adobe
TESTING SERVICES, INC.

GEOTECHNICAL & MATERIALS ENGINEERS
MATERIALS TESTING LABORATORIES

5616 S 122nd East Ave
Tulsa, Oklahoma 74146
Ph: 918-872-9898
Fax: 918-994-6390

July 23, 2012

Cherokee Nation Main Warehouse
22361 Bald Hill Road
Tahlequah, OK 74464

Attn: Ms. Vivian Kernes, Manager – Roads Operations

Re: Soil Boring Services – Four (4) Sites
P.O. #125092
Tahlequah, Oklahoma
ATSI Project No.: CN53012

Dear Ms. Kernes;

This letter report was prepared to summarize the results of a field investigation performed for the above referenced project. This investigation was authorized by a Cherokee Nation Purchase Order (PO #125092). The four (4) Cherokee Nation projects drilled during this investigation included;

- Hulbert/Lost City Rd. – Cherokee County – Project No. CN-0914-02
- CNI Industrial Access Rd. – Adair County – Project No. CN-0807-09
- Lyon Switch Rd. – Adair County – Project No. CN-0827-06
- Dreadfulwater Rd. – Cherokee County – CN-0957-07

It is understood this project will include design and construction of new roadways for the above existing alignments. The primary focus of this investigation was to characterize the existing subsurface conditions by field drilling and laboratory testing. Details regarding the field investigation and laboratory testing performed, as well as a summary of classification tests, are presented in the following sections of this report.

Field Investigation

Subsurface conditions at the sites were investigated by drilling a total of thirty (30) borings. Boring locations were selected and staked in the field by the Client's surveyor and are shown in Appendix I: Boring Locations Plans. It should be noted that all borings are designated with a "TH" followed by the boring number. For organization purposes all boring logs and references to boring locations in this report use a different lettering scheme followed by the same number given by Cherokee Nation. As previously mentioned, this numbering scheme was used to so that samples and logs could be organized more efficiently. All borings were drilled within or directly adjacent to the existing roadway to the depth specified by the Client, which ranged from 5 to 15 ft. below the existing ground surface. Borings were drilled using 4.5-inch O.D. continuous flight augers powered by a truck mounted BK-51 drill rig. Three (3) boring locations required the use

of rock coring procedures to extend the borings to the specified depth. Rock coring was performed using an NQ2 core barrel and diamond impregnated core bit. Following drilling, borings were backfilled and pavement patched, if present. Boring logs presenting the soil and rock types encountered, as well as results of laboratory testing (described below) are presented in Appendix II.

Laboratory Testing

Collected sampled were transported back to the laboratory for further evaluation and testing. Laboratory testing performed upon selected soil samples included grain size analyses and Atterberg Limit values. These tests were performed for verification of soil classification. Rock core obtained was logged and evaluated for recovery and rock quality designation (RQD). Laboratory testing results are presented on the Boring Logs in Appendix I. A summary of all laboratory soil testing is presented in the table below.

Summary of Soil Laboratory Testing

Project Location	Boring Number/Depth (ft)	Liquid Limit, LL	Plastic Limit, PL	Plasticity Index, PI	USCS Classification	USCS Symbol
Hulbert/Lost City	HL-1 / 0.5 -2	25	13	12	Clayey Sand w/ Gravel	SC
Hulbert/Lost City	HL-3 / 3-4.5	50	18	32	Sandy Fat Clay	CH
Hulbert/Lost City	HL-4 / 0.5-1.3	NP	NP	NP	Silty Sand w/ Gravel	SM
Hulbert/Lost City	HL-4 / 3-4.5	49	17	32	Clayey Sand	SC
Hulbert/Lost City	HL-5 / 3.5-5	NP	NP	NP	Clayey Sand w/ Gravel	SC
Hulbert/Lost City	HL-6 / 3.5-4.4	NP	NP	NP	Silty Sand w/ Gravel	SM
Hulbert/Lost City	HL-7 / 0.5-1.5	23	19	4	Silty, Clayey Sand w/ Gravel	SC-SM
Hulbert/Lost City	HL-8 / 0.5-2	34	26	8	Silty Sand w/ Gravel	SM
Hulbert/Lost City	HL-10 / 0.5-2	NP	NP	NP	Silty Gravel w/ Sand	GM
Hulbert/Lost City	HL-10 / 3.5-4.6	64	20	44	Clayey Sand w/ Gravel	SC
Lyon Switch	LS-1 / 3.5-5	30	14	16	Lean Clay	CL
Lyon Switch	LS-3 / 1-2.5	40	17	23	Lean Clay	CL
Lyon Switch	LS-4 / 0.5-2	NP	NP	NP	Gravelly Lean Clay w/ Sand	CL
Lyon Switch	LS-5 / 0.5-1.4	NP	NP	NP	Silty Sand w/ Gravel	SM
Lyon Switch	LS-6 / 1-2.5	23	15	8	Lean Clay w/ Gravel	CL
Lyon Switch	LS-7 / 0.5-2	61	24	37	Fat Clay	CH
Lyon Switch	LS-8 / 0.5-2	19	17	2	Silt	ML
Lyon Switch	LS-8 / 3.5-5	44	21	23	Lean Clay	CL
Lyon Switch	LS-9 / 3.5-5	28	12	16	Lean Clay	CL
Lyon Switch	LS-10 / 0.5-2	24	18	6	Gravelly Silty Clay	CL-ML

Note: NP = Non-Plastic

Summary of Soil Laboratory Testing – Cont'd

Project Location	Boring Number/Depth (ft)	Liquid Limit, LL	Plastic Limit, PL	Plasticity Index, PI	USCS Classification	USCS Symbol
Dreadfulwater	DW-1 / 0.5-1.4	NP	NP	NP	Silty Gravel w/ Sand	GM
Dreadfulwater	DW-1 / 3.5-3.8	NP	NP	NP	Sandy Silt w/ Gravel	SM
Dreadfulwater	DW-2 / 0.5-1.4	NP	NP	NP	Silty Gravel w/ Sand	GM
Dreadfulwater	DW-3 / 0.5-1.4	NP	NP	NP	Poorly Graded Gravel w/ Silt & Sand	GP-GM
Dreadfulwater	DW-4 / 1-2.5	NP	NP	NP	Silty Gravel w/ Sand	GM
Dreadfulwater	DW-4 / 3-4.5	NP	NP	NP	Silty Gravel w/ Sand	GM
Dreadfulwater	DW-5 / 0.5-2	27	16	11	Lean Clay	CL
Dreadfulwater	DW-5 / 3.5-5	27	17	20	Lean Clay	CL
CNI Industrial Access Rd.	CN-1 / 0-1.3	NP	NP	NP	Gravelly Silt w/ Sand	ML
CNI Industrial Access Rd.	CN-2 / 0-1.5	NP	NP	NP	Silt w/ Gravel	ML
CNI Industrial Access Rd.	CN-3 / 0-1.5	19	16	3	Silt	ML
CNI Industrial Access Rd.	CN-3 / 3.5-5	43	19	24	Lean Clay w/ Gravel	CL
CNI Industrial Access Rd.	CN-4 / 0-0.9	NP	NP	NP	Clayey Sand w/ Gravel & Asphalt Debris	SM
CNI Industrial Access Rd.	CN-5 / 1-2.5	26	14	12	Lean Clay w/ Gravel	CL
CNI Industrial Access Rd.	CN-5 / 3.5-5	28	13	15	Lean Clay	CL

Note: NP = Non-Plastic

Letter Report Limitations

This letter report has been prepared in accordance with generally accepted practices of other consultants undertaking similar studies at the same time and in the same geographical area. Adobe Testing Services, Inc., observed that degree of care and skill generally exercised by other consultants under similar circumstances and conditions. Adobe Testing's findings and conclusions must be considered not as scientific certainties, but as opinions based on our professional judgment concerning the significance of the data gathered during the course of this investigation. Other than this, no warranty is implied or intended.

ADOBE TESTING SERVICES, INC.

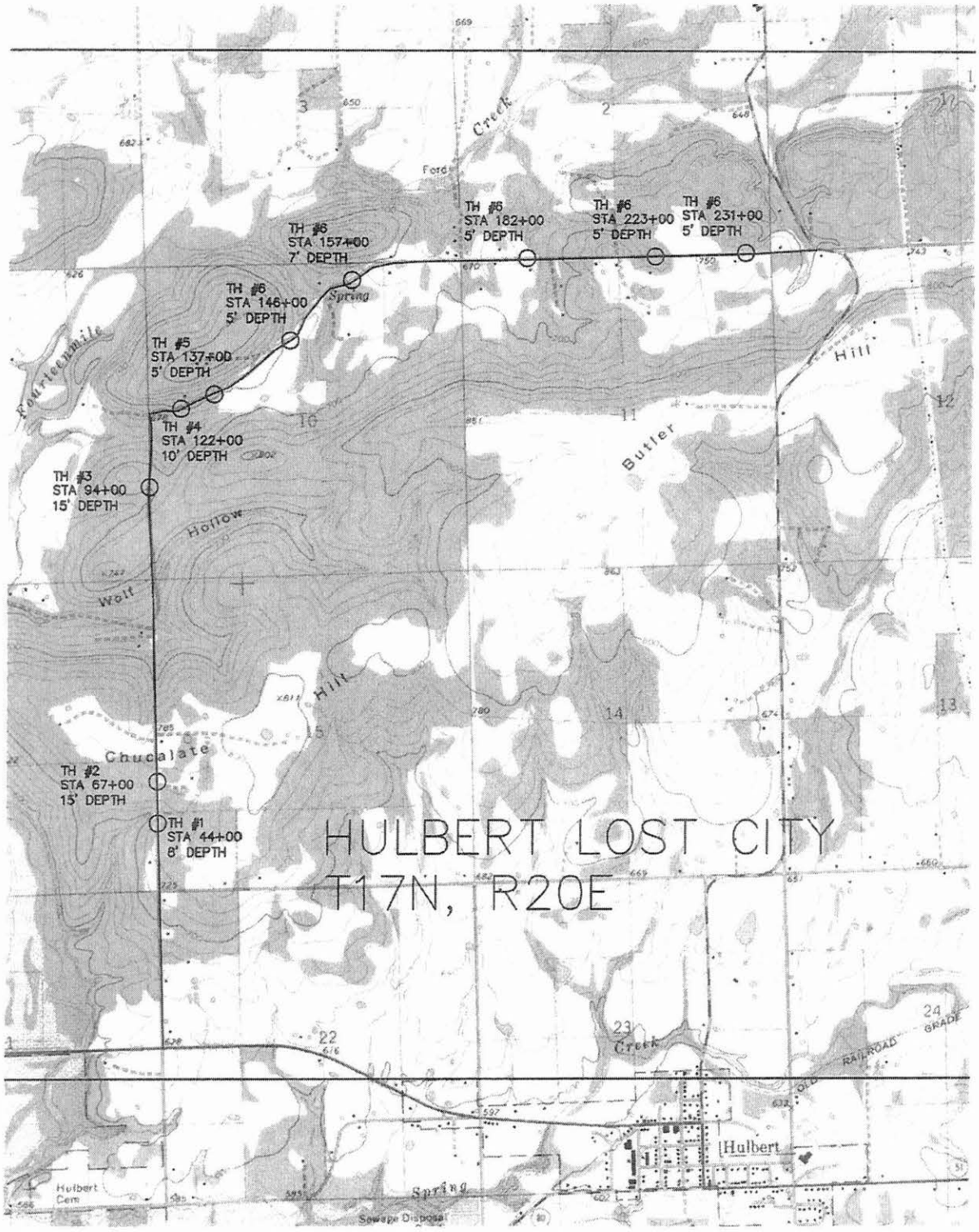
By:

