TETRA TECH

October 9, 2017

Ms. Lisa Fischer, P.E.
HDR, Inc.
682 South Ferguson Ave, Suite 1
Bozeman, MT 59718

Subject: Preliminary Materials and Geotechnical Investigation – Mullan Road
West of Missoula – NW Reconstruction Project
MDT Project Number STPS 263 – 1(28)6
UPN 6141000
Tetra Tech Project No. 114-571120

Dear Ms. Fischer:

At your request, we have completed our preliminary investigation and prepared a Preliminary Geotechnical and Materials Report for the Montana Department of Transportation (MDT) reconstruction project referenced above. The report that follows describes in detail our investigations, summarizes our findings, and presents our preliminary materials and geotechnical recommendations, including Preliminary Soil Survey Investigation (450).

Should HDR or MDT have any questions or comments after reviewing this letter, please contact us at 406-543-3045 to discuss or to schedule a meeting time.

Sincerely,

TETRA TECH

Jeremy Dierking, P.E.
Project Geotechnical Engineer

Marco Fellin, P.E.
Project Manager

Tetra Tech
2525 Palmer Street, Suite 2, MT 59808
Tel 406.543.3045 Fax 406.543.3088 www.tetratech.com

West of Missoula - NW
STPS 263-1(28)6
UPN 6141000

ACTIVITY 440: **Preliminary Geotechnical and Materials Review**

DEFINITION: Initial review of Geotech and Materials plan recommendations from consultant designed project.

TASKS:

	Preliminary Soil survey Investigation (450) (Soil Survey Report Form 111)	**Yes**	**No**	**N/A**	**Initial**
		X			MF
1.	Log of each test hole.	X			MF
2.	Location of each test hole noted.	X			MF
3.	Soil Class shown for each sample (AASHTO).	X			MF
4.	Moisture/Density curve for each soil sample. **(Moisture density tests were performed on representative samples of the subbase/subgrade materials.**	X			MF
5.	In place density at each location. **(Relative densities obtained from SPT blow counts at each test hole).**	X			MF
6.	Natural moisture shown for each soil sample. **(Natural moisture contents were obtained at the majority of the sample locations. Some of the large bulk samples did not have moisture samples taken).**	X			MF
7.	R-Value or other acceptable test method for each soil sample.	X			MF
8.	Soil survey adequate for entire project.	X			MF
9.	Chemical and corrosion sample taken at each pipe installation.	X			MF
10.	Report submitted describing in-place pipe condition.	X			MF
11.	Test holes plotted on plan and profile sheets.	X			MF
12.	Narrative describing unusual conditions or potential problems soils or drainage.	X			MF

Borrow & Surface Pit Investigation (452) (Form 99, 92 & Pit Sketch)	**Yes**	**No**	**N/A**	**Initial**
		X		MF
1. Completed Prospected Area Report submitted. **(Borrow and Surface Pit Investigation not completed for this project since multiple local pit sources are available).**			X	MF
2. Map showing location of pit submitted.			X	MF
3. Pit sketch submitted showing location of test holes, legal description and quantity of aggregate available.			X	MF
4. Completed Field Sample Analysis Report submitted.			X	MF
5. Materials Bureau Prospected Area Report completed.			X	MF
6. Is the pit satisfactory for use as bituminized or non-bituminized surfacing?			X	MF

Preliminary Surfacing Typical Sections (600)				
1. Have 3 alternate typical sections been recommended?	X			MF
2. Is there an economic analysis for each alternate?	X			MF
3. Is the method of design satisfactory?	X			MF
4. Are the designs based on subgrade R-Value? Other? **Design based on CBR and backcalculated resilient modulus.**	X			MF
5. Are the design ESAL's current?	X			MF
6. Are the proposed surfacing layer thicknesses reasonable?	X			MF
7. Has special borrow or a 2' subgrade cap been considered to reduce the surfacing?	X			MF
8. Is the recommended typical alternate satisfactory?	X			MF

Deflection Analysis	Yes	No	N/A	Initial
1. Are back calculated layer modulus values needed for this project? (If no, skip b, c & d) **These were obtained from MDT.**	X			MF
2. Was an acceptable back-calculation technique utilized?	X			MF
3. Are back calculated moduli values available for all in-place layers? **Just subgrade layer.**		X		MF
4. Are values representative of the area? (Compare to network data)	X			MF

Preliminary Geotechnical Evaluation (460)	Yes	No	N/A	Initial
1. Has a literature and map review been performed?	X			MF
2. Has a site visit been completed to look at geology, slopes, roadway, drainage, wetlands and other geotechnical issues?	X			MF
3. Have any potential Geotechnical problems been identified? **Soft and wet areas, these areas will be reviewed in depth for the Consultant Activity 130 Report.**	X			MF
4. Has a written report been provided?	X			MF

Date Received: _____ Date Approved: _____

Reviewed by: _____ Date: _____
(Signature/Title)

START
DEPENDENCIES: Completion of Activity 106.

Consultant Activity 106 - Preliminary Geotechnical and Materials Report
Montana Department of Transportation

West of Missoula – NW (Mullan Rd)
STPS 263 – 1(28)6, UPN 614100
Missoula, Montana

Tetra Tech Project No. 114-571120
October 9, 2017

PRESENTED TO

HDR, Inc.
Ms. Lisa Fischer, P.E.
682 South Ferguson Avenue, Suite 1
Bozeman, Montana 59718

PRESENTED BY

Tetra Tech
2525 Palmer Street,
Suite 2
Missoula MT 59808

P +1-406-543-3045
F +1-406-543-3088
tetratech.com

Prepared by:

Name: Jeremy Dierking, P.E. Date: October 9, 2017
Title: Project Geotechnical Engineer

Reviewed by:

Name: Marco Fellin, P.E. Date: October 9, 2017
Title: Senior Geotechnical Engineer

TABLE OF CONTENTS

APPENDIX

1.0 PROJECT DESCRIPTION

This project is located in Missoula County, beginning on S-263 (Mullan Road) at RP 5.5, located west of the intersection with Deschamps Lane. The project extends west to RP 10.6, west of the intersection of S-263 (Mullan Road) with S-474 (Pulp Mill Road). The project will include improving the driving surface and safety by widening the roadway shoulders, flattening the side slopes, improving the horizontal and vertical alignments, and upgrading the clear zone. The updating of guardrail, pavement markings, signing, and fencing will also be included. The project will require full pavement reconstruction the entire length. The project will likely require the relocation and/or removal of irrigation canals and privately owned structures that closely parallel the roadway.

Eleven culverts intersect the existing roadway within the project limits. An approximately 40-foot long, single span bridge is located near the intersection of Mullan Road and Primrose Drive.

Secondary 263 (Mullan Road) is functionally classified as a Rural Collector Road located west of Missoula, Montana. The project segment traverses the west side of the Clark Fork River flood plain in the Missoula Valley through residential and farm land. The existing terrain is relatively flat with overall natural topography sloping and draining towards the Clark Fork River to the east. The existing roadway was originally a military road that was later adopted and maintained by Missoula County prior to it becoming a State road. Available as-built information is limited but previous records date as far back as 1939. The roadway is currently two 12-foot wide travel lanes and no shoulders. The existing side slopes along the project segment are relatively steep with deep borrow ditches. Irrigation ditches closely parallel the roadway from approximately RP 7.3 to RP 9.3.

Based on measurements from the preliminary soil survey borings drilled by Tetra Tech, the existing pavement section thickness on S-263 varies from 5 to 12 inches of asphalt concrete underlain with 1.1 to 4.7 feet of granular base and subbase course.

Figures 1A-1 and 1A-2 in Appendix 1A show the approximate project limits, boring locations, and other pertinent site features.

2.0 PRELIMINARY SOIL SURVEY INVESTIGATION

The geotechnical subgrade soils investigation described in this section includes the field subsurface investigation and laboratory testing. Soil survey boring locations and depths were chosen based on preliminary design information and information provided by HDR. The fieldwork was performed to obtain subsurface information, and to provide preliminary recommendations for the design and construction of the anticipated roadway alignment.

2.1 SUBSURFACE FIELD INVESTIGATION

The field exploration was conducted from June 19, 2017 to June 23, 2017. Dates of individual soil survey borings are indicated on the borings logs (Appendix 2A). A total of 26 borings were drilled during the subgrade soil investigation to explore subsurface conditions. The locations of the borings are shown on Figures 1A-1 and 1A-2 in Appendix 1A.

Locations of the borings were initially marked in the field by Tetra Tech utilizing the project location map provided by HDR and MDT. Following completion of the soil survey drilling, the boring locations were surveyed using GPS equipment by DJ&A to obtain the horizontal and vertical coordinates of each boring. Mile posts, coordinates, and elevations of the borehole locations listed on the boring logs were determined using the GPS data obtained. The borings were advanced through the overburden soils with

a truck-mounted drill rig equipped with; 8 1/4-inch outside-diameter (O.D.) hollow-stem augers. Drilling activities and borings were overseen and logged by a Tetra Tech geotechnical engineer.

Samples of the subsurface materials were taken with a 2-inch outside diameter (O.D.) split-spoon sampler. The sampler was driven into the various strata using a 140-pound hammer falling 30 inches. The number of blows required to advance the sampler each successive 6-inch increment was recorded; the total number of blows required to advance the sampler the second and third 6-inch increments is the penetration resistance (N value). The 2-inch O.D. sampler is the standard penetration test described by American Society for Testing and Materials (ASTM) Method D1586. Penetration resistance values indicate the relative density or consistency of the soils. Bulk samples of soil were obtained from the hollow-stem augers cuttings at select locations. Relatively undisturbed subsurface samples were obtained by hydraulically pushing 3-inch I.D. thin walled Shelby Tube samplers. The depth at which the samples were taken and the penetration resistance values are shown on the log of exploration boring.

2.2 LABORATORY TESTING

Samples obtained during the field exploration were taken to Tetra Tech's laboratory, where they were observed and visually classified in accordance with ASTM Method D2487, which is based on the Unified Soil Classification System. Representative soil samples were selected for testing to determine their engineering and physical properties in general accordance with the Montana Materials Manual of Test Procedures, American Association of State Highway and Transportation Officials (AASHTO), ASTM, or other approved procedures.

Tests Conducted:	To Determine:
Atterberg Limits	The effect of varying water content on the consistency of fine-grained soils.
Grain-size Distribution	Size and distribution of soil particles (i.e., clay, silt, sand, and gravel).
California Bearing Ratio	The capacity of a subgrade or subbase to support a pavement section designed to carry a specific traffic load.
Moisture-Density Relationship	The optimum moisture content for compacting soil and the maximum dry unit weight (density) for a given compactive effort.
Natural Dry Density	Dry unit weight of samples, representative of in-place conditions.
Natural Moisture Content	Moisture content representative of field conditions at the time samples were taken.
Direct Shear	Consolidated-Drained soil strength properties.
Consolidation/Swell	The amount a soil sample compresses with loading and the influence of wetting on its behavior. For use in settlement analysis, determining expansive potential and foundation design.
Resistivity and pH	The combination of these characteristics determines the potential of soil to corrode metal.
Sulfate Content	Potential of soils to deteriorate normal strength concrete.

Results of field and laboratory tests are summarized on Table 2.1.1 in Appendix G and presented graphically in Appendices 2B through 2F. These data, along with the field information, were used to prepare the exploration boring logs in Appendix 2A.

2.3 SUBSURFACE CONDITIONS

Subsurface soils were classified in accordance with standards set by AASHTO. Descriptive terms were obtained using the ASTM Soil Classification System. Both the AASHTO and ASTM classifications are noted on the logs and laboratory data presented in Appendices 2A through 2F for each soil sample. Table 2.1.1 is a summary of all of the soil types and properties obtained in the borings drilled along the project length. In general, the classifications and engineering properties of the subsurface soils are consistent across the project length. Throughout the project segment subgrade soils classified as A-1-a, A-1-b, A-2-4, A-2-6, A-4, A-6, and A-7-6. Each soil type encountered is briefly described below.

2.3.1 Pavement Section

Based on measurements obtained by Tetra Tech during the field investigation, the current roadway pavement section consists of approximately 5 to 12 inches of asphaltic concrete. The majority of the project length from was overlaid with approximately 2 inches of asphalt in Spring 2017. Fill was encountered in all of the borings directly below the pavement section extending to depths ranging from 1.1 to 4.7 feet. Tetra Tech was unable to identify a distinct layer of crushed base course below the pavement. The fill generally classified as A-1-a, A-1-b, and A-2-4 which are further discussed below.

2.3.2 A-1 Fill Soils

Sand and gravel fill was encountered in borings SS-1 through SS-5, SS-12 through SS-21, and SS-23 through SS-25 beneath the pavement extending to depths on the order of 1.3 to 4.7 feet. The fill material classified as poorly graded gravel with silt and sand, silty gravel with sand, and poorly graded sand with gravel (A-1-a to A-1-b). Penetration resistance values in the fill ranged from 5 to greater than 50 blows per foot which indicates a loose to very dense soil stratum. The natural moisture content of samples obtained in the fill above the water table ranged from 1 to 23 percent at the time of drilling. Laboratory testing indicates the fill soils have a plasticity index on the order of non-plastic to 2 percent. Laboratory testing performed on bulk samples of the A-1 fill soils indicate rock-corrected maximum dry densities ranging from 137.6 to 146.2 pcf, and rock-corrected optimum moisture contents ranging from 3.7 to 5.8 percent (Appendix 2C). Results of California Bearing Ratio tests on the A-1 fill soils indicate a California Bearing Ratio on the order of 13 to 45 indicative of a medium to high strength subgrade.

2.3.3 A-2 Fill Soils

A-2 fill soils were encountered in borings SS-6 through SS-11, SS-22, SS-25, and SS-26 beneath the pavement extending to depths on the order of 1.1 to 4.0 feet. The fill material classified as poorly graded gravel with clay and silty clayey sand with gravel. Penetration resistance values in the fill ranged from 9 to greater than 50 blows per foot which indicates a loose to very dense soil stratum. The natural moisture content of samples obtained in the fill above the water table ranged from 1 to 13 percent at the time of drilling. Laboratory testing indicates the fill soils have a plasticity index on the order of 6 to 13 percent.

2.3.4 A-1 Native Soils

Natural sand and gravel were encountered in all borings at depths ranging from 1.2 to 12.0 feet and extended to depths beyond the maximum depth explored (25.5 feet). The natural sand visually classified as poorly graded sand with gravel with varying percentages of silt (A-1-a to A-1-b). Penetration resistance values in the sand ranged from 10 to greater than 50 blows per foot which indicates a loose to very dense soil stratum. The natural moisture content of samples obtained in the sand above the water table ranged from 1 to 10 percent at the time of drilling. Lower blow counts were typically encountered in layers with higher moisture contents or beneath the water table. Hydraulic pressure gradients encountered in the sand layers below the water table created flowing/heaving sand conditions while drilling.

The natural gravel classified as poorly graded gravel with silt and sand and silty gravel with sand (A-1-a to A-1-b). Penetration resistance values in the gravel ranged from 23 to greater than 50 blows per foot which indicates a medium dense to very dense soil stratum. The natural moisture content of samples obtained in the gravel above the water table ranged from 1 to 12 percent at the time of drilling. Laboratory testing indicates the gravel soils have a plasticity index on the order of non-plastic to 2 percent. Laboratory testing performed on bulk samples of the A-1 soil obtained from SS-17 indicated a rock-corrected maximum dry density of 136.6 pcf, and a rock-corrected optimum moisture content on the order of 6.0 percent (Appendix 2C).

2.3.5 A-4 Native Soils

A-4 soils were encountered in borings SS-2, SS-4 through SS-16, SS-18 through SS-23, SS-25, and SS-26 at depths ranging from 1.3 to 8.0 feet and extending to depths ranging from 3.0 to 12.0 feet. The A-4 soils classified as lean clay with sand, silty clayey sand with gravel, sandy silty clay, and silty sand with AASHTO group indices ranging from 0 to 1 (Appendix 2B). Penetration resistance values in the A-4 soils ranged from 0 to 16 blows per foot, indicating a very soft to very stiff soil stratum.

The natural moisture content varied from 6 to 41 percent at the time of drilling, depending on the amount of silt and clay fines in the sample. Laboratory testing indicates the A-4 soils have a plasticity index on the order of non-plastic to 8 percent. Laboratory testing performed on two bulk samples of A-4 soil indicate rock-corrected maximum dry densities ranging from 114.9 to 116.1 pcf, and rock-corrected optimum moisture contents ranging from 12.8 to 14.1 percent (Appendix 2C). Results of California Bearing Ratio tests on the A-4 soils indicate a California Bearing Ratio on the order of 4 to 11 indicative of a low to medium strength subgrade.

Consolidation testing data is included in Appendix 2E. Direct shear strength testing (Appendix 2F) performed on a sample of the A-4 soil indicates a friction angles on the order of 24.7 degrees, and a cohesion value on the order of 800 psf.

2.3.6 A-6 Native Soils

A-6 soils were encountered in borings SS-16, SS-22, SS-23, and SS-24 at depths ranging from 1.5 to 6.0 feet and extending to depths ranging from 5.5 to 10.0 feet. The A-6 soils classified as sandy lean clay with AASHTO group indices ranging from 4 to 8 (Appendix 2B). Penetration resistance values in the A-6 soils ranged from 3 to 7 blows per foot, indicating a medium stiff soil stratum.

The natural moisture content varied from 18 to 33 percent at the time of drilling, depending on the amount of silt and clay fines in the sample. Laboratory testing indicates the A-6 soils have a plasticity index on the order of 13 to 15 percent. In-place densities measured on a sample of the A-6 soils was on the order of 102.7 pcf. Laboratory testing performed on two bulk samples of A-6 soil indicate rock-corrected maximum dry densities ranging from 105.3 to 111.1 pcf, and rock-corrected optimum moisture contents ranging from 12.6 to 17.6 percent (Appendix 2C).

Consolidation testing data is included in Appendix 2E. Direct shear strength testing (Appendix 2F) performed on a sample of the A-6 soil indicates a friction angles on the order of 30.9 degrees, and a cohesion value on the order of 400 psf.

2.3.7 A-7 Native Soils

A-7 soils were encountered in borings SS-16, SS-24, and SS-26 at depths ranging from 4.0 to 9.0 feet and extending to depths ranging from 6.0 to 11.0 feet. The A-7 soils often included discontinuous layers of silt and sand at various locations and generally consisted of lean to fat clay with varying percentages of sand and small percentages of gravel, with a classification of A-7-6 and group indices ranging from 17 to

44, per the AASHTO classification system (Appendix 2B). Penetration resistance values ranged from 8 to 12 blows per foot, indicating a medium stiff soil stratum.

The natural moisture content ranged from 19 to 28 percent at the time of drilling. Laboratory testing determined plasticity indices ranging from 23 to 39 percent. In-place densities measured in samples of the A-7 soils ranged from 93.5 to 97.7 pcf. Direct shear strength testing (Appendix 2F) indicates friction angles ranging from 9.8 to 29.9 degrees, with cohesion values ranging from 350 to 370 psf.

2.3.8 Groundwater

Subsurface water was encountered in borings SS-1 through SS-23 at the time of the field investigation. Groundwater levels were measured immediately after drilling and varied from as shallow as 5 feet in boring SS-12 to as deep as 13.4 feet below existing grade in boring SS-17 at the time of drilling, with an average depth of 9.2 feet. The groundwater data is indicated on the boring logs and included in Table 2.1.1.

Water levels will rise with seasonal fluctuations in the Clark Fork River, seasonal precipitation and local irrigation practices in the area. Groundwater will be encountered and should be anticipated by the contractor during construction. It is our opinion that the existing groundwater conditions and normal rainfall may decrease the bearing capacity of the subgrade soils and that these soils could pump under construction wheel loads. Tetra Tech will develop recommendations and Special Provisions as necessary and include in the Consultant Activity 130 Final Geotechnical Report.

2.4 FIELD CULVERT SOIL SAMPLING

In June 2017, Tetra Tech performed a field survey to observe the condition of the existing culverts, and collected soil and water samples from existing culvert locations. Soil samples were obtained at the invert elevation of 11 existing culverts located below Mullan Road. At the time of our sample collection, standing or flowing water was observed at five culvert locations and five water samples were collected for testing.

The horizontal locations of the culverts were marked on an aerial photo of the project site, as shown in Figure 2H-1 in Appendix 2H. The culverts are identified in this report using nomenclature C1, C2, etc. The existing culverts are constructed of both reinforced Portland cement concrete (PCC), corrugated steel pipe (CSP), and solid steel, ranging in diameter from 12 to 48 inches. The MDT Drainage Evaluation Form and Culvert Condition Form are included in Appendix 2H. Soil and water samples were delivered to Energy Labs in Billings, Montana. Soil samples were tested for marble pH and sulfate testing, and resistivity and pH testing was performed in the Missoula Tetra Tech lab. Five water samples collected were tested for pH, resistivity, conductivity, and sulfate content. The laboratory data is included in Appendix 2I, along with the MDT Culvert Design Life Spreadsheet, Table 2I-1. Photographs of the culverts and pavement section near the culverts are included in Appendix 2J.

In accordance with Appendix E from the 2011 *MDT Road Design Manual, Chapter 11*, the design service life for new or replacement culverts will be 75 years for mainline and major county roads. The design service life for reconstruction and major widening projects will be 25 to 50 years for in-place culverts that will not be replaced. Based on soil resistivity and pH data presented in Appendix 2I, the estimated years for perforation of 16-guage galvanized metal culverts will range between 52 to 105 years. Table 2I-1 should be consulted prior to designing or sizing culverts to determine the appropriate culvert material or required coating to use at each location.

Per the 2008 *MDT Road Design Manual*, the following culvert options are available, depending on the chemical corrosion characteristics of the soil encountered at each location.

- CSP with or without an approved bituminous or polymeric coating.
- Type II aluminized steel or aluminum.
- Concrete pipe. Per MDT current specifications, Type V concrete is standard.

3.0 PRELIMINARY SURFACING TYPICAL SECTIONS

The project will consist of complete reconstruction and partial realignment of segments of Secondary 263 (Mullan Road) from RP5.5 to RP 10.6, including widening, and horizontal and vertical alignment modifications to meet current design standards. Based on the undated Preliminary Field Review Report obtained from MDT, the existing roadway width is approximately 24 feet, and the planned width will be somewhere between 36 and 40 feet depending on whether 6 or 8-foot shoulders are constructed.

A pavement section is a layered system designed to distribute concentrated traffic loads to the subgrade. Performance of the pavement structure is directly related to the physical properties of the subgrade soils and traffic loadings. The following references were used during pavement design for this preliminary report:

1. AASHTO Guide for Design of Pavement Structures, 1993
2. *MDT Asphalt Pavement Design Manual*, 2016
3. Undated Preliminary Field Review Report from MDT
4. MDT FWD and backcalculated modulus data

The following sections discuss subgrade soils, projected annual daily traffic counts, flexible pavement design parameters, pavement alternatives, and costs for each alternative.

3.1 SUBGRADE SOILS

The subgrade soil types and depths encountered were variable throughout the project length. A base course or gravel fill layer was encountered in each boring, extending to depths on the order of 1.3 to approximately 6 feet below the existing pavement grade. The fill or base course layer had varying percentages of silt and clay fines, with the minus 200 content ranging from 6 to 32 percent for the 6 samples tested. To be considered a subgrade layer per MDT design, a layer must be a minimum of 2 feet thick. At this time, the final grade has not been determined, however it is estimated the grade will remain similar, or even lowered due to the amount of driveway and road approaches on the project. Therefore, considering the existing road section must be excavated to construct the new road section, the existing gravel layer thickness is not thick enough to be considered a subgrade layer.

As discussed in Section 2, a clayey subgrade layer with varying amounts of sand and gravel exists beneath the gravel fill. The layer was generally encountered within two to three feet of the pavement surface.

Tetra Tech obtained a printout of the backcalculated resilient modulus values for the project, Appendix 3A. The 'lab equivalent resilient modulus backcalculated by MDT is 5,000 psi. Tetra Tech has estimated there are likely a few areas on the project where the subgrade backcalculated value is based on the sand and gravel fill layer, however the 5,000 value represents the entire subgrade, including the clay. Given that the clay samples tested on this project contained higher percentages of sand and some gravel, Tetra Tech has assumed the 5,000 psi backcalculated value to a reasonable subgrade resilient modulus for the soils encountered in the geotechnical investigation.

Six subgrade samples were tested in the lab for CBR, with the following results:

Boring	Depth (ft)	Subgrade Classification	CBR Value
SS-2	3-6	Silty Clayey Sand with Gravel	11
SS-9	3-7	Sandy Silty Clay	10
SS-14	3-9	Lean Clay with Sand	4
SS-16	3-9	Sandy Lean Clay	4

Per MDT design procedures, MDT does not perform R-value testing on A-6 or A-7 samples, thus the majority of the subgrade samples on this project were not tested. Published correlations between CBR and resilient modulus values indicate a CBR of 4 roughly correlates to a resilient modulus value of 5,000 to 6,000 psi. Tetra Tech has chosen a CBR value of 5,000 for the clay subgrade.

Should a 2-foot gravel subgrade cap be utilized, Tetra Tech has assumed a minimum subgrade R-value of 20 for a pit run gravel, or a minimum resilient modulus of 12,000 psi.

3.2 TRAFFIC COUNTS

Traffic information was obtained from an August 10, 2017 Memorandum from MDT, included in Appendix 3A, as follows:

2017 AADT: 1,670

2021 AADT: 1,770

2041 AADT: 2,390

DHV: 250

Percent Trucks: 7.7%

ESAL Daily: 77

20-Year ESAL: 561,162

3.3 FLEXIBLE PAVEMENT DESIGN PARAMETERS

The variables (Chapter 2, *AASHTO Guide for Design of Pavement Structures*) required for design of flexible pavements and corresponding information for this project are provided below.

Analysis Period: 20 years (*MDT Asphalt Pavement Design Manual*, 2016).

Traffic Data: Based on the MDT data, the 20-year ESAL count is approximately 1.2 Million.

Reliability: 95 percent for primary roadway. A high level of reliability was chosen for the primary roadway due to the high volume of traffic, the difficulty of diverting traffic, and the high public expectation of availability of the roadway.

Standard Deviation: 0.45 (*AASHTO Guide for Design of Pavement Structures*, 1993).

Serviceability: Initial serviceability Index (Po) = 4.2, Terminal serviceability index (Pt) = 2.5. A Pt of 2.5 or higher is recommended by AASHTO for major highways, and is used by MDT for primary highways. The initial serviceability is assumed to be 4.2 per the 1993 AASHTO design guide.

Effective Roadbed Soil Resilient Modulus: 5,000 psi for the clay subgrade and 12,000 psi for 2-foot gravel cap, as discussed above.

Layer Coefficients: Layer coefficients were obtained from the MDT pavement design manual and recent memos as follows:

New Plant Mix Asphalt Concrete:	0.41
Existing Plant Mix Asphalt Concrete:	0.33
Crushed Gravel, 50 mm Maximum Size:	0.14
Existing Crushed Base Course:	0.12
Pulverized Asphalt/Base Mixture:	0.12
Cement or Base One treated Base Course:	0.20

Drainage Coefficient: Since the quality of drainage for the pavements to be constructed is assumed to be good, the drainage coefficient was assumed to be 1.0 (*AASHTO Guide for Design of Pavement Structures*, Table 2.4, 1993) for the asphalt, base, and subbase layers.

Roadbed Swelling and Frost Heave: For preliminary design, we have not designed for roadbed swelling and frost heave. Tetra Tech will evaluate roadbed swelling and frost heave in the final design depending on the final roadway grade.

3.4 TYPICAL SECTION ALTERNATIVES

Based on Surfacing Design Guideline from MDT, MDT recommends the following minimum plant mix thickness for roadway sections:

Daily Equivalent Single Axle Loads (ESAL)	Recommended Plant Mix Thickness (ft)
>2,000	0.7
1,000 to 2,000	0.6-0.7
501 to 1,000	0.5-0.6
201 to 500	0.4-0.5
Urban Curb and Gutter	0.4

MDT requires the following minimum thicknesses (if used): 8 inches of crushed aggregate course (CAC) and 8 inches of cement-treated base course.

For this project, a Portland Cement Concrete surfacing option will not be analyzed because the sections of roadway connected to this project are asphaltic concrete. The following table presents typical asphalt concrete section alternatives based on the minimum thicknesses described above. The design printouts are included in Appendix 3B.

Table 3-1. Pavement Section Alternatives for Northbound and Southbound Couplet

Design Section	Asphalt Concrete Surfacing Thickness (in)	Granular Base Thickness (inches)	Treated Base (inches)	Assumed Subgrade Type
Alternative 1	3.6	8.5	0	Two-Foot Pit Run Subgrade Cap
Alternative 2	3.6	16.0	0	Lean Clay
Alternative 3	3.6	0	11.0	Lean Clay

3.5 COST ANALYSIS

A cost analysis was performed using the pavement sections in Table 3-1. Average unit rate costs for each cost item were obtained from the MDT Internet web page for projects constructed in Montana in 2016. The plant mix costs are assumed to include mixing, placing, and compacting the asphalt concrete. Figure 3C-1 in Appendix 3C summarizes the cost analysis for each pavement section utilizing the MDT average price units.

3.6 SUMMARY

Since the roadway width will increase by approximately 12 to 16 feet or more to construct shoulders, the project will likely be a significant 'borrow' project. Several options were considered to re-use existing materials, including; 1) reclaiming the existing asphalt and base layer in place, stockpiling, then re-using for all or part of the 2-foot cap layer, or 2) ripping or reclaiming the existing asphalt and base layer in place then grading into the widening fill areas. Tetra Tech recommends that, given the variability of the base and gravel fill layer with varying percentage of silt and clay fines it is not particularly suited as a 2-foot cap layer. In addition, trying to reuse the existing base layer would not be cost efficient due to the need to process or handle the material up to three times to get it back into place for use as subbase or the subgrade cap. It would be most economical to reclaim or rip the existing asphalt layer in place, then grade or haul the reclaimed layer into the fill areas. This method would save the cost to break up and haul the existing asphalt off site, and would also save on fill costs for import fill.

The cost estimate in Figure 3C-1 indicates that placing a 2-foot subgrade cap would be the most economical pavement section, by about $500,000 for the entire 5.1-mile project length. The 2-foot subgrade cap is not included in the cost estimate because; the two feet of cut material for the cap will be graded or hauled into the fill areas, so in essence this is saving the cost of material that needs to be placed in the shoulder fills. And, since gravel will likely be used for import fill material, this alternative takes advantage of the gravel strength for the pavement design.

Given the variability of the existing gravel fill and clay subgrade, in addition to a cost savings, placing a 2-foot cap gravel subgrade would serve several other functions:

1) Provide a homogenous subgrade throughout the project length, which would prevent differential movement due to varying subgrade types,
2) Provide better drainage beneath the pavement section,
3) Lower the potential for frost heave or swelling potential of the clay subgrade soils.

Based on the above discussion, Tetra Tech recommends the 2-foot subgrade cap alternative be utilized for this preliminary design. Once the final road cross sections and elevations are determined, Tetra Tech will re-evaluate the preliminary design for the Activity 130 Report.

4.0 PRELIMINARY GEOTECHNICAL EVALUATION (460)

This section discusses site geology, Tetra Tech's site reconnaissance, and review of geological literature, and presents preliminary geotechnical recommendations that could impact the planned roadway design.

4.1 SITE GEOLOGY

Tetra Tech performed a reconnaissance of the site geology, topography, utility conflicts, drill rig access, and current land use as they relate to geotechnical issues along the project length. This information was supplemented with published geologic references and data from the field investigation. The objectives of the geologic reconnaissance were to 1) provide a general geologic framework for the project corridor, and 2) provide additional data for design issues associated with proposed design alternatives. Work under this item generally followed guidelines outlined in MDT's *Geotechnical Manual* (June 2008).

The Missoula Valley is a wide, northwest trending valley where the Bitterroot River and many smaller tributaries flow into the Clark Fork River. The project is located on the south side of the Missoula Valley, and generally follows the eastern flank of the historic Clark Fork River flood plain, approximately ½- to 1-mile east of the Clark Fork River. The project alignment is located on relatively level floodplain terrain. Historic river meanders and oxbow channels (sloughs), small creeks, and irrigation ditches are adjacent to the roadway at various locations along the alignment. Adjacent property primarily consists of residential homes on larger rural tracts of privately-owned land and open fields used for agricultural purposes or for grazing livestock.

The Missoula Valley is part of the Northern Rocky Mountains physiographic province, where north- to northwest-trending mountain ranges separate intermontane valleys drained by the Clark Fork River and its tributaries. The Missoula Valley is a northwest trending intermontane basin bounded by the Rattlesnake Mountains and Reservation Divide to the north, the Grave Creek Range to the south, Hellgate Canyon and the Sapphire Mountains to the east, and the Clark Fork and Ninemile Valleys to the west. The Missoula Valley is a relatively wide valley characterized by large areas of low-relief grassy and wooded terrain into which modern streams have cut relatively narrow channels 50 to 100 feet below the valley floor.

The valley basin is filled with unconsolidated to weakly lithified materials ranging in thickness from less than 100 feet to as much as several thousand feet thick in areas that have been down-dropped by faults relative to the surrounding mountains. Near-surface alluvial sediments consist of coarse-grained sand and gravel with minor interbeds of silt and clay along the modern stream floodplains and low terraces. Since Pleistocene time, the Bitterroot and Clark Fork Rivers have down cut and removed nearly 800 feet of sediment from the valley floor as they meander across their floodplains.

Review of the Geologic Map of Montana part of the Missoula West 30' by 60' Quadrangle, Western Montana (MBMG, 1998), indicates that the project site is predominately underlain by alluvium deposited by the Clark Fork River. The natural subsurface alluvial profile within the flood plain of the Clark Fork River

is best characterized as surficial layers of silt and clay overlying a dense alluvial deposit of sand, gravel, cobbles, and boulders extending to depths on the order of 200 feet or greater. In the Missoula Valley, built construction projects document boulders from about 1.5 to more than 5 feet in size as a common occurrence in the alluvium, due to the sequential filling and draining of the glacial lake. These materials are predominantly Bonner Quartzite with a minor amount of sand and argillite intermixed. We did not observe any slope instability features along the existing alignment that would impact the project.

4.2 SITE VISIT

Tetra Tech performed a reconnaissance of the site geology, topography and surface drainage features/unusual drainage problems as they relate to geotechnical issues. Work under this item followed procedures outlined in MT-407, Method of Test for Preliminary Soils and Geological Reconnaissance. Our main concerns were design issues associated with construction over areas of shallow groundwater and soft soils.

Due to the deteriorating condition of the asphalt section, the majority of the project length was recently overlaid with approximately 2 inches of asphalt, which was included on the asphalt thicknesses indicated on the logs of the borings.

4.3 PRELIMINARY GEOTECHNICAL RECOMMENDATIONS

During the Consultant Activity 130 Phase of this project, we anticipate the following areas will need to be evaluated;

- Foundation recommendations for the Primrose Irrigation Canal Bridge.
- Foundation recommendations for large culverts, such as at O'Keefe Creek.
- Fill and cut slope recommendations as needed.
- MSE or gravity wall or reinforced soil slope/foundation type and design if steeper or vertical fill slopes are necessary for embankment placement within right-of-way.
- Foundation recommendations for soft soil areas and areas of high groundwater along fill areas, including settlement analyses.
- Potential soft areas within roadway alignment needing specific subgrade treatments.
- Need for subsurface drainage requirements as needed.
- Liquefaction potential of site soils due to granular soils and high groundwater.

Preliminary cut and fill depths along the project length have not yet been determined. Once project cross sections and bridge and culvert locations have been developed by HDR, Tetra Tech will review the project plan and cross section set and determine where additional geotechnical borings will need to be drilled for the Consultant Activity 130 Report. Following drilling and laboratory testing, Tetra Tech will provide comprehensive geotechnical recommendations for each of the above-mentioned geotechnical items.

APPENDIX

APPENDIX 1A

Important Information about Your
Geotechnical Engineering Report (Published by ASFE)

Tetra Tech Boring Log Descriptive Terminology Key
to Soil and Rock Symbols and Terms

Classification of Soils for Engineering Purposes

Figure 1A-1 – Location of Exploratory Borings

IMPORTANT INFORMATION
ABOUT YOUR
GEOTECHNICAL ENGINEERING REPORT

More construction problems are caused by site subsurface conditions than any other factor. As troublesome as subsurface problems can be, their frequency and extent have been lessened considerably in recent years, due in large measure to programs and publications of ASFE/The Association of Engineering Firms Practicing in the Geosciences.

The following suggestions and observations are offered to help you reduce the Geotechnical-related delays, cost-overruns and other costly headaches that can occur during a construction project.

A GEOTECHNICAL ENGINEERING REPORT IS BASED ON A UNIQUE SET OF PROJECT-SPECIFIC FACTORS

A Geotechnical engineering report is based on a subsurface exploration plan designed to incorporate a unique set of project-specific factors. These typically include: the general nature of the structure involved, its size and configuration; the location of the structure on the site and its orientation; physical concomitants such as access roads, parking lots, and underground utilities, and the level of additional risk which the client assumed by virtue of limitations imposed upon the exploratory program. To help avoid costly problems, consult the geotechnical engineer to determine how any factors which change subsequent to the date of the report may affect its recommendations.

Unless your consulting Geotechnical engineer indicates otherwise, *your Geotechnical engineer report should not be used:*

- When the nature of the proposed structure is changed, for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one;
- when the size or configuration of the proposed structure is altered;
- when the location or orientation of the proposed structure is modified:
- when there is a change of ownership, or
- for application to an adjacent site.

Geotechnical engineers cannot accept responsibility for problems which may develop if they are not consulted after factors considered in their reports' development have changed.

MOST GEOTECHNICAL "FINDINGS" ARE PROFESSIONAL ESTIMATES

Site exploration identifies actual subsurface conditions only at those points where samples are taken, when they are taken. Data derived through sampling and subsequent laboratory testing are extrapolated by Geotechnical engineers who then render an opinion about overall subsurface conditions, their likely reaction to proposed conditions, their likely reaction to proposed construction activity, and appropriate foundation design. Even under optimal circumstances actual conditions may differ from those inferred to exist, because no Geotechnical engineer, no matter how qualified, and not subsurface exploration program, no matter how comprehensive, can reveal what is hidden by earth, rock and time. The actual interface between materials may be fare more gradual or abrupt than a report indicates. Actual conditions in areas not sampled may differ from predictions. *Nothing can be done to prevent the unanticipated, but steps can be taken to help minimize their impact.* For this reason, *most experienced owners retain their Geotechnical consultants through the construction stage*, to identify variances, conduct additional tests which may be needed, and to recommend solutions to problems encountered on site.

SUBSURFACE CONDITIONS CAN CHANGE

Subsurface conditions may be modified by constantly-changing natural forces. Because a Geotechnical engineering report is based on conditions which existed at the time of subsurface exploration, *construction decisions should not be based on a Geotechnical engineering report whose adequacy may have been affected by time.* Speak with the Geotechnical consultant to learn if additional tests are advisable before construction starts.

Construction operations at or adjacent to the site and natural events such as flood, earthquakes or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical report. The geotechnical engineer should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

GEOTECHNICAL SERVICES ARE PREFORMED FOR SPECIFIC PURPOSES AND PERSONS

Geotechnical engineers' reports are prepared to meet the specific needs of specific individuals. A report prepared for a consulting civil engineer may not be adequate for a construction contractor, or even some other consulting civil engineer. Unless indicated otherwise, this report was prepared expressly for the client involved and expressly for purposes indicated by the client. Use by any other persons for any purpose, or by the client for a different purpose, may result in problems. *No individual other than the client should apply this report for its intended purpose without first conferring with the*

geotechnical engineer. No person should apply this report for any purpose other than that originally contemplated without first conferring with the geotechnical engineer.

