PAVEMENT EVALUATION
TUCSON PAVEMENT RECONSTRUCTION PROGRAM
CALLE POLAR
TUCSON, ARIZONA

PREPARED FOR:
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PREPARED BY:
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December 9, 2015
Project No. 604817002

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Project No. 604817002

Mr. Rick Solis, P.E.
Kimley-Horn
333 East Wetmore Road, Suite 280
Tucson, Arizona 85705

Subject: Pavement Evaluation
Tucson Pavement Reconstruction Program – Calle Polar
Tucson, Arizona

Dear Mr. Solis:

In accordance with our proposal dated August 12, 2015, and your authorization on September 21, 2015, Ninyo & Moore has performed a pavement evaluation for the above-referenced site. The attached report presents our methodology, findings, conclusions, and recommendations regarding the geotechnical conditions at the project site.

We appreciate the opportunity to be of service to you during this phase of the project.

Sincerely,
NINYO & MOORE

Registered Professional Engineer (Civil)
CERTIFICATE NO.
44704
MAREK J.
KASZTALSKI
Date Signed 12.9.15
ARIZONA, U.S.A.

Marek J. Kasztalski, PE, PMP, LEED AP
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Distribution: (1) Addressee (Electronic Copy)

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1. INTRODUCTION

In accordance with our proposal dated August 12, 2015, and your authorization on September 21, 2015, we have performed a pavement evaluation for the Calle Polar Pavement Reconstruction project between Nicaragua Drive and Escalante Road, in Tucson, Arizona. The purpose of our evaluation was to assess the pavement and subgrade conditions along the project alignment in order to provide geotechnical recommendations for design and construction. This report presents the results of our evaluation, conclusions, and recommendations regarding the proposed construction.

2. SCOPE OF SERVICES

The scope of our services generally included:

- Preparing a field testing plan and associated permit application for submittal to the City of Tucson (COT).
- Conducting a visual reconnaissance of the pavement along the alignment and marking out the boring locations.
- Notifying Arizona811 of our boring locations prior to conducting the field work.
- Arranging for traffic control measures to conduct the field work.
- Coring the existing asphaltic concrete (AC) pavement at two locations along the project alignment.
- Exploring the subsurface soils within the project limits by drilling, logging, and sampling two exploratory soil borings to approximate depths of 3 feet below ground surface (bgs). The boring logs are presented in Appendix A.
- Performing laboratory tests on selected samples collected from our borings to evaluate gradation and Atterberg limits. The results of the laboratory tests are included in Appendix B.
- Preparing this report presenting our findings, conclusions and recommendations regarding the proposed reconstruction.

Our scope of services did not include environmental consulting services such as hazardous waste sampling or analytical testing at the site. A detailed scope of services and estimated fee for such services can be provided upon request.

3. SITE DESCRIPTION

The project site is located in Section 30 of Township 14 South, Range 15 East relative to the Gila and Salt River Base Line and Meridian. The project alignment extends along Calle Polar between Nicaragua Drive and Escalante Road, in Tucson, Arizona (Figure 1).

At the time of our evaluation residential developments existed to the east of the project alignment. West of Calle Polar, the project alignment was adjacent to the Davis Monthan Air Force Base. The roadway section consisted of one travel lane in each direction, concrete sidewalks on the east side of the roadway, and no gutter. A wedge curb was observed on the east side, while no curb existing along most of the west side.

4. PROPOSED CONSTRUCTION

The COT has identified several segments of the existing street network for reconstruction and/or rehabilitation in fiscal year (FY) 2016 under Bid Package 2. The scope of this report includes Calle Polar between Nicaragua Drive and Escalante Road. The project alignment is approximately 1,200 feet long.

We understand that the COT anticipates full-depth reconstruction of the existing roadway along the project alignment. The City proposes a new pavement section consisting of 5 inches of AC per of the COT Department of Transportation Standard Specifications Section 406 over 5 inches of aggregate base (AB) per Section 303 of the COT Standard Specifications.

We further understand that the COT intends to use Tucson Department of Transportation (TDOT) AC Mix No. 2 PG 76-22TR+ for the surface layer and TDOT AC Mix No. 1 PG 70-10 for the underlying layer. Both layers are proposed to be 2.5 inches thick.

Due to conflicts with shallow utility lines, subgrade improvement by overexcavation will not be performed and the new pavement section will be constructed on subgrade improved with Geogrid (Tensar Geogrid TX5 or equivalent).

The scope of this exploration included evaluation of the existing pavement section and subgrade soils in order to provide recommendations for pavement reconstruction in accordance with the current COT practice. Calculations for the new pavement section supporting the new construction proposed by the COT are presented in Section 9.3 and in Appendix E of this report.

5. EXISTING PAVEMENT CONDITION

On September 28, 2015, Ninyo & Moore conducted a limited visual evaluation of the pavement surface along the project alignment. Based on our field observations, the AC pavement exhibited signs of severe distress in many locations along the project alignment primarily consisting of extensive alligator cracking with considerable spalling, longitudinal, transverse and irregular cracking, rutting ½-inch in both wheel tracks, and potholes. Some of the cracks exhibited evidence of past sealing. Asphaltic concrete patches were observed at some locations which were probably associated with past maintenance efforts (pothole and crack repairs) or with underground utility work. The crack widths generally varied between hairline (less than 1/8-inch) and over one inch.

In our opinion, the distress observed along the project alignment indicates structural failure and is related to a combination of pavement age, traffic, and environmental impacts.

6. FIELD EXPLORATION AND LABORATORY TESTING

On September 28, 2015, Ninyo & Moore conducted a geotechnical exploration in order to evaluate the subsurface conditions and collect AC cores and soil samples for laboratory testing. Our evaluation consisted of coring the existing AC pavement, drilling, logging, and sampling two small-diameter borings, denoted as B-1 and B-2, utilizing a CME-45 truck-mounted drill rig equipped with hollow-stem augers. The borings extended to depths of approximately 3 feet bgs. The approximate locations of the borings are depicted on Figure 2.

Ninyo & Moore personnel logged the borings in general accordance with the Unified Soil Classification System (USCS) and American Society for Testing and Materials (ASTM) D 2488 by observing cuttings and drive samples. Collected ring samples were trimmed in the field, wrapped in plastic bags, and placed in cylindrical plastic containers to retain in-place moisture conditions.

The soil samples collected from our drilling activities were transported to the Ninyo & Moore laboratory in Tucson, Arizona for geotechnical laboratory testing. The tests included gradation and Atterberg limits. A description of each laboratory test method and the test results are presented in Appendix B.

7. SUBSURFACE CONDITIONS

Our knowledge of the subsurface conditions at the project site is based on our field exploration, laboratory testing, and general experience in the area. More detailed stratigraphic information is presented on the boring logs in Appendix A, attached to this report. The boring logs contain our field and laboratory test results, as well as our interpretation of conditions believed to exist between actual samples retrieved. Therefore, these boring logs contain both factual and interpretive information. Lines delineating subsurface strata on the boring logs are intended to group soils having similar engineering properties and characteristics. They should be considered approximate as the actual transition between soil types (strata) may be gradual. A key to the soil symbols and terms used on the boring logs is provided in Appendix A.

7.1. Asphaltic Concrete

Asphaltic concrete pavement was encountered at the surface of each of our borings. The AC thickness varied between approximately 3 and 4 inches, in our borings. It should be noted that the thickness of the AC pavement between the sampling locations may vary and could be different from that encountered at our sampling locations. Detailed core descriptions are presented in Appendix C.

Aggregate base was not observed in our borings. It is possible the AB material blended with the native subgrade soils, such that delineation of the AB/subgrade interface was not easily interpreted.

7.2. Fill

Fill soils were observed under the AC in Boring B-2 and extended to an approximate depth of 2 feet bgs. The fill generally consisted of medium dense poorly graded sand.

7.3. Alluvium

Native alluvial soils were encountered below the pavement section and fill described above, and extended to the boring termination depths. The alluvium generally consisted of medium dense, clayey sands with varying amounts of gravel.

8. CONCLUSIONS

Based on the results of our visual and subsurface evaluations, laboratory testing, and data analysis, geotechnical considerations include the following:

- The on-site soils generally include clayey sands, with a plasticity index (PI) of 26. These soils may be sensitive to moisture content fluctuations and may be difficult to compact especially at higher moisture contents. The contractor should be aware of this condition.
- Due to the relatively widely spaced nature of our borings, soil conditions may differ from what was observed during our field exploration.
- The pavement exhibits significant distress in many locations along the project alignment consisting mainly of transverse, block and irregular cracking.
- Full-depth pavement reconstruction is considered for this project as proposed by the COT.

9. RECOMMENDATIONS

The following sections present our geotechnical recommendations for the project. If the proposed construction is changed from that discussed in this report, Ninyo & Moore should be contacted for additional recommendations.

9.1. Recommended Pavement Structural Sections

The recommended pavement sections are presented in the table below:

Pavement Section	Service Life (years)	AC (in)[1]	AB (in)[2]
COT Preferred Pavement with Geogrid	20	5	5
Alternative Pavement Section without Geogrid	20	6	7

Notes:
[1] TDOT AC Mix No. 2 PG 76-22TR+ as the surface mix and TDOT AC Mix No. 1 PG 70-10 for the underlying layers per Section 406 of the COT Specifications.
[2] AB per Section 303 of the COT Specifications.

9.2. Earthwork

The following sections provide our earthwork recommendations for this project. In general, the earthwork specifications contained in the *City of Tucson/Pima County Standard Specifications for Public Improvements, 2003 Edition (COT/PC Specifications)* are expected to apply unless specifically noted.

9.2.1. Site Preparation

Construction areas should be cleared of deleterious materials, if any are present, including abandoned utilities, construction debris, vegetation, and any other material that might interfere with the performance or progress of the work. These materials should be disposed of at a legal dumpsite. Existing features that call for relocation or removal and extend below finish grade, if present, should be removed, and the resulting excavations backfilled with engineered fill.

9.2.2. Excavations

Our evaluation of the excavation characteristics of the on-site soils is based on the results of our exploratory borings, site observations, and experience with similar materials.

9.2.3. Fill Materials

Soils with PI values of 15 or less (as evaluated by ASTM D 4318) are generally suitable for use as engineered fill. Our Atterberg limits test indicated the PI value of 26. Based on this test result, some of the on-site soils are not suitable for re-use as engineered fill.

Engineered fill should not include organic material, construction debris, or other non-soil fill materials. Rock particles and clay lumps should not be larger than 4 inches in dimension. Unsuitable material should be disposed of off-site or in non-structural areas.

9.2.4. Grading and Subgrade Preparation

In general, grading operations should be performed in accordance with Section 205 of the COT/PC Specifications.

Due to potential conflicts with underground utilities, we recommend that the subgrade be improved by the application of Geogrid (Tensar Geogrid TX5 or equivalent). Geogrid should be placed in accordance with the manufacturer's instructions.

Alternatively, if Geogrid is not applied we recommend new pavements be supported on 6 inches of subgrade that is compacted by appropriate mechanical methods to a relative compaction of 95 percent as evaluated by ASTM D 698 at a moisture content generally near optimum. The thickness of the improvement zone should be measured from the bottom of the AB layer.

In areas where excessive moisture is encountered so that the above compaction cannot be achieved and/or the subgrade surface is unstable and yielding (pumping) under the roller wheels, subgrade soils should be scarified to a depth of 12 inches, aerated, and re-compacted as specified above. Alternatively, subgrade soils in problem areas should be and replaced with engineered fill to a depth of 12 inches below the bottom of the AB.

9.3. Pavement Design Summary

The following sections present our design assumptions and recommendations for the new flexible pavement section of Calle Polar as this roadway is scheduled for full-depth pavement reconstruction.

The pavement section was developed using the Active Practices Guidelines issued by the COT Department of Transportation (Guidelines) and the Arizona Department of Transportation (ADOT) Preliminary Engineering and Design Manual (PEDM). We assumed that the subgrade will be improved by the application of Geogrid or overexcavation, as outlined in Section 9.2.4 of this report. The new pavement sections are designed for a 20-year service life.

9.3.1. Traffic

The future traffic numbers used in this report are based on traffic counts provided by Kimley-Horn and Associates, Inc. (KHA), and later communication with the KHA. This information is presented in Appendix D. Based on the above information, and using the procedures outlined in the Guidelines and PEDM, the design number of equivalent single axle loads (ESALs) for the design lane during the 20-year design period was calculated as approximately 4,358,830.

9.3.2. R-Value and Resilient Modulus

The analysis for the design R-value for the pavement section has been performed based on procedures detailed in the Guidelines and the PEDM, using a correlated R-value. The correlated R-value was derived from the PI and percent passing No. 200 Sieve test results. The R-value calculated for these methods for this project is 27. In the interest of conservatism conservatism, we recommend that an R-value of 25 be used for pavement design for this project.

If the project needs fill from an off-site source, we recommend the soils used for subgrade support should have an R-value of 25 or more. If during construction, the subgrade is found to vary from the expected soil conditions, we should be contacted so we may re-evaluate our recommended R-values. Based on the above design R-values, the design subgrade resilient modulus (M_R) value of 10,844 pounds per square inch (psi) was calculated in accordance with the Guidelines.

9.3.3. Statistical Parameters

A standard deviation of 0.40 was used for design of the flexible pavement in accordance with the Guidelines. The level of reliability and standard normal deviation (Z_R) values were selected in accordance with the Guidelines for the arterial functional classification. Their respective values are presented in the table below:

Table 1 – Summary of Statistical Parameters

Roadway	Functional Classification	Standard Deviation	Level of Reliability	Standard Normal Deviation
Calle Polar	Arterial	0.40	95 %	-1.645

9.3.4. Serviceability Index

Initial and terminal serviceability indices were selected for the pavement design of the roadways in accordance with the Guidelines. A summary of the serviceability indices for each roadway is provided in the table below:

Table 2 – Summary of Serviceability Parameters

Roadway	Functional Classification	Initial Serviceability Index	Terminal Serviceability Index	Change in Serviceability
Calle Polar	Arterial	4.5	2.5	2.0

9.3.5. Layer Coefficients

The following structural coefficients were used for the pavement structure in accordance with the Guidelines:

- AC: 0.44.

- AB: 0.14.

A drainage coefficient of 1.25 was used for the AB coefficient as recommended in the Guidelines.

As mentioned in Section 4 above, due to conflicts with existing shallow utilities, it is recommended that the subgrade be improved using Geogrid (Tensar Geogrid TX5 or equivalent). In this case the AB layer coefficient is 0.286.

9.3.6. Asphalt Pavement Section Recommendations

The structural number (SN) was calculated based on the parameters described above. The table below presents the calculated SN value and the recommended structural pavement sections. The AC thickness meets the COT requirements. Supporting documentation of the pavement optimization design using Geogrid is presented in Appendix E:

Table 3 – Structural Pavement Sections for 20-Year Design Life

Roadway	SN	AC (in)[1]	AB (in)[2]
COT Preferred Pavement with Geogrid	3.99	5	5
Alternative Pavement without Geogrid	3.81	6	7

Notes:
[1] TDOT AC Mix No. 2 PG 76-22TR+ as the surface mix and TDOT AC Mix No. 1 PG 70-10 for the underlying layers per Section 406 of the COT Specifications.
[2] AB per Section 303 of the COT Specifications.

The above pavement structural section has been designed with the assumption that the subgrade is prepared by as recommended in Section 9.2.4.

10. SITE DRAINAGE

Surface drainage should be provided to divert water away from paved surfaces. Surface water should also not be permitted to pond on or below pavement areas. Positive drainage for this project is defined as a slope of 2 percent or more for a distance of 5 feet or more away from the pavements. To deter accumulation of water below the new pavement sections, the bottom of the overexcavated zone below the new pavement should be sloped toward the edges of the roadway.

11. PRE-CONSTRUCTION CONFERENCE

We recommend that a pre-construction conference be held. Representatives of the owner, the civil engineer, Ninyo & Moore, and the contractor should be in attendance to discuss the project plans and schedule. Our office should be notified if the project description included herein is incorrect or if the project characteristics are significantly changed.

12. CONSTRUCTION OBSERVATION AND TESTING

During construction operations, we recommend that Ninyo & Moore perform observation and testing services for the project. These services should be performed to evaluate exposed subgrade conditions, including the extent and depth of overexcavation, to evaluate the suitability of proposed borrow materials for use as engineered fill and to observe placement and test compaction of fill soils. Qualified subcontractors utilizing appropriate techniques and construction materials should perform construction of the proposed improvements.

13. LIMITATIONS

The field evaluation, laboratory testing, and geotechnical analyses presented in this geotechnical report have been conducted in general accordance with current practice and the standard of care exercised by geotechnical consultants performing similar tasks in the project area. No warranty, expressed or implied, is made regarding the conclusions, recommendations, and opinions presented in this report. There is no evaluation detailed enough to reveal every subsurface condition. Variations may exist and conditions not observed or described in this report may be encountered during construction. Uncertainties relative to subsurface conditions can be reduced through additional subsurface exploration. Additional subsurface evaluation will be performed upon request. Please also note that our evaluation was limited to assessment of the geotechnical aspects of the project, and did not include evaluation of structural issues, environmental concerns, or the presence of hazardous materials.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. Ninyo & Moore should be contacted if the reader requires additional information or has questions regarding the content, interpretations presented, or completeness of this document.

This report is intended for design purposes only. It does not provide sufficient data to prepare an accurate bid by contractors. It is suggested that the bidders and their geotechnical consultant perform an independent evaluation of the subsurface conditions in the project areas. The independent evaluations may include, but not be limited to, review of other geotechnical reports prepared for the adjacent areas, site reconnaissance, and additional exploration and laboratory testing.

Our conclusions, recommendations, and opinions are based on an analysis of the observed site conditions. If geotechnical conditions different from those described in this report are encountered, our office should be notified and additional recommendations, if warranted, will be provided upon request. It should be understood that the conditions of a site could change with time as a result of natural processes or the activities of man at the subject site or nearby sites. In addition, changes to the applicable laws, regulations, codes, and standards of practice may occur due to government action or the broadening of knowledge. The findings of this report may, therefore, be invalidated over time, in part or in whole, by changes over which Ninyo & Moore has no control.

This report is intended exclusively for use by the client. Any use or reuse of the findings, conclusions, and/or recommendations of this report by parties other than the client is undertaken at said parties' sole risk.

14. REFERENCES

American Society for Testing and Materials (ASTM), Annual Book of ASTM Standards.

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

City of Tucson, Arizona, Department of Transportation, Engineering Division, 1987, Active Practices Guidelines: dated June 1.

Ninyo & Moore, In-house proprietary information.

Source: Phoenix Mapping Service, Tucson Metro Edition, 2012.

0 3300

Approximate Scale:
1 inch = 3300 feet

Note: Dimensions, directions, and locations are approximate.

Ninyo & Moore		SITE LOCATION	FIGURE
PROJECT NO: 604817002	DATE: 12/15	TUCSON PAVEMENT RECONSTRUCTION - CALLE POLAR TUCSON, ARIZONA	1

file no: 4817vmap1015b

Source: NAVTEQ, 03/27/14.

N

0 230

Approximate Scale:
1 inch = 230 feet

Note: Dimensions, directions, and locations are approximate.

file no: 4817blm1015b

Ninyo & Moore	BORING LOCATIONS		FIGURE 2
PROJECT NO: 604817002	DATE: 12/15	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - CALLE POLAR TUCSON, ARIZONA	

APPENDIX A

BORING LOGS

Field Procedure for the Collection of Relatively Undisturbed Samples

Relatively undisturbed soil samples were obtained in the field using the following methods.

The Modified Split-Barrel Drive Sampler

The sampler, with an external diameter of 3.0 inches, was lined with 1-inch long, thin brass rings with inside diameters of approximately 2.4 inches. The sample barrel was driven into the ground with the weight of a hammer or the Kelly bar of the drill rig in general accordance with ASTM D 3550. The driving weight was permitted to fall freely. The approximate length of the fall, the weight of the hammer or bar, and the number of blows per foot of driving are presented on the boring logs as an index to the relative resistance of the materials sampled. The samples were removed from the sample barrel in the brass rings, sealed, and transported to the laboratory for testing.

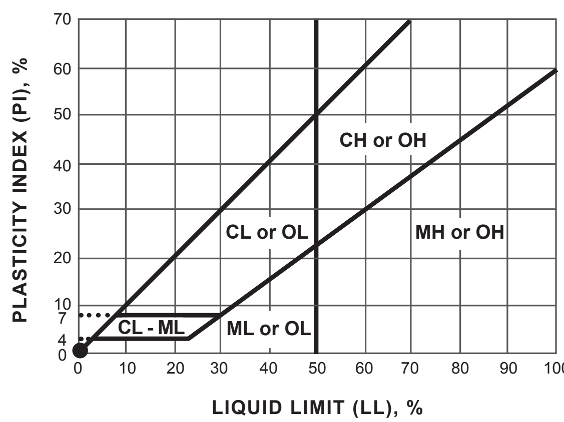
SOIL CLASSIFICATION CHART PER ASTM D 2488

PRIMARY DIVISIONS			SECONDARY DIVISIONS: GROUP SYMBOL	SECONDARY DIVISIONS: GROUP NAME
COARSE-GRAINED SOILS more than 50% retained on No. 200 sieve	GRAVEL more than 50% of coarse fraction retained on No. 4 sieve	CLEAN GRAVEL less than 5% fines	GW	well-graded GRAVEL
			GP	poorly graded GRAVEL
		GRAVEL with DUAL CLASSIFICATIONS 5% to 12% fines	GW-GM	well-graded GRAVEL with silt
			GP-GM	poorly graded GRAVEL with silt
			GW-GC	well-graded GRAVEL with clay
			GP-GC	poorly graded GRAVEL with clay
		GRAVEL with FINES more than 12% fines	GM	silty GRAVEL
			GC	clayey GRAVEL
			GC-GM	silty, clayey GRAVEL
	SAND 50% or more of coarse fraction passes No. 4 sieve	CLEAN SAND less than 5% fines	SW	well-graded SAND
			SP	poorly graded SAND
		SAND with DUAL CLASSIFICATIONS 5% to 12% fines	SW-SM	well-graded SAND with silt
			SP-SM	poorly graded SAND with silt
			SW-SC	well-graded SAND with clay
			SP-SC	poorly graded SAND with clay
		SAND with FINES more than 12% fines	SM	silty SAND
			SC	clayey SAND
			SC-SM	silty, clayey SAND
FINE-GRAINED SOILS 50% or more passes No. 200 sieve	SILT and CLAY liquid limit less than 50%	INORGANIC	CL	lean CLAY
			ML	SILT
			CL-ML	silty CLAY
		ORGANIC	OL (PI > 4)	organic CLAY
			OL (PI < 4)	organic SILT
	SILT and CLAY liquid limit 50% or more	INORGANIC	CH	fat CLAY
			MH	elastic SILT
		ORGANIC	OH (plots on or above "A"-line)	organic CLAY
			OH (plots below "A"-line)	organic SILT
	Highly Organic Soils		PT	Peat

GRAIN SIZE

DESCRIPTION		SIEVE SIZE	GRAIN SIZE	APPROXIMATE SIZE
Boulders		> 12"	> 12"	Larger than basketball-sized
Cobbles		3 - 12"	3 - 12"	Fist-sized to basketball-sized
Gravel	Coarse	3/4 - 3"	3/4 - 3"	Thumb-sized to fist-sized
	Fine	#4 - 3/4"	0.19 - 0.75"	Pea-sized to thumb-sized
Sand	Coarse	#10 - #4	0.079 - 0.19"	Rock-salt-sized to pea-sized
	Medium	#40 - #10	0.017 - 0.079"	Sugar-sized to rock-salt-sized
	Fine	#200 - #40	0.0029 - 0.017"	Flour-sized to sugar-sized
Fines		Passing #200	< 0.0029"	Flour-sized and smaller

PLASTICITY CHART



APPARENT DENSITY - COARSE-GRAINED SOIL

APPARENT DENSITY	SPOOLING CABLE OR CATHEAD: SPT (blows/foot)	SPOOLING CABLE OR CATHEAD: MODIFIED SPLIT BARREL (blows/foot)	AUTOMATIC TRIP HAMMER: SPT (blows/foot)	AUTOMATIC TRIP HAMMER: MODIFIED SPLIT BARREL (blows/foot)
Very Loose	≤ 4	≤ 8	≤ 3	≤ 5
Loose	5 - 10	9 - 21	4 - 7	6 - 14
Medium Dense	11 - 30	22 - 63	8 - 20	15 - 42
Dense	31 - 50	64 - 105	21 - 33	43 - 70
Very Dense	> 50	> 105	> 33	> 70

CONSISTENCY - FINE-GRAINED SOIL

CONSIS-TENCY	SPOOLING CABLE OR CATHEAD: SPT (blows/foot)	SPOOLING CABLE OR CATHEAD: MODIFIED SPLIT BARREL (blows/foot)	AUTOMATIC TRIP HAMMER: SPT (blows/foot)	AUTOMATIC TRIP HAMMER: MODIFIED SPLIT BARREL (blows/foot)
Very Soft	< 2	< 3	< 1	< 2
Soft	2 - 4	3 - 5	1 - 3	2 - 3
Firm	5 - 8	6 - 10	4 - 5	4 - 6
Stiff	9 - 15	11 - 20	6 - 10	7 - 13
Very Stiff	16 - 30	21 - 39	11 - 20	14 - 26
Hard	> 30	> 39	> 20	> 26

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USCS METHOD OF SOIL CLASSIFICATION

Explanation of USCS Method of Soil Classification

PROJECT NO.	DATE	FIGURE

BORING LOG EXPLANATION SHEET

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	
0								Bulk sample.
								Modified split-barrel drive sampler.
								No recovery with modified split-barrel drive sampler.
								Sample retained by others.
								Standard Penetration Test (SPT).
5								No recovery with a SPT.
			XX/XX					Shelby tube sample. Distance pushed in inches/length of sample recovered in inches.
								No recovery with Shelby tube sampler.
								Continuous Push Sample.
								Seepage.
10								Groundwater encountered during drilling.
								Groundwater measured after drilling.
							SM	<u>MAJOR MATERIAL TYPE (SOIL)</u>: Solid line denotes unit change.
							CL	Dashed line denotes material change.
15								Attitudes: Strike/Dip b: Bedding c: Contact j: Joint f: Fracture F: Fault cs: Clay Seam s: Shear bss: Basal Slide Surface sf: Shear Fracture sz: Shear Zone sbs: Shear Bedding Surface
20								The total depth line is a solid line that is drawn at the bottom of the boring.

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BORING LOG

Explanation of Boring Log Symbols

PROJECT NO.	DATE	FIGURE

Updated Nov. 2011

DATE DRILLED	9/28/15	BORING NO.	B-1
GROUND ELEVATION	2,696' ± (MSL)	SHEET 1 OF 1	
METHOD OF DRILLING	CME-45, 8" Hollow-Stem Auger (Southlands)		
DRIVE WEIGHT	140 lbs. (Automatic)	DROP	30"
SAMPLED BY	NAG	LOGGED BY NAG	REVIEWED BY DT

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 3 inches thick
							SC	ALLUVIUM: Reddish brown, dry, medium dense, clayey SAND; few gravel.
		■	26					
								Total Depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt conrete patched on 9/28/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
5								
10								
15								
20								

Ninyo & Moore

BORING LOG

Tucson Pavement Reconstruction Program - Calle Polar
Tucson, Arizona

PROJECT NO.	DATE	FIGURE
604817002	12/15	B-1

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONRETE: Approximately 4 inches thick.
							SP	FILL: Reddish brown, moist, loose, poorly graded SAND; trace gravel.
			35				SC	Light brown, dry, medium dense, clayey SAND.
								Total Depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt concrete patched on 9/28/15 shortly after completion of drilling.
5								Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.
								The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
10								
15								
20								

DATE DRILLED 9/28/15 BORING NO. B-2

GROUND ELEVATION 2,698' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-45, 8" Hollow Stem Auger (Southlands)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY NAG LOGGED BY NAG REVIEWED BY DT

Ninyo & Moore

BORING LOG

Tucson Pavement Reconstruction Program - Calle Polar
Tucson, Arizona

PROJECT NO.	DATE	FIGURE
604817002	12/15	B-2

APPENDIX B

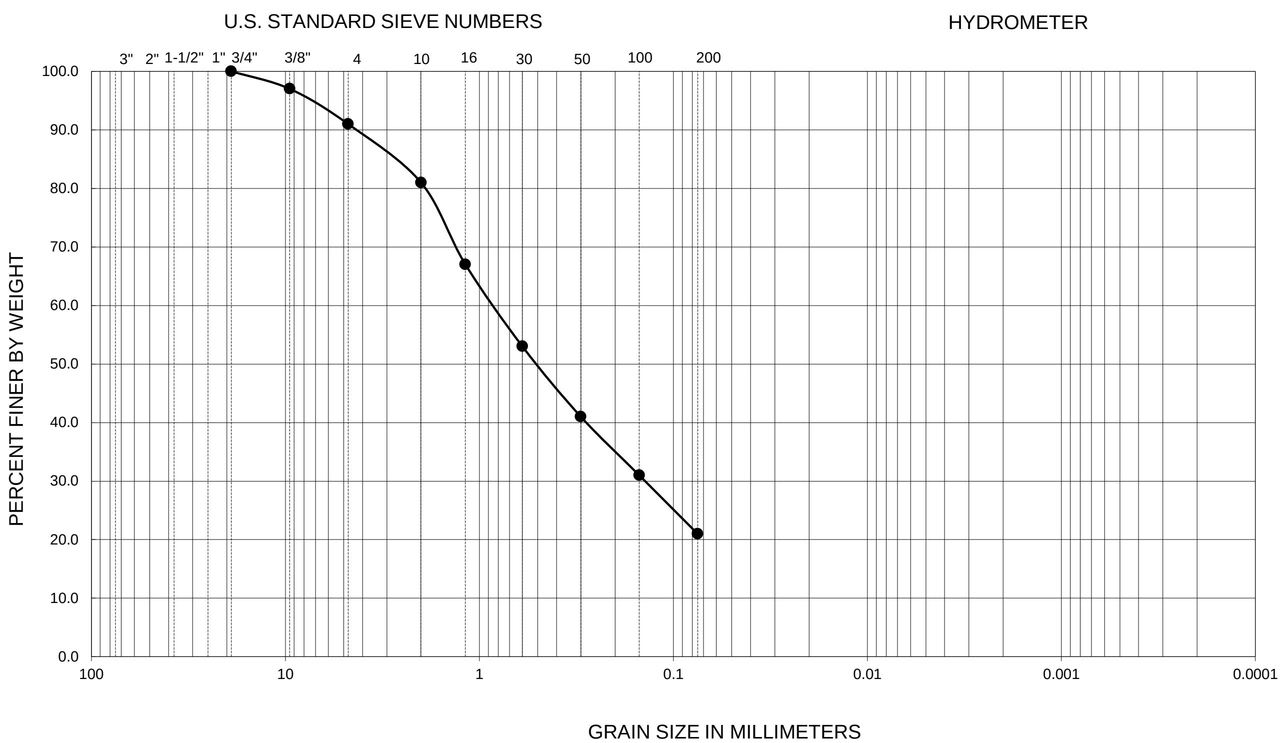
LABORATORY TESTING

Classification
Soils were visually and texturally classified in accordance with the Unified Soil Classification System (USCS) in general accordance with ASTM D 2488. Soil classifications are indicated on the logs of the exploratory borings in Appendix A.

Gradation Analysis
One gradation analysis test was performed on a selected representative soil sample in general accordance with ASTM D 422. The grain-size distribution curve is shown in Figure B-1. These test results were utilized in evaluating the soil classification in accordance with the USCS.

Atterberg Limits
Tests were performed on a selected representative fine-grained soil sample to evaluate the liquid limit, plastic limit, and plasticity index in general accordance with ASTM D 4318. These test results were utilized to evaluate the soil classification in accordance with the USCS. The test results and classifications are shown on Figure B-2.

<table>
<tr><td colspan="2">GRAVEL</td><td colspan="3">SAND</td><td colspan="2">FINES</td></tr>
<tr><td>Coarse</td><td>Fine</td><td>Coarse</td><td>Medium</td><td>Fine</td><td>SILT</td><td>CLAY</td></tr>
</table>

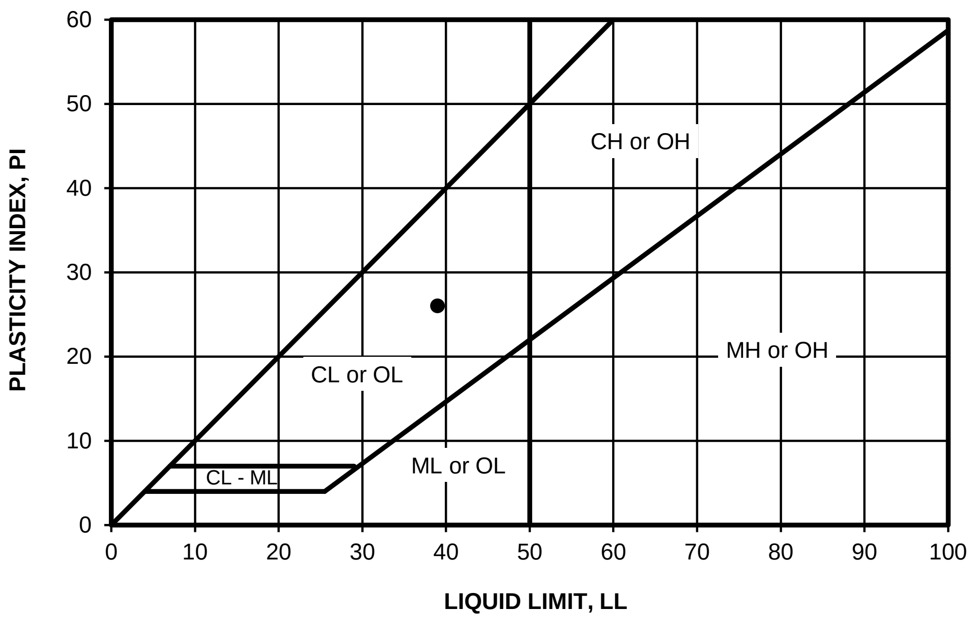


Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
●	B-1	1.5-3.0	39	13	26	--	--	--	--	--	21	SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore	GRADATION TEST RESULTS	FIGURE
PROJECT NO. / DATE	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - CALLE POLAR TUCSON, ARIZONA	B-1
604817001 / 12/15		

SYMBOL	LOCATION	DEPTH (FT)	LIQUID LIMIT, LL	PLASTIC LIMIT, PL	PLASTICITY INDEX, PI	USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve)	USCS (Entire Sample)
●	B-1	1.5-3.0	39	13	26	CL	SC



PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4318

Ninyo & Moore

ATTERBERG LIMITS TEST RESULTS

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - CALLE POLAR
TUCSON, ARIZONA

PROJECT NO.	DATE
604817001	12/15

FIGURE

B-2

APPENDIX C

PAVEMENT AND CORE SUMMARY

CALLE POLAR - PAVEMENT AND CORE SUMMARY

No.	Location	Approximate AC thickness (in)*	Recovered AC Thickness (in)	Core Description	Pavement Condition
B-1	SB, 440 ft north of Barrow Street	3	3	One lift, numerous voids.	Extensive alligator, longitudinal, transverse and block cracking, rutting along wheel paths, patches.
B-2	SB, 120 ft south of Barrow Street	4	4	Two lifts, 2" and 2", numerous voids.	Extensive alligator, longitudinal, transverse and block cracking, rutting along wheel paths, patches.

Notes:
* Measured in the boring

APPENDIX D

TRAFFIC DATA

Field Data Services of Arizona
21636 N. Dietz Dr.
Maricopa, AZ 85138
520.316.6745

Site Code: 15-1283-001
Station ID: Wed 10/14/2015
Calle Polar btwn. Nicaragua Dr. & Barrow St. 32.179560, -110.853668
Latitude: 0' 0.000 Undefined

Northbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/14/15	0	18	3	0	0	0	0	0	0	0	0	0	0	21
01:00	0	5	2	0	0	0	0	0	0	0	0	0	0	7
02:00	0	11	1	0	0	0	0	0	0	0	0	0	0	12
03:00	0	24	6	0	0	0	0	0	0	0	0	0	0	30
04:00	0	60	16	0	1	0	0	0	0	0	0	0	0	77
05:00	1	208	82	1	**4**	0	0	0	0	0	0	0	0	296
06:00	2	352	**122**	2	1	0	0	**2**	**2**	0	0	0	0	483
07:00	3	**499**	95	1	3	0	0	1	1	0	**2**	0	0	**605**
08:00	**4**	330	53	0	1	**1**	0	1	0	0	0	0	**1**	391
09:00	1	250	61	0	1	0	0	1	2	0	0	0	0	316
10:00	1	192	60	**3**	2	0	0	0	0	0	0	**1**	0	259
11:00	0	232	55	0	4	0	0	2	1	**1**	0	1	0	296
12 PM	0	207	47	3	3	2	0	0	0	1	0	0	1	264
13:00	0	**212**	**51**	2	4	3	0	**2**	1	**2**	1	**1**	1	**280**
14:00	1	209	49	1	1	1	0	1	1	0	**2**	0	**2**	268
15:00	1	191	43	**7**	0	1	0	0	0	1	1	0	1	246
16:00	1	182	39	3	0	0	0	1	**2**	0	1	0	0	229
17:00	1	199	34	1	**6**	1	0	0	0	0	0	1	1	244
18:00	**2**	162	31	4	0	**4**	0	0	0	0	0	0	0	203
19:00	0	114	20	1	3	1	0	0	1	0	0	0	0	140
20:00	0	60	13	1	0	0	0	0	0	0	0	0	0	74
21:00	0	47	5	2	1	0	0	0	0	0	0	0	0	55
22:00	0	47	2	0	0	0	0	0	0	0	0	0	0	49
23:00	0	22	6	0	0	0	0	0	0	0	0	0	0	28
Day Total	18	3833	896	32	35	14	0	11	11	5	7	4	7	4873
Percent	0.4%	78.7%	18.4%	0.7%	0.7%	0.3%	0.0%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	
AM Peak	08:00	07:00	06:00	10:00	05:00	08:00		06:00	06:00	11:00	07:00	10:00	08:00	07:00
Vol.	4	499	122	3	4	1		2	2	1	2	1	1	605
PM Peak	18:00	13:00	13:00	15:00	17:00	18:00		13:00	16:00	13:00	14:00	13:00	14:00	13:00
Vol.	2	212	51	7	6	4		2	2	2	2	1	2	280
Grand Total	18	3833	896	32	35	14	0	11	11	5	7	4	7	4873
Percent	0.4%	78.7%	18.4%	0.7%	0.7%	0.3%	0.0%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	

Field Data Services of Arizona
21636 N. Dietz Dr.
Maricopa, AZ 85138
520.316.6745

Site Code: 15-1283-001
Station ID: Wed 10/14/2015
Calle Polar btwn. Nicaragua Dr. & Barrow St. 32.179560, -110.853668
Latitude: 0' 0.000 Undefined

Southbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/14/15	0	31	11	0	0	0	0	0	0	0	0	0	0	42
01:00	0	18	1	0	0	0	0	0	0	0	0	0	0	19
02:00	0	18	3	0	0	0	0	0	0	0	0	0	0	21
03:00	1	14	3	0	0	0	0	0	0	0	0	0	0	18
04:00	0	21	7	0	0	0	0	0	0	0	0	0	0	28
05:00	0	52	18	1	1	0	**1**	0	0	0	0	0	0	73
06:00	1	95	33	3	3	0	0	0	2	0	0	1	**2**	140
07:00	0	145	43	**4**	0	**1**	1	1	0	0	0	0	1	196
08:00	1	134	27	2	1	0	1	0	**3**	**1**	0	0	0	170
09:00	0	153	30	2	0	0	0	1	2	0	0	**2**	1	191
10:00	0	191	39	2	1	0	1	**3**	2	0	1	0	1	241
11:00	**2**	**250**	**65**	1	**4**	1	0	2	1	0	**2**	0	1	**329**
12 PM	0	289	64	0	4	0	**1**	0	2	0	1	0	0	361
13:00	1	283	66	2	2	0	0	0	1	0	2	1	0	358
14:00	1	373	91	**4**	**6**	**1**	0	3	1	0	1	0	0	481
15:00	0	454	143	3	5	0	1	**4**	**5**	1	2	1	**2**	621
16:00	**2**	**580**	**156**	4	2	0	1	2	1	0	4	1	2	**755**
17:00	0	535	114	3	3	0	1	4	0	1	**5**	0	1	667
18:00	1	370	60	2	0	1	1	1	0	1	2	**2**	1	442
19:00	0	272	55	0	2	0	1	0	0	**2**	0	0	0	332
20:00	0	253	57	0	0	0	0	1	0	0	0	1	1	313
21:00	0	168	27	0	0	1	0	0	0	0	0	0	0	196
22:00	0	102	26	0	0	0	0	0	0	0	0	0	0	128
23:00	0	65	10	0	0	0	0	0	0	0	0	0	0	75
Day Total	10	4866	1149	33	34	5	10	22	20	6	20	9	13	6197
Percent	0.2%	78.5%	18.5%	0.5%	0.5%	0.1%	0.2%	0.4%	0.3%	0.1%	0.3%	0.1%	0.2%	
AM Peak	11:00	11:00	11:00	07:00	11:00	07:00	05:00	10:00	08:00	08:00	11:00	09:00	06:00	11:00
Vol.	2	250	65	4	4	1	1	3	3	1	2	2	2	329
PM Peak	16:00	16:00	16:00	14:00	14:00	14:00	12:00	15:00	15:00	19:00	17:00	18:00	15:00	16:00
Vol.	2	580	156	4	6	1	1	4	5	2	5	2	2	755
Grand Total	10	4866	1149	33	34	5	10	22	20	6	20	9	13	6197
Percent	0.2%	78.5%	18.5%	0.5%	0.5%	0.1%	0.2%	0.4%	0.3%	0.1%	0.3%	0.1%	0.2%	

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Latitude: 0' 0.000 Undefined

Northbound, Southbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/14/15	0	49	14	0	0	0	0	0	0	0	0	0	0	63
01:00	0	23	3	0	0	0	0	0	0	0	0	0	0	26
02:00	0	29	4	0	0	0	0	0	0	0	0	0	0	33
03:00	1	38	9	0	0	0	0	0	0	0	0	0	0	48
04:00	0	81	23	0	1	0	0	0	0	0	0	0	0	105
05:00	1	260	100	2	5	0	**1**	0	0	0	0	0	0	369
06:00	3	447	**155**	**5**	4	0	0	2	**4**	0	0	1	**2**	623
07:00	3	**644**	138	5	3	**1**	1	2	1	0	**2**	0	1	**801**
08:00	**5**	464	80	2	2	1	1	1	3	**1**	0	0	1	561
09:00	1	403	91	2	1	0	0	2	4	0	0	**2**	1	507
10:00	1	383	99	5	3	0	1	3	2	0	1	1	1	500
11:00	2	482	120	1	**8**	1	0	**4**	2	1	2	1	1	625
12 PM	0	496	111	3	7	2	**1**	0	2	1	1	0	1	625
13:00	1	495	117	4	6	3	0	2	2	**2**	3	**2**	1	638
14:00	2	582	140	5	7	2	0	**4**	2	0	3	0	2	749
15:00	1	645	186	**10**	5	1	1	4	**5**	2	3	1	**3**	867
16:00	**3**	**762**	**195**	7	2	0	1	3	3	0	**5**	1	2	**984**
17:00	1	734	148	4	**9**	1	1	4	0	1	5	1	2	911
18:00	3	532	91	6	0	**5**	1	1	0	1	2	2	1	645
19:00	0	386	75	1	5	1	1	0	1	2	0	0	0	472
20:00	0	313	70	1	0	0	0	1	0	0	0	1	1	387
21:00	0	215	32	2	1	1	0	0	0	0	0	0	0	251
22:00	0	149	28	0	0	0	0	0	0	0	0	0	0	177
23:00	0	87	16	0	0	0	0	0	0	0	0	0	0	103
Day Total	28	8699	2045	65	69	19	10	33	31	11	27	13	20	11070
Percent	0.3%	78.6%	18.5%	0.6%	0.6%	0.2%	0.1%	0.3%	0.3%	0.1%	0.2%	0.1%	0.2%	
AM Peak	08:00	07:00	06:00	06:00	11:00	07:00	05:00	11:00	06:00	08:00	07:00	09:00	06:00	07:00
Vol.	5	644	155	5	8	1	1	4	4	1	2	2	2	801
PM Peak	16:00	16:00	16:00	15:00	17:00	18:00	12:00	14:00	15:00	13:00	16:00	13:00	15:00	16:00
Vol.	3	762	195	10	9	5	1	4	5	2	5	2	3	984
Grand Total	28	8699	2045	65	69	19	10	33	31	11	27	13	20	11070
Percent	0.3%	78.6%	18.5%	0.6%	0.6%	0.2%	0.1%	0.3%	0.3%	0.1%	0.2%	0.1%	0.2%	

APPENDIX E

PAVEMENT OPTIMIZATION DESIGN ANALYSIS BY TENSAR

Tensar

SpectraPave4 PRO™
Pavement Optimization Design Analysis

Design Parameters for AASHTO (1993) Equation

Reliability (%)	= 95	Initial Serviceability	= 4.5
Standard Normal Deviate	= -1.645	Terminal Serviceability	= 2.5
Standard Deviation	= 0.4	Change in Serviceability	= 2

Aggregate fill shall conform to following requirement:

D50 <= 27mm (Base course)

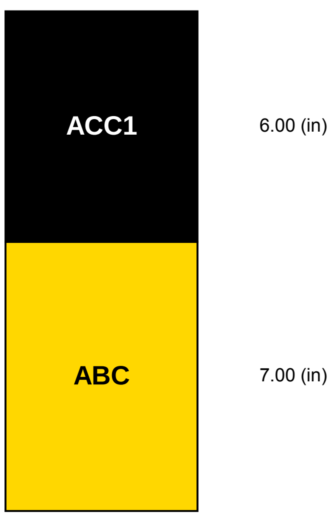
Unstabilized Section Material Properties

Layer	Description	Cost ($/ton)	Layer coefficient	Drainage factor
ACC1	Asphalt Wearing Course	70	0.440	N/A
ABC	Aggregate Base Course	20	0.140	1.25

Stabilized Section Material Properties

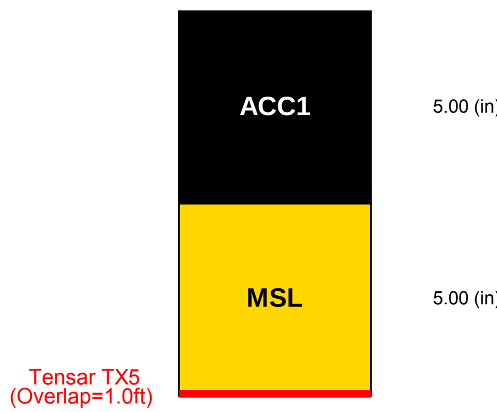
Layer	Description	Cost ($/ton)	Layer coefficient	Drainage factor
ACC1	Asphalt Wearing Course	70	0.440	N/A
MSL	Mechanically Stabilized Base Cour	20	0.286	1.25

Unstabilized Pavement



Subgrade Modulus = 10,844 (psi)
Structural Number = 3.865
Calculated Traffic (ESALs) = 4,763,000

Stabilized Pavement



Subgrade Modulus = 10,844 (psi)
Structural Number = 3.988
Calculated Traffic (ESALs) = 5,872,000

LIMITATIONS OF THE REPORT

The designs, illustrations, information and other content included in this report are necessarily general and conceptual in nature, and do not constitute engineering advice or any design intended for actual construction. Specific design recommendations can be provided as the project develops.

Project Name	Calle Polar		
Company Name	Tensar		
Designer	Schlessinger	Date	11/30/15

PAVEMENT EVALUATION
TUCSON PAVEMENT RECONSTRUCTION PROGRAM
ELM STREET
TUCSON, ARIZONA

PREPARED FOR:
Kimley-Horn & Associates, Inc.
333 East Wetmore Road, Suite 280
Tucson, Arizona 85705

PREPARED BY:
Ninyo & Moore
Geotechnical and Environmental Sciences Consultants
1991 East Ajo Way, Suite 145
Tucson, Arizona 85713

December 16, 2015
Project No. 604817002

December 16, 2015
Project No. 604817002

Mr. Rick Solis, P.E.
Kimley-Horn
333 East Wetmore Road, Suite 280
Tucson, Arizona 85705

Subject: Pavement Evaluation
Tucson Pavement Reconstruction Program – Elm Street
Tucson, Arizona

Dear Mr. Solis:

In accordance with our proposal dated August 12, 2015, and your authorization on September 21, 2015, Ninyo & Moore has performed a pavement evaluation for the above-referenced site. The attached report presents our methodology, findings, conclusions, and recommendations regarding the geotechnical conditions at the project site.

We appreciate the opportunity to be of service to you during this phase of the project.

Sincerely,
NINYO & MOORE

Registered Professional Engineer (Civil)
CERTIFICATE NO. 44704
MAREK J. KASZTALSKI
Date Signed 12.16.15
ARIZONA, U.S.A.
EXPIRES 9/30/18

Marek J. Kasztalski, PE, PMP, LEED AP
Senior Geotechnical Engineer

Fred Narcaroti
Principal/Tucson Office Manager

MJK/DT/FFN/tlp

Distribution: (1) Addressee (Electronic Copy)

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Tables

Figures

Appendices

1. INTRODUCTION

In accordance with our proposal dated August 12, 2015, and your authorization on September 21, 2015, we have performed a pavement evaluation for the Elm Street Pavement Reconstruction project between Tucson Boulevard and Country Club Road, in Tucson, Arizona. The purpose of our evaluation was to assess the pavement and subgrade conditions along the project alignment in order to provide geotechnical recommendations for design and construction. This report presents the results of our evaluation, conclusions, and recommendations regarding the proposed construction.

2. SCOPE OF SERVICES

The scope of our services generally included:

- Preparing a field testing plan and associated permit application for submittal to the City of Tucson (COT).
- Conducting a visual reconnaissance of the pavement along the alignment and marking out the boring locations.
- Notifying Arizona811 of our boring locations prior to conducting the field work.
- Arranging for traffic control measures to conduct the field work.
- Coring the existing asphaltic concrete (AC) pavement at three locations along the project alignment.
- Exploring the subsurface soils within the project limits by drilling, logging, and sampling three exploratory soil borings to approximate depths of 3 feet below ground surface (bgs). The boring logs are presented in Appendix A.
- Performing laboratory tests on selected samples collected from our borings to evaluate gradation and Atterberg limits. The results of the laboratory tests are included in Appendix B.
- Preparing this report presenting our findings, conclusions and recommendations regarding the proposed reconstruction.

Our scope of services did not include environmental consulting services such as hazardous waste sampling or analytical testing at the site. A detailed scope of services and estimated fee for such services can be provided upon request.

3. SITE DESCRIPTION

The project site is located in Section 5 of Township 14 South, Range 14 East relative to the Gila and Salt River Base Line and Meridian. The project alignment extends along Elm Street between Tucson Boulevard and Country Club Road in Tucson, Arizona (Figure 1).

At the time of our evaluation residential developments existed along the project alignment. The roadway section consisted of one travel lane in each direction, concrete curb and sidewalks along both sides of the roadway.

4. PROPOSED CONSTRUCTION

The COT has identified several segments of the existing street network for reconstruction and/or rehabilitation in fiscal year (FY) 2016 under Bid Package 2. The scope of this report includes Elm Street between Tucson Boulevard and Country Club Road. The project alignment is approximately 0.5-mile long.

We understand that the COT anticipates full-depth reconstruction of the existing roadway along the project alignment. The City proposes a new pavement section consisting of 3.5 inches of AC per of the COT Department of Transportation Standard Specifications Section 406 over 5 inches of aggregate base (AB) per Section 303 of the COT Standard Specifications.

We further understand that the COT intends to use Tucson Department of Transportation (TDOT) AC Mix No. 2 PG 76-22TR+ for the AC layer.

Due to conflicts with shallow utility lines, subgrade improvement by overexcavation will not be performed and the new pavement section will be constructed on subgrade improved with Geogrid (Tensar Geogrid TX5 or equivalent).

The scope of this exploration included evaluation of the existing pavement section and subgrade soils in order to provide recommendations for pavement reconstruction in accordance with the current COT practice. Calculations for the new pavement section supporting the new construction proposed by the COT are presented in Section 9.3 and in Appendix E of this report.

5. EXISTING PAVEMENT CONDITION

On September 30, 2015, Ninyo & Moore conducted a limited visual evaluation of the pavement surface along the project alignment. Based on our field observations, the AC pavement exhibited signs of severe distress in many locations along the project alignment primarily consisting of extensive alligator cracking and potholes. Asphaltic concrete patches were observed at some locations which were probably associated with past maintenance efforts (pothole and crack repairs) or with underground utility work. The crack widths generally varied between hairline (less than 1/8-inch) to one inch.

In our opinion, the distress observed along the project alignment indicates structural failure and is related to a combination of pavement age, subgrade condition, traffic, and environmental impacts.

6. FIELD EXPLORATION AND LABORATORY TESTING

On September 30, 2015, Ninyo & Moore conducted a geotechnical exploration in order to evaluate the subsurface conditions and collect AC cores and soil samples for laboratory testing. Our evaluation consisted of coring the existing AC pavement, drilling, logging, and sampling three small-diameter borings, denoted as B-1 through B-3, utilizing a CME-75 truck-mounted drill rig equipped with hollow-stem augers. The borings extended to depths of approximately 3 feet bgs. The approximate locations of the borings are depicted on Figure 2.

Ninyo & Moore personnel logged the borings in general accordance with the Unified Soil Classification System (USCS) and American Society for Testing and Materials (ASTM) D 2488 by observing cuttings and drive samples. Collected ring samples were trimmed in the field, wrapped in plastic bags, and placed in cylindrical plastic containers to retain in-place moisture conditions.

The soil samples collected from our drilling activities were transported to the Ninyo & Moore laboratory in Tucson, Arizona for geotechnical laboratory testing. The tests included gradation and Atterberg limits. A description of each laboratory test method and the test results are presented in Appendix B.

7. SUBSURFACE CONDITIONS

Our knowledge of the subsurface conditions at the project site is based on our field exploration, laboratory testing, and general experience in the area. More detailed stratigraphic information is presented on the boring logs in Appendix A, attached to this report. The boring logs contain our field and laboratory test results, as well as our interpretation of conditions believed to exist between actual samples retrieved. Therefore, these boring logs contain both factual and interpretive information. Lines delineating subsurface strata on the boring logs are intended to group soils having similar engineering properties and characteristics. They should be considered approximate as the actual transition between soil types (strata) may be gradual. A key to the soil symbols and terms used on the boring logs is provided in Appendix A.

7.1. Asphaltic Concrete

Asphaltic concrete pavement was encountered at the surface of each of our borings. The AC thickness varied between approximately 2 to 3 inches, in our borings. It should be noted that the thickness of the AC pavement between the sampling locations may vary and could be different from that encountered at our sampling locations. Detailed core descriptions are presented in Appendix C.

Aggregate base with an approximate thickness of 3 inches was encountered in our Borings B-2 and B-3 and was not observed in Boring B-1. It is possible the AB material blended with the native subgrade soils, such that delineation of the AB/subgrade interface was not easily interpreted.

7.2. Alluvium

Native alluvial soils were encountered below the pavement section, and extended to the boring termination depths. The alluvium generally consisted of medium dense to very dense, clayey and silty sands with varying amounts of gravel and scattered caliche cementation.

8. CONCLUSIONS

Based on the results of our visual and subsurface evaluations, laboratory testing, and data analysis, geotechnical considerations include the following:

- The on-site soils generally include clayey and silty sands, with a plasticity index (PI) value varying between 11 and 21. Many on-site soils may be sensitive to moisture content fluctuations and may be difficult to compact especially at higher moisture contents. The contractor should be aware of this condition.
- Due to the relatively widely spaced nature of our borings, soil conditions may differ from what was observed during our field exploration.
- The pavement exhibits significant distress in many locations along the project alignment consisting mainly of extensive alligator cracking.
- Full-depth pavement reconstruction is considered for this project as proposed by the COT.

9. RECOMMENDATIONS

The following sections present our geotechnical recommendations for the project. If the proposed construction is changed from that discussed in this report, Ninyo & Moore should be contacted for additional recommendations.

9.1. Recommended Pavement Structural Sections

The recommended pavement sections are presented in the table below:

Pavement Section	Service Life (years)	AC (in)[1]	AB (in)[2]
COT Preferred Pavement with Geogrid	20	3.5	5
Alternative Pavement Section without Geogrid	20	4	8

Notes:
[1] TDOT AC Mix No. 2 PG 76-22TR+ as the surface mix and TDOT AC Mix No. 1 PG 70-10 for the underlying layers per Section 406 of the COT Specifications.
[2] AB per Section 303 of the COT Specifications.

9.2. Earthwork

The following sections provide our earthwork recommendations for this project. In general, the earthwork specifications contained in the *City of Tucson/Pima County Standard Specifications for Public Improvements, 2003 Edition (COT/PC Specifications)* are expected to apply unless specifically noted.

9.2.1. Site Preparation

Construction areas should be cleared of deleterious materials, if any are present, including abandoned utilities, construction debris, vegetation, and any other material that might interfere with the performance or progress of the work. These materials should be disposed of at a legal dumpsite. Existing features that call for relocation or removal and extend below finish grade, if present, should be removed, and the resulting excavations backfilled with engineered fill.

9.2.2. Excavations

Our evaluation of the excavation characteristics of the on-site soils is based on the results of our exploratory borings, site observations, and experience with similar materials.

9.2.3. Fill Materials

Soils with PI values of 15 or less (as evaluated by ASTM D 4318) are generally suitable for use as engineered fill. Our Atterberg limits tests indicated PI values ranging between

11 and 21. Based on these test results, some of the on-site soils are not suitable for re-use as engineered fill.

Engineered fill should not include organic material, construction debris, or other non-soil fill materials. Rock particles and clay lumps should not be larger than 4 inches in dimension. Unsuitable material should be disposed of off-site or in non-structural areas.

9.2.4. Grading and Subgrade Preparation

In general, grading operations should be performed in accordance with Section 205 of the COT/PC Specifications.

Due to potential conflicts with underground utilities, we recommend that the subgrade be improved by the application of Geogrid (Tensar Geogrid TX5 or equivalent). Geogrid should be placed in accordance with the manufacturer's instructions.

Alternatively, if Geogrid is not applied we recommend new pavements be supported on 6 inches of subgrade that is compacted by appropriate mechanical methods to a relative compaction of 95 percent as evaluated by ASTM D 698 at a moisture content generally near optimum. The thickness of the improvement zone should be measured from the bottom of the AB layer.

In areas where excessive moisture is encountered so that the above compaction cannot be achieved and/or the subgrade surface is unstable and yielding (pumping) under the roller wheels, subgrade soils should be scarified to a depth of 12 inches, aerated, and re-compacted as specified above. Alternatively, subgrade soils in problem areas should be and replaced with engineered fill to a depth of 12 inches below the bottom of the AB.

9.3. Pavement Design Summary

The following sections present our design assumptions and recommendations for the new flexible pavement section of Elm Street between Tucson Boulevard and Country Club Road, as this roadway is scheduled for full-depth pavement reconstruction.

The pavement section was developed using the Active Practices Guidelines issued by the COT Department of Transportation (Guidelines) and the Arizona Department of Transportation (ADOT) Preliminary Engineering and Design Manual (PEDM). We assumed that the subgrade will be improved by the application of Geogrid or overexcavation, as outlined in Section 9.2.4 of this report. The new pavement sections are designed for a 20-year service life.

9.3.1. Traffic

The future traffic numbers used in this report are based on traffic counts provided by Kimley-Horn and Associates, Inc. (KHA), and later communication with the KHA. This information is presented in Appendix D. Based on the above information, and using the procedures outlined in the Guidelines and PEDM, the design number of equivalent single axle loads (ESALs) for the design lane during the 20-year design period was calculated as approximately 1,522,780.

9.3.2. R-Value and Resilient Modulus

The analysis for the design R-value for the pavement section has been performed based on procedures detailed in the Guidelines and the PEDM, using correlated R-values. The correlated R-values were derived from the PI and percent passing No. 200 Sieve test results. A summary of the R-values for this project is presented in Table 1 below:

Table 1 – R-value Summary

Location	Sample Depth (ft)	Correlated R-Value
B-1	1.5-3.0	28
B-3	1.5-3.0	59

In the interest of conservatism, we recommend that an R-value of 25 be used for pavement design for this project.

If the project needs fill from an off-site source, we recommend the soils used for subgrade support should have an R-value of 25 or more. If during construction, the subgrade is found to vary from the expected soil conditions, we should be contacted so we may re-evaluate our recommended R-values. Based on the above design R-values, the design subgrade resilient modulus (M_R) value of 10,844 pounds per square inch (psi) was calculated in accordance with the Guidelines.

9.3.3. Statistical Parameters

A standard deviation of 0.40 was used for design of the flexible pavement in accordance with the Guidelines. The level of reliability and standard normal deviation (Z_R) values were selected in accordance with the Guidelines for the collector/local functional classification. Their respective values are presented in the table below:

Table 2 – Summary of Statistical Parameters

Roadway	Functional Classification	Standard Deviation	Level of Reliability	Standard Normal Deviation
Elm Street	Collector/Local	0.40	90 %	-1.282

9.3.4. Serviceability Index

Initial and terminal serviceability indices were selected for the pavement design of the roadways in accordance with the Guidelines. A summary of the serviceability indices for each roadway is provided in the table below:

Table 3 – Summary of Serviceability Parameters

Roadway	Functional Classification	Initial Serviceability Index	Terminal Serviceability Index	Change in Serviceability
Elm Street	Collector/Local	4.5	2.5	2.0

9.3.5. Layer Coefficients

The following structural coefficients were used for the pavement structure in accordance with the Guidelines:

- AC: 0.44.
- AB: 0.14.

A drainage coefficient of 1.25 was used for the AB coefficient as recommended in the Guidelines.

As mentioned in Section 4 above, due to conflicts with existing shallow utilities, it is recommended that the subgrade be improved using Geogrid (Tensar Geogrid TX5 or equivalent). In this case the AB layer coefficient is 0.286.

9.3.6. Asphalt Pavement Section Recommendations

The structural number (SN) was calculated based on the parameters described above. The table below presents the calculated SN value and the recommended structural pavement sections. The AC thickness meets the COT requirements. Supporting documentation of the pavement optimization design using Geogrid is presented in Appendix E:

Table 4 – Structural Pavement Sections for 20-Year Design Life

Roadway	SN	AC (in)[1]	AB (in)[2]
COT Preferred Pavement with Geogrid	3.33	3.5	5
Alternative Pavement without Geogrid	3.08	4	8

Notes:
[1] TDOT AC Mix No. 2 PG 76-22TR+ per Section 406 of the COT Specifications.
[2] AB per Section 303 of the COT Specifications.

The above pavement structural section has been designed with the assumption that the subgrade is prepared by as recommended in Section 9.2.4.

10. SITE DRAINAGE

Surface drainage should be provided to divert water away from paved surfaces. Surface water should also not be permitted to pond on or below pavement areas. Positive drainage for this project is defined as a slope of 2 percent or more for a distance of 5 feet or more away from the pavements. To deter accumulation of water below the new pavement sections, the bottom of the overexcavated zone below the new pavement should be sloped toward the edges of the roadway.

11. PRE-CONSTRUCTION CONFERENCE

We recommend that a pre-construction conference be held. Representatives of the owner, the civil engineer, Ninyo & Moore, and the contractor should be in attendance to discuss the project plans and schedule. Our office should be notified if the project description included herein is incorrect or if the project characteristics are significantly changed.

12. CONSTRUCTION OBSERVATION AND TESTING

During construction operations, we recommend that Ninyo & Moore perform observation and testing services for the project. These services should be performed to evaluate exposed subgrade conditions, including the extent and depth of overexcavation, to evaluate the suitability of proposed borrow materials for use as engineered fill and to observe placement and test compaction of fill soils. Qualified subcontractors utilizing appropriate techniques and construction materials should perform construction of the proposed improvements.

13. LIMITATIONS

The field evaluation, laboratory testing, and geotechnical analyses presented in this geotechnical report have been conducted in general accordance with current practice and the standard of care exercised by geotechnical consultants performing similar tasks in the project area. No warranty, expressed or implied, is made regarding the conclusions, recommendations, and opinions presented in this report. There is no evaluation detailed enough to reveal every subsurface condition. Variations may exist and conditions not observed or described in this report may be encountered during construction. Uncertainties relative to subsurface conditions can be reduced through additional subsurface exploration. Additional subsurface evaluation will be performed upon request. Please also note that our evaluation was limited to assessment of the geotechnical aspects of the project, and did not include evaluation of structural issues, environmental concerns, or the presence of hazardous materials.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. Ninyo & Moore should be contacted if the reader requires additional information or has questions regarding the content, interpretations presented, or completeness of this document.

This report is intended for design purposes only. It does not provide sufficient data to prepare an accurate bid by contractors. It is suggested that the bidders and their geotechnical consultant perform an independent evaluation of the subsurface conditions in the project areas. The independent evaluations may include, but not be limited to, review of other geotechnical reports prepared for the adjacent areas, site reconnaissance, and additional exploration and laboratory testing.

Our conclusions, recommendations, and opinions are based on an analysis of the observed site conditions. If geotechnical conditions different from those described in this report are encountered, our office should be notified and additional recommendations, if warranted, will be provided upon request. It should be understood that the conditions of a site could change with time as a result of natural processes or the activities of man at the subject site or nearby sites. In addition, changes to the applicable laws, regulations, codes, and standards of practice may occur due to government action or the broadening of knowledge. The findings of this report may, therefore, be invalidated over time, in part or in whole, by changes over which Ninyo & Moore has no control.

This report is intended exclusively for use by the client. Any use or reuse of the findings, conclusions, and/or recommendations of this report by parties other than the client is undertaken at said parties' sole risk.

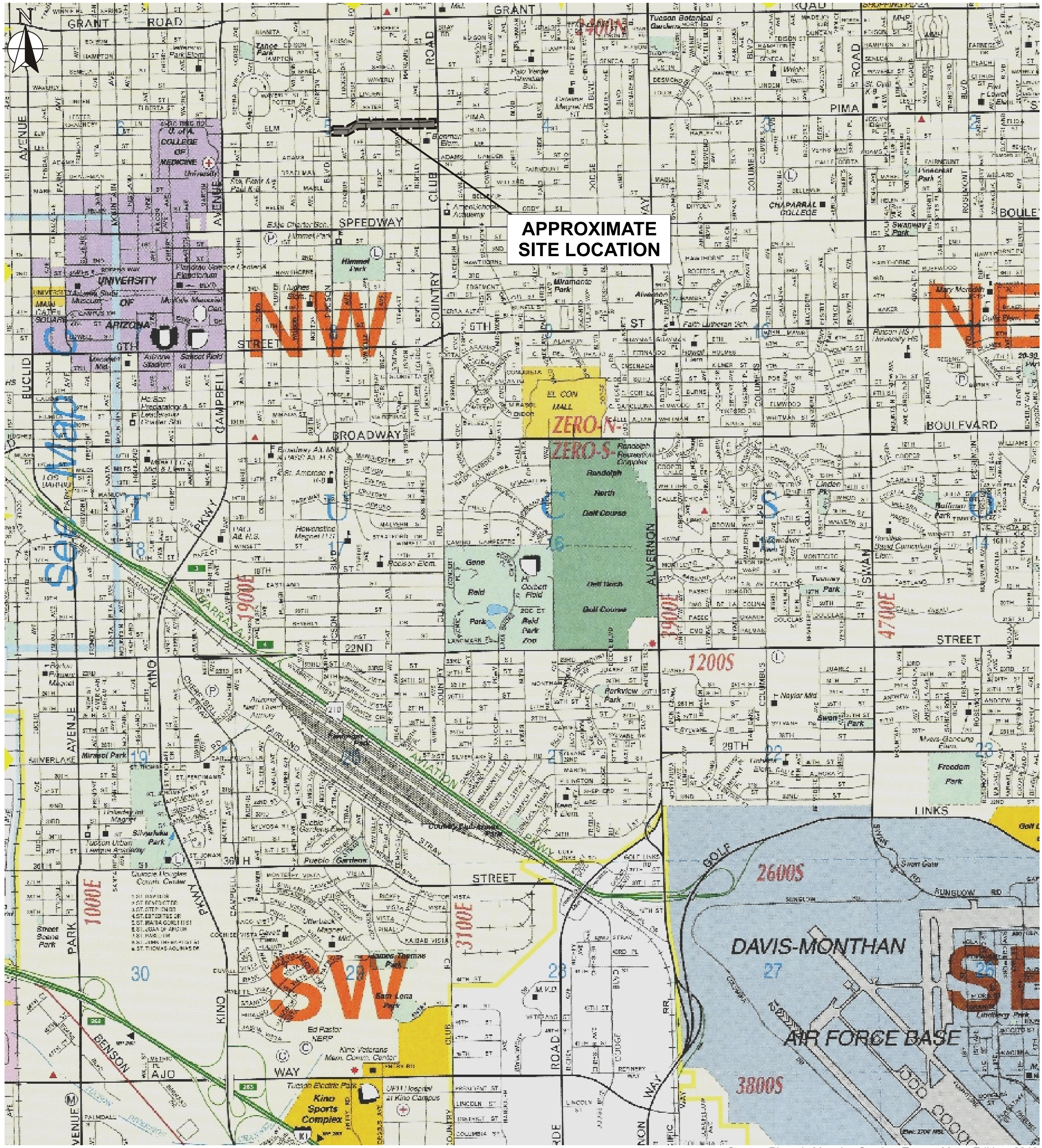
14. REFERENCES

American Society for Testing and Materials (ASTM), Annual Book of ASTM Standards.

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

City of Tucson, Arizona, Department of Transportation, Engineering Division, 1987, Active Practices Guidelines: dated June 1.

Ninyo & Moore, In-house proprietary information.



Source: Phoenix Mapping Service, Tucson Metro Edition, 2012.

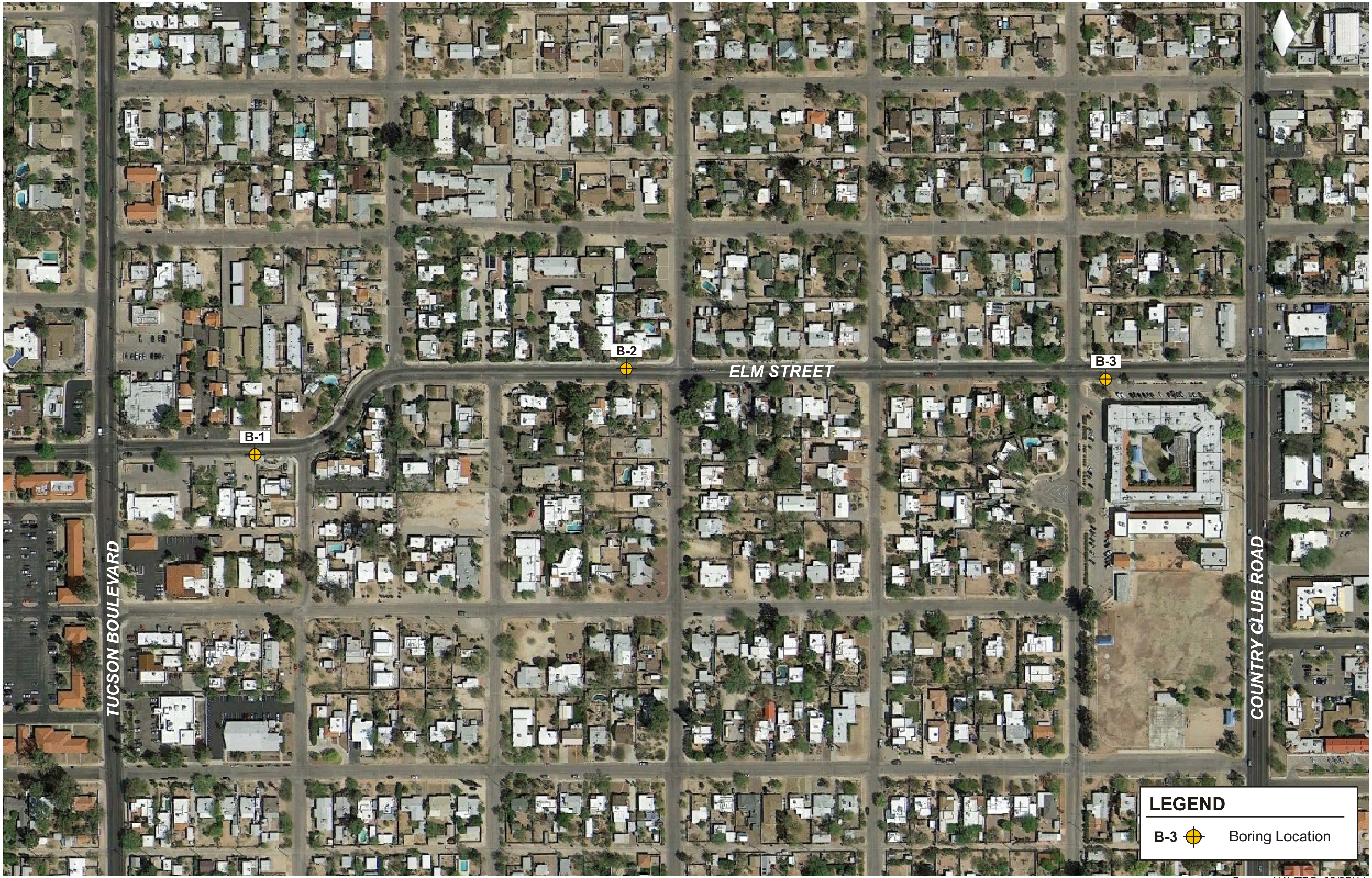
0 3300

Approximate Scale:
1 inch = 3300 feet

Note: Dimensions, directions, and locations are approximate.

Ninyo & Moore	SITE LOCATION		FIGURE
PROJECT NO: 604817002	DATE: 12/15	TUCSON PAVEMENT RECONSTRUCTION - ELM STREET TUCSON, ARIZONA	1

file no: 4817vmap1015e



Source: NAVTEQ, 03/27/14.

N

0 300

Approximate Scale:
1 inch = 300 feet

Note: Dimensions, directions, and locations are approximate.

file no: 4817blm1015e

Ninyo & Moore		BORING LOCATIONS	FIGURE 2
PROJECT NO: 604817002	DATE: 12/15	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ELM STREET TUCSON, ARIZONA	

APPENDIX A

BORING LOGS

Field Procedure for the Collection of Relatively Undisturbed Samples

Relatively undisturbed soil samples were obtained in the field using the following methods.

