Draft Geotechnical Investigation and Pavement Design Report
BIA Project N8066(3), N8065(1), and School Spur
Black Mesa Community School, AZ (Navajo Nation)
BIA Order No. A15PD00791
BIA Requisition No. 0040235503
Architect – Engineer IDIQ Contract No. A12PC00121

Submitted to:

Bureau of Indian Affairs, Navajo Regional Office
Gallup, New Mexico

Submitted by:

Amec Foster Wheeler
Environment & Infrastructure, Inc.
Phoenix, Arizona

February 15, 2016

Project No. 17-2015-4045

February 15, 2016
Project No. 17-2015-4045

Bureau of Indian Affairs, Navajo Regional Office
Division of Acquisition
PO Box 1060
301 West Hill, Room 346
Gallup, New Mexico 87301

Attn: Christopher Becenti

Re: Draft Geotechnical Investigation and Pavement Design Report
BIA Project N8066(3), N8065(1), and School Spur
Black Mesa Community School, AZ (Navajo Nation)
BIA Order No. A15PD00791
BIA Requisition No. 0040235503
Architect – Engineer IDIQ Contract No. A12PC00121

Amec Foster Wheeler Environment & Infrastructure, Inc. (Amec Foster Wheeler) has completed this Draft Geotechnical Investigation and Pavement Design Report in support of the proposed improvements of Bureau of Indian Affairs (BIA) Route N8066 (3), BIA Route N8065 (1), and School Spur near Black Mesa Community School, Arizona. This work was performed in general accordance with BIA Order No. A15PD00791 dated September 18, 2015. The sections of this report include a project description, discussions of the geotechnical profile encountered at the site, recommendations for design of roadway pavements, and other aspects of the project where geotechnical recommendations are appropriate. The Geotechnical Investigation and Foundation Recommendation Report will be provided under a separate cover.

We at Amec Foster Wheeler appreciate the opportunity to provide these services for you. If you have any questions regarding this report, please do not hesitate to contact us.

Respectfully submitted,

Amec Foster Wheeler
Environment & Infrastructure, Inc.

Naida Causevic, PE
Senior Geotechnical Engineer

Reviewed by:

Mark Hartig, PE
Geotechnical Operations Manager

c: Addressee (2)

G:\Geotechnical\2015 Projects\17-2015-4045 BIA_School Spur-Spur Road Geotechnical Investigation\Report\DRAFT\Geotechnical and Pavement Report\Geotech Investigation and Pavement Design Report.docx

4600 East Washington Street Suite 600
Phoenix, Arizona 85034-1917
Tel: (602) 733-6000
Fax: (602) 733-6100
www.amecfw.com

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 PROJECT INFORMATION AND PURPOSE

Included in this report are the results of our investigation in support of the planned improvements to Bureau of Indian Affairs (BIA) Route N8066(3), between approximately Stations 13+800 and 22+975, a distance of 9.175 kilometers (5.70 miles), BIA Route N8065(1), between approximately Stations 0+000 and 1+974, a distance of 1.974 kilometers (1.23 miles), and School Spur between Stations 0+000 and 0+700, a distance of 0.700 kilometers (0.43 miles). The project consists of roadway improvements to the existing unpaved roads and the addition of two bridge structures across two drainage features. Foundation recommendations for the bridge structures will be provided under separate cover in the Geotechnical Investigation and Foundation Recommendation Report.

At the request of the BIA, our investigation consisted of a subsurface exploration and a laboratory testing program to classify and evaluate the subgrade soils at approximately 200-meter intervals along the proposed roadway. This report also provides recommendations for pavement subgrade support, pavement thickness, earthwork factors, and other aspects of the project where geotechnical properties or behavior require consideration. In addition, our investigation included obtaining resistivity readings at BIA provided locations to evaluate the soil corrosivity and degradation potential of pipes to be installed at drainage structures.

This report does not address any environmental issues related to the site or the project. If you have any questions concerning environmental aspects of this project please contact us and we can discuss additional services with you.

This report has been prepared for BIA, Navajo Regional Office for the purpose of providing the information described below. This report has not been prepared for any other parties, and may not contain sufficient information for purposes of other parties. If any of the project information described in Section 1.0 of this report has changed, we should be notified so that we may amend our recommendations, as necessary.

2.0 FIELD INVESTIGATION

2.1 Subsurface Exploration

The subsurface exploration for this project was performed from December 8 to December 12, 2015 and January 14 to January 19, 2016. Field direction, sample collection, and logging of borings were performed by Joseph Zaleski, EIT and Mark Keyes, PG, of Amec Foster Wheeler Environment & Infrastructure, Inc. (Amec Foster Wheeler). Logs of the completed borings are presented in Appendix A of this report. Appendix A also includes a description of drilling and sampling procedures. Amec Foster Wheeler advanced 60 soil borings along the proposed roadway alignment to depths ranging from 0 to 13.5 meters below existing site grades for a total drill footage of approximately 106.5 meters. The total drill footage was less than the targeted/proposed footage of 112.5 meters due to the following reasons: boring SS-9 reached refusal at the surface on top of bedrock, and boring SS-8 needed to be moved in the field due to access issues and the drill depth was adjusted based on elevation change. Forty-six borings, R-1 through R-46, were completed for the roadway improvements approximately along centerline of the proposed BIA Route N8066(3) road alignment and were spaced at approximately 200-meter

intervals. Ten borings, SS-1 through SS-10, were advanced for the roadway improvements approximately along centerline of the proposed School Spur alignment, at approximately 200-meter intervals. Four borings, RS-1 through RS-4, were advanced for the roadway improvements approximately along centerline of the proposed BIA Route N8065(1) alignment, at approximately 200-meter intervals. Locations of the borings are shown on Figures 1 through 4, the Boring and Resistivity Location Map, and are presented in tabular format in Table 1.

The borings were completed by Southlands Engineering, LLC (Southlands) with a truck-mounted CME 75 drill rig utilizing a 168 millimeter outside diameter continuous-flight hollow stem auger and a specialized ATV mounted CME 75 drill rig utilizing a 206 millimeter outside diameter continuous-flight hollow stem auger. Completed soil borings were backfilled with soil cuttings and left slightly mounded to allow for settlement.

Each boring location was established in the field using the laid out proposed alignments for each roadway segment and confirmed with a handheld GPS unit in NAD 83 – UTM Zone 12N coordinates. The locations of the borings are shown on the boring logs and are presented in Appendix A. Encountered soils were visually inspected, labeled and classified in the field, and logged in general accordance with ASTM D2488 and the Unified Soil Classification System. After completion of the laboratory tests on the samples retrieved, the field logs were reviewed and modified, where necessary, to produce the final boring logs presented in Appendix A.

2.2 Laboratory Testing

Laboratory tests were performed on representative bulk, split spoon and ring samples obtained during our subsurface exploration to evaluate and characterize the site soils for engineering analysis and design. The following tests were performed in general accordance with applicable American Association of State Highway and Transportation Officials (AASHTO) test methods. In absence of an AASHTO test method, American Society for Testing and Materials (ASTM) test methods were used.

- Sieve Analysis (Gradation and Minus 75 micrometer wash) (AASHTO T11,T27)
- Plasticity Index (AASHTO T89, T90)
- Moisture-Density Relationship Test (Proctor) (ASHTO T99 Method A)
- Resistance Value Test (R-Value) (AASHTO T190)
- Density Test (ASTM D2937)
- Moisture (ASTM D2937)
- One-Dimensional Swell or Settlement Potential of Cohesive Soils Test (ASTM D-4546)

A summary of the laboratory test results is presented in Table B-1 in Appendix B along with the test worksheets.

2.3 Resistivity Arrays

Twenty-five resistivity arrays were performed with a MiniRes Resistivity Meter (L and R Instruments, Inc.) on the subsurface materials at locations provided by the BIA, shown on Figures 1 through 4, the Boring and Resistivity Location Map, as resistivity readings, in general accordance with the Wenner Four-Pin Method (IEEE Std. 81-2012). The purpose of the resistivity

arrays was to evaluate the corrosivity and degradation potential of pipes to be installed at drainage structures. This method of measuring subsurface resistivity involves placing four electrodes in the ground in a straight line at spacings of an equal distance, applying a measured alternating current (AC) to the outer two electrodes and measuring the voltage between the inner two electrodes. A measured resistance is calculated by dividing the measured voltage by the measured current. This resistance is then multiplied by a geometric factor, which includes the spacing between each electrode to determine the apparent resistivity. The arrays were performed with a straight current process. The pin spacing used for the arrays was 0.76, 1.52, 3.05, 4.57, and 6.10 meters. Electrical resistivity arrays were performed and overseen by Joe Zaleski, EIT, of Amec Foster Wheeler. Electrical resistivity results are attached and presented in Table 2.

3.0 GEOTECHNICAL PROFILE

3.1 Geologic Setting

Surficial geologic units exposed within the project site include Holocene-aged and/or Pleistocene-aged Quaternary alluvial and eolian deposits and Upper Cretaceous-aged sandstone and siltstone. The Holocene deposits are comprised of stream deposits and windblown silt and sand deposited on benches, small terraces and in broad valleys. These deposits have been reworked by water. The Upper Cretaceous-aged sandstones and siltstones of the Wepo Formation are part of the Mesaverde Group. The Wepo Formation is comprised of alternating siltstone and sandstone of continental and near-shore origin, and to some extent coal beds of up to 1.5 meters in thickness. The siltstone is generally olive-green in color and the sandstone is typically yellowish-gray. This unit varies from 40 meters to 225 meters in thickness. (Haynes and Hackman, 1978).

3.2 Geotechnical Profile

Native soils encountered at the site primarily consist of sandy clays to clays, interfingered with silty sands to sandy silts. The sandy clay to clay and occasional clayey sand soils were encountered throughout approximately 70 percent of the roadway alignments of N8065(1), N8066(3) and School Spur, 25 percent was silty sand to sandy silt and the remaining 5 percent was bedrock. The Wepo Formation bedrock is exposed at the surface in several locations along the northern section of the project sites, in the vicinity of BIA Route N8066(3) and School Spur.

3.2.1 BIA Route N8066(3)

Native soils encountered along BIA Route N8066(3) primarily consist of sandy clays to clays, which are interfingered by silty sands to sandy silts in close proximately to washes. The Wepo Formation sandstone and siltstone was encountered in boring R-41 at the surface and boring R-42 at approximately 2.7 meters below ground surface. The lab testing on the sandy clay to clay soils indicate they contain approximately 50 to 90 percent fines (material passing the 75-micrometer sieve), and generally none-to-less than 5 percent gravel. The silty sand to sandy silt soils contain approximately 40 to 60 percent fines (material passing the 75-micrometer sieve), and generally none to less than 5 percent gravel. Plasticity ranged from medium to high for the clayey soils, and was generally non plastic for the silty sand to sandy silt soils. The soils typically ranged from uncemented to moderately-cemented and in general had uncorrected SPT blow counts that ranged from “weight of hammer” near the surface to refusal (i.e., 50 blows for less

than a 150 millimeter interval). The blow counts were typically lower in soil zones of increased moisture, and refusal blow counts were typically related to the encounter of the sandstone in the borings. The firmness of the soil ranged from very soft to hard.

3.2.2 BIA Route N8065(1)

Native soils encountered along BIA Route N8065(1) primarily consist of clay on the southeast side of the wash and clay to clayey sand overlaying silty sand on the northwest side of the wash. The lab testing on the clay soils indicate they contain approximately 90 percent or more fines (material passing the 75-micrometer sieve), and generally no gravel. Plasticity ranged from medium to high for the clayey soils, and was generally non plastic for the silty sand soils. The soils were uncemented with some thin calcium carbonate filaments and in general had uncorrected SPT blow counts that ranged from 9 to 41. The firmness of the soil ranged from moderately firm to very firm.

3.2.3 School Spur

Native soils encountered along School Spur primarily consist of clayey sands to sandy clay, with occasional clayey gravels and silty sands. The Wepo Formation sandstone and siltstone was encountered in borings SS-8 and SS-9 at the surface and SS-6 at approximately 0.5 meters below ground surface. The lab testing on the clayey sand to sandy clay soils indicate they contain approximately 35 to 60 percent fines (material passing the 75-micrometer sieve) and generally none to less than 10 percent gravel. The silty sand soils contain approximately 20 percent fines (material passing the 75-micrometer sieve), and generally none to less than 5 percent gravel. Plasticity ranged from low-to-medium plasticity for the clayey soils and was generally non plastic for the silty sand soils. The soils were generally uncemented with occasional weakly-cemented zones, and in general had uncorrected SPT blow counts that ranged from 3 near the surface to refusal (i.e., 50 blows for less than a 150 millimeter interval). The blow counts were typically lower in soil zones of increased moisture, and refusal blow counts were typically related to the encounter of the sandstone in the borings. The firmness of the soil ranged from very soft to hard. Roadway fill was encountered along School Spur at boring SS-10 between about 0 to 1.35 meters. Gravels, cobbles, and boulders were encountered at the surface along sections of School Spur near borings SS-2 and SS-6.

3.3 Expansion Potential

One-dimensional swell or settlement tests (ASTM D4546) were performed on 10 samples. The tests were completed on six relatively undisturbed samples and four on remolded samples compacted to 95 percent of maximum dry density and 2 percent below optimum moisture content as determined by AASHTO T99, standard Proctor. Five out of the six relatively undisturbed samples experienced negligible swell or collapse, typically less than 2 percent swell, with one of the six sample, at R-26, experiencing 7.1 percent swell. The four remolded samples experienced expansion potential that ranged from 1.2 percent to 6.8 percent.

3.4 Material Densities

Laboratory density tests (ASTM D2937) were performed to determine in situ dry densities to be used in shrink-swell analysis for near-surface materials (see Section 4.7). The samples collected

for these tests were taken along the roadway alignment primarily between 0 and 1.05 meters below the site grades. Twenty-five density tests were completed with in situ dry density values ranging between 1,098.2 and 1645.4 kilograms per cubic meter (kcm), with an average of approximately 1,476 kcm.

Sixteen moisture-density relationships (AASHTO T99) were performed on bulk samples collected within the upper 1.35 meters to be used in shrink-swell analyses. The maximum dry densities developed from these moisture-density relationships tests were between 1,557.0 and 1882.2 kcm with an average value of approximately 1,759 kcm.

3.5 Groundwater and Soil Moisture Conditions

Groundwater was not encountered in any of the soil borings throughout the depth of this investigation. Moisture content tests developed as part of the density tests (ASTM D2937) were used to evaluate the on-site soil moisture characteristics. The site soils were generally described as being slightly moist with occasional moist zones, and measured soil moisture contents varied from 7.4 to 22.6 percent (of dry weight), with an average value of approximately 14 percent.

3.6 Pavement Subgrade Support

Sixteen laboratory R-Value tests (AASHTO T190) and 19 correlated R-Values, determined using Table 202.02-3 in the Arizona Department of Transportation (ADOT) Preliminary Engineering & Design (PE&D) Manual (ADOT 1989), were completed in order to evaluate potential pavement subgrade. The tested samples were within 1.5 meters or less of the proposed finished grade and are representative of the materials that will form the final roadway subgrade. The 16 tested laboratory R-Values ranged from 6 to 37, with an average of 19 and a lower quartile of 9. By comparison, the 19 correlated R-Values ranged from 8 to 74, with an average of 31 and a lower quartile of 14. For these site soils, the correlated R-Values were noticeably higher, 1.5 and up to 3 times, than the tested R-Values. In addition, there was a great difference in the tested R-Values between the clayey and silty soils. The clayey soil R-Values were generally less than 20 with more than half being less than 10, while the silty soil R-Values were generally greater than 30. A summary of the R-Values is presented in Table 3.

The pavement subgrade was divided into three segments for design: BIA Route N8066(3), BIA Route N8065(1) and School Spur. BIA Route N8066(3) and School Spur were combined for pavement design based on similar soil conditions. Both roadway alignments encountered primarily clayey sand to sandy clay soils interfingered by silty sands to sandy silts. The design R-Value for these two roadway segments was weighted toward the clayey soils due to the incidence of occurrence throughout these two roadway alignments as discussed in Section 3.2. The average design R-Value for BIA Route N8066(3) and School Spur excluded the silty soil R-Values since they did not represent the majority of the site soils at these two alignments; therefore, skewing the average.

The segment design mean R-Values are as follows:

Table 3.1: Mean R-Values

Description	Location	Mean R-Value (Using ADOT Methodology)
BIA Route N8066(3)	Station 13+800 to 22+975	12
BIA Route N8065(1)	Station 0+000 to 0+700	7
School Spur	Station 0+000 to 1+974	12

4.0 DISCUSSION AND RECOMMENDATIONS

The following sections provide information on the pavement design of BIA Route N8066(3), N8065(1) and School Spur, along with geotechnical recommendations for roadway construction. Two design alternatives were considered for BIA Route N8065(1) based on the ESAL calculation: a flexible pavement design and a low volume road design.

4.1 General Pavement Design Parameters

4.1.1 Traffic Analysis

Traffic data for the project site was provided in the BIA Route N8066(3), N8065(1) and School Spur, BIA Order No. A15PD00791 Section C – Descriptions and Specifications, Subsection B. Scope of Work for Roadway (BIA Order No. A15PD00791). Table 4 (attached to this report) presents the projected average daily traffic (ADT) for the design years and computed equivalent single-axle loads (ESALs) used in the pavement design for BIA Route N8066(3) & School Spur, and N8065(1). The ADT and ESAL estimates were developed using data from the following sections.

4.1.1.1 Growth Rate

An annual growth rate of two percent was provided for BIA Route N8066(3), School Spur, and N8065(1) in BIA Order No. A15PD00791. This annual growth rate and the provided 2015 ADT were utilized in Amec Foster Wheeler's analyses of the projected 2016 ADT and was assumed to be constant over the design life of the roadway.

4.1.1.2 Design Life

A design life of 20 years for new construction was used to compute ESALs used in the flexible pavement design of for BIA Route N8066(3), School Spur, and N8065(1).

4.1.1.3 Percent Trucks and Truck Factors

The percentage of trucks and the percentage of buses were based on provided traffic data from BIA Order No. A15PD00791. BIA Route N8066(3) and School Spur had one percent trucks and two percent buses of total traffic, and BIA Route N8065(1) had no trucks and one percent buses of total traffic.

A truck factor equal to 0.8646, which corresponds to a 3-axle tractor semi-trailer, a bus factor equal to 0.6806, and an automobile factor equal to 0.0008 were used in the design to compute ESALs (AASHTO 1993).

4.1.1.4 Directional Distribution

For the design of BIA Route N8066(3) & School Spur, and N8065(1) the directional distribution of traffic was assumed to be a split 50 percent to 50 percent.

4.1.1.5 Lane Distribution Factor

BIA Route N8066(3) & School Spur and N8065(1) will consist of one lane of traffic in each direction. A lane distribution factor of 100 percent was used for traffic analysis.

4.1.2 Combined Standard Error and Level of Reliability

An overall standard deviation of 0.49 was used for design of flexible pavements in accordance with AASHTO (1993). A reliability level of 80 percent was assigned for BIA Route N8066(3) and School Spur. The associated standard normal deviate (Zr) for an 80 percent reliability level is -0.841. A reliability level of 75 percent was assigned for BIA Route N8065(1) due to low traffic volumes. The associated standard normal deviate (Zr) for a 75 percent reliability level is -0.674.

4.1.3 Serviceability Index

Initial and terminal values of the serviceability index were selected as follows:

Initial Serviceability – Po	=	4.2
Terminal Serviceability – Pt	=	2.0
Change in Serviceability	=	2.2

The project site has areas of frost-susceptible soils. AASHTO's guidelines were followed to estimate the serviceability loss associated with frost heave. The serviceability loss due to frost heave was determined to be 0.2. Therefore, the design serviceability loss for flexible pavement was adjusted to 2.0.

4.1.4 Resilient Modulus of Subgrade Reaction

A correlation developed in the AASHTO Guide for Design of Pavement Structures (1993), Part I, Section 1.5, was used to determine the resilient modulus (Mr) to be utilized in pavement design. Using the available R-Value data presented in Section 3.6, Amec Foster Wheeler assigned a design R-Value of 12 for BIA Route N8066(3) and School Spur. BIA Route N8065(1) of the project has relatively high plasticity clayey soils throughout the segment length with a very low tested and correlated R-Value. Amec Foster Wheeler assigned a design R-Value of 7 for this segment. Using the selected design R-Value of 12, a resilient modulus (Mr) of 52,814 kilopascals (kPa) was determined per AASHTO procedures for BIA Route N8066(3) & School Spur, and using a design R-Value of 7, a resilient modulus of 33,681 kPa was determined for BIA Route N8065(1).

4.2 Flexible Pavement Design

The flexible pavement design outlined in the following sections was completed in accordance with the AASHTO Guide for Design of Pavement Structures (1993). The subgrade strength for BIA Route N8066(3), N8065(1), and School Spur was assigned based on Section 4.1.4. The following sections go through the design parameters used for the pavement sections for BIA Route N8066(3), N8065(1), and School Spur. Pavement design calculations are presented in Appendix C.

4.2.1 Structural Coefficients

The following structural coefficients and drainage coefficients for the flexible pavement section components were selected for design based on the AASHTO Guide for Design of Pavement Structures (1993):

Table 4.1: Structural Coefficients

Pavement Component	Drainage Coefficient	Structural Coefficient (per millimeter)
Asphaltic Concrete	N/A	0.0173
Aggregate Base	0.8	0.0055

Note: N/A = not applicable

4.2.2 Pavement Section

Using the design criteria presented in the previous sections, the required pavement structural sections were calculated. The design calculations for the pavement sections are presented in Appendix C. The minimum structural number calculated for BIA Route N8066(3) & School Spur is 1.68, and BIA Route N8065(1) is 1.22. The recommended pavement sections for each segment are summarized in Table 4.2.

Table 4.2: Recommended Flexible Pavement Section

Location	AB (millimeters)	AC (millimeters)	Total Thickness (millimeters)
BIA Route N8066(3) & School Spur	100	75	175
BIA Route N8065(1)	100	50	150

Notes: AB = aggregate base, AC = asphaltic concrete

4.3 Alternative Pavement Design for Low-Volume Roads

The alternative pavement design for the low volume BIA Route N8065(1) is presented in the following sections, and was completed in accordance with the AASHTO Guide for Design of Pavement Structures (1993). The subgrade strength for BIA Route N8065(1) was assigned based Section 4.1.4. The following sections go through the design for the alternative pavement section.

4.3.1 Minimum Aggregate Surface Road

The design criteria presented in Chapter 4 of the AASHTO Guide for Design of Pavement Structures was used in the determination of the minimum aggregate surface road. An iterative design process, using the charts in Chapter 4, was followed to account for the serviceability loss presented in Section 4.1.3, allowable rutting depth and a portion of the aggregate base layer becoming the subbase. The minimum recommended aggregate surface road section thickness determined is 275 millimeters for BIA Route N8065(1).

4.3.2 Double Course Chip Seal

Amec Foster Wheeler recommends using a double course chip seal over the compacted aggregate surface road. The double course chip seal should be in accordance with Federal Highway Administration (FHWA) FP-14 Standard Specifications for Construction of Roads and Bridges Section 407. The double course chip seal requirements for the aggregate gradation and layer thickness should be in accordance with FHWA FP-14 Standard Specifications for Construction of Roads and Bridges Table 407-2 and Table 703-7, application 2B, summarized below in Tables 4.3 and 4.4 of this report.

Table 4.3: Recommended Double Course Chip Seal Requirements

Type (Thickness)	Nominal Maximum Size of Aggregate (millimeters)	Aggregate Gradation(1)
1st Application	12.5	B
2nd Application	9.5	C

Notes: (1) See Table 4.4

Table 4.4: Aggregate Gradation

Sieve Size (Square Openings)	Percent Passing by Dry Weight	
	B	C
19-millimeter	100	---
12.5-millimeter	90-100	100
9.5-millimeter	0-35	85-100
4.75-millimeter	0-12	0-35
2.36-millimeter	---	0-8
75-micrometer	0-1	0-1

The asphalt binder for the double course chip seal should be chosen based on the time of year the road segment will be constructed. The asphalt binder should be in accordance with FHWA FP-14 Standard Specifications for Construction of Roads and Bridges Section 407 and Section 702.

4.4 Subgrade Improvement

The expansion potential test results identified in Section 3.3 are consistent with the presence of moisture sensitive, predominantly medium-to-high plasticity clayey soils generally located

throughout the site. The expansion potential of the tested remolded samples showed a significant increase over the relatively undisturbed in-place samples that ranged generally from 5 to 7 percent, with one sample that showed a swell potential of approximately 1 percent. For an expansion potential of 5 percent or greater, Amec Foster Wheeler recommends treating the subgrade to a depth of 0.3 meters to stabilize the soil in place. In accordance with BIA guidelines, RoadBond by RoadPacker International can be used to stabilize the expansive soils. Amec Foster Wheeler recommends soils located within the roadway alignment of BIA N8065(1), BIA N8066(3), and School Spur - Stations 0+000 to 0+900, be treated with RoadBond to stabilize the area from expansion potential.

4.5 Site Grading and Subgrade Preparation

Subgrade material shall meet a minimum construction control R-Value of 20 for BIA Route N8066(3) and School Spur and 10 for BIA Route N8065(1). The subgrade for BIA Route N8066(3) and School Spur should not exceed a Plasticity Index value of 50, and for BIA Route N8065(1) the Plasticity Index value should be less than 50. It is recommended that materials that possess a correlated R-Value of less than 20 or 10 for the respective segments, or a Plasticity Index of 50 or greater, not be accepted for use within 1 meter of finished subgrade elevation. Materials that do not meet this criterion should be excavated and removed from the roadway prism, or placed and compacted at a depth greater than 1 meter below finished grade elevation.

For BIA Route N8066(3) and School Spur, the excavated areas should be backfilled with material that meets a minimum construction control R-Value of 20 and does not exceed a Plasticity Index of 50, as determined from Figure 5 (attached), the Subgrade Acceptance Chart, or by the following equation.

$$\text{Percent Fines} + 2.83 \times (\text{Plasticity Index}) \leq 116$$

For example, this can be achieved by utilizing materials that contain less than 50 percent fines (material passing the 75 micrometer sieve) and have a plastic index of less than 20. It is also recommended that the maximum particle size be limited to less than 75 millimeters and the material be free of vegetation and debris.

For BIA Route N8065(1), the excavated areas should be backfilled with material that meets a minimum construction control R-Value of 10 and does not exceed a Plasticity Index of 50 as determined from Figure 6 (attached), the Subgrade Acceptance Chart, or by the following equation.

$$\text{Percent Fines} + 2.83 \times (\text{Plasticity Index}) \leq 166$$

For example, this can be achieved by utilizing materials that contain less than 50 percent fines (material passing the 75 micrometer sieve) and have a plastic index of less than 30. It is also recommended that the maximum particle size be limited to less than 75 millimeters and the material be free of vegetation and debris.

All vegetation and debris should be removed from areas designated for pavement. Materials and construction of pavements for the project should be in accordance with the BIA requirements and project specifications.

The exposed native surfaces upon which pavements are to be placed should be scarified to a minimum depth of 0.15 meters, adjusted to a moisture content within the range of plus or minus 3 percentage points of optimum, and compacted to at least 95 percent of maximum dry density (standard Proctor) as determined by the applicable AASHTO test methods.

4.6 Roadway Embankment Fill

Pavements to be constructed on roadway embankment fill soils should use the following guideline for embankment fill compaction and moisture conditioning. Moisture conditioning is recommended to consist of maintaining the fill soils between one percent below to three percent above the optimum moisture content as determined by AASHTO T99, standard Proctor. Embankment fill compaction should be at least 95 percent of maximum dry density as determined by AASHTO T99, standard Proctor, to a depth of 1.5 meters, and embankment fills exceeding 1.5 meters in height, should be compacted to 95 percent of maximum dry density as determined by AASHTO T180, modified Proctor from a depth of 1.5 meters and below. The purpose of the moisture conditioning and compaction requirement is to decrease future settlements of the soils beneath the pavement. The area to be moisture conditioned and compacted should be equal to the pavement width with 1H:1V side slopes continuing to the top of existing grade. The area that falls outside of 1H:1V side slope prism may be treated as typical roadway embankment fill and compacted to at least 95 percent of maximum dry density and a moisture content within the range of plus or minus 3 percentage points of optimum as determined by AASHTO T99, standard Proctor.

4.7 Earthwork Factors

The determination of earthwork factors was completed for near surface soils located along the project site. The earthwork factor calculations assume material will be compacted to 95 percent of the maximum dry density. This calculation is not applicable to any soils that will be imported. Imported soils will need to be evaluated separately to determine earthwork factors.

Development of earthwork factors for near surface materials was based on the evaluation and analysis of data from density tests on in situ soil samples and laboratory moisture-density relationships. The recommended earthwork factor for onsite materials was calculated using the following equation.

$$\% \text{ Shrink-Swell} = \left[1 - \frac{\gamma_{ex}}{\gamma_{fill}}\right] 100$$

Where:

γ_{ex} = in situ dry density of material to be excavated

γ_{fill} = 95 percent of the rock corrected maximum dry density

Moisture-density relationships (Proctors) were developed using AASHTO T99, standard Proctor – Method A. In general, the samples collected on the project contained less than 10 percent rock (material retained above the 4.75 millimeter sieve). Since the amount of rock was less than 10 percent, a rock correction for the analysis was not required. The average maximum

dry density of 1758.7 kcm was utilized to calculate earthwork factors. This data is presented in Table 5.

Individual density samples were evaluated using in situ dry densities as described in Section 3.4, and maximum dry densities. For example, the sample collected at 0 to 0.30 meters in boring R-2 had an in situ dry density of 1421.9 kcm. Using 95 percent of the maximum dry density (1670.8 kcm) and the tested in situ dry density the following calculation was made:

γ_{fill} = 0.95(1758.7) = 1670.8 kcm
γ_{ex} = 1421.9 kcm

$$\% \text{ Shrink-Swell} = \left[1 - \frac{1421.9}{1670.8}\right] 100 = 15\%.$$

Based on the positive result, the material represented by the sample is anticipated to shrink approximately 15 percent when compacted to 95 percent of the maximum dry density. This process was completed for 25 in situ samples collected on the project near grade or in cut areas. Earthwork factors varied between 2 percent and 34 percent shrink across the project. Calculations for individual samples are provided in Table 6.

Based on the variability the earthwork factors evaluated, Amec Foster Wheeler recommends an earthwork factor of 15 percent shrink be utilized for the project.

4.8 Temporary Excavation Slopes

Temporary excavation slopes should conform to Occupational Safety and Health Administration (OSHA) regulations. Within this system, the classification of the on-site soils is Type C. It is recommended that unsupported temporary cut slopes in these soils be made no steeper than 1.5H:1V.

Spoil piles should be located no closer than 2 meters from the crest of the slopes. Large particles, including large clods, should be kept away from the crest of the slopes. Moisture increases in the soils will weaken them and could cause slope failures. Some localized raveling could occur as the exposed soils dry. The excavations should be protected from stormwater runoff or other sources of moisture. Small berms may be necessary to protect the excavations from storm runoff. If the soils are subjected to moisture increases, the stability of the slopes should be reevaluated.

4.9 Corrosion or Degradation Potential

Twenty-five soil locations were tested to evaluate the corrosion potential on metal pipes to be installed at drainage structures. A general characterization of the entire site is presented in this section. The corrosion potential for the site was characterized using Wenner 4-pin resistivity arrays performed on the subsurface materials at the BIA provided locations. Results of the resistivity readings are summarized in Table 2, attached.

The resistivity values ranged from 200 to 3,600 ohm-centimeters (ohm-cm). These values should be used to determine potential corrosive characteristics of the on-site soils with respect to contact with the various underground materials, which will be used for project construction. Soil with

resistivity readings less than 2,000 ohm-cm requires the use of special pipes and/or pipe coatings. It is recommended that the pipe type and/or coating be selected in accordance with Figure 203.04-5 of the ADOT PE&D Manual (ADOT 1989). The majority of the site soils had resistivity readings of less than 2,000 ohm-cm, with three readings at RA-1, RA-16 and RA18 of less than 500 ohm-cm.

The following criteria should be used for selecting an allowable pipe coating (ADOT 1989):

Table 4.5: Allowable Types of Culvert Pipe

Resistivity (ohm-cm)	Allowable Pipe
2,000 or greater	A) Galvanized Coated Steel (AASHTO M-36) B) Aluminum Coated Steel (AASHTO M-36) C) Aluminum Alloy (AASHTO M-196) D) Bituminous Coated (AASHTO M-190)
500 to 1,999	C) Aluminum Alloy (AASHTO M-196) D) Bituminous Coated (AASHTO M-190)
Less than 500	D) Bituminous Coated (AASHTO M-190)

Note: If pH is outside the range of 5.0 to 9.0 a special study of the situation should be made

5.0 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO), 1993. AASHTO Guide for Design of Pavement Structures, Washington, D.C.

Arizona Department of Transportation (ADOT), Materials, 1989. *Preliminary Engineering and Design Manual.* 3rd Edition. March.

Federal Highway Administration (FHWA), 2014. Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects. FP-14. Washington, DC. United States Department of Transportation.

Haynes, Donald D. and Robert J. Hackman, 1978. Geology, Structure, and Uranium Deposits of the Marble Canyon 1º x 2º Quadrangle, Arizona. USGS Map I-1003. Scale 1:250,000

TABLES

amec foster wheeler

TABLE 1
Boring Locations

Boring Number	Station Reference	Location	Elevation (m)	Direction[1]	Offset (m)	Boring Type[2]	Cut/Fill	Final Grade (m)[3]	Targeted Boring Depth (m)	Actual Boring Depth (m)
R-1	Proposed BIA Route N8066 CL	13+900	1986.8	CL	-	HSA	At Grade	0	1.5	1.5
R-2	Proposed BIA Route N8066 CL	14+100	1986.5	CL	-	HSA	At Grade	0	1.5	1.5
R-3	Proposed BIA Route N8066 CL	14+300	1988.0	CL	-	HSA	At Grade	0	1.5	1.5
R-4	Proposed BIA Route N8066 CL	14+500	1989.6	CL	-	HSA	Fill	0.5	1.5	1.5
R-5	Proposed BIA Route N8066 CL	14+700	1990.6	CL	-	HSA	Fill	0.5	1.5	1.5
R-6	Proposed BIA Route N8066 CL	14+900	1989.4	CL	-	HSA	Fill	1	1.5	1.5
R-7	Proposed BIA Route N8066 CL	15+100	1991.2	CL	-	HSA	Fill	1	1.5	1.5
R-8	Proposed BIA Route N8066 CL	15+300	1993.7	CL	-	HSA	At Grade	0	1.5	1.5
R-9	Proposed BIA Route N8066 CL	15+500	1992.8	CL	-	HSA	Fill	0.5	1.5	1.5
R-10	Proposed BIA Route N8066 CL	15+700	1993.4	CL	-	HSA	Fill	1	1.5	1.5
R-11	Proposed BIA Route N8066 CL	15+900	1994.3	CL	-	HSA	Fill	0.5	1.5	1.5
R-12	Proposed BIA Route N8066 CL	16+100	1997.3	CL	-	HSA	Fill	1	1.5	1.5
R-13	Proposed BIA Route N8066 CL	16+300	2002.3	CL	-	HSA	Cut	-0.5	1.5	1.5
R-14	Proposed BIA Route N8066 CL	16+500	2003.1	CL	-	HSA	Fill	0.5	1.5	1.5
R-15	Proposed BIA Route N8066 CL	16+700	2001.7	CL	-	HSA	Fill	1	1.5	1.5
R-16	Proposed BIA Route N8066 CL	16+900	2003.0	R	4	HSA	At Grade	0	1.5	1.5
R-17	Proposed BIA Route N8066 CL	17+100	2006.7	CL	-	HSA	Fill	0.5	1.5	1.5
R-18	Proposed BIA Route N8066 CL	17+300	2007.8	CL	-	HSA	At Grade	0	1.5	1.5
R-19	Proposed BIA Route N8066 CL	17+500	2008.6	CL	-	HSA	Fill	2	1.5	1.5
R-20	Proposed BIA Route N8066 CL	17+700	2009.5	CL	-	HSA	Fill	1.5	1.5	1.5
R-21	Proposed BIA Route N8066 CL	17+900	2010.4	CL	-	HSA	Fill	1	1.5	1.5
R-22	Proposed BIA Route N8066 CL	18+100	2011.3	CL	-	HSA	Fill	0.5	1.5	1.5
R-23	Proposed BIA Route N8066 CL	18+300	2012.1	CL	-	HSA	At Grade	0	1.5	1.5
R-24	Proposed BIA Route N8066 CL	18+500	2011.3	CL	-	HSA	At Grade	0	1.5	1.5
R-25	Proposed BIA Route N8066 CL	18+700	2010.8	CL	-	HSA	Fill	1	1.5	1.5
R-26	Proposed BIA Route N8066 CL	18+900	2011.6	CL	-	HSA	At Grade	0	1.5	1.5
R-27	Proposed BIA Route N8066 CL	19+087	2012.3	CL	-	HSA	Fill	1.5	1.5	1.5
R-28	Proposed BIA Route N8066 CL	19+300	2013.1	CL	-	HSA	Fill	1.5	1.5	1.5
R-29	Proposed BIA Route N8066 CL	19+500	2013.9	CL	-	HSA	At Grade	0	1.5	1.5
R-30	Proposed BIA Route N8066 CL	19+700	2014.6	CL	-	HSA	Fill	0.5	1.5	1.5
R-31	Proposed BIA Route N8066 CL	19+900	2015.4	CL	-	HSA	At Grade	0	1.5	1.5
R-32	Proposed BIA Route N8066 CL	20+100	2016.3	CL	-	HSA	At Grade	0	1.5	1.5
R-33	Proposed BIA Route N8066 CL	20+300	2017.6	CL	-	HSA	At Grade	0	1.5	1.5
R-34	Proposed BIA Route N8066 CL	20+500	2018.8	CL	-	HSA	At Grade	0	1.5	1.5
R-35	Proposed BIA Route N8066 CL	20+700	2020.1	CL	-	HSA	At Grade	0	1.5	1.5
R-36	Proposed BIA Route N8066 CL	20+900	2021.5	CL	-	HSA	At Grade	0	1.5	1.5
R-37	Proposed BIA Route N8066 CL	21+100	2023.0	CL	-	HSA	At Grade	0	1.5	1.5
R-38	Proposed BIA Route N8066 CL	21+300	2024.6	CL	-	HSA	At Grade	0	1.5	1.5
R-39	Proposed BIA Route N8066 CL	21+500	2026.2	CL	-	HSA	Fill	1.5	1.5	1.5
R-40	Proposed BIA Route N8066 CL	21+700	2027.7	CL	-	HSA	At Grade	0	1.5	1.5
R-41	Proposed BIA Route N8066 CL	21+882	2034.0	CL	-	HSA	Fill	1.5	1.5	1.5
R-42	Proposed BIA Route N8066 CL	22+055	2039.6	CL	-	HSA	Cut	-2.5	4.5	4.5
R-43	Proposed BIA Route N8066 CL	22+300	2033.8	CL	-	HSA	Fill	1.5	1.5	1.5
R-44	Proposed BIA Route N8066 CL	22+600	2033.5	CL	-	HSA	At Grade	0	1.5	1.5
R-45	Proposed BIA Route N8066 CL	22+800	2033.8	CL	-	HSA	Fill	0.5	1.5	1.5
R-46	Proposed BIA Route N8066 CL	22+979	2034.1	CL	-	HSA	At Grade	0	1.5	1.5
SS-1	Proposed School Spur CL	0+100	2034.5	CL	-	HSA	Fill	1	1.5	1.5
SS-2	Proposed School Spur CL	0+300	2036.1	CL	-	HSA	Fill	0.5	1.5	1.5
SS-3	Proposed School Spur CL	0+500	2037.0	CL	-	HSA	Fill	1	1.5	1.5
SS-4	Proposed School Spur CL	0+700	2037.3	CL	-	HSA	Fill	1.5	1.5	1.5
SS-5	Proposed School Spur CL	0+900	2038.0	CL	-	HSA	Fill	1	1.5	1.5
SS-6	Proposed School Spur CL	1+040	2038.9	CL	-	HSA	Cut	-11.5	13.5	13.5
SS-7	Proposed School Spur CL	1+250	2045.0	CL	-	HSA	Fill	5.5	1.5	1.5
SS-8	Proposed School Spur CL	1+335	2048.9	CL	-	HSA	Cut	-5	6	4.5
SS-9	Proposed School Spur CL	1+608	2061.2	CL	-	HSA	Cut	-3	4.5	0*
SS-10	Proposed School Spur CL	1+800	2070.3	CL	-	HSA	Fill	1	1.5	1.5
RS-1	Proposed BIA Route N8065 Spur CL	0+052	1973.1	CL	-	ATV	At Grade	0	1.5	1.5
RS-2	Proposed BIA Route N8065 Spur CL	0+250	1972.9	CL	-	ATV	At Grade	0	1.5	1.5
RS-3	Proposed BIA Route N8065 Spur CL	0+450	1974.0	CL	-	ATV	At Grade	0	1.5	1.5
RS-4	Proposed BIA Route N8065 Spur CL	0+650	1976.2	CL	-	ATV	At Grade	0	1.5	1.5