Brandon Parrish, P.E.
Geotechnical Engineer

Attachments:

Appendix I – Boring Location Plans
Appendix II – Borings Logs
Appendix III – General Notes
Appendix IV – Grain Size Analysis Results

APPENDIX I
BORING LOCATION PLANS


TH #6
STA 157+00
7' DEPTH
TH #6
STA 182+00
5' DEPTH
TH #6
STA 223+00
5' DEPTH
TH #6
STA 231+00
5' DEPTH
TH #6
STA 146+00
5' DEPTH
TH #5
STA 137+00
5' DEPTH
TH #4
STA 122+00
10' DEPTH
TH #3
STA 94+00
15' DEPTH
TH #2
STA 67+00
15' DEPTH
TH #1
STA 44+00
8' DEPTH
HULBERT LOST CITY
T17N, R20E
Creek
Ford
Spring
Fourteenmile
Hollow
Wolf
Hill
Butler
Chocolate
Hulbert
Hulbert Cem
Sewage Disposal
OLD RAILROAD GRADE

APPENDIX II
BORING LOGS

adobe TESTING SERVICES, INC.
5616 S. 122nd Ave.
Tulsa, OK 74146
Ph.: (918) 872-9898
Fax: (918) 994-6390

GEOTECHNICAL BORING LOG

BORING NUMBER HL-1

CLIENT Cherokee Nation
PROJECT NAME Hulbert/Lost City - Project No. CN-0914-02
PROJECT NO. CN53012
PROJECT LOCATION Hulbert, OK
DATE STARTED 7/3/12 **COMPLETED** 7/3/12
SURFACE ELEVATION _____ **BENCHMARK EL.** _____
DRILLER MA **DRILL RIG** BK-51 TM
GROUND WATER LEVELS
HAMMER TYPE Cathead
AT TIME OF DRILLING None
LOGGED BY RA **CHECKED BY** BP
AT END OF DRILLING _____
NOTES Sta. 44+00

DEPTH (ft)	DRILLING METHOD	STRATA SYMBOL	MATERIAL DESCRIPTION Unified Soil Classification System	SAMPLE TYPE NUMBER	RECOVERY % (RQD %)	CORRECTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	◇ DRY UNIT WT (pcf) ◇ 20 40 60 80 100 ▲ N VALUE ▲ 20 40 60 80 PL MC LL 20 40 60 80 ☐ SHEAR STRENGTH (ksf) ☐ 1 2 3 4	ELEVATION (ft)
0	CFA - 4.5" O.D.		ASPHALT (3") 0.3 ft CLAYEY SAND w/ GRAVEL, Brown Red & Tan, Medium Dense, Slightly Moist (SC)	SPT 1		14-8-8 (16)		▲	
			2.0 ft LEAN CLAY w/ SAND, Brown Tan & Red, Stiff, Moist, Shaley (CL)	SPT 2		7-10-6 (16)		▲	
			5.0 ft						
5			CHERT, Hard 6.0 ft						
			SANDY LEAN CLAY, Brown Tan, Very Stiff to Hard, Slightly Moist, w/ Shale Layers & Seams (CL) 8.0 ft	SPT 3		50			

Bottom of borehole at 8.0 feet.

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GEOTECHNICAL BORING LOG

BORING NUMBER HL-2

CLIENT Cherokee Nation
PROJECT NAME Hulbert/Lost City - Project No. CN-0914-02
PROJECT NO. CN53012
PROJECT LOCATION Hulbert, OK
DATE STARTED 7/3/12 **COMPLETED** 7/3/12
SURFACE ELEVATION _____ **BENCHMARK EL.** _____
DRILLER MA **DRILL RIG** BK-51 TM
GROUND WATER LEVELS
HAMMER TYPE Cathead
AT TIME OF DRILLING None
LOGGED BY RA **CHECKED BY** BP
AT END OF DRILLING _____
NOTES Sta. 67+00

DEPTH (ft)	DRILLING METHOD	STRATA SYMBOL	MATERIAL DESCRIPTION Unified Soil Classification System	SAMPLE TYPE NUMBER	RECOVERY % (RQD %)	CORRECTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	◇ DRY UNIT WT (pcf) ◇ 20 40 60 80 100 ▲ N VALUE ▲ 20 40 60 80 PL MC LL 20 40 60 80 ☐ SHEAR STRENGTH (ksf) ☐ 1 2 3 4	ELEVATION (ft)
0	CFA - 4.5" O.D.		ASPHALT (3") 0.3 ft 0.5 ft LEAN CLAY w/ SAND, Brown Red & Tan, Stiff, Slightly Moist (CL)	SPT 1		50/0"			
			LIMESTONE, Tan Gray, Medium to Moderately Hard, Slightly Weathered, Fine Crystalline, Thick Bedded, w/ Occasional Shale Partings	NQ 1	92 (63)				
			-Weathered & Soft from 4' to 4.5' 4.5 ft						
5	CORE BARREL - 2" I.D.		LIMESTONE, Light & Dark Gray, Medium to Moderately Hard, Fine Crystalline, Thick Bedded, w/ Interbedded Limestone & Shale Layers						
			8.5 ft	NQ 2	100 (63)				
			SILTSTONE, Gray, Medium Hard, Fine Crystalline, Thick Bedded, Slightly Calcareous, w/ Numerous Shale Partings 10.2 ft						
10			SILTSTONE, Dark & Light Gray, Medium Hard, Fine Crystalline, Thick Bedded, w/ Interbedded Shale Layers						
				NQ 3	100 (0)				
			15.0 ft						
15			Bottom of borehole at 15.0 feet.						

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GEOTECHNICAL BORING LOG

BORING NUMBER HL-3

CLIENT Cherokee Nation
PROJECT NAME Hulbert/Lost City - Project No. CN-0914-02
PROJECT NO. CN53012
PROJECT LOCATION Hulbert, OK
DATE STARTED 7/3/12 **COMPLETED** 7/3/12
SURFACE ELEVATION _____ **BENCHMARK EL.** _____
DRILLER MA **DRILL RIG** BK-51 TM
GROUND WATER LEVELS
HAMMER TYPE Cathead
AT TIME OF DRILLING None
LOGGED BY RA **CHECKED BY** BP
AT END OF DRILLING _____
NOTES Sta. 94+00

DEPTH (ft)	DRILLING METHOD	STRATA SYMBOL	MATERIAL DESCRIPTION Unified Soil Classification System	SAMPLE TYPE NUMBER	RECOVERY % (RQD %)	CORRECTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	ELEVATION (ft)
0	CFA - 4.5" O.D.		LEAN CLAY, w/ Scattered Gravel, Brown, Stiff, Moist (CL) 1.0 ft	SPT 1		12-9-8 (17)		
			SANDY FAT CLAY, Red Tan Gray, Stiff, Moist, Shaley (CH)	SPT 2		16-16-24 (40)		
			5.0 ft					
5			SILTSTONE, Highly Weathered, Soft 7.0 ft					
	CORE BARREL - 2" I.D.		SANDY SILTSTONE, Tan Gray, Medium Hard, Weathered to Slightly Weathered, Fine Grained, Thick Bedded, Slightly Calcareous 9.0 ft	NQ 1	55 (55)			
10			SANDSTONE, Tan Brown Gray, Medium Hard, Slightly Weathered, Fine to Medium Grained, Thick Bedded 13.0 ft	NQ 2	100 (53)			
			SANDY SHALE, Tan Brown Gray, Soft, Weathered, Thick Bedded	NQ 3	100 (0)			
15			15.5 ft					

◇ DRY UNIT WT (pcf) ◇ 20 40 60 80 100
▲ N VALUE ▲ 20 40 60 80
PL MC LL 20 40 60 80
☐ SHEAR STRENGTH (ksf) ☐ 1 2 3 4

Bottom of borehole at 15.5 feet.

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GEOTECHNICAL BORING LOG

BORING NUMBER HL-4

CLIENT Cherokee Nation
PROJECT NAME Hulbert/Lost City - Project No. CN-0914-02
PROJECT NO. CN53012
PROJECT LOCATION Hulbert, OK
DATE STARTED 7/10/12 **COMPLETED** 7/10/12
SURFACE ELEVATION _____ **BENCHMARK EL.** _____
DRILLER MA **DRILL RIG** BK-51 TM
GROUND WATER LEVELS
HAMMER TYPE Cathead
AT TIME OF DRILLING None
LOGGED BY SS **CHECKED BY** BP
AT END OF DRILLING _____
NOTES Sta. 122+00

DEPTH (ft)	DRILLING METHOD	STRATA SYMBOL	MATERIAL DESCRIPTION Unified Soil Classification System	SAMPLE TYPE NUMBER	RECOVERY % (RQD %)	CORRECTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	ELEVATION (ft)
0	CFA - 4.5" O.D.		ASPHALT (2") 0.2 ft SILTY SAND w/ GRAVEL, Brown Tan, Dense, Slightly Moist (SM)	SPT 1		40-50/4"		
			3.0 ft CLAYED SAND, Brown Tan, Dense, Moist, w/ Shale Seams & Layers (SC)	SPT 2		11-11-15 (26)		
5			7.5 ft SHALE, Soft, Highly Weathered	SPT 3		27-16-14 (30)		
10			10.0 ft Bottom of borehole at 10.0 feet.					