A GEOTECHNICAL ENGINEERING REPORT IS SUBJECT TO MISINTERPRETATION

Costly problems can occur when other design professionals develop their plants based on misinterpretations of a geotechnical engineering report. To help avoid these problems, the geotechnical engineer should be retained to work with other appropriate design professionals to explain relevant geotechnical findings and to review the adequacy of their plans and specifications relative to geotechnical issues.

BORING LOGS SHOULD NOT BE SEPARATED FROM THE ENGINEERING REPORT

Final boring logs are developed by geotechnical engineers based upon their interpretation of field logs (assembled by site personnel) and laboratory evalution of field samples. Only final boring logs customarily are included in geotechnical engineering reports. *These logs should not under any circumstances be redrawn* for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process. Although photographic reproduction eliminates this problem, it does nothing to minimize the possibility of contractors misinterpreting the logs during bid preparation. When this occurs, delays, disputes and unanticipated costs are the all-too-frequent result.

To minimize the likelihood of boring log misinterpretation, *give contractors ready access to the complete geotechnical engineering report* prepared or authorized for their use. Those who do not provide such access may proceed under the *mistaken* impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes which aggravate them to disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY

Because geotechnical engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against geotechnical consultants. To help prevent this problem, geotechnical engineers have developed model clauses for use in written transmittals. These are *not* exculpatory clauses designed to foist geotechnical engineers' liabilities onto someone else. Rather, they are definitive clauses which identify where geotechnical engineers' responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your geotechnical engineering report, and you are encouraged to read them closely. your geotechnical engineer will be pleased to give full and frank answers to your questions.

OTHER STEPS YOU CAN TAKE TO REDUCE RISK

Your consulting geotechnical engineer will be pleased to discuss other techniques which can be employed to mitigate risk. In addition, ASFE as developed a variety of materials which may be beneficial. Contact ASFE for a complimentary copy of its publications directory.

Published by

8811 Colesville Road/Suite G106/Silver Spring, Maryland 20910/(301)565-2733

Tetra Tech Boring Log Descriptive Terminology
Key to Soil Symbols and Terms

12/06/12

TETRA TECH

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS (MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE)	GRAVEL AND GRAVELLY SOILS (MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE)	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	Well-graded gravels, gravel sand mixtures, little or no fines.
				GP	Poorly graded gravels, gravel-sand mixtures, little or no fines.
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	Silty gravels, gravel-sand-silt mixtures.
				GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS (MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE)	CLEAN SANDS (LITTLE OR NO FINES)		SW	Well-graded sands, gravelly sands, little or no fines.
				SP	Poorly graded sands, gravelly sands, little or no fines.
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	Silty sands, sand-silt mixtures.
				SC	Clayey sands, sand-clay mixures.
FINE GRAINED SOILS (MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE)	SILTS AND CLAYS (LIQUID LIMIT LESS THAN 50)			ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
				CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
				OL	Organic silts and organic silty clays of low plasticity.
	SILTS AND CLAYS (LIQUID LIMIT GREATER THAN 50)			MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
				CH	Inorganic clays of high plasticity, fat clays.
				OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS				PT	Peat and other highly organic soils.

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

Notes

See Soil Boring Information Special Provision.

SPT (Standard Penetration Test-ASTM D1586):
The number of blows of a 140 lb (63.6 kg) hammer falling 2.5 ft (750 mm) used to drive a 2 in (50 mm) O.D. Split Spoon sampler for a total of 1.5 ft (0.45 m) of penetration.
Written as follows:
first 0.5 ft (0.15 m) - second 0.5 ft (0.15 m) - third 0.5 ft (0.15 m) (ex: 1-3-9)
Note: if the number of blows exceeds 50 before 0.5 ft (0.15 m) of penetration is achieved, the actual penetration rounded to the nearest 0.1 ft (0.03 m) follows the number of blows in parentheses (ex: 12-24-50 (0.09 m), 34-50 (0.4 ft), or 100 (0.3 ft)).WR denotes a zero blow count with the weight of the rods only.
WH denotes a zero blow count with the weight of the rods plus the weight of the hammer.

MC=Moisture Content, LL=Liquid limit, PL=Plastic Limit
-200%=percent soil passing 200 sieve, DD=Dry Density

Soil Classifications are Based on the Unified Soil Classification System, ASTM D2487 and D2488. Also included are the AASHTO group classifications (M145). Descriptions are based on visual observation, except where they have been modified to reflect results of laboratory tests as deemed appropriate.

Order of Descriptors

- Group Name
- Consistency or Relative Density
- Moisture Condition
- Color
- Particle size descriptor(s) (coarse grained soils only)
- Angularity of coarse grained soils
- Other relevant notes

Criteria For Descriptors

Consistency of Fine Grained Soils

Consistency	N-Value (uncorrected)
Very Soft	< 2
Soft	2 - 4
Medium Stiff	5 - 8
Stiff	9 - 15
Very Stiff	16 - 30
Hard	> 30

Apparent Density of Coarse Grained Soils

Relative Density	N-Value (uncorrected)
Very Loose	< 4
Loose	4 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

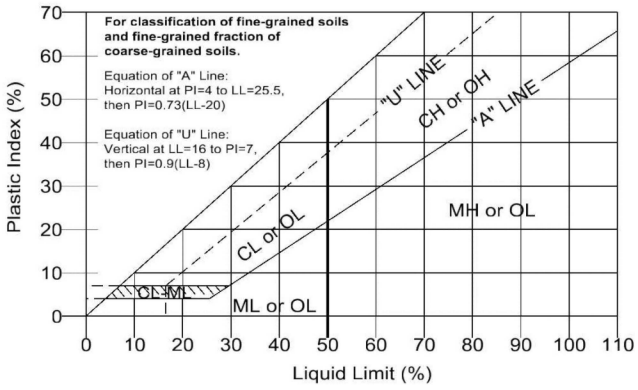
Moisture Condition

Dry	-Absence of moisture, dusty, dry to the touch.
Moist	-Damp, but no visible water.
Wet	-Visible free water.

Definition of Particle Size Ranges

Soil Component	Size Range
Boulder	> 12 in (300 mm)
Cobble	3 in (75 mm) - 12 in (300 mm)
Gravel	No. 4 Sieve (4.75 mm) to 3 in (75 mm)
Sand	No. 200 (0.075 mm) to No. 4 Sieves (4.75 mm)
Silt	< No. 200 Sieve (0.075 mm)*
Clay	< No. 200 Sieve (0.075 mm)*

*Atterberg limits and chart below to differentiate between silt and clay.



Angularity of Coarse-Grained Particles

Angular	-Particles have sharp edges and relative plane sides with unpolished surfaces.
Subangular	-Particles are similar to angular description, but have rounded edges.
Subrounded	-Particles have nearly plane sides, but have no edges.
Rounded	-Particles have smoothly curved sides and well-rounded corners and edges.

Example soil description: Sandy FAT CLAY (CH), soft, wet, brown. (A-7)

Tetra Tech Boring Log Descriptive Terminology
Key to Rock Symbols and Terms

12/06/12

TETRA TECH

Rock Type	Symbol	Rock Type	Symbol	Rock Type	Symbol
Argillite		Dolomite		Quartzite	
Basalt		Gneiss		Rhyolite	
Bedrock (other)		Granitic		Sandstone	
Breccia		Limestone		Schist	
Claystone		Siltstone		Shale	
		Conglomerate			

Order of Descriptors

- Rock Type
- Color
- Grain size (if applicable)
- Stratification/Foliation (as applicable)
- Field Hardness
- Other relevant notes

Criteria For Descriptors

Grain Size

Description	Characteristic
Coarse Grained	-Individual grains can be easily distinguished by eye
Fine Grained	-Individual grains can be distinguished with difficulty

Stratum Thickness

Thickly Bedded	3-10 ft (1-3 m)
Medium Bedded	1-3 ft (300 mm - 1 m)
Thinly Bedded	2-12 in (50-300 mm)
Very Thinly Bedded	< 2 in (50 mm)

Rock Field Hardness

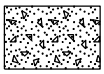
Very Soft	-Can be carved with knife. Can be excavated readily with point of rock hammer. Can be scratched readily by fingernail.
Soft	-Can be grooved or gouged readily by knife or point of rock hammer. Can be excavated in fragments from chips to several inches in size by moderate blows of the point of a rock hammer.
Medium	-Can be grooved or gouged 0.05 in (2 mm) deep by firm pressure of knife or rock hammer point. Can be excavated in small chips to pieces about 1 in (25 mm) maximum size by hard blows of the point of a rock hammer.
Moderately hard	-Can be scratched with knife or pick. Gouges or grooves to 0.25 in (6 mm) can be excavated by hard blow of rock hammer. Hand specimen can be detached by moderate blows.
Hard	-Can be scratched with knife or pick only with difficulty. Hard hammer blows required to detach hand specimen.
Very Hard	-Cannot be scratched with knife or sharp rock hammer point. Breaking of hand specimens requires several hard blows of a rock hammer.

Notes:

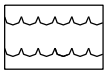
UCS = Unconfined Compressive Strength obtained from laboratory testing at the given depth.

See Soil Boring Information Special Provision.

Miscellaneous Soil/Rock Symbols and Terms

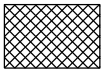

Concrete

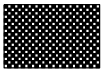

Asphalt

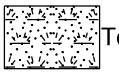

Water


Boulders and Cobbles


Coal


Fill


Millings


Topsoil

Explanation of Text Fields In Boring Logs:

Material Description: Lithologic Description of soil or rock encountered.

Remarks: Comments on drilling, including method, bit type, and problems encountered.

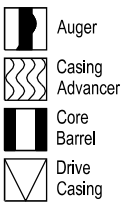
Unless stated on logs as being surveyed by district survey, all locations are considered approximate.

General Notes

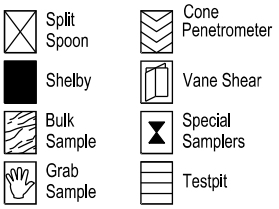
- Descriptions on these boring logs apply only at the specific boring, and at the time the time the borings were made. These logs are not warranted to be representative of subsurface conditions at other locations or times.
- Water level observations apply only at the specific boring, and at the time the borings were made. Due to the variability of groundwater measurements given the type of drilling used, and the stratification of the soil in the boring, these logs are not warranted to be representative of groundwater conditions at other locations or times.
- Other terms may be used as descriptors, as defined by the profession.

-Soil and Rock descriptions are based on visual observation, except where they have been modified to reflect results of laboratory tests as deemed appropriate.

Operation Types:



Sample Types:



Example Rock Log

SANDSTONE, gray, fine grained, thickly bedded, hard field hardness.

TETRA TECH

CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

ASTM Designation: D 2487 – 83

(Based on Unified Soil Classification System)

MAJOR DIVISIONS				GROUP SYMBOL	GROUP NAME
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines	Cu ≥ 4 and 1 ≤ Cc ≤ 3[E]	GW	Well graded gravel [F]
			Cu < 4 and/or 1 > Cc > 3[E]	GP	Poorly graded gravel [F]
		Gravels with Fines More than 12% fines	Fines classify as ML or MH	GM	Silty gravel [F G H]
			Fines classify as CL or CH	GC	Clayey gravel [F G H]
	Sands 50% or more of coarse faction passes No. 4 sieve	Clean Sands Less than 5% fines	Cu ≥ 6 and 1 ≤ Cc ≤ 3[E]	SW	Well-graded sand [I]
			Cu < 6 and/or 1 > Cc > 3[E]	SP	Poorly graded sand [I]
		Sands with Fines More than 12% fines	Fines classify as ML or MH	SM	Silty Sand [G H I]
			Fines classify as CL or CH	SC	Clayey sand [G H I]
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	Inorganic	PI > 7 and plots on or above "A" line	CL	Lean clay [K L M]
			PI < 4 or plots below "A" line	ML	Silt [K L M]
		Organic	Liquid limit – oven dried / Liquid limit – not dried < 0.75	OL	Organic clay [K L M N] Organic silt [K L M O]
	Silts and Clays Liquid limit 50 or more	Inorganic	PI plots on or above "A" line	CH	Fat clay [K L M]
			PI plots below "A" line	MH	Elastic silt [K L M]
		Organic	Liquid limit – oven dried / Liquid limit – not dried < 0.75	OH	Organic clay [K L M O] Organic silt [K L M O]
Highly organic soils	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% require dual symbols:
GW-GM well-graded gravel with silt
GW-GC well-graded gravel with clay
GP-GM poorly graded gravel with silt
GP-GC poorly graded gravel with clay

[D] Sands with 5 to 12% fines require dual symbols:
SW-SM well-graded sand with silt
SW-SC well-graded sand with clay
SP-SM poorly graded sand with silt
SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $Cc=(D_{30})^2 / (D_{10} \times D_{90})$

[F] If soil contains ≥15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥15% gravel, add "with gravel" to group name.
If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.

[K]. If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel", whichever is predominant.

[L] If solid contains ≥ 30% plus No. 200, predominantly sand, add "sandy" to group name.

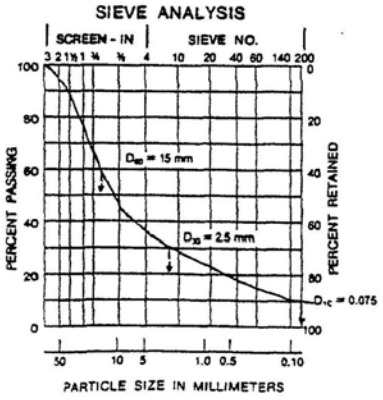
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

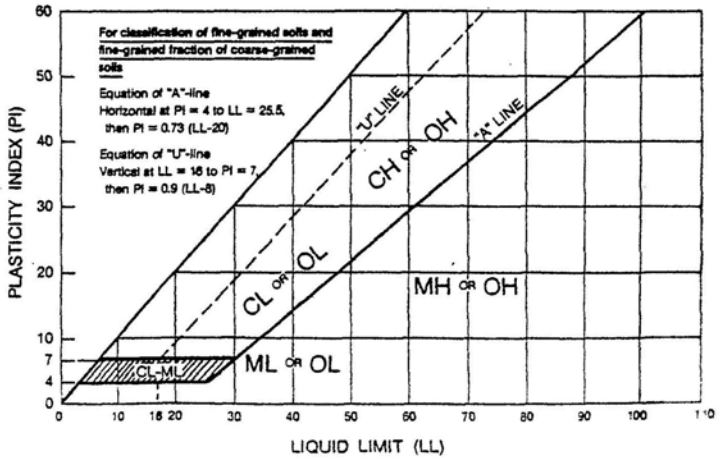
[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A: line.

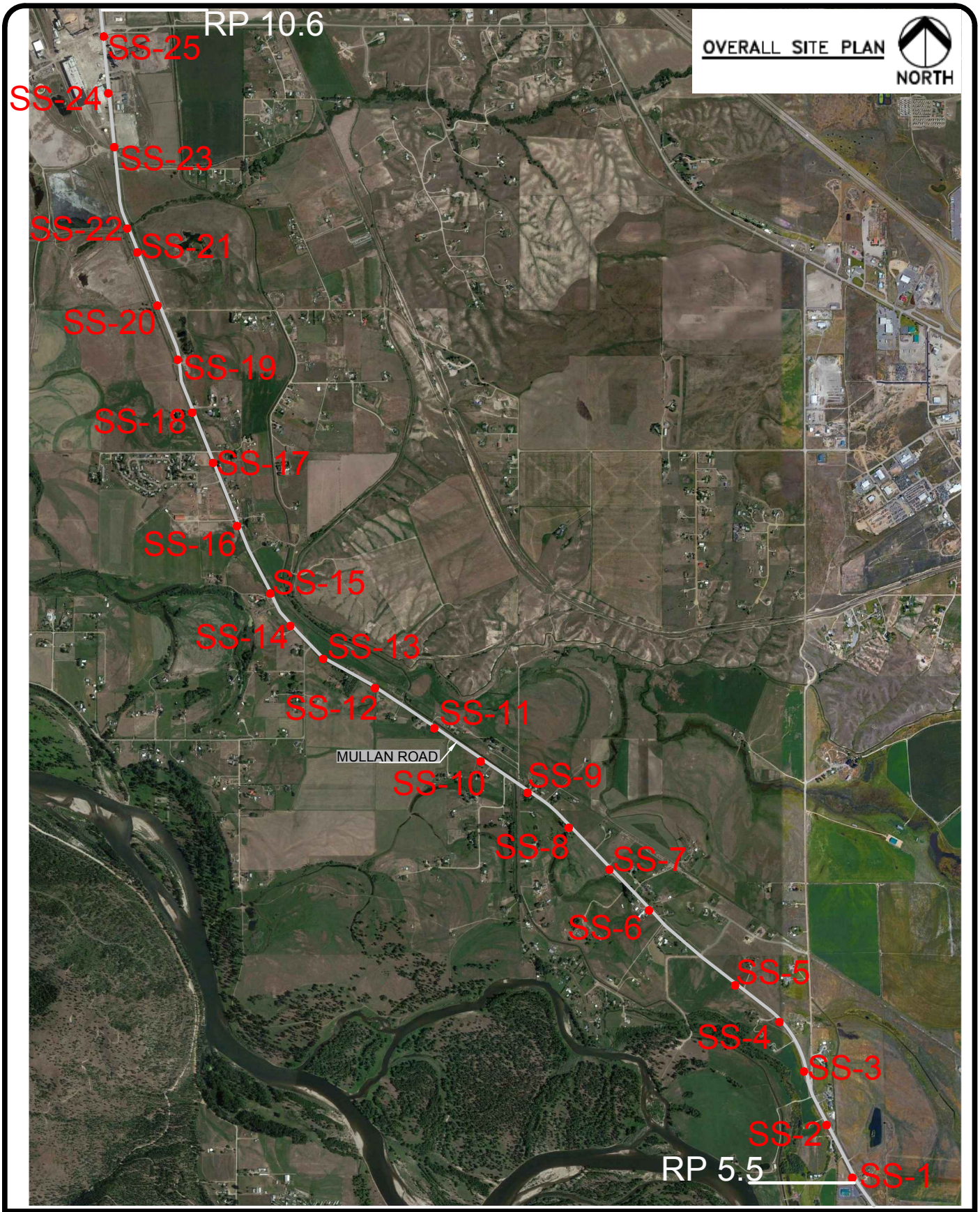
[P] PI plots on or above "A: line.

[Q] PI plots below "A: line.





$C_u = \frac{D_{50}}{D_{1e}} = \frac{15}{0.075} = 200$ $C_c = \frac{(D_{30})2}{D_{12} \times 10_{36}} + \frac{(2.5)-}{0.075 \times 15} = 5.6$



TETRA TECH
www.tetratech.com
2525 Palmer St. Suite 2
Missoula, MT 59808
Phone: (406) 543-3045

Client: HDR, Inc.

West of Missoula - NW (Mullan Road)
RP 5.5 to RP 10.6
Missoula, MT
EXPLORATORY BORING LOCATIONS

Project No.:	STPS 263 - 1(28)6
Date:	October 2017
Drawn By:	A. Hotaling

Drawing Number
1A-1

APPENDIX 2A

Log of Exploratory Borings (Figures 2A-1 through 2A-26)

2525 Palmer Street, Suite 2
Missoula, MT 59808
Phone: (406)543-3045
Fax: (406)543-3088

LOG OF BORING

Boring 614100-SS-1

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 1002838.05 ft **Coordinates** E: 809606.65 ft	**Station:** **Offset:**
Project Number: STPS 263 - 1(28)6	**UPN:** 614100	**Boring Diameter:** 8 in	**System:** MT S.P. (E) **Datum:** WGS84	**Top of Boring Elevation:** 3093.5 ft
Date Started: 6/19/17	**Date Finished:** 6/19/17	**Drilling Fluid:** None	**Location Source:** GPS and Plans	**Elevation Source:** GPS
Driller: O'Keefe **Logger:** Aric Hotaling		**Abandonment Method:** Cuttings and Grout	**Township, Range, and Section:** 13N 20W S9	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
			87		18 - 32 - 50		Asphalt. FILL, Poorly-Graded GRAVEL with silt and sand (GP-GM), [A-1]. very dense, slightly moist, tan/brown to gray, fine to coarse grained, subrounded to subangular.	0.5 *3093.0*	1	NV	NP	6		
5 *3088.5*			87		29 - 37 - 44		Poorly-Graded SAND with gravel (SP), [A-1]. medium dense to very dense, slightly moist to wet, tan/brown, fine to coarse grained, subangular to subrounded.	4.0 *3089.5*	1					
10 *3083.5*			67		16 - 32 - 41				1					
15 *3078.5*			53		9 - 13 - 14			15.5 *3078.0*						

Boring Depth: 15.5 ft, *Elevation: 3078.0 ft*

Water Level Observations		Remarks:
After Drilling: Not Recorded	During Drilling: 12.0 ft *(3081.5 ft)*	
	After Drilling: Not Recorded	

MDT_LOG OF BORING - MDT_REVISED_2009+.GDT - 10/6/17 16:14 - N:\GEOTECH\REPORTS\REPORT 2017\MDT PROJECTS\MULLAN ROAD\106 REPORT\LOGS\MULLAN RD.GPJ

2525 Palmer Street, Suite 2
Missoula, MT 59808
Phone: (406)543-3045
Fax: (406)543-3088

LOG OF BORING

Boring 614100-SS-2

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 1003933.87 ft **Coordinates** E: 809136.7 ft	**Station:** **Offset:**
Project Number: STPS 263 - 1(28)6	**UPN:** 614100	**Boring Diameter:** 8 in	**System:** MT S.P. (E) **Datum:** WGS84	**Top of Boring Elevation:** 3090.4 ft
Date Started: 6/19/17	**Date Finished:** 6/19/17	**Drilling Fluid:** None	**Location Source:** GPS and Plans	**Elevation Source:** GPS
Driller: O'Keefe **Logger:** Aric Hotaling		**Abandonment Method:** Cuttings and Grout	**Township, Range, and Section:** 13N 20W S4	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							Asphalt.	0.4	1					
			80		25 - 29 - 30		FILL, Poorly-Graded SAND with gravel (SP), [A-1]. very dense, slightly moist, tan/brown, fine to coarse grained, subrounded.	3090.0						
							Silty, Clayey SAND with gravel (SC-SM), [A-4]. very loose, moist, brown to gray, subrounded.	3.0 3087.4	23	27	20	50		
5 3085.4			73		2 - 2 - 2									
			100											
10 3080.4			47		12 - 25 - 22		Poorly-Graded SAND with gravel (SP), [A-1]. medium dense to dense, moist to wet, tan/brown, fine to coarse grained, subangular to subrounded. ▽	9.8 3080.6	1					
15 3075.4			47		32 - 17 - 9			15.5 3074.9						

Boring Depth: 15.5 ft, *Elevation: 3074.9 ft*

Water Level Observations		Remarks:
▽ During Drilling: 11.1 ft *(3079.3 ft)*	▼ After Drilling: Not Recorded	
▼ After Drilling: Not Recorded		

2525 Palmer Street, Suite 2
Missoula, MT 59808
Phone: (406)543-3045
Fax: (406)543-3088

LOG OF BORING

Boring 614100-SS-3

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 1004828.68 ft **Coordinates** E: 808830.35 ft	**Station:** **Offset:**
Project Number: STPS 263 - 1(28)6	**UPN:** 614100	**Boring Diameter:** 8 in	**System:** MT S.P. (E) **Datum:** WGS84	**Top of Boring Elevation:** 3088.2 ft
Date Started: 6/19/17	**Date Finished:** 6/19/17	**Drilling Fluid:** None	**Location Source:** GPS and Plans	**Elevation Source:** GPS
Driller: O'Keefe **Logger:** Aric Hotaling		**Abandonment Method:** Cuttings and Grout	**Township, Range, and Section:** 13N 20W S5	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							Asphalt, Top 2 inches are recent overlay.	0.7	5	17	15	10		
			93		12 - 17 - 15		FILL, Poorly-Graded GRAVEL with silt and sand (GP-GM), [A-1]. dense, slightly moist, tan/brown, fine to coarse grained, subrounded.	*3087.5*						
								4.0	1					
5 *3083.2*			60		8 - 9 - 6		Poorly-Graded SAND with gravel (SP), [A-1]. medium dense to very dense, moist to wet, tan/brown, fine to coarse grained, subangular to subrounded.	*3084.2*						
			0		50/0.4ft									
10 *3078.2*														
15 *3073.2*			13		26 - 27 - 22			15.5 *3072.7*						

Boring Depth: 15.5 ft, *Elevation: 3072.7 ft*

Water Level Observations		Remarks:
After Drilling: Not Recorded	During Drilling: 11.0 ft *(3077.2 ft)*	
	After Drilling: Not Recorded	

MDT_LOG OF BORING - MDT_REVISED_2009+.GDT - 10/6/17 16:14 - N:\GEOTECH\REPORTS\REPORT 2017\MDT PROJECTS\MULLAN ROAD\106 REPORT\LOGS\MULLAN RD.GPJ

2525 Palmer Street, Suite 2
Missoula, MT 59808
Phone: (406)543-3045
Fax: (406)543-3088

LOG OF BORING

Boring 614100-SS-4

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 1005715.51 ft **Coordinates** E: 808486.4 ft	**Station:** **Offset:**
Project Number: STPS 263 - 1(28)6	**UPN:** 614100	**Boring Diameter:** 8 in	**System:** MT S.P. (E) **Datum:** WGS84	**Top of Boring Elevation:** 3086.2 ft
Date Started: 6/19/17	**Date Finished:** 6/19/17	**Drilling Fluid:** None	**Location Source:** GPS and Plans	**Elevation Source:** GPS
Driller: O'Keefe **Logger:** Aric Hotaling		**Abandonment Method:** Cuttings and Grout	**Township, Range, and Section:** 13N 20W S5	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
			67		6 - 7 - 10		Asphalt, Top 2 inches are recent overlay.	0.6	7					
							FILL, Poorly-Graded GRAVEL with silt and sand (GP-GM), [A-1]. medium dense, slightly moist, gray to black, fine to coarse grained, subrounded.	3085.6						
								2.0						
							Silty CLAY with sand (CL-ML), [A-4]. very stiff, slightly moist, gray to black, low plasticity.	3084.2						
5			100											
3081.2								5.0	1					
			67		12 - 19 - 21		Poorly-Graded SAND with gravel (SP), [A-1]. dense, moist to wet, tan/brown, fine to coarse grained, subrounded to subangular.	3081.2						
									4					
10			53		21 - 26 - 20		▽							
3076.2														
15			60		23 - 24 - 23									
3071.2								15.5						
							Boring Depth: 15.5 ft, *Elevation: 3070.7 ft*	3070.7						

Water Level Observations		Remarks:
▽ During Drilling: 10.0 ft *(3076.2 ft)*	▼ After Drilling: Not Recorded	
▼ After Drilling: Not Recorded		

2525 Palmer Street, Suite 2
Missoula, MT 59808
Phone: (406)543-3045
Fax: (406)543-3088

LOG OF BORING

Boring 614100-SS-5

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 1006480.41 ft **Coordinates** E: 807671.16 ft	**Station:** **Offset:**
Project Number: STPS 263 - 1(28)6	**UPN:** 614100	**Boring Diameter:** 8 in	**System:** MT S.P. (E) **Datum:** WGS84	**Top of Boring Elevation:** 3084.0 ft
Date Started: 6/19/17	**Date Finished:** 6/19/17	**Drilling Fluid:** None	**Location Source:** GPS and Plans	**Elevation Source:** GPS
Driller: O'Keefe **Logger:** Aric Hotaling		**Abandonment Method:** Cuttings and Grout	**Township, Range, and Section:** 13N 20W S5	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							Asphalt, Top 2 inches are recent overlay.	0.7						
			47		7 - 9 - 9		FILL, Poorly-Graded GRAVEL with silt and sand (GP-GM), [A-1]. medium dense, slightly moist, gray to black, fine to coarse grained, subrounded.	*3083.3*	3	17	15	12		
									14					
5 *3079.0*			87		14 - 9 - 8		Silty CLAY with sand (CL-ML), [A-4]. very stiff, slightly moist, gray to black, low plasticity.	4.7 *3079.3*						
							▽	8.0 *3076.0*	5					
10 *3074.0*			60		13 - 15 - 15		Poorly-Graded SAND with gravel (SP), [A-1]. medium dense, moist to wet, tan/brown, fine to coarse grained, subrounded to subangular.							
15 *3069.0*			60		7 - 10 - 10			15.5 *3068.5*						

Boring Depth: 15.5 ft, *Elevation: 3068.5 ft*

Water Level Observations		Remarks:
▽ During Drilling: 8.0 ft *(3076.0 ft)*	▼ After Drilling: Not Recorded	
▼ After Drilling: Not Recorded		

MDT_LOG OF BORING - MDT_REVISED_2009+.GDT - 10/6/17 16:14 - N:\GEOTECH\REPORTS\REPORT 2017\MDT PROJECTS\MULLAN ROAD\106 REPORT\LOGS\MULLAN RD.GPJ

2525 Palmer Street, Suite 2
Missoula, MT 59808
Phone: (406)543-3045
Fax: (406)543-3088

LOG OF BORING

Boring 614100-SS-6

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location Coordinates** N: 1007229.8 ft E: 806848.49 ft	**Station:** **Offset:**
Project Number: STPS 263 - 1(28)6	**UPN:** 614100	**Boring Diameter:** 8 in	**System:** MT S.P. (E) **Datum:** WGS84	**Top of Boring Elevation:** 3081.6 ft
Date Started: 6/20/17	**Date Finished:** 6/20/17	**Drilling Fluid:** None	**Location Source:** GPS and Plans	**Elevation Source:** GPS
Driller: O'Keefe **Logger:** Aric Hotaling		**Abandonment Method:** Cuttings and Grout	**Township, Range, and Section:** 13N 20W S5	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							Asphalt, Top 2 inches are recent overlay.	0.7						
			53		16 - 7 - 7		FILL, Silty, Clayey SAND with gravel (SC-SM), [A-2]. medium dense, slightly moist, gray to black, fine to coarse grained, subrounded.	*3080.9*	1					
								4.0	19					
5			67		2 - 3 - 8		Silty CLAY with sand (CL-ML), [A-4]. stiff, moist, gray to black, low plasticity.	*3077.6*						
3076.6							Poorly-Graded SAND with gravel (SP), [A-1]. medium dense to very dense, moist to wet, tan/brown, fine to coarse grained, subrounded to subangular.	5.0 *3076.6*						
10			47		9 - 19 - 14									
3071.6														
15			80		8 - 50/0.5ft									
3066.6							Boring Depth: 15.0 ft, *Elevation: 3066.6 ft*	15.0 *3066.6*						

Water Level Observations		Remarks:
After Drilling: Not Recorded	During Drilling: 6.5 ft *(3075.1 ft)*	
	After Drilling: Not Recorded	

2525 Palmer Street, Suite 2
Missoula, MT 59808
Phone: (406)543-3045
Fax: (406)543-3088

LOG OF BORING

Boring 614100-SS-7

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 1007952.98 ft **Coordinates** E: 806143.68 ft	**Station:** **Offset:**
Project Number: STPS 263 - 1(28)6	**UPN:** 614100	**Boring Diameter:** 8 in	**System:** MT S.P. (E) **Datum:** WGS84	**Top of Boring Elevation:** 3081.7 ft
Date Started: 6/20/17	**Date Finished:** 6/20/17	**Drilling Fluid:** None	**Location Source:** GPS and Plans	**Elevation Source:** GPS
Driller: O'Keefe **Logger:** Aric Hotaling		**Abandonment Method:** Cuttings and Grout	**Township, Range, and Section:** 13N 20W S5	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							Asphalt, Top 2 inches are recent overlay.	0.8	13					
			47		7 - 5 - 8		FILL, Silty, Clayey SAND with gravel (SC-SM), [A-2]. medium dense, slightly moist, gray to black, fine to coarse grained, subrounded.	*3081.0*						
							Silty CLAY with sand (CL-ML), [A-4]. medium stiff, slightly moist, gray to black, low plasticity.	3.0 *3078.7*						
5 *3076.7*			67		12 - 24 - 27		Poorly-Graded SAND with gravel (SP), [A-1]. very dense, moist to wet, tan/brown, fine to coarse grained, subrounded to subangular.	4.5 *3077.2*	2					Attempted shelby tube. Refusal on cobble at 4.5 feet.
10 *3071.7*			67		26 - 23 - 28									
15 *3066.7*			67		12 - 17 - 41									
							Boring Depth: 15.5 ft, *Elevation: 3066.2 ft*	15.5 *3066.2*						

Water Level Observations		Remarks:
▽ During Drilling: 7.4 ft *(3074.3 ft)*	▼ After Drilling: Not Recorded	
▼ After Drilling: Not Recorded		

2525 Palmer Street, Suite 2
Missoula, MT 59808
Phone: (406)543-3045
Fax: (406)543-3088

LOG OF BORING

Boring 614100-SS-8

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 1008762.74 ft **Coordinates** E: 805460.4 ft	**Station:** **Offset:**
Project Number: STPS 263 - 1(28)6	**UPN:** 614100	**Boring Diameter:** 8 in	**System:** MT S.P. (E) **Datum:** WGS84	**Top of Boring Elevation:** 3080.4 ft
Date Started: 6/20/17	**Date Finished:** 6/20/17	**Drilling Fluid:** None	**Location Source:** GPS and Plans	**Elevation Source:** GPS
Driller: O'Keefe **Logger:** Aric Hotaling		**Abandonment Method:** Cuttings and Grout	**Township, Range, and Section:** 14N 20W S32	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							Asphalt, Top 2 inches are recent overlay.							
			47		9 - 5 - 4		FILL, Silty, Clayey SAND with gravel (SC-SM), [A-2]. medium dense, slightly moist, gray to black, fine to coarse grained, subrounded.	1.0 *3079.4*	1					
			43					2.0 *3078.4*						
							Silty CLAY with sand (CL-ML), [A-4]. stiff, slightly moist, gray to black, low plasticity.	3.4 *3077.0*	12					
5 *3075.4*			67		10 - 12 - 8		Poorly-Graded SAND with gravel (SP), [A-1]. medium dense, moist to wet, tan/brown, fine to coarse grained, subrounded to subangular.							
							Silty CLAY with sand (CL-ML), [A-4]. medium stiff, wet, gray to black, low plasticity.	8.0 *3072.4*						
10 *3070.4*			100		2 - 2 - 3									
							Poorly-Graded SAND with gravel (SP), [A-1]. dense, wet, tan/brown, fine to coarse grained, subrounded to subangular.	10.5 *3069.9*						
15 *3065.4*			47		8 - 14 - 28			15.5 *3064.9*						

Boring Depth: 15.5 ft, *Elevation: 3064.9 ft*

Water Level Observations		Remarks:
After Drilling: Not Recorded	During Drilling: 7.4 ft *(3073.0 ft)*	
	After Drilling: Not Recorded	

2525 Palmer Street, Suite 2
Missoula, MT 59808
Phone: (406)543-3045
Fax: (406)543-3088

LOG OF BORING

Boring 614100-SS-9

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 1009578.03 ft **Coordinates** E: 804748.11 ft	**Station:** **Offset:**
Project Number: STPS 263 - 1(28)6	**UPN:** 614100	**Boring Diameter:** 8 in	**System:** MT S.P. (E) **Datum:** WGS84	**Top of Boring Elevation:** 3077.3 ft
Date Started: 6/20/17	**Date Finished:** 6/20/17	**Drilling Fluid:** None	**Location Source:** GPS and Plans	**Elevation Source:** GPS
Driller: O'Keefe **Logger:** Aric Hotaling		**Abandonment Method:** Cuttings and Grout	**Township, Range, and Section:** 14N 20W S32	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							Asphalt, Top 2 inches are recent overlay.	0.8 *3076.6*	12					
			100		7 - 10 - 6		FILL, Silty, Clayey SAND with gravel (SC-SM), [A-2]. medium dense, slightly moist, gray to black, fine to coarse grained, subrounded.	1.7 *3075.6*						
							Silty CLAY with sand (CL-ML), [A-4]. very stiff, slightly moist, gray to black, low plasticity.	3.0 *3074.3*	23	23	18	54		
5 *3072.3*			100		2 - 1 - 3		Sandy, Silty CLAY (CL-ML), [A-4]. soft, moist to wet, tan/brown, very fine grained, low plasticity.							
							Poorly-Graded SAND with gravel (SP), [A-1]. dense, wet, tan/brown, fine to coarse grained, subrounded to subangular.	7.0 *3070.3*						
10 *3067.3*			67		8 - 16 - 23									
15 *3062.3*			80		12 - 16 - 20									
							Boring Depth: 15.5 ft, *Elevation: 3061.8 ft*	15.5 *3061.8*						

Water Level Observations		Remarks:
After Drilling: Not Recorded	During Drilling: 6.1 ft *(3071.2 ft)*	
	After Drilling: Not Recorded	

2525 Palmer Street, Suite 2
Missoula, MT 59808
Phone: (406)543-3045
Fax: (406)543-3088

LOG OF BORING

Boring 614100-SS-10

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location Coordinates** N: 1010355.84 ft E: 803891.83 ft	**Station:** **Offset:**
Project Number: STPS 263 - 1(28)6	**UPN:** 614100	**Boring Diameter:** 8 in	**System:** MT S.P. (E) **Datum:** WGS84	**Top of Boring Elevation:** 3076.3 ft
Date Started: 6/20/17	**Date Finished:** 6/20/17	**Drilling Fluid:** None	**Location Source:** GPS and Plans	**Elevation Source:** GPS
Driller: O'Keefe **Logger:** Aric Hotaling		**Abandonment Method:** Cuttings and Grout	**Township, Range, and Section:** 14N 20W S32	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							Asphalt, Top 2 inches are recent overlay.	0.8						
			87		12 - 10 - 4		FILL, Silty, Clayey SAND with gravel (SC-SM), [A-2]. medium dense, slightly moist, gray to black, fine to coarse grained, subrounded.	*3075.5* 1.6 *3074.7*	11	23	17	32		
							Silty CLAY with sand (CL-ML), [A-4]. slightly moist, gray to black, low plasticity.	2.0 *3074.3*	14	NV	NP	37		
5 *3071.3*			90				Silty SAND (SM), [A-4]. medium dense, moist to wet, tan/brown, very fine grained, subangular.		16					Cohesion = 800 psf Friction Angle = 24.7 degrees
			53		4 - 9 - 10		Poorly-Graded SAND with gravel (SP), [A-1]. medium dense to very dense, wet, tan/brown, fine to coarse grained, subrounded to subangular.	6.5 *3069.8*						
10 *3066.3*			67		6 - 8 - 8									
15 *3061.3*			60		13 - 20 - 31			15.5 *3060.8*						

Boring Depth: 15.5 ft, *Elevation: 3060.8 ft*

Water Level Observations		Remarks:
After Drilling: Not Recorded	During Drilling: 6.3 ft *(3070.0 ft)*	
	After Drilling: Not Recorded	

