Drill - Jeff
Weather:
Coordinates: N: E:
Logged By: T. Allen
Final By: T. Allen
Inclination: Vertical

Ground Water Notes:

Depth	-	-	-	-
Date	-	-	-	-
Time	-	-	-	-

Elevation (feet)	Depth (feet)	Run / Sample Type	Recovery (%)	Rock RQD	Soil Samples Blows per 6 in	Soil Samples N	Lithology	Material Description	Field Notes and Lab Tests
								0.0 - 0.3 ft. 3" Asphalt.	
								0.3 - 1.8 ft. sandy GRAVEL Silty, Fill.	
								1.8 - 5.0 ft. silty SAND, tan to red-brown, no plasticity, moist to damp, loose.	
					12/4/2	6			MC= 0.6% #4= 45% #200= 19% LL= NV PL= NP PI= NP AASHTO: A-1-b USCS: GM
	5							Bottom of Hole at 5.0 ft.	

BORING LOG 211-052 LOGS.GPJ YEH ASSOCIATES.GDT 7/8/11

Appendix C – Laboratory Test Results

YEH & ASSOCIATES, INC

Summary of Laboratory Test Results

Project No: 211-052 Project Name: Lee's Ferry Date: 5/6/2011

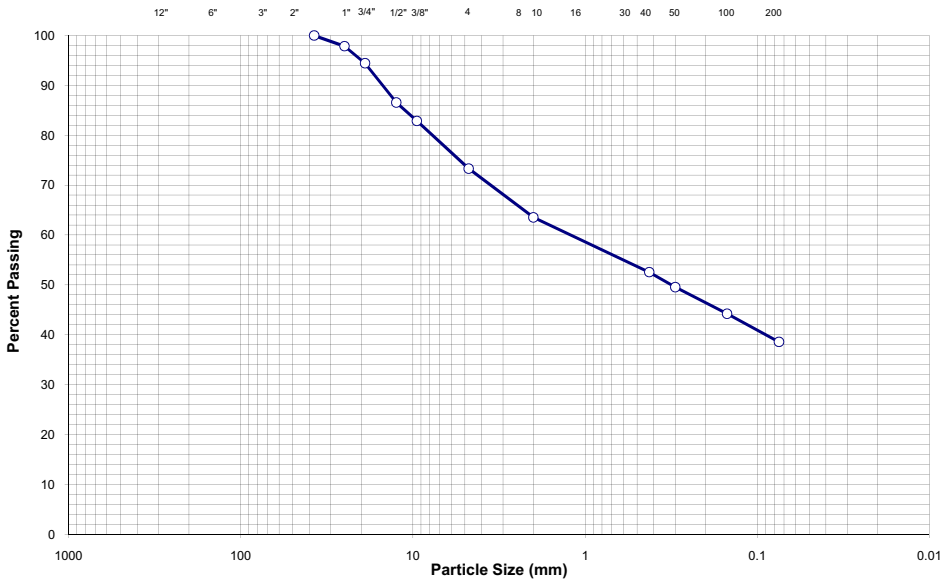
Sample Location			Natural Moisture Content (%)	Natural Dry Density (pcf)	Gradation			Atterberg			pH	Water Soluble Sulfate %	Chloride %	% Swell (+) / Consoli-dation (-)	R-VALUE	Resistivity Ohm-cm	CLASSIFICATION	
Boring NO.	Depth (ft)	Sample Type			Gravel > #4 (%)	Sand (%)	Fines < #200 (%)	LL	PL	PI							AASHTO	USCS
P-1	1-3'	BULK			27	34	39	NV	NP	NP							A-4 (0)	SM
P-2	1-5'	BULK			24	39	37	24	21	3							A-4 (0)	SM
P-3	1-5'	BULK			17	39	44	24	21	3							A-4 (0)	SM
P-4	1-3'	BULK			18	44	38	26	21	5					42		A-4 (0)	SM-SC
P-4	.5-1.0	CAL	12.9	128.4										-0.061				
P-5	.5-1.0	CAL	13.0	114.0										-0.037				
P-6	1-5'	BULK			20	43	47	23	17	6	8.7	0.27	0			777	A-4 (0)	SM-SC
P-7	1-5'	BULK			16	61	23	22	17	5							A-1-b (0)	SM-SC
P-8	4"-6"	BULK			37	54	9	NV	NP	NP							A-1-b (0)	SP-SM
P-8	6"-2'	BULK			30	40	30	25	22	3							A-2-4 (0)	SM
P-9	6"-1'	BULK			56	28	16	NV	NP	NP							A-1-b (0)	GM
P-10	6"-5'	BULK			20	35	45	NV	NP	NP					35		A-4 (0)	SM
P-11	1-5'	BULK			19	33	48	24	18	6	8.6	0.23	0			715	A-4 (0)	SM-SC
P-12	1-5'	BULK			21	39	40	24	19	5							A-4 (0)	SM-SC
P-13	1-5'	BULK			20	32	48	24	20	4							A-4 (0)	SM-SC
P-14	1-5'	BULK			13	41	46	26	17	9							A-4 (1)	SC
P-15	1-5'	BULK			6	54	40	18	12	6							A-4 (0)	SM-SC
P-16	1-5'	BULK			20	47	33	20	15	5							A-2-4 (0)	SM-SC
P-17	1-5'	BULK			34	45	21	NV	NP	NP							A-2-4 (0)	SM
P-18	1-5'	BULK			40	44	16	NV	NP	NP					61		A-1-b (0)	SM
P-19	1-5'	BULK			17	45	38	21	15	6							A-4 (0)	SM-SC

YEH & ASSOCIATES, INC

Summary of Laboratory Test Results

Project No: 211-052 Project Name: Lee's Ferry Date: 5/6/2011

Sample Location			Natural Moisture Content (%)	Natural Dry Density (pcf)	Gradation			Atterberg			pH	Water Soluble Sulfate %	Chloride %	% Swell (+) / Consoli-dation (-)	R-VALUE	Resistivity Ohm-cm	CLASSIFICATION	
Boring NO.	Depth (ft)	Sample Type			Gravel > #4 (%)	Sand (%)	Fines < #200 (%)	LL	PL	PI							AASHTO	USCS
P-20	1-5'	BULK			28	42	30	22	15	7							A-2-4 (0)	SM-SC
P-21	1-5'	BULK			2	82	16	NV	NP	NP					64		A-2-4 (0)	SM
P-21	2.0-3.0	CAL	3.8	105.9										-0.076				
P-22		CAL	6.2	107.1														
P-22	1-5'	BULK			6	46	48	NV	NP	NP	9.0	0.08	0			1124	A-4 (0)	SM
P-23	2-5'	BULK			45	36	19	NV	NP	NP							A-1-b (0)	GM



Sieve Size	% Passing
3"	-
2 ½"	-
2"	-
1 ½"	100
1"	98
¾ "	94
½"	87
⅜"	83
#4	73
#10	64
#40	53
#200	38.6

Gravel (%)	27	LL	NP	Project Name:	Lee's Ferry Road
Sand (%)	34	PL	NP	Boring:	P-1
Fines (%)	39	PI	NP	Sample Depth (ft):	1'-3'
Sample Description:	silty sand	SM		A-4	(0)

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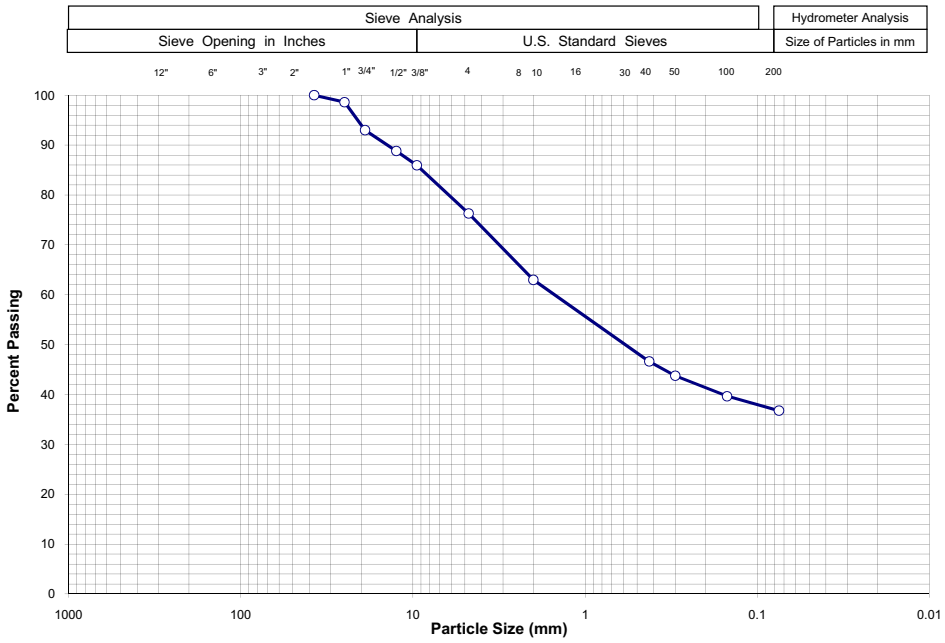
SIEVE ANALYSIS

Drawn By:	FJP	Project No.:	211-052
Checked By:	TLA	Figure No.:	-
Date:	05/10/11		

Revised 04/27/2004



Sieve Size	% Passing
3"	-
2 ½"	-
2"	-
1 ½"	100
1"	99
¾ "	93
½"	89
⅜"	86
#4	76
#10	63
#40	47
#200	36.8

Gravel (%)	24	LL	24	Project Name:	Lee's Ferry Road
Sand (%)	39	PL	21	Boring:	P-2
Fines (%)	37	PI	3	Sample Depth (ft):	1'-5'
Sample Description:	silty sand	SM		A-4	(0)

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SIEVE ANALYSIS

Drawn By:	FJP	Project No.:	211-052
Checked By:	TLA	Figure No.:	-
Date:	05/13/11		

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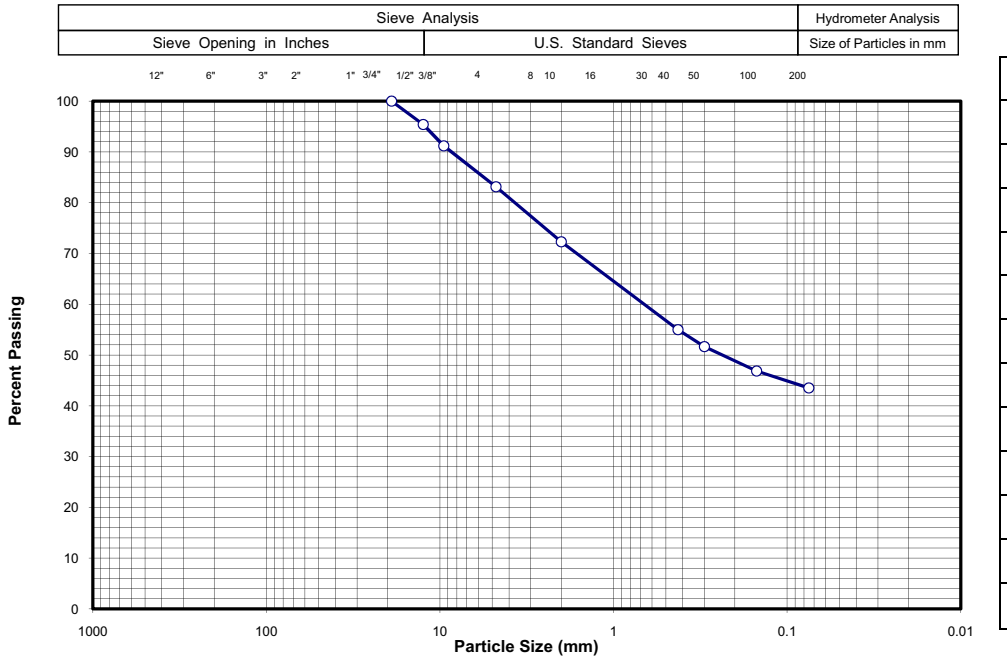

Sieve Size	% Passing
3"	-
2 ½"	-
2"	-
1 ½"	-
1"	-
¾ "	100
½"	95
⅜"	91
#4	83
#10	72
#40	55
#200	43.5

