GEOMAT INC.
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September 11, 2014

Drew Chandler, P.E.
Russell Planning and Engineering, Inc.
934 Main Avenue, Unit C
Durango, Colorado 81301

RE: Geotechnical Engineering Study
City of Aztec North Main Corridor
Aztec, New Mexico
GEOMAT Project No. 132-1862

GEOMAT Inc. (GEOMAT) has completed the geotechnical engineering exploration for the proposed North Main Corridor project located in Aztec, New Mexico. This study was performed in general accordance with the scope of work described in our Proposal No. 132-06-09, dated July 19, 2013.

The purpose of our exploration was to characterize and evaluate the subsurface conditions along the proposed project alignment and to provide pavement thickness options for the street. This report presents the results of our exploratory drilling, laboratory testing, and engineering analyses, including the following:

- logs of the test borings, a site plan showing their locations, and a description of procedures and equipment used during subsurface exploration;
- a description of the subsurface soil and groundwater conditions;
- recommended pavement thickness options; and
- recommendations for supporting the box culvert.

Project Understanding:

We understand the project will consist of constructing a new street between the intersection of North Main Avenue and Aztec Boulevard on the south to its terminus near Martinez Lane on the north, a distance of roughly 1,500 linear feet. The street will be two lanes in width, and it will terminate in a turn-around and/or parking area on the north end.

We also understand that the project will include a twin concrete box culvert structure where the alignment crosses Hampton Arroyo near the north end of the project. Each box culvert will be approximately 8 feet wide by 32 feet long by 12 feet high; the two culverts will be installed side-by-side to form a single structure.

Subsurface Exploration:

Subsurface conditions along the proposed alignment were explored on October 10, 2013, by drilling a total of four exploratory borings at the approximate locations shown on the **Site Plan** in Appendix A. The borings, designated B-1 through B-4, were advanced to depths of approximately 6 to 10 feet using a CME-45 truck-mounted drill rig with continuous-flight, 7.25-inch O.D. hollow-stem auger.

The borings were continuously monitored by a geologist from our office who examined and classified the subsurface materials encountered, obtained representative bulk samples of the auger cuttings, observed groundwater conditions, and maintained a continuous log of each boring. Soils were classified in accordance with the Unified Soil Classification System described in Appendix A. **Boring Logs** were prepared and are presented in Appendix A.

Subsurface Conditions:

As presented on the **Boring Logs** in Appendix A, we encountered generally sandy soils overlying clayey soils. The sandy soils extended to depths of approximately 2 to 7 feet below existing ground surface, and ranged in composition from silty sand to clayey sand. The sandy soils were generally fine-grained and damp to moist.

Below the sandy soils, we encountered clayey soils extending to the total depths explored, except at the location of boring B-4, where we encountered dense gravel and cobbles beneath the clayey soils at a depth of approximately 5.5 feet. The clayey soils were generally moist, except at the location of B-3, where they were moist to wet. In B-4, gravel/cobbles were encountered at a depth of approximately 5.5 feet; the boring was terminated short of its planned depth due to auger refusal on cobbles.

Groundwater was encountered in boring B-3 during drilling at a depth of approximately 7 feet below existing ground surface. Groundwater was not encountered in the other borings to the depths explored. Groundwater elevations can fluctuate over time depending upon precipitation, irrigation, runoff/infiltration of surface water, and the level of water in the Animas River. We do not have any information regarding the historical fluctuation of the groundwater level in this vicinity.

Laboratory Analysis:

Selected samples of the native subgrade soils were tested for grain-size distribution (sieve analysis, ASTM C136/C117), plasticity index (ASTM D4318), and R-Value (ASTM D2844). Each sample tested was classified per ASTM procedures.

Laboratory analyses of representative samples indicate the native soils have fines contents (silt- and/or clay-sized particles passing the U.S. No. 200 sieve) ranging from approximately 18 to 59 percent. The plasticity index of a representative sample of the clayey soil was 31.

The results of all laboratory tests are presented in the **Summary of Soil Tests** Table in Appendix B.