◇ DRY UNIT WT (pcf) ◇ 20 40 60 80 100
▲ N VALUE ▲ 20 40 60 80
PL MC LL 20 40 60 80
☐ SHEAR STRENGTH (ksf) ☐ 1 2 3 4

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Fax: (918) 994-6390

GEOTECHNICAL BORING LOG

BORING NUMBER HL-5

CLIENT Cherokee Nation
PROJECT NAME Hulbert/Lost City - Project No. CN-0914-02
PROJECT NO. CN53012
PROJECT LOCATION Hulbert, OK
DATE STARTED 7/3/12 **COMPLETED** 7/3/12
SURFACE ELEVATION _____ **BENCHMARK EL.** _____
DRILLER MA **DRILL RIG** BK-51 TM
GROUND WATER LEVELS
HAMMER TYPE Cathead
AT TIME OF DRILLING None
LOGGED BY RA **CHECKED BY** BP
AT END OF DRILLING _____
NOTES Sta. 137+00

DEPTH (ft)	DRILLING METHOD	STRATA SYMBOL	MATERIAL DESCRIPTION Unified Soil Classification System	SAMPLE TYPE NUMBER	RECOVERY % (RQD %)	CORRECTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	◇ DRY UNIT WT (pcf) ◇ 20 40 60 80 100 ▲ N VALUE ▲ 20 40 60 80 PL MC LL 20 40 60 80 ☐ SHEAR STRENGTH (ksf) ☐ 1 2 3 4	ELEVATION (ft)
0	CFA - 4.5" O.D.		ASPHALT (3") 0.3 ft CLAYEY SAND w/ GRAVEL, Brown Tan, Dense (SC)	SPT 1		23-23-12 (35)		▲	
				SPT 2		12-20-30 (50)		▲	
5			5.0 ft Bottom of borehole at 5.0 feet.						

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GEOTECHNICAL BORING LOG

BORING NUMBER HL-6

CLIENT Cherokee Nation
PROJECT NAME Hulbert/Lost City - Project No. CN-0914-02
PROJECT NO. CN53012
PROJECT LOCATION Hulbert, OK
DATE STARTED 7/3/12 **COMPLETED** 7/3/12
SURFACE ELEVATION _____ **BENCHMARK EL.** _____
DRILLER MA **DRILL RIG** BK-51 TM
GROUND WATER LEVELS
HAMMER TYPE Cathead
AT TIME OF DRILLING None
LOGGED BY RA **CHECKED BY** BP
AT END OF DRILLING _____
NOTES Sta. 146+00

DEPTH (ft)	DRILLING METHOD	STRATA SYMBOL	MATERIAL DESCRIPTION Unified Soil Classification System	SAMPLE TYPE NUMBER	RECOVERY % (RQD %)	CORRECTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	◇ DRY UNIT WT (pcf) ◇ 20 40 60 80 100 ▲ N VALUE ▲ 20 40 60 80 PL MC LL 20 40 60 80 ☐ SHEAR STRENGTH (ksf) ☐ 1 2 3 4	ELEVATION (ft)
0	CFA - 4.5" O.D.		ASPHALT (3") 0.3 ft SANDY LEAN CLAY, Trace Gravel, Brown, Stiff, Dry (CL)	SPT 1		50/0"			
			2.0 ft SILTY SAND w/ GRAVEL, Brown, Dense to Very Dense (SM)	SPT 2		12-50/5"			
5			5.0 ft Bottom of borehole at 5.0 feet.						

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GEOTECHNICAL BORING LOG

BORING NUMBER HL-7

CLIENT Cherokee Nation
PROJECT NAME Hulbert/Lost City - Project No. CN-0914-02
PROJECT NO. CN53012
PROJECT LOCATION Hulbert, OK
DATE STARTED 7/2/12 **COMPLETED** 7/2/12
SURFACE ELEVATION _____ **BENCHMARK EL.** _____
DRILLER MA **DRILL RIG** BK-51 TM
GROUND WATER LEVELS
HAMMER TYPE Cathead
AT TIME OF DRILLING None
LOGGED BY RA **CHECKED BY** BP
AT END OF DRILLING _____
NOTES Sta. 157+00

DEPTH (ft)	DRILLING METHOD	STRATA SYMBOL	MATERIAL DESCRIPTION Unified Soil Classification System	SAMPLE TYPE NUMBER	RECOVERY % (RQD %)	CORRECTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	◇ DRY UNIT WT (pcf) ◇ 20 40 60 80 100 ▲ N VALUE ▲ 20 40 60 80 PL MC LL 20 40 60 80 ☐ SHEAR STRENGTH (ksf) ☐ 1 2 3 4	ELEVATION (ft)
0	CFA - 4.5" O.D.		ASPHALT (3") 0.3 ft SILTY, CLAYEY SAND w/ GRAVEL, Tan Brown, Very Dense, Slightly Moist (SC-SM)	SPT 1		15-33-50/0"			
			3.0 ft SANDY LEAN CLAY w/ GRAVEL, Brown Tan, Stiff, Moist (CL)	SPT 2		50/0"			
5				SPT 3		33-25-50/1"			
			7.0 ft						

Bottom of borehole at 7.0 feet.

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Tulsa, OK 74146
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Fax: (918) 994-6390

GEOTECHNICAL BORING LOG

BORING NUMBER HL-8

CLIENT Cherokee Nation
PROJECT NAME Hulbert/Lost City - Project No. CN-0914-02
PROJECT NO. CN53012
PROJECT LOCATION Hulbert, OK
DATE STARTED 7/2/12 **COMPLETED** 7/2/12
SURFACE ELEVATION _____ **BENCHMARK EL.** _____
DRILLER MA **DRILL RIG** BK-51 TM
GROUND WATER LEVELS
HAMMER TYPE Cathead
AT TIME OF DRILLING None
LOGGED BY RA **CHECKED BY** BP
AT END OF DRILLING _____
NOTES Sta. 182+00

DEPTH (ft)	DRILLING METHOD	STRATA SYMBOL	MATERIAL DESCRIPTION Unified Soil Classification System	SAMPLE TYPE NUMBER	RECOVERY % (RQD %)	CORRECTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	ELEVATION (ft)
0	CFA - 4.5" O.D.		ASPHALT (3") 0.3 ft SILTY SAND w/ GRAVEL, Brown Tan, Dense, Moist (SM)	SPT 1		8-12-17 (29)		
			2.0 ft SHALE, Weathered	SPT 2		50/1"		
5			5.0 ft Bottom of borehole at 5.0 feet.					

◇ DRY UNIT WT (pcf) ◇ 20 40 60 80 100
▲ N VALUE ▲ 20 40 60 80
PL MC LL 20 40 60 80
☐ SHEAR STRENGTH (ksf) ☐ 1 2 3 4

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GEOTECHNICAL BORING LOG

BORING NUMBER **HL-9**

CLIENT Cherokee Nation
PROJECT NAME Hulbert/Lost City - Project No. CN-0914-02
PROJECT NO. CN53012
PROJECT LOCATION Hulbert, OK
DATE STARTED 7/2/12 **COMPLETED** 7/2/12
SURFACE ELEVATION **BENCHMARK EL.**
DRILLER MA **DRILL RIG** BK-51 TM
GROUND WATER LEVELS
HAMMER TYPE Cathead
AT TIME OF DRILLING None
LOGGED BY RA **CHECKED BY** BP
AT END OF DRILLING
NOTES Sta. 223+00

DEPTH (ft)	DRILLING METHOD	STRATA SYMBOL	MATERIAL DESCRIPTION Unified Soil Classification System	SAMPLE TYPE NUMBER	RECOVERY % (RQD %)	CORRECTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	◇ DRY UNIT WT (pcf) ◇ 20 40 60 80 100 ▲ N VALUE ▲ 20 40 60 80 PL MC LL 20 40 60 80 ☐ SHEAR STRENGTH (ksf) ☐ 1 2 3 4	ELEVATION (ft)
0	CFA - 4.5" O.D.		ASPHALT (3") 0.3 ft SANDY LEAN CLAY w/ GRAVEL, Brown Red, Stiff, Dry (CL)	SPT 1		50/1"			
			4.0 ft GRAVELLY FAT CLAY, Red Brown, Stiff, Slightly Moist (CH) 5.0 ft	SPT 2		50/1"			
5			Bottom of borehole at 5.0 feet.						

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GEOTECHNICAL BORING LOG

BORING NUMBER HL-10

CLIENT Cherokee Nation
PROJECT NAME Hulbert/Lost City - Project No. CN-0914-02
PROJECT NO. CN53012
PROJECT LOCATION Hulbert, OK
DATE STARTED 7/2/12 **COMPLETED** 7/2/12
SURFACE ELEVATION _____ **BENCHMARK EL.** _____
DRILLER MA **DRILL RIG** BK-51 TM
GROUND WATER LEVELS
HAMMER TYPE Cathead
AT TIME OF DRILLING None
LOGGED BY RA **CHECKED BY** BP
AT END OF DRILLING _____
NOTES Sta. 231+00

DEPTH (ft)	DRILLING METHOD	STRATA SYMBOL	MATERIAL DESCRIPTION Unified Soil Classification System	SAMPLE TYPE NUMBER	RECOVERY % (RQD %)	CORRECTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	ELEVATION (ft)
0	CFA - 4.5" O.D.		ASPHALT (3") 0.3 ft SILTY GRAVEL w/ SAND, Red Brown, Dense, Slightly Moist (GM)	SPT 1		14-17-12 (29)		
			2.0 ft CLAYEY SAND w/ GRAVEL, Red Brown, Very Dense, Moist (SC)	SPT 2		30-45-50/0"		
5			5.0 ft Bottom of borehole at 5.0 feet.					

◇ DRY UNIT WT (pcf) ◇ 20 40 60 80 100
▲ N VALUE ▲ 20 40 60 80
PL MC LL 20 40 60 80
☐ SHEAR STRENGTH (ksf) ☐ 1 2 3 4

APPENDIX III
GENERAL NOTES

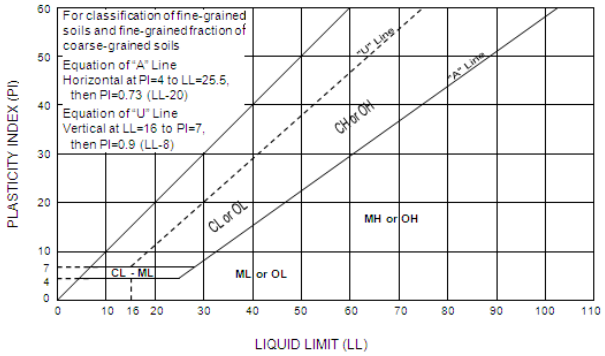
GENERAL NOTES

adobe TESTING SERVICES, INC.