2525 Palmer Street, Suite 2
Missoula, MT 59808
Phone: (406)543-3045
Fax: (406)543-3088

LOG OF BORING

Boring 614100-SS-11

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 1010860.65 ft **Coordinates** E: 803221.08 ft	**Station:** **Offset:**
Project Number: STPS 263 - 1(28)6	**UPN:** 614100	**Boring Diameter:** 8 in	**System:** MT S.P. (E) **Datum:** WGS84	**Top of Boring Elevation:** 3074.8 ft
Date Started: 6/20/17	**Date Finished:** 6/20/17	**Drilling Fluid:** None	**Location Source:** GPS and Plans	**Elevation Source:** GPS
Driller: O'Keefe **Logger:** Aric Hotaling		**Abandonment Method:** Cuttings and Grout	**Township, Range, and Section:** 14N 20W S31	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							Asphalt, Top 2 inches are recent overlay.	0.9 *3073.9*	8					
			87		9 - 9 - 6		FILL, Silty, Clayey SAND with gravel (SC-SM), [A-2]. medium dense, slightly moist, gray to black, fine to coarse grained, subrounded.	1.8 *3073.0*						
							Silty SAND (SM), [A-4]. medium dense, moist, tan/brown to gray, fine grained, subangular.	4.0 *3070.8*	4					
5 *3069.8*			53		6 - 11 - 15		Poorly-Graded GRAVEL with silt and sand (GP-GM), [A-1]. medium dense to very dense, wet, tan/brown, fine to coarse grained, subrounded to subangular. ▽			NV	NP	6		
10 *3064.8*			53		22 - 31 - 35									
15 *3059.8*			53		17 - 25 - 27			15.5 *3059.3*						

Boring Depth: 15.5 ft, *Elevation: 3059.3 ft*

Water Level Observations		Remarks:
▽ During Drilling: 6.2 ft *(3068.6 ft)*	▽ After Drilling: Not Recorded	
▼ After Drilling: Not Recorded		

MDT_LOG OF BORING - MDT_REVISED_2009+.GDT - 10/6/17 16:14 - N:\GEOTECH\REPORTS\REPORT 2017\MDT PROJECTS\MULLAN ROAD\106 REPORT\LOGS\MULLAN RD.GPJ

2525 Palmer Street, Suite 2
Missoula, MT 59808
Phone: (406)543-3045
Fax: (406)543-3088

LOG OF BORING

Boring 614100-SS-12

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 1011566.19 ft **Coordinates** E: 802355.91 ft	**Station:** **Offset:**
Project Number: STPS 263 - 1(28)6	**UPN:** 614100	**Boring Diameter:** 8 in	**System:** MT S.P. (E) **Datum:** WGS84	**Top of Boring Elevation:** 3072.2 ft
Date Started: 6/21/17	**Date Finished:** 6/21/17	**Drilling Fluid:** None	**Location Source:** GPS and Plans	**Elevation Source:** GPS
Driller: O'Keefe **Logger:** Aric Hotaling		**Abandonment Method:** Cuttings and Grout	**Township, Range, and Section:** 14N 20W S31	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							Asphalt, Top 2 inches are recent overlay.	0.9 *3071.3*	12					
			73		5 - 4 - 5		FILL, Poorly-Graded SAND with gravel (SP), [A-1]. loose, slightly moist, brown, fine to medium grained, subangular.	1.4 *3070.8*						
							Silty SAND (SM), [A-4]. loose, slightly moist, brown, fine grained, subangular.	3.0 *3069.2*	10					
5 *3067.2*			33		8 - 6 - 6		Poorly-Graded SAND with gravel (SP), [A-1]. medium dense to very dense, very moist to wet, brown, fine to coarse grained, subangular, Heaving sand.							
10 *3062.2*			33		8 - 10 - 15									
15 *3057.2*			0		22 - 21 - 50/0.4ft			15.4 *3056.8*						

Boring Depth: 15.4 ft, *Elevation: 3056.8 ft*

Water Level Observations		Remarks:
After Drilling: Not Recorded	During Drilling: 5.0 ft *(3067.2 ft)*	
	After Drilling: Not Recorded	

MDT_LOG OF BORING - MDT_REVISED_2009+.GDT - 10/6/17 16:14 - N:\GEOTECH\REPORTS\REPORT 2017\MDT PROJECTS\MULLAN ROAD\106 REPORT\LOGS\MULLAN RD.GPJ

2525 Palmer Street, Suite 2
Missoula, MT 59808
Phone: (406)543-3045
Fax: (406)543-3088

LOG OF BORING

Boring 614100-SS-13

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 1012366.44 ft **Coordinates** E: 801275.28 ft	**Station:** **Offset:**
Project Number: STPS 263 - 1(28)6	**UPN:** 614100	**Boring Diameter:** 8 in	**System:** MT S.P. (E) **Datum:** WGS84	**Top of Boring Elevation:** 3072.6 ft
Date Started: 6/21/17	**Date Finished:** 6/21/17	**Drilling Fluid:** None	**Location Source:** GPS and Plans	**Elevation Source:** GPS
Driller: O'Keefe **Logger:** Aric Hotaling		**Abandonment Method:** Cuttings and Grout	**Township, Range, and Section:** 14N 20W S31	

Depth (ft) Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							Asphalt.	0.8	18					
			20		2 - 3 - 3		FILL, Poorly-Graded SAND with gravel (SP), [A-1]. loose, moist to moist, brown, fine to medium grained, subangular.	*3071.8* 1.1 *3071.5*						
							Silty SAND (SM), [A-4]. very loose to loose, moist to very moist, black to gray, very fine grained, subangular.		25					
5 *3067.6*			80		2 - 1 - 1									
							Silty SAND (SM), [A-4]. loose, very moist to wet, brown, fine to medium grained, subangular. ▽	5.5 *3067.1*						
10 *3062.6*			87		3 - 4 - 4									
							Poorly-Graded GRAVEL with silt and sand (GP-GM), [A-1]. medium dense to very dense, wet, brown, fine to coarse grained, subangular.	12.0 *3060.6*						
15 *3057.6*			33		9 - 12 - 15									
20 *3052.6*			42		12 - 40 - 50/0.2ft									
			50		20 - 50/0.3ft			24.8 *3047.8*						

Boring Depth: 24.8 ft, *Elevation: 3047.8 ft*

Water Level Observations		Remarks:
▽ During Drilling: 7.0 ft *(3065.6 ft)*	▼ After Drilling: Not Recorded	
▼ After Drilling: Not Recorded		

MDT_LOG OF BORING - MDT_REVISED_2009+.GDT - 10/6/17 16:14 - N:\GEOTECH\REPORTS\REPORT 2017\MDT PROJECTS\MULLAN ROAD\106 REPORT\LOGS\MULLAN RD.GPJ

2525 Palmer Street, Suite 2
Missoula, MT 59808
Phone: (406)543-3045
Fax: (406)543-3088

LOG OF BORING

Boring 614100-SS-14

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 1012942.98 ft **Coordinates** E: 800377.44 ft	**Station:** **Offset:**
Project Number: STPS 263 - 1(28)6	**UPN:** 614100	**Boring Diameter:** 8 in	**System:** MT S.P. (E) **Datum:** WGS84	**Top of Boring Elevation:** 3069.5 ft
Date Started: 6/21/17	**Date Finished:** 6/21/17	**Drilling Fluid:** None	**Location Source:** GPS and Plans	**Elevation Source:** GPS
Driller: O'Keefe **Logger:** Aric Hotaling		**Abandonment Method:** Cuttings and Grout	**Township, Range, and Section:** 14N 20W S31	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							Asphalt, Top 2 inches are recent overlay.	0.8	23					
			80		4 - 3 - 2		FILL, Poorly-Graded SAND with gravel (SP), [A-1]. loose, slightly moist, brown, fine to medium grained, subangular.	*3068.7* 1.3 *3068.2*						
							Lean CLAY with sand (CL), [A-4]. very soft, slightly moist to very moist, brown to gray, fine grained, medium plasticity.		32	28	20	75		
5 *3064.5*			100		0 - 0 - 0									SS @ 4 ft. Advanced by weight of hammer.
10 *3059.5*			100											
			53		17 - 19 - 23		Poorly-Graded GRAVEL with silt and sand (GP-GM), [A-1]. dense to very dense, wet, brown, fine to coarse grained, subangular, Heaving sand.	10.4 *3059.1*						
15 *3054.5*			53		22 - 24 - 40									
							Boring Depth: 15.5 ft, *Elevation: 3054.0 ft*	15.5 *3054.0*						

Water Level Observations		Remarks:
▽ During Drilling: 5.5 ft *(3064.0 ft)*	▼ After Drilling: Not Recorded	
▼ After Drilling: Not Recorded		

2525 Palmer Street, Suite 2
Missoula, MT 59808
Phone: (406)543-3045
Fax: (406)543-3088

LOG OF BORING

Boring 614100-SS-15

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 1013579.73 ft **Coordinates** E: 799807.58 ft	**Station:** **Offset:**
Project Number: STPS 263 - 1(28)6	**UPN:** 614100	**Boring Diameter:** 8 in	**System:** MT S.P. (E) **Datum:** WGS84	**Top of Boring Elevation:** 3070.5 ft
Date Started: 6/21/17	**Date Finished:** 6/21/17	**Drilling Fluid:** None	**Location Source:** GPS and Plans	**Elevation Source:** GPS
Driller: O'Keefe **Logger:** Aric Hotaling		**Abandonment Method:** Cuttings and Grout	**Township, Range, and Section:** 14N 20W S31	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							Asphalt, Top 2 inches are recent overlay.	0.7	5	17	15	20		
			20		9 - 9 - 6		FILL, Silty GRAVEL with sand (GM), [A-1]. medium dense, slightly moist, brown, fine to medium grained, subangular.	*3069.8*						
							Silty SAND (SM), [A-4]. slightly moist to moist, brown, fine grained, subangular.	2.5 *3068.0*						
5 *3065.5*			67		9 - 11 - 8		Poorly-Graded SAND with gravel (SP), [A-1]. medium dense to very dense, moist to wet, brown, fine to coarse grained, subangular, Heaving sand.	4.0 *3066.5*	2					
10 *3060.5*			0		10 - 27 - 30									
15 *3055.5*			57		7 - 14 - 50/0.4ft			15.4 *3055.1*						

Boring Depth: 15.4 ft, *Elevation: 3055.1 ft*

Water Level Observations		Remarks:
After Drilling: Not Recorded	During Drilling: 7.8 ft *(3062.7 ft)*	
	After Drilling: Not Recorded	

2525 Palmer Street, Suite 2
Missoula, MT 59808
Phone: (406)543-3045
Fax: (406)543-3088

LOG OF BORING

Boring 614100-SS-16

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 1014204.44 ft **Coordinates** E: 799461.96 ft	**Station:** **Offset:**
Project Number: STPS 263 - 1(28)6	**UPN:** 614100	**Boring Diameter:** 8 in	**System:** MT S.P. (E) **Datum:** WGS84	**Top of Boring Elevation:** 3069.6 ft
Date Started: 6/21/17	**Date Finished:** 6/21/17	**Drilling Fluid:** None	**Location Source:** GPS and Plans	**Elevation Source:** GPS
Driller: O'Keefe **Logger:** Aric Hotaling		**Abandonment Method:** Cuttings and Grout	**Township, Range, and Section:** 14N 20W S30	

Depth (ft) Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							Asphalt, Top 2 inches are recent overlay.	0.8	17					
			67		4 - 3 - 7		FILL, Poorly-Graded SAND with gravel (SP), [A-1]. loose, slightly moist, brown, fine to medium grained, subangular.	*3068.9* 1.6 *3068.0*						
							Silty SAND (SM), [A-4]. loose, slightly moist to moist, gray, fine grained, subangular.	2.3 *3067.3*	22	29	16	57		
5 *3064.6*			67		2 - 1 - 2		Sandy Lean CLAY (CL), [A-6]. soft, moist, black to gray, medium plasticity.							
									26	41	18	79		
10 *3059.6*			100											
			100		21 - 50/0.3ft		Poorly-Graded SAND with gravel (SP), [A-1]. loose to very dense, moist to wet, brown, fine to coarse grained, subangular, Heaving sand. ▽	10.0 *3059.6*						Cohesion = 350 psf Friction Angle = 29.9 degrees
15 *3054.6*			53		5 - 5 - 5									
20 *3049.6*			47		6 - 14 - 33									
25 *3044.6*			100		6 - 11 - 19									SS @ 24 ft. Mostly heave recovered in spoon
							Boring Depth: 25.5 ft, *Elevation: 3044.1 ft*	25.5 *3044.1*						

Water Level Observations	
▽ During Drilling: 12.0 ft *(3057.6 ft)*	Remarks:
▼ After Drilling: Not Recorded	▼ After Drilling: Not Recorded

MDT_LOG OF BORING - MDT_REVISED_2009+.GDT - 10/6/17 16:14 - N:\GEOTECH\REPORTS\REPORT 2017\MDT PROJECTS\MULLAN ROAD\106 REPORT\LOGS\MULLAN RD.GPJ

2525 Palmer Street, Suite 2
Missoula, MT 59808
Phone: (406)543-3045
Fax: (406)543-3088

LOG OF BORING

Boring 614100-SS-17

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 1015556.43 ft **Coordinates** E: 798901.89 ft	**Station:** **Offset:**
Project Number: STPS 263 - 1(28)6	**UPN:** 614100	**Boring Diameter:** 8 in	**System:** MT S.P. (E) **Datum:** WGS84	**Top of Boring Elevation:** 3070.0 ft
Date Started: 6/22/17	**Date Finished:** 6/22/17	**Drilling Fluid:** None	**Location Source:** GPS and Plans	**Elevation Source:** GPS
Driller: O'Keefe **Logger:** Aric Hotaling		**Abandonment Method:** Cuttings and Grout	**Township, Range, and Section:** 14N 21W S25	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							Asphalt, Top 2 inches are recent overlay.	0.5 *3069.5*	6					
			60		9 - 18 - 12		FILL, Poorly-Graded SAND with silt and gravel (SP-SM), [A-1]. medium dense, slightly moist, brown, fine to medium grained, subangular to subrounded.	1.2 *3068.8*		18	15	19		
5 *3065.0*			60		4 - 11 - 12		Silty GRAVEL with sand (GM), [A-1]. medium dense to very dense, moist to wet, brown, fine to coarse grained, subangular.		12					
10 *3060.0*			53		12 - 15 - 19				2					
15 *3055.0*			73		28 - 34 - 39			15.5 *3054.5*						

Boring Depth: 15.5 ft, *Elevation: 3054.5 ft*

Water Level Observations		Remarks:
During Drilling: 13.4 ft *(3056.6 ft)*		
After Drilling: Not Recorded	After Drilling: Not Recorded	

MDT_LOG OF BORING - MDT_REVISED_2009+.GDT - 10/6/17 16:14 - N:\GEOTECH\REPORTS\REPORT 2017\MDT PROJECTS\MULLAN ROAD\106 REPORT\LOGS\MULLAN RD.GPJ

2525 Palmer Street, Suite 2
Missoula, MT 59808
Phone: (406)543-3045
Fax: (406)543-3088

LOG OF BORING

Boring 614100-SS-18

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 1016649.26 ft **Coordinates** E: 798533.15 ft	**Station:** **Offset:**
Project Number: STPS 263 - 1(28)6	**UPN:** 614100	**Boring Diameter:** 8 in	**System:** MT S.P. (E) **Datum:** WGS84	**Top of Boring Elevation:** 3066.1 ft
Date Started: 6/22/17	**Date Finished:** 6/22/17	**Drilling Fluid:** None	**Location Source:** GPS and Plans	**Elevation Source:** GPS
Driller: O'Keefe **Logger:** Aric Hotaling		**Abandonment Method:** Cuttings and Grout	**Township, Range, and Section:** 14N 21W S25	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							Asphalt, Top 2 inches are recent overlay.	0.7	12					
			73		8 - 6 - 2		FILL, Silty GRAVEL with sand (GM), [A-1]. loose, slightly moist, brown, fine to medium grained, subangular to subrounded.	*3065.4* 1.3 *3064.8*		18	16	38		
							Silty SAND (SM), [A-4]. loose to medium dense, slightly moist to moist, brown to black, fine to medium grained, subangular.		10					
5 *3061.1*			67		2 - 5 - 16		Poorly-Graded SAND with silt and gravel (SP-SM), [A-1]. medium dense to very dense, moist to wet, brown, fine to coarse grained, subangular, heaving sand.	4.5 *3061.6*						
10 *3056.1*			53		22 - 41 - 35				9					
15 *3051.1*			33		17 - 14 - 13			15.5 *3050.6*						

Boring Depth: 15.5 ft, *Elevation: 3050.6 ft*

Water Level Observations		Remarks:
After Drilling: Not Recorded	During Drilling: 11.0 ft *(3055.1 ft)*	
	After Drilling: Not Recorded	

2525 Palmer Street, Suite 2
Missoula, MT 59808
Phone: (406)543-3045
Fax: (406)543-3088

LOG OF BORING

Boring 614100-SS-19

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 1017637.66 ft **Coordinates** E: 798184.08 ft	**Station:** **Offset:**
Project Number: STPS 263 - 1(28)6	**UPN:** 614100	**Boring Diameter:** 8 in	**System:** MT S.P. (E) **Datum:** WGS84	**Top of Boring Elevation:** 3065.2 ft
Date Started: 6/22/17	**Date Finished:** 6/22/17	**Drilling Fluid:** None	**Location Source:** GPS and Plans	**Elevation Source:** GPS
Driller: O'Keefe **Logger:** Aric Hotaling		**Abandonment Method:** Cuttings and Grout	**Township, Range, and Section:** 14N 21W S25	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							Asphalt, Top 2 inches are recent overlay.	0.7	13					
			80		6 - 5 - 3		FILL, Silty GRAVEL with sand (GM), [A-1]. loose, slightly moist, brown, fine to medium grained, subangular to subrounded.	*3064.5* 1.3 *3063.9*						
							Silty SAND (SM), [A-4]. loose, slightly moist to moist, brown, fine to medium grained, subangular.	3.5 *3061.7*	2					
5 *3060.2*			71		19 - 32 - 50/0.4ft		Poorly-Graded SAND with gravel (SP), [A-1]. dense to very dense, moist to wet, brown, fine to coarse grained, subangular, heaving sand.							
									10					
10 *3055.2*			67		17 - 22 - 24									
15 *3050.2*			67		14 - 28 - 42			15.5 *3049.7*						

Boring Depth: 15.5 ft, *Elevation: 3049.7 ft*

Water Level Observations		Remarks:
After Drilling: Not Recorded	During Drilling: 10.6 ft *(3054.6 ft)*	
	After Drilling: Not Recorded	

2525 Palmer Street, Suite 2
Missoula, MT 59808
Phone: (406)543-3045
Fax: (406)543-3088

LOG OF BORING

Boring 614100-SS-20

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 1018731.26 ft **Coordinates** E: 797974.39 ft	**Station:** **Offset:**
Project Number: STPS 263 - 1(28)6	**UPN:** 614100	**Boring Diameter:** 8 in	**System:** MT S.P. (E) **Datum:** WGS84	**Top of Boring Elevation:** 3067.0 ft
Date Started: 6/22/17	**Date Finished:** 6/22/17	**Drilling Fluid:** None	**Location Source:** GPS and Plans	**Elevation Source:** GPS
Driller: O'Keefe **Logger:** Aric Hotaling		**Abandonment Method:** Cuttings and Grout	**Township, Range, and Section:** 14N 21W S25	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							Asphalt, Top 2 inches are recent overlay.	0.6	6					
			67		10 - 12 - 20		FILL, Silty GRAVEL with sand (GM), [A-1]. dense, slightly moist, brown, fine to medium grained, subangular to angular.	*3066.4* 1.1 *3065.9*						
							FILL, Silty SAND with gravel (SM), [A-2]. dense, slightly moist, brown, fine to medium grained, subrounded to subangular.	3.5 *3063.5*	6					
5 *3062.0*			67		4 - 7 - 6		Silty SAND (SM), [A-4]. medium dense, slightly moist to moist, brown, fine to medium grained, subangular.	6.0 *3061.0*						
							Poorly-Graded SAND with gravel (SP), [A-1]. dense to very dense, moist to wet, brown, fine to coarse grained, subangular.		5					
10 *3057.0*			20		7 - 21 - 26									
15 *3052.0*			80		16 - 26 - 38			15.5 *3051.5*						

Boring Depth: 15.5 ft, *Elevation: 3051.5 ft*

Water Level Observations		Remarks:
▽ During Drilling: 12.5 ft *(3054.5 ft)*	▼ After Drilling: Not Recorded	
▼ After Drilling: Not Recorded		

2525 Palmer Street, Suite 2
Missoula, MT 59808
Phone: (406)543-3045
Fax: (406)543-3088

LOG OF BORING

Boring 614100-SS-21

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 1019658.58 ft **Coordinates** E: 797664.55 ft	**Station:** **Offset:**
Project Number: STPS 263 - 1(28)6	**UPN:** 614100	**Boring Diameter:** 8 in	**System:** MT S.P. (E) **Datum:** WGS84	**Top of Boring Elevation:** 3065.2 ft
Date Started: 6/22/17	**Date Finished:** 6/22/17	**Drilling Fluid:** None	**Location Source:** GPS and Plans	**Elevation Source:** GPS
Driller: O'Keefe **Logger:** Aric Hotaling		**Abandonment Method:** Cuttings and Grout	**Township, Range, and Section:** 14N 21W S24	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							Asphalt, Top 2 inches are recent overlay.	0.6	5					
			73		14 - 17 - 16		FILL, Silty GRAVEL with sand (GM), [A-1]. dense, slightly moist, brown, fine to medium grained, subrounded to subangular.	*3064.6* 2.2						
							Silty SAND (SM), [A-4]. loose, slightly moist to moist, brown, fine to medium grained, subangular.	*3063.0* 4.0	1					
5 *3060.2*			67		6 - 11 - 38		Poorly-Graded GRAVEL with silt and sand (GP-GM), [A-1]. medium dense to very dense, moist to wet, brown, fine to coarse grained, subangular.	*3061.2*		16	15	5		
10 *3055.2*			80		43 - 37 - 31				3					
15 *3050.2*			53		7 - 16 - 10			15.5 *3049.7*						

Boring Depth: 15.5 ft, *Elevation: 3049.7 ft*

Water Level Observations		Remarks:
After Drilling: Not Recorded	During Drilling: 10.7 ft *(3054.5 ft)*	
	After Drilling: Not Recorded	

2525 Palmer Street, Suite 2
Missoula, MT 59808
Phone: (406)543-3045
Fax: (406)543-3088

LOG OF BORING

Boring 614100-SS-22

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 1020823.47 ft **Coordinates** E: 797281.19 ft	**Station:** **Offset:**
Project Number: STPS 263 - 1(28)6	**UPN:** 614100	**Boring Diameter:** 8 in	**System:** MT S.P. (E) **Datum:** WGS84	**Top of Boring Elevation:** 3064.8 ft
Date Started: 6/22/17	**Date Finished:** 6/22/17	**Drilling Fluid:** None	**Location Source:** GPS and Plans	**Elevation Source:** GPS
Driller: O'Keefe **Logger:** Aric Hotaling		**Abandonment Method:** Cuttings and Grout	**Township, Range, and Section:** 14N 21W S24	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							Asphalt, Top 2 inches are recent overlay.	0.5 *3064.3*	9					
			80		10 - 8 - 8		FILL, Silty, Clayey SAND with gravel (SC-SM), [A-2]. medium dense, slightly moist, brown, fine to medium grained, subrounded to subangular.	1.1 *3063.7*		18	16	40		
							Silty SAND (SM), [A-4]. loose to medium dense, slightly moist to moist, brown to black, fine to medium grained, subangular.		18					
5 *3059.8*			67		3 - 2 - 3		Sandy Lean CLAY (CL), [A-6]. medium stiff, moist, brown to black, low plasticity.	4.5 *3060.3*	18	33	18	63		
			60				Silty SAND (SM), [A-4]. medium dense, moist, brown, fine to medium grained, subangular.	7.0 *3057.8*						Cohesion = 400 psf Friction Angle = 30.9 degrees
10 *3054.8*			73		7 - 21 - 47		Poorly-Graded GRAVEL with silt and sand (GP-GM), [A-1]. very dense, moist to wet, brown, fine to coarse grained, subangular. ▽	9.3 *3055.5*	3					
15 *3049.8*			80		14 - 28 - 31			15.5 *3049.3*						

Boring Depth: 15.5 ft, *Elevation: 3049.3 ft*

Water Level Observations		Remarks:
▽ After Drilling: Not Recorded	▽ During Drilling: 11.3 ft *(3053.5 ft)*	
	▼ After Drilling: Not Recorded	

2525 Palmer Street, Suite 2
Missoula, MT 59808
Phone: (406)543-3045
Fax: (406)543-3088

LOG OF BORING

Boring 614100-SS-23

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 1021128.35 ft **Coordinates** E: 797162.04 ft	**Station:** **Offset:**
Project Number: STPS 263 - 1(28)6	**UPN:** 614100	**Boring Diameter:** 8 in	**System:** MT S.P. (E) **Datum:** WGS84	**Top of Boring Elevation:** 3064.6 ft
Date Started: 6/22/17	**Date Finished:** 6/22/17	**Drilling Fluid:** None	**Location Source:** GPS and Plans	**Elevation Source:** GPS
Driller: O'Keefe **Logger:** Aric Hotaling		**Abandonment Method:** Cuttings and Grout	**Township, Range, and Section:** 14N 21W S24	

Depth (ft) Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							Asphalt, Top 2 inches are recent overlay.	0.7	3					
			27		8 - 5 - 7		FILL, Silty GRAVEL with sand (GM), [A-1]. medium dense, slightly moist, brown, fine to medium grained, subrounded to subangular.	3063.9 2.0 3062.6						
5 3059.6			80		0 - 2 - 2		Silty SAND (SM), [A-4]. very loose to medium dense, slightly moist to very moist, brown, fine to medium grained, subangular.		25					
							Sandy Lean CLAY (CL), [A-6]. soft, very moist, brown, low plasticity.	6.0 3058.6	33					
10 3054.6			87		0 - 6 - 14		Poorly-Graded SAND with gravel (SP), [A-1]. loose to very dense, moist to wet, brown, fine to coarse grained, subangular, heaving sand, SS @ 19 ft. encountered sand seam, no gravel. ▽	10.0 3054.6						
15 3049.6			73		19 - 26 - 31									
20 3044.6			67		7 - 4 - 3									
25 3039.6			36		13 - 42 - 50/0.4ft			25.4 3039.2						

Boring Depth: 25.4 ft, *Elevation: 3039.2 ft*

Water Level Observations		Remarks:
▽ During Drilling: 12.5 ft *(3052.1 ft)*	▽ After Drilling: Not Recorded	
▼ After Drilling: Not Recorded		

MDT_LOG OF BORING - MDT_REVISED_2009+.GDT - 10/6/17 16:14 - N:\GEOTECH\REPORTS\REPORT 2017\MDT PROJECTS\MULLAN ROAD\106 REPORT\LOGS\MULLAN RD.GPJ

2525 Palmer Street, Suite 2
Missoula, MT 59808
Phone: (406)543-3045
Fax: (406)543-3088

LOG OF BORING

Boring 614100-SS-24

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 1022715.27 ft **Coordinates** E: 796984.08 ft	**Station:** **Offset:**
Project Number: STPS 263 - 1(28)6	**UPN:** 614100	**Boring Diameter:** 8 in	**System:** MT S.P. (E) **Datum:** WGS84	**Top of Boring Elevation:** 3068.7 ft
Date Started: 6/23/17	**Date Finished:** 6/23/17	**Drilling Fluid:** None	**Location Source:** GPS and Plans	**Elevation Source:** GPS
Driller: O'Keefe **Logger:** Aric Hotaling		**Abandonment Method:** Cuttings and Grout	**Township, Range, and Section:** 14N 21W S24	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							Asphalt.	0.8	9	17	15	13		
			80		12 - 10 - 7		FILL, Silty GRAVEL with sand (GM), [A-1]. medium dense, slightly moist, brown, fine to medium grained, subrounded to subangular.	*3068.0* 1.5 *3067.2*		34	20	68		
							Sandy Lean CLAY (CL), [A-6]. medium stiff to stiff, moist, brown to black, fine grained, medium plasticity.		22					
5 *3063.7*			47		4 - 3 - 4			5.5 *3063.2*						
							Fat CLAY (CH), [A-7]. medium stiff to stiff, moist, brown to black, fine grained, high plasticity.		28	63	24	98		Cohesion = 370 psf Friction Angle = 9.8 degrees
			85											
									19					
10 *3058.7*			87		3 - 4 - 4									
							Poorly-Graded GRAVEL with silt and sand (GP-GM), [A-1]. medium dense, moist, brown, fine to coarse grained, subangular.	11.0 *3057.7*						
									3					
15 *3053.7*			60		14 - 14 - 15									
							Boring Depth: 15.5 ft, *Elevation: 3053.2 ft*	15.5 *3053.2*						

Water Level Observations		Remarks:
During Drilling: Not Encountered		
After Drilling: Not Recorded	After Drilling: Not Recorded	

2525 Palmer Street, Suite 2
Missoula, MT 59808
Phone: (406)543-3045
Fax: (406)543-3088

LOG OF BORING

Boring 614100-SS-25

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 1023734.55 ft **Coordinates** E: 796930.97 ft	**Station:** **Offset:**
Project Number: STPS 263 - 1(28)6	**UPN:** 614100	**Boring Diameter:** 8 in	**System:** MT S.P. (E) **Datum:** WGS84	**Top of Boring Elevation:** 3068.5 ft
Date Started: 6/23/17	**Date Finished:** 6/23/17	**Drilling Fluid:** None	**Location Source:** GPS and Plans	**Elevation Source:** GPS
Driller: O'Keefe **Logger:** Aric Hotaling		**Abandonment Method:** Cuttings and Grout	**Township, Range, and Section:** 14N 21W S24	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							Asphalt.	0.7	11					
			87		6 - 7 - 9		FILL, Silty GRAVEL with sand (GM), [A-1]. medium dense, slightly moist, brown, fine to medium grained, subrounded to subangular.	*3067.8* 1.3 *3067.2*						
							FILL, Silty, Clayey SAND (SC-SM), [A-2]. medium dense, moist, brown to black, fine grained, subangular, low plasticity, Scattered gravels.	3.0 *3065.5*						
5 *3063.5*			80		4 - 3 - 2		Silty SAND (SM), [A-4]. loose, slightly moist to very moist, tan/brown, very fine grained, subangular.	6.0 *3062.5*						
							Poorly-Graded GRAVEL with silt and sand (GP-GM), [A-1]. dense to very dense, moist, brown, fine to coarse grained, subangular.		7					
10 *3058.5*			73		22 - 38 - 41									
									4					
15 *3053.5*			67		18 - 24 - 25			15.5 *3053.0*						

Boring Depth: 15.5 ft, *Elevation: 3053.0 ft*

Water Level Observations		Remarks:
During Drilling: Not Encountered	After Drilling: Not Recorded	
After Drilling: Not Recorded		

2525 Palmer Street, Suite 2
Missoula, MT 59808
Phone: (406)543-3045
Fax: (406)543-3088

LOG OF BORING

Boring 614100-SS-26

TETRA TECH

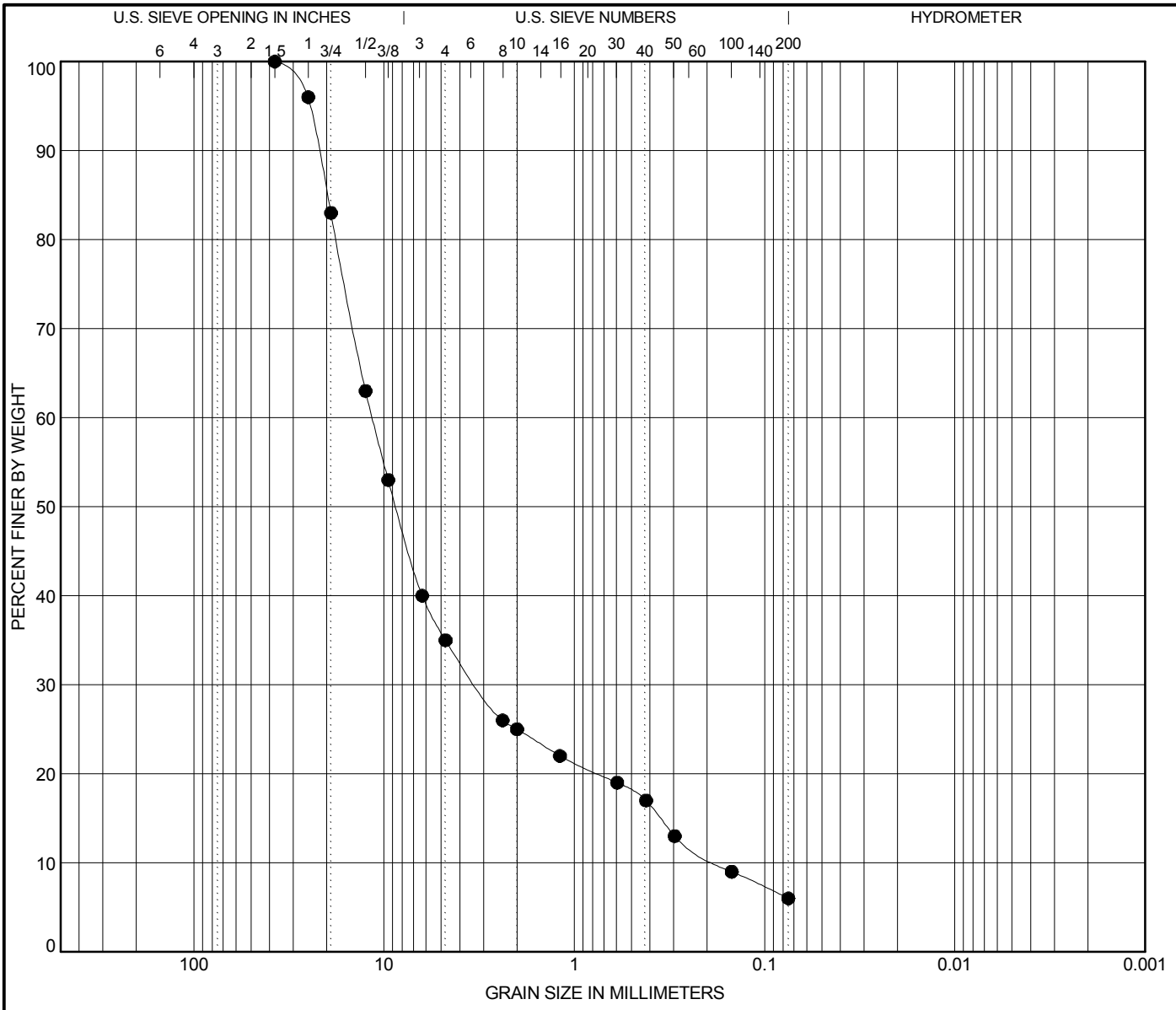
Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 1024801.75 ft **Coordinates** E: 796900.89 ft	**Station:** **Offset:**
Project Number: STPS 263 - 1(28)6	**UPN:** 614100	**Boring Diameter:** 8 in	**System:** MT S.P. (E) **Datum:** WGS84	**Top of Boring Elevation:** 3066.3 ft
Date Started: 6/23/17	**Date Finished:** 6/23/17	**Drilling Fluid:** None	**Location Source:** GPS and Plans	**Elevation Source:** GPS
Driller: O'Keefe **Logger:** Aric Hotaling		**Abandonment Method:** Cuttings and Grout	**Township, Range, and Section:** 14N 21W S24	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							Asphalt.							
			63		12 - 50/0.3ft		FILL, Poorly-Graded GRAVEL with clay (GP-GC), [A-2]. medium dense to very dense, slightly moist to moist, brown to black, fine to medium grained, subrounded to subangular, cobbles.	0.9 *3065.4*	1	30	17	12		
5 *3061.3*			73		11 - 5 - 7		Lean CLAY with sand (CL), [A-7]. stiff, slightly moist, red to tan/brown, very fine grained, subangular, medium plasticity.	4.0 *3062.3*	22	46	19	73		
							Poorly-Graded GRAVEL with silt and sand (GP-GM), [A-1]. medium dense to very dense, moist, brown, fine to coarse grained, subangular.	6.0 *3060.3*						
10 *3056.3*			87		24 - 46 - 47				2					
									1					
15 *3051.3*			53		5 - 10 - 7									
							Boring Depth: 15.5 ft, *Elevation: 3050.8 ft*	15.5 *3050.8*						

Water Level Observations		Remarks:
During Drilling: Not Encountered	After Drilling: Not Recorded	
After Drilling: Not Recorded		

APPENDIX 2B

Gradations (Figures 2B-1 through 2B-22)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

SIEVE SIZE	% PASSING
1.5 in	100
1 in	96
3/4 in	83
1/2 in	63
3/8 in	53
1/4 in	40
No. 4	35
No. 8	26
No. 10	25
No. 16	22
No. 30	19
No. 40	17
No. 50	13
No. 100	9
No. 200	6

Specimen Identification
SS-1 - (0.5 - 3 ft)

Classification	LL	PL	PI	Cc	Cu
POORLY GRADED GRAVEL with SILT and SAND(GP-GM)	**NV**	**NV**	**NP**	**5.14**	**65.02**
AASHTO : A-1-a(1)					

% Gravel	% Sand	% Silt	% Clay
65	29	6	

D100	D60	D30	D10
37.5	11.512	3.236	0.177

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: West of Missoula - NW (Mullan Rd),

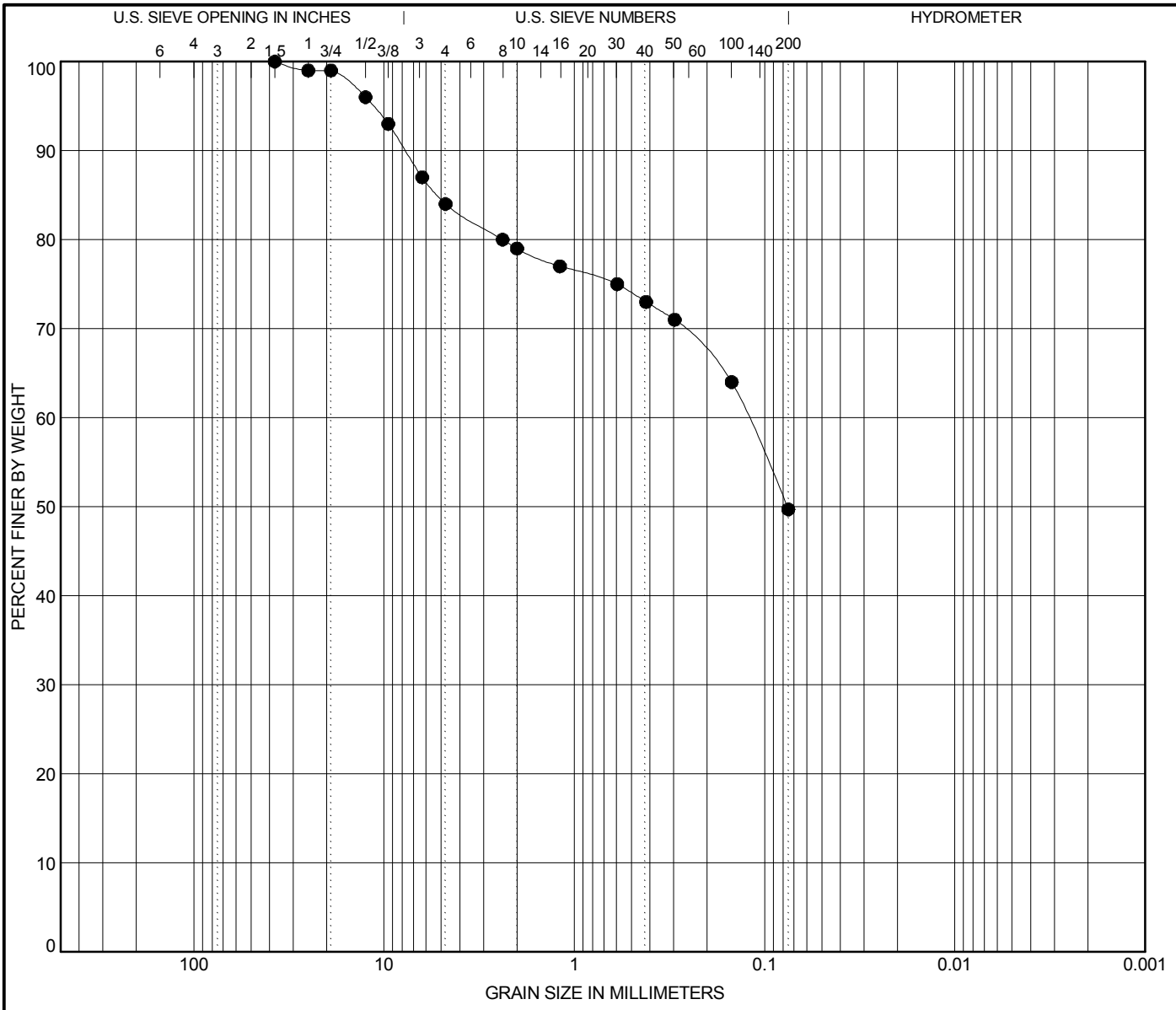
Location: RP-5.5

Number: STPS 263 - 1(28)6

Figure No. 2B-1

MULLAN RD.GPJ ` 10-4-17 ` ` TT_US GRAIN SIZE (SIEVE DATA)