Gravel (%)	17	LL	24	Project Name:	Lee's Ferry Road
Sand (%)	39	PL	21	Sample ID:	P-3
Fines (%)	44	PI	3	Sample Depth (m):	1'-5'
Sample Description:	silty sand		A-4	(0)	

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SIEVE ANALYSIS

Drawn By:	FJP	Project No.:	211-052
Checked By:	TLA	Figure No.:	-
Date:	05/13/11		

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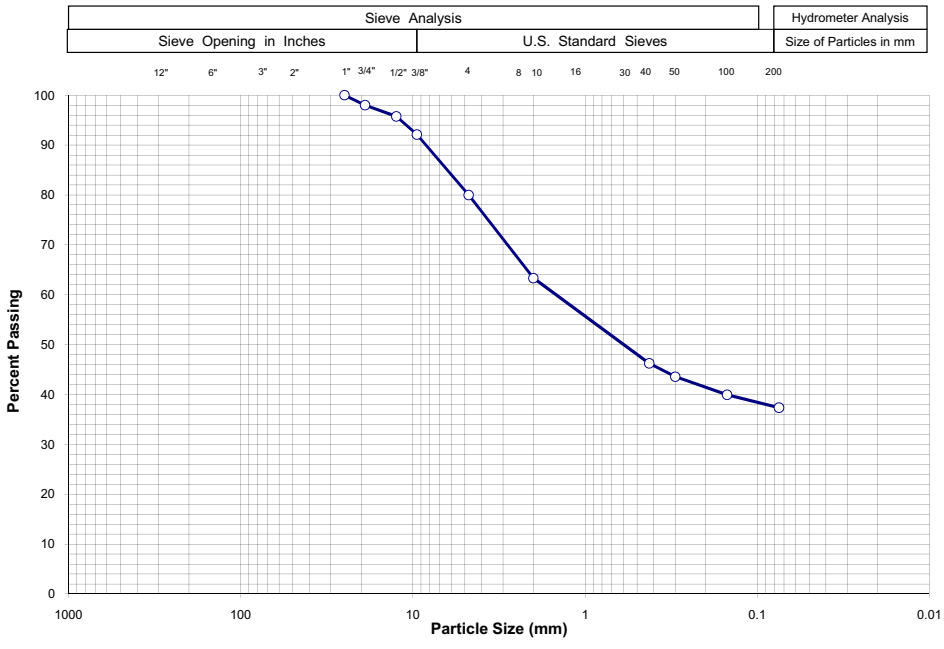

Sieve Size	% Passing
3"	-
2 ½"	-
2"	-
1 ½"	-
1"	100
¾ "	98
½"	96
⅜"	92
#4	80
#10	63
#40	46
#200	37.3

Gravel (%)	20	LL	23	Project Name:	Lee's Ferry Road
Sand (%)	43	PL	17	Boring:	P-6
Fines (%)	37	PI	6	Sample Depth (ft):	1'-5'
Sample Description:	silty sand	SM-SC	A-4	(0)	

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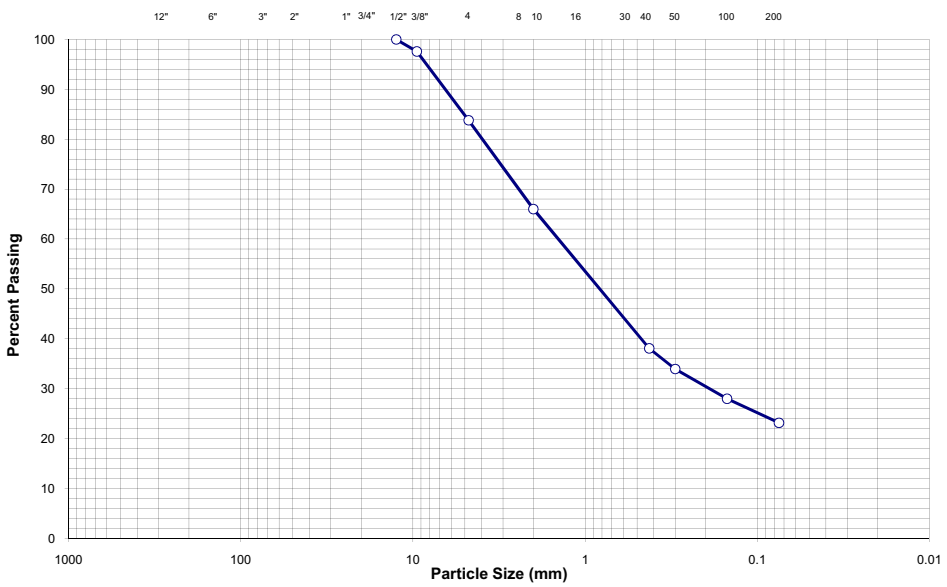
SIEVE ANALYSIS

Drawn By:	FJP	Project No.:	211-052
Checked By:	TLA	Figure No.:	-
Date:	05/10/11		

Revised 04/27/2004



Sieve Size	% Passing
3"	-
2 ½"	-
2"	-
1 ½"	-
1"	-
¾ "	-
½"	100
⅜"	98
#4	84
#10	66
#40	38
#200	23.2

Gravel (%)	16	LL	22	Project Name:	Lee's Ferry Road
Sand (%)	61	PL	17	Boring:	P-7
Fines (%)	23	PI	5	Sample Depth (ft):	6"-2'
Sample Description:	silty sand	SM-SC		A-1-b	(0)

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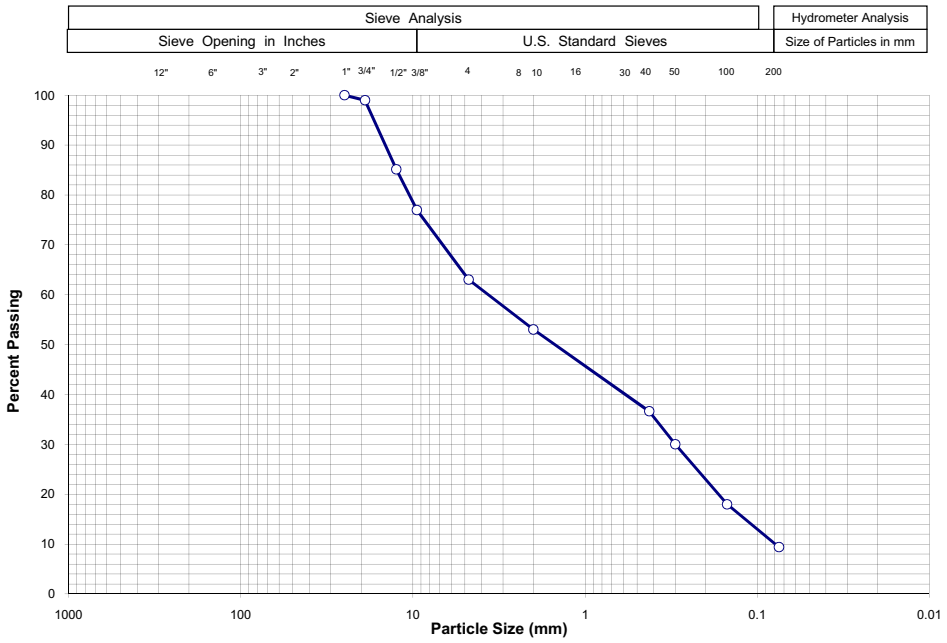
SIEVE ANALYSIS

Drawn By:	FJP	Project No.:	211-052
Checked By:	TLA	Figure No.:	-
Date:	05/10/11		

Revised 04/27/2004



Sieve Size	% Passing
3"	-
2 ½"	-
2"	-
1 ½"	-
1"	100
¾ "	99
½"	85
⅜"	77
#4	63
#10	53
#40	37
#200	9.4

Gravel (%)	37	LL	NV	Project Name:	Lee's Ferry Road
Sand (%)	54	PL	NP	Boring:	P-8
Fines (%)	9	PI	NP	Sample Depth (ft):	ABC 4"-6"
Sample Description:	poorly-graded sand with silt	SP-SM		A-1-b	(0)

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SIEVE ANALYSIS

Drawn By:	FJP	Project No.:	211-052
Checked By:	TLA	Figure No.:	-
Date:	05/10/11		

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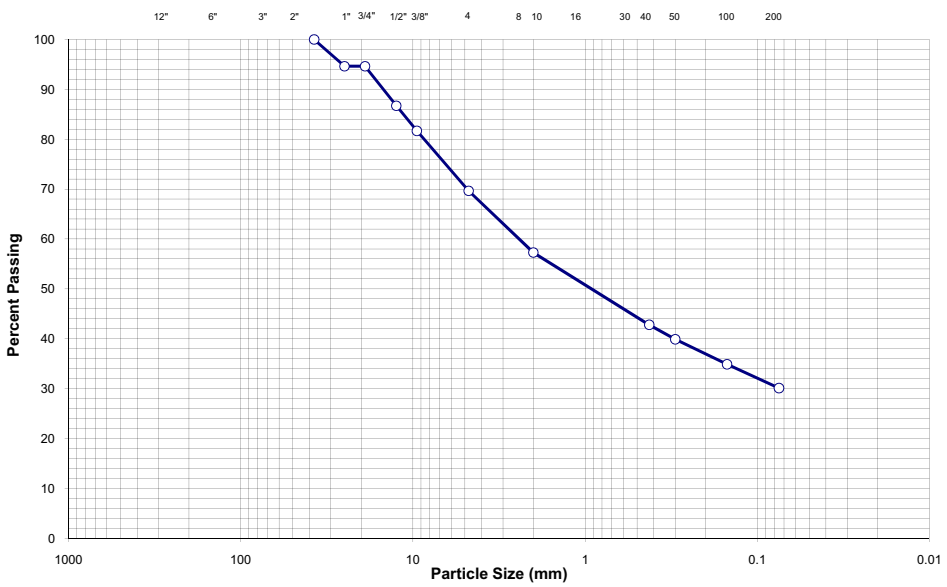

Sieve Size	% Passing
3"	-
2 ½"	-
2"	-
1 ½"	100
1"	95
¾ "	95
½"	87
⅜"	82
#4	70
#10	57
#40	43
#200	30.1

Gravel (%)	30	LL	25	Project Name:	Lee's Ferry Road
Sand (%)	40	PL	22	Boring:	P-8
Fines (%)	30	PI	3	Sample Depth (ft):	6"-2'
Sample Description:	silty sand	SM	A-2-4	(0)	

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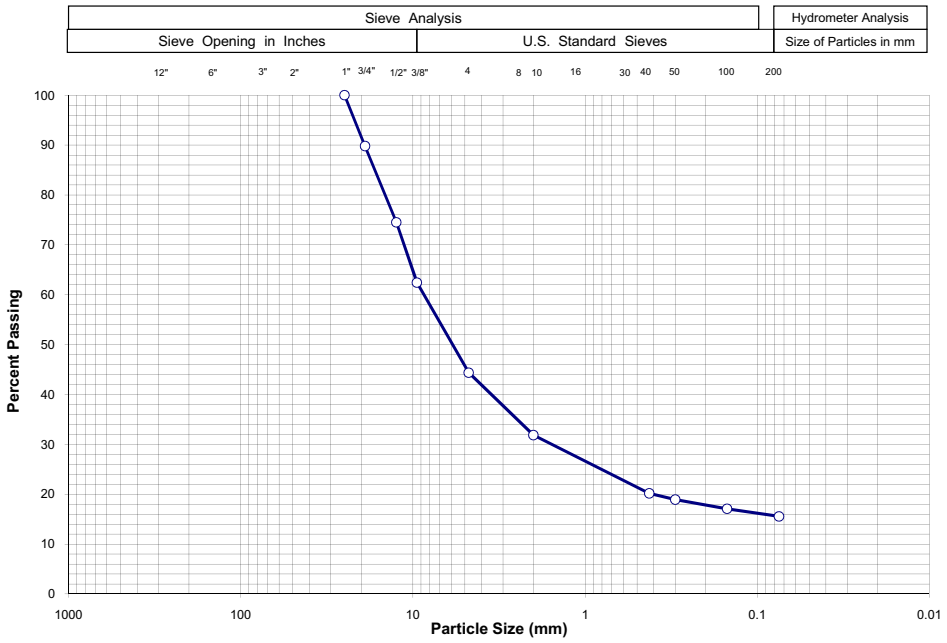
SIEVE ANALYSIS