The Modified Split-Barrel Drive Sampler

The sampler, with an external diameter of 3.0 inches, was lined with 1-inch long, thin brass rings with inside diameters of approximately 2.4 inches. The sample barrel was driven into the ground with the weight of a hammer or the Kelly bar of the drill rig in general accordance with ASTM D 3550. The driving weight was permitted to fall freely. The approximate length of the fall, the weight of the hammer or bar, and the number of blows per foot of driving are presented on the boring logs as an index to the relative resistance of the materials sampled. The samples were removed from the sample barrel in the brass rings, sealed, and transported to the laboratory for testing.

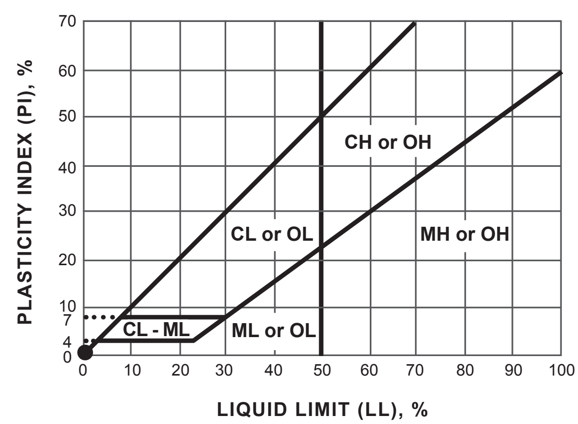
SOIL CLASSIFICATION CHART PER ASTM D 2488

PRIMARY DIVISIONS			SECONDARY DIVISIONS	
			GROUP SYMBOL	GROUP NAME
COARSE-GRAINED SOILS more than 50% retained on No. 200 sieve	GRAVEL more than 50% of coarse fraction retained on No. 4 sieve	CLEAN GRAVEL less than 5% fines	GW	well-graded GRAVEL
			GP	poorly graded GRAVEL
		GRAVEL with DUAL CLASSIFICATIONS 5% to 12% fines	GW-GM	well-graded GRAVEL with silt
			GP-GM	poorly graded GRAVEL with silt
			GW-GC	well-graded GRAVEL with clay
			GP-GC	poorly graded GRAVEL with clay
		GRAVEL with FINES more than 12% fines	GM	silty GRAVEL
			GC	clayey GRAVEL
			GC-GM	silty, clayey GRAVEL
	SAND 50% or more of coarse fraction passes No. 4 sieve	CLEAN SAND less than 5% fines	SW	well-graded SAND
			SP	poorly graded SAND
		SAND with DUAL CLASSIFICATIONS 5% to 12% fines	SW-SM	well-graded SAND with silt
			SP-SM	poorly graded SAND with silt
			SW-SC	well-graded SAND with clay
			SP-SC	poorly graded SAND with clay
		SAND with FINES more than 12% fines	SM	silty SAND
			SC	clayey SAND
			SC-SM	silty, clayey SAND
FINE-GRAINED SOILS 50% or more passes No. 200 sieve	SILT and CLAY liquid limit less than 50%	INORGANIC	CL	lean CLAY
			ML	SILT
			CL-ML	silty CLAY
		ORGANIC	OL (PI > 4)	organic CLAY
			OL (PI < 4)	organic SILT
	SILT and CLAY liquid limit 50% or more	INORGANIC	CH	fat CLAY
			MH	elastic SILT
		ORGANIC	OH (plots on or above "A"-line)	organic CLAY
			OH (plots below "A"-line)	organic SILT
	Highly Organic Soils		PT	Peat

GRAIN SIZE

DESCRIPTION		SIEVE SIZE	GRAIN SIZE	APPROXIMATE SIZE
Boulders		> 12"	> 12"	Larger than basketball-sized
Cobbles		3 - 12"	3 - 12"	Fist-sized to basketball-sized
Gravel	Coarse	3/4 - 3"	3/4 - 3"	Thumb-sized to fist-sized
	Fine	#4 - 3/4"	0.19 - 0.75"	Pea-sized to thumb-sized
Sand	Coarse	#10 - #4	0.079 - 0.19"	Rock-salt-sized to pea-sized
	Medium	#40 - #10	0.017 - 0.079"	Sugar-sized to rock-salt-sized
	Fine	#200 - #40	0.0029 - 0.017"	Flour-sized to sugar-sized
Fines		Passing #200	< 0.0029"	Flour-sized and smaller

PLASTICITY CHART



APPARENT DENSITY - COARSE-GRAINED SOIL

APPARENT DENSITY	SPOOLING CABLE OR CATHEAD		AUTOMATIC TRIP HAMMER	
	SPT (blows/foot)	MODIFIED SPLIT BARREL (blows/foot)	SPT (blows/foot)	MODIFIED SPLIT BARREL (blows/foot)
Very Loose	≤ 4	≤ 8	≤ 3	≤ 5
Loose	5 - 10	9 - 21	4 - 7	6 - 14
Medium Dense	11 - 30	22 - 63	8 - 20	15 - 42
Dense	31 - 50	64 - 105	21 - 33	43 - 70
Very Dense	> 50	> 105	> 33	> 70

CONSISTENCY - FINE-GRAINED SOIL

CONSIS-TENCY	SPOOLING CABLE OR CATHEAD		AUTOMATIC TRIP HAMMER	
	SPT (blows/foot)	MODIFIED SPLIT BARREL (blows/foot)	SPT (blows/foot)	MODIFIED SPLIT BARREL (blows/foot)
Very Soft	< 2	< 3	< 1	< 2
Soft	2 - 4	3 - 5	1 - 3	2 - 3
Firm	5 - 8	6 - 10	4 - 5	4 - 6
Stiff	9 - 15	11 - 20	6 - 10	7 - 13
Very Stiff	16 - 30	21 - 39	11 - 20	14 - 26
Hard	> 30	> 39	> 20	> 26

Ninyo & Moore

USCS METHOD OF SOIL CLASSIFICATION

Explanation of USCS Method of Soil Classification

PROJECT NO.	DATE	FIGURE

BORING LOG EXPLANATION SHEET

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	
0								Bulk sample.
								Modified split-barrel drive sampler.
								No recovery with modified split-barrel drive sampler.
								Sample retained by others.
								Standard Penetration Test (SPT).
5								No recovery with a SPT.
			XX/XX					Shelby tube sample. Distance pushed in inches/length of sample recovered in inches.
								No recovery with Shelby tube sampler.
								Continuous Push Sample.
								Seepage.
10								Groundwater encountered during drilling.
								Groundwater measured after drilling.
							SM	MAJOR MATERIAL TYPE (SOIL): Solid line denotes unit change.
							CL	Dashed line denotes material change.
								Attitudes: Strike/Dip b: Bedding c: Contact j: Joint f: Fracture F: Fault cs: Clay Seam s: Shear bss: Basal Slide Surface sf: Shear Fracture sz: Shear Zone sbs: Shear Bedding Surface
15								
								The total depth line is a solid line that is drawn at the bottom of the boring.
20								

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BORING LOG

Explanation of Boring Log Symbols

PROJECT NO.	DATE	FIGURE

Updated Nov. 2011

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DATE DRILLED 9/30/15 BORING NO. B-1 GROUND ELEVATION 2,440' ± (MSL) SHEET 1 OF 1 METHOD OF DRILLING CME-75, 8" Hollow Stem Auger (Southlands) DRIVE WEIGHT 140 lbs. (Automatic) DROP 30" SAMPLED BY DM LOGGED BY DM REVIEWED BY DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 3 inches thick.
							SC	ALLUVIUM: Brown, dry, medium dense, clayey SAND; few gravel; numerous caliche nodules.
			21					
								Total Depth = 3 feet. Groundwater not encountered during drilling.
								Backfilled and asphalt concrete patched on 9/30/15 shortly after completion of drilling.
5								Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.
								The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
10								
15								
20								

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ELM STREET
TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-1

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.
0							
			50/4"				SW-SM
5							
10							
15							
20							

DATE DRILLED 9/30/15 BORING NO. B-2

GROUND ELEVATION 2,447' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Hollow Stem Auger (Southlands)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY

DESCRIPTION/INTERPRETATION

ASPHALT CONCRETE: Approximately 2 inches thick.

AGGREGATE BASE: Approximately 3 inches thick.

ALLUVIUM:
Light brown, dry, very dense, well-graded SAND with silt; with gravel; numerous caliche nodules, moderate cementation.

Total Depth = 3 feet.
Groundwater not encountered during drilling.

Backfilled and asphalt concrete patched on 9/30/15 shortly after completion of drilling.

Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ELM STREET
TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-2

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DATE DRILLED 9/30/15 BORING NO. B-3 GROUND ELEVATION 2,455' ± (MSL) SHEET 1 OF 1 METHOD OF DRILLING CME-75, 8" Hollow Stem Auger (Southlands) DRIVE WEIGHT 140 lbs. (Automatic) DROP 30" SAMPLED BY DM LOGGED BY DM REVIEWED BY DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 2 1/2 inches thick.
							SW-SM	AGGREGATE BASE: Approximately 3 inches thick.
			70					ALLUVIUM: Light brown, dry, dense, well-graded SAND with silt; with gravel, numerous caliche nodules.
5								Total Depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt concrete patched on 9/30/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
10								
15								
20								

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ELM STREET
TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-3

APPENDIX B

LABORATORY TESTING

Classification

Soils were visually and texturally classified in accordance with the Unified Soil Classification System (USCS) in general accordance with ASTM D 2488. Soil classifications are indicated on the logs of the exploratory borings in Appendix A.

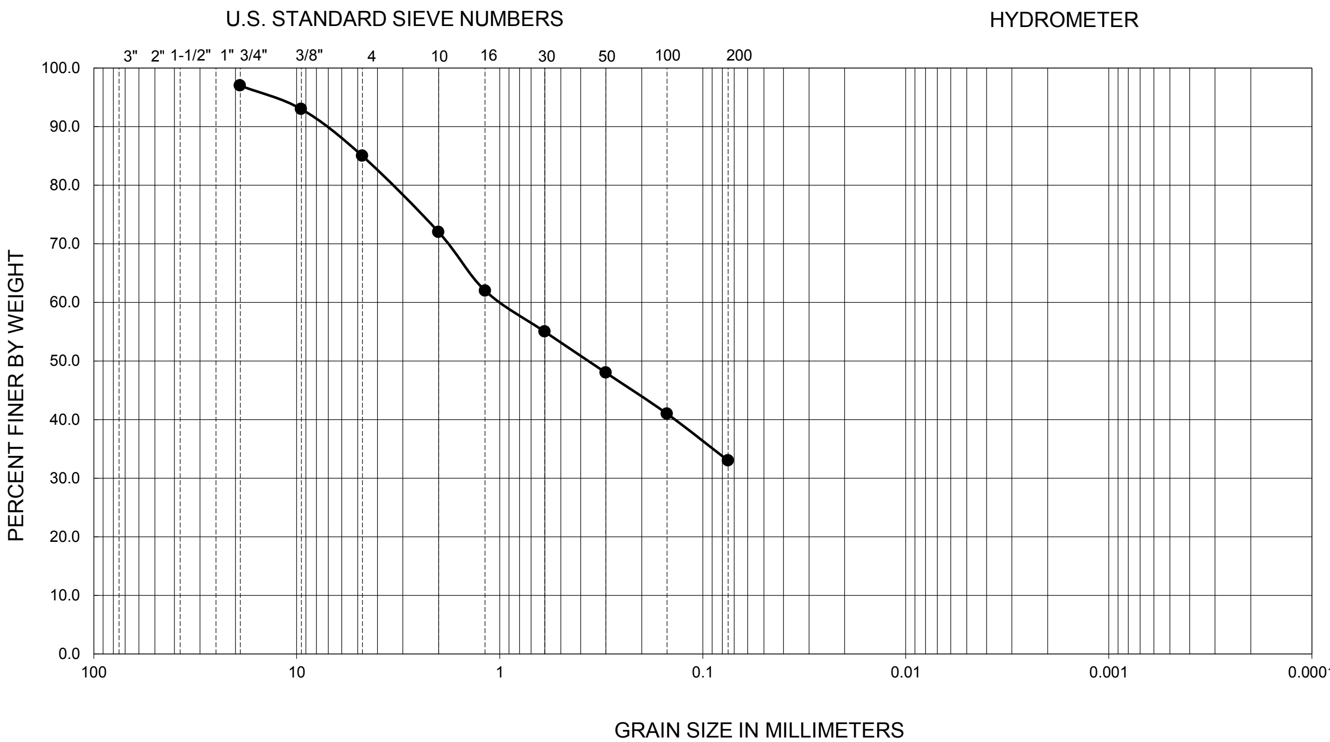
Gradation Analysis

One gradation analysis test was performed on a selected representative soil sample in general accordance with ASTM D 422. The grain-size distribution curves are shown in Figures B-1 and B-2. These test results were utilized in evaluating the soil classification in accordance with the USCS.

Atterberg Limits

Tests were performed on a selected representative fine-grained soil sample to evaluate the liquid limit, plastic limit, and plasticity index in general accordance with ASTM D 4318. These test results were utilized to evaluate the soil classification in accordance with the USCS. The test results and classifications are shown on Figure B-3.

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY

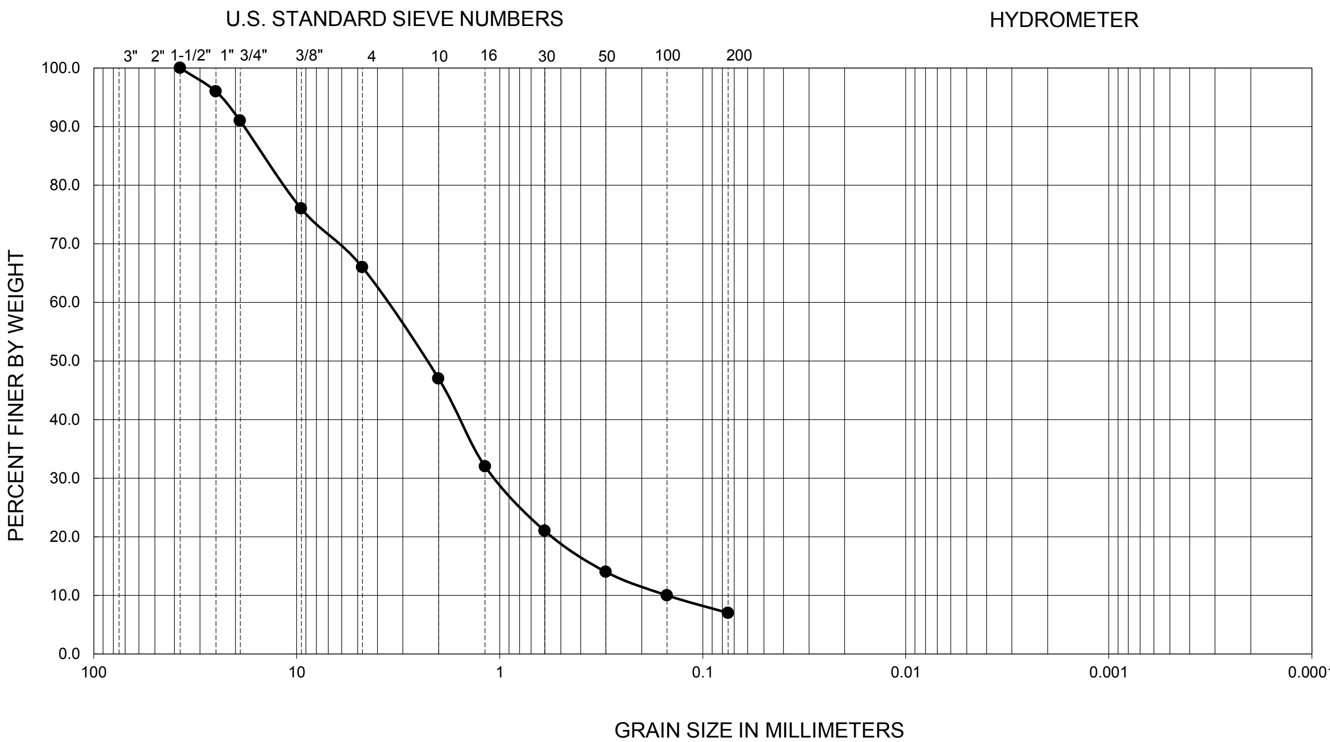


Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
●	B-1	1.5-3.0	43	22	21	--	--	--	--	--	33	SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore		GRADATION TEST RESULTS	FIGURE
PROJECT NO.	DATE	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ELM STREET TUCSON, ARIZONA	B-1
604817002	12/15		

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
●	B-3	1.5-3.0	44	33	11	0.15	1.10	3.60	24.0	2.2	7	SW-SM

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore

GRADATION TEST RESULTS

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ELM STREET
TUCSON, ARIZONA

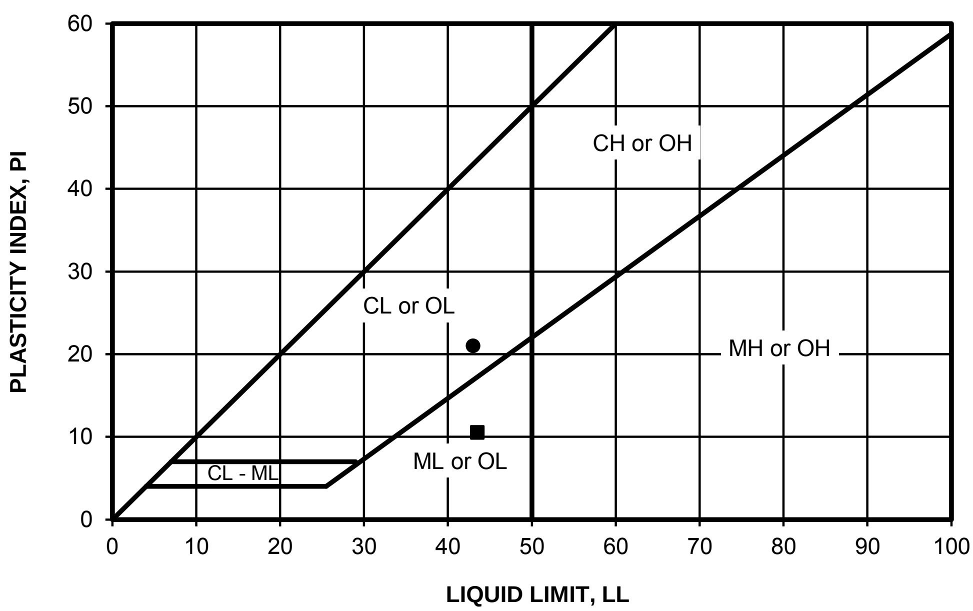
FIGURE

B-2

PROJECT NO.	DATE
604817002	12/15

SYMBOL	LOCATION	DEPTH (FT)	LIQUID LIMIT, LL	PLASTIC LIMIT, PL	PLASTICITY INDEX, PI	USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve)	USCS (Entire Sample)
●	B-1	1.5-3.0	43	22	21	CL	SC
■	B-3	1.5-3.0	44	33	11	ML	SW-SM

NP - INDICATES NON-PLASTIC



PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4318

Ninyo & Moore		ATTERBERG LIMITS TEST RESULTS	FIGURE
PROJECT NO.	DATE	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ELM STREET TUCSON, ARIZONA	B-3
604817002	12/15		

APPENDIX C

PAVEMENT AND CORE SUMMARY

ELM STREET - PAVEMENT AND CORE SUMMARY

No.	Location	Approximate AC thickness (in)*	Recovered AC Thickness (in)	Core Description	Pavement Condition
B-1	Eastbound, 290 feet east of Tucson Boulevard	3	3	Two lifts, 1" and 2", few voids, crack thoughout core.	Extensive alligator and irregular cracking, potholes, patches.
B-2	Westbound, 120 feet west of Treat Avenue	2	2	Two lifts, 1" and 1", bottom lift decomposed, numerous voids.	Extensive alligator and irregular cracking, potholes, patches.
B-3	Eastbound, 310 feet west of Country Club Road	2.5	2.5	Two lifts, 1" and 1.5", numerous voids.	Extensive alligator and irregular cracking, potholes, patches.

Notes:

* Measured in the boring

APPENDIX D

TRAFFIC DATA

Field Data Services of Arizona
21636 N. Dietz Dr.
Maricopa, AZ 85138
520.316.6745

Site Code: 15-1283-007
Station ID: Wed 10/07/2015
Elm St. btwn. Bentley Ave. & Country Club Rd. 32.243187 -110.927567
Latitude: 0' 0.000 Undefined

Eastbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/7/15	0	2	2	0	2	0	0	0	0	0	0	0	0	6
01:00	0	4	1	0	0	0	0	0	0	0	0	0	0	5
02:00	0	1	2	0	0	0	0	0	0	0	0	0	0	3
03:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04:00	0	2	1	0	0	0	0	**1**	0	0	0	0	0	4
05:00	0	7	2	0	3	0	0	0	0	0	0	0	0	12
06:00	**1**	20	10	2	2	0	0	0	0	0	0	0	0	35
07:00	0	47	33	**3**	4	0	0	0	0	0	0	0	0	87
08:00	0	**85**	**35**	1	**6**	**2**	**2**	1	0	0	0	0	0	**132**
09:00	1	61	22	2	1	0	0	0	0	0	0	0	0	87
10:00	1	49	21	2	4	1	0	1	0	0	0	0	0	79
11:00	0	60	23	3	2	0	0	0	0	0	0	0	0	88
12 PM	0	70	29	2	5	0	0	0	0	0	0	0	0	106
13:00	1	93	**55**	**4**	6	0	0	0	0	0	0	0	0	159
14:00	1	77	41	2	4	2	0	0	0	0	0	0	0	127
15:00	1	124	43	2	**10**	2	0	0	0	0	0	0	0	182
16:00	2	143	49	2	5	1	**1**	0	0	**1**	0	0	0	204
17:00	**7**	**161**	53	1	9	**3**	1	0	0	0	0	0	0	**235**
18:00	1	77	23	2	8	0	0	0	0	0	0	0	0	111
19:00	0	39	20	1	3	0	0	0	0	0	0	0	0	63
20:00	0	37	16	0	6	0	0	0	0	0	0	0	0	59
21:00	1	26	8	0	2	0	0	0	0	0	0	0	0	37
22:00	0	18	1	0	0	0	0	0	0	0	0	0	0	19
23:00	0	9	2	0	0	0	0	0	0	0	0	0	0	11
Day Total	17	1212	492	29	82	11	4	3	0	1	0	0	0	1851
Percent	0.9%	65.5%	26.6%	1.6%	4.4%	0.6%	0.2%	0.2%	0.0%	0.1%	0.0%	0.0%	0.0%	
AM Peak	06:00	08:00	08:00	07:00	08:00	08:00	08:00	04:00						08:00
Vol.	1	85	35	3	6	2	2	1						132
PM Peak	17:00	17:00	13:00	13:00	15:00	17:00	16:00			16:00				17:00
Vol.	7	161	55	4	10	3	1			1				235
Grand Total	17	1212	492	29	82	11	4	3	0	1	0	0	0	1851
Percent	0.9%	65.5%	26.6%	1.6%	4.4%	0.6%	0.2%	0.2%	0.0%	0.1%	0.0%	0.0%	0.0%	

Field Data Services of Arizona
21636 N. Dietz Dr.
Maricopa, AZ 85138
520.316.6745

Site Code: 15-1283-007
Station ID: Wed 10/07/2015
Elm St. btwn. Bentley Ave. & Country Club Rd. 32.243187 -110.927567
Latitude: 0' 0.000 Undefined

Westbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/7/15	0	8	0	0	0	0	0	0	0	0	0	0	0	8
01:00	0	2	1	0	0	0	0	0	0	0	0	0	0	3
02:00	0	0	2	0	0	0	0	0	0	0	0	0	0	2
03:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04:00	0	5	0	0	1	0	0	0	0	0	0	0	0	6
05:00	0	13	7	0	1	0	0	0	0	0	0	0	0	21
06:00	0	57	9	2	4	0	0	0	0	0	0	0	0	72
07:00	**1**	149	28	**6**	14	0	0	0	0	0	0	0	0	198
08:00	1	**181**	**40**	2	**16**	0	**1**	0	0	0	0	0	0	**241**
09:00	1	100	16	2	14	0	0	0	0	0	0	0	0	133
10:00	0	81	23	2	12	0	0	0	0	0	0	0	0	118
11:00	0	108	13	3	6	0	0	0	0	0	0	0	0	130
12 PM	0	95	21	**2**	**16**	0	0	0	0	0	0	0	0	134
13:00	**2**	107	26	2	14	0	0	**1**	0	0	0	0	0	152
14:00	0	83	20	1	10	0	0	0	0	0	0	0	0	114
15:00	1	105	27	2	10	0	0	0	0	0	0	0	0	145
16:00	2	**160**	**37**	2	14	0	0	1	0	0	0	0	0	**216**
17:00	1	158	17	1	10	0	0	0	0	0	0	0	0	187
18:00	0	96	15	1	11	0	0	0	0	0	0	0	0	123
19:00	0	56	8	0	3	0	0	0	0	0	0	0	0	67
20:00	0	47	6	0	2	0	0	0	0	0	0	0	0	55
21:00	0	35	6	0	2	0	0	0	0	0	0	0	0	43
22:00	1	15	3	0	1	0	0	0	0	0	0	0	0	20
23:00	0	7	1	0	0	0	0	0	0	0	0	0	0	8
Day Total	10	1668	326	28	161	0	1	2	0	0	0	0	0	2196
Percent	0.5%	76.0%	14.8%	1.3%	7.3%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	
AM Peak	07:00	08:00	08:00	07:00	08:00		08:00							08:00
Vol.	1	181	40	6	16		1							241
PM Peak	13:00	16:00	16:00	12:00	12:00			13:00						16:00
Vol.	2	160	37	2	16			1						216
Grand Total	10	1668	326	28	161	0	1	2	0	0	0	0	0	2196
Percent	0.5%	76.0%	14.8%	1.3%	7.3%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	

Field Data Services of Arizona
21636 N. Dietz Dr.
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Site Code: 15-1283-007
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Elm St. btwn. Bentley Ave. & Country Club Rd. 32.243187 -110.927567
Latitude: 0' 0.000 Undefined

Eastbound, Westbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/7/15	0	10	2	0	2	0	0	0	0	0	0	0	0	14
01:00	0	6	2	0	0	0	0	0	0	0	0	0	0	8
02:00	0	1	4	0	0	0	0	0	0	0	0	0	0	5
03:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04:00	0	7	1	0	1	0	0	**1**	0	0	0	0	0	10
05:00	0	20	9	0	4	0	0	0	0	0	0	0	0	33
06:00	1	77	19	4	6	0	0	0	0	0	0	0	0	107
07:00	1	196	61	**9**	18	0	0	0	0	0	0	0	0	285
08:00	1	**266**	**75**	3	**22**	**2**	**3**	1	0	0	0	0	0	**373**
09:00	**2**	161	38	4	15	0	0	0	0	0	0	0	0	220
10:00	1	130	44	4	16	1	0	1	0	0	0	0	0	197
11:00	0	168	36	6	8	0	0	0	0	0	0	0	0	218
12 PM	0	165	50	4	**21**	0	0	0	0	0	0	0	0	240
13:00	3	200	81	**6**	20	0	0	**1**	0	0	0	0	0	311
14:00	1	160	61	3	14	2	0	0	0	0	0	0	0	241
15:00	2	229	70	4	20	2	0	0	0	0	0	0	0	327
16:00	4	303	**86**	4	19	1	**1**	1	0	**1**	0	0	0	420
17:00	**8**	**319**	70	2	19	**3**	1	0	0	0	0	0	0	**422**
18:00	1	173	38	3	19	0	0	0	0	0	0	0	0	234
19:00	0	95	28	1	6	0	0	0	0	0	0	0	0	130
20:00	0	84	22	0	8	0	0	0	0	0	0	0	0	114
21:00	1	61	14	0	4	0	0	0	0	0	0	0	0	80
22:00	1	33	4	0	1	0	0	0	0	0	0	0	0	39
23:00	0	16	3	0	0	0	0	0	0	0	0	0	0	19
Day Total	27	2880	818	57	243	11	5	5	0	1	0	0	0	4047
Percent	0.7%	71.2%	20.2%	1.4%	6.0%	0.3%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	
AM Peak	09:00	08:00	08:00	07:00	08:00	08:00	08:00	04:00						08:00
Vol.	2	266	75	9	22	2	3	1						373
PM Peak	17:00	17:00	16:00	13:00	12:00	17:00	16:00	13:00		16:00				17:00
Vol.	8	319	86	6	21	3	1	1		1				422
Grand Total	27	2880	818	57	243	11	5	5	0	1	0	0	0	4047
Percent	0.7%	71.2%	20.2%	1.4%	6.0%	0.3%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	

APPENDIX E

PAVEMENT OPTIMIZATION DESIGN ANALYSIS BY TENSAR

Standard Asphalt Pavement - TWH Edition - 20151207

Tensar

SpectraPave4 PRO™
Pavement Optimization Design Analysis

Design Parameters for AASHTO (1993) Equation

Reliability (%)	= 90	Initial Serviceability	= 4.5
Standard Normal Deviate	= -1.282	Terminal Serviceability	= 2.5
Standard Deviation	= 0.45	Change in Serviceability	= 2

Aggregate fill shall conform to following requirement:

D50 <= 27mm (Base course)

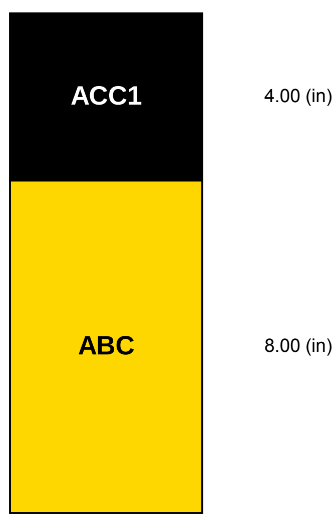
Unstabilized Section Material Properties

Layer	Description	Cost ($/ton)	Layer coefficient	Drainage factor
ACC1	Asphalt Wearing Course	70	0.440	N/A
ABC	Aggregate Base Course	20	0.140	1.25

Stabilized Section Material Properties

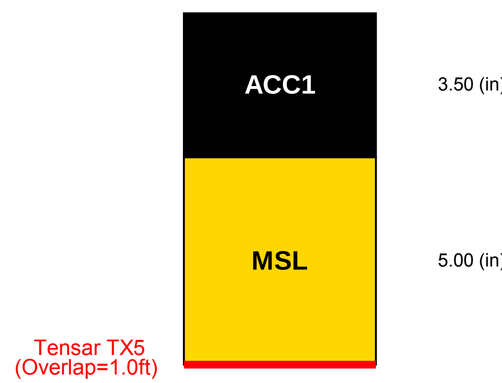
Layer	Description	Cost ($/ton)	Layer coefficient	Drainage factor
ACC1	Asphalt Wearing Course	70	0.440	N/A
MSL	Mechanically Stabilized Base Cour	20	0.286	1.25

Unstabilized Pavement



Subgrade Modulus = 10,844 (psi)
Structural Number = 3.160
Calculated Traffic (ESALs) = 1,541,000

Stabilized Pavement



Subgrade Modulus = 10,844 (psi)
Structural Number = 3.328
Calculated Traffic (ESALs) = 2,149,000

LIMITATIONS OF THE REPORT

The designs, illustrations, information and other content included in this report are necessarily general and conceptual in nature, and do not constitute engineering advice or any design intended for actual construction. Specific design recommendations can be provided as the project develops.

Project Name	Elm Street		
Company Name	Tensar		
Designer	Schlessinger	Date	12/15/15

Printed on 12-15-2015 C:\Tensar International Corporation\SpectraPave4 PRO\Untitled.sp4p

PAVEMENT EVALUATION
TUCSON PAVEMENT RECONSTRUCTION PROGRAM
ESCALANTE ROAD BETWEEN PANTANO ROAD
AND APACHE WELL DRIVE
TUCSON, ARIZONA

PREPARED FOR:
Kimley-Horn & Associates, Inc.
333 East Wetmore Road, Suite 280
Tucson, Arizona 85705

PREPARED BY:
Ninyo & Moore
Geotechnical and Environmental Sciences Consultants
1991 East Ajo Way, Suite 145
Tucson, Arizona 85713

December 14, 2015
Project No. 604817002

December 14, 2015
Project No. 604817002

Mr. Rick Solis, P.E.
Kimley-Horn
333 East Wetmore Road, Suite 280
Tucson, Arizona 85705

Subject: Pavement Evaluation
Tucson Pavement Reconstruction Program – Escalante Road
Between Pantano Road and Apache Well Drive
Tucson, Arizona

Dear Mr. Solis:

In accordance with our proposal dated August 12, 2015, and your authorization on September 21, 2015, Ninyo & Moore has performed a pavement evaluation for the above-referenced site. The attached report presents our methodology, findings, conclusions, and recommendations regarding the geotechnical conditions at the project site.

We appreciate the opportunity to be of service to you during this phase of the project.

Sincerely,
NINYO & MOORE

Registered Professional Engineer (Civil)
CERTIFICATE NO.
44704
MAREK J.
KASZTALSKI
Date Signed 12.14.15
ARIZONA, U.S.A.
EXPIRES 9/30/18

Marek J. Kasztalski, PE, PMP, LEED AP	Fred Narcaroti
Senior Geotechnical Engineer	Principal/Tucson Office Manager

MJK/DT/FFN/tlp

Distribution: (1) Addressee (Electronic Copy)

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Figures

Appendices

1. INTRODUCTION

In accordance with our proposal dated August 12, 2015, and your authorization on September 21, 2015, we have performed a pavement evaluation for the Escalante Road Pavement Reconstruction project between Pantano Road and Apache Well Drive, in Tucson, Arizona. The purpose of our evaluation was to assess the pavement and subgrade conditions along the project alignment in order to provide geotechnical recommendations for design and construction. This report presents the results of our evaluation, conclusions, and recommendations regarding the proposed construction.

2. SCOPE OF SERVICES

The scope of our services generally included:

- Preparing a field testing plan and associated permit application for submittal to the City of Tucson (COT).
- Conducting a visual reconnaissance of the pavement along the alignment and marking out the boring locations.
- Notifying Arizona811 of our boring locations prior to conducting the field work.
- Arranging for traffic control measures to conduct the field work.
- Coring the existing asphaltic concrete (AC) pavement at six locations along the project alignment.
- Exploring the subsurface soils within the project limits by drilling, logging, and sampling six exploratory soil borings to approximate depths of 3 feet below ground surface (bgs). The boring logs are presented in Appendix A.
- Performing laboratory tests on selected samples collected from our borings to evaluate gradation and Atterberg limits. The results of the laboratory tests are included in Appendix B.
- Preparing this report presenting our findings, conclusions and recommendations regarding the proposed reconstruction.

Our scope of services did not include environmental consulting services such as hazardous waste sampling or analytical testing at the site. A detailed scope of services and estimated fee for such services can be provided upon request.

3. SITE DESCRIPTION

The project site is located in Sections 28 and 34 of Township 14 South, Range 15 East relative to the Gila and Salt River Base Line and Meridian. The project alignment extends along Escalante Road between Pantano Road and Apache Well Drive in Tucson, Arizona (Figure 1).

At the time of our evaluation residential developments existed along the project alignment. South of Escalante Road, the project alignment was adjacent to the Davis Monthan Air Force Base. The roadway section consisted of one travel lane in each direction, a wide median, concrete curb and sidewalks along portions of the north side of the roadway. No gutter was observed along the project alignment.

4. PROPOSED CONSTRUCTION

The COT has identified several segments of the existing street network for reconstruction and/or rehabilitation in fiscal year (FY) 2016 under Bid Package 2. The scope of this report includes Escalante Road between a point located approximately 157 feet east of Pantano Road and a point located approximately 726 feet east of Apache Well Drive (Wingate Boulevard). The project alignment is approximately 1.4 miles long.

We understand that the COT anticipates full-depth reconstruction of the existing roadway along the project alignment. The City proposes a new pavement section consisting of 5 inches of AC per of the COT Department of Transportation Standard Specifications Section 406 over 5 inches of aggregate base (AB) per Section 303 of the COT Standard Specifications.

We further understand that the COT intends to use Tucson Department of Transportation (TDOT) AC Mix No. 2 PG 76-22TR+ for the surface layer and TDOT AC Mix No. 1 PG 70-10 for the underlying layer. Both layers are proposed to be 2.5 inches thick.

Due to conflicts with shallow utility lines, subgrade improvement by overexcavation will not be performed and the new pavement section will be constructed on subgrade improved with Geogrid (Tensar Geogrid TX5 or equivalent).

The scope of this exploration included evaluation of the existing pavement section and subgrade soils in order to provide recommendations for pavement reconstruction in accordance with the current COT practice. Calculations for the new pavement section supporting the new construction proposed by the COT are presented in Section 9.3 and in Appendix E of this report.

5. EXISTING PAVEMENT CONDITION

On September 28, 2015, Ninyo & Moore conducted a limited visual evaluation of the pavement surface along the project alignment. Based on our field observations, the AC pavement exhibited signs of severe distress in many locations along the project alignment primarily consisting of extensive raveling of the pavement surface, longitudinal, transverse and irregular cracking, and potholes. Asphaltic concrete patches were observed at some locations which were probably associated with past maintenance efforts (pothole and crack repairs) or with underground utility work. The crack widths generally varied between hairline (less than 1/8-inch) and over one inch.

In our opinion, the distress observed along the project alignment indicates structural failure and is related to a combination of pavement age, traffic, and environmental impacts.

6. FIELD EXPLORATION AND LABORATORY TESTING

On September 28, 2015, Ninyo & Moore conducted a geotechnical exploration in order to evaluate the subsurface conditions and collect AC cores and soil samples for laboratory testing. Our evaluation consisted of coring the existing AC pavement, drilling, logging, and sampling six small-diameter borings, denoted as B-1 through B-6, utilizing a CME-45 truck-mounted drill rig equipped with hollow-stem augers. The borings extended to depths of approximately 3 feet bgs. The approximate locations of the borings are depicted on Figure 2.

Ninyo & Moore personnel logged the borings in general accordance with the Unified Soil Classification System (USCS) and American Society for Testing and Materials (ASTM) D 2488 by observing cuttings and drive samples. Collected ring samples were trimmed in the field, wrapped in plastic bags, and placed in cylindrical plastic containers to retain in-place moisture conditions.

The soil samples collected from our drilling activities were transported to the Ninyo & Moore laboratory in Tucson, Arizona for geotechnical laboratory testing. The tests included gradation and Atterberg limits. A description of each laboratory test method and the test results are presented in Appendix B.

7. SUBSURFACE CONDITIONS

Our knowledge of the subsurface conditions at the project site is based on our field exploration, laboratory testing, and general experience in the area. More detailed stratigraphic information is presented on the boring logs in Appendix A, attached to this report. The boring logs contain our field and laboratory test results, as well as our interpretation of conditions believed to exist between actual samples retrieved. Therefore, these boring logs contain both factual and interpretive information. Lines delineating subsurface strata on the boring logs are intended to group soils having similar engineering properties and characteristics. They should be considered approximate as the actual transition between soil types (strata) may be gradual. A key to the soil symbols and terms used on the boring logs is provided in Appendix A.

7.1. Asphaltic Concrete

Asphaltic concrete pavement was encountered at the surface of each of our borings. The AC thickness varied between approximately 2 ½ and 5 inches, in our borings. It should be noted that the thickness of the AC pavement between the sampling locations may vary and could be different from that encountered at our sampling locations. Detailed core descriptions are presented in Appendix C.

Aggregate base was not observed in our borings. It is possible the AB material blended with the native subgrade soils, such that delineation of the AB/subgrade interface was not easily interpreted.

7.2. Alluvium

Native alluvial soils were encountered below the pavement section, and extended to the boring termination depths. The alluvium generally consisted of loose to dense, silty and clayey sands with varying amounts of gravel.

8. CONCLUSIONS

Based on the results of our visual and subsurface evaluations, laboratory testing, and data analysis, geotechnical considerations include the following:

- The on-site soils generally include clayey sands, with a plasticity index (PI) varying between 0 (non-plastic) and 21. These soils may be sensitive to moisture content fluctuations and may be difficult to compact especially at higher moisture contents. The contractor should be aware of this condition.
- Due to the relatively widely spaced nature of our borings, soil conditions may differ from what was observed during our field exploration.
- The pavement exhibits significant distress in many locations along the project alignment consisting mainly of transverse, block and irregular cracking.
- Full-depth pavement reconstruction is considered for this project as proposed by the COT.

9. RECOMMENDATIONS

The following sections present our geotechnical recommendations for the project. If the proposed construction is changed from that discussed in this report, Ninyo & Moore should be contacted for additional recommendations.

9.1. Recommended Pavement Structural Sections

The recommended pavement sections are presented in the table below:

Pavement Section	Service Life (years)	AC (in)[1]	AB (in)[2]
COT Preferred Pavement with Geogrid	20	5	5
Alternative Pavement Section without Geogrid	20	5.5	5

Notes:
[1] TDOT AC Mix No. 2 PG 76-22TR+ as the surface mix and TDOT AC Mix No. 1 PG 70-10 for the underlying layers per Section 406 of the COT Specifications.
[2] AB per Section 303 of the COT Specifications.

9.2. Earthwork

The following sections provide our earthwork recommendations for this project. In general, the earthwork specifications contained in the *City of Tucson/Pima County Standard Specifications for Public Improvements, 2003 Edition (COT/PC Specifications)* are expected to apply unless specifically noted.

9.2.1. Site Preparation

Construction areas should be cleared of deleterious materials, if any are present, including abandoned utilities, construction debris, vegetation, and any other material that might interfere with the performance or progress of the work. These materials should be disposed of at a legal dumpsite. Existing features that call for relocation or removal and extend below finish grade, if present, should be removed, and the resulting excavations backfilled with engineered fill.

9.2.2. Excavations

Our evaluation of the excavation characteristics of the on-site soils is based on the results of our exploratory borings, site observations, and experience with similar materials.

9.2.3. Fill Materials

Soils with PI values of 15 or less (as evaluated by ASTM D 4318) are generally suitable for use as engineered fill. Our Atterberg limits test indicated the PI values ranging between 0 (non-plastic) and 21. Based on this test result, some of the on-site soils are not suitable for re-use as engineered fill.

Engineered fill should not include organic material, construction debris, or other non-soil fill materials. Rock particles and clay lumps should not be larger than 4 inches in dimension. Unsuitable material should be disposed of off-site or in non-structural areas.

9.2.4. Grading and Subgrade Preparation

In general, grading operations should be performed in accordance with Section 205 of the COT/PC Specifications.

Due to potential conflicts with underground utilities, we recommend that the subgrade be improved by the application of Geogrid (Tensar Geogrid TX5 or equivalent). Geogrid should be placed in accordance with the manufacturer’s instructions.

Alternatively, if Geogrid is not applied we recommend new pavements be supported on 6 inches of subgrade that is compacted by appropriate mechanical methods to a relative compaction of 95 percent as evaluated by ASTM D 698 at a moisture content generally near optimum. The thickness of the improvement zone should be measured from the bottom of the AB layer.

In areas where excessive moisture is encountered so that the above compaction cannot be achieved and/or the subgrade surface is unstable and yielding (pumping) under the roller wheels, subgrade soils should be scarified to a depth of 12 inches, aerated, and re-compacted as specified above. Alternatively, subgrade soils in problem areas should be and replaced with engineered fill to a depth of 12 inches below the bottom of the AB.

9.3. Pavement Design Summary

The following sections present our design assumptions and recommendations for the new flexible pavement section of Escalante Road between Pantano Road and Apache Well Drive, as this roadway is scheduled for full-depth pavement reconstruction.

The pavement section was developed using the Active Practices Guidelines issued by the COT Department of Transportation (Guidelines) and the Arizona Department of Transportation (ADOT) Preliminary Engineering and Design Manual (PEDM). We assumed that the subgrade will be improved by the application of Geogrid or overexcavation, as outlined in Section 9.2.4 of this report. The new pavement sections are designed for a 20-year service life.

9.3.1. Traffic

The future traffic numbers used in this report are based on traffic counts provided by Kimley-Horn and Associates, Inc. (KHA), and later communication with the KHA. This information is presented in Appendix D. Based on the above information, and using the procedures outlined in the Guidelines and PEDM, the design number of equivalent single axle loads (ESALs) for the design lane during the 20-year design period was calculated as approximately 2,106,780.

9.3.2. R-Value and Resilient Modulus

The analysis for the design R-value for the pavement section has been performed based on procedures detailed in the Guidelines and the PEDM, using correlated R-values. The correlated R-values were derived from the PI and percent passing No. 200 Sieve test results. A summary of the R-values for this project is presented in Table 1 below:

Table 1 – R-value Summary

Location	Sample Depth (ft)	Correlated R-Value
B-1	1.5-3.0	34
B-3	1.5-3.0	59
B-5	1.5-3.0	88

In the interest of conservatism, we recommend that an R-value of 30 be used for pavement design for this project.

If the project needs fill from an off-site source, we recommend the soils used for subgrade support should have an R-value of 30 or more. If during construction, the subgrade is found to vary from the expected soil conditions, we should be contacted so we may re-evaluate our recommended R-values. Based on the above design R-values, the design subgrade resilient modulus (M_R) value of 13,009 pounds per square inch (psi) was calculated in accordance with the Guidelines.

9.3.3. Statistical Parameters

A standard deviation of 0.40 was used for design of the flexible pavement in accordance with the Guidelines. The level of reliability and standard normal deviation (Z_R) values were selected in accordance with the Guidelines for the arterial functional classification. Their respective values are presented in the table below:

Table 2 – Summary of Statistical Parameters

Roadway	Functional Classification	Standard Deviation	Level of Reliability	Standard Normal Deviation
Escalante Road between Pantano Road and Apache Well Drive	Arterial	0.40	95 %	-1.645

9.3.4. Serviceability Index

Initial and terminal serviceability indices were selected for the pavement design of the roadways in accordance with the Guidelines. A summary of the serviceability indices for each roadway is provided in the table below:

Table 3 – Summary of Serviceability Parameters

Roadway	Functional Classification	Initial Serviceability Index	Terminal Serviceability Index	Change in Serviceability
Escalante Road between Pantano Road and Apache Well Drive	Arterial	4.5	2.5	2.0

9.3.5. Layer Coefficients

The following structural coefficients were used for the pavement structure in accordance with the Guidelines:

- AC: 0.44.
- AB: 0.14.

A drainage coefficient of 1.25 was used for the AB coefficient as recommended in the Guidelines.

As mentioned in Section 4 above, due to conflicts with existing shallow utilities, it is recommended that the subgrade be improved using Geogrid (Tensar Geogrid TX5 or equivalent). In this case the AB layer coefficient is 0.286.

9.3.6. Asphalt Pavement Section Recommendations

The structural number (SN) was calculated based on the parameters described above. The table below presents the calculated SN value and the recommended structural pavement sections. The AC thickness meets the COT requirements. Supporting documentation of the pavement optimization design using Geogrid is presented in Appendix E:

Table 4 – Structural Pavement Sections for 20-Year Design Life

Roadway	SN	AC (in)[1]	AB (in)[2]
COT Preferred Pavement with Geogrid	3.99	5	5
Alternative Pavement without Geogrid	3.20	5.5	5

Notes:
[1] TDOT AC Mix No. 2 PG 76-22TR+ as the surface mix and TDOT AC Mix No. 1 PG 70-10 for the underlying layers per Section 406 of the COT Specifications.
[2] AB per Section 303 of the COT Specifications.

The above pavement structural section has been designed with the assumption that the subgrade is prepared by as recommended in Section 9.2.4.

10. SITE DRAINAGE

Surface drainage should be provided to divert water away from paved surfaces. Surface water should also not be permitted to pond on or below pavement areas. Positive drainage for this project is defined as a slope of 2 percent or more for a distance of 5 feet or more away from the pavements. To deter accumulation of water below the new pavement sections, the bottom of the overexcavated zone below the new pavement should be sloped toward the edges of the roadway.

11. PRE-CONSTRUCTION CONFERENCE

We recommend that a pre-construction conference be held. Representatives of the owner, the civil engineer, Ninyo & Moore, and the contractor should be in attendance to discuss the project plans and schedule. Our office should be notified if the project description included herein is incorrect or if the project characteristics are significantly changed.

12. CONSTRUCTION OBSERVATION AND TESTING

During construction operations, we recommend that Ninyo & Moore perform observation and testing services for the project. These services should be performed to evaluate exposed subgrade conditions, including the extent and depth of overexcavation, to evaluate the suitability of proposed borrow materials for use as engineered fill and to observe placement and test compaction of fill soils. Qualified subcontractors utilizing appropriate techniques and construction materials should perform construction of the proposed improvements.

13. LIMITATIONS

The field evaluation, laboratory testing, and geotechnical analyses presented in this geotechnical report have been conducted in general accordance with current practice and the standard of care exercised by geotechnical consultants performing similar tasks in the project area. No warranty, expressed or implied, is made regarding the conclusions, recommendations, and opinions presented in this report. There is no evaluation detailed enough to reveal every subsurface condition. Variations may exist and conditions not observed or described in this report may be encountered during construction. Uncertainties relative to subsurface conditions can be reduced through additional subsurface exploration. Additional subsurface evaluation will be performed upon request. Please also note that our evaluation was limited to assessment of the geotechnical aspects of the project, and did not include evaluation of structural issues, environmental concerns, or the presence of hazardous materials.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. Ninyo & Moore should be contacted if the reader requires additional information or has questions regarding the content, interpretations presented, or completeness of this document.

This report is intended for design purposes only. It does not provide sufficient data to prepare an accurate bid by contractors. It is suggested that the bidders and their geotechnical consultant perform an independent evaluation of the subsurface conditions in the project areas. The independent evaluations may include, but not be limited to, review of other geotechnical reports prepared for the adjacent areas, site reconnaissance, and additional exploration and laboratory testing.

Our conclusions, recommendations, and opinions are based on an analysis of the observed site conditions. If geotechnical conditions different from those described in this report are encountered, our office should be notified and additional recommendations, if warranted, will be provided upon request. It should be understood that the conditions of a site could change with time as a result of natural processes or the activities of man at the subject site or nearby sites. In addition, changes to the applicable laws, regulations, codes, and standards of practice may occur due to government action or the broadening of knowledge. The findings of this report may, therefore, be invalidated over time, in part or in whole, by changes over which Ninyo & Moore has no control.

This report is intended exclusively for use by the client. Any use or reuse of the findings, conclusions, and/or recommendations of this report by parties other than the client is undertaken at said parties' sole risk.

14. REFERENCES

American Society for Testing and Materials (ASTM), Annual Book of ASTM Standards.

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

City of Tucson, Arizona, Department of Transportation, Engineering Division, 1987, Active Practices Guidelines: dated June 1.

Ninyo & Moore, In-house proprietary information.

Source: Phoenix Mapping Service, Tucson Metro Edition, 2012.

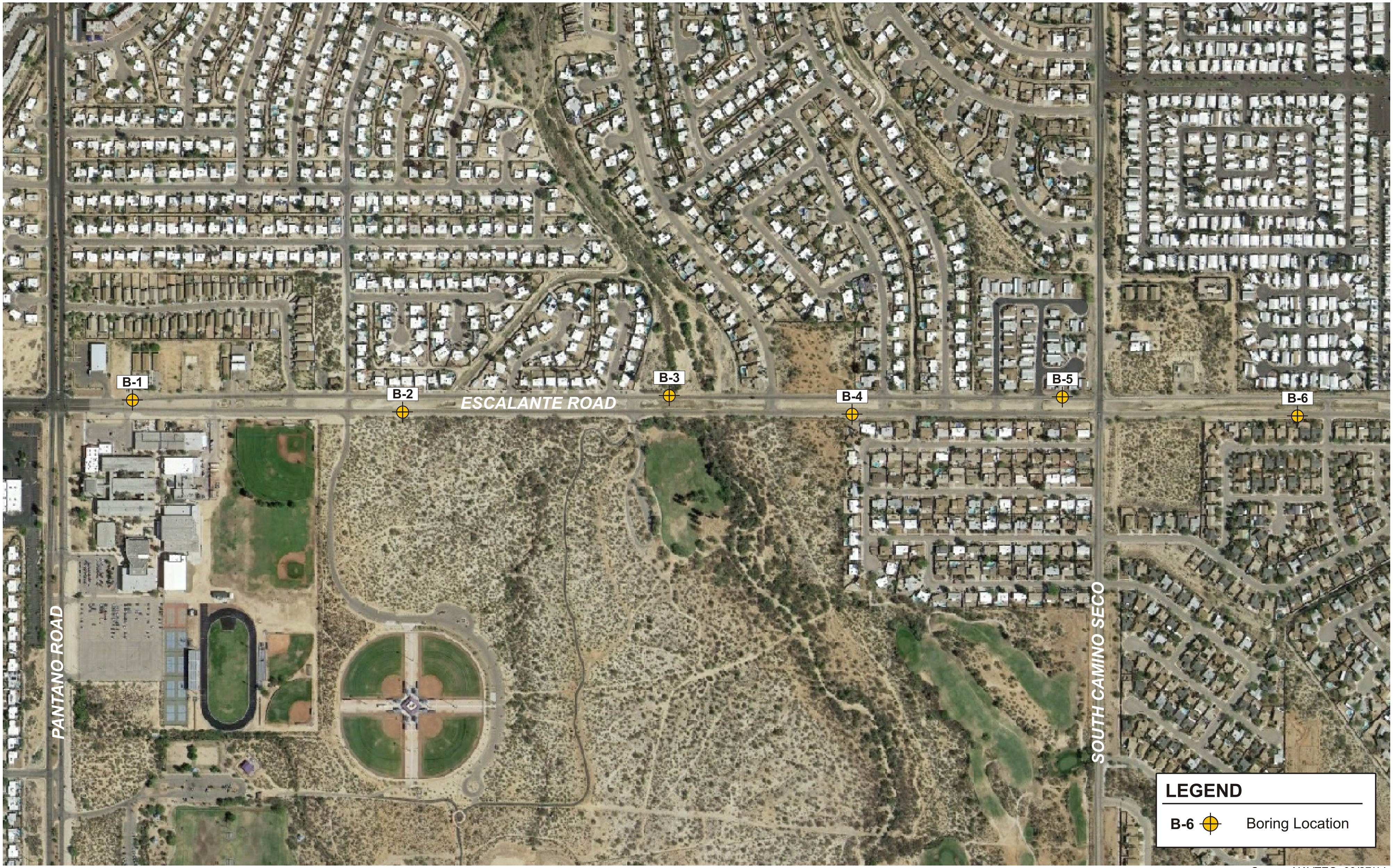
0 3300

Approximate Scale:
1 inch = 3300 feet

Note: Dimensions, directions, and locations are approximate.

Ninyo & Moore	SITE LOCATION	FIGURE
PROJECT NO: 604817002	DATE: 12/15	TUCSON PAVEMENT RECONSTRUCTION - ESCALANTE ROAD BETWEEN PANTANO ROAD AND APACHE WELL DRIVE TUCSON, ARIZONA	1

file no: 4817vmap1015d



Source: NAVTEQ, 03/27/14.

N

0 650

Approximate Scale:
1 inch = 650 feet

Note: Dimensions, directions, and locations are approximate.

file no: 4817blm1015d

Ninyo & Moore

BORING LOCATIONS

PROJECT NO:	DATE:	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ESCALANTE ROAD BETWEEN PANTANO ROAD AND APACHE WELL DRIVE TUCSON, ARIZONA	FIGURE 2
604817002	12/15		

APPENDIX A

BORING LOGS

Field Procedure for the Collection of Relatively Undisturbed Samples

Relatively undisturbed soil samples were obtained in the field using the following methods.

The Modified Split-Barrel Drive Sampler

The sampler, with an external diameter of 3.0 inches, was lined with 1-inch long, thin brass rings with inside diameters of approximately 2.4 inches. The sample barrel was driven into the ground with the weight of a hammer or the Kelly bar of the drill rig in general accordance with ASTM D 3550. The driving weight was permitted to fall freely. The approximate length of the fall, the weight of the hammer or bar, and the number of blows per foot of driving are presented on the boring logs as an index to the relative resistance of the materials sampled. The samples were removed from the sample barrel in the brass rings, sealed, and transported to the laboratory for testing.

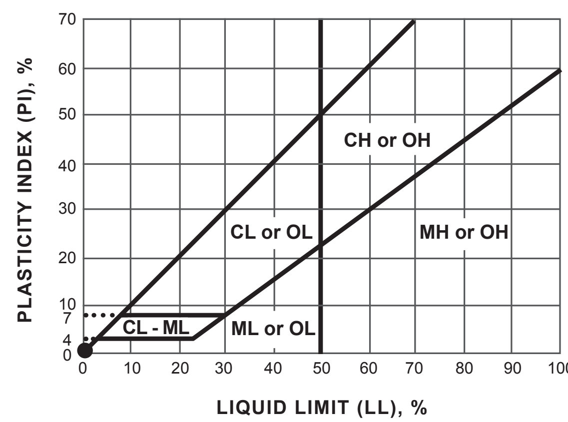
SOIL CLASSIFICATION CHART PER ASTM D 2488

PRIMARY DIVISIONS			SECONDARY DIVISIONS: GROUP SYMBOL	SECONDARY DIVISIONS: GROUP NAME
COARSE-GRAINED SOILS more than 50% retained on No. 200 sieve	**GRAVEL** more than 50% of coarse fraction retained on No. 4 sieve	CLEAN GRAVEL less than 5% fines	GW	well-graded GRAVEL
			GP	poorly graded GRAVEL
		GRAVEL with DUAL CLASSIFICATIONS 5% to 12% fines	GW-GM	well-graded GRAVEL with silt
			GP-GM	poorly graded GRAVEL with silt
			GW-GC	well-graded GRAVEL with clay
			GP-GC	poorly graded GRAVEL with clay
		GRAVEL with FINES more than 12% fines	GM	silty GRAVEL
			GC	clayey GRAVEL
			GC-GM	silty, clayey GRAVEL
	SAND 50% or more of coarse fraction passes No. 4 sieve	CLEAN SAND less than 5% fines	SW	well-graded SAND
			SP	poorly graded SAND
		SAND with DUAL CLASSIFICATIONS 5% to 12% fines	SW-SM	well-graded SAND with silt
			SP-SM	poorly graded SAND with silt
			SW-SC	well-graded SAND with clay
			SP-SC	poorly graded SAND with clay
		SAND with FINES more than 12% fines	SM	silty SAND
			SC	clayey SAND
			SC-SM	silty, clayey SAND
FINE-GRAINED SOILS 50% or more passes No. 200 sieve	**SILT and CLAY** liquid limit less than 50%	INORGANIC	CL	lean CLAY
			ML	SILT
			CL-ML	silty CLAY
		ORGANIC	OL (PI > 4)	organic CLAY
			OL (PI < 4)	organic SILT
	SILT and CLAY liquid limit 50% or more	INORGANIC	CH	fat CLAY
			MH	elastic SILT
		ORGANIC	OH (plots on or above "A"-line)	organic CLAY
			OH (plots below "A"-line)	organic SILT
	Highly Organic Soils		PT	Peat

GRAIN SIZE

DESCRIPTION		SIEVE SIZE	GRAIN SIZE	APPROXIMATE SIZE
Boulders		> 12"	> 12"	Larger than basketball-sized
Cobbles		3 - 12"	3 - 12"	Fist-sized to basketball-sized
Gravel	Coarse	3/4 - 3"	3/4 - 3"	Thumb-sized to fist-sized
	Fine	#4 - 3/4"	0.19 - 0.75"	Pea-sized to thumb-sized
Sand	Coarse	#10 - #4	0.079 - 0.19"	Rock-salt-sized to pea-sized
	Medium	#40 - #10	0.017 - 0.079"	Sugar-sized to rock-salt-sized
	Fine	#200 - #40	0.0029 - 0.017"	Flour-sized to sugar-sized
Fines		Passing #200	< 0.0029"	Flour-sized and smaller

PLASTICITY CHART



APPARENT DENSITY - COARSE-GRAINED SOIL

APPARENT DENSITY	SPOOLING CABLE OR CATHEAD: SPT (blows/foot)	SPOOLING CABLE OR CATHEAD: MODIFIED SPLIT BARREL (blows/foot)	AUTOMATIC TRIP HAMMER: SPT (blows/foot)	AUTOMATIC TRIP HAMMER: MODIFIED SPLIT BARREL (blows/foot)
Very Loose	≤ 4	≤ 8	≤ 3	≤ 5
Loose	5 - 10	9 - 21	4 - 7	6 - 14
Medium Dense	11 - 30	22 - 63	8 - 20	15 - 42
Dense	31 - 50	64 - 105	21 - 33	43 - 70
Very Dense	> 50	> 105	> 33	> 70

CONSISTENCY - FINE-GRAINED SOIL

CONSIS-TENCY	SPOOLING CABLE OR CATHEAD: SPT (blows/foot)	SPOOLING CABLE OR CATHEAD: MODIFIED SPLIT BARREL (blows/foot)	AUTOMATIC TRIP HAMMER: SPT (blows/foot)	AUTOMATIC TRIP HAMMER: MODIFIED SPLIT BARREL (blows/foot)
Very Soft	< 2	< 3	< 1	< 2
Soft	2 - 4	3 - 5	1 - 3	2 - 3
Firm	5 - 8	6 - 10	4 - 5	4 - 6
Stiff	9 - 15	11 - 20	6 - 10	7 - 13
Very Stiff	16 - 30	21 - 39	11 - 20	14 - 26
Hard	> 30	> 39	> 20	> 26

Ninyo & Moore

USCS METHOD OF SOIL CLASSIFICATION

Explanation of USCS Method of Soil Classification

PROJECT NO.	DATE	FIGURE

BORING LOG EXPLANATION SHEET

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	
0								Bulk sample.
								Modified split-barrel drive sampler.
								No recovery with modified split-barrel drive sampler.
								Sample retained by others.
								Standard Penetration Test (SPT).
5								No recovery with a SPT.
			XX/XX					Shelby tube sample. Distance pushed in inches/length of sample recovered in inches.
								No recovery with Shelby tube sampler.
								Continuous Push Sample.
								Seepage.
10								Groundwater encountered during drilling.
								Groundwater measured after drilling.
							SM	<u>MAJOR MATERIAL TYPE (SOIL)</u>: Solid line denotes unit change.
							CL	Dashed line denotes material change.
15								Attitudes: Strike/Dip b: Bedding c: Contact j: Joint f: Fracture F: Fault cs: Clay Seam s: Shear bss: Basal Slide Surface sf: Shear Fracture sz: Shear Zone sbs: Shear Bedding Surface
20								The total depth line is a solid line that is drawn at the bottom of the boring.

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BORING LOG

Explanation of Boring Log Symbols

PROJECT NO.	DATE	FIGURE

Updated Nov. 2011

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DATE DRILLED 9/29/15 BORING NO. B-1 / GROUND ELEVATION 2,754' ± (MSL) SHEET 1 OF 1 / METHOD OF DRILLING CME-75, 8" Hollow Stem Auger (Southlands) / DRIVE WEIGHT 140 lbs. (Automatic) DROP 30" / SAMPLED BY NAG LOGGED BY NAG REVIEWED BY DT / DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 5 inches thick.
							SC	ALLUVIUM: Reddish brown, moist, medium dense, clayey SAND; trace gravel.
			41					
								Total Depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt concrete patched on 9/29/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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15								
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Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM ESCALANTE, PANTANO ROAD TO APACHE WELL DRIVE, TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-1

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 2 1/2 inches thick.
		X	59				SP-SM	ALLUVIUM: Light brown, dry, dense, poorly graded SAND with silt; trace gravel.
								Total Depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt concrete patched on 9/29/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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DATE DRILLED 9/29/15 BORING NO. B-2

GROUND ELEVATION 2,752' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Hollow Stem Auger (Southlands)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY NAG LOGGED BY NAG REVIEWED BY DT

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM ESCALANTE, PANTANO ROAD TO APACHE WELL DRIVE, TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-2

DATE DRILLED 9/29/15	BORING NO. B-3	
GROUND ELEVATION 2,719' ± (MSL)	SHEET 1 OF 1	
METHOD OF DRILLING CME-75, 8" Hollow Stem Auger (Southlands)		
DRIVE WEIGHT 140 lbs. (Automatic)	DROP 30"	
SAMPLED BY NAG	LOGGED BY NAG	REVIEWED BY DT

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 3 1/4 inches thick.
							SC-SM	ALLUVIUM: Brown, dry, medium dense, silty clayey SAND; few gravel.
		■	28					
								Total Depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt concrete patched on 9/29/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM ESCALANTE, PANTANO ROAD TO APACHE WELL DRIVE, TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-3

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DATE DRILLED 9/29/15 BORING NO. B-4 GROUND ELEVATION 2,753' ± (MSL) SHEET 1 OF 1 METHOD OF DRILLING CME-75, 8" Hollow Stem Auger (Southlands) DRIVE WEIGHT 140 lbs. (Automatic) DROP 30" SAMPLED BY NAG LOGGED BY NAG REVIEWED BY DT DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 3 inches thick.
			59				SM	ALLUVIUM: Light brown, dry, dense, silty SAND.
5								Total Depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt conrete patched on 9/29/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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Ninyo & Moore

BORING LOG		
TUCSON PAVEMENT RECONSTRUCTION PROGRAM ESCALANTE, PANTANO ROAD TO APACHE WELL DRIVE, TUCSON, ARIZONA		
PROJECT NO.	DATE	FIGURE
604817002	12/15	A-4

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DATE DRILLED 9/29/15 BORING NO. B-5
								GROUND ELEVATION 2,740' ± (MSL) SHEET 1 OF 1
								METHOD OF DRILLING CME-75, 8" Hollow Stem Auger (Southlands)
								DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"
								SAMPLED BY NAG LOGGED BY NAG REVIEWED BY DT
								DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 2 1/2 inches thick.
							SP-SM	ALLUVIUM: Brown, moist, medium dense, poorly graded SAND with silt; trace gravel.
			23					
								Total Depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt conrete patched on 9/29/15 shortly after completion of drilling.
5								Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM ESCALANTE, PANTANO ROAD TO APACHE WELL DRIVE, TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-5

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DATE DRILLED 9/29/15 BORING NO. B-6 GROUND ELEVATION 2,721' ± (MSL) SHEET 1 OF 1 METHOD OF DRILLING CME-75, 8" Hollow Stem Auger (Southlands) DRIVE WEIGHT 140 lbs. (Automatic) DROP 30" SAMPLED BY NAG LOGGED BY NAG REVIEWED BY DT DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 2 3/4 inches thick.
			13				SM	ALLUVIUM: Reddish brown, moist, loose, silty SAND; trace gravel.
								Total Depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt conrete patched on 9/29/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM ESCALANTE, PANTANO ROAD TO APACHE WELL DRIVE, TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-6

APPENDIX B

LABORATORY TESTING

Classification

Soils were visually and texturally classified in accordance with the Unified Soil Classification System (USCS) in general accordance with ASTM D 2488. Soil classifications are indicated on the logs of the exploratory borings in Appendix A.

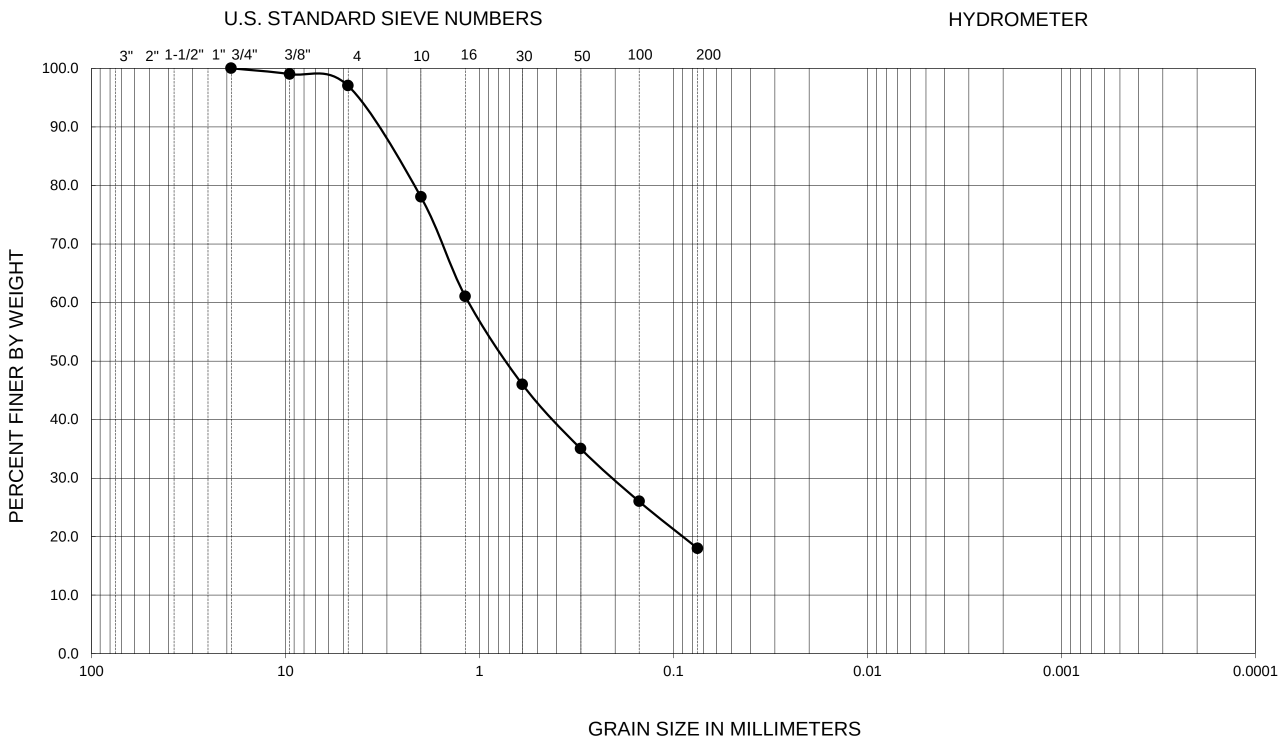
Gradation Analysis

One gradation analysis test was performed on a selected representative soil sample in general accordance with ASTM D 422. The grain-size distribution curves are shown in Figures B-1 through B-3. These test results were utilized in evaluating the soil classification in accordance with the USCS.

Atterberg Limits

Tests were performed on a selected representative fine-grained soil sample to evaluate the liquid limit, plastic limit, and plasticity index in general accordance with ASTM D 4318. These test results were utilized to evaluate the soil classification in accordance with the USCS. The test results and classifications are shown on Figure B-4.