Revised 1-23-08 (MAT)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

SIEVE SIZE	% PASSING
1.5 in	100
1 in	99
3/4 in	99
1/2 in	96
3/8 in	93
1/4 in	87
No. 4	84
No. 8	80
No. 10	79
No. 16	77
No. 30	75
No. 40	73
No. 50	71
No. 100	64
No. 200	49.7

Specimen Identification
SS-2 - (3 - 6 ft)

Classification	LL	PL	PI	Cc	Cu
SILTY, CLAYEY SAND with GRAVEL(SC-SM) AASHTO : A-4(1)	**27**	**20**	**7**		

% Gravel	% Sand	% Silt	% Clay
16	34	50	

D100	D60	D30	D10
37.5	0.123		

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: West of Missoula - NW (Mullan Rd),

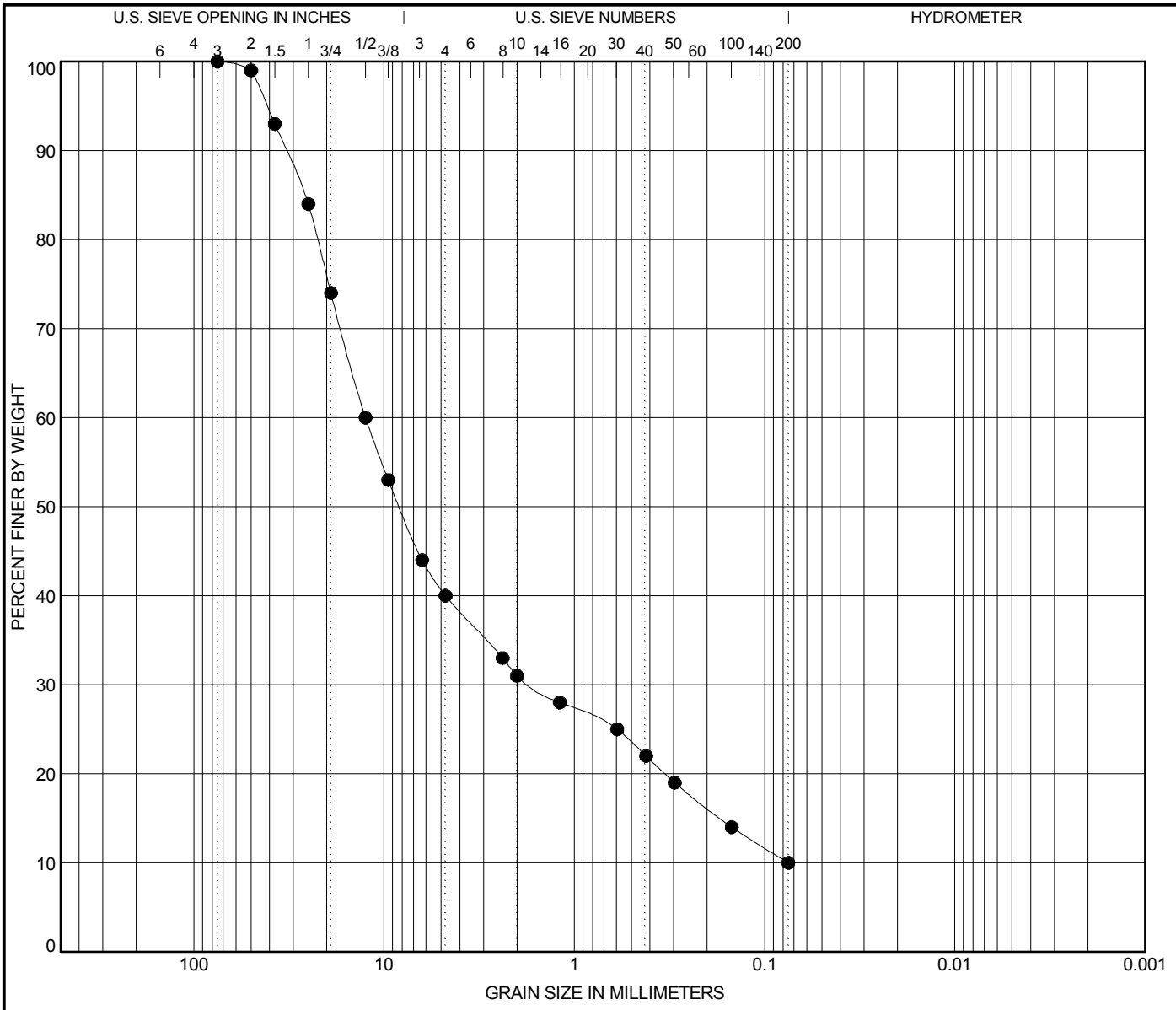
Location: RP-5.7

Number: STPS 263 - 1(28)6

Figure No. 2B-2

MULLAN RD.GPJ ` 10-4-17 ` ` TT_US GRAIN SIZE (SIEVE DATA)

Revised 1-23-08 (MAT)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

SIEVE SIZE	% PASSING
3 in	100
2 in	99
1.5 in	93
1 in	84
3/4 in	74
1/2 in	60
3/8 in	53
1/4 in	44
No. 4	40
No. 8	33
No. 10	31
No. 16	28
No. 30	25
No. 40	22
No. 50	19
No. 100	14
No. 200	10

Specimen Identification
SS-3 - (0.7 - 4 ft)

Classification	LL	PL	PI	Cc	Cu
POORLY GRADED GRAVEL with SILT and SAND(GP-GM)	**17**	**15**	**2**	**3.02**	**166.67**
AASHTO : A-1-a(0)					

% Gravel	% Sand	% Silt	% Clay
60	30	10	

D100	D60	D30	D10
75	12.5	1.682	0.075

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: West of Missoula - NW (Mullan Rd),

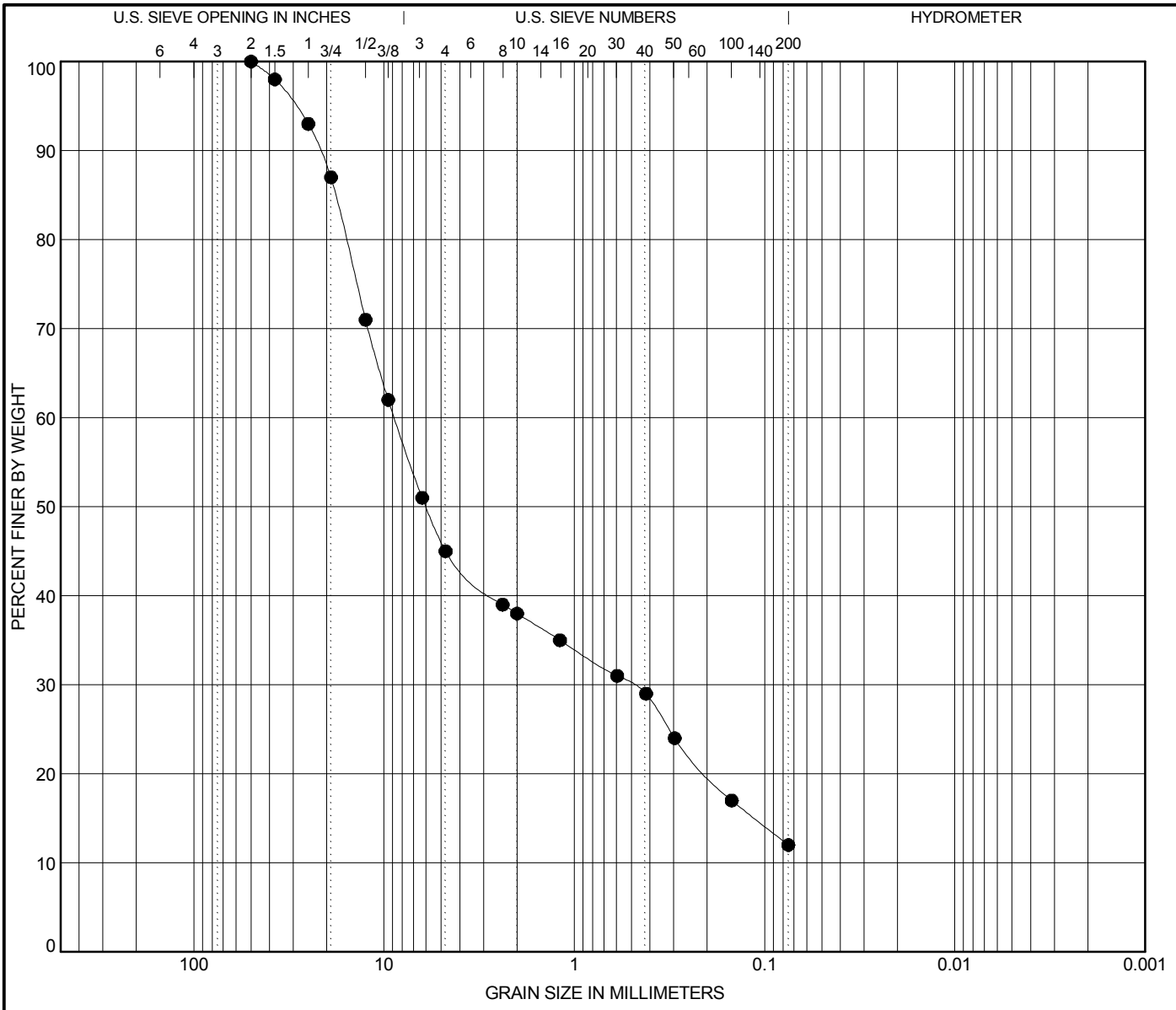
Location: RP-5.9

Number: STPS 263 - 1(28)6

Figure No. 2B-3

MULLAN RD.GPJ ` 10-4-17 ` ` TT_US GRAIN SIZE (SIEVE DATA)

Revised 1-23-08 (MAT)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

SIEVE SIZE	% PASSING
2 in	100
1.5 in	98
1 in	93
3/4 in	87
1/2 in	71
3/8 in	62
1/4 in	51
No. 4	45
No. 8	39
No. 10	38
No. 16	35
No. 30	31
No. 40	29
No. 50	24
No. 100	17
No. 200	12

Specimen Identification
SS-5 - (0.8 - 4 ft)

Classification	LL	PL	PI	Cc	Cu
POORLY GRADED GRAVEL with SILT and SAND(GP-GM)	**17**	**16**	**1**	**0.50**	**154.70**
AASHTO : A-1-a(0)					

% Gravel	% Sand	% Silt	% Clay
55	33	12	

D100	D60	D30	D10
50	8.816	0.5	

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: West of Missoula - NW (Mullan Rd),

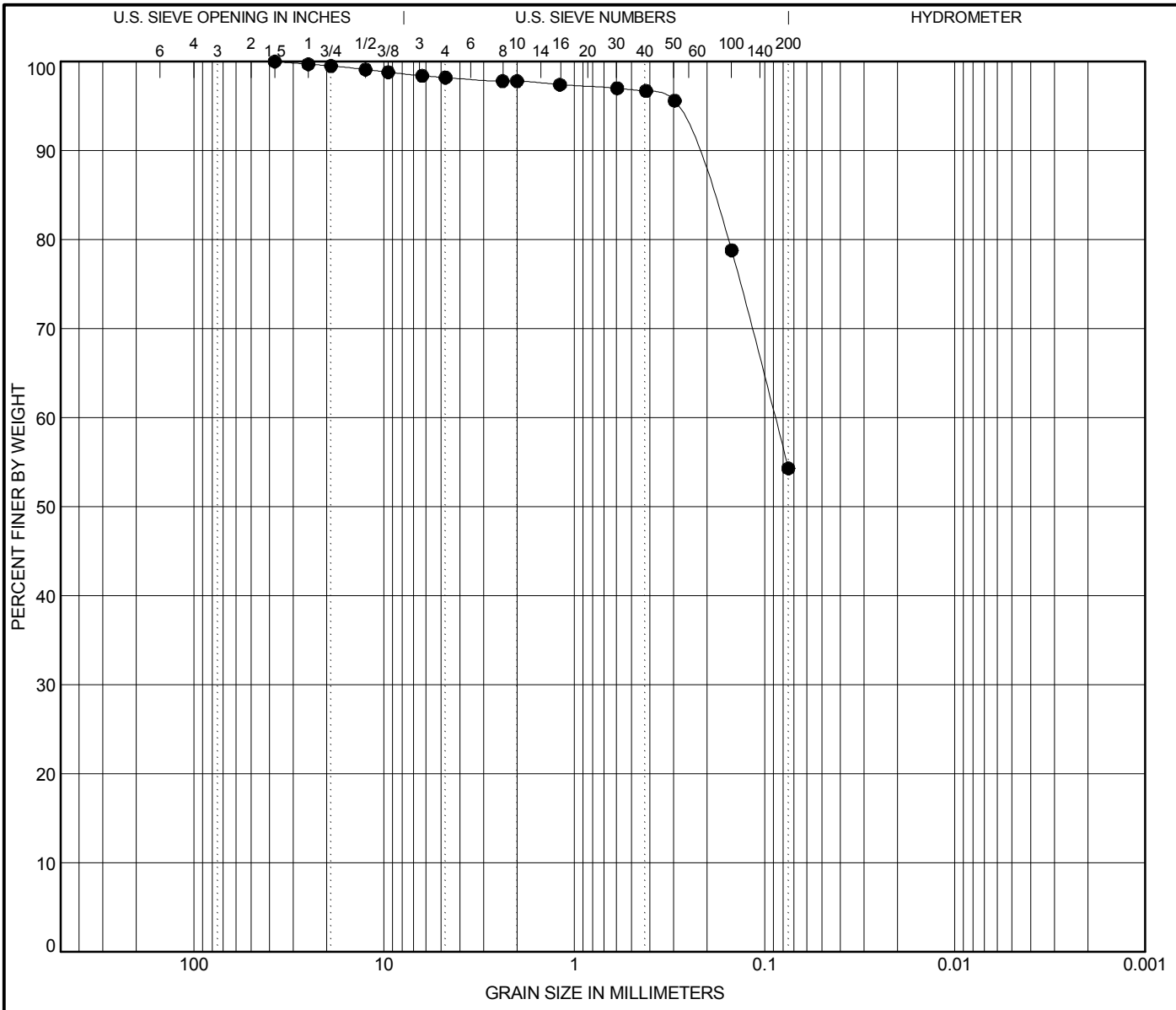
Location: RP-6.3

Number: STPS 263 - 1(28)6

Figure No. 2B-4

MULLAN RD.GPJ ` 10-4-17 ` ` TT_US GRAIN SIZE (SIEVE DATA)

Revised 1-23-08 (MAT)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

SIEVE SIZE	% PASSING
1.5 in	100
1 in	99.7
3/4 in	99.5
1/2 in	99.1
3/8 in	98.8
1/4 in	98.4
No. 4	98.2
No. 8	97.8
No. 10	97.8
No. 16	97.4
No. 30	97
No. 40	96.7
No. 50	95.6
No. 100	78.8
No. 200	54.3

Specimen Identification
SS-9 - (3 - 7 ft)

Classification	LL	PL	PI	Cc	Cu
SANDY SILTY CLAY(CL-ML)					
AASHTO : A-4(0)	**23**	**18**	**5**		

% Gravel	% Sand	% Silt	% Clay
2	44	54	

D100	D60	D30	D10
37.5	0.088		

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: West of Missoula - NW (Mullan Rd),

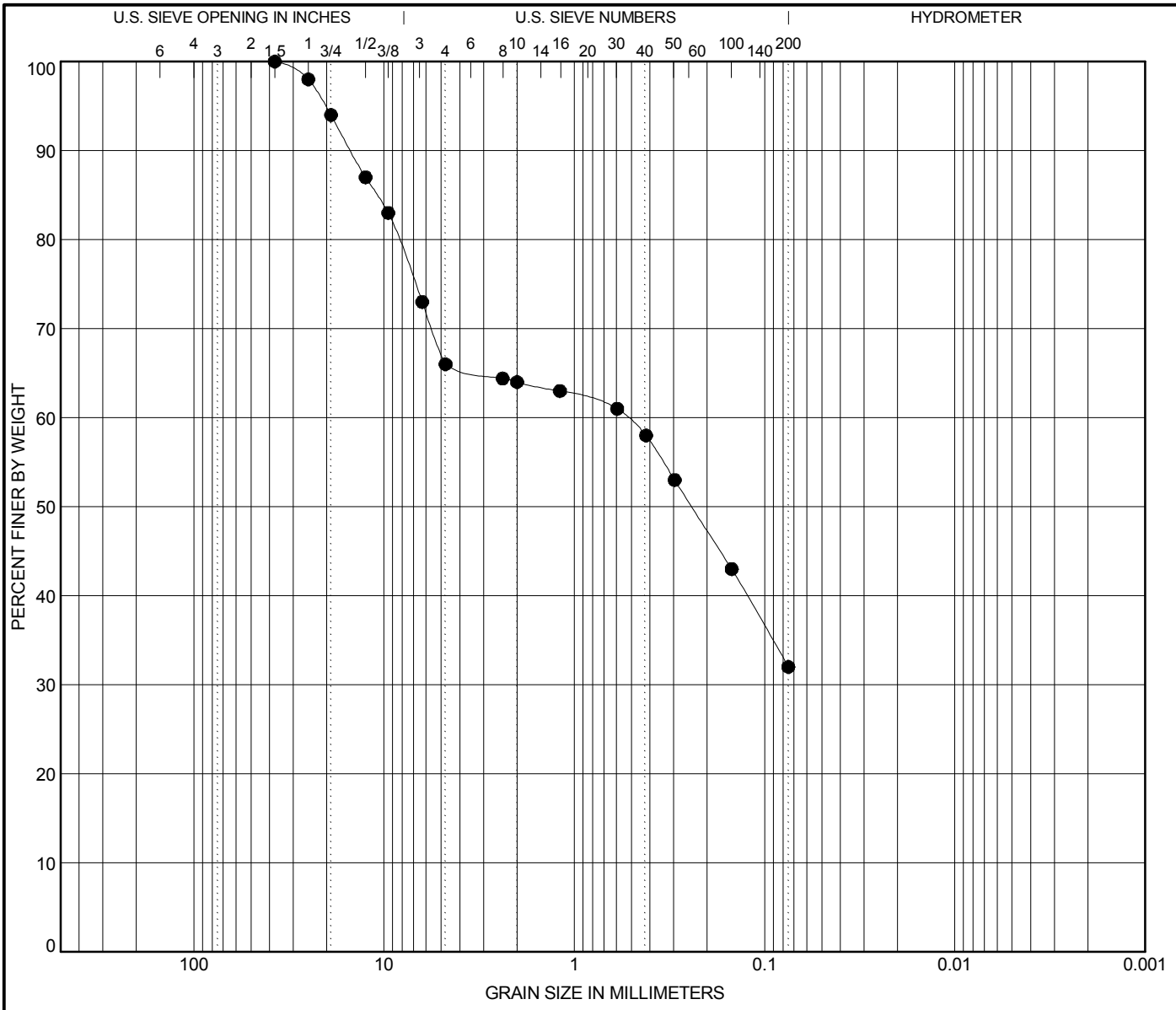
Location: RP-7.1

Number: STPS 263 - 1(28)6

Figure No. 2B-5

MULLAN RD.GPJ ` 10-4-17 ` ` TT_US GRAIN SIZE (SIEVE DATA)

Revised 1-23-08 (MAT)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

SIEVE SIZE	% PASSING
1.5 in	100
1 in	98
3/4 in	94
1/2 in	87
3/8 in	83
1/4 in	73
No. 4	66
No. 8	64.4
No. 10	64
No. 16	63
No. 30	61
No. 40	58
No. 50	53
No. 100	43
No. 200	32

Specimen Identification
SS-10 - (0.8 - 2 ft)

Classification	LL	PL	PI	Cc	Cu
SILTY, CLAYEY SAND with GRAVEL(SC-SM)	**23**	**17**	**6**		
AASHTO : A-2-4(0)					

% Gravel	% Sand	% Silt	% Clay
34	34	32	

D100	D60	D30	D10
37.5	0.53		

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: West of Missoula - NW (Mullan Rd),

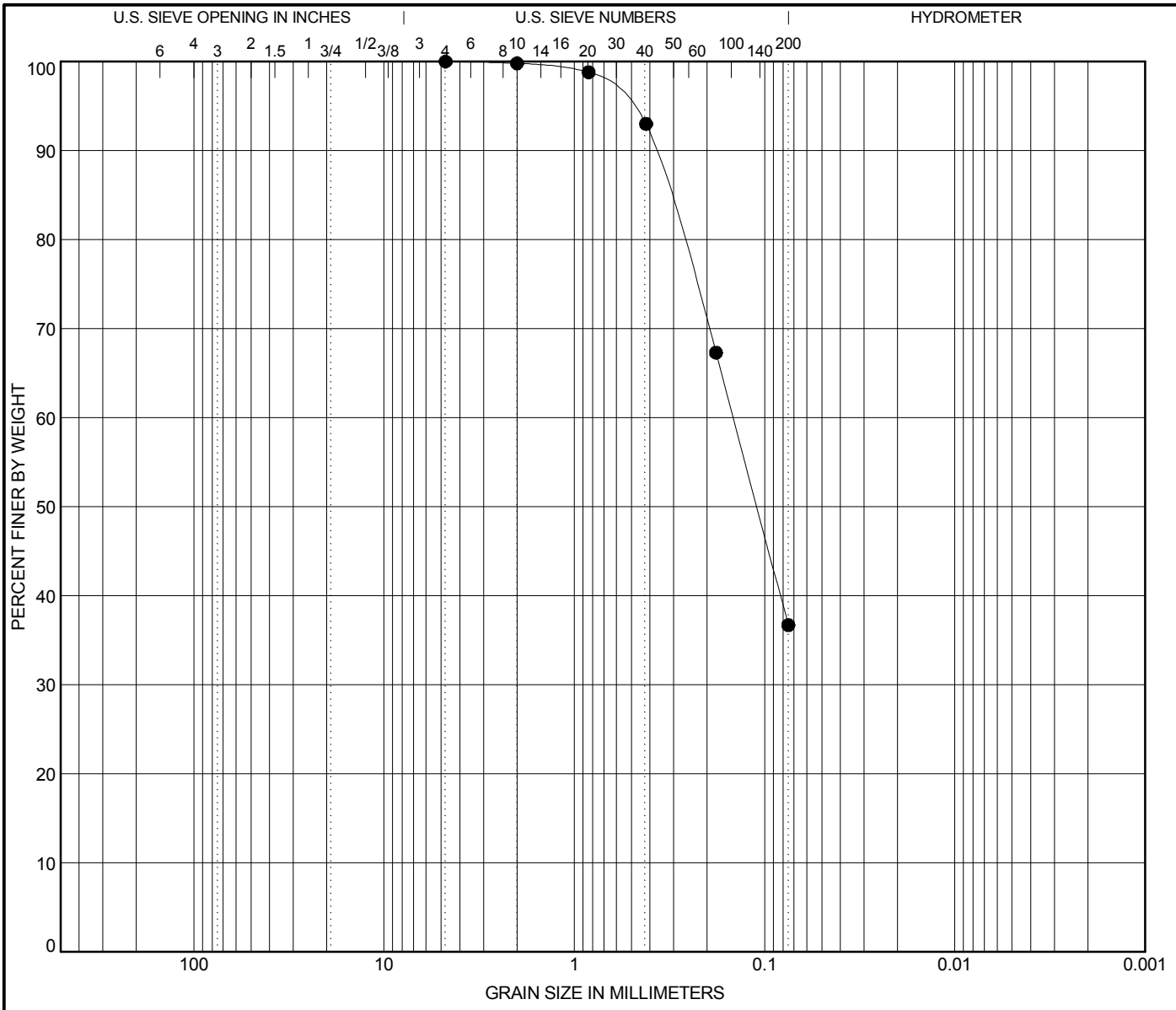
Location: RP-7.3

Number: STPS 263 - 1(28)6

Figure No. 2B-6

MULLAN RD.GPJ ` 10-4-17 ` ` TT_US GRAIN SIZE (SIEVE DATA)

Revised 1-23-08 (MAT)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

SIEVE SIZE	% PASSING
No. 4	100
No. 10	99.8
No. 20	98.8
No. 40	93
No. 80	67.3
No. 200	36.7

Specimen Identification
SS-10 - (4 - 6 ft)

Classification	LL	PL	PI	Cc	Cu
SILTY SAND(SM)					
AASHTO : A-4(0)	**NV**	**NV**	**NP**		

% Gravel	% Sand	% Silt	% Clay
0	63	37	

D100	D60	D30	D10
4.75	0.146		

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: West of Missoula - NW (Mullan Rd),

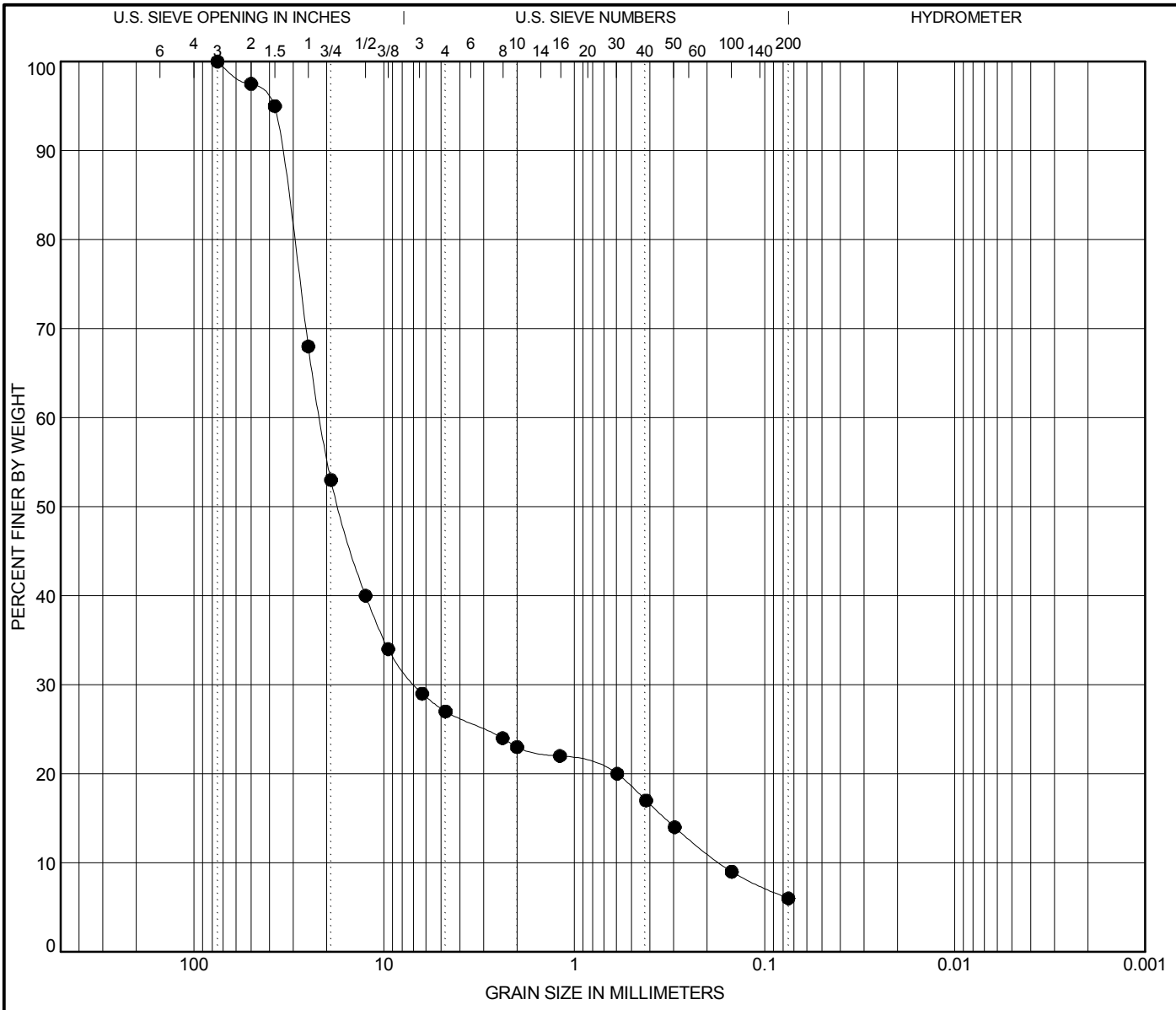
Location: RP-7.3

Number: STPS 263 - 1(28)6

Figure No. 2B-7

MULLAN RD.GPJ ` 10-4-17 ` ` TT_US GRAIN SIZE (SIEVE DATA)

Revised 1-23-08 (MAT)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

SIEVE SIZE	% PASSING
3 in	100
2 in	97.5
1.5 in	95
1 in	68
3/4 in	53
1/2 in	40
3/8 in	34
1/4 in	29
No. 4	27
No. 8	24
No. 10	23
No. 16	22
No. 30	20
No. 40	17
No. 50	14
No. 100	9
No. 200	6

Specimen Identification
SS-11 - (7 - 14 ft)

Classification	LL	PL	PI	Cc	Cu
POORLY GRADED GRAVEL with SILT and SAND(GP-GM)	**NV**	**NV**	**NP**	**12.66**	**126.26**
AASHTO : A-1-a(1)					

% Gravel	% Sand	% Silt	% Clay
73	21	6	

D100	D60	D30	D10
75	21.596	6.839	0.171

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: West of Missoula - NW (Mullan Rd),

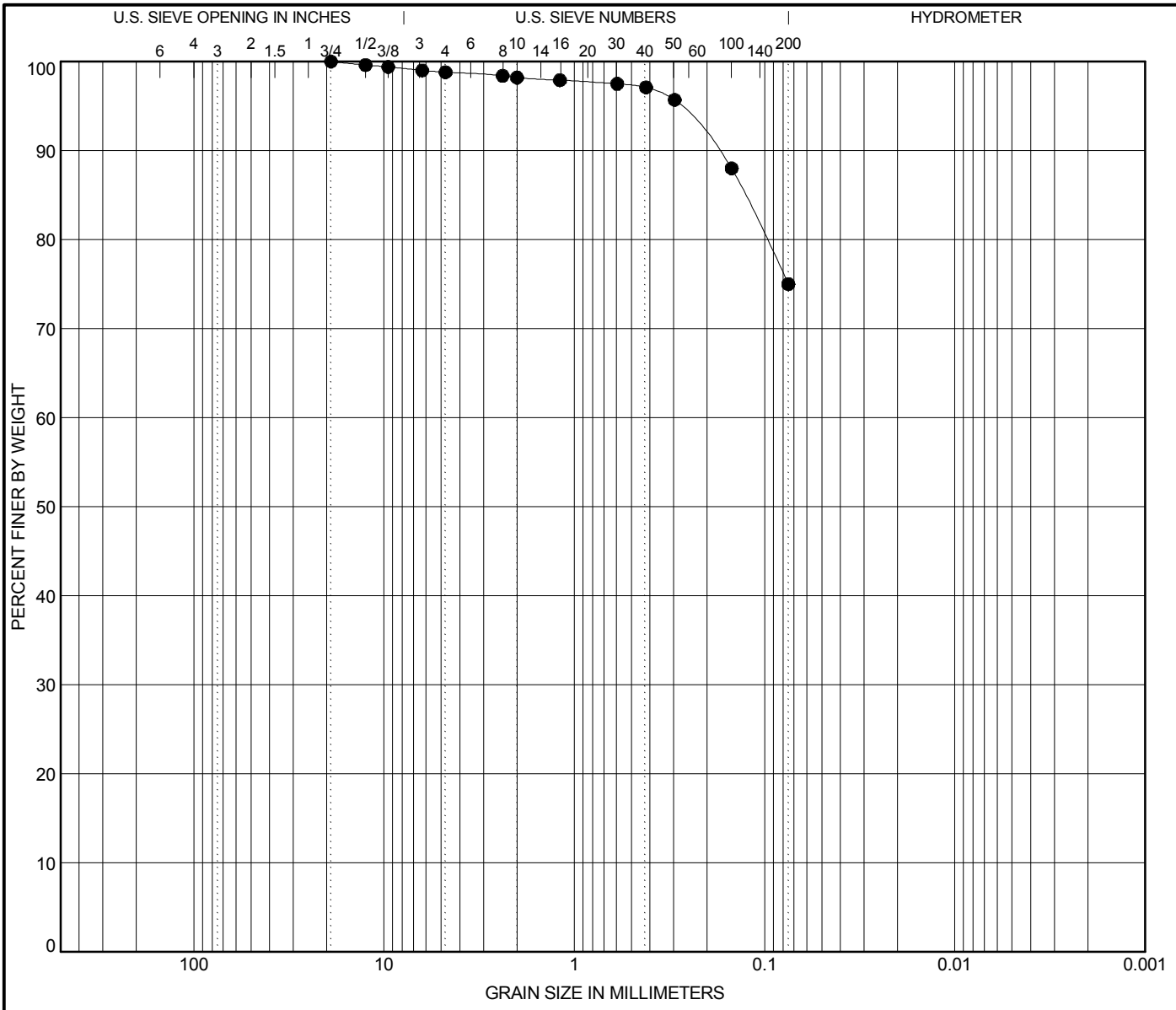
Location: RP-7.5

Number: STPS 263 - 1(28)6

Figure No. 2B-8

MULLAN RD.GPJ ` 10-4-17 ` ` TT_US GRAIN SIZE (SIEVE DATA)

Revised 1-23-08 (MAT)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

SIEVE SIZE	% PASSING
3/4 in	100
1/2 in	99.6
3/8 in	99.4
1/4 in	99
No. 4	98.8
No. 8	98.4
No. 10	98.2
No. 16	97.9
No. 30	97.5
No. 40	97.1
No. 50	95.7
No. 100	88
No. 200	75

Specimen Identification
SS-14 - (3 - 9 ft)

Classification	LL	PL	PI	Cc	Cu
LEAN CLAY with SAND(CL)					
AASHTO : A-4(4)	**28**	**20**	**8**		

% Gravel	% Sand	% Silt	% Clay
1	24	75	

D100	D60	D30	D10
19			

GRAIN SIZE DISTRIBUTION

TETRA TECH

Project: West of Missoula - NW (Mullan Rd),

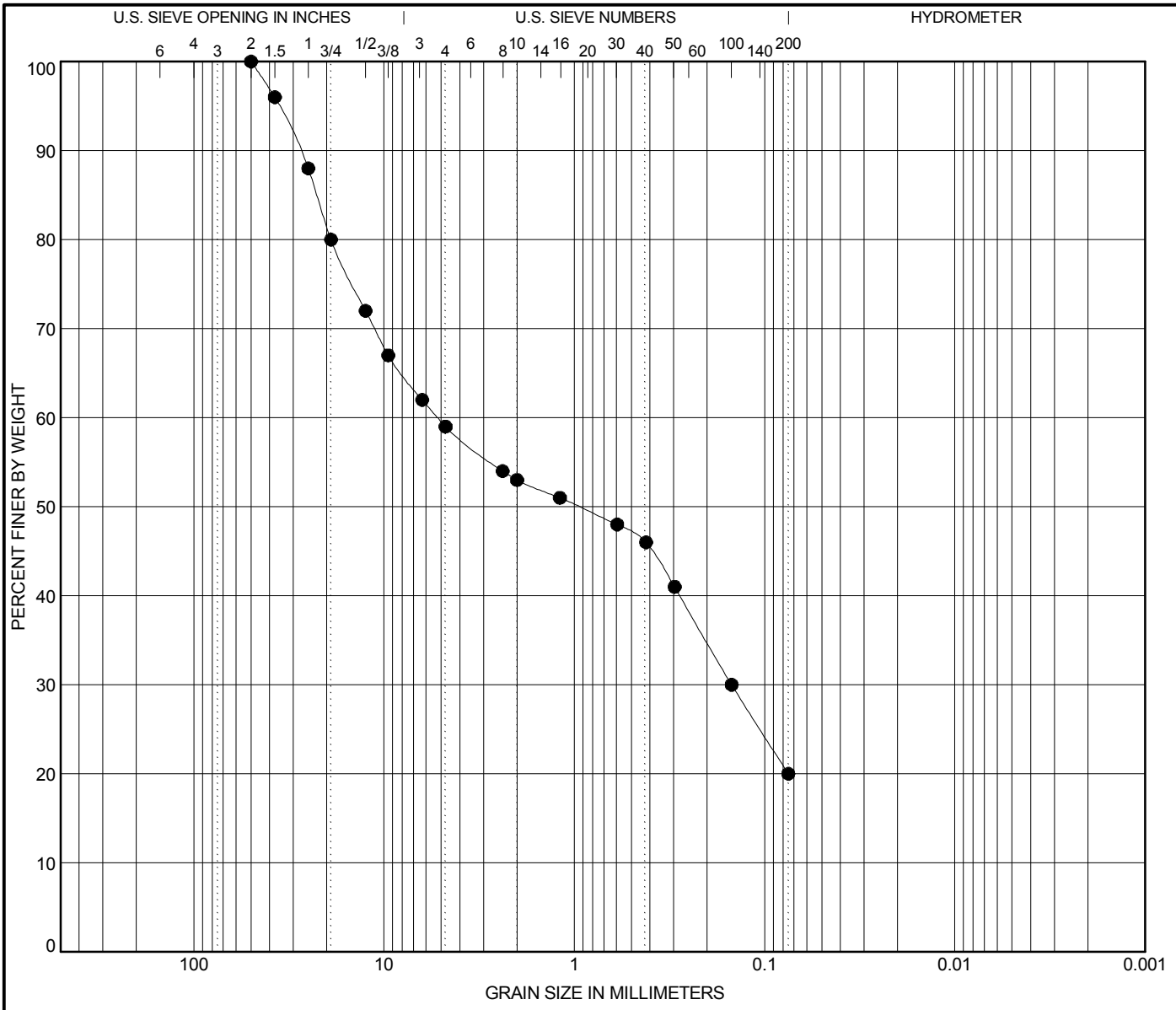
Location: RP-8.1

Number: STPS 263 - 1(28)6

Figure No. 2B-9

MULLAN RD.GPJ ` 10-4-17 ` ` TT_US GRAIN SIZE (SIEVE DATA)