Drawn By:	FJP	Project No.:	211-052
Checked By:	TLA	Figure No.:	-
Date:	05/10/11		

Revised 04/27/2004



Sieve Size	% Passing
3"	-
2 ½"	-
2"	-
1 ½"	-
1"	100
¾ "	90
½"	75
⅜"	62
#4	44
#10	32
#40	20
#200	15.6

Gravel (%)	56	LL	NV	Project Name:	Lee's Ferry Road
Sand (%)	28	PL	NP	Boring:	P-9
Fines (%)	16	PI	NP	Sample Depth (ft):	6"-1'
Sample Description:	silty gravel	GM	A-1-b	(0)	

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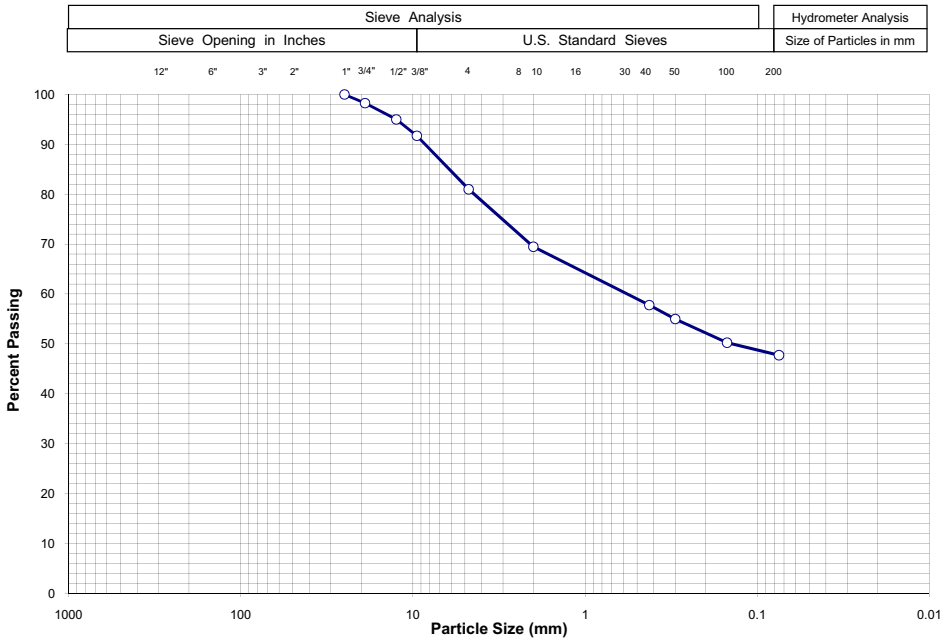
SIEVE ANALYSIS

Drawn By:	FJP	Project No.:	211-052
Checked By:	TLA	Figure No.:	-
Date:	05/10/11		

Revised 04/27/2004



Sieve Size	% Passing
3"	-
2 ½"	-
2"	-
1 ½"	-
1"	100
¾ "	98
½"	95
⅜"	92
#4	81
#10	69
#40	58
#200	47.7

Gravel (%)	19	LL	24	Project Name:	Lee's Ferry Road
Sand (%)	33	PL	18	Boring:	P-11
Fines (%)	48	PI	6	Sample Depth (ft):	1'-5'
Sample Description:	silty sand	SM-SC	A-4	(0)	

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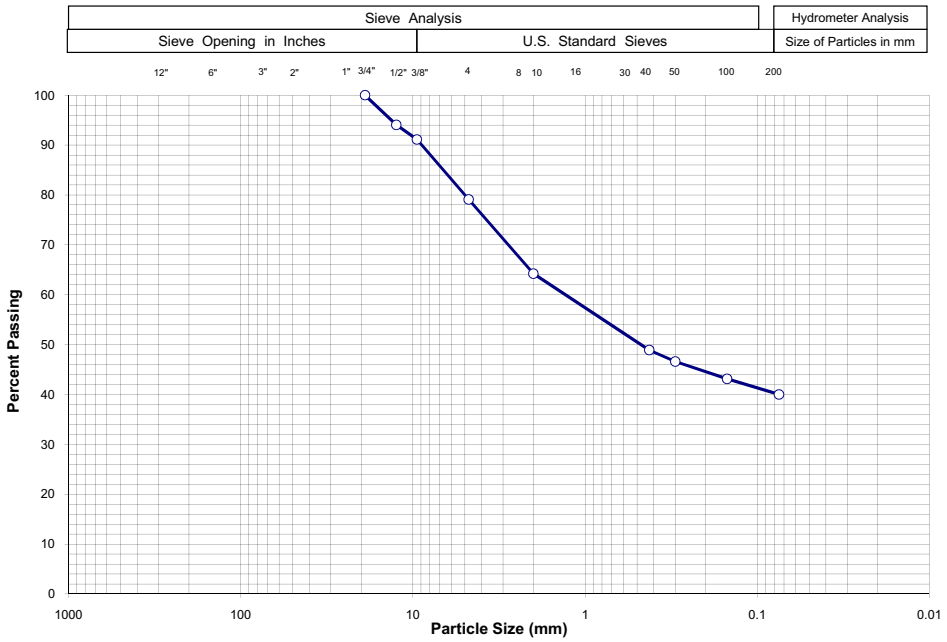
SIEVE ANALYSIS

Drawn By:	FJP	Project No.:	211-052
Checked By:	TLA	Figure No.:	-
Date:	05/13/11		

Revised 04/27/2004



Sieve Size	% Passing
3"	-
2 ½"	-
2"	-
1 ½"	-
1"	-
¾ "	100
½"	94
⅜"	91
#4	79
#10	64
#40	49
#200	40.0

Gravel (%)	21	LL	24	Project Name:	Lee's Ferry Road
Sand (%)	39	PL	19	Boring:	P-12
Fines (%)	40	PI	5	Sample Depth (ft):	1'-5'
Sample Description:	silty sand	SM-SC	A-4	(0)	

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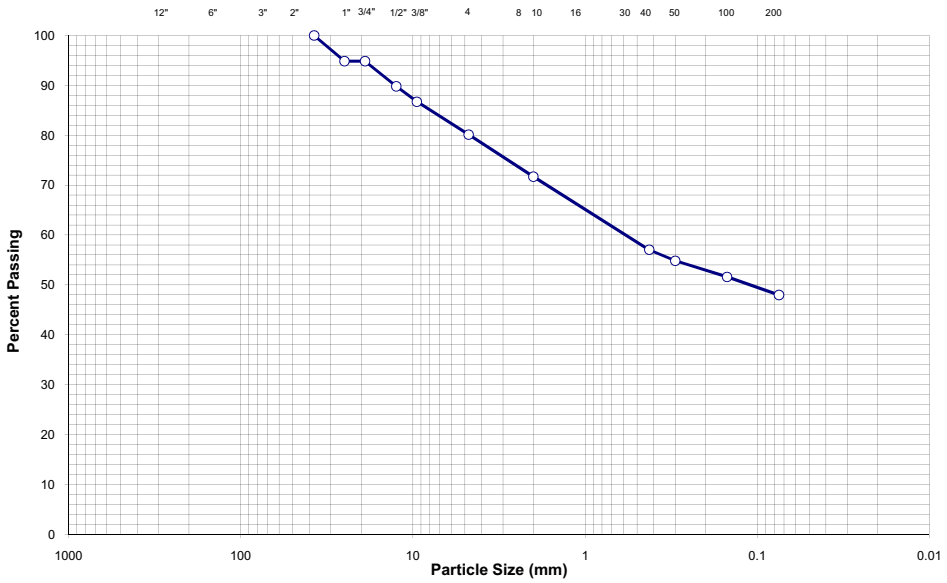
SIEVE ANALYSIS

Drawn By:	FJP	Project No.:	211-052
Checked By:	TLA	Figure No.:	-
Date:	05/23/11		

Revised 04/27/2004



Sieve Size	% Passing
3"	-
2 ½"	-
2"	-
1 ½"	100
1"	95
¾ "	95
½"	90
⅜"	87
#4	80
#10	72
#40	57
#200	48.0

Gravel (%)	20	LL	24	Project Name:	Lee's Ferry Road
Sand (%)	32	PL	20	Boring:	P-13
Fines (%)	48	PI	4	Sample Depth (ft):	1'-5'
Sample Description:	silty sand	SM-SC	A-4	(0)	

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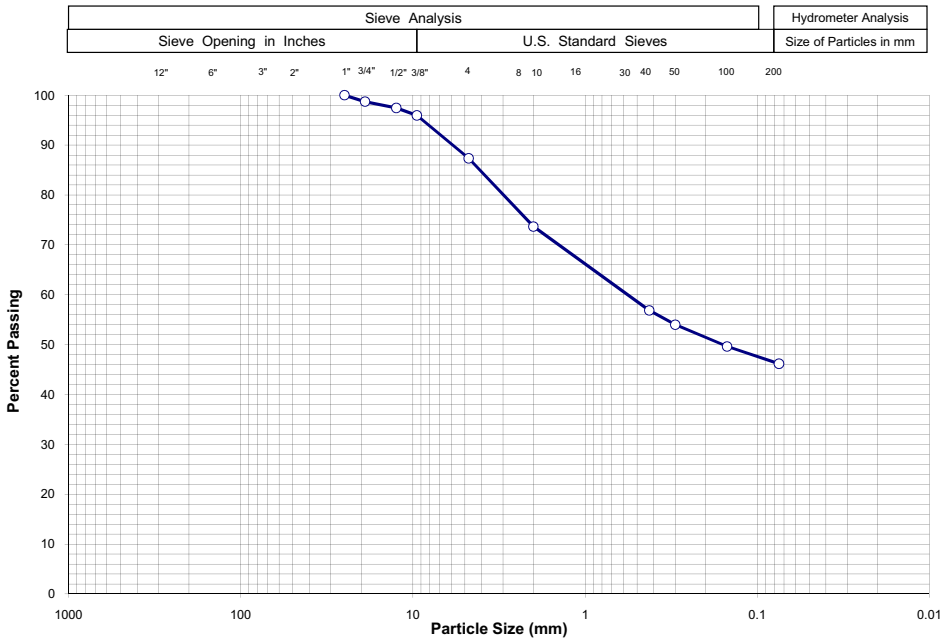
SIEVE ANALYSIS

Drawn By:	FJP	Project No.:	211-052
Checked By:	TLA	Figure No.:	-
Date:	05/23/11		

Revised 04/27/2004



Sieve Size	% Passing
3"	-
2 ½"	-
2"	-
1 ½"	-
1"	100
¾ "	99
½"	97
⅜"	96
#4	87
#10	74
#40	57
#200	46.2

Gravel (%)	13	LL	26	Project Name:	Lee's Ferry Road
Sand (%)	41	PL	17	Boring:	P-14
Fines (%)	46	PI	9	Sample Depth (ft):	1'-5'
Sample Description:	clayey sand	SC	A-4	(1)	

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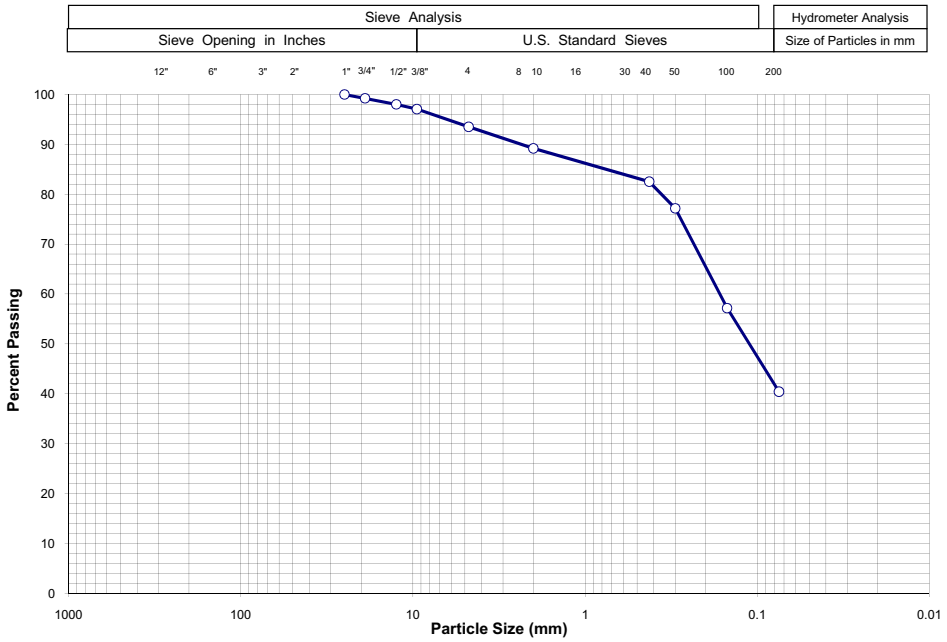
SIEVE ANALYSIS