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
●	B-1	1.5-3.0	36	15	21	--	--	--	--	--	18	SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore

GRADATION TEST RESULTS

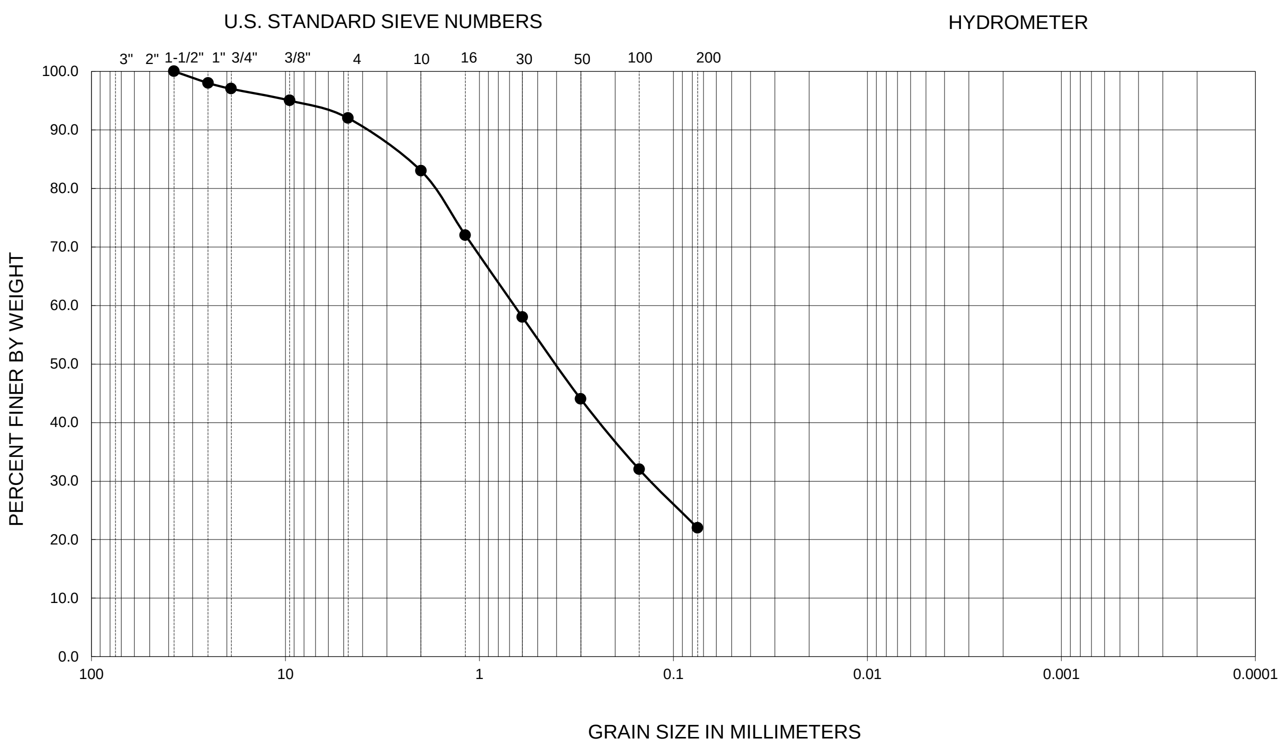
FIGURE

PROJECT NO.	DATE
604817001	12/15

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ESCALANTE ROAD
PANTANO ROAD TO APACHE WELL DRIVE
TUCSON, ARIZONA

B-1

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY

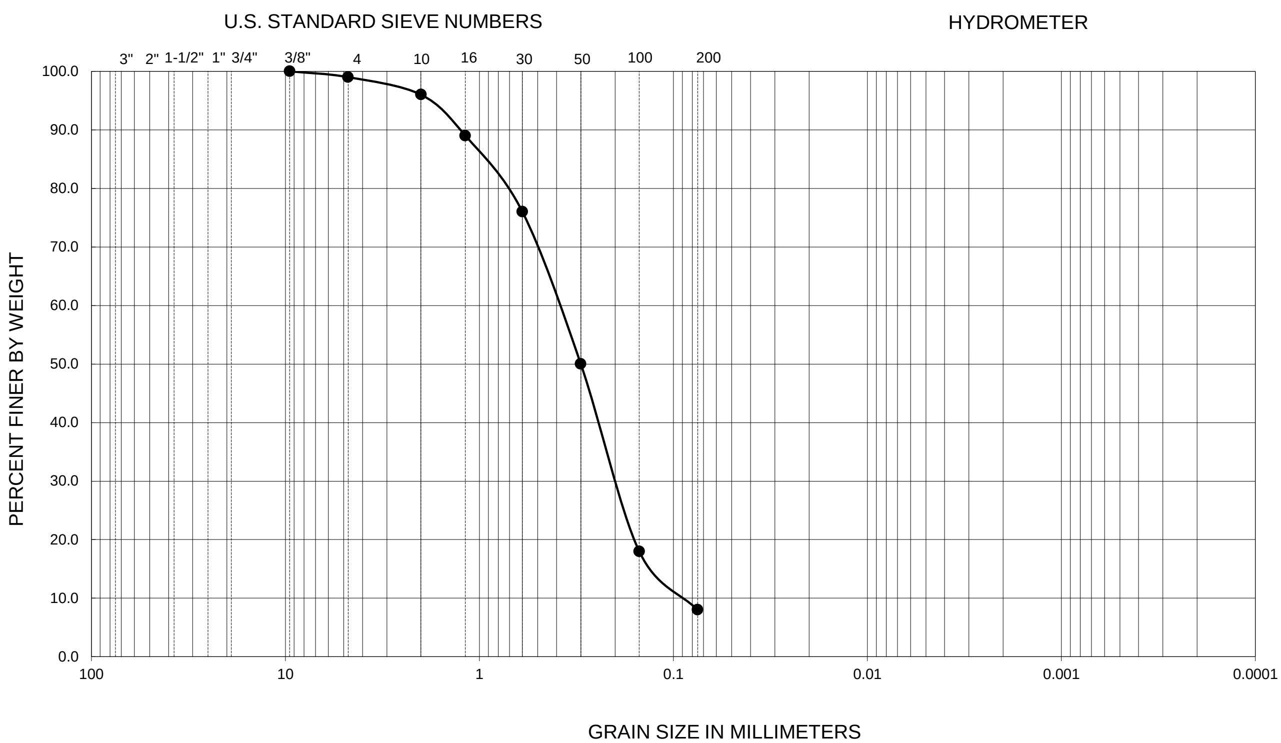


Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
●	B-3	1.5-3.0	22	16	6	--	--	--	--	--	22	SC-SM

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore		GRADATION TEST RESULTS	FIGURE
PROJECT NO.	DATE	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ESCALANTE ROAD PANTANO ROAD TO APACHE WELL DRIVE TUCSON, ARIZONA	B-2
604817001	12/15		

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
●	B-5	1.5-3.0	NP	--	NP	0.09	0.20	0.38	4.2	1.2	8	SP-SM

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

NP - INDICATES NON-PLASTIC

Ninyo & Moore

GRADATION TEST RESULTS

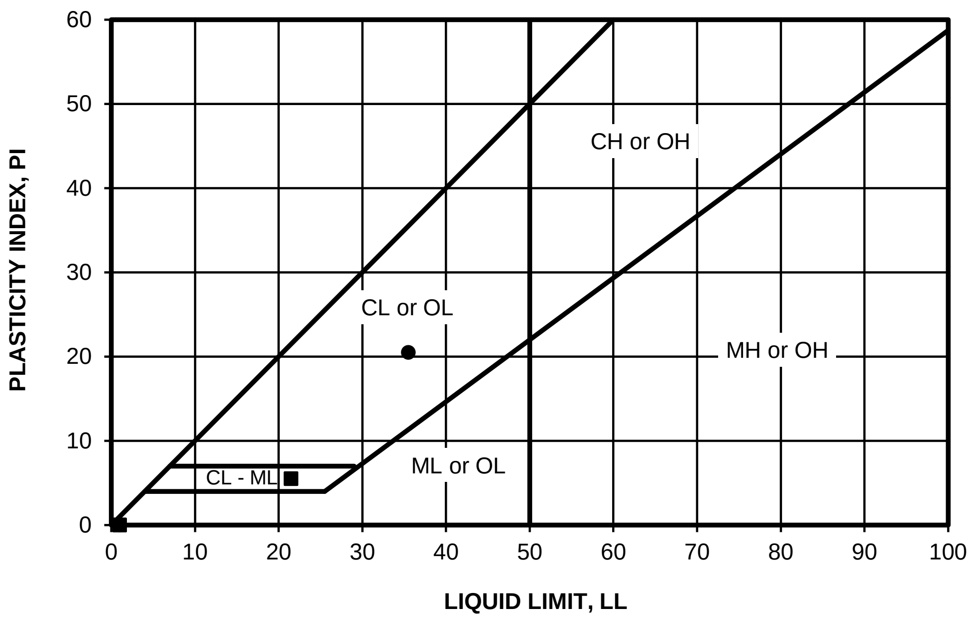
PROJECT NO.	DATE
604817001	12/15

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ESCALANTE ROAD
PANTANO ROAD TO APACHE WELL DRIVE
TUCSON, ARIZONA

FIGURE **B-3**

SYMBOL	LOCATION	DEPTH (FT)	LIQUID LIMIT, LL	PLASTIC LIMIT, PL	PLASTICITY INDEX, PI	USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve)	USCS (Entire Sample)
●	B-1	1.5-3.0	36	15	21	CL	SC
■	B-3	1.5-3.0	22	16	6	CL-ML	SC-SM
◆	B-5	1.5-3.0	--	--	NP	ML	SP-SM

NP - INDICATES NON-PLASTIC



PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4318

Ninyo & Moore		ATTERBERG LIMITS TEST RESULTS	FIGURE
PROJECT NO.	DATE	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ESCALANTE ROAD PANTANO ROAD TO APACHE WELL DRIVE TUCSON, ARIZONA	B-4
604817001	12/15		

APPENDIX C

PAVEMENT AND CORE SUMMARY

ESCALANTE ROAD (PANTANO RD TO APACHE WELL DR) - PAVEMENT AND CORE SUMMARY

No.	Location	Approximate AC thickness (in)*	Recovered AC Thickness (in)	Core Description	Pavement Condition
B-1	Westbound, 300 feet east of Pantano Road	5	5	Two lifts, 2" and 3", numerous voids.	Extensive longitudinal, transverse, block and irregular cracking, some sealed.
B-2	Eastbound, 240 feet east of Manitoba Avenue	2.5	2.5	Two lifts, 1.5" and 1", few voids.	Extensive longitudinal, transverse and irregular cracking, severe raveling, potholes, patches, some cracks sealed.
B-3	Westbound, 480 feet west of Sarnoff Drive	3.25	3.25	Two lifts, 2.0" and 1.25", numerous interconnected voids.	Extensive longitudinal, transverse and irregular cracking, severe raveling, potholes, patches, some cracks sealed.
B-4	Eastbound, 350 feet east of Sarnoff Drive	3	3	Two lifts, 1.5" and 1.5", few voids, crack throughout core.	Extensive longitudinal, transverse and irregular cracking, severe raveling, potholes, patches, some cracks sealed.
B-5	Westbound, 240 feet west of Camino Seco	2.5	2.5	Two lifts, 1.5" and 1", few voids, week bond between lifts.	Extensive longitudinal, transverse and irregular cracking, severe raveling, potholes, patches, some cracks sealed.
B-6	Eastbound, 930 feet east of Camino Seco	2.75	2.75	One lift, 1.75", few voids.	Extensive longitudinal, transverse and irregular cracking, severe raveling, potholes, patches, some cracks sealed.

Notes:

* Measured in the boring

APPENDIX D

TRAFFIC DATA

Field Data Services of Arizona
21636 N. Dietz Dr.
Maricopa, AZ 85138
520.316.6745

Site Code: 15-1283-002
Station ID: Wed 10/07/2015
Escalante Rd. btwn. Pantano Rd. &
Manitoba Ave. 32.1773848, -110.820204
Latitude: 0' 0.000 Undefined

Eastbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/7/15	0	7	2	0	0	0	0	0	0	0	0	0	0	9
01:00	0	8	1	0	0	0	0	0	0	0	0	0	0	9
02:00	0	1	0	0	0	0	0	0	0	0	0	0	0	1
03:00	0	4	0	0	0	0	0	0	0	0	0	0	0	4
04:00	0	6	0	0	0	0	0	0	0	0	0	0	0	6
05:00	0	9	3	2	0	0	0	0	0	0	0	0	0	14
06:00	0	26	4	**5**	1	0	0	0	0	0	0	0	0	36
07:00	0	**81**	**12**	4	**6**	0	0	0	0	0	0	0	0	**103**
08:00	0	61	5	2	0	**1**	0	0	0	0	0	0	0	69
09:00	**2**	43	3	2	2	1	0	0	**1**	0	0	0	0	54
10:00	0	47	11	2	3	0	0	0	1	0	0	0	0	64
11:00	0	58	9	2	3	1	0	0	0	0	0	0	0	73
12 PM	**1**	93	16	3	4	0	0	0	0	0	0	0	0	117
13:00	0	81	13	3	0	0	0	0	0	0	0	0	0	97
14:00	1	106	19	**4**	3	0	0	0	0	0	0	0	0	133
15:00	0	116	29	4	7	0	0	0	0	0	0	0	0	156
16:00	0	165	**32**	1	5	0	0	0	0	0	0	0	0	203
17:00	0	**201**	20	2	3	0	0	0	0	0	0	0	0	**226**
18:00	0	142	17	2	**9**	0	0	0	0	0	0	0	0	170
19:00	1	91	12	1	2	0	0	0	0	0	0	0	0	107
20:00	1	79	7	1	0	0	0	0	0	0	0	0	0	88
21:00	0	57	3	1	0	0	0	0	0	0	0	0	0	61
22:00	0	31	2	1	0	0	0	0	0	0	0	0	0	34
23:00	0	21	2	0	0	0	0	0	0	0	0	0	0	23
Day Total	6	1534	222	42	48	3	0	0	2	0	0	0	0	1857
Percent	0.3%	82.6%	12.0%	2.3%	2.6%	0.2%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	
AM Peak	09:00	07:00	07:00	06:00	07:00	08:00			09:00					07:00
Vol.	2	81	12	5	6	1			1					103
PM Peak	12:00	17:00	16:00	14:00	18:00									17:00
Vol.	1	201	32	4	9									226
Grand Total	6	1534	222	42	48	3	0	0	2	0	0	0	0	1857
Percent	0.3%	82.6%	12.0%	2.3%	2.6%	0.2%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	

Field Data Services of Arizona

21636 N. Dietz Dr.
Maricopa, AZ 85138
520.316.6745

Site Code: 15-1283-002
Station ID: Wed 10/07/2015
Escalante Rd. btwn. Pantano Rd. &
Manitoba Ave. 32.1773848, -110.820204
Latitude: 0' 0.000 Undefined

Westbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/7/15	0	5	0	0	0	0	0	0	0	0	0	0	0	5
01:00	0	7	0	0	0	0	0	0	0	0	0	0	0	7
02:00	0	1	0	0	0	0	0	0	0	0	0	0	0	1
03:00	0	4	1	0	1	0	0	0	0	0	0	0	0	6
04:00	0	19	5	0	1	0	0	0	0	0	0	0	0	25
05:00	0	45	11	0	3	0	0	0	0	0	0	0	0	59
06:00	**1**	93	21	2	**17**	**1**	0	0	0	0	0	0	0	135
07:00	1	**206**	**37**	**4**	10	0	0	0	0	0	0	0	0	**258**
08:00	0	113	19	3	4	0	0	0	0	0	0	0	0	139
09:00	0	58	10	3	4	0	0	0	0	0	0	0	0	75
10:00	1	66	13	2	5	0	0	0	0	0	0	0	0	87
11:00	0	66	7	2	5	0	0	**1**	0	0	0	0	0	81
12 PM	0	89	**19**	2	6	0	0	0	0	0	0	0	0	116
13:00	**1**	74	11	2	2	0	0	0	0	0	0	0	0	90
14:00	1	95	16	3	3	0	0	0	0	0	0	0	0	118
15:00	1	76	19	**5**	4	0	0	0	0	0	0	0	0	105
16:00	1	**100**	14	4	1	**1**	0	0	0	0	0	0	0	121
17:00	0	99	16	3	**7**	0	0	0	0	0	0	0	0	**125**
18:00	0	83	9	2	7	0	0	0	0	0	0	0	0	101
19:00	0	54	12	2	3	0	0	0	0	0	0	0	0	71
20:00	0	47	7	2	1	0	0	0	0	0	0	0	0	57
21:00	0	24	5	1	2	0	0	0	0	0	0	0	0	32
22:00	0	18	6	1	0	0	0	0	0	0	0	0	0	25
23:00	0	9	1	1	0	0	0	0	0	0	0	0	0	11
Day Total	7	1451	259	44	86	2	0	1	0	0	0	0	0	1850
Percent	0.4%	78.4%	14.0%	2.4%	4.6%	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	
AM Peak	06:00	07:00	07:00	07:00	06:00	06:00		11:00						07:00
Vol.	1	206	37	4	17	1		1						258
PM Peak	13:00	16:00	12:00	15:00	17:00	16:00								17:00
Vol.	1	100	19	5	7	1								125
Grand Total	7	1451	259	44	86	2	0	1	0	0	0	0	0	1850
Percent	0.4%	78.4%	14.0%	2.4%	4.6%	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	

Field Data Services of Arizona
21636 N. Dietz Dr.
Maricopa, AZ 85138
520.316.6745

Site Code: 15-1283-002
Station ID: Wed 10/07/2015
Escalante Rd. btwn. Pantano Rd. &
Manitoba Ave. 32.1773848, -110.820204
Latitude: 0' 0.000 Undefined

Eastbound, Westbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/7/15	0	12	2	0	0	0	0	0	0	0	0	0	0	14
01:00	0	15	1	0	0	0	0	0	0	0	0	0	0	16
02:00	0	2	0	0	0	0	0	0	0	0	0	0	0	2
03:00	0	8	1	0	1	0	0	0	0	0	0	0	0	10
04:00	0	25	5	0	1	0	0	0	0	0	0	0	0	31
05:00	0	54	14	2	3	0	0	0	0	0	0	0	0	73
06:00	1	119	25	7	**18**	**1**	0	0	0	0	0	0	0	171
07:00	1	**287**	**49**	**8**	16	0	0	0	0	0	0	0	0	**361**
08:00	0	174	24	5	4	1	0	0	0	0	0	0	0	208
09:00	**2**	101	13	5	6	1	0	0	**1**	0	0	0	0	129
10:00	1	113	24	4	8	0	0	0	1	0	0	0	0	151
11:00	0	124	16	4	8	1	0	**1**	0	0	0	0	0	154
12 PM	1	182	35	5	10	0	0	0	0	0	0	0	0	233
13:00	1	155	24	5	2	0	0	0	0	0	0	0	0	187
14:00	**2**	201	35	7	6	0	0	0	0	0	0	0	0	251
15:00	1	192	**48**	**9**	11	0	0	0	0	0	0	0	0	261
16:00	1	265	46	5	6	**1**	0	0	0	0	0	0	0	324
17:00	0	**300**	36	5	10	0	0	0	0	0	0	0	0	**351**
18:00	0	225	26	4	**16**	0	0	0	0	0	0	0	0	271
19:00	1	145	24	3	5	0	0	0	0	0	0	0	0	178
20:00	1	126	14	3	1	0	0	0	0	0	0	0	0	145
21:00	0	81	8	2	2	0	0	0	0	0	0	0	0	93
22:00	0	49	8	2	0	0	0	0	0	0	0	0	0	59
23:00	0	30	3	1	0	0	0	0	0	0	0	0	0	34
Day Total	13	2985	481	86	134	5	0	1	2	0	0	0	0	3707
Percent	0.4%	80.5%	13.0%	2.3%	3.6%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	
AM Peak	09:00	07:00	07:00	07:00	06:00	06:00		11:00	09:00					07:00
Vol.	2	287	49	8	18	1		1	1					361
PM Peak	14:00	17:00	15:00	15:00	18:00	16:00								17:00
Vol.	2	300	48	9	16	1								351
Grand Total	13	2985	481	86	134	5	0	1	2	0	0	0	0	3707
Percent	0.4%	80.5%	13.0%	2.3%	3.6%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	

APPENDIX E

PAVEMENT OPTIMIZATION DESIGN ANALYSIS BY TENSAR

SpectraPave4 PRO™
Pavement Optimization Design Analysis

Design Parameters for AASHTO (1993) Equation

Reliability (%)	= 95	Initial Serviceability	= 4.5
Standard Normal Deviate	= -1.645	Terminal Serviceability	= 2.5
Standard Deviation	= 0.4	Change in Serviceability	= 2

Aggregate fill shall conform to following requirement:

D50 <= 27mm (Base course)

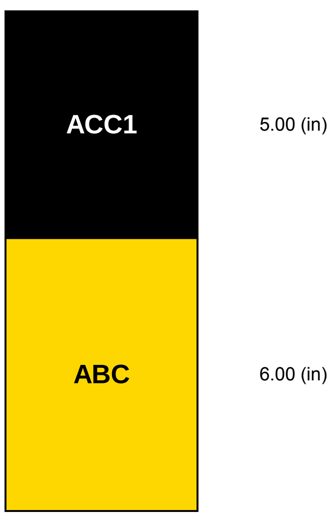
Unstabilized Section Material Properties

Layer	Description	Cost ($/ton)	Layer coefficient	Drainage factor
ACC1	Asphalt Wearing Course	70	0.440	N/A
ABC	Aggregate Base Course	20	0.140	1.25

Stabilized Section Material Properties

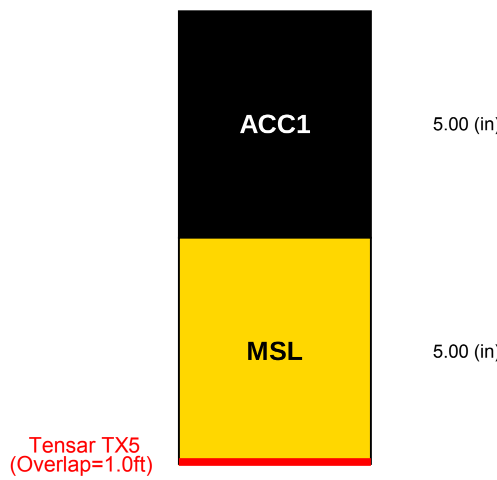
Layer	Description	Cost ($/ton)	Layer coefficient	Drainage factor
ACC1	Asphalt Wearing Course	70	0.440	N/A
MSL	Mechanically Stabilized Base Cour	20	0.286	1.25

Unstabilized Pavement



Subgrade Modulus = 13,009 (psi)
Structural Number = 3.250
Calculated Traffic (ESALs) = 2,336,000

Stabilized Pavement



Subgrade Modulus = 13,009 (psi)
Structural Number = 3.988
Calculated Traffic (ESALs) = 8,957,000

LIMITATIONS OF THE REPORT

The designs, illustrations, information and other content included in this report are necessarily general and conceptual in nature, and do not constitute engineering advice or any design intended for actual construction. Specific design recommendations can be provided as the project develops.

Project Name	Escalante East		
Company Name	Tensar		
Designer	Schlessinger	Date	11/30/15

This document was prepared using SpectraPave4 PRO™ Software Version 4.6.1
Developed by Tensar International Corporation

PAVEMENT EVALUATION
TUCSON PAVEMENT RECONSTRUCTION PROGRAM
ESCALANTE ROAD BETWEEN CALLE POLAR AND KOLB ROAD
TUCSON, ARIZONA

PREPARED FOR:
Kimley-Horn & Associates, Inc.
333 East Wetmore Road, Suite 280
Tucson, Arizona 85705

PREPARED BY:
Ninyo & Moore
Geotechnical and Environmental Sciences Consultants
1991 East Ajo Way, Suite 145
Tucson, Arizona 85713

December 14, 2015
Project No. 604817002

December 14, 2015
Project No. 604817002

Mr. Rick Solis, P.E.
Kimley-Horn
333 East Wetmore Road, Suite 280
Tucson, Arizona 85705

Subject: Pavement Evaluation
Tucson Pavement Reconstruction Program – Escalante Road
Between Calle Polar and Kolb Road
Tucson, Arizona

Dear Mr. Solis:

In accordance with our proposal dated August 12, 2015, and your authorization on September 21, 2015, Ninyo & Moore has performed a pavement evaluation for the above-referenced site. The attached report presents our methodology, findings, conclusions, and recommendations regarding the geotechnical conditions at the project site.

We appreciate the opportunity to be of service to you during this phase of the project.

Sincerely,
NINYO & MOORE

Registered Professional Engineer (Civil) CERTIFICATE NO. 48704 MAREK J. KASZTALSKI Date Signed 12·14·15 ARIZONA, U.S.A.

Marek J. Kasztalski, PE, PMP, LEED AP	Fred Narcaroti
Senior Geotechnical Engineer	Principal/Tucson Office Manager
EXPIRES 9/30/18	

MJK/DT/FFN/tlp

Distribution: (1) Addressee (Electronic Copy)

TABLE OF CONTENTS

TABLES

Figures

Appendices

1. INTRODUCTION

In accordance with our proposal dated August 12, 2015, and your authorization on September 21, 2015, we have performed a pavement evaluation for the Escalante Road Pavement Reconstruction project between Calle Polar and Kolb Road, in Tucson, Arizona. The purpose of our evaluation was to assess the pavement and subgrade conditions along the project alignment in order to provide geotechnical recommendations for design and construction. This report presents the results of our evaluation, conclusions, and recommendations regarding the proposed construction.

2. SCOPE OF SERVICES

The scope of our services generally included:

- Preparing a field testing plan and associated permit application for submittal to the City of Tucson (COT).
- Conducting a visual reconnaissance of the pavement along the alignment and marking out the boring locations.
- Notifying Arizona811 of our boring locations prior to conducting the field work.
- Arranging for traffic control measures to conduct the field work.
- Coring the existing asphaltic concrete (AC) pavement at 4 locations along the project alignment.
- Exploring the subsurface soils within the project limits by drilling, logging, and sampling 4 exploratory soil borings to approximate depths of 3 feet below ground surface (bgs). The boring logs are presented in Appendix A.
- Performing laboratory tests on selected samples collected from our borings to evaluate gradation and Atterberg limits. The results of the laboratory tests are included in Appendix B.
- Preparing this report presenting our findings, conclusions and recommendations regarding the proposed reconstruction.

Our scope of services did not include environmental consulting services such as hazardous waste sampling or analytical testing at the site. A detailed scope of services and estimated fee for such services can be provided upon request.

3. SITE DESCRIPTION

The project site is located in Section 30 of Township 14 South, Range 15 East relative to the Gila and Salt River Base Line and Meridian. The project alignment extends along Escalante Road, between Calle Polar and Kolb Road in Tucson, Arizona (Figure 1).

At the time of our evaluation residential developments existed to the north of the project alignment. South of Escalante Road, the project alignment was adjacent to the Davis Monthan Air Force Base. The roadway section consisted of one travel lane in each direction, concrete curb and sidewalks along most of the north side of the roadway. No gutter was observed along the project alignment.

4. PROPOSED CONSTRUCTION

The COT has identified several segments of the existing street network for reconstruction and/or rehabilitation in fiscal year (FY) 2016 under Bid Package 2. The scope of this report includes Escalante Road, between Calle Polar and Kolb Road. The project alignment is approximately ¾ of a mile long.

We understand that the COT anticipates full-depth reconstruction of the existing roadway along the project alignment. The City proposes a new pavement section consisting of 5 inches of AC per of the COT Department of Transportation Standard Specifications Section 406 over 5 inches of aggregate base (AB) per Section 303 of the COT Standard Specifications.

We further understand that the COT intends to use Tucson Department of Transportation (TDOT) AC Mix No. 2 PG 76-22TR+ for the surface layer and TDOT AC Mix No. 1 PG 70-10 for the underlying layer. Both layers are proposed to be 2.5 inches thick.

Due to conflicts with shallow utility lines, subgrade improvement by overexcavation will not be performed and the new pavement section will be constructed on subgrade improved with Geogrid (Tensar Geogrid TX5 or equivalent).

The scope of this exploration included evaluation of the existing pavement section and subgrade soils in order to provide recommendations for pavement reconstruction in accordance with the current COT practice. Calculations for the new pavement section supporting the new construction proposed by the COT are presented in Section 9.3 and in Appendix E of this report.

5. EXISTING PAVEMENT CONDITION

On September 28, 2015, Ninyo & Moore conducted a limited visual evaluation of the pavement surface along the project alignment. Based on our field observations, the AC pavement exhibited signs of severe distress in many locations along the project alignment primarily consisting of extensive alligator cracking with considerable spalling, longitudinal, transverse and irregular cracking, flushing and potholes. Some of the cracks exhibited evidence of past sealing. Asphaltic concrete patches were observed at some locations which were probably associated with past maintenance efforts (pothole and crack repairs) or with underground utility work. The crack widths generally varied between hairline (less than 1/8-inch) and over one inch.

In our opinion, the distress observed along the project alignment indicates structural failure and is related to a combination of pavement age, traffic, and environmental impacts.

6. FIELD EXPLORATION AND LABORATORY TESTING

On September 28, 2015, Ninyo & Moore conducted a geotechnical exploration in order to evaluate the subsurface conditions and collect AC cores and soil samples for laboratory testing. Our evaluation consisted of coring the existing AC pavement, drilling, logging, and sampling four small-diameter borings, denoted as B-1 through B-4, utilizing a CME-45 truck-mounted drill rig equipped with hollow-stem augers. The borings extended to depths of approximately 3 feet bgs. The approximate locations of the borings are depicted on Figure 2.

Ninyo & Moore personnel logged the borings in general accordance with the Unified Soil Classification System (USCS) and American Society for Testing and Materials (ASTM) D 2488 by observing cuttings and drive samples. Collected ring samples were trimmed in the field, wrapped in plastic bags, and placed in cylindrical plastic containers to retain in-place moisture conditions.

The soil samples collected from our drilling activities were transported to the Ninyo & Moore laboratory in Tucson, Arizona for geotechnical laboratory testing. The tests included gradation and Atterberg limits. A description of each laboratory test method and the test results are presented in Appendix B.

7. SUBSURFACE CONDITIONS

Our knowledge of the subsurface conditions at the project site is based on our field exploration, laboratory testing, and general experience in the area. More detailed stratigraphic information is presented on the boring logs in Appendix A, attached to this report. The boring logs contain our field and laboratory test results, as well as our interpretation of conditions believed to exist between actual samples retrieved. Therefore, these boring logs contain both factual and interpretive information. Lines delineating subsurface strata on the boring logs are intended to group soils having similar engineering properties and characteristics. They should be considered approximate as the actual transition between soil types (strata) may be gradual. A key to the soil symbols and terms used on the boring logs is provided in Appendix A.

7.1. Asphaltic Concrete

Asphaltic concrete pavement was encountered at the surface of each of our borings. The AC thickness varied between approximately 2 ¾ and 3 inches in our borings. It should be noted that the thickness of the AC pavement between the sampling locations may vary and could be different from that encountered at our sampling locations. Detailed core descriptions are presented in Appendix C.

Aggregate base was not observed in our borings. It is possible the AB material blended with the native subgrade soils, such that delineation of the AB/subgrade interface was not easily interpreted.

7.2. Alluvium

Native alluvial soils were encountered below the pavement section, and extended to the boring termination depths. The alluvium generally consisted of medium dense, clayey sands with varying amounts of gravel.

8. CONCLUSIONS

Based on the results of our visual and subsurface evaluations, laboratory testing, and data analysis, geotechnical considerations include the following:

- The on-site soils generally include clayey sands, with a plasticity index (PI) varying between 12 and 15. These soils may be sensitive to moisture content fluctuations and may be difficult to compact especially at higher moisture contents. The contractor should be aware of this condition.

- Due to the relatively widely spaced nature of our borings, soil conditions may differ from what was observed during our field exploration.

- The pavement exhibits significant distress in many locations along the project alignment consisting mainly of transverse, block and irregular cracking.

- Full-depth pavement reconstruction is considered for this project as proposed by the COT.

9. RECOMMENDATIONS

The following sections present our geotechnical recommendations for the project. If the proposed construction is changed from that discussed in this report, Ninyo & Moore should be contacted for additional recommendations.

9.1. Recommended Pavement Structural Sections

The recommended pavement sections are presented in the table below:

Pavement Section	Service Life (years)	AC (in)[1]	AB (in)[2]
COT Preferred Pavement with Geogrid	20	5	5
Alternative Pavement Section without Geogrid	20	5.5	7

Notes:
[1] TDOT AC Mix No. 2 PG 76-22TR+ as the surface mix and TDOT AC Mix No. 1 PG 70-10 for the underlying layers per Section 406 of the COT Specifications.
[2] AB per Section 303 of the COT Specifications.

9.2. Earthwork

The following sections provide our earthwork recommendations for this project. In general, the earthwork specifications contained in the *City of Tucson/Pima County Standard Specifications for Public Improvements, 2003 Edition (COT/PC Specifications)* are expected to apply unless specifically noted.

9.2.1. Site Preparation

Construction areas should be cleared of deleterious materials, if any are present, including abandoned utilities, construction debris, vegetation, and any other material that might interfere with the performance or progress of the work. These materials should be disposed of at a legal dumpsite. Existing features that call for relocation or removal and extend below finish grade, if present, should be removed, and the resulting excavations backfilled with engineered fill.

9.2.2. Excavations

Our evaluation of the excavation characteristics of the on-site soils is based on the results of our exploratory borings, site observations, and experience with similar materials.

9.2.3. Fill Materials

Soils with PI values of 15 or less (as evaluated by ASTM D 4318) are generally suitable for use as engineered fill. Our Atterberg limits test indicated the PI values ranging between 12 and 15. Based on this test result, many of the on-site soils are suitable for re-use as engineered fill.

Engineered fill should not include organic material, construction debris, or other non-soil fill materials. Rock particles and clay lumps should not be larger than 4 inches in dimension. Unsuitable material should be disposed of off-site or in non-structural areas.

9.2.4. Grading and Subgrade Preparation

In general, grading operations should be performed in accordance with Section 205 of the COT/PC Specifications.

Due to potential conflicts with underground utilities, we recommend that the subgrade be improved by the application of Geogrid (Tensar Geogrid TX5 or equivalent). Geogrid should be placed in accordance with the manufacturer’s instructions.

Alternatively, if Geogrid is not applied we recommend new pavements be supported on 6 inches of subgrade that is compacted by appropriate mechanical methods to a relative compaction of 95 percent as evaluated by ASTM D 698 at a moisture content generally near optimum. The thickness of the improvement zone should be measured from the bottom of the AB layer.

In areas where excessive moisture is encountered so that the above compaction cannot be achieved and/or the subgrade surface is unstable and yielding (pumping) under the roller wheels, subgrade soils should be scarified to a depth of 12 inches, aerated, and re-compacted as specified above. Alternatively, subgrade soils in problem areas should be and replaced with engineered fill to a depth of 12 inches below the bottom of the AB.

9.3. Pavement Design Summary

The following sections present our design assumptions and recommendations for the new flexible pavement section of Escalante Road between Calle Polar and Kolb Road, as this roadway is scheduled for full-depth pavement reconstruction.

The pavement section was developed using the Active Practices Guidelines issued by the COT Department of Transportation (Guidelines) and the Arizona Department of Transportation (ADOT) Preliminary Engineering and Design Manual (PEDM). We assumed that the subgrade will be improved by the application of Geogrid or overexcavation, as outlined in Section 9.2.4 of this report. The new pavement sections are designed for a 20-year service life.

9.3.1. Traffic

The future traffic numbers used in this report are based on traffic counts provided by Kimley-Horn and Associates, Inc. (KHA), and later communication with the KHA. This information is presented in Appendix D. Based on the above information, and using the procedures outlined in the Guidelines and PEDM, the design number of equivalent single axle loads (ESALs) for the design lane during the 20-year design period was calculated as approximately 4,358,830.

9.3.2. R-Value and Resilient Modulus

The analysis for the design R-value for the pavement section has been performed based on procedures detailed in the Guidelines and the PEDM, using correlated R-values. The correlated R-values were derived from the PI and percent passing No. 200 Sieve test results. A summary of the R-values for this project is presented in Table 1 below:

Table 1 – R-value Summary

Location	Sample Depth (ft)	Correlated R-Value
B-2	1.5-3.0	39
B-4	1.5-3.0	36

In the interest of conservatism, we recommend that an R-value of 30 be used for pavement design for this project.

If the project needs fill from an off-site source, we recommend the soils used for subgrade support should have an R-value of 30 or more. If during construction, the subgrade is found to vary from the expected soil conditions, we should be contacted so we may re-evaluate our recommended R-values. Based on the above design R-values, the design subgrade resilient modulus (M_R) value of 13,009 pounds per square inch (psi) was calculated in accordance with the Guidelines.

9.3.3. Statistical Parameters

A standard deviation of 0.40 was used for design of the flexible pavement in accordance with the Guidelines. The level of reliability and standard normal deviation (Z_R) values were selected in accordance with the Guidelines for the arterial functional classification. Their respective values are presented in the table below:

Table 2 – Summary of Statistical Parameters

Roadway	Functional Classification	Standard Deviation	Level of Reliability	Standard Normal Deviation
Escalante Road between Calle Polar and Kolb Road	Arterial	0.40	95 %	-1.645

9.3.4. Serviceability Index

Initial and terminal serviceability indices were selected for the pavement design of the roadways in accordance with the Guidelines. A summary of the serviceability indices for each roadway is provided in the table below:

Table 3 – Summary of Serviceability Parameters

Roadway	Functional Classification	Initial Serviceability Index	Terminal Serviceability Index	Change in Serviceability
Escalante Road between Calle Polar and Kolb Road	Arterial	4.5	2.5	2.0

9.3.5. Layer Coefficients

The following structural coefficients were used for the pavement structure in accordance with the Guidelines:

- AC: 0.44.
- AB: 0.14.

A drainage coefficient of 1.25 was used for the AB coefficient as recommended in the Guidelines.

As mentioned in Section 4 above, due to conflicts with existing shallow utilities, it is recommended that the subgrade be improved using Geogrid (Tensar Geogrid TX5 or equivalent). In this case the AB layer coefficient is 0.286.

9.3.6. Asphalt Pavement Section Recommendations

The structural number (SN) was calculated based on the parameters described above. The table below presents the calculated SN value and the recommended structural pavement sections. The AC thickness meets the COT requirements. Supporting documentation of the pavement optimization design using Geogrid is presented in Appendix E:

Table 4 – Structural Pavement Sections for 20-Year Design Life

Roadway	SN	AC (in)[1]	AB (in)[2]
COT Preferred Pavement with Geogrid	3.99	5	5
Alternative Pavement without Geogrid	3.58	5.5	7

Notes:
[1] TDOT AC Mix No. 2 PG 76-22TR+ as the surface mix and TDOT AC Mix No. 1 PG 70-10 for the underlying layers per Section 406 of the COT Specifications.
[2] AB per Section 303 of the COT Specifications.

The above pavement structural section has been designed with the assumption that the subgrade is prepared by as recommended in Section 9.2.4.

10. SITE DRAINAGE

Surface drainage should be provided to divert water away from paved surfaces. Surface water should also not be permitted to pond on or below pavement areas. Positive drainage for this project is defined as a slope of 2 percent or more for a distance of 5 feet or more away from the pavements. To deter accumulation of water below the new pavement sections, the bottom of the overexcavated zone below the new pavement should be sloped toward the edges of the roadway.

11. PRE-CONSTRUCTION CONFERENCE

We recommend that a pre-construction conference be held. Representatives of the owner, the civil engineer, Ninyo & Moore, and the contractor should be in attendance to discuss the project plans and schedule. Our office should be notified if the project description included herein is incorrect or if the project characteristics are significantly changed.

12. CONSTRUCTION OBSERVATION AND TESTING

During construction operations, we recommend that Ninyo & Moore perform observation and testing services for the project. These services should be performed to evaluate exposed subgrade conditions, including the extent and depth of overexcavation, to evaluate the suitability of

proposed borrow materials for use as engineered fill and to observe placement and test compaction of fill soils. Qualified subcontractors utilizing appropriate techniques and construction materials should perform construction of the proposed improvements.

13. LIMITATIONS

The field evaluation, laboratory testing, and geotechnical analyses presented in this geotechnical report have been conducted in general accordance with current practice and the standard of care exercised by geotechnical consultants performing similar tasks in the project area. No warranty, expressed or implied, is made regarding the conclusions, recommendations, and opinions presented in this report. There is no evaluation detailed enough to reveal every subsurface condition. Variations may exist and conditions not observed or described in this report may be encountered during construction. Uncertainties relative to subsurface conditions can be reduced through additional subsurface exploration. Additional subsurface evaluation will be performed upon request. Please also note that our evaluation was limited to assessment of the geotechnical aspects of the project, and did not include evaluation of structural issues, environmental concerns, or the presence of hazardous materials.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. Ninyo & Moore should be contacted if the reader requires additional information or has questions regarding the content, interpretations presented, or completeness of this document.

This report is intended for design purposes only. It does not provide sufficient data to prepare an accurate bid by contractors. It is suggested that the bidders and their geotechnical consultant perform an independent evaluation of the subsurface conditions in the project areas. The independent evaluations may include, but not be limited to, review of other geotechnical reports prepared for the adjacent areas, site reconnaissance, and additional exploration and laboratory testing.

Our conclusions, recommendations, and opinions are based on an analysis of the observed site conditions. If geotechnical conditions different from those described in this report are encountered, our office should be notified and additional recommendations, if warranted, will be provided upon request. It should be understood that the conditions of a site could change with time as a result of natural processes or the activities of man at the subject site or nearby sites. In addition, changes to the applicable laws, regulations, codes, and standards of practice may occur due to government action or the broadening of knowledge. The findings of this report may, therefore, be invalidated over time, in part or in whole, by changes over which Ninyo & Moore has no control.

This report is intended exclusively for use by the client. Any use or reuse of the findings, conclusions, and/or recommendations of this report by parties other than the client is undertaken at said parties' sole risk.

14. REFERENCES

American Society for Testing and Materials (ASTM), Annual Book of ASTM Standards.

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

City of Tucson, Arizona, Department of Transportation, Engineering Division, 1987, Active Practices Guidelines: dated June 1.

Ninyo & Moore, In-house proprietary information.

Source: Phoenix Mapping Service, Tucson Metro Edition, 2012.

0 3300

Approximate Scale:
1 inch = 3300 feet

Note: Dimensions, directions, and locations are approximate.

Ninyo & Moore		SITE LOCATION	FIGURE
PROJECT NO: 604817002	DATE: 12/15	TUCSON PAVEMENT RECONSTRUCTION - ESCALANTE ROAD BETWEEN CALLE POLAR AND KOLB ROAD TUCSON, ARIZONA	1

file no: 4817vmap1015c

Source: NAVTEQ, 03/27/14.

LEGEND

B-4 ⊕ Boring Location

N

0 420

Approximate Scale:
1 inch = 420 feet

Note: Dimensions, directions, and locations are approximate.

file no: 4817blm1015c

Ninyo & Moore

BORING LOCATIONS

PROJECT NO:	DATE:		FIGURE
604817002	12/15	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ESCALANTE ROAD BETWEEN CALLE POLAR AND KOLB ROAD TUCSON, ARIZONA	2

APPENDIX A

BORING LOGS

Field Procedure for the Collection of Relatively Undisturbed Samples
Relatively undisturbed soil samples were obtained in the field using the following methods.

The Modified Split-Barrel Drive Sampler
The sampler, with an external diameter of 3.0 inches, was lined with 1-inch long, thin brass rings with inside diameters of approximately 2.4 inches. The sample barrel was driven into the ground with the weight of a hammer or the Kelly bar of the drill rig in general accordance with ASTM D 3550. The driving weight was permitted to fall freely. The approximate length of the fall, the weight of the hammer or bar, and the number of blows per foot of driving are presented on the boring logs as an index to the relative resistance of the materials sampled. The samples were removed from the sample barrel in the brass rings, sealed, and transported to the laboratory for testing.

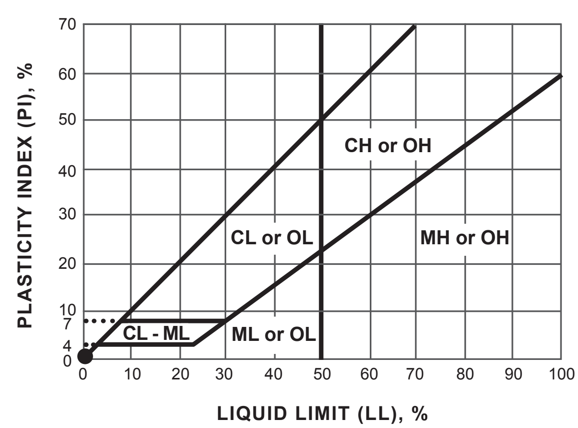
SOIL CLASSIFICATION CHART PER ASTM D 2488

PRIMARY DIVISIONS			SECONDARY DIVISIONS	
			GROUP SYMBOL	GROUP NAME
COARSE-GRAINED SOILS more than 50% retained on No. 200 sieve	**GRAVEL** more than 50% of coarse fraction retained on No. 4 sieve	CLEAN GRAVEL less than 5% fines	GW	well-graded GRAVEL
			GP	poorly graded GRAVEL
		GRAVEL with DUAL CLASSIFICATIONS 5% to 12% fines	GW-GM	well-graded GRAVEL with silt
			GP-GM	poorly graded GRAVEL with silt
			GW-GC	well-graded GRAVEL with clay
			GP-GC	poorly graded GRAVEL with clay
		GRAVEL with FINES more than 12% fines	GM	silty GRAVEL
			GC	clayey GRAVEL
			GC-GM	silty, clayey GRAVEL
	SAND 50% or more of coarse fraction passes No. 4 sieve	CLEAN SAND less than 5% fines	SW	well-graded SAND
			SP	poorly graded SAND
		SAND with DUAL CLASSIFICATIONS 5% to 12% fines	SW-SM	well-graded SAND with silt
			SP-SM	poorly graded SAND with silt
			SW-SC	well-graded SAND with clay
			SP-SC	poorly graded SAND with clay
		SAND with FINES more than 12% fines	SM	silty SAND
			SC	clayey SAND
			SC-SM	silty, clayey SAND
FINE-GRAINED SOILS 50% or more passes No. 200 sieve	**SILT and CLAY** liquid limit less than 50%	INORGANIC	CL	lean CLAY
			ML	SILT
			CL-ML	silty CLAY
		ORGANIC	OL (PI > 4)	organic CLAY
			OL (PI < 4)	organic SILT
	SILT and CLAY liquid limit 50% or more	INORGANIC	CH	fat CLAY
			MH	elastic SILT
		ORGANIC	OH (plots on or above "A"-line)	organic CLAY
			OH (plots below "A"-line)	organic SILT
	Highly Organic Soils		PT	Peat

GRAIN SIZE

DESCRIPTION		SIEVE SIZE	GRAIN SIZE	APPROXIMATE SIZE
Boulders		> 12"	> 12"	Larger than basketball-sized
Cobbles		3 - 12"	3 - 12"	Fist-sized to basketball-sized
Gravel	Coarse	3/4 - 3"	3/4 - 3"	Thumb-sized to fist-sized
	Fine	#4 - 3/4"	0.19 - 0.75"	Pea-sized to thumb-sized
Sand	Coarse	#10 - #4	0.079 - 0.19"	Rock-salt-sized to pea-sized
	Medium	#40 - #10	0.017 - 0.079"	Sugar-sized to rock-salt-sized
	Fine	#200 - #40	0.0029 - 0.017"	Flour-sized to sugar-sized
Fines		Passing #200	< 0.0029"	Flour-sized and smaller

PLASTICITY CHART



APPARENT DENSITY - COARSE-GRAINED SOIL

APPARENT DENSITY	SPOOLING CABLE OR CATHEAD		AUTOMATIC TRIP HAMMER	
	SPT (blows/foot)	MODIFIED SPLIT BARREL (blows/foot)	SPT (blows/foot)	MODIFIED SPLIT BARREL (blows/foot)
Very Loose	≤ 4	≤ 8	≤ 3	≤ 5
Loose	5 - 10	9 - 21	4 - 7	6 - 14
Medium Dense	11 - 30	22 - 63	8 - 20	15 - 42
Dense	31 - 50	64 - 105	21 - 33	43 - 70
Very Dense	> 50	> 105	> 33	> 70

CONSISTENCY - FINE-GRAINED SOIL

CONSIS-TENCY	SPOOLING CABLE OR CATHEAD		AUTOMATIC TRIP HAMMER	
	SPT (blows/foot)	MODIFIED SPLIT BARREL (blows/foot)	SPT (blows/foot)	MODIFIED SPLIT BARREL (blows/foot)
Very Soft	< 2	< 3	< 1	< 2
Soft	2 - 4	3 - 5	1 - 3	2 - 3
Firm	5 - 8	6 - 10	4 - 5	4 - 6
Stiff	9 - 15	11 - 20	6 - 10	7 - 13
Very Stiff	16 - 30	21 - 39	11 - 20	14 - 26
Hard	> 30	> 39	> 20	> 26

Ninyo & Moore

USCS METHOD OF SOIL CLASSIFICATION

Explanation of USCS Method of Soil Classification

PROJECT NO.	DATE	FIGURE

BORING LOG EXPLANATION SHEET

DEPTH (feet)	SAMPLES Bulk / Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	
0							Bulk sample.
							Modified split-barrel drive sampler.
							No recovery with modified split-barrel drive sampler.
							Sample retained by others.
							Standard Penetration Test (SPT).
5							No recovery with a SPT.
		XX/XX					Shelby tube sample. Distance pushed in inches/length of sample recovered in inches.
							No recovery with Shelby tube sampler.
							Continuous Push Sample.
							Seepage.
10							Groundwater encountered during drilling.
							Groundwater measured after drilling.
						SM	MAJOR MATERIAL TYPE (SOIL): Solid line denotes unit change.
						CL	Dashed line denotes material change.
							Attitudes: Strike/Dip b: Bedding c: Contact j: Joint f: Fracture F: Fault cs: Clay Seam s: Shear bss: Basal Slide Surface sf: Shear Fracture sz: Shear Zone sbs: Shear Bedding Surface
15							
							The total depth line is a solid line that is drawn at the bottom of the boring.
20							

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BORING LOG

Explanation of Boring Log Symbols

PROJECT NO.	DATE	FIGURE

Updated Nov. 2011

DATE DRILLED 9/28/15 BORING NO. B-1

GROUND ELEVATION 2,701' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-45, 8" Hollow Stem Auger (Southlands)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY NAG LOGGED BY NAG REVIEWED BY DT

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 3 inches thick.
							SC	ALLUVIUM: Reddish brown, moist, medium dense, clayey SAND; trace gravel.
		X	18					
								Total Depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt concrete patched on 9/28/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
5								
10								
15								
20								

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTIONS PROGRAM - ESCALANTE ROAD, CALLE POLAR TO KOLB ROAD, TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-1

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	

DATE DRILLED 9/28/15 BORING NO. B-2

GROUND ELEVATION 2,710' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-45, 8" Hollow Stem Auger (Southlands)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY NAG LOGGED BY NAG REVIEWED BY DT

DESCRIPTION/INTERPRETATION

Depth	Bulk	Driven	Blows/Foot	Moisture (%)	Dry Density (PCF)	Symbol	Classification U.S.C.S.	Description/Interpretation
0								ASPHALT CONCRETE: Approximately 3 inches thick.
							SC	ALLUVIUM: Reddish brown, moist, medium dense, clayey SAND; few gravel.
			25					
								Total Depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt concrete patched on 9/28/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
5								
10								
15								
20								

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTIONS PROGRAM - ESCALANTE ROAD, CALLE POLAR TO KOLB ROAD, TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-2

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DATE DRILLED 9/28/15 BORING NO. B-3 / GROUND ELEVATION 2,717' ± (MSL) SHEET 1 OF 1 / METHOD OF DRILLING CME-45, 8" Hollow Stem Auger (Southlands) / DRIVE WEIGHT 140 lbs. (Automatic) DROP 30" / SAMPLED BY NAG LOGGED BY NAG REVIEWED BY DT / DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 3 inches thick.
							SC	ALLUVIUM: Reddish brown, moist, medium dense, clayey SAND; trace gravel.
			24					
								Total Depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt concrete patched on 9/28/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
5								
10								
15								
20								

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTIONS PROGRAM - ESCALANTE ROAD, CALLE POLAR TO KOLB ROAD, TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-3

DATE DRILLED 9/28/15 BORING NO. B-4

GROUND ELEVATION 2,725' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-45, 8" Hollow Stem Auger (Southlands)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY NAG LOGGED BY NAG REVIEWED BY

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 2 3/4 inches thick.
							SC	ALLUVIUM: Reddish brown, moist, medium dense, clayey SAND.
			36					
								Total Depth = 3 feet. Groundwater not encountered during drilling.
5								
10								
15								
20								

Total Depth = 3 feet.
Groundwater not encountered during drilling.

Backfilled and asphalt concrete patched on 9/28/15 shortly after completion of drilling.

Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

APPENDIX B

LABORATORY TESTING

Classification

Soils were visually and texturally classified in accordance with the Unified Soil Classification System (USCS) in general accordance with ASTM D 2488. Soil classifications are indicated on the logs of the exploratory borings in Appendix A.

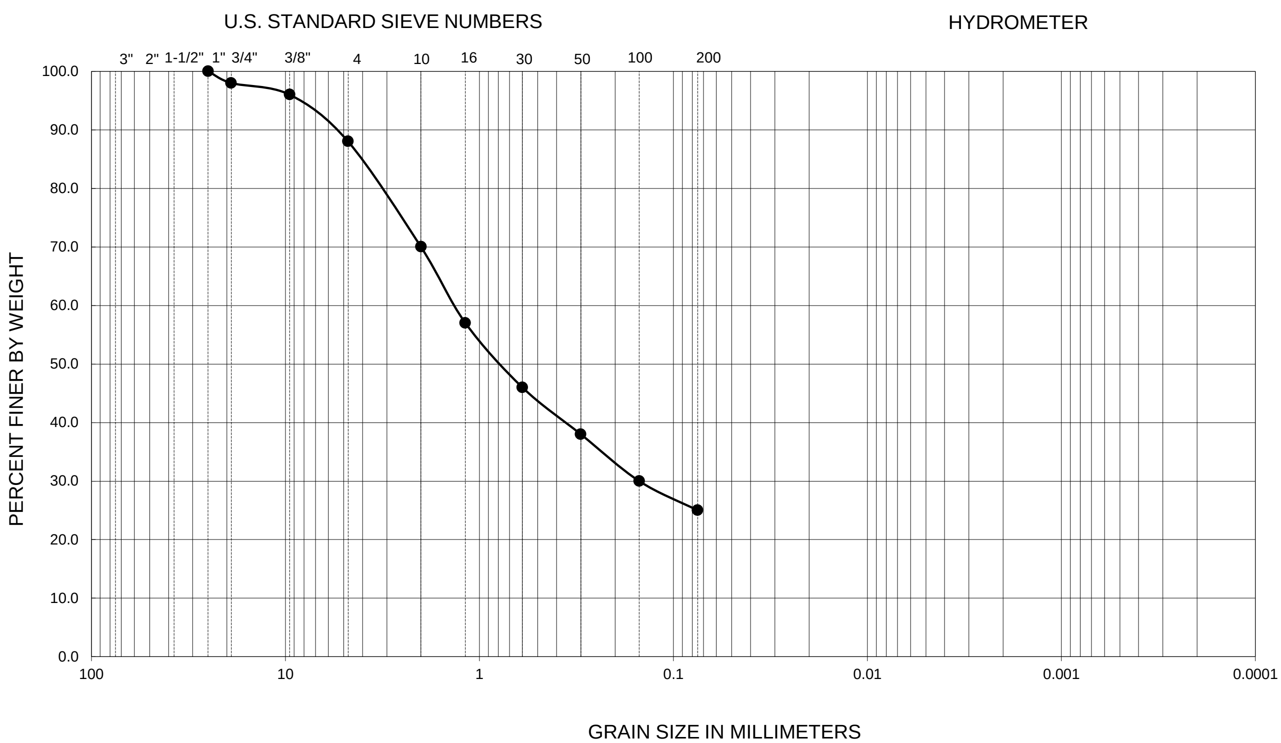
Gradation Analysis

One gradation analysis test was performed on a selected representative soil sample in general accordance with ASTM D 422. The grain-size distribution curves are shown in Figures B-1 and B-2. These test results were utilized in evaluating the soil classification in accordance with the USCS.

Atterberg Limits

Tests were performed on a selected representative fine-grained soil sample to evaluate the liquid limit, plastic limit, and plasticity index in general accordance with ASTM D 4318. These test results were utilized to evaluate the soil classification in accordance with the USCS. The test results and classifications are shown on Figure B-3.

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY

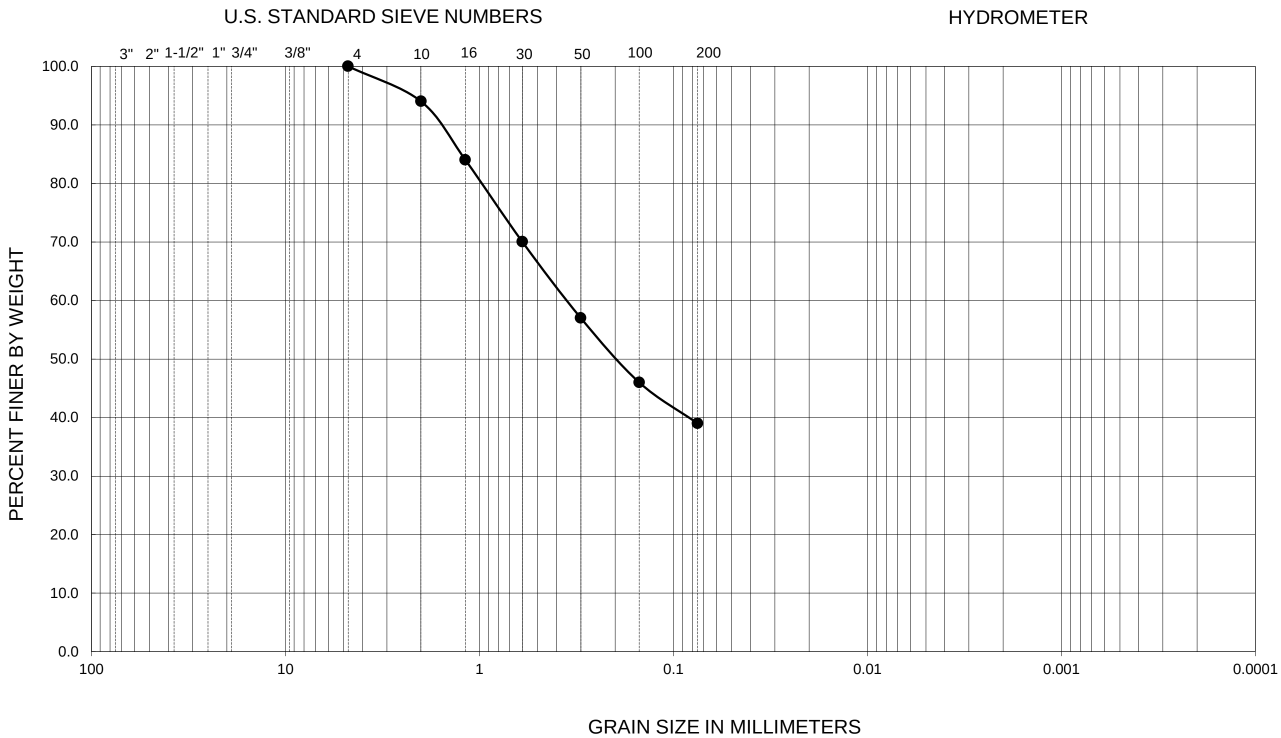


Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
●	B-2	1.5-3.0	29	14	15	--	--	--	--	--	25	SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore		GRADATION TEST RESULTS	FIGURE
PROJECT NO.	DATE	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ESCALANTE ROAD BETWEEN CALLE POLAR TO KOLB ROAD TUCSON, ARIZONA	B-1
604817001	12/15		

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
●	B-4	1.5-3.0	22	10	12	--	--	--	--	--	39	SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore

GRADATION TEST RESULTS

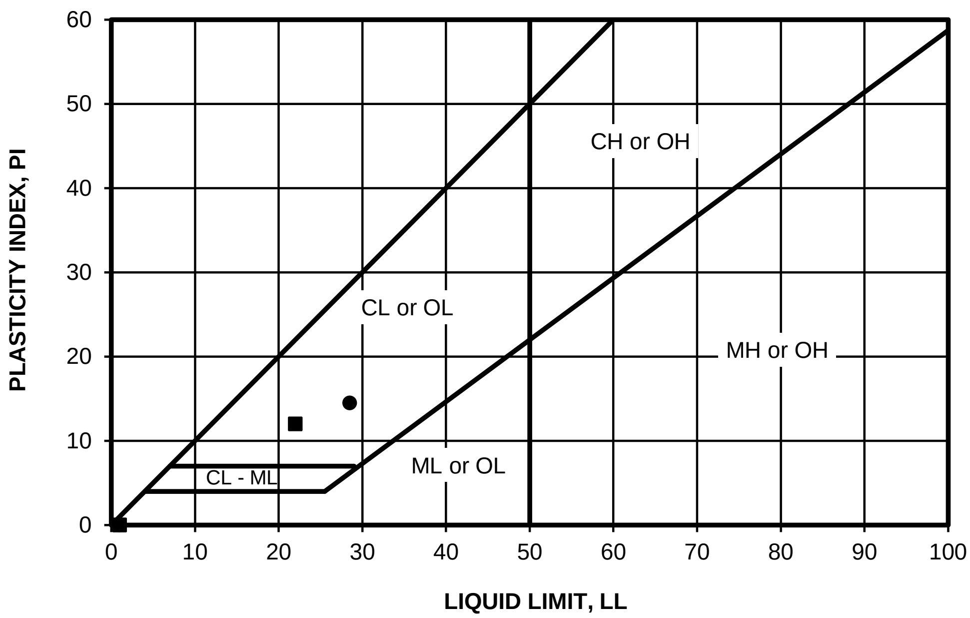
PROJECT NO.	DATE
604817001	12/15

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ESCALANTE ROAD
BETWEEN CALLE POLAR TO KOLB ROAD
TUCSON, ARIZONA

FIGURE

B-2

SYMBOL	LOCATION	DEPTH (FT)	LIQUID LIMIT, LL	PLASTIC LIMIT, PL	PLASTICITY INDEX, PI	USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve)	USCS (Entire Sample)
●	B-2	1.5-3.0	29	14	15	CL	SC
■	B-4	1.5-3.0	22	10	12	CL	SC



PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4318

Ninyo & Moore

ATTERBERG LIMITS TEST RESULTS

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ESCALANTE ROAD
BETWEEN CALLE POLAR TO KOLB ROAD
TUCSON, ARIZONA

PROJECT NO.	DATE
604817001	12/15

FIGURE

B-3

APPENDIX C

PAVEMENT AND CORE SUMMARY

ESCALANTE ROAD (CALLE POLAR TO KOLB ROAD) - PAVEMENT AND CORE SUMMARY

No.	Location	Approximate AC thickness (in)*	Recovered AC Thickness (in)	Core Description	Pavement Condition
B-1	Westbound, 950 feet west of Mann Avenue	3	2.5	One lift with chip seal, numerous voids.	Extensive alligator, transverse and block cracking, areas of flushing, patches, some cracks sealed.
B-2	Eastbound, 80 feet west of Mann Avenue	3	2.5	One lift, numerous voids, core broke into pieces.	Extensive alligator, transverse and block cracking, areas of flushing, patches, some cracks sealed.
B-3	Westbound, 630 feet east of Mann Avenue	3	2.5	One lift with chip seal, numerous voids.	Extensive alligator, transverse and block cracking, areas of flushing, patches, some cracks sealed.
B-4	Eastbound, 450 feet east of Jessica Avenue	2.75	2.75	One lift with chip seal, numerous voids, core broke into pieces.	Extensive alligator, transverse and block cracking, areas of flushing, patches, some cracks sealed.

Notes:

* Measured in the boring

APPENDIX D

TRAFFIC DATA

Field Data Services of Arizona
21636 N. Dietz Dr.
Maricopa, AZ 85138
520.316.6745

Site Code: 15-1283-001
Station ID: Wed 10/14/2015
Calle Polar btwn. Nicaragua Dr. & Barrow
St. 32.179560, -110.853668
Latitude: 0' 0.000 Undefined

Northbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/14/15	0	18	3	0	0	0	0	0	0	0	0	0	0	21
01:00	0	5	2	0	0	0	0	0	0	0	0	0	0	7
02:00	0	11	1	0	0	0	0	0	0	0	0	0	0	12
03:00	0	24	6	0	0	0	0	0	0	0	0	0	0	30
04:00	0	60	16	0	1	0	0	0	0	0	0	0	0	77
05:00	1	208	82	1	**4**	0	0	0	0	0	0	0	0	296
06:00	2	352	**122**	2	1	0	0	**2**	**2**	0	0	0	0	483
07:00	3	**499**	95	1	3	0	0	1	1	0	**2**	0	0	**605**
08:00	**4**	330	53	0	1	**1**	0	1	0	0	0	0	**1**	391
09:00	1	250	61	0	1	0	0	1	2	0	0	0	0	316
10:00	1	192	60	**3**	2	0	0	0	0	0	0	**1**	0	259
11:00	0	232	55	0	4	0	0	2	1	**1**	0	1	0	296
12 PM	0	207	47	3	3	2	0	0	0	1	0	0	1	264
13:00	0	**212**	**51**	2	4	3	0	**2**	1	**2**	1	**1**	1	**280**
14:00	1	209	49	1	1	1	0	1	1	0	**2**	0	**2**	268
15:00	1	191	43	**7**	0	1	0	0	0	1	1	0	1	246
16:00	1	182	39	3	0	0	0	1	**2**	0	1	0	0	229
17:00	1	199	34	1	**6**	1	0	0	0	0	0	1	1	244
18:00	**2**	162	31	4	0	**4**	0	0	0	0	0	0	0	203
19:00	0	114	20	1	3	1	0	0	1	0	0	0	0	140
20:00	0	60	13	1	0	0	0	0	0	0	0	0	0	74
21:00	0	47	5	2	1	0	0	0	0	0	0	0	0	55
22:00	0	47	2	0	0	0	0	0	0	0	0	0	0	49
23:00	0	22	6	0	0	0	0	0	0	0	0	0	0	28
Day Total	18	3833	896	32	35	14	0	11	11	5	7	4	7	4873
Percent	0.4%	78.7%	18.4%	0.7%	0.7%	0.3%	0.0%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	
AM Peak	08:00	07:00	06:00	10:00	05:00	08:00		06:00	06:00	11:00	07:00	10:00	08:00	07:00
Vol.	4	499	122	3	4	1		2	2	1	2	1	1	605
PM Peak	18:00	13:00	13:00	15:00	17:00	18:00		13:00	16:00	13:00	14:00	13:00	14:00	13:00
Vol.	2	212	51	7	6	4		2	2	2	2	1	2	280
Grand Total	18	3833	896	32	35	14	0	11	11	5	7	4	7	4873
Percent	0.4%	78.7%	18.4%	0.7%	0.7%	0.3%	0.0%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	

Field Data Services of Arizona
21636 N. Dietz Dr.
Maricopa, AZ 85138
520.316.6745

Site Code: 15-1283-001
Station ID: Wed 10/14/2015
Calle Polar btwn. Nicaragua Dr. & Barrow St. 32.179560, -110.853668
Latitude: 0' 0.000 Undefined

Southbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/14/15	0	31	11	0	0	0	0	0	0	0	0	0	0	42
01:00	0	18	1	0	0	0	0	0	0	0	0	0	0	19
02:00	0	18	3	0	0	0	0	0	0	0	0	0	0	21
03:00	1	14	3	0	0	0	0	0	0	0	0	0	0	18
04:00	0	21	7	0	0	0	0	0	0	0	0	0	0	28
05:00	0	52	18	1	1	0	**1**	0	0	0	0	0	0	73
06:00	1	95	33	3	3	0	0	0	2	0	0	1	**2**	140
07:00	0	145	43	**4**	0	**1**	1	1	0	0	0	0	1	196
08:00	1	134	27	2	1	0	1	0	**3**	**1**	0	0	0	170
09:00	0	153	30	2	0	0	0	1	2	0	0	**2**	1	191
10:00	0	191	39	2	1	0	1	**3**	2	0	1	0	1	241
11:00	**2**	**250**	**65**	1	**4**	1	0	2	1	0	**2**	0	1	**329**
12 PM	0	289	64	0	4	0	**1**	0	2	0	1	0	0	361
13:00	1	283	66	2	2	0	0	0	1	0	2	1	0	358
14:00	1	373	91	**4**	**6**	**1**	0	3	1	0	1	0	0	481
15:00	0	454	143	3	5	0	1	**4**	**5**	1	2	1	**2**	621
16:00	**2**	**580**	**156**	4	2	0	1	2	1	0	4	1	2	**755**
17:00	0	535	114	3	3	0	1	4	0	1	**5**	0	1	667
18:00	1	370	60	2	0	1	1	1	0	1	2	**2**	1	442
19:00	0	272	55	0	2	0	1	0	0	**2**	0	0	0	332
20:00	0	253	57	0	0	0	0	1	0	0	0	1	1	313
21:00	0	168	27	0	0	1	0	0	0	0	0	0	0	196
22:00	0	102	26	0	0	0	0	0	0	0	0	0	0	128
23:00	0	65	10	0	0	0	0	0	0	0	0	0	0	75
Day Total	10	4866	1149	33	34	5	10	22	20	6	20	9	13	6197
Percent	0.2%	78.5%	18.5%	0.5%	0.5%	0.1%	0.2%	0.4%	0.3%	0.1%	0.3%	0.1%	0.2%	
AM Peak	11:00	11:00	11:00	07:00	11:00	07:00	05:00	10:00	08:00	08:00	11:00	09:00	06:00	11:00
Vol.	2	250	65	4	4	1	1	3	3	1	2	2	2	329
PM Peak	16:00	16:00	16:00	14:00	14:00	14:00	12:00	15:00	15:00	19:00	17:00	18:00	15:00	16:00
Vol.	2	580	156	4	6	1	1	4	5	2	5	2	2	755
Grand Total	10	4866	1149	33	34	5	10	22	20	6	20	9	13	6197
Percent	0.2%	78.5%	18.5%	0.5%	0.5%	0.1%	0.2%	0.4%	0.3%	0.1%	0.3%	0.1%	0.2%	

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Latitude: 0' 0.000 Undefined

Northbound, Southbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/14/15	0	49	14	0	0	0	0	0	0	0	0	0	0	63
01:00	0	23	3	0	0	0	0	0	0	0	0	0	0	26
02:00	0	29	4	0	0	0	0	0	0	0	0	0	0	33
03:00	1	38	9	0	0	0	0	0	0	0	0	0	0	48
04:00	0	81	23	0	1	0	0	0	0	0	0	0	0	105
05:00	1	260	100	2	5	0	**1**	0	0	0	0	0	0	369
06:00	3	447	**155**	**5**	4	0	0	2	**4**	0	0	1	**2**	623
07:00	3	**644**	138	5	3	**1**	1	2	1	0	**2**	0	1	**801**
08:00	**5**	464	80	2	2	1	1	1	3	**1**	0	0	1	561
09:00	1	403	91	2	1	0	0	2	4	0	0	**2**	1	507
10:00	1	383	99	5	3	0	1	3	2	0	1	1	1	500
11:00	2	482	120	1	**8**	1	0	**4**	2	1	2	1	1	625
12 PM	0	496	111	3	7	2	**1**	0	2	1	1	0	1	625
13:00	1	495	117	4	6	3	0	2	2	**2**	3	**2**	1	638
14:00	2	582	140	5	7	2	0	**4**	2	0	3	0	2	749
15:00	1	645	186	**10**	5	1	1	4	**5**	2	3	1	**3**	867
16:00	**3**	**762**	**195**	7	2	0	1	3	3	0	**5**	1	2	**984**
17:00	1	734	148	4	**9**	1	1	4	0	1	5	1	2	911
18:00	3	532	91	6	0	**5**	1	1	0	1	2	2	1	645
19:00	0	386	75	1	5	1	1	0	1	2	0	0	0	472
20:00	0	313	70	1	0	0	0	1	0	0	0	1	1	387
21:00	0	215	32	2	1	1	0	0	0	0	0	0	0	251
22:00	0	149	28	0	0	0	0	0	0	0	0	0	0	177
23:00	0	87	16	0	0	0	0	0	0	0	0	0	0	103
Day Total	28	8699	2045	65	69	19	10	33	31	11	27	13	20	11070
Percent	0.3%	78.6%	18.5%	0.6%	0.6%	0.2%	0.1%	0.3%	0.3%	0.1%	0.2%	0.1%	0.2%	
AM Peak	08:00	07:00	06:00	06:00	11:00	07:00	05:00	11:00	06:00	08:00	07:00	09:00	06:00	07:00
Vol.	5	644	155	5	8	1	1	4	4	1	2	2	2	801
PM Peak	16:00	16:00	16:00	15:00	17:00	18:00	12:00	14:00	15:00	13:00	16:00	13:00	15:00	16:00
Vol.	3	762	195	10	9	5	1	4	5	2	5	2	3	984
Grand Total	28	8699	2045	65	69	19	10	33	31	11	27	13	20	11070
Percent	0.3%	78.6%	18.5%	0.6%	0.6%	0.2%	0.1%	0.3%	0.3%	0.1%	0.2%	0.1%	0.2%	

APPENDIX E

PAVEMENT OPTIMIZATION DESIGN ANALYSIS BY TENSAR

Tensar

SpectraPave4 PRO™
Pavement Optimization Design Analysis

Standard Asphalt Pavement - TWH Edition - 20150503

Design Parameters for AASHTO (1993) Equation

Reliability (%)	= 95	Initial Serviceability	= 4.5
Standard Normal Deviate	= -1.645	Terminal Serviceability	= 2.5
Standard Deviation	= 0.4	Change in Serviceability	= 2

Aggregate fill shall conform to following requirement:

D50 <= 27mm (Base course)

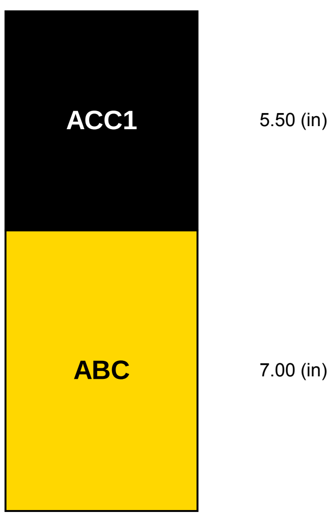
Unstabilized Section Material Properties

Layer	Description	Cost ($/ton)	Layer coefficient	Drainage factor
ACC1	Asphalt Wearing Course	70	0.440	N/A
ABC	Aggregate Base Course	20	0.140	1.25

Stabilized Section Material Properties

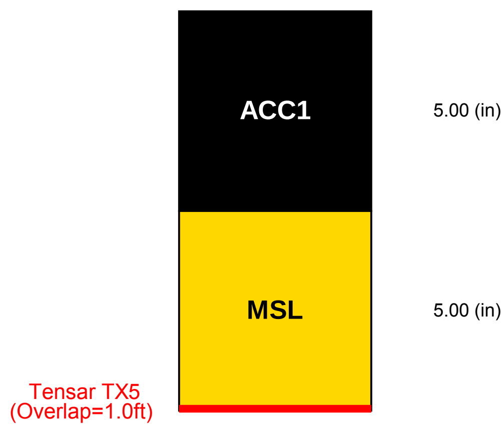
Layer	Description	Cost ($/ton)	Layer coefficient	Drainage factor
ACC1	Asphalt Wearing Course	70	0.440	N/A
MSL	Mechanically Stabilized Base Cour	20	0.286	1.25

Unstabilized Pavement



Subgrade Modulus = 13,009 (psi)
Structural Number = 3.645
Calculated Traffic (ESALs) = 4,927,000

Stabilized Pavement



Subgrade Modulus = 13,009 (psi)
Structural Number = 3.988
Calculated Traffic (ESALs) = 8,957,000

LIMITATIONS OF THE REPORT

The designs, illustrations, information and other content included in this report are necessarily general and conceptual in nature, and do not constitute engineering advice or any design intended for actual construction. Specific design recommendations can be provided as the project develops.

Project Name	Escalante West		
Company Name	Tensar		
Designer	Schlessinger	Date	11/30/15

Printed on 11-30-2015 C:\Tensar International Corporation\SpectraPave4 PRO\Untitled.sp4p

PAVEMENT EVALUATION
TUCSON PAVEMENT RECONSTRUCTION PROGRAM
IRVINGTON ROAD
TUCSON, ARIZONA

PREPARED FOR:

Kimley-Horn & Associates, Inc.
333 East Wetmore Road, Suite 280
Tucson, Arizona 85705

PREPARED BY:

Ninyo & Moore
Geotechnical and Environmental Sciences Consultants
1991 East Ajo Way, Suite 145
Tucson, Arizona 85713

December 16, 2015
Project No. 604817002

Ninyo & Moore

Contractor's License No. ROC206210

Geotechnical and Environmental Sciences Consultants

December 16, 2015
Project No. 604817002

Mr. Rick Solis, P.E.
Kimley-Horn
333 East Wetmore Road, Suite 280
Tucson, Arizona 85705

Subject: Pavement Evaluation
Tucson Pavement Reconstruction Program – Irvington Road
Tucson, Arizona

Dear Mr. Solis:

In accordance with our proposal dated August 12, 2015, and your authorization on September 21, 2015, Ninyo & Moore has performed a pavement evaluation for the above-referenced site. The attached report presents our methodology, findings, conclusions, and recommendations regarding the geotechnical conditions at the project site.

We appreciate the opportunity to be of service to you during this phase of the project.

Sincerely,
NINYO & MOORE

Registered Professional Engineer (Civil)
CERTIFICATE NO.
44704
MAREK J.
KASZTALSKI
Date Signed 12.16.15
ARIZONA, U.S.A.
EXPIRES 9/30/18

Marek J. Kasztalski, PE, PMP, LEED AP
Senior Geotechnical Engineer

Fred Narcaroti
Principal/Tucson Office Manager

MJK/DT/FFN/tlp

Distribution: (1) Addressee (Electronic Copy)

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Tables

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Appendices

1. INTRODUCTION

In accordance with our proposal dated August 12, 2015, and your authorization on September 21, 2015, we have performed a pavement evaluation for the Irvington Road Pavement Reconstruction project between Interstate 19 (I-19) ramp (east) and 6th Avenue, in Tucson, Arizona. The purpose of our evaluation was to assess the pavement and subgrade conditions along the project alignment in order to provide geotechnical recommendations for design and construction. This report presents the results of our evaluation, conclusions, and recommendations regarding the proposed construction.

2. SCOPE OF SERVICES

The scope of our services generally included:

- Preparing a field testing plan and associated permit application for submittal to the City of Tucson (COT).
- Conducting a visual reconnaissance of the pavement along the alignment and marking out the boring locations.
- Notifying Arizona811 of our boring locations prior to conducting the field work.
- Arranging for traffic control measures to conduct the field work.
- Coring the existing asphaltic concrete (AC) pavement at five locations along the project alignment.
- Exploring the subsurface soils within the project limits by drilling, logging, and sampling five exploratory soil borings to approximate depths of 3 feet below ground surface (bgs). The boring logs are presented in Appendix A.
- Performing laboratory tests on selected samples collected from our borings to evaluate gradation and Atterberg limits. The results of the laboratory tests are included in Appendix B.
- Preparing this report presenting our findings, conclusions and recommendations regarding the proposed reconstruction.