SOIL PROPERTIES & DESCRIPTIONS

COHESIVE SOILS

Consistency	Unconfined Compressive Strength (Qu)	Pocket Penetrometer Strength	N-Value
	(psf)	(tsf)	(blows/ft)
Very Soft	<500	<0.25	0-1
Soft	500-1000	0.25-0.50	2-4
Medium Stiff	1001-2000	0.50-1.00	5-8
Stiff	2001-4000	1.00-2.00	9-15
Very Stiff	4001-8000	2.00-4.00	16-30
Hard	>8000	>4.00	31-60
Very Hard			>60



Group Symbol	Group Name
CL –	Lean Clay
ML –	Silt
OL –	Organic Clay or Silt
CH –	Fat Clay
MH –	Elastic Silt
OH –	Organic Clay or Silt
PT –	Peat
CL-CH –	Lean to Fat Clay

Plasticity		Moisture	
Description	Liquid Limit (LL)	Descriptive Term	Guide
Lean	<45%	Dry	No indication of water
Lean to Fat	45-49%	Moist	Indication of water
Fat	≥50%	Wet	Visible water

Fine Grained Soil Subclassification	Percent (by weight) of Total Sample
Terms: SILT, LEAN CLAY, FAT CLAY, ELASTIC SILT	PRIMARY CONSTITUENT
Sandy,gravelly, abundant cobbles, abundant boulders	>30-50]
with sand, with gravel, with cobbles, with boulders	>15-30] – secondary coarse grained constituents
scattered sand, scattered gravel, scattered cobbles, scattered boulders	5-15]
a trace sand, a trace gravel, a few cobbles, a few boulders	<5]
The relationship of clay and silt constituents is based on plasticity and normally determined by performing index tests. Refined classifications are based on Atterberg Limits tests and the Plasticity Chart.	

NON-COHESIVE (GRANULAR) SOILS

RELATIVE DENSITY	N-VALUE
Very Loose	0-4
Loose	5-10
Medium Dense	11-24
Dense	25-50
Very Dense	≥51

MOISTURE CONDITION	
Descriptive Term	Guide
Dry	No indication of water
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table.

**GRAIN SIZE IDENTIFICATION		
Name	Size Limits	Familiar Example
Boulder	12 in. or more	Larger than basketball
Cobbles	3 in. to 12 in.	Grapefruit
Coarse Gravel	¾-in. to 3 in.	Orange or lemon
Fine Gravel	No. 4 sieve to ¾-in.	Grape or pea
Coarse Sand	No. 10 sieve to No. 4 sieve	Rock salt
Medium Sand	No. 40 sieve to No. 10 sieve	Sugar, table salt
Fine Sand*	No. 200 sieve to No. 40 sieve	Powdered sugar
Fines	Less than No. 200 sieve	
*Particles finer than fine sand cannot be discerned with the naked eye at a distance of 8 in.		

Coarse Grained Soil Subclassification	Percent (by weight) of Total Sample
Terms: GRAVEL, SAND, COBBLES, BOULDERS	PRIMARY CONSTITUENT
Sandy,gravelly, abundant cobbles, abundant boulders	>30-50]
with gravel, with sand, with cobbles, with boulders	>15-30] – secondary coarse grained constituents
scattered gravel, scattered sand, scattered cobbles, scattered boulders	5-15]
a trace gravel, a trace sand, a few cobbles, a few boulders	<5]
Silty (MH & ML)*, clayey (CL & CH)*	<15]
(with silt, with clay)*	5-15] – secondary fine grained constituents
(trace silt, trace clay)*	<5]
*Index tests and/or plasticity tests are performed to determine whether the term "silt" or "clay" is used.	

*Modified after Ref. ASTM D2487-93 & D2488-93
**Modified after Ref. Oregon DOT 1987 & FHWA 1997
***Modified after Ref. AASHTO 1988, DM 7.1 1982, and Oregon DOT 1987

GENERAL NOTES

adobe TESTING SERVICES, INC.

BEDROCK PROPERTIES & DESCRIPTIONS

ROCK QUALITY DESIGNATION (RQD)	
Description of Rock Quality	*RQD (%)
Very Poor	< 25
Poor	25-50
Fair	50-75
Good	75-90
Excellent	90-100

*RQD is defined as the total length of sound core pieces 4 in. or greater in length, expressed as a percentage of the total length cored. RQD provides an indication of the integrity of the rock mass and relative extent of seams and bedding planes.

SCALE OF RELATIVE ROCK HARDNESS		
Term	Field Identification	Approx. Unconfined Compressive Strength (tsf)
Extremely Soft	Can be indented by thumbnail	2.6-10
Very Soft	Can be peeled by pocket knife	10-50
Soft	Can be peeled with difficulty by pocket knife	50-260
Medium Hard	Can be grooved 2 mm deep by firm pressure of knife	260-520
Moderately Hard	Requires one hammer blow to fracture	520-1040
Hard	Can be scratched with knife or pick only with difficulty	1040-2610
Very Hard	Cannot be scratched by knife or sharp pick	>2610

DEGREE OF WEATHERING	
Slightly Weathered	Rock generally fresh, joints stained and discoloration extends into rock up to 25mm (1 in), open joints may contain clay, core rings under hammer impact.
Weathered	Rock mass is decomposed 50% or less, significant portions of rock show discoloration and weathering effects, cores cannot be broken by hand or scraped by knife.
Highly Weathered	Rock mass is more than 50% decomposed, complete discoloration of rock fabric, core may be extremely broken and gives clunk sound when struck by hammer, may be shaved with a knife.

GRAIN SIZE (TYPICALLY FOR SEDIMENTARY ROCKS)		
Description	Diameter (mm)	Field Identification
Very Coarse Grained	>4.76	
Coarse Grained	2.0-4.76	Individual grains can easily be distinguished by eye.
Medium Grained	0.42-2.0	Individual grains can be distinguished by eye.
Fine Grained	0.074-0.42	Individual grains can be distinguished by eye with difficulty.
Very Fine Grained	<0.074	Individual grains cannot be distinguished by unaided eye.

VOIDS	
Pit	Voids barely seen with naked eye to 6mm (¼-in)
Vug	Voids 6 to 50mm (¼ to 2 in) in diameter
Cavity	50 to 6000mm (2 to 24 in) in diameter
Cave	>600mm

BEDDING THICKNESS	
Very Thick Bedded	> 3' thick
Thick Bedded	1' to 3' thick
Medium Bedded	4" to 1' thick
Thin Bedded	1¼" to 4" thick
Very Thin Bedded	½" to 1¼" thick
Thickly Laminated	⅛" to ½" thick
Thinly Laminated	⅛" or less (paper thin)

DRILLING NOTES

Drilling and Sampling Symbols

NQ – Rock Core (2-in. diameter)
HQ – Rock Core (3 in. diameter)
HSA – Hollow Stem Auger
CFA – Continuous Flight (Solid Stem) Auger
SS – Split Spoon Sampler
ST – Shelby Tube
WB – Wash Bore or Mud Rotary
TP – Test-Pit
HA – Hand Auger

Soil Sample Types

Shelby Tube Samples: Relatively undisturbed soil samples were obtained from the borings using thin wall (Shelby) tube samplers pushed hydraulically into the soil in advance of drilling. This sampling, which is considered to be undisturbed, was performed in accordance with the requirements of ASTM D 1587. This type of sample is considered best for the testing of "in-situ" soil properties such as natural density and strength characteristics. The use of this sampling method is basically restricted to soil containing little to no chert fragments and to softer shale deposits.

Split Spoon Samples: The Standard Penetration Test is conducted in conjunction with the split-barrel sampling procedure. The "N" value corresponds to the number of blows required to drive the last 1 foot of an 18-in. long, 2-in. O.D. split-barrel sampler with a 140 lb. hammer falling a distance of 30 in. The Standard Penetration Test is carried out according to ASTM D-1586.

Water Level Measurements

Water levels indicated on the boring logs are levels measured in the borings at the times indicated. In permeable materials, the indicated levels may reflect the location of groundwater. In low permeability soils, shallow groundwater may indicate a perched condition. Caution is merited when interpreting short-term water level readings from open bore holes. Accurate water levels are best determined from piezometers.

Automatic Hammer

Palmerton and Parrish's CME's are equipped with automatic hammers. The conventional method used to obtain disturbed soil samples used a safety hammer operated by company personnel with a cat head and rope. However, use of an automatic hammer allows a greater mechanical efficiency to be achieved in the field while performing a Standard Penetration resistance test based upon automatic hammer efficiencies calibrated using dynamic testing techniques.