Drawn By:	FJP	Project No.:	211-052
Checked By:	TLA	Figure No.:	-
Date:	05/23/11		

Revised 04/27/2004



Sieve Size	% Passing
3"	-
2 ½"	-
2"	-
1 ½"	-
1"	100
¾ "	99
½"	98
⅜"	97
#4	94
#10	89
#40	83
#200	40.4

Gravel (%)	6	LL	18	Project Name:	Lee's Ferry Road
Sand (%)	54	PL	12	Boring:	P-15
Fines (%)	40	PI	6	Sample Depth (ft):	1'-5'
Sample Description:	silty sand	SM-SC		A-4	(0)

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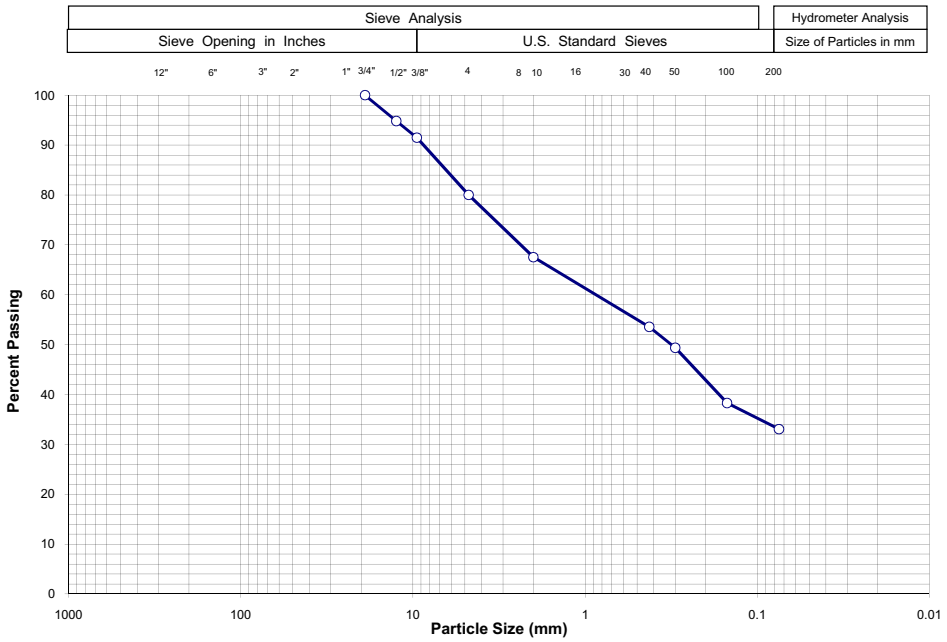
SIEVE ANALYSIS

Drawn By:	FJP	Project No.:	211-052
Checked By:	TLA	Figure No.:	-
Date:	05/23/11		

Revised 04/27/2004



Sieve Size	% Passing
3"	-
2 ½"	-
2"	-
1 ½"	-
1"	-
¾ "	100
½"	95
⅜"	91
#4	80
#10	68
#40	54
#200	33.1

Gravel (%)	20	LL	20	Project Name:	Lee's Ferry Road
Sand (%)	47	PL	15	Boring:	P-16
Fines (%)	33	PI	5	Sample Depth (ft):	1'-5'
Sample Description:	silty-clayey sand	SM-SC		A-2-4	(0)

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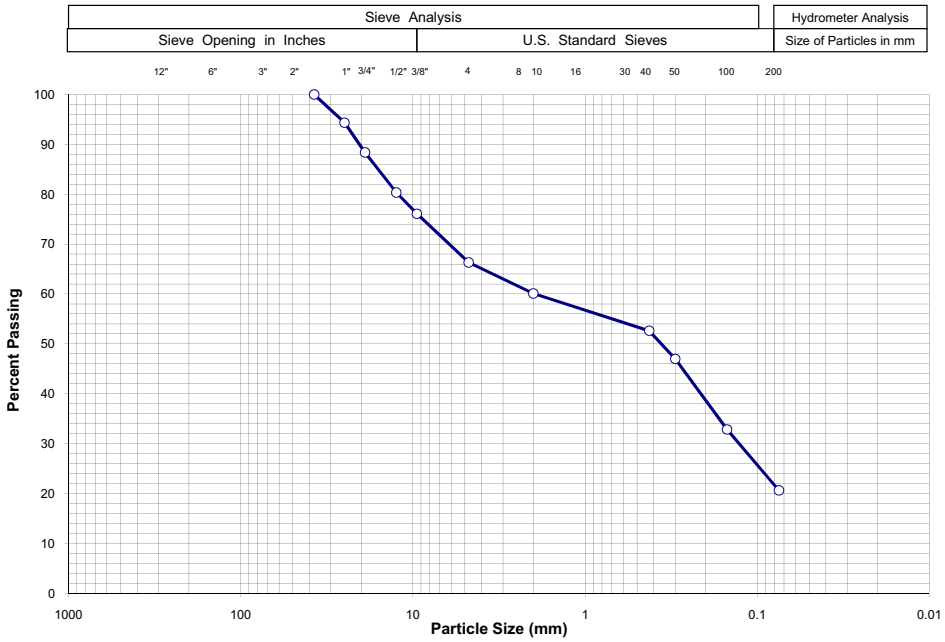
SIEVE ANALYSIS

Drawn By:	FJP	Project No.:	211-052
Checked By:	TLA	Figure No.:	-
Date:	05/23/11		

Revised 04/27/2004



Sieve Size	% Passing
3"	-
2 ½"	-
2"	-
1 ½"	100
1"	94
¾ "	88
½"	80
⅜"	76
#4	66
#10	60
#40	53
#200	20.6

Gravel (%)	34	LL	NV	Project Name:	Lee's Ferry Road
Sand (%)	45	PL	NP	Boring:	P-17
Fines (%)	21	PI	NP	Sample Depth (ft):	1'-5'
Sample Description:	silty sand	SM	A-2-4	(0)	

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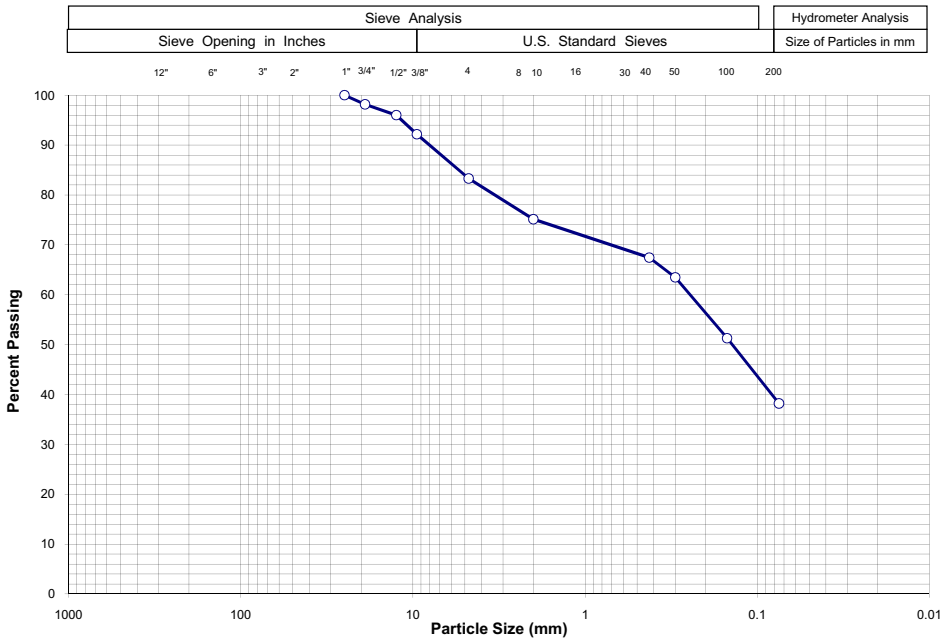
SIEVE ANALYSIS

Drawn By:	FJP	Project No.:	211-052
Checked By:	TLA	Figure No.:	-
Date:	05/23/11		

Revised 04/27/2004



Sieve Size	% Passing
3"	-
2 ½"	-
2"	-
1 ½"	-
1"	100
¾ "	98
½"	96
⅜"	92
#4	83
#10	75
#40	67
#200	38.2

Gravel (%)	17	LL	21	Project Name:	Lee's Ferry Road
Sand (%)	45	PL	15	Boring:	P-19
Fines (%)	38	PI	6	Sample Depth (ft):	1'-5'
Sample Description:	silty sand	SM-SC	A-4	(0)	

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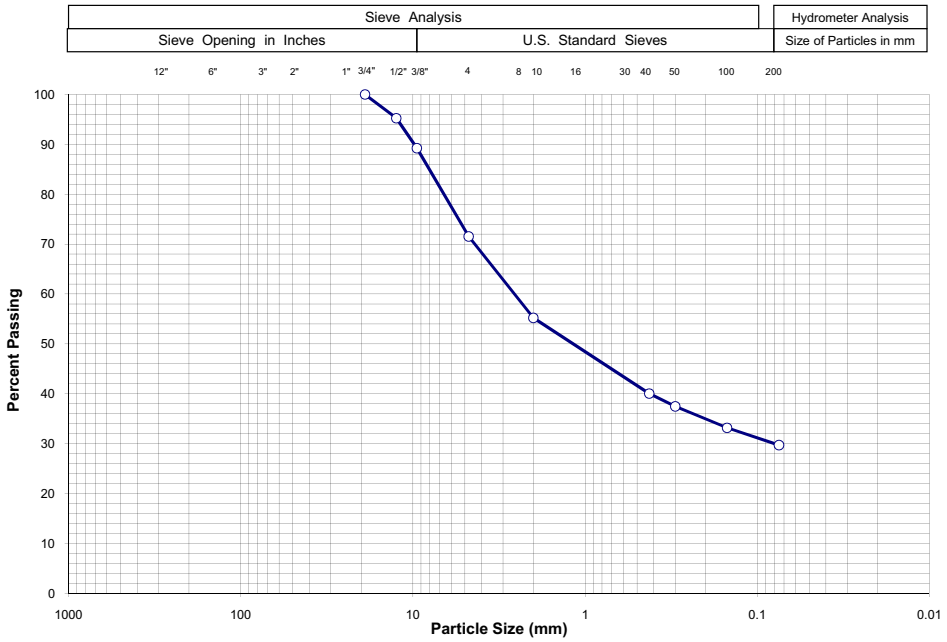
SIEVE ANALYSIS

Drawn By:	FJP	Project No.:	211-052
Checked By:	TLA	Figure No.:	-
Date:	05/23/11		

Revised 04/27/2004



Sieve Size	% Passing
3"	-
2 ½"	-
2"	-
1 ½"	-
1"	-
¾ "	100
½"	95
⅜"	89
#4	72
#10	55
#40	40
#200	29.7

Gravel (%)	28	LL	22	Project Name:	Lee's Ferry Road
Sand (%)	42	PL	15	Boring:	P-20
Fines (%)	30	PI	7	Sample Depth (ft):	1'-5'
Sample Description:	silty sand	SM-SC	A-2-4	(0)	