Our scope of services did not include environmental consulting services such as hazardous waste sampling or analytical testing at the site. A detailed scope of services and estimated fee for such services can be provided upon request.

3. SITE DESCRIPTION

The project site is located in Sections 35 and 36 of Townships 14 South, Range 14 East relative to the Gila and Salt River Base Line and Meridian. The project alignment extends along Irvington Road between I-19 ramp (east) and 6th Avenue, in Tucson, Arizona (Figure 1).

At the time of our evaluation commercial developments existed to the north and south of the project alignment. The roadway section consisted of two travel lanes in each direction, a center lane, concrete sidewalks, and concrete curb and gutter.

4. PROPOSED CONSTRUCTION

The COT has identified several segments of the existing street network for reconstruction and/or rehabilitation in fiscal year (FY) 2016 under Bid Package 2. The scope of this report includes Irvington Road between I-19 ramp (east) and 6th Avenue. The project alignment is approximately one mile long.

We understand that the COT anticipates pavement rehabilitation consisting of milling and overlaying the existing pavement along the project alignment. The existing AC will be milled to a depth of 3 inches. The cracks on the AC surface exposed after milling will be sealed and ½-inch thick Asphalt Rubber Stress Absorbing Membrane (SAME) will be placed. A new 2 ½-inch thick AC overlay of will be placed on top of SAME.

It is also our understanding that the COT intends to use Tucson Department of Transportation (TDOT) AC Mix No. 2 PG 76-22TR+ for the overlay.

In the event that full-depth pavement repairs are needed in areas of severe distress, we have also provided in this report a new pavement structural section, which assumes the use of TDOT AC Mix No. 2 PG 76-22TR+ for the surface layers and TDOT AC Mix No. 1 PG 70-10 for the underlying layer. Due to conflicts with shallow utility lines, subgrade improvement by overexcavation will not be performed and the new pavement section will be constructed on subgrade improved with Geogrid (Tensar Geogrid TX7 or equivalent).

The scope of this exploration included evaluation of the existing pavement section and subgrade soils in order to provide recommendations for pavement rehabilitation and/or reconstruction in accordance with the current COT practice.

5. EXISTING PAVEMENT CONDITION

On September 30, 2015, Ninyo & Moore conducted a limited visual evaluation of the pavement surface along the project alignment. Based on our field observations, the AC pavement exhibited signs of distress in many locations along the project alignment primarily consisting of extensive block, longitudinal, transverse and irregular cracking with considerable spalling, and potholes. Alligator cracking in both wheel tacks was observed at some locations near the east end of the project alignment. Some of the cracks exhibited evidence of past sealing but they have re-opened since then. The crack widths generally varied between hairline (less than 1/8-inch) and over one inch. Asphaltic concrete patches were observed at some locations which were probably associated with past maintenance efforts (pothole and crack repairs) or with underground utility work.

In our opinion, the distress observed along the project alignment indicates structural failure and is related to a combination of pavement age, subgrade condition, traffic, and environmental impacts.

6. FIELD EXPLORATION AND LABORATORY TESTING

On September 30, 2015, Ninyo & Moore conducted a geotechnical exploration in order to evaluate the subsurface conditions and collect AC cores and soil samples for laboratory testing. Our evaluation consisted of coring the existing AC pavement, drilling, logging, and sampling five small-diameter borings, denoted as B-1 through B-5, utilizing a CME-75 truck-mounted drill rig equipped with hollow-stem augers. The borings extended to depths of approximately 3 feet bgs. The approximate locations of the borings are depicted on Figure 2.

Ninyo & Moore personnel logged the borings in general accordance with the Unified Soil Classification System (USCS) and American Society for Testing and Materials (ASTM) D 2488 by observing cuttings and drive samples. Collected ring samples were trimmed in the field, wrapped in plastic bags, and placed in cylindrical plastic containers to retain in-place moisture conditions.

The soil samples collected from our drilling activities were transported to the Ninyo & Moore laboratory in Tucson, Arizona for geotechnical laboratory testing. The tests included gradation and Atterberg limits. A description of each laboratory test method and the test results are presented in Appendix B.

7. SUBSURFACE CONDITIONS

Our knowledge of the subsurface conditions at the project site is based on our field exploration, laboratory testing, and general experience in the area. More detailed stratigraphic information is presented on the boring logs in Appendix A, attached to this report. The boring logs contain our field and laboratory test results, as well as our interpretation of conditions believed to exist between actual samples retrieved. Therefore, these boring logs contain both factual and interpretive information. Lines delineating subsurface strata on the boring logs are intended to group soils having similar engineering properties and characteristics. They should be considered approximate as the actual transition between soil types (strata) may be gradual. A key to the soil symbols and terms used on the boring logs is provided in Appendix A.

7.1. Asphaltic Concrete

Asphaltic concrete pavement was encountered at the surface of each of our borings. The AC thickness varied between approximately 8 and 9 ½ inches, in our borings. It should be noted that the thickness of the AC pavement between the sampling locations may vary and could be different from that encountered at our sampling locations. Detailed core descriptions are presented in Appendix C.

Aggregate base varied between approximately 2 and 12 inches in our borings. It is possible the AB material blended with the native subgrade soils, such that delineation of the AB/subgrade interface was not easily interpreted.

7.2. Alluvium

Native alluvial soils were encountered below the pavement sections described above, and extended to the boring termination depths. The alluvium generally consisted of loose to dense, clayey and silty sands with varying amounts of gravel and scattered caliche cementation.

8. CONCLUSIONS

Based on the results of our visual and subsurface evaluations, laboratory testing, and data analysis, geotechnical considerations include the following:

- The on-site soils generally include clayey and silty sands, with plasticity index (PI) values ranging between 0 (non-plastic) and 17. Some soils may be sensitive to moisture content fluctuations and may be difficult to compact especially at higher moisture contents. The contractor should be aware of this condition.

- Due to the relatively widely spaced nature of our borings, soil conditions may differ from what was observed during our field exploration.

- The pavement exhibits significant distress in many locations along the project alignment consisting mainly of block, longitudinal, transverse and irregular cracking with considerable spalling, and potholes. Alligator cracking in both wheel tacks was observed at some locations near the east end of the project alignment.

- Mill and overlay pavement rehabilitation is considered for this project as proposed by the COT.

9. RECOMMENDATIONS

The following sections present our geotechnical recommendations for the project. If the proposed construction is changed from that discussed in this report, Ninyo & Moore should be contacted for additional recommendations.

9.1. Recommended Pavement Treatment

The recommended pavement treatments are briefly summarized below.

9.1.1. Mill and Overlay

Mill and overlay rehabilitation is recommended for the project alignment. It is anticipated that this treatment will include:

- Milling 3 inches of the existing AC.
- Sealing the cracks at the surface.
- Placing a ½-inch thick SAME membrane.
- Placing an overlay of a new AC that is 2 ½ -inches thick using TCOT Mix No. 2 PG 76-22TR+.

It is important that after milling and prior to the overlay, the pavement surface be cleaned of any debris using mechanical sweepers or similar equipment and carefully inspected for distress. Cracks wider than 1/8-inch should be sealed with an approved sealant and cracks wider than 1½-inches should be sealed with AC mix No. 3 (per Section 406 of the COT/PC Specifications). In areas where following the milling operation structural failure or disintegration is observed on the exposed AC surface, the affected areas should be removed and replaced with a new pavement section, as defined in Section 9, above. Such areas are typically characterized by extensively cracked, disintegrated, yielding and/or otherwise unstable AC.

Based on the future traffic data available and our experience with similar pavement rehabilitation projects within the Tucson Metro Area, we estimate that the service life of the milled and overlaid pavement will be on the order of 10 to 15 years. This service life includes the beneficial effect of SAME, which is anticipated to defer propagation of the cracks to the pavement surface.

9.1.2. Full-Depth Reconstruction

In the event that full-depth reconstruction is needed in areas of severe pavement distress, the recommended pavement sections are presented in the table below:

Pavement Section	Service Life (years)	AC (in)[1]	AB (in)[2]
COT Preferred Pavement with Geogrid	20	6	5
Alternative Pavement Section without Geogrid	20	7	8

Notes:
[1] TDOT AC Mix No. 2 PG 76-22TR+ as the surface mix and TDOT AC Mix No. 1 PG 70-10 for the underlying layers per Section 406 of the COT Specifications.
[2] AB per Section 303 of the COT Specifications.

9.2. Earthwork (Where Full-Depth Reconstruction is Needed)

The following sections provide our earthwork recommendations for areas where full-depth pavement reconstruction is needed due to pavement distress. In general, the earthwork specifications contained in the *City of Tucson/Pima County Standard Specifications for Public Improvements, 2003 Edition (COT/PC Specifications)* are expected to apply unless specifically noted.

9.2.1. Site Preparation

Construction areas should be cleared of deleterious materials, if any are present, including abandoned utilities, construction debris, vegetation, and any other material that might interfere with the performance or progress of the work. These materials should be disposed of at a legal dumpsite. Existing features that call for relocation or removal and extend below finish grade, if present, should be removed, and the resulting excavations backfilled with engineered fill.

9.2.2. Excavations

Our evaluation of the excavation characteristics of the on-site soils is based on the results of our exploratory borings, site observations, and experience with similar materials.

9.2.3. Fill Materials

Soils with PI values of 15 or less (as evaluated by ASTM D 4318) are generally suitable for use as engineered fill. Our Atterberg limits tests indicated PI values ranging between 0 (non-plastic) and 17. Based on these test results, some of the on-site soils are not suitable for re-use as engineered fill.

Engineered fill should not include organic material, construction debris, or other non-soil fill materials. Rock particles and clay lumps should not be larger than 4 inches in dimension. Unsuitable material should be disposed of off-site or in non-structural areas.

9.2.4. Grading and Subgrade Preparation

In general, grading operations should be performed in accordance with Section 205 of the COT/PC Specifications.

Due to potential conflicts with underground utilities, we recommend that the subgrade be improved by the application of Geogrid (Tensar Geogrid TX7 or equivalent). Geogrid should be placed in accordance with the manufacturer’s instructions.

Alternatively, if Geogrid is not applied we recommend new pavements be supported on 6 inches of subgrade that is compacted by appropriate mechanical methods to a relative compaction of 95 percent as evaluated by ASTM D 698 at a moisture content generally near optimum. The thickness of the improvement zone should be measured from the bottom of the AB layer.

In areas where excessive moisture is encountered so that the above compaction cannot be achieved and/or the subgrade surface is unstable and yielding (pumping) under the roller wheels, subgrade soils should be scarified to a depth of 12 inches, aerated, and re-compacted as specified above. Alternatively, subgrade soils in problem areas should be and replaced with engineered fill to a depth of 12 inches below the bottom of the AB.

9.3. Pavement Design Summary (Full-Depth Reconstruction)

The following sections present our design assumptions and recommendations for a new flexible pavement sections in areas where full-depth pavement reconstruction is needed due to severe pavement distress.

The pavement sections were developed using the Active Practices Guidelines issued by the COT Department of Transportation (Guidelines) and the Arizona Department of Transportation (ADOT) Preliminary Engineering and Design Manual (PEDM). The new pavement sections are designed for a 20-year service life.

9.3.1. Traffic

The future traffic numbers used in this report are based on traffic counts provided by Kimley-Horn and Associates, Inc. (KHA), and later communication with the KHA. This information is presented in Appendix D. Based on the above information, and using the procedures outlined in the Guidelines and PEDM, the design number of equivalent single axle loads (ESALs) for the design lane during the 20-year design period was calculated as approximately 12,161,070.

9.3.2. R-Value and Resilient Modulus

The analysis for the design R-value for the pavement section has been performed based on procedures detailed in the Guidelines and the PEDM, using correlated R-values. The correlated R-values were derived from the PI and percent passing No. 200 Sieve test results. A summary of the R-values for this project is presented in Table 1 below:

Table 1 – R-value Summary

Location	Sample Depth (ft)	Correlated R-Value
B-1	1.5-3.0	29
B-3	1.5-3.0	84
B-5	1.5-3.0	52

In the interest of conservatism, we recommend that an R-value of 25 be used for pavement design for this project.

If the project needs fill from an off-site source, we recommend the soils used for subgrade support should have an R-value of 25 or more. If during construction, the subgrade is found to vary from the expected soil conditions, we should be contacted so we may re-evaluate our recommended R-values. Based on the above design R-values, the design subgrade resilient modulus (M_R) value of 10,844 pounds per square inch (psi) was calculated in accordance with the Guidelines.

9.3.3. Statistical Parameters

A standard deviation of 0.40 was used for design of the flexible pavement in accordance with the Guidelines. The level of reliability and standard normal deviation (Z_R) values were selected in accordance with the Guidelines for the arterial functional classification. Their respective values are presented in the table below:

Table 2 – Summary of Statistical Parameters

Roadway	Functional Classification	Standard Deviation	Level of Reliability	Standard Normal Deviation
Irvington Road	Arterial	0.40	95 %	-1.645

9.3.4. Serviceability Index

Initial and terminal serviceability indices were selected for the pavement design of the roadways in accordance with the Guidelines. A summary of the serviceability indices for each roadway is provided in the table below:

Table 3 – Summary of Serviceability Parameters

Roadway	Functional Classification	Initial Serviceability Index	Terminal Serviceability Index	Change in Serviceability
Irvington Road	Arterial	4.5	2.5	2.0

9.3.5. Layer Coefficients

The following structural coefficients were used for the pavement structure in accordance with the Guidelines:

- AC: 0.44.
- AB: 0.14.

A drainage coefficient of 1.25 was used for the AB coefficient as recommended in the Guidelines.

As mentioned in Section 4 above, due to conflicts with existing shallow utilities, it is recommended that the subgrade be improved using Geogrid (Tensar Geogrid TX7 or equivalent). In this case the AB layer coefficient is 0.314.

9.3.6. Asphalt Pavement Section Recommendations

The structural number (SN) was calculated based on the parameters described above. The table below presents the calculated SN value and the recommended structural pavement sections. Supporting documentation of the pavement optimization design using Geogrid is presented in Appendix E:

Table 4 – Structural Pavement Sections for 20-Year Design Life

Roadway	SN	AC (in)[1]	AB (in)[2]
COT Preferred Pavement with Geogrid	4.60	6	5
Alternative Pavement without Geogrid	4.43	7	8

Notes:
[1] TDOT AC Mix No. 2 PG 76-22TR+ as the surface mix and TDOT AC Mix No. 1 PG 70-10 for the underlying layers per Section 406 of the COT Specifications.
[2] AB per Section 303 of the COT Specifications.

The above pavement structural section has been designed with the assumption that the subgrade is prepared by as recommended in Section 9.2.4.

10. SITE DRAINAGE

Surface drainage should be provided to divert water away from paved surfaces. Surface water should also not be permitted to pond on or below pavement areas. Positive drainage for this project is defined as a slope of 2 percent or more for a distance of 5 feet or more away from the pavements. To deter accumulation of water below the new pavement sections, the bottom of the overexcavated zone below the new pavement should be sloped toward the edges of the roadway.

11. PRE-CONSTRUCTION CONFERENCE

We recommend that a pre-construction conference be held. Representatives of the owner, the civil engineer, Ninyo & Moore, and the contractor should be in attendance to discuss the project plans and schedule. Our office should be notified if the project description included herein is incorrect or if the project characteristics are significantly changed.

12. CONSTRUCTION OBSERVATION AND TESTING

During construction operations, we recommend that Ninyo & Moore perform observation and testing services for the project. These services should be performed to evaluate exposed subgrade conditions, including the extent and depth of overexcavation, to evaluate the suitability of proposed borrow materials for use as engineered fill and to observe placement and test compaction of fill soils. Qualified subcontractors utilizing appropriate techniques and construction materials should perform construction of the proposed improvements.

13. LIMITATIONS

The field evaluation, laboratory testing, and geotechnical analyses presented in this geotechnical report have been conducted in general accordance with current practice and the standard of care exercised by geotechnical consultants performing similar tasks in the project area. No warranty, expressed or implied, is made regarding the conclusions, recommendations, and opinions presented in this report. There is no evaluation detailed enough to reveal every subsurface condition. Variations may exist and conditions not observed or described in this report may be encountered during construction. Uncertainties relative to subsurface conditions can be reduced through additional subsurface exploration. Additional subsurface evaluation will be performed upon request. Please also note that our evaluation was limited to assessment of the geotechnical aspects of the project, and did not include evaluation of structural issues, environmental concerns, or the presence of hazardous materials.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. Ninyo & Moore should be contacted if the reader requires additional information or has questions regarding the content, interpretations presented, or completeness of this document.

This report is intended for design purposes only. It does not provide sufficient data to prepare an accurate bid by contractors. It is suggested that the bidders and their geotechnical consultant perform an independent evaluation of the subsurface conditions in the project areas. The independent evaluations may include, but not be limited to, review of other geotechnical reports prepared for the adjacent areas, site reconnaissance, and additional exploration and laboratory testing.

Our conclusions, recommendations, and opinions are based on an analysis of the observed site conditions. If geotechnical conditions different from those described in this report are encountered, our office should be notified and additional recommendations, if warranted, will be provided upon request. It should be understood that the conditions of a site could change with time as a result of natural processes or the activities of man at the subject site or nearby sites. In addition, changes to the applicable laws, regulations, codes, and standards of practice may occur due to government action or the broadening of knowledge. The findings of this report may, therefore, be invalidated over time, in part or in whole, by changes over which Ninyo & Moore has no control.

This report is intended exclusively for use by the client. Any use or reuse of the findings, conclusions, and/or recommendations of this report by parties other than the client is undertaken at said parties' sole risk.

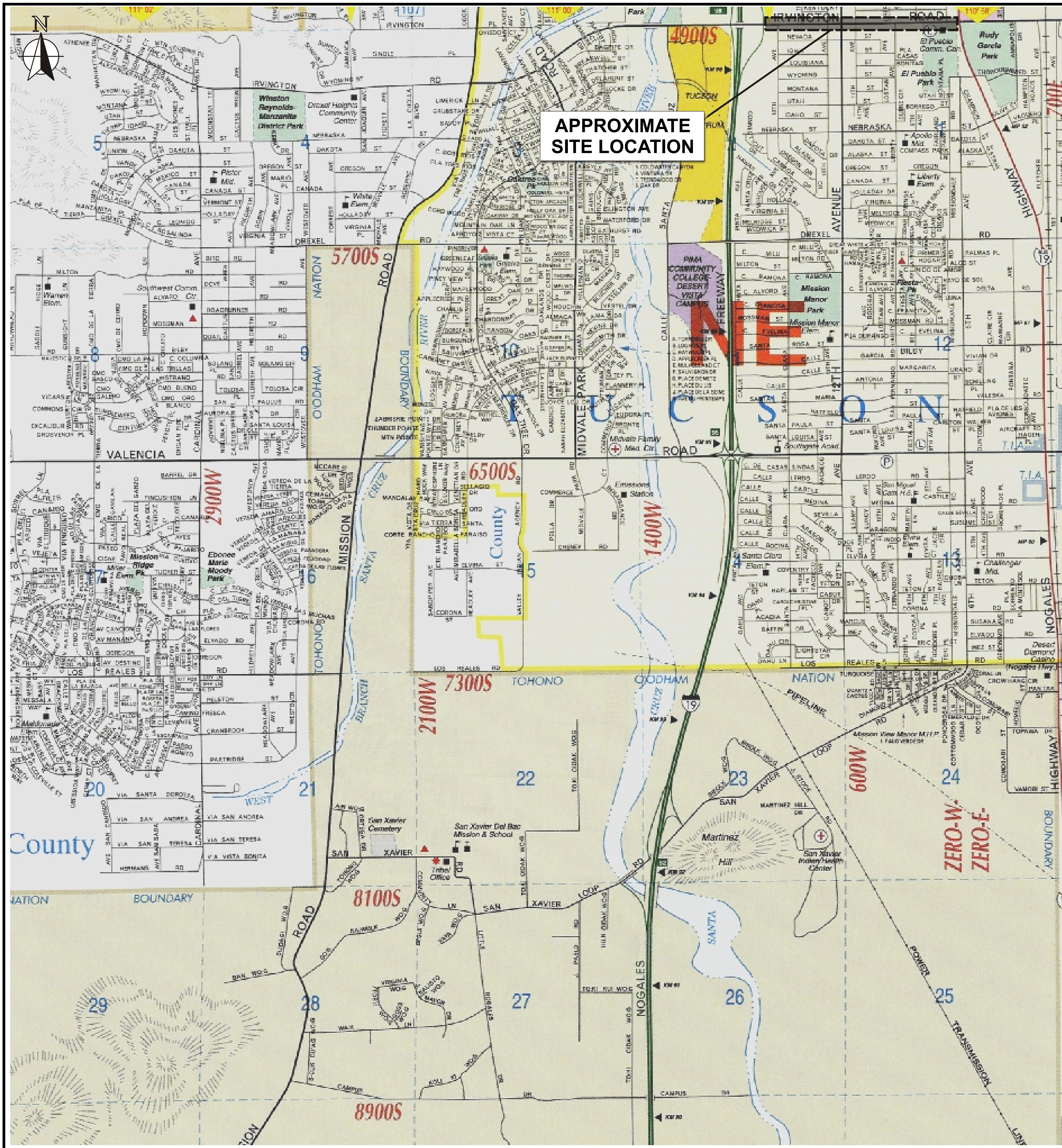
14. REFERENCES

American Society for Testing and Materials (ASTM), Annual Book of ASTM Standards.

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

City of Tucson, Arizona, Department of Transportation, Engineering Division, 1987, Active Practices Guidelines: dated June 1.

Ninyo & Moore, In-house proprietary information.



Source: Phoenix Mapping Service, Tucson Metro Edition, 2012.

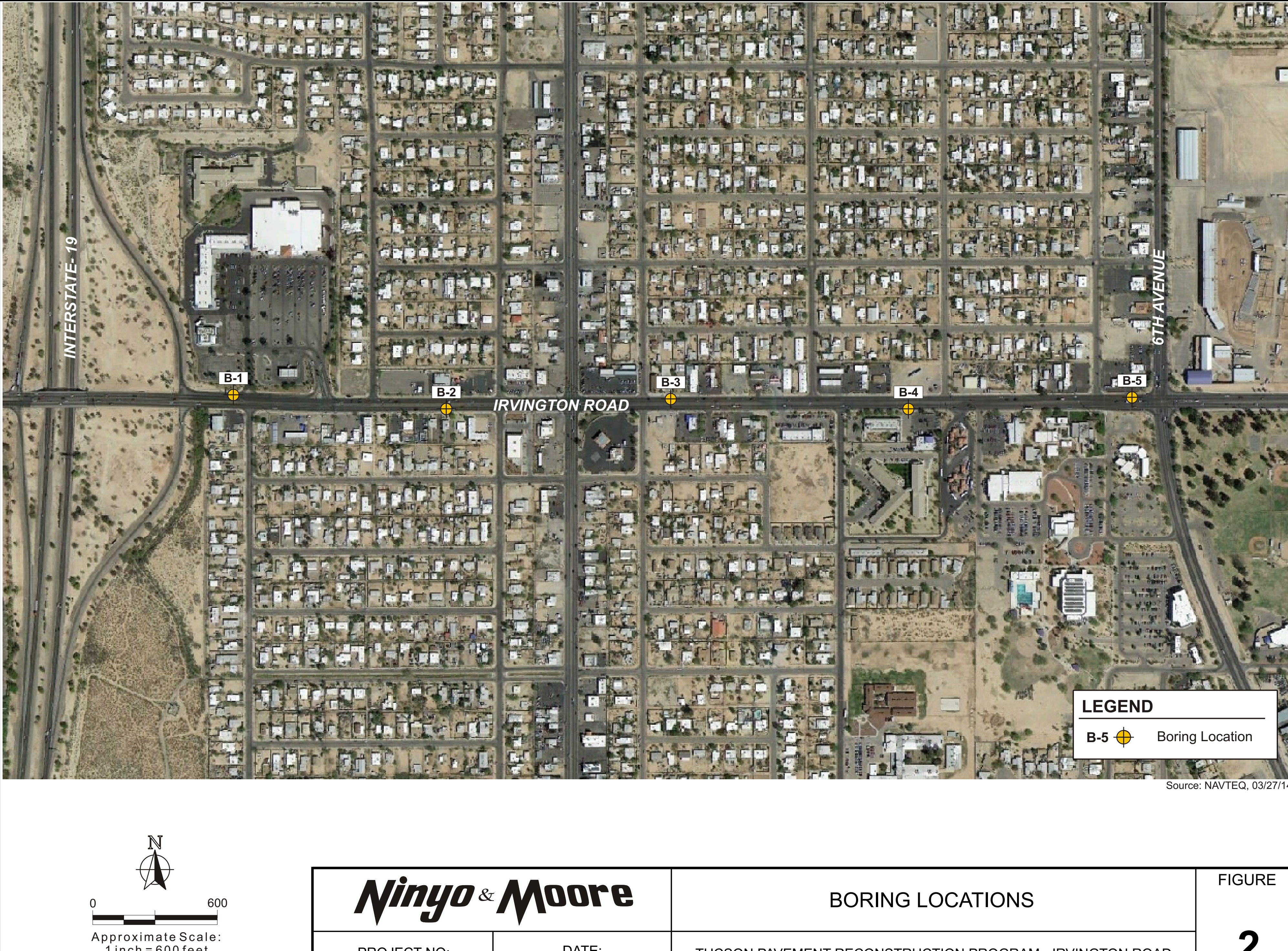
0 3300

Approximate Scale:
1 inch = 3300 feet

Note: Dimensions, directions, and locations are approximate.

Ninyo & Moore		SITE LOCATION	FIGURE
PROJECT NO: 604817002	DATE: 12/15	TUCSON PAVEMENT RECONSTRUCTION - IRVINGTON ROAD TUCSON, ARIZONA	1

file no: 4817vmap1015f



Note: Dimensions, directions, and locations are approximate.

file no: 4817blm1015f

Ninyo & Moore

BORING LOCATIONS

PROJECT NO: 604817002

DATE: 12/15

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - IRVINGTON ROAD
TUCSON, ARIZONA

FIGURE 2

APPENDIX A

BORING LOGS

Field Procedure for the Collection of Relatively Undisturbed Samples

Relatively undisturbed soil samples were obtained in the field using the following methods.

The Modified Split-Barrel Drive Sampler

The sampler, with an external diameter of 3.0 inches, was lined with 1-inch long, thin brass rings with inside diameters of approximately 2.4 inches. The sample barrel was driven into the ground with the weight of a hammer or the Kelly bar of the drill rig in general accordance with ASTM D 3550. The driving weight was permitted to fall freely. The approximate length of the fall, the weight of the hammer or bar, and the number of blows per foot of driving are presented on the boring logs as an index to the relative resistance of the materials sampled. The samples were removed from the sample barrel in the brass rings, sealed, and transported to the laboratory for testing.

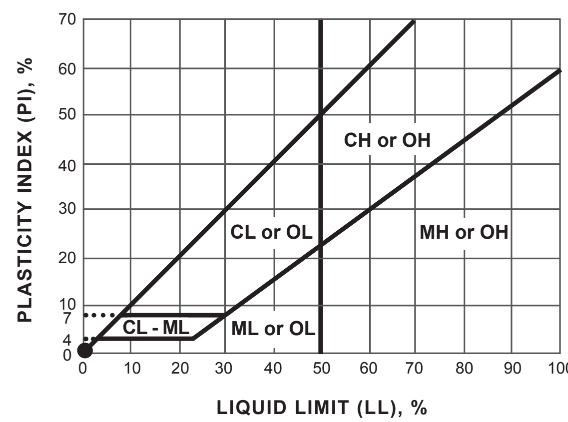
SOIL CLASSIFICATION CHART PER ASTM D 2488

PRIMARY DIVISIONS			SECONDARY DIVISIONS: GROUP SYMBOL	GROUP NAME
COARSE-GRAINED SOILS more than 50% retained on No. 200 sieve	GRAVEL more than 50% of coarse fraction retained on No. 4 sieve	CLEAN GRAVEL less than 5% fines	GW	well-graded GRAVEL
			GP	poorly graded GRAVEL
		GRAVEL with DUAL CLASSIFICATIONS 5% to 12% fines	GW-GM	well-graded GRAVEL with silt
			GP-GM	poorly graded GRAVEL with silt
			GW-GC	well-graded GRAVEL with clay
			GP-GC	poorly graded GRAVEL with clay
		GRAVEL with FINES more than 12% fines	GM	silty GRAVEL
			GC	clayey GRAVEL
			GC-GM	silty, clayey GRAVEL
	SAND 50% or more of coarse fraction passes No. 4 sieve	CLEAN SAND less than 5% fines	SW	well-graded SAND
			SP	poorly graded SAND
		SAND with DUAL CLASSIFICATIONS 5% to 12% fines	SW-SM	well-graded SAND with silt
			SP-SM	poorly graded SAND with silt
			SW-SC	well-graded SAND with clay
			SP-SC	poorly graded SAND with clay
		SAND with FINES more than 12% fines	SM	silty SAND
			SC	clayey SAND
			SC-SM	silty, clayey SAND
FINE-GRAINED SOILS 50% or more passes No. 200 sieve	SILT and CLAY liquid limit less than 50%	INORGANIC	CL	lean CLAY
			ML	SILT
			CL-ML	silty CLAY
		ORGANIC	OL (PI > 4)	organic CLAY
			OL (PI < 4)	organic SILT
	SILT and CLAY liquid limit 50% or more	INORGANIC	CH	fat CLAY
			MH	elastic SILT
		ORGANIC	OH (plots on or above "A"-line)	organic CLAY
			OH (plots below "A"-line)	organic SILT
	Highly Organic Soils		PT	Peat

GRAIN SIZE

DESCRIPTION		SIEVE SIZE	GRAIN SIZE	APPROXIMATE SIZE
Boulders		> 12"	> 12"	Larger than basketball-sized
Cobbles		3 - 12"	3 - 12"	Fist-sized to basketball-sized
Gravel	Coarse	3/4 - 3"	3/4 - 3"	Thumb-sized to fist-sized
	Fine	#4 - 3/4"	0.19 - 0.75"	Pea-sized to thumb-sized
Sand	Coarse	#10 - #4	0.079 - 0.19"	Rock-salt-sized to pea-sized
	Medium	#40 - #10	0.017 - 0.079"	Sugar-sized to rock-salt-sized
	Fine	#200 - #40	0.0029 - 0.017"	Flour-sized to sugar-sized
Fines		Passing #200	< 0.0029"	Flour-sized and smaller

PLASTICITY CHART



APPARENT DENSITY - COARSE-GRAINED SOIL

APPARENT DENSITY	SPOOLING CABLE OR CATHEAD: SPT (blows/foot)	SPOOLING CABLE OR CATHEAD: MODIFIED SPLIT BARREL (blows/foot)	AUTOMATIC TRIP HAMMER: SPT (blows/foot)	AUTOMATIC TRIP HAMMER: MODIFIED SPLIT BARREL (blows/foot)
Very Loose	≤ 4	≤ 8	≤ 3	≤ 5
Loose	5 - 10	9 - 21	4 - 7	6 - 14
Medium Dense	11 - 30	22 - 63	8 - 20	15 - 42
Dense	31 - 50	64 - 105	21 - 33	43 - 70
Very Dense	> 50	> 105	> 33	> 70

CONSISTENCY - FINE-GRAINED SOIL

CONSIS-TENCY	SPOOLING CABLE OR CATHEAD: SPT (blows/foot)	SPOOLING CABLE OR CATHEAD: MODIFIED SPLIT BARREL (blows/foot)	AUTOMATIC TRIP HAMMER: SPT (blows/foot)	AUTOMATIC TRIP HAMMER: MODIFIED SPLIT BARREL (blows/foot)
Very Soft	< 2	< 3	< 1	< 2
Soft	2 - 4	3 - 5	1 - 3	2 - 3
Firm	5 - 8	6 - 10	4 - 5	4 - 6
Stiff	9 - 15	11 - 20	6 - 10	7 - 13
Very Stiff	16 - 30	21 - 39	11 - 20	14 - 26
Hard	> 30	> 39	> 20	> 26

Ninyo & Moore

USCS METHOD OF SOIL CLASSIFICATION

Explanation of USCS Method of Soil Classification

PROJECT NO.	DATE	FIGURE

BORING LOG EXPLANATION SHEET

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	
0								Bulk sample.
								Modified split-barrel drive sampler.
								No recovery with modified split-barrel drive sampler.
								Sample retained by others.
								Standard Penetration Test (SPT).
5								No recovery with a SPT.
			XX/XX					Shelby tube sample. Distance pushed in inches/length of sample recovered in inches.
								No recovery with Shelby tube sampler.
								Continuous Push Sample.
								Seepage.
10								Groundwater encountered during drilling.
								Groundwater measured after drilling.
							SM	MAJOR MATERIAL TYPE (SOIL): Solid line denotes unit change.
							CL	Dashed line denotes material change.
15								Attitudes: Strike/Dip b: Bedding c: Contact j: Joint f: Fracture F: Fault cs: Clay Seam s: Shear bss: Basal Slide Surface sf: Shear Fracture sz: Shear Zone sbs: Shear Bedding Surface
20								The total depth line is a solid line that is drawn at the bottom of the boring.

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BORING LOG		
Explanation of Boring Log Symbols		
PROJECT NO.	DATE	FIGURE

Updated Nov. 2011

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 9 1/2 inches thick.
								AGGREGATE BASE: Approximately 4 1/2 inches thick.
			6				SC	FILL: Brown, moist, loose, clayey SAND; few gravel.
5								Total depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt concrete patched on 9/30/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
10								
15								
20								

DATE DRILLED 9/30/15 BORING NO. B-1

GROUND ELEVATION 2,455' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Hollow-Stem Auger (Southlands)

DRIVE WEIGHT 140 lbs. Automatic DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - IRVINGTON ROAD
TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-1

DATE DRILLED 9/30/15 BORING NO. B-2

GROUND ELEVATION 2,459' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Hollow-Stem Auger (Southlands)

DRIVE WEIGHT 140 lbs. Automatic DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 8 1/2 inches thick.
								AGGREGATE BASE: Approximately 12 inches thick.
			12				SC	ALLUVIUM: Brown, dry, loose, clayey SAND; scattered caliche nodules.
5								Total depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt concrete patched on 9/30/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
10								
15								
20								

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - IRVINGTON ROAD
TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-2

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DATE DRILLED 9/30/15 BORING NO. B-3 GROUND ELEVATION 2,466' ± (MSL) SHEET 1 OF 1 METHOD OF DRILLING CME-75, 8" Hollow-Stem Auger (Southlands) DRIVE WEIGHT 140 lbs. Automatic DROP 30" SAMPLED BY DM LOGGED BY DM REVIEWED BY DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 8 inches thick.
							SM	AGGREGATE BASE: Approximately 2 inches thick. ALLUVIUM: Brown, dry, dense, silty SAND; few to little gravel, numerous caliche nodules.
			58					
								Total depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt concrete patched on 9/30/15 shortly after completion of drilling.
5								Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
10								
15								
20								

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - IRVINGTON ROAD
TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-3

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DATE DRILLED 9/30/15 BORING NO. B-4 GROUND ELEVATION 2,472' ± (MSL) SHEET 1 OF 1 METHOD OF DRILLING CME-75, 8" Hollow-Stem Auger (Southlands) DRIVE WEIGHT 140 lbs. Automatic DROP 30" SAMPLED BY DM LOGGED BY DM REVIEWED BY DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 8 inches thick.
								AGGREGATE BASE: Approximately 10 inches thick.
			15				SC	ALLUVIUM: Brown, dry, medium dense, clayey SAND; trace fine gravel, scattered caliche nodules.
5 10 15 20								Total depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt concrete patched on 9/30/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - IRVINGTON ROAD
TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-4

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
								DATE DRILLED 9/30/15 BORING NO. B-5
								GROUND ELEVATION 2,481' ± (MSL) SHEET 1 OF 1
								METHOD OF DRILLING CME-75, 8" Hollow-Stem Auger (Southlands)
								DRIVE WEIGHT 140 lbs. Automatic DROP 30"
								SAMPLED BY DM LOGGED BY DM REVIEWED BY
0								<u>ASPHALT CONCRETE</u>: Approximately 8 1/2 inches thick.
								<u>AGGREGATE BASE</u>: Approximately 4 1/2 inches thick.
			28				SC	<u>ALLUVIUM</u>: Brown, dry, medium dense, clayey SAND; scattered caliche nodules.
5								Total depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt concrete patched on 9/30/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
10								
15								
20								

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - IRVINGTON ROAD
TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-5

APPENDIX B

LABORATORY TESTING

Classification

Soils were visually and texturally classified in accordance with the Unified Soil Classification System (USCS) in general accordance with ASTM D 2488. Soil classifications are indicated on the logs of the exploratory borings in Appendix A.

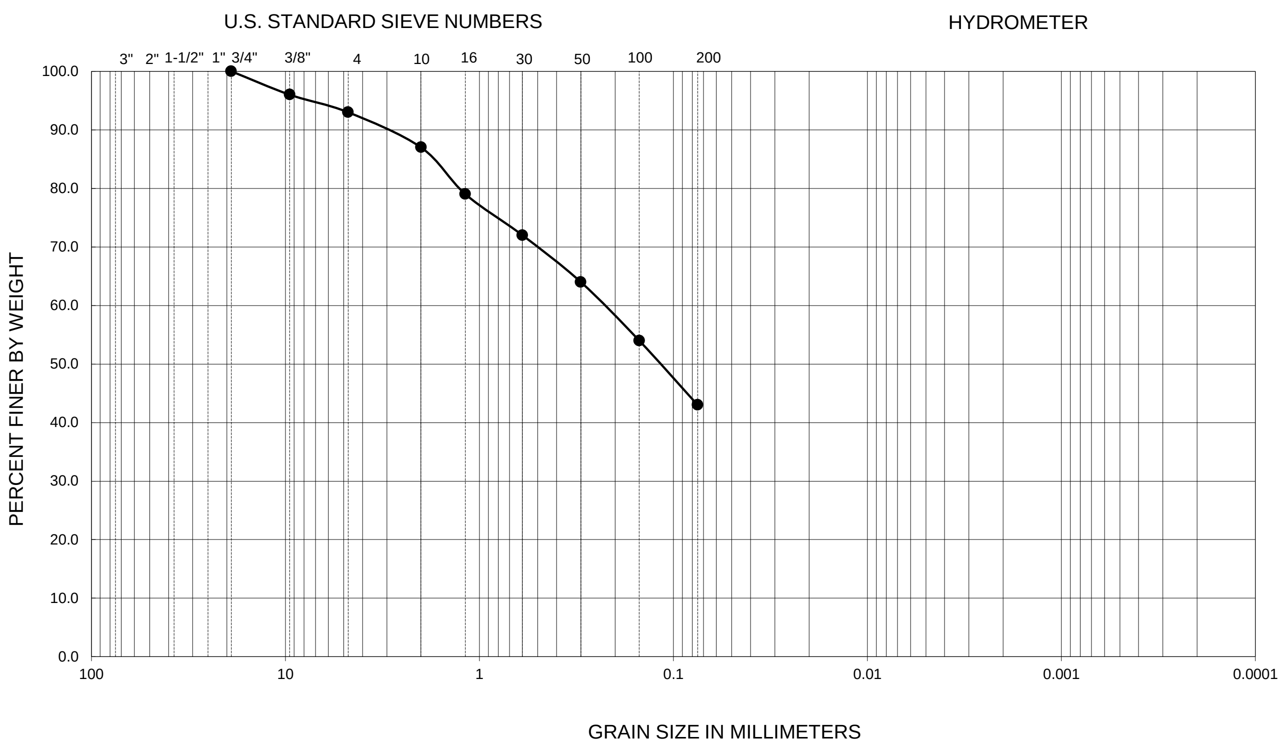
Gradation Analysis

One gradation analysis test was performed on a selected representative soil sample in general accordance with ASTM D 422. The grain-size distribution curves are shown in Figures B-1 through B-3. These test results were utilized in evaluating the soil classification in accordance with the USCS.

Atterberg Limits

Tests were performed on a selected representative fine-grained soil sample to evaluate the liquid limit, plastic limit, and plasticity index in general accordance with ASTM D 4318. These test results were utilized to evaluate the soil classification in accordance with the USCS. The test results and classifications are shown on Figure B-4.

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY

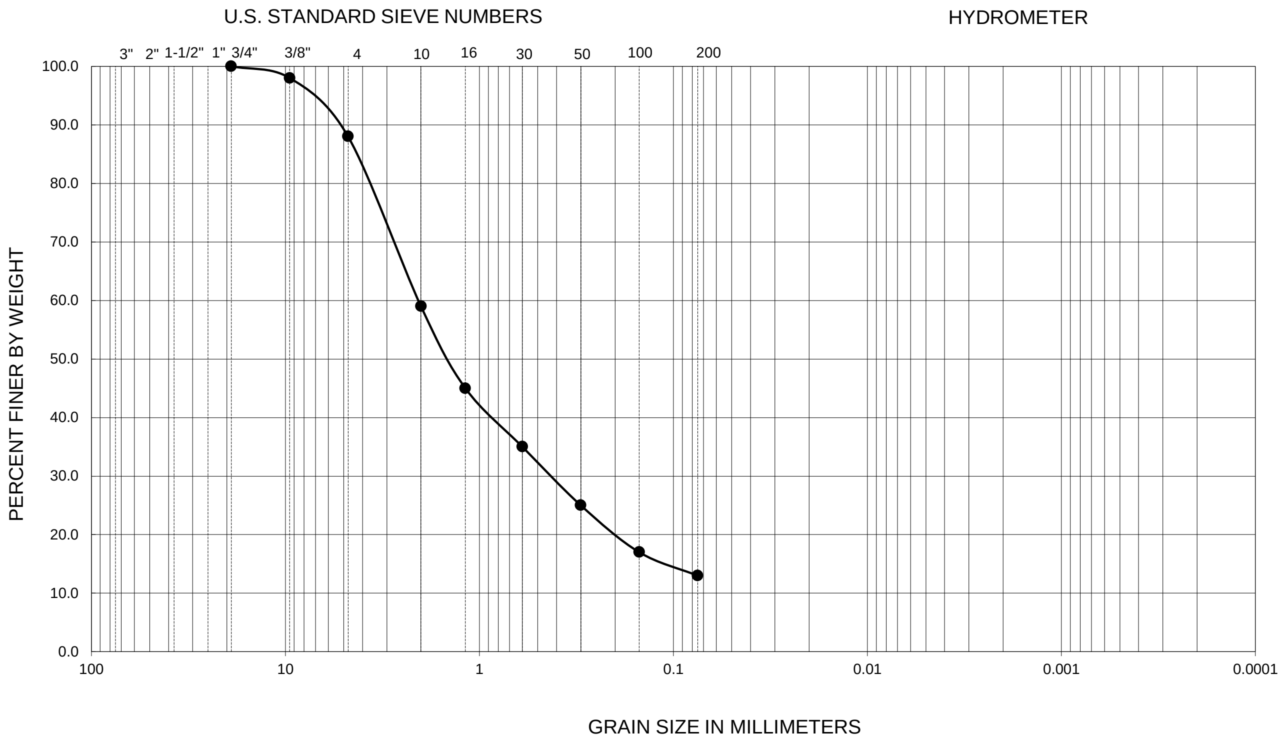


Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
●	B-1	1.5-3.0	35	18	17	--	--	--	--	--	43	SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore		GRADATION TEST RESULTS	FIGURE
PROJECT NO.	DATE	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - IRVINGTON ROAD TUCSON, ARIZONA	B-1
604817002	12/15		

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY

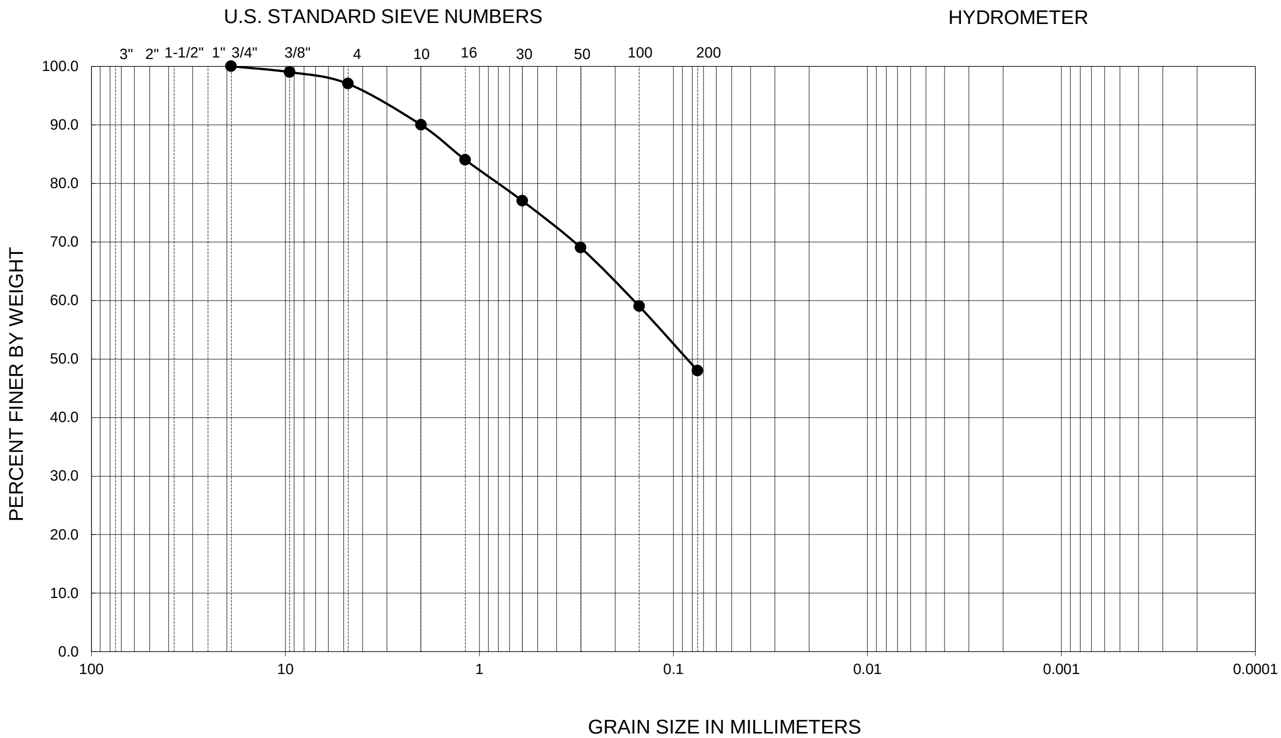


Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
●	B-3	1.5-3.0	--	--	NP	--	--	--	--	--	13	SM

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore		GRADATION TEST RESULTS	FIGURE
PROJECT NO.	DATE	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - IRVINGTON ROAD TUCSON, ARIZONA	B-2
604817002	12/15		

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



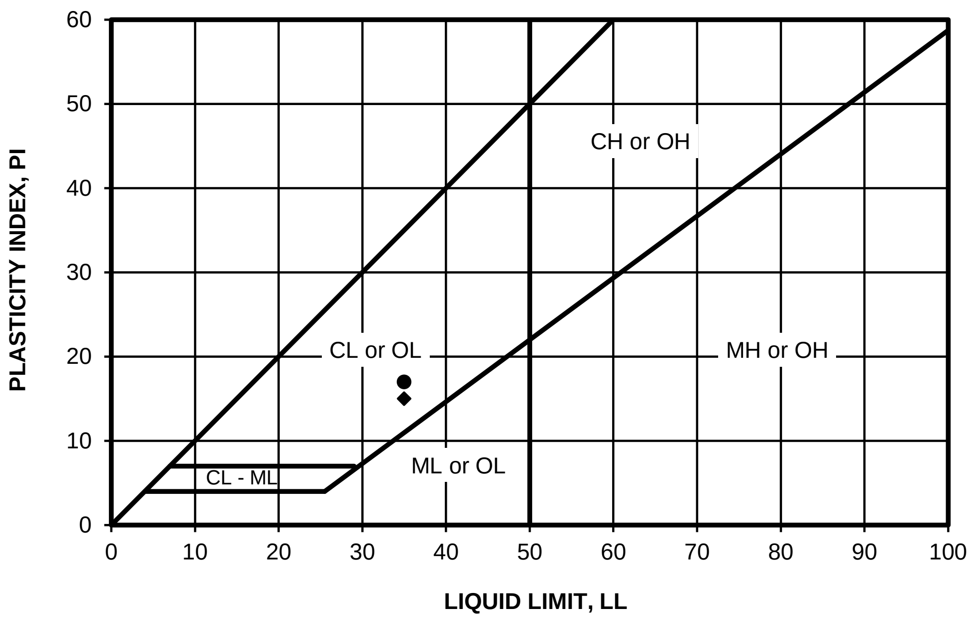
Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
●	B-5	1.5-3.0	35	20	15	--	--	--	--	--	48	SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore		GRADATION TEST RESULTS	FIGURE
PROJECT NO.	DATE	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - IRVINGTON ROAD TUCSON, ARIZONA	B-3
604817002	12/15		

SYMBOL	LOCATION	DEPTH (FT)	LIQUID LIMIT, LL	PLASTIC LIMIT, PL	PLASTICITY INDEX, PI	USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve)	USCS (Entire Sample)
●	B-1	1.5-3.0	35	18	17	CL	SC
■	B-3	1.5-3.0	--	--	NP	ML	SM
◆	B-5	1.5-3.0	35	20	15	CL	SC

NP - INDICATES NON-PLASTIC



PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4318

Ninyo & Moore

PROJECT NO.	DATE
604817002	12/15

ATTERBERG LIMITS TEST RESULTS

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - IRVINGTON ROAD
TUCSON, ARIZONA

FIGURE

B-4

APPENDIX C

PAVEMENT AND CORE SUMMARY

IRVINGTON ROAD - PAVEMENT AND CORE SUMMARY

No.	Location	Approximate AC thickness (in)*	Recovered AC Thickness (in)	Core Description	Pavement Condition
B-1	Westbound, 120 feet west of 17th Avenue	9.5	9.25	Three lifts, 2", 3.5" and 4", few voids.	Extensive, block, transverse, longitudinal and irregular cracking, potholes developing at crack crossings.
B-2	Eastbound, 250 feet west of 13th Avenue	8.5	8.5	Three lifts, 2", 2.5" and 4", few voids.	Extensive, block, transverse, longitudinal and irregular cracking.
B-3	Westbound, 500 feet east of 12th Avenue	8	8	Three lifts, 2", 3" and 3", few voids.	Extensive, block, transverse, longitudinal and irregular cracking.
B-4	Eastbound, 150 feet west of 9th Avenue	8	8	Three lifts, 2", 3" and 3", few voids.	Extensive, block, transverse, longitudinal and irregular cracking.
B-5	Eastbound, 200 feet west of 6th Avenue	8.5	8.5	Three lifts, 2", 4" and 2.5", few voids.	Extensive, block, transverse, longitudinal and irregular cracking, alligator cracking developing in wheel path.

Notes:

* Measured in the boring

APPENDIX D

TRAFFIC DATA

Field Data Services of Arizona
21636 N. Dietz Dr.
Maricopa, AZ 85138
(520) 316-6745

Site Code: 15-1283-003
Station ID: Wed 10/07/2015
Irvington Rd. btwn. 11th Ave. & Lostan Ave. 32.163336, -110.975293
Latitude: 0' 0.000 Undefined

Eastbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/7/15	0	53	13	2	2	1	0	0	0	0	0	0	0	71
01:00	0	30	7	2	0	1	1	0	1	0	0	0	0	42
02:00	0	29	5	0	0	0	0	0	0	0	0	0	0	34
03:00	0	38	8	0	2	0	0	0	0	0	0	0	0	48
04:00	2	97	30	1	3	3	0	0	0	0	0	0	0	136
05:00	6	265	103	11	24	4	0	1	0	0	1	1	0	416
06:00	16	326	133	11	35	9	1	2	1	0	1	1	0	536
07:00	**30**	**669**	154	12	36	19	**5**	4	0	**1**	2	**4**	2	**938**
08:00	20	569	**169**	**13**	37	**20**	4	4	**3**	0	**3**	1	**3**	846
09:00	11	481	111	11	33	20	5	1	1	1	0	0	0	675
10:00	10	507	141	9	**43**	10	0	**6**	0	0	0	1	0	727
11:00	13	529	128	10	24	13	3	6	1	0	1	0	0	728
12 PM	12	574	145	8	37	15	1	**6**	**2**	**1**	2	1	0	804
13:00	8	608	147	8	37	16	1	2	2	0	2	1	1	833
14:00	16	592	140	10	33	**18**	**4**	2	1	1	**3**	1	1	822
15:00	11	670	**158**	11	38	15	2	1	0	0	0	1	0	907
16:00	**19**	610	133	**14**	37	13	4	1	1	0	0	**2**	1	835
17:00	18	**673**	147	11	**47**	13	3	3	2	0	0	2	1	**920**
18:00	17	639	112	11	27	17	2	4	1	0	1	0	**2**	833
19:00	15	452	98	6	20	7	1	1	1	0	1	2	0	604
20:00	4	372	53	5	16	2	0	0	1	1	0	0	1	455
21:00	5	267	49	5	4	4	0	0	1	0	0	0	0	335
22:00	2	193	19	4	10	3	0	0	1	0	0	0	0	232
23:00	0	114	18	3	2	1	0	0	0	0	0	0	0	138
Total	235	9357	2221	178	547	224	37	44	20	5	17	18	12	12915
Percent	1.8%	72.5%	17.2%	1.4%	4.2%	1.7%	0.3%	0.3%	0.2%	0.0%	0.1%	0.1%	0.1%	
AM Peak	07:00	07:00	08:00	08:00	10:00	08:00	07:00	10:00	08:00	07:00	08:00	07:00	08:00	07:00
Vol.	30	669	169	13	43	20	5	6	3	1	3	4	3	938
PM Peak	16:00	17:00	15:00	16:00	17:00	14:00	14:00	12:00	12:00	12:00	14:00	16:00	18:00	17:00
Vol.	19	673	158	14	47	18	4	6	2	1	3	2	2	920
Grand Total	235	9357	2221	178	547	224	37	44	20	5	17	18	12	12915
Percent	1.8%	72.5%	17.2%	1.4%	4.2%	1.7%	0.3%	0.3%	0.2%	0.0%	0.1%	0.1%	0.1%	

Field Data Services of Arizona
21636 N. Dietz Dr.
Maricopa, AZ 85138
(520) 316-6745

Site Code: 15-1283-003
Station ID: Wed 10/07/2015
Irvington Rd. btwn. 11th Ave. & Lostan Ave. 32.163336, -110.975293
Latitude: 0' 0.000 Undefined

Westbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/7/15	2	72	10	2	1	0	0	0	1	0	0	0	0	88
01:00	0	38	8	0	1	0	0	0	0	0	0	0	0	47
02:00	1	36	6	0	1	0	0	0	0	0	0	0	0	44
03:00	0	36	1	0	0	0	0	0	0	0	0	0	0	37
04:00	0	79	10	0	0	1	0	0	2	0	0	0	0	92
05:00	0	161	30	**4**	11	7	0	0	1	0	0	0	0	214
06:00	6	244	51	3	12	9	1	1	2	0	0	0	0	329
07:00	6	409	74	2	21	3	3	2	1	0	**1**	0	0	522
08:00	12	509	89	4	**25**	9	3	**4**	**3**	0	0	0	**1**	659
09:00	9	528	106	1	18	**12**	1	1	3	0	0	0	1	680
10:00	8	534	**125**	0	16	12	**4**	1	3	0	0	**1**	1	705
11:00	**19**	**631**	115	0	23	11	0	1	2	0	1	1	0	**804**
12 PM	12	656	132	1	21	13	3	2	3	1	2	2	1	849
13:00	12	685	91	5	17	16	7	3	1	0	2	0	0	839
14:00	11	694	136	3	**27**	11	0	2	0	0	2	0	2	888
15:00	25	800	138	4	21	17	6	**9**	2	0	1	1	1	1025
16:00	**34**	**835**	**160**	2	18	**26**	9	6	0	1	3	2	3	**1099**
17:00	30	514	77	**8**	14	22	**23**	7	**11**	**2**	**8**	**6**	**11**	733
18:00	13	766	134	4	9	13	5	4	2	0	2	1	0	953
19:00	16	602	93	1	6	11	0	0	0	0	0	1	0	730
20:00	10	536	73	0	6	8	0	2	2	0	1	0	0	638
21:00	4	360	36	0	2	5	1	0	2	0	1	0	0	411
22:00	3	204	19	0	3	1	0	0	0	0	0	0	0	230
23:00	0	115	18	5	0	1	0	0	1	0	0	0	0	140
Total	233	10044	1732	49	273	208	66	45	42	4	24	15	21	12756
Percent	1.8%	78.7%	13.6%	0.4%	2.1%	1.6%	0.5%	0.4%	0.3%	0.0%	0.2%	0.1%	0.2%	
AM Peak	11:00	11:00	10:00	05:00	08:00	09:00	10:00	08:00	08:00		07:00	10:00	08:00	11:00
Vol.	19	631	125	4	25	12	4	4	3		1	1	1	804
PM Peak	16:00	16:00	16:00	17:00	14:00	16:00	17:00	15:00	17:00	17:00	17:00	17:00	17:00	16:00
Vol.	34	835	160	8	27	26	23	9	11	2	8	6	11	1099
Grand Total	233	10044	1732	49	273	208	66	45	42	4	24	15	21	12756
Percent	1.8%	78.7%	13.6%	0.4%	2.1%	1.6%	0.5%	0.4%	0.3%	0.0%	0.2%	0.1%	0.2%	

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Station ID: Wed 10/07/2015
Irvington Rd. btwn. 11th Ave. & Lostan Ave. 32.163336, -110.975293
Latitude: 0' 0.000 Undefined

Eastbound, Westbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/7/15	2	125	23	4	3	1	0	0	1	0	0	0	0	159
01:00	0	68	15	2	1	1	1	0	1	0	0	0	0	89
02:00	1	65	11	0	1	0	0	0	0	0	0	0	0	78
03:00	0	74	9	0	2	0	0	0	0	0	0	0	0	85
04:00	2	176	40	1	3	4	0	0	2	0	0	0	0	228
05:00	6	426	133	15	35	11	0	1	1	0	1	1	0	630
06:00	22	570	184	14	47	18	2	3	3	0	1	1	0	865
07:00	**36**	1078	228	14	57	22	**8**	6	1	**1**	**3**	**4**	2	1460
08:00	32	1078	258	**17**	**62**	29	7	**8**	**6**	0	3	1	**4**	1505
09:00	20	1009	217	12	51	**32**	6	2	4	1	0	0	1	1355
10:00	18	1041	**266**	9	59	22	4	7	3	0	0	2	1	1432
11:00	32	**1160**	243	10	47	24	3	7	3	0	2	1	0	**1532**
12 PM	24	1230	277	9	58	28	4	8	5	**2**	4	3	1	1653
13:00	20	1293	238	13	54	32	8	5	3	0	4	1	1	1672
14:00	27	1286	276	13	60	29	4	4	1	1	5	1	3	1710
15:00	36	**1470**	**296**	15	59	32	8	**10**	2	0	1	2	1	1932
16:00	**53**	1445	293	16	55	**39**	13	7	1	1	3	4	4	**1934**
17:00	48	1187	224	**19**	**61**	35	**26**	10	**13**	2	**8**	**8**	**12**	1653
18:00	30	1405	246	15	36	30	7	8	3	0	3	1	2	1786
19:00	31	1054	191	7	26	18	1	1	1	0	1	3	0	1334
20:00	14	908	126	5	22	10	0	2	3	1	1	0	1	1093
21:00	9	627	85	5	6	9	1	0	3	0	1	0	0	746
22:00	5	397	38	4	13	4	0	0	1	0	0	0	0	462
23:00	0	229	36	8	2	2	0	0	1	0	0	0	0	278
Total	468	19401	3953	227	820	432	103	89	62	9	41	33	33	25671
Percent	1.8%	75.6%	15.4%	0.9%	3.2%	1.7%	0.4%	0.3%	0.2%	0.0%	0.2%	0.1%	0.1%	
AM Peak	07:00	11:00	10:00	08:00	08:00	09:00	07:00	08:00	08:00	07:00	07:00	07:00	08:00	11:00
Vol.	36	1160	266	17	62	32	8	8	6	1	3	4	4	1532
PM Peak	16:00	15:00	15:00	17:00	17:00	16:00	17:00	15:00	17:00	12:00	17:00	17:00	17:00	16:00
Vol.	53	1470	296	19	61	39	26	10	13	2	8	8	12	1934
Grand Total	468	19401	3953	227	820	432	103	89	62	9	41	33	33	25671
Percent	1.8%	75.6%	15.4%	0.9%	3.2%	1.7%	0.4%	0.3%	0.2%	0.0%	0.2%	0.1%	0.1%	

APPENDIX E

PAVEMENT OPTIMIZATION DESIGN ANALYSIS BY TENSAR

SpectraPave4 PRO™
Pavement Optimization Design Analysis

Design Parameters for AASHTO (1993) Equation

Reliability (%)	= 95	Initial Serviceability	= 4.5
Standard Normal Deviate	= -1.645	Terminal Serviceability	= 2.5
Standard Deviation	= 0.4	Change in Serviceability	= 2

Aggregate fill shall conform to following requirement:

D50 <= 27mm (Base course)

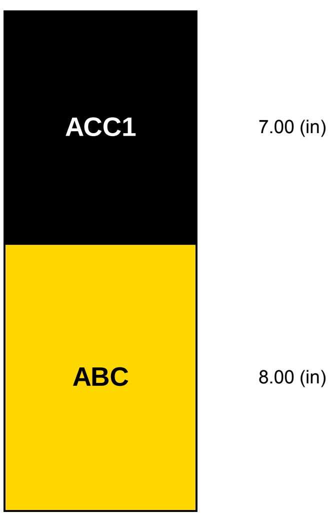
Unstabilized Section Material Properties

Layer	Description	Cost ($/ton)	Layer coefficient	Drainage factor
ACC1	Asphalt Wearing Course	70	0.440	N/A
ABC	Aggregate Base Course	20	0.140	1.25

Stabilized Section Material Properties

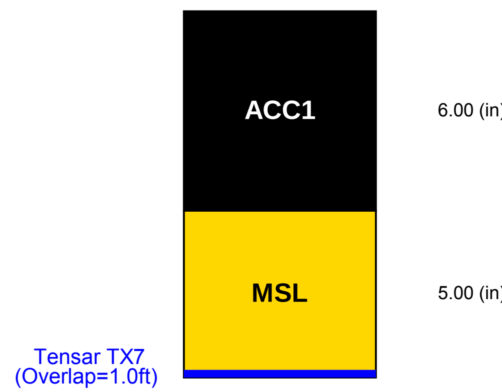
Layer	Description	Cost ($/ton)	Layer coefficient	Drainage factor
ACC1	Asphalt Wearing Course	70	0.440	N/A
MSL	Mechanically Stabilized Base Cour	20	0.314	1.25

Unstabilized Pavement



Subgrade Modulus = 10,844 (psi)
Structural Number = 4.480
Calculated Traffic (ESALs) = 13,063,000

Stabilized Pavement



Subgrade Modulus = 10,844 (psi)
Structural Number = 4.602
Calculated Traffic (ESALs) = 15,793,000

LIMITATIONS OF THE REPORT

The designs, illustrations, information and other content included in this report are necessarily general and conceptual in nature, and do not constitute engineering advice or any design intended for actual construction. Specific design recommendations can be provided as the project develops.

Project Name	Irvington Road		
Company Name	Tensar		
Designer	Schlessinger	Date	11/16/15

PAVEMENT EVALUATION
TUCSON PAVEMENT RECONSTRUCTION PROGRAM
NICARAGUA DRIVE
TUCSON, ARIZONA

PREPARED FOR:
Kimley-Horn & Associates, Inc.
333 East Wetmore Road, Suite 280
Tucson, Arizona 85705

PREPARED BY:
Ninyo & Moore
Geotechnical and Environmental Sciences Consultants
1991 East Ajo Way, Suite 145
Tucson, Arizona 85713

December 15, 2015
Project No. 604817002

December 15, 2015
Project No. 604817002

Mr. Rick Solis, P.E.
Kimley-Horn
333 East Wetmore Road, Suite 280
Tucson, Arizona 85705

Subject: Pavement Evaluation
Tucson Pavement Reconstruction Program – Nicaragua Drive
Tucson, Arizona

Dear Mr. Solis:

In accordance with our proposal dated August 12, 2015, and your authorization on September 21, 2015, Ninyo & Moore has performed a pavement evaluation for the above-referenced site. The attached report presents our methodology, findings, conclusions, and recommendations regarding the geotechnical conditions at the project site.

We appreciate the opportunity to be of service to you during this phase of the project.

Sincerely,
NINYO & MOORE

Registered Professional Engineer (Civil)
CERTIFICATE NO. 44704
MAREK J. KASZTALSKI
Date Signed 12-15-15
ARIZONA, U.S.A.

Marek J. Kasztalski, PE, PMP, LEED AP
Senior Geotechnical Engineer
EXPIRES 9/30/18

Fred Narcaroti
Principal/Tucson Office Manager

MJK/DT/FFN/tlp

Distribution: (1) Addressee (Electronic Copy)

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Appendices

1. INTRODUCTION

In accordance with our proposal dated August 12, 2015, and your authorization on September 21, 2015, we have performed a pavement evaluation for the Nicaragua Drive Pavement Reconstruction project between Wilmot Road and Calle Polar, in Tucson, Arizona. The purpose of our evaluation was to assess the pavement and subgrade conditions along the project alignment in order to provide geotechnical recommendations for design and construction. This report presents the results of our evaluation, conclusions, and recommendations regarding the proposed construction.

2. SCOPE OF SERVICES

The scope of our services generally included:

- Preparing a field testing plan and associated permit application for submittal to the City of Tucson (COT).
- Conducting a visual reconnaissance of the pavement along the alignment and marking out the boring locations.
- Notifying Arizona811 of our boring locations prior to conducting the field work.
- Arranging for traffic control measures to conduct the field work.
- Coring the existing asphaltic concrete (AC) pavement at two locations along the project alignment.
- Exploring the subsurface soils within the project limits by drilling, logging, and sampling two exploratory soil borings to approximate depths of 3 feet below ground surface (bgs). The boring logs are presented in Appendix A.
- Performing laboratory tests on selected samples collected from our borings to evaluate gradation and Atterberg limits. The results of the laboratory tests are included in Appendix B.
- Preparing this report presenting our findings, conclusions and recommendations regarding the proposed reconstruction.

Our scope of services did not include environmental consulting services such as hazardous waste sampling or analytical testing at the site. A detailed scope of services and estimated fee for such services can be provided upon request.

3. SITE DESCRIPTION

The project site is located in Section 30 of Township 14 South, Range 15 East relative to the Gila and Salt River Base Line and Meridian. The project alignment extends along Nicaragua Drive between Wilmot Road and Calle Polar, in Tucson, Arizona (Figure 1).

At the time of our evaluation residential and commercial developments existed to the north of the project alignment. South of Nicaragua Drive, the project alignment was adjacent to the Davis Monthan Air Force Base. The roadway section consisted of one travel lane in each direction, concrete sidewalks, concrete curb, and no gutter, along the project alignment. A wedge curb was observed on portions of the north side of the roadway.

4. PROPOSED CONSTRUCTION

The COT has identified several segments of the existing street network for reconstruction and/or rehabilitation in fiscal year (FY) 2016 under Bid Package 2. The scope of this report includes Nicaragua Drive between Wilmot Road and Calle Polar. The project alignment is approximately 1,300 feet long.

We understand that the COT anticipates full-depth reconstruction of the existing roadway along the project alignment. The City proposes a new pavement section consisting of 5 inches of AC per of the COT Department of Transportation Standard Specifications Section 406 over 5 inches of aggregate base (AB) per Section 303 of the COT Standard Specifications.

We further understand that the COT intends to use Tucson Department of Transportation (TDOT) AC Mix No. 2 PG 76-22TR+ for the surface layer and TDOT AC Mix No. 1 PG 70-10 for the underlying layer. Both layers are proposed to be 2.5 inches thick.

Due to conflicts with shallow utility lines, subgrade improvement by overexcavation will not be performed and the new pavement section will be constructed on subgrade improved with Geogrid (Tensar Geogrid TX7 or equivalent).

The scope of this exploration included evaluation of the existing pavement section and subgrade soils in order to provide recommendations for pavement reconstruction in accordance with the current COT practice. Calculations for the new pavement section supporting the new construction proposed by the COT are presented in Section 9.3 and in Appendix E of this report.

5. EXISTING PAVEMENT CONDITION

On September 28, 2015, Ninyo & Moore conducted a limited visual evaluation of the pavement surface along the project alignment. Based on our field observations, the AC pavement exhibited signs of distress in many locations along the project alignment primarily consisting of longitudinal, transverse and irregular cracking, potholes and pavement surface raveling. Some of the cracks exhibited evidence of past sealing but they have re-opened since then. Asphaltic concrete patches were observed at some locations which were probably associated with past maintenance efforts (pothole and crack repairs) or with underground utility work. The crack widths generally varied between hairline (less than 1/8-inch) and over one inch.

In our opinion, the distress observed along the project alignment indicates structural failure and is related to a combination of pavement age, traffic, and environmental impacts.

6. FIELD EXPLORATION AND LABORATORY TESTING

On September 28, 2015, Ninyo & Moore conducted a geotechnical exploration in order to evaluate the subsurface conditions and collect AC cores and soil samples for laboratory testing. Our evaluation consisted of coring the existing AC pavement, drilling, logging, and sampling two small-diameter borings, denoted as B-1 and B-2, utilizing a CME-45 truck-mounted drill rig equipped with hollow-stem augers. The borings extended to depths of approximately 3 feet bgs. The approximate locations of the borings are depicted on Figure 2.

Ninyo & Moore personnel logged the borings in general accordance with the Unified Soil Classification System (USCS) and American Society for Testing and Materials (ASTM) D 2488 by observing cuttings and drive samples. Collected ring samples were trimmed in the field, wrapped in plastic bags, and placed in cylindrical plastic containers to retain in-place moisture conditions.

The soil samples collected from our drilling activities were transported to the Ninyo & Moore laboratory in Tucson, Arizona for geotechnical laboratory testing. The tests included gradation and Atterberg limits. A description of each laboratory test method and the test results are presented in Appendix B.

7. SUBSURFACE CONDITIONS

Our knowledge of the subsurface conditions at the project site is based on our field exploration, laboratory testing, and general experience in the area. More detailed stratigraphic information is presented on the boring logs in Appendix A, attached to this report. The boring logs contain our field and laboratory test results, as well as our interpretation of conditions believed to exist between actual samples retrieved. Therefore, these boring logs contain both factual and interpretive information. Lines delineating subsurface strata on the boring logs are intended to group soils having similar engineering properties and characteristics. They should be considered approximate as the actual transition between soil types (strata) may be gradual. A key to the soil symbols and terms used on the boring logs is provided in Appendix A.

7.1. Asphaltic Concrete

Asphaltic concrete pavement was encountered at the surface of each of our borings. The AC thickness varied between approximately 3 ½ and 4 inches, in our borings. It should be noted that the thickness of the AC pavement between the sampling locations may vary and could be different from that encountered at our sampling locations. Detailed core descriptions are presented in Appendix C.

Aggregate base was not observed in our borings. It is possible the AB material blended with the native subgrade soils, such that delineation of the AB/subgrade interface was not easily interpreted.

7.2. Alluvium

Native alluvial soils were encountered below the pavement sections described above, and extended to the boring termination depths. The alluvium generally consisted of medium dense to very dense, clayey sands with varying amounts of gravel.

8. CONCLUSIONS

Based on the results of our visual and subsurface evaluations, laboratory testing, and data analysis, geotechnical considerations include the following:

- The on-site soils generally include clayey sands, with a plasticity index (PI) of 29. These soils may be sensitive to moisture content fluctuations and may be difficult to compact especially at higher moisture contents. The contractor should be aware of this condition.
- Due to the relatively widely spaced nature of our borings, soil conditions may differ from what was observed during our field exploration.
- The pavement exhibits significant distress in many locations along the project alignment consisting mainly of transverse, block and irregular cracking.
- Full-depth pavement reconstruction is considered for this project as proposed by the COT.

9. RECOMMENDATIONS

The following sections present our geotechnical recommendations for the project. If the proposed construction is changed from that discussed in this report, Ninyo & Moore should be contacted for additional recommendations.

9.1. Recommended Pavement Structural Sections

The recommended pavement sections are presented in the table below:

Pavement Section	Service Life (years)	AC (in)[1]	AB (in)[2]
COT Preferred Pavement with Geogrid	20	5	5
Alternative Pavement Section without Geogrid	20	6.5	7
Notes: [1] TDOT AC Mix No. 2 PG 76-22TR+ as the surface mix and TDOT AC Mix No. 1 PG 70-10 for the underlying layers per Section 406 of the COT Specifications. [2] AB per Section 303 of the COT Specifications.			

9.2. Earthwork

The following sections provide our earthwork recommendations for this project. In general, the earthwork specifications contained in the *City of Tucson/Pima County Standard Specifications for Public Improvements, 2003 Edition (COT/PC Specifications)* are expected to apply unless specifically noted.

9.2.1. Site Preparation

Construction areas should be cleared of deleterious materials, if any are present, including abandoned utilities, construction debris, vegetation, and any other material that might interfere with the performance or progress of the work. These materials should be disposed of at a legal dumpsite. Existing features that call for relocation or removal and extend below finish grade, if present, should be removed, and the resulting excavations backfilled with engineered fill.

9.2.2. Excavations

Our evaluation of the excavation characteristics of the on-site soils is based on the results of our exploratory borings, site observations, and experience with similar materials.

9.2.3. Fill Materials

Soils with PI values of 15 or less (as evaluated by ASTM D 4318) are generally suitable for use as engineered fill. Our Atterberg limits test indicated a PI value of 29. Based on this test result, some of the on-site soils are not suitable for re-use as engineered fill.

Engineered fill should not include organic material, construction debris, or other non-soil fill materials. Rock particles and clay lumps should not be larger than 4 inches in dimension. Unsuitable material should be disposed of off-site or in non-structural areas.

9.2.4. Grading and Subgrade Preparation

In general, grading operations should be performed in accordance with Section 205 of the COT/PC Specifications.

Due to potential conflicts with underground utilities, we recommend that the subgrade be improved by the application of Geogrid (Tensar Geogrid TX7 or equivalent). Geogrid should be placed in accordance with the manufacturer's instructions.

Alternatively, if Geogrid is not applied we recommend new pavements be supported on 6 inches of subgrade that is compacted by appropriate mechanical methods to a relative compaction of 95 percent as evaluated by ASTM D 698 at a moisture content generally near optimum. The thickness of the improvement zone should be measured from the bottom of the AB layer.

In areas where excessive moisture is encountered so that the above compaction cannot be achieved and/or the subgrade surface is unstable and yielding (pumping) under the roller wheels, subgrade soils should be scarified to a depth of 12 inches, aerated, and re-compacted as specified above. Alternatively, subgrade soils in problem areas should be and replaced with engineered fill to a depth of 12 inches below the bottom of the AB.