*Modified after Ref. ASTM D2487-93 & D2488-93
**Modified after Ref. Oregon DOT 1987 & FHWA 1997
***Modified after Ref. AASHTO 1988, DM 7.1 1982, and Oregon DOT 1987

APPENDIX IV
GRAIN SIZE ANALYSIS RESULTS

Particle Size Distribution Report

% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	19.3	11.3	12.5	22.1	34.8	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4 in.	100.0		
3/8 in.	92.5		
#4	80.7		
#10	69.4		
#16	63.6		
#30	59.3		
#40	56.9		
#50	52.9		
#100	40.2		
#200	34.9		

* (no specification provided)

Material Description

Clayey sand with gravel

Atterberg Limits

PL= 13 LL= 25 PI= 12

Coefficients

D_{85}= 6.09 D_{60}= 0.680 D_{50}= 0.254
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= SC AASHTO=

Remarks

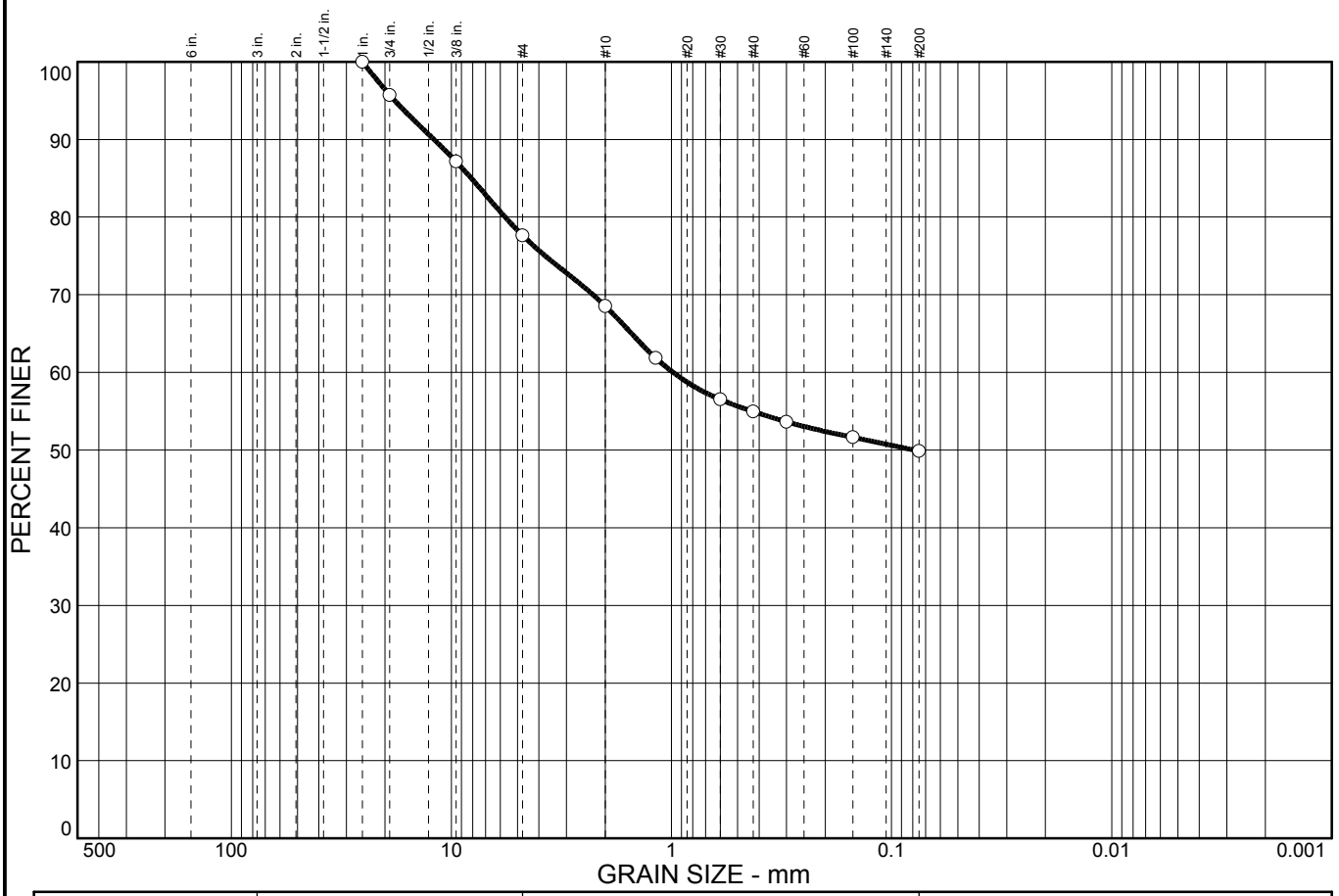
Sample No.: **Source of Sample:** **Date:** 7/23/2012
Location: HL-1 **Elev./Depth:** .5'-2'

PALMERTON & PARRISH, INC.
Springfield, MO

Client: Cherokee Nation
Project: Hulbert/Lost City

Project No: 209490 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	4.3	18.1	9.1	13.6	5.0	49.9	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1 in.	100.0		
3/4 in.	95.7		
3/8 in.	87.2		
#4	77.6		
#10	68.5		
#16	61.9		
#30	56.5		
#40	55.0		
#50	53.6		
#100	51.7		
#200	49.9		

* (no specification provided)

Material Description

Clayey sand with gravel

Atterberg Limits

PL= 20 LL= 64 PI= 44

Coefficients

D_{85}= 8.13 D_{60}= 0.985 D_{50}= 0.0783
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= SC AASHTO=

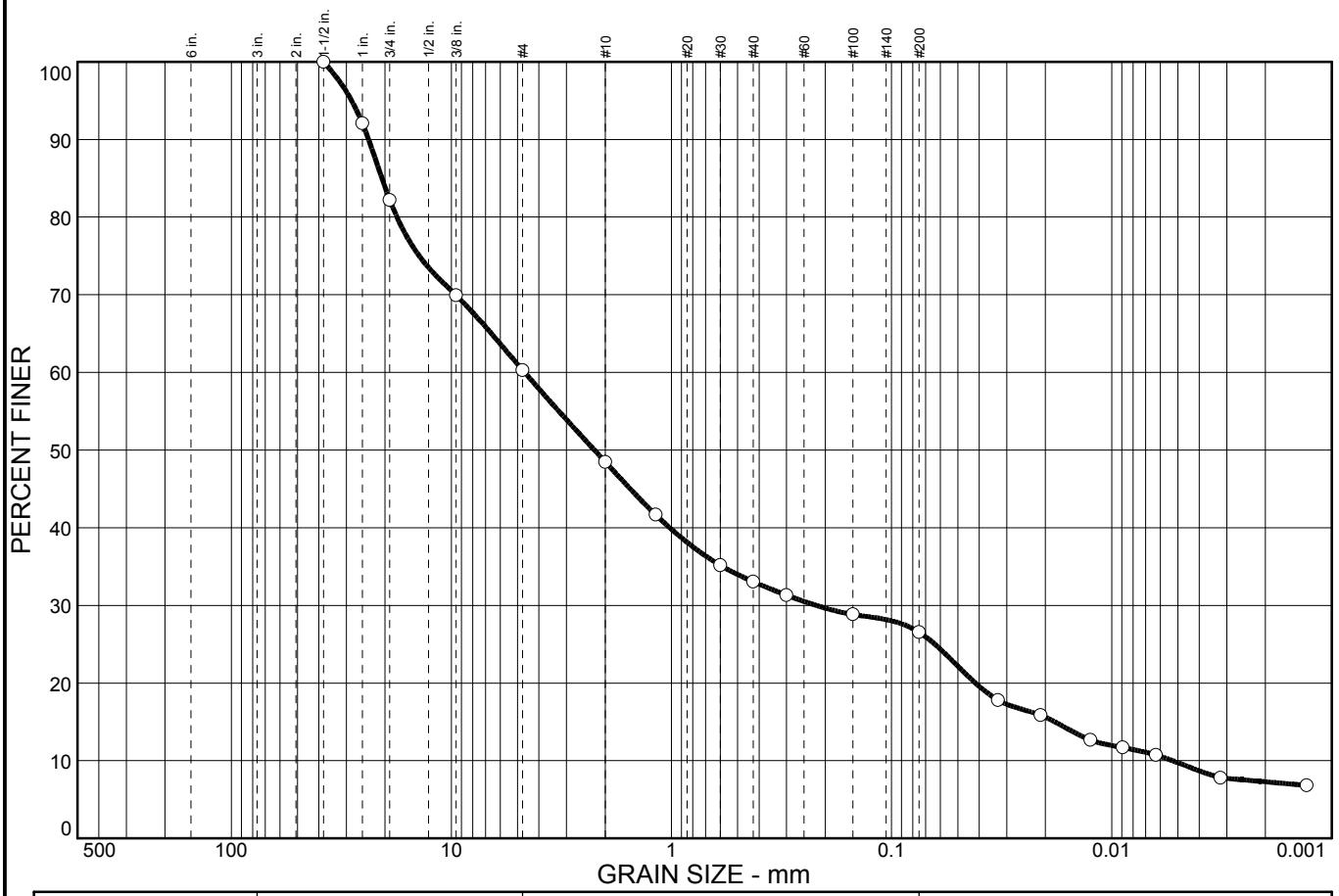
Remarks

Sample No.: **Source of Sample:** **Date:** 7/20/2012
Location: HL-10 **Elev./Depth:** 3.5'-4.58'

PALMERTON & PARRISH, INC.
Springfield, MO

Client: Cherokee Nation
Project: Hulbert/Lost City
Project No: 209490 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	17.8	21.9	11.8	15.4	6.6	16.8	9.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1-1/2 in.	100.0		
1 in.	92.1		
3/4 in.	82.2		
3/8 in.	69.9		
#4	60.3		
#10	48.5		
#16	41.7		
#30	35.2		
#40	33.1		
#50	31.3		
#100	28.8		
#200	26.5		

* (no specification provided)

Material Description

Silty gravel with sand

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 20.7 D_{60}= 4.65 D_{50}= 2.24
D_{30}= 0.220 D_{15}= 0.0181 D_{10}= 0.0053
C_u= 880.50 C_c= 1.97