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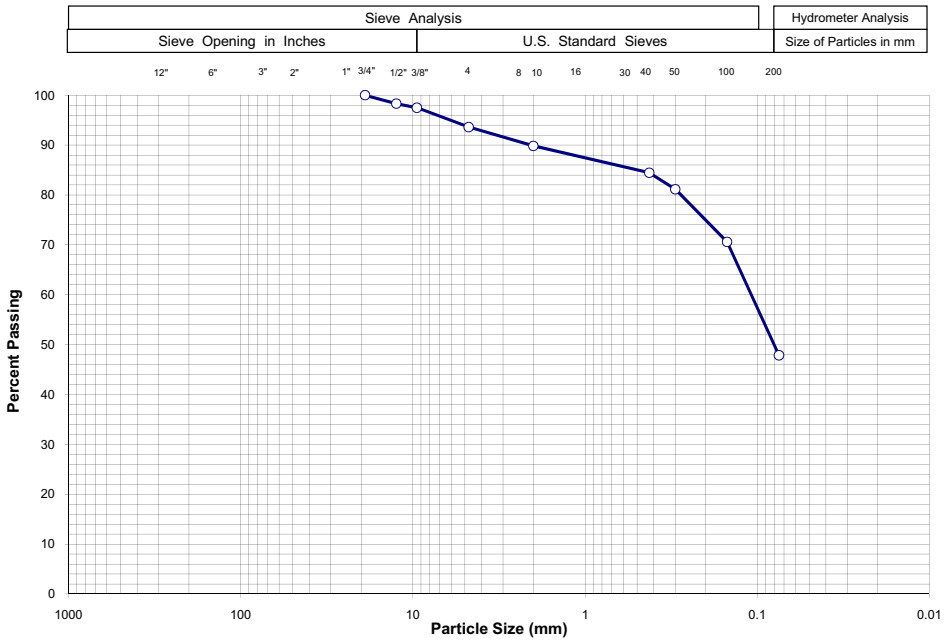
SIEVE ANALYSIS

Drawn By:	FJP	Project No.:	211-052
Checked By:	TLA	Figure No.:	-
Date:	05/23/11		

Revised 04/27/2004



Sieve Size	% Passing
3"	-
2 ½"	-
2"	-
1 ½"	-
1"	-
¾ "	100
½"	98
⅜"	97
#4	94
#10	90
#40	84
#200	47.9

Gravel (%)	6	LL	NV	Project Name:	Lee's Ferry Road
Sand (%)	46	PL	NP	Boring:	P22
Fines (%)	48	PI	NP	Sample Depth (ft):	1'-5'
Sample Description:	silty Sand	SM	A-4	(0)	

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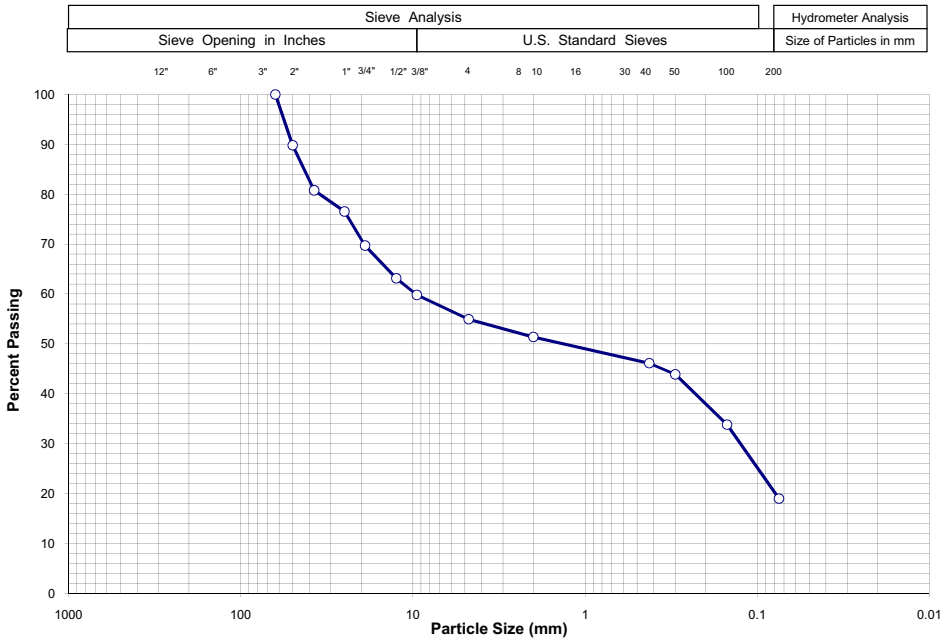
SIEVE ANALYSIS

Drawn By:	FJP	Project No.:	211-052
Checked By:	TLA	Figure No.:	-
Date:	06/01/11		

Revised 04/27/2004



Sieve Size	% Passing
3"	-
2 ½"	100
2"	90
1 ½"	81
1"	77
¾ "	70
½"	63
⅜"	60
#4	55
#10	51
#40	46
#200	19.0

Gravel (%)	45	LL	NV	Project Name:	Lee's Ferry Road
Sand (%)	36	PL	NP	Boring:	P23
Fines (%)	19	PI	NP	Sample Depth (ft):	2'-5'
Sample Description:	silty Gravel	GM		A-1-b	(0)

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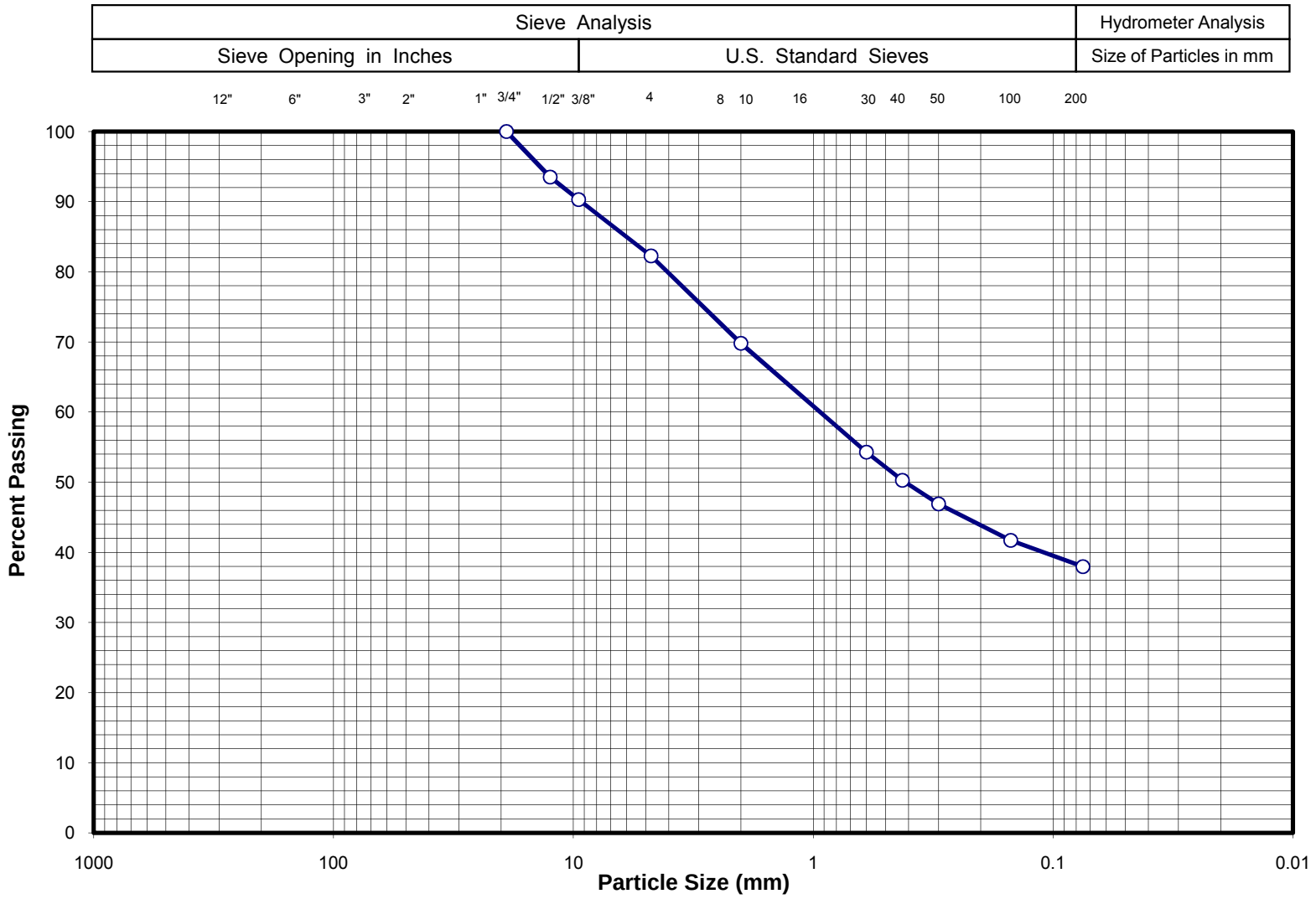
SIEVE ANALYSIS

Drawn By:	FJP	Project No.:	211-052
Checked By:	TLA	Figure No.:	-
Date:	06/01/11		

Revised 04/27/2004



Sieve Size	% Passing
3"	-
2 ½"	-
2"	-
1 ½"	-
1"	-
¾ "	100
½"	93
⅜"	90
#4	82
#10	70
#40	50
#200	38

Gravel (%)	18	LL	-168	Project Name:	Lee's Ferry Road
Sand (%)	44	PL	-174	Sample ID:	P-4
Fines (%)	38	PI	6	Sample Depth (ft.):	1-3
Sample Description:	SM - SC / A - 4 (0)				

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Geotechnical Engineering Consultants

SIEVE ANALYSIS

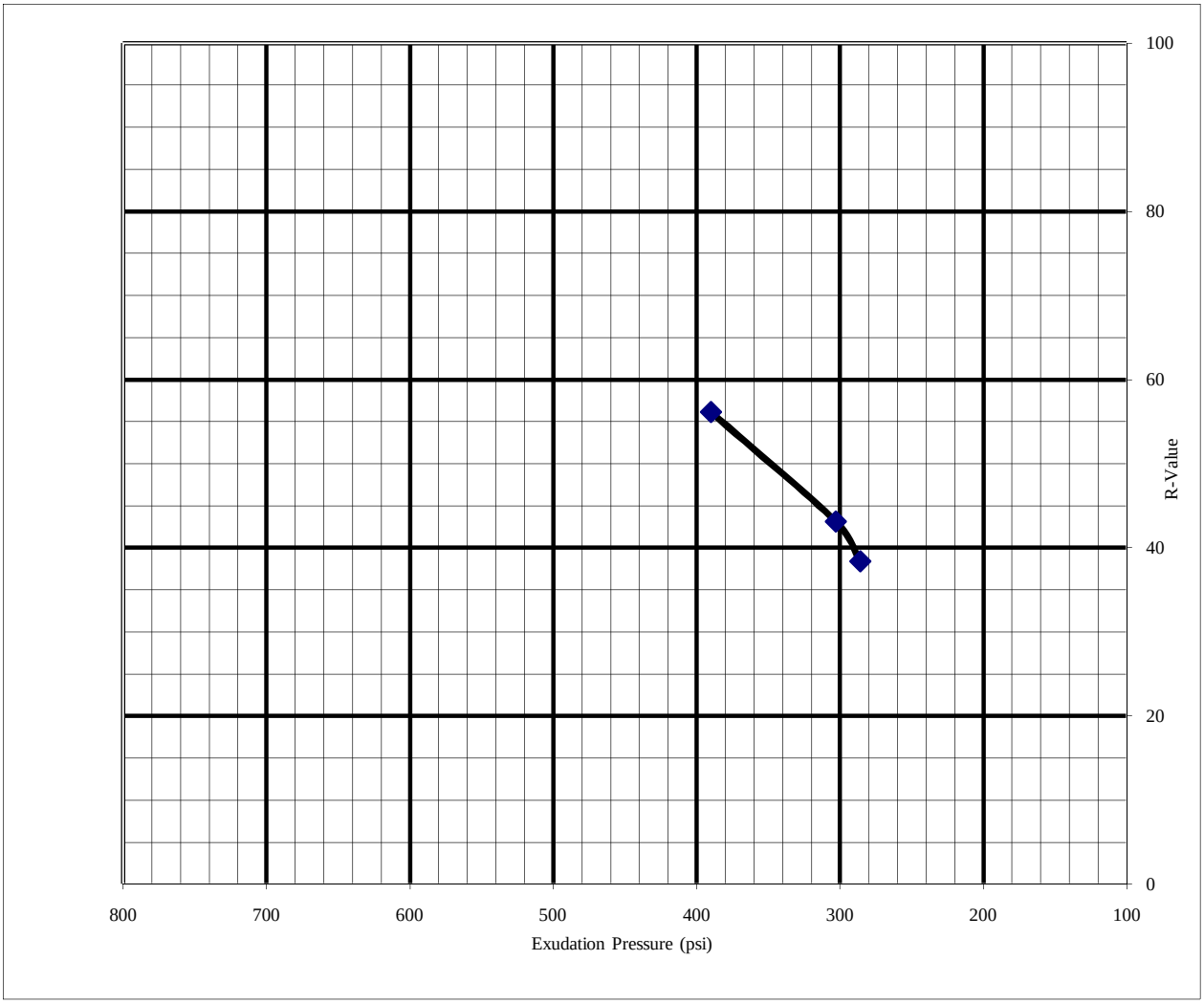
Drawn By:	MA	Project No.:	211 - 052
Checked By:	RFL	Figure No.:	-
Date:	5/112/11		