9.3. Pavement Design Summary

The following sections present our design assumptions and recommendations for the new flexible pavement section of Nicaragua Drive as this roadway is scheduled for full-depth pavement reconstruction.

The pavement section was developed using the Active Practices Guidelines issued by the COT Department of Transportation (Guidelines) and the Arizona Department of Transportation (ADOT) Preliminary Engineering and Design Manual (PEDM). We assumed that the subgrade will be improved by the application of Geogrid or overexcavation, as outlined in Section 9.2.4 of this report. The new pavement sections are designed for a 20-year service life.

9.3.1. Traffic

The future traffic numbers used in this report are based on traffic counts provided by Kimley-Horn and Associates, Inc. (KHA), and later communication with the KHA. This information is presented in Appendix D. Based on the above information, and using the procedures outlined in the Guidelines and PEDM, the design number of equivalent single axle loads (ESALs) for the design lane during the 20-year design period was calculated as approximately 4,358,830.

9.3.2. R-Value and Resilient Modulus

The analysis for the design R-value for the pavement section has been performed based on procedures detailed in the Guidelines and the PEDM, using a correlated R-value. The correlated R-value was derived from the PI and percent passing No. 200 Sieve test results. The R-value calculated for these methods for this project is 22. In the interest of conservatism, we recommend that an R-value of 20 be used for pavement design for this project.

If the project needs fill from an off-site source, we recommend the soils used for subgrade support should have an R-value of 20 or more. If during construction, the subgrade is found to vary from the expected soil conditions, we should be contacted so we may re-evaluate our recommended R-values. Based on the above design R-values, the design subgrade resilient modulus (M_R) value of 8,824 pounds per square inch (psi) was calculated in accordance with the Guidelines.

9.3.3. Statistical Parameters

A standard deviation of 0.40 was used for design of the flexible pavement in accordance with the Guidelines. The level of reliability and standard normal deviation (Z_R) values were selected in accordance with the Guidelines for the arterial functional classification. Their respective values are presented in the table below:

Table 1 – Summary of Statistical Parameters

Roadway	Functional Classification	Standard Deviation	Level of Reliability	Standard Normal Deviation
Nicaragua Drive	Arterial	0.40	95 %	-1.645

9.3.4. Serviceability Index

Initial and terminal serviceability indices were selected for the pavement design of the roadways in accordance with the Guidelines. A summary of the serviceability indices for each roadway is provided in the table below:

Table 2 – Summary of Serviceability Parameters

Roadway	Functional Classification	Initial Serviceability Index	Terminal Serviceability Index	Change in Serviceability
Nicaragua Drive	Arterial	4.5	2.5	2.0

9.3.5. Layer Coefficients

The following structural coefficients were used for the pavement structure in accordance with the Guidelines:

- AC: 0.44.

- AB: 0.14.

A drainage coefficient of 1.25 was used for the AB coefficient as recommended in the Guidelines.

As mentioned in Section 4 above, due to conflicts with existing shallow utilities, it is recommended that the subgrade be improved using Geogrid (Tensar Geogrid TX7 or equivalent). In this case the AB layer coefficient is 0.318.

9.3.6. Asphalt Pavement Section Recommendations

The structural number (SN) was calculated based on the parameters described above. The table below presents the calculated SN value and the recommended structural pavement sections. The AC thickness meets the COT requirements. Supporting documentation of the pavement optimization design using Geogrid is presented in Appendix E:

Table 3 – Structural Pavement Sections for 20-Year Design Life

Roadway	SN	AC (in)[1]	AB (in)[2]
COT Preferred Pavement with Geogrid	4.19	5	5
Alternative Pavement without Geogrid	4.09	6.5	7

Notes:
[1] TDOT AC Mix No. 2 PG 76-22TR+ as the surface mix and TDOT AC Mix No. 1 PG 70-10 for the underlying layers per Section 406 of the COT Specifications.
[2] AB per Section 303 of the COT Specifications.

The above pavement structural section has been designed with the assumption that the subgrade is prepared by as recommended in Section 9.2.4.

10. SITE DRAINAGE

Surface drainage should be provided to divert water away from paved surfaces. Surface water should also not be permitted to pond on or below pavement areas. Positive drainage for this project is defined as a slope of 2 percent or more for a distance of 5 feet or more away from the pavements. To deter accumulation of water below the new pavement sections, the bottom of the overexcavated zone below the new pavement should be sloped toward the edges of the roadway.

11. PRE-CONSTRUCTION CONFERENCE

We recommend that a pre-construction conference be held. Representatives of the owner, the civil engineer, Ninyo & Moore, and the contractor should be in attendance to discuss the project plans and schedule. Our office should be notified if the project description included herein is incorrect or if the project characteristics are significantly changed.

12. CONSTRUCTION OBSERVATION AND TESTING

During construction operations, we recommend that Ninyo & Moore perform observation and testing services for the project. These services should be performed to evaluate exposed subgrade conditions, including the extent and depth of overexcavation, to evaluate the suitability of proposed borrow materials for use as engineered fill and to observe placement and test compaction of fill soils. Qualified subcontractors utilizing appropriate techniques and construction materials should perform construction of the proposed improvements.

13. LIMITATIONS

The field evaluation, laboratory testing, and geotechnical analyses presented in this geotechnical report have been conducted in general accordance with current practice and the standard of care exercised by geotechnical consultants performing similar tasks in the project area. No warranty, expressed or implied, is made regarding the conclusions, recommendations, and opinions presented in this report. There is no evaluation detailed enough to reveal every subsurface condition. Variations may exist and conditions not observed or described in this report may be encountered during construction. Uncertainties relative to subsurface conditions can be reduced through additional subsurface exploration. Additional subsurface evaluation will be performed upon request. Please also note that our evaluation was limited to assessment of the geotechnical aspects of the project, and did not include evaluation of structural issues, environmental concerns, or the presence of hazardous materials.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. Ninyo & Moore should be contacted if the reader requires additional information or has questions regarding the content, interpretations presented, or completeness of this document.

This report is intended for design purposes only. It does not provide sufficient data to prepare an accurate bid by contractors. It is suggested that the bidders and their geotechnical consultant perform an independent evaluation of the subsurface conditions in the project areas. The independent evaluations may include, but not be limited to, review of other geotechnical reports prepared for the adjacent areas, site reconnaissance, and additional exploration and laboratory testing.

Our conclusions, recommendations, and opinions are based on an analysis of the observed site conditions. If geotechnical conditions different from those described in this report are encountered, our office should be notified and additional recommendations, if warranted, will be provided upon request. It should be understood that the conditions of a site could change with time as a result of natural processes or the activities of man at the subject site or nearby sites. In addition, changes to the applicable laws, regulations, codes, and standards of practice may occur due to government action or the broadening of knowledge. The findings of this report may, therefore, be invalidated over time, in part or in whole, by changes over which Ninyo & Moore has no control.

This report is intended exclusively for use by the client. Any use or reuse of the findings, conclusions, and/or recommendations of this report by parties other than the client is undertaken at said parties' sole risk.

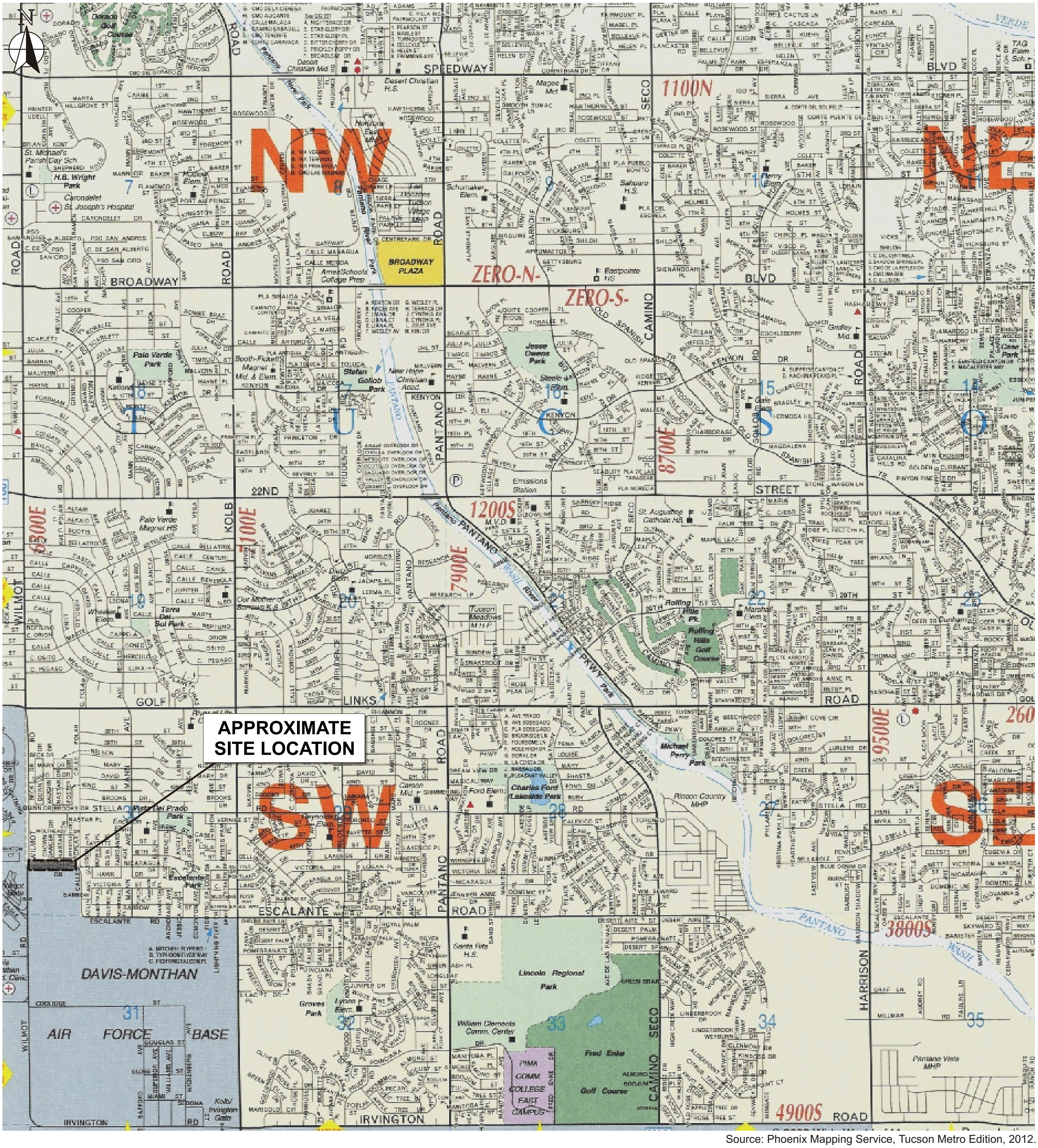
14. REFERENCES

American Society for Testing and Materials (ASTM), Annual Book of ASTM Standards.

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

City of Tucson, Arizona, Department of Transportation, Engineering Division, 1987, Active Practices Guidelines: dated June 1.

Ninyo & Moore, In-house proprietary information.



Source: Phoenix Mapping Service, Tucson Metro Edition, 2012.

0 3300

Approximate Scale:
1 inch = 3300 feet

Note: Dimensions, directions, and locations are approximate.

Ninyo & Moore		SITE LOCATION	FIGURE
PROJECT NO: 604817002	DATE: 12/15	TUCSON PAVEMENT RECONSTRUCTION - NICARAGUA DRIVE TUCSON, ARIZONA	1

file no: 4817vmap1015a

Source: NAVTEQ, 03/27/14.

N

0 160

Approximate Scale:
1 inch = 160 feet

Note: Dimensions, directions, and locations are approximate.

file no: 4817blm1015a

Ninyo & Moore	BORING LOCATIONS		FIGURE 2
PROJECT NO: 604817002	DATE: 12/15	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - NICARAGUA DRIVE TUCSON, ARIZONA	

APPENDIX A

BORING LOGS

Field Procedure for the Collection of Relatively Undisturbed Samples

Relatively undisturbed soil samples were obtained in the field using the following methods.

The Modified Split-Barrel Drive Sampler

The sampler, with an external diameter of 3.0 inches, was lined with 1-inch long, thin brass rings with inside diameters of approximately 2.4 inches. The sample barrel was driven into the ground with the weight of a hammer or the Kelly bar of the drill rig in general accordance with ASTM D 3550. The driving weight was permitted to fall freely. The approximate length of the fall, the weight of the hammer or bar, and the number of blows per foot of driving are presented on the boring logs as an index to the relative resistance of the materials sampled. The samples were removed from the sample barrel in the brass rings, sealed, and transported to the laboratory for testing.

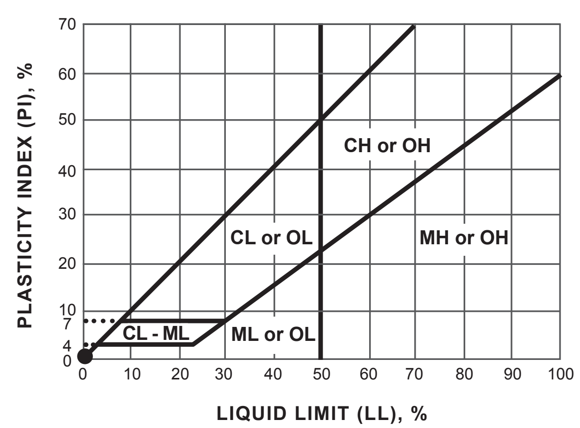
SOIL CLASSIFICATION CHART PER ASTM D 2488

PRIMARY DIVISIONS			SECONDARY DIVISIONS: GROUP SYMBOL	SECONDARY DIVISIONS: GROUP NAME
COARSE-GRAINED SOILS more than 50% retained on No. 200 sieve	**GRAVEL** more than 50% of coarse fraction retained on No. 4 sieve	CLEAN GRAVEL less than 5% fines	GW	well-graded GRAVEL
			GP	poorly graded GRAVEL
		GRAVEL with DUAL CLASSIFICATIONS 5% to 12% fines	GW-GM	well-graded GRAVEL with silt
			GP-GM	poorly graded GRAVEL with silt
			GW-GC	well-graded GRAVEL with clay
			GP-GC	poorly graded GRAVEL with clay
		GRAVEL with FINES more than 12% fines	GM	silty GRAVEL
			GC	clayey GRAVEL
			GC-GM	silty, clayey GRAVEL
	SAND 50% or more of coarse fraction passes No. 4 sieve	CLEAN SAND less than 5% fines	SW	well-graded SAND
			SP	poorly graded SAND
		SAND with DUAL CLASSIFICATIONS 5% to 12% fines	SW-SM	well-graded SAND with silt
			SP-SM	poorly graded SAND with silt
			SW-SC	well-graded SAND with clay
			SP-SC	poorly graded SAND with clay
		SAND with FINES more than 12% fines	SM	silty SAND
			SC	clayey SAND
			SC-SM	silty, clayey SAND
FINE-GRAINED SOILS 50% or more passes No. 200 sieve	**SILT and CLAY** liquid limit less than 50%	INORGANIC	CL	lean CLAY
			ML	SILT
			CL-ML	silty CLAY
		ORGANIC	OL (PI > 4)	organic CLAY
			OL (PI < 4)	organic SILT
	SILT and CLAY liquid limit 50% or more	INORGANIC	CH	fat CLAY
			MH	elastic SILT
		ORGANIC	OH (plots on or above "A"-line)	organic CLAY
			OH (plots below "A"-line)	organic SILT
	Highly Organic Soils		PT	Peat

GRAIN SIZE

DESCRIPTION		SIEVE SIZE	GRAIN SIZE	APPROXIMATE SIZE
Boulders		> 12"	> 12"	Larger than basketball-sized
Cobbles		3 - 12"	3 - 12"	Fist-sized to basketball-sized
Gravel	Coarse	3/4 - 3"	3/4 - 3"	Thumb-sized to fist-sized
	Fine	#4 - 3/4"	0.19 - 0.75"	Pea-sized to thumb-sized
Sand	Coarse	#10 - #4	0.079 - 0.19"	Rock-salt-sized to pea-sized
	Medium	#40 - #10	0.017 - 0.079"	Sugar-sized to rock-salt-sized
	Fine	#200 - #40	0.0029 - 0.017"	Flour-sized to sugar-sized
Fines		Passing #200	< 0.0029"	Flour-sized and smaller

PLASTICITY CHART



APPARENT DENSITY - COARSE-GRAINED SOIL

APPARENT DENSITY	SPOOLING CABLE OR CATHEAD: SPT (blows/foot)	SPOOLING CABLE OR CATHEAD: MODIFIED SPLIT BARREL (blows/foot)	AUTOMATIC TRIP HAMMER: SPT (blows/foot)	AUTOMATIC TRIP HAMMER: MODIFIED SPLIT BARREL (blows/foot)
Very Loose	≤ 4	≤ 8	≤ 3	≤ 5
Loose	5 - 10	9 - 21	4 - 7	6 - 14
Medium Dense	11 - 30	22 - 63	8 - 20	15 - 42
Dense	31 - 50	64 - 105	21 - 33	43 - 70
Very Dense	> 50	> 105	> 33	> 70

CONSISTENCY - FINE-GRAINED SOIL

CONSIS-TENCY	SPOOLING CABLE OR CATHEAD: SPT (blows/foot)	SPOOLING CABLE OR CATHEAD: MODIFIED SPLIT BARREL (blows/foot)	AUTOMATIC TRIP HAMMER: SPT (blows/foot)	AUTOMATIC TRIP HAMMER: MODIFIED SPLIT BARREL (blows/foot)
Very Soft	< 2	< 3	< 1	< 2
Soft	2 - 4	3 - 5	1 - 3	2 - 3
Firm	5 - 8	6 - 10	4 - 5	4 - 6
Stiff	9 - 15	11 - 20	6 - 10	7 - 13
Very Stiff	16 - 30	21 - 39	11 - 20	14 - 26
Hard	> 30	> 39	> 20	> 26

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USCS METHOD OF SOIL CLASSIFICATION

Explanation of USCS Method of Soil Classification

PROJECT NO.	DATE	FIGURE

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	BORING LOG EXPLANATION SHEET
0								Bulk sample.
								Modified split-barrel drive sampler.
								No recovery with modified split-barrel drive sampler.
								Sample retained by others.
								Standard Penetration Test (SPT).
5								No recovery with a SPT.
			XX/XX					Shelby tube sample. Distance pushed in inches/length of sample recovered in inches.
								No recovery with Shelby tube sampler.
								Continuous Push Sample.
								Seepage.
10								Groundwater encountered during drilling.
								Groundwater measured after drilling.
							SM	MAJOR MATERIAL TYPE (SOIL): Solid line denotes unit change.
							CL	Dashed line denotes material change.
15								Attitudes: Strike/Dip b: Bedding c: Contact j: Joint f: Fracture F: Fault cs: Clay Seam s: Shear bss: Basal Slide Surface sf: Shear Fracture sz: Shear Zone sbs: Shear Bedding Surface
								The total depth line is a solid line that is drawn at the bottom of the boring.
20								

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BORING LOG

Explanation of Boring Log Symbols

PROJECT NO.	DATE	FIGURE

Updated Nov. 2011

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 4 inches thick.
							SC	ALLUVIUM: Brown, moist, medium dense, clayey SAND; few gravel.
			27					
								Total Depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt conrete patched on 9/28/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
5								
10								
15								
20								

DATE DRILLED 9/28/15 BORING NO. B-1

GROUND ELEVATION 2,685' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-45, 8" Hollow-Stem Auger (Southlands)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY NAG LOGGED BY NAG REVIEWED BY

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - NICARAGUA DRIVE
TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-1

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
								DATE DRILLED 9/28/15 BORING NO. B-2
								GROUND ELEVATION 2,691' ± (MSL) SHEET 1 OF 1
								METHOD OF DRILLING CME-45, 8" Hollow-Stem Auger (Southlands)
								DRIVE WEIGHT 140 lbs (Automatic) DROP 30"
								SAMPLED BY NAG LOGGED BY NAG REVIEWED BY
0								ASPHALT CONCRETE: Approximately 3-1/2 inches thick.
							SC	ALLUVIUM: Brown, moist, very dense, clayey SAND; few gravel.
			50/5"					
								Total Depth = 2.9 feet. Groundwater not encountered during drilling. Backfilled and asphalt conrete patched on 9/28/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
5								
10								
15								
20								

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - NICARAGUA DRIVE
TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-2

APPENDIX B

LABORATORY TESTING

Classification

Soils were visually and texturally classified in accordance with the Unified Soil Classification System (USCS) in general accordance with ASTM D 2488. Soil classifications are indicated on the logs of the exploratory borings in Appendix A.

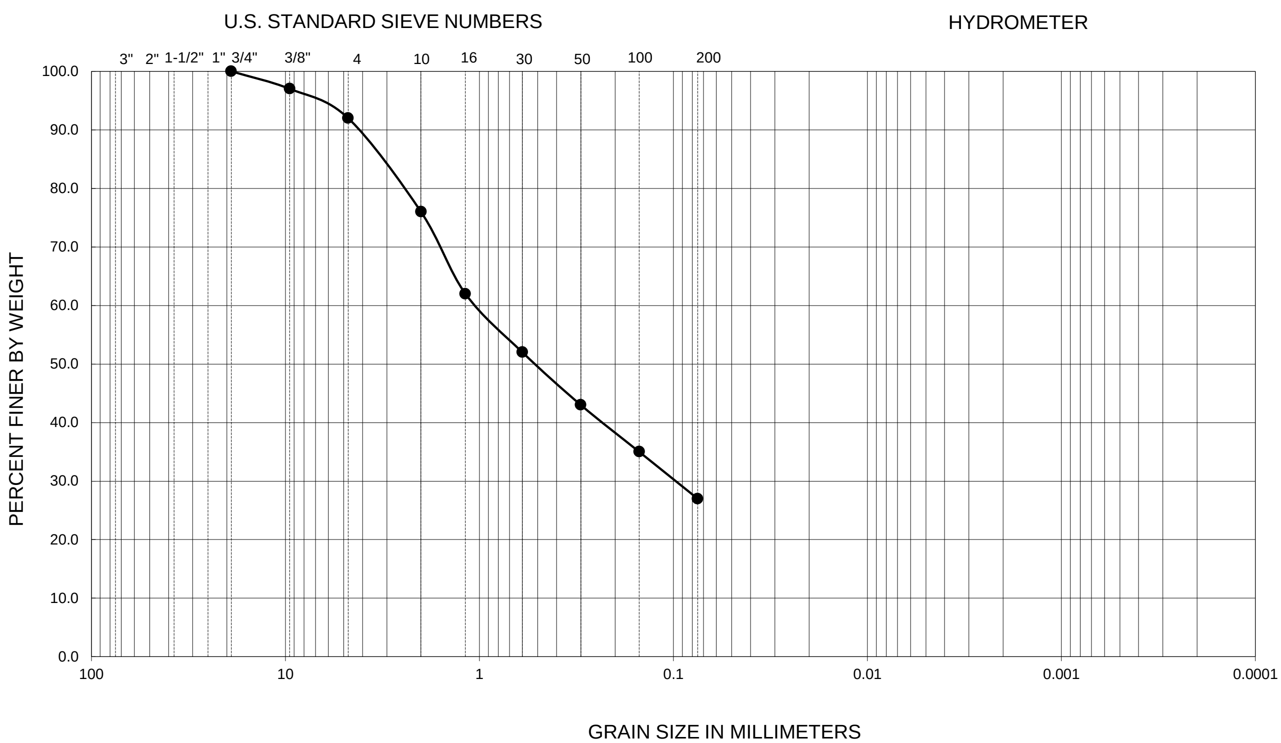
Gradation Analysis

One gradation analysis test was performed on a selected representative soil sample in general accordance with ASTM D 422. The grain-size distribution curve is shown in Figure B-1. These test results were utilized in evaluating the soil classification in accordance with the USCS.

Atterberg Limits

Tests were performed on a selected representative fine-grained soil sample to evaluate the liquid limit, plastic limit, and plasticity index in general accordance with ASTM D 4318. These test results were utilized to evaluate the soil classification in accordance with the USCS. The test results and classifications are shown on Figure B-2.

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY

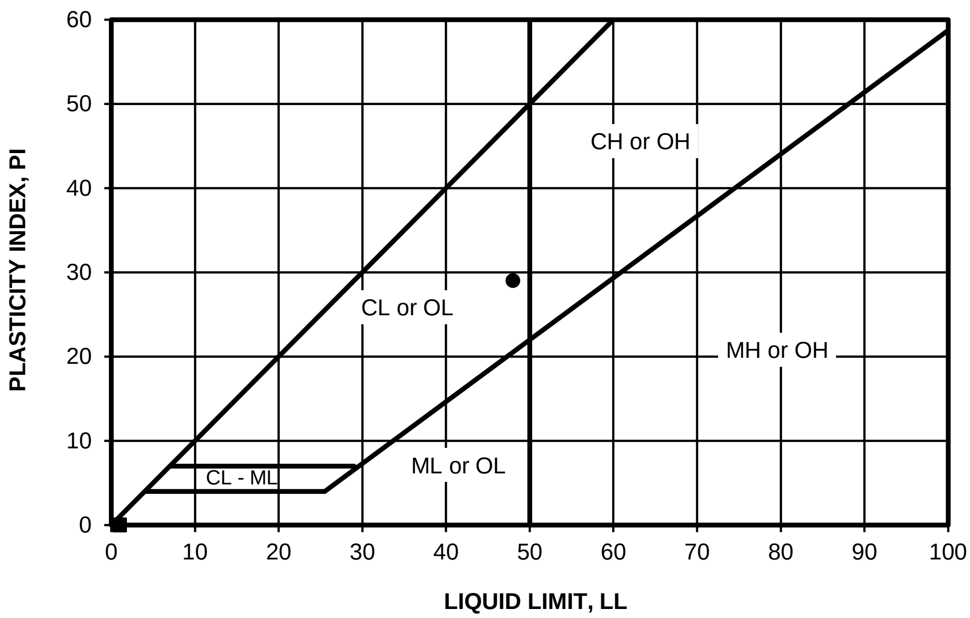


Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
●	B-2	1.5-3.0	48	19	29	--	--	--	--	--	27	SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore		GRADATION TEST RESULTS	FIGURE
PROJECT NO.	DATE	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - NICARAGUA DRIVE TUCSON, ARIZONA	B-1
604817001	12/15		

SYMBOL	LOCATION	DEPTH (FT)	LIQUID LIMIT, LL	PLASTIC LIMIT, PL	PLASTICITY INDEX, PI	USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve)	USCS (Entire Sample)
●	B-2	1.5-3.0	48	19	29	CL	SC



PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4318

Ninyo & Moore	ATTERBERG LIMITS TEST RESULTS	FIGURE
PROJECT NO. 604817001 / DATE 12/15	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - NICARAGUA DRIVE TUCSON, ARIZONA	B-2

APPENDIX C

PAVEMENT AND CORE SUMMARY

NICARAGUA DRIVE - PAVEMENT AND CORE SUMMARY

No.	Location	Approximate AC thickness (in)*	Recovered AC Thickness (in)	Core Description	Pavement Condition
B-1	Westbound, 250 feet east of Wilmot Road	4	4	Two lifts, 1.5" and 2.5", few voids.	Transverse, longitudinal and irregular cracking, some sealed, severe near Wilmot.
B-2	Eastbound, 80 feet east of Nastar Drive	3.5	3.5	Two lifts, 1.5" and 2", crack throughout core.	Transverse, longitudinal and irregular cracking, aligator cracks developing along wheel paths.

Notes:

* Measured in the boring

APPENDIX D

TRAFFIC DATA

Field Data Services of Arizona
21636 N. Dietz Dr.
Maricopa, AZ 85138
520.316.6745

Site Code: 15-1283-001
Station ID: Wed 10/14/2015
Calle Polar btwn. Nicaragua Dr. & Barrow St. 32.179560, -110.853668
Latitude: 0' 0.000 Undefined

Northbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/14/15	0	18	3	0	0	0	0	0	0	0	0	0	0	21
01:00	0	5	2	0	0	0	0	0	0	0	0	0	0	7
02:00	0	11	1	0	0	0	0	0	0	0	0	0	0	12
03:00	0	24	6	0	0	0	0	0	0	0	0	0	0	30
04:00	0	60	16	0	1	0	0	0	0	0	0	0	0	77
05:00	1	208	82	1	**4**	0	0	0	0	0	0	0	0	296
06:00	2	352	**122**	2	1	0	0	**2**	**2**	0	0	0	0	483
07:00	3	**499**	95	1	3	0	0	1	1	0	**2**	0	0	**605**
08:00	**4**	330	53	0	1	**1**	0	1	0	0	0	0	**1**	391
09:00	1	250	61	0	1	0	0	1	2	0	0	0	0	316
10:00	1	192	60	**3**	2	0	0	0	0	0	0	**1**	0	259
11:00	0	232	55	0	4	0	0	2	1	**1**	0	1	0	296
12 PM	0	207	47	3	3	2	0	0	0	1	0	0	1	264
13:00	0	**212**	**51**	2	4	3	0	**2**	1	**2**	1	**1**	1	**280**
14:00	1	209	49	1	1	1	0	1	1	0	**2**	0	**2**	268
15:00	1	191	43	**7**	0	1	0	0	0	1	1	0	1	246
16:00	1	182	39	3	0	0	0	1	**2**	0	1	0	0	229
17:00	1	199	34	1	**6**	1	0	0	0	0	0	1	1	244
18:00	**2**	162	31	4	0	**4**	0	0	0	0	0	0	0	203
19:00	0	114	20	1	3	1	0	0	1	0	0	0	0	140
20:00	0	60	13	1	0	0	0	0	0	0	0	0	0	74
21:00	0	47	5	2	1	0	0	0	0	0	0	0	0	55
22:00	0	47	2	0	0	0	0	0	0	0	0	0	0	49
23:00	0	22	6	0	0	0	0	0	0	0	0	0	0	28
Day Total	18	3833	896	32	35	14	0	11	11	5	7	4	7	4873
Percent	0.4%	78.7%	18.4%	0.7%	0.7%	0.3%	0.0%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	
AM Peak	08:00	07:00	06:00	10:00	05:00	08:00		06:00	06:00	11:00	07:00	10:00	08:00	07:00
Vol.	4	499	122	3	4	1		2	2	1	2	1	1	605
PM Peak	18:00	13:00	13:00	15:00	17:00	18:00		13:00	16:00	13:00	14:00	13:00	14:00	13:00
Vol.	2	212	51	7	6	4		2	2	2	2	1	2	280
Grand Total	18	3833	896	32	35	14	0	11	11	5	7	4	7	4873
Percent	0.4%	78.7%	18.4%	0.7%	0.7%	0.3%	0.0%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	

Field Data Services of Arizona
21636 N. Dietz Dr.
Maricopa, AZ 85138
520.316.6745

Site Code: 15-1283-001
Station ID: Wed 10/14/2015
Calle Polar btwn. Nicaragua Dr. & Barrow St. 32.179560, -110.853668
Latitude: 0' 0.000 Undefined

Southbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/14/15	0	31	11	0	0	0	0	0	0	0	0	0	0	42
01:00	0	18	1	0	0	0	0	0	0	0	0	0	0	19
02:00	0	18	3	0	0	0	0	0	0	0	0	0	0	21
03:00	1	14	3	0	0	0	0	0	0	0	0	0	0	18
04:00	0	21	7	0	0	0	0	0	0	0	0	0	0	28
05:00	0	52	18	1	1	0	**1**	0	0	0	0	0	0	73
06:00	1	95	33	3	3	0	0	0	2	0	0	1	**2**	140
07:00	0	145	43	**4**	0	**1**	1	1	0	0	0	0	1	196
08:00	1	134	27	2	1	0	1	0	**3**	**1**	0	0	0	170
09:00	0	153	30	2	0	0	0	1	2	0	0	**2**	1	191
10:00	0	191	39	2	1	0	1	**3**	2	0	1	0	1	241
11:00	**2**	**250**	**65**	1	**4**	1	0	2	1	0	**2**	0	1	**329**
12 PM	0	289	64	0	4	0	**1**	0	2	0	1	0	0	361
13:00	1	283	66	2	2	0	0	0	1	0	2	1	0	358
14:00	1	373	91	**4**	**6**	**1**	0	3	1	0	1	0	0	481
15:00	0	454	143	3	5	0	1	**4**	**5**	1	2	1	**2**	621
16:00	**2**	**580**	**156**	4	2	0	1	2	1	0	4	1	2	**755**
17:00	0	535	114	3	3	0	1	4	0	1	**5**	0	1	667
18:00	1	370	60	2	0	1	1	1	0	1	2	**2**	1	442
19:00	0	272	55	0	2	0	1	0	0	**2**	0	0	0	332
20:00	0	253	57	0	0	0	0	1	0	0	0	1	1	313
21:00	0	168	27	0	0	1	0	0	0	0	0	0	0	196
22:00	0	102	26	0	0	0	0	0	0	0	0	0	0	128
23:00	0	65	10	0	0	0	0	0	0	0	0	0	0	75
Day Total	10	4866	1149	33	34	5	10	22	20	6	20	9	13	6197
Percent	0.2%	78.5%	18.5%	0.5%	0.5%	0.1%	0.2%	0.4%	0.3%	0.1%	0.3%	0.1%	0.2%	
AM Peak	11:00	11:00	11:00	07:00	11:00	07:00	05:00	10:00	08:00	08:00	11:00	09:00	06:00	11:00
Vol.	2	250	65	4	4	1	1	3	3	1	2	2	2	329
PM Peak	16:00	16:00	16:00	14:00	14:00	14:00	12:00	15:00	15:00	19:00	17:00	18:00	15:00	16:00
Vol.	2	580	156	4	6	1	1	4	5	2	5	2	2	755
Grand Total	10	4866	1149	33	34	5	10	22	20	6	20	9	13	6197
Percent	0.2%	78.5%	18.5%	0.5%	0.5%	0.1%	0.2%	0.4%	0.3%	0.1%	0.3%	0.1%	0.2%	

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Northbound, Southbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/14/15	0	49	14	0	0	0	0	0	0	0	0	0	0	63
01:00	0	23	3	0	0	0	0	0	0	0	0	0	0	26
02:00	0	29	4	0	0	0	0	0	0	0	0	0	0	33
03:00	1	38	9	0	0	0	0	0	0	0	0	0	0	48
04:00	0	81	23	0	1	0	0	0	0	0	0	0	0	105
05:00	1	260	100	2	5	0	**1**	0	0	0	0	0	0	369
06:00	3	447	**155**	**5**	4	0	0	2	**4**	0	0	1	**2**	623
07:00	3	**644**	138	5	3	**1**	1	2	1	0	**2**	0	1	**801**
08:00	**5**	464	80	2	2	1	1	1	3	**1**	0	0	1	561
09:00	1	403	91	2	1	0	0	2	4	0	0	**2**	1	507
10:00	1	383	99	5	3	0	1	3	2	0	1	1	1	500
11:00	2	482	120	1	**8**	1	0	**4**	2	1	2	1	1	625
12 PM	0	496	111	3	7	2	**1**	0	2	1	1	0	1	625
13:00	1	495	117	4	6	3	0	2	2	**2**	3	**2**	1	638
14:00	2	582	140	5	7	2	0	**4**	2	0	3	0	2	749
15:00	1	645	186	**10**	5	1	1	4	**5**	2	3	1	**3**	867
16:00	**3**	**762**	**195**	7	2	0	1	3	3	0	**5**	1	2	**984**
17:00	1	734	148	4	**9**	1	1	4	0	1	5	1	2	911
18:00	3	532	91	6	0	**5**	1	1	0	1	2	2	1	645
19:00	0	386	75	1	5	1	1	0	1	2	0	0	0	472
20:00	0	313	70	1	0	0	0	1	0	0	0	1	1	387
21:00	0	215	32	2	1	1	0	0	0	0	0	0	0	251
22:00	0	149	28	0	0	0	0	0	0	0	0	0	0	177
23:00	0	87	16	0	0	0	0	0	0	0	0	0	0	103
Day Total	28	8699	2045	65	69	19	10	33	31	11	27	13	20	11070
Percent	0.3%	78.6%	18.5%	0.6%	0.6%	0.2%	0.1%	0.3%	0.3%	0.1%	0.2%	0.1%	0.2%	
AM Peak	08:00	07:00	06:00	06:00	11:00	07:00	05:00	11:00	06:00	08:00	07:00	09:00	06:00	07:00
Vol.	5	644	155	5	8	1	1	4	4	1	2	2	2	801
PM Peak	16:00	16:00	16:00	15:00	17:00	18:00	12:00	14:00	15:00	13:00	16:00	13:00	15:00	16:00
Vol.	3	762	195	10	9	5	1	4	5	2	5	2	3	984
Grand Total	28	8699	2045	65	69	19	10	33	31	11	27	13	20	11070
Percent	0.3%	78.6%	18.5%	0.6%	0.6%	0.2%	0.1%	0.3%	0.3%	0.1%	0.2%	0.1%	0.2%	

APPENDIX E

PAVEMENT OPTIMIZATION DESIGN ANALYSIS BY TENSAR

SpectraPave4 PRO™
Pavement Optimization Design Analysis

Design Parameters for AASHTO (1993) Equation

Reliability (%)	= 95	Initial Serviceability	= 4.5
Standard Normal Deviate	= -1.645	Terminal Serviceability	= 2.5
Standard Deviation	= 0.40	Change in Serviceability	= 2

Aggregate fill shall conform to following requirement:

D50 <= 27mm (Base course)

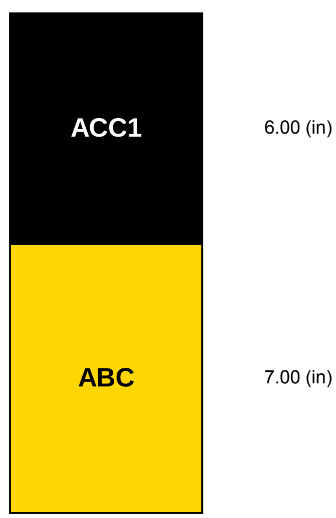
Unstabilized Section Material Properties

Layer	Description	Cost ($/ton)	Layer coefficient	Drainage factor
ACC1	Asphalt Wearing Course	70	0.440	N/A
ABC	Aggregate Base Course	20	0.140	1.25

Stabilized Section Material Properties

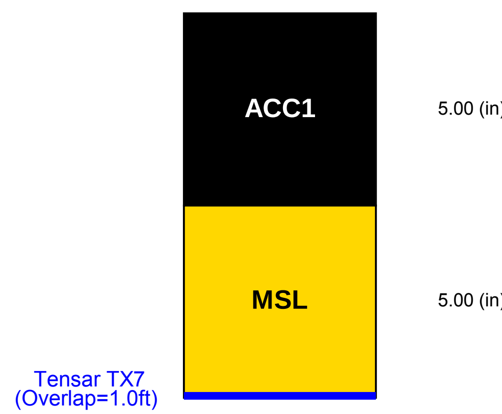
Layer	Description	Cost ($/ton)	Layer coefficient	Drainage factor
ACC1	Asphalt Wearing Course	70	0.440	N/A
MSL	Mechanically Stabilized Base Cour	20	0.318	1.25

Unstabilized Pavement



Subgrade Modulus = 8,824 (psi)
Structural Number = 3.865
Calculated Traffic (ESALs) = 2,952,000

Stabilized Pavement



Subgrade Modulus = 8,824 (psi)
Structural Number = 4.188
Calculated Traffic (ESALs) = 5,075,000

LIMITATIONS OF THE REPORT

The designs, illustrations, information and other content included in this report are necessarily general and conceptual in nature, and do not constitute engineering advice or any design intended for actual construction. Specific design recommendations can be provided as the project develops.

Project Name	Nicaragua Drive		
Company Name	Tensar		
Designer	Schlessinger	Date	12/14/15

PAVEMENT EVALUATION
TUCSON PAVEMENT RECONSTRUCTION PROGRAM
PIMA STREET
TUCSON, ARIZONA

PREPARED FOR:
Kimley-Horn & Associates, Inc.
333 East Wetmore Road, Suite 280
Tucson, Arizona 85705

PREPARED BY:
Ninyo & Moore
Geotechnical and Environmental Sciences Consultants
1991 East Ajo Way, Suite 145
Tucson, Arizona 85713

December 16, 2015
Project No. 604817002

December 16, 2015
Project No. 604817002

Mr. Rick Solis, P.E.
Kimley-Horn
333 East Wetmore Road, Suite 280
Tucson, Arizona 85705

Subject: Pavement Evaluation
Tucson Pavement Reconstruction Program – Pima Street
Tucson, Arizona

Dear Mr. Solis:

In accordance with our proposal dated August 12, 2015, and your authorization on September 21, 2015, Ninyo & Moore has performed a pavement evaluation for the above-referenced site. The attached report presents our methodology, findings, conclusions, and recommendations regarding the geotechnical conditions at the project site.

We appreciate the opportunity to be of service to you during this phase of the project.

Sincerely,
NINYO & MOORE

Registered Professional Engineer (Civil)
CERTIFICATE NO. 44704
MAREK J. KASZTALSKI
Date Signed 12.16.15
ARIZONA, U.S.A.
EXPIRES 9/30/18

Marek J. Kasztalski, PE, PMP, LEED AP
Senior Geotechnical Engineer

Fred Narcaroti
Principal/Tucson Office Manager

MJK/DT/FFN/tlp

Distribution: (1) Addressee (Electronic Copy)

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1. INTRODUCTION

In accordance with our proposal dated August 12, 2015, and your authorization on September 21, 2015, we have performed a pavement evaluation for the Pima Street Pavement Reconstruction project between Country Club Road and Columbus Boulevard, in Tucson, Arizona. The purpose of our evaluation was to assess the pavement and subgrade conditions along the project alignment in order to provide geotechnical recommendations for design and construction. This report presents the results of our evaluation, conclusions, and recommendations regarding the proposed construction.

2. SCOPE OF SERVICES

The scope of our services generally included:

- Preparing a field testing plan and associated permit application for submittal to the City of Tucson (COT).
- Conducting a visual reconnaissance of the pavement along the alignment and marking out the boring locations.
- Notifying Arizona811 of our boring locations prior to conducting the field work.
- Arranging for traffic control measures to conduct the field work.
- Coring the existing asphaltic concrete (AC) pavement at eight locations along the project alignment.
- Exploring the subsurface soils within the project limits by drilling, logging, and sampling eight exploratory soil borings to approximate depths of 3 feet below ground surface (bgs). The boring logs are presented in Appendix A.
- Performing laboratory tests on selected samples collected from our borings to evaluate gradation and Atterberg limits. The results of the laboratory tests are included in Appendix B.
- Preparing this report presenting our findings, conclusions and recommendations regarding the proposed reconstruction.

Our scope of services did not include environmental consulting services such as hazardous waste sampling or analytical testing at the site. A detailed scope of services and estimated fee for such services can be provided upon request.

3. SITE DESCRIPTION

The project site is located in Sections 3 and 4 of Townships 14 South, Range 14 East relative to the Gila and Salt River Base Line and Meridian. The project alignment extends along Pima Street between Country Club Road and Columbus Boulevard, in Tucson, Arizona (Figure 1).

At the time of our evaluation residential developments existed along the project alignment. The roadway section consisted of one travel lane in each direction, a center lane, concrete sidewalks on the north side of the roadway, and concrete curb.

4. PROPOSED CONSTRUCTION

The COT has identified several segments of the existing street network for reconstruction and/or rehabilitation in fiscal year (FY) 2016 under Bid Package 2. The scope of this report includes Pima Street between Country Club Road and Columbus Boulevard. The project alignment is approximately1 ½ miles long.

We understand that the COT anticipates the following treatments:

- Between Country Club Road and Dodge Boulevard and between Alvernon Way and Columbus Boulevard: full-depth reconstruction of the existing roadway consisting of 5 inches of AC per of the COT Department of Transportation Standard Specifications Section 406 over 5 inches of aggregate base (AB) per Section 303 of the COT Standard Specifications.

- Between Dodge Boulevard and Alvernon Way: milling 3 inches of the existing pavement, placing ½-inch thick Asphalt Rubber Stress Absorbing Membrane (SAME) and overlaying with 2 ½ inches of AC.

We further understand that the COT intends to use Tucson Department of Transportation (TDOT) AC Mix No. 2 PG 76-22TR+ for the surface layers and TDOT AC Mix No. 1 PG 70-10 for the underlying layer. The AC layers will be 2.5 inches thick.

Due to conflicts with shallow utility lines, subgrade improvement by overexcavation will not be performed and the new pavement section will be constructed on subgrade improved with Geogrid (Tensar Geogrid TX5 or equivalent).

The scope of this exploration included evaluation of the existing pavement section and subgrade soils in order to provide recommendations for pavement reconstruction in accordance with the current COT practice. Calculations for the new pavement section supporting the new construction proposed by the COT are presented in Section 9.3 and in Appendix E of this report.

5. EXISTING PAVEMENT CONDITION

On October 2, 2015, Ninyo & Moore conducted a limited visual evaluation of the pavement surface along the project alignment. Based on our field observations, the AC pavement exhibited signs of severe distress in many locations along the project alignment primarily consisting of extensive alligator, block, transverse and irregular cracking with considerable spalling, rutting in both wheel tracks, flushing and potholes. Some of the cracks exhibited evidence of past sealing. Asphaltic concrete patches were observed at some locations which were probably associated with past maintenance efforts (pothole and crack repairs) or with underground utility work. The crack widths generally varied between hairline (less than 1/8-inch) and over one inch.

In our opinion, the distress observed along the project alignment indicates structural failure and is related to a combination of pavement age, subgrade condition, traffic, and environmental impacts.

6. FIELD EXPLORATION AND LABORATORY TESTING

On October 2, 2015, Ninyo & Moore conducted a geotechnical exploration in order to evaluate the subsurface conditions and collect AC cores and soil samples for laboratory testing. Our evaluation consisted of coring the existing AC pavement, drilling, logging, and sampling eight small-diameter borings, denoted as B-1 through B-8, utilizing a CME-45 truck-mounted drill rig equipped with hollow-stem augers. The borings extended to depths of approximately 3 feet bgs. The approximate locations of the borings are depicted on Figures 2A and 2B.

Ninyo & Moore personnel logged the borings in general accordance with the Unified Soil Classification System (USCS) and American Society for Testing and Materials (ASTM) D 2488 by observing cuttings and drive samples. Collected ring samples were trimmed in the field, wrapped in plastic bags, and placed in cylindrical plastic containers to retain in-place moisture conditions.

The soil samples collected from our drilling activities were transported to the Ninyo & Moore laboratory in Tucson, Arizona for geotechnical laboratory testing. The tests included gradation and Atterberg limits. A description of each laboratory test method and the test results are presented in Appendix B.

7. SUBSURFACE CONDITIONS

Our knowledge of the subsurface conditions at the project site is based on our field exploration, laboratory testing, and general experience in the area. More detailed stratigraphic information is presented on the boring logs in Appendix A, attached to this report. The boring logs contain our field and laboratory test results, as well as our interpretation of conditions believed to exist between actual samples retrieved. Therefore, these boring logs contain both factual and interpretive information. Lines delineating subsurface strata on the boring logs are intended to group soils having similar engineering properties and characteristics. They should be considered approximate as the actual transition between soil types (strata) may be gradual. A key to the soil symbols and terms used on the boring logs is provided in Appendix A.

7.1. Asphaltic Concrete

Asphaltic concrete pavement was encountered at the surface of each of our borings. The AC thickness varied between approximately 2 ½ to 7 inches, in our borings. It should be noted that the thickness of the AC pavement between the sampling locations may vary and could be different from that encountered at our sampling locations. Detailed core descriptions are presented in Appendix C.

Aggregate base was observed in some of our borings and its thickness varied between 2 and 4 inches. It is possible the AB material blended with the native subgrade soils, such that delineation of the AB/subgrade interface was not easily interpreted.

7.2. Alluvium

Native alluvial soils were encountered below the pavement section, and extended to the boring termination depths. The alluvium generally consisted of loose to medium dense, low to high plasticity clayey sands with varying amounts of gravel in our borings.

8. CONCLUSIONS

Based on the results of our visual and subsurface evaluations, laboratory testing, and data analysis, geotechnical considerations include the following:

- The on-site soils generally include clayey sand, with a plasticity index (PI) value varying between 11 and 35. Many on-site soils may be sensitive to moisture content fluctuations and may be difficult to compact especially at higher moisture contents. The contractor should be aware of this condition.
- Clayey sands of high plasticity were encountered in our borings.
- Due to the relatively widely spaced nature of our borings, soil conditions may differ from what was observed during our field exploration.
- The pavement exhibits significant distress in many locations along the project alignment consisting mainly of alligator, block, transverse and irregular cracking with considerable spalling, rutting in both wheel tracks, flushing and potholes.

9. RECOMMENDATIONS

The following sections present our geotechnical recommendations for the project. If the proposed construction is changed from that discussed in this report, Ninyo & Moore should be contacted for additional recommendations.

9.1. Recommended Pavement Treatment

The recommended pavement treatments are briefly summarized below.

9.1.1. Full-Depth Reconstruction

Full depth reconstruction is recommended between Country Club Road and Dodge Boulevard and between Alvernon Way and Columbus Boulevard. The recommended pavement sections are presented in the table below:

Pavement Section	Service Life (years)	AC (in)[1]	AB (in)[2]
COT Preferred Pavement with Geogrid	20	5	5
Alternative Pavement Section without Geogrid	20	5.5	7

Notes:
[1] TDOT AC Mix No. 2 PG 76-22TR+ as the surface mix and TDOT AC Mix No. 1 PG 70-10 for the underlying layers per Section 406 of the COT Specifications.
[2] AB per Section 303 of the COT Specifications.

9.1.2. Mill and Overlay

Milling 3 inches of the existing pavement, placing ½-inch thick Asphalt Rubber SAME and overlaying with 2 ½ inches of AC is recommended for the project segment between Dodge Boulevard an Alvernon Way.

9.2. Earthwork

The following sections provide our earthwork recommendations for this project. In general, the earthwork specifications contained in the *City of Tucson/Pima County Standard Specifications for Public Improvements, 2003 Edition (COT/PC Specifications)* are expected to apply unless specifically noted.

9.2.1. Site Preparation

Construction areas should be cleared of deleterious materials, if any are present, including abandoned utilities, construction debris, vegetation, and any other material that might interfere with the performance or progress of the work. These materials should be disposed of at a legal dumpsite. Existing features that call for relocation or removal and extend below finish grade, if present, should be removed, and the resulting excavations backfilled with engineered fill.

9.2.2. Excavations

Our evaluation of the excavation characteristics of the on-site soils is based on the results of our exploratory borings, site observations, and experience with similar materials.

9.2.3. Fill Materials

Soils with PI values of 15 or less (as evaluated by ASTM D 4318) are generally suitable for use as engineered fill. Our Atterberg limits tests indicated PI values ranging between 11 and 35. Based on these test results, many of the on-site soils are not suitable for re-use as engineered fill.

Engineered fill should not include organic material, construction debris, or other non-soil fill materials. Rock particles and clay lumps should not be larger than 4 inches in dimension. Unsuitable material should be disposed of off-site or in non-structural areas.

9.2.4. Grading and Subgrade Preparation

In general, grading operations should be performed in accordance with Section 205 of the COT/PC Specifications.

Due to potential conflicts with underground utilities, we recommend that the subgrade beneath new pavements be improved by the application of Geogrid (Tensar Geogrid TX5 or equivalent). Geogrid should be placed in accordance with the manufacturer's instructions.

Alternatively, if Geogrid is not applied we recommend new pavements be supported on 6 inches of subgrade that is compacted by appropriate mechanical methods to a relative compaction of 95 percent as evaluated by ASTM D 698 at a moisture content generally near optimum. The thickness of the improvement zone should be measured from the bottom of the AB layer.

In areas where excessive moisture is encountered so that the above compaction cannot be achieved and/or the subgrade surface is unstable and yielding (pumping) under the roller wheels, subgrade soils should be scarified to a depth of 12 inches, aerated, and re-compacted as specified above. Alternatively, subgrade soils in problem areas should be and replaced with engineered fill to a depth of 12 inches below the bottom of the AB.

9.3. Pavement Design Summary

The following sections present our design assumptions and recommendations for the new flexible pavement section of Pima Street between Country Club Road and Dodge Boulevard and between Alvernon Way and Columbus Boulevard, as this roadway is scheduled for full-depth pavement reconstruction.

The pavement section was developed using the Active Practices Guidelines issued by the COT Department of Transportation (Guidelines) and the Arizona Department of Transportation (ADOT) Preliminary Engineering and Design Manual (PEDM). We assumed that the subgrade will be improved by the application of Geogrid or overexcavation, as outlined in Section 9.2.4 of this report. The new pavement sections are designed for a 20-year service life.

9.3.1. Traffic

The future traffic numbers used in this report are based on traffic counts provided by Kimley-Horn and Associates, Inc. (KHA), and later communication with the KHA. This information is presented in Appendix D. Based on the above information, and using the procedures outlined in the Guidelines and PEDM, the design number of equivalent single axle loads (ESALs) for the design lane during the 20-year design period was calculated as approximately 1,546,140.

9.3.2. R-Value and Resilient Modulus

The analysis for the design R-value for the pavement section has been performed based on procedures detailed in the Guidelines and the PEDM, using correlated R-values. The correlated R-values were derived from the PI and percent passing No. 200 Sieve test results. A summary of the R-values for this project is presented in Table 1 below:

Table 1 – R-value Summary

Location	Sample Depth (ft)	Correlated R-Value
B-1	1.5-3.0	19
B-3	1.5-3.0	32
B-5	1.5-3.0	55
B-7	1.5-3.0	13

In the interest of conservatism, we recommend that an R-value of 20 be used for pavement design for this project.

If the project needs fill from an off-site source, we recommend the soils used for subgrade support should have an R-value of 20 or more. If during construction, the subgrade is found to vary from the expected soil conditions, we should be contacted so we may re-evaluate our recommended R-values. Based on the above design R-values, the design subgrade resilient modulus (M_R) value of 8,824 pounds per square inch (psi) was calculated in accordance with the Guidelines.

9.3.3. Statistical Parameters

A standard deviation of 0.40 was used for design of the flexible pavement in accordance with the Guidelines. The level of reliability and standard normal deviation (Z_R) values were selected in accordance with the Guidelines for the arterial functional classification. Their respective values are presented in the table below:

Table 2 – Summary of Statistical Parameters

Roadway	Functional Classification	Standard Deviation	Level of Reliability	Standard Normal Deviation
Pima Street	Arterial	0.40	95 %	-1.645

9.3.4. Serviceability Index

Initial and terminal serviceability indices were selected for the pavement design of the roadways in accordance with the Guidelines. A summary of the serviceability indices for each roadway is provided in the table below:

Table 3 – Summary of Serviceability Parameters

Roadway	Functional Classification	Initial Serviceability Index	Terminal Serviceability Index	Change in Serviceability
Pima Street	Arterial	4.5	2.5	2.0

9.3.5. Layer Coefficients

The following structural coefficients were used for the pavement structure in accordance with the Guidelines:

- AC: 0.44.
- AB: 0.14.

A drainage coefficient of 1.25 was used for the AB coefficient as recommended in the Guidelines.

As mentioned in Section 4 above, due to conflicts with existing shallow utilities, it is recommended that the subgrade be improved using Geogrid (Tensar Geogrid TX5 or equivalent). In this case the AB layer coefficient is 0.289.

9.3.6. Asphalt Pavement Section Recommendations

The structural number (SN) was calculated based on the parameters described above. The table below presents the calculated SN value and the recommended structural pavement sections. The AC thickness meets the COT requirements. Supporting documentation of the pavement optimization design using Geogrid is presented in Appendix E:

Table 4 – Structural Pavement Sections for 20-Year Design Life

Roadway	SN	AC (in)[1]	AB (in)[2]
COT Preferred Pavement with Geogrid	4.01	5	5
Alternative Pavement without Geogrid	3.50	5.5	7

Notes:
[1] TDOT AC Mix No. 2 PG 76-22TR+ as the surface mix and TDOT AC Mix No. 1 PG 70-10 for the underlying layers per Section 406 of the COT Specifications.
[2] AB per Section 303 of the COT Specifications.

The above pavement structural section has been designed with the assumption that the subgrade is prepared by as recommended in Section 9.2.4.

10. MILL AND OVERLAY

We understand the COT is anticipating a mill and overlay pavement rehabilitation for the project segment between Dodge Boulevard and Alvernon Way. It is anticipated that this treatment will include:

- Milling 3 inches of the existing AC.
- Sealing the cracks at the surface.
- Placing a ½-inch thick SAME membrane.
- Placing an overlay of a new AC that is 2 ½ -inches thick using TCOT Mix No. 2 PG 76-22TR+.

In our opinion, the treatment proposed by the COT is feasible. However, it is important that after milling and prior to the overlay, the pavement surface be cleaned of any debris using mechanical sweepers or similar equipment and carefully inspected for distress. Cracks wider than 1/8-inch should be sealed with an approved sealant and cracks wider than 1½-inches should be sealed with AC mix No. 3 (per Section 406 of the COT/PC Specifications). In areas where following the milling operation structural failure or disintegration is observed on the exposed AC surface, the affected areas should be removed and replaced with a new pavement section, as defined in Section 9, above. Such areas are typically characterized by extensively cracked, disintegrated, yielding and/or otherwise unstable AC.

Based on the previously discussed future traffic data and our experience with similar pavement rehabilitation projects within the Tucson Metro Area, we estimate that the service life of the milled and overlaid pavement will be on the order of 15 to 20 years. This service life includes the beneficial effect of SAME, which is anticipated to defer propagation of the cracks to the pavement surface.

11. SITE DRAINAGE

Surface drainage should be provided to divert water away from paved surfaces. Surface water should also not be permitted to pond on or below pavement areas. Positive drainage for this project is defined as a slope of 2 percent or more for a distance of 5 feet or more away from the pavements. To deter accumulation of water below the new pavement sections, the bottom of the overexcavated zone below the new pavement should be sloped toward the edges of the roadway.

12. PRE-CONSTRUCTION CONFERENCE

We recommend that a pre-construction conference be held. Representatives of the owner, the civil engineer, Ninyo & Moore, and the contractor should be in attendance to discuss the project plans and schedule. Our office should be notified if the project description included herein is incorrect or if the project characteristics are significantly changed.

13. CONSTRUCTION OBSERVATION AND TESTING

During construction operations, we recommend that Ninyo & Moore perform observation and testing services for the project. These services should be performed to evaluate exposed subgrade conditions, including the extent and depth of overexcavation, to evaluate the suitability of proposed borrow materials for use as engineered fill and to observe placement and test compaction of fill soils. Qualified subcontractors utilizing appropriate techniques and construction materials should perform construction of the proposed improvements.

14. LIMITATIONS

The field evaluation, laboratory testing, and geotechnical analyses presented in this geotechnical report have been conducted in general accordance with current practice and the standard of care exercised by geotechnical consultants performing similar tasks in the project area. No warranty, expressed or implied, is made regarding the conclusions, recommendations, and opinions presented in this report. There is no evaluation detailed enough to reveal every subsurface condition. Variations may exist and conditions not observed or described in this report may be encountered during construction. Uncertainties relative to subsurface conditions can be reduced through additional subsurface exploration. Additional subsurface evaluation will be performed upon request. Please also note that our evaluation was limited to assessment of the geotechnical aspects of the project, and did not include evaluation of structural issues, environmental concerns, or the presence of hazardous materials.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. Ninyo & Moore should be contacted if the reader requires additional information or has questions regarding the content, interpretations presented, or completeness of this document.

This report is intended for design purposes only. It does not provide sufficient data to prepare an accurate bid by contractors. It is suggested that the bidders and their geotechnical consultant perform an independent evaluation of the subsurface conditions in the project areas. The independent evaluations may include, but not be limited to, review of other geotechnical reports prepared for the adjacent areas, site reconnaissance, and additional exploration and laboratory testing.

Our conclusions, recommendations, and opinions are based on an analysis of the observed site conditions. If geotechnical conditions different from those described in this report are encountered, our office should be notified and additional recommendations, if warranted, will be provided upon request. It should be understood that the conditions of a site could change with time as a result of natural processes or the activities of man at the subject site or nearby sites. In addition, changes to the applicable laws, regulations, codes, and standards of practice may occur due to government action or the broadening of knowledge. The findings of this report may, therefore, be invalidated over time, in part or in whole, by changes over which Ninyo & Moore has no control.

This report is intended exclusively for use by the client. Any use or reuse of the findings, conclusions, and/or recommendations of this report by parties other than the client is undertaken at said parties' sole risk.

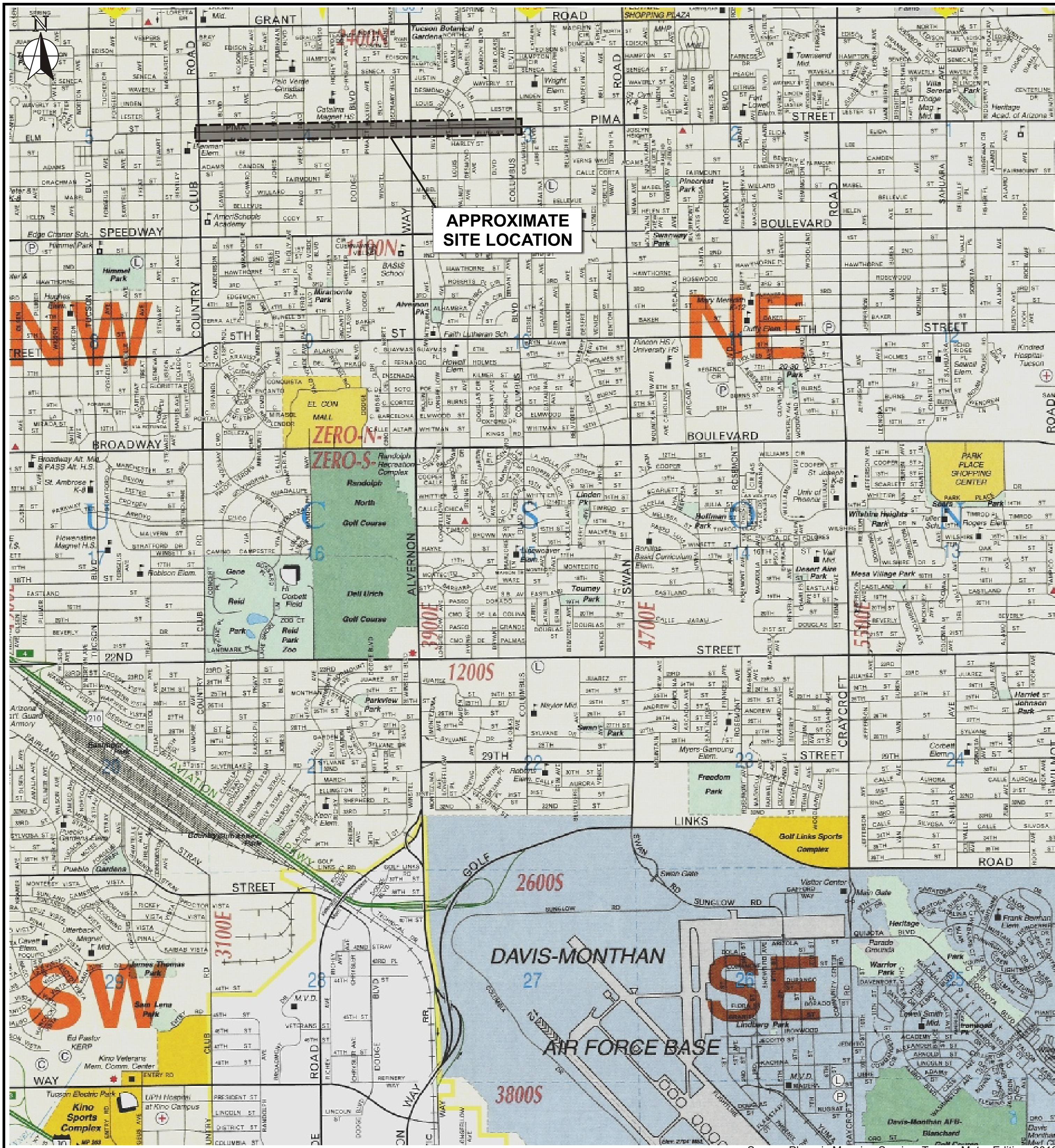
15. REFERENCES

American Society for Testing and Materials (ASTM), Annual Book of ASTM Standards.

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

City of Tucson, Arizona, Department of Transportation, Engineering Division, 1987, Active Practices Guidelines: dated June 1.

Ninyo & Moore, In-house proprietary information.



Source: Phoenix Mapping Service, Tucson Metro Edition, 2012.

0 3300

Approximate Scale:
1 inch = 3300 feet

Note: Dimensions, directions, and locations are approximate.

Ninyo & Moore	SITE LOCATION	FIGURE
PROJECT NO: 604817002 / DATE: 12/15	TUCSON PAVEMENT RECONSTRUCTION - PIMA STREET TUCSON, ARIZONA	1

file no: 4817vmap1015g

Source: NAVTEQ, 03/27/14.

N

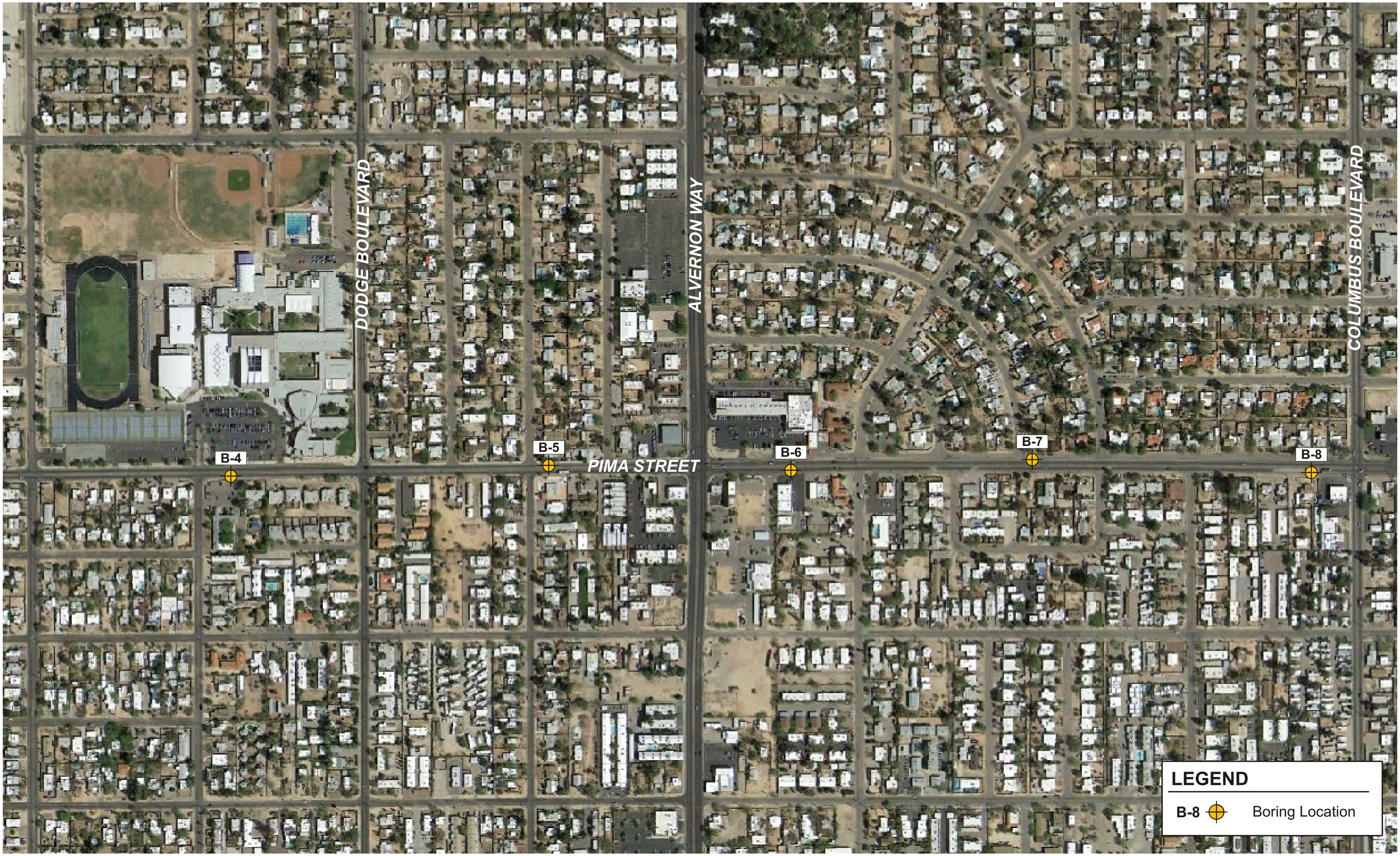
0 550

Approximate Scale:
1 inch = 550 feet

Note: Dimensions, directions, and locations are approximate.

file no: 4817blm1015g

Ninyo & Moore	BORING LOCATIONS	FIGURE
PROJECT NO: 604817002 / DATE: 12/15	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - PIMA STREET TUCSON, ARIZONA	2A



Source: NAVTEQ, 03/27/14.

N

0 550

Approximate Scale:
1 inch = 550 feet

Note: Dimensions, directions, and locations are approximate.

file no: 4817blm1015gb

Ninyo & Moore	BORING LOCATIONS	FIGURE
PROJECT NO: 604817002 / DATE: 12/15	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - PIMA STREET TUCSON, ARIZONA	2B

APPENDIX A

BORING LOGS

Field Procedure for the Collection of Relatively Undisturbed Samples

Relatively undisturbed soil samples were obtained in the field using the following methods.

The Modified Split-Barrel Drive Sampler

The sampler, with an external diameter of 3.0 inches, was lined with 1-inch long, thin brass rings with inside diameters of approximately 2.4 inches. The sample barrel was driven into the ground with the weight of a hammer or the Kelly bar of the drill rig in general accordance with ASTM D 3550. The driving weight was permitted to fall freely. The approximate length of the fall, the weight of the hammer or bar, and the number of blows per foot of driving are presented on the boring logs as an index to the relative resistance of the materials sampled. The samples were removed from the sample barrel in the brass rings, sealed, and transported to the laboratory for testing.

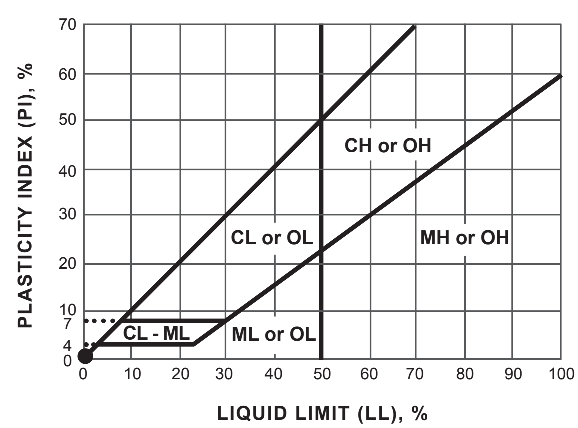
SOIL CLASSIFICATION CHART PER ASTM D 2488

PRIMARY DIVISIONS			SECONDARY DIVISIONS		
			GROUP SYMBOL		GROUP NAME
COARSE-GRAINED SOILS more than 50% retained on No. 200 sieve	GRAVEL more than 50% of coarse fraction retained on No. 4 sieve	CLEAN GRAVEL less than 5% fines		GW	well-graded GRAVEL
				GP	poorly graded GRAVEL
		GRAVEL with DUAL CLASSIFICATIONS 5% to 12% fines		GW-GM	well-graded GRAVEL with silt
				GP-GM	poorly graded GRAVEL with silt
				GW-GC	well-graded GRAVEL with clay
				GP-GC	poorly graded GRAVEL with clay
		GRAVEL with FINES more than 12% fines		GM	silty GRAVEL
				GC	clayey GRAVEL
				GC-GM	silty, clayey GRAVEL
	SAND 50% or more of coarse fraction passes No. 4 sieve	CLEAN SAND less than 5% fines		SW	well-graded SAND
				SP	poorly graded SAND
		SAND with DUAL CLASSIFICATIONS 5% to 12% fines		SW-SM	well-graded SAND with silt
				SP-SM	poorly graded SAND with silt
				SW-SC	well-graded SAND with clay
				SP-SC	poorly graded SAND with clay
		SAND with FINES more than 12% fines		SM	silty SAND
				SC	clayey SAND
				SC-SM	silty, clayey SAND
FINE-GRAINED SOILS 50% or more passes No. 200 sieve	SILT and CLAY liquid limit less than 50%	INORGANIC		CL	lean CLAY
				ML	SILT
				CL-ML	silty CLAY
		ORGANIC		OL (PI > 4)	organic CLAY
				OL (PI < 4)	organic SILT
	SILT and CLAY liquid limit 50% or more	INORGANIC		CH	fat CLAY
				MH	elastic SILT
		ORGANIC		OH (plots on or above "A"-line)	organic CLAY
				OH (plots below "A"-line)	organic SILT
	Highly Organic Soils			PT	Peat

GRAIN SIZE

DESCRIPTION		SIEVE SIZE	GRAIN SIZE	APPROXIMATE SIZE
Boulders		> 12"	> 12"	Larger than basketball-sized
Cobbles		3 - 12"	3 - 12"	Fist-sized to basketball-sized
Gravel	Coarse	3/4 - 3"	3/4 - 3"	Thumb-sized to fist-sized
	Fine	#4 - 3/4"	0.19 - 0.75"	Pea-sized to thumb-sized
Sand	Coarse	#10 - #4	0.079 - 0.19"	Rock-salt-sized to pea-sized
	Medium	#40 - #10	0.017 - 0.079"	Sugar-sized to rock-salt-sized
	Fine	#200 - #40	0.0029 - 0.017"	Flour-sized to sugar-sized
Fines		Passing #200	< 0.0029"	Flour-sized and smaller

PLASTICITY CHART



APPARENT DENSITY - COARSE-GRAINED SOIL

APPARENT DENSITY	SPOOLING CABLE OR CATHEAD		AUTOMATIC TRIP HAMMER	
	SPT (blows/foot)	MODIFIED SPLIT BARREL (blows/foot)	SPT (blows/foot)	MODIFIED SPLIT BARREL (blows/foot)
Very Loose	≤ 4	≤ 8	≤ 3	≤ 5
Loose	5 - 10	9 - 21	4 - 7	6 - 14
Medium Dense	11 - 30	22 - 63	8 - 20	15 - 42
Dense	31 - 50	64 - 105	21 - 33	43 - 70
Very Dense	> 50	> 105	> 33	> 70

CONSISTENCY - FINE-GRAINED SOIL

CONSIS-TENCY	SPOOLING CABLE OR CATHEAD		AUTOMATIC TRIP HAMMER	
	SPT (blows/foot)	MODIFIED SPLIT BARREL (blows/foot)	SPT (blows/foot)	MODIFIED SPLIT BARREL (blows/foot)
Very Soft	< 2	< 3	< 1	< 2
Soft	2 - 4	3 - 5	1 - 3	2 - 3
Firm	5 - 8	6 - 10	4 - 5	4 - 6
Stiff	9 - 15	11 - 20	6 - 10	7 - 13
Very Stiff	16 - 30	21 - 39	11 - 20	14 - 26
Hard	> 30	> 39	> 20	> 26

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USCS METHOD OF SOIL CLASSIFICATION

Explanation of USCS Method of Soil Classification

PROJECT NO.	DATE	FIGURE

BORING LOG EXPLANATION SHEET

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	
0								Bulk sample.
								Modified split-barrel drive sampler.
								No recovery with modified split-barrel drive sampler.
								Sample retained by others.
								Standard Penetration Test (SPT).
5								No recovery with a SPT.
			XX/XX					Shelby tube sample. Distance pushed in inches/length of sample recovered in inches.
								No recovery with Shelby tube sampler.
								Continuous Push Sample.
								Seepage.
10								Groundwater encountered during drilling.
								Groundwater measured after drilling.
							SM	MAJOR MATERIAL TYPE (SOIL): Solid line denotes unit change.
							CL	Dashed line denotes material change.
15								Attitudes: Strike/Dip b: Bedding c: Contact j: Joint f: Fracture F: Fault cs: Clay Seam s: Shear bss: Basal Slide Surface sf: Shear Fracture sz: Shear Zone sbs: Shear Bedding Surface
								The total depth line is a solid line that is drawn at the bottom of the boring.
20								

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BORING LOG

Explanation of Boring Log Symbols

PROJECT NO.	DATE	FIGURE

Updated Nov. 2011

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
								DATE DRILLED 10/02/15 BORING NO. B-1
								GROUND ELEVATION 2,449' ± (MSL) SHEET 1 OF 1
								METHOD OF DRILLING CME-45 Hollow-Stem Auger (Southlands)
								DRIVE WEIGHT 140 lbs. Automatic DROP 30"
								SAMPLED BY NAG LOGGED BY NAG REVIEWED BY
0								ASPHALT CONCRETE: Approximately 3 inches thick.
							SC	AGGREGATE BASE: Approximately 3 inches thick.
								ALLUVIUM: Brown, dry, medium dense, clayey SAND; few gravel.
			16					
								Total Depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt concrete patched on 10/02/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this e valuation. It is not sufficiently accurate for preparing construction bids and design documents.
5								
10								
15								
20								

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - PIMA STREET
TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-1

DATE DRILLED	10/02/15	BORING NO.	B-2
GROUND ELEVATION	2,447' ± (MSL)	SHEET 1 OF 1	
METHOD OF DRILLING	CME-45 Hollow-Stem Auger (Southlands)		
DRIVE WEIGHT	140 lbs. Automatic	DROP	30"
SAMPLED BY	NAG	LOGGED BY NAG	REVIEWED BY

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 3 inches thick.
								AGGREGATE BASE: Approximately 2 inches thick.
		X	22				SC	ALLUVIUM: Brown, dry, medium dense, clayey SAND; trace gravel.
								Total Depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt concrete patched on 10/02/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this e valuation. It is not sufficiently accurate for preparing construction bids and design documents.
5								
10								
15								
20								

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - PIMA STREET
TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-2

DATE DRILLED 10/02/15 BORING NO. B-3

GROUND ELEVATION 2,451' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-45 Hollow-Stem Auger (Southlands)

DRIVE WEIGHT 140 lbs. Automatic DROP 30"

SAMPLED BY NAG LOGGED BY NAG REVIEWED BY

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 3 inches thick.
		X	11				SC	ALLUVIUM: Brown, dry, loose, clayey SAND; trace gravel.
3								Total Depth = 3 feet. Groundwater not encountered during drilling.