Revised 1-23-08 (MAT)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

SIEVE SIZE	% PASSING
2 in	100
1.5 in	96
1 in	88
3/4 in	80
1/2 in	72
3/8 in	67
1/4 in	62
No. 4	59
No. 8	54
No. 10	53
No. 16	51
No. 30	48
No. 40	46
No. 50	41
No. 100	30
No. 200	20

Specimen Identification
SS-15 - (0.8 - 2 ft)

Classification	LL	PL	PI	Cc	Cu
SILTY GRAVEL with SAND(GM)					
AASHTO : A-1-b(0)	**17**	**15**	**2**		

% Gravel	% Sand	% Silt	% Clay
41	39	20	

D100	D60	D30	D10
50	5.219	0.149	

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: West of Missoula - NW (Mullan Rd),

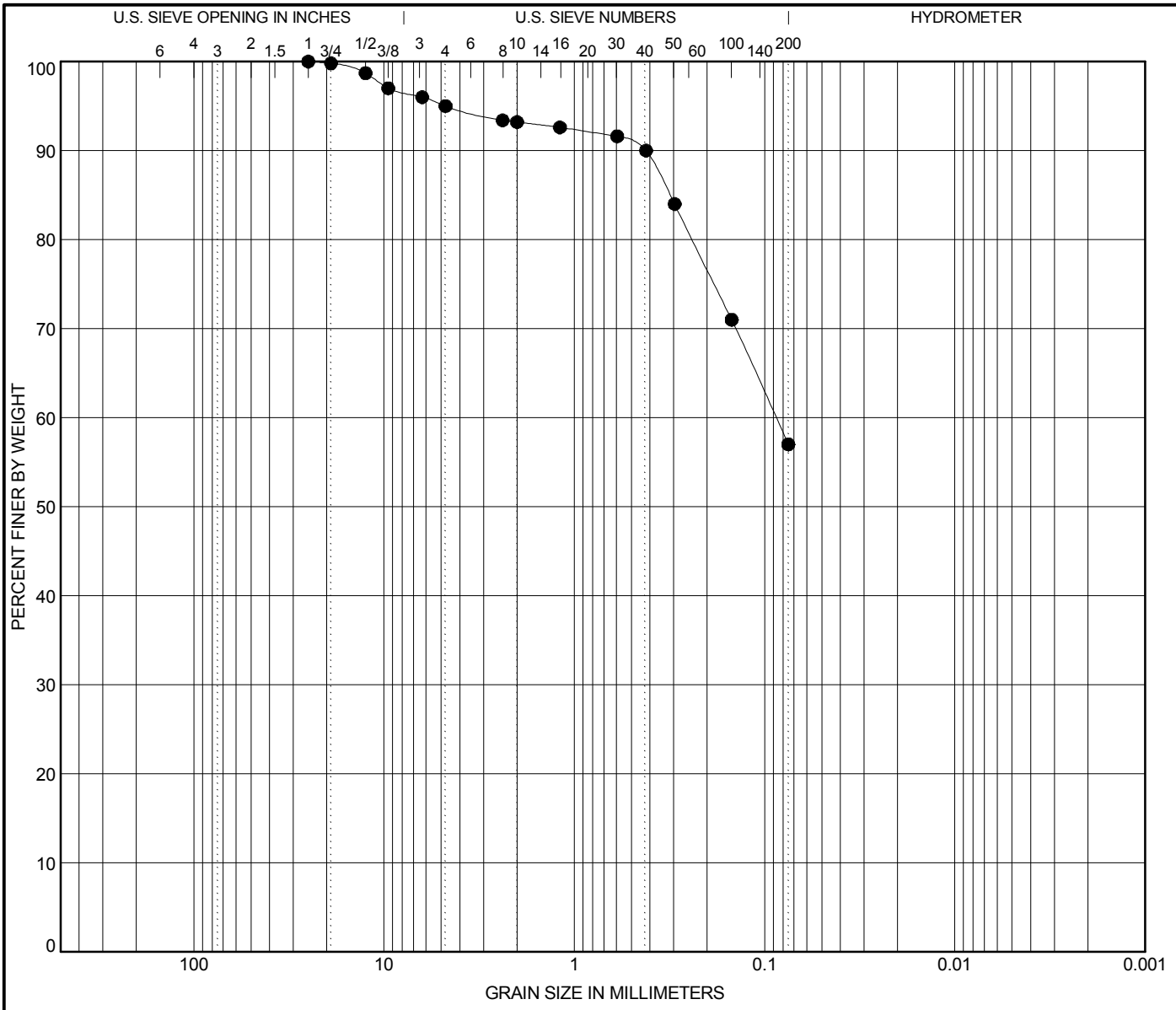
Location: RP-8.3

Number: STPS 263 - 1(28)6

Figure No. 2B-10

MULLAN RD.GPJ ` 10-4-17 ` ` TT_US GRAIN SIZE (SIEVE DATA)

Revised 1-23-08 (MAT)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

SIEVE SIZE	% PASSING
1 in	100
3/4 in	99.8
1/2 in	98.7
3/8 in	97
1/4 in	96
No. 4	95
No. 8	93.4
No. 10	93.2
No. 16	92.6
No. 30	91.6
No. 40	90
No. 50	84
No. 100	71
No. 200	57

Specimen Identification
SS-16 - (3 - 9 ft)

Classification	LL	PL	PI	Cc	Cu
SANDY LEAN CLAY(CL)					
AASHTO : A-6(4)	**29**	**16**	**13**		

% Gravel	% Sand	% Silt	% Clay
5	38	57	

D100	D60	D30	D10
25	0.087		

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: West of Missoula - NW (Mullan Rd),

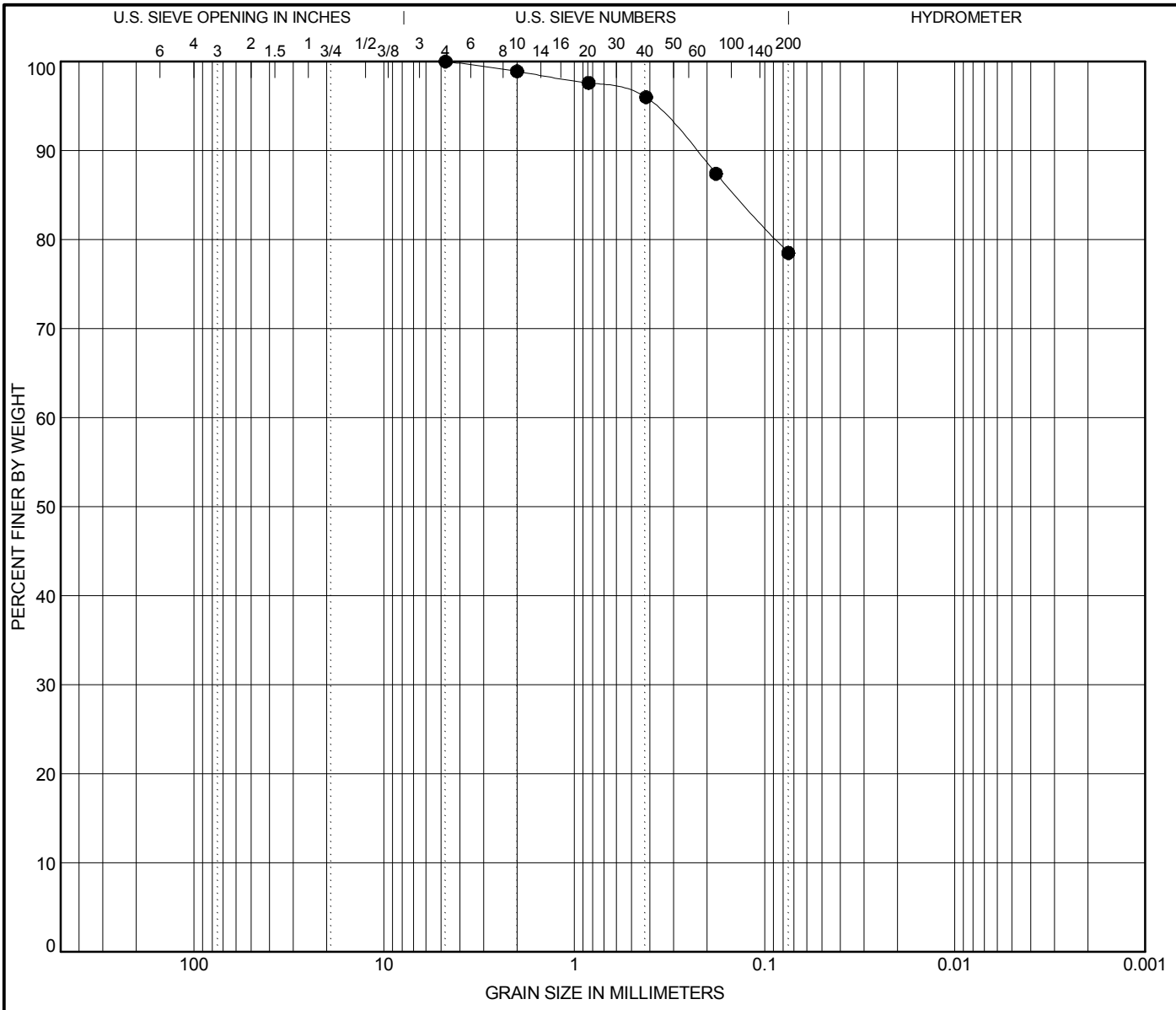
Location: RP-8.5

Number: STPS 263 - 1(28)6

Figure No. 2B-11

MULLAN RD.GPJ ` 10-4-17 ` ` TT_US GRAIN SIZE (SIEVE DATA)

Revised 1-23-08 (MAT)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

SIEVE SIZE	% PASSING
No. 4	100
No. 10	98.9
No. 20	97.6
No. 40	96
No. 80	87.4
No. 200	78.5

Specimen Identification
SS-16 - (9 - 10 ft)

Classification	LL	PL	PI	Cc	Cu
LEAN CLAY with SAND(CL)					
AASHTO : A-7-6(17)	**41**	**18**	**23**		

% Gravel	% Sand	% Silt	% Clay
0	22	79	

D100	D60	D30	D10
4.75			

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: West of Missoula - NW (Mullan Rd),

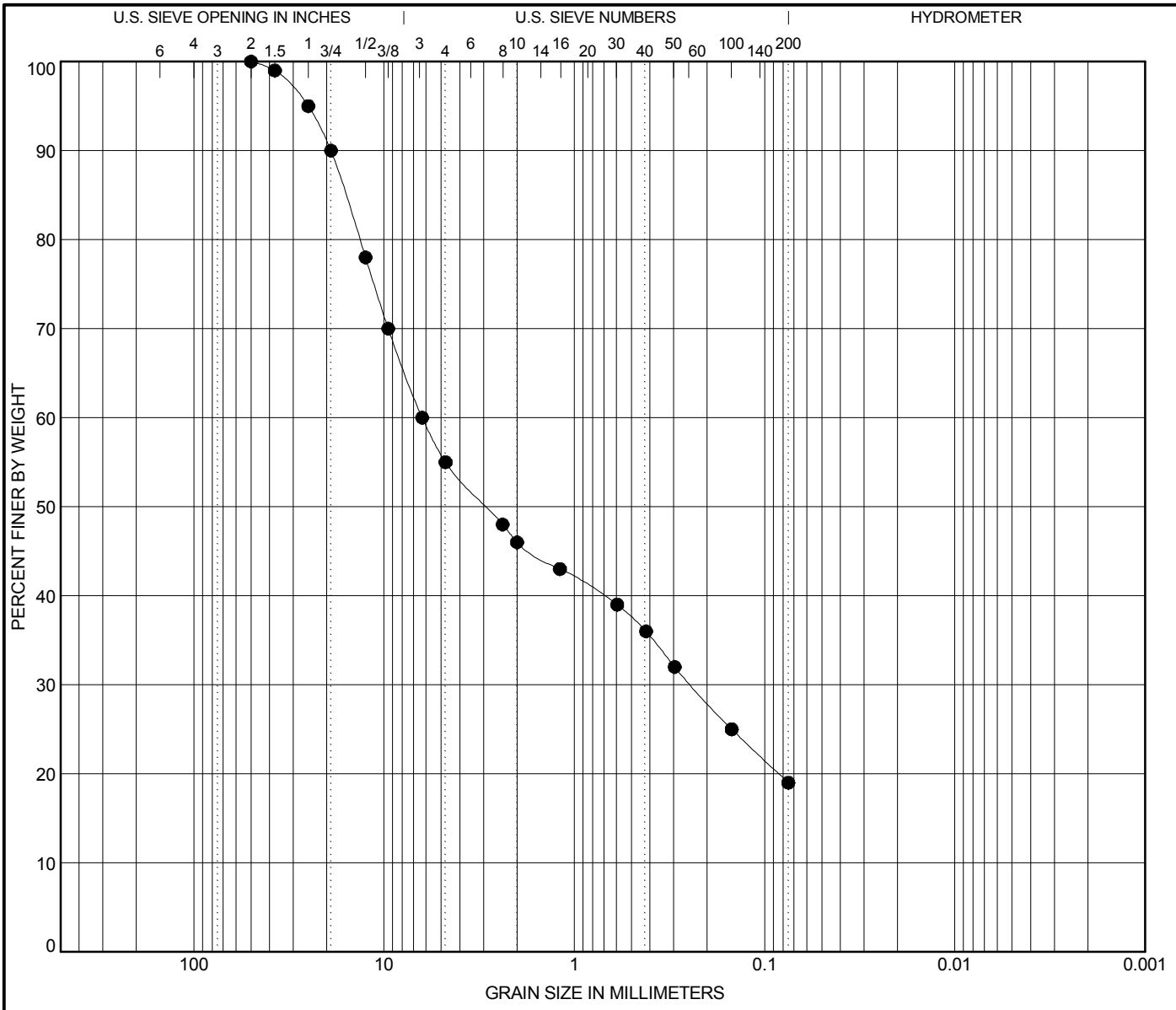
Location: RP-8.5

Number: STPS 263 - 1(28)6

Figure No. 2B-12

MULLAN RD.GPJ ` 10-4-17 ` ` TT_US GRAIN SIZE (SIEVE DATA)

Revised 1-23-08 (MAT)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

SIEVE SIZE	% PASSING
2 in	100
1.5 in	99
1 in	95
3/4 in	90
1/2 in	78
3/8 in	70
1/4 in	60
No. 4	55
No. 8	48
No. 10	46
No. 16	43
No. 30	39
No. 40	36
No. 50	32
No. 100	25
No. 200	19

Specimen Identification
SS-17 - (1.2 - 5 ft)

Classification	LL	PL	PI	Cc	Cu
SILTY GRAVEL with SAND(GM)					
AASHTO : A-1-b(0)	**18**	**15**	**3**		

% Gravel	% Sand	% Silt	% Clay
45	36	19	

D100	D60	D30	D10
50	6.3	0.244	

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: West of Missoula - NW (Mullan Rd),

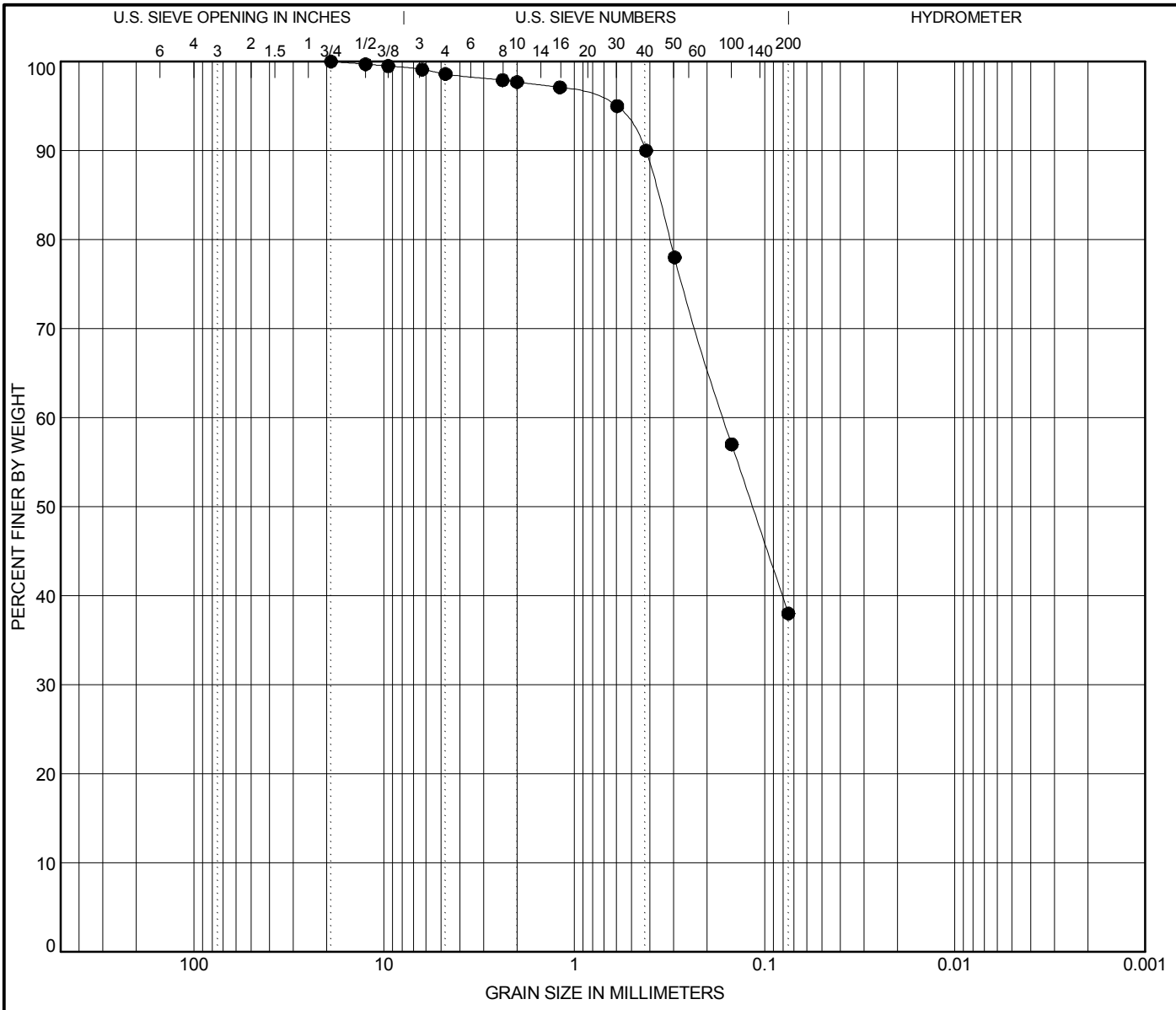
Location: RP-8.7

Number: STPS 263 - 1(28)6

Figure No. 2B-13

MULLAN RD.GPJ ` 10-4-17 ` ` TT_US GRAIN SIZE (SIEVE DATA)

Revised 1-23-08 (MAT)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

SIEVE SIZE	% PASSING
3/4 in	100
1/2 in	99.7
3/8 in	99.5
1/4 in	99.1
No. 4	98.6
No. 8	97.9
No. 10	97.7
No. 16	97.1
No. 30	95
No. 40	90
No. 50	78
No. 100	57
No. 200	38

Specimen Identification
SS-18 - (1.3 - 4.5 ft)

Classification	LL	PL	PI	Cc	Cu
SILTY SAND(SM)					
AASHTO : A-4(0)	**18**	**16**	**2**		

% Gravel	% Sand	% Silt	% Clay
1	61	38	

D100	D60	D30	D10
19	0.164		

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: West of Missoula - NW (Mullan Rd),

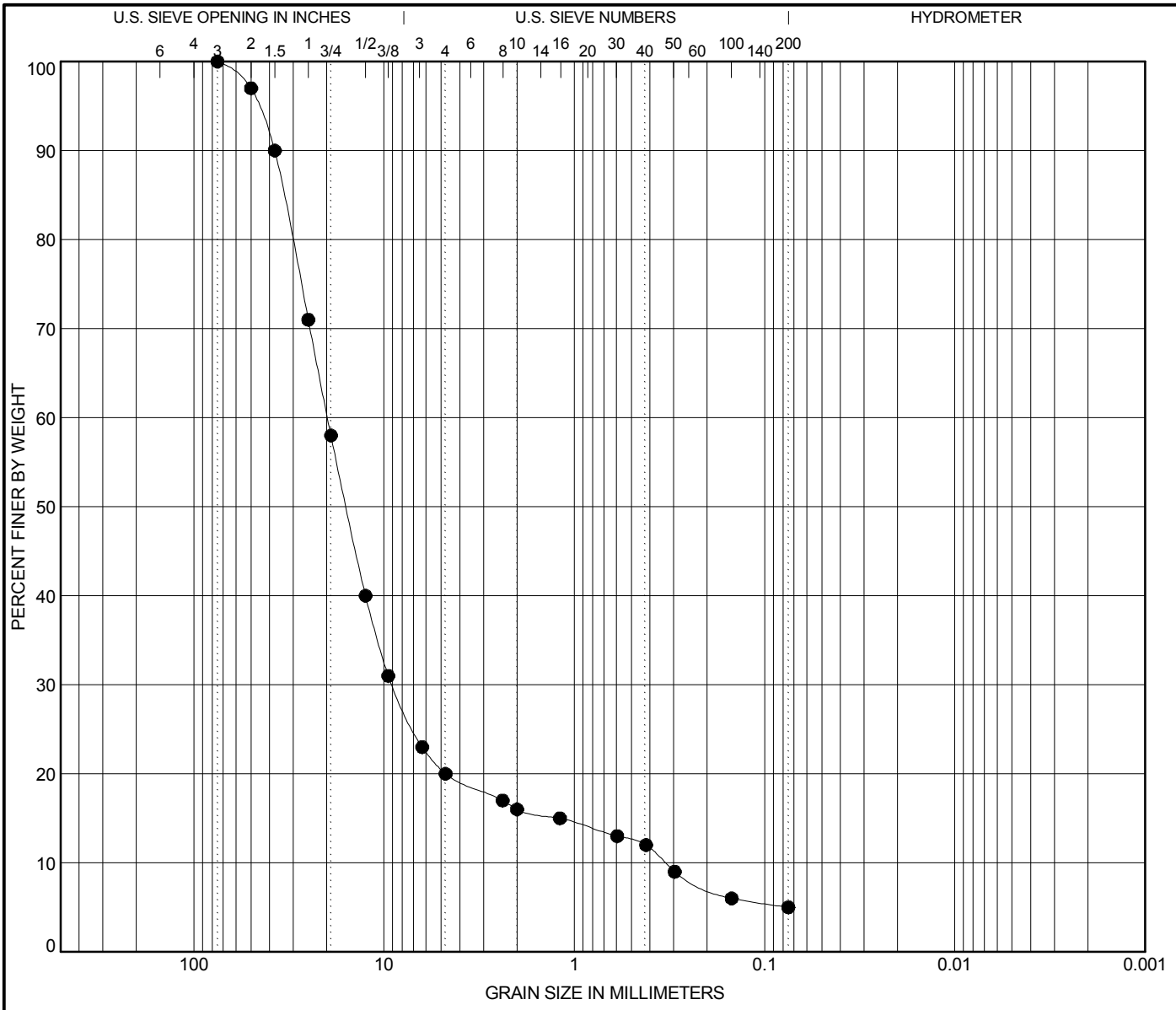
Location: RP-8.9

Number: STPS 263 - 1(28)6

Figure No. 2B-14

MULLAN RD.GPJ ` 10-4-17 ` ` TT_US GRAIN SIZE (SIEVE DATA)

Revised 1-23-08 (MAT)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

SIEVE SIZE	% PASSING
3 in	100
2 in	97
1.5 in	90
1 in	71
3/4 in	58
1/2 in	40
3/8 in	31
1/4 in	23
No. 4	20
No. 8	17
No. 10	16
No. 16	15
No. 30	13
No. 40	12
No. 50	9
No. 100	6
No. 200	5

Specimen Identification
SS-21 - (5 - 10 ft)

Classification	LL	PL	PI	Cc	Cu
POORLY GRADED GRAVEL with SILT and SAND(GP-GM)	**16**	**15**	**1**	**12.33**	**59.45**
AASHTO : A-1-a(0)					

% Gravel	% Sand	% Silt	% Clay
80	15	5	

D100	D60	D30	D10
75	19.819	9.025	0.333

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: West of Missoula - NW (Mullan Rd),

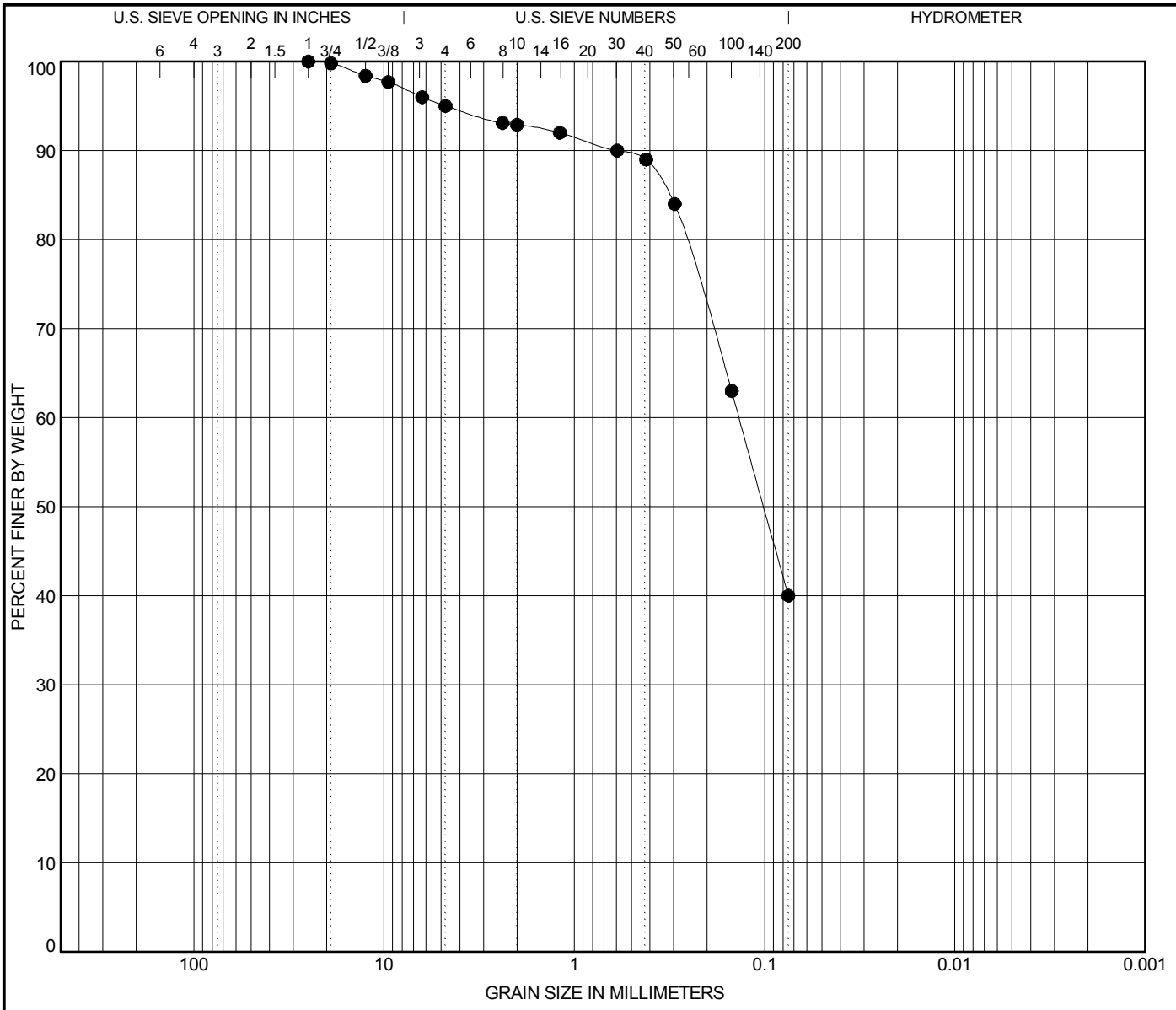
Location: RP-9.5

Number: STPS 263 - 1(28)6

Figure No. 2B-15

MULLAN RD.GPJ ` 10-4-17 ` ` TT_US GRAIN SIZE (SIEVE DATA)

Revised 1-23-08 (MAT)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

SIEVE SIZE	% PASSING
1 in	100
3/4 in	99.8
1/2 in	98.4
3/8 in	97.7
1/4 in	96
No. 4	95
No. 8	93.1
No. 10	92.9
No. 16	92
No. 30	90
No. 40	89
No. 50	84
No. 100	63
No. 200	40

Specimen Identification
SS-22 - (1.1 - 4 ft)

Classification	LL	PL	PI	Cc	Cu
SILTY SAND(SM)					
AASHTO : A-4(0)	**18**	**16**	**2**		

% Gravel	% Sand	% Silt	% Clay
5	55	40	

D100	D60	D30	D10
25	0.136		

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: West of Missoula - NW (Mullan Rd),

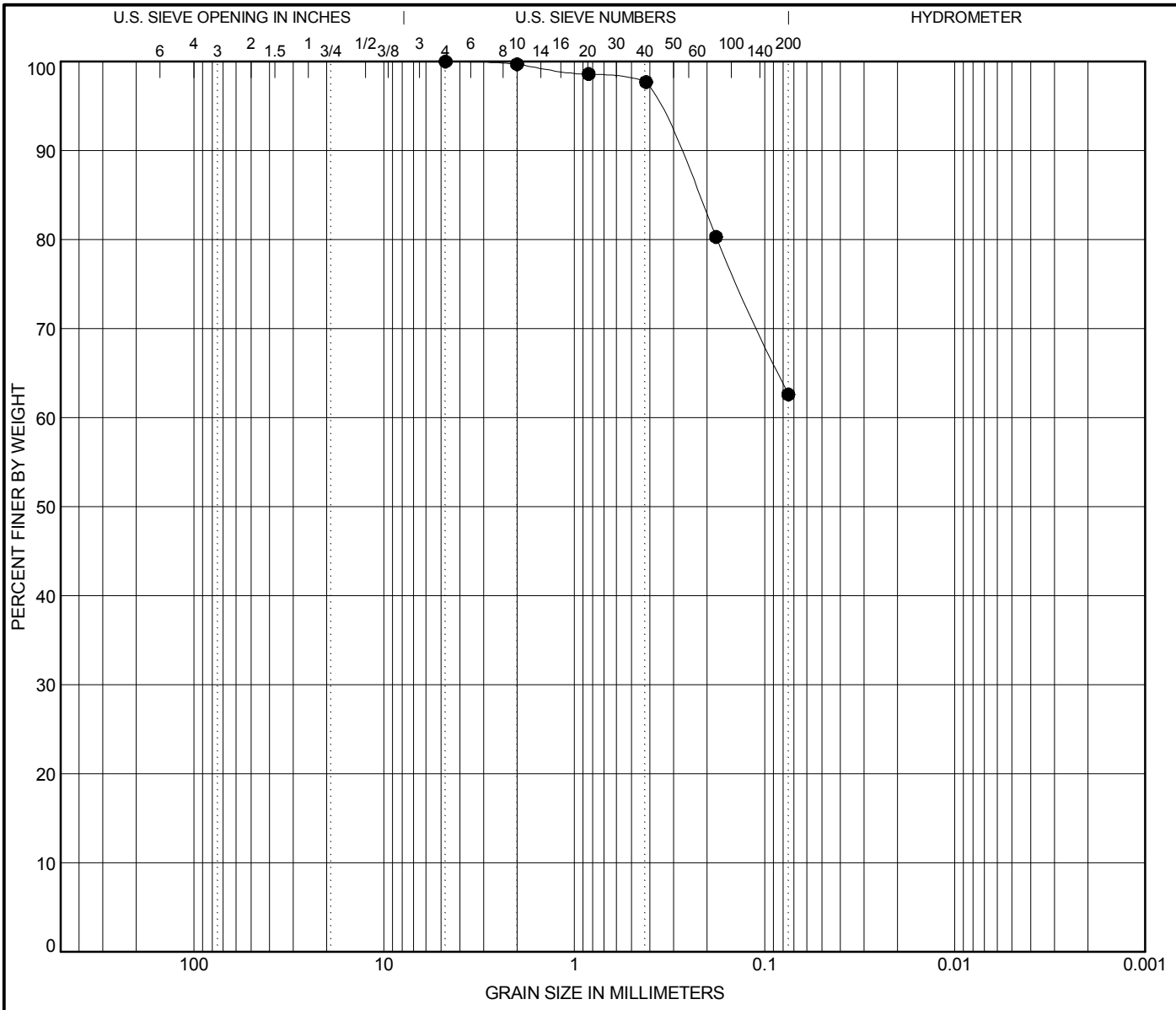
Location: RP-9.7

Number: STPS 263 - 1(28)6

Figure No. 2B-16

MULLAN RD.GPJ ` 10-4-17 ` ` TT_US GRAIN SIZE (SIEVE DATA)

Revised 1-23-08 (MAT)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

SIEVE SIZE	% PASSING
No. 4	100
No. 10	99.7
No. 20	98.6
No. 40	97.7
No. 80	80.3
No. 200	62.6

Specimen Identification
SS-22 - (6 - 8 ft)

Classification	LL	PL	PI	Cc	Cu
SANDY LEAN CLAY(CL)					
AASHTO : A-6(7)	**33**	**18**	**15**		

% Gravel	% Sand	% Silt	% Clay
0	37	63	

D100	D60	D30	D10
4.75			

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: West of Missoula - NW (Mullan Rd),

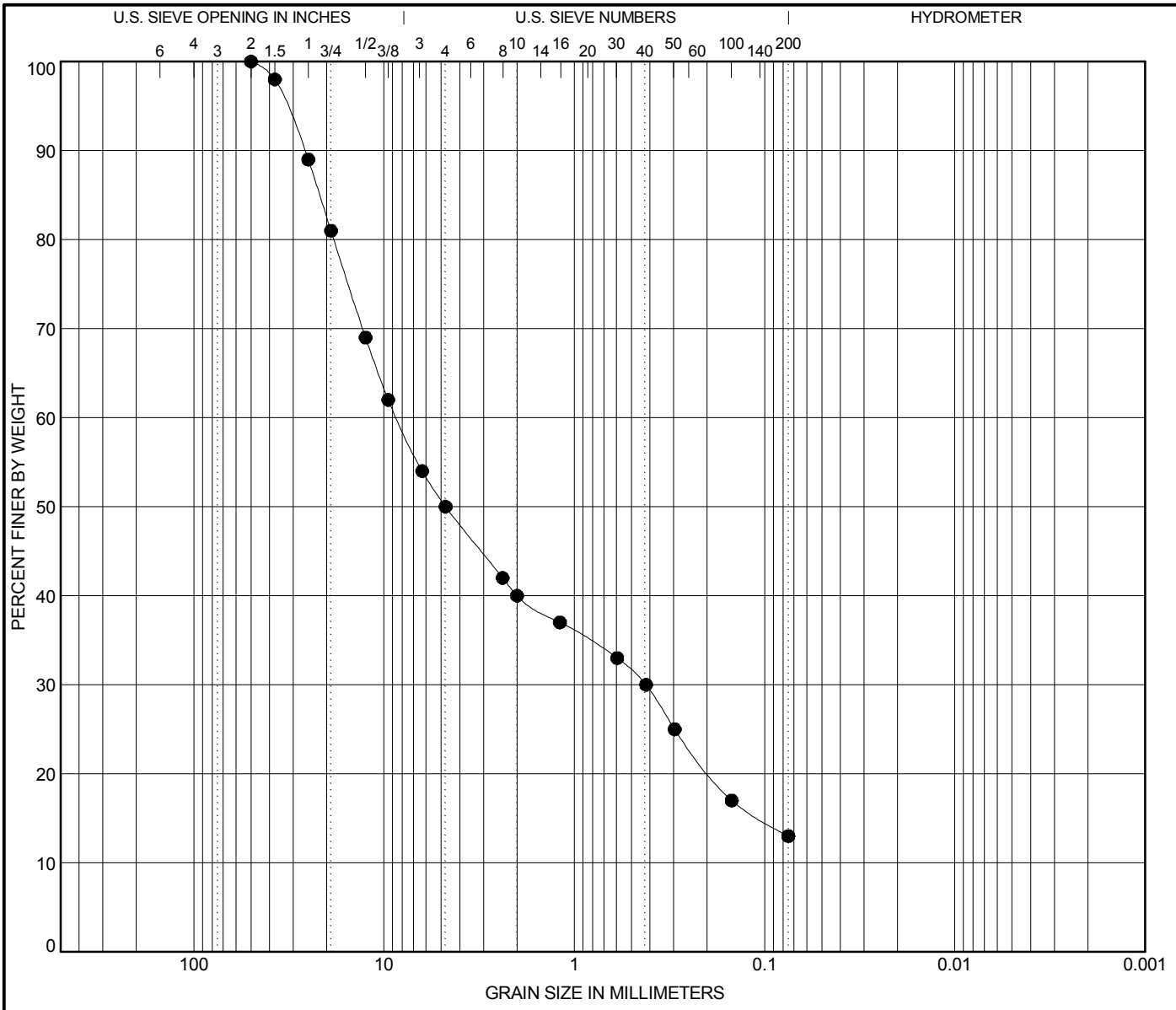
Location: RP-9.7

Number: STPS 263 - 1(28)6

Figure No. 2B-17

MULLAN RD.GPJ ` 10-4-17 ` ` TT_US GRAIN SIZE (SIEVE DATA)

Revised 1-23-08 (MAT)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

SIEVE SIZE	% PASSING
2 in	100
1.5 in	98
1 in	89
3/4 in	81
1/2 in	69
3/8 in	62
1/4 in	54
No. 4	50
No. 8	42
No. 10	40
No. 16	37
No. 30	33
No. 40	30
No. 50	25
No. 100	17
No. 200	13

Specimen Identification
SS-24 - (0.75 - 1.5 ft)

Classification	LL	PL	PI	Cc	Cu
SILTY GRAVEL with SAND(GM)					
AASHTO : A-1-a(0)	**17**	**15**	**2**		

% Gravel	% Sand	% Silt	% Clay
50	37	13	

D100	D60	D30	D10
50	8.573	0.42	

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: West of Missoula - NW (Mullan Rd),