Revised 04/27/2004

YEH AND ASSOCIATES, INC

R-Value Test Report

Project Number:211-052 **Project Name:** Lee's Ferry Road
Sample Id:P-4 **Depth (ft):** 1-3
Soil Description: silty SAND with clay **Classification:** A-4(0)/ SM-SC
R-Value at 300 psi exudation pressure = **42**

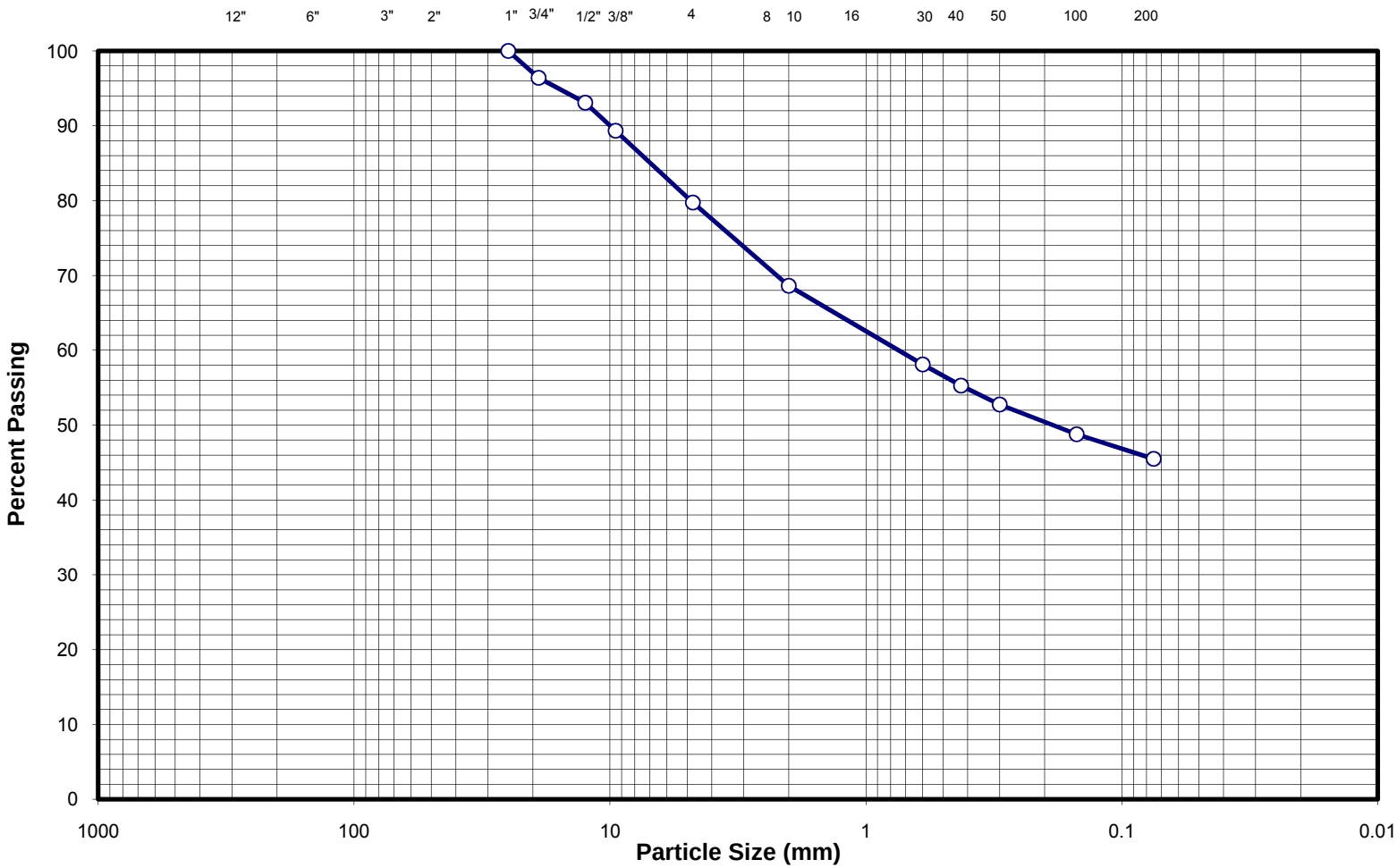


Test No.	Compact. Press. (psi)	Density (pcf)	Moist. (%)	Horizont. Pressure (psi)'@ 160 psi	Sample Height (in).	Exud. Pressure (psi)	R Value	R Value Correct.
1	300	133.7	11	60	2.51	390	51	56
2	300	133.6	12	66	2.49	303	45	43
3	300	133.3	13	82	2.55	286	33	38

Tested by: Mustapha Aichiouene **Checked by:** RFL

Rev.2-2/2011

Sieve Analysis		Hydrometer Analysis
Sieve Opening in Inches	U.S. Standard Sieves	Size of Particles in mm



Sieve Size	% Passing
3"	-
2 ½"	-
2"	-
1 ½"	-
1"	100
¾ "	96
½"	93
⅜"	89
#4	80
#10	69
#40	55
#200	45

Gravel (%)	20	LL	NV	Project Name:	Lee's Ferry Road
Sand (%)	35	PL	NP	Sample ID:	P-10
Fines (%)	45	PI	NP	Sample Depth (ft.):	7"-5
Sample Description:	SM / A - 4 (0)				

Yeh & Associates, Inc.
Geotechnical Engineering Consultants

SIEVE ANALYSIS

Drawn By:	MA	Project No.:	211 - 052
Checked By:	RFL	Figure No.:	-
Date:	05/12/11		

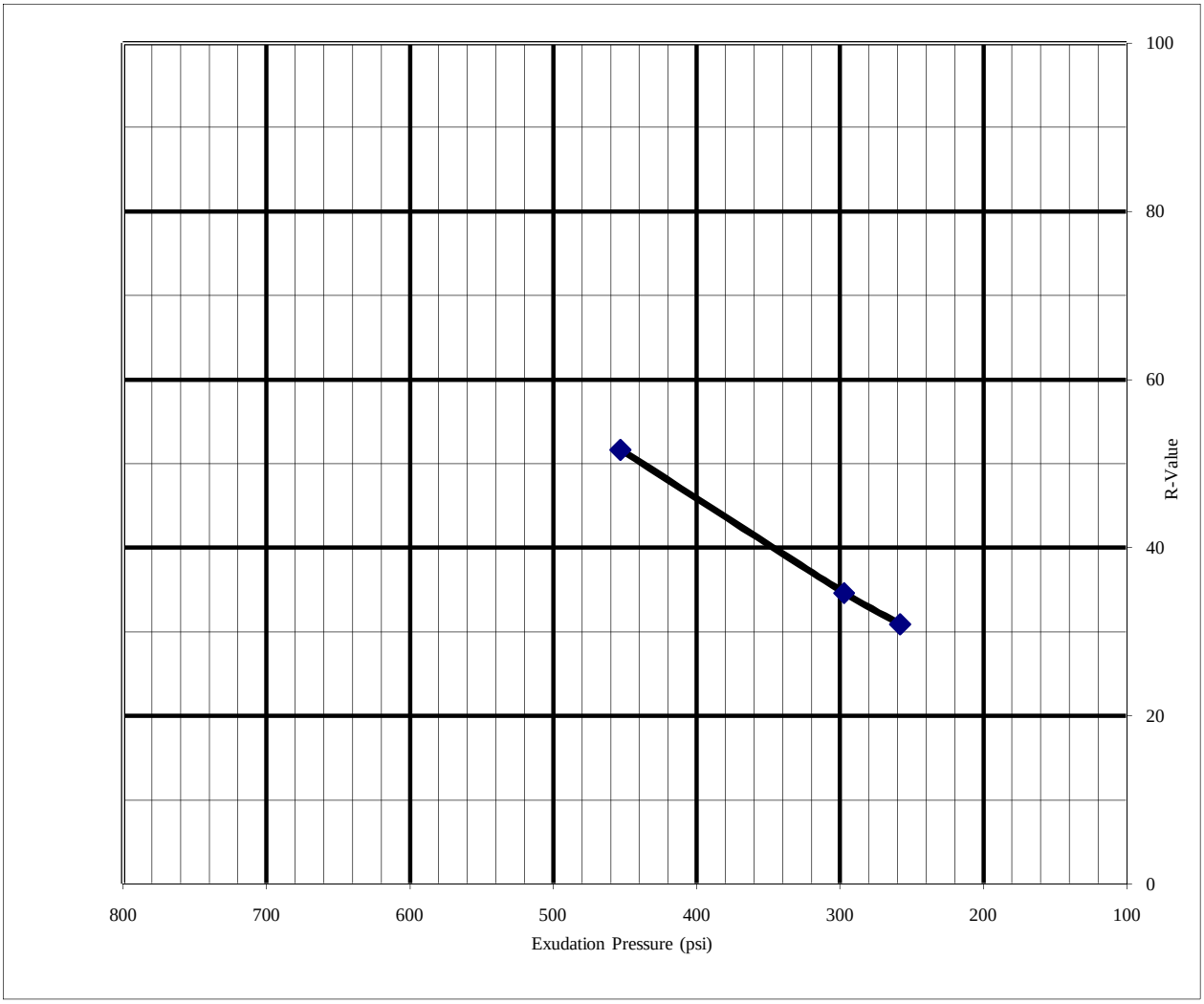
Revised 04/27/2004

YEH AND ASSOCIATES, INC

R-Value Test Report

Project Number: 211-052 **Project Name:** Lee's Ferry Road
Sample Id: P-10 **Depth (ft):** 0.6-5
Soil Description: silty SAND **Classification:** A-4(0)/SM

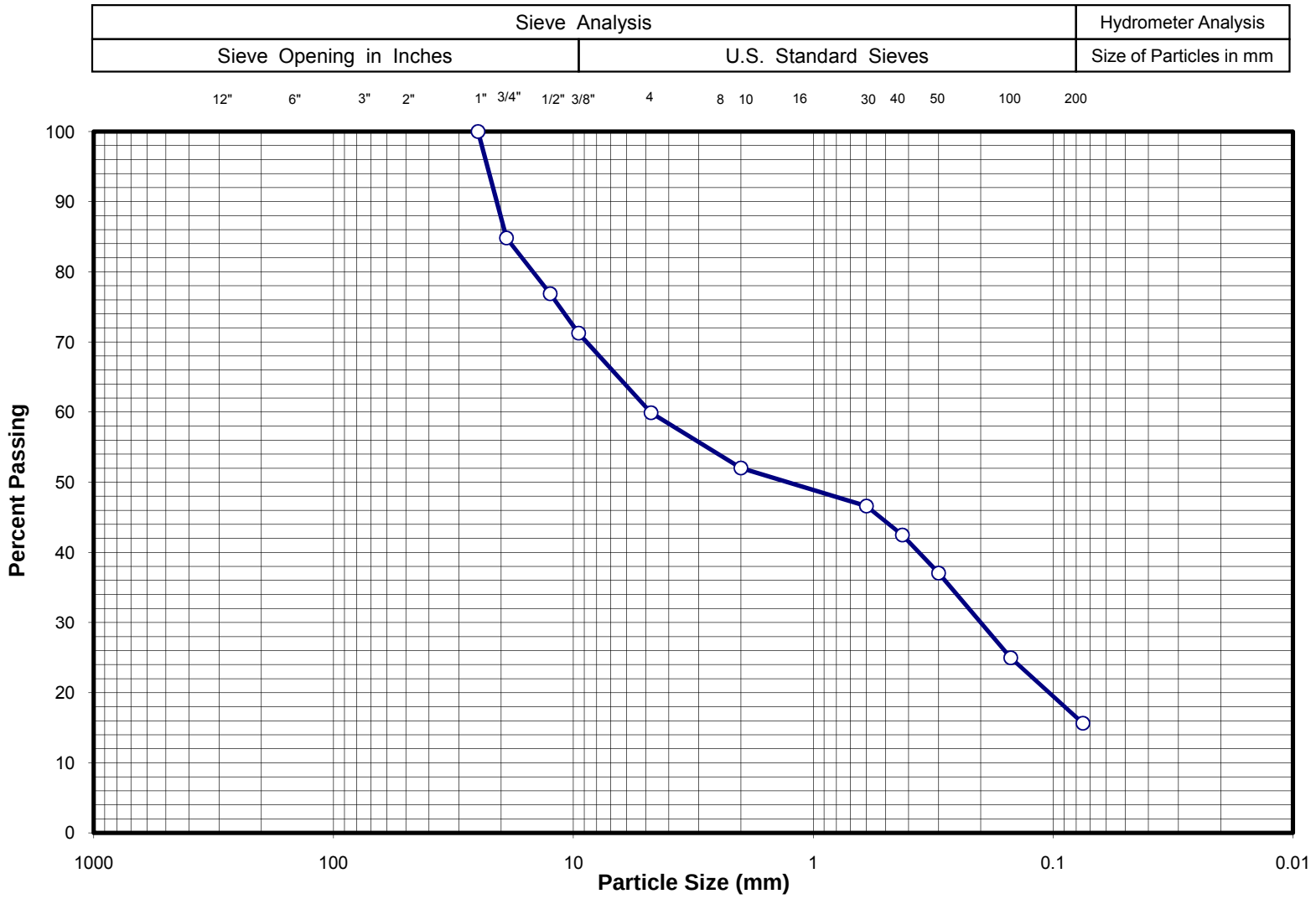
R-Value at 300 psi exudation pressure = 35