Backfilled and asphalt concrete patched on 10/02/15 shortly after completion of drilling.

Notes:
Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this e valuation. It is not sufficiently accurate for preparing construction bids and design documents.

Depth scale: 0, 5, 10, 15, 20

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BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - PIMA STREET
TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-3

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 2 1/2 inches thick.
								AGGREGATE BASE: Approximately 4 inches thick.
							SC	ALLUVIUM: Brown, moist, loose, clayey SAND; trace gravel.
			11					
								Total Depth = 3 feet. Groundwater not encountered during drilling.
5								
10								
15								
20								

DATE DRILLED 10/02/15 BORING NO. B-4

GROUND ELEVATION 2,457' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-45 Hollow-Stem Auger (Southlands)

DRIVE WEIGHT 140 lbs. Automatic DROP 30"

SAMPLED BY NAG LOGGED BY NAG REVIEWED BY

Backfilled and asphalt concrete patched on 10/02/15 shortly after completion of drilling.

Notes:
Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this e valuation. It is not sufficiently accurate for preparing construction bids and design documents.

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BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - PIMA STREET
TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-4

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DATE DRILLED 10/02/15 BORING NO. B-5 GROUND ELEVATION 2,468' ± (MSL) SHEET 1 OF 1 METHOD OF DRILLING CME-45 Hollow-Stem Auger (Southlands) DRIVE WEIGHT 140 lbs. Automatic DROP 30" SAMPLED BY NAG LOGGED BY NAG REVIEWED BY ___ DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 7 1/2 inches thick.
								AGGREGATE BASE: Approximately 3 inches thick.
			20				SC	ALLUVIUM: Brown, dry, medium dense, clayey SAND; with gravel.
5								Total Depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt concrete patched on 10/02/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this e valuation. It is not sufficiently accurate for preparing construction bids and design documents.
10								
15								
20								

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - PIMA STREET
TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-5

DATE DRILLED 10/02/15 BORING NO. B-6

GROUND ELEVATION 2,461' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-45 Hollow-Stem Auger (Southlands)

DRIVE WEIGHT 140 lbs. Automatic DROP 30"

SAMPLED BY NAG LOGGED BY NAG REVIEWED BY

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 6 inches thick.
								AGGREGATE BASE: Approximately 2 inches thick.
							SC	ALLUVIUM: Brown, moist, loose, clayey SAND; few gravel.
			11					
5								Total Depth = 3 feet. Groundwater not encountered during drilling.
10								
15								
20								

Total Depth = 3 feet.
Groundwater not encountered during drilling.

Backfilled and asphalt concrete patched on 10/02/15 shortly after completion of drilling.

Notes:
Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this e valuation. It is not sufficiently accurate for preparing construction bids and design documents.

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - PIMA STREET
TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-6

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DATE DRILLED 10/02/15 BORING NO. B-7 GROUND ELEVATION 2,464' ± (MSL) SHEET 1 OF 1 METHOD OF DRILLING CME-45 Hollow-Stem Auger (Southlands) DRIVE WEIGHT 140 lbs. Automatic DROP 30" SAMPLED BY NAG LOGGED BY NAG REVIEWED BY DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 6 inches thick.
			25				SC	ALLUVIUM: Brown, dry, medium dense, clayey SAND; few gravel.
5								Total Depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt concrete patched on 10/02/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this e valuation. It is not sufficiently accurate for preparing construction bids and design documents.
10								
15								
20								

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - PIMA STREET
TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-7

DATE DRILLED 10/02/15 BORING NO. B-8

GROUND ELEVATION 2,467' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-45 Hollow-Stem Auger (Southlands)

DRIVE WEIGHT 140 lbs. Automatic DROP 30"

SAMPLED BY NAG LOGGED BY NAG REVIEWED BY

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 6 1/2 inches thick.
								AGGREGATE BASE: Approximately 2 inches thick.
			13				SC	ALLUVIUM: Light brown, dry, loose, clayey SAND; trace gravel.
								Total Depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt concrete patched on 10/02/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this e valuation. It is not sufficiently accurate for preparing construction bids and design documents.
5								
10								
15								
20								

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - PIMA STREET
TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-8

APPENDIX B

LABORATORY TESTING

Classification

Soils were visually and texturally classified in accordance with the Unified Soil Classification System (USCS) in general accordance with ASTM D 2488. Soil classifications are indicated on the logs of the exploratory borings in Appendix A.

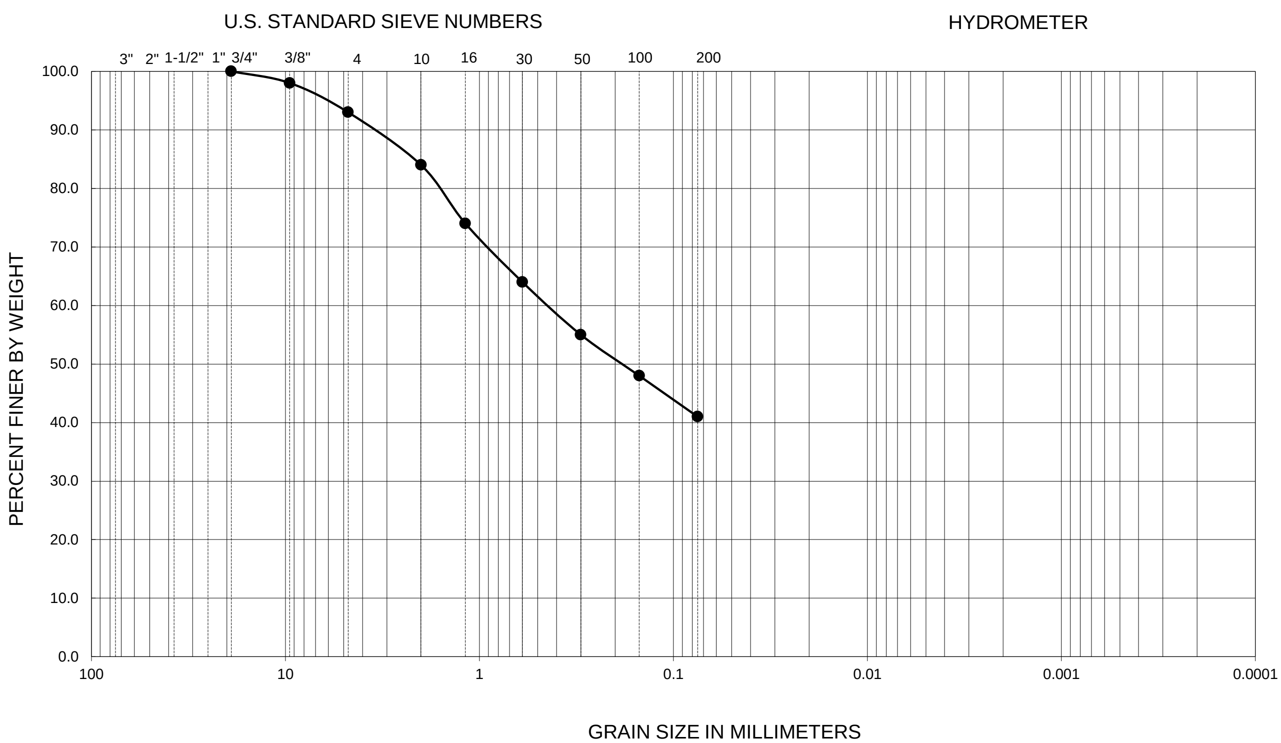
Gradation Analysis

One gradation analysis test was performed on a selected representative soil sample in general accordance with ASTM D 422. The grain-size distribution curves are shown in Figures B-1 through B-4. These test results were utilized in evaluating the soil classification in accordance with the USCS.

Atterberg Limits

Tests were performed on a selected representative fine-grained soil sample to evaluate the liquid limit, plastic limit, and plasticity index in general accordance with ASTM D 4318. These test results were utilized to evaluate the soil classification in accordance with the USCS. The test results and classifications are shown on Figure B-5.

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY

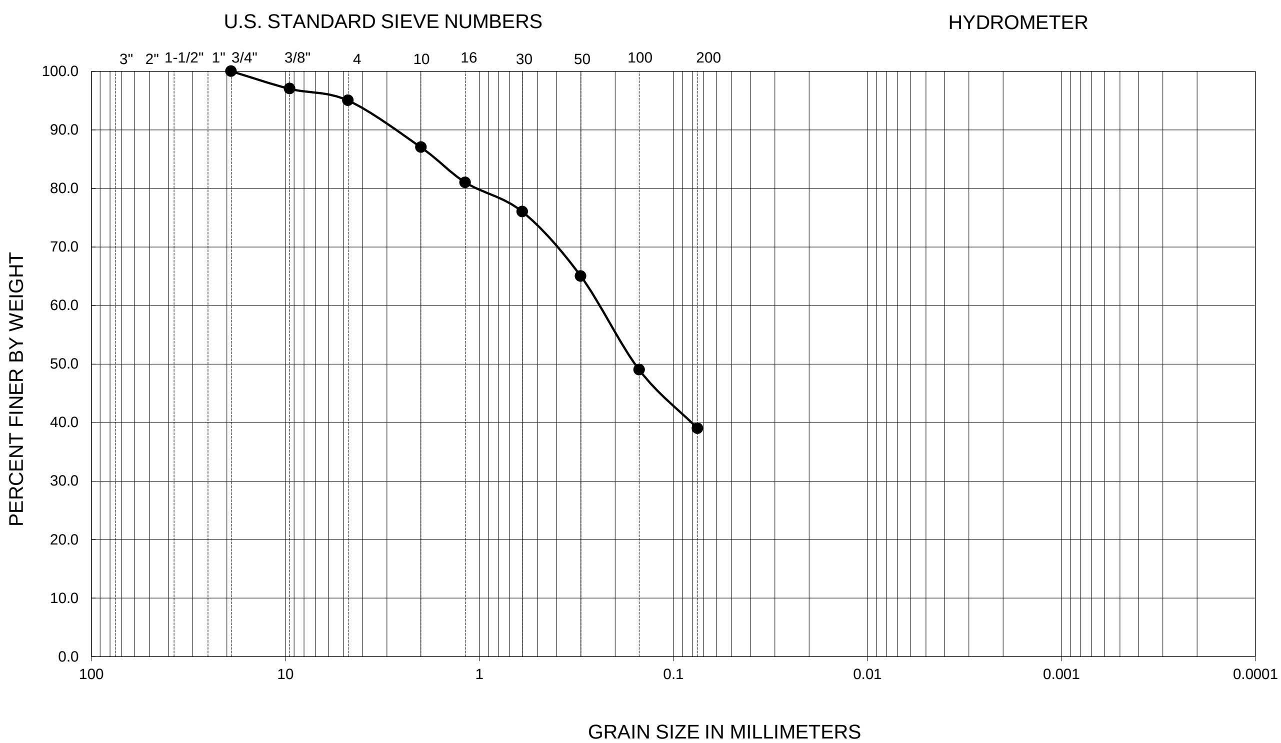


Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
●	B-1	1.5-3.0	50	22	28	--	--	--	--	--	41	SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore		GRADATION TEST RESULTS	FIGURE
PROJECT NO.	DATE	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - PIMA STREET TUCSON, ARIZONA	B-1
604817002	12/15		

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY

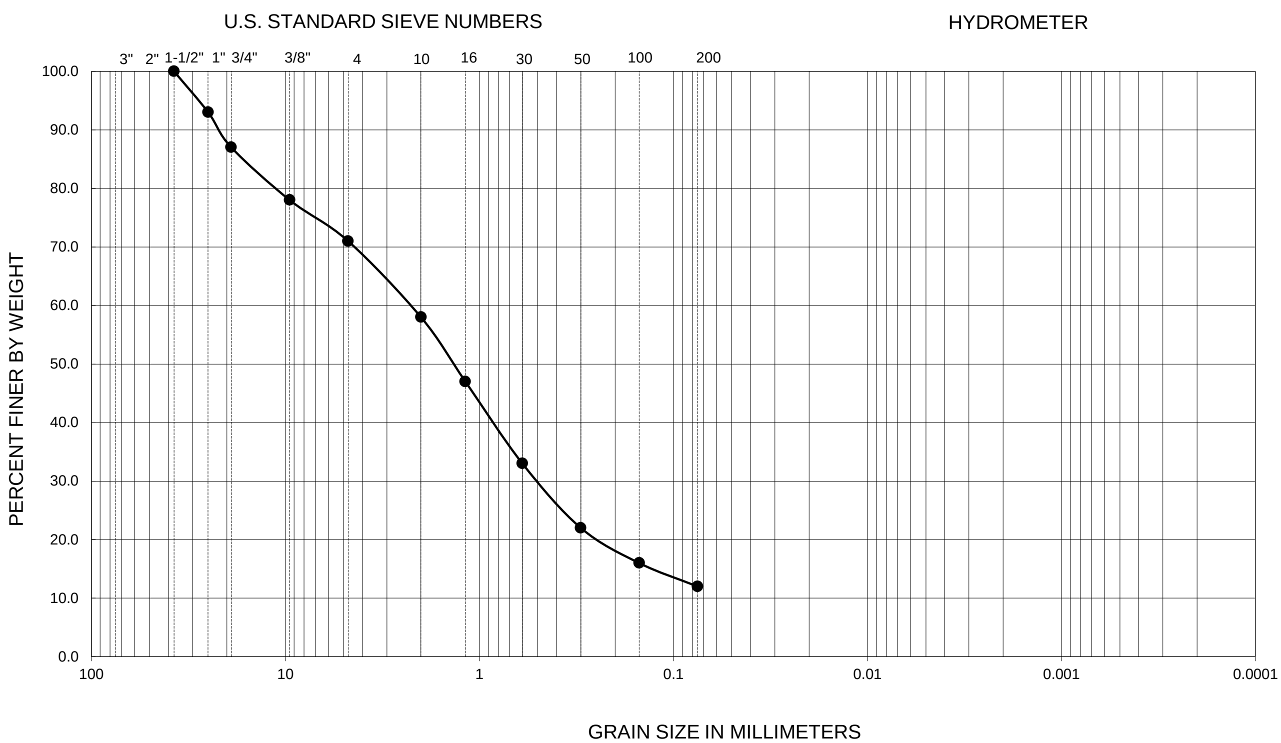


Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
●	B-3	1.5-3.0	29	15	14	--	--	--	--	--	39	SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore		GRADATION TEST RESULTS	FIGURE
PROJECT NO.	DATE	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - PIMA STREET TUCSON, ARIZONA	B-2
604817002	12/15		

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY

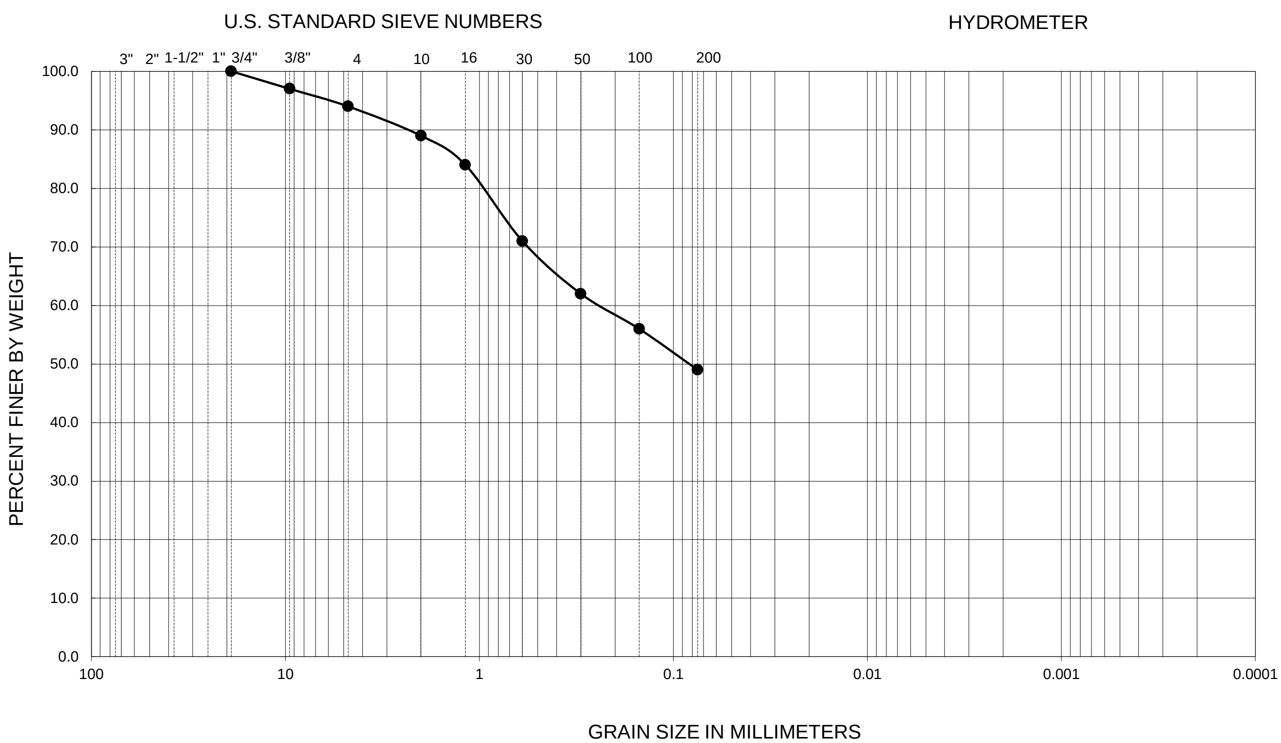


Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
●	B-5	1.5-3.0	35	24	11	--	--	--	--	--	12	SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore	GRADATION TEST RESULTS	FIGURE
PROJECT NO. / DATE	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - PIMA STREET TUCSON, ARIZONA	B-3
604817002 / 12/15		

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
●	B-7	1.5-3.0	51	16	35	--	--	--	--	--	49	SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore

GRADATION TEST RESULTS

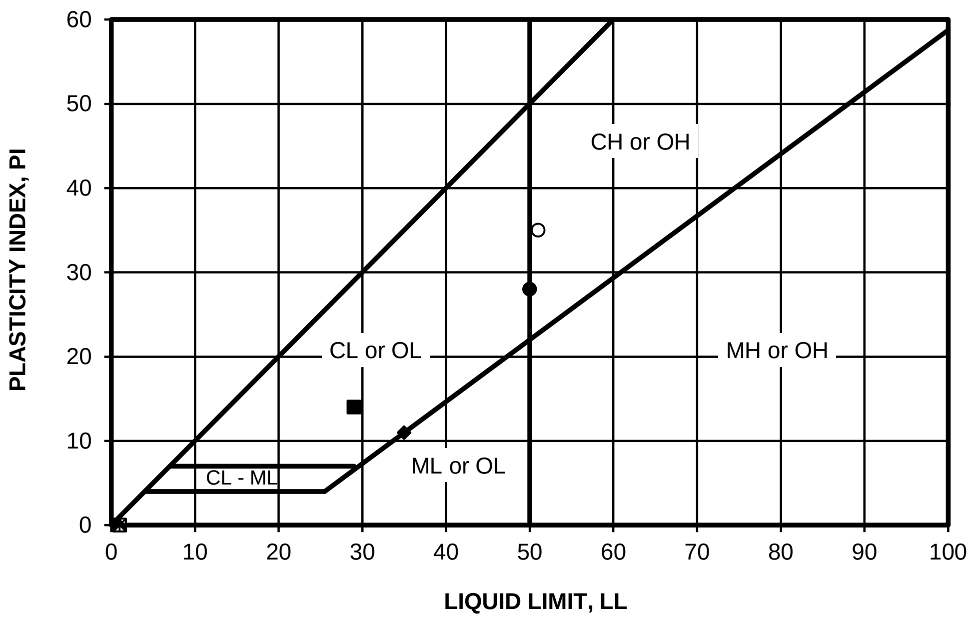
PROJECT NO.	DATE
604817002	12/15

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - PIMA STREET
TUCSON, ARIZONA

FIGURE

B-4

SYMBOL	LOCATION	DEPTH (FT)	LIQUID LIMIT, LL	PLASTIC LIMIT, PL	PLASTICITY INDEX, PI	USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve)	USCS (Entire Sample)
●	B-1	1.5-3.0	50	22	28	CH	SC
■	B-3	1.0-2.5	29	15	14	CL	SC
◆	B-5	1.5-3.0	35	24	11	CL	SC
○	B-7	1.5-3.0	51	16	35	CH	SC



PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4318

Ninyo & Moore

ATTERBERG LIMITS TEST RESULTS

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - PIMA STREET
TUCSON, ARIZONA

PROJECT NO.	DATE
604817002	12/15

FIGURE

B-5

APPENDIX C

PAVEMENT AND CORE SUMMARY

PIMA STREET - PAVEMENT AND CORE SUMMARY

No.	Location	Approximate AC thickness (in)*	Recovered AC Thickness (in)	Core Description	Pavement Condition
B-1	Westbound, 290 feet east of Country Club Road	3	3	Two lifts, 1.5" and 1.5", numerous voids, poor quality bottom lift.	Severe alligator and irregular cracking, rutting in both wheet tracks, considerable spalling, flushing.
B-2	Eastbound, 110 feet east of Howard Boulevard	3	3	Two lifts, 1" and 2", numerous voids, poor quality bottom lift.	Severe alligator and irregular cracking, rutting in both wheet tracks, considerable spalling, flushing.
B-3	Westbound, 140 feet west of Palo Verde Boulevard	3	3	Two lifts, 1" and 2", few voids.	Severe alligator and irregular cracking, rutting in both wheet tracks, considerable spalling, flushing.
B-4	Eastbound, 770 feet east of Palo Verde Boulevard	2.5	2.5	Two lifts, 1.5" and 1", numerous voids, poor quality bottom lift.	Severe alligator and irregular cracking, rutting in both wheet tracks, considerable spalling, flushing.
B-5	Westbound, 540 feet west of Alvernon Way	7.5	7	Three lifts, 1.5", 3", and 3", few voids.	Some tranverse and irregular cracking, flushing.
B-6	Eastbound, 290 feet east of Alvernon Way	6	6	Three lifts, 1.5", 2", and 2.5", numerous voids, bottom lift disintegrated.	Severe alligator, longitudinal, and irregular cracking, considerable spalling, rutting, patches, flushing.
B-7	Westbound, 50 feet east of Desmond Lane	6	6	Three lifts, 2", 1.5", and 2.5", numerous voids, bottom lift disintegrated and poor quality.	Severe alligator, longitudinal, and irregular cracking, considerable spalling, rutting, patches, flushing.
B-8	Eastbound, 180 feet west of Columbus Boulevard	6.5	6.5	Two lifts, 3.5" and 3", numerous voids.	Severe alligator, longitudinal, and irregular cracking, considerable spalling, rutting, patches, flushing.

Notes:

* Measured in the boring

APPENDIX D

TRAFFIC DATA

Field Data Services of Arizona
21636 N. Dietz Dr.
Maricopa, AZ 85138
(520) 316-6745

Site Code: 15-1283-008
Station ID: Wed 10/07/2015
Pima St. btwn. Winstal Blvd. & Alvernon Way 32.243491 -110.911159
Latitude: 0' 0.000 Undefined

Eastbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/7/15	0	12	2	0	0	0	0	0	0	0	0	0	0	14
01:00	0	9	1	0	0	0	0	0	0	0	0	0	0	10
02:00	0	4	0	0	0	0	0	0	0	0	0	0	0	4
03:00	0	4	1	0	0	0	0	0	0	0	0	0	0	5
04:00	0	2	1	0	0	0	0	0	0	0	0	0	0	3
05:00	0	25	3	0	1	0	0	0	0	0	0	0	0	29
06:00	0	61	7	1	2	0	0	0	0	0	0	0	0	71
07:00	**1**	207	21	**3**	**8**	1	0	0	0	0	0	0	0	241
08:00	1	**259**	23	2	6	1	0	0	0	0	0	0	0	**292**
09:00	0	176	21	1	6	0	0	0	0	0	0	0	0	204
10:00	0	173	22	3	6	**2**	0	**1**	0	0	0	0	0	207
11:00	0	185	**29**	2	7	0	0	0	0	0	0	0	0	223
12 PM	**1**	171	42	2	5	0	0	0	0	0	0	0	0	221
13:00	1	245	31	2	6	0	0	0	0	0	0	0	0	285
14:00	1	262	37	2	**9**	0	0	0	0	0	0	0	0	311
15:00	1	297	**43**	**3**	9	0	0	**1**	0	0	0	0	0	354
16:00	0	330	40	1	6	2	0	0	0	0	0	**1**	0	380
17:00	1	**349**	32	1	4	**3**	0	0	0	0	0	0	0	**390**
18:00	0	195	28	2	4	1	0	0	0	0	0	0	0	230
19:00	0	98	12	1	2	0	0	0	0	0	0	0	0	113
20:00	0	95	12	0	2	0	0	0	0	0	0	0	0	109
21:00	0	74	5	0	1	0	0	0	0	0	0	0	0	80
22:00	0	31	5	0	1	0	0	0	0	0	0	0	0	37
23:00	0	17	0	0	0	0	0	0	0	0	0	0	0	17
Total	7	3281	418	26	85	10	0	2	0	0	0	1	0	3830
Percent	0.2%	85.7%	10.9%	0.7%	2.2%	0.3%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	
AM Peak	07:00	08:00	11:00	07:00	07:00	10:00		10:00						08:00
Vol.	1	259	29	3	8	2		1						292
PM Peak	12:00	17:00	15:00	15:00	14:00	17:00		15:00				16:00		17:00
Vol.	1	349	43	3	9	3		1				1		390
Grand Total	7	3281	418	26	85	10	0	2	0	0	0	1	0	3830
Percent	0.2%	85.7%	10.9%	0.7%	2.2%	0.3%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	

Field Data Services of Arizona
21636 N. Dietz Dr.
Maricopa, AZ 85138
(520) 316-6745

Site Code: 15-1283-008
Station ID: Wed 10/07/2015
Pima St. btwn. Winstal Blvd. & Alvernon Way 32.243491 -110.911159
Latitude: 0' 0.000 Undefined

Westbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/7/15	1	13	0	0	0	0	0	0	0	0	0	0	0	14
01:00	0	7	1	0	0	0	0	0	0	0	0	0	0	8
02:00	0	1	1	0	0	0	0	0	0	0	0	0	0	2
03:00	0	3	1	0	0	0	0	0	0	0	0	0	0	4
04:00	0	7	2	0	0	0	0	0	0	0	0	0	0	9
05:00	0	16	1	0	2	0	0	0	0	0	0	0	0	19
06:00	2	82	12	4	5	0	0	0	0	0	0	0	0	105
07:00	3	**299**	**41**	**5**	**11**	0	0	0	0	0	0	0	0	**359**
08:00	**4**	285	34	5	8	0	0	0	0	0	0	0	0	336
09:00	1	173	31	1	2	0	0	0	**1**	0	0	0	0	209
10:00	1	160	28	4	5	0	0	0	0	0	0	0	0	198
11:00	2	204	23	1	5	0	0	0	0	0	0	0	0	235
12 PM	**4**	190	30	2	8	**1**	0	0	0	0	0	0	0	235
13:00	2	209	34	**3**	8	1	0	0	0	0	0	0	**1**	258
14:00	1	233	**46**	3	7	1	0	0	0	0	0	0	0	291
15:00	0	229	29	2	3	0	0	0	0	0	0	0	0	263
16:00	1	281	42	2	**14**	1	0	0	0	0	0	0	0	341
17:00	0	**306**	31	1	6	1	0	0	0	0	0	0	0	**345**
18:00	1	210	29	1	3	0	0	0	0	0	0	0	0	244
19:00	0	105	20	1	2	0	0	0	0	0	0	0	0	128
20:00	0	99	15	0	1	0	0	0	0	0	0	0	0	115
21:00	0	83	7	0	2	0	0	0	0	0	0	0	0	92
22:00	1	36	5	0	1	0	0	0	0	0	0	0	0	43
23:00	1	30	1	0	0	0	0	0	0	0	0	0	0	32
Total	25	3261	464	35	93	5	0	0	1	0	0	0	1	3885
Percent	0.6%	83.9%	11.9%	0.9%	2.4%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
AM Peak	08:00	07:00	07:00	07:00	07:00				09:00					07:00
Vol.	4	299	41	5	11				1					359
PM Peak	12:00	17:00	14:00	13:00	16:00	12:00							13:00	17:00
Vol.	4	306	46	3	14	1							1	345
Grand Total	25	3261	464	35	93	5	0	0	1	0	0	0	1	3885
Percent	0.6%	83.9%	11.9%	0.9%	2.4%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

Field Data Services of Arizona
21636 N. Dietz Dr.
Maricopa, AZ 85138
(520) 316-6745

Site Code: 15-1283-008
Station ID: Wed 10/07/2015
Pima St. btwn. Winstal Blvd. & Alvernon Way 32.243491 -110.911159
Latitude: 0' 0.000 Undefined

Eastbound, Westbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/7/15	1	25	2	0	0	0	0	0	0	0	0	0	0	28
01:00	0	16	2	0	0	0	0	0	0	0	0	0	0	18
02:00	0	5	1	0	0	0	0	0	0	0	0	0	0	6
03:00	0	7	2	0	0	0	0	0	0	0	0	0	0	9
04:00	0	9	3	0	0	0	0	0	0	0	0	0	0	12
05:00	0	41	4	0	3	0	0	0	0	0	0	0	0	48
06:00	2	143	19	5	7	0	0	0	0	0	0	0	0	176
07:00	4	506	**62**	**8**	**19**	1	0	0	0	0	0	0	0	600
08:00	**5**	**544**	57	7	14	1	0	0	0	0	0	0	0	**628**
09:00	1	349	52	2	8	0	0	0	**1**	0	0	0	0	413
10:00	1	333	50	7	11	**2**	0	**1**	0	0	0	0	0	405
11:00	2	389	52	3	12	0	0	0	0	0	0	0	0	458
12 PM	**5**	361	72	4	13	1	0	0	0	0	0	0	0	456
13:00	3	454	65	**5**	14	1	0	0	0	0	0	0	**1**	543
14:00	2	495	**83**	5	16	1	0	0	0	0	0	0	0	602
15:00	1	526	72	5	12	0	0	**1**	0	0	0	0	0	617
16:00	1	611	82	3	**20**	3	0	0	0	0	0	**1**	0	721
17:00	1	**655**	63	2	10	**4**	0	0	0	0	0	0	0	**735**
18:00	1	405	57	3	7	1	0	0	0	0	0	0	0	474
19:00	0	203	32	2	4	0	0	0	0	0	0	0	0	241
20:00	0	194	27	0	3	0	0	0	0	0	0	0	0	224
21:00	0	157	12	0	3	0	0	0	0	0	0	0	0	172
22:00	1	67	10	0	2	0	0	0	0	0	0	0	0	80
23:00	1	47	1	0	0	0	0	0	0	0	0	0	0	49
Total	32	6542	882	61	178	15	0	2	1	0	0	1	1	7715
Percent	0.4%	84.8%	11.4%	0.8%	2.3%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
AM Peak	08:00	08:00	07:00	07:00	07:00	10:00		10:00	09:00					08:00
Vol.	5	544	62	8	19	2		1	1					628
PM Peak	12:00	17:00	14:00	13:00	16:00	17:00		15:00				16:00	13:00	17:00
Vol.	5	655	83	5	20	4		1				1	1	735
Grand Total	32	6542	882	61	178	15	0	2	1	0	0	1	1	7715
Percent	0.4%	84.8%	11.4%	0.8%	2.3%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

APPENDIX E

PAVEMENT OPTIMIZATION DESIGN ANALYSIS BY TENSAR

Tensar

SpectraPave4 PRO™
Pavement Optimization Design Analysis

Design Parameters for AASHTO (1993) Equation

Reliability (%)	= 95	Initial Serviceability	= 4.5
Standard Normal Deviate	= -1.645	Terminal Serviceability	= 2.5
Standard Deviation	= 0.40	Change in Serviceability	= 2

Aggregate fill shall conform to following requirement:

D50 <= 27mm (Base course)

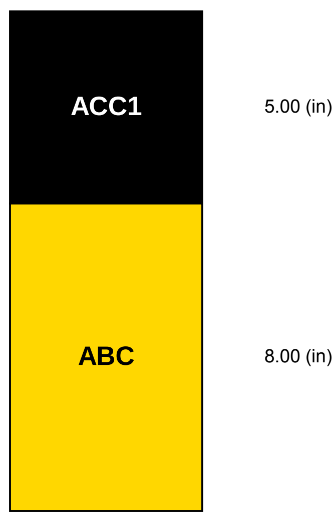
Unstabilized Section Material Properties

Layer	Description	Cost ($/ton)	Layer coefficient	Drainage factor
ACC1	Asphalt Wearing Course	70	0.440	N/A
ABC	Aggregate Base Course	20	0.140	1.25

Stabilized Section Material Properties

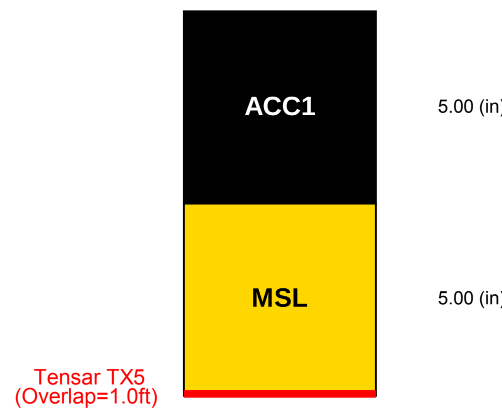
Layer	Description	Cost ($/ton)	Layer coefficient	Drainage factor
ACC1	Asphalt Wearing Course	70	0.440	N/A
MSL	Mechanically Stabilized Base Cour	20	0.289	1.25

Unstabilized Pavement



Subgrade Modulus = 8,824 (psi)
Structural Number = 3.600
Calculated Traffic (ESALs) = 1,845,000

Stabilized Pavement



Subgrade Modulus = 8,824 (psi)
Structural Number = 4.006
Calculated Traffic (ESALs) = 3,757,000

LIMITATIONS OF THE REPORT

The designs, illustrations, information and other content included in this report are necessarily general and conceptual in nature, and do not constitute engineering advice or any design intended for actual construction. Specific design recommendations can be provided as the project develops.

Project Name	Pima Street		
Company Name	Tensar		
Designer	Schlessinger	Date	12/14/15

PAVEMENT EVALUATION
TUCSON PAVEMENT RECONSTRUCTION PROGRAM
ROSEMONT BOULEVARD
TUCSON, ARIZONA

PREPARED FOR:
Kimley-Horn & Associates, Inc.
333 East Wetmore Road, Suite 280
Tucson, Arizona 85705

PREPARED BY:
Ninyo & Moore
Geotechnical and Environmental Sciences Consultants
1991 East Ajo Way, Suite 145
Tucson, Arizona 85713

December 14, 2015
Project No. 604817002

December 14, 2015
Project No. 604817002

Mr. Rick Solis, P.E.
Kimley-Horn
333 East Wetmore Road, Suite 280
Tucson, Arizona 85705

Subject: Pavement Evaluation
Tucson Pavement Reconstruction Program – Rosemont Boulevard
Tucson, Arizona

Dear Mr. Solis:

In accordance with our proposal dated August 12, 2015, and your authorization on September 21, 2015, Ninyo & Moore has performed a pavement evaluation for the above-referenced site. The attached report presents our methodology, findings, conclusions, and recommendations regarding the geotechnical conditions at the project site.

We appreciate the opportunity to be of service to you during this phase of the project.

Sincerely,
NINYO & MOORE

Registered Professional Engineer (Civil)
CERTIFICATE NO. 47704
MAREK J. KASZTALSKI
Date Signed 12.14.15
ARIZONA, U.S.A.
EXPIRES 9/30/18

Marek J. Kasztalski, PE, PMP, LEED AP	Fred Narcaroti
Senior Geotechnical Engineer	Principal/Tucson Office Manager

MJK/DT/FFN/tlp

Distribution: (1) Addressee (Electronic Copy)

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Appendices

1. INTRODUCTION

In accordance with our proposal dated August 12, 2015, and your authorization on September 21, 2015, we have performed a pavement evaluation for the Rosemont Boulevard Pavement Reconstruction project between Speedway Boulevard and Winsett Street, in Tucson, Arizona. The purpose of our evaluation was to assess the pavement and subgrade conditions along the project alignment in order to provide geotechnical recommendations for design and construction. This report presents the results of our evaluation, conclusions, and recommendations regarding the proposed construction.

2. SCOPE OF SERVICES

The scope of our services generally included:

- Preparing a field testing plan and associated permit application for submittal to the City of Tucson (COT).
- Conducting a visual reconnaissance of the pavement along the alignment and marking out the boring locations.
- Notifying Arizona811 of our boring locations prior to conducting the field work.
- Arranging for traffic control measures to conduct the field work.
- Coring the existing asphaltic concrete (AC) pavement at eight locations along the project alignment.
- Exploring the subsurface soils within the project limits by drilling, logging, and sampling eight exploratory soil borings to approximate depths of 3 feet below ground surface (bgs). The boring logs are presented in Appendix A.
- Performing laboratory tests on selected samples collected from our borings to evaluate gradation and Atterberg limits. The results of the laboratory tests are included in Appendix B.
- Preparing this report presenting our findings, conclusions and recommendations regarding the proposed reconstruction.

Our scope of services did not include environmental consulting services such as hazardous waste sampling or analytical testing at the site. A detailed scope of services and estimated fee for such services can be provided upon request.

3. SITE DESCRIPTION

The project site is located in Sections 11 and 14 of Township 14 South, Range 14 East relative to the Gila and Salt River Base Line and Meridian. The project alignment extends along Rosemont Boulevard between Speedway Boulevard and Winsett Street in Tucson, Arizona (Figure 1).

At the time of our evaluation mostly residential developments existed along the project alignment. The roadway section consisted of one travel lane in each direction, a center lane (north of Broadway Boulevard), concrete sidewalks and concrete curb along the project alignment.

4. PROPOSED CONSTRUCTION

The COT has identified several segments of the existing street network for reconstruction and/or rehabilitation in fiscal year (FY) 2016 under Bid Package 2. The scope of this report includes Rosemont Boulevard between Speedway Boulevard and Winsett Street. The project alignment is approximately 1 ½ miles long.

We understand that the COT anticipates full-depth reconstruction of the existing roadway along the project alignment. The City proposes a new pavement section consisting of 5 inches of AC per of the COT Department of Transportation Standard Specifications Section 406 over 5 inches of aggregate base (AB) per Section 303 of the COT Standard Specifications.

We further understand that the COT intends to use Tucson Department of Transportation (TDOT) AC Mix No. 2 PG 76-22TR+ for the surface layer and TDOT AC Mix No. 1 PG 70-10 for the underlying layer. Both layers are proposed to be 2.5 inches thick.

Due to conflicts with shallow utility lines, subgrade improvement by overexcavation will not be performed and the new pavement section will be constructed on subgrade improved with Geogrid (Tensar Geogrid TX5 or equivalent).

The scope of this exploration included evaluation of the existing pavement section and subgrade soils in order to provide recommendations for pavement reconstruction in accordance with the current COT practice. Calculations for the new pavement section supporting the new construction proposed by the COT are presented in Section 9.3 and in Appendix E of this report.

5. EXISTING PAVEMENT CONDITION

On October 1, 2015, Ninyo & Moore conducted a limited visual evaluation of the pavement surface along the project alignment. Based on our field observations, the AC pavement exhibited signs of severe distress in many locations along the project alignment primarily consisting of extensive alligator, block, transverse and irregular cracking, flushing and potholes. Some of the cracks exhibited evidence of past sealing. Asphaltic concrete patches were observed at some locations which were probably associated with past maintenance efforts (pothole and crack repairs) or with underground utility work. The crack widths generally varied between hairline (less than 1/8-inch) and over one inch.

In our opinion, the distress observed along the project alignment indicates structural failure and is related to a combination of pavement age, subgrade condition, traffic, and environmental impacts.

6. FIELD EXPLORATION AND LABORATORY TESTING

On October 1, 2015, Ninyo & Moore conducted a geotechnical exploration in order to evaluate the subsurface conditions and collect AC cores and soil samples for laboratory testing. Our evaluation consisted of coring the existing AC pavement, drilling, logging, and sampling eight small-diameter borings, denoted as B-1 through B-8, utilizing a CME-45 truck-mounted drill rig equipped with hollow-stem augers. The borings extended to depths of approximately 3 feet bgs. The approximate locations of the borings are depicted on Figure 2.

Ninyo & Moore personnel logged the borings in general accordance with the Unified Soil Classification System (USCS) and American Society for Testing and Materials (ASTM) D 2488 by observing cuttings and drive samples. Collected ring samples were trimmed in the field, wrapped in plastic bags, and placed in cylindrical plastic containers to retain in-place moisture conditions.

The soil samples collected from our drilling activities were transported to the Ninyo & Moore laboratory in Tucson, Arizona for geotechnical laboratory testing. The tests included gradation and Atterberg limits. A description of each laboratory test method and the test results are presented in Appendix B.

7. SUBSURFACE CONDITIONS

Our knowledge of the subsurface conditions at the project site is based on our field exploration, laboratory testing, and general experience in the area. More detailed stratigraphic information is presented on the boring logs in Appendix A, attached to this report. The boring logs contain our field and laboratory test results, as well as our interpretation of conditions believed to exist between actual samples retrieved. Therefore, these boring logs contain both factual and interpretive information. Lines delineating subsurface strata on the boring logs are intended to group soils having similar engineering properties and characteristics. They should be considered approximate as the actual transition between soil types (strata) may be gradual. A key to the soil symbols and terms used on the boring logs is provided in Appendix A.

7.1. Asphaltic Concrete

Asphaltic concrete pavement was encountered at the surface of each of our borings. The AC thickness varied between approximately 2 and 4 inches, in our borings. It should be noted that the thickness of the AC pavement between the sampling locations may vary and could be different from that encountered at our sampling locations. Detailed core descriptions are presented in Appendix C.

Aggregate base was not observed in our borings. It is possible the AB material blended with the native subgrade soils, such that delineation of the AB/subgrade interface was not easily interpreted.

7.2. Alluvium

Native alluvial soils were encountered below the pavement section, and extended to the boring termination depths. The alluvium generally consisted of loose to very dense, silty and clayey sands with varying amounts of gravel and scattered caliche cementation.

8. CONCLUSIONS

Based on the results of our visual and subsurface evaluations, laboratory testing, and data analysis, geotechnical considerations include the following:

- The on-site soils generally include clayey and silty sands, with a plasticity index (PI) value varying between 13 and 31. Many on-site soils may be sensitive to moisture content fluctuations and may be difficult to compact especially at higher moisture contents. The contractor should be aware of this condition.
- Clayey sands of high plasticity were encountered in our borings.
- Due to the relatively widely spaced nature of our borings, soil conditions may differ from what was observed during our field exploration.
- The pavement exhibits significant distress in many locations along the project alignment consisting mainly of alligator, transverse, block and irregular cracking.
- Full-depth pavement reconstruction is considered for this project as proposed by the COT.

9. RECOMMENDATIONS

The following sections present our geotechnical recommendations for the project. If the proposed construction is changed from that discussed in this report, Ninyo & Moore should be contacted for additional recommendations.

9.1. Recommended Pavement Structural Sections

The recommended pavement sections are presented in the table below:

Pavement Section	Service Life (years)	AC (in)[1]	AB (in)[2]
COT Preferred Pavement with Geogrid	20	5	5
Alternative Pavement Section without Geogrid	20	6	8

Notes:
[1] TDOT AC Mix No. 2 PG 76-22TR+ as the surface mix and TDOT AC Mix No. 1 PG 70-10 for the underlying layers per Section 406 of the COT Specifications.
[2] AB per Section 303 of the COT Specifications.

9.2. Earthwork

The following sections provide our earthwork recommendations for this project. In general, the earthwork specifications contained in the *City of Tucson/Pima County Standard Specifications for Public Improvements, 2003 Edition (COT/PC Specifications)* are expected to apply unless specifically noted.

9.2.1. Site Preparation

Construction areas should be cleared of deleterious materials, if any are present, including abandoned utilities, construction debris, vegetation, and any other material that might interfere with the performance or progress of the work. These materials should be disposed of at a legal dumpsite. Existing features that call for relocation or removal and extend below finish grade, if present, should be removed, and the resulting excavations backfilled with engineered fill.

9.2.2. Excavations

Our evaluation of the excavation characteristics of the on-site soils is based on the results of our exploratory borings, site observations, and experience with similar materials.

9.2.3. Fill Materials

Soils with PI values of 15 or less (as evaluated by ASTM D 4318) are generally suitable for use as engineered fill. Our Atterberg limits test indicated the PI values ranging between 13 and 31. Based on this test result, many of the on-site soils are not suitable for re-use as engineered fill.

Engineered fill should not include organic material, construction debris, or other non-soil fill materials. Rock particles and clay lumps should not be larger than 4 inches in dimension. Unsuitable material should be disposed of off-site or in non-structural areas.

9.2.4. Grading and Subgrade Preparation

In general, grading operations should be performed in accordance with Section 205 of the COT/PC Specifications.

Due to potential conflicts with underground utilities, we recommend that the subgrade be improved by the application of Geogrid (Tensar Geogrid TX5 or equivalent). Geogrid should be placed in accordance with the manufacturer's instructions.

Alternatively, if Geogrid is not applied we recommend new pavements be supported on 6 inches of subgrade that is compacted by appropriate mechanical methods to a relative compaction of 95 percent as evaluated by ASTM D 698 at a moisture content generally near optimum. The thickness of the improvement zone should be measured from the bottom of the AB layer.

In areas where excessive moisture is encountered so that the above compaction cannot be achieved and/or the subgrade surface is unstable and yielding (pumping) under the roller wheels, subgrade soils should be scarified to a depth of 12 inches, aerated, and re-compacted as specified above. Alternatively, subgrade soils in problem areas should be and replaced with engineered fill to a depth of 12 inches below the bottom of the AB.

9.3. Pavement Design Summary

The following sections present our design assumptions and recommendations for the new flexible pavement section of Rosemont Boulevard between Speedway Boulevard and Winsett Street, as this roadway is scheduled for full-depth pavement reconstruction.

The pavement section was developed using the Active Practices Guidelines issued by the COT Department of Transportation (Guidelines) and the Arizona Department of Transportation (ADOT) Preliminary Engineering and Design Manual (PEDM). We assumed that the subgrade will be improved by the application of Geogrid or overexcavation, as outlined in Section 9.2.4 of this report. The new pavement sections are designed for a 20-year service life.

9.3.1. Traffic

The future traffic numbers used in this report are based on traffic counts provided by Kimley-Horn and Associates, Inc. (KHA), and later communication with the KHA. This information is presented in Appendix D. Based on the above information, and using the procedures outlined in the Guidelines and PEDM, the design number of equivalent single axle loads (ESALs) for the design lane during the 20-year design period was calculated as approximately 3,395,960.

9.3.2. R-Value and Resilient Modulus

The analysis for the design R-value for the pavement section has been performed based on procedures detailed in the Guidelines and the PEDM, using correlated R-values. The correlated R-values were derived from the PI and percent passing No. 200 Sieve test results. A summary of the R-values for this project is presented in Table 1 below:

Table 1 – R-value Summary

Location	Sample Depth (ft)	Correlated R-Value
B-1	1.5-3.0	35
B-3	1.5-3.0	37
B-5	1.5-3.0	17
B-7	1.5-3.0	28

In the interest of conservatism, we recommend that an R-value of 20 be used for pavement design for this project.

If the project needs fill from an off-site source, we recommend the soils used for subgrade support should have an R-value of 20 or more. If during construction, the subgrade is found to vary from the expected soil conditions, we should be contacted so we may re-evaluate our recommended R-values. Based on the above design R-values, the design subgrade resilient modulus (M_R) value of 8,824 pounds per square inch (psi) was calculated in accordance with the Guidelines.

9.3.3. Statistical Parameters

A standard deviation of 0.40 was used for design of the flexible pavement in accordance with the Guidelines. The level of reliability and standard normal deviation (Z_R) values were selected in accordance with the Guidelines for the arterial functional classification. Their respective values are presented in the table below:

Table 2 – Summary of Statistical Parameters

Roadway	Functional Classification	Standard Deviation	Level of Reliability	Standard Normal Deviation
Rosemont Boulevard	Arterial	0.40	95 %	-1.645

9.3.4. Serviceability Index

Initial and terminal serviceability indices were selected for the pavement design of the roadways in accordance with the Guidelines. A summary of the serviceability indices for each roadway is provided in the table below:

Table 3 – Summary of Serviceability Parameters

Roadway	Functional Classification	Initial Serviceability Index	Terminal Serviceability Index	Change in Serviceability
Rosemont Boulevard	Arterial	4.5	2.5	2.0

9.3.5. Layer Coefficients

The following structural coefficients were used for the pavement structure in accordance with the Guidelines:

- AC: 0.44.
- AB: 0.14.

A drainage coefficient of 1.25 was used for the AB coefficient as recommended in the Guidelines.

As mentioned in Section 4 above, due to conflicts with existing shallow utilities, it is recommended that the subgrade be improved using Geogrid (Tensar Geogrid TX5 or equivalent). In this case the AB layer coefficient is 0.289.

9.3.6. Asphalt Pavement Section Recommendations

The structural number (SN) was calculated based on the parameters described above. The table below presents the calculated SN value and the recommended structural pavement sections. The AC thickness meets the COT requirements. Supporting documentation of the pavement optimization design using Geogrid is presented in Appendix E:

Table 4 – Structural Pavement Sections for 20-Year Design Life

Roadway	SN	AC (in)[1]	AB (in)[2]
COT Preferred Pavement with Geogrid	3.99	5	5
Alternative Pavement without Geogrid	4.01	6	8

Notes:
[1] TDOT AC Mix No. 2 PG 76-22TR+ as the surface mix and TDOT AC Mix No. 1 PG 70-10 for the underlying layers per Section 406 of the COT Specifications.
[2] AB per Section 303 of the COT Specifications.

The above pavement structural section has been designed with the assumption that the subgrade is prepared by as recommended in Section 9.2.4.

10. SITE DRAINAGE

Surface drainage should be provided to divert water away from paved surfaces. Surface water should also not be permitted to pond on or below pavement areas. Positive drainage for this project is defined as a slope of 2 percent or more for a distance of 5 feet or more away from the pavements. To deter accumulation of water below the new pavement sections, the bottom of the overexcavated zone below the new pavement should be sloped toward the edges of the roadway.

11. PRE-CONSTRUCTION CONFERENCE

We recommend that a pre-construction conference be held. Representatives of the owner, the civil engineer, Ninyo & Moore, and the contractor should be in attendance to discuss the project plans and schedule. Our office should be notified if the project description included herein is incorrect or if the project characteristics are significantly changed.

12. CONSTRUCTION OBSERVATION AND TESTING

During construction operations, we recommend that Ninyo & Moore perform observation and testing services for the project. These services should be performed to evaluate exposed subgrade conditions, including the extent and depth of overexcavation, to evaluate the suitability of proposed borrow materials for use as engineered fill and to observe placement and test compaction of fill soils. Qualified subcontractors utilizing appropriate techniques and construction materials should perform construction of the proposed improvements.

13. LIMITATIONS

The field evaluation, laboratory testing, and geotechnical analyses presented in this geotechnical report have been conducted in general accordance with current practice and the standard of care exercised by geotechnical consultants performing similar tasks in the project area. No warranty, expressed or implied, is made regarding the conclusions, recommendations, and opinions presented in this report. There is no evaluation detailed enough to reveal every subsurface condition. Variations may exist and conditions not observed or described in this report may be encountered during construction. Uncertainties relative to subsurface conditions can be reduced through additional subsurface exploration. Additional subsurface evaluation will be performed upon request. Please also note that our evaluation was limited to assessment of the geotechnical aspects of the project, and did not include evaluation of structural issues, environmental concerns, or the presence of hazardous materials.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. Ninyo & Moore should be contacted if the reader requires additional information or has questions regarding the content, interpretations presented, or completeness of this document.

This report is intended for design purposes only. It does not provide sufficient data to prepare an accurate bid by contractors. It is suggested that the bidders and their geotechnical consultant perform an independent evaluation of the subsurface conditions in the project areas. The independent evaluations may include, but not be limited to, review of other geotechnical reports prepared for the adjacent areas, site reconnaissance, and additional exploration and laboratory testing.

Our conclusions, recommendations, and opinions are based on an analysis of the observed site conditions. If geotechnical conditions different from those described in this report are encountered, our office should be notified and additional recommendations, if warranted, will be provided upon request. It should be understood that the conditions of a site could change with time as a result of natural processes or the activities of man at the subject site or nearby sites. In addition, changes to the applicable laws, regulations, codes, and standards of practice may occur due to government action or the broadening of knowledge. The findings of this report may, therefore, be invalidated over time, in part or in whole, by changes over which Ninyo & Moore has no control.

This report is intended exclusively for use by the client. Any use or reuse of the findings, conclusions, and/or recommendations of this report by parties other than the client is undertaken at said parties' sole risk.

14. REFERENCES

American Society for Testing and Materials (ASTM), Annual Book of ASTM Standards.

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

City of Tucson, Arizona, Department of Transportation, Engineering Division, 1987, Active Practices Guidelines: dated June 1.

Ninyo & Moore, In-house proprietary information.

Source: Phoenix Mapping Service, Tucson Metro Edition, 2012.

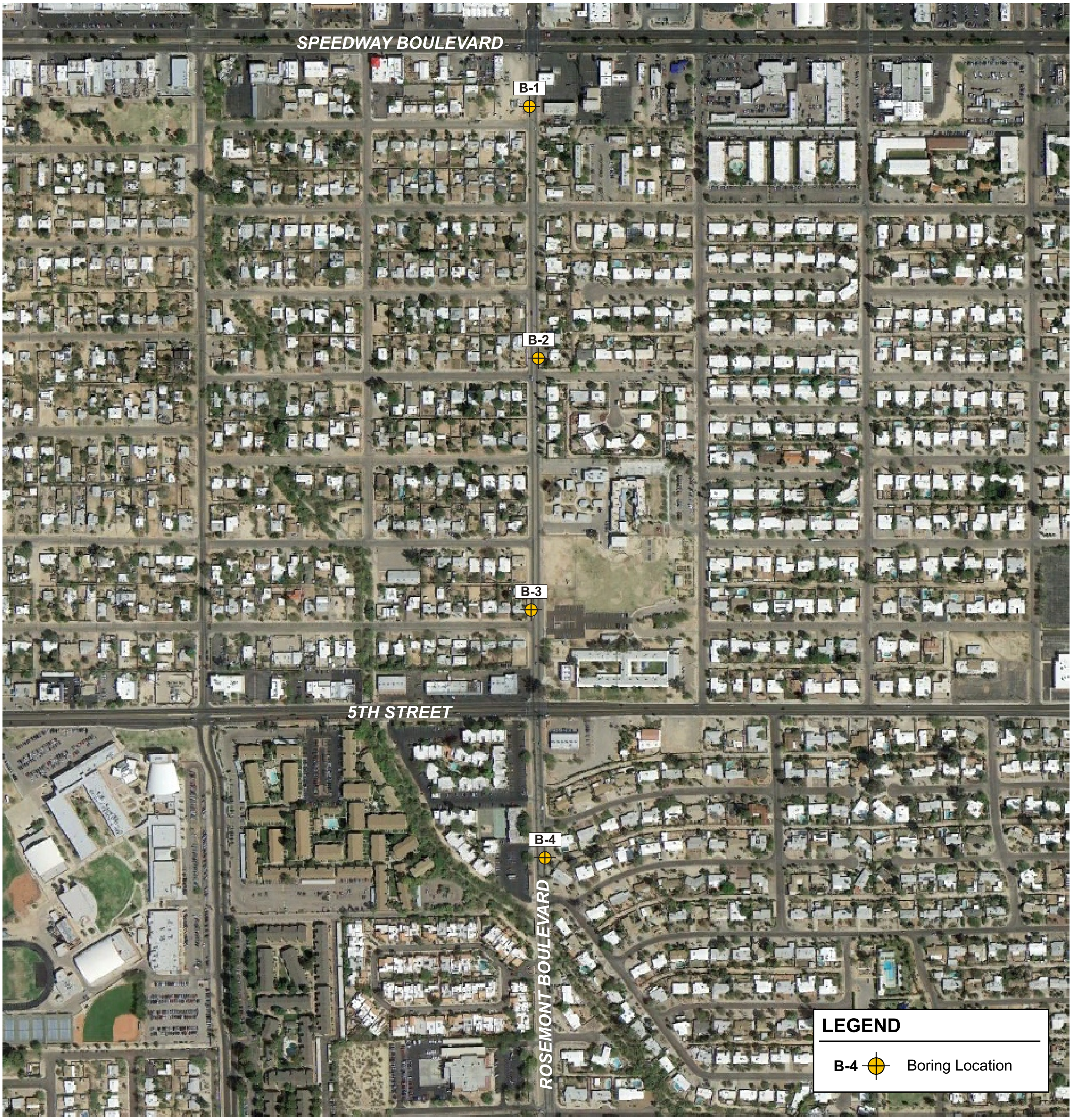
0 3300

Approximate Scale:
1 inch = 3300 feet

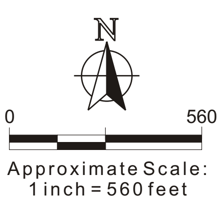
Note: Dimensions, directions, and locations are approximate.

Ninyo & Moore		SITE LOCATION	FIGURE
PROJECT NO: 604817002	DATE: 12/15	TUCSON PAVEMENT RECONSTRUCTION - ROSEMONT BOULEVARD TUCSON, ARIZONA	1

file no: 4817vmap1015h



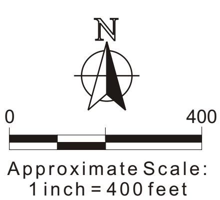
Source: NAVTEQ, 03/07/14.



Ninyo & Moore	BORING LOCATIONS		FIGURE
PROJECT NO: 604817002	DATE: 12/15	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ROSEMONT BOULEVARD TUCSON, ARIZONA	2A

file no: 4817blm1015h

Source: NAVTEQ, 03/07/14.



Ninyo & Moore

BORING LOCATIONS

FIGURE

2B

PROJECT NO:
604817002

DATE:
12/15

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ROSEMONT BOULEVARD
TUCSON, ARIZONA

file no: 4817blm1015hb

APPENDIX A

BORING LOGS

Field Procedure for the Collection of Relatively Undisturbed Samples

Relatively undisturbed soil samples were obtained in the field using the following methods.

The Modified Split-Barrel Drive Sampler

The sampler, with an external diameter of 3.0 inches, was lined with 1-inch long, thin brass rings with inside diameters of approximately 2.4 inches. The sample barrel was driven into the ground with the weight of a hammer or the Kelly bar of the drill rig in general accordance with ASTM D 3550. The driving weight was permitted to fall freely. The approximate length of the fall, the weight of the hammer or bar, and the number of blows per foot of driving are presented on the boring logs as an index to the relative resistance of the materials sampled. The samples were removed from the sample barrel in the brass rings, sealed, and transported to the laboratory for testing.

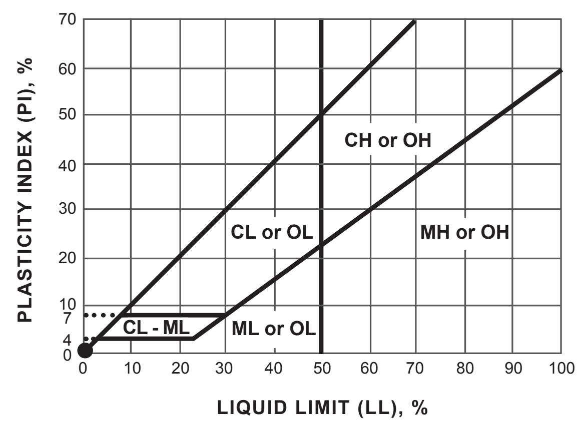
SOIL CLASSIFICATION CHART PER ASTM D 2488

PRIMARY DIVISIONS			SECONDARY DIVISIONS: GROUP SYMBOL	GROUP NAME
COARSE-GRAINED SOILS more than 50% retained on No. 200 sieve	GRAVEL more than 50% of coarse fraction retained on No. 4 sieve	CLEAN GRAVEL less than 5% fines	GW	well-graded GRAVEL
			GP	poorly graded GRAVEL
		GRAVEL with DUAL CLASSIFICATIONS 5% to 12% fines	GW-GM	well-graded GRAVEL with silt
			GP-GM	poorly graded GRAVEL with silt
			GW-GC	well-graded GRAVEL with clay
			GP-GC	poorly graded GRAVEL with clay
		GRAVEL with FINES more than 12% fines	GM	silty GRAVEL
			GC	clayey GRAVEL
			GC-GM	silty, clayey GRAVEL
	SAND 50% or more of coarse fraction passes No. 4 sieve	CLEAN SAND less than 5% fines	SW	well-graded SAND
			SP	poorly graded SAND
		SAND with DUAL CLASSIFICATIONS 5% to 12% fines	SW-SM	well-graded SAND with silt
			SP-SM	poorly graded SAND with silt
			SW-SC	well-graded SAND with clay
			SP-SC	poorly graded SAND with clay
		SAND with FINES more than 12% fines	SM	silty SAND
			SC	clayey SAND
			SC-SM	silty, clayey SAND
FINE-GRAINED SOILS 50% or more passes No. 200 sieve	SILT and CLAY liquid limit less than 50%	INORGANIC	CL	lean CLAY
			ML	SILT
			CL-ML	silty CLAY
		ORGANIC	OL (PI > 4)	organic CLAY
			OL (PI < 4)	organic SILT
	SILT and CLAY liquid limit 50% or more	INORGANIC	CH	fat CLAY
			MH	elastic SILT
		ORGANIC	OH (plots on or above "A"-line)	organic CLAY
			OH (plots below "A"-line)	organic SILT
	Highly Organic Soils		PT	Peat

GRAIN SIZE

DESCRIPTION		SIEVE SIZE	GRAIN SIZE	APPROXIMATE SIZE
Boulders		> 12"	> 12"	Larger than basketball-sized
Cobbles		3 - 12"	3 - 12"	Fist-sized to basketball-sized
Gravel	Coarse	3/4 - 3"	3/4 - 3"	Thumb-sized to fist-sized
	Fine	#4 - 3/4"	0.19 - 0.75"	Pea-sized to thumb-sized
Sand	Coarse	#10 - #4	0.079 - 0.19"	Rock-salt-sized to pea-sized
	Medium	#40 - #10	0.017 - 0.079"	Sugar-sized to rock-salt-sized
	Fine	#200 - #40	0.0029 - 0.017"	Flour-sized to sugar-sized
Fines		Passing #200	< 0.0029"	Flour-sized and smaller

PLASTICITY CHART



APPARENT DENSITY - COARSE-GRAINED SOIL

APPARENT DENSITY	SPOOLING CABLE OR CATHEAD: SPT (blows/foot)	SPOOLING CABLE OR CATHEAD: MODIFIED SPLIT BARREL (blows/foot)	AUTOMATIC TRIP HAMMER: SPT (blows/foot)	AUTOMATIC TRIP HAMMER: MODIFIED SPLIT BARREL (blows/foot)
Very Loose	≤ 4	≤ 8	≤ 3	≤ 5
Loose	5 - 10	9 - 21	4 - 7	6 - 14
Medium Dense	11 - 30	22 - 63	8 - 20	15 - 42
Dense	31 - 50	64 - 105	21 - 33	43 - 70
Very Dense	> 50	> 105	> 33	> 70

CONSISTENCY - FINE-GRAINED SOIL

CONSIS-TENCY	SPOOLING CABLE OR CATHEAD: SPT (blows/foot)	SPOOLING CABLE OR CATHEAD: MODIFIED SPLIT BARREL (blows/foot)	AUTOMATIC TRIP HAMMER: SPT (blows/foot)	AUTOMATIC TRIP HAMMER: MODIFIED SPLIT BARREL (blows/foot)
Very Soft	< 2	< 3	< 1	< 2
Soft	2 - 4	3 - 5	1 - 3	2 - 3
Firm	5 - 8	6 - 10	4 - 5	4 - 6
Stiff	9 - 15	11 - 20	6 - 10	7 - 13
Very Stiff	16 - 30	21 - 39	11 - 20	14 - 26
Hard	> 30	> 39	> 20	> 26

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USCS METHOD OF SOIL CLASSIFICATION

Explanation of USCS Method of Soil Classification

PROJECT NO.	DATE	FIGURE

BORING LOG EXPLANATION SHEET

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	
0								Bulk sample.
								Modified split-barrel drive sampler.
								No recovery with modified split-barrel drive sampler.
								Sample retained by others.
								Standard Penetration Test (SPT).
5								No recovery with a SPT.
			XX/XX					Shelby tube sample. Distance pushed in inches/length of sample recovered in inches.
								No recovery with Shelby tube sampler.
								Continuous Push Sample.
								Seepage.
10								Groundwater encountered during drilling.
								Groundwater measured after drilling.
							SM	MAJOR MATERIAL TYPE (SOIL): Solid line denotes unit change.
							CL	Dashed line denotes material change.
15								Attitudes: Strike/Dip b: Bedding c: Contact j: Joint f: Fracture F: Fault cs: Clay Seam s: Shear bss: Basal Slide Surface sf: Shear Fracture sz: Shear Zone sbs: Shear Bedding Surface
20								The total depth line is a solid line that is drawn at the bottom of the boring.

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BORING LOG

Explanation of Boring Log Symbols

PROJECT NO.	DATE	FIGURE

Updated Nov. 2011

DATE DRILLED	10/1/15	BORING NO.	B-1
GROUND ELEVATION	2,510' ± (MSL)	SHEET	1 OF 1
METHOD OF DRILLING	CME-75, 8" Hollow Stem Auger (Southlands)		
DRIVE WEIGHT	140 lbs. Automatic	DROP	30"
SAMPLED BY	DM	LOGGED BY	DM
REVIEWED BY	DT		

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 2 1/2 inches thick.
							SC	AGGREGATE BASE: Approximately 2 inches thick.
								ALLUVIUM: Brown, dry, medium dense, clayey SAND; few gravel; scattered caliche nodules.
			28					
								Total Depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt concrete patched on 10/1/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
5								
10								
15								
20								

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ROSEMONT BOULEVARD
TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-1

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.
0							
							SC
			12				
5							
10							
15							
20							

DATE DRILLED 10/1/15 BORING NO. B-2

GROUND ELEVATION 2,518' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Hollow Stem Auger (Southlands)

DRIVE WEIGHT 140 lbs. Automatic DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY DT

DESCRIPTION/INTERPRETATION

ASPHALT CONCRETE: Approximately 4 inches thick.

AGGREGATE BASE: Approximately 3 inches thick.

ALLUVIUM:
Brown, dry, loose, clayey SAND; scattered caliche nodules.

Total Depth = 3 feet.
Groundwater not encountered during drilling.

Backfilled and asphalt concrete patched on 10/1/15 shortly after completion of drilling.

Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 2 1/2 inches thick.
								AGGREGATE BASE: Approximately 2 inches thick.
							SC	ALLUVIUM: Brown, moist, medium dense, clayey SAND; few gravel; scattered caliche nodules.
			16					
5								
10								
15								
20								

DATE DRILLED 10/1/15 BORING NO. B-3

GROUND ELEVATION 2,524' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Hollow Stem Auger (Southlands)

DRIVE WEIGHT 140 lbs. Automatic DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY DT

Total Depth = 3 feet.
Groundwater not encountered during drilling.

Backfilled and asphalt concrete patched on 10/1/15 shortly after completion of drilling.

Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 4 inches thick.
							SC	ALLUVIUM: Brown, dry, loose, clayey SAND; few gravel.
			14					
								Total Depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt concrete patched on 10/1/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
5								
10								
15								
20								

DATE DRILLED 10/1/15 BORING NO. B-4

GROUND ELEVATION 2,529' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Hollow Stem Auger (Southlands)

DRIVE WEIGHT 140 lbs. Automatic DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY DT

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ROSEMONT BOULEVARD
TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-4

DATE DRILLED	10/1/15	BORING NO.	B-5
GROUND ELEVATION	2,539' ± (MSL)	SHEET	1 OF 1
METHOD OF DRILLING	CME-75, 8" Hollow Stem Auger (Southlands)		
DRIVE WEIGHT	140 lbs. Automatic	DROP	30"
SAMPLED BY	DM	LOGGED BY	DM
REVIEWED BY	DT		

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 3 1/2 inches thick.
							SC	ALLUVIUM: Brown, dry, medium dense, clayey SAND; few gravel, scattered caliche nodules.
		■	23					
								Total Depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt concrete patched on 10/1/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
5								
10								
15								
20								

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ROSEMONT BOULEVARD
TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-5

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.
0							
			20				SC
5							
10							
15							
20							

DATE DRILLED 10/1/15 BORING NO. B-6

GROUND ELEVATION 2,554' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Hollow Stem Auger (Southlands)

DRIVE WEIGHT 140 lbs. Automatic DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY DT

DESCRIPTION/INTERPRETATION

ASPHALT CONCRETE: Approximately 3 1/4 inches thick.

ALLUVIUM:
Brown, moist, medium dense, clayey SAND; few gravel; scattered caliche nodules.

Total Depth = 3 feet.
Groundwater not encountered during drilling.

Backfilled and asphalt concrete patched on 10/1/15 shortly after completion of drilling.

Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ROSEMONT BOULEVARD
TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-6

DATE DRILLED	10/1/15	BORING NO.	B-7
GROUND ELEVATION	2,569' ± (MSL)	SHEET 1 OF 1	
METHOD OF DRILLING	CME-75, 8" Hollow Stem Auger (Southlands)		
DRIVE WEIGHT	140 lbs. Automatic	DROP	30"
SAMPLED BY DM	LOGGED BY DM	REVIEWED BY	DT

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 2 inches thick.
							SC	ALLUVIUM: Brown, dry, very dense, clayey SAND; few gravel; numerous caliche nodules.
		■	50/3					
								Total Depth = 2.3 feet. Groundwater not encountered during drilling.
								Backfilled and asphalt concrete patched on 10/1/15 shortly after completion of drilling.
5								Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.
								The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
10								
15								
20								

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ROSEMONT BOULEVARD
TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-7

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 2 inches thick.
								AGGREGATE BASE: Approximately 3 inches thick.
							SC	ALLUVIUM: Brown, dry, medium dense, clayey SAND; scattered caliche nodules.
			19					
								Total Depth = 3 feet. Groundwater not encountered during drilling.
								Backfilled and asphalt concrete patched on 10/1/15 shortly after completion of drilling.
5								Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.
								The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
10								
15								
20								

DATE DRILLED 10/1/15 BORING NO. B-8

GROUND ELEVATION 2,569' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Hollow Stem Auger (Southlands)

DRIVE WEIGHT 140 lbs. Automatic DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY DT

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ROSEMONT BOULEVARD
TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-8

APPENDIX B

LABORATORY TESTING

Classification

Soils were visually and texturally classified in accordance with the Unified Soil Classification System (USCS) in general accordance with ASTM D 2488. Soil classifications are indicated on the logs of the exploratory borings in Appendix A.