[1] CL - Centerline, R - Right, L - Left
[2] HSA - Truck Mounted Drill Rig with 168mm Hollow Stem Auger, ATV - Specialized ATV Mounted Drill Righ with 206mm Hollow Stem Auger
[3] Final Grade to the nearest 0.5 meters ----> At grade | Cut | Fill
* symbolizes auger refusal at boring

amec foster wheeler

TABLE 2
Resistivity Arrays

Array ID	Spacing (ft)	Spacing (m)	Reading (Ohm)	Ohm-cm[1]
RA-1	2.50	0.76	0.897	400
	5.00	1.52	0.393	400
	10.00	3.05	0.312	600
	15.00	4.57	0.232	700
	20.00	6.10	0.173	700
RA-2	2.50	0.76	4.636	2,200
	5.00	1.52	0.744	700
	10.00	3.05	0.397	800
	15.00	4.57	0.322	900
	20.00	6.10	0.290	1,100
RA-3	2.50	0.76	3.462	1,700
	5.00	1.52	1.617	1,500
	10.00	3.05	1.048	2,000
	15.00	4.57	0.669	1,900
	20.00	6.10	0.387	1,500
RA-4	2.50	0.76	2.250	1,100
	5.00	1.52	2.015	1,900
	10.00	3.05	1.851	3,500
	15.00	4.57	1.270	3,600
	20.00	6.10	0.867	3,300
RA-5	2.50	0.76	3.845	1,800
	5.00	1.52	2.068	2,000
	10.00	3.05	1.332	2,600
	15.00	4.57	1.063	3,100
	20.00	6.10	0.766	2,900
RA-6	2.50	0.76	6.212	3,000
	5.00	1.52	3.763	3,600
	10.00	3.05	1.188	2,300
	15.00	4.57	0.861	2,500
	20.00	6.10	0.588	2,300
RA-7	2.50	0.76	4.201	2,000
	5.00	1.52	2.279	2,200
	10.00	3.05	1.031	2,000
	15.00	4.57	0.649	1,900
	20.00	6.10	0.512	2,000
RA-8	2.50	0.76	3.432	1,600
	5.00	1.52	2.253	2,200
	10.00	3.05	1.733	3,300
	15.00	4.57	1.127	3,200
	20.00	6.10	0.596	2,300
RA-9	2.50	0.76	2.416	1,200
	5.00	1.52	0.524	500
	10.00	3.05	0.588	1,100
	15.00	4.57	0.529	1,500
	20.00	6.10	0.481	1,800
RA-10	2.50	0.76	2.316	1,100
	5.00	1.52	1.954	1,900
	10.00	3.05	1.479	2,800
	15.00	4.57	0.996	2,900
	20.00	6.10	0.672	2,600
RA-11	2.50	0.76	2.757	1,300
	5.00	1.52	2.016	1,900
	10.00	3.05	0.797	1,500
	15.00	4.57	0.337	1,000
	20.00	6.10	0.278	1,100
RA-12	2.50	0.76	2.644	1,300
	5.00	1.52	1.912	1,800
	10.00	3.05	1.328	2,500
	15.00	4.57	0.870	2,500
	20.00	6.10	0.685	2,600

TABLE 2
Resistivity Arrays

Array ID	Spacing (ft)	Spacing (m)	Reading (Ohm)	Ohm-cm[1]
RA-13	2.50	0.76	1.827	900
	5.00	1.52	1.312	1,300
	10.00	3.05	0.914	1,800
	15.00	4.57	0.521	1,500
	20.00	6.10	0.303	1,200
RA-14	2.50	0.76	3.257	1,600
	5.00	1.52	2.069	2,000
	10.00	3.05	1.407	2,700
	15.00	4.57	0.759	2,200
	20.00	6.10	0.569	2,200
RA-15	2.50	0.76	5.996	2,900
	5.00	1.52	2.352	2,300
	10.00	3.05	1.058	2,000
	15.00	4.57	0.632	1,800
	20.00	6.10	0.371	1,400
RA-16	2.50	0.76	0.804	400
	5.00	1.52	0.251	200
	10.00	3.05	0.158	300
	15.00	4.57	0.141	400
	20.00	6.10	0.124	500
RA-17	2.50	0.76	5.469	2,600
	5.00	1.52	1.942	1,900
	10.00	3.05	0.647	1,200
	15.00	4.57	0.339	1,000
	20.00	6.10	0.206	800
RA-18	2.50	0.76	1.301	600
	5.00	1.52	0.291	300
	10.00	3.05	0.132	300
	15.00	4.57	0.102	300
	20.00	6.10	0.093	400
RA-19	2.50	0.76	1.744	800
	5.00	1.52	1.125	1,100
	10.00	3.05	0.463	900
	15.00	4.57	0.240	700
	20.00	6.10	0.163	600
RA-20	2.50	0.76	1.251	600
	5.00	1.52	1.035	1,000
	10.00	3.05	0.613	1,200
	15.00	4.57	0.284	800
	20.00	6.10	0.163	600
RA-21	2.50	0.76	1.608	800
	5.00	1.52	1.017	1,000
	10.00	3.05	0.547	1,000
	15.00	4.57	0.320	900
	20.00	6.10	0.260	1,000
RA-22	2.50	0.76	6.120	2,900
	5.00	1.52	1.602	1,500
	10.00	3.05	0.883	1,700
	15.00	4.57	0.503	1,400
	20.00	6.10	0.269	1,000
RA-23	2.50	0.76	2.518	1,200
	5.00	1.52	0.496	500
	10.00	3.05	0.393	800
	15.00	4.57	0.311	900
	20.00	6.10	0.246	900
RA-24	2.50	0.76	4.935	2,400
	5.00	1.52	2.196	2,100
	10.00	3.05	1.232	2,400
	15.00	4.57	0.475	1,400
	20.00	6.10	0.232	900

TABLE 2
Resistivity Arrays

Array ID	Spacing (ft)	Spacing (m)	Reading (Ohm)	Ohm-cm[1]
RA-25	2.50	0.76	6.500	3,100
	5.00	1.52	1.681	1,600
	10.00	3.05	0.800	1,500
	15.00	4.57	0.455	1,300
	20.00	6.10	0.339	1,300
			MAXIMUM	**3,600**
			MINIMUM	**200**

Note:
[1] Ohm-cm is calculated based on the following formula: Ohm*cm = [R(in Ohms)*spacing(in meters)*191.5]/0.3048

Cell Color	Resistivity (ohm-cm)
	2,000 or greater
	500 to 1,999
	Less than 500

TABLE 3
Correlated and Tested R-Values

Boring Number	Station Reference	Location	Offset (m)	Direction	Depth (m)		USCS/Group Symbol	Liquid Limit	Plasticity Index	Percent Fines (minus 200)	Correlated R-Value[1]	Tested R-Value (AASHTO T190)
					Begin	End						
R-1	Proposed BIA Route N8066 CL	13+900	CL	-	0.00	1.35	CH	52	31	86	9	8
R-4	Proposed BIA Route N8066 CL	14+500	CL	-	0.00	1.35	CL	33	16	51	26	9
R-8	Proposed BIA Route N8066 CL	15+300	CL	-	0.00	1.35	SC-SM	25	6	45	42	24
R-10	Proposed BIA Route N8066 CL	15+700	CL	-	0.00	1.20	CL	33	16	67	21	9
R-14	Proposed BIA Route N8066 CL	16+500	CL	-	0.00	1.35	SM	NV	NP	42	56	37
R-18	Proposed BIA Route N8066 CL	17+300	CL	-	0.00	1.35	CL	27	10	50	34	22
R-23	Proposed BIA Route N8066 CL	18+300	CL	-	0.00	1.35	ML	NV	NP	54	47	31
R-26	Proposed BIA Route N8066 CL	18+900	CL	-	0.00	1.35	CL	43	25	64	16	9
R-31	Proposed BIA Route N8066 CL	19+900	CL	-	0.00	1.35	CH	55	39	61	9	12
R-35	Proposed BIA Route N8066 CL	20+700	CL	-	0.00	1.35	SM	NV	NP	46	53	35
R-38	Proposed BIA Route N8066 CL	21+300	CL	-	0.00	1.35	CH	59	35	88	8	---
R-40	Proposed BIA Route N8066 CL	21+700	CL	-	0.00	1.35	CL	30	14	53	28	18
R-42	Proposed BIA Route N8066 CL	22+055	CL	-	0.00	1.35	ML	NV	NP	59	44	36
R-45	Proposed BIA Route N8066 CL	22+800	CL	-	0.00	1.35	CL	47	23	91	12	9
RS-1	Proposed BIA Route N8065 Spur CL	0+052	CL	-	0.00	1.35	CH	55	31	98	8	6
SS-3	Proposed School Spur CL	0+100	CL	-	0.00	1.35	CL	25	9	60	31	16
SS-5	Proposed School Spur CL	0+900	CL	-	0.00	1.35	SM	NV	NP	22	74	---
SS-6	Proposed School Spur CL	0+900	CL	-	0.00	1.35	GC	26	9	24	50	---
SS-8	Proposed School Spur CL	1+335	CL	-	0.00	1.35	SC	25	9	36	43	30
							MEAN	**--**	**--**	**58**	**32**	**19**
							STANDARD DEVIATION	**--**	**--**	**21**	**19**	**11**
							MAXIMUM	**59**	**39**	**98**	**74**	**37**
							MINIMUM	**NV**	**NP**	**22**	**8**	**6**
							COUNT	**19**	**19**	**19**	**19**	**16**

[1] Correlated R-Value as Determined by Table 202.02-3 ADOT Materials Preliminary Engineering and Design Manual

TABLE 4
Traffic Data Analysis - BIA Project N8066(3), N8065(1), and School Spur

Segment	ADT 2015 (count)	Growth Rate	ADT 2016 (projected from 2015)	Design Life	Percent Trucks	Percent Buses	D_D	Lanes Each Direction	D_L	Design ESAL
N8066(3) & School Road	198	2.0%	202	20	1%	2%	0.50	1	1.0	24,079
N8065(1)	45	2.0%	46	20	0%	1%	0.50	1	1.0	1,577

Note: See report text for explanation of variables

amec foster wheeler

TABLE 5
Moisture Density Relationship (Proctor) Data

All Soil Data

Boring No.	Station Reference	Location	Offset (m)	Direction	Depth (m)		Proctor Method	USCS/ Group Symbol	Maximum Dry Density (kg/cu.m)	Optimum Moisture Content (%)	Percent Rock in Proctor Sample[1]	Rock Corrected Maximum Dry Density[2] (kg/cu.m)	Rock Corrected Optimum Moisture Content[2] (%)
					Begin	End							
R-1	Proposed BIA Route N8066 CL	13+900	CL	-	0.00	1.35	A	CH	1595.4	20.1	0	1595.4	20.1
R-4	Proposed BIA Route N8066 CL	14+500	CL	-	0.00	1.35	A	CL	1731.6	15.8	1	1731.6	15.8
R-8	Proposed BIA Route N8066 CL	15+300	CL	-	0.00	1.35	A	SC-SM	1834.1	13.5	2	1834.1	13.5
R-10	Proposed BIA Route N8066 CL	15+700	CL	-	0.00	1.20	A	CL	1746.0	15.7	0	1746.0	15.7
R-14	Proposed BIA Route N8066 CL	16+500	CL	-	0.00	1.35	A	SM	1822.9	13.7	1	1822.9	13.7
R-18	Proposed BIA Route N8066 CL	17+300	CL	-	0.00	1.35	A	CL	1829.3	13.1	1	1829.3	13.1
R-23	Proposed BIA Route N8066 CL	18+300	CL	-	0.00	1.35	A	ML	1880.6	12.3	1	1880.6	12.3
R-26	Proposed BIA Route N8066 CL	18+900	CL	-	0.00	1.35	A	CL	1720.4	15.2	1	1720.4	15.2
R-31	Proposed BIA Route N8066 CL	19+900	CL	-	0.00	1.35	A	CH	1738.0	15.7	0	1738.0	15.7
R-35	Proposed BIA Route N8066 CL	20+700	CL	-	0.00	1.35	A	SM	1787.7	14.2	0	1787.7	14.2
R-40	Proposed BIA Route N8066 CL	21+700	CL	-	0.00	1.35	A	CL	1784.5	15.1	0	1784.5	15.1
R-42	Proposed BIA Route N8066 CL	22+055	CL	-	0.00	1.35	A	ML	1811.7	13.6	0	1811.7	13.6
R-45	Proposed BIA Route N8066 CL	22+800	CL	-	0.00	1.35	A	CL	1557.0	20.3	0	1557.0	20.3
RS-1	Proposed BIA Route N8065 Spur CL	0+052	CL	-	0.00	1.35	A	CH	1568.2	20.9	0	1568.2	20.9
SS-3	Proposed School Spur CL	0+500	CL	-	0.00	1.35	A	CL	1882.2	12.5	0	1882.2	12.5
SS-8	Proposed School Spur CL	1+335	CL	-	0.00	1.35	A	SC	1850.1	13.9	6	1850.1	13.9
								MEAN	**1758.7**	**15.4**	**0.8**	**1758.7**	**15.4**
								STANDARD DEVIATION	**104.6**	**2.8**	**1.5**	**104.6**	**2.8**
								MAXIMUM	**1882.2**	**20.9**	**6.0**	**1882.2**	**20.9**
								MINIMUM	**1557.0**	**12.3**	**0.0**	**1557.0**	**12.3**
								COUNT	**16**	**16**	**16**	**16**	**16**

[1] Percent Rock as determined by the weight of material retained above the 4.75-millimeter sieve for Method A Proctors. Samples with 10% or more rock were rock corrected per AZ 277c.
[2] Rock corrected maximum dry density and optimum moisture content completed per AZ 227c using an assumed specific gravity of 2.62.

amec foster wheeler

TABLE 6
Shrink-Swell Analysis

Boring No.	Station Reference	Location	Offset (m)	Direction	Depth (m)		USCS/ Group Symbol*	Maximum Dry Density (kg/cu.m)[1]	In-Place Dry Density (kg/cu.m)[2]	Value Compacted to 95%	Shrink (+) Swell (-) Percentage[3]
					Begin	End					
R-2	Proposed BIA Route N8066 CL	14+100	CL	-	0.00	0.30	CL	1758.7	1421.9	1670.8	15
R-4	Proposed BIA Route N8066 CL	14+500	CL	-	0.00	0.30	CL	1758.7	1603.3	1670.8	4
R-6	Proposed BIA Route N8066 CL	14+900	CL	-	0.00	0.30	SC	1758.7	1514.5	1670.8	9
R-8	Proposed BIA Route N8066 CL	15+300	CL	-	0.00	0.30	SC-SM	1758.7	1538.0	1670.8	8
R-10	Proposed BIA Route N8066 CL	15+700	CL	-	0.00	0.30	CL	1758.7	1488.8	1670.8	11
R-13	Proposed BIA Route N8066 CL	16+300	CL	-	0.00	0.30	SM	1758.7	1364.8	1670.8	18
R-14	Proposed BIA Route N8066 CL	16+500	CL	-	0.00	0.30	SM	1758.7	1477.0	1670.8	12
R-16	Proposed BIA Route N8066 CL	16+900	4	R	0.00	0.30	SM	1758.7	1308.8	1670.8	22
R-18	Proposed BIA Route N8066 CL	17+300	CL	-	0.00	0.30	SC/CL	1758.7	1592.8	1670.8	5
R-20	Proposed BIA Route N8066 CL	17+700	CL	-	0.00	0.30	CL	1758.7	1433.2	1670.8	14
R-22	Proposed BIA Route N8066 CL	18+100	CL	-	0.00	0.30	SM	1758.7	1641.6	1670.8	2
R-24	Proposed BIA Route N8066 CL	18+500	CL	-	0.00	0.30	SM	1758.7	1460.1	1670.8	13
R-26	Proposed BIA Route N8066 CL	18+900	CL	-	0.75	1.05	CL	1758.7	1449.5	1670.8	13
R-32	Proposed BIA Route N8066 CL	20+100	CL	-	0.00	0.30	SM	1758.7	1467.1	1670.8	12
R-34	Proposed BIA Route N8066 CL	20+500	CL	-	0.00	0.30	SM	1758.7	1438.5	1670.8	14
R-36	Proposed BIA Route N8066 CL	20+900	CL	-	0.00	0.30	SM	1758.7	1306.5	1670.8	22
R-38	Proposed BIA Route N8066 CL	21+300	CL	-	0.00	0.30	CH	1758.7	1422.8	1670.8	15
R-40	Proposed BIA Route N8066 CL	21+700	CL	-	0.00	0.30	CL	1758.7	1497.9	1670.8	10
R-42	Proposed BIA Route N8066 CL	22+055	CL	-	0.75	1.05	ML	1758.7	1599.5	1670.8	4
R-43	Proposed BIA Route N8066 CL	22+300	CL	-	0.00	0.30	CL	1758.7	1544.1	1670.8	8
R-45	Proposed BIA Route N8066 CL	22+800	CL	-	0.75	1.05	CL	1758.7	1098.2	1670.8	34
RS-1	Proposed BIA Route N8065 Spur CL	0+052	CL	-	0.75	1.05	CH	1758.7	1512.9	1670.8	9
SS-3	Proposed School Spur CL	0+500	CL	-	0.75	1.05	CL	1758.7	1592.1	1670.8	5
SS-8	Proposed School Spur CL	1+335	CL	-	0.00	0.30	Sandstone	1758.7	1489.7	1670.8	11
SS-8	Proposed School Spur CL	1+335	CL	-	0.75	1.05	Sandstone	1758.7	1645.4	1670.8	2
										MEAN	**12**
										STANDARD DEVIATION	**7**
										MAXIMUM	**34**
										MINIMUM	**2**
										COUNT	**25**

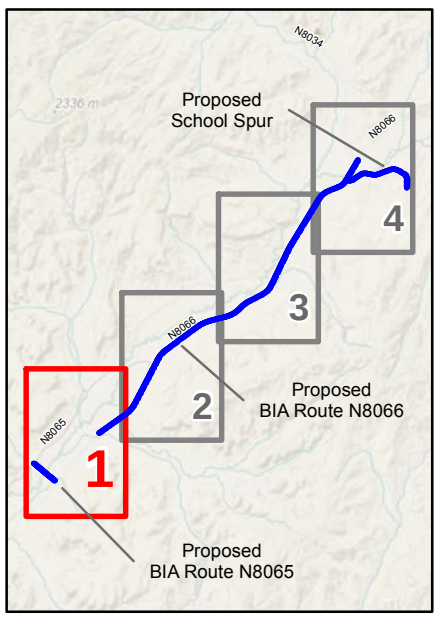
* USGS/Group Symbols are listed as depicted in logs from Appendix A.

[1] Average maximum dry density from Table 5.

[2] In situ dry density values from laboratory results of ring samples.

[3] Percent shrink or swell - Positive values = shrink, negative values = swell

FIGURES



Borings

Resistivity Readings

Aerial Imagery: ESRI, NAIP 2013

13+900
13+800
13+700
13+600
13+500
13+400
13+300
13+200
13+100
13+060

Proposed
BIA Route N8066(3)

N8065

N8066

Proposed
BIA Route N8065(1)

RS-4
0+699.999
0+650
0+600
0+550
0+500
0+450
0+400
RS-3
BS-5
BS-3
BS-1
0+350
RS-2
BS-6
0+300
RA-21
BS-4
0+250
BS-2
0+200
RS-1
0+150
RA-20
0+100
0+050
0+000

0 150 300 600
Meters

Job No.:	1720154045
PM:	NC
Date:	2/11/2016
Scale:	1 cm = 100 meters

N

The map shown here has been created with all due and reasonable care and is strictly for use with Amec Foster Wheeler Project Number 1720154045. This map has not been certified by a licensed land surveyor, and any third party use of this map comes without warranties of any kind. Amec Foster Wheeler assumes no liability, direct or indirect, whatsoever for any such third party or unintended use.

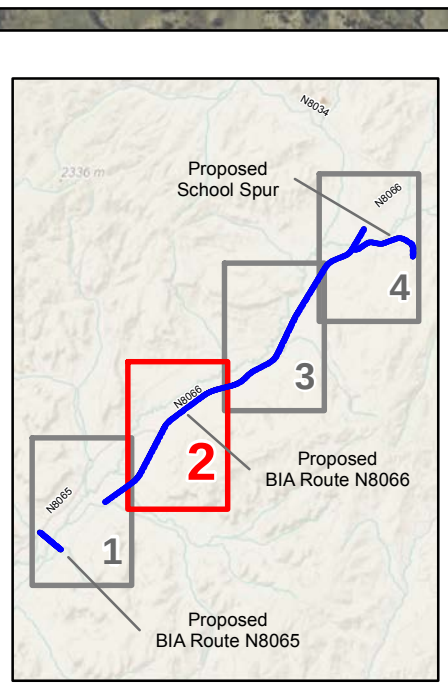
BIA Project N8066(3), N8065(1), and School Spur
Black Mesa Community School
Arizona

Boring and Resistivity Location Map

FIGURE
1

amec foster wheeler

Path: X:\Projects\2015 Projects\1720154045 BIA_School Spur-Spur Road Geotechnical Investigation\MXD\Figure1_BoringLocationMap.mxd



Borings

Resistivity Readings

Aerial Imagery: ESRI, NAIP 2013

R-1 R-2 R-3 R-4 R-5 R-6 R-7 R-8 R-9 R-10 R-11 R-12 R-13 R-14 R-15 R-16 R-17 R-18

RA-1 RA-2 RA-3 RA-4 RA-5 RA-6 RA-7 RA-8 RA-9 RA-10 RA-11

13+900 14+000 14+100 14+200 14+300 14+400 14+500 14+600 14+700 14+800 14+900 15+000 15+100 15+200 15+300 15+400 15+500 15+600 15+700 15+800 15+900 16+000 16+100 16+200 16+300 16+400 16+500 16+600 16+700 16+800 16+900 17+000 17+100 17+200 17+300 17+400 17+500

N8066

Proposed
BIA Route N8066(3)

N8065

0 150 300 600
Meters

Job No.:	1720154045
PM:	NC
Date:	2/11/2016
Scale:	1 cm = 100 meters

N

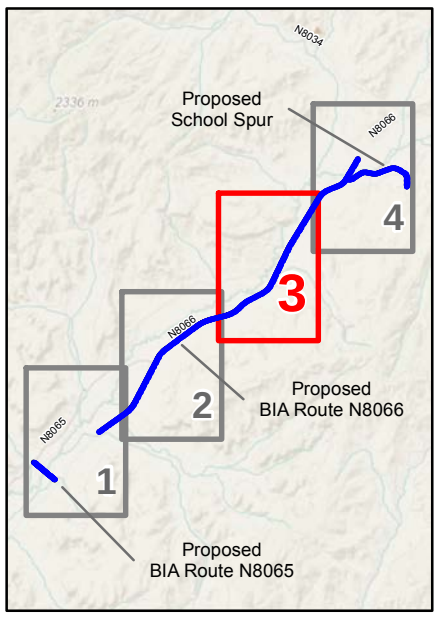
BIA Project N8066(3), N8065(1), and School Spur
Black Mesa Community School
Arizona

Boring and Resistivity Location Map

FIGURE **2**

amec foster wheeler

Path: X:\Projects\2015 Projects\1720154045 BIA_School Spur-Spur Road Geotechnical Investigation\MXD\Figure1_BoringLocationMap.mxd



Borings

Resistivity Readings

Aerial Imagery: ESRI, NAIP 2013

21+500
21+400
21+300
R-38
21+200
21+100
R-37
21+000
20+900
R-36
20+800
20+700
R-35
20+600
20+500
R-34
20+400
20+300
R-33
20+200
N8066
20+100
R-32
20+000
19+900
R-31
19+800
19+700
R-30
19+600
19+500
RA-17
R-29
19+400
Proposed
BIA Route N8066(3)
19+300
R-28
19+200
19+100
R-27
19+000
18+900
R-26
18+800
18+700
R-25
18+600
RA-16
18+500
R-24
18+400
RA-15
18+300
R-23
18+200
18+100
R-22
18+000
RA-14
17+900
RA-13
17+800
R-21
17+700
17+600
R-20
17+500
RA-12
R-19

0 150 300 600
Meters

Job No.:	1720154045
PM:	NC
Date:	2/11/2016
Scale:	1 cm = 100 meters

N

The map shown here has been created with all due and reasonable care and is strictly for use with Amec Foster Wheeler Project Number 1720154045. This map has not been certified by a licensed land surveyor, and any third party use of this map comes without warranties of any kind. Amec Foster Wheeler assumes no liability, direct or indirect, whatsoever for any such third party or unintended use.

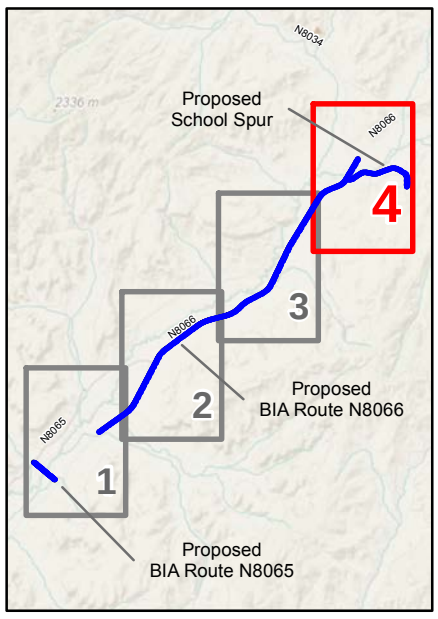
BIA Project N8066(3), N8065(1), and School Spur
Black Mesa Community School
Arizona

Boring and Resistivity Location Map

FIGURE
3

amec foster wheeler

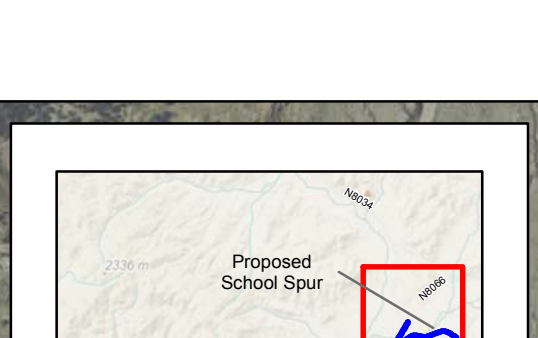
Path: X:\Projects\2015 Projects\1720154045 BIA School Spur-Spur Road Geotechnical Investigation\MXD\Figure1_BoringLocationMap.mxd



Borings

Resistivity Readings

Aerial Imagery: ESRI, NAIP 2013



N8034

N8066

R-46 22+979 22+900 R-45 22+800 22+700 R-44 22+600 22+500 22+400 22+300 22+200 22+100 22+000 R-43 21+900 R-42 21+800 R-41 21+700 R-40 21+600 21+500 R-39 +400 R-38

B-1 B-4 B-3 B-5 B-2

RA-19 RA-18 SS-1 SS-2 0+400 0+300 0+200 0+100 0+000 RA-22 SS-3 0+500 RA-23 0+600 SS-4 0+700 0+800 SS-5 0+900 1+000 SS-6 1+100 1+200 RA-24 SS-7 1+300 SS-8 1+400 RA-25 1+500 SS-9 1+600 1+700 1+800 SS-10 1+900 1+952

Proposed
School Spur

Proposed
BIA Route N8066(3)

0 150 300 600
Meters

Job No.:	1720154045
PM:	NC
Date:	2/11/2016
Scale:	1 cm = 100 meters

N

The map shown here has been created with all due and reasonable care and is strictly for use with Amec Foster Wheeler Project Number 1720154045. This map has not been certified by a licensed land surveyor, and any third party use of this map comes without warranties of any kind. Amec Foster Wheeler assumes no liability, direct or indirect, whatsoever for any such third party or unintended use.

BIA Project N8066(3), N8065(1), and School Spur
Black Mesa Community School
Arizona

Boring and Resistivity Location Map

FIGURE
4

amec foster wheeler

Path: X:\Projects\2015 Projects\1720154045 BIA_School Spur-Spur Road Geotechnical Investigation\MXD\Figure1_BoringLocationMap.mxd

amec foster wheeler

FIGURE 5
Subgrade Acceptance Chart (BIA Route N8066(3) & School Spur)

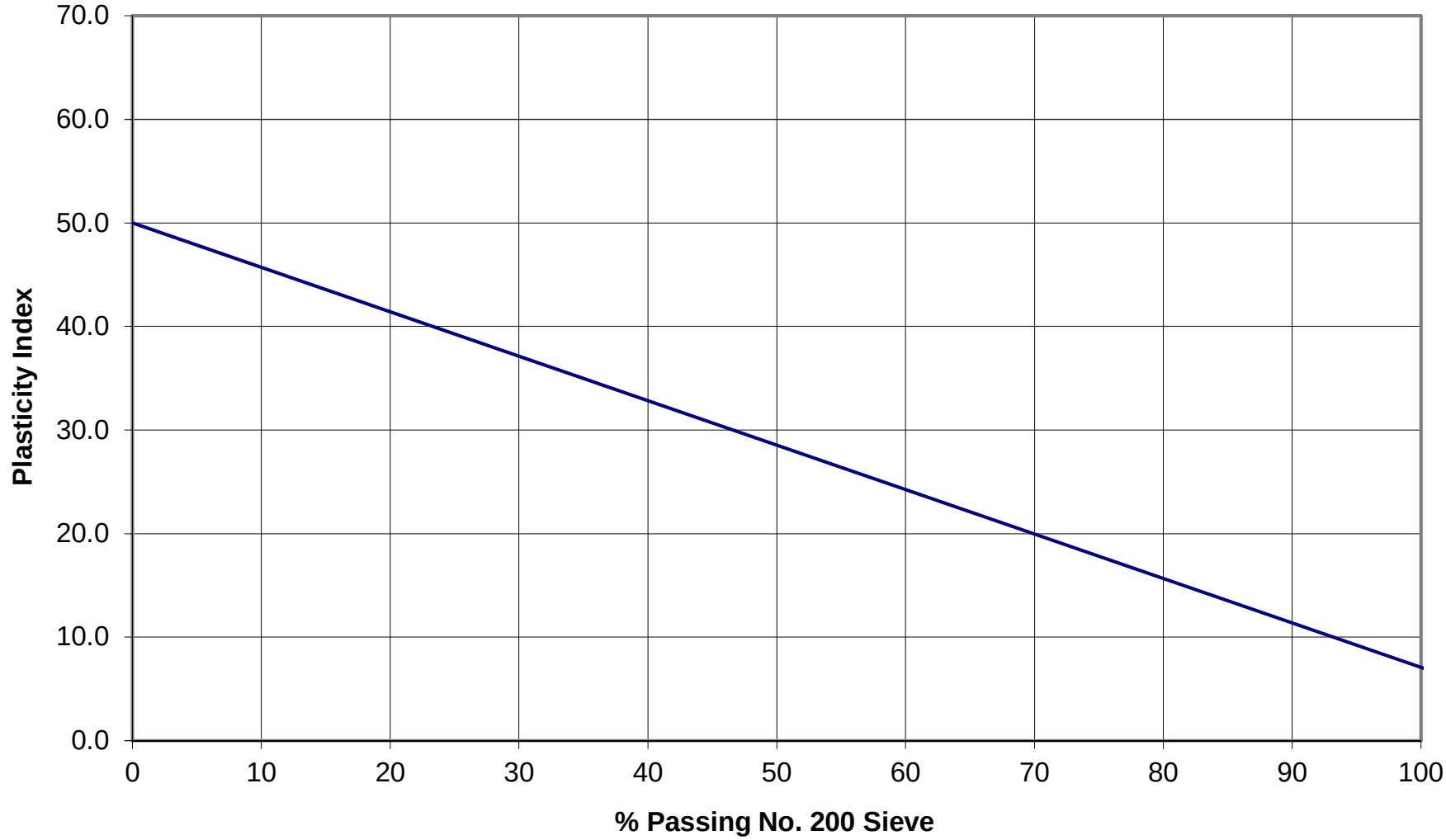
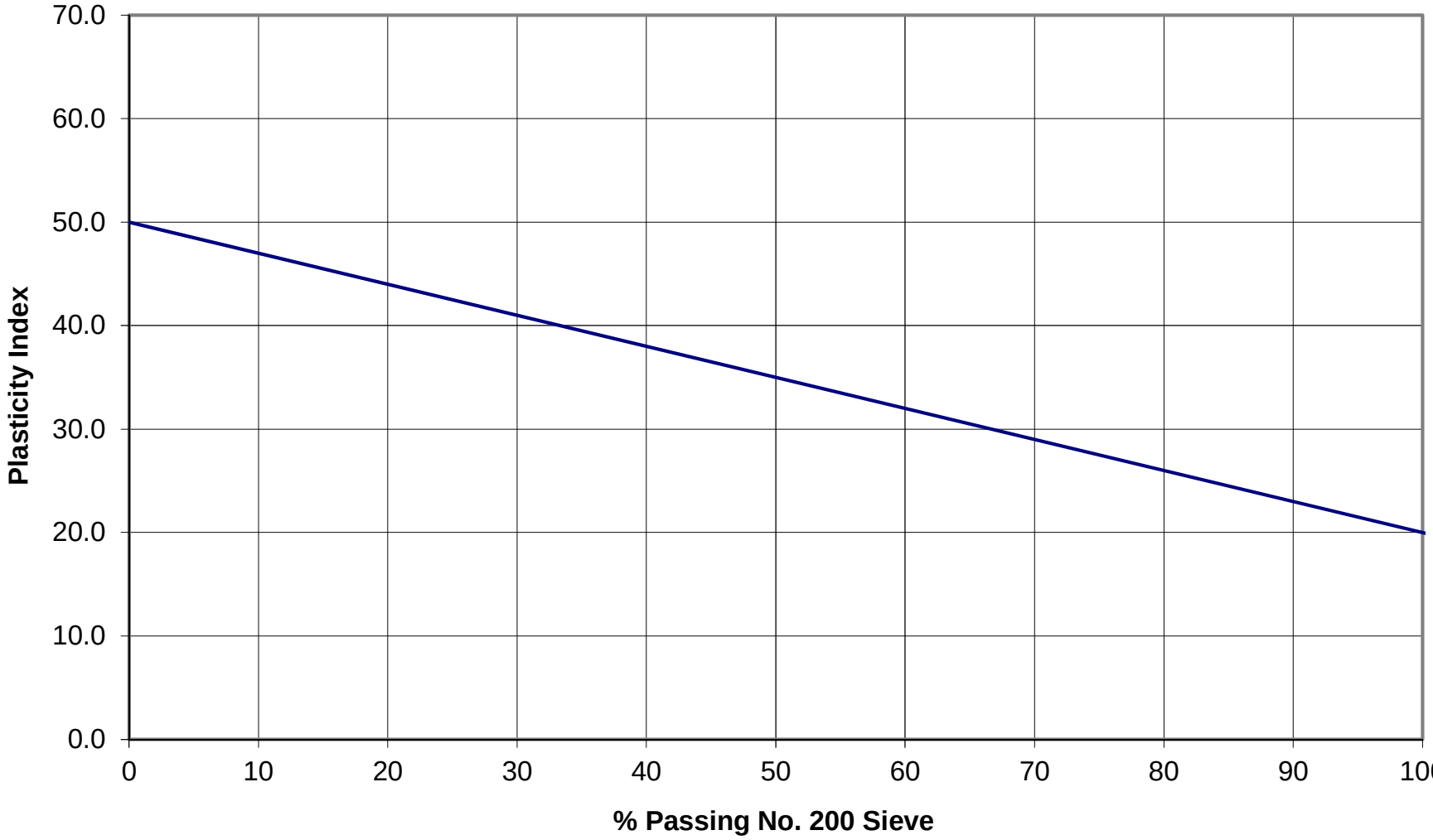


FIGURE 6
Subgrade Acceptance Chart (BIA Route N8065(1))



APPENDIX A

FIELD INVESTIGATION

TEST DRILLING EQUIPMENT AND PROCEDURES

Description of Subsurface Exploration Methods

Auger Boring Drilling through overburden soils is performed with 6 5/8-inch O.D., 3 1/4-inch I.D. hollow stem auger or 4 1/2-inch solid stem continuous flight auger. Carbide insert teeth are normally used on bits so they can penetrate soft rock or very strongly cemented soils. A CME-75 truck-mounted drill rig is used to advance the auger. The drill rigs are powered with six-cylinder Cummins diesel engines capable of delivering about 11.4 kN-m torque to the drill spindle. The spindle is advanced with twin hydraulic rams capable of exerting 90 kN (20,000 pounds) downward force.

Generally, refusal to penetration of the auger is adopted as top of the SGC or "river-run" material or harder bedrock, which require other techniques for penetration. Grab samples or auger cuttings may be taken as necessary. Standard penetration tests or 2.42-inch diameter ring samples are taken in conjunction with the auger borings as needed, with the sampling interval and type being indicated on the boring logs.

Hammer Drill Drilling with the Hammer drill is accomplished with a Drill Systems AP-1000 drill rig advancing a double-walled drive casing with a link-belt 180 diesel pile driving hammer, having a rated energy of 8,100 foot-pounds per blow. Where noted on the boring log, the hammer is equipped with a supercharger which can boost the energy to approximately 12,000 foot-pounds per blow. The supercharger is used only in portions of the boring where blow counts are relatively high. Cuttings are removed with compressed air by a reverse circulation process, and are collected in a cyclone from which grab samples are obtained. The drive casing is either 9-inch O.D. by 6-inch I.D. or 6 5/8-inch O.D. by 4-inch I.D. and employs an expendable bit of slightly larger diameter than the O.D. of the casing. Hammer blows required to advance the drive casing are recorded in 1-foot increments, as noted on the boring logs. Standard penetration tests or 2.42-inch diameter ring samples taken are noted on the boring logs.

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

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

TEST DRILLING EQUIPMENT AND PROCEDURES (Cont.)

Sampling Procedures Dynamically driven tube samples are usually obtained at selected intervals in the borings by the ASTM D1586 test procedure. In many cases, 2-inch O.D., 1 3/8-inch I.D. samples are used to obtain the standard penetration resistance. “Undisturbed” samples of firmer soils are often obtained with 3-inch O.D. samples lined with 2.42-inch I.D. brass rings. The driving energy is generally recorded as the number of blows of a 140-pound, 30-inch free fall drop hammer required to advance the samples in 6-inch increments. However, in stratified soils, driving resistance is sometimes recorded in 2- or 3-inch increments so that soil changes and the presence of scattered gravel or cemented layers can be readily detected and the realistic penetration values obtained for consideration in design. These values are expressed in blows per 6 inches on the boring logs. "Undisturbed" sampling of softer soils is sometimes performed with thin walled Shelby tubes (ASTM D1587), pitcher samplers, Denison samplers or continuous CME samplers. Where samples of rock are required, they are obtained by NQ diamond core drilling (ASTM D2113). Tube samples are labeled and placed in watertight containers to maintain field moisture contents for testing. When necessary for testing, larger bulk samples are taken from auger cuttings. Also, representative samples are obtained from the cuttings from the hammer and Schramm drill rig.

Boring Records Drilling operations are directed by our field engineer or geologist who examines soil recovery and prepares the boring logs. Soils are visually classified in accordance with the Unified Soil Classification System (ASTM D2487), with appropriate group symbols being shown on the boring logs.

TERMINOLOGY USED TO DESCRIBE THE RELATIVE DENSITY, CONSISTENCY OR FIRMNESS OF SOILS

The terminology used on the boring logs to describe the relative density, consistency or firmness of soils relative to the standard penetration resistance is presented below. The standard penetration resistance (N) in blows per foot is obtained by the ASTM D1586 procedure using 2" O.D., 1 3/8" I.D. samplers.

1. **Relative Density.** Terms for description of relative density of cohesionless, uncemented sands and sand-gravel mixtures.