Classification

USCS= GM AASHTO=

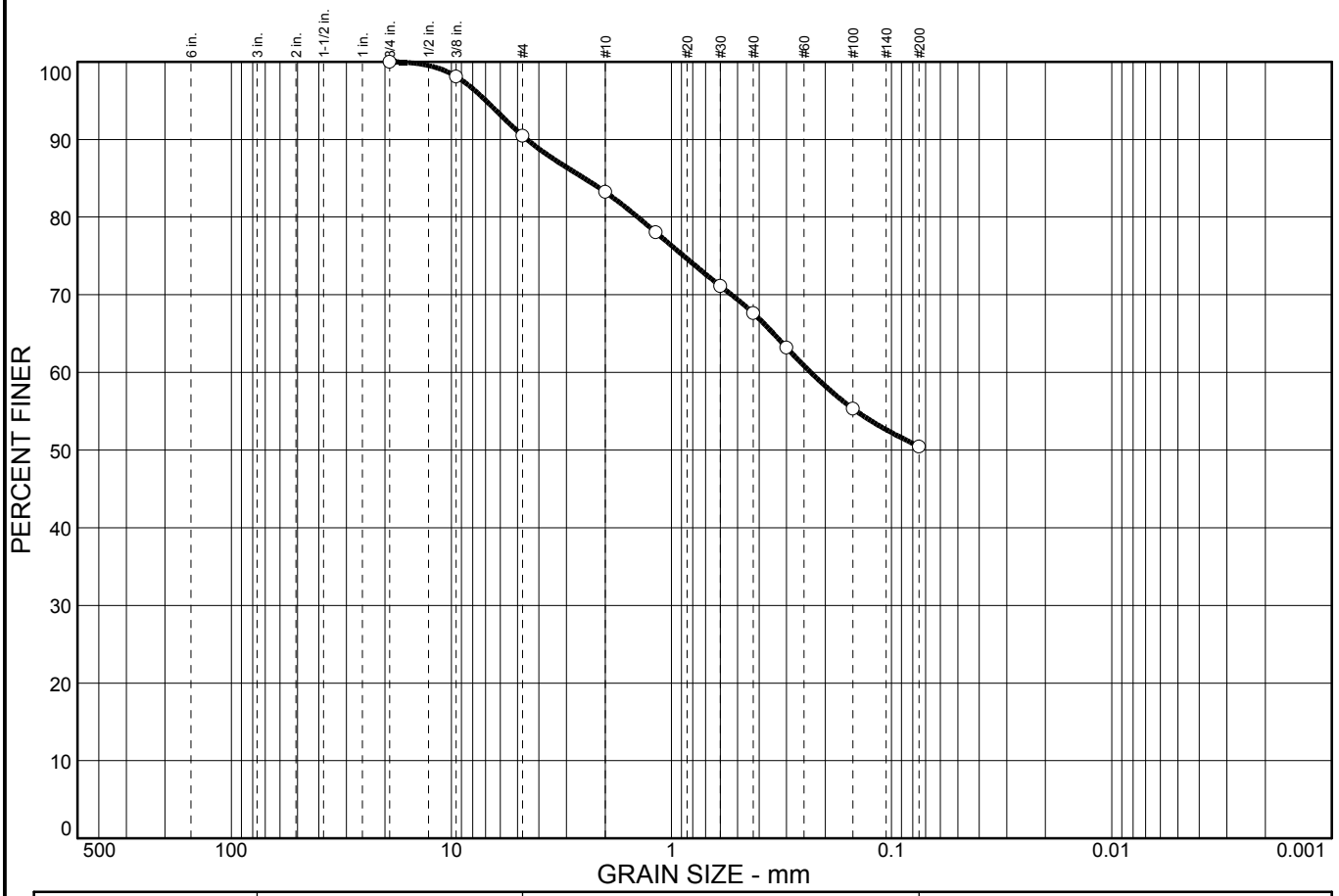
Remarks

Sample No.: **Source of Sample:** **Date:** 7/23/2012
Location: HL-10 **Elev./Depth:** .5'-2'

PALMERTON & PARRISH, INC.
Springfield, MO

Client: Cherokee Nation
Project: Hulbert/Lost City
Project No: 209490 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	9.5	7.3	15.6	17.1	50.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4 in.	100.0		
3/8 in.	98.1		
#4	90.5		
#10	83.2		
#16	78.1		
#30	71.1		
#40	67.6		
#50	63.2		
#100	55.3		
#200	50.5		

* (no specification provided)

Material Description

Sandy fat clay

Atterberg Limits

PL= 18 LL= 50 PI= 32

Coefficients

D_{85}= 2.49 D_{60}= 0.233 D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= CH AASHTO=

Remarks

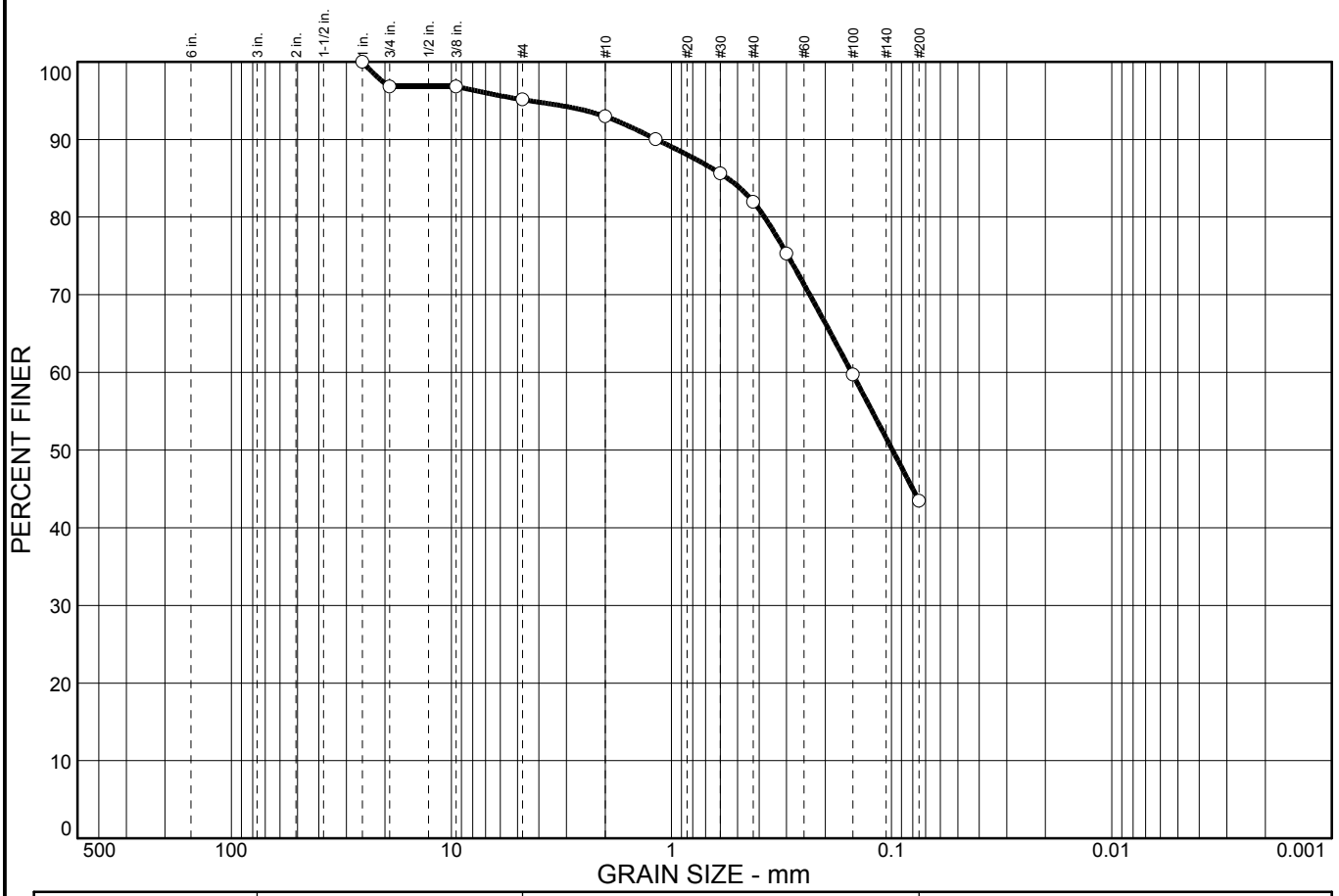
Sample No.: **Source of Sample:** **Date:** 7/23/2012
Location: HL-3 **Elev./Depth:** 3'-4.5'

PALMERTON & PARRISH, INC.
Springfield, MO

Client: Cherokee Nation
Project: Hulbert/Lost City

Project No: 209490 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	3.2	1.7	2.2	11.0	38.5	43.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1 in.	100.0		
3/4 in.	96.8		
3/8 in.	96.8		
#4	95.1		
#10	93.0		
#16	90.0		
#30	85.6		
#40	82.0		
#50	75.3		
#100	59.7		
#200	43.5		

* (no specification provided)

Material Description

Clayey sand

Atterberg Limits

PL= 17 LL= 49 PI= 32

Coefficients

D_{85}= 0.557 D_{60}= 0.152 D_{50}= 0.0990
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= SC AASHTO=

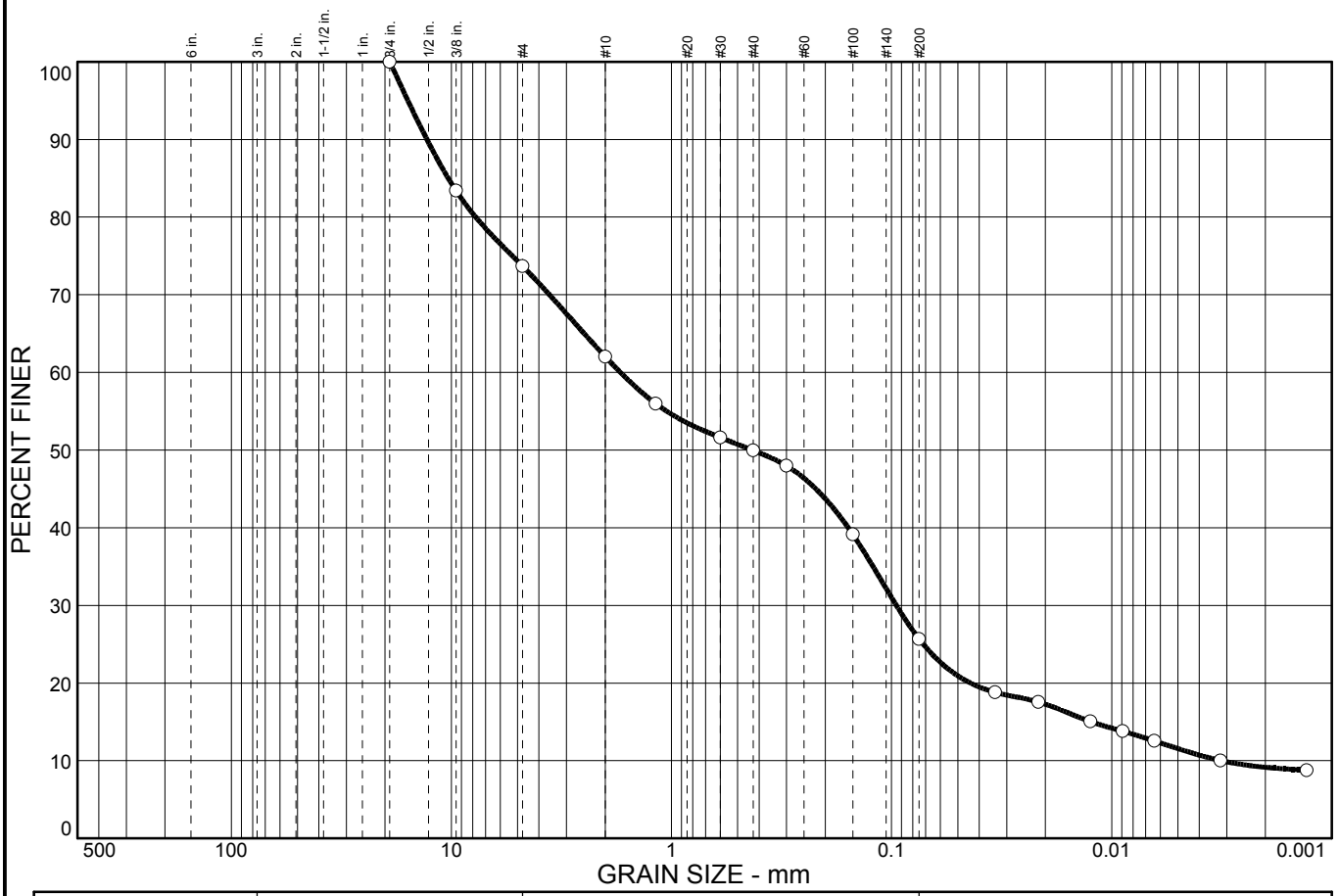
Remarks

Sample No.: **Source of Sample:** **Date:** 7/23/2012
Location: HL-4 **Elev./Depth:** 3'-4.5'