Recommended Pavement Sections:

Design of pavements for the project has been based on the procedures outlined in the Guideline for Design of Pavement Structures by the American Association of State Highway and Transportation Officials (AASHTO), and on the Guide for the Design and Construction of Concrete Parking Lots by the American Concrete Institute (ACI 330).

Average daily traffic (ADT) volume projections for this project were provided by the City of Aztec. We understand the average daily traffic (ADT) is estimated to be 3,000 vehicles per day, with trucks comprising approximately 10 percent of the total traffic.

A design R-Value of 59 was used for our analyses. Any imported fill material required for the project should have a minimum R-Value of 59.

We are presenting options for both flexible (asphalt) and rigid (concrete) pavement sections. The recommended pavement sections are presented in the tables below.

Recommended Asphalt Pavement Sections for North Main Corridor			
Option	**Hot Mix Asphalt** (inches)	**Aggregate Base Course** (inches)	**Geogrid**
A	4.0	8.0	--
B	3.0	7.0	TX5

Recommended Concrete Pavement Sections for North Main Corridor			
Option	**Edge Support (Curb and Gutter)**	**Portland Cement Concrete** (inches)	**Maximum Transverse Joint Spacing** (feet)
C	Yes	5.0	8.75
D	No	6.0	10.5

Construction Recommendations for Flexible (Asphalt) Pavements:

The subgrade should be proof-rolled prior to placement of the aggregate base course, using a heavy vehicle such as a loaded dump truck or water truck, and any soft or pumping areas should be repaired by removing and replacing the soft material with suitable fill material having a minimum R-Value of 59. The proof-rolling should be conducted under the observation of a representative of GEOMAT.

If the geogrid-reinforced option (Option B) is used, the geogrid should be placed on top of the prepared subgrade prior to placing the aggregate base course. The geogrid should be Tensar TX5 or equivalent.

Aggregate base course should conform to Section 303 of the NMDOT specifications for Base Course.

If the hot-mix asphalt is placed in more than one mat, the surface of each underlying mat should be treated with a tack coat immediately prior to placement of the subsequent mat of hot-mix asphalt. Asphalt concrete should be obtained from an engineer-approved mix design prepared in accordance with NMDOT specifications. The hot-mix paving should be placed and compacted in accordance with NMDOT specifications.

Construction Recommendations for Rigid (Concrete) Pavements:

The subgrade should be proof-rolled prior to paving, using a heavy vehicle such as a loaded dump truck or water truck, and any soft or pumping areas should be repaired by removing and replacing the soft material with suitable fill material having a minimum R-Value of 59. The proof-rolling should be conducted under the observation of a representative of GEOMAT.

Concrete should be placed directly on the prepared subgrade. Reinforcing steel is not required or recommended for rigid pavement sections. Concrete used for pavement sections should conform to NMDOT specifications and have a minimum 28-day compressive strength of 4,000 pounds per square inch (psi).

General Pavement Considerations:

The performance of the recommended pavement sections can be enhanced by minimizing excess moisture that can reach the subgrade soils. The following recommendations should be considered at minimum:

- Site grading at a minimum 2% grade away from the pavements;
- Compaction of any utility trenches to the same criteria as the pavement subgrade.

The recommended pavement sections are considered minimal sections based on the anticipated traffic volumes and the subgrade conditions encountered during our exploration. We estimate the design life of the new pavement will be on the order of 20 years. The pavement is expected to perform adequately when used in conjunction with preventive maintenance and good drainage. The pavement must be maintained for durability and integrity during that period. Periodic seal coating, crack sealing and/or patching may be required. Preventive maintenance activities are intended to slow the rate of pavement deterioration and to preserve the pavement investment.

Recommendations presented above are predicated on observation and testing by GEOMAT during construction. Testing and observation should be conducted as specified in the aforementioned NMDOT specifications.

Culvert Structure Support:

The site is considered suitable for the proposed culvert structure based on the geotechnical conditions encountered and tested for this report. Based on our understanding of the type of culvert structure to be built and the results of our field subsurface exploration and laboratory testing, the structure could be supported on compacted native gravel/cobbles.