N	Relative Density
0-4	Very loose
5-10	Loose
11-30	Medium dense
31-50	Dense
50+	Very dense

2. **Relative Consistency.** Terms for description of clays which are saturated or near saturation.

N	Relative Consistency	Remarks
0-2	Very soft	Easily penetrated several inches with fist.
3-4	Soft	Easily penetrated several inches with thumb.
5-8	Medium stiff	Can be penetrated several inches with thumb with moderate effort.
9-15	Stiff	Readily indented with thumb, but penetrated only with great effort.
16-30	Very stiff	Readily indented with thumbnail.
30+	Hard	Indented only with difficulty by thumbnail.

3. **Relative Firmness.** Terms for description of partially saturated and/or cemented soils which commonly occur in the Southwest including clays, cemented granular materials, silts and silty and clayey granular soils.

N	Relative Firmness
0-4	Very soft
5-8	Soft
9-15	Moderately firm
16-30	Firm
31-50	Very firm
50+	Hard

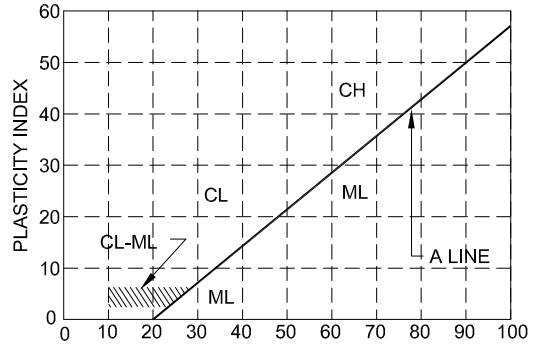
UNIFIED CLASSIFICATION SYSTEM FOR SOILS

Soils are visually classified by the United Soil Classification System on the boring logs presented in this report. Grain-size analysis and Atterberg Limits Tests are often performed on selected samples to aid in classification. The classification system is briefly outlined on this chart. For a more detailed description of the system, see " The Unified Soil Classification System " ASTM Designation: D2487

MAJOR DIVISION				GRAPH SYMBOL	GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE-GRAINED SOILS (Less than 50% passes No. 200 sieve)	**GRAVELS** (50% or less of coarse fraction passes No. 4 sieve)	**CLEAN GRAVELS** (Less than 5% passes No. 200 sieve)			GW	Well graded gravels, gravel-sized mixtures or sand-gravel-cobble mixture.
					GP	Poorly graded gravels, gravel-sized mixtures or sand-gravel-cobble mixture.
		GRAVELS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart		GM	Silty gravels, gravel-sand-silt mixture.
			Limits plot below "A" line & hatched zone on plasticity chart		GC	Clayey gravels, gravel-sand-clay mixture.
	SANDS (More than 50% of coarse fraction passes No. 4 sieve)	**CLEAN SANDS** (Less than 5% passes No. 200 sieve)			SW	Well graded sands, gravelly sands.
					SP	Poorly graded sands, gravelly sands.
		SANDS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart		SM	Silty sands, sand-silt mixtures.
			Limits plot below "A" line & hatched zone on plasticity chart		SC	Clayey sands, sand-clay mixtures.
FINE-GRAINED SOILS (50% or more passes No. 200 sieve)	**SILTS** LIMITS PLOT BELOW "A" LINE & HATCH ZONE ON PLASTICITY CHART	**SILTS OF LOW PLASTICITY** (Liquid limit less than 50)			ML	Inorganic silts, clayey silts with slight plasticity.
		SILTS OF HIGH PLASTICITY (Liquid limit more than 50)			MH	Inorganic silts of high plasticity, silty soils, elastic silts.
	CLAYS LIMITS PLOT BELOW "A" LINE & HATCH ZONE ON PLASTICITY CHART	**CLAYS OF LOW PLASTICITY** (Liquid limit less than 50)			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		CLAYS OF HIGH PLASTICITY (Liquid limit more than 50)			CH	Inorganic clays of high plasticity, fat clays, silty and sandy clays of high plasticity.

NOTE: Coarse-grained soils with between 5% to 12% passing the No. 200 sieve and fine-grained soils with limits plotting in the hatched zone on the plasticity chart to have dual symbol.

PLASTICITY CHART



DEFINITIONS OF SOIL FRACTIONS

SOIL COMPONENT	PARTICLE SIZE RANGE
Boulders	Above 300mm (12in.)
Cobbles	300mm to 75mm (12in. to 3in.)
Gravel	75mm (3in.) to No. 4 sieve
Coarse gravel	75mm to 19mm (3in to 3/4in.)
Fine gravel	19mm (3/4in.) to No. 4 sieve
Sand	No. 4 to No. 200
Coarse	No. 4 to No. 10
Medium	No. 10 to No. 40
Fine	No. 40 to No. 200
Fines (silt or clay)	Below No. 200 sieve

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/11/15

LOCATION (M) N. 4016677.2 E. 577856.6
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 1986.8m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	3-10-			CH	slightly moist	**CLAY,** trace predominantly fine grained, subrounded sand, weakly to moderately cemented, high plasticity, light brown
				A	15				firm to very firm	note: calcium carbonate filaments throughout
				S	12-16-					
					22					
1.5				S	6-13-					
					19					
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-1

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/11/15

LOCATION (M) N. 4016819.2 E. 577996.4
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 1986.5m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				U	13	1421.9	20.5	CL	moist at surace slightly moist below 0.6m moderately firm to very firm	**SANDY CLAY,** considerable predominantly fine grained, subrounded sand, weakly to moderately cemented, medium plasticity, brown to light brown note: weakly to moderately cemented below 0.6m
				A						
				S	11-9-20					
1.5				S	14-20-23					
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-2

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/11/15

LOCATION (M) N. 4016990.6 E. 578098.5
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 1988.0m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	1-1-1			SM	slightly moist very soft at surface moderately firm	**SILTY SAND,** predominantly fine grained, subrounded sand, nonplastic, brown to light brown note: up to 150mm thick clayey sand zones throughout, medium plasticity, light brown
				A						
				S	5-6-6					
								CL	slightly moist moderately firm to firm	**SANDY CLAY,** considerable predominantly fine grained, subrounded sand, uncemented to weakly cemented, medium plasticity, light brown
1.5				S	4-7-8					
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-3

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/11/15

LOCATION (M) N. 4017168.4 E. 578189.6
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 1989.6m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				U	5	1603.3	15.0	CL	slightly moist to moist	**SANDY CLAY,** predominantly fine grained, subrounded sand, uncemented to weakly cemented, medium plasticity, brown to light brown
				A					very soft at surface	
				S	5-8-10				slightly moist below 0.6m	note: decrease in clay with depth
1.5				S	4-5-5				firm to moderately firm	
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-4

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/11/15

LOCATION (M) N. 4017346.3 E. 578280.6
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 1990.6m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	WOH *			CL	moist	**SANDY CLAY,** considerable predominantly fine grained, subrounded sand, medium plasticity, brown
				A					very soft at surface	note: up to 75mm thick silty sand zones throughout, nonplastic, brown
				S	2-2-2					note: decrease in clay content with depth
									slightly moist below 1.1m	* note: WOH - Weight of Hammer
1.5				S	4-6-6					
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-5

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/11/15

LOCATION (M) N. 4017524.1 E. 578371.6
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 1989.4m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				U	7	1514.5	17.2	SC	slightly moist to moist	**CLAYEY SAND,** predominantly fine grained, subrounded sand, medium plasticity, light brown to brown
				A					soft at surface	
				S	3-5-7				slightly moist below 0.6m	
									moderately firm	
1.5				S	4-5-7					note: up to 150mm thick silty sand zones below 1.5m
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-6

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/11/15

LOCATION (M) N. 4017702 E. 578462.6
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 1991.2m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	1-2-1			SM	slightly moist to moist	**SILTY SAND,** predominantly fine grained, subrounded sand, nonplastic, brown to light brown
				A					very soft to soft	note: up to 150mm thick clayey sand zones throughout, low plasticity, brown
				S	2-2-3					
1.5				S	2-3-3					
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-7

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/11/15

LOCATION (M) N. 4017879.8 E. 578553.6
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 1993.7m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				U	11	1538.0	12.6	SC-SM	slightly moist soft to moderately firm	**SILTY CLAYEY SAND,** occasional fine grained, subrounded gravel, predominantly fine grained, subrounded sand, low to medium plasticity, light brown note: decrease in clay content with depth
				A						
				S	5-6-5					
1.5				S	4-6-7			SM	slightly moist moderately firm	**SILTY SAND,** predominantly fine grained, subrounded sand, nonplastic, light brown
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-8

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/11/15

LOCATION (M) N. 4018057.7 E. 578644.7
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 1992.8m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	1-1-3			CL	moist	**SANDY CLAY,** considerable predominantly fine grained, subangular to subrounded sand, medium plasticity, brown
				A					very soft	
										note: decrease in clay content with depth
				S	11-19-23				very firm to firm	note: weakly to moderately cemented from 0.6m to 1.2m
1.5				S	5-11-14					note: weakly cemented below 1.2m
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-9

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/11/15

LOCATION (M) N. 4018221 E. 578758.5
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 1993.4m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				U	5	1488.8	21.2	CL	moist	**SANDY CLAY,** considerable predominantly fine grained, subangular to subrounded sand, medium plasticity, brown
				A					very soft at surface	
				S	2-8-6				slightly moist below 0.9m	note: silty sand zones, nonplastic, light brown from 1.2m to 1.5m
1.5				S	6-7-10				moderately firm to firm	note: decrease in clay content with depth
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-10

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/11/15

LOCATION (M) N. 4018349.2 E. 578911.3
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 1994.3m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	5-3-5			SC	slightly moist	**CLAYEY SAND,** predominantly fine grained, subrounded sand, low plasticity, light brown
				A					soft to moderately firm	note: slight decrease in clay with depth
				S	3-5-7					
1.5				S	4-4-6			SM	slightly moist	**SILTY SAND,** predominantly fine grained, subrounded sand, nonplastic, light brown
									moderately firm	
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-11

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/10/15

LOCATION (M) N. 4018469.4 E. 579070.9
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 1997.3m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				U	8			SC	slightly moist	**CLAYEY SAND,** predominantly fine grained, subrounded sand, low plasticity, light brown
				A					soft at surface	note: up to 75mm thick silty sand zones throughout, nonplastic, light brown
				S	7-8-8				moderately firm to firm	
1.5				S	4-5-9					
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-12

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/10/15

LOCATION (M) N. 4018589.6 E. 579230.5
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2002.3m ±
DATUM NAVD88

Depth in Meters	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0		U	3	1364.8	14.3	SM	slightly moist	**SILTY SAND,** predominantly fine grained, subrounded sand, nonplastic, light brown
		A					very soft at surface	note: rare clay at 1.05m
		S	3-3-5				soft	note: occasional predominantly fine grained, subangular to subrounded gravel below 1.5m
1.5		S	4-3-4					
								Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0								
4.5								
6.0								
7.5								

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-13

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/10/15

LOCATION (M) N. 4018709.8 E. 579390.1
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2003.1m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				U	6	1477.0	10.6	SM	slightly moist	**SILTY SAND,** predominantly fine grained, subrounded sand, nonplastic, light brown
				A					very soft at surface	note: trace clay from 0.6m to 1.2m
				S	4-5-6				moderately firm	note: trace pedominantly fine grained, subangular to subrounded gravel below 1.2m
1.5				S	5-5-7					
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-14

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/10/15

LOCATION (M) N. 4018829.9 E. 579549.7
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2001.7m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	4-6-4			CL	slightly moist	**SANDY CLAY,** considerable predominantly fine grained, subrounded sand, low plasticity, light brown
				A					moderately firm to firm	note: up to 150mm thick silty sand zones throughout, nonplastic, brown
				S	5-7-8					note: weakly to moderately cemented below 1.5m
1.5				S	6-10-16					
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-15

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/11/15

LOCATION (M) N. 4018943.7 E. 579713.7
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2003.0m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				U	17	1308.8	11.7	SM	slightly moist	**SILTY SAND,** predominantly fine grained, subrounded sand, nonplastic, light brown
				A					moderately firm	note: up to 150mm thick clayey sand zones throughout, low plasticity, light brown
				S	4-4-5					note: trace predominantly fine grained, subangular to subrounded gravel below 1.5m
1.5				S	4-5-5					
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-16

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/10/15

LOCATION (M) N. 4019029.4 E. 579893.9
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2006.7m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	2-2-2			SM	slightly moist	**SILTY SAND,** predominantly fine to medium grained, subrounded sand, nonplastic, light brown to brown
				A					very soft at surface	
				S	4-4-6				moderately firm to firm	note: trace predominantly fine grained, subangular to subrounded gravel below 0.6m
1.5				S	6-9-11					note: increase in gravel content with depth
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-17

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/10/15

LOCATION (M) N. 4019086.2 E. 580085.4
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2007.8m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				U	6	1592.8	7.4	SC/CL	slightly moist soft at surface moderately firm to firm	**CLAYEY SAND TO SANDY CLAY,** trace silt, predominantly fine grained, subrounded sand, medium plasticity, light brown
				A						
				S	5-5-10					
1.5				S	4-4-5					
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-18

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/10/15

LOCATION (M) N. 4019137.6 E. 580278.4
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2008.6m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	2-1-1			SC	slightly moist	**CLAYEY SAND,** predominantly fine grained, subrounded sand, medium plasticity, light brown
				A					very soft at surface	note: slight decrease in clay with depth
				S	3-3-5				soft to moderately firm	
1.5				S	2-5-6					
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-19

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/10/15

LOCATION (M) N. 4019196.1 E. 580469.3
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2009.5m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				U	7	1433.2	21.3	CL	moist	**SANDY CLAY,** considerable predominantly fine grained, subrounded sand, uncemented to weakly cemented, medium to high plasticity, light brown to brown
				A					soft at surface	
									slightly moist	note: decrease in clay content with depth
				S	9-10-15				firm to very firm	note: weakly to moderately cemented below 0.6m
1.5				S	12-25-20					
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-20

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/10/15

LOCATION (M) N. 4019299.9 E. 580639.1
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2010.4m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	3-2-5			CL	slightly moist to moist	**SANDY CLAY,** predominantly fine grained, subrounded sand, medium plasticity, brown to light brown
				A					soft to moderately firm	note: hard zone from 0.6m to 1.2m, increase in medium grained sand, moderately cemented
				S	17-23-27					
1.5				S	5-6-8					
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-21

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/10/15

LOCATION (M) N. 4019440.2 E. 580781.2
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2011.3m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				U	6	1641.6	10.0	SM	slightly moist	**SILTY SAND,** predominantly fine to medium grained, subrounded sand, nonplastic, light brown to brown
				A					soft at surface	
									moderately firm to firm	note: up to 300mm thick clayey sand zones throughout, medium plasticity, brown
				S	9-9-9					
1.5				S	4-5-7					
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-22

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/10/15

LOCATION (M) N. 4019554.9 E. 580944
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2012.1m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	1-4-6			SM/ML	slightly moist	**SILTY SAND TO SANDY SILT,** predominantly fine grained, subrounded sand, nonplastic, light brown
				A					moderately firm to firm	note: up to 300mm thick clayey sand zones, medium plasticity, light brown below 0.6m
				S	5-7-8					
1.5				S	4-5-6					note: trace gravel below 1.5m
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-23

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/10/15

LOCATION (M) N. 4019647.9 E. 581120.8
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2011.3m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				U	6	1460.1	10.4	SM	slightly moist very soft	**SILTY SAND,** predominantly fine grained, subrounded sand, nonplastic, light brown to brown
				A						
								CL		**SANDY CLAY,** considerable predominantly fine grained, subrounded sand, medium plasticity, light brown
				S	7-8-6				slightly moist moderately firm	
1.5				S	4-5-7					note: silty sand zones about 150mm thick throughout, nonplastic, light brown
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-24

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/10/15

LOCATION (M) N. 4019741.1 E. 581297.6
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2010.8m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	1-1-8			CL	slightly moist	**SANDY CLAY,** considerable predominantly fine grained, subrounded sand, medium to high plasticity, light brown to brown
				A					moderately firm at surface	
				S	18-16-15				very firm to hard	note: weakly to moderately cemented below 0.6m
1.5				S	16-23-28					
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-25

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/10/15

LOCATION (M) N. 4019870.9 E. 581447.7
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2011.6m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	2-2-5			CL	slightly moist	**SANDY CLAY,** considerable predominantly fine grained, subrounded sand, uncemented to weakly cemented, medium to high plasticity, light brown
				A					soft at surface	
				U	37	1449.5	8.8		firm to very firm	note: weakly to moderately cemented below 1.2m
1.5				S	15-17-26					
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-26

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/10/15

LOCATION (M) N. 4020035.4 E. 581538
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2012.3m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	3-10-			SC	slightly moist	**CLAYEY SAND,** predominantly fine grained, subrounded sand, weakly cemented, medium plasticity, light brown
				A	12				firm	
				S	8-12-					
					12					note: decrease in fines below 1.2m
1.5				S	6-12-					
					12					Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-27

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/10/15

LOCATION (M) N. 4020226.7 E. 581628.1
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2013.1m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				U	19			SM	slightly moist	**SILTY SAND,** predominantly fine grained, subrounded sand, nonplastic, light brown
				A					moderately firm	
				S	3-5-9					
								CL	slightly moist	**SANDY CLAY,** considerable predominantly fine grained, subrounded sand, uncemented to weakly cemented, medium plasticity, light brown to brown
1.5				S	9-13-14				firm	
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-28

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/10/15

LOCATION (M) N. 4020407.4 E. 581713.2
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2013.9m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	2-3-3			SM	slightly moist	**SILTY SAND,** predominantly fine grained, subrounded sand, nonplastic, light brown to brown
				A					soft	
				S	1-2-3				slightly moist to moist	
				S	WOH *					* note: WOH - Weight of Hammer
1.5								CL	moist	**SANDY CLAY,** considerable predominantly fine grained, subrounded sand, medium plasticity, brown
									very soft	
										Stopped Auger at 1.35m
										Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-29

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/10/15

LOCATION (M) N. 4020588.2 E. 581798.2
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2014.6m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				U	8			SM	slightly moist	**SILTY SAND,** predominantly fine grained, subrounded sand, nonplastic, light brown
				A					soft to moderately firm	note: clayey sand at surface, low plasticity, brown
				S	3-4-6					
								CL	slightly moist	**SANDY CLAY,** considerable predominantly fine grained, subrounded sand, uncemented to weakly cemented, medium plasticity, light brown to brown
1.5				S	2-7-9				firm	
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-30

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/10/15

LOCATION (M) N. 4020769 E. 581883.3
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2015.4m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	5-8-8			CH	slightly moist	**SANDY CLAY,** considerable predominantly fine grained, subrounded sand, high plasticity, light brown
				A					firm at surface	
									moderately firm	note: decrease in clay with depth
				S	3-4-5					
1.5				S	7-4-5					
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-31

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/9/15

LOCATION (M) N. 4020947.1 E. 581973.7
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2016.3m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				U	7	1467.1	12.6	SM	slightly moist	**SILTY SAND,** predominantly fine grained, subrounded sand, nonplastic, brown to light brown
				A					soft to moderately firm	note: up to 75mm thick clayey sand zones throughout, medium plasticity, light brown
				S	3-4-4					
1.5				S	3-5-5					
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-32

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/9/15

LOCATION (M) N. 4021120.1 E. 582073.7
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2017.6m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S A	1-2-2			SM	slightly moist very soft	**SILTY SAND,** predominantly fine grained, subrounded sand, nonplastic, light brown note: up to 150mm thick clayey sand zones throughout, low plasticity, light brown
				S	4-4-8			ML	slightly moist moderately firm	**SANDY SILT,** considerable predominantly fine grained, subangular to subrounded sand, nonplastic, light brown note: up to 150mm thick silty sand zones throughout, nonplastic, light brown
1.5				S	5-10-14			CL	slightly moist firm	**SANDY CLAY,** considerable predominantly fine grained, subangular to subrounded sand, weakly cemented, medium plasticity, light brown note: calcium carbonate filaments throughout
3.0										Stopped Auger at 1.35m Stopped Sampler at 1.8m
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-33

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/9/15

LOCATION (M) N. 4021291.7 E. 582176
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2018.8m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				U	6	1438.5	10.5	SM	slightly moist very soft to soft	**SILTY SAND,** predominantly fine grained, subrounded sand, nonplastic, light brown to brown note: decrease in fines with depth
				A						
				S	2-2-4					
1.5				S	4-7-10					
								CL	slightly moist firm	**SANDY CLAY,** considerable predominantly fine grained, subangular to subrounded sand, medium plasticity, light brown
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-34

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/9/15

LOCATION (M) N. 4021463.3 E. 582278.3
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2020.1m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	1-			SM	slightly moist	**SILTY SAND,** predominantly fine grained, subrounded sand, nonplastic, light brown to brown
				A	WOH *-				very soft at surface	note: 75mm thick at surface clayey sand zone, low plasticity, brown
					1					note: silt content varies with depth
				S	3-5-6					* note: WOH - Weight of Hammer
1.5				S	4-6-7			SC	slightly moist	**CLAYEY SAND,** predominantly fine grained, subrounded sand, medium plasticity, light brown
										note: trace calcium carbonate
										Stopped Auger at 1.35m
										Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-35

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/9/15

LOCATION (M) N. 4021634.9 E. 582380.6
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2021.5m ±
DATUM NAVD88

Depth in Meters	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0	U	9	1306.5	22.6	SM	slightly moist	**SILTY SAND,** predominantly fine grained, subrounded sand, nonplastic, light brown to brown
	A					soft to moderately firm	note: up to 75mm thick clayey sand zone near surface clayey sand, low plasticity, brown
	S	1-2-4					note: decrease in fines with depth
1.5	S	3-4-6					
							Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0							
4.5							
6.0							
7.5							

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-36

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/9/15

LOCATION (M) N. 4021806.5 E. 582482.9
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2023.0m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	WOH *-			SM	slightly moist	**SILTY SAND,** predominantly fine grained, subangular to subrounded sand, nonplastic, light brown to brown
				A	WOH *-					
					1				very soft at surface moderately firm	note: up to 150mm thick clayey sand zones throughout, low plasticity, brown
				S	1-4-5					* note: WOH - Weight of Hammer
1.5				S	3-5-6					
										Stopped Auger at 1.35m
										Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-37

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/9/15

LOCATION (M) N. 4021978.1 E. 582585.3
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2024.6m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				U	15	1422.8	22.0	CH	slightly moist to moist moderately firm	**CLAY,** trace predominantly fine grained, subangular to subrounded sand, high plasticity, brown
				A						
									slightly moist below 0.6m very firm	note: up to 300mm thick clayey sand zones throughout
				S	11-16-16					
1.5				S	5-7-9			SM	slightly moist firm	**SILTY SAND,** predominantly fine grained, subangular to subrounded sand, nonplastic, light brown
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-38

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/9/15

LOCATION (M) N. 4022149.7 E. 582687.6
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2026.2m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	WOH *-			SM	slightly moist	**SILTY SAND,** predominantly fine grained, subrounded sand, nonplastic, light brown
				A	WOH *-				very soft to soft	
					1					note: up to 50mm thick sandy clay zones throughout, medium plasticity, brown
				S	2-2-3					* note: WOH - Weight of Hammer
1.5				S	2-3-3			CL	slightly moist	**SANDY CLAY,** considerable predominantly fine grained, subangular to subrounded sand, medium plasticity, light brown
									soft	
										Stopped Auger at 1.35m
										Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-39

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/9/15

LOCATION (M) N. 4022302.1 E. 582814.4
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2027.7m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				U	11	1497.9	16.6	CL	slightly moist to moist soft	**SANDY CLAY,** predominantly fine grained, subangular to subrounded sand, medium plasticity, dark brown
				A						
									slightly moist	note: up to 150mm thick silty sand zones throughout, nonplastic, light brown
				S	6-7-9				firm	note: decrease in fines with depth
1.5				S	8-10-15					
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-40

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/9/15

LOCATION (M) N. 4022387.4 E. 582978.3
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2034.0m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	7-30-				slightly moist	**WEPO FORMANTION SANDSTONE,** moderately soft to moderately hard, yellowish-brown
				A	34				hard	
										note: 75mm of sandy clay at surface, medium plasticity, brown
				S	20-39-					note: fat clay zones up to 75mm thick throughout
					50/					
					75mm					
1.5				S	20-50/					
					100mm					Stopped Auger at 1.35m Sampler refused at 1.6m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-41

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/9/15

LOCATION (M) N. 4022453.9 E. 583132
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2039.6m ±
DATUM NAVD88

Depth in Meters	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0		S	2-2-4			ML	slightly moist to moist soft	**SANDY SILT,** predominantly fine grained, subrounded sand, nonplastic, orangish-brown
		A						
		U	12	1599.5	9.3			
		S	5-9-14					
1.5						CL	slightly moist firm	**SANDY CLAY,** considerable predominantly fine grained, subangular to subrounded sand, weakly cemented, low plasticity, brown note: calcium carbonate filaments throughout
3.0		U	50/ 75mm				slightly moist hard	**WEPO FORMATION** **SILTSTONE,** moderately soft to moderately hard, dark gray note: recovery at 3m, fat clay with sand, high plasticity, dark gray
		S	50/ 75mm				slightly moist hard	**WEPO FORMATION** **SANDSTONE,** moderately soft to moderately hard, white note: recovery at 4.5m, sand & silt, nonplastic, white
4.5								Stopped Auger at 4.35m Sampler refused at 4.425m
6.0								
7.5								

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-42

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/9/15

LOCATION (M) N. 4022584.9 E. 583337.6
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2033.8m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				U	12	1544.1	18.1	CL	slightly moist	**SANDY CLAY,** considerable predominantly fine grained, subangular to subrounded sand, medium plasticity, light brown
				A					soft at surface	
									firm	note: slight decrease in fines at 0.6m
				S	12-14-12					note: weakly cemented below 0.6m
1.5				S	2-4-3			SC	slightly moist	**CLAYEY SAND,** predominantly fine grained, subangular to subrounded sand, low plasticity, light brown
									soft	
										Stopped Auger at 1.35m
										Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-43

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/9/15

LOCATION (M) N. 4022840.4 E. 583493.5
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2033.5m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	4-2-6			CL	slightly moist to moist	**SANDY CLAY,** considerable predominantly fine grained, subangular to subrounded sand, medium plasticity, light brown to brown
				A					soft	note: some roots present
				S	8-14-16				firm at 0.8m	note: weakly cemented below 0.6m
1.5				S	3-3-3					note: up to 75mm thick silty sand zones below 1.5m, nonplastic, light brown
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-44

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/9/15

LOCATION (M) N. 4023013.3 E. 583593.7
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2033.8m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	4-4-8			CL	slightly moist to moist	**CLAY,** trace predominantly fine grained, subangular to subrounded sand, medium to high plasticity, light brown to brown
				A						
									soft to moderately firm	note: up to 75mm thick silty sand zones throughout, nonplastic, light brown
				U	12	1098.2	9.2			note: weakly cemented below 1.35m
									firm	
1.5				S	6-12-15					
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-45

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/8/15

LOCATION (M) N. 4023168.2 E. 583683.5
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2034.1m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	12-6-8			CL	slightly moist to moist	**SANDY CLAY,** considerable predominantly fine to medium grained, subangular to subrounded sand, medium plasticity, light brown
				A					moderately firm to firm	note: up to 300mm thick silty sand zones throughout, nonplastic, light brown
				S	2-2-2				very soft at 0.75m	note: possibly weakly cemented below 1.2m
1.5				S	2-8-11					
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. R-46

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 1/14/16

LOCATION (M) N. 4014992.2 E. 576020.8
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 206mm Hollow Stem Auger
SURFACE EL. (M) 1973.1m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	4-5-10			CH	slightly moist	**CLAY,** medium plasticity, light brown
				A						
									moderately firm to firm	note: ground frozen from 0m to 0.6m
				U	41					note: some thin, calcium carbonate filaments below 0.6m
1.5				S	6-12-16					note: some clayey sand zones below 1.2m
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. RS-1

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 1/14/16

LOCATION (M) N. 4015117.1 E. 575867.9
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 206mm Hollow Stem Auger
SURFACE EL. (M) 1972.9m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	19-17-			CH	slightly moist	**CLAY WITH SAND,** some predominantly fine grained sand, high plasticity, brown
				A	24					
									firm to very firm	note: ground frozen from 0m to 0.6m
				S	5-11-					note: 50mm to 75mm thick clayey sand zones throughout
					10					
1.5				S	14-12-					note: occasional thin, calcium carbonate filament below 0.6m
					12					
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. RS-2

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 1/19/16

LOCATION (M) N. 4015243.4 E. 575713
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 206mm Hollow Stem Auger
SURFACE EL. (M) 1973.4m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	10-6-6			CH	slightly moist to moist	**CLAY WITH SAND,** some predominantly fine grained sand, high plasticity, brown
				A					moderately firm	note: trace gravel on the ground surface
										note: ground frozen from 0m to 0.45m
				U	16			SM		note: up to 75mm thick silty sand zones
1.5				S	3-3-6				slightly moist	**SILTY SAND,** predominantly fine grained, subangular sand, nonplastic, light brown
									moderately firm to firm	
										Stopped Auger at 1.35m
										Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. RS-3

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 1/19/16

LOCATION (M) N. 4015369.8 E. 575558.2
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 206mm Hollow Stem Auger
SURFACE EL. (M) 1974.0m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	13-6-6			SC	moist	**CLAYEY SAND,** trace fine grained, subangular gravel, fine grained, subangular sand, medium plasticity, dark brown
				A						
								SM	moderately firm	**SILTY SAND,** fine grained, subangular sand, nonplastic, light brown
				S	2-4-6				slightly moist	note: trace predominantly fine grained gravel below 0.9m
1.5				S	4-4-5				moderately firm	
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. RS-4

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/8/15

LOCATION (M) N. 4022637.1 E. 583485.5
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2034.5m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				U	13			CL	slightly moist to moist moderately firm	**SANDY CLAY,** considerable predominantly fine grained, subangular to subrounded sand, medium plasticity, light brown to brown
				A						
									slightly moist	note: weakly cemented below 0.6m
				S	10-16-19				very firm	
1.5				S	8-13-18					
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. SS-1

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/8/15

LOCATION (M) N. 4022734.4 E. 583657.8
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2036.1m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	4-5-6			SM	slightly moist	**SILTY SAND,** predominantly fine to medium grained, subrounded sand, nonplastic, light brown
				A				CL	moderately firm at surface	note: up to 200mm in diameter cobbles at surface & some to considerable gravel
				S	39-14-12					
				S	10-15-18				slightly moist firm to very firm	**SANDY CLAY,** some predominantly fine grained, subangular to subrounded gravel, considerable predominantly fine grained, subrounded sand, medium plasticity, light orangish-brown note: 200mm diameter cobbles at 0.75m note: weakly cemented below 1.2m
1.5										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. SS-2

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/8/15

LOCATION (M) N. 4022825 E. 583833.4
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2037.0m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	5-2-3			CL	slightly moist to moist	**SANDY CLAY,** predominantly fine grained, subangular to subrounded sand, medium plasticity, brown to light brown
				A					soft to moderately firm	note: silty sand at surface, nonplastic, brown
				U	8	1592.1	11.5			note: up to 150mm thick silty sand zones throughout, nonplastic, orangish-brown
1.5				S	4-5-4					note: decrease in clay content with depth
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. SS-3

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/8/15

LOCATION (M) N. 4022799.8 E. 584030.8
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2037.3m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	1-3-14			CL	moist	**CLAY WITH SAND,** some predominantly fine grained, subangular to subrounded sand, medium plasticity, dark brown
				A					firm to moderately firm	note: decrease in clay content with depth
				S	2-4-5					note: up to 300mm thick silty sand zones throughout below 0.6m, nonplastic, light brown
1.5				S	4-5-5					
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. SS-4

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/8/15

LOCATION (M) N. 4022820.6 E. 584226
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2038.0m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				U	3			SM	slightly moist to moist very soft	**SILTY SAND,** predominantly fine grained, subrounded sand, nonplastic, dark brown to brown
				A						
				S	2-3-1				very soft to moderately firm slightly moist	note: trace clay below 1.65m
1.5				S	3-4-5					
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. SS-5

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/8/15

LOCATION (M) N. 4022870.7 E. 584356.6
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2038.9m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	14-22-			GC	slightly moist hard	**CLAYEY GRAVEL WITH SAND,** considerable predominantly fine grained, subangular to subrounded sand, predominantly fine grained, subangular to subrounded gravel, medium plasticity, light brown note: boulders up to 500mm in diameter exposed at surface
				A	50/					
					100mm					
				S	50/					
					125mm					
				S	30-					**WEPO FORMATION** **SANDSTONE,** fine grained textuer, moderately soft to moderately hard, light brown note: nonplastic, brown note: recovery below 3m is clayey sand, low to medium plasticity, brown
1.5					50/					
					25mm					
									slightly moist hard	
				S	37-					
3.0					50/					
					50mm					
				S	50/					
4.5					125mm					note: nonplastic, light brown below 5.5m
				S	50/					
6.0					125mm					
					14-32-					
7.5				S	50					

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. SS-6

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/8/15

LOCATION (M) N. 4022870.7 E. 584356.6
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2038.9m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
									slightly moist hard	**WEPO FORMATION** **SANDSTONE,** continued note: low to medium plasticity, gray note: nonplastic, light brown below 8.5m
9.0				S	50/ 75mm					
10.5				S	50/ 75mm					
12.0				S	50/ 50mm					
					50/					
				S	50mm					note: recovery light gray below 13.4m
13.5										Stopped Auger at 13.35m Sampler refused at 13.4m
15.0										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. SS-6

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/8/15

LOCATION (M) N. 4022937 E. 584555.1
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2045.0m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	6-3-2			SC	slightly moist to moist	**CLAYEY SAND,** occasional predominantly fine grained, subangular to subrounded gravel, predominantly fine to medium grained, subangular to subrounded sand, medium plasticity, brown
				A					soft to moderately firm	
				U	20					note: possible calcium carbonate filaments at 1.5m
1.5				S	5-6-6					
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. SS-7

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/9/15

LOCATION (M) N. 4022932.3 E. 584639.1
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2048.9m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				U	15	1489.7	13.6		slightly moist	**WEPO FORMATION** **SANDSTONE,** moderately soft to moderately hard, light brown
				A					moderately firm to firm at surface	note: sandy clay layer up to 0.15m thick, low to medium plasticity, brown
				U	45	1646.4	15.3			note: low to medium plasticity, dark brown below 1.35m
1.5				S	50/ 125mm				hard below 1.2m	note: nonplastic, light brown below 1.8m
3.0				S	50/ 125mm					
				S	50/ 100mm					
4.5										Stopped Auger at 4.35m Sampler refused at 4.45m
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. SS-8

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/9/15

LOCATION (M) N. 4022801.6 E. 584878
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2061.2m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	50/ 75mm				slightly moist	**WEPO FORMATION SANDSTONE,** moderately soft to moderately hard, light brown
										Auger refused at surface Sampler refused at 75mm
1.5										
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

	DEPTH (m)	HOUR	DATE
▽		none	
▼			

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. SS-9

PROJECT BIA N80661(3), N8065(1) & School Spur
Black Mesa Community School, Arizona
Navajo Nation

JOB NO. 17-2015-4045 **DATE** 12/9/15

LOCATION (M) N. 4022623.4 E. 584923.6
PROJECTION NAD 1983 UTM Zone 12N (Meters)
RIG TYPE CME-75
BORING TYPE 168mm Hollow Stem Auger
SURFACE EL. (M) 2070.3m ±
DATUM NAVD88

Depth in Meters	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blow Counts	Dry Density Kg. per Cubic meter	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0.0				S	15-5-6			SC	slightly moist to moist moderately firm	**FILL - Roadway** **CLAYEY SAND,** predominantly fine to medium grained, subangular to subrounded sand, low plasticity, light brown note: decrease in fines with depth
				A						
				U	15					
1.5				S	8-12-14			CL	moist firm	**NATIVE** **SANDY CLAY,** predominantly fine grained, subangular to subrounded sand, uncemented to weakly cemented, medium plasticity, dark brown
										Stopped Auger at 1.35m Stopped Sampler at 1.8m
3.0										
4.5										
6.0										
7.5										

GROUNDWATER

DEPTH (m)	HOUR	DATE
	none	

SAMPLE TYPE
A - Auger cuttings; NR-No Recovery
S - 51mm O.D. 35mm I.D. tube sample.
U - 76mm O.D. 61mm I.D. tube sample.
T - 25mm O.D. thin-walled tube sample

LOG OF TEST BORING NO. SS-10

APPENDIX B

LABORATORY TEST RESULTS

LABORATORY TESTING PROCEDURES

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

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

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

amec foster wheeler

TABLE B-1

SUMMARY OF LABORATORY TEST RESULTS

Station Reference	Location	Offset	Direction	Boring Number	Depth (m)		USCS/Group Symbol	Liquid Limit	Plasticity Index	Percent Fines (minus 75µm)	Correlated R-Value	Tested R-Value (at 2068kPa)[1]	Moisture Content (%)	In Place Dry Density (kg/cu.m)[2]	One Dimensional Swell or Settlement Potential (Undisturbed Samples) (ASTM D4546) [Swell (+)/Collapse(-)]	Optimum Moisture Content (%) (AASHTO T99)	Maximum Dry Density (kg/cu.m)[2] (AASTHO T99)
		feet			Begin	End											
Proposed BIA Route N8066 CL	13+900	CL	-	R-1	0.00	1.35	CH	52	31	86	9	8			5.4	20.1	1595.4
Proposed BIA Route N8066 CL	14+100	CL	-	R-2	0.00	0.30							20.5	1421.9			
Proposed BIA Route N8066 CL	14+500	CL	-	R-4	0.00	0.30							15	1603.3	0.3		
Proposed BIA Route N8066 CL	14+500	CL	-	R-4	0.00	1.35	CL	33	16	51	26	9				15.8	1731.6
Proposed BIA Route N8066 CL	14+900	CL	-	R-6	0.00	0.30							17.2	1514.5			
Proposed BIA Route N8066 CL	15+300	CL	-	R-8	0.00	0.30							12.6	1538.0			
Proposed BIA Route N8066 CL	15+300	CL	-	R-8	0.00	1.35	SC-SM	25	6	45	42	24				13.5	1834.1
Proposed BIA Route N8066 CL	15+700	CL	-	R-10	0.00	0.30							21.2	1488.8	0.4		
Proposed BIA Route N8066 CL	15+700	CL	-	R-10	0.00	1.20	CL	33	16	67	21	9				15.7	1746.0
Proposed BIA Route N8066 CL	16+300	CL	-	R-13	0.00	0.30							14.3	1364.8			
Proposed BIA Route N8066 CL	16+500	CL	-	R-14	0.00	0.30							10.6	1477.0			
Proposed BIA Route N8066 CL	16+500	CL	-	R-14	0.00	1.35	SM	NV	NP	42	56	37				13.7	1822.9
Proposed BIA Route N8066 CL	16+900	4	R	R-16	0.00	0.30							11.7	1308.8			
Proposed BIA Route N8066 CL	17+300	CL	-	R-18	0.00	0.30							7.4	1592.8			
Proposed BIA Route N8066 CL	17+300	CL	-	R-18	0.00	1.35	CL	27	10	50	34	22				13.1	1829.3
Proposed BIA Route N8066 CL	17+700	CL	-	R-20	0.00	0.30							21.3	1433.2	1.0		
Proposed BIA Route N8066 CL	17+700	CL	-	R-20	0.00	1.35	CL	41	23	66	16						
Proposed BIA Route N8066 CL	18+100	CL	-	R-22	0.00	0.30							10	1641.6			
Proposed BIA Route N8066 CL	18+300	CL	-	R-23	0.00	1.35	ML	NV	NP	54	47	31				12.3	1880.6
Proposed BIA Route N8066 CL	18+500	CL	-	R-24	0.00	0.30							10.4	1460.1			
Proposed BIA Route N8066 CL	18+900	CL	-	R-26	0.00	1.35	CL	43	25	64	16	9			5.1	15.2	1720.4
Proposed BIA Route N8066 CL	18+900	CL	-	R-26	0.75	1.05							8.8	1449.5	7.1		
Proposed BIA Route N8066 CL	19+900	CL	-	R-31	0.00	1.35	CH	55	39	61	9	12				15.7	1738.0
Proposed BIA Route N8066 CL	20+100	CL	-	R-32	0.00	0.30							12.6	1467.1			
Proposed BIA Route N8066 CL	20+500	CL	-	R-34	0.00	0.30							10.5	1438.5			
Proposed BIA Route N8066 CL	20+700	CL	-	R-35	0.00	1.35	SM	NV	NP	46	53	35				14.2	1787.7
Proposed BIA Route N8066 CL	20+900	CL	-	R-36	0.00	0.30							22.6	1306.5			
Proposed BIA Route N8066 CL	21+300	CL	-	R-38	0.00	0.30							22	1422.8	1.0		
Proposed BIA Route N8066 CL	21+300	CL	-	R-38	0.00	1.35	CH	59	35	88	8						
Proposed BIA Route N8066 CL	21+700	CL	-	R-40	0.00	0.30							16.6	1497.9			
Proposed BIA Route N8066 CL	21+700	CL	-	R-40	0.00	1.35	CL	30	14	53	28	18			1.2	15.1	1784.5
Proposed BIA Route N8066 CL	22+055	CL	-	R-42	0.00	1.35	ML	NV	NP	59	44	36				13.6	1811.7
Proposed BIA Route N8066 CL	22+055	CL	-	R-42	0.75	1.05							9.3	1599.5			
Proposed BIA Route N8066 CL	22+300	CL	-	R-43	0.00	0.30							18.1	1544.1			
Proposed BIA Route N8066 CL	22+800	CL	-	R-45	0.00	1.35	CL	47	23	91	12	9				20.3	1557.0
Proposed BIA Route N8066 CL	22+800	CL	-	R-45	0.75	1.05							9.2	1098.2	0.9		
Proposed BIA Route N8065 Spur CL	0+052	CL	-	RS-1	0.00	1.35	CH	55	31	98	8	6			6.8	20.9	1568.2
Proposed BIA Route N8065 Spur CL	0+052	CL	-	RS-1	0.75	1.05							10.6	1512.9			
Proposed School Spur CL	0+100	CL	-	SS-3	0.00	1.35	CL	25	9	60	31	16				12.5	1882.2
Proposed School Spur CL	0+500	CL	-	SS-3	0.75	1.05							11.5	1592.1			
Proposed School Spur CL	0+900	CL	-	SS-5	0.00	1.35	SM	NV	NP	22	74						