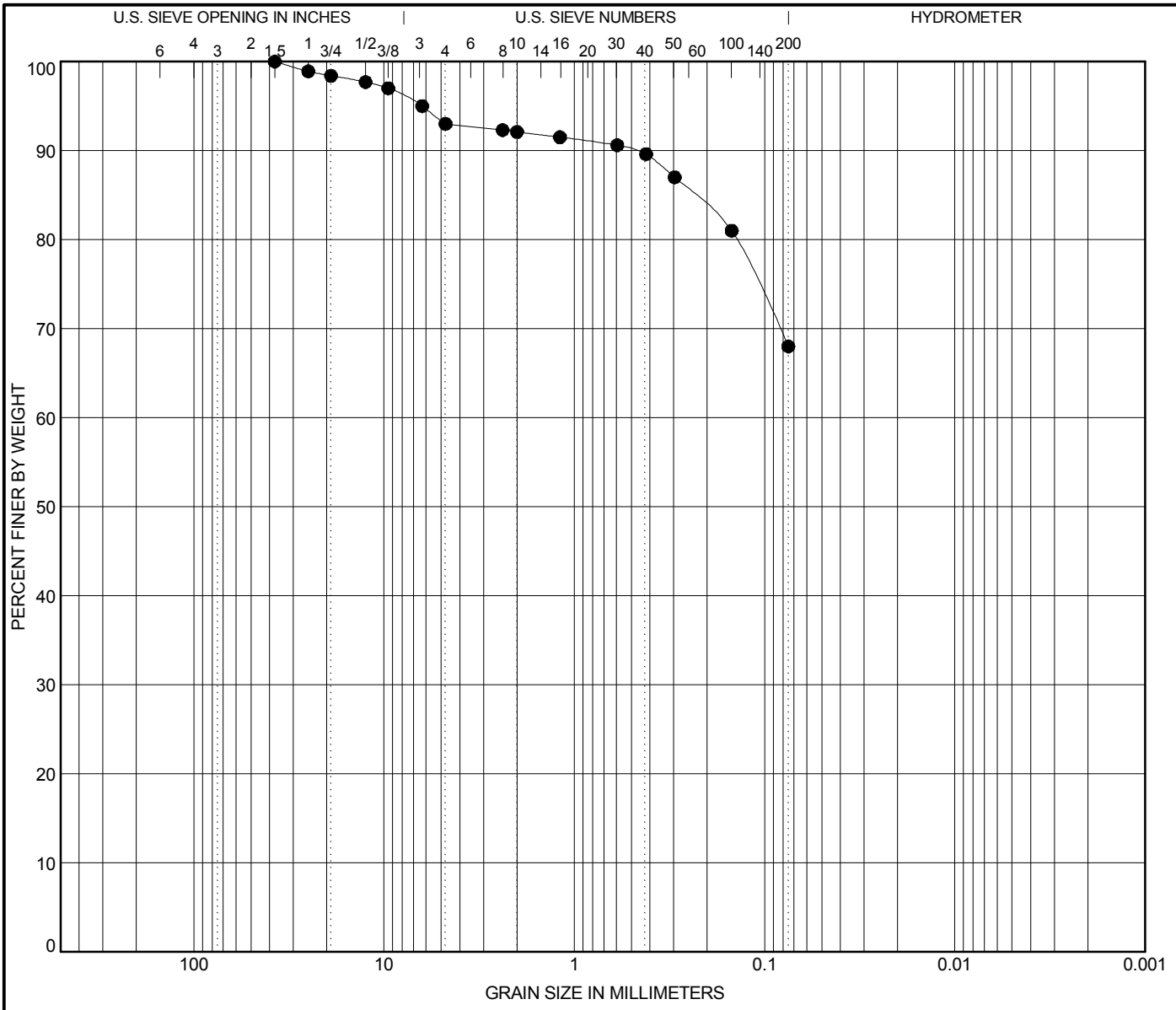
Location: RP-10.1

Number: STPS 263 - 1(28)6

Figure No. 2B-18

MULLAN RD.GPJ ` 10-4-17 ` ` TT_US GRAIN SIZE (SIEVE DATA)

Revised 1-23-08 (MAT)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

SIEVE SIZE	% PASSING
1.5 in	100
1 in	98.9
3/4 in	98.4
1/2 in	97.7
3/8 in	97
1/4 in	95
No. 4	93
No. 8	92.3
No. 10	92.1
No. 16	91.5
No. 30	90.6
No. 40	89.6
No. 50	87
No. 100	81
No. 200	68

Specimen Identification
SS-24 - (2 - 5 ft)

Classification	LL	PL	PI	Cc	Cu
SANDY LEAN CLAY(CL)					
AASHTO : A-6(8)	**34**	**20**	**14**		

% Gravel	% Sand	% Silt	% Clay
7	25	68	

D100	D60	D30	D10
37.5			

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: West of Missoula - NW (Mullan Rd),

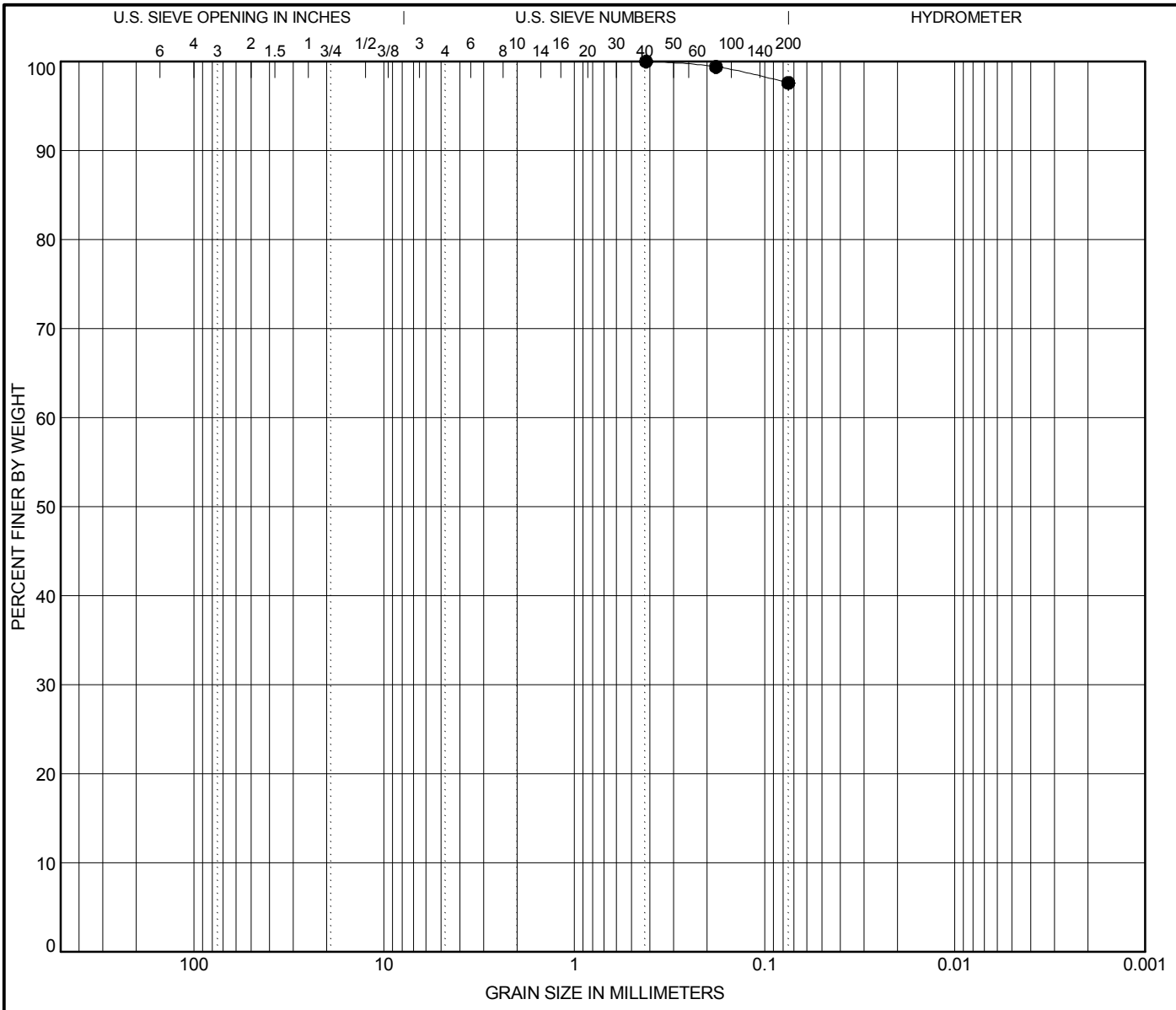
Location: RP-10.1

Number: STPS 263 - 1(28)6

Figure No. 2B-19

MULLAN RD.GPJ ` 10-4-17 ` ` TT_US GRAIN SIZE (SIEVE DATA)

Revised 1-23-08 (MAT)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

SIEVE SIZE	% PASSING
No. 40	100
No. 80	99.4
No. 200	97.6

Specimen Identification
SS-24 - (6 - 8 ft)

Classification	LL	PL	PI	Cc	Cu
FAT CLAY(CH)					
AASHTO : A-7-6(44)	**63**	**24**	**39**		

% Gravel	% Sand	% Silt	% Clay
0	2	98	

D100	D60	D30	D10
0.42			

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: West of Missoula - NW (Mullan Rd),

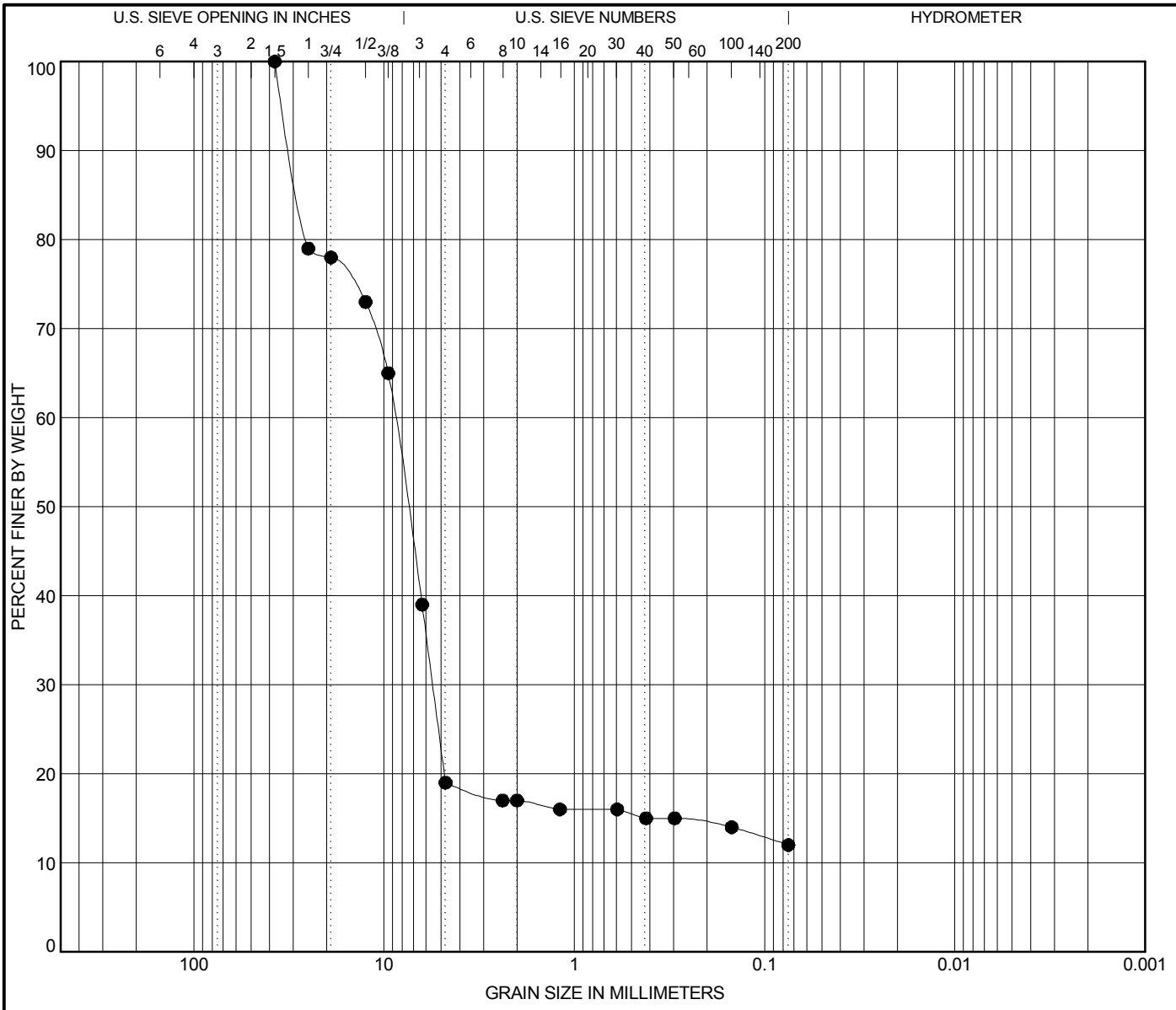
Location: RP-10.1

Number: STPS 263 - 1(28)6

Figure No. 2B-20

MULLAN RD.GPJ ` 10-4-17 ` ` TT_US GRAIN SIZE (SIEVE DATA)

Revised 1-23-08 (MAT)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

SIEVE SIZE	% PASSING
1.5 in	100
1 in	79
3/4 in	78
1/2 in	73
3/8 in	65
1/4 in	39
No. 4	19
No. 8	17
No. 10	17
No. 16	16
No. 30	16
No. 40	15
No. 50	15
No. 100	14
No. 200	12

Specimen Identification
SS-26 - (1.5 - 4 ft)

Classification	LL	PL	PI	Cc	Cu
POORLY GRADED GRAVEL with CLAY(GP-GC)	**30**	**17**	**13**	**92.88**	**232.53**
AASHTO : A-2-6(0)					

% Gravel	% Sand	% Silt	% Clay
81	7	12	

D100	D60	D30	D10
37.5	8.778	5.548	

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: West of Missoula - NW (Mullan Rd),

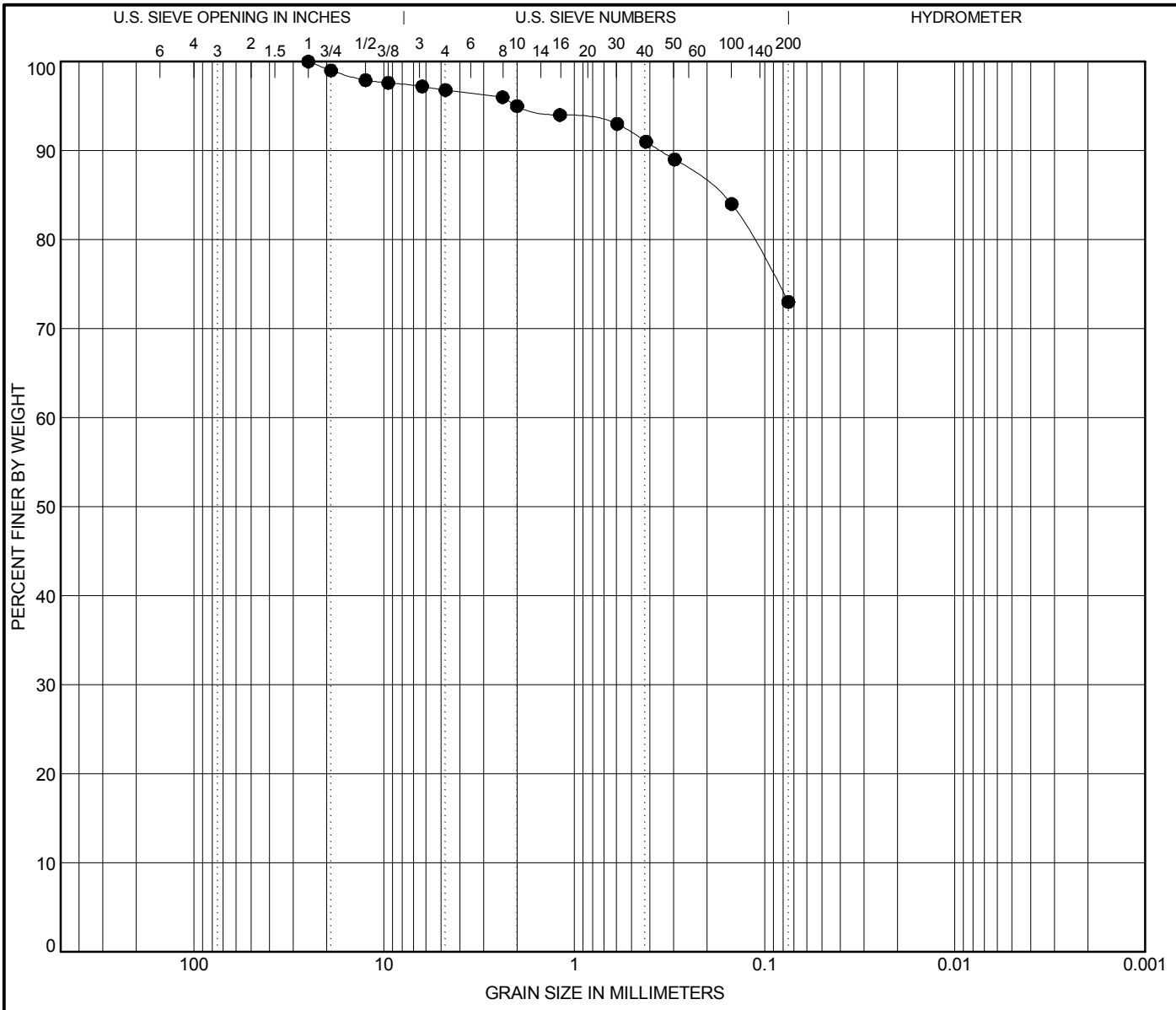
Location: RP-10.5

Number: STPS 263 - 1(28)6

Figure No. 2B-21

MULLAN RD.GPJ ` 10-4-17 ` ` TT_US GRAIN SIZE (SIEVE DATA)

Revised 1-23-08 (MAT)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

SIEVE SIZE	% PASSING
1 in	100
3/4 in	99
1/2 in	97.9
3/8 in	97.6
1/4 in	97.2
No. 4	96.8
No. 8	96
No. 10	95
No. 16	94
No. 30	93
No. 40	91
No. 50	89
No. 100	84
No. 200	73

Specimen Identification
SS-26 - (4.1 - 6 ft)

Classification	LL	PL	PI	Cc	Cu
LEAN CLAY with SAND(CL)					
AASHTO : A-7-6(19)	**46**	**19**	**27**		

% Gravel	% Sand	% Silt	% Clay
3	24	73	

D100	D60	D30	D10
25			

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: West of Missoula - NW (Mullan Rd),

Location: RP-10.5

Number: STPS 263 - 1(28)6

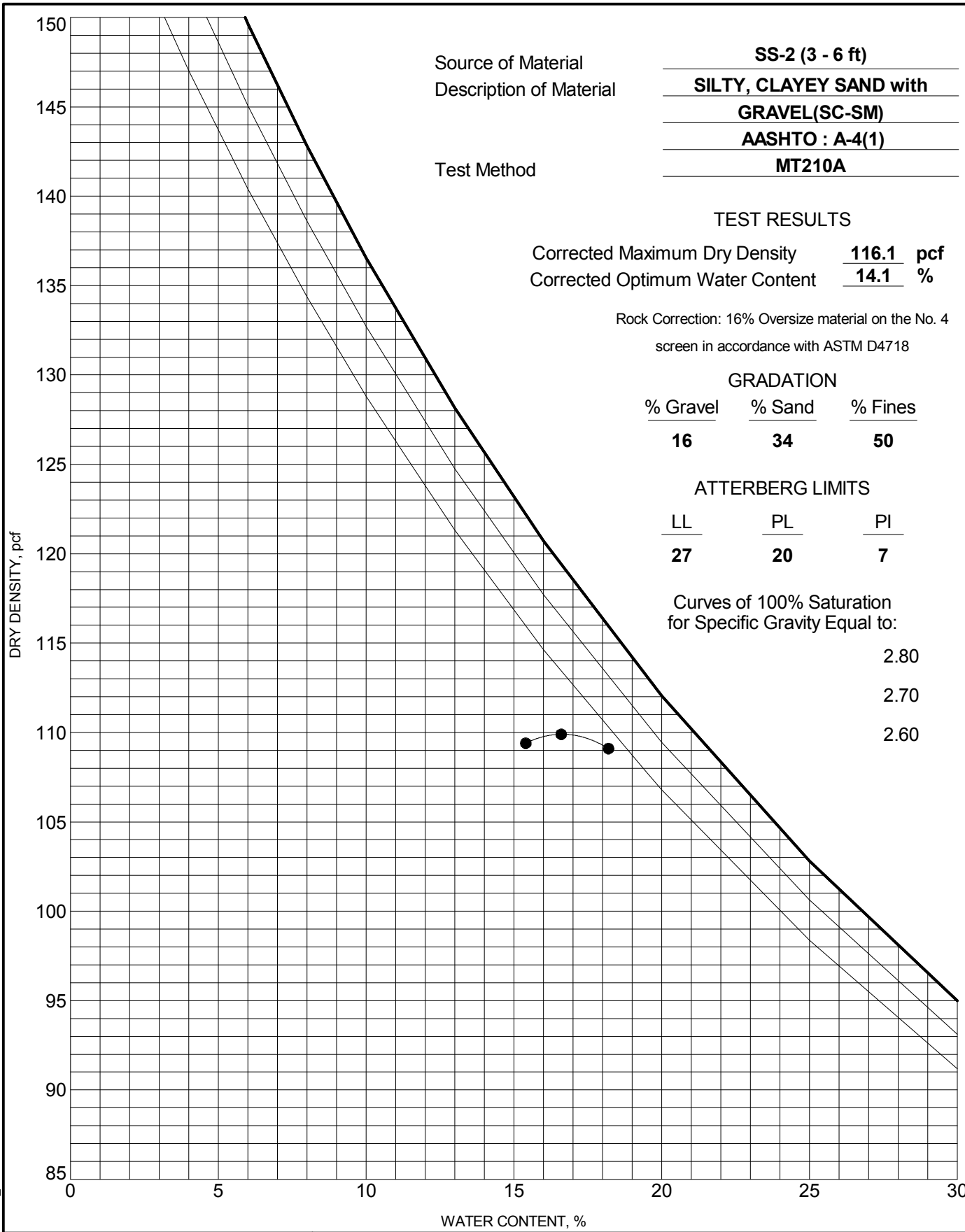
Figure No. 2B-22

MULLAN RD.GPJ ` 10-4-17 ` ` TT_US GRAIN SIZE (SIEVE DATA)

Revised 1-23-08 (MAT)

APPENDIX 2C

Proctors (Figures 2C-1 through 2C-10)



Source of Material	**SS-2 (3 - 6 ft)**
Description of Material	**SILTY, CLAYEY SAND with GRAVEL(SC-SM)**
	AASHTO : A-4(1)
Test Method	**MT210A**

TEST RESULTS

Corrected Maximum Dry Density	**116.1**	**pcf**
Corrected Optimum Water Content	**14.1**	**%**

Rock Correction: 16% Oversize material on the No. 4 screen in accordance with ASTM D4718

GRADATION

% Gravel	% Sand	% Fines
16	**34**	**50**

ATTERBERG LIMITS

LL	PL	PI
27	**20**	**7**

Curves of 100% Saturation for Specific Gravity Equal to:

2.80

2.70

2.60

TETRA TECH

MOISTURE-DENSITY RELATIONSHIP

Project: West of Missoula - NW (Mullan Rd)

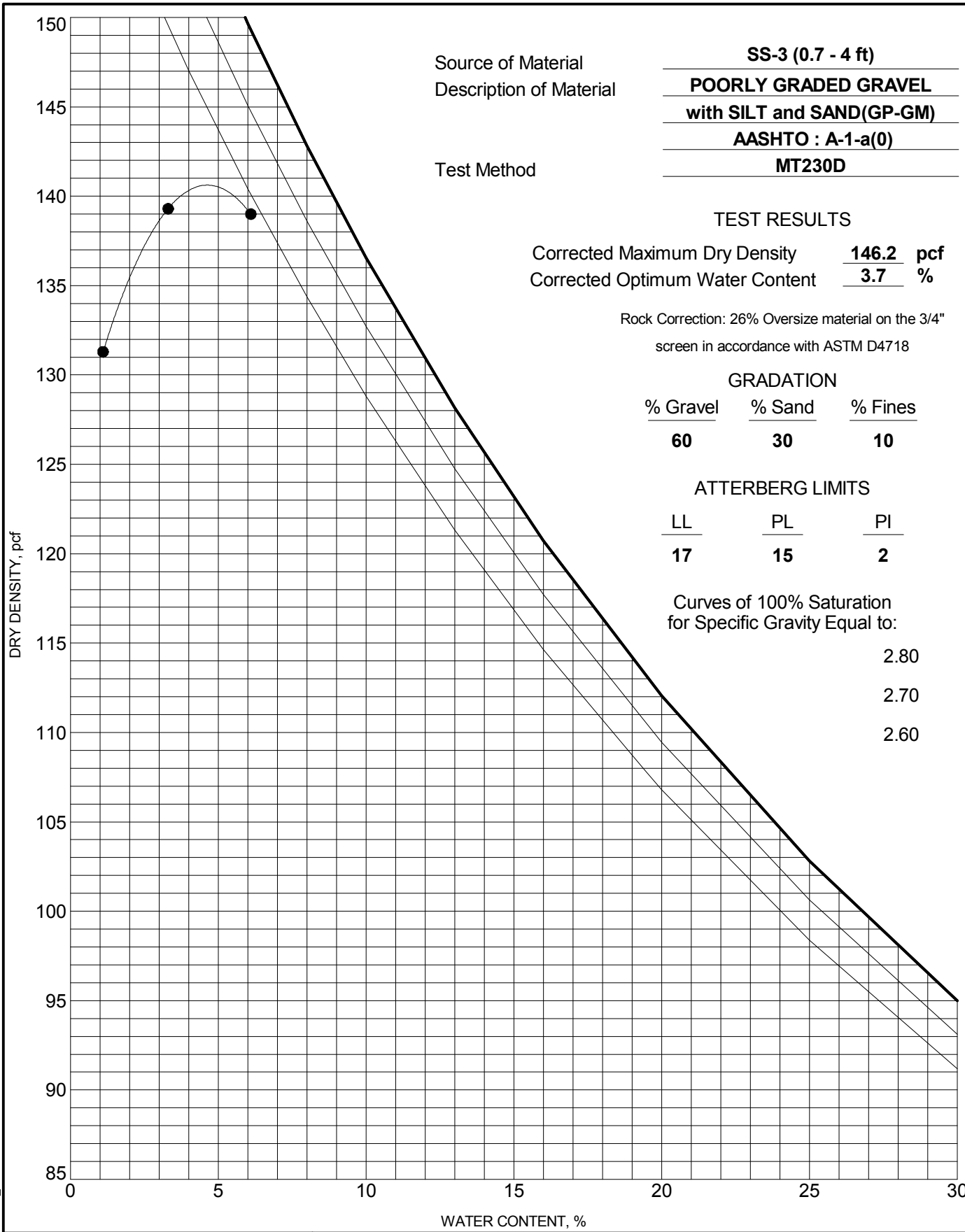
Location: RP-5.7

Number: STPS 263 - 1(28)6

Figure No. 2C-1

MULLAN RD.GPJ ` 10-4-17 ` ` TT_COMPACTION W/CURVE

Revised 1-23-08 (MAT)



Source of Material: **SS-3 (0.7 - 4 ft)**

Description of Material: **POORLY GRADED GRAVEL with SILT and SAND(GP-GM)**

AASHTO : A-1-a(0)

Test Method: **MT230D**

TEST RESULTS

Corrected Maximum Dry Density	**146.2**	**pcf**
Corrected Optimum Water Content	**3.7**	**%**

Rock Correction: 26% Oversize material on the 3/4" screen in accordance with ASTM D4718

GRADATION

% Gravel	% Sand	% Fines
60	**30**	**10**

ATTERBERG LIMITS

LL	PL	PI
17	**15**	**2**

Curves of 100% Saturation for Specific Gravity Equal to:

2.80

2.70

2.60

TETRA TECH

MOISTURE-DENSITY RELATIONSHIP

Project: West of Missoula - NW (Mullan Rd)

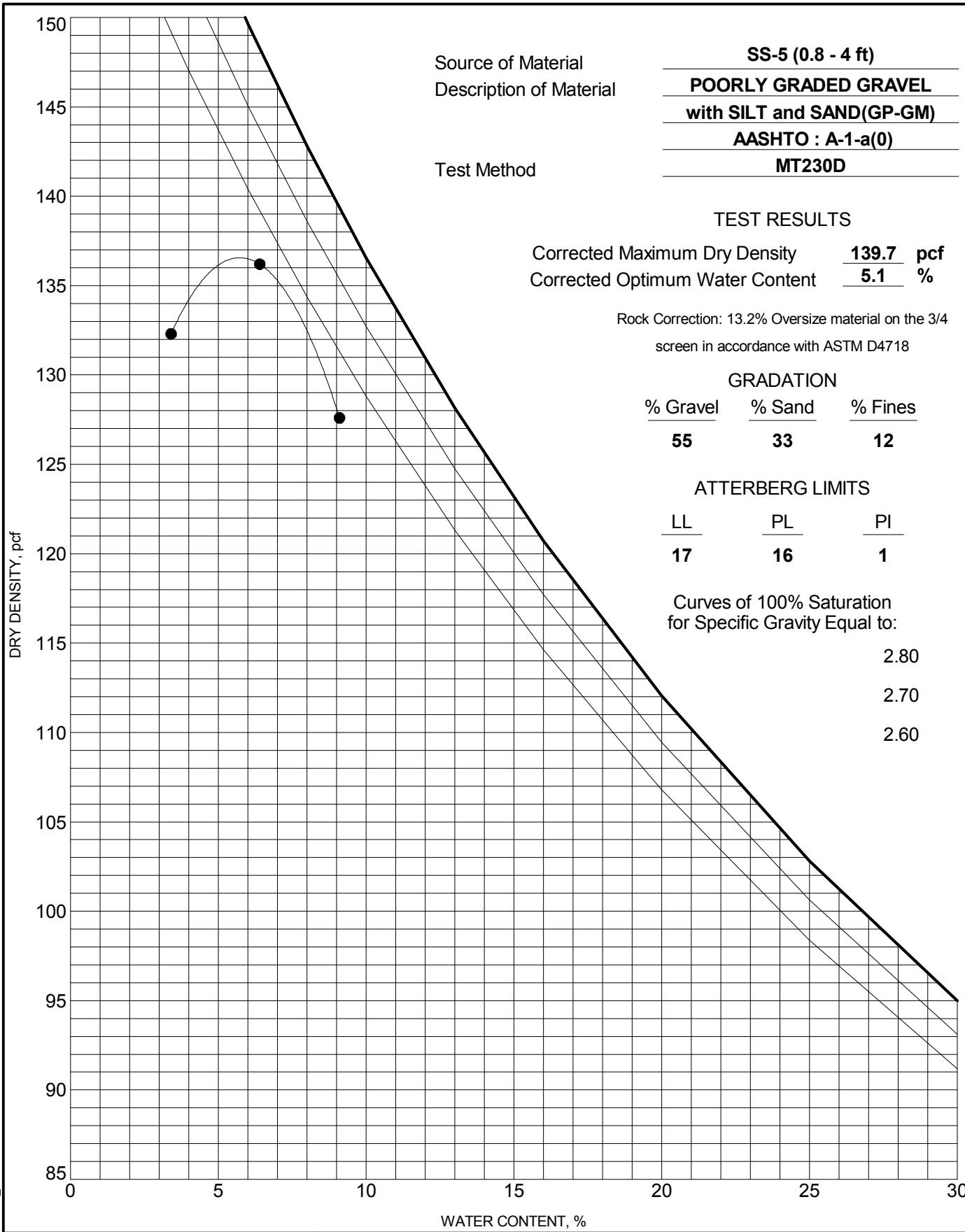
Location: RP-5.9

Number: STPS 263 - 1(28)6

Figure No. 2C-2

MULLAN RD.GPJ ` 10-4-17 ` ` TT_COMPACTION W/CURVE

Revised 1-23-08 (MAT)



Source of Material: **SS-5 (0.8 - 4 ft)**

Description of Material: **POORLY GRADED GRAVEL with SILT and SAND(GP-GM)**

AASHTO : A-1-a(0)

Test Method: **MT230D**

TEST RESULTS

Corrected Maximum Dry Density	**139.7**	**pcf**
Corrected Optimum Water Content	**5.1**	**%**

Rock Correction: 13.2% Oversize material on the 3/4 screen in accordance with ASTM D4718

GRADATION

% Gravel	% Sand	% Fines
55	**33**	**12**

ATTERBERG LIMITS

LL	PL	PI
17	**16**	**1**

Curves of 100% Saturation for Specific Gravity Equal to:

2.80

2.70

2.60

TETRA TECH

MOISTURE-DENSITY RELATIONSHIP

Project: West of Missoula - NW (Mullan Rd)

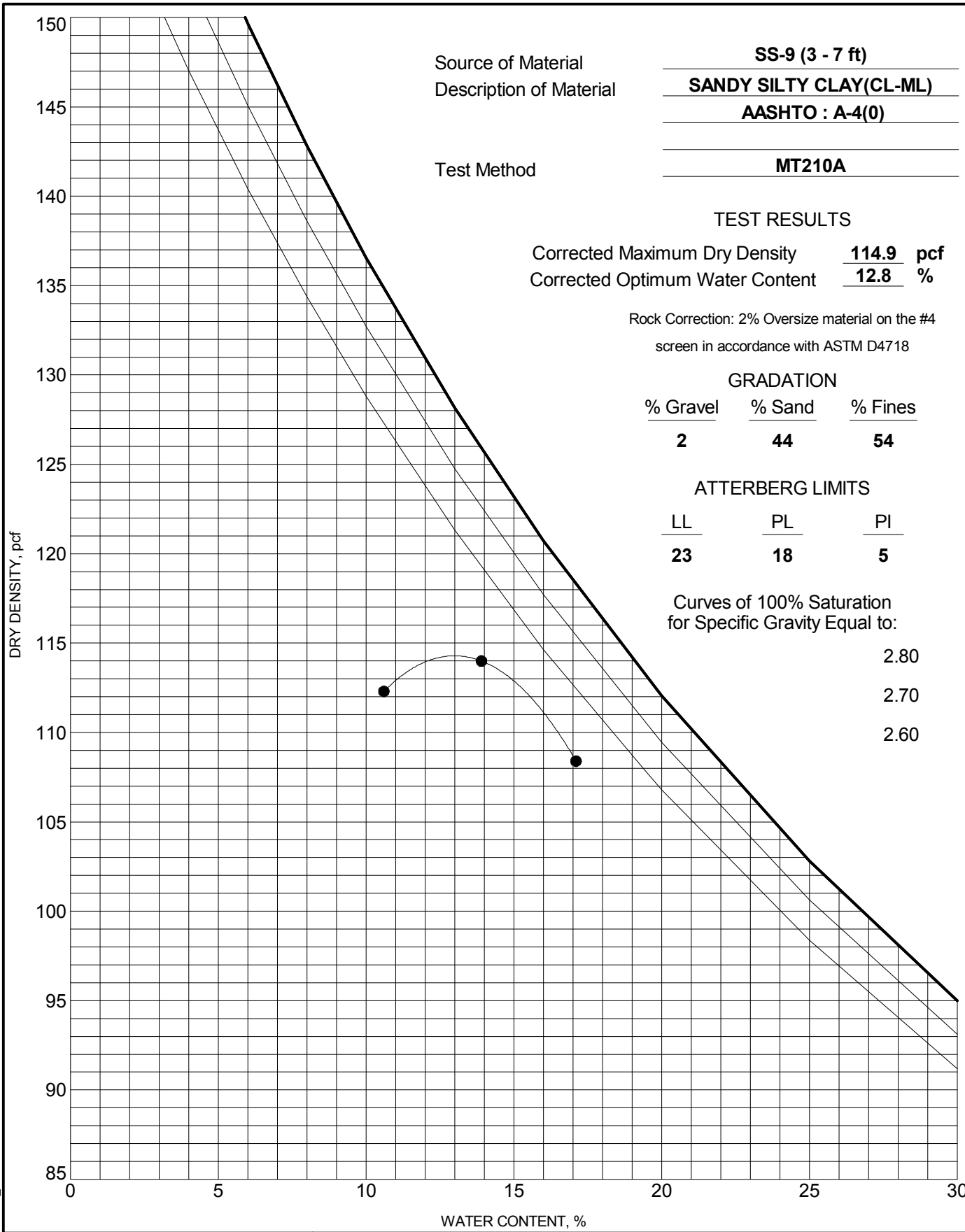
Location: RP-6.3

Number: STPS 263 - 1(28)6

Figure No. 2C-3

MULLAN RD.GPJ ` 10-4-17 ` ` TT_COMPACTION W/CURVE

Revised 1-23-08 (MAT)



Source of Material: **SS-9 (3 - 7 ft)**

Description of Material: **SANDY SILTY CLAY(CL-ML)**

AASHTO : A-4(0)

Test Method: **MT210A**

TEST RESULTS

Corrected Maximum Dry Density	**114.9**	**pcf**
Corrected Optimum Water Content	**12.8**	**%**

Rock Correction: 2% Oversize material on the #4 screen in accordance with ASTM D4718

GRADATION

% Gravel	% Sand	% Fines
2	**44**	**54**

ATTERBERG LIMITS

LL	PL	PI
23	**18**	**5**

Curves of 100% Saturation for Specific Gravity Equal to:

2.80

2.70

2.60

MOISTURE-DENSITY RELATIONSHIP

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)

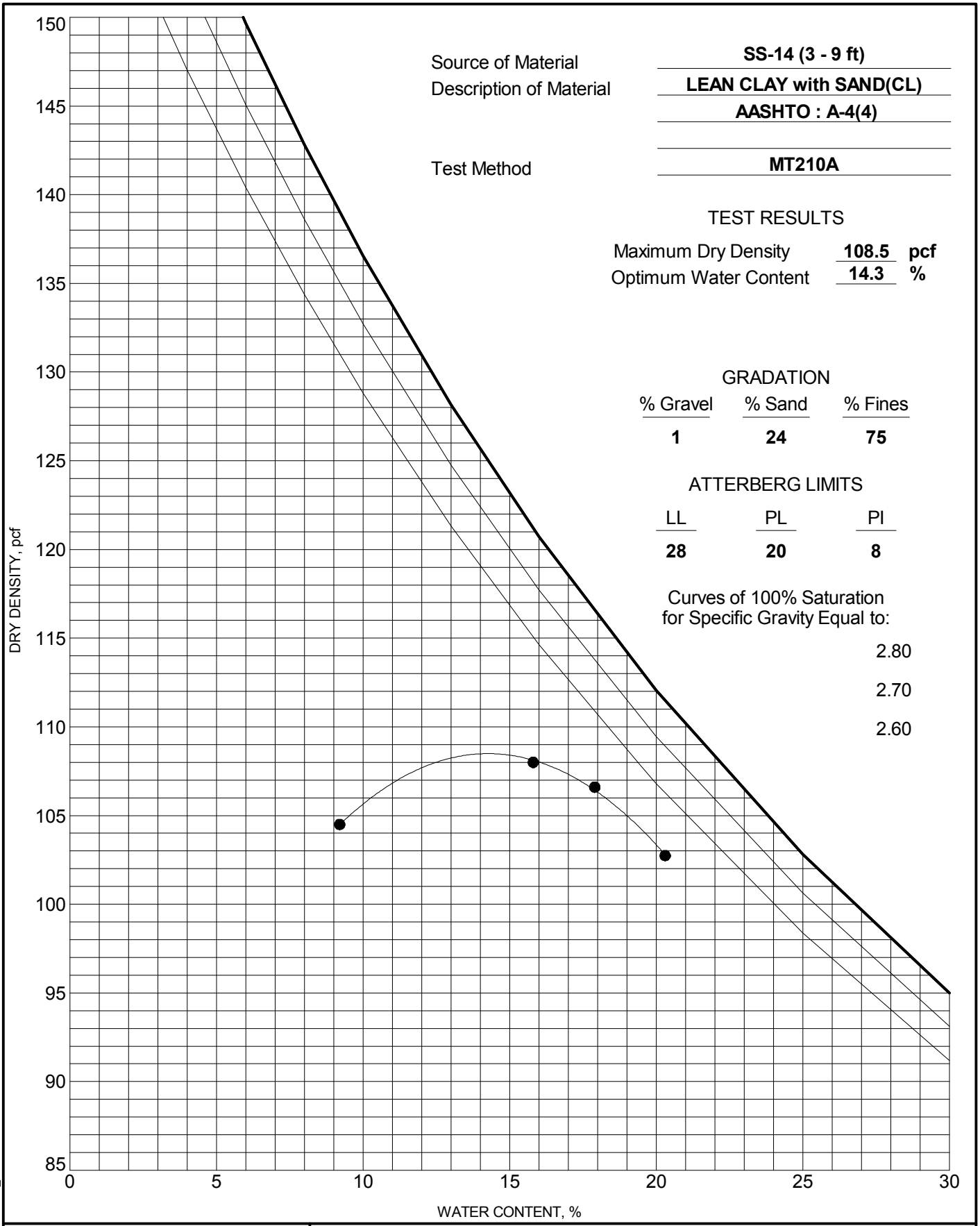
Location: RP-7.1

Number: STPS 263 - 1(28)6

Figure No. 2C-4

MULLAN RD.GPJ ` 10-4-17 ` ` TT_COMPACTION W/CURVE

Revised 1-23-08 (MAT)