PALMERTON & PARRISH, INC.
Springfield, MO

Client: Cherokee Nation
Project: Hulbert/Lost City
Project No: 209490 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	26.3	11.7	12.1	24.2	14.1	11.6

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4 in.	100.0		
3/8 in.	83.4		
#4	73.7		
#10	62.0		
#16	56.0		
#30	51.6		
#40	50.0		
#50	48.0		
#100	39.1		
#200	25.7		

* (no specification provided)

Material Description

Silty sand with gravel

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 10.3 D_{60}= 1.71 D_{50}= 0.429
D_{30}= 0.0952 D_{15}= 0.0124 D_{10}= 0.0032
C_u= 539.22 C_c= 1.68

Classification

USCS= SM AASHTO=

Remarks

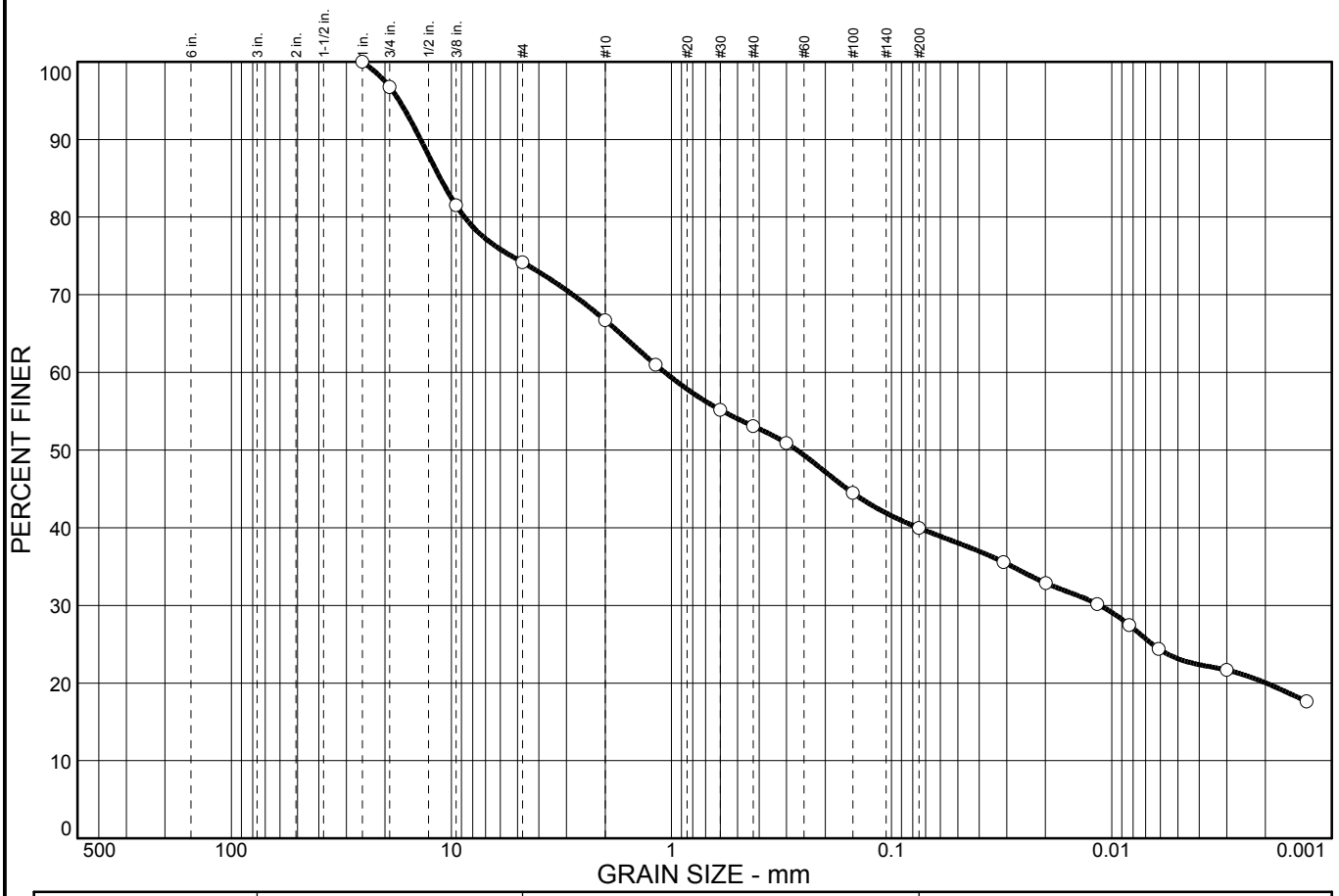
Sample No.: **Source of Sample:** **Date:** 7/23/2012
Location: HL-4 **Elev./Depth:** .5'-1.33'

PALMERTON & PARRISH, INC.
Springfield, MO

Client: Cherokee Nation
Project: Hulbert/Lost City

Project No: 209490 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	3.3	22.5	7.5	13.6	13.1	16.8	23.2

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1 in.	100.0		
3/4 in.	96.7		
3/8 in.	81.5		
#4	74.2		
#10	66.7		
#16	61.0		
#30	55.2		
#40	53.1		
#50	50.9		
#100	44.5		
#200	40.0		

* (no specification provided)

Material Description

Clayey sand with gravel

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 11.2 D_{60}= 1.07 D_{50}= 0.269
D_{30}= 0.0113 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= SC AASHTO=

Remarks

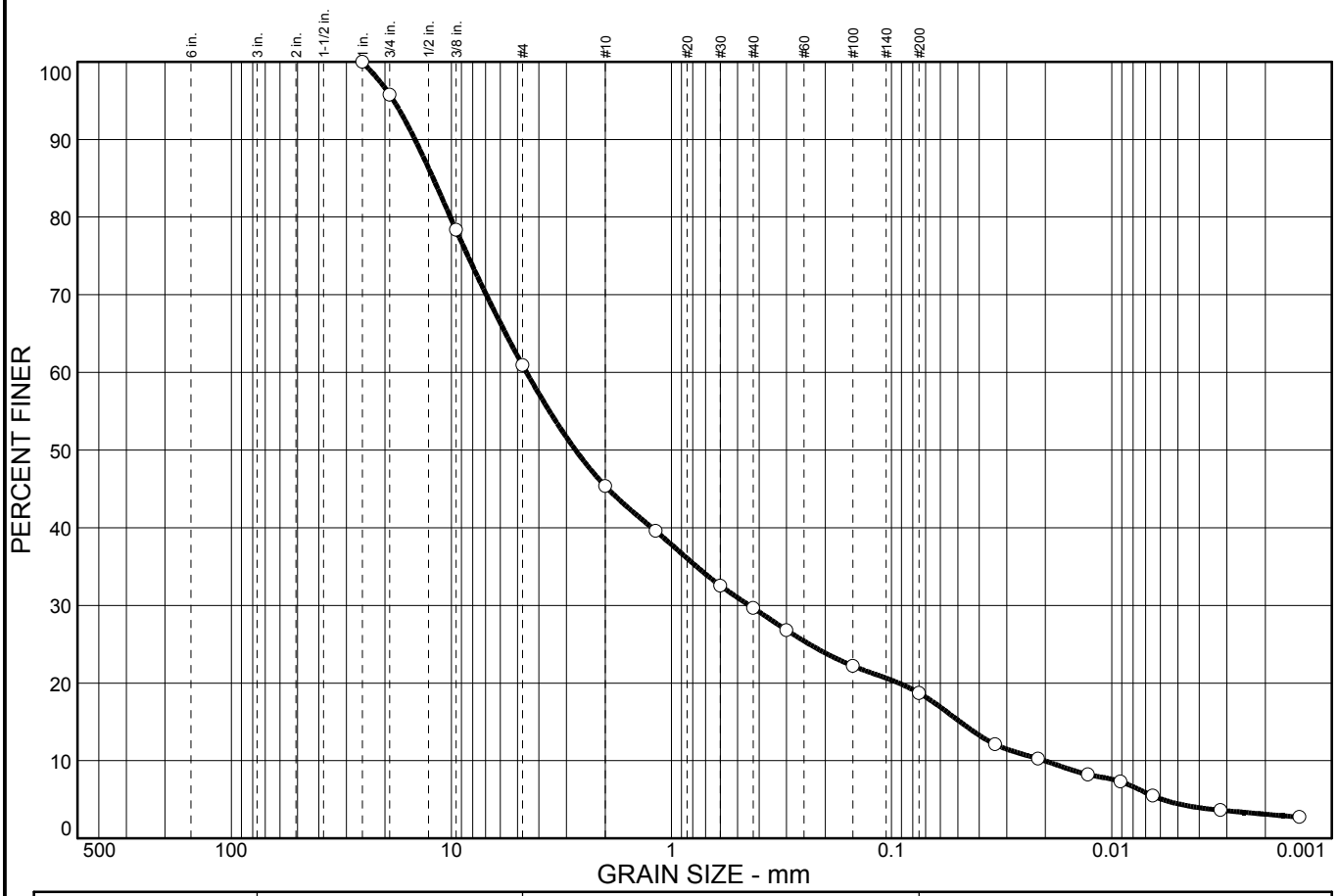
Sample No.: **Source of Sample:** **Date:** 7/23/2012
Location: HL-5 **Elev./Depth:** 3.5'-5'