[1](kPa) = kilopascal

[2](kg/cu.m) = kilograms per cubic meter

TABLE B-1

SUMMARY OF LABORATORY TEST RESULTS

Station Reference	Location	Offset	Direction	Boring Number	Depth (m)		USCS/Group Symbol	Liquid Limit	Plasticity Index	Percent Fines (minus 75µm)	Correlated R-Value	Tested R-Value (at 2068kPa)[1]	Moisture Content (%)	In Place Dry Density (kg/cu.m)[2]	One Dimensional Swell or Settlement Potential (Undisturbed Samples) (ASTM D4546) [Swell (+)/Collapse(-)]	Optimum Moisture Content (%) (AASHTO T99)	Maximum Dry Density (kg/cu.m)[2] (AASTHO T99)
		feet			Begin	End											
Proposed School Spur CL	1+040	CL	-	SS-6	0.00	1.35	GC	26	9	24	50						
Proposed School Spur CL	1+335	CL	-	SS-8	0.00	0.30							13.6	1489.7			
Proposed School Spur CL	1+335	CL	-	SS-8	0.00	1.35	SC	25	9	36	43	30				13.9	1850.1
Proposed School Spur CL	1+335	CL	-	SS-8	0.75	1.05							15.3	1645.4			
							MEAN	**---**	**---**	**58**	**31**	**19**	**14.1**	**1476.4**	**2.9**	**15.4**	**1758.7**
							STDEV	**---**	**---**	**21**	**19**	**11**	**4.6**	**120.5**	**2.8**	**2.8**	**104.6**
							MAXIMUM	**59**	**39**	**98**	**74**	**37**	**22.6**	**1645.4**	**7.1**	**20.9**	**1882.2**
							MINIMUM	**25**	**6**	**22**	**8**	**6**	**7.4**	**1098.2**	**0.3**	**12.3**	**1557.0**
							COUNT	**20**	**20**	**20**	**20**	**16**	**25**	**25**	**10**	**16**	**16**

[1](kPa) = kilopascal
[2](kg/cu.m) = kilograms per cubic meter

amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: SEE BELOW

JOB NO: 17-2015-4045
WORK ORDER NO: 1
DATE ASSIGNED: 1/12/16

MECHANICAL SIEVE ANALYSIS
GROUP SYMBOL, USCS (AASHTO T27/T11/T89/T90)

PERCENT PASSING BY WEIGHT

				Silt or	SAND								GRAVEL									COBBLES	
				Clay	Fine			Medium			Coarse		Fine				Coarse						
Location & Depth	USCS	LL	PI	75um	150um	300um	425um	600um	1.18um	2.00mm	2.36mm	4.75mm	6.3mm	9.5mm	12.5mm	19mm	25mm	31.2mm	37.5mm	50mm	75mm	152mm	Lab #
R-1 (0.00m-1.35m)	CH	52	31	86	93	97	99	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100	16-0885-01
R-4 (0.00m-1.35m)	CL	33	16	51	67	78	82	84	86	98	98	99	99	100	100	100	100	100	100	100	100	100	16-0885-13
R-8 (0.00m-1.35m)	SC-SM	25	6	45	66	83	88	91	94	96	96	97	98	99	99	100	100	100	100	100	100	100	16-0885-29
R-10 (0.00m-1.20m)	CL	33	16	67	84	94	96	97	99	99	99	100	100	100	100	100	100	100	100	100	100	100	16-0885-37
R-14 (0.00m-1.35m)	SM	NV	NP	42	64	86	92	95	98	98	99	99	99	99	100	100	100	100	100	100	100	100	16-0885-53
R-18 (0.00m-1.35m)	CL	27	10	50	70	88	93	95	98	98	99	99	99	100	100	100	100	100	100	100	100	100	16-0885-69
R-20 (0.00m-1.35m)	CL	41	23	66	82	93	95	97	98	98	99	99	99	100	100	100	100	100	100	100	100	100	16-0885-77
R-23 (0.00m-1.35m)	ML	NV	NP	54	64	84	89	93	97	98	98	99	99	99	100	100	100	100	100	100	100	100	16-0885-89
R-26 (0.00m-1.35m)	CL	43	25	64	79	88	91	93	96	97	98	99	99	100	100	100	100	100	100	100	100	100	16-0885-101
R-31 (0.00m-1.35m)	CH	55	39	61	76	96	99	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100	16-0885-121

amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

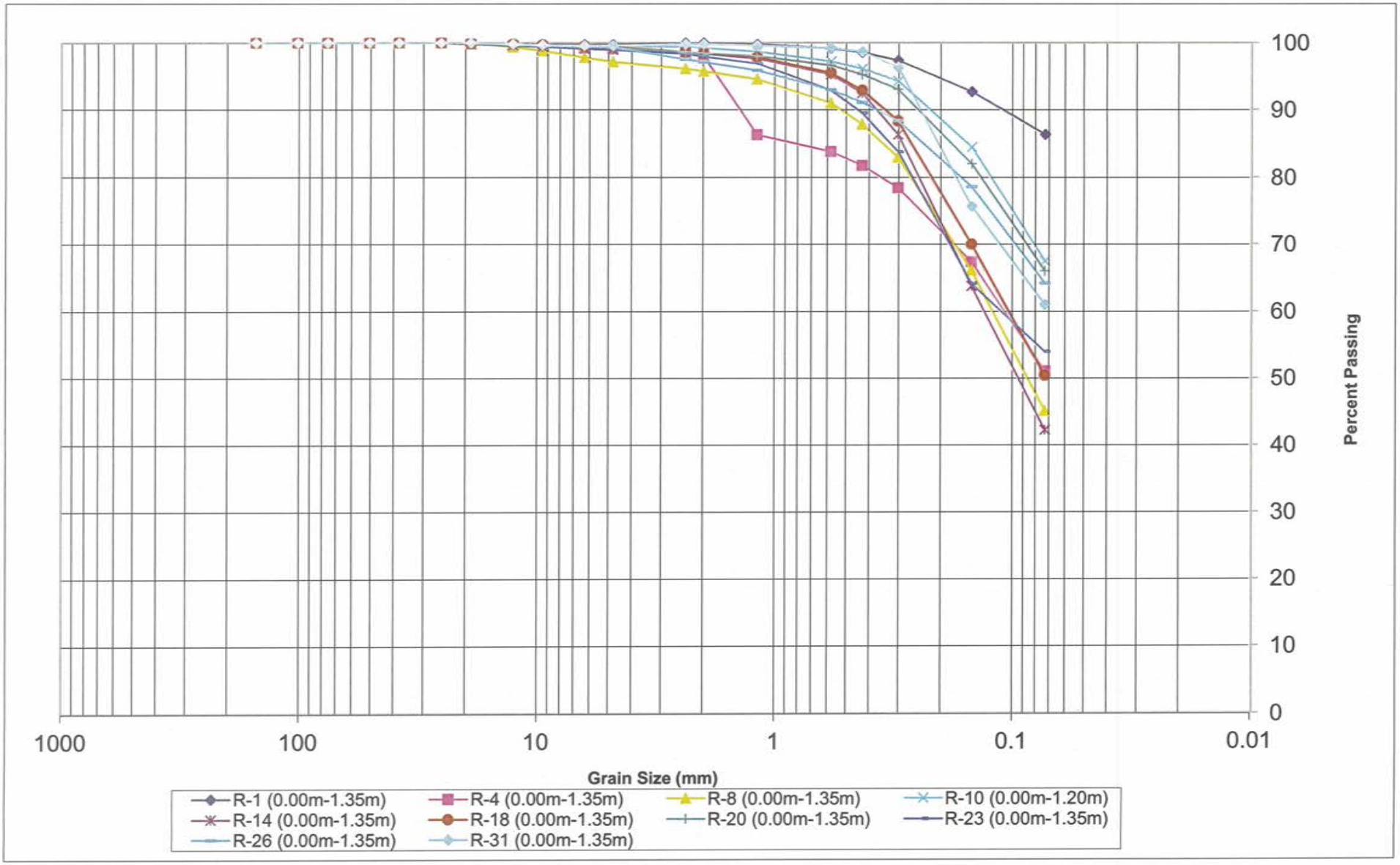
REVIEWED BY _____

amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
SAMPLE SOURCE: SEE BELOW

JOB NO: 17-2015-4045
WORK ORDER NO: 1
DATE ASSIGNED: 1/12/16

MECHANICAL SIEVE ANALYSIS



amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: SEE BELOW

JOB NO: 17-2015-4045
WORK ORDER NO: 1
DATE ASSIGNED: 1/12/16

MECHANICAL SIEVE ANALYSIS
GROUP SYMBOL, USCS (AASHTO T27/T11/T89/T90)

PERCENT PASSING BY WEIGHT

				Silt or	SAND								GRAVEL									COBBLES	
				Clay	Fine			Medium			Coarse		Fine				Coarse						
Location & Depth	USCS	LL	PI	75um	150um	300um	425um	600um	1.18um	2.00mm	2.36mm	4.75mm	6.3mm	9.5mm	12.5mm	19mm	25mm	31.2mm	37.5mm	50mm	75mm	152mm	Lab #
R-35 (0.00m-1.35m)	SM	NV	NP	46	73	97	99	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100	16-0885-137
R-38 (0.00m-1.35m)	CH	59	35	88	93	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	16-0885-149
R-40 (0.00m-1.35m)	CL	30	14	53	72	97	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	16-0885-157
R-42 (0.00m-1.35m)	ML	NV	NP	59	90	99	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	16-0885-165
R-45 (0.00m-1.35m)	CL	47	23	91	96	98	99	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100	16-0885-179
SS-3 (0.00m-1.35m)	CL	25	9	60	80	95	97	98	99	99	100	100	100	100	100	100	100	100	100	100	100	100	16-0885-195
SS-5 (0.00m-1.35m)	SM	NV	NP	22	53	92	96	96	97	97	97	97	97	98	99	100	100	100	100	100	100	100	16-0885-203
SS-6 (0.00m-1.35m)	GC	26	9	24	33	38	39	40	42	45	46	51	54	61	66	74	78	81	82	84	87	100	16-0885-207
SS-8 (0.00m-1.35m)	SC	25	9	36	46	71	81	83	87	89	89	93	94	96	98	99	100	100	100	100	100	100	16-0885-223

amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

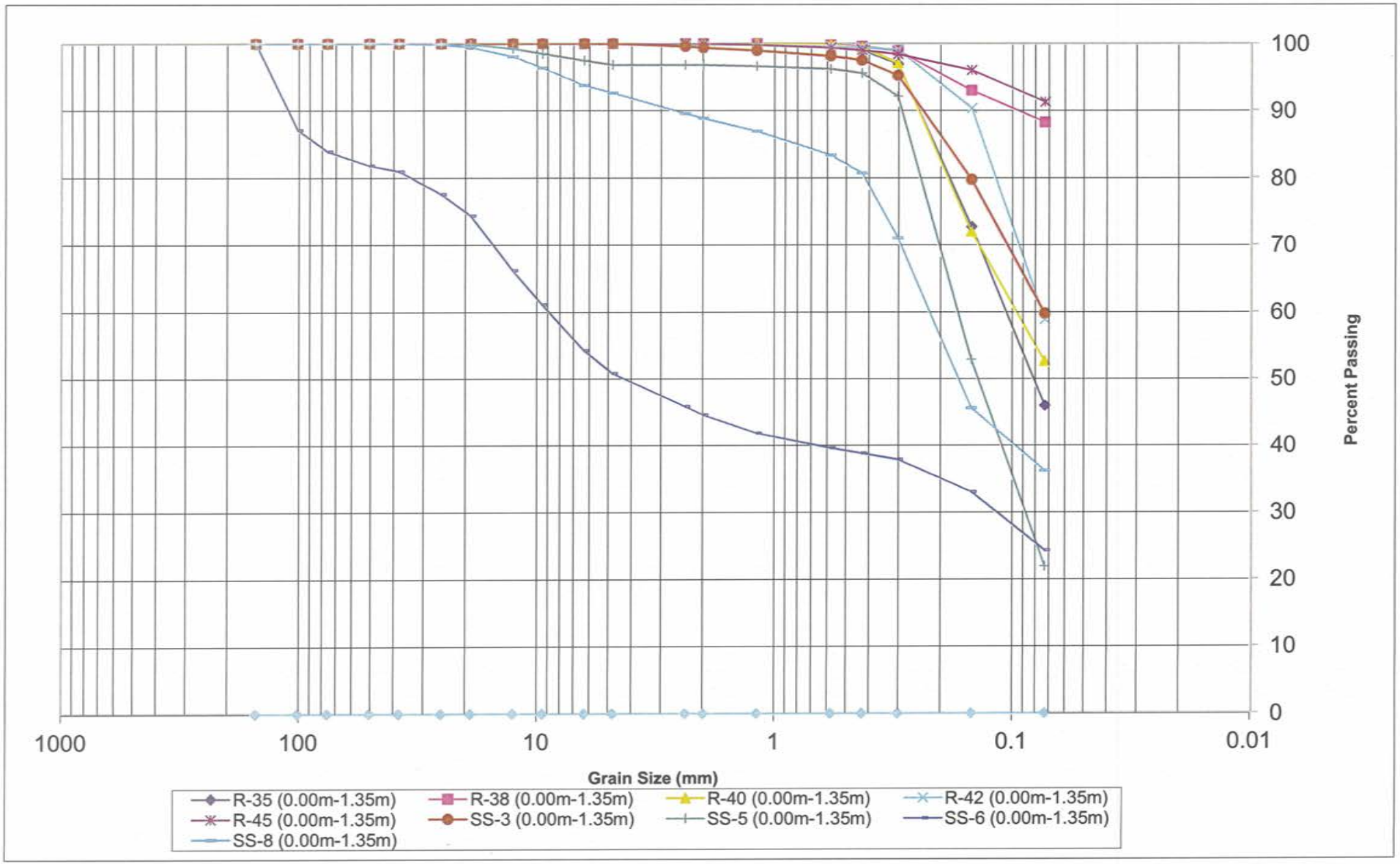
REVIEWED BY _____

amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
SAMPLE SOURCE: SEE BELOW

JOB NO: 17-2015-4045
WORK ORDER NO: 1
DATE ASSIGNED: 1/12/16

MECHANICAL SIEVE ANALYSIS



amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: SEE BELOW

JOB NO: 17-2015-4045
WORK ORDER NO: 2
DATE ASSIGNED: 1/28/16

MECHANICAL SIEVE ANALYSIS
GROUP SYMBOL, USCS (AASHTO T27/T11/T89/T90)

PERCENT PASSING BY WEIGHT

				Silt or	SAND								GRAVEL									COBBLES	
				Clay	Fine			Medium			Coarse		Fine				Coarse						
Location & Depth	USCS	LL	PI	75um	150um	300um	425um	600um	1.18um	2.00mm	2.36mm	4.75mm	6.3mm	9.5mm	12.5mm	19mm	25mm	31.2mm	37.5mm	50mm	75mm	152mm	Lab #
RS-1 (0.00m-1.35m)	CH	55	31	98	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	16-0918-01

amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

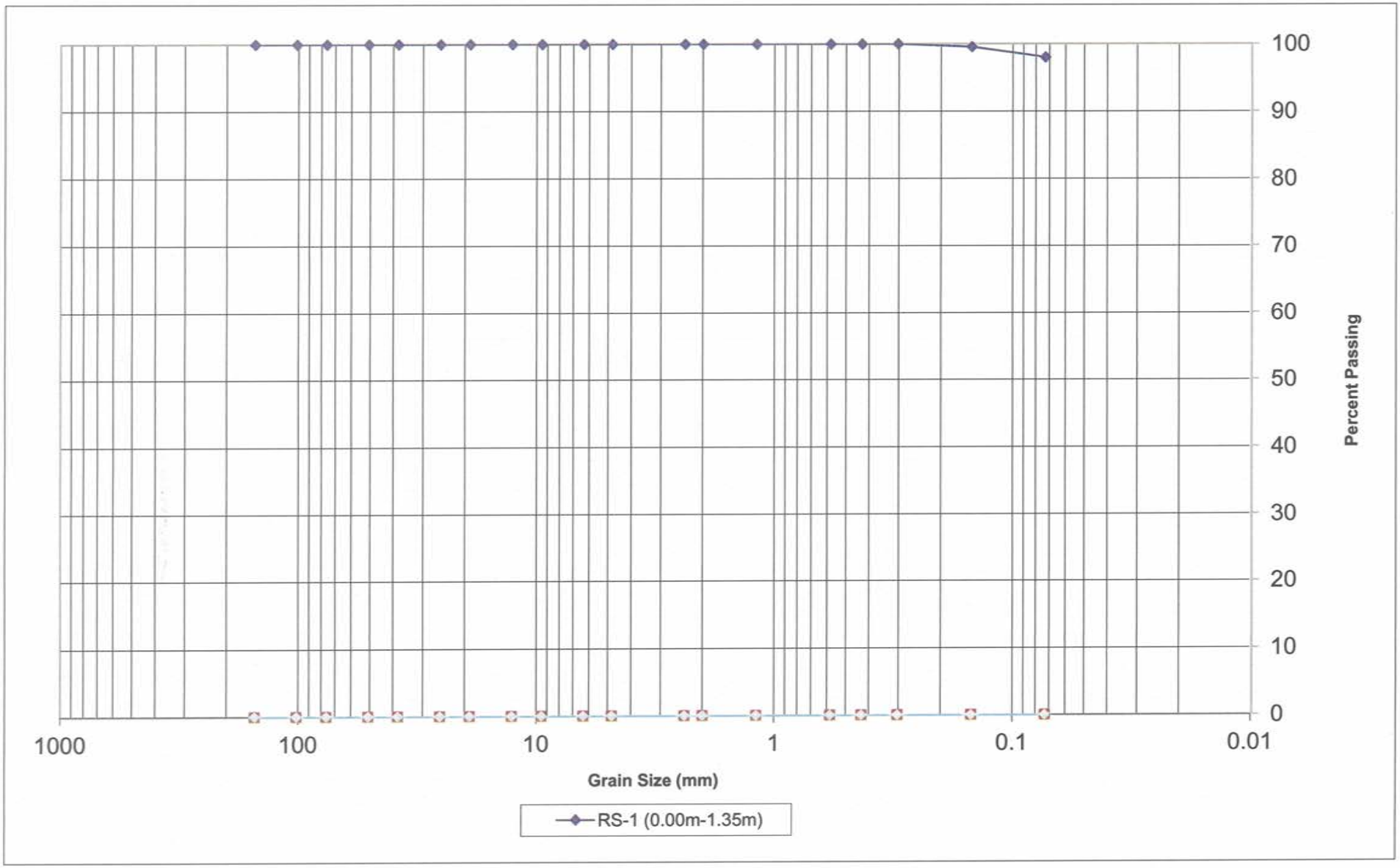
REVIEWED BY _____

amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
SAMPLE SOURCE: SEE BELOW

JOB NO: 17-2015-4045
WORK ORDER NO: 2
DATE ASSIGNED: 1/28/16

MECHANICAL SIEVE ANALYSIS



amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: SEE BORING

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: SEE BELOW
DATE SAMPLED: 1/12/16

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

LAB #	BORING	MOISTURE			NUMBER OF RINGS	WET WGT. + RINGS (g)	WEIGHT OF RINGS (g)	DRY DENSITY (kg/m³)
		WET WT. (g)	DRY WT. (g)	MOISTURE CONTENT				
16-0885-06	R-2 (0.00m-0.30m)	774.7	643.0	20.5%	6	1,039.3	264.3	1421.9
16-0885-14	R-4 (0.00m-0.30m)	448.5	390.1	15.0%	4	729.7	173.8	1603.3
16-0885-22	R-6 (0.00m-0.30m)	802.5	684.7	17.2%	6	1,074.8	271.8	1514.5
16-0885-30	R-8 (0.00m-0.30m)	783.5	695.6	12.6%	6	1,039.9	256.2	1538.0
16-0885-38	R-10 (0.00m-0.30m)	509.4	420.3	21.2%	4	715.4	171.2	1488.8
16-0885-50	R-13 (0.00m-0.30m)	703.9	615.9	14.3%	6	968.5	262.9	1364.8
16-0885-54	R-14 (0.00m-0.30m)	739.0	667.9	10.6%	6	1,007.3	268.0	1477.0
16-0885-62	R-16 (0.00m-0.30m)	551.1	493.3	11.7%	5	778.3	227.1	1308.8
16-0885-70	R-18 (0.00m-0.30m)	774.7	721.2	7.4%	6	1,039.6	265.6	1592.8
16-0885-78	R-20 (0.00m-0.30m)	436.4	359.9	21.3%	4	703.1	179.0	1433.2
16-0885-86	R-22 (0.00m-0.30m)	816.5	742.4	10.0%	6	1,076.4	259.6	1641.6
16-0885-94	R-24 (0.00m-0.30m)	606.8	549.7	10.4%	5	823.4	215.8	1460.1
16-0885-103	R-26 (0.75m-1.05m)	262.1	240.8	8.8%	4	651.7	175.9	1449.5
16-0885-126	R-32 (0.00m-0.30m)	622.5	552.7	12.6%	5	846.3	223.4	1467.1
16-0885-134	R-34 (0.00m-0.30m)	718.3	650.2	10.5%	6	986.6	267.7	1438.5
16-0885-142	R-36 (0.00m-0.30m)	724.0	590.4	22.6%	6	987.4	262.6	1306.5
16-0885-150	R-38 (0.00m-0.30m)	474.7	389.1	22.0%	4	702.3	178.8	1422.8
16-0885-158	R-40 (0.00m-0.30m)	789.1	677.0	16.6%	6	1,055.4	265.6	1497.9
16-0885-167	R-42 (0.75m-1.05m)	659.2	602.9	9.3%	5	878.8	219.5	1599.5
16-0885-172	R-43 (0.00m-0.30m)	686.9	581.6	18.1%	5	908.7	221.2	1544.1
16-0885-181	R-45 (0.75m-1.05m)	361.7	331.2	9.2%	4	538.1	176.4	1098.2
16-0885-197	SS-3 (0.75m-1.05m)	669.0	600.0	11.5%	5	890.5	221.3	1592.1
16-0885-224	SS-8 (0.00m-0.30m)	637.9	561.6	13.6%	5	847.7	209.8	1489.7
16-0885-225	SS-8 (0.75m-1.05m)	857.8	744.2	15.3%	6	1,117.6	259.7	1645.4

amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY 

amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: SEE BORING

JOB NO: 17-2015-4045
WORK ORDER NO: 2
LAB NO: SEE BELOW
DATE SAMPLED: 1/28/16

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

LAB #	BORING	MOISTURE			NUMBER OF RINGS	WET WGT. + RINGS (g)	WEIGHT OF RINGS (g)	DRY DENSITY (kg/m³)
		WET WT. (g)	DRY WT. (g)	MOISTURE CONTENT				
16-0918-03	RS-1 (0.75m-1.05m)	629.9	569.6	10.6%	5	845.5	214.8	1512.9

amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY

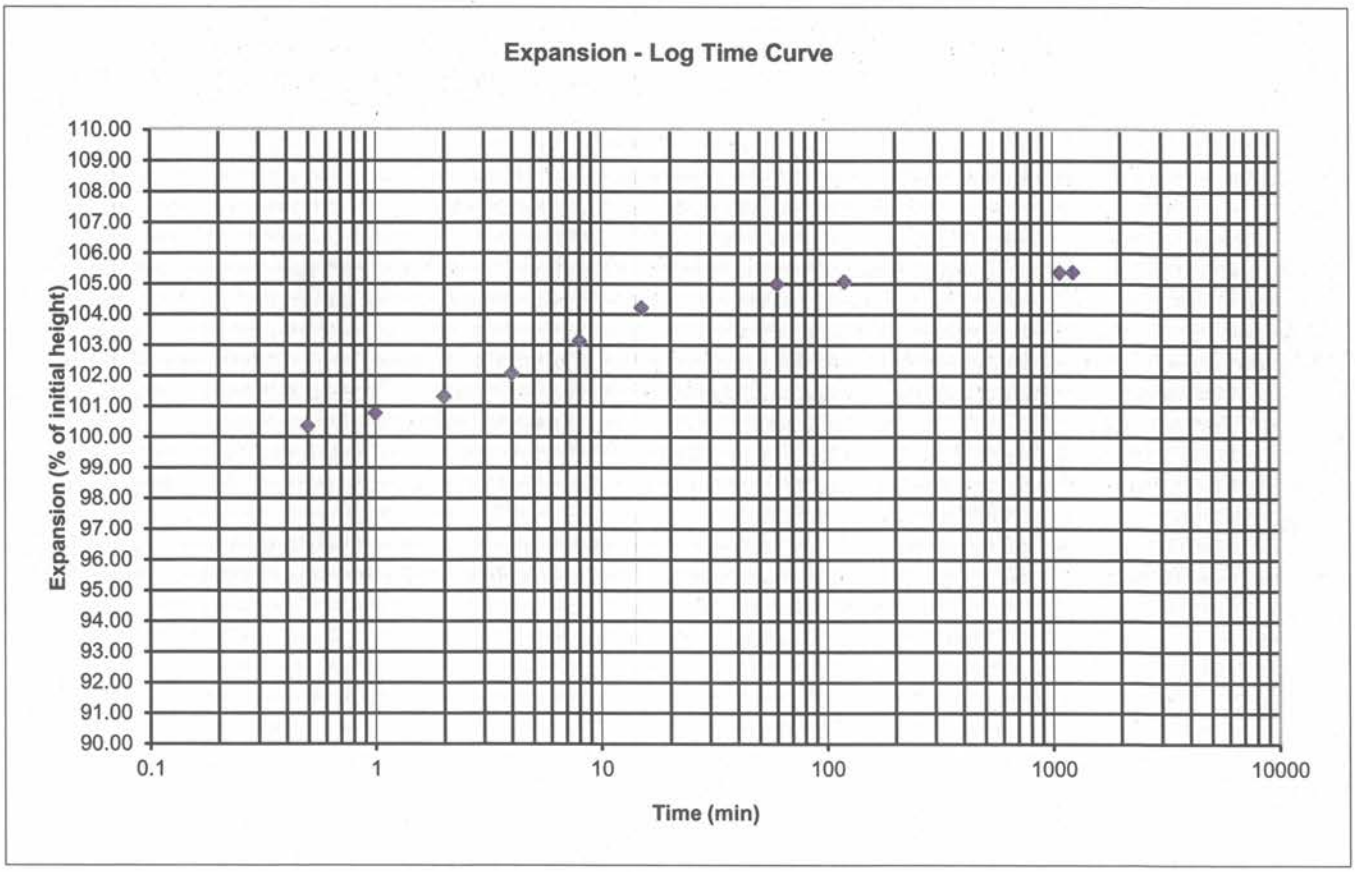
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-1 (0.00m-1.35m)
SAMPLE PREP: Remolded to 95% max dry density and 2% below optimum moisture
Max dry density D698A 1595.4 kg/cu.m @ 20.8% opt. moisture

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-885-01
DATE SAMPLED: 1/12/16
LOAD: 144 psf

ONE DIMENSIONAL SWELL OR SETTLEMENT POTENTIAL OF COHESIVE SOILS (ASTM D-4546)

INITIAL DRY DENSITY (kg/cu.m)	1516.5
FINAL DRY DENSITY (kg/cu.m)	1443.6
INITIAL MOISTURE CONTENT	18.5%
FINAL MOISTURE CONTENT	28.3%
MOIST. PICK-UP (% DRY WT.)	9.8%
MOIST. PICK-UP (% IN. VOL.)	14.9%
SWELL (% INITIAL HT.)	5.4%
TYPE OF WATER USED	TAP WATER



amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY _____

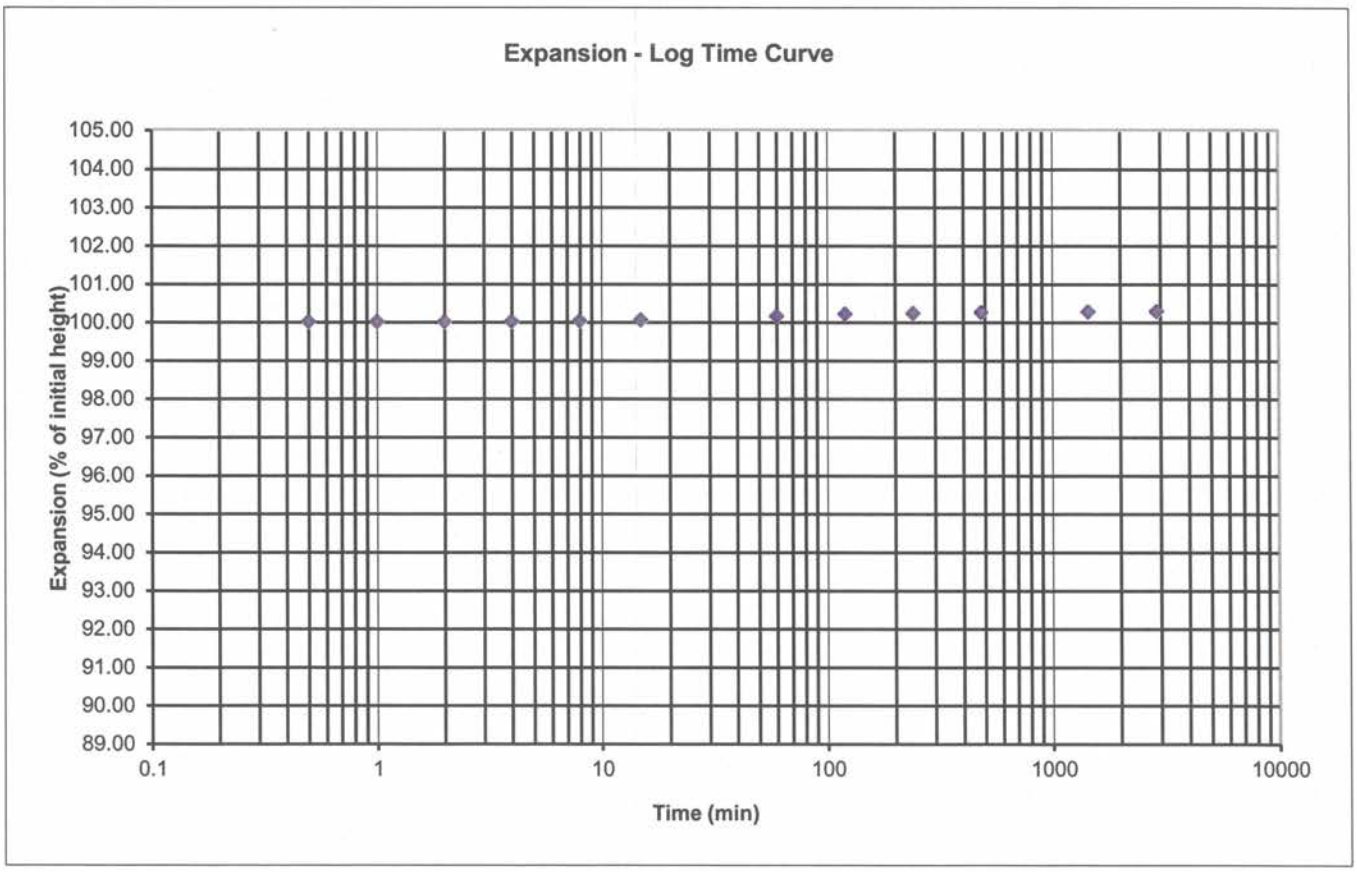
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-4 (0.00m-0.30m)
SAMPLE PREP: Insitu

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-885-14
DATE SAMPLED: 1/12/16
LOAD: 144 psf

ONE DIMENSIONAL SWELL OR SETTLEMENT POTENTIAL OF COHESIVE SOILS (ASTM D-4546)

INITIAL DRY DENSITY (kg/cu.m)	1700.3
FINAL DRY DENSITY (kg/cu.m)	1697.0
INITIAL MOISTURE CONTENT	16.8%
FINAL MOISTURE CONTENT	20.5%
MOIST. PICK-UP (% DRY WT.)	3.7%
MOIST. PICK-UP (% IN. VOL.)	6.3%
SWELL (% INITIAL HT.)	0.3%
TYPE OF WATER USED	TAP WATER



amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY

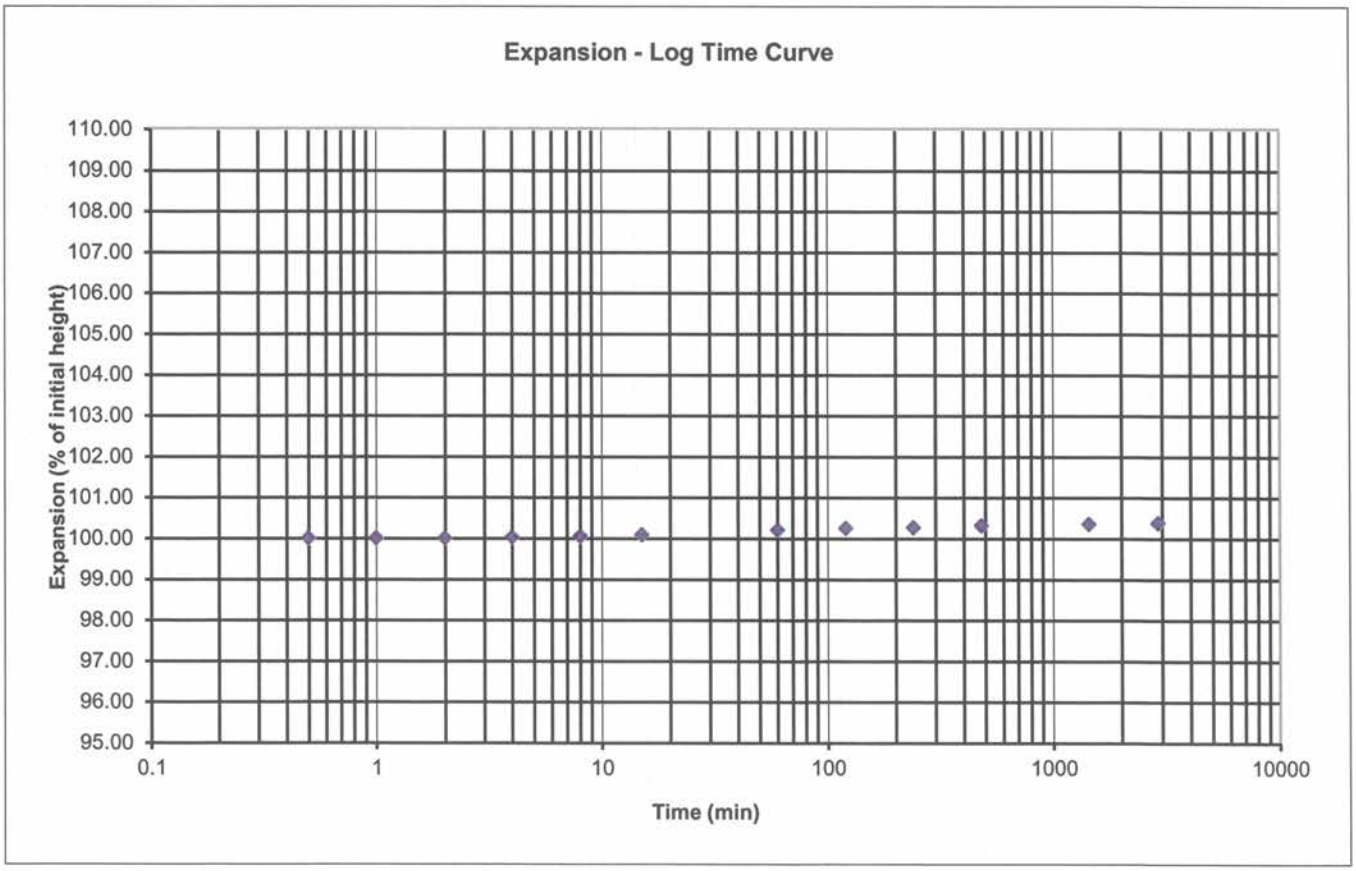
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-10 (0.00m-0.30m)
SAMPLE PREP: Insitu

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-885-38
DATE SAMPLED: 1/12/16
LOAD: 144 psf

ONE DIMENSIONAL SWELL OR SETTLEMENT POTENTIAL OF COHESIVE SOILS (ASTM D-4546)

INITIAL DRY DENSITY (kg/cu.m)	1597.4
FINAL DRY DENSITY (kg/cu.m)	1593.4
INITIAL MOISTURE CONTENT	20.7%
FINAL MOISTURE CONTENT	23.0%
MOIST. PICK-UP (% DRY WT.)	2.3%
MOIST. PICK-UP (% IN. VOL.)	3.7%
SWELL (% INITIAL HT.)	0.4%
TYPE OF WATER USED	TAP WATER



amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY

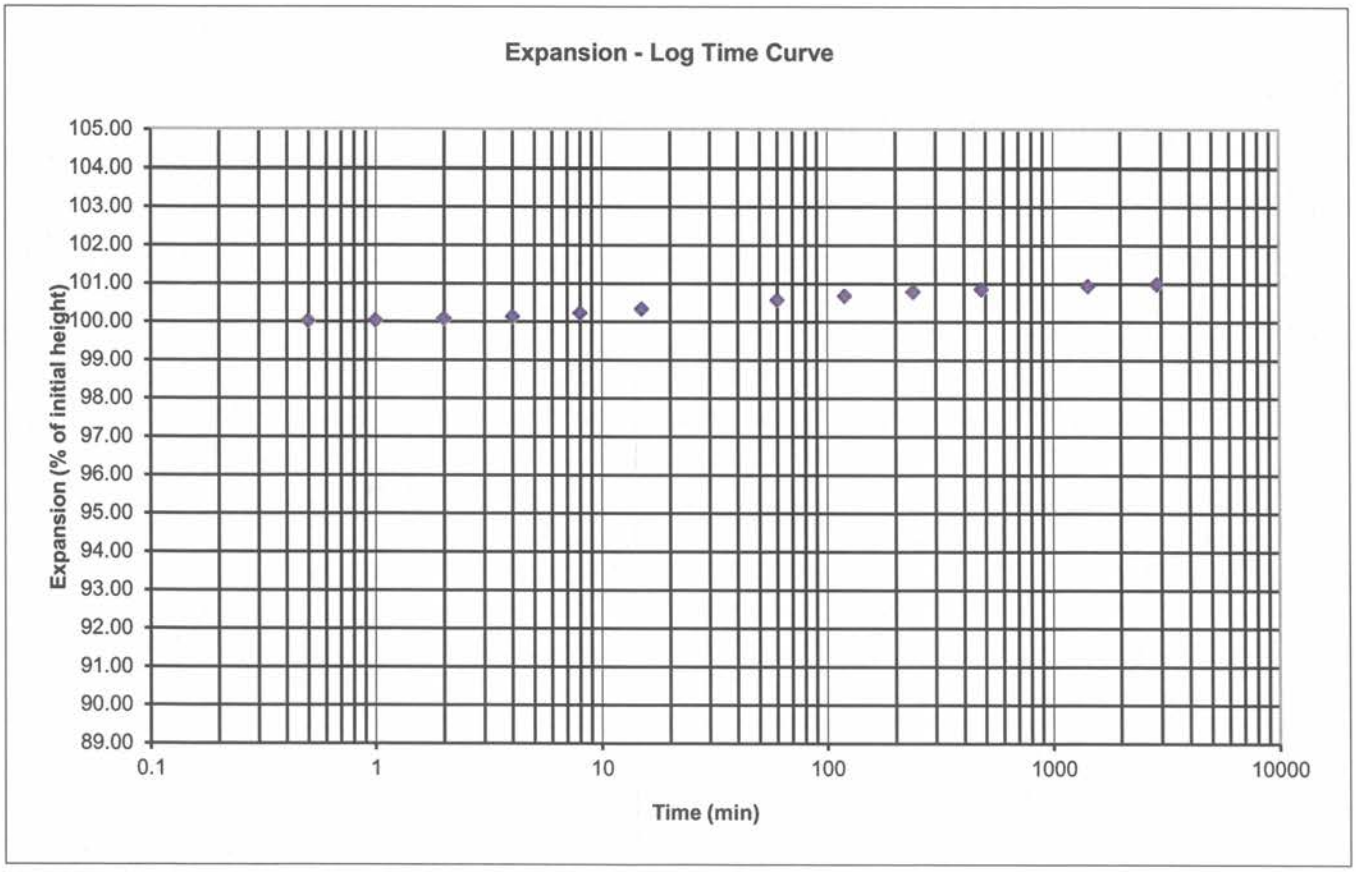
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-20 (0.00m-0.30m)
SAMPLE PREP: Insitu