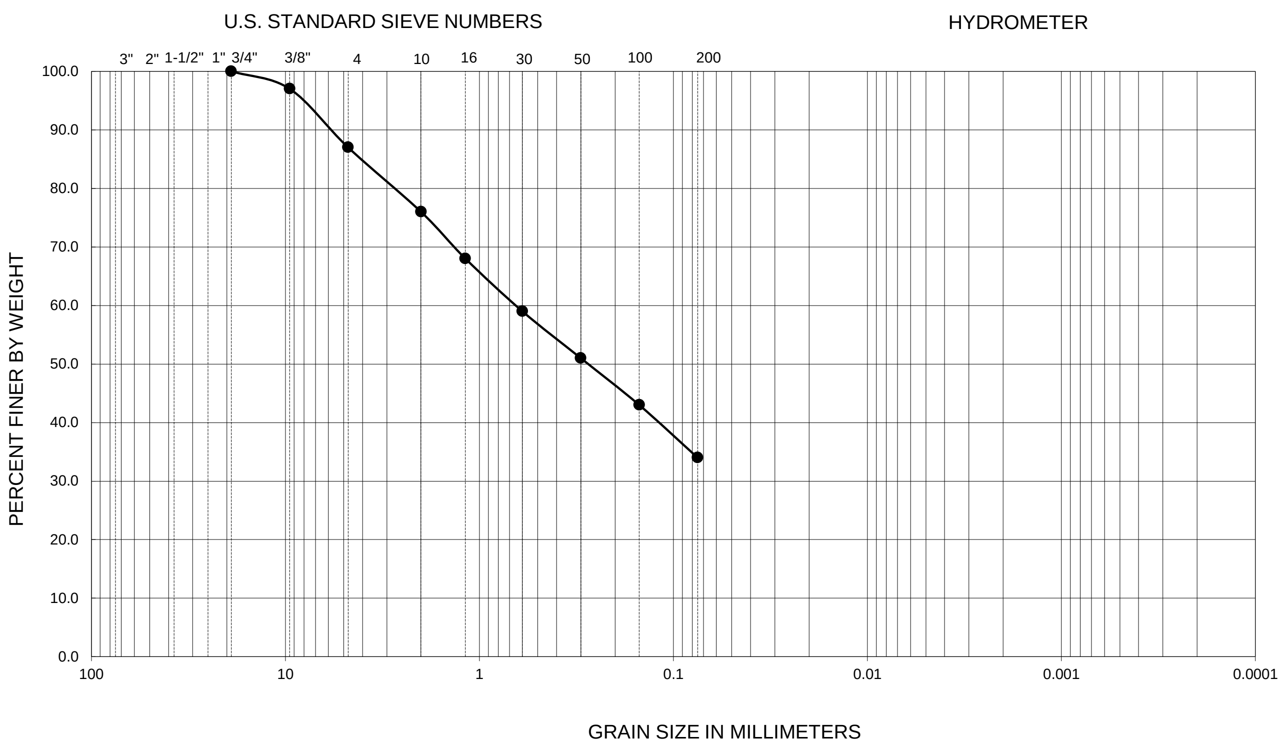
Gradation Analysis

One gradation analysis test was performed on a selected representative soil sample in general accordance with ASTM D 422. The grain-size distribution curves are shown in Figures B-1 through B-4. These test results were utilized in evaluating the soil classification in accordance with the USCS.

Atterberg Limits

Tests were performed on a selected representative fine-grained soil sample to evaluate the liquid limit, plastic limit, and plasticity index in general accordance with ASTM D 4318. These test results were utilized to evaluate the soil classification in accordance with the USCS. The test results and classifications are shown on Figure B-5.

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY

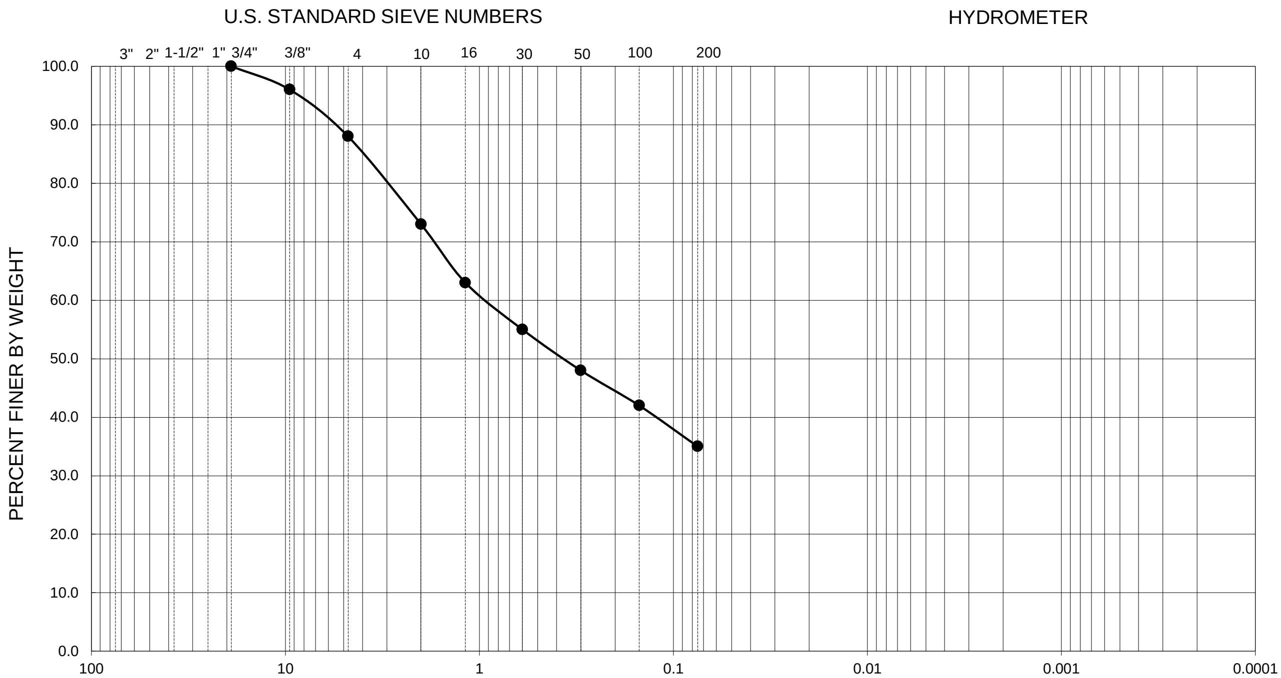


Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
●	B-1	1.5-3.0	44	29	15	--	--	--	--	--	34	SM

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore		GRADATION TEST RESULTS	FIGURE
PROJECT NO.	DATE	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ROSEMONT BOULEVARD TUCSON, ARIZONA	B-1
604817002	12/15		

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY

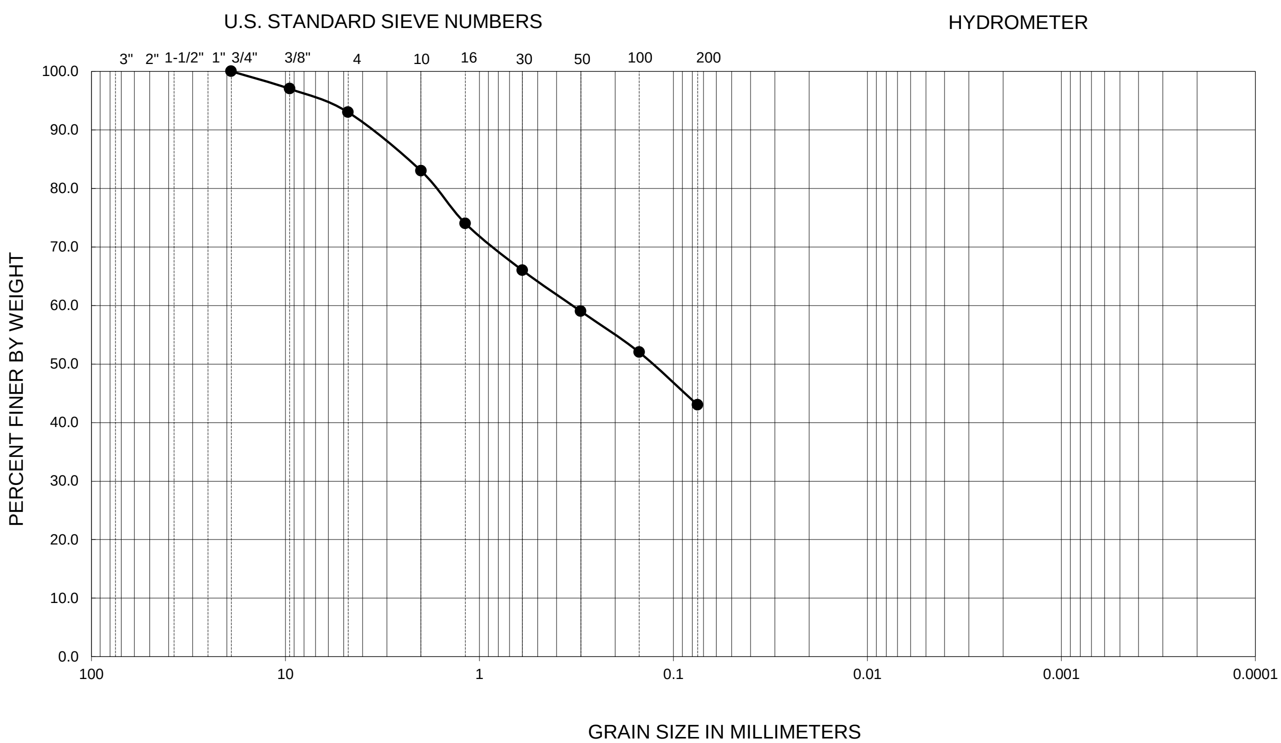


Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
●	B-3	1.5-3.0	38	25	13	--	--	--	--	--	35	SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore		GRADATION TEST RESULTS	FIGURE
PROJECT NO.	DATE	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ROSEMONT BOULEVARD TUCSON, ARIZONA	B-2
604817002	12/15		

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY

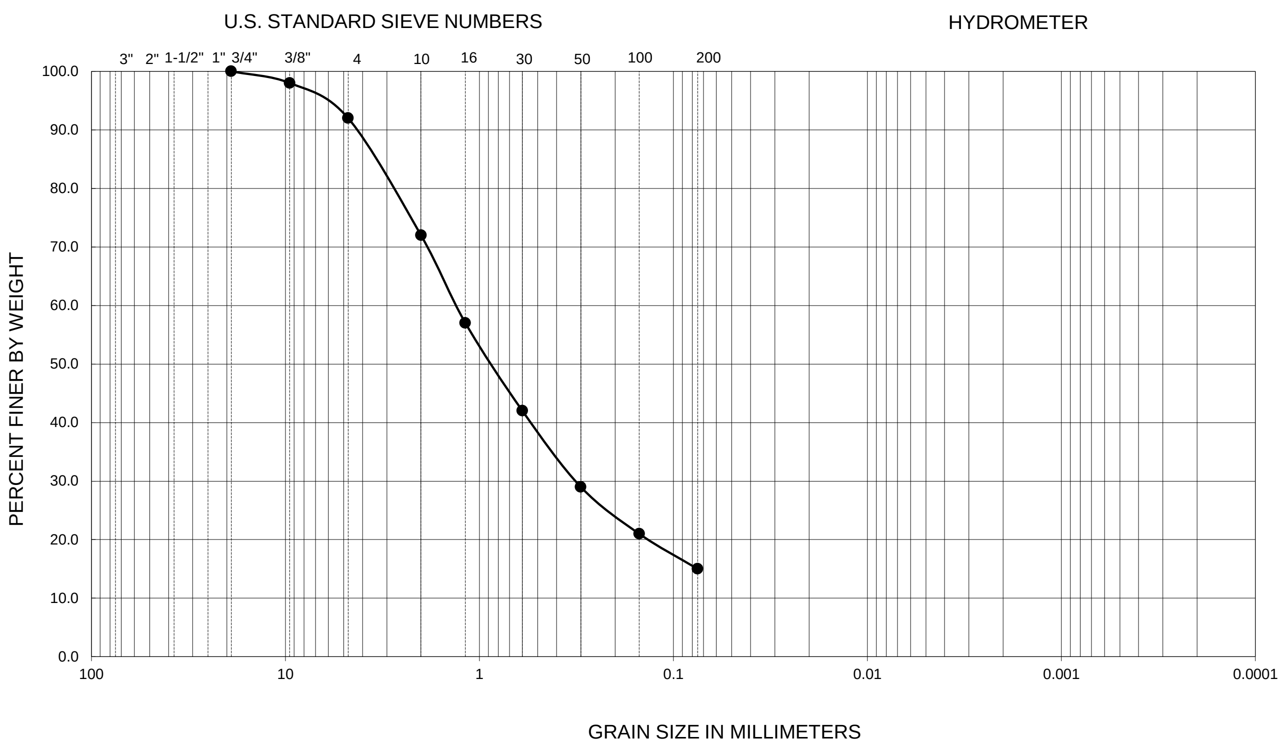


Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
●	B-5	1.5-3.0	53	22	31	--	--	--	--	--	43	SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore		GRADATION TEST RESULTS	FIGURE
PROJECT NO.	DATE	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ROSEMONT BOULEVARD TUCSON, ARIZONA	B-3
604817002	12/15		

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
●	B-7	1.5-3.0	55	28	27	--	--	--	--	--	15	SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore

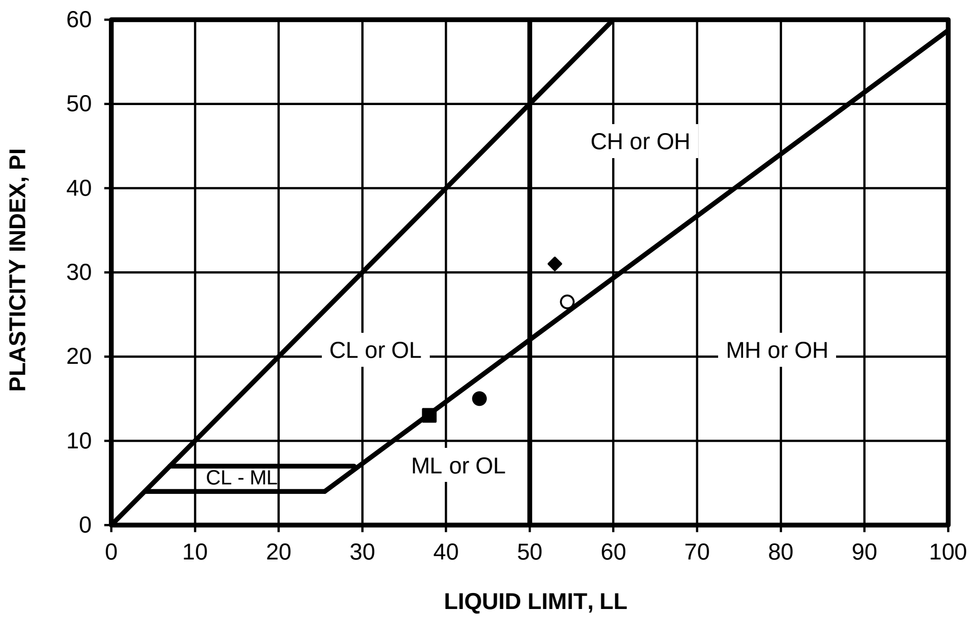
GRADATION TEST RESULTS

PROJECT NO.	DATE
604817002	12/15

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ROSEMONT BOULEVARD
TUCSON, ARIZONA

FIGURE
B-4

SYMBOL	LOCATION	DEPTH (FT)	LIQUID LIMIT, LL	PLASTIC LIMIT, PL	PLASTICITY INDEX, PI	USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve)	USCS (Entire Sample)
●	B-1	1.5-3.0	44	29	15	ML	SM
■	B-3	1.5-3.0	38	25	13	CL	SC
◆	B-5	1.5-3.0	53	22	31	CH	SC
○	B-7	1.5-3.0	55	28	27	CH	SC



PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4318

Ninyo & Moore

ATTERBERG LIMITS TEST RESULTS

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - ROSEMONT BOULEVARD
TUCSON, ARIZONA

PROJECT NO.	DATE
604817002	12/15

FIGURE

B-5

APPENDIX C

PAVEMENT AND CORE SUMMARY

ROSEMONT BOULEVARD - PAVEMENT AND CORE SUMMARY

No.	Location	Approximate AC thickness (in)*	Recovered AC Thickness (in)	Core Description	Pavement Condition
B-1	Southbound, 180 feet south of Speedway Boulevard	2.5	2.25	One lift, numerous voids.	Extensive transverse, block, alligator and block cracking, some sealed.
B-2	Northbound, 60 feet north of Rosewood Street	4	4	Two lifts, 2.5" and 1.5", crack throughout core.	Transverse, alligator and irregular cracking, some sealed.
B-3	Southbound, 50 feet north of Baker Street	2.5	2	One lift with decomposed bottom, numerous voids.	Extensive transverse, alligator and irregular cracking, some sealed.
B-4	Northbound, 500 feet south of 5th Street	4	4	Two lifts, 1.5" and 2.5", bottom lift cracked, numerous voids.	Extensive longitudinal, alligator and irregular cracking, potholes, flushing.
B-5	Southbound, 50 feet north of 9th Street	3.5	3.5	Two lifts, 1.25" and 2.25", few voids.	Extensive longitudinal, alligator and irregular cracking, potholes, patches, flushing.
B-6	Northbound, 250 feet south of Broadway Boulevard	3.25	3	Two lifts, 1" and 2.25", numerous voids.	Extensive alligator and irregular cracking, potholes, flushing.
B-7	Southbound, 130 feet south of Scarlett Street	2	2	One lift with decomposed bottom, numerous voids.	Block, alligator and irregular cracking, potholes, flushing.
B-8	Northbound, 160 feet north of Winsett Street	2	2	Two lifts, 1" and 1", numerous voids.	Block, alligator and irregular cracking, potholes, flushing.

Notes:

* Measured in the boring

APPENDIX D

TRAFFIC DATA

Field Data Services of Arizona
21636 N. Dietz Dr.
Maricopa, AZ 85138
520.316.6745

Site Code: 15-1283-004
Station ID: Wed 10/07/2015
Rosemont Blvd. btwn. Broadway Blvd. &
9th St. 32.222934, -110.883861
Latitude: 0' 0.000 Undefined

Northbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/7/15	0	2	0	0	4	0	0	0	0	0	0	0	0	6
01:00	0	3	0	0	2	0	0	0	0	0	0	0	0	5
02:00	0	4	0	0	0	0	0	0	0	0	0	0	0	4
03:00	0	3	1	0	4	0	0	0	0	0	0	0	0	8
04:00	0	3	0	0	4	0	0	0	0	0	0	0	0	7
05:00	0	22	1	0	8	0	0	0	0	0	0	0	0	31
06:00	**1**	40	3	**3**	23	0	0	0	0	0	0	0	0	70
07:00	1	125	14	2	58	0	0	0	0	0	0	0	0	**200**
08:00	0	121	14	0	**63**	0	0	0	0	0	0	0	0	198
09:00	0	105	7	0	45	0	0	0	0	0	0	0	0	157
10:00	0	102	6	2	46	0	0	**1**	0	0	0	0	0	157
11:00	0	**126**	**18**	2	48	0	0	0	0	0	0	0	0	194
12 PM	0	172	14	1	48	**1**	0	**1**	0	0	0	0	0	237
13:00	0	177	16	0	64	0	0	0	0	0	0	0	0	257
14:00	0	190	27	2	61	0	0	0	0	0	0	0	0	280
15:00	0	173	11	**3**	66	0	0	1	0	0	0	0	0	254
16:00	0	**197**	**32**	0	**79**	1	0	0	0	0	0	0	0	**309**
17:00	0	169	15	0	74	0	0	0	**1**	0	0	0	0	259
18:00	0	117	7	0	37	0	0	0	0	0	0	0	0	161
19:00	0	74	9	0	19	1	0	0	0	0	0	0	0	103
20:00	0	42	5	0	11	0	0	0	0	0	0	0	0	58
21:00	0	27	3	0	10	0	0	0	0	0	0	0	0	40
22:00	0	21	3	0	8	0	0	0	0	0	0	0	0	32
23:00	0	14	0	0	0	0	0	0	0	0	0	0	0	14
Day Total	2	2029	206	15	782	3	0	3	1	0	0	0	0	3041
Percent	0.1%	66.7%	6.8%	0.5%	25.7%	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	
AM Peak	06:00	11:00	11:00	06:00	08:00			10:00						07:00
Vol.	1	126	18	3	63			1						200
PM Peak		16:00	16:00	15:00	16:00	12:00		12:00	17:00					16:00
Vol.		197	32	3	79	1		1	1					309
Grand Total	2	2029	206	15	782	3	0	3	1	0	0	0	0	3041
Percent	0.1%	66.7%	6.8%	0.5%	25.7%	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	

Field Data Services of Arizona
21636 N. Dietz Dr.
Maricopa, AZ 85138
520.316.6745

Site Code: 15-1283-004
Station ID: Wed 10/07/2015
Rosemont Blvd. btwn. Broadway Blvd. & 9th St. 32.222934, -110.883861
Latitude: 0' 0.000 Undefined

Southbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/7/15	0	5	0	0	1	0	0	0	0	0	0	0	0	6
01:00	0	2	0	0	1	0	0	0	0	0	0	0	0	3
02:00	0	2	0	0	1	0	0	0	0	0	0	0	0	3
03:00	0	3	0	0	0	0	0	1	0	0	0	0	0	4
04:00	0	5	0	0	1	0	0	0	0	0	0	0	0	6
05:00	0	12	1	0	9	1	0	1	0	0	0	0	0	24
06:00	0	38	2	1	13	0	0	0	0	0	0	0	0	54
07:00	3	142	13	0	38	1	0	**2**	0	0	0	0	0	199
08:00	**4**	128	12	**3**	28	**2**	0	1	0	0	0	0	0	178
09:00	1	114	12	3	38	0	0	0	**1**	0	0	0	0	169
10:00	2	135	20	0	28	0	0	0	1	0	0	0	0	186
11:00	1	**161**	**24**	1	**45**	1	0	0	1	0	0	0	0	**234**
12 PM	1	169	16	2	55	0	0	0	0	0	0	0	0	243
13:00	2	146	17	2	46	0	0	0	0	0	0	0	0	213
14:00	3	**243**	12	**4**	**66**	0	0	1	0	0	0	0	0	**329**
15:00	1	159	16	3	51	0	0	1	0	0	0	0	0	231
16:00	**5**	184	**26**	1	53	**1**	0	0	0	0	0	0	0	270
17:00	4	185	12	1	52	1	0	0	0	0	0	0	0	255
18:00	2	100	14	1	27	0	0	0	0	0	0	0	0	144
19:00	0	70	13	0	20	0	0	**3**	0	0	0	0	0	106
20:00	0	56	16	0	9	0	0	0	0	0	0	0	0	81
21:00	0	46	12	0	5	0	0	0	0	0	0	0	0	63
22:00	0	14	3	0	6	0	0	0	0	0	0	0	0	23
23:00	0	18	1	0	3	0	0	0	0	0	0	0	0	22
Day Total	29	2137	242	22	596	7	0	10	3	0	0	0	0	3046
Percent	1.0%	70.2%	7.9%	0.7%	19.6%	0.2%	0.0%	0.3%	0.1%	0.0%	0.0%	0.0%	0.0%	
AM Peak	08:00	11:00	11:00	08:00	11:00	08:00		07:00	09:00					11:00
Vol.	4	161	24	3	45	2		2	1					234
PM Peak	16:00	14:00	16:00	14:00	14:00	16:00		19:00						14:00
Vol.	5	243	26	4	66	1		3						329
Grand Total	29	2137	242	22	596	7	0	10	3	0	0	0	0	3046
Percent	1.0%	70.2%	7.9%	0.7%	19.6%	0.2%	0.0%	0.3%	0.1%	0.0%	0.0%	0.0%	0.0%	

Field Data Services of Arizona

21636 N. Dietz Dr.
Maricopa, AZ 85138
520.316.6745

Site Code: 15-1283-004
Station ID: Wed 10/07/2015
Rosemont Blvd. btwn. Broadway Blvd. & 9th St. 32.222934, -110.883861
Latitude: 0' 0.000 Undefined

Northbound, Southbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/7/15	0	7	0	0	5	0	0	0	0	0	0	0	0	12
01:00	0	5	0	0	3	0	0	0	0	0	0	0	0	8
02:00	0	6	0	0	1	0	0	0	0	0	0	0	0	7
03:00	0	6	1	0	4	0	0	1	0	0	0	0	0	12
04:00	0	8	0	0	5	0	0	0	0	0	0	0	0	13
05:00	0	34	2	0	17	1	0	1	0	0	0	0	0	55
06:00	1	78	5	**4**	36	0	0	0	0	0	0	0	0	124
07:00	**4**	267	27	2	**96**	1	0	**2**	0	0	0	0	0	399
08:00	4	249	26	3	91	**2**	0	1	0	0	0	0	0	376
09:00	1	219	19	3	83	0	0	0	**1**	0	0	0	0	326
10:00	2	237	26	2	74	0	0	1	1	0	0	0	0	343
11:00	1	**287**	**42**	3	93	1	0	0	1	0	0	0	0	**428**
12 PM	1	341	30	3	103	1	0	1	0	0	0	0	0	480
13:00	2	323	33	2	110	0	0	0	0	0	0	0	0	470
14:00	3	**433**	39	**6**	127	0	0	1	0	0	0	0	0	**609**
15:00	1	332	27	6	117	0	0	2	0	0	0	0	0	485
16:00	**5**	381	**58**	1	**132**	**2**	0	0	0	0	0	0	0	579
17:00	4	354	27	1	126	1	0	0	**1**	0	0	0	0	514
18:00	2	217	21	1	64	0	0	0	0	0	0	0	0	305
19:00	0	144	22	0	39	1	0	**3**	0	0	0	0	0	209
20:00	0	98	21	0	20	0	0	0	0	0	0	0	0	139
21:00	0	73	15	0	15	0	0	0	0	0	0	0	0	103
22:00	0	35	6	0	14	0	0	0	0	0	0	0	0	55
23:00	0	32	1	0	3	0	0	0	0	0	0	0	0	36
Day Total	31	4166	448	37	1378	10	0	13	4	0	0	0	0	6087
Percent	0.5%	68.4%	7.4%	0.6%	22.6%	0.2%	0.0%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	
AM Peak	07:00	11:00	11:00	06:00	07:00	08:00		07:00	09:00					11:00
Vol.	4	287	42	4	96	2		2	1					428
PM Peak	16:00	14:00	16:00	14:00	16:00	16:00		19:00	17:00					14:00
Vol.	5	433	58	6	132	2		3	1					609
Grand Total	31	4166	448	37	1378	10	0	13	4	0	0	0	0	6087
Percent	0.5%	68.4%	7.4%	0.6%	22.6%	0.2%	0.0%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	

APPENDIX E

PAVEMENT OPTIMIZATION DESIGN ANALYSIS BY TENSAR

SpectraPave4 PRO™
Pavement Optimization Design Analysis

Design Parameters for AASHTO (1993) Equation

Reliability (%)	= 95	Initial Serviceability	= 4.5
Standard Normal Deviate	= -1.645	Terminal Serviceability	= 2.5
Standard Deviation	= 0.4	Change in Serviceability	= 2

Aggregate fill shall conform to following requirement:

D50 <= 27mm (Base course)

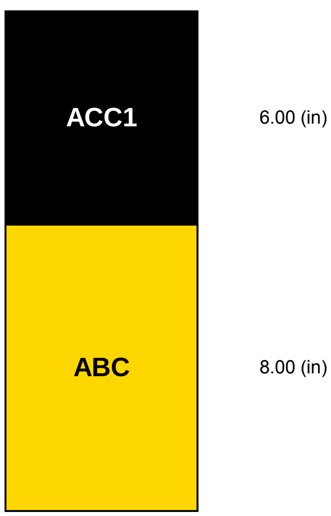
Unstabilized Section Material Properties

Layer	Description	Cost ($/ton)	Layer coefficient	Drainage factor
ACC1	Asphalt Wearing Course	70	0.440	N/A
ABC	Aggregate Base Course	20	0.140	1.25

Stabilized Section Material Properties

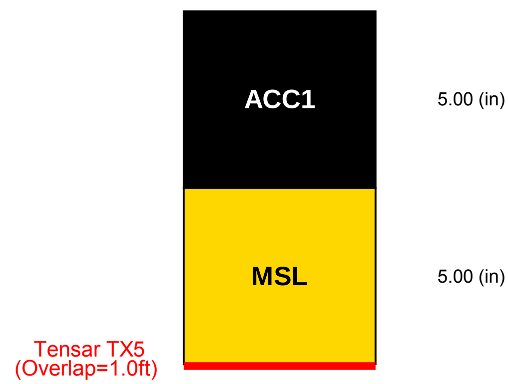
Layer	Description	Cost ($/ton)	Layer coefficient	Drainage factor
ACC1	Asphalt Wearing Course	70	0.440	N/A
MSL	Mechanically Stabilized Base Cour	20	0.289	1.25

Unstabilized Pavement



Subgrade Modulus = 8,824 (psi)
Structural Number = 4.040
Calculated Traffic (ESALs) = 3,976,000

Stabilized Pavement



Subgrade Modulus = 8,824 (psi)
Structural Number = 4.006
Calculated Traffic (ESALs) = 3,757,000

LIMITATIONS OF THE REPORT

The designs, illustrations, information and other content included in this report are necessarily general and conceptual in nature, and do not constitute engineering advice or any design intended for actual construction. Specific design recommendations can be provided as the project develops.

Project Name	Rosemont Blvd.		
Company Name	Tensar		
Designer	Schlessinger	Date	11/30/15

PAVEMENT EVALUATION
TUCSON PAVEMENT RECONSTRUCTION PROGRAM
TUCSON BOULEVARD, FORT LOWELL ROAD TO GLENN STREET
TUCSON, ARIZONA

PREPARED FOR:
Kimley-Horn & Associates, Inc.
333 East Wetmore Road, Suite 280
Tucson, Arizona 85705

PREPARED BY:
Ninyo & Moore
Geotechnical and Environmental Sciences Consultants
1991 East Ajo Way, Suite 145
Tucson, Arizona 85713

December 15, 2015
Project No. 604817002

December 15, 2015
Project No. 604817002

Mr. Rick Solis, P.E.
Kimley-Horn
333 East Wetmore Road, Suite 280
Tucson, Arizona 85705

Subject: Pavement Evaluation
Tucson Pavement Reconstruction Program – Tucson Boulevard
Fort Lowell Road to Glenn Street
Tucson, Arizona

Dear Mr. Solis:

In accordance with our proposal dated August 12, 2015, and your authorization on September 21, 2015, Ninyo & Moore has performed a pavement evaluation for the above-referenced site. The attached report presents our methodology, findings, conclusions, and recommendations regarding the geotechnical conditions at the project site.

We appreciate the opportunity to be of service to you during this phase of the project.

Sincerely,
NINYO & MOORE

Registered Professional Engineer (Civil)
CERTIFICATE NO.
48704
MAREK J.
KASZTALSKI
Date Signed 12.15.15
ARIZONA, U.S.A.

Marek J. Kasztalski, PE, PMP, LEED AP
Senior Geotechnical Engineer
EXPIRES 9/30/18

Fred Narcaroti
Principal/Tucson Office Manager

MJK/DT/FFN/tlp

Distribution: (1) Addressee (Electronic Copy)

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1. INTRODUCTION

In accordance with our proposal dated August 12, 2015, and your authorization on September 21, 2015, we have performed a pavement evaluation for the Tucson Boulevard Pavement Reconstruction project between Fort Lowell Road and Glenn Street, in Tucson, Arizona. The purpose of our evaluation was to assess the pavement and subgrade conditions along the project alignment in order to provide geotechnical recommendations for design and construction. This report presents the results of our evaluation, conclusions, and recommendations regarding the proposed construction.

2. SCOPE OF SERVICES

The scope of our services generally included:

- Preparing a field testing plan and associated permit application for submittal to the City of Tucson (COT).
- Conducting a visual reconnaissance of the pavement along the alignment and marking out the boring locations.
- Notifying Arizona811 of our boring locations prior to conducting the field work.
- Arranging for traffic control measures to conduct the field work.
- Coring the existing asphaltic concrete (AC) pavement at three locations along the project alignment.
- Exploring the subsurface soils within the project limits by drilling, logging, and sampling three exploratory soil borings to approximate depths of 3 feet below ground surface (bgs). The boring logs are presented in Appendix A.
- Performing laboratory tests on selected samples collected from our borings to evaluate gradation and Atterberg limits. The results of the laboratory tests are included in Appendix B.
- Preparing this report presenting our findings, conclusions and recommendations regarding the proposed reconstruction.

Our scope of services did not include environmental consulting services such as hazardous waste sampling or analytical testing at the site. A detailed scope of services and estimated fee for such services can be provided upon request.

3. SITE DESCRIPTION

The project site is located in Sections 32 and 14 of Township 13 South, Range 14 East relative to the Gila and Salt River Base Line and Meridian. The project alignment extends along Tucson Boulevard between Fort Lowell Road and Glenn Street in Tucson, Arizona (Figure 1).

At the time of our evaluation residential and commercial developments existed along the project alignment. The roadway section consisted of one travel lane in each direction, a center lane, concrete sidewalks on the east and west side of the roadway, and concrete curb along most of the project alignment.

4. PROPOSED CONSTRUCTION

The COT has identified several segments of the existing street network for reconstruction and/or rehabilitation in fiscal year (FY) 2016 under Bid Package 2. The scope of this report includes Tucson Boulevard between Fort Lowell Road and Glenn Street. The project alignment is approximately 0.5-mile long.

We understand that the COT anticipates full-depth reconstruction of the existing roadway along the project alignment. The City proposes a new pavement section consisting of 5 inches of AC per of the COT Department of Transportation Standard Specifications Section 406 over 5 inches of aggregate base (AB) per Section 303 of the COT Standard Specifications.

We further understand that the COT intends to use Tucson Department of Transportation (TDOT) AC Mix No. 2 PG 76-22TR+ for the surface layer and TDOT AC Mix No. 1 PG 70-10 for the underlying layer. Both layers are proposed to be 2.5 inches thick.

Due to conflicts with shallow utility lines, subgrade improvement by overexcavation will not be performed and the new pavement section will be constructed on subgrade improved with Geogrid (Tensar Geogrid TX5 or equivalent).

The scope of this exploration included evaluation of the existing pavement section and subgrade soils in order to provide recommendations for pavement reconstruction in accordance with the current COT practice. Calculations for the new pavement section supporting the new construction proposed by the COT are presented in Section 9.3 and in Appendix E of this report.

5. EXISTING PAVEMENT CONDITION

On September 30, 2015, Ninyo & Moore conducted a limited visual evaluation of the pavement surface along the project alignment. Based on our field observations, the AC pavement exhibited signs of severe distress in many locations along the project alignment primarily consisting of extensive block, transverse, irregular and alligator cracking with considering spalling, and potholes. Asphaltic concrete patches were observed at some locations which were probably associated with past maintenance efforts (pothole and crack repairs) or with underground utility work. The crack widths generally varied between hairline (less than 1/8-inch) to over 1 ½ inches.

In our opinion, the distress observed along the project alignment indicates structural failure and is related to a combination of pavement age, subgrade condition, traffic, and environmental impacts.

6. FIELD EXPLORATION AND LABORATORY TESTING

On September 30, 2015, Ninyo & Moore conducted a geotechnical exploration in order to evaluate the subsurface conditions and collect AC cores and soil samples for laboratory testing. Our evaluation consisted of coring the existing AC pavement, drilling, logging, and sampling three small-diameter borings, denoted as B-1 through B-3, utilizing a CME-75 truck-mounted drill rig equipped with hollow-stem augers. The borings extended to depths of approximately 3 feet bgs. The approximate locations of the borings are depicted on Figure 2.

Ninyo & Moore personnel logged the borings in general accordance with the Unified Soil Classification System (USCS) and American Society for Testing and Materials (ASTM) D 2488 by observing cuttings and drive samples. Collected ring samples were trimmed in the field, wrapped in plastic bags, and placed in cylindrical plastic containers to retain in-place moisture conditions.

The soil samples collected from our drilling activities were transported to the Ninyo & Moore laboratory in Tucson, Arizona for geotechnical laboratory testing. The tests included gradation and Atterberg limits. A description of each laboratory test method and the test results are presented in Appendix B.

7. SUBSURFACE CONDITIONS

Our knowledge of the subsurface conditions at the project site is based on our field exploration, laboratory testing, and general experience in the area. More detailed stratigraphic information is presented on the boring logs in Appendix A, attached to this report. The boring logs contain our field and laboratory test results, as well as our interpretation of conditions believed to exist between actual samples retrieved. Therefore, these boring logs contain both factual and interpretive information. Lines delineating subsurface strata on the boring logs are intended to group soils having similar engineering properties and characteristics. They should be considered approximate as the actual transition between soil types (strata) may be gradual. A key to the soil symbols and terms used on the boring logs is provided in Appendix A.

7.1. Asphaltic Concrete

Asphaltic concrete pavement was encountered at the surface of each of our borings. The AC thickness varied between approximately 4 and 5 inches, in our borings. It should be noted that the thickness of the AC pavement between the sampling locations may vary and could be different from that encountered at our sampling locations. Detailed core descriptions are presented in Appendix C.

Aggregate base was not observed in our borings. It is possible the AB material blended with the native subgrade soils, such that delineation of the AB/subgrade interface was not easily interpreted.

7.2. Alluvium

Native alluvial soils were encountered below the pavement section, and extended to the boring termination depths. The alluvium generally consisted of stiff to hard, sandy clay with varying amounts of gravel and scattered caliche cementation.

8. CONCLUSIONS

Based on the results of our visual and subsurface evaluations, laboratory testing, and data analysis, geotechnical considerations include the following:

- The on-site soils generally include sandy clays, with a plasticity index value (PI) varying between 16 and 22. Many on-site soils may be sensitive to moisture content fluctuations and may be difficult to compact especially at higher moisture contents. The contractor should be aware of this condition.
- Due to the relatively widely spaced nature of our borings, soil conditions may differ from what was observed during our field exploration.
- The pavement exhibits significant distress in many locations along the project alignment consisting mainly of extensive block, transverse, irregular and alligator cracking with considering spalling, and potholes.
- Full-depth pavement reconstruction is considered for this project as proposed by the COT.

9. RECOMMENDATIONS

The following sections present our geotechnical recommendations for the project. If the proposed construction is changed from that discussed in this report, Ninyo & Moore should be contacted for additional recommendations.

9.1. Recommended Pavement Structural Sections

The recommended pavement sections are presented in the table below:

Pavement Section	Service Life (years)	AC (in)[1]	AB (in)[2]
COT Preferred Pavement with Geogrid	20	5	5
Alternative Pavement Section without Geogrid	20	5.5	8

Notes:
[1] TDOT AC Mix No. 2 PG 76-22TR+ as the surface mix and TDOT AC Mix No. 1 PG 70-10 for the underlying layers per Section 406 of the COT Specifications.
[2] AB per Section 303 of the COT Specifications.

9.2. Earthwork

The following sections provide our earthwork recommendations for this project. In general, the earthwork specifications contained in the *City of Tucson/Pima County Standard Specifications for Public Improvements, 2003 Edition (COT/PC Specifications)* are expected to apply unless specifically noted.

9.2.1. Site Preparation

Construction areas should be cleared of deleterious materials, if any are present, including abandoned utilities, construction debris, vegetation, and any other material that might interfere with the performance or progress of the work. These materials should be disposed of at a legal dumpsite. Existing features that call for relocation or removal and extend below finish grade, if present, should be removed, and the resulting excavations backfilled with engineered fill.

9.2.2. Excavations

Our evaluation of the excavation characteristics of the on-site soils is based on the results of our exploratory borings, site observations, and experience with similar materials.

9.2.3. Fill Materials

Soils with PI values of 15 or less (as evaluated by ASTM D 4318) are generally suitable for use as engineered fill. Our Atterberg limits test indicated PI values ranging between 16 and 22. Based on this test result, many of the on-site soils are not suitable for re-use as engineered fill.

Engineered fill should not include organic material, construction debris, or other non-soil fill materials. Rock particles and clay lumps should not be larger than 4 inches in dimension. Unsuitable material should be disposed of off-site or in non-structural areas.

9.2.4. Grading and Subgrade Preparation

In general, grading operations should be performed in accordance with Section 205 of the COT/PC Specifications.

Due to potential conflicts with underground utilities, we recommend that the subgrade be improved by the application of Geogrid (Tensar Geogrid TX5 or equivalent). Geogrid should be placed in accordance with the manufacturer’s instructions.

Alternatively, if Geogrid is not applied we recommend new pavements be supported on 6 inches of subgrade that is compacted by appropriate mechanical methods to a relative compaction of 95 percent as evaluated by ASTM D 698 at a moisture content generally near optimum. The thickness of the improvement zone should be measured from the bottom of the AB layer.

In areas where excessive moisture is encountered so that the above compaction cannot be achieved and/or the subgrade surface is unstable and yielding (pumping) under the roller wheels, subgrade soils should be scarified to a depth of 12 inches, aerated, and re-compacted as specified above. Alternatively, subgrade soils in problem areas should be and replaced with engineered fill to a depth of 12 inches below the bottom of the AB.

9.3. Pavement Design Summary

The following sections present our design assumptions and recommendations for the new flexible pavement section of Tucson Boulevard between Fort Lowell Road and Glenn Street, as this roadway is scheduled for full-depth pavement reconstruction.

The pavement section was developed using the Active Practices Guidelines issued by the COT Department of Transportation (Guidelines) and the Arizona Department of Transportation (ADOT) Preliminary Engineering and Design Manual (PEDM). We assumed that the subgrade will be improved by the application of Geogrid or overexcavation, as outlined in Section 9.2.4 of this report. The new pavement sections are designed for a 20-year service life.

9.3.1. Traffic

The future traffic numbers used in this report are based on traffic counts provided by Kimley-Horn and Associates, Inc. (KHA), and later communication with the KHA. This information is presented in Appendix D. Based on the above information, and using the procedures outlined in the Guidelines and PEDM, the design number of equivalent single axle loads (ESALs) for the design lane during the 20-year design period was calculated as approximately 2,455,360.

9.3.2. R-Value and Resilient Modulus

The analysis for the design R-value for the pavement section has been performed based on procedures detailed in the Guidelines and the PEDM, using correlated R-values. The correlated R-values were derived from the PI and percent passing No. 200 Sieve test results. A summary of the R-values for this project is presented in Table 1 below:

Table 1 – R-value Summary

Location	Sample Depth (ft)	Correlated R-Value
B-1	1.5-3.0	20
B-3	1.5-3.0	23

In the interest of conservatism, we recommend that an R-value of 20 be used for pavement design for this project.

If the project needs fill from an off-site source, we recommend the soils used for subgrade support should have an R-value of 20 or more. If during construction, the subgrade is found to vary from the expected soil conditions, we should be contacted so we may re-evaluate our recommended R-values. Based on the above design R-values, the design subgrade resilient modulus (M_R) value of 8,824 pounds per square inch (psi) was calculated in accordance with the Guidelines.

9.3.3. Statistical Parameters

A standard deviation of 0.40 was used for design of the flexible pavement in accordance with the Guidelines. The level of reliability and standard normal deviation (Z_R) values were selected in accordance with the Guidelines for the arterial functional classification. Their respective values are presented in the table below:

Table 2 – Summary of Statistical Parameters

Roadway	Functional Classification	Standard Deviation	Level of Reliability	Standard Normal Deviation
Tucson Boulevard Fort Lowell Road to Glenn Street	Arterial	0.40	95 %	-1.645

9.3.4. Serviceability Index

Initial and terminal serviceability indices were selected for the pavement design of the roadways in accordance with the Guidelines. A summary of the serviceability indices for each roadway is provided in the table below:

Table 3 – Summary of Serviceability Parameters

Roadway	Functional Classification	Initial Serviceability Index	Terminal Serviceability Index	Change in Serviceability
Tucson Boulevard Fort Lowell Road to Glenn Street	Arterial	4.5	2.5	2.0

9.3.5. Layer Coefficients

The following structural coefficients were used for the pavement structure in accordance with the Guidelines:

- AC: 0.44.
- AB: 0.14.

A drainage coefficient of 1.25 was used for the AB coefficient as recommended in the Guidelines.

As mentioned in Section 4 above, due to conflicts with existing shallow utilities, it is recommended that the subgrade be improved using Geogrid (Tensar Geogrid TX5 or equivalent). In this case the AB layer coefficient is 0.289.

9.3.6. Asphalt Pavement Section Recommendations

The structural number (SN) was calculated based on the parameters described above. The table below presents the calculated SN value and the recommended structural pavement sections. The AC thickness meets the COT requirements. Supporting documentation of the pavement optimization design using Geogrid is presented in Appendix E:

Table 4 – Structural Pavement Sections for 20-Year Design Life

Roadway	SN	AC (in)[1]	AB (in)[2]
COT Preferred Pavement with Geogrid	4,01	5	5
Alternative Pavement without Geogrid	3.76	5.5	8

Notes:
[1] TDOT AC Mix No. 2 PG 76-22TR+ as the surface mix and TDOT AC Mix No. 1 PG 70-10 for the underlying layers per Section 406 of the COT Specifications.
[2] AB per Section 303 of the COT Specifications.

The above pavement structural section has been designed with the assumption that the subgrade is prepared by as recommended in Section 9.2.4.

10. SITE DRAINAGE

Surface drainage should be provided to divert water away from paved surfaces. Surface water should also not be permitted to pond on or below pavement areas. Positive drainage for this project is defined as a slope of 2 percent or more for a distance of 5 feet or more away from the pavements. To deter accumulation of water below the new pavement sections, the bottom of the overexcavated zone below the new pavement should be sloped toward the edges of the roadway.

11. PRE-CONSTRUCTION CONFERENCE

We recommend that a pre-construction conference be held. Representatives of the owner, the civil engineer, Ninyo & Moore, and the contractor should be in attendance to discuss the project plans and schedule. Our office should be notified if the project description included herein is incorrect or if the project characteristics are significantly changed.

12. CONSTRUCTION OBSERVATION AND TESTING

During construction operations, we recommend that Ninyo & Moore perform observation and testing services for the project. These services should be performed to evaluate exposed subgrade conditions, including the extent and depth of overexcavation, to evaluate the suitability of

proposed borrow materials for use as engineered fill and to observe placement and test compaction of fill soils. Qualified subcontractors utilizing appropriate techniques and construction materials should perform construction of the proposed improvements.

13. LIMITATIONS

The field evaluation, laboratory testing, and geotechnical analyses presented in this geotechnical report have been conducted in general accordance with current practice and the standard of care exercised by geotechnical consultants performing similar tasks in the project area. No warranty, expressed or implied, is made regarding the conclusions, recommendations, and opinions presented in this report. There is no evaluation detailed enough to reveal every subsurface condition. Variations may exist and conditions not observed or described in this report may be encountered during construction. Uncertainties relative to subsurface conditions can be reduced through additional subsurface exploration. Additional subsurface evaluation will be performed upon request. Please also note that our evaluation was limited to assessment of the geotechnical aspects of the project, and did not include evaluation of structural issues, environmental concerns, or the presence of hazardous materials.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. Ninyo & Moore should be contacted if the reader requires additional information or has questions regarding the content, interpretations presented, or completeness of this document.

This report is intended for design purposes only. It does not provide sufficient data to prepare an accurate bid by contractors. It is suggested that the bidders and their geotechnical consultant perform an independent evaluation of the subsurface conditions in the project areas. The independent evaluations may include, but not be limited to, review of other geotechnical reports prepared for the adjacent areas, site reconnaissance, and additional exploration and laboratory testing.

Our conclusions, recommendations, and opinions are based on an analysis of the observed site conditions. If geotechnical conditions different from those described in this report are encountered, our office should be notified and additional recommendations, if warranted, will be provided upon request. It should be understood that the conditions of a site could change with time as a result of natural processes or the activities of man at the subject site or nearby sites. In addition, changes to the applicable laws, regulations, codes, and standards of practice may occur due to government action or the broadening of knowledge. The findings of this report may, therefore, be invalidated over time, in part or in whole, by changes over which Ninyo & Moore has no control.

This report is intended exclusively for use by the client. Any use or reuse of the findings, conclusions, and/or recommendations of this report by parties other than the client is undertaken at said parties' sole risk.

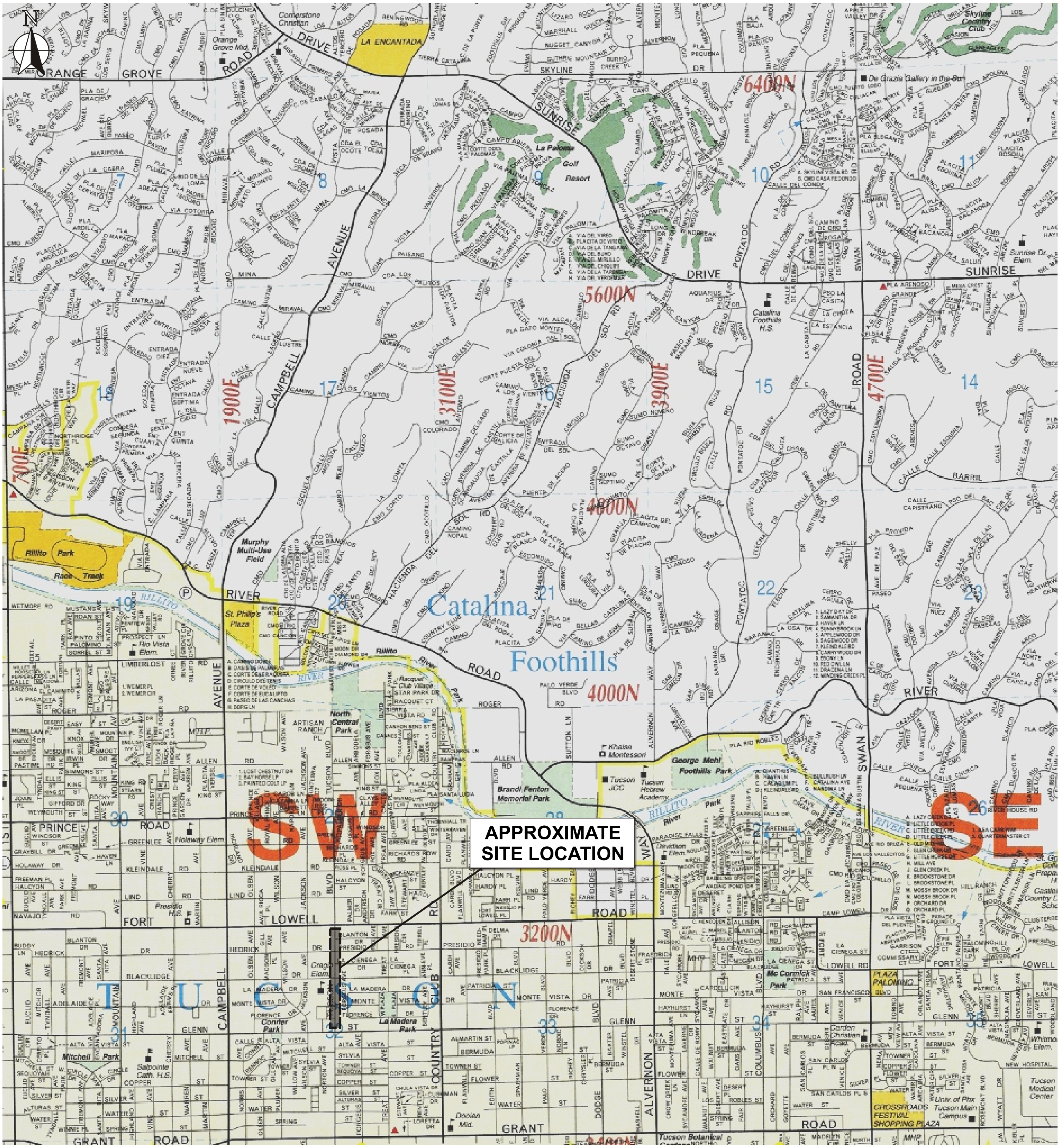
14. REFERENCES

American Society for Testing and Materials (ASTM), Annual Book of ASTM Standards.

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

City of Tucson, Arizona, Department of Transportation, Engineering Division, 1987, Active Practices Guidelines: dated June 1.

Ninyo & Moore, In-house proprietary information.



Source: Phoenix Mapping Service, Tucson Metro Edition, 2012.

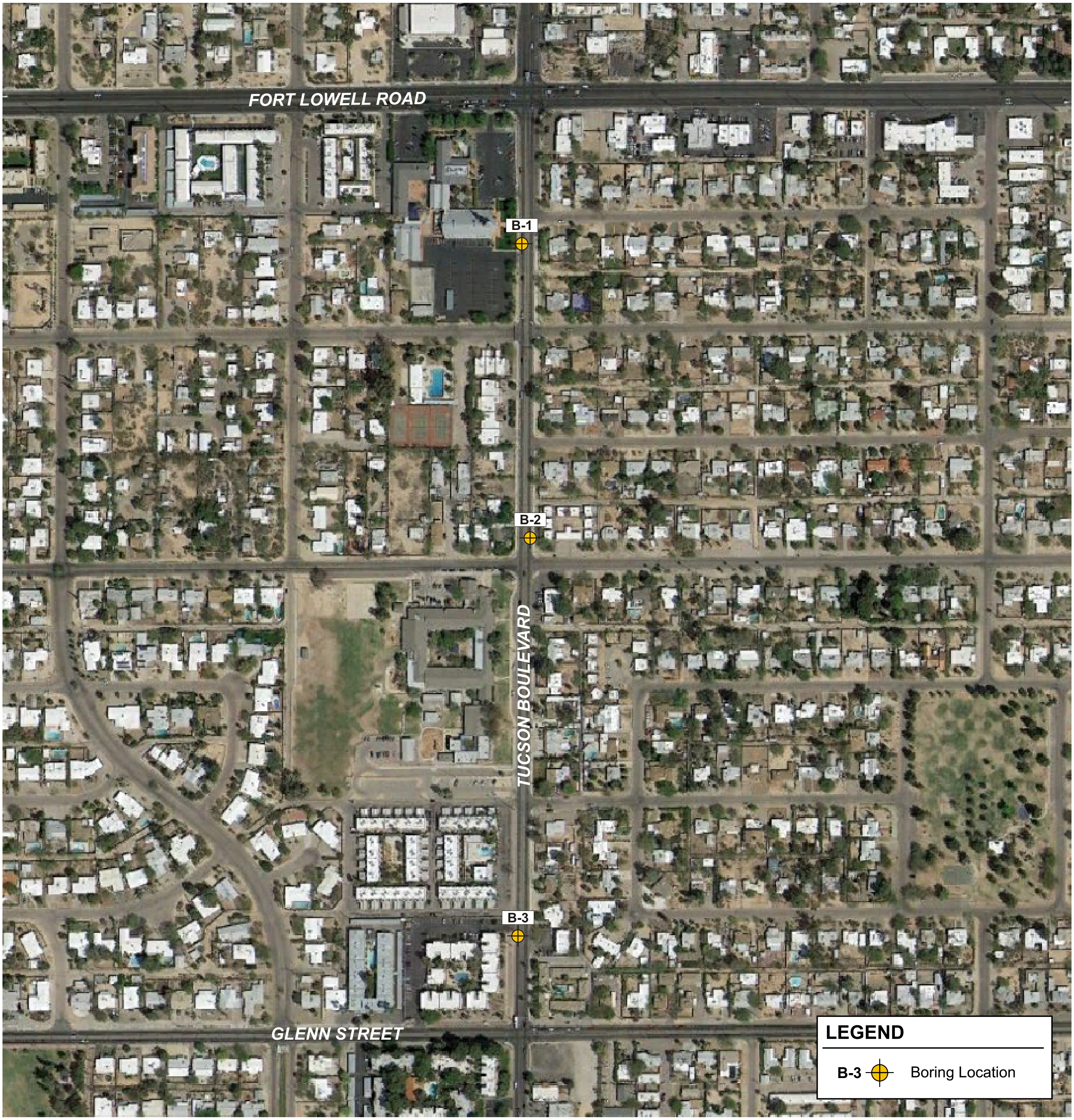
0 3300

Approximate Scale:
1 inch = 3300 feet

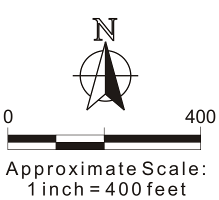
Note: Dimensions, directions, and locations are approximate.

Ninyo & Moore	SITE LOCATION	FIGURE
PROJECT NO: 604817002	DATE: 12/15	TUCSON PAVEMENT RECONSTRUCTION - TUCSON BOULEVARD BETWEEN FORT LOWELL ROAD AND GLENN STREET TUCSON, ARIZONA	1

file no: 4817vmap1015i



Source: NAVTEQ, 03/07/14.



Ninyo & Moore

BORING LOCATIONS

PROJECT NO:	DATE:		FIGURE
604817002	12/15	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - TUCSON BOULEVARD BETWEEN FORT LOWELL ROAD AND GLENN STREET TUCSON, ARIZONA	2

file no: 4817blm1015i

APPENDIX A

BORING LOGS

Field Procedure for the Collection of Relatively Undisturbed Samples

Relatively undisturbed soil samples were obtained in the field using the following methods.

The Modified Split-Barrel Drive Sampler

The sampler, with an external diameter of 3.0 inches, was lined with 1-inch long, thin brass rings with inside diameters of approximately 2.4 inches. The sample barrel was driven into the ground with the weight of a hammer or the Kelly bar of the drill rig in general accordance with ASTM D 3550. The driving weight was permitted to fall freely. The approximate length of the fall, the weight of the hammer or bar, and the number of blows per foot of driving are presented on the boring logs as an index to the relative resistance of the materials sampled. The samples were removed from the sample barrel in the brass rings, sealed, and transported to the laboratory for testing.

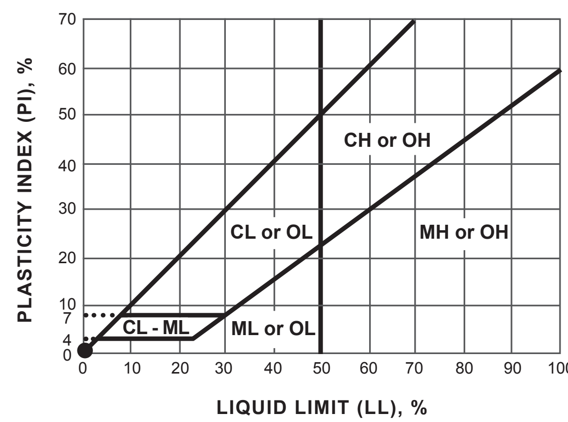
SOIL CLASSIFICATION CHART PER ASTM D 2488

PRIMARY DIVISIONS			SECONDARY DIVISIONS: GROUP SYMBOL	SECONDARY DIVISIONS: GROUP NAME
COARSE-GRAINED SOILS more than 50% retained on No. 200 sieve	**GRAVEL** more than 50% of coarse fraction retained on No. 4 sieve	CLEAN GRAVEL less than 5% fines	GW	well-graded GRAVEL
			GP	poorly graded GRAVEL
		GRAVEL with DUAL CLASSIFICATIONS 5% to 12% fines	GW-GM	well-graded GRAVEL with silt
			GP-GM	poorly graded GRAVEL with silt
			GW-GC	well-graded GRAVEL with clay
			GP-GC	poorly graded GRAVEL with clay
		GRAVEL with FINES more than 12% fines	GM	silty GRAVEL
			GC	clayey GRAVEL
			GC-GM	silty, clayey GRAVEL
	SAND 50% or more of coarse fraction passes No. 4 sieve	CLEAN SAND less than 5% fines	SW	well-graded SAND
			SP	poorly graded SAND
		SAND with DUAL CLASSIFICATIONS 5% to 12% fines	SW-SM	well-graded SAND with silt
			SP-SM	poorly graded SAND with silt
			SW-SC	well-graded SAND with clay
			SP-SC	poorly graded SAND with clay
		SAND with FINES more than 12% fines	SM	silty SAND
			SC	clayey SAND
			SC-SM	silty, clayey SAND
FINE-GRAINED SOILS 50% or more passes No. 200 sieve	**SILT and CLAY** liquid limit less than 50%	INORGANIC	CL	lean CLAY
			ML	SILT
			CL-ML	silty CLAY
		ORGANIC	OL (PI > 4)	organic CLAY
			OL (PI < 4)	organic SILT
	SILT and CLAY liquid limit 50% or more	INORGANIC	CH	fat CLAY
			MH	elastic SILT
		ORGANIC	OH (plots on or above "A"-line)	organic CLAY
			OH (plots below "A"-line)	organic SILT
	Highly Organic Soils		PT	Peat

GRAIN SIZE

DESCRIPTION		SIEVE SIZE	GRAIN SIZE	APPROXIMATE SIZE
Boulders		> 12"	> 12"	Larger than basketball-sized
Cobbles		3 - 12"	3 - 12"	Fist-sized to basketball-sized
Gravel	Coarse	3/4 - 3"	3/4 - 3"	Thumb-sized to fist-sized
	Fine	#4 - 3/4"	0.19 - 0.75"	Pea-sized to thumb-sized
Sand	Coarse	#10 - #4	0.079 - 0.19"	Rock-salt-sized to pea-sized
	Medium	#40 - #10	0.017 - 0.079"	Sugar-sized to rock-salt-sized
	Fine	#200 - #40	0.0029 - 0.017"	Flour-sized to sugar-sized
Fines		Passing #200	< 0.0029"	Flour-sized and smaller

PLASTICITY CHART



APPARENT DENSITY - COARSE-GRAINED SOIL

APPARENT DENSITY	SPOOLING CABLE OR CATHEAD: SPT (blows/foot)	SPOOLING CABLE OR CATHEAD: MODIFIED SPLIT BARREL (blows/foot)	AUTOMATIC TRIP HAMMER: SPT (blows/foot)	AUTOMATIC TRIP HAMMER: MODIFIED SPLIT BARREL (blows/foot)
Very Loose	≤ 4	≤ 8	≤ 3	≤ 5
Loose	5 - 10	9 - 21	4 - 7	6 - 14
Medium Dense	11 - 30	22 - 63	8 - 20	15 - 42
Dense	31 - 50	64 - 105	21 - 33	43 - 70
Very Dense	> 50	> 105	> 33	> 70

CONSISTENCY - FINE-GRAINED SOIL

CONSIS-TENCY	SPOOLING CABLE OR CATHEAD: SPT (blows/foot)	SPOOLING CABLE OR CATHEAD: MODIFIED SPLIT BARREL (blows/foot)	AUTOMATIC TRIP HAMMER: SPT (blows/foot)	AUTOMATIC TRIP HAMMER: MODIFIED SPLIT BARREL (blows/foot)
Very Soft	< 2	< 3	< 1	< 2
Soft	2 - 4	3 - 5	1 - 3	2 - 3
Firm	5 - 8	6 - 10	4 - 5	4 - 6
Stiff	9 - 15	11 - 20	6 - 10	7 - 13
Very Stiff	16 - 30	21 - 39	11 - 20	14 - 26
Hard	> 30	> 39	> 20	> 26

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USCS METHOD OF SOIL CLASSIFICATION

Explanation of USCS Method of Soil Classification

PROJECT NO.	DATE	FIGURE

BORING LOG EXPLANATION SHEET

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	
0								Bulk sample.
								Modified split-barrel drive sampler.
								No recovery with modified split-barrel drive sampler.
								Sample retained by others.
								Standard Penetration Test (SPT).
5								No recovery with a SPT.
			XX/XX					Shelby tube sample. Distance pushed in inches/length of sample recovered in inches.
								No recovery with Shelby tube sampler.
								Continuous Push Sample.
								Seepage.
10								Groundwater encountered during drilling.
								Groundwater measured after drilling.
							SM	MAJOR MATERIAL TYPE (SOIL): Solid line denotes unit change.
							CL	Dashed line denotes material change.
15								Attitudes: Strike/Dip b: Bedding c: Contact j: Joint f: Fracture F: Fault cs: Clay Seam s: Shear bss: Basal Slide Surface sf: Shear Fracture sz: Shear Zone sbs: Shear Bedding Surface
20								The total depth line is a solid line that is drawn at the bottom of the boring.

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BORING LOG		
Explanation of Boring Log Symbols		
PROJECT NO.	DATE	FIGURE

Updated Nov. 2011

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 5 inches thick.
							CL	ALLUVIUM: Brown, dry, hard sandy CLAY; trace gravel; scattered caliche nodules.
			36					
								Total Depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt concrete patched on 9/30/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of pub-lished maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
5								
10								
15								
20								

DATE DRILLED 9/30/15 BORING NO. B-1

GROUND ELEVATION 2,396 ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Hollow Stem Auger (Southlands)

DRIVE WEIGHT 140 lbs. Automatic DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - TUCSON BLVD NORTH
FORT LOWELL ROAD TO GLENN STREET TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-1

DATE DRILLED 9/30/15 BORING NO. B-2

GROUND ELEVATION 2,397 ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Hollow Stem Auger (Southlands)

DRIVE WEIGHT 140 lbs. Automatic DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 4 inches thick.
							CL	ALLUVIUM: Brown, dry, very stiff sandy CLAY; scattered caliche nodules.
			16					
								Total Depth = 3 feet. Groundwater not encountered during drilling.
								Backfilled and asphalt concrete patched on 9/30/15 shortly after completion of drilling.
5								Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.
								The ground elevation shown above is an estimation only. It is based on our interpretations of pub-lished maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
10								
15								
20								

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - TUCSON BLVD NORTH
FORT LOWELL ROAD TO GLENN STREET TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-2

DATE DRILLED 10/1/15 BORING NO. B-3

GROUND ELEVATION 2,400 ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Hollow Stem Auger (Southlands)

DRIVE WEIGHT 140 lbs. Automatic DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 4 inches thick.
			10				CL	ALLUVIUM: Brown, dry, stiff sandy CLAY; trace gravel; scattered caliche nodules.
5								Total Depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt concrete patched on 10/1/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of pub-lished maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
10								
15								
20								

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - TUCSON BLVD NORTH
FORT LOWELL ROAD TO GLENN STREET TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-3

APPENDIX B

LABORATORY TESTING

Classification

Soils were visually and texturally classified in accordance with the Unified Soil Classification System (USCS) in general accordance with ASTM D 2488. Soil classifications are indicated on the logs of the exploratory borings in Appendix A.

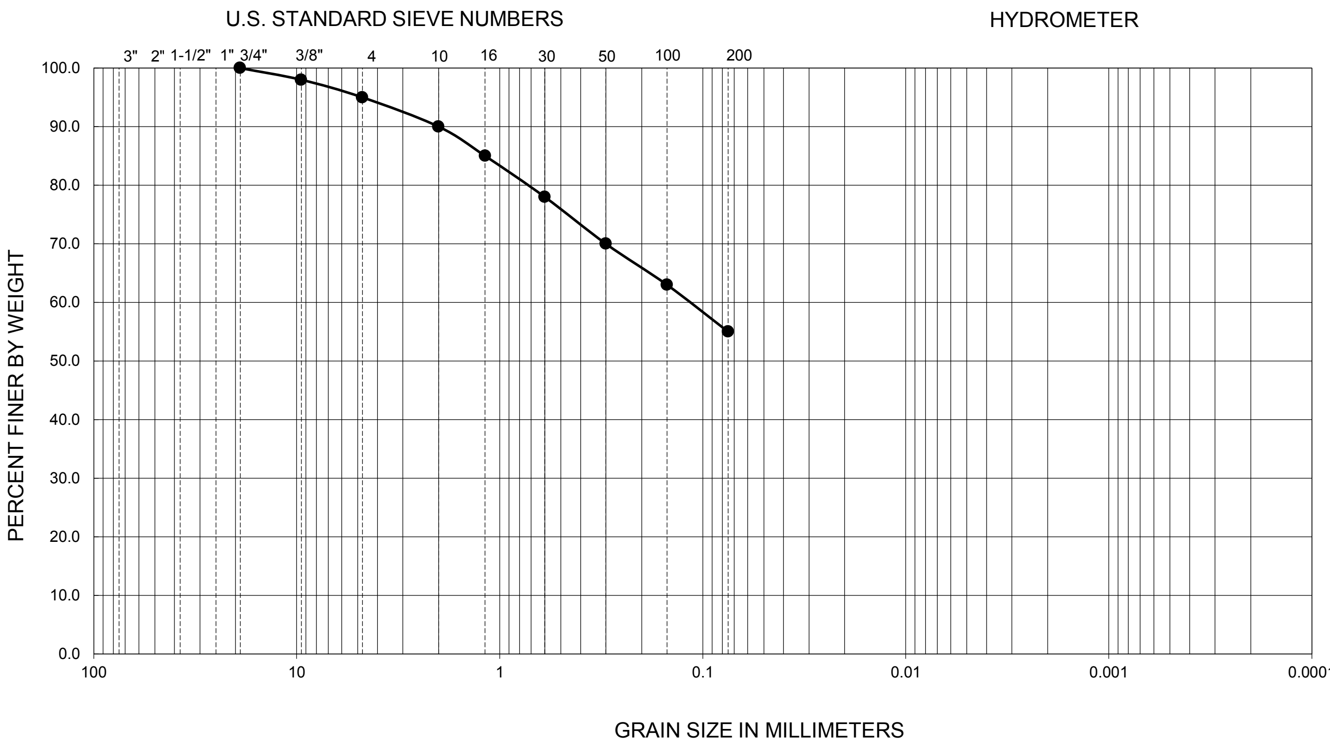
Gradation Analysis

One gradation analysis test was performed on a selected representative soil sample in general accordance with ASTM D 422. The grain-size distribution curves are shown in Figures B-1 and B-2. These test results were utilized in evaluating the soil classification in accordance with the USCS.

Atterberg Limits

Tests were performed on a selected representative fine-grained soil sample to evaluate the liquid limit, plastic limit, and plasticity index in general accordance with ASTM D 4318. These test results were utilized to evaluate the soil classification in accordance with the USCS. The test results and classifications are shown on Figure B-3.

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY

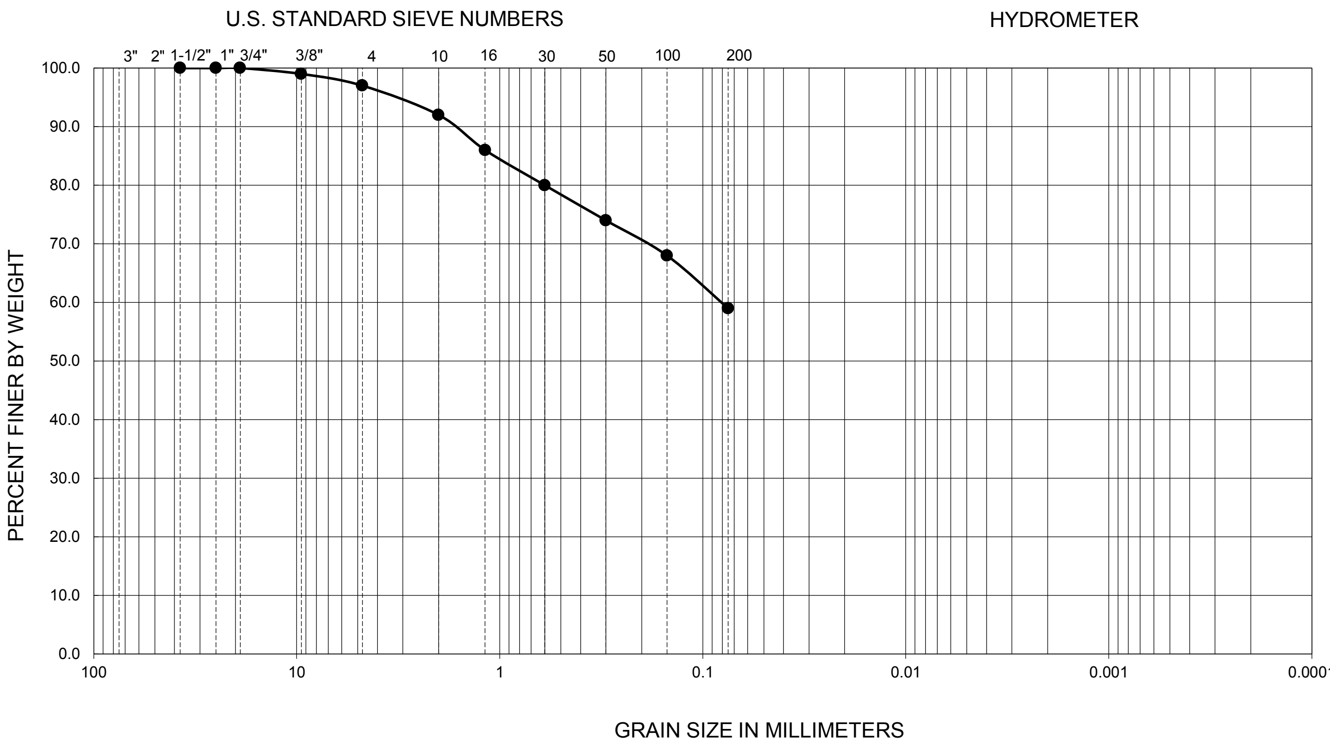


Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
●	B-1	1.5-3.0	42	20	22	--	--	--	--	--	55	CL

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore		GRADATION TEST RESULTS	FIGURE
PROJECT NO.	DATE	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - TUCSON BOULEVARD BETWEEN FORT LOWELL ROAD AND GLENN STREET TUCSON, ARIZONA	B-1
604817002	12/15		

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY

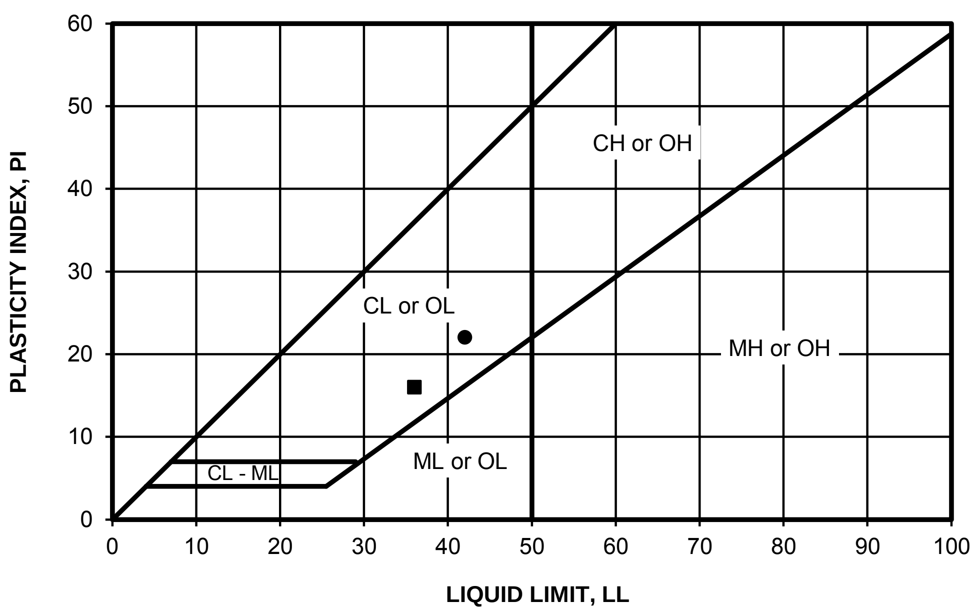


Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
●	B-3	1.5-3.0	36	20	16	--	--	--	--	--	59	CL

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore		GRADATION TEST RESULTS	FIGURE
PROJECT NO.	DATE	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - TUCSON BOULEVARD BETWEEN FORT LOWELL ROAD AND GLENN STREET TUCSON, ARIZONA	B-2
604817002	12/15		

SYMBOL	LOCATION	DEPTH (FT)	LIQUID LIMIT, LL	PLASTIC LIMIT, PL	PLASTICITY INDEX, PI	USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve)	USCS (Entire Sample)
●	B-1	1.5-3.0	42	20	22	CL	CL
■	B-3	1.5-3.0	36	20	16	CL	CL



PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4318

Ninyo & Moore

ATTERBERG LIMITS TEST RESULTS

PROJECT NO.	DATE
604817002	12/15

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - TUCSON BOULEVARD
BETWEEN FORT LOWELL ROAD AND GLENN STREET
TUCSON, ARIZONA

FIGURE

B-3

APPENDIX C

PAVEMENT AND CORE SUMMARY

TUCSON BOULEVARD (FORT LOWELL RD TO GLENN STREET) - PAVEMENT AND CORE SUMMARY

No.	Location	Approximate AC thickness (in)*	Recovered AC Thickness (in)	Core Description	Pavement Condition
B-1	Southbound, 380 feet south of Fort Lowell Road	5	5	Two lifts, 2" and 3", few voids.	Extensive transverse, longitudinal, alligator and irregular cracking, some sealed, patches.
B-2	Northbound, 80 feet north of Blacklidge Drive	4	4	Two lifts, 1.5" and 2.5", bottom lift decomposed, numerous voids.	Extensive transverse, longitudinal, alligator and irregular cracking, some sealed, patches, developing potholes.
B-3	Soutnbound, 270 feet north of Glenn Street	4	4	Two lifts, 1.5" and 2.5", few voids.	Extensive transverse, longitudinal, alligator and irregular cracking, some sealed, patches.