Source of Material: **SS-14 (3 - 9 ft)**

Description of Material: **LEAN CLAY with SAND(CL)**

AASHTO : A-4(4)

Test Method: **MT210A**

TEST RESULTS

Maximum Dry Density	**108.5**	**pcf**
Optimum Water Content	**14.3**	**%**

GRADATION

% Gravel	% Sand	% Fines
1	**24**	**75**

ATTERBERG LIMITS

LL	PL	PI
28	**20**	**8**

Curves of 100% Saturation for Specific Gravity Equal to:

2.80

2.70

2.60

MOISTURE-DENSITY RELATIONSHIP

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)

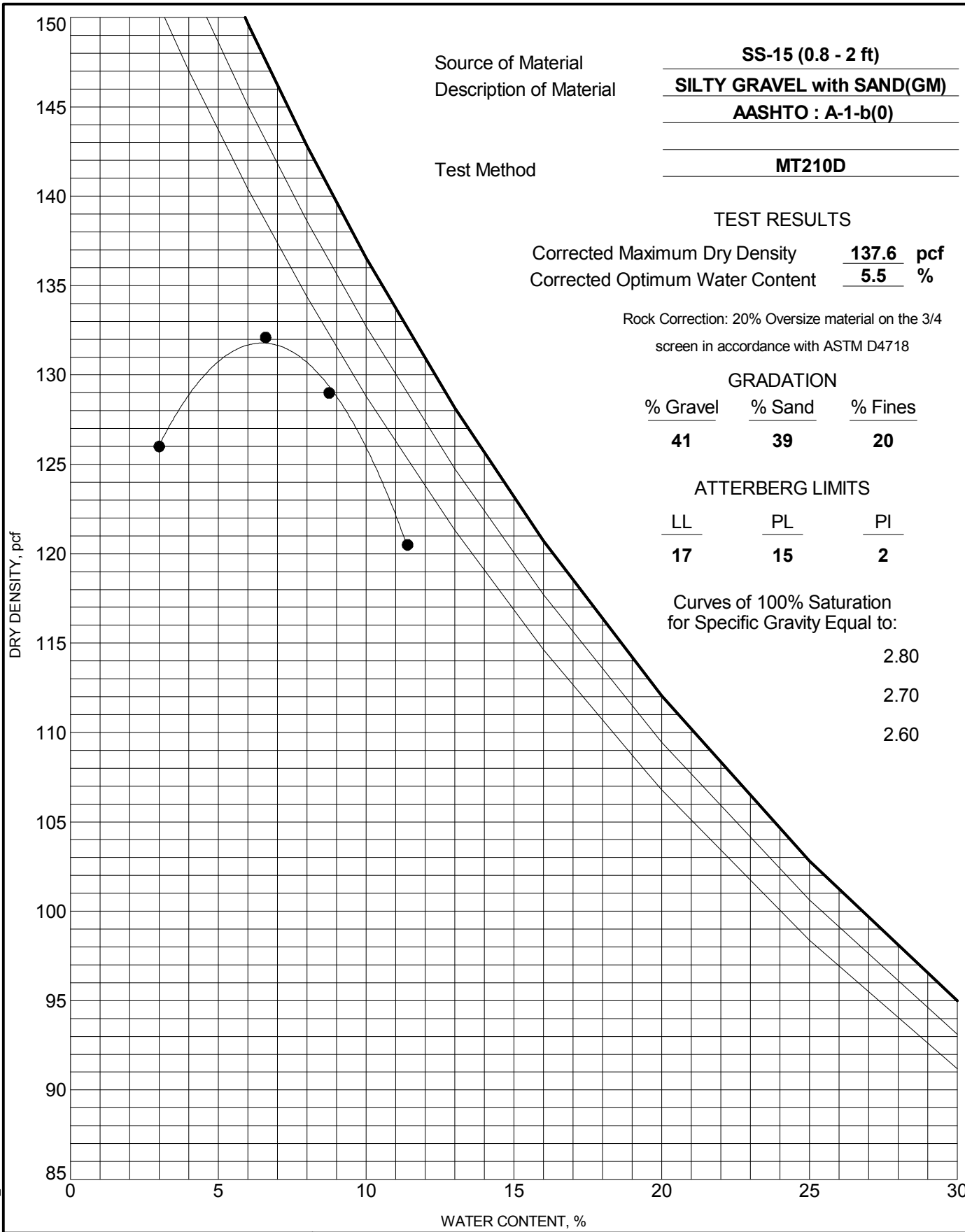
Location: RP-8.1

Number: STPS 263 - 1(28)6

Figure No. 2C-5

MULLAN RD.GPJ ` 10-4-17 ` ` TT_COMPACTION W/CURVE

Revised 1-23-08 (MAT)



Source of Material: **SS-15 (0.8 - 2 ft)**

Description of Material: **SILTY GRAVEL with SAND(GM)**

AASHTO : A-1-b(0)

Test Method: **MT210D**

TEST RESULTS

Corrected Maximum Dry Density	**137.6**	**pcf**
Corrected Optimum Water Content	**5.5**	**%**

Rock Correction: 20% Oversize material on the 3/4 screen in accordance with ASTM D4718

GRADATION

% Gravel	% Sand	% Fines
41	**39**	**20**

ATTERBERG LIMITS

LL	PL	PI
17	**15**	**2**

Curves of 100% Saturation for Specific Gravity Equal to:

2.80

2.70

2.60

TETRA TECH

MOISTURE-DENSITY RELATIONSHIP

Project: West of Missoula - NW (Mullan Rd)

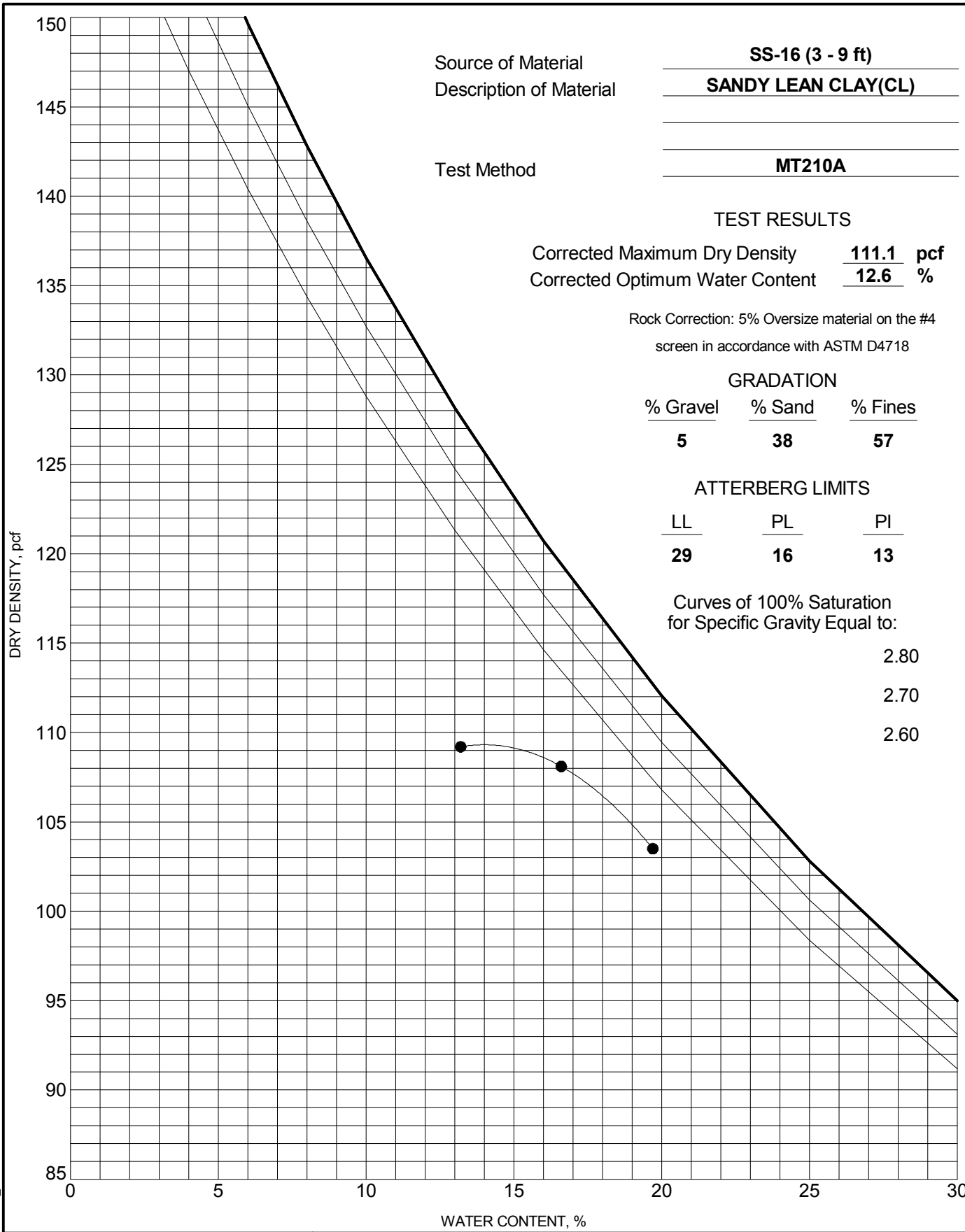
Location: RP-8.3

Number: STPS 263 - 1(28)6

Figure No. 2C-6

MULLAN RD.GPJ ` 10-4-17 ` ` TT_COMPACTION W/CURVE

Revised 1-23-08 (MAT)



Source of Material: **SS-16 (3 - 9 ft)**

Description of Material: **SANDY LEAN CLAY(CL)**

Test Method: **MT210A**

TEST RESULTS

Corrected Maximum Dry Density	**111.1**	**pcf**
Corrected Optimum Water Content	**12.6**	**%**

Rock Correction: 5% Oversize material on the #4 screen in accordance with ASTM D4718

GRADATION

% Gravel	% Sand	% Fines
5	**38**	**57**

ATTERBERG LIMITS

LL	PL	PI
29	**16**	**13**

Curves of 100% Saturation for Specific Gravity Equal to:

2.80

2.70

2.60

TETRA TECH

MOISTURE-DENSITY RELATIONSHIP

Project: West of Missoula - NW (Mullan Rd)

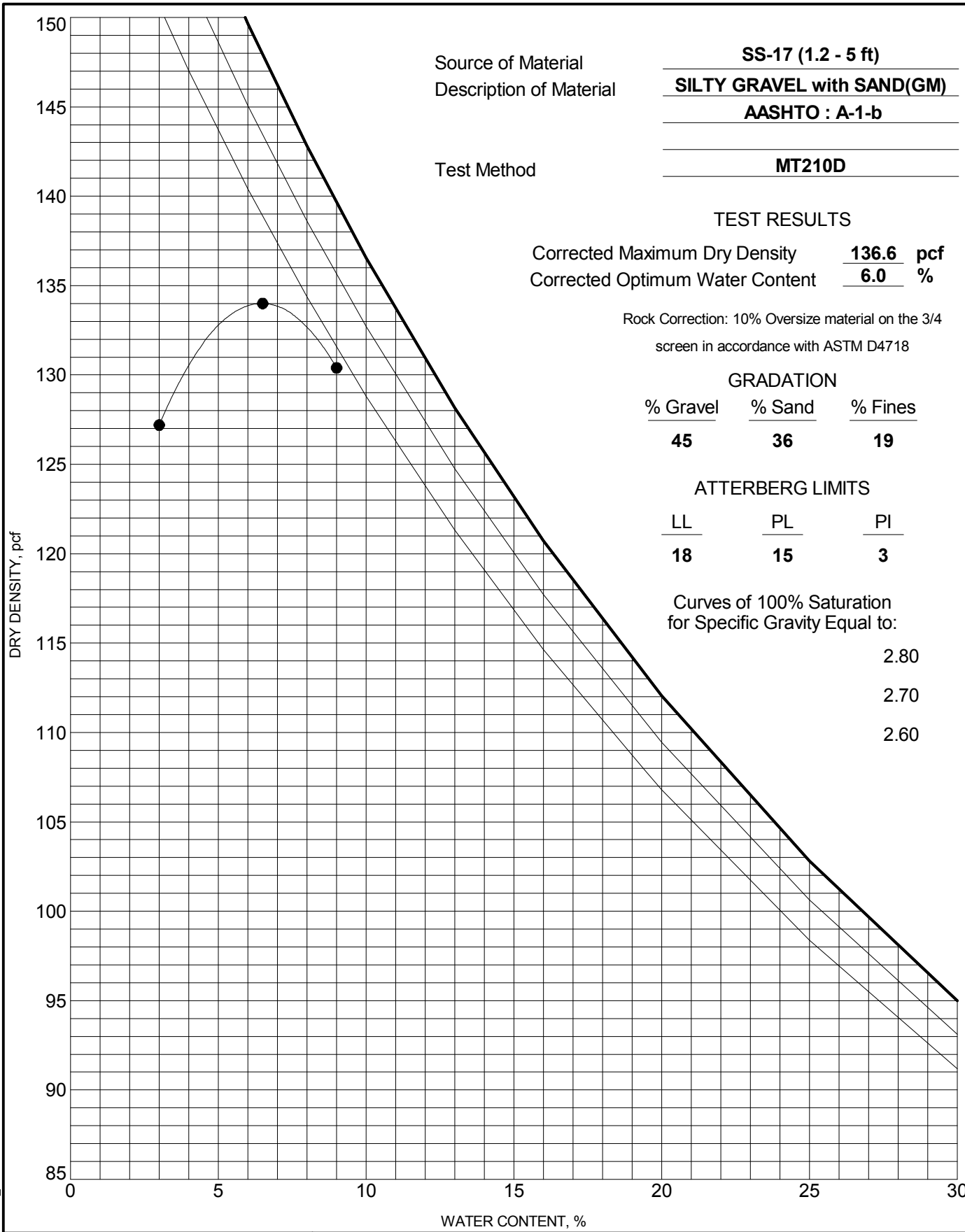
Location: RP-8.5

Number: STPS 263 - 1(28)6

Figure No. 2C-7

MULLAN RD.GPJ ` 10-4-17 ` ` TT_COMPACTION W/CURVE

Revised 1-23-08 (MAT)



Source of Material: **SS-17 (1.2 - 5 ft)**

Description of Material: **SILTY GRAVEL with SAND(GM)**

AASHTO : A-1-b

Test Method: **MT210D**

TEST RESULTS

Corrected Maximum Dry Density	**136.6**	**pcf**
Corrected Optimum Water Content	**6.0**	**%**

Rock Correction: 10% Oversize material on the 3/4 screen in accordance with ASTM D4718

GRADATION

% Gravel	% Sand	% Fines
45	**36**	**19**

ATTERBERG LIMITS

LL	PL	PI
18	**15**	**3**

Curves of 100% Saturation for Specific Gravity Equal to:

2.80

2.70

2.60

TETRA TECH

MOISTURE-DENSITY RELATIONSHIP

Project: West of Missoula - NW (Mullan Rd)

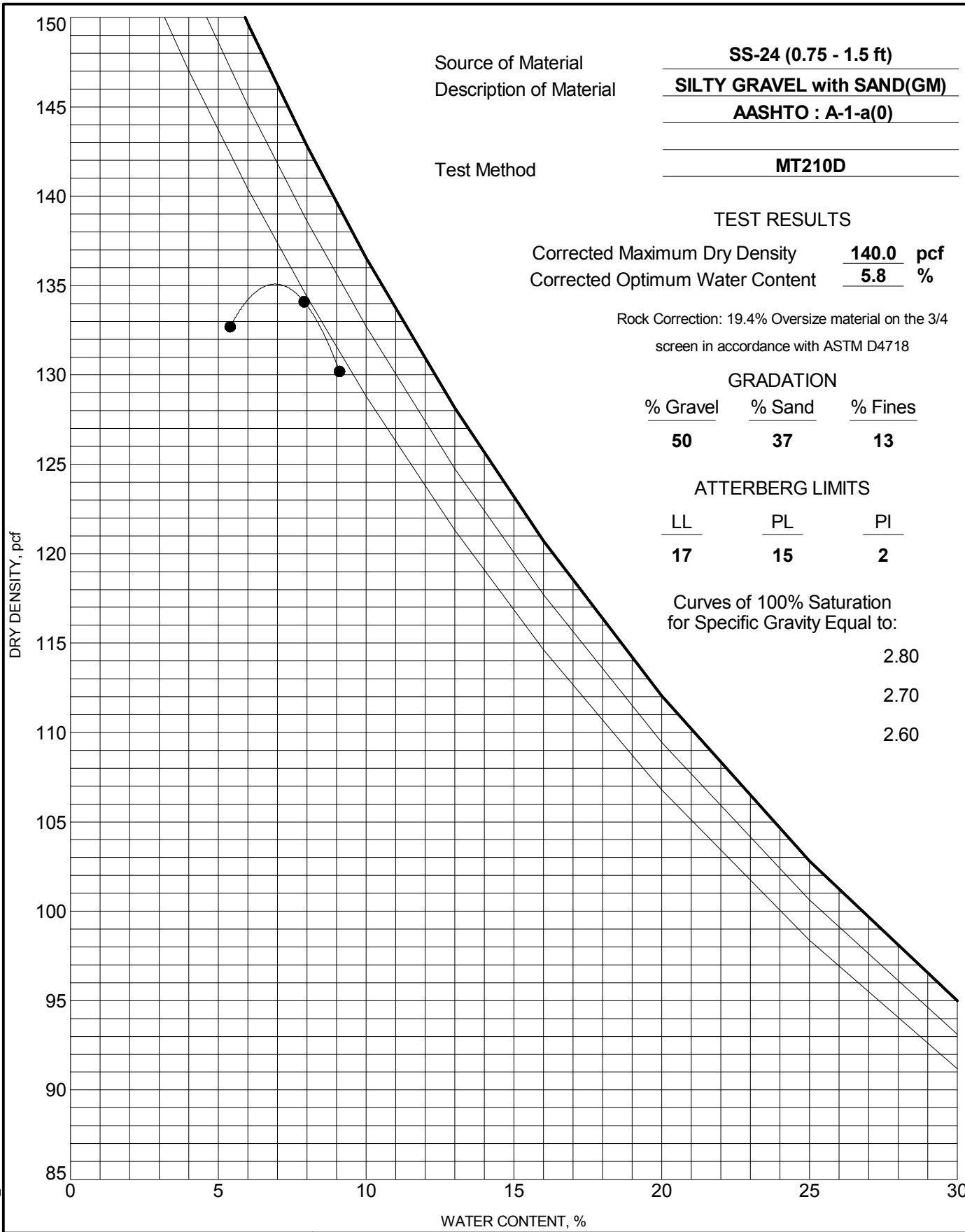
Location: RP-8.7

Number: STPS 263 - 1(28)6

Figure No. 2C-8

MULLAN RD.GPJ ` 10-4-17 ` ` TT_COMPACTION W/CURVE

Revised 1-23-08 (MAT)



Source of Material	**SS-24 (0.75 - 1.5 ft)**
Description of Material	**SILTY GRAVEL with SAND(GM)**
	AASHTO : A-1-a(0)
Test Method	**MT210D**

TEST RESULTS

Corrected Maximum Dry Density	**140.0**	**pcf**
Corrected Optimum Water Content	**5.8**	**%**

Rock Correction: 19.4% Oversize material on the 3/4 screen in accordance with ASTM D4718

GRADATION

% Gravel	% Sand	% Fines
50	**37**	**13**

ATTERBERG LIMITS

LL	PL	PI
17	**15**	**2**

Curves of 100% Saturation for Specific Gravity Equal to:

2.80

2.70

2.60

TETRA TECH

MOISTURE-DENSITY RELATIONSHIP

Project: West of Missoula - NW (Mullan Rd)

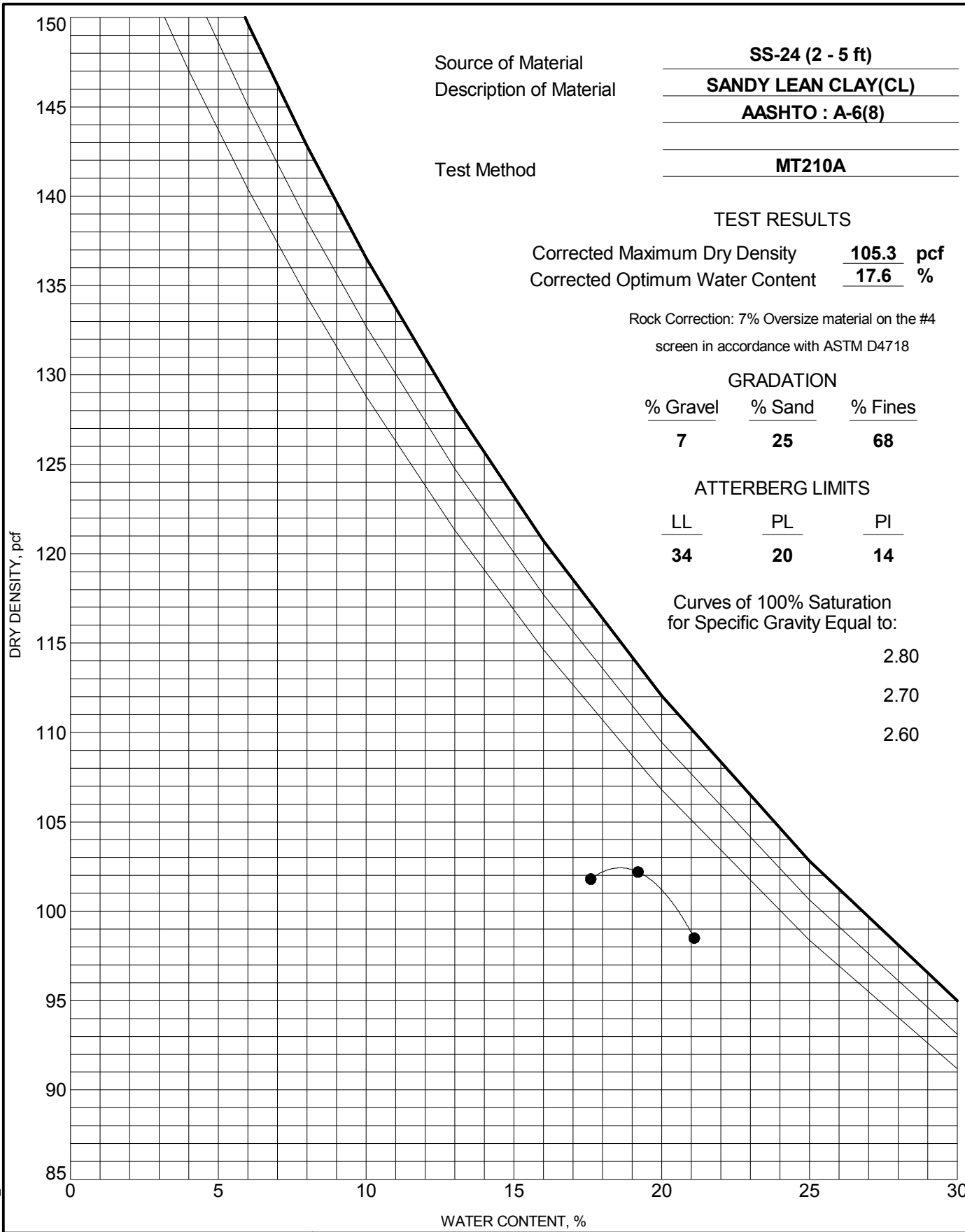
Location: RP-10.1

Number: STPS 263 - 1(28)6

Figure No. 2C-9

MULLAN RD.GPJ ` 10-4-17 ` ` TT_COMPACTION W/CURVE

Revised 1-23-08 (MAT)



Source of Material: **SS-24 (2 - 5 ft)**

Description of Material: **SANDY LEAN CLAY(CL)**

AASHTO : A-6(8)

Test Method: **MT210A**

TEST RESULTS

Corrected Maximum Dry Density	**105.3**	**pcf**
Corrected Optimum Water Content	**17.6**	**%**

Rock Correction: 7% Oversize material on the #4 screen in accordance with ASTM D4718

GRADATION

% Gravel	% Sand	% Fines
7	**25**	**68**

ATTERBERG LIMITS

LL	PL	PI
34	**20**	**14**

Curves of 100% Saturation for Specific Gravity Equal to:

2.80

2.70

2.60

TETRA TECH

MOISTURE-DENSITY RELATIONSHIP

Project: West of Missoula - NW (Mullan Rd)

Location: RP-10.1

Number: STPS 263 - 1(28)6

Figure No. 2C-10

MULLAN RD.GPJ ` 10-4-17 ` ` TT_COMPACTION W/CURVE

Revised 1-23-08 (MAT)

APPENDIX 2D

California Bearing Ratio (2D-1 through 2D-5)

TETRA TECH

PROJECT:	West of Missoula - NW (Mullan Road)	**PROJECT NO:**	STPS 263-1(28)6
LOCATION:	Mullan Road	**WORK ORDER NO:**	1
MATERIAL:	Silty, Clayey Sand with Gravel	**LAB NO:**	2
SAMPLE SOURCE:	SS-2, 3-6'	**DATE SAMPLED:**	6/19/2017
REVIEWED BY:	A. Hotaling		

CBR(CALIFORNIA BEARING RATIO) OF LABORATORY-COMPACTED SOILS(ASTM D1883)

COMPACTION(%) 92.4

PERCENT SWELL 0.57%

	BEFORE SOAK	AFTER SOAK
DRY DENSITY	107.0 lbs./cu.ft	108.1 lbs./cu.ft
PERCENT MOISTURE	16.0 %	18.1 %

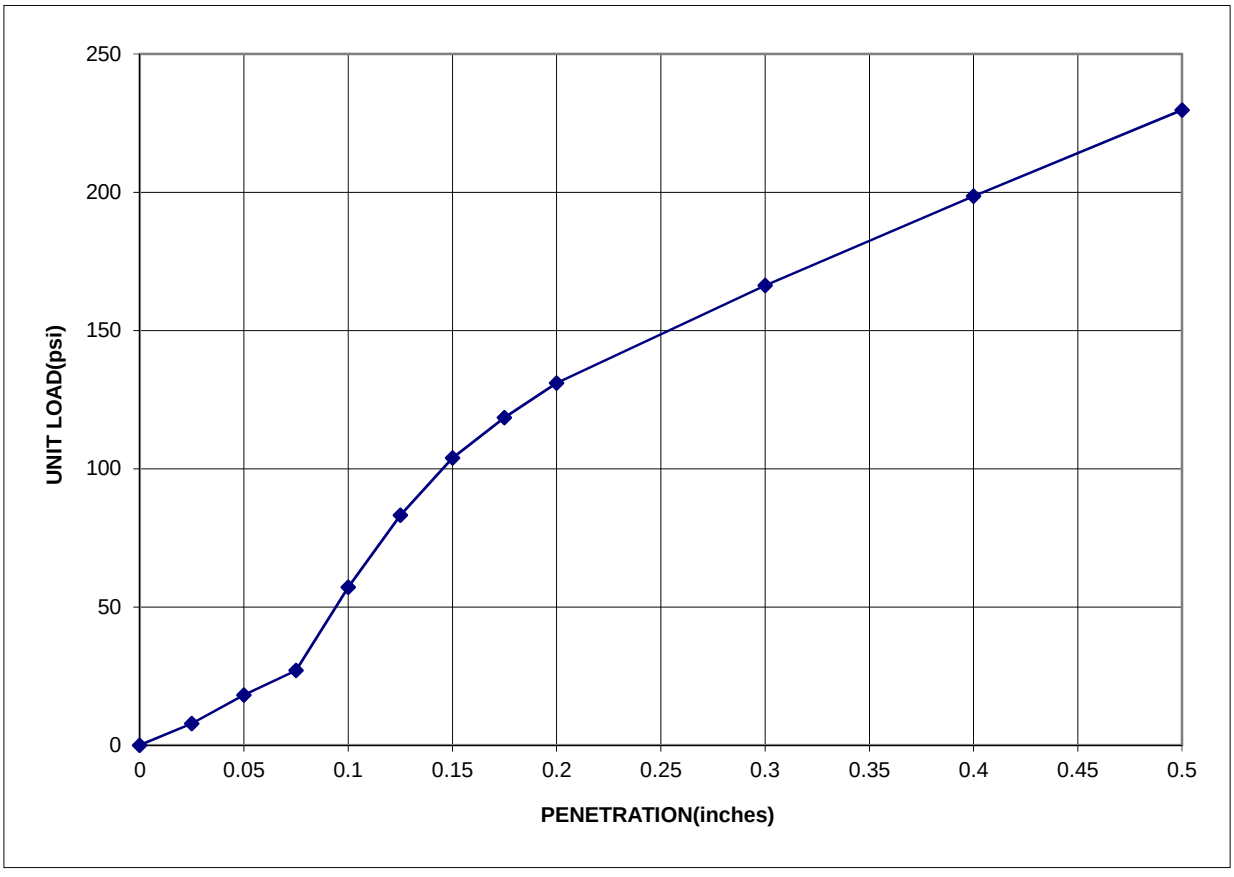
SURCHARGE WEIGHT 10 lbs.

PENETRATION	CORRECTED C B R
0.100	11
0.200	10

MT 210 D

DRY DENSITY(pcf) 115.8

MOISTURE(%) 14.2



CBR 11

FIGURE 2D-1

TETRA TECH

PROJECT:	West of Missoula - NW (Mullan Road)	**PROJECT NO:**	STPS 263-1(28)6
LOCATION:	Mullan Road	**WORK ORDER NO:**	1
MATERIAL:	Poorly Graded Gravel with Silt and Sand	**LAB NO:**	3
SAMPLE SOURCE:	SS-3, 0.7-4'	**DATE SAMPLED:**	6/19/2017
REVIEWED BY:	A. Hotaling		

CBR(CALIFORNIA BEARING RATIO) OF LABORATORY-COMPACTED SOILS(ASTM D1883)

COMPACTION(%) 98.1

PERCENT SWELL 0.02%

	BEFORE SOAK	AFTER SOAK
DRY DENSITY	137.8 lbs./cu.ft	138.1 lbs./cu.ft
PERCENT MOISTURE	5.0 %	6.0 %

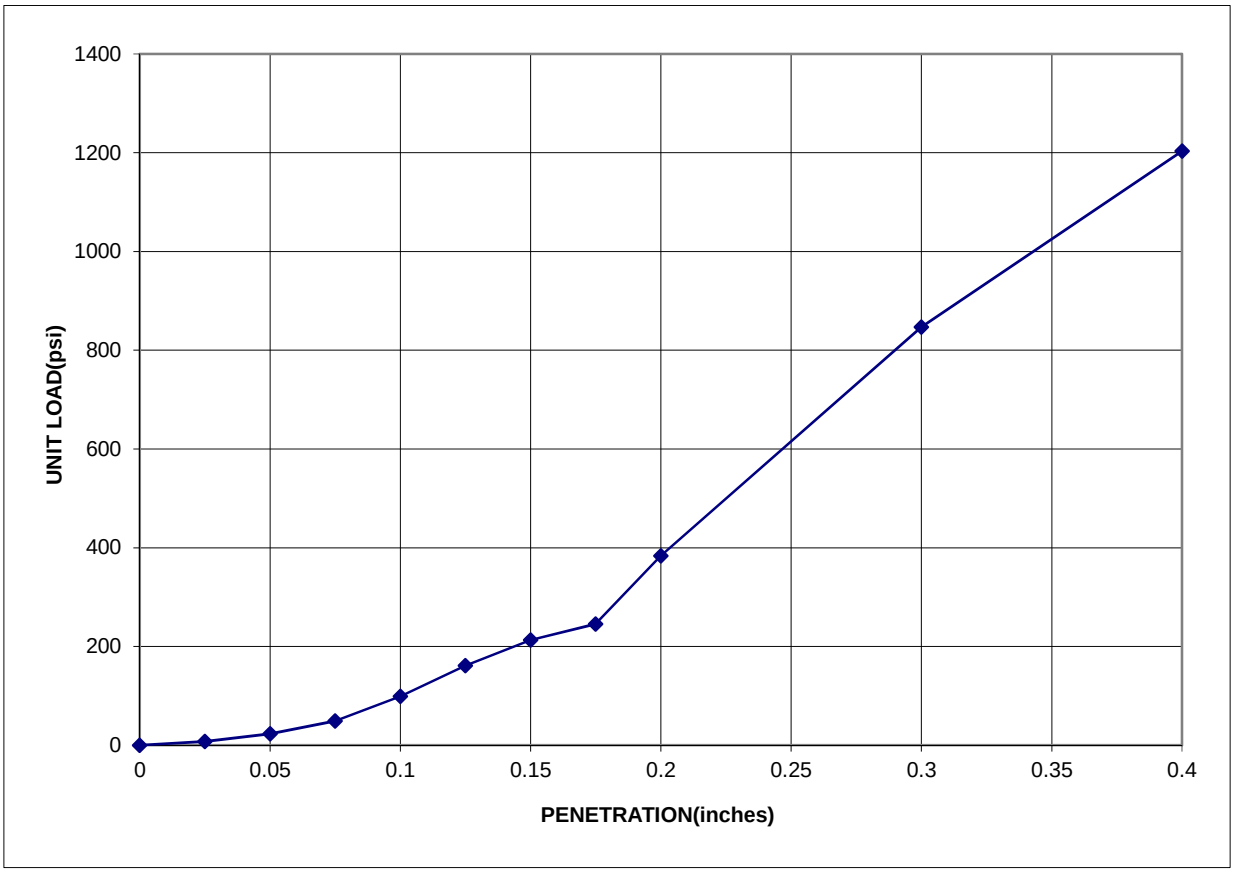
SURCHARGE WEIGHT 10 lbs.

PENETRATION	CORRECTED C B R
0.100	45
0.200	60

MT 230 D

DRY DENSITY(pcf) 140.5

MOISTURE(%) 4.7



CBR 45

FIGURE 2D-2

TETRA TECH

PROJECT:	West of Missoula - NW (Mullan Road)	**PROJECT NO:**	STPS 263-1(28)6
LOCATION:	Mullan Road	**WORK ORDER NO:**	1
MATERIAL:	Poorly Graded Gravel with Silt and Sand	**LAB NO:**	5
SAMPLE SOURCE:	SS-5, 0.8-4'	**DATE SAMPLED:**	6/19/2017
REVIEWED BY:	A. Hotaling		

CBR(CALIFORNIA BEARING RATIO) OF LABORATORY-COMPACTED SOILS(ASTM D1883)

COMPACTION(%) 94.4

PERCENT SWELL -0.57%

	BEFORE SOAK	AFTER SOAK
DRY DENSITY	128.8 lbs./cu.ft	130.6 lbs./cu.ft
PERCENT MOISTURE	3.2 %	8.4 %

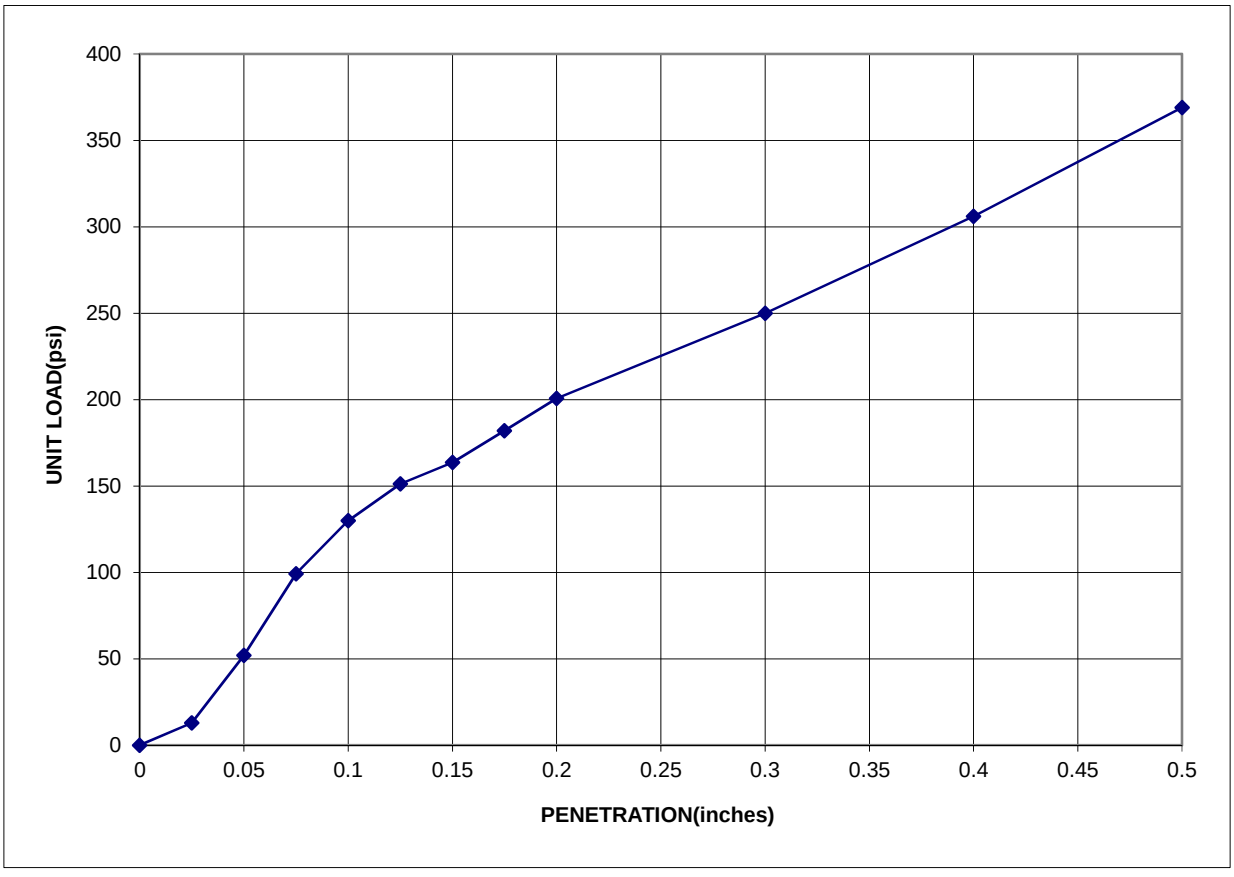
SURCHARGE WEIGHT 10 lbs.