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-885-78
DATE SAMPLED: 1/12/16
LOAD: 144 psf

ONE DIMENSIONAL SWELL OR SETTLEMENT POTENTIAL OF COHESIVE SOILS (ASTM D-4546)

INITIAL DRY DENSITY (kg/cu.m)	1519.2
FINAL DRY DENSITY (kg/cu.m)	1509.2
INITIAL MOISTURE CONTENT	22.3%
FINAL MOISTURE CONTENT	25.9%
MOIST. PICK-UP (% DRY WT.)	3.7%
MOIST. PICK-UP (% IN. VOL.)	5.6%
SWELL (% INITIAL HT.)	1.0%
TYPE OF WATER USED	TAP WATER



amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY

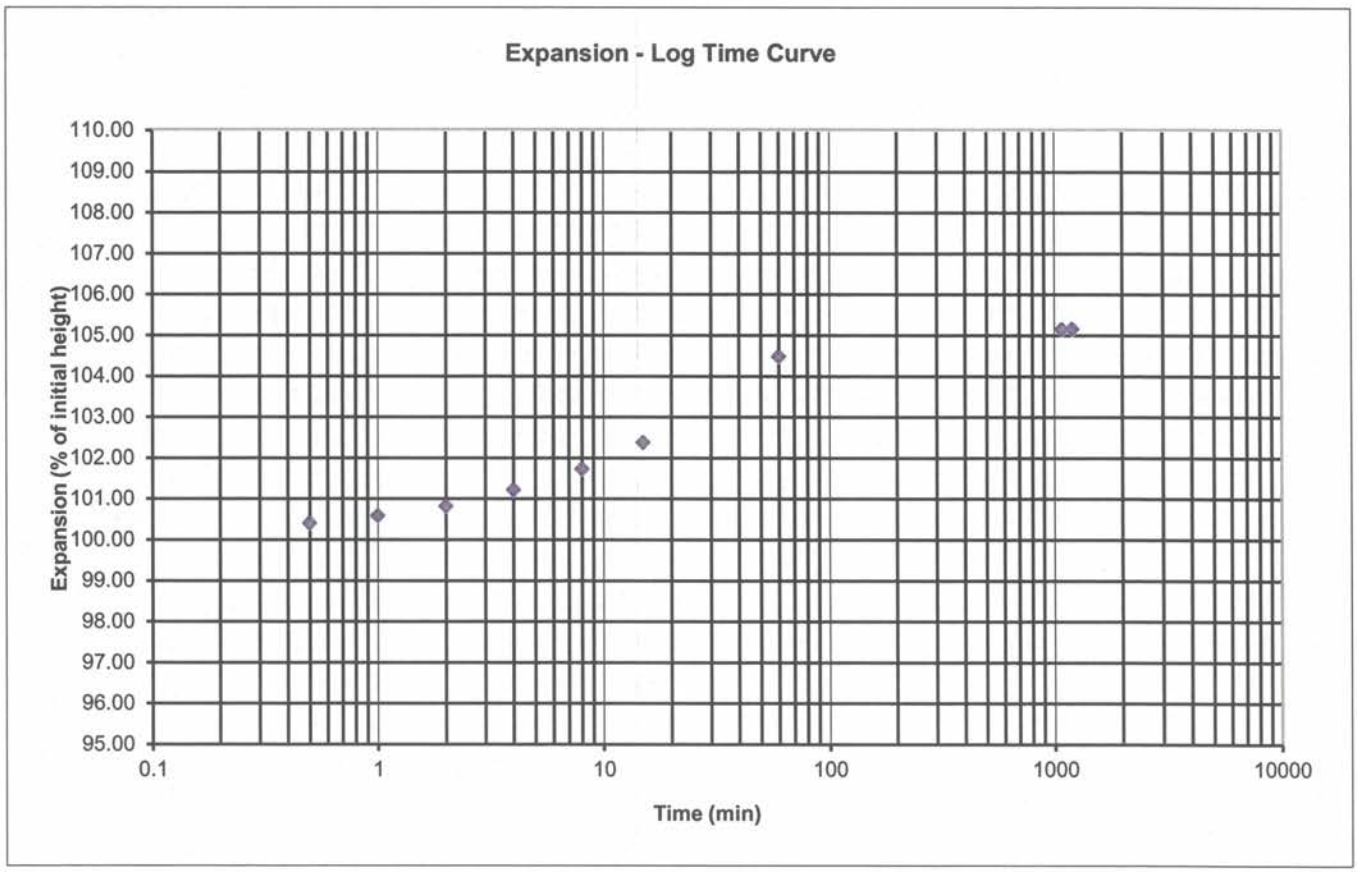
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-26 (0.00m-1.35m)
SAMPLE PREP: Remolded to 95% max dry density and 2% below optimum moisture
Max dry density D698A 1720.4 kg/cu.m @ 15.2% opt. moisture

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-885-101
DATE SAMPLED: 1/12/16
LOAD: 144 psf

ONE DIMENSIONAL SWELL OR SETTLEMENT POTENTIAL OF COHESIVE SOILS (ASTM D-4546)

INITIAL DRY DENSITY (kg/cu.m)	1635.2
FINAL DRY DENSITY (kg/cu.m)	1555.4
INITIAL MOISTURE CONTENT	13.5%
FINAL MOISTURE CONTENT	22.8%
MOIST. PICK-UP (% DRY WT.)	9.3%
MOIST. PICK-UP (% IN. VOL.)	15.3%
SWELL (% INITIAL HT.)	5.1%
TYPE OF WATER USED	TAP WATER



amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY _____

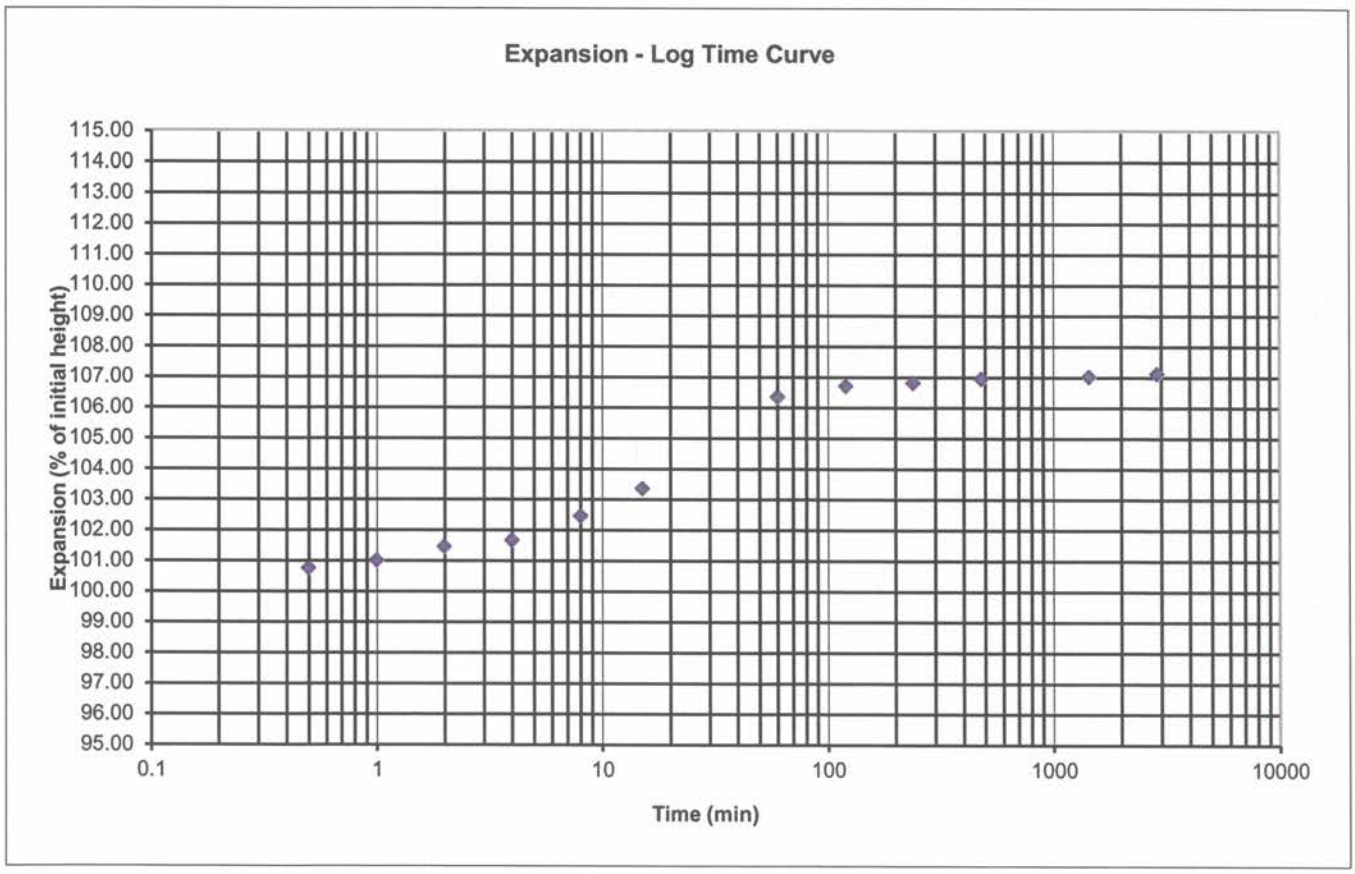
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-26 (0.75m-1.05m)
SAMPLE PREP: Insitu

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-885-103
DATE SAMPLED: 1/12/16
LOAD: 144 psf

ONE DIMENSIONAL SWELL OR SETTLEMENT POTENTIAL OF COHESIVE SOILS (ASTM D-4546)

INITIAL DRY DENSITY (kg/cu.m)	1597.7
FINAL DRY DENSITY (kg/cu.m)	1497.5
INITIAL MOISTURE CONTENT	9.6%
FINAL MOISTURE CONTENT	27.3%
MOIST. PICK-UP (% DRY WT.)	17.7%
MOIST. PICK-UP (% IN. VOL.)	28.3%
SWELL (% INITIAL HT.)	7.1%
TYPE OF WATER USED	TAP WATER



amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY

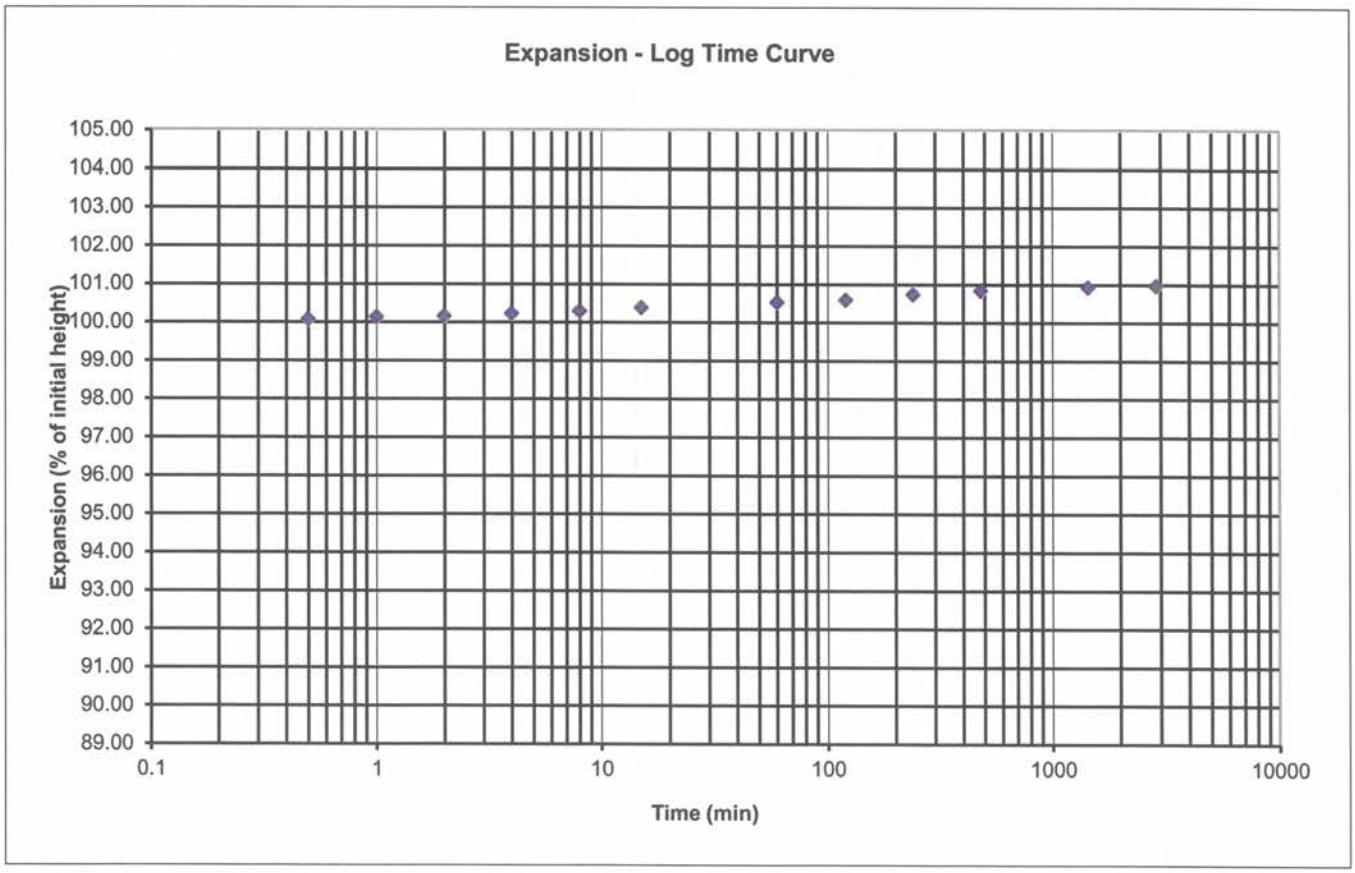
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-38 (0.00m-0.30m)
SAMPLE PREP: Insitu

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-885-150
DATE SAMPLED: 1/12/16
LOAD: 144 psf

ONE DIMENSIONAL SWELL OR SETTLEMENT POTENTIAL OF COHESIVE SOILS (ASTM D-4546)

INITIAL DRY DENSITY (kg/cu.m)	1422.5
FINAL DRY DENSITY (kg/cu.m)	1409.1
INITIAL MOISTURE CONTENT	28.8%
FINAL MOISTURE CONTENT	31.6%
MOIST. PICK-UP (% DRY WT.)	2.9%
MOIST. PICK-UP (% IN. VOL.)	4.1%
SWELL (% INITIAL HT.)	1.0%
TYPE OF WATER USED	TAP WATER



amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY RJN

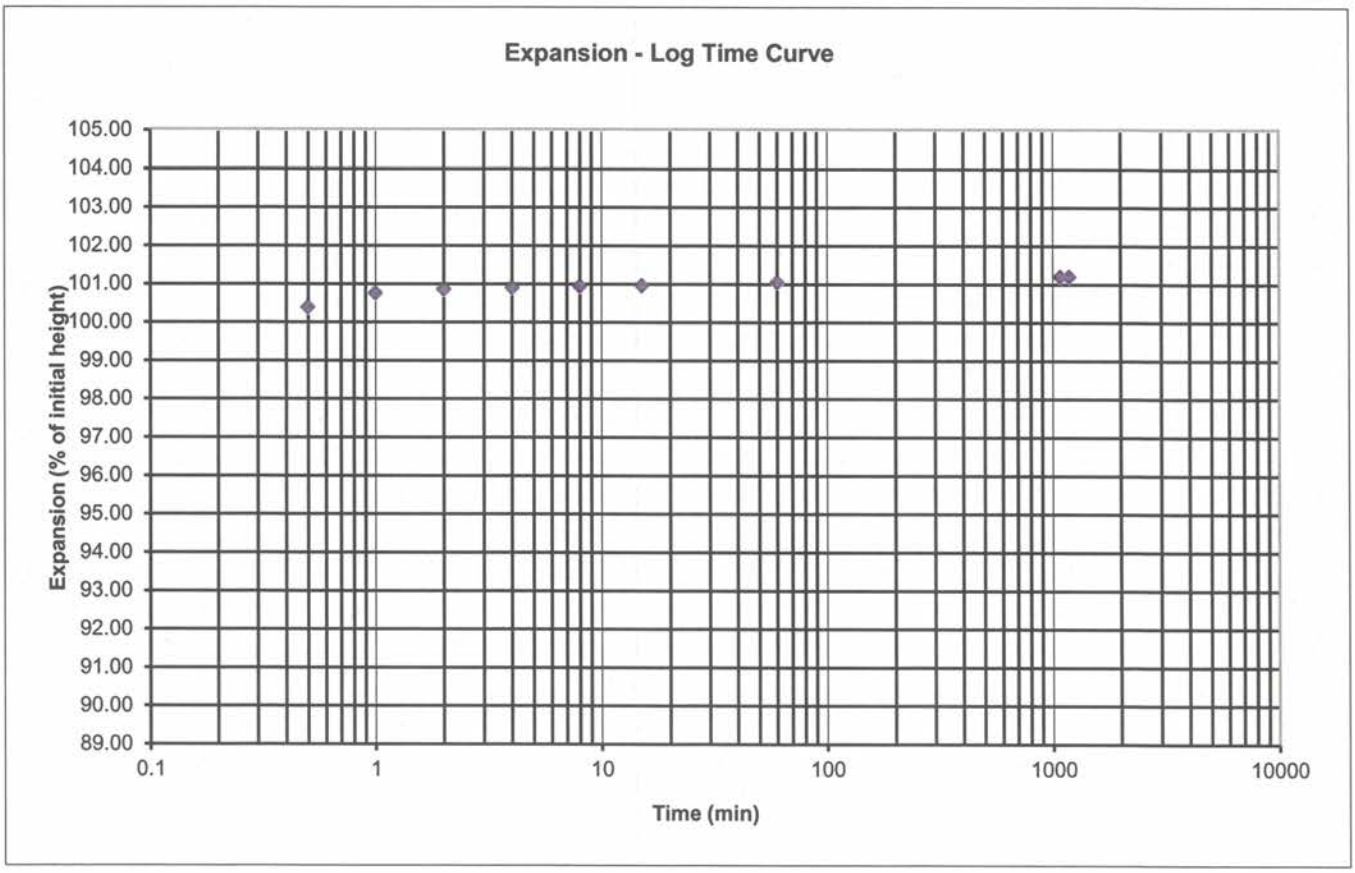
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-40 (0.00m-1.35m)
SAMPLE PREP: Remolded to 95% max dry density and 2% below optimum moisture
Max dry density D698A 1784.5 kg/cu.m @ 15.1% opt. moisture

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-885-157
DATE SAMPLED: 1/12/16
LOAD: 144 psf

ONE DIMENSIONAL SWELL OR SETTLEMENT POTENTIAL OF COHESIVE SOILS (ASTM D-4546)

INITIAL DRY DENSITY (kg/cu.m)	1689.5
FINAL DRY DENSITY (kg/cu.m)	1669.8
INITIAL MOISTURE CONTENT	12.9%
FINAL MOISTURE CONTENT	22.6%
MOIST. PICK-UP (% DRY WT.)	9.7%
MOIST. PICK-UP (% IN. VOL.)	16.4%
SWELL (% INITIAL HT.)	1.2%
TYPE OF WATER USED	TAP WATER



amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY

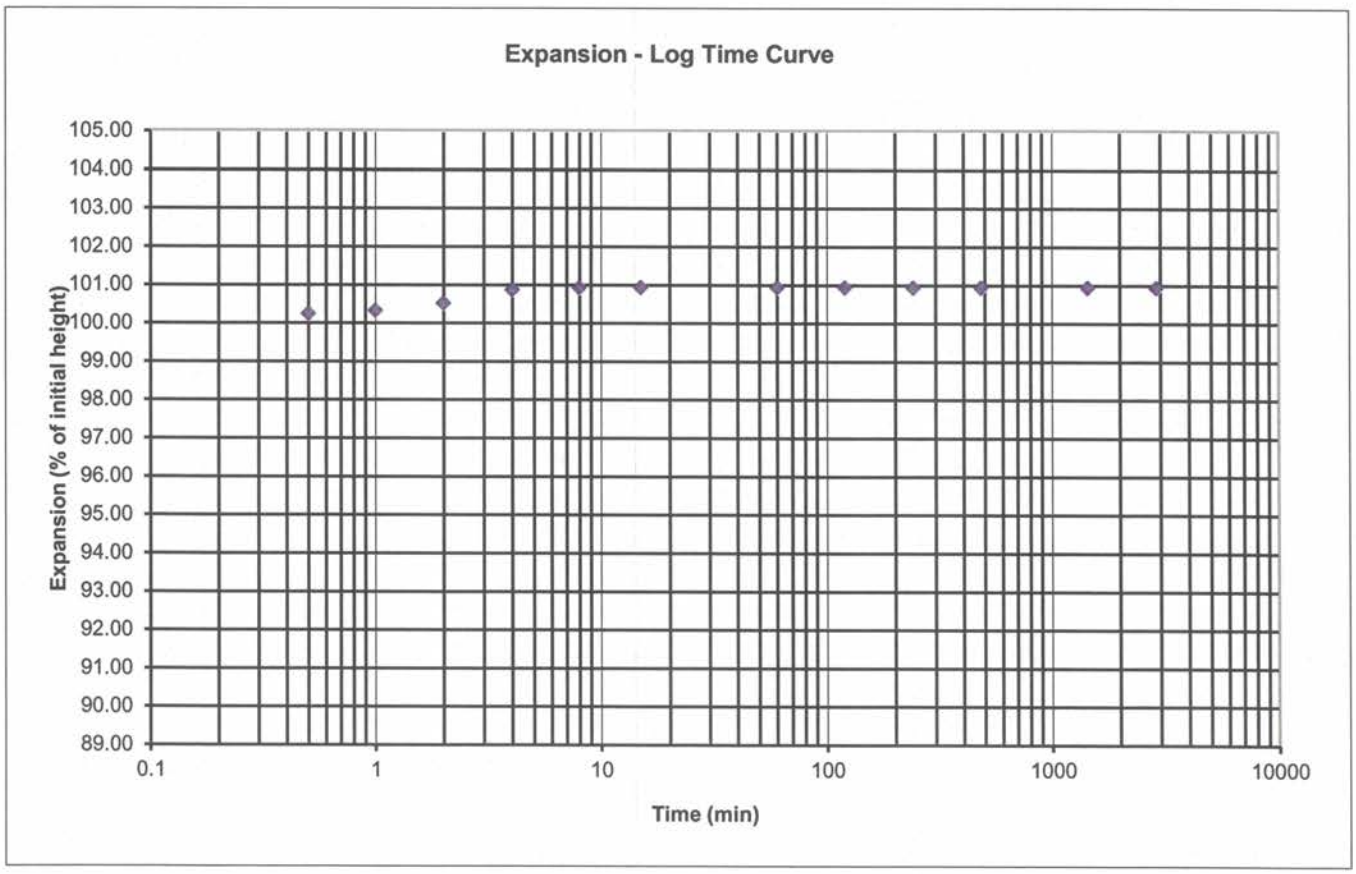
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-45 (0.75m-1.05m)
SAMPLE PREP: Insitu

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-885-181
DATE SAMPLED: 1/12/16
LOAD: 144 psf

ONE DIMENSIONAL SWELL OR SETTLEMENT POTENTIAL OF COHESIVE SOILS (ASTM D-4546)

INITIAL DRY DENSITY (kg/cu.m)	1282.6
FINAL DRY DENSITY (kg/cu.m)	1270.9
INITIAL MOISTURE CONTENT	6.3%
FINAL MOISTURE CONTENT	35.0%
MOIST. PICK-UP (% DRY WT.)	28.7%
MOIST. PICK-UP (% IN. VOL.)	37.0%
SWELL (% INITIAL HT.)	0.9%
TYPE OF WATER USED	TAP WATER



amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY

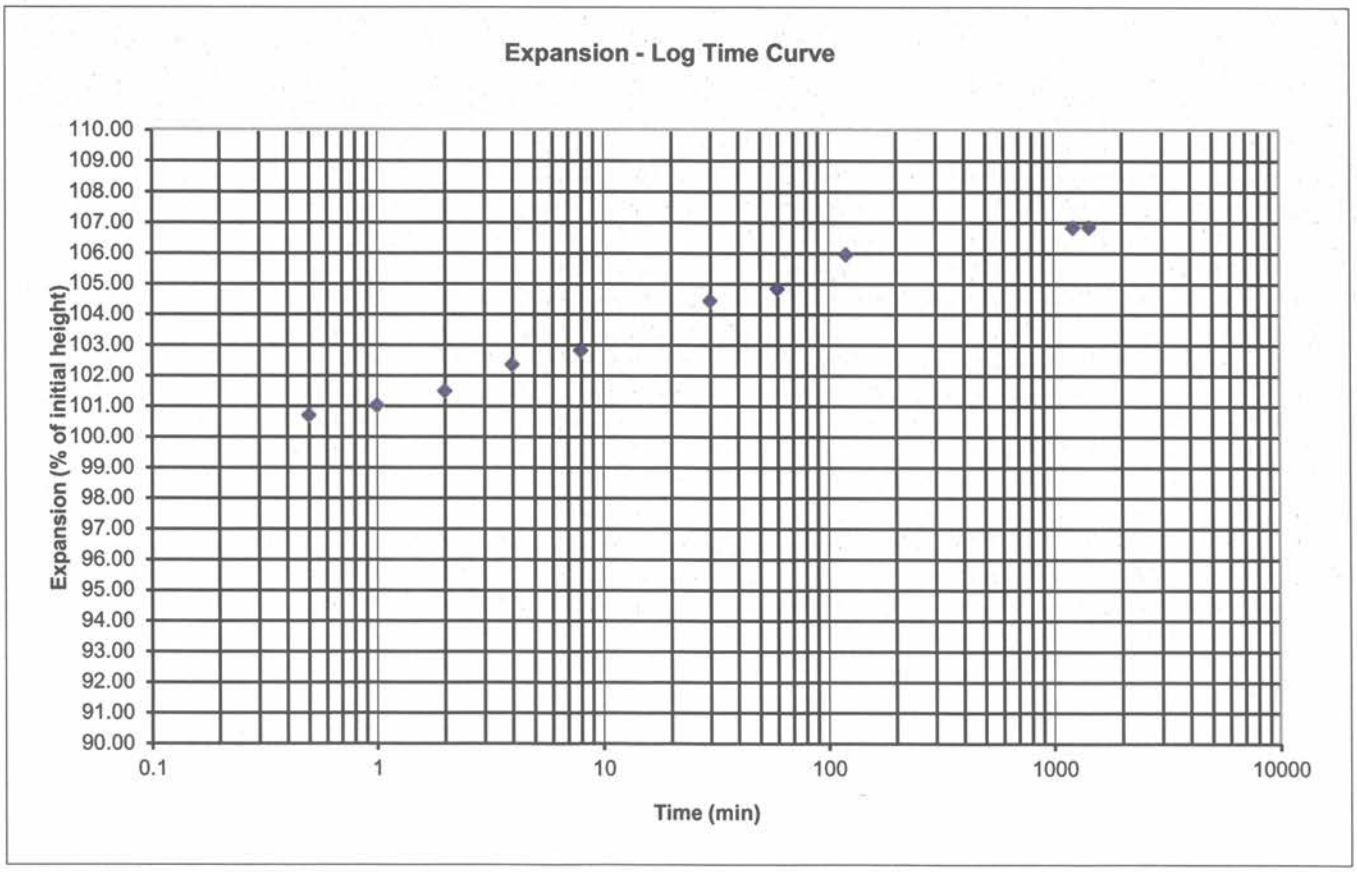
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: RS-1 (0.00m-1.35m)
SAMPLE PREP: Remolded to 95% max dry density and 2% below optimum moisture
Max dry density 1568.2 kg/cu.m @ 20.9% opt. moisture

JOB NO: 17-2015-4045
WORK ORDER NO: 2
LAB NO: 16-0918-01
DATE SAMPLED: 1/28/16
LOAD: 144 psf

ONE DIMENSIONAL SWELL OR SETTLEMENT POTENTIAL OF COHESIVE SOILS (ASTM D-4546)

INITIAL DRY DENSITY (kg/cu.m)	1482.8
FINAL DRY DENSITY (kg/cu.m)	1399.8
INITIAL MOISTURE CONTENT	18.6%
FINAL MOISTURE CONTENT	31.3%
MOIST. PICK-UP (% DRY WT.)	12.8%
MOIST. PICK-UP (% IN. VOL.)	19.0%
SWELL (% INITIAL HT.)	6.8%
TYPE OF WATER USED	TAP WATER



amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY

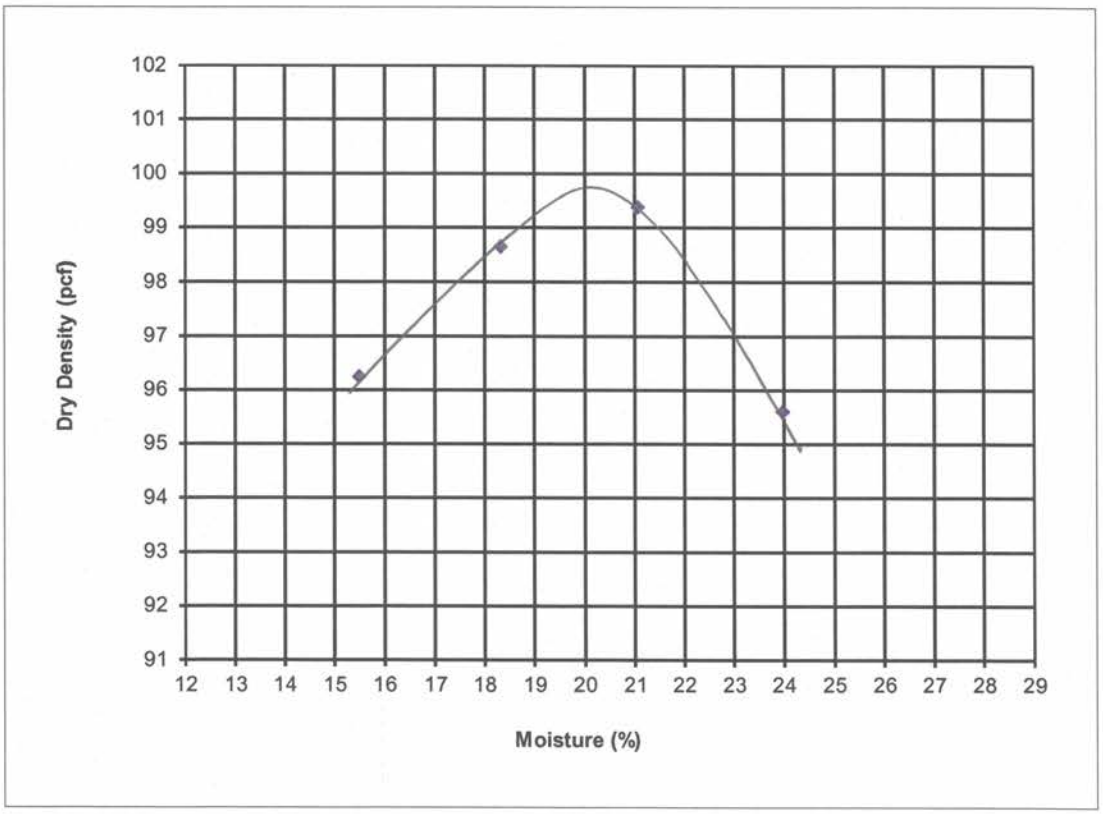
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-1 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-01
DATE SAMPLED: 1/12/16

MOISTURE-DENSITY RELATIONS OF SOILS USING A 5.5lb RAMMER AND A 12in DROP (AASHTO T99 Method A)

MAXIMUM DRY DENSITY (kg/cu.m):	1595.4
MAXIMUM DRY DENSITY (pcf):	99.6
OPTIMUM MOISTURE (%):	20.1



amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY _____

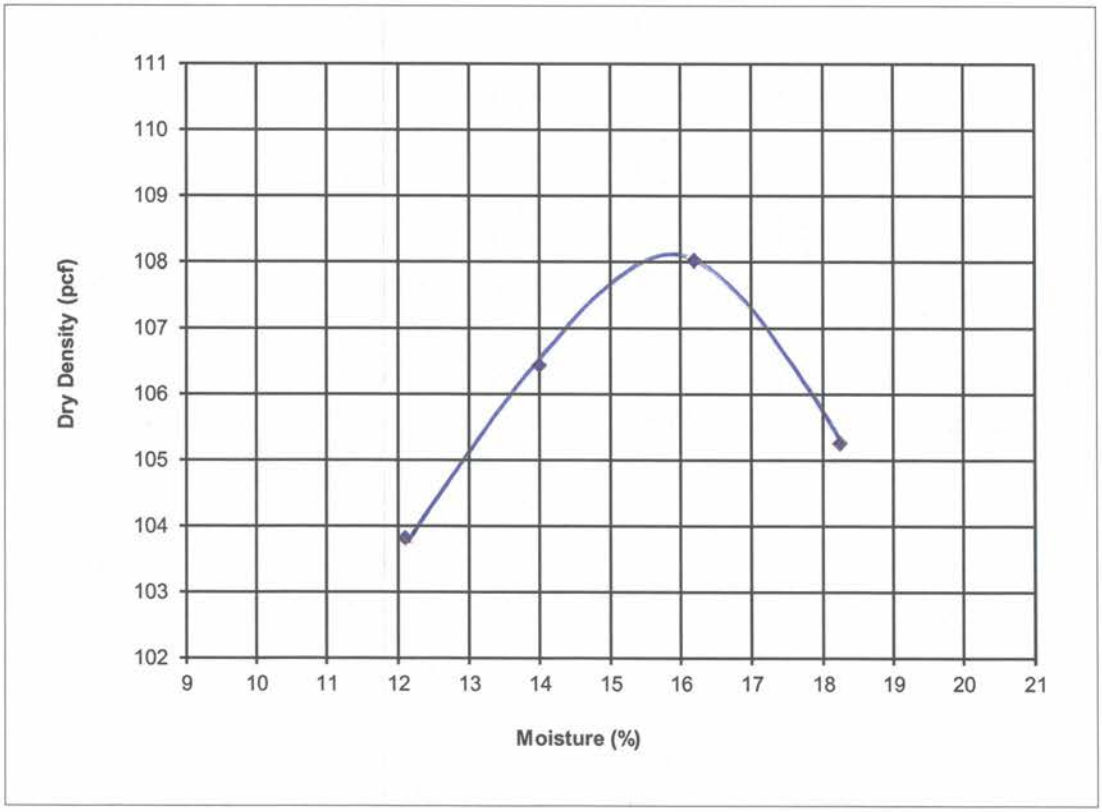
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-4 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-13
DATE SAMPLED: 1/12/16

MOISTURE-DENSITY RELATIONS OF SOILS USING A 5.5lb RAMMER AND A 12in DROP (AASHTO T99 Method A)

MAXIMUM DRY DENSITY (kg/cu.m):	1731.6
MAXIMUM DRY DENSITY (pcf):	108.1
OPTIMUM MOISTURE (%):	15.8



amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY _____

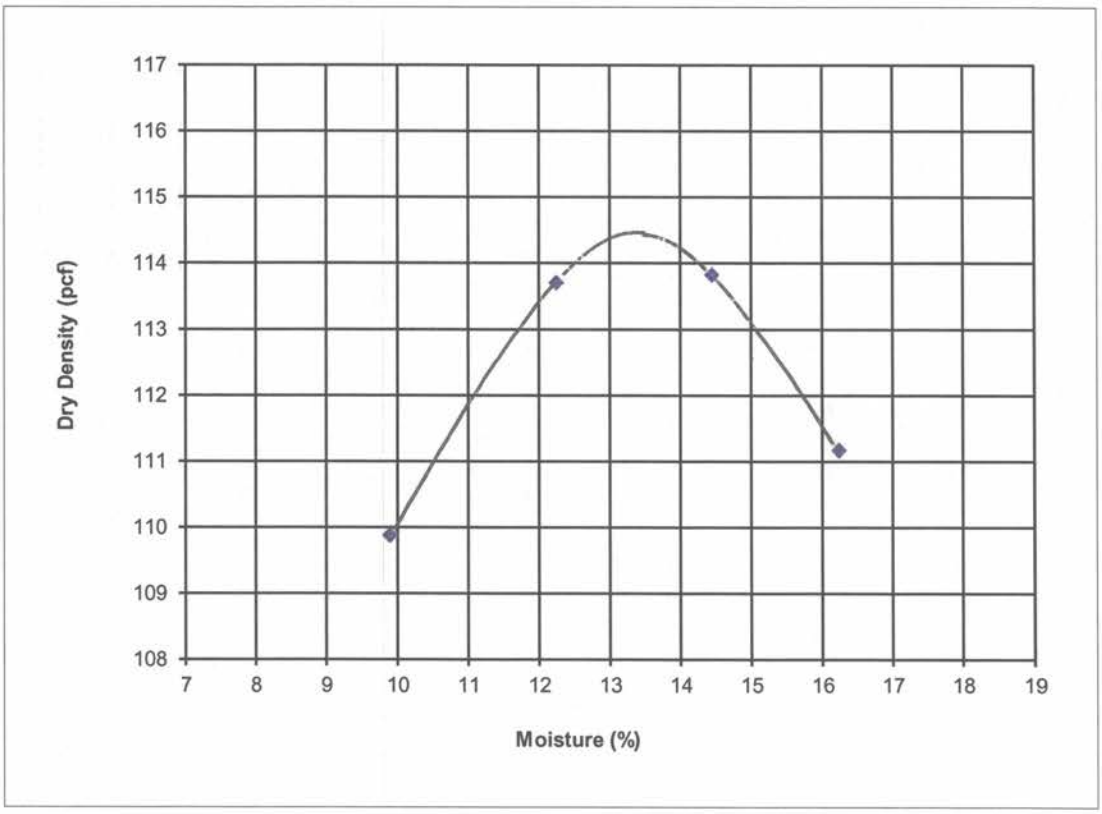
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-8 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-29
DATE SAMPLED: 1/12/16

MOISTURE-DENSITY RELATIONS OF SOILS USING A 5.5lb RAMMER AND A 12in DROP (AASHTO T99 Method A)