Notes:

* Measured in the boring

APPENDIX D

TRAFFIC DATA

Field Data Services of Arizona
21636 N. Dietz Dr.
Maricopa, AZ 85138
520.316.6745

Site Code: 15-1283-006
Station ID: Wed 10/14/2015
Tucson Blvd. btwn. Blacklidge Dr. & Hedrick Dr. 32.262981 -110.935175
Latitude: 0' 0.000 Undefined

Northbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/14/15	0	13	1	0	0	0	0	0	0	0	0	0	0	14
01:00	0	8	4	0	0	0	0	0	0	0	0	0	0	12
02:00	**1**	6	1	0	0	0	0	0	0	0	0	0	0	8
03:00	0	3	0	0	0	0	0	0	0	0	0	0	0	3
04:00	0	2	2	0	0	0	0	0	0	0	0	0	0	4
05:00	0	19	4	0	0	0	0	0	0	0	0	0	0	23
06:00	0	60	4	0	0	0	0	0	0	0	0	0	0	64
07:00	0	207	36	**1**	0	0	0	1	0	0	0	0	0	245
08:00	0	**292**	24	1	0	1	**3**	1	**1**	**1**	0	0	0	**324**
09:00	0	178	37	0	0	**2**	0	0	1	1	0	0	**1**	220
10:00	1	172	**39**	1	0	0	1	**3**	0	0	**1**	**1**	0	219
11:00	0	179	29	0	0	1	1	2	1	0	0	1	1	215
12 PM	0	219	42	1	**1**	0	0	0	**1**	0	0	**1**	0	265
13:00	0	205	31	1	0	0	3	2	1	1	0	0	1	245
14:00	0	186	43	0	1	0	1	**3**	0	1	0	1	1	237
15:00	**1**	224	38	**5**	0	**1**	**4**	2	0	**3**	0	1	0	279
16:00	0	252	**50**	2	1	1	4	2	1	0	**1**	0	1	**315**
17:00	0	**264**	30	3	1	0	4	3	1	0	0	0	**2**	308
18:00	0	181	19	3	1	0	2	0	1	0	0	0	0	207
19:00	0	130	14	0	0	0	1	0	0	0	0	0	1	146
20:00	0	108	6	0	0	0	0	0	1	0	0	0	0	115
21:00	0	68	6	0	0	0	0	0	0	0	0	0	0	74
22:00	0	40	7	0	0	0	0	0	0	0	0	0	0	47
23:00	0	27	4	0	0	0	0	0	0	0	0	0	0	31
Day Total	3	3043	471	18	5	6	24	19	9	7	2	5	8	3620
Percent	0.1%	84.1%	13.0%	0.5%	0.1%	0.2%	0.7%	0.5%	0.2%	0.2%	0.1%	0.1%	0.2%	
AM Peak	02:00	08:00	10:00	07:00		09:00	08:00	10:00	08:00	08:00	10:00	10:00	09:00	08:00
Vol.	1	292	39	1		2	3	3	1	1	1	1	1	324
PM Peak	15:00	17:00	16:00	15:00	12:00	15:00	15:00	14:00	12:00	15:00	16:00	12:00	17:00	16:00
Vol.	1	264	50	5	1	1	4	3	1	3	1	1	2	315
Grand Total	3	3043	471	18	5	6	24	19	9	7	2	5	8	3620
Percent	0.1%	84.1%	13.0%	0.5%	0.1%	0.2%	0.7%	0.5%	0.2%	0.2%	0.1%	0.1%	0.2%	

Field Data Services of Arizona
21636 N. Dietz Dr.
Maricopa, AZ 85138
520.316.6745

Site Code: 15-1283-006
Station ID: Wed 10/14/2015
Tucson Blvd. btwn. Blacklidge Dr. &
Hedrick Dr. 32.262981 -110.935175
Latitude: 0' 0.000 Undefined

Southbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/14/15	0	10	2	0	0	0	0	0	0	0	0	0	0	12
01:00	0	8	2	0	1	0	0	0	0	0	0	0	0	11
02:00	0	5	3	0	0	0	0	0	0	0	0	0	0	8
03:00	0	5	2	0	0	0	0	0	0	0	0	0	0	7
04:00	0	5	3	0	0	0	0	0	0	0	0	0	0	8
05:00	0	9	9	0	0	0	1	0	0	0	0	0	0	19
06:00	0	33	18	0	2	1	0	0	0	0	0	0	0	54
07:00	0	93	28	0	0	**3**	**2**	0	0	0	0	0	0	126
08:00	**1**	**155**	**53**	1	**3**	1	0	**1**	0	0	0	0	0	**215**
09:00	0	93	37	**2**	2	2	1	0	0	0	0	0	0	137
10:00	0	118	44	0	1	0	1	0	0	0	0	0	0	164
11:00	1	134	46	0	0	3	1	0	0	0	0	0	0	185
12 PM	0	124	52	**3**	0	0	0	0	0	0	1	0	0	180
13:00	0	144	37	0	1	**4**	**1**	**1**	0	0	0	**1**	0	189
14:00	0	135	42	2	1	1	0	1	0	0	0	0	0	182
15:00	0	140	40	1	3	1	1	0	0	0	0	0	0	186
16:00	**1**	170	**60**	1	**4**	1	0	0	**1**	0	0	0	0	238
17:00	1	**240**	45	0	2	3	0	1	0	0	0	0	0	**292**
18:00	0	182	38	0	0	3	0	1	0	0	**2**	0	**1**	227
19:00	0	82	14	0	2	0	0	0	0	0	0	0	0	98
20:00	1	90	26	0	1	2	0	1	0	0	0	0	0	121
21:00	0	50	15	0	0	1	0	0	0	0	0	0	0	66
22:00	0	42	7	0	0	0	0	0	0	0	0	0	0	49
23:00	0	28	5	0	0	0	0	0	0	0	0	0	0	33
Day Total	5	2095	628	10	23	26	8	6	1	0	3	1	1	2807
Percent	0.2%	74.6%	22.4%	0.4%	0.8%	0.9%	0.3%	0.2%	0.0%	0.0%	0.1%	0.0%	0.0%	
AM Peak	08:00	08:00	08:00	09:00	08:00	07:00	07:00	08:00						08:00
Vol.	1	155	53	2	3	3	2	1						215
PM Peak	16:00	17:00	16:00	12:00	16:00	13:00	13:00	13:00	16:00		18:00	13:00	18:00	17:00
Vol.	1	240	60	3	4	4	1	1	1		2	1	1	292
Grand Total	5	2095	628	10	23	26	8	6	1	0	3	1	1	2807
Percent	0.2%	74.6%	22.4%	0.4%	0.8%	0.9%	0.3%	0.2%	0.0%	0.0%	0.1%	0.0%	0.0%	

Field Data Services of Arizona

21636 N. Dietz Dr.
Maricopa, AZ 85138
520.316.6745

Site Code: 15-1283-006
Station ID: Wed 10/14/2015
Tucson Blvd. btwn. Blacklidge Dr. &
Hedrick Dr. 32.262981 -110.935175
Latitude: 0' 0.000 Undefined

Northbound, Southbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/14/15	0	23	3	0	0	0	0	0	0	0	0	0	0	26
01:00	0	16	6	0	1	0	0	0	0	0	0	0	0	23
02:00	**1**	11	4	0	0	0	0	0	0	0	0	0	0	16
03:00	0	8	2	0	0	0	0	0	0	0	0	0	0	10
04:00	0	7	5	0	0	0	0	0	0	0	0	0	0	12
05:00	0	28	13	0	0	0	1	0	0	0	0	0	0	42
06:00	0	93	22	0	2	1	0	0	0	0	0	0	0	118
07:00	0	300	64	1	0	3	2	1	0	0	0	0	0	371
08:00	1	**447**	77	**2**	**3**	2	**3**	2	**1**	**1**	0	0	0	**539**
09:00	0	271	74	2	2	**4**	1	0	1	1	0	0	**1**	357
10:00	1	290	**83**	1	1	0	2	**3**	0	0	**1**	**1**	0	383
11:00	1	313	75	0	0	4	2	2	1	0	0	1	1	400
12 PM	0	343	94	4	1	0	0	0	1	0	1	**1**	0	445
13:00	0	349	68	1	1	**4**	4	3	1	1	0	1	1	434
14:00	0	321	85	2	2	1	1	**4**	0	1	0	1	1	419
15:00	**1**	364	78	**6**	3	2	**5**	2	0	**3**	0	1	0	465
16:00	1	422	**110**	3	**5**	2	4	2	**2**	0	1	0	1	553
17:00	1	**504**	75	3	3	3	4	4	1	0	0	0	**2**	**600**
18:00	0	363	57	3	1	3	2	1	1	0	**2**	0	1	434
19:00	0	212	28	0	2	0	1	0	0	0	0	0	1	244
20:00	1	198	32	0	1	2	0	1	1	0	0	0	0	236
21:00	0	118	21	0	0	1	0	0	0	0	0	0	0	140
22:00	0	82	14	0	0	0	0	0	0	0	0	0	0	96
23:00	0	55	9	0	0	0	0	0	0	0	0	0	0	64
Day Total	8	5138	1099	28	28	32	32	25	10	7	5	6	9	6427
Percent	0.1%	79.9%	17.1%	0.4%	0.4%	0.5%	0.5%	0.4%	0.2%	0.1%	0.1%	0.1%	0.1%	
AM Peak	02:00	08:00	10:00	08:00	08:00	09:00	08:00	10:00	08:00	08:00	10:00	10:00	09:00	08:00
Vol.	1	447	83	2	3	4	3	3	1	1	1	1	1	539
PM Peak	15:00	17:00	16:00	15:00	16:00	13:00	15:00	14:00	16:00	15:00	18:00	12:00	17:00	17:00
Vol.	1	504	110	6	5	4	5	4	2	3	2	1	2	600
Grand Total	8	5138	1099	28	28	32	32	25	10	7	5	6	9	6427
Percent	0.1%	79.9%	17.1%	0.4%	0.4%	0.5%	0.5%	0.4%	0.2%	0.1%	0.1%	0.1%	0.1%	

APPENDIX E

PAVEMENT OPTIMIZATION DESIGN ANALYSIS BY TENSAR

SpectraPave4 PRO™
Pavement Optimization Design Analysis

Design Parameters for AASHTO (1993) Equation

Reliability (%)	= 95	Initial Serviceability	= 4.5
Standard Normal Deviate	= -1.645	Terminal Serviceability	= 2.5
Standard Deviation	= 0.4	Change in Serviceability	= 2

Aggregate fill shall conform to following requirement:

D50 <= 27mm (Base course)

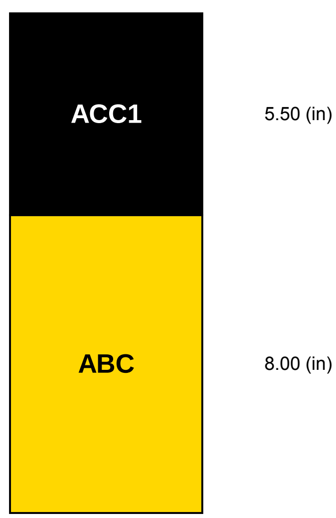
Unstabilized Section Material Properties

Layer	Description	Cost ($/ton)	Layer coefficient	Drainage factor
ACC1	Asphalt Wearing Course	70	0.440	N/A
ABC	Aggregate Base Course	15	0.140	1.25

Stabilized Section Material Properties

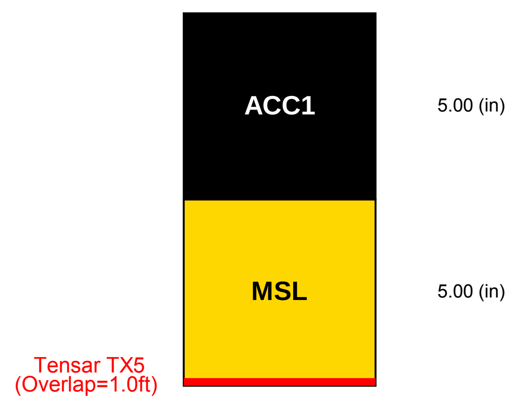
Layer	Description	Cost ($/ton)	Layer coefficient	Drainage factor
ACC1	Asphalt Wearing Course	70	0.440	N/A
MSL	Mechanically Stabilized Base Cour	15	0.289	1.25

Unstabilized Pavement



Subgrade Modulus = 8,824 (psi)
Structural Number = 3.820
Calculated Traffic (ESALs) = 2,730,000

Stabilized Pavement



Subgrade Modulus = 8,824 (psi)
Structural Number = 4.006
Calculated Traffic (ESALs) = 3,757,000

LIMITATIONS OF THE REPORT

The designs, illustrations, information and other content included in this report are necessarily general and conceptual in nature, and do not constitute engineering advice or any design intended for actual construction. Specific design recommendations can be provided as the project develops.

Project Name	Tucson North		
Company Name	Tensar		
Designer	Schlessinger	Date	12/11/15

PAVEMENT EVALUATION
TUCSON PAVEMENT RECONSTRUCTION PROGRAM
TUCSON BOULEVARD, GLENN STREET TO GRANT ROAD
TUCSON, ARIZONA

PREPARED FOR:
Kimley-Horn & Associates, Inc.
333 East Wetmore Road, Suite 280
Tucson, Arizona 85705

PREPARED BY:
Ninyo & Moore
Geotechnical and Environmental Sciences Consultants
1991 East Ajo Way, Suite 145
Tucson, Arizona 85713

December 15, 2015
Project No. 604817002

December 15, 2015
Project No. 604817002

Mr. Rick Solis, P.E.
Kimley-Horn
333 East Wetmore Road, Suite 280
Tucson, Arizona 85705

Subject: Pavement Evaluation
Tucson Pavement Reconstruction Program – Tucson Boulevard
Glenn Street to Grant Road
Tucson, Arizona

Dear Mr. Solis:

In accordance with our proposal dated August 12, 2015, and your authorization on September 21, 2015, Ninyo & Moore has performed a pavement evaluation for the above-referenced site. The attached report presents our methodology, findings, conclusions, and recommendations regarding the geotechnical conditions at the project site.

We appreciate the opportunity to be of service to you during this phase of the project.

Sincerely,
NINYO & MOORE

Registered Professional Engineer (Civil)
CERTIFICATE NO. 48704
MAREK J. KASZTALSKI
Date Signed 12.15.15
ARIZONA, U.S.A.
EXPIRES 9/30/18

Marek J. Kasztalski, PE, PMP, LEED AP
Senior Geotechnical Engineer

Fred Narcaroti
Principal/Tucson Office Manager

MJK/DT/FFN/tlp

Distribution: (1) Addressee (Electronic Copy)

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Appendices

1. INTRODUCTION

In accordance with our proposal dated August 12, 2015, and your authorization on September 21, 2015, we have performed a pavement evaluation for the Tucson Boulevard Pavement Reconstruction project between Glenn Street and Grant Road, in Tucson, Arizona. The purpose of our evaluation was to assess the pavement and subgrade conditions along the project alignment in order to provide geotechnical recommendations for design and construction. This report presents the results of our evaluation, conclusions, and recommendations regarding the proposed construction.

2. SCOPE OF SERVICES

The scope of our services generally included:

- Preparing a field testing plan and associated permit application for submittal to the City of Tucson (COT).
- Conducting a visual reconnaissance of the pavement along the alignment and marking out the boring locations.
- Notifying Arizona811 of our boring locations prior to conducting the field work.
- Arranging for traffic control measures to conduct the field work.
- Coring the existing asphaltic concrete (AC) pavement at three locations along the project alignment.
- Exploring the subsurface soils within the project limits by drilling, logging, and sampling three exploratory soil borings to approximate depths of 3 feet below ground surface (bgs). The boring logs are presented in Appendix A.
- Performing laboratory tests on selected samples collected from our borings to evaluate gradation and Atterberg limits. The results of the laboratory tests are included in Appendix B.
- Preparing this report presenting our findings, conclusions and recommendations regarding the proposed reconstruction.

Our scope of services did not include environmental consulting services such as hazardous waste sampling or analytical testing at the site. A detailed scope of services and estimated fee for such services can be provided upon request.

3. SITE DESCRIPTION

The project site is located in Sections 5 and 32 of Township 13 South, Range 14 East relative to the Gila and Salt River Base Line and Meridian. The project alignment extends along Tucson Boulevard between Glenn Street and Grant Road in Tucson, Arizona (Figure 1).

At the time of our evaluation residential and commercial developments existed along the project alignment. The roadway section consisted of one travel lane in each direction, a center lane, concrete sidewalks on the east and west side of the roadway, and concrete curb along most of the project alignment.

4. PROPOSED CONSTRUCTION

The COT has identified several segments of the existing street network for reconstruction and/or rehabilitation in fiscal year (FY) 2016 under Bid Package 2. The scope of this report includes Tucson Boulevard between Glenn Street and Grant Road. The project alignment is approximately 0.5-mile long.

We understand that the COT anticipates full-depth reconstruction of the existing roadway along the project alignment. The City proposes a new pavement section consisting of 5 inches of AC per of the COT Department of Transportation Standard Specifications Section 406 over 5 inches of aggregate base (AB) per Section 303 of the COT Standard Specifications.

We further understand that the COT intends to use Tucson Department of Transportation (TDOT) AC Mix No. 2 PG 76-22TR+ for the surface layer and TDOT AC Mix No. 1 PG 70-10 for the underlying layer. Both layers are proposed to be 2.5 inches thick.

Due to conflicts with shallow utility lines, subgrade improvement by overexcavation will not be performed and the new pavement section will be constructed on subgrade improved with Geogrid (Tensar Geogrid TX5 or equivalent).

The scope of this exploration included evaluation of the existing pavement section and subgrade soils in order to provide recommendations for pavement reconstruction in accordance with the current COT practice. Calculations for the new pavement section supporting the new construction proposed by the COT are presented in Section 9.3 and in Appendix E of this report.

5. EXISTING PAVEMENT CONDITION

On September 30, 2015, Ninyo & Moore conducted a limited visual evaluation of the pavement surface along the project alignment. Based on our field observations, the AC pavement exhibited signs of severe distress in many locations along the project alignment primarily consisting of extensive block, transverse, irregular and alligator cracking with considering spalling, and potholes. Asphaltic concrete patches were observed at some locations which were probably associated with past maintenance efforts (pothole and crack repairs) or with underground utility work. The crack widths generally varied between hairline (less than 1/8-inch) to over 1 ½ inches.

In our opinion, the distress observed along the project alignment indicates structural failure and is related to a combination of pavement age, subgrade condition, traffic, and environmental impacts.

6. FIELD EXPLORATION AND LABORATORY TESTING

On September 30, 2015, Ninyo & Moore conducted a geotechnical exploration in order to evaluate the subsurface conditions and collect AC cores and soil samples for laboratory testing. Our evaluation consisted of coring the existing AC pavement, drilling, logging, and sampling three small-diameter borings, denoted as B-1 through B-3, utilizing a CME-75 truck-mounted drill rig equipped with hollow-stem augers. The borings extended to depths of approximately 3 feet bgs. The approximate locations of the borings are depicted on Figure 2.

Ninyo & Moore personnel logged the borings in general accordance with the Unified Soil Classification System (USCS) and American Society for Testing and Materials (ASTM) D 2488 by observing cuttings and drive samples. Collected ring samples were trimmed in the field, wrapped in plastic bags, and placed in cylindrical plastic containers to retain in-place moisture conditions.

The soil samples collected from our drilling activities were transported to the Ninyo & Moore laboratory in Tucson, Arizona for geotechnical laboratory testing. The tests included gradation and Atterberg limits. A description of each laboratory test method and the test results are presented in Appendix B.

7. SUBSURFACE CONDITIONS

Our knowledge of the subsurface conditions at the project site is based on our field exploration, laboratory testing, and general experience in the area. More detailed stratigraphic information is presented on the boring logs in Appendix A, attached to this report. The boring logs contain our field and laboratory test results, as well as our interpretation of conditions believed to exist between actual samples retrieved. Therefore, these boring logs contain both factual and interpretive information. Lines delineating subsurface strata on the boring logs are intended to group soils having similar engineering properties and characteristics. They should be considered approximate as the actual transition between soil types (strata) may be gradual. A key to the soil symbols and terms used on the boring logs is provided in Appendix A.

7.1. Asphaltic Concrete

Asphaltic concrete pavement was encountered at the surface of each of our borings. The AC thickness varied between approximately 4 and 5 inches, in our borings. It should be noted that the thickness of the AC pavement between the sampling locations may vary and could be different from that encountered at our sampling locations. Detailed core descriptions are presented in Appendix C.

Aggregate base with an approximate thickness of 3 inches was encountered in our Boring B-2. In the locations of our other borings, it is possible the AB material blended with the native subgrade soils, such that delineation of the AB/subgrade interface was not easily interpreted.

7.2. Alluvium

Native alluvial soils were encountered below the pavement section, and extended to the boring termination depths. The alluvium generally consisted of medium dense to dense, clayey sand with varying amounts of gravel and scattered caliche cementation.

8. CONCLUSIONS

Based on the results of our visual and subsurface evaluations, laboratory testing, and data analysis, geotechnical considerations include the following:

- The on-site soils generally include sandy clays, with a plasticity index (PI) value varying between 13 and 17. Many on-site soils may be sensitive to moisture content fluctuations and may be difficult to compact especially at higher moisture contents. The contractor should be aware of this condition.
- Due to the relatively widely spaced nature of our borings, soil conditions may differ from what was observed during our field exploration.
- The pavement exhibits significant distress in many locations along the project alignment consisting mainly of extensive block, transverse, irregular and alligator cracking with considering spalling, and potholes.
- Full-depth pavement reconstruction is considered for this project as proposed by the COT.

9. RECOMMENDATIONS

The following sections present our geotechnical recommendations for the project. If the proposed construction is changed from that discussed in this report, Ninyo & Moore should be contacted for additional recommendations.

9.1. Recommended Pavement Structural Sections

The recommended pavement sections are presented in the table below:

Pavement Section	Service Life (years)	AC (in)[1]	AB (in)[2]
COT Preferred Pavement with Geogrid	20	5	5
Alternative Pavement Section without Geogrid	20	5.5	8

Notes:
[1] TDOT AC Mix No. 2 PG 76-22TR+ as the surface mix and TDOT AC Mix No. 1 PG 70-10 for the underlying layers per Section 406 of the COT Specifications.
[2] AB per Section 303 of the COT Specifications.

9.2. Earthwork

The following sections provide our earthwork recommendations for this project. In general, the earthwork specifications contained in the *City of Tucson/Pima County Standard Specifications for Public Improvements, 2003 Edition (COT/PC Specifications)* are expected to apply unless specifically noted.

9.2.1. Site Preparation

Construction areas should be cleared of deleterious materials, if any are present, including abandoned utilities, construction debris, vegetation, and any other material that might interfere with the performance or progress of the work. These materials should be disposed of at a legal dumpsite. Existing features that call for relocation or removal and extend below finish grade, if present, should be removed, and the resulting excavations backfilled with engineered fill.

9.2.2. Excavations

Our evaluation of the excavation characteristics of the on-site soils is based on the results of our exploratory borings, site observations, and experience with similar materials.

9.2.3. Fill Materials

Soils with PI values of 15 or less (as evaluated by ASTM D 4318) are generally suitable for use as engineered fill. Our Atterberg limits test indicated PI values ranging between 13 and 17. Based on this test result, some of the on-site soils are not suitable for re-use as engineered fill.

Engineered fill should not include organic material, construction debris, or other non-soil fill materials. Rock particles and clay lumps should not be larger than 4 inches in dimension. Unsuitable material should be disposed of off-site or in non-structural areas.

9.2.4. Grading and Subgrade Preparation

In general, grading operations should be performed in accordance with Section 205 of the COT/PC Specifications.

Due to potential conflicts with underground utilities, we recommend that the subgrade be improved by the application of Geogrid (Tensar Geogrid TX5 or equivalent). Geogrid should be placed in accordance with the manufacturer's instructions.

Alternatively, if Geogrid is not applied we recommend new pavements be supported on 6 inches of subgrade that is compacted by appropriate mechanical methods to a relative compaction of 95 percent as evaluated by ASTM D 698 at a moisture content generally near optimum. The thickness of the improvement zone should be measured from the bottom of the AB layer.

In areas where excessive moisture is encountered so that the above compaction cannot be achieved and/or the subgrade surface is unstable and yielding (pumping) under the roller wheels, subgrade soils should be scarified to a depth of 12 inches, aerated, and re-compacted as specified above. Alternatively, subgrade soils in problem areas should be and replaced with engineered fill to a depth of 12 inches below the bottom of the AB.

9.3. Pavement Design Summary

The following sections present our design assumptions and recommendations for the new flexible pavement section of Tucson Boulevard between Glenn Street and Grant Road, as this roadway is scheduled for full-depth pavement reconstruction.

The pavement section was developed using the Active Practices Guidelines issued by the COT Department of Transportation (Guidelines) and the Arizona Department of Transportation (ADOT) Preliminary Engineering and Design Manual (PEDM). We assumed that the subgrade will be improved by the application of Geogrid or overexcavation, as outlined in Section 9.2.4 of this report. The new pavement sections are designed for a 20-year service life.

9.3.1. Traffic

The future traffic numbers used in this report are based on traffic counts provided by Kimley-Horn and Associates, Inc. (KHA), and later communication with the KHA. This information is presented in Appendix D. Based on the above information, and using the procedures outlined in the Guidelines and PEDM, the design number of equivalent single axle loads (ESALs) for the design lane during the 20-year design period was calculated as approximately 3,542,330.

9.3.2. R-Value and Resilient Modulus

The analysis for the design R-value for the pavement section has been performed based on procedures detailed in the Guidelines and the PEDM, using correlated R-values. The correlated R-values were derived from the PI and percent passing No. 200 Sieve test results. A summary of the R-values for this project is presented in Table 1 below:

Table 1 – R-value Summary

Location	Sample Depth (ft)	Correlated R-Value
B-1	1.5-3.0	29
B-3	1.5-3.0	48

In the interest of conservatism, we recommend that an R-value of 25 be used for pavement design for this project.

If the project needs fill from an off-site source, we recommend the soils used for subgrade support should have an R-value of 25 or more. If during construction, the subgrade is found to vary from the expected soil conditions, we should be contacted so we may re-evaluate our recommended R-values. Based on the above design R-values, the design subgrade resilient modulus (M_R) value of 10,844 pounds per square inch (psi) was calculated in accordance with the Guidelines.

9.3.3. Statistical Parameters

A standard deviation of 0.40 was used for design of the flexible pavement in accordance with the Guidelines. The level of reliability and standard normal deviation (Z_R) values were selected in accordance with the Guidelines for the arterial functional classification. Their respective values are presented in the table below:

Table 2 – Summary of Statistical Parameters

Roadway	Functional Classification	Standard Deviation	Level of Reliability	Standard Normal Deviation
Tucson Boulevard Glenn Street to Grant Road	Arterial	0.40	95 %	-1.645

9.3.4. Serviceability Index

Initial and terminal serviceability indices were selected for the pavement design of the roadways in accordance with the Guidelines. A summary of the serviceability indices for each roadway is provided in the table below:

Table 3 – Summary of Serviceability Parameters

Roadway	Functional Classification	Initial Serviceability Index	Terminal Serviceability Index	Change in Serviceability
Tucson Boulevard Glenn Street to Grant Road	Arterial	4.5	2.5	2.0

9.3.5. Layer Coefficients

The following structural coefficients were used for the pavement structure in accordance with the Guidelines:

- AC: 0.44.
- AB: 0.14.

A drainage coefficient of 1.25 was used for the AB coefficient as recommended in the Guidelines.

As mentioned in Section 4 above, due to conflicts with existing shallow utilities, it is recommended that the subgrade be improved using Geogrid (Tensar Geogrid TX5 or equivalent). In this case the AB layer coefficient is 0.286.

9.3.6. Asphalt Pavement Section Recommendations

The structural number (SN) was calculated based on the parameters described above. The table below presents the calculated SN value and the recommended structural pavement sections. The AC thickness meets the COT requirements. Supporting documentation of the pavement optimization design using Geogrid is presented in Appendix E:

Table 4 – Structural Pavement Sections for 20-Year Design Life

Roadway	SN	AC (in)[1]	AB (in)[2]
COT Preferred Pavement with Geogrid	3.99	5	5
Alternative Pavement without Geogrid	3.76	5.5	8

Notes:
[1] TDOT AC Mix No. 2 PG 76-22TR+ as the surface mix and TDOT AC Mix No. 1 PG 70-10 for the underlying layers per Section 406 of the COT Specifications.
[2] AB per Section 303 of the COT Specifications.

The above pavement structural section has been designed with the assumption that the subgrade is prepared by as recommended in Section 9.2.4.

10. SITE DRAINAGE

Surface drainage should be provided to divert water away from paved surfaces. Surface water should also not be permitted to pond on or below pavement areas. Positive drainage for this project is defined as a slope of 2 percent or more for a distance of 5 feet or more away from the pavements. To deter accumulation of water below the new pavement sections, the bottom of the overexcavated zone below the new pavement should be sloped toward the edges of the roadway.

11. PRE-CONSTRUCTION CONFERENCE

We recommend that a pre-construction conference be held. Representatives of the owner, the civil engineer, Ninyo & Moore, and the contractor should be in attendance to discuss the project plans and schedule. Our office should be notified if the project description included herein is incorrect or if the project characteristics are significantly changed.

12. CONSTRUCTION OBSERVATION AND TESTING

During construction operations, we recommend that Ninyo & Moore perform observation and testing services for the project. These services should be performed to evaluate exposed subgrade conditions, including the extent and depth of overexcavation, to evaluate the suitability of

proposed borrow materials for use as engineered fill and to observe placement and test compaction of fill soils. Qualified subcontractors utilizing appropriate techniques and construction materials should perform construction of the proposed improvements.

13. LIMITATIONS

The field evaluation, laboratory testing, and geotechnical analyses presented in this geotechnical report have been conducted in general accordance with current practice and the standard of care exercised by geotechnical consultants performing similar tasks in the project area. No warranty, expressed or implied, is made regarding the conclusions, recommendations, and opinions presented in this report. There is no evaluation detailed enough to reveal every subsurface condition. Variations may exist and conditions not observed or described in this report may be encountered during construction. Uncertainties relative to subsurface conditions can be reduced through additional subsurface exploration. Additional subsurface evaluation will be performed upon request. Please also note that our evaluation was limited to assessment of the geotechnical aspects of the project, and did not include evaluation of structural issues, environmental concerns, or the presence of hazardous materials.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. Ninyo & Moore should be contacted if the reader requires additional information or has questions regarding the content, interpretations presented, or completeness of this document.

This report is intended for design purposes only. It does not provide sufficient data to prepare an accurate bid by contractors. It is suggested that the bidders and their geotechnical consultant perform an independent evaluation of the subsurface conditions in the project areas. The independent evaluations may include, but not be limited to, review of other geotechnical reports prepared for the adjacent areas, site reconnaissance, and additional exploration and laboratory testing.

Our conclusions, recommendations, and opinions are based on an analysis of the observed site conditions. If geotechnical conditions different from those described in this report are encountered, our office should be notified and additional recommendations, if warranted, will be provided upon request. It should be understood that the conditions of a site could change with time as a result of natural processes or the activities of man at the subject site or nearby sites. In addition, changes to the applicable laws, regulations, codes, and standards of practice may occur due to government action or the broadening of knowledge. The findings of this report may, therefore, be invalidated over time, in part or in whole, by changes over which Ninyo & Moore has no control.

This report is intended exclusively for use by the client. Any use or reuse of the findings, conclusions, and/or recommendations of this report by parties other than the client is undertaken at said parties' sole risk.

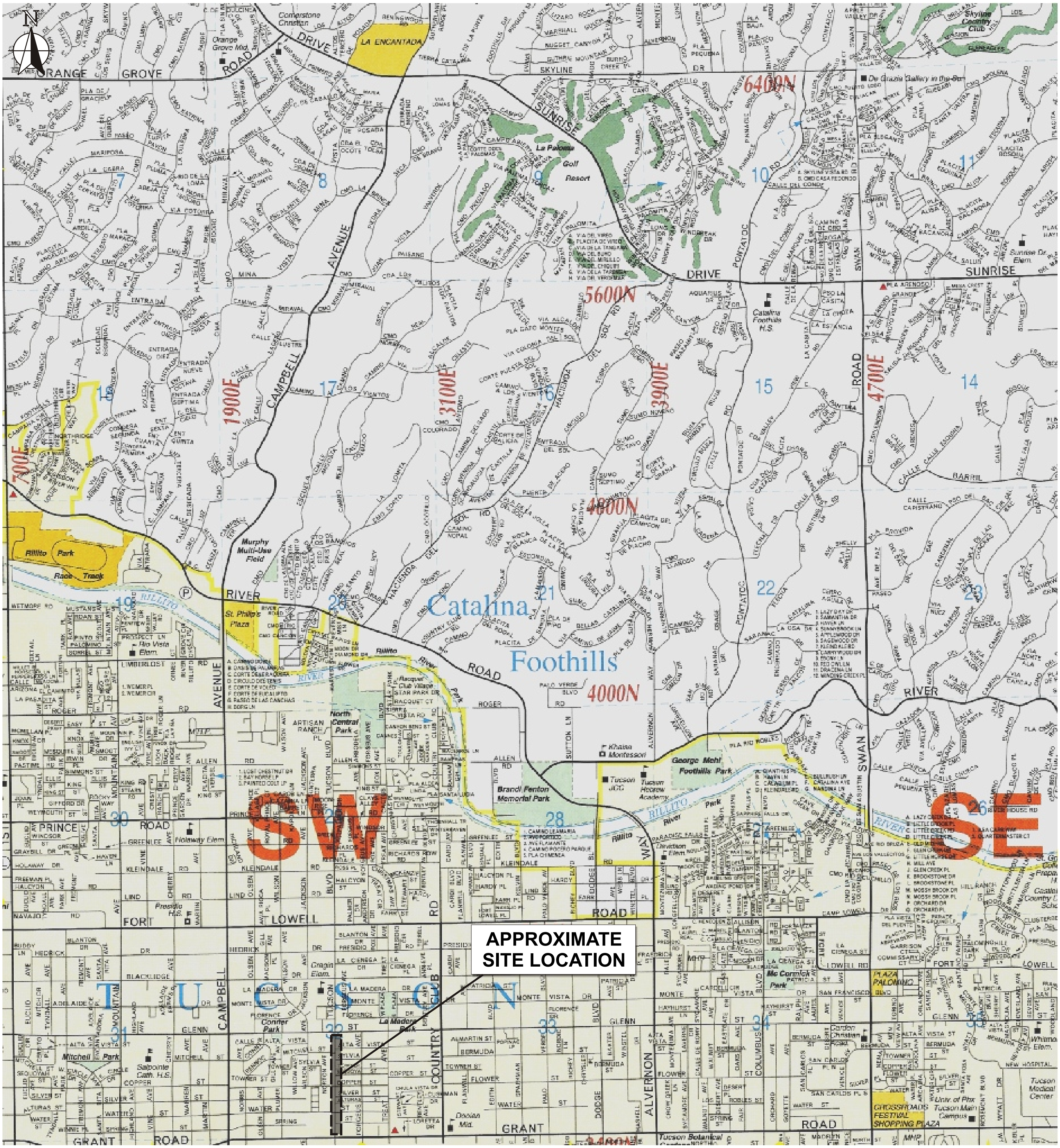
14. REFERENCES

American Society for Testing and Materials (ASTM), Annual Book of ASTM Standards.

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

City of Tucson, Arizona, Department of Transportation, Engineering Division, 1987, Active Practices Guidelines: dated June 1.

Ninyo & Moore, In-house proprietary information.



Source: Phoenix Mapping Service, Tucson Metro Edition, 2012.

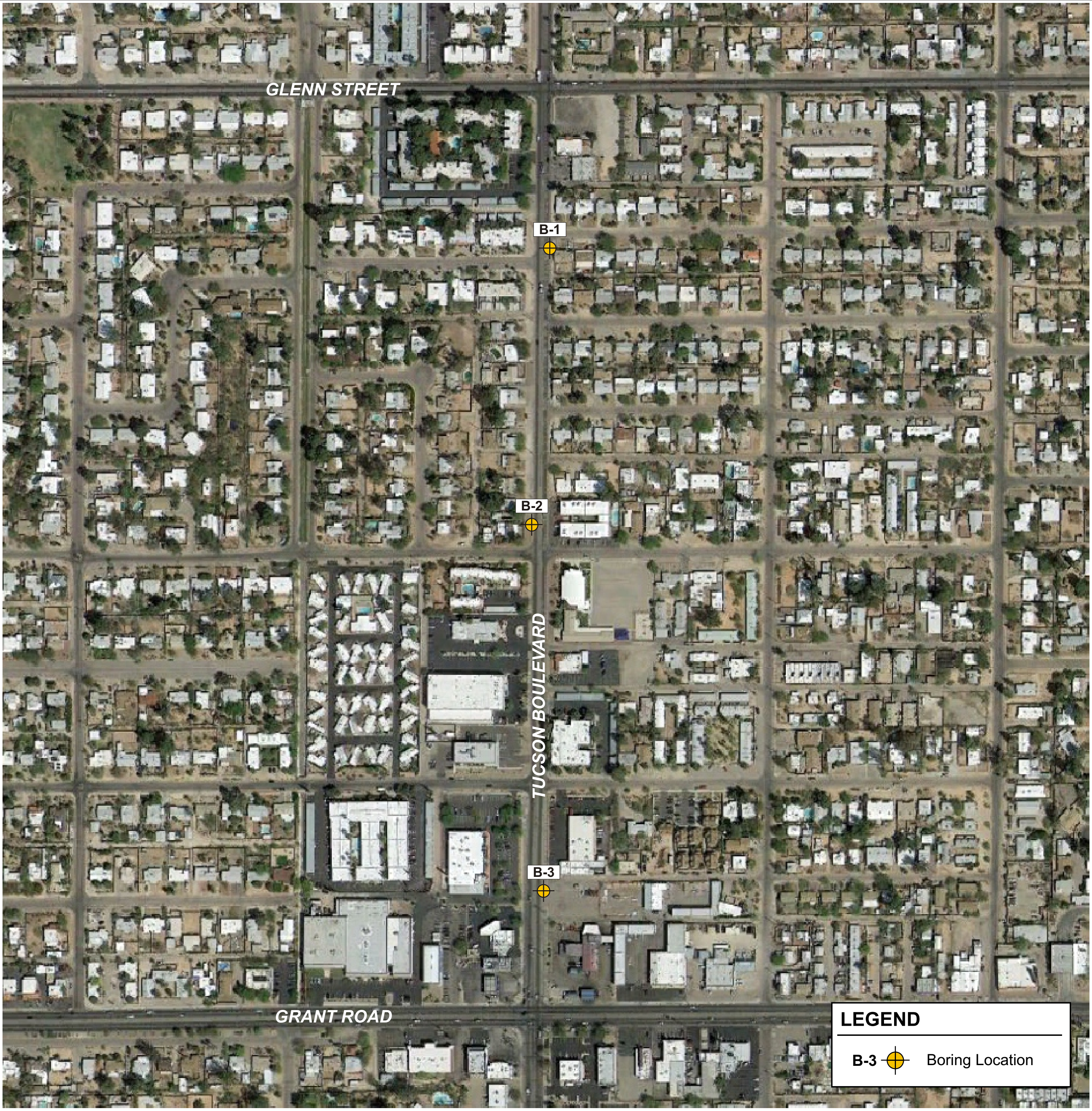
0 3300

Approximate Scale:
1 inch = 3300 feet

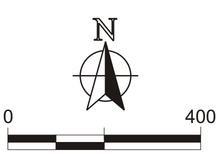
Note: Dimensions, directions, and locations are approximate.

Ninyo & Moore	SITE LOCATION		FIGURE 1
PROJECT NO: 604817002	DATE: 12/15	TUCSON PAVEMENT RECONSTRUCTION - TUCSON BOULEVARD BETWEEN GLENN AND GRANT ROAD TUCSON, ARIZONA	

file no: 4817vmap1015j



Source: NAVTEQ, 03/07/14.



Ninyo & Moore

BORING LOCATIONS

FIGURE

2

PROJECT NO:
604817002

DATE:
12/15

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - TUCSON BOULEVARD
BETWEEN GLENN STREET AND GRANT ROAD
TUCSON, ARIZONA

file no: 4817blm1015j

APPENDIX A

BORING LOGS

Field Procedure for the Collection of Relatively Undisturbed Samples

Relatively undisturbed soil samples were obtained in the field using the following methods.

The Modified Split-Barrel Drive Sampler

The sampler, with an external diameter of 3.0 inches, was lined with 1-inch long, thin brass rings with inside diameters of approximately 2.4 inches. The sample barrel was driven into the ground with the weight of a hammer or the Kelly bar of the drill rig in general accordance with ASTM D 3550. The driving weight was permitted to fall freely. The approximate length of the fall, the weight of the hammer or bar, and the number of blows per foot of driving are presented on the boring logs as an index to the relative resistance of the materials sampled. The samples were removed from the sample barrel in the brass rings, sealed, and transported to the laboratory for testing.

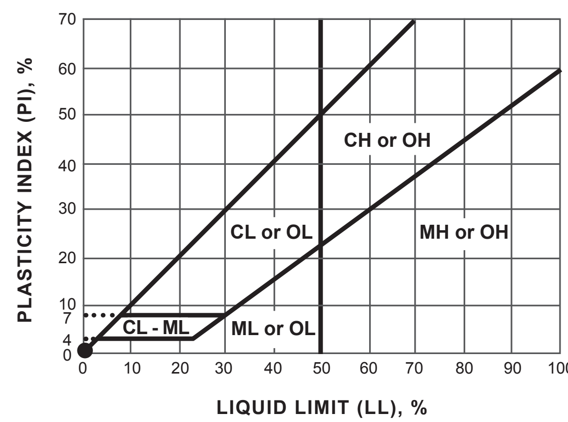
SOIL CLASSIFICATION CHART PER ASTM D 2488

PRIMARY DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE-GRAINED SOILS more than 50% retained on No. 200 sieve	GRAVEL more than 50% of coarse fraction retained on No. 4 sieve	CLEAN GRAVEL less than 5% fines	GW	well-graded GRAVEL
			GP	poorly graded GRAVEL
		GRAVEL with DUAL CLASSIFICATIONS 5% to 12% fines	GW-GM	well-graded GRAVEL with silt
			GP-GM	poorly graded GRAVEL with silt
			GW-GC	well-graded GRAVEL with clay
			GP-GC	poorly graded GRAVEL with clay
		GRAVEL with FINES more than 12% fines	GM	silty GRAVEL
			GC	clayey GRAVEL
			GC-GM	silty, clayey GRAVEL
	SAND 50% or more of coarse fraction passes No. 4 sieve	CLEAN SAND less than 5% fines	SW	well-graded SAND
			SP	poorly graded SAND
		SAND with DUAL CLASSIFICATIONS 5% to 12% fines	SW-SM	well-graded SAND with silt
			SP-SM	poorly graded SAND with silt
			SW-SC	well-graded SAND with clay
			SP-SC	poorly graded SAND with clay
		SAND with FINES more than 12% fines	SM	silty SAND
			SC	clayey SAND
			SC-SM	silty, clayey SAND
FINE-GRAINED SOILS 50% or more passes No. 200 sieve	SILT and CLAY liquid limit less than 50%	INORGANIC	CL	lean CLAY
			ML	SILT
			CL-ML	silty CLAY
		ORGANIC	OL (PI > 4)	organic CLAY
			OL (PI < 4)	organic SILT
	SILT and CLAY liquid limit 50% or more	INORGANIC	CH	fat CLAY
			MH	elastic SILT
		ORGANIC	OH (plots on or above "A"-line)	organic CLAY
			OH (plots below "A"-line)	organic SILT
	Highly Organic Soils		PT	Peat

GRAIN SIZE

DESCRIPTION		SIEVE SIZE	GRAIN SIZE	APPROXIMATE SIZE
Boulders		> 12"	> 12"	Larger than basketball-sized
Cobbles		3 - 12"	3 - 12"	Fist-sized to basketball-sized
Gravel	Coarse	3/4 - 3"	3/4 - 3"	Thumb-sized to fist-sized
	Fine	#4 - 3/4"	0.19 - 0.75"	Pea-sized to thumb-sized
Sand	Coarse	#10 - #4	0.079 - 0.19"	Rock-salt-sized to pea-sized
	Medium	#40 - #10	0.017 - 0.079"	Sugar-sized to rock-salt-sized
	Fine	#200 - #40	0.0029 - 0.017"	Flour-sized to sugar-sized
Fines		Passing #200	< 0.0029"	Flour-sized and smaller

PLASTICITY CHART



APPARENT DENSITY - COARSE-GRAINED SOIL

APPARENT DENSITY	SPOOLING CABLE OR CATHEAD		AUTOMATIC TRIP HAMMER	
	SPT (blows/foot)	MODIFIED SPLIT BARREL (blows/foot)	SPT (blows/foot)	MODIFIED SPLIT BARREL (blows/foot)
Very Loose	≤ 4	≤ 8	≤ 3	≤ 5
Loose	5 - 10	9 - 21	4 - 7	6 - 14
Medium Dense	11 - 30	22 - 63	8 - 20	15 - 42
Dense	31 - 50	64 - 105	21 - 33	43 - 70
Very Dense	> 50	> 105	> 33	> 70

CONSISTENCY - FINE-GRAINED SOIL

CONSIS-TENCY	SPOOLING CABLE OR CATHEAD		AUTOMATIC TRIP HAMMER	
	SPT (blows/foot)	MODIFIED SPLIT BARREL (blows/foot)	SPT (blows/foot)	MODIFIED SPLIT BARREL (blows/foot)
Very Soft	< 2	< 3	< 1	< 2
Soft	2 - 4	3 - 5	1 - 3	2 - 3
Firm	5 - 8	6 - 10	4 - 5	4 - 6
Stiff	9 - 15	11 - 20	6 - 10	7 - 13
Very Stiff	16 - 30	21 - 39	11 - 20	14 - 26
Hard	> 30	> 39	> 20	> 26

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USCS METHOD OF SOIL CLASSIFICATION

Explanation of USCS Method of Soil Classification

PROJECT NO.	DATE	FIGURE

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	BORING LOG EXPLANATION SHEET
0								Bulk sample.
								Modified split-barrel drive sampler.
								No recovery with modified split-barrel drive sampler.
								Sample retained by others.
								Standard Penetration Test (SPT).
5								No recovery with a SPT.
			XX/XX					Shelby tube sample. Distance pushed in inches/length of sample recovered in inches.
								No recovery with Shelby tube sampler.
								Continuous Push Sample.
								Seepage.
10								Groundwater encountered during drilling.
								Groundwater measured after drilling.
							SM	<u>MAJOR MATERIAL TYPE (SOIL)</u>: Solid line denotes unit change.
							CL	Dashed line denotes material change.
								Attitudes: Strike/Dip b: Bedding c: Contact j: Joint f: Fracture F: Fault cs: Clay Seam s: Shear bss: Basal Slide Surface sf: Shear Fracture sz: Shear Zone sbs: Shear Bedding Surface
15								
								The total depth line is a solid line that is drawn at the bottom of the boring.
20								

Ninyo & Moore

BORING LOG

Explanation of Boring Log Symbols

PROJECT NO.	DATE	FIGURE

Updated Nov. 2011

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 5 inches thick.
							SC	ALLUVIUM: Brown, dry, medium dense, clayey SAND; few gravel; scattered caliche nodules.
			26					
								Total Depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt concrete patched on 9/30/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of pub-lished maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
5								
10								
15								
20								

DATE DRILLED 9/30/15 BORING NO. B-1

GROUND ELEVATION 2,404 ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Hollow Stem Auger (Southlands)

DRIVE WEIGHT 140 lbs. Automatic DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - TUCSON BLVD
GLENN STREET TO GRANT ROAD TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-1

DATE DRILLED	10/1/15	BORING NO.	B-2
GROUND ELEVATION	2,413 ± (MSL)	SHEET 1 OF 1	
METHOD OF DRILLING	CME-75, 8" Hollow Stem Auger (Southlands)		
DRIVE WEIGHT	140 lbs. Automatic	DROP	30"
SAMPLED BY	DM	LOGGED BY DM	REVIEWED BY

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 4 1/2 inches thick.
							GP	Aggregate base - 3 inches.
							SC	ALLUVIUM: Brown, dry, dense, clayey SAND; few gravel; numerous caliche nodules.
		X	63					
								Total Depth = 3 feet. Groundwater not encountered during drilling. Backfilled and asphalt concrete patched on 10/1/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of pub-lished maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
5								
10								
15								
20								

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - TUCSON BLVD
GLENN STREET TO GRANT ROAD TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-2

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 4 inches thick.
							SC	ALLUVIUM: Brown, dry, very dense, clayey SAND; few to little gravel, scattered caliche nodules.
		X	50/3					
								Total Depth = 2 1/4 feet. Groundwater not encountered during drilling. Backfilled and asphalt concrete patched on 9/30/15 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of pub-lished maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
5								
10								
15								
20								

DATE DRILLED 9/30/15 BORING NO. B-3

GROUND ELEVATION 2,421 ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Hollow Stem Auger (Southlands)

DRIVE WEIGHT 140 lbs. Automatic DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY

Ninyo & Moore

BORING LOG

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - TUCSON BLVD
GLENN STREET TO GRANT ROAD TUCSON, ARIZONA

PROJECT NO.	DATE	FIGURE
604817002	12/15	A-3

APPENDIX B

LABORATORY TESTING

Classification

Soils were visually and texturally classified in accordance with the Unified Soil Classification System (USCS) in general accordance with ASTM D 2488. Soil classifications are indicated on the logs of the exploratory borings in Appendix A.

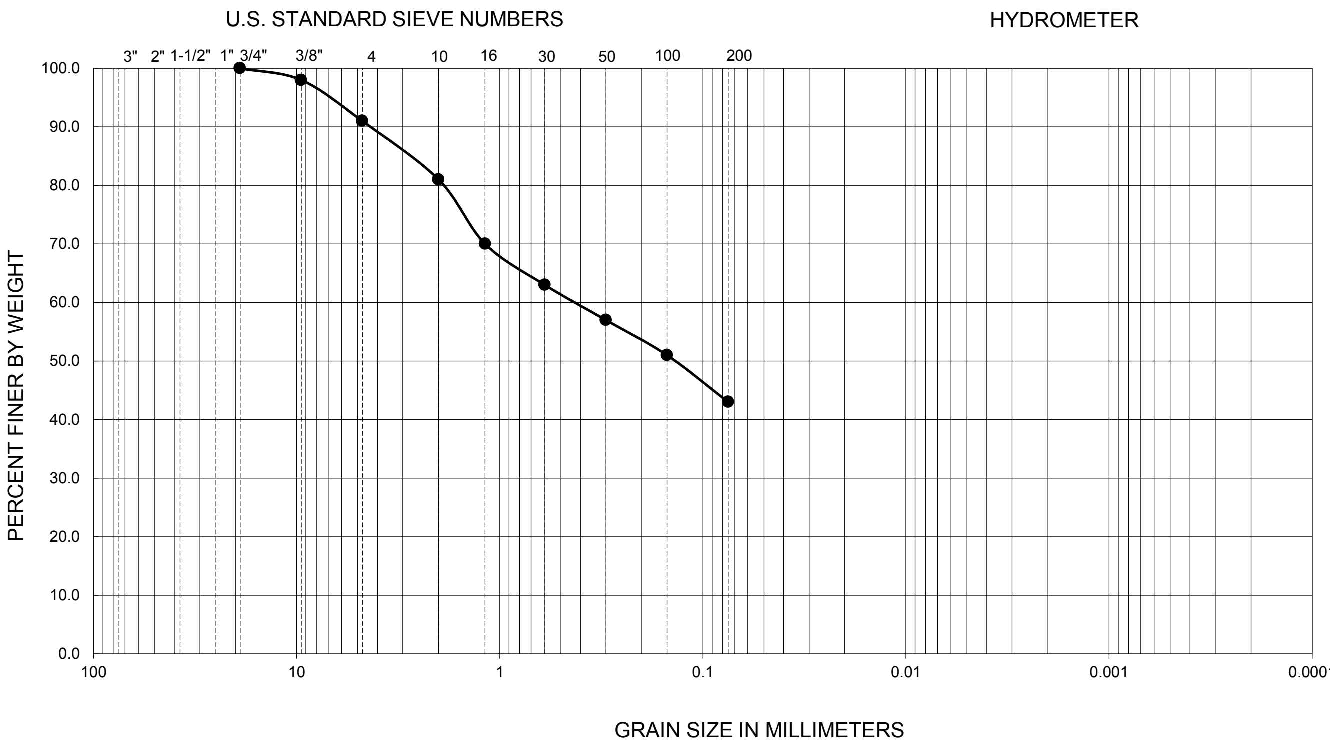
Gradation Analysis

One gradation analysis test was performed on a selected representative soil sample in general accordance with ASTM D 422. The grain-size distribution curves are shown in Figures B-1 and B-2. These test results were utilized in evaluating the soil classification in accordance with the USCS.

Atterberg Limits

Tests were performed on a selected representative fine-grained soil sample to evaluate the liquid limit, plastic limit, and plasticity index in general accordance with ASTM D 4318. These test results were utilized to evaluate the soil classification in accordance with the USCS. The test results and classifications are shown on Figure B-3.

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
●	B-1	1.5-3.0	39	22	17	--	--	--	--	--	43	SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore

GRADATION TEST RESULTS

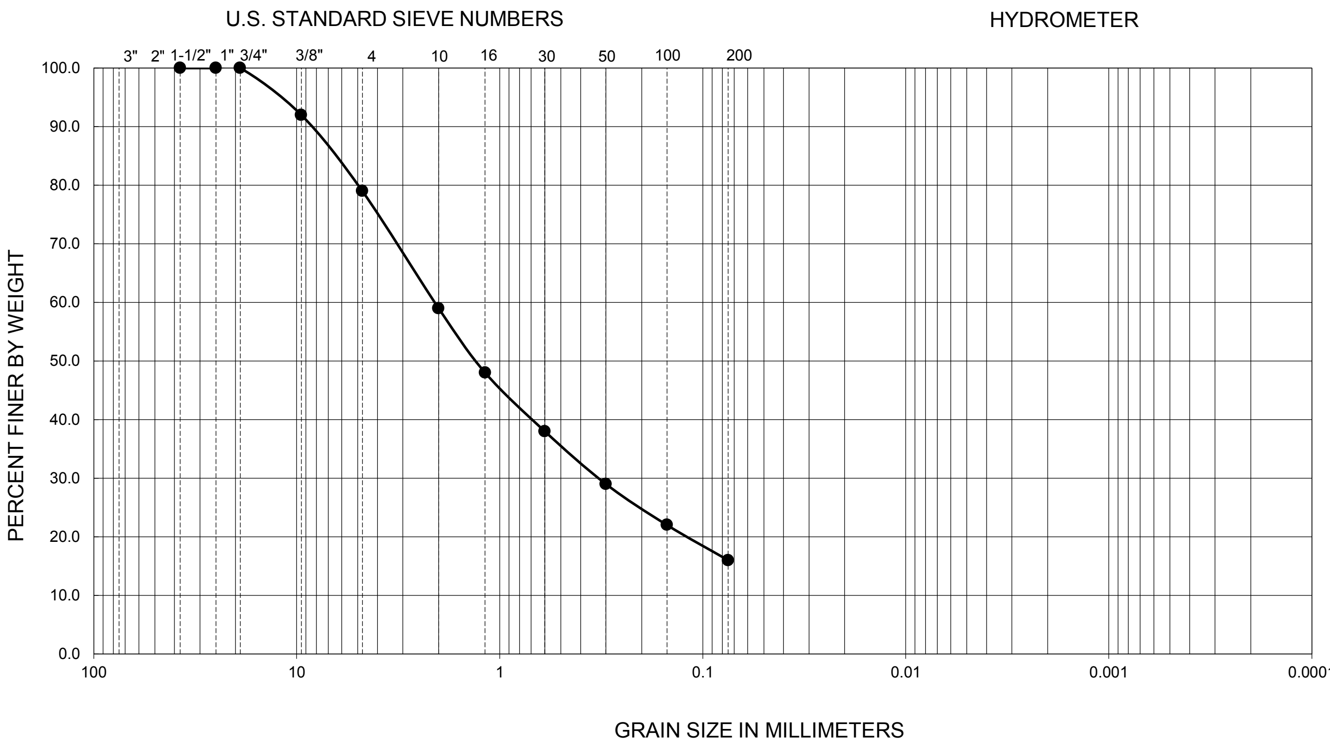
PROJECT NO.	DATE
604817002	12/15

TUCSON PAVEMENT RECONSTRUCTION PROGRAM - TUCSON BOULEVARD
BETWEEN GLENN STREET AND GRANT ROAD
TUCSON, ARIZONA

FIGURE

B-1

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



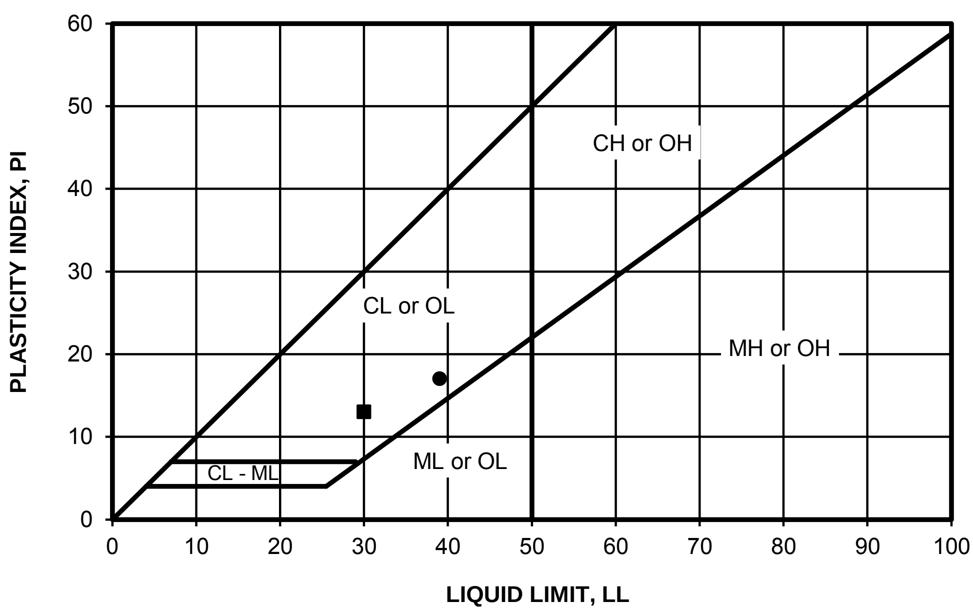
Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
●	B-3	1.5-3.0	30	17	13	--	--	--	--	--	16	SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore		GRADATION TEST RESULTS	FIGURE
PROJECT NO.	DATE	TUCSON PAVEMENT RECONSTRUCTION PROGRAM - TUCSON BOULEVARD BETWEEN GLENN STREET AND GRANT ROAD TUCSON, ARIZONA	B-2
604817002	12/15		

SYMBOL	LOCATION	DEPTH (FT)	LIQUID LIMIT, LL	PLASTIC LIMIT, PL	PLASTICITY INDEX, PI	USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve)	USCS (Entire Sample)
●	B-1	1.5-3.0	39	22	17	CL	SC
■	B-3	1.5-3.0	30	17	13	CL	SC

NP - INDICATES NON-PLASTIC



PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4318

APPENDIX C

PAVEMENT AND CORE SUMMARY

TUCSON BOULEVARD (GLENN STREET TO GRANT ROAD) - PAVEMENT AND CORE SUMMARY

No.	Location	Approximate AC thickness (in)*	Recovered AC Thickness (in)	Core Description	Pavement Condition
B-1	Northbound, 425 feet south of Glenn Street	5	5	Two lifts, 2" and 3", few voids.	Extensive transverse, block and irregular cracking, some sealed, raveling, potholes developing. patches.
B-2	Southbound, 80 feet north of Cooper Street	4.5	4.5	Two lifts, 2" and 2.5", numerous voids.	Extensive transverse, longitudinal, alligator and irregular cracking, some sealed, raveling, patches.
B-3	Northbound, 340 feet north of Grant Street	4	4	Two lifts, 2.5" and 1.5", bottom lift cracked, numerous voids.	Extensive transverse, longitudinal, alligator and irregular cracking, some sealed, raveling, patches.

Notes:

* Measured in the boring

APPENDIX D

TRAFFIC DATA

Field Data Services of Arizona

21636 N. Dietz Dr.
Maricopa, AZ 85138
(520) 316-6745

Site Code: 15-1283-005
Station ID: Wed 10/14/2015
Tucson Blvd. btwn. Grant Rd. & Water St.
32.251453, -110.935304
Latitude: 0' 0.000 Undefined

Northbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/14/15	0	30	9	0	0	1	0	0	0	0	0	0	0	40
01:00	0	14	5	0	0	0	0	0	0	0	0	0	0	19
02:00	0	13	3	0	0	0	0	0	0	0	0	0	0	16
03:00	0	8	0	0	0	0	0	1	0	0	0	0	0	9
04:00	0	13	3	0	0	0	0	0	0	0	0	0	0	16
05:00	0	33	7	0	0	0	0	0	0	0	0	0	0	40
06:00	0	73	22	0	1	**3**	0	1	1	0	1	0	0	102
07:00	**1**	238	29	**2**	3	0	0	2	3	**1**	2	**1**	**4**	286
08:00	1	222	41	2	**6**	1	**2**	3	0	1	**3**	0	1	283
09:00	1	216	43	1	0	0	0	1	0	0	1	0	0	263
10:00	1	230	42	2	1	1	0	**4**	1	0	0	1	0	283
11:00	1	**246**	**46**	1	1	0	1	1	**4**	0	1	0	0	**302**
12 PM	3	287	**52**	0	**5**	0	0	3	1	1	2	0	2	356
13:00	3	275	49	2	2	0	0	1	0	0	2	0	1	335
14:00	4	308	48	0	0	0	1	1	2	0	0	1	**5**	370
15:00	2	374	49	2	0	0	0	3	0	1	0	1	3	435
16:00	4	431	36	3	2	0	**2**	4	4	**2**	1	1	5	495
17:00	**8**	**483**	47	**4**	4	**1**	0	3	**5**	0	**4**	**5**	3	**567**
18:00	3	288	25	0	0	0	1	**5**	1	0	0	0	1	324
19:00	0	203	20	0	0	0	0	1	1	0	0	0	0	225
20:00	0	152	15	0	0	0	0	0	0	0	0	0	0	167
21:00	0	118	8	0	0	0	0	0	0	0	0	0	0	126
22:00	0	74	6	0	0	0	0	0	0	0	0	0	0	80
23:00	0	49	9	0	0	0	0	0	0	0	0	0	0	58
Total	32	4378	614	19	25	7	7	34	23	6	17	10	25	5197
Percent	0.6%	84.2%	11.8%	0.4%	0.5%	0.1%	0.1%	0.7%	0.4%	0.1%	0.3%	0.2%	0.5%	
AM Peak	07:00	11:00	11:00	07:00	08:00	06:00	08:00	10:00	11:00	07:00	08:00	07:00	07:00	11:00
Vol.	1	246	46	2	6	3	2	4	4	1	3	1	4	302
PM Peak	17:00	17:00	12:00	17:00	12:00	17:00	16:00	18:00	17:00	16:00	17:00	17:00	14:00	17:00
Vol.	8	483	52	4	5	1	2	5	5	2	4	5	5	567
Grand Total	32	4378	614	19	25	7	7	34	23	6	17	10	25	5197
Percent	0.6%	84.2%	11.8%	0.4%	0.5%	0.1%	0.1%	0.7%	0.4%	0.1%	0.3%	0.2%	0.5%	

Field Data Services of Arizona

21636 N. Dietz Dr.
Maricopa, AZ 85138
(520) 316-6745

Site Code: 15-1283-005
Station ID: Wed 10/14/2015
Tucson Blvd. btwn. Grant Rd. & Water St.
32.251453, -110.935304
Latitude: 0' 0.000 Undefined

Southbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/14/15	0	20	3	0	0	0	0	0	0	0	0	0	0	23
01:00	0	10	3	0	0	0	0	0	0	0	0	0	0	13
02:00	0	2	0	0	0	0	0	0	0	0	0	0	0	2
03:00	0	5	1	0	1	0	0	1	0	0	0	0	0	8
04:00	0	13	5	0	0	0	0	0	0	0	0	0	0	18
05:00	0	60	18	0	0	1	0	0	0	0	0	0	0	79
06:00	1	178	44	0	0	1	0	0	0	0	0	0	0	224
07:00	2	**338**	**66**	2	1	1	0	1	0	0	0	**1**	1	**413**
08:00	**3**	288	37	**5**	**6**	**2**	0	**3**	**2**	1	0	1	**3**	351
09:00	1	233	51	5	1	2	0	0	0	**2**	0	0	1	296
10:00	0	213	53	3	2	0	0	0	1	0	**1**	0	0	273
11:00	2	264	58	2	3	1	0	2	0	0	0	0	0	332
12 PM	**3**	251	57	3	3	**3**	0	0	1	0	1	1	1	324
13:00	0	261	55	4	2	3	0	2	0	0	**2**	0	1	330
14:00	2	239	58	3	0	2	0	3	2	0	1	1	**4**	315
15:00	0	267	57	5	**6**	2	1	**4**	**4**	0	2	0	2	350
16:00	2	**289**	**65**	**6**	3	1	**2**	3	1	0	2	**3**	3	**380**
17:00	2	238	48	3	5	1	0	0	0	**1**	1	1	0	300
18:00	1	184	28	0	0	1	2	1	1	0	0	0	1	219
19:00	0	201	32	2	2	0	0	1	2	0	0	0	0	240
20:00	0	132	20	0	1	0	0	0	0	0	0	0	0	153
21:00	0	89	10	0	1	0	0	0	0	0	0	0	0	100
22:00	0	45	7	0	0	0	0	0	0	0	0	0	0	52
23:00	0	29	4	0	0	0	0	0	0	0	0	0	0	33
Total	19	3849	780	43	37	21	5	21	14	4	10	8	17	4828
Percent	0.4%	79.7%	16.2%	0.9%	0.8%	0.4%	0.1%	0.4%	0.3%	0.1%	0.2%	0.2%	0.4%	
AM Peak	08:00	07:00	07:00	08:00	08:00	08:00		08:00	08:00	09:00	10:00	07:00	08:00	07:00
Vol.	3	338	66	5	6	2		3	2	2	1	1	3	413
PM Peak	12:00	16:00	16:00	16:00	15:00	12:00	16:00	15:00	15:00	17:00	13:00	16:00	14:00	16:00
Vol.	3	289	65	6	6	3	2	4	4	1	2	3	4	380
Grand Total	19	3849	780	43	37	21	5	21	14	4	10	8	17	4828
Percent	0.4%	79.7%	16.2%	0.9%	0.8%	0.4%	0.1%	0.4%	0.3%	0.1%	0.2%	0.2%	0.4%	

Field Data Services of Arizona
21636 N. Dietz Dr.
Maricopa, AZ 85138
(520) 316-6745

Site Code: 15-1283-005
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Tucson Blvd. btwn. Grant Rd. & Water St.
32.251453, -110.935304
Latitude: 0' 0.000 Undefined

Northbound, Southbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/14/15	0	50	12	0	0	1	0	0	0	0	0	0	0	63
01:00	0	24	8	0	0	0	0	0	0	0	0	0	0	32
02:00	0	15	3	0	0	0	0	0	0	0	0	0	0	18
03:00	0	13	1	0	1	0	0	2	0	0	0	0	0	17
04:00	0	26	8	0	0	0	0	0	0	0	0	0	0	34
05:00	0	93	25	0	0	1	0	0	0	0	0	0	0	119
06:00	1	251	66	0	1	**4**	0	1	1	0	1	0	0	326
07:00	3	**576**	95	4	4	1	0	3	3	1	2	**2**	**5**	**699**
08:00	**4**	510	78	**7**	**12**	3	**2**	**6**	2	**2**	**3**	1	4	634
09:00	2	449	94	6	1	2	0	1	0	2	1	0	1	559
10:00	1	443	95	5	3	1	0	4	2	0	1	1	0	556
11:00	3	510	**104**	3	4	1	1	3	**4**	0	1	0	0	634
12 PM	6	538	**109**	3	8	**3**	0	3	2	1	3	1	3	680
13:00	3	536	104	6	4	3	0	3	0	0	4	0	2	665
14:00	6	547	106	3	0	2	1	4	4	0	1	2	**9**	685
15:00	2	641	106	7	6	2	1	**7**	4	1	2	1	5	785
16:00	6	720	101	**9**	5	1	**4**	7	**5**	**2**	3	4	8	**875**
17:00	**10**	**721**	95	7	**9**	2	0	3	5	1	**5**	**6**	3	867
18:00	4	472	53	0	0	1	3	6	2	0	0	0	2	543
19:00	0	404	52	2	2	0	0	2	3	0	0	0	0	465
20:00	0	284	35	0	1	0	0	0	0	0	0	0	0	320
21:00	0	207	18	0	1	0	0	0	0	0	0	0	0	226
22:00	0	119	13	0	0	0	0	0	0	0	0	0	0	132
23:00	0	78	13	0	0	0	0	0	0	0	0	0	0	91
Total	51	8227	1394	62	62	28	12	55	37	10	27	18	42	10025
Percent	0.5%	82.1%	13.9%	0.6%	0.6%	0.3%	0.1%	0.5%	0.4%	0.1%	0.3%	0.2%	0.4%	
AM Peak	08:00	07:00	11:00	08:00	08:00	06:00	08:00	08:00	11:00	08:00	08:00	07:00	07:00	07:00
Vol.	4	576	104	7	12	4	2	6	4	2	3	2	5	699
PM Peak	17:00	17:00	12:00	16:00	17:00	12:00	16:00	15:00	16:00	16:00	17:00	17:00	14:00	16:00
Vol.	10	721	109	9	9	3	4	7	5	2	5	6	9	875
Grand Total	51	8227	1394	62	62	28	12	55	37	10	27	18	42	10025
Percent	0.5%	82.1%	13.9%	0.6%	0.6%	0.3%	0.1%	0.5%	0.4%	0.1%	0.3%	0.2%	0.4%	

APPENDIX E

PAVEMENT OPTIMIZATION DESIGN ANALYSIS BY TENSAR

Tensar

SpectraPave4 PRO™
Pavement Optimization Design Analysis

Design Parameters for AASHTO (1993) Equation

Reliability (%)	= 95	Initial Serviceability	= 4.5
Standard Normal Deviate	= -1.645	Terminal Serviceability	= 2.5
Standard Deviation	= 0.4	Change in Serviceability	= 2

Aggregate fill shall conform to following requirement:

D50 <= 27mm (Base course)

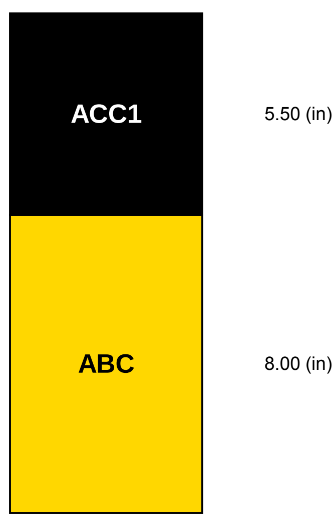
Unstabilized Section Material Properties

Layer	Description	Cost ($/ton)	Layer coefficient	Drainage factor
ACC1	Asphalt Wearing Course	70	0.440	N/A
ABC	Aggregate Base Course	15	0.140	1.25

Stabilized Section Material Properties

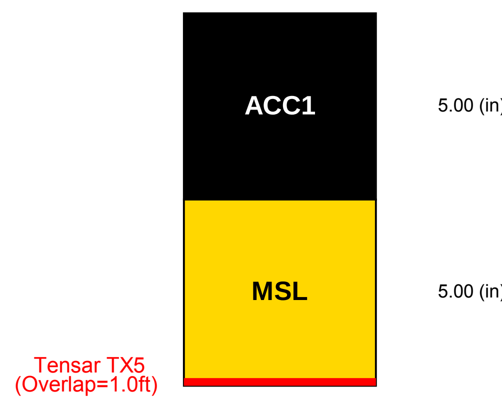
Layer	Description	Cost ($/ton)	Layer coefficient	Drainage factor
ACC1	Asphalt Wearing Course	70	0.440	N/A
MSL	Mechanically Stabilized Base Cour	15	0.286	1.25

Unstabilized Pavement



Subgrade Modulus = 10,844 (psi)
Structural Number = 3.820
Calculated Traffic (ESALs) = 4,405,000

Stabilized Pavement



Subgrade Modulus = 10,844 (psi)
Structural Number = 3.988
Calculated Traffic (ESALs) = 5,872,000

LIMITATIONS OF THE REPORT

The designs, illustrations, information and other content included in this report are necessarily general and conceptual in nature, and do not constitute engineering advice or any design intended for actual construction. Specific design recommendations can be provided as the project develops.

Project Name	Tucson South		
Company Name	Tensar		
Designer	Schlessinger	Date	12/11/15

This document was prepared using SpectraPave4 PRO™ Software Version 4.6.1
Developed by Tensar International Corporation