Test No.	Compact. Press. (psi)	Density (pcf)	Moist. (%)	Horizont. Pressure (psi)'@ 160 psi	Sample Height (in).	Exud. Pressure (psi)	R Value	R Value Correct.
1	300	134.0	10	68	2.51	453	47	52
2	300	133.7	11	83	2.60	297	33	35
3	300	133.5	12	93	2.55	258	27	31

Tested by: Mustapha Aichiouene **Checked by:** Sam Yu

Rev.2-2/2011



Sieve Size	% Passing
3"	-
2 ½"	-
2"	-
1 ½"	-
1"	100
¾ "	85
½"	77
⅜"	71
#4	60
#10	52
#40	42
#200	16

Gravel (%)	40	LL	NV	Project Name:	Lee's Ferry Road
Sand (%)	44	PL	NP	Sample ID:	P-18
Fines (%)	16	PI	NP	Sample Depth (ft.):	1-5
Sample Description:	SM / A - 1 -b (0)				

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Geotechnical Engineering Consultants

SIEVE ANALYSIS

Drawn By:	MA	Project No.:	211 - 052
Checked By:	RFL	Figure No.:	-
Date:	05/12/11		

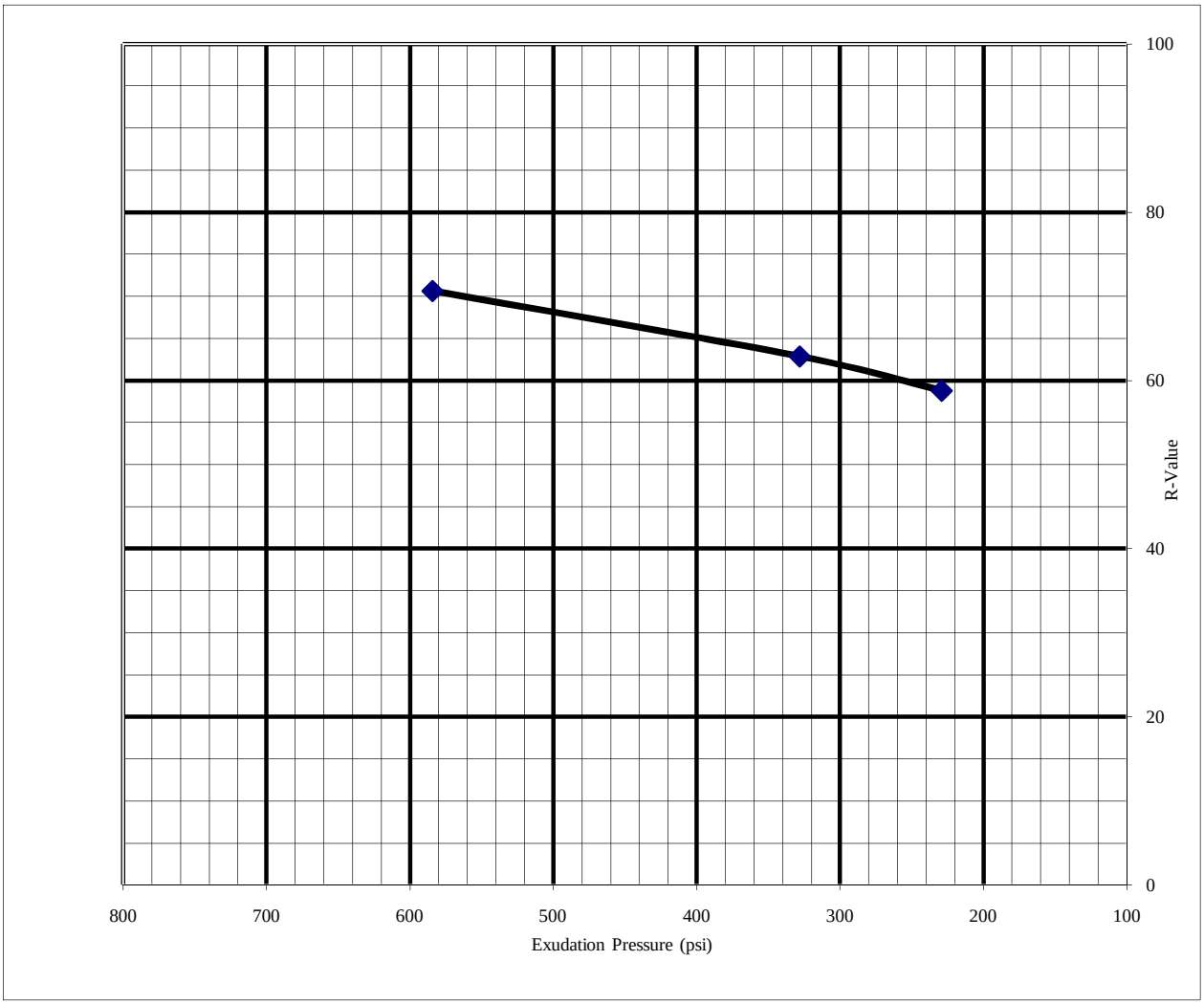
Revised 04/27/2004

YEH AND ASSOCIATES, INC

R-Value Test Report

Project Number: 211-052 **Project Name:** Lee's Ferry Rd
Sample Id:P-18 **Depth (ft): 1** - 5
Soil Description: silty SAND **Classification:** A-1-b(0)/ SM

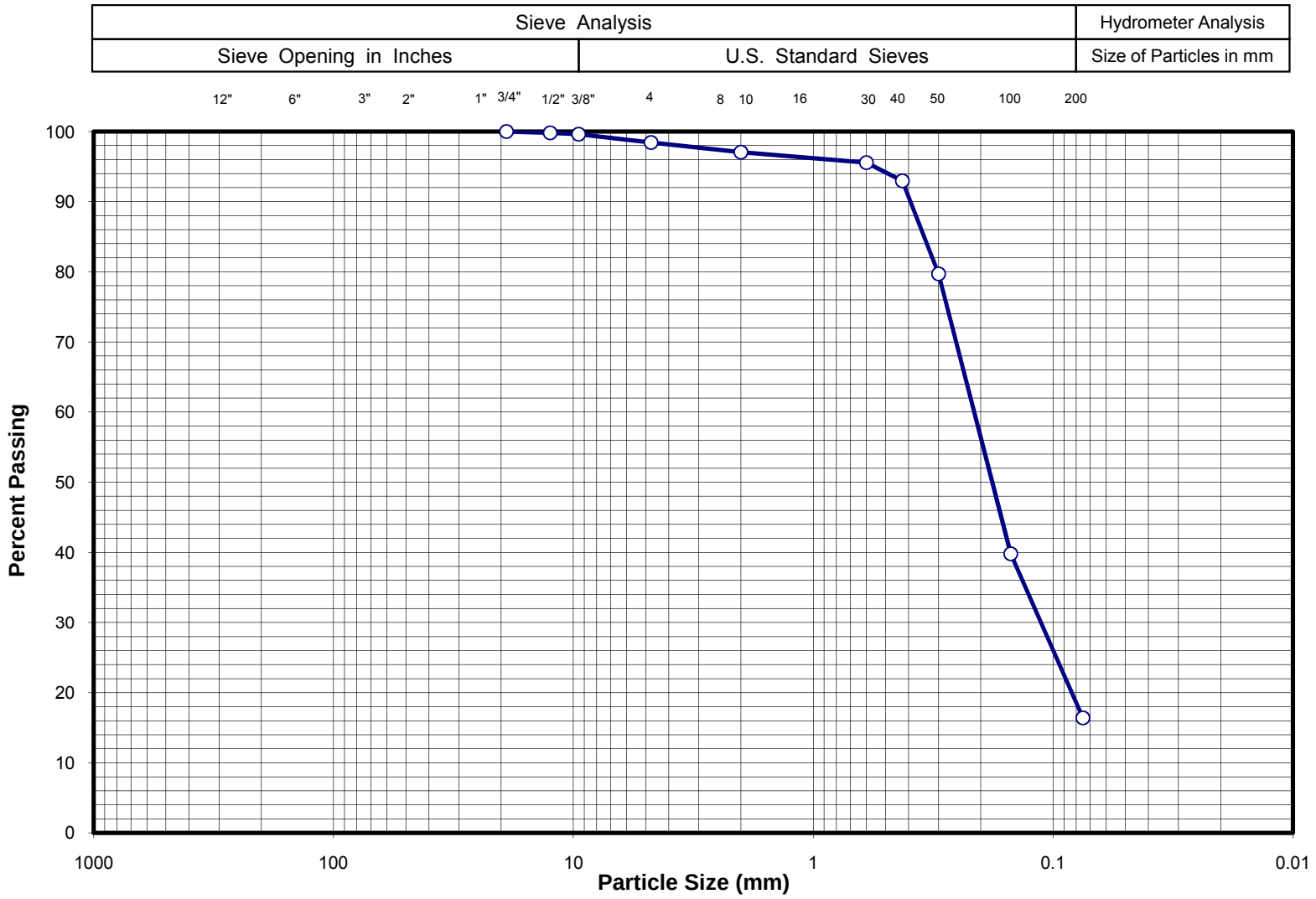
R-Value at 300 psi exudation pressure = **61**



Test No.	Compact. Press. (psi)	Density (pcf)	Moist. (%)	Horizont. Pressure (psi)'@ 160 psi	Sample Height (in).	Exud. Pressure (psi)	R Value	R Value Correct.
1	300	141.4	7	31	2.49	584	73	71
2	300	141.1	8	49	2.53	328	58	63
3	300	141.0	8	54	2.57	229	54	59

Tested by: Mustapha Aichiouene **Checked by:** Sam Yu

Rev.2-2/2011



Sieve Size	% Passing
3"	-
2 ½"	-
2"	-
1 ½"	-
1"	-
¾ "	100
½"	100
⅜"	100
#4	98
#10	97
#40	93
#200	16

Gravel (%)	2	LL	NV	Project Name:	Lee's Ferry Road
Sand (%)	82	PL	NP	Sample ID:	P-21
Fines (%)	16	PI	NP	Sample Depth (ft.):	1-5
Sample Description:	SM / A - 2 - 4 (0)				