MAXIMUM DRY DENSITY (kg/cu.m):	1834.1
MAXIMUM DRY DENSITY (pcf):	114.5
OPTIMUM MOISTURE (%):	13.5



amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY RJN

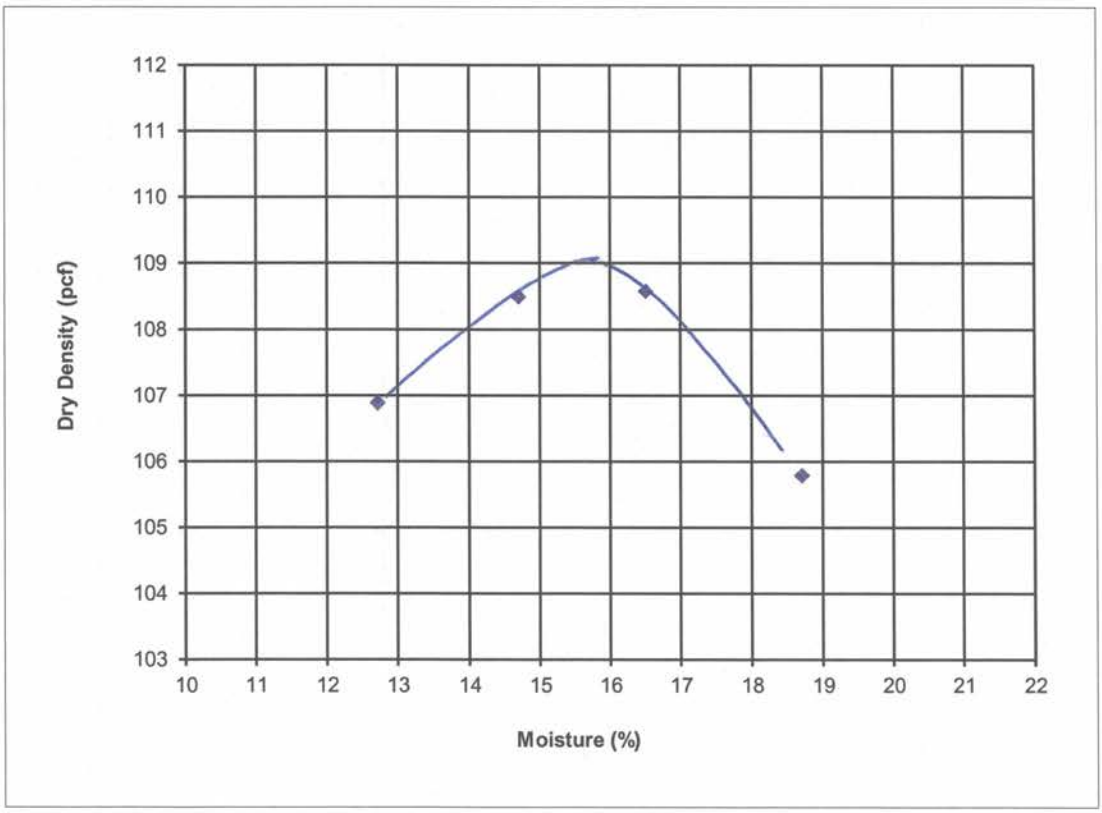
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-10 (0.00m-1.20m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-37
DATE SAMPLED: 1/12/16

MOISTURE-DENSITY RELATIONS OF SOILS USING A 5.5lb RAMMER AND A 12in DROP (AASHTO T99 Method A)

MAXIMUM DRY DENSITY (kg/cu.m):	1746.0
MAXIMUM DRY DENSITY (pcf):	109.0
OPTIMUM MOISTURE (%):	15.7



amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY RJN

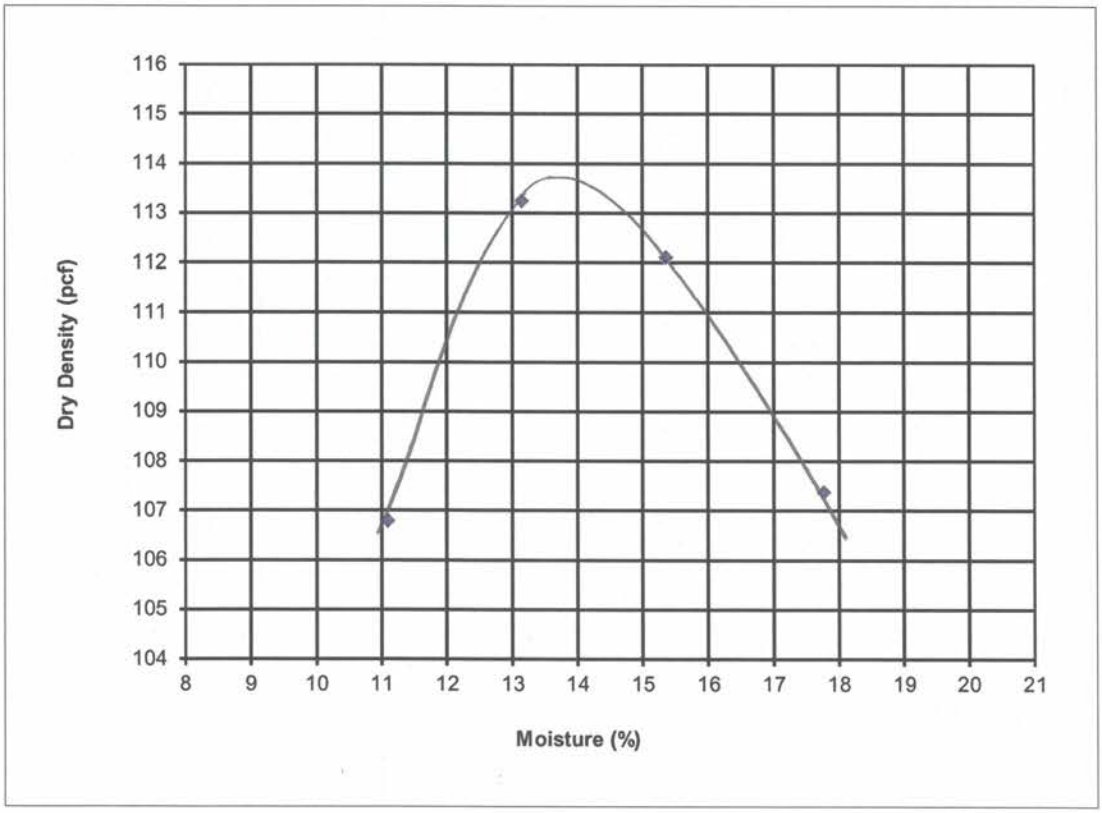
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-14 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-53
DATE SAMPLED: 1/12/16

MOISTURE-DENSITY RELATIONS OF SOILS USING A 5.5lb RAMMER AND A 12in DROP (AASHTO T99 Method A)

MAXIMUM DRY DENSITY (kg/cu.m):	1822.9
MAXIMUM DRY DENSITY (pcf):	113.8
OPTIMUM MOISTURE (%):	13.7



amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY _____

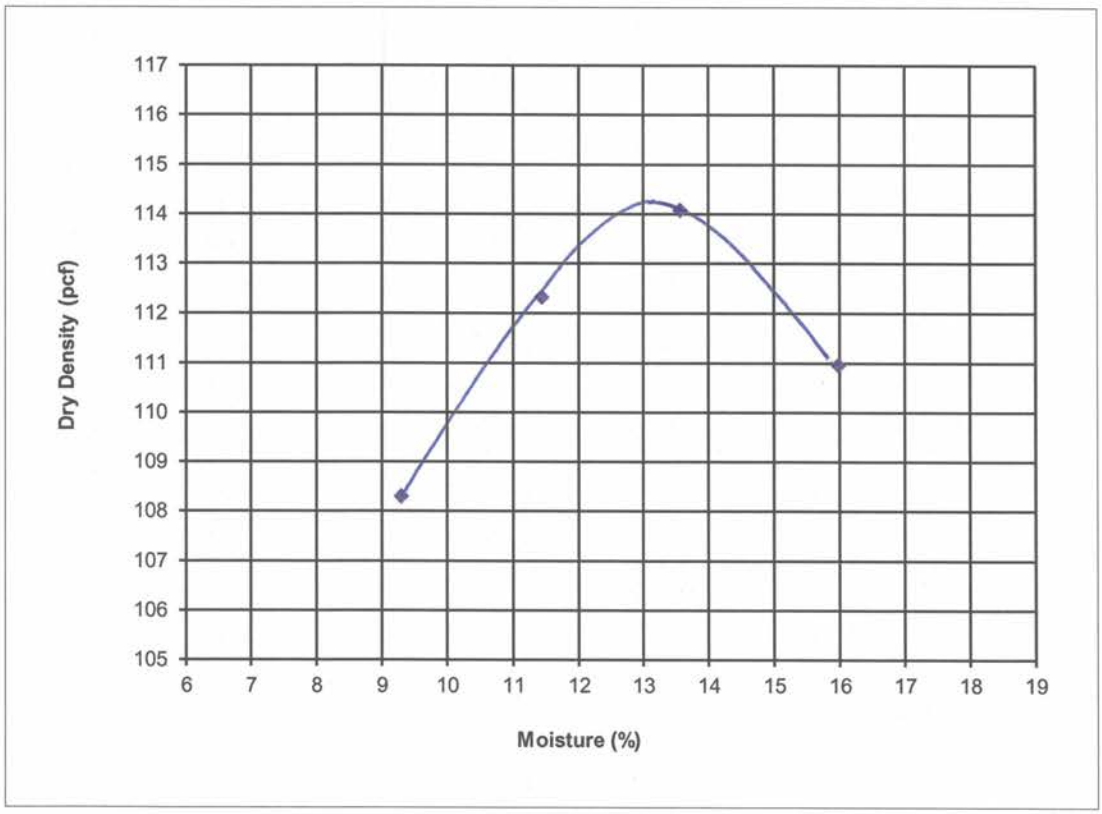
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-18 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-69
DATE SAMPLED: 1/12/16

MOISTURE-DENSITY RELATIONS OF SOILS USING A 5.5lb RAMMER AND A 12in DROP (AASHTO T99 Method A)

MAXIMUM DRY DENSITY (kg/cu.m):	1829.3
MAXIMUM DRY DENSITY (pcf):	114.2
OPTIMUM MOISTURE (%):	13.1



amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY RJN

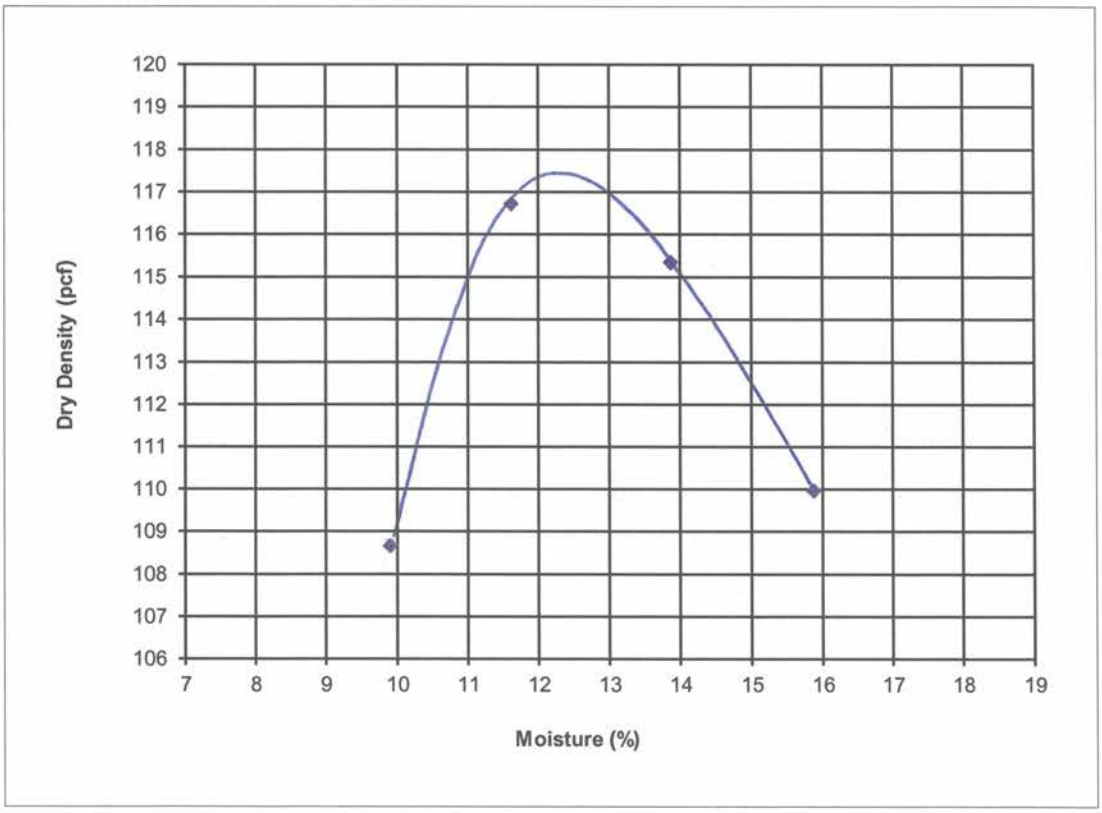
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-23 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-89
DATE SAMPLED: 1/12/16

MOISTURE-DENSITY RELATIONS OF SOILS USING A 5.5lb RAMMER AND A 12in DROP (AASHTO T99 Method A)

MAXIMUM DRY DENSITY (kg/cu.m):	1880.6
MAXIMUM DRY DENSITY (pcf):	117.4
OPTIMUM MOISTURE (%):	12.3



amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY _____

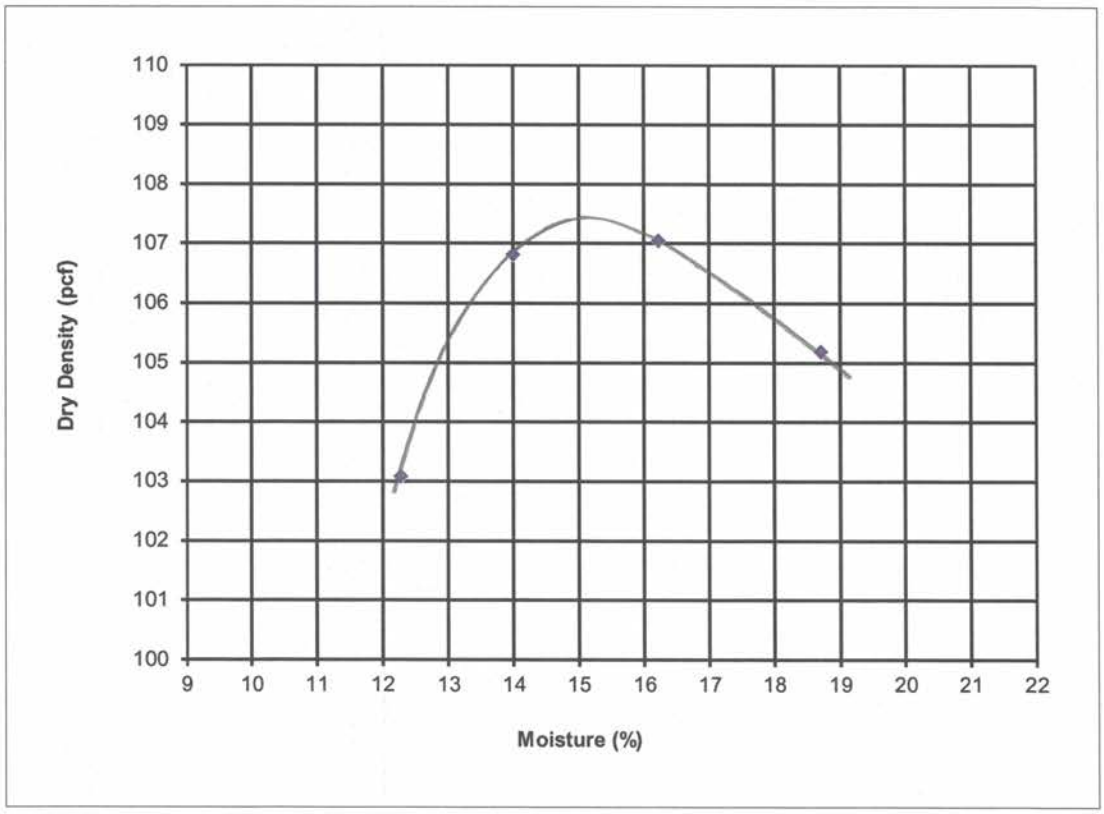
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-26 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-101
DATE SAMPLED: 1/12/16

MOISTURE-DENSITY RELATIONS OF SOILS USING A 5.5lb RAMMER AND A 12in DROP (AASHTO T99 Method A)

MAXIMUM DRY DENSITY (kg/cu.m):	1720.4
MAXIMUM DRY DENSITY (pcf):	107.4
OPTIMUM MOISTURE (%):	15.2



amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY _____

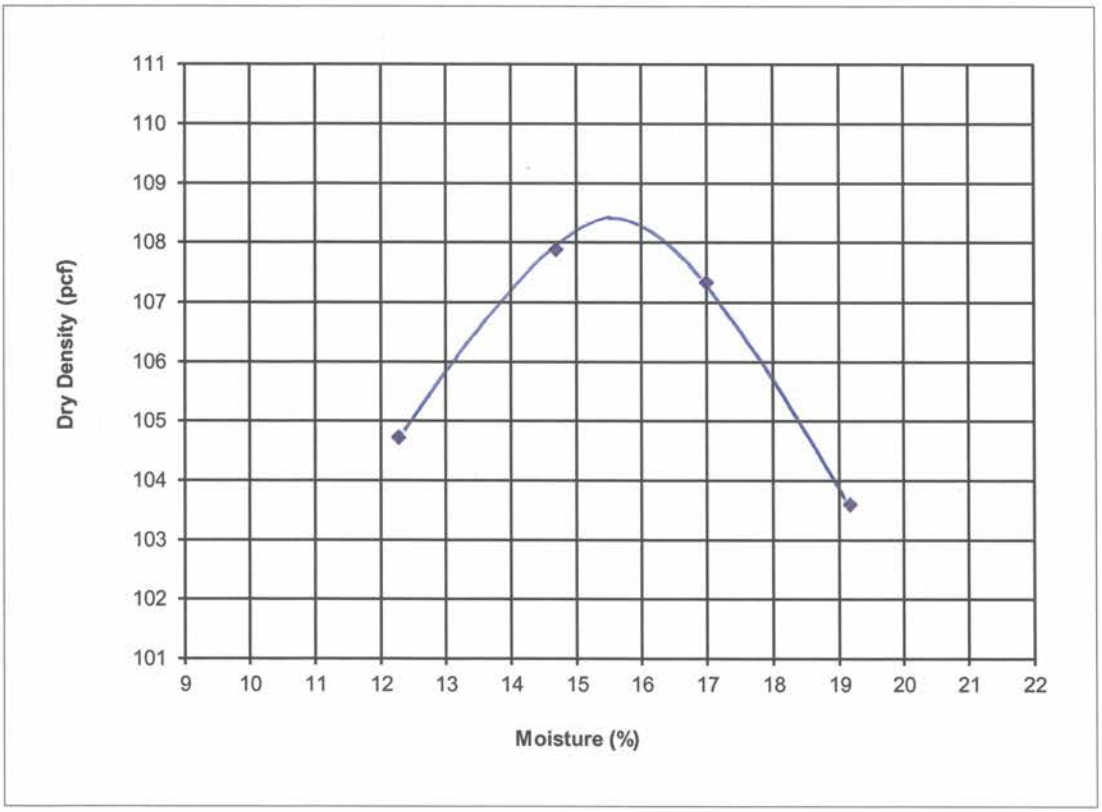
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-31 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-121
DATE SAMPLED: 1/12/16

MOISTURE-DENSITY RELATIONS OF SOILS USING A 5.5lb RAMMER AND A 12in DROP (AASHTO T99 Method A)

MAXIMUM DRY DENSITY (kg/cu.m):	1738.0
MAXIMUM DRY DENSITY (pcf):	108.5
OPTIMUM MOISTURE (%):	15.7



amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY _____

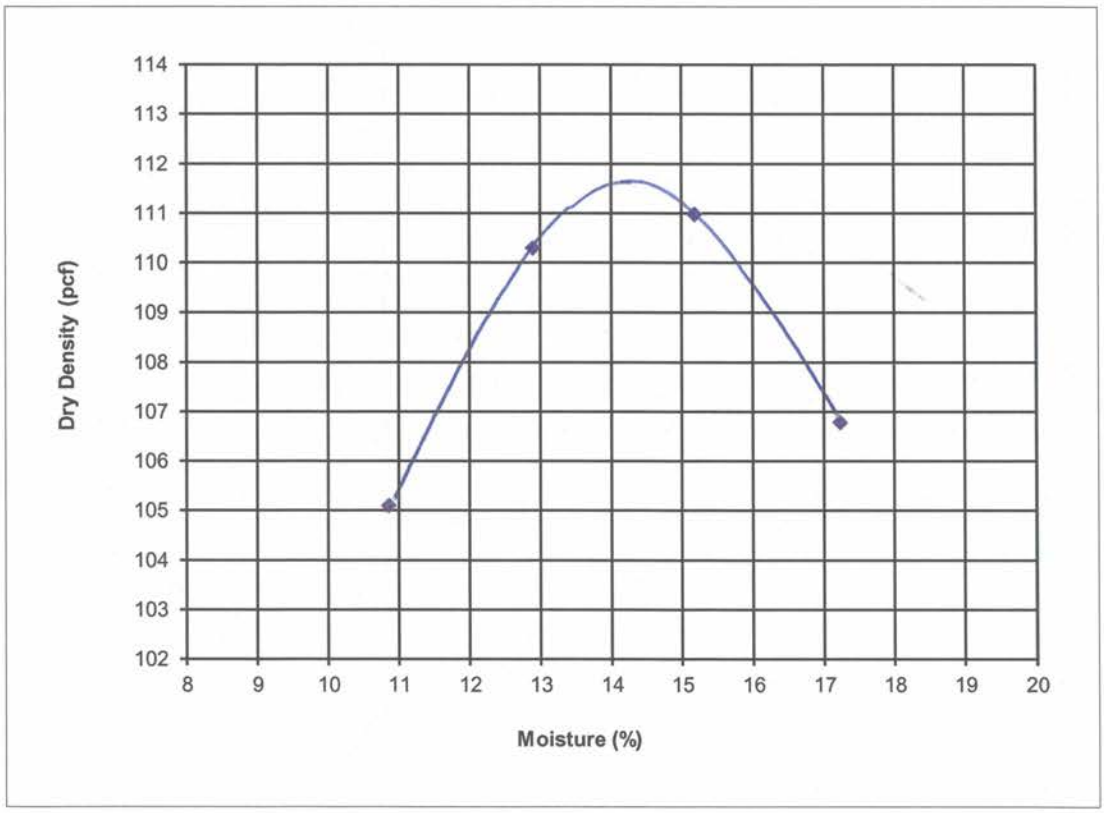
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-35 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-137
DATE SAMPLED: 1/12/16

MOISTURE-DENSITY RELATIONS OF SOILS USING A 5.5lb RAMMER AND A 12in DROP (AASHTO T99 Method A)

MAXIMUM DRY DENSITY (kg/cu.m):	1787.7
MAXIMUM DRY DENSITY (pcf):	111.6
OPTIMUM MOISTURE (%):	14.2



amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY _____

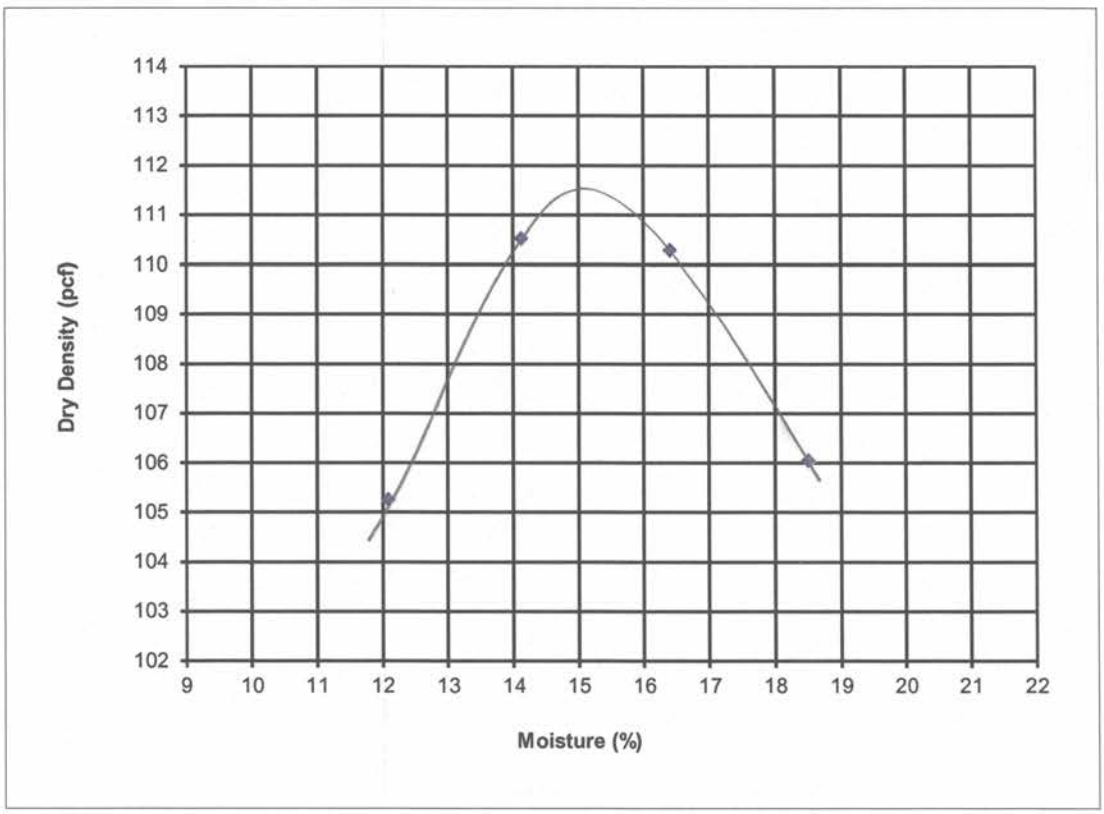
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-40 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-157
DATE SAMPLED: 1/12/16

MOISTURE-DENSITY RELATIONS OF SOILS USING A 5.5lb RAMMER AND A 12in DROP (AASHTO T99 Method A)

MAXIMUM DRY DENSITY (kg/cu.m):	1784.5
MAXIMUM DRY DENSITY (pcf):	111.4
OPTIMUM MOISTURE (%):	15.1



amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY _____

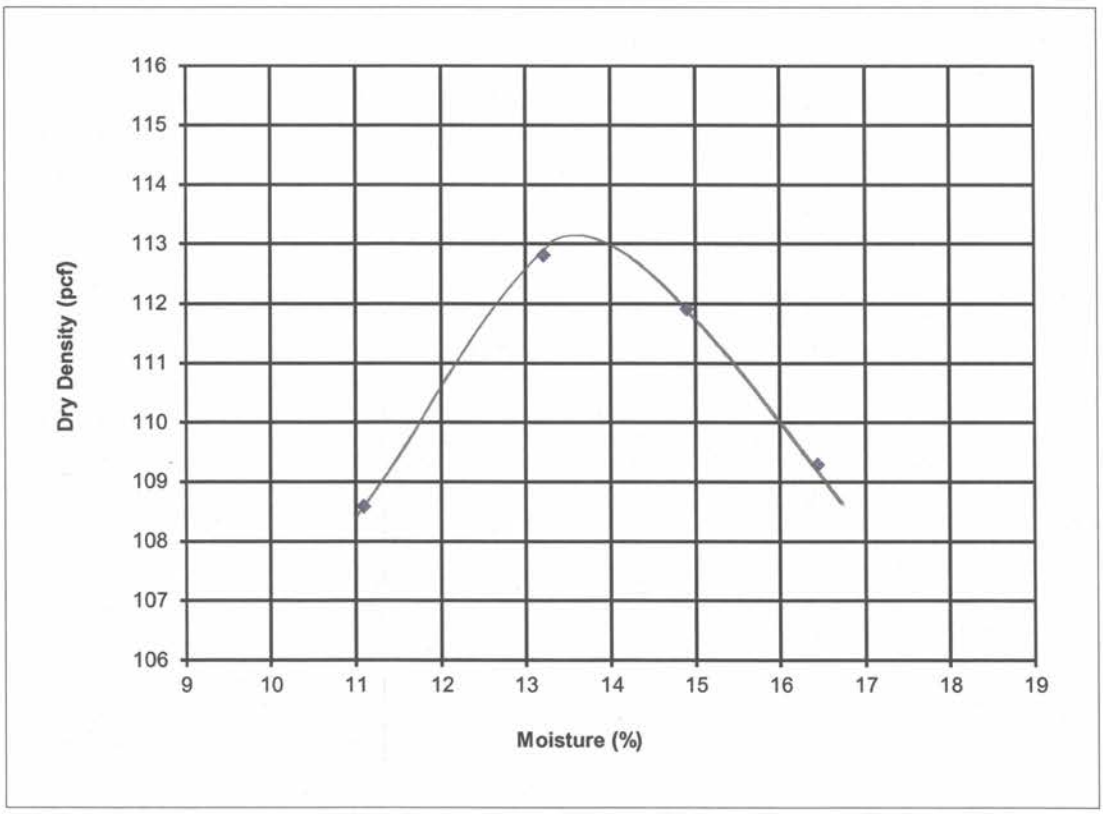
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-42 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-165
DATE SAMPLED: 1/12/16

MOISTURE-DENSITY RELATIONS OF SOILS USING A 5.5lb RAMMER AND A 12in DROP (AASHTO T99 Method A)

MAXIMUM DRY DENSITY (kg/cu.m):	1811.7
MAXIMUM DRY DENSITY (pcf):	113.1
OPTIMUM MOISTURE (%):	13.6



amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY _____

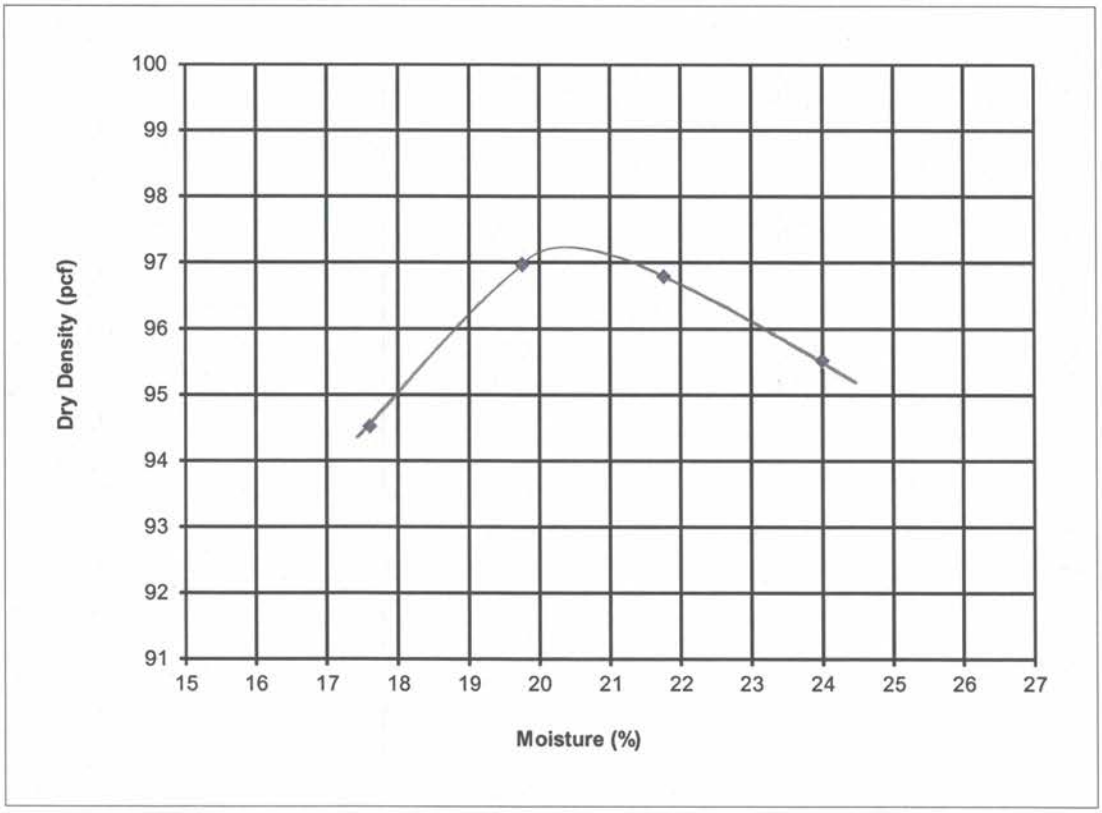
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-45 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-179
DATE SAMPLED: 1/12/16

MOISTURE-DENSITY RELATIONS OF SOILS USING A 5.5lb RAMMER AND A 12in DROP (AASHTO T99 Method A)

MAXIMUM DRY DENSITY (kg/cu.m):	1557.0
MAXIMUM DRY DENSITY (pcf):	97.2
OPTIMUM MOISTURE (%):	20.3



amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY _____

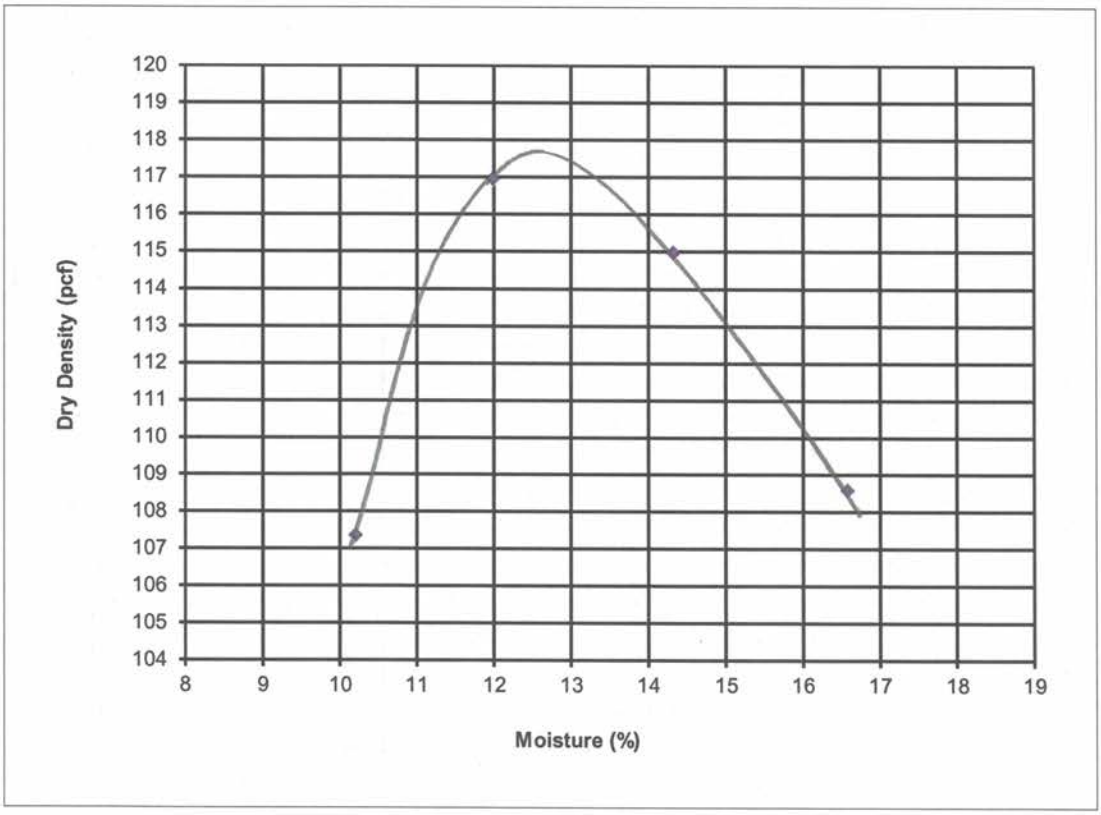
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: SS-3 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-195
DATE SAMPLED: 1/12/16

MOISTURE-DENSITY RELATIONS OF SOILS USING A 5.5lb RAMMER AND A 12in DROP (AASHTO T99 Method A)

MAXIMUM DRY DENSITY (kg/cu.m):	1882.2
MAXIMUM DRY DENSITY (pcf):	117.5
OPTIMUM MOISTURE (%):	12.5



amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY RJN

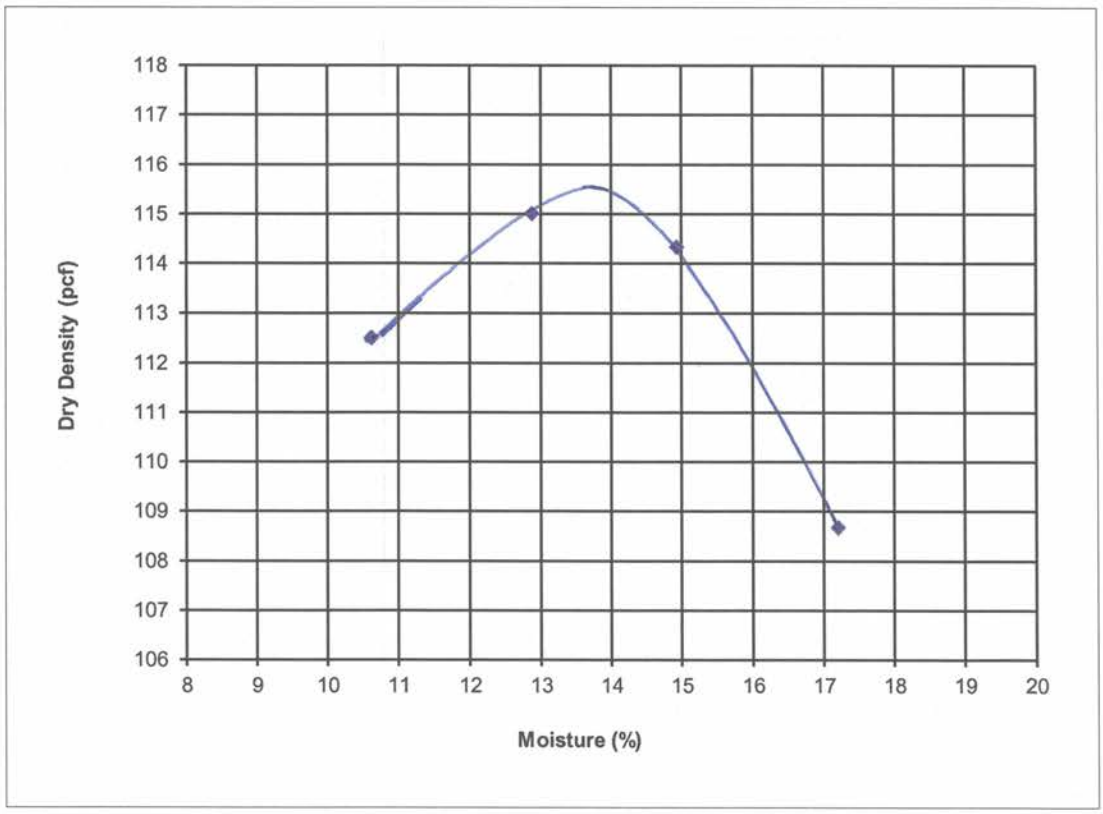
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: SS-8 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-223
DATE SAMPLED: 1/12/16

MOISTURE-DENSITY RELATIONS OF SOILS USING A 5.5lb RAMMER AND A 12in DROP (AASHTO T99 Method A)