The bottom of the structure should bear a minimum of three feet below the invert depth of the channel and at least two feet below the maximum anticipated scour depth, whichever is deeper. To provide more uniform bearing conditions, the bottom of the excavation should be proof-compacted prior to installation of the structure. If necessary, a minimum thickness of four (4.0) inches of compacted aggregate base course or flowable fill could be placed on top of the gravel/cobble surface to provide a smooth bearing surface for the structure.

GEOMAT should observe the foundation excavation to verify that the intended bearing stratum has been exposed. If soil conditions are encountered that differ significantly from those presented in this report, supplemental recommendations will be required.

The recommended design bearing capacities and footing depths are as shown on the table below:

Footing Depth[1] (ft)		**Allowable Bearing Pressure (psf)**	**Bearing Soil**
Below Finish Grade	Below Scour Depth		
3	2	2,500	Gravel/Cobbles
4	2	3,000	Gravel/Cobbles

[1]Footing depth referenced below lowest adjacent finished grade or below scour depth, whichever is deeper. Finished grade is the lowest adjacent grade.

Total and differential settlements resulting from the assumed structural loads are estimated to be on the order of ½ inch or less.

We have appreciated being of service to you in the geotechnical engineering phase of this project. If you have any questions concerning this report, please contact us.

Sincerely yours,
GEOMAT Inc.

Donald R. Baldwin
Geologist

GEORGE A. MADRID
NEW MEXICO
9110
REGISTERED PROFESSIONAL ENGINEER

George A. Madrid, P.E.
President, Principal Engineer

9.11.14

Copies to: Addressee (1)

Approximate Not to Scale	SITE PLAN Boring Locations (approximate) GEOMAT Project No. 132-1862 Date of Exploration: Oct 10, 2013	PROJECT City of Aztec North Main Corridor

GEOMAT INC

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Borehole B-1

Project Name: COA North Main Corridor
Project Number: 132-1862
Client: Russell Engineering, Inc.
Site Location: Aztec, New Mexico
Rig Type: CME-45
Drilling Method: 7.25" O.D. Hollow Stem Auger
Sampling Method: Bulk sample from auger cuttings
Hammer Weight: N/A
Hammer Fall: N/A

Date Drilled: 10/10/2013
Latitude: Not Determined
Longitude: Not Determined
Elevation: Not Determined
Boring Location: See Site Plan
Groundwater Depth: None Encountered
Logged By: DB
Remarks: None

Laboratory Results: Dry Density (pcf)	Laboratory Results: % Passing #200 Sieve	Laboratory Results: Plasticity Index	Laboratory Results: Moisture Content (%)	Blows per 6"	Sample Type & Length (in)	Recovery	USCS	Soil Symbol	Depth (ft)	Soil Description
					A		SM		1 2 3	SILTY SAND, brown, fine-grained, damp (probable FILL)
							SC		4 5 6	CLAYEY SAND with trace gravel, dark brown, fine-grained, moist
	77	31			GRAB		CL/CH		7 8 9 10	LEAN to FAT CLAY with sand, blue-gray, moist
									11 12 13 14 15	Total Depth 10 feet

A = Auger Cuttings MC = Modified California (Ring Sample) SS = Split Spoon PP = Pocket Penetrometer bgs = Below Existing Ground Surface

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Borehole B-2

Project Name:	COA North Main Corridor	Date Drilled:	10/10/2013
Project Number:	132-1862	Latitude:	Not Determined
Client:	Russell Engineering, Inc.	Longitude:	Not Determined
Site Location:	Aztec, New Mexico	Elevation:	Not Determined
Rig Type:	CME-45	Boring Location:	See Site Plan
Drilling Method:	7.25" O.D. Hollow Stem Auger	Groundwater Depth:	None Encountered
Sampling Method:	Bulk sample from auger cuttings	Logged By:	DB
Hammer Weight:	N/A	Remarks:	None
Hammer Fall:	N/A		