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SIEVE ANALYSIS

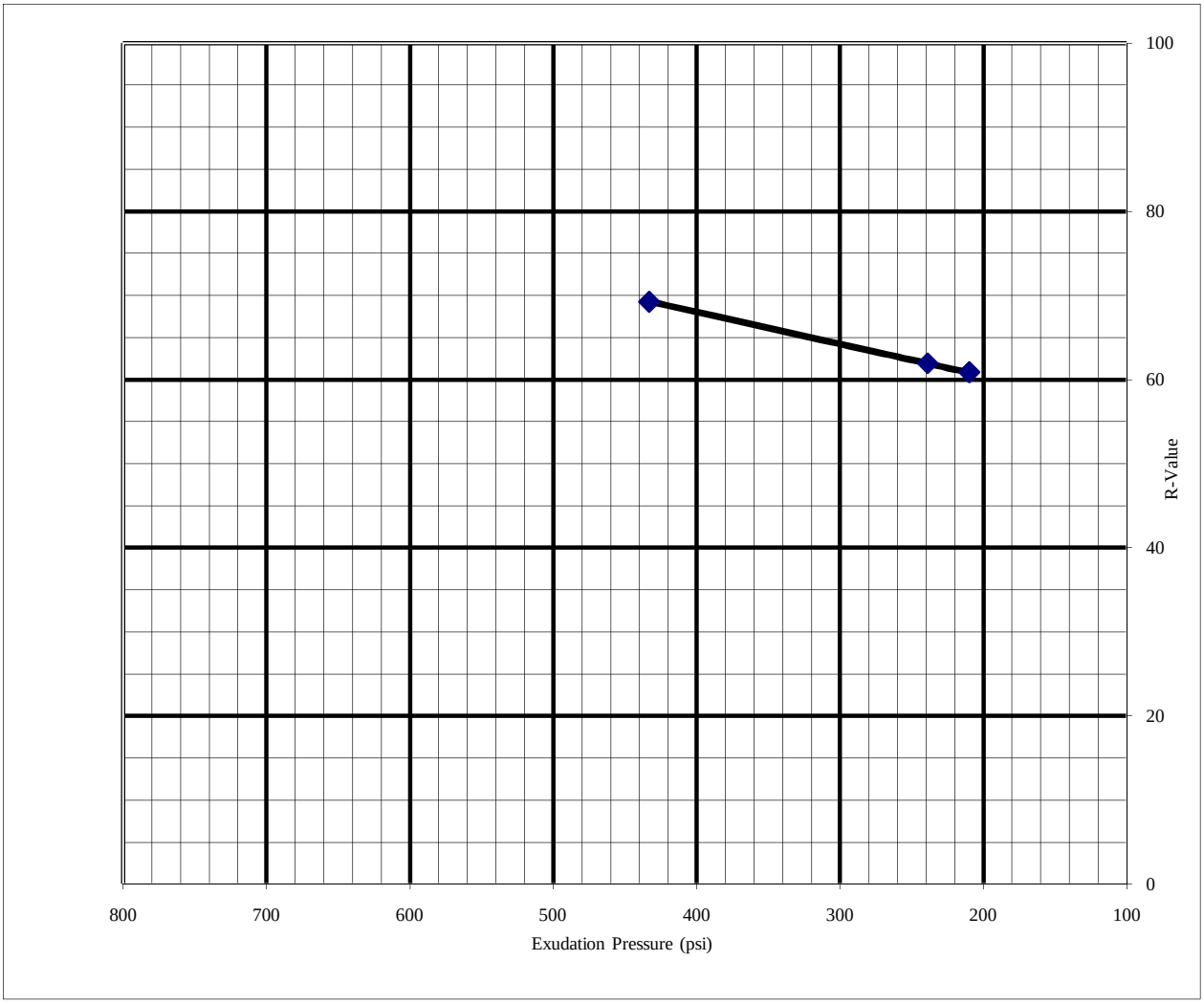
Drawn By:	MA	Project No.:	211 - 052
Checked By:	RFL	Figure No.:	-
Date:	05/12/11		

Revised 04/27/2004

YEH AND ASSOCIATES, INC

R-Value Test Report

Project Number: 211 - 052 **Project Name:** Lee's Ferry Road
Sample Id: P-21 **Depth (ft):** 0 - 5
Soil Description: silty SAND **Classification:** A-2-4(0)/ SM
R-Value at 300 psi exudation pressure = **64**



Test No.	Compact. Press. (psi)	Density (pcf)	Moist. (%)	Horizont. Pressure (psi)'@ 160 psi	Sample Height (in).	Exud. Pressure (psi)	R Value	R Value Correct.
1	300	121.4	10	38	2.60	433	67	69
2	300	121.4	11	43	2.50	239	62	62
3	300	121.4	12	51	2.52	210	56	61

Tested by: Mustapha Aichiouene **Checked by:** Sam Yu

Rev.2-2/2011

Appendix D – Pavement Condition and Drilling Photos

Photo 1 - Typical pavement condition between intersection with US 89 to Pay Station

Photo 2 - Start of subgrade problem area near Station 131+00 extra ABC and edge drain recommended

Photo 3 - Drilling P-4 extensive thermal transverse and block cracking in existing pavement

Photo 4 - Lower end of rough section near Sta. 178+00 where edge drain is recommended

Photo 5 - Typical condition near center of project, thermal cracking with deteriorated center line and some wheel path fatigue cracking

Photo 6 - Drilling P-16 with extensive block cracking

Photo 7 - Near Boring P-18 showing thermal cracks deteriorating to block and utility patch outbound as road descends to Paria River Bridge

Photo 8 - Edge deterioration and patching from utility installation - block cracking in NB lane

Photo 9 - Floodplain from Paria Bridge to launch area

Photo 10 - Launch area with bus recently slurry sealed, good pavement condition

Appendix E – Traffic Loading Calculations

TRAFFIC COUNT IN NUMBER OF VEHICLES

LEES FERRY ACCESS ROAD

GLEN CANYON NRA

	COUNT YEARS						Standard Vehicles	Standard		Maximum Reported
MONTH	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**Average**	**Deviation**		**Volumes**
January	1695	1266	926	1295	584	996	1127	380		1695
February	1180	1708	1582	1490	1870	1003	1472	326		1870
March	2350	3070	1867	1775		1979	2208	529		3070
April	3502	5910	4043	4485	8112	4597	5108	1675		8112
May	5218	6240	4044	2689	6041	4363	4766	1342		6240
June	6868	5709	6766	4793	7498	7528	6527	1076		7528
July	4313	5949	4565	4793	6522	6028	5362	916		6522
August	4523	2827	2353	2851	4963		3503	1159		4963
September	4890	4566	4110	3522	5821		4582	863		5821
October	4489	3337	3888	3888	4583		4037	509		4583
November	2543	2639	1994	2206	2295		2335	260		2639
December	869	1275	1142	1998	1440		1345	421		1998
Total	42440	44496	37280	35785	49729		42372			55041

Note: This data was reported with the comment that the traffic counters may not have been continuously functioning, so for the design of the pavement, the maximum historic monthly volume was used. Additionally, Chapter 11 of the CFL PDDM states that in the absence of a reported 20-Year growth factor, 2% should be used.

For the river trip ESALs, the calculated loading from the classification and count data was used to calculate the design ESALs instead of the counts supplied on page 2 of this original data. (Calculations attached)

Lee's Ferry Access Road ESAL Calculations

Assumption: Standard Traffic is comprised of 25% camper sized vehicles and 75% passenger cars and pick-ups

Standard Vehicles Maximum Annual Volume	Float Trip Busses & Trucks Annual Volume	Car & PU ESAL factor 75% 0.0004 1-yr ESALs	Camper ESAL factor 25% 0.5000 1-yr ESALs	River Trip Trucks Additional ESALS
1695		0.5	211.9	(See
1870		0.7	93.5	Attached)
3070	62	1.1	153.5	
8112	112	2.9	405.6	
6240	248	2.2	312.0	
7528	240	2.7	376.4	
6522	248	2.3	326.1	
4963	248	1.8	248.2	
5821	210	2.1	291.1	
4583	124	1.6	229.2	
2639	40	1.0	132.0	
1998		0.7	99.9	
One Year Total ESALs =		19.7	2879.2	1449.0
Total One Year ESALs =				4347.9 ESALs
20-Year ESALS = 1-yr * 20				
Total 20-Year ESALs =				86958
(PDDM Table 11.2)		Design Lane Factor =		1
20-Year ESALs =				86958
(PDDM P. 11-12) Growth Factor =				2%
20-Year Design ESALs =				88697
20-Year DESIGN ESALS		**USE**		**88700 ESALs**

TRAFFIC COUNT IN NUMBER OF VEHICLES
LEES FERRY ACCESS ROAD
GLEN CANYON NRA

	COUNT YEARS					
MONTH	2006	2007	2008	2009	2010	2011
January	1695	1266	926	1295	584	996
February	1180	1708	1582	1490	1870	1003
March	2350	3070	1867	1775	0	1979
April	3502	5910	4043	4485	8112	4597
May	5218	6240	4044	2689	6041	4363
June	6868	5709	6766	4793	7498	7528
July	4313	5949	4565	4793	6522	6028
August	4523	2827	2353	2851	4963	0
September	4890	4566	4110	3522	5821	
October	4489	3337	3888	3888	4583	
November	2543	2639	1994	2206	2295	
December	869	1275	1142	1998	1440	
Total	42440	44496	37280	35785	49729	

BUSES ASSOCIATED WITH COLORADO RIVER DISCOVERIES FLOAT TRIPS*

MONTH	2011
January	
February	
March	62
April	112
May	248
June	240
July	248
August	248
September	210
October	124
November	40
December	

Lees Ferry Access Road Raft Trip Traffic Loading 211-052

ESAL Calcs based on vehicle count and classification information Tim Windle Traffic Report
Based on 2010 Launches - Count assumed to be 2/3 (67%) of outfitter launches

	Number of Veh.	Veh Type	ESAL Factor	ESALs
ARR	57	Semi	2.2	125.4
	98	Pass Van	0.5	49.0
	14	Pass Van	0.5	7.0
	6	2 axle 6 tire	0.6	3.6
	14	Bus	0.88	12.3
AzRA	38	Semi	2.2	83.6
	40	2 axle 6 tire	0.6	24.0
	6	2 axle 6 tire	0.6	3.6
Can Esp	16	2 axle 6 tire	0.6	9.6
Can-eers	27	Semi	2.2	59.4
	3	2 axle 6 tire	0.6	1.8
CRATE	15	2 axle 6 tire	0.6	9.0
	6	2 axle 6 tire	0.6	3.6
	4	Bus	0.88	3.5
	32	2 axle 6 tire	0.6	19.2
	11	Bus	0.88	9.7
	7	2 axle 6 tire	0.6	4.2
	7	Semi	2.2	15.4
WhiteW	7	Pass Vans	0.5	3.5
	7	Bus	0.88	6.2
	39	2 axle 6 tire	0.6	23.4
	5	2 axle 6 tire	0.6	3.0
Cany E	12	2 axle 6 tire	0.6	7.2
	2	Semi	2.2	4.4
	3	Bus	0.88	2.6
	7	Pass Vans	0.5	3.5
Hatch	66	2 axle 6 tire	0.6	39.6
	2	2 axle 6 tire	0.6	1.2
	2	Pass Vans	0.5	1.0
	1	2 axle 6 tire	0.6	0.6
	1	Pass Vans	0.5	0.5
Moki	9	Semi	2.2	19.8
	15	2 axle 6 tire	0.6	9.0
	1	2 axle 6 tire	0.6	0.6
OARS	34	2 axle 6 tire	0.6	20.4
Outdoors	2	2 axle 6 tire	0.6	1.2
	2	Pass Vans	0.5	1.0
	1	2 axle 6 tire	0.6	0.6
Tour West	21	2 axle 6 tire	0.6	12.6

	2	2 axle 6 tire	0.6	1.2	
	2	Pass Vans	0.5	1.0	
	8	2 axle 6 tire	0.6	4.8	
	2	Pass Vans	0.5	1.0	
Western	51	Semi	2.2	112.2	
	208	Pass Vans	0.5	104.0	
	104	Trail	0.5	52.0	
Wilderness	38	Semi	2.2	83.6	
	10	Pass Vans	0.5	5.0	
	1065		Total one-Yr ESALs =	971	ESALs
			Reported to only be 2/3 of trips, so divid by 0.67 =	1449	ESALs

Appendix F – Pavement Design Calculations

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Flexible Structural Design Module

Lees Ferry Road
211-052
Pulverize Existing
R = 35

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	88,700
Initial Serviceability	4.2
Terminal Serviceability	2
Reliability Level	75 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	8,065 psi
Stage Construction	1
Calculated Design Structural Number	2.03 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HACP	0.4	1	3.6	12	1.44
2	FDR Pulveizing	0.1	1	6	12	0.60
Total	-	-	-	9.60	-	2.04

Use 4.0 Inches