MAXIMUM DRY DENSITY (kg/cu.m):	1850.1
MAXIMUM DRY DENSITY (pcf):	115.5
OPTIMUM MOISTURE (%):	13.9



amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY RJN

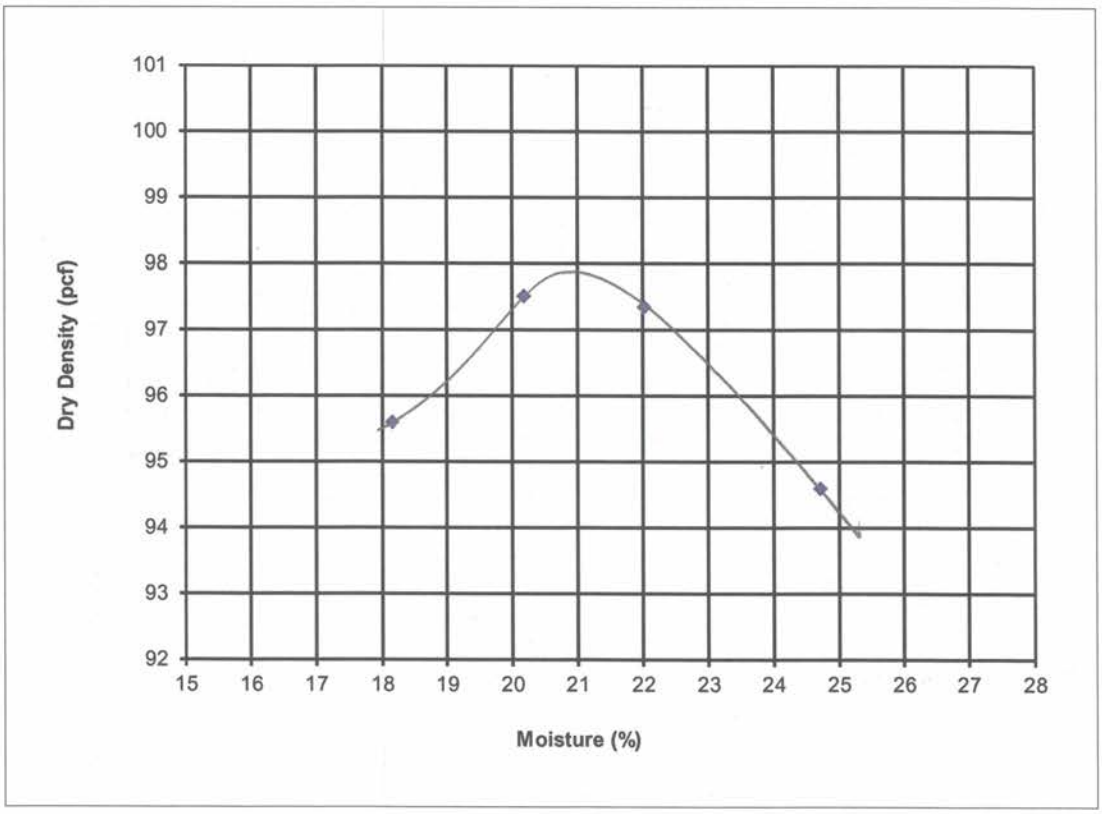
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: RS-1 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 2
LAB NO: 16-0918-01
DATE SAMPLED: 1/28/16

MOISTURE-DENSITY RELATIONS OF SOILS USING A 5.5lb RAMMER AND A 12in DROP (AASHTO T99 Method A)

MAXIMUM DRY DENSITY (kg/cu.m):	1568.2
MAXIMUM DRY DENSITY (pcf):	97.9
OPTIMUM MOISTURE (%):	20.9



amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY _____

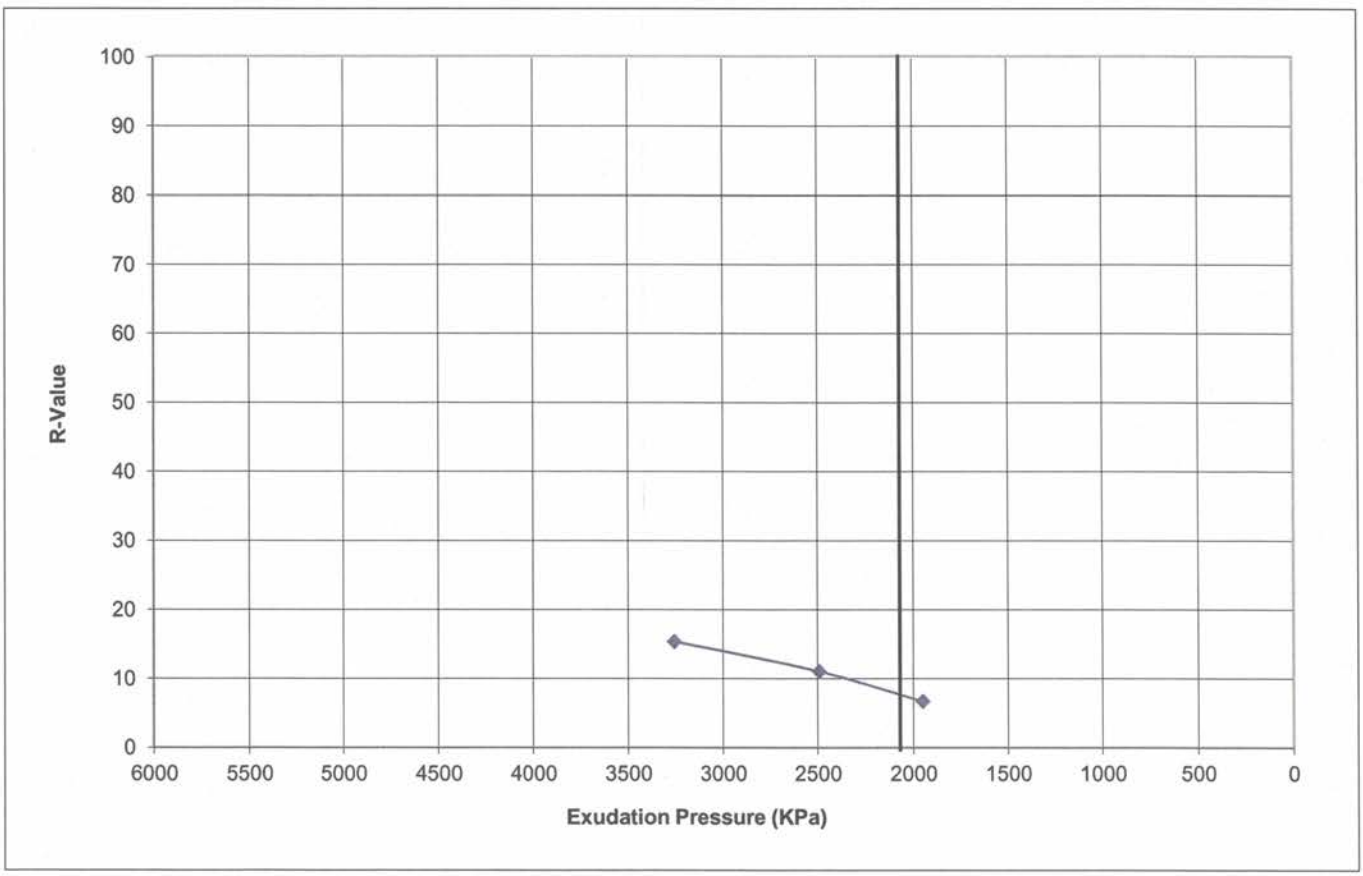
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-1 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-01
DATE SAMPLED: 01/12/16

RESISTANCE R-VALUE AND EXPANSION PRESSURE OF COMPACTED SOILS (AASHTO T190)

SPECIMEN I. D.	A	B	C
Moisture Content	11.6%	10.4%	9.0%
Compaction Pressure (KPa)	483	552	689
Specimen Height (mm)	66.55	66.80	63.50
Dry Density (kg/cu.m)	1752.1	1806.4	1851.4
Horiz. Pres. @ 1000lbs (KPa)	399.9	372.3	337.8
Horiz. Pres. @ 2000lbs (KPa)	965.3	923.9	841.2
Displacement(mm)	14.17	11.28	10.92
Expansion Pressure (KPa)	13.6	34.4	102.2
Exudation Pressure (KPa)	1950	2491	3258
R Value	7	11	15



R Value at 2068 KPa = 8

amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY _____

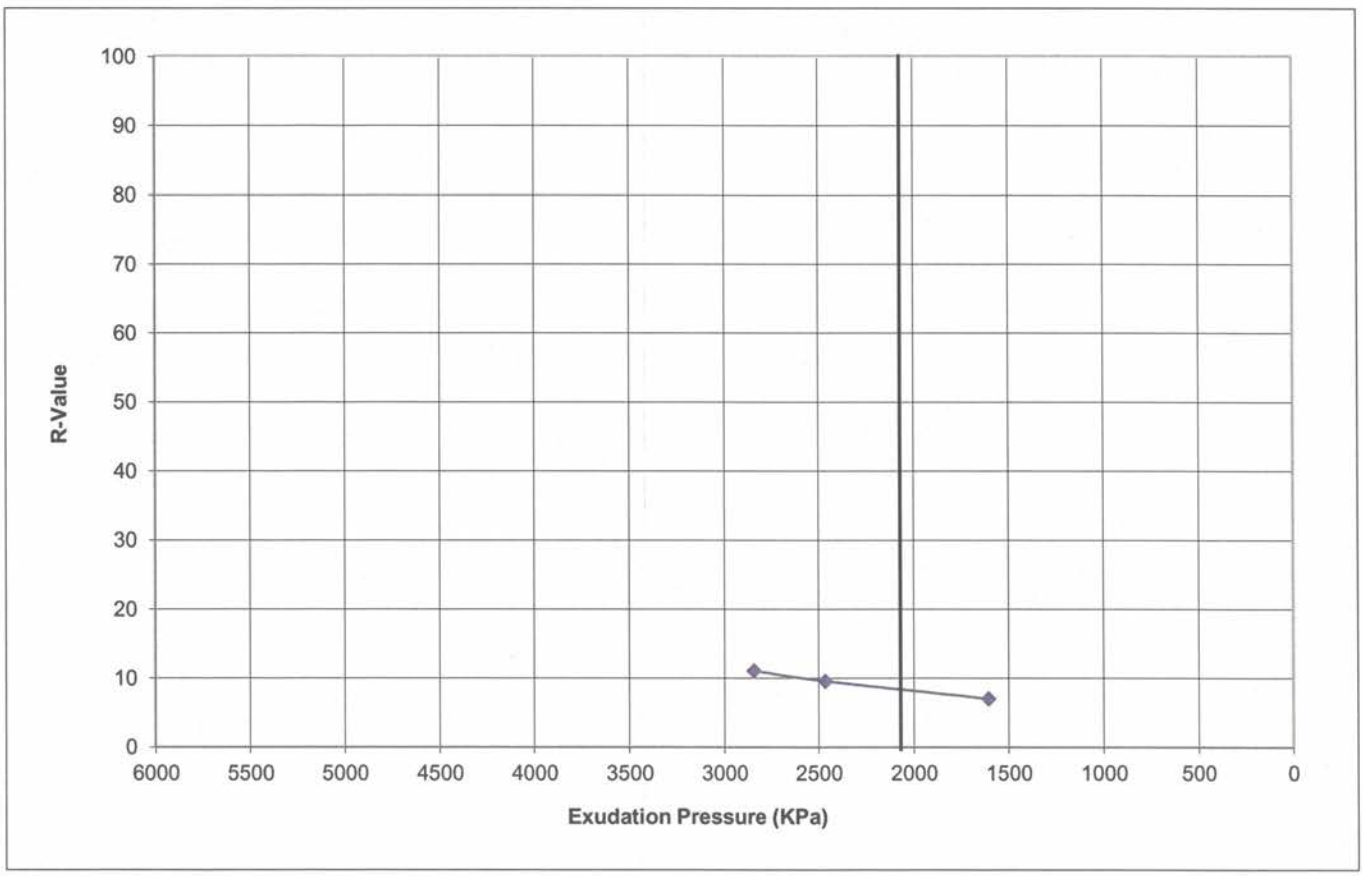
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-4 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-13
DATE SAMPLED: 01/12/16

RESISTANCE R-VALUE AND EXPANSION PRESSURE OF COMPACTED SOILS (AASHTO T190)

SPECIMEN I. D.	A	B	C
Moisture Content	18.3%	16.4%	15.3%
Compaction Pressure (KPa)	483	689	1034
Specimen Height (mm)	65.79	61.98	61.47
Dry Density (kg/cu.m)	1696.8	1767.9	1819.8
Horiz. Pres. @ 1000lbs (KPa)	393.0	358.5	351.6
Horiz. Pres. @ 2000lbs (KPa)	958.4	903.2	896.3
Displacement(mm)	13.89	12.52	10.87
Expansion Pressure (KPa)	7.2	17.2	28.0
Exudation Pressure (KPa)	1604	2466	2844
R Value	7	10	11



R Value at 2068 KPa = 9

amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY

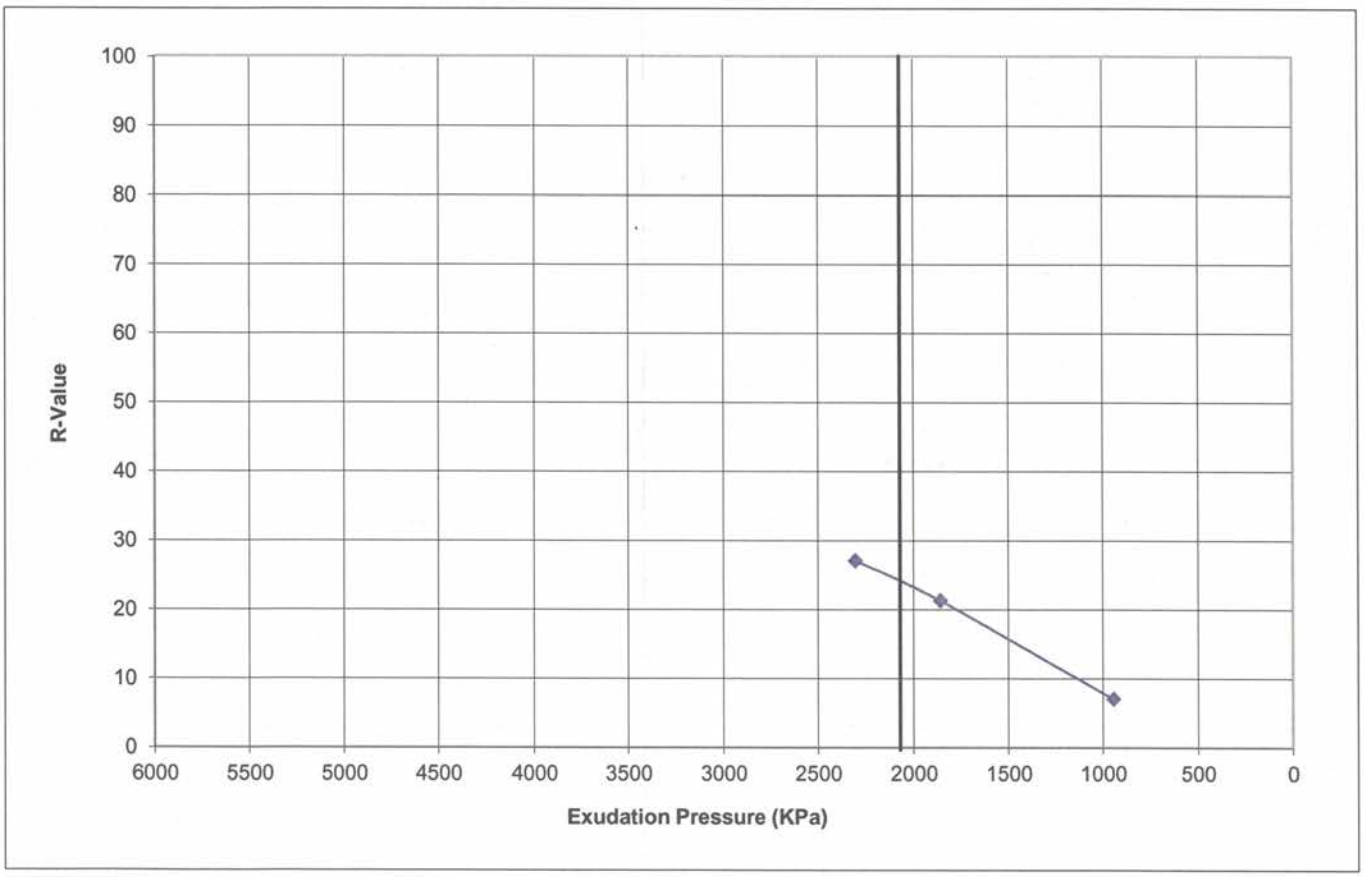
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-8 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-29
DATE SAMPLED: 01/12/16

RESISTANCE R-VALUE AND EXPANSION PRESSURE OF COMPACTED SOILS (AASHTO T190)

SPECIMEN I. D.	A	B	C
Moisture Content	14.9%	13.1%	12.2%
Compaction Pressure (KPa)	1241	1551	1827
Specimen Height (mm)	64.26	63.75	61.98
Dry Density (kg/cu.m)	1817.9	1878.9	1937.3
Horiz. Pres. @ 1000lbs (KPa)	386.1	275.8	248.2
Horiz. Pres. @ 2000lbs (KPa)	944.6	710.2	634.3
Displacement(mm)	14.02	13.00	11.91
Expansion Pressure (KPa)	0.0	0.0	1.8
Exudation Pressure (KPa)	942	1859	2303
R Value	7	21	27



R Value at 2068 KPa = 24

amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY _____

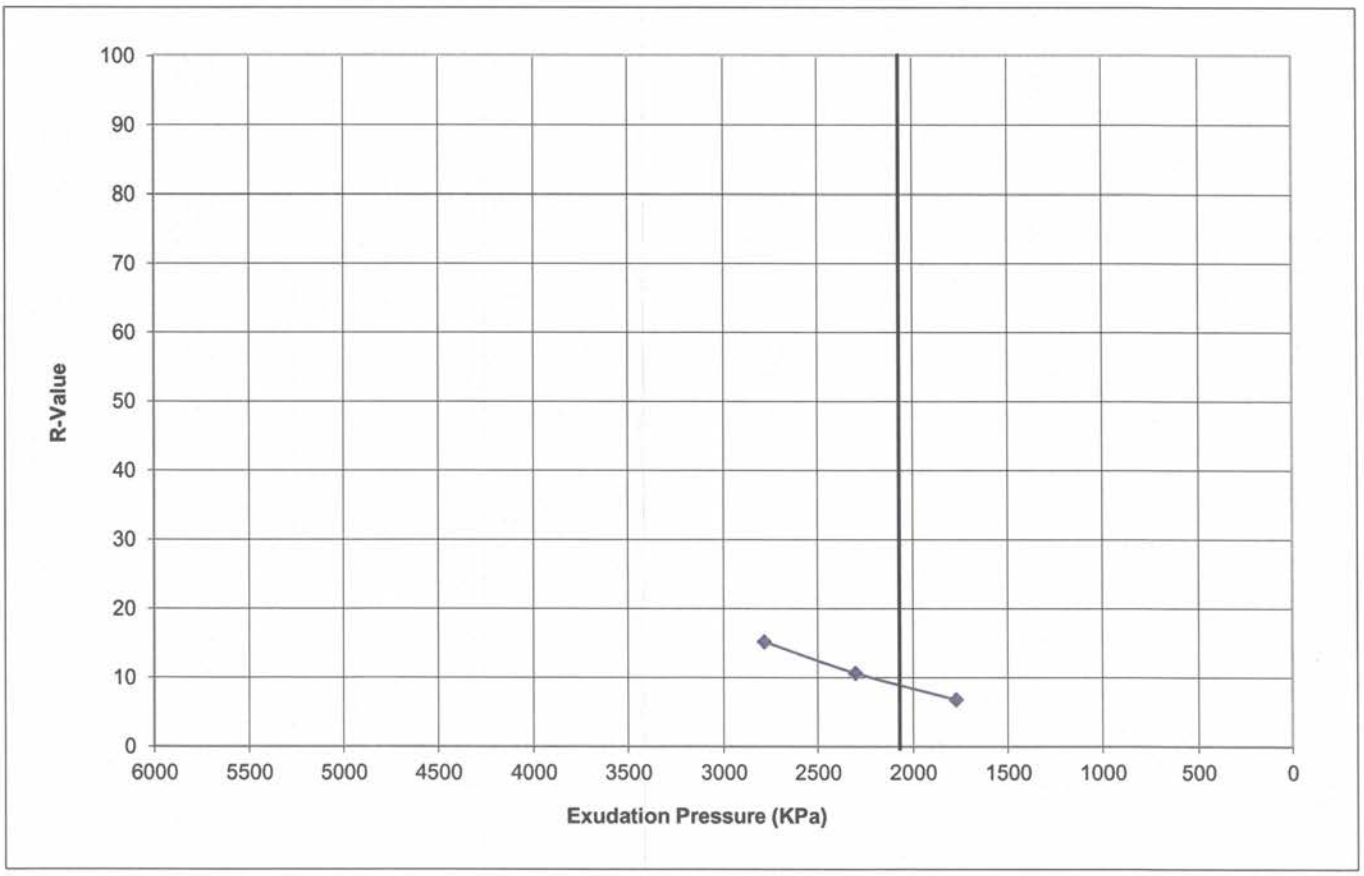
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-10 (0.00m-1.20m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-37
DATE SAMPLED: 01/12/16

RESISTANCE R-VALUE AND EXPANSION PRESSURE OF COMPACTED SOILS (AASHTO T190)

SPECIMEN I. D.	A	B	C
Moisture Content	18.1%	17.0%	15.4%
Compaction Pressure (KPa)	345	552	965
Specimen Height (mm)	65.28	66.55	62.23
Dry Density (kg/cu.m)	1722.6	1764.9	1808.3
Horiz. Pres. @ 1000lbs (KPa)	413.7	379.2	337.8
Horiz. Pres. @ 2000lbs (KPa)	965.3	923.9	855.0
Displacement(mm)	13.36	11.63	10.34
Expansion Pressure (KPa)	0.0	3.6	9.0
Exudation Pressure (KPa)	1773	2301	2784
R Value	7	11	15



R Value at 2068 KPa = 9

amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY _____

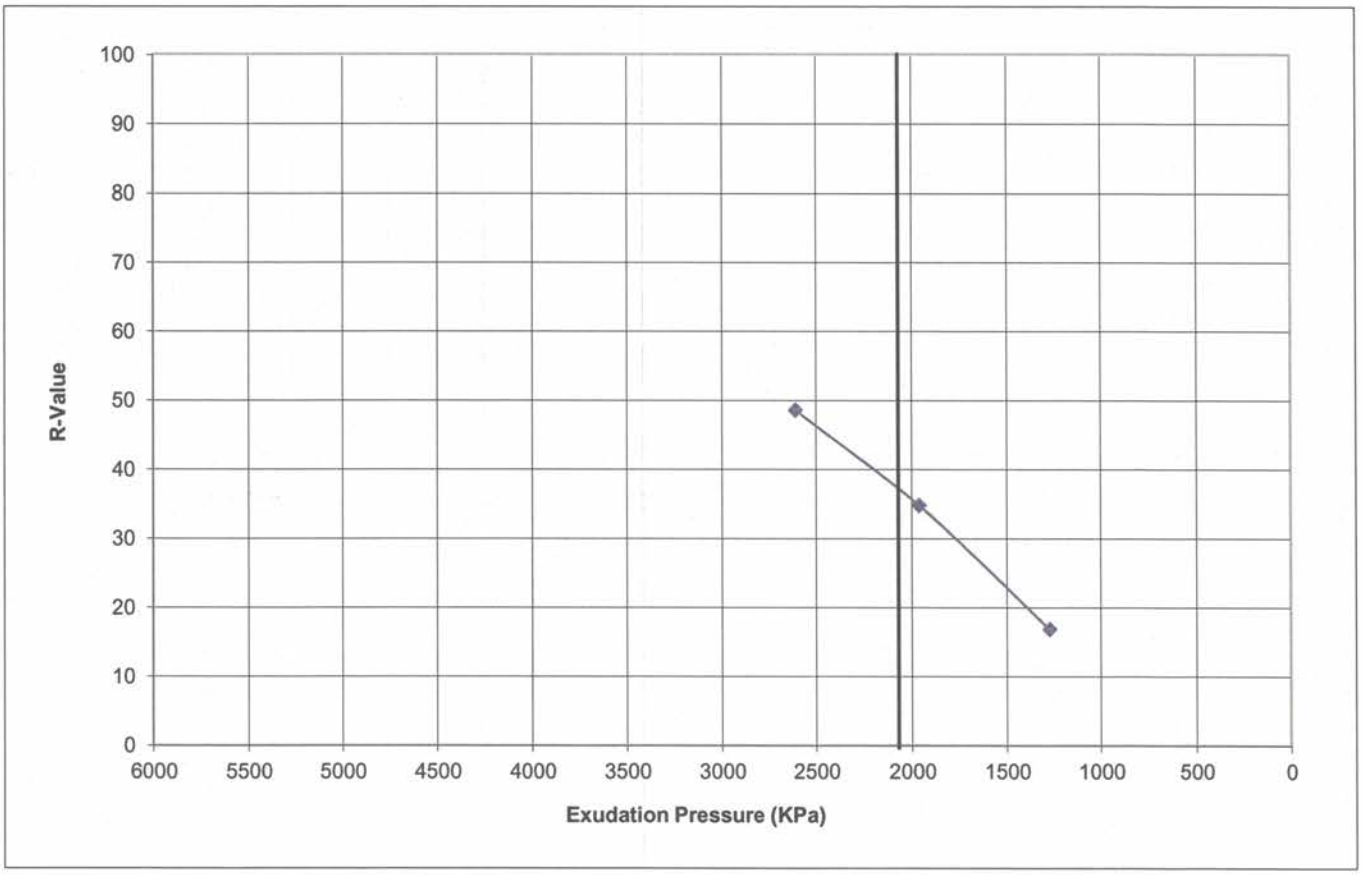
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-14 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-53
DATE SAMPLED: 01/12/16

RESISTANCE R-VALUE AND EXPANSION PRESSURE OF COMPACTED SOILS (AASHTO T190)

SPECIMEN I. D.	A	B	C
Moisture Content	14.1%	12.0%	11.1%
Compaction Pressure (KPa)	896	1724	1862
Specimen Height (mm)	63.50	61.98	62.23
Dry Density (kg/cu.m)	1829.8	1906.2	2005.2
Horiz. Pres. @ 1000lbs (KPa)	317.2	234.4	179.3
Horiz. Pres. @ 2000lbs (KPa)	786.0	551.6	420.6
Displacement(mm)	12.65	11.20	10.92
Expansion Pressure (KPa)	9.0	13.6	25.3
Exudation Pressure (KPa)	1273	1964	2609
R Value	17	35	49



R Value at 2068 KPa = 37

amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY _____

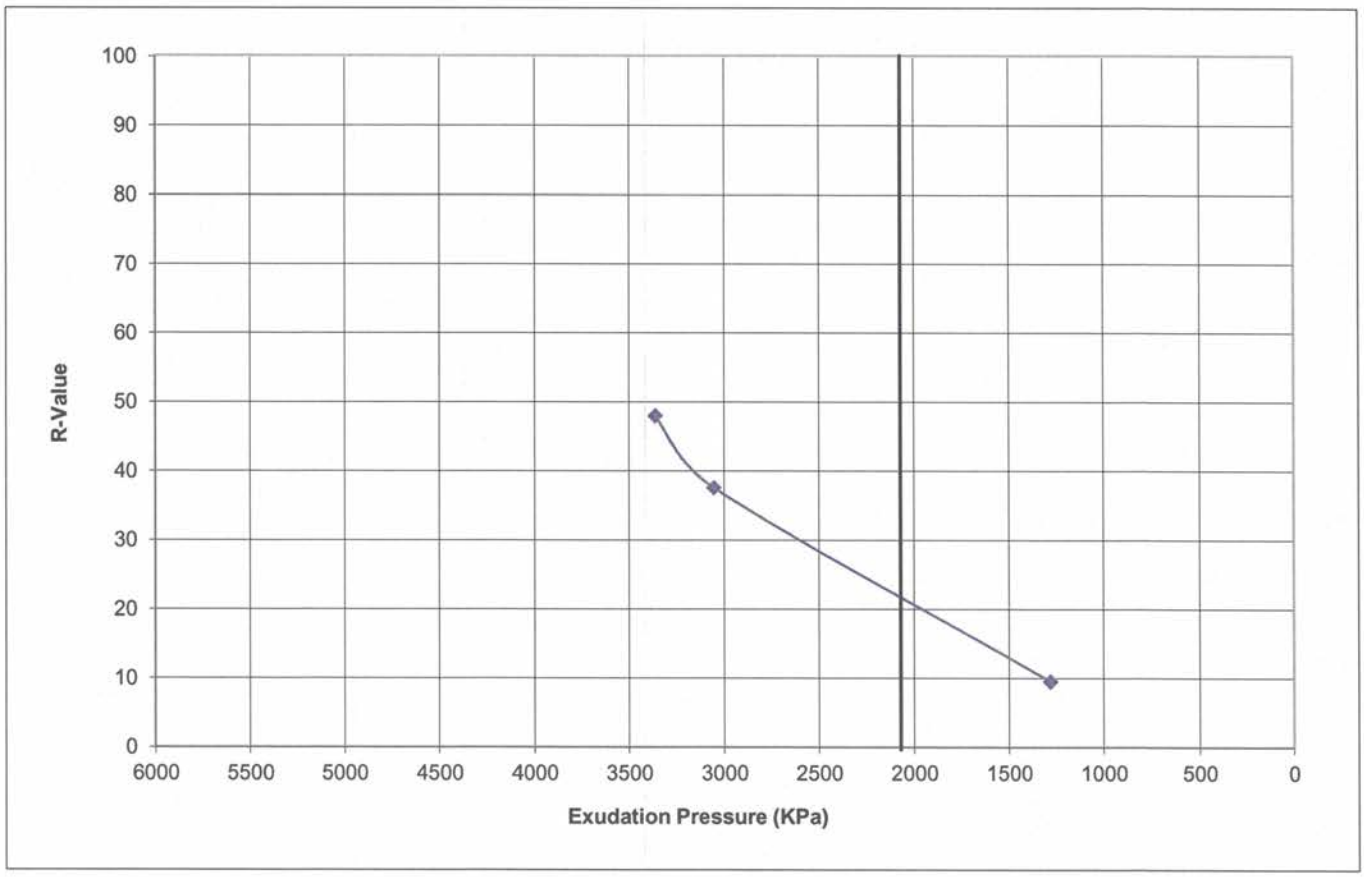
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-18 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-69
DATE SAMPLED: 01/12/16

RESISTANCE R-VALUE AND EXPANSION PRESSURE OF COMPACTED SOILS (AASHTO T190)

SPECIMEN I. D.	A	B	C
Moisture Content	13.2%	11.5%	10.7%
Compaction Pressure (KPa)	896	2137	2413
Specimen Height (mm)	63.25	62.99	62.23
Dry Density (kg/cu.m)	1867.3	1946.1	1964.6
Horiz. Pres. @ 1000lbs (KPa)	372.3	220.6	193.1
Horiz. Pres. @ 2000lbs (KPa)	910.1	517.1	448.2
Displacement(mm)	12.83	11.99	10.08
Expansion Pressure (KPa)	0.0	37.1	55.2
Exudation Pressure (KPa)	1278	3055	3362
R Value	10	38	48



R Value at 2068 KPa = 22

amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY _____

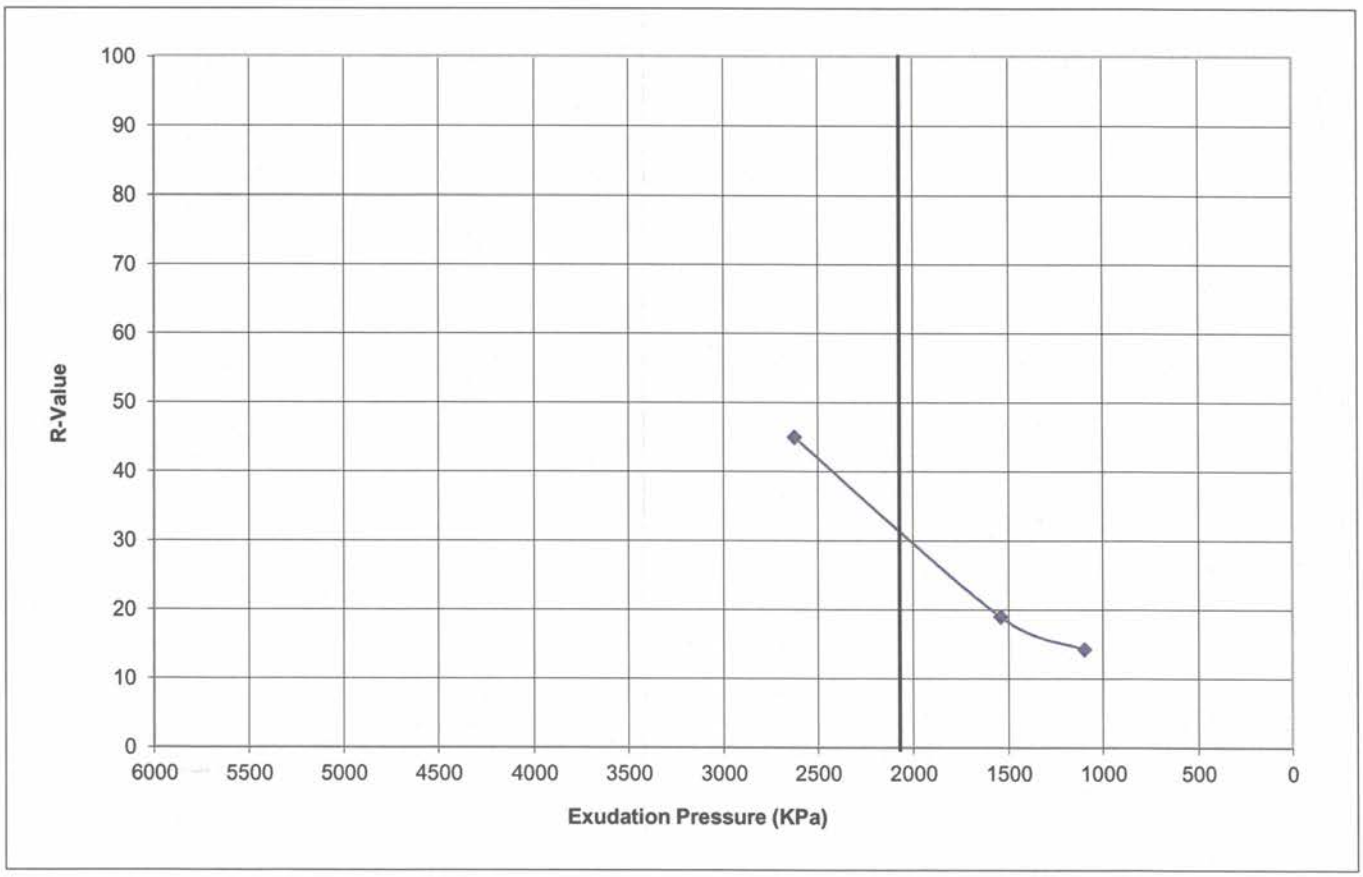
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-23 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-89
DATE SAMPLED: 01/12/16

RESISTANCE R-VALUE AND EXPANSION PRESSURE OF COMPACTED SOILS (AASHTO T190)

SPECIMEN I. D.	A	B	C
Moisture Content	12.7%	12.0%	11.2%
Compaction Pressure (KPa)	965	1931	2344
Specimen Height (mm)	62.23	61.21	60.96
Dry Density (kg/cu.m)	1952.3	1916.7	1959.4
Horiz. Pres. @ 1000lbs (KPa)	344.7	303.4	186.2
Horiz. Pres. @ 2000lbs (KPa)	841.2	765.3	441.3
Displacement(mm)	11.94	10.92	10.57
Expansion Pressure (KPa)	0.9	10.9	16.3
Exudation Pressure (KPa)	1096	1541	2625
R Value	14	19	45



R Value at 2068 KPa = 31

amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY _____

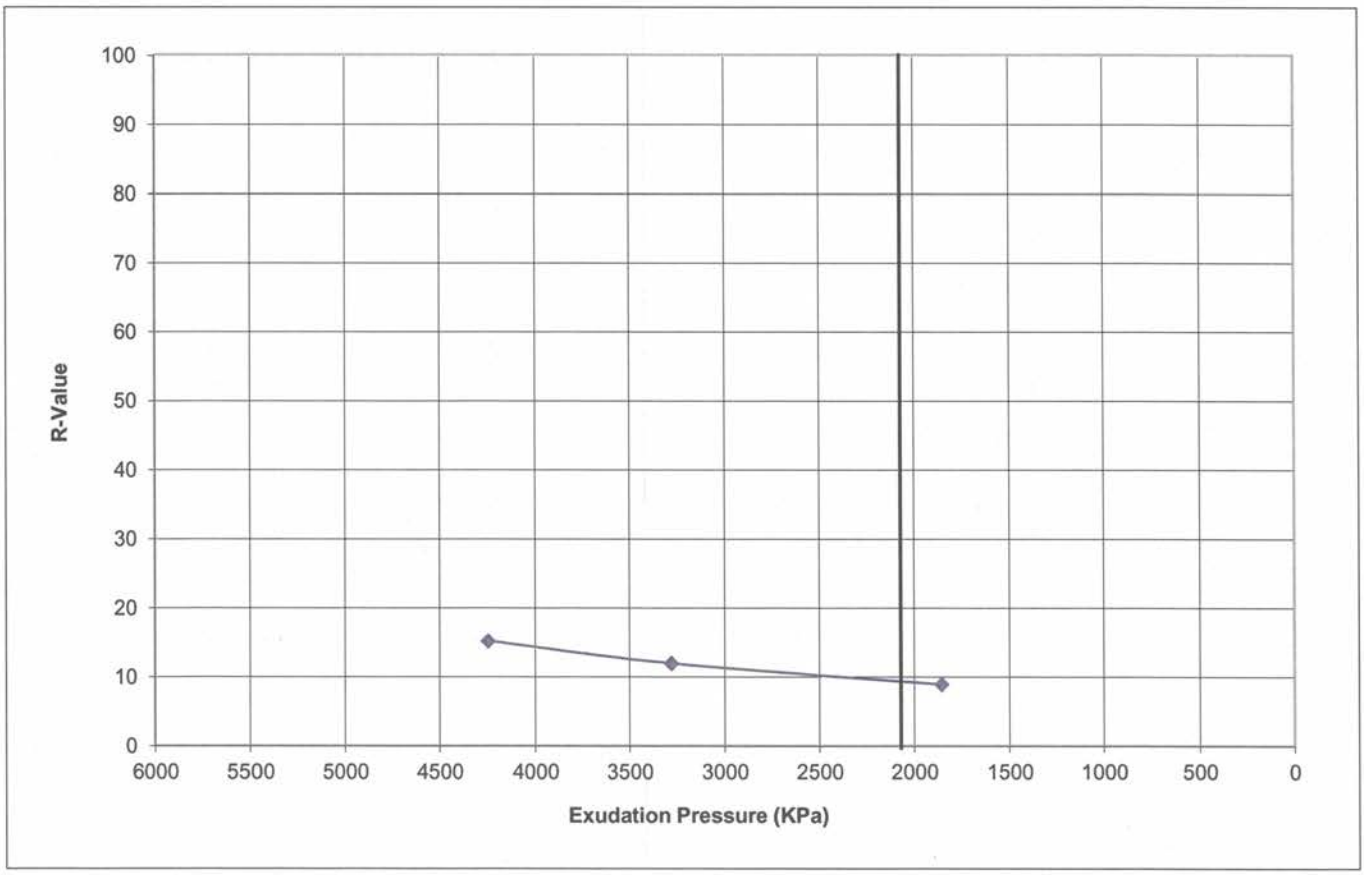
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-26 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-101
DATE SAMPLED: 01/12/16

RESISTANCE R-VALUE AND EXPANSION PRESSURE OF COMPACTED SOILS (AASHTO T190)

SPECIMEN I. D.	A	B	C
Moisture Content	20.2%	17.3%	15.9%
Compaction Pressure (KPa)	552	689	1241
Specimen Height (mm)	68.58	62.48	64.52
Dry Density (kg/cu.m)	1697.7	1839.7	1799.3
Horiz. Pres. @ 1000lbs (KPa)	386.1	372.3	337.8
Horiz. Pres. @ 2000lbs (KPa)	951.5	896.3	848.1
Displacement(mm)	12.50	10.82	10.69
Expansion Pressure (KPa)	8.1	17.2	21.7
Exudation Pressure (KPa)	1856	3280	4245
R Value	9	12	15