Laboratory Results: Dry Density (pcf)	Laboratory Results: % Passing #200 Sieve	Laboratory Results: Plasticity Index	Laboratory Results: Moisture Content (%)	Blows per 6"	Sample Type & Length (in)	Recovery	USCS	Soil Symbol	Depth (ft)	Soil Description
	38				A		SM		1 2	SILTY SAND with gravel, brown, fine-grained, damp
					GRAB		CL/CH		3 4 5 6 7 8 9 10	LEAN to FAT CLAY with sand, brown, moist blue-gray
									11 12 13 14 15	Total Depth 10 feet

A = Auger Cuttings MC = Modified California (Ring Sample) SS = Split Spoon PP = Pocket Penetrometer bgs = Below Existing Ground Surface

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Borehole B-3

Project Name:	COA North Main Corridor	Date Drilled:	10/10/2013
Project Number:	132-1862	Latitude:	Not Determined
Client:	Russell Engineering, Inc.	Longitude:	Not Determined
Site Location:	Aztec, New Mexico	Elevation:	Not Determined
Rig Type:	CME-45	Boring Location:	See Site Plan
Drilling Method:	7.25" O.D. Hollow Stem Auger	Groundwater Depth:	Approx. 7 ft during drilling
Sampling Method:	Bulk sample from auger cuttings	Logged By:	DB
Hammer Weight:	N/A	Remarks:	None
Hammer Fall:	N/A		

Laboratory Results: Dry Density (pcf)	Laboratory Results: % Passing #200 Sieve	Laboratory Results: Plasticity Index	Laboratory Results: Moisture Content (%)	Blows per 6"	Sample Type & Length (in)	Recovery	USCS	Soil Symbol	Depth (ft)	Soil Description
	26				A		SM		1–7	SILTY SAND, tan, fine-grained, damp red-brown
							CL/CH		7–10	LEAN to FAT CLAY with sand, gray, moist to wet
									10	Total Depth 10 feet

A = Auger Cuttings MC = Modified California (Ring Sample) SS = Split Spoon PP = Pocket Penetrometer bgs = Below Existing Ground Surface

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Borehole B-4

Project Name: COA North Main Corridor
Project Number: 132-1862
Client: Russell Engineering, Inc.
Site Location: Aztec, New Mexico
Rig Type: CME-45
Drilling Method: 7.25" O.D. Hollow Stem Auger
Sampling Method: Bulk sample from auger cuttings
Hammer Weight: N/A
Hammer Fall: N/A

Date Drilled: 10/10/2013
Latitude: Not Determined
Longitude: Not Determined
Elevation: Not Determined
Boring Location: See Site Plan
Groundwater Depth: None Encountered
Logged By: DB
Remarks: None

Laboratory Results: Dry Density (pcf)	Laboratory Results: % Passing #200 Sieve	Laboratory Results: Plasticity Index	Laboratory Results: Moisture Content (%)	Blows per 6"	Sample Type & Length (in)	Recovery	USCS	Soil Symbol	Depth (ft)	Soil Description
					GRAB		SM		1 2 3 4	SILTY SAND with gravel, brown, fine-grained, damp
							CL/CH		5	LEAN to FAT CLAY with sand, blue-gray, moist
							GP		6	GRAVEL with sand and cobbles, brown to gray, fine- to coarse-grained, moist
									7 8 9 10 11 12 13 14 15	Boring terminated at 6 feet due to auger refusal on cobbles Total Depth 6 feet

A = Auger Cuttings MC = Modified California (Ring Sample) SS = Split Spoon PP = Pocket Penetrometer bgs = Below Existing Ground Surface