PALMERTON & PARRISH, INC.
Springfield, MO

Client: Cherokee Nation
Project: Hulbert/Lost City

Project No: 209490 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	4.3	34.8	15.6	15.7	10.9	14.3	4.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1 in.	100.0		
3/4 in.	95.7		
3/8 in.	78.4		
#4	60.9		
#10	45.4		
#16	39.6		
#30	32.5		
#40	29.7		
#50	26.8		
#100	22.2		
#200	18.7		

* (no specification provided)

Material Description

Silty sand with gravel

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 12.1 D_{60}= 4.55 D_{50}= 2.73
D_{30}= 0.443 D_{15}= 0.0488 D_{10}= 0.0202
C_u= 225.72 C_c= 2.14

Classification

USCS= SM AASHTO=

Remarks

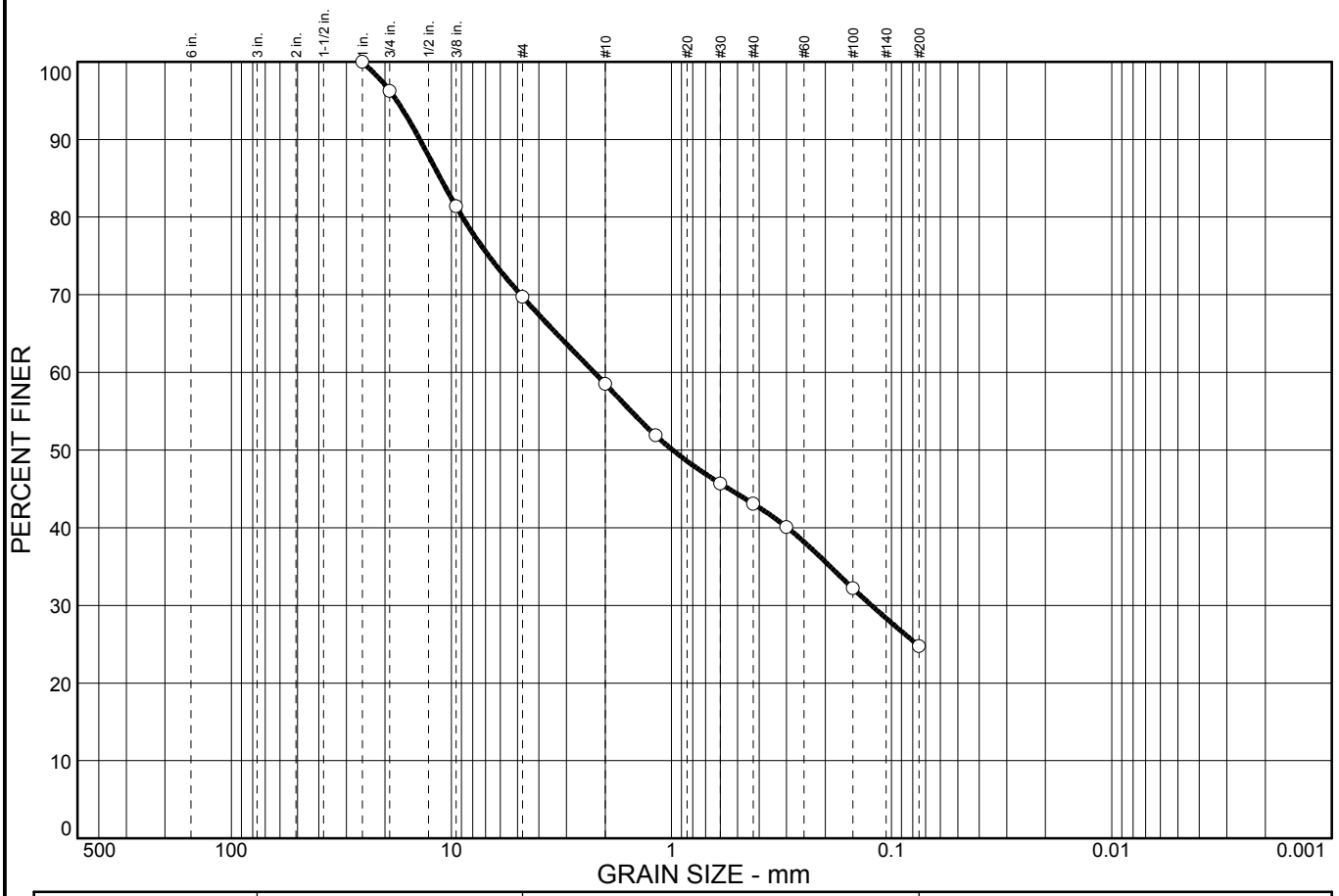
Sample No.: **Source of Sample:** **Date:** 7/20/2012
Location: HL-6 **Elev./Depth:** 3.5'-4.5'

PALMERTON & PARRISH, INC.
Springfield, MO

Client: Cherokee Nation
Project: Hulbert/Lost City

Project No: 209490 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	3.8	26.5	11.2	15.4	18.4	24.6	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1 in.	100.0		
3/4 in.	96.2		
3/8 in.	81.4		
#4	69.7		
#10	58.5		
#16	51.9		
#30	45.7		
#40	43.1		
#50	40.1		
#100	32.2		
#200	24.8		

* (no specification provided)

Material Description

Silty, clayey sand with gravel

Atterberg Limits

PL= 19 LL= 23 PI= 4

Coefficients

D_{85}= 11.2 D_{60}= 2.24 D_{50}= 0.988
D_{30}= 0.123 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= SC-SM AASHTO=

Remarks

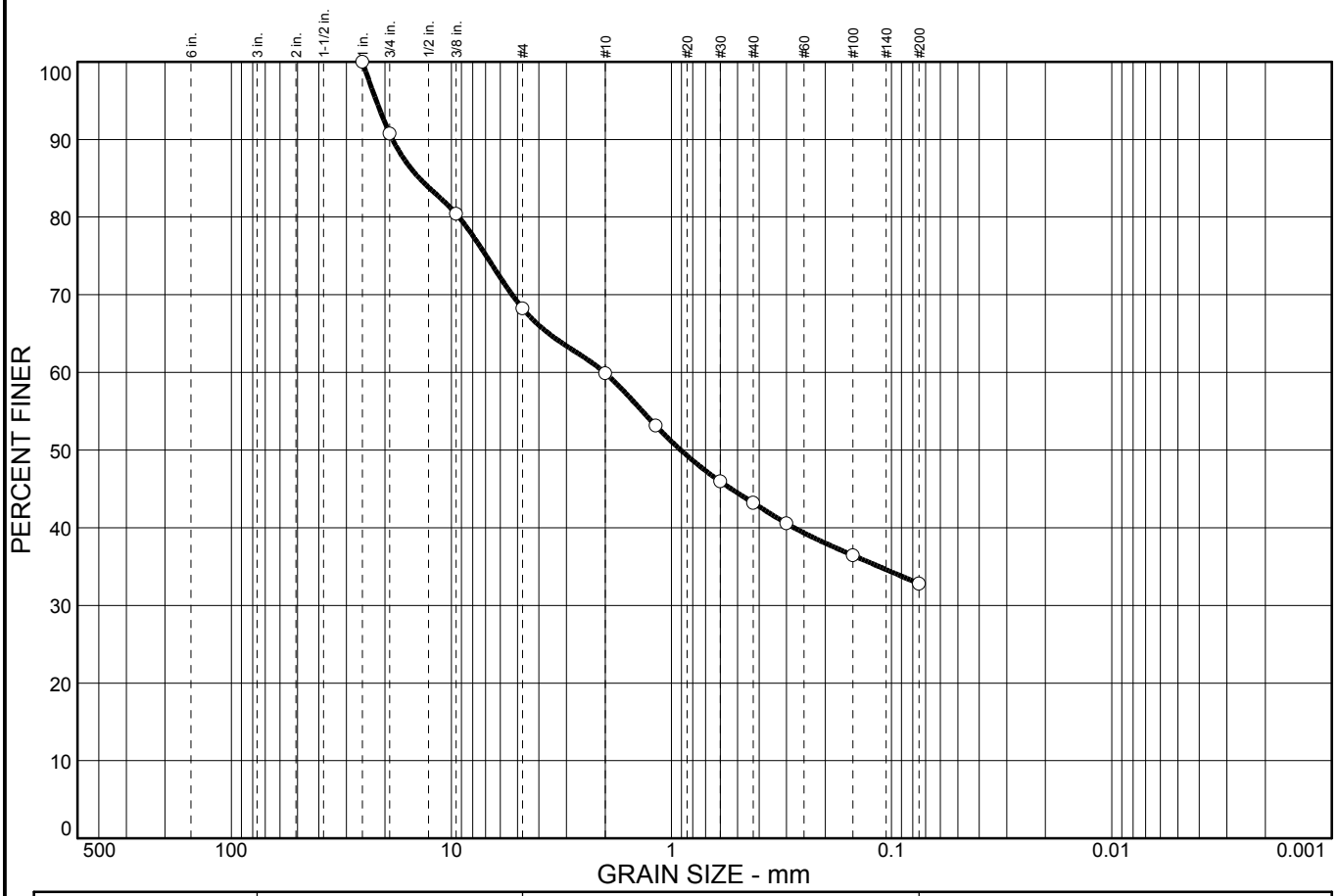
Sample No.: **Source of Sample:** **Date:** 7/23/2012
Location: HL-7 **Elev./Depth:** .5'-1.5'

PALMERTON & PARRISH, INC.
Springfield, MO

Client: Cherokee Nation
Project: Hulbert/Lost City

Project No: 209490 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	9.3	22.5	8.3	16.7	10.5	32.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1 in.	100.0		
3/4 in.	90.8		
3/8 in.	80.4		
#4	68.3		
#10	59.9		
#16	53.2		
#30	46.0		
#40	43.2		
#50	40.5		
#100	36.5		
#200	32.8		

* (no specification provided)

Material Description

Silty sand with gravel

Atterberg Limits

PL= 26 LL= 34 PI= 8

Coefficients

D_{85}= 14.0 D_{60}= 2.02 D_{50}= 0.907
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= SM AASHTO=

Remarks

Sample No.: **Source of Sample:** **Date:** 7/23/2012
Location: HL-8 **Elev./Depth:** .5'-2'

PALMERTON & PARRISH, INC.
Springfield, MO

Client: Cherokee Nation
Project: Hulbert/Lost City

Project No: 209490 **Figure**