R Value at 2068 KPa = 9

amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY _____

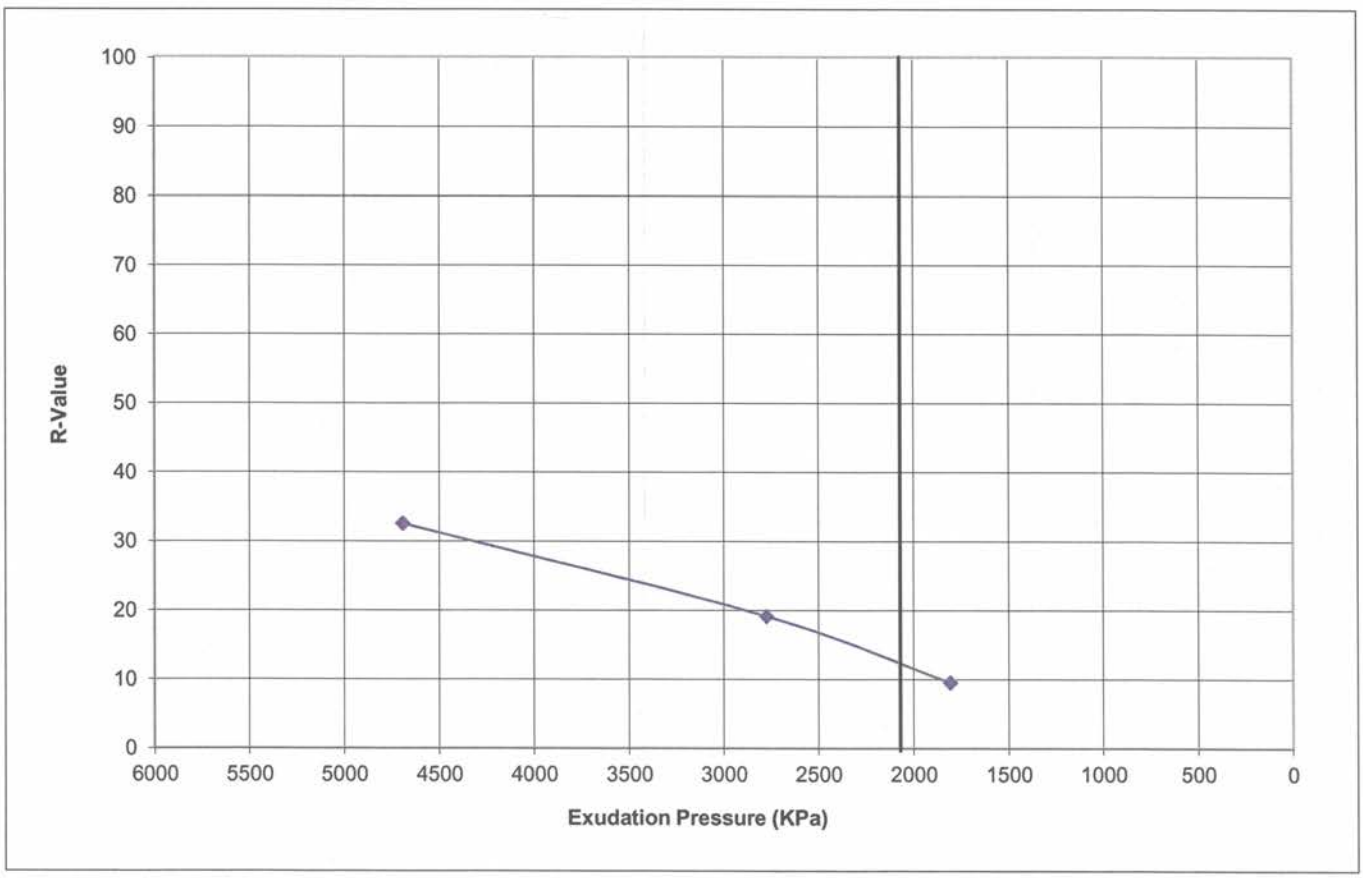
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-31 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-121
DATE SAMPLED: 01/12/16

RESISTANCE R-VALUE AND EXPANSION PRESSURE OF COMPACTED SOILS (AASHTO T190)

SPECIMEN I. D.	A	B	C
Moisture Content	15.4%	13.6%	12.7%
Compaction Pressure (KPa)	552	1482	2206
Specimen Height (mm)	65.53	61.72	60.96
Dry Density (kg/cu.m)	1760.3	1845.9	1888.5
Horiz. Pres. @ 1000lbs (KPa)	386.1	296.5	234.4
Horiz. Pres. @ 2000lbs (KPa)	930.8	779.1	620.5
Displacement(mm)	12.09	10.41	9.27
Expansion Pressure (KPa)	36.2	42.5	77.8
Exudation Pressure (KPa)	1805	2773	4690
R Value	10	19	32



R Value at 2068 KPa = 12

amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY _____

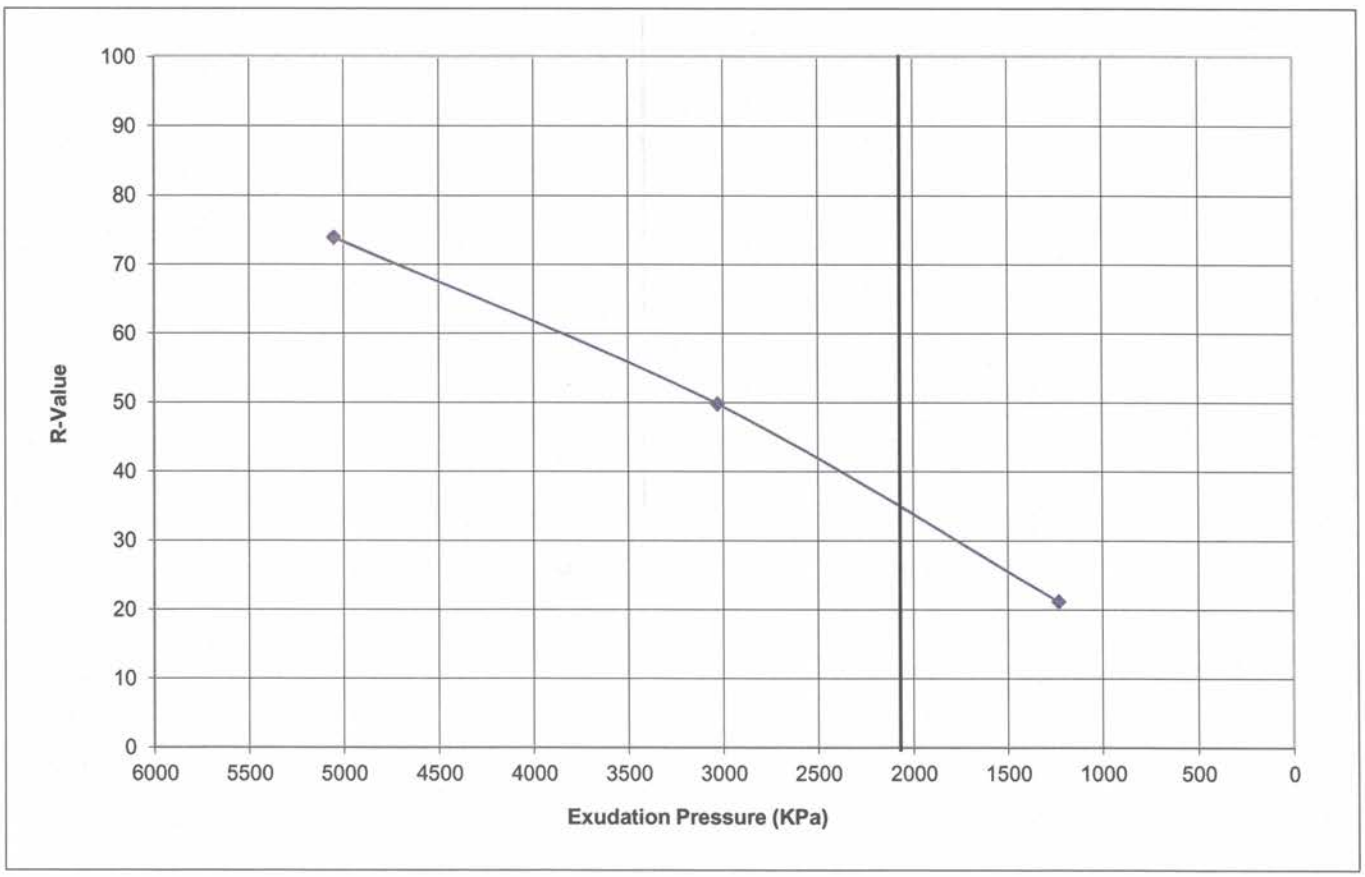
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-35 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-137
DATE SAMPLED: 01/12/16

RESISTANCE R-VALUE AND EXPANSION PRESSURE OF COMPACTED SOILS (AASHTO T190)

SPECIMEN I. D.	A	B	C
Moisture Content	14.2%	12.4%	10.6%
Compaction Pressure (KPa)	1586	2068	2413
Specimen Height (mm)	64.77	64.26	64.01
Dry Density (kg/cu.m)	1807.6	1848.3	1867.7
Horiz. Pres. @ 1000lbs (KPa)	275.8	172.4	96.5
Horiz. Pres. @ 2000lbs (KPa)	689.5	372.3	179.3
Displacement(mm)	14.22	12.60	11.61
Expansion Pressure (KPa)	5.4	12.7	27.1
Exudation Pressure (KPa)	1230	3029	5050
R Value	21	50	74



R Value at 2068 KPa = 35

amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY _____

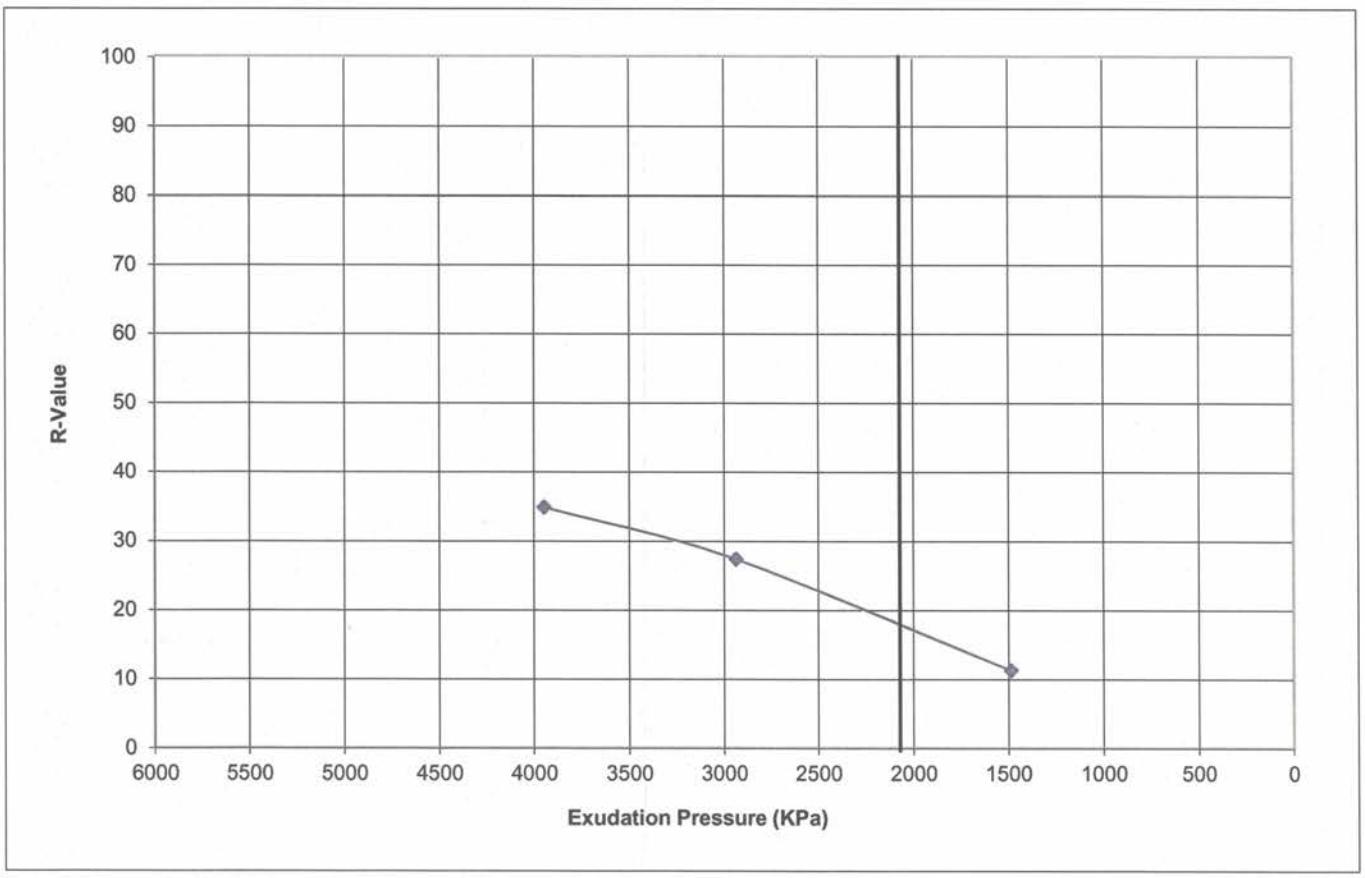
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-40 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-157
DATE SAMPLED: 01/12/16

RESISTANCE R-VALUE AND EXPANSION PRESSURE OF COMPACTED SOILS (AASHTO T190)

SPECIMEN I. D.	A	B	C
Moisture Content	15.9%	14.1%	13.4%
Compaction Pressure (KPa)	689	1724	2137
Specimen Height (mm)	65.28	62.99	61.21
Dry Density (kg/cu.m)	1798.7	1869.6	1873.9
Horiz. Pres. @ 1000lbs (KPa)	365.4	262.0	179.3
Horiz. Pres. @ 2000lbs (KPa)	889.4	675.7	586.1
Displacement(mm)	12.85	10.69	9.58
Expansion Pressure (KPa)	0.0	36.2	58.8
Exudation Pressure (KPa)	1486	2938	3947
R Value	11	27	35



R Value at 2068 KPa = 18

amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY _____

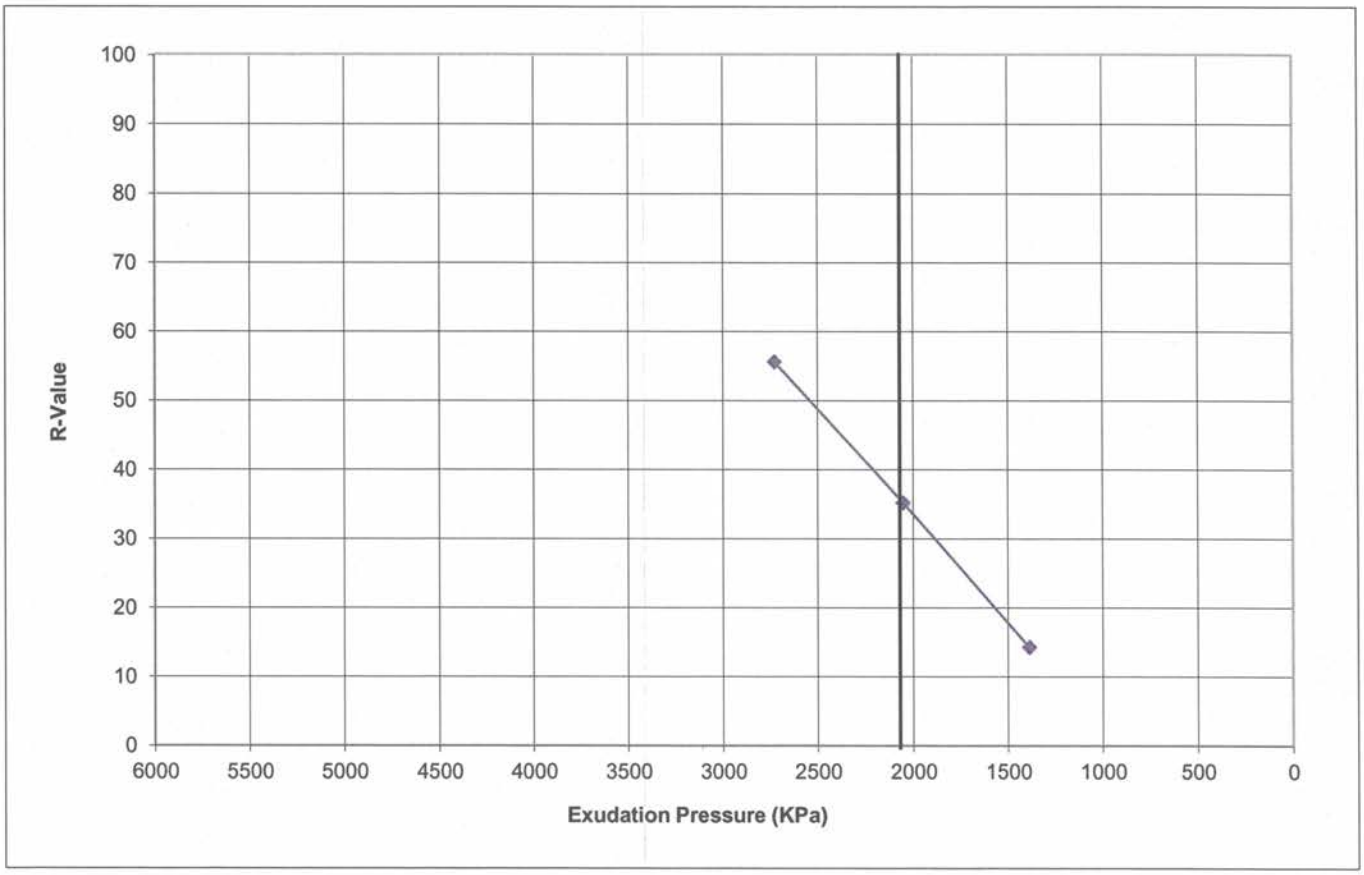
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-42 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-165
DATE SAMPLED: 01/12/16

RESISTANCE R-VALUE AND EXPANSION PRESSURE OF COMPACTED SOILS (AASHTO T190)

SPECIMEN I. D.	A	B	C
Moisture Content	14.6%	13.2%	11.4%
Compaction Pressure (KPa)	1034	1517	2068
Specimen Height (mm)	64.01	64.01	62.48
Dry Density (kg/cu.m)	1813.3	1841.2	1901.5
Horiz. Pres. @ 1000lbs (KPa)	337.8	227.5	186.2
Horiz. Pres. @ 2000lbs (KPa)	813.6	510.2	420.6
Displacement(mm)	13.59	13.61	8.26
Expansion Pressure (KPa)	0.0	0.0	0.0
Exudation Pressure (KPa)	1385	2051	2726
R Value	14	35	56



R Value at 2068 KPa = 36

amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY _____

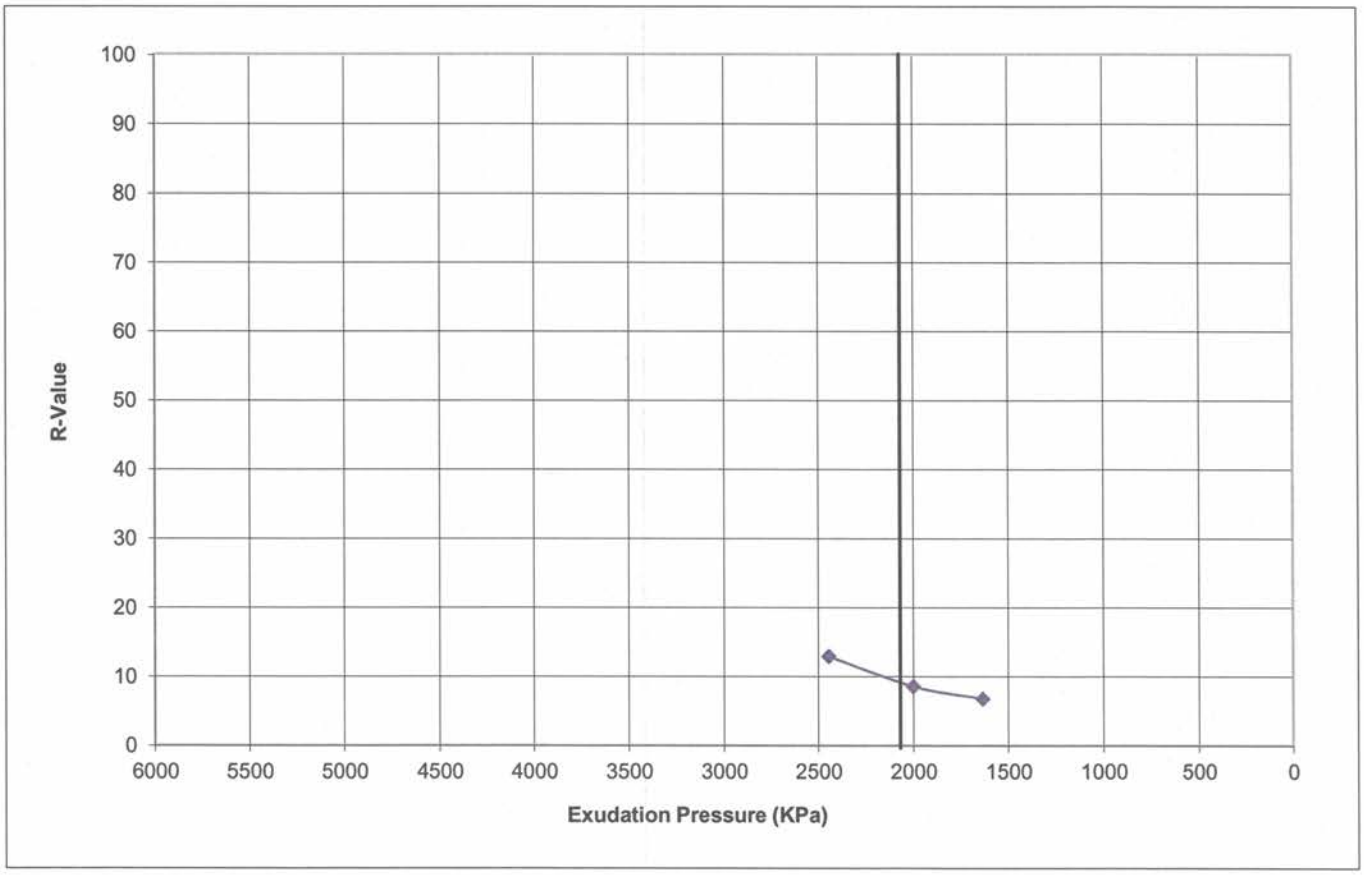
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: R-45 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-179
DATE SAMPLED: 01/12/16

RESISTANCE R-VALUE AND EXPANSION PRESSURE OF COMPACTED SOILS (AASHTO T190)

SPECIMEN I. D.	A	B	C
Moisture Content	19.4%	18.4%	17.2%
Compaction Pressure (KPa)	517	689	827
Specimen Height (mm)	67.31	67.06	66.04
Dry Density (kg/cu.m)	1612.7	1626.4	1656.8
Horiz. Pres. @ 1000lbs (KPa)	420.6	406.8	365.4
Horiz. Pres. @ 2000lbs (KPa)	979.1	958.4	896.3
Displacement(mm)	12.78	11.68	10.90
Expansion Pressure (KPa)	11.8	16.3	40.7
Exudation Pressure (KPa)	1635	2002	2446
R Value	7	9	13



R Value at 2068 KPa = 9

amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY _____

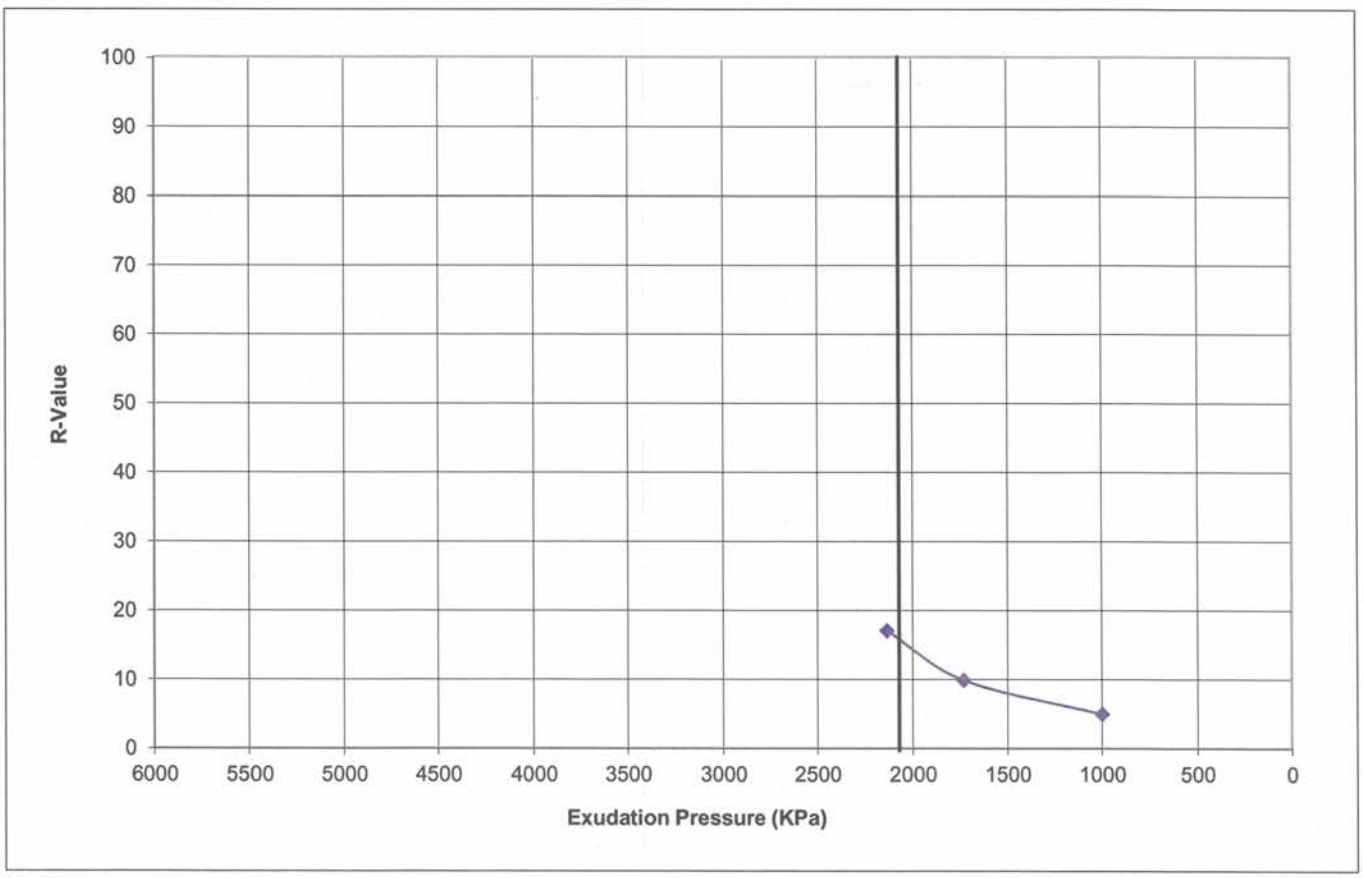
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: SS-3 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-195
DATE SAMPLED: 01/12/16

RESISTANCE R-VALUE AND EXPANSION PRESSURE OF COMPACTED SOILS (AASHTO T190)

SPECIMEN I. D.	A	B	C
Moisture Content	16.4%	13.6%	12.2%
Compaction Pressure (KPa)	483	931	1034
Specimen Height (mm)	62.48	63.25	59.69
Dry Density (kg/cu.m)	1785.1	1860.8	1902.7
Horiz. Pres. @ 1000lbs (KPa)	455.1	337.8	310.3
Horiz. Pres. @ 2000lbs (KPa)	999.7	930.8	799.8
Displacement(mm)	12.57	10.74	10.03
Expansion Pressure (KPa)	0.0	0.0	0.0
Exudation Pressure (KPa)	998	1733	2134
R Value	5	10	17



R Value at 2068 KPa = 16

amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY _____

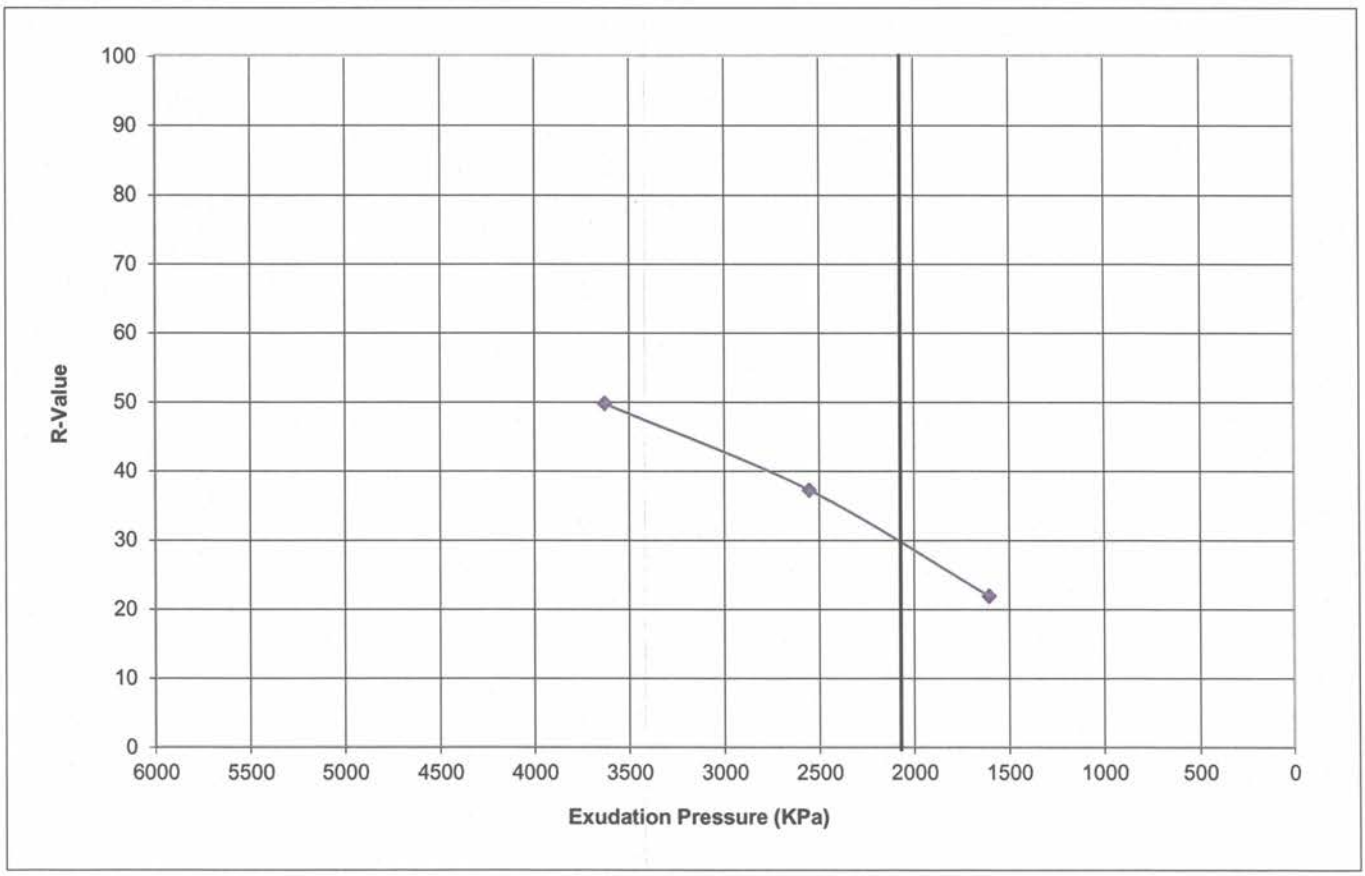
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: SS-8 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 1
LAB NO: 16-0885-223
DATE SAMPLED: 01/12/16

RESISTANCE R-VALUE AND EXPANSION PRESSURE OF COMPACTED SOILS (AASHTO T190)

SPECIMEN I. D.	A	B	C
Moisture Content	14.3%	12.5%	11.7%
Compaction Pressure (KPa)	931	2068	2413
Specimen Height (mm)	62.74	61.21	61.21
Dry Density (kg/cu.m)	1857.7	1931.7	1964.0
Horiz. Pres. @ 1000lbs (KPa)	289.6	220.6	165.5
Horiz. Pres. @ 2000lbs (KPa)	730.8	517.1	393.0
Displacement(mm)	11.56	11.10	10.62
Expansion Pressure (KPa)	0.0	12.7	31.7
Exudation Pressure (KPa)	1607	2554	3628
R Value	22	37	50



R Value at 2068 KPa = 30

amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY _____

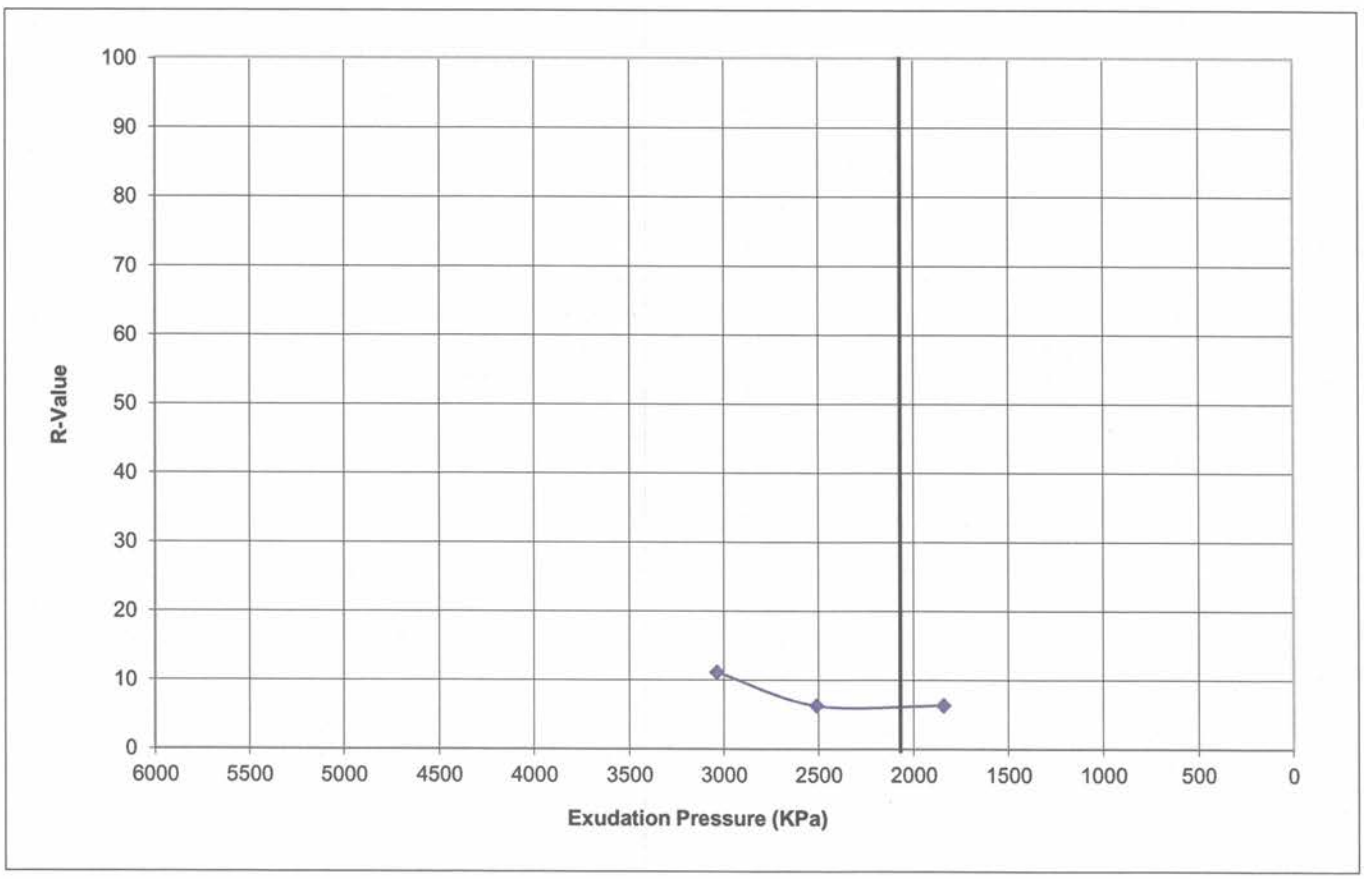
amec foster wheeler

PROJECT: BIA N8066(3), 8065(1), & School Spur
LOCATION: Black Mesa Community School, AZ
MATERIAL: Native Soil
SAMPLE SOURCE: RS-1 (0.00m-1.35m)

JOB NO: 17-2015-4045
WORK ORDER NO: 2
LAB NO: 16-0918-01
DATE SAMPLED: 01/28/16

RESISTANCE R-VALUE AND EXPANSION PRESSURE OF COMPACTED SOILS (AASHTO T190)

SPECIMEN I. D.	A	B	C
Moisture Content	27.2%	25.7%	23.7%
Compaction Pressure (KPa)	345	689	758
Specimen Height (mm)	69.34	65.79	66.55
Dry Density (kg/cu.m)	1485.1	1485.2	1569.6
Horiz. Pres. @ 1000lbs (KPa)	434.4	427.5	393.0
Horiz. Pres. @ 2000lbs (KPa)	999.7	992.9	930.8
Displacement(mm)	12.04	11.48	10.54
Expansion Pressure (KPa)	6.3	15.4	40.7
Exudation Pressure (KPa)	1842	2510	3039
R Value	6	6	11



R Value at 2068 KPa = 6

amec foster wheeler
3630 E Wier Ave.
Phoenix, AZ 85040

REVIEWED BY RJN

APPENDIX C

PAVEMENT DESIGN CALCULATIONS

AASHTO Guide for Design of Pavement Structures, 1993

$$R_{mean} = \frac{N_t R_t \sigma_c^2 + N_c R_c \sigma_t^2}{N_t \sigma_c^2 + N_c \sigma_t^2}$$

Number of R-Value Tests	1		Number of Correlated R-Values	1

6		

8					

Mean of R-value Tests	6		Mean of Correlated R-Values	8
Strd. Dev. of R-Value Tests	N/A		Strd. Dev. of Correlated Values	N/A
Mean R-value	N/A			
Design R-value	7		Seasonal Variation Factor	2.6
ADOT Resilient Modulus	3295	psi		
AASHTO Resilient Modulus	4885	psi		
Maximum Resilient Modulus	26000	psi		
Design Resilient Modulus	4885	psi		
Standard Normal Deviate	-0.674	75%	Equivalent 18-k Single Axle Loads	1,577
Standard Error	0.49			
Design Sevicability Loss	2		Structural Number	1.22 -0.000479791

$$M_{R(ADOT)} = \frac{1815 + 225 * R_{mean} + 2.4 * R_{mean}^2}{0.6 * SVF^{0.6}}$$

$$M_{R(AASHTO)} = 1000 + 555 * R - value$$

To Calculate Structural Number go to "Tools" Pulldown

Select	"Goal Seek"	Enter	Set Cell	J43
			To Value	0
			By Changing Cell	I43

$$\log_{10}(W_{18}) = Z_R * S_O + 9.36 * \log_{10}(SN + 1) - 0.20 + \frac{\log_{10}\frac{\Delta PSI}{4.2 - 1.5}}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 * \log_{10}(M_R) - 8.07$$

AASHTO Guide for Design of Pavement Structures, 1993

$$R_{mean} = \frac{N_t R_t \sigma_c^2 + N_c R_c \sigma_t^2}{N_t \sigma_c^2 + N_c \sigma_t^2}$$

Number of R-Value Tests: **8**

Number of Correlated R-Values: **9**

8	18	
9	9	
9	16	
9		
12		

9	8			
26	28			
21	12			
16	31			
9				

Mean of R-value Tests: **11**

Mean of Correlated R-Values: **18**

Strd. Dev. of R-Value Tests: 4

Strd. Dev. of Correlated Values: 9

Mean R-value: **12**

Design R-value: **12**

Seasonal Variation Factor: **2.6**

ADOT Resilient Modulus: **4566** psi

AASHTO Resilient Modulus: **7660** psi

$$M_{R(ADOT)} = \frac{1815 + 225 * R_{mean} + 2.4 * R_{mean}^2}{0.6 * SVF^{0.6}}$$

$$M_{R(AASHTO)} = 1000 + 555 * R - value$$

Maximum Resilient Modulus: **26000** psi

Design Resilient Modulus: **7660** psi

Standard Normal Deviate: **-0.841** **80%**

Equivalent 18-k Single Axle Loads: **21,041**

Standard Error: **0.49**

Design Sevicability Loss: **2**

Structural Number: **1.68** -0.000542721

To Calculate Structural Number go to "Tools" Pulldown

Select "Goal Seek" Enter Set Cell **J43**

To Value **0**

By Changing Cell **I43**

$$\log_{10}(W_{18}) = Z_R * S_O + 9.36 * \log_{10}(SN + 1) - 0.20 + \frac{\log_{10}\frac{\Delta PSI}{4.2 - 1.5}}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 * \log_{10}(M_R) - 8.07$$