UNIFIED SOIL CLASSIFICATION SYSTEM					CONSISTENCY OR RELATIVE DENSITY CRITERIA		
Major Divisions			Group Symbols	Typical Names			
Coarse-Grained Soils More than 50% retained on No. 4 sieve	**Gravels** 50% or more of coarse fraction retained on No. 4 sieve	Clean Gravels	GW	Well-graded gravels and gravel-sand mixtures, little or no fines	Standard Penetration Test Density of Granular Soils		
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines	Penetration Resistance, N (blows/ft.)	Relative Density	
		Gravels with Fines	GM	Silty gravels, gravel-sand-silt mixtures	0-4	Very Loose	
			GC	Clayey gravels, gravel-sand-clay mixtures	5-10	Loose	
	Sands More than 50% of coarse fraction passes No. 4 sieve	Clean Sands	SW	Well-graded sands and gravelly sands, little or no fines	11-30	Medium Dense	
			SP	Poorly graded sands and gravelly sands, little or no fines	31-50	Dense	
		Sands with Fines	SM	Silty sands, sand-silt mixtures	>50	Very Dense	
			SC	Clayey sands, sand-clay mixtures	Standard Penetration Test Density of Granular Soils		
Fine-Grained Soils 50% or more passes No. 200 sieve	**Silts and Clays** Liquid Limit 50 or less		ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands	Penetration Resistance, N (blows/ft.)	Consistency	Unconfined Compressive Strength (Tons/ft2)
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	<2	Very Soft	<0.25
			OL	Organic silts and organic silty clays of low plasticity	2-4	Soft	0.25-0.50
	Silts and Clays Liquid Limit greater than 50		MH	Inorganic silts, micaceous or diatomaceous free sands or silts, elastic silts	4-8	Firm	0.50-1.00
			CH	Inorganic clays of high plasticity, fat clays	8-15	Stiff	1.00-2.00
			OH	Organic clays of medium to high plasticity	15-30	Very Stiff	2.00-4.00
Highly Organic Soils			PT	Peat, mucic & other highly organic soils	>30	Hard	>4.0

U.S. Standard Sieve Sizes	3"	3/4"	#4	#10		#40	#200
Unified Soil Classification	Cobbles	Gravel		Sand			Silt or Clay
		coarse	fine	coarse	medium	fine	

MOISTURE CONDITIONS	
Dry	Absence of moist, dusty, dry to the touch
Slightly Damp	Below optimum moisture content for compaction
Moist	Near optimum moisture content, will moisten the hand
Very Moist	Above optimum moisture content
Wet	Visible free water, below water table

MATERIAL QUANTITY	
trace	0-5%
few	5-10%
little	10-25%
some	25-45%
mostly	50-100%

OTHER SYMBOLS	
R	Ring Sample
S	SPT Sample
B	Bulk Sample
▼	Ground Water

BASIC LOG FORMAT:

Group name, Group symbol, (grain size), color, moisture, consistency or relative density. Additional comments: odor, presence of roots, mica, gypsum, coarse particles, etc.

EXAMPLE:

SILTY SAND w/trace silt (SM-SP), Brown, loose to med. Dense, fine to medium grained, damp

UNIFIED SOIL CLASSIFICATION SYSTEM

TEST DRILLING EQUIPMENT & PROCEDURES

Description of Subsurface Exploration Methods

Drilling Equipment – Truck-mounted drill rigs powered with gasoline or diesel engines are used in advancing test borings. Drilling through soil or softer rock is performed with hollow-stem auger or continuous flight auger. Carbide insert teeth are normally used on bits to penetrate soft rock or very strongly cemented soils which require blasting or very heavy equipment for excavation. Where refusal is experienced in auger drilling, the holes are sometimes advanced with tricone gear bits and NX rods using water or air as a drilling fluid.

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

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

LAB NO.	BORING NO.	SAMPLE DEPTH (ft)	SIEVE ANALYSIS, ACCUMULATIVE % PASSING														ATTERBERG LIMITS			R-VALUE	USCS CLASSIFICATION
			2"	1 1/2"	1"	3/4"	1/2"	3/8"	No. 4	No. 8	No. 10	No. 16	No. 30	No. 40	No. 50	No. 100	No. 200	LL	PL	PI		
15360	B-1	6 - 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	77	49	18	31	-	Lean CLAY w/ sand (CL)
15358	B-2	0 - 2.5	100.0	92	87	86	81	79	76	74	73	71	65	60	55	46	38	-	-	-	18	Silty SAND w/ gravel (SM)
15359	B-3	0 - 5	100.0	100	100	100	100	100	100	100	100	99	92	81	67	41	26	-	-	-	59	Silty SAND (SM)

GEOMAT INC.

SUMMARY OF SOIL TESTS

Project	North Main Corridor
Job No.	132-1862
Location	Aztec, New Mexico
Dates of Exploration	10/10/2013