PENETRATION	CORRECTED C B R
0.100	13
0.200	13

MT 230 D

DRY DENSITY(pcf) 136.5

MOISTURE(%) 5.7



CBR 13

FIGURE 2D-3

TETRA TECH

PROJECT:	West of Missoula - NW (Mullan Road)	**PROJECT NO:**	STPS 263-1(28)6
LOCATION:	Mullan Road	**WORK ORDER NO:**	1
MATERIAL:	Sandy Silty Clay	**LAB NO:**	9
SAMPLE SOURCE:	SS-9, 3-7'	**DATE SAMPLED:**	6/20/2017
REVIEWED BY:	A. Hotaling		

CBR(CALIFORNIA BEARING RATIO) OF LABORATORY-COMPACTED SOILS(ASTM D1883)

COMPACTION(%) 102.2

PERCENT SWELL 0.63%

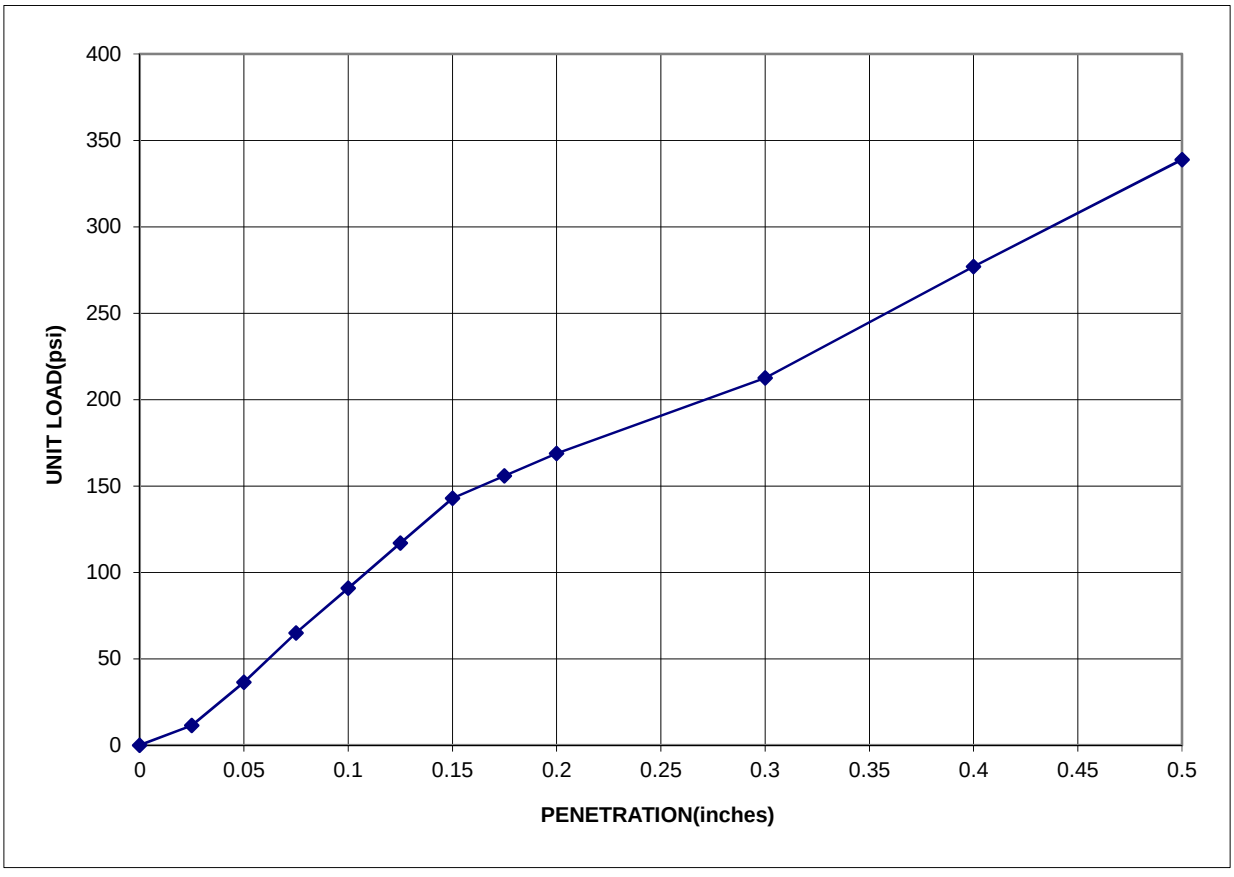
	BEFORE SOAK	AFTER SOAK
DRY DENSITY	117.4 lbs./cu.ft	116.2 lbs./cu.ft
PERCENT MOISTURE	8.1 %	14.2 %

SURCHARGE WEIGHT 10 lbs.

PENETRATION	CORRECTED C B R
0.100	10
0.200	11

MT 210 D

DRY DENSITY(pcf)	114.9
MOISTURE(%)	12.8



CBR 10

FIGURE 2D-4

TETRA TECH

PROJECT:	West of Missoula - NW (Mullan Road)	**PROJECT NO:**	STPS 263-1(28)6
LOCATION:	Mullan Road	**WORK ORDER NO:**	1
MATERIAL:	Lean Clay with Sand	**LAB NO:**	14
SAMPLE SOURCE:	SS-14, 3-9'	**DATE SAMPLED:**	6/21/2017
REVIEWED BY:	A. Hotaling		

CBR(CALIFORNIA BEARING RATIO) OF LABORATORY-COMPACTED SOILS(ASTM D1883)

COMPACTION(%) 97.6

PERCENT SWELL 1.68%

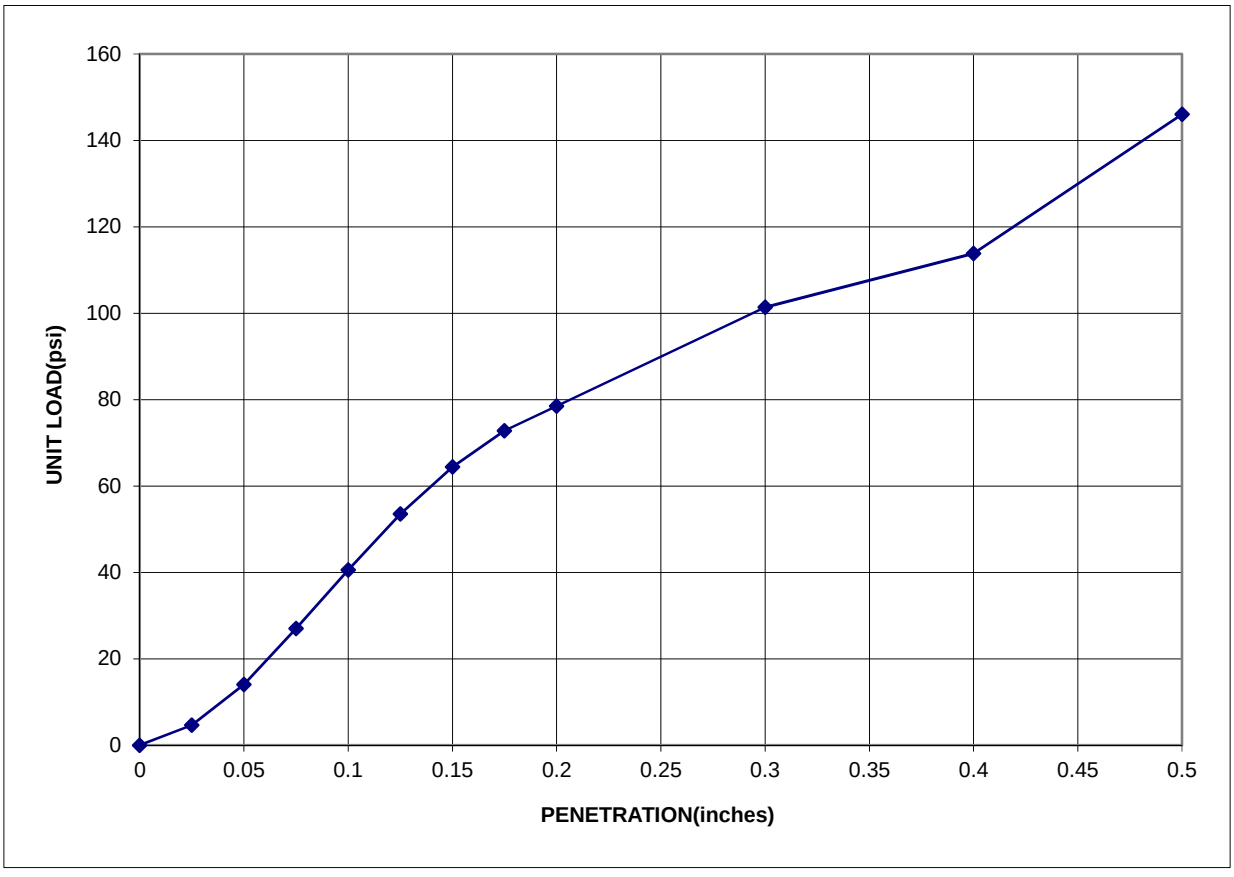
	BEFORE SOAK	AFTER SOAK
DRY DENSITY	105.9 lbs./cu.ft	105.6 lbs./cu.ft
PERCENT MOISTURE	11.9 %	19.8 %

SURCHARGE WEIGHT 10 lbs.

PENETRATION	CORRECTED C B R
0.100	4
0.200	5

MT 210 D

DRY DENSITY(pcf)	108.5
MOISTURE(%)	14.3



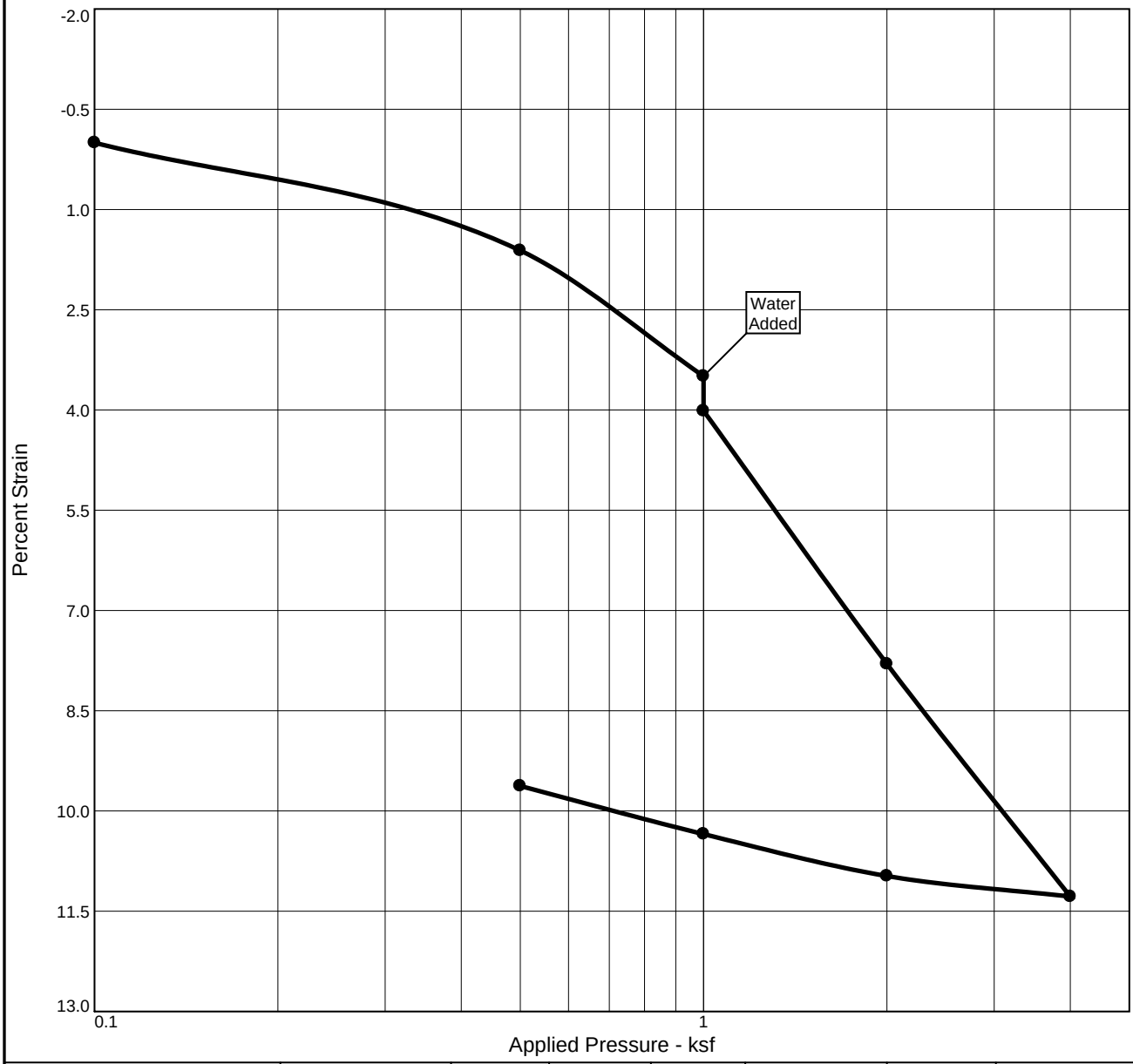
CBR 4

FIGURE 2D-5

APPENDIX 2E

Consolidation Data (2E-1 and 2E-2)

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	P_c (ksf)	C_c	Initial Void Ratio
Saturation	Moisture							
58.5 %	14.2 %	100.7	NV	NP	2.65	2.0	0.19	0.643

MATERIAL DESCRIPTION	USCS	AASHTO
Silty SAND	SM	A-4(0)

Project No. 114-571120 **Client:** HDR, Inc.

Project: Mullan Road

Source of Sample: SS-10 **Depth:** 4' - 6'

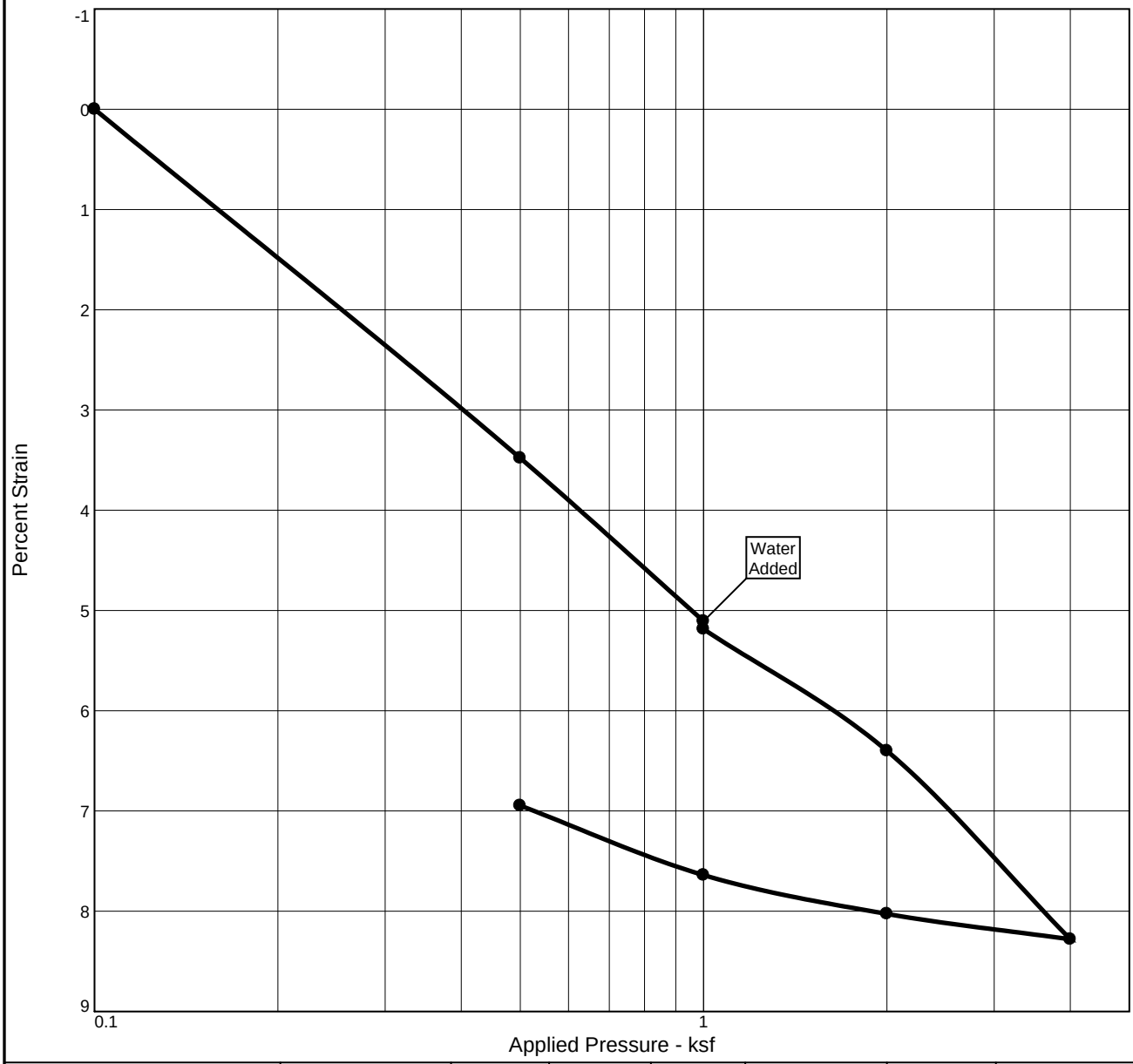
Remarks:

Tetra Tech

Billings, MT

Figure 2E-1

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	P_c (ksf)	C_c	Initial Void Ratio
Saturation	Moisture							
81.4 %	17.7 %	106.2	33	15	2.70	2.1	0.10	0.587

MATERIAL DESCRIPTION	USCS	AASHTO
Sandy Lean CLAY	CL	A-6(7)

Project No. 114-571120 **Client:** HDR, Inc.

Project: Mullan Road

Source of Sample: SS-22 **Depth:** 6' - 8'

Remarks:

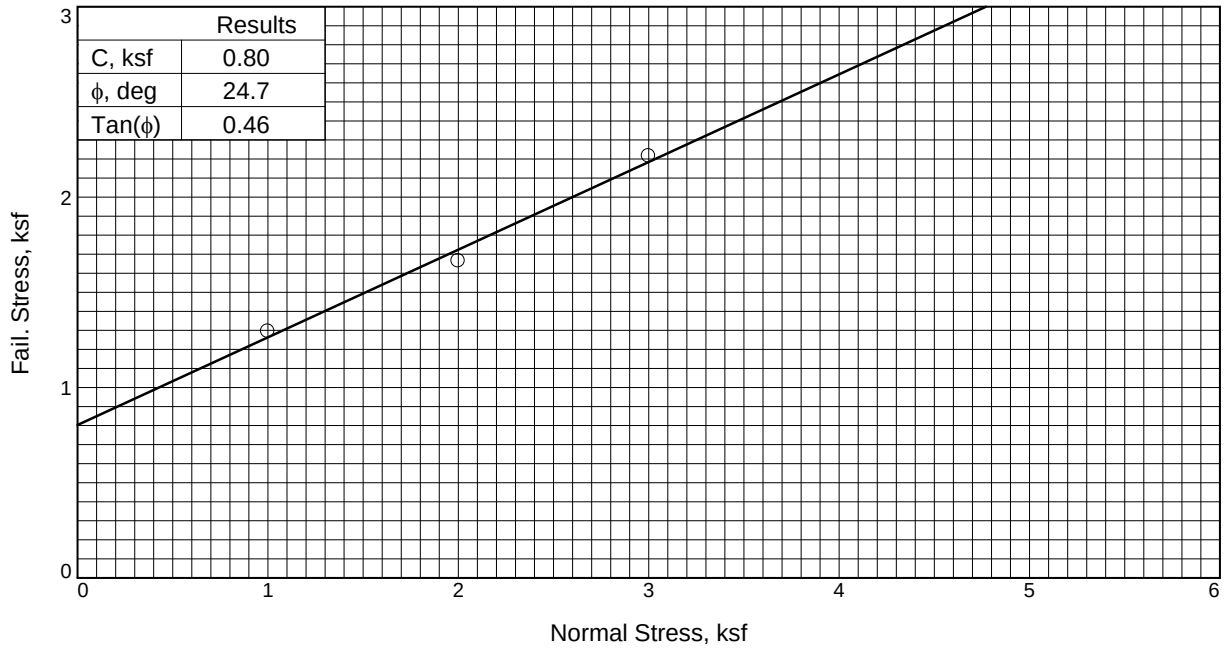
Tetra Tech

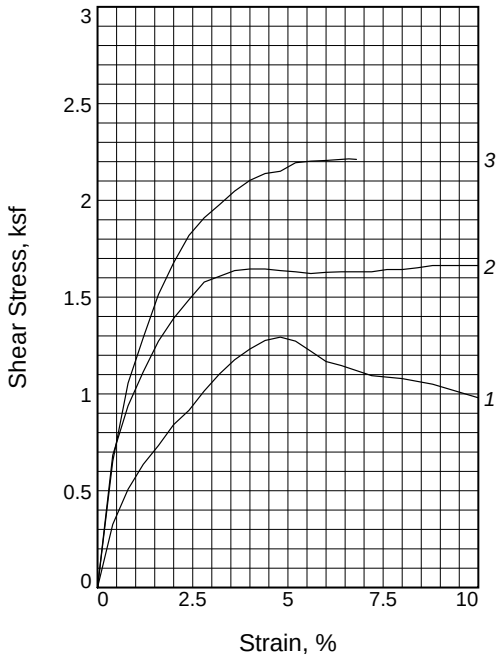
Billings, MT

Figure 2E-2

APPENDIX 2F

Direct Shear Data (2F-1 through 2F-4)





Sample No.		1	2	3
Initial	Water Content, %	14.2	14.2	14.2
	Dry Density, pcf	101.8	103.0	103.1
	Saturation, %	60.3	62.1	62.3
	Void Ratio	0.6245	0.6059	0.6045
	Diameter, in.	2.50	2.50	2.50
	Height, in.	0.75	0.75	0.75
At Test	Water Content, %	21.7	21.3	18.8
	Dry Density, pcf	104.2	105.4	109.0
	Saturation, %	98.0	99.0	96.2
	Void Ratio	0.5874	0.5695	0.5172
	Diameter, in.	2.50	2.50	2.50
	Height, in.	0.73	0.73	0.71
Normal Stress, ksf		1.00	2.00	3.00
Fail. Stress, ksf		1.29	1.66	2.21
Strain, %		4.8	8.8	6.6
Ult. Stress, ksf				
Strain, %				
Strain rate, in./min.		0.00	0.00	0.00

Sample Type: Shelby Tube
Description: Silty SAND

LL= NV **PI=** NP
Assumed Specific Gravity= 2.65
Remarks:

Figure 2F-1

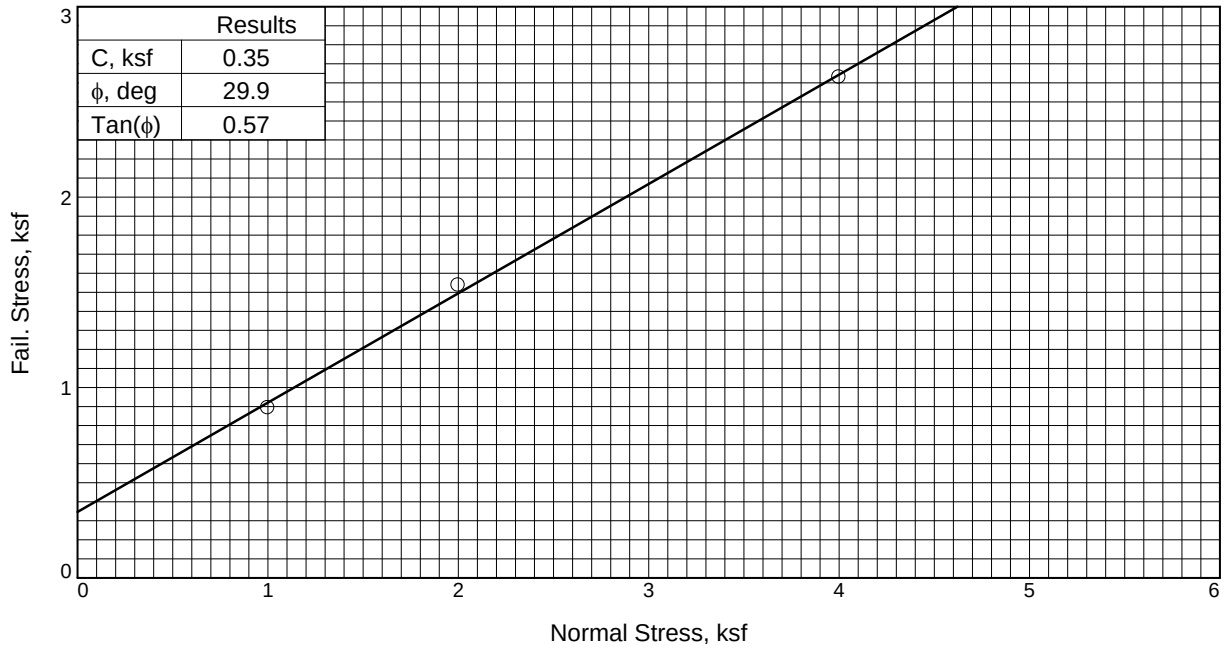
Client: HDR, Inc.

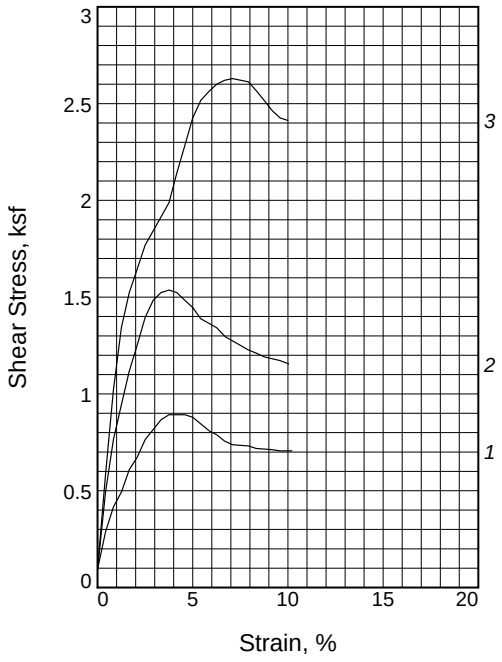
Project: Mullan Road

Source of Sample: SS-10 **Depth:** 4' - 6'

Proj. No.: 114-571120 **Date Sampled:** 8-24-17

DIRECT SHEAR TEST REPORT
Tetra Tech
Billings, MT





Sample No.		1	2	3
Initial	Water Content, %	26.1	26.1	26.1
	Dry Density, pcf	94.9	90.9	94.8
	Saturation, %	90.8	82.5	90.6
	Void Ratio	0.7754	0.8537	0.7771
	Diameter, in.	2.40	2.40	2.40
	Height, in.	0.75	0.75	0.75
At Test	Water Content, %	27.3	30.5	26.8
	Dry Density, pcf	95.7	92.2	97.2
	Saturation, %	96.9	99.4	98.4
	Void Ratio	0.7610	0.8290	0.7344
	Diameter, in.	2.40	2.40	2.40
	Height, in.	0.74	0.74	0.73
Normal Stress, ksf		1.00	2.00	4.00
Fail. Stress, ksf		0.89	1.54	2.63
Strain, %		3.8	3.8	7.1
Ult. Stress, ksf				
Strain, %				
Strain rate, in./min.		0.00	0.00	0.00

Sample Type: Shelby Tube
Description: Lean CLAY with Sand

LL= 41 **PL=** 18 **PI=** 23
Assumed Specific Gravity= 2.70
Remarks:

Figure 2F-2

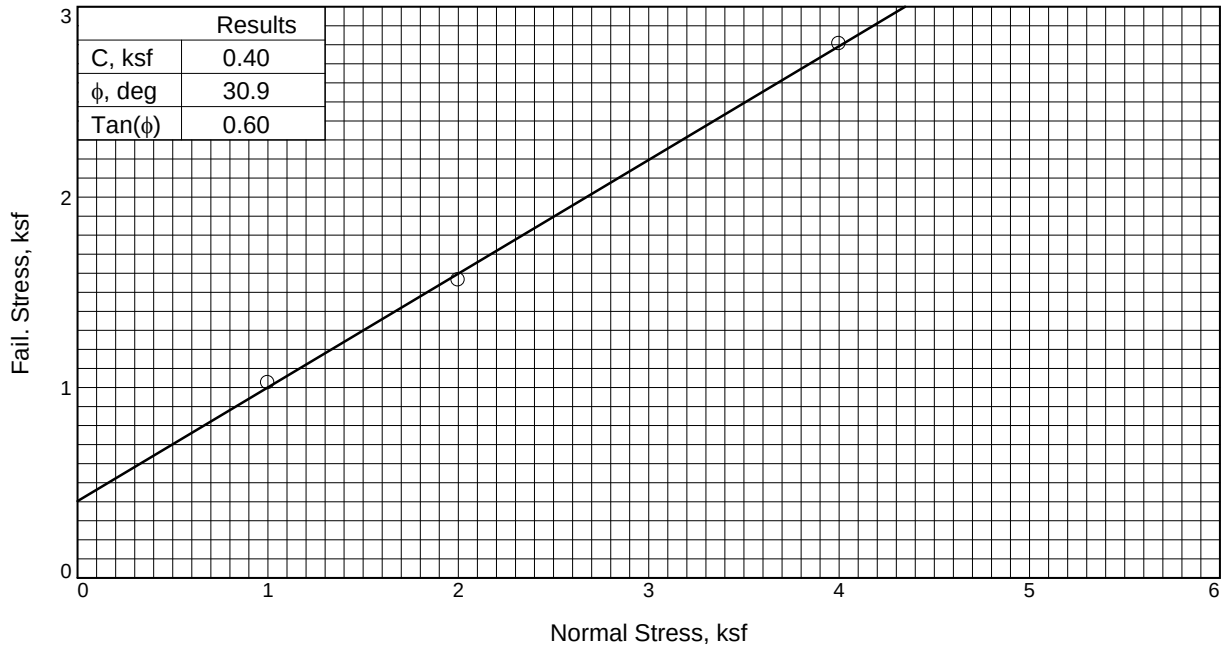
Client: HDR, Inc.

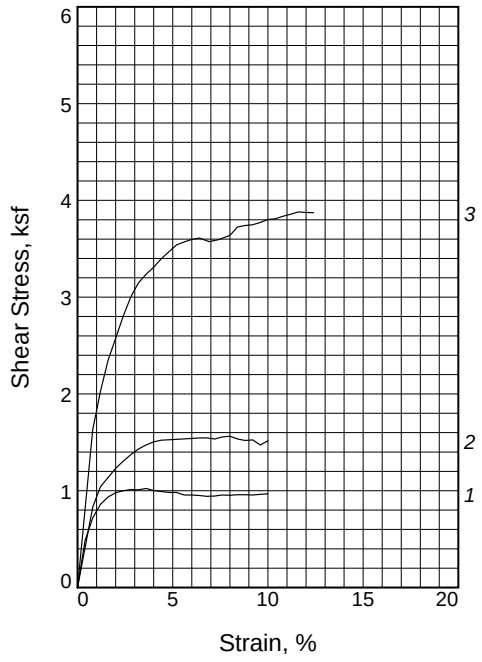
Project: Mullan Road

Source of Sample: SS-16 **Depth:** 9' - 10'

Proj. No.: 114-571120 **Date Sampled:** 8-24-17

DIRECT SHEAR TEST REPORT
Tetra Tech
Billings, MT





Sample No.		1	2	3
Initial	Water Content, %	17.7	17.7	17.7
	Dry Density, pcf	102.7	100.3	102.8
	Saturation, %	74.5	70.2	74.6
	Void Ratio	0.6414	0.6802	0.6399
	Diameter, in.	2.50	2.50	2.50
	Height, in.	0.75	0.75	0.75
At Test	Water Content, %	21.7	22.0	19.7
	Dry Density, pcf	105.0	105.2	108.4
	Saturation, %	97.1	98.5	95.7
	Void Ratio	0.6046	0.6018	0.5551
	Diameter, in.	2.50	2.50	2.50
	Height, in.	0.73	0.71	0.71
Normal Stress, ksf		1.00	2.00	4.00
Fail. Stress, ksf		1.02	1.56	2.80
Strain, %		3.6	8.0	2.4
Ult. Stress, ksf				
Strain, %				
Strain rate, in./min.		0.00	0.00	0.00

Sample Type: Shelby Tube
Description: Sandy Lean CLAY

LL= 33 **PL=** 18 **PI=** 15
Assumed Specific Gravity= 2.70
Remarks:

Figure 2F-3

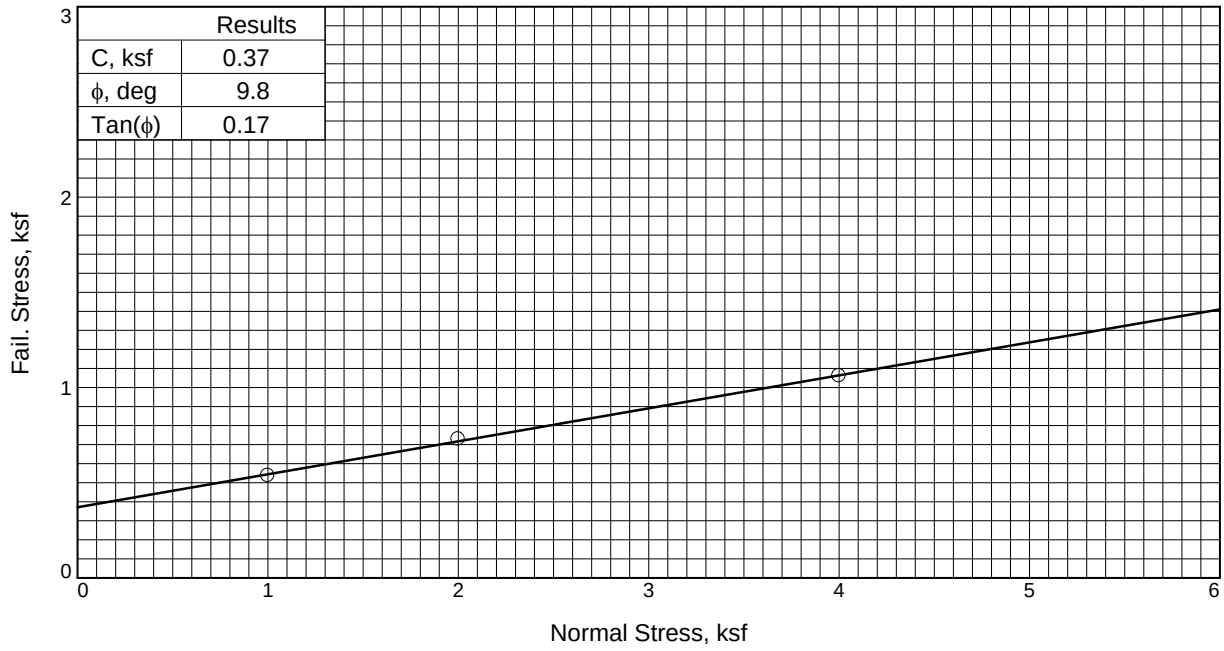
Client: HDR, Inc.

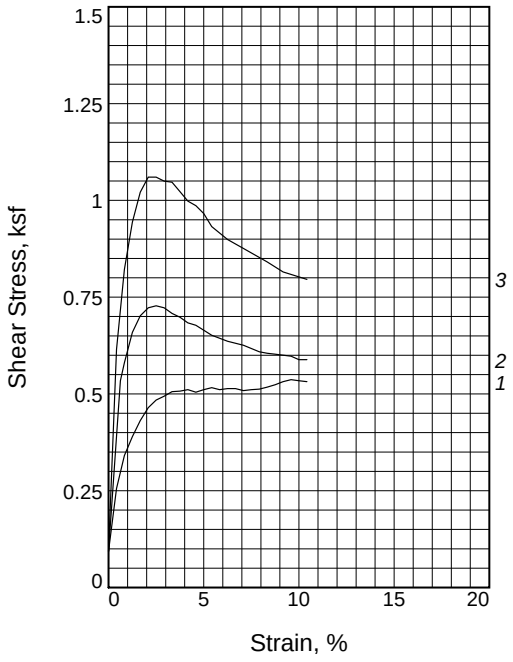
Project: Mullan Road

Source of Sample: SS-22 **Depth:** 6' - 8'

Proj. No.: 114-571120 **Date Sampled:** 8-25-17

DIRECT SHEAR TEST REPORT
Tetra Tech
Billings, MT





Sample No.		1	2	3
Initial	Water Content, %	28.2	28.2	25.1
	Dry Density, pcf	95.6	96.7	100.9
	Saturation, %	97.6	100.0	98.3
	Void Ratio	0.7952	0.7757	0.7014
	Diameter, in.	2.40	2.40	2.40
	Height, in.	0.75	0.75	0.75
At Test	Water Content, %	28.1	26.7	23.5
	Dry Density, pcf	96.5	98.9	104.1
	Saturation, %	99.2	99.7	99.6
	Void Ratio	0.7785	0.7357	0.6486
	Diameter, in.	2.40	2.40	2.40
	Height, in.	0.74	0.73	0.73
Normal Stress, ksf		1.00	2.00	4.00
Fail. Stress, ksf		0.54	0.73	1.06
Strain, %		9.6	2.5	2.1
Ult. Stress, ksf				
Strain, %				
Strain rate, in./min.		0.00	0.00	0.00

Sample Type: Shelby Tube
Description: Fat CLAY

LL= 63 **PL=** 24 **PI=** 39
Assumed Specific Gravity= 2.75
Remarks:

Figure 2F-4

Client: HDR, Inc.

Project: Mullan Road

Source of Sample: SS-24 **Depth:** 6' - 8'

Proj. No.: 114-571120 **Date Sampled:** 8-25-17

DIRECT SHEAR TEST REPORT
Tetra Tech
Billings, MT

APPENDIX 2G

Summary of Laboratory Testing (Table 2.1.1)

Table 2.1.1
Montana Department of Highways (Form 111)

Summary of Laboratory Testing

Project Number STPS 263 - 1(28)6 / UPN 6141000 Designation West of Missoula - NW (Mullan Rd) Length 5.1 miles Date August 2017

Submitted by Tetra Tech Title Consultant County Missoula

Boring Number	Date Drilled	Northing (feet)	Easting (feet)	Elevation (feet)	Depth (feet)	Soil Class (MT 214)	LL (%)	PI (%)	10 Mesh (%)	40 Mesh (%)	200 Mesh (%)	In-place Density (pcf)	Percent Natural Moisture	Maximum Dry Density (pcf)	Percent Optimum Moisture	California Bearing Ratio	Depth to Water Table (feet)	Liquidity Index	Cc	Friction Angle	Cohesion (psf)
SS-1	6/19/2017				0.4 - 1.9								1				12.0				
SS-1	6/19/2017				0.5 - 3	A-1-a(1)	NV	NP	25	17	6						12.0	0.0			
SS-1	6/19/2017				4 - 5.5								1				12.0				
SS-1	6/19/2017				9 - 10.5								1				12.0				
SS-1	6/19/2017				14 - 15.5												12.0				
SS-2	6/19/2017				0.3 - 1.8								1				11.1				
SS-2	6/19/2017				0.4 - 1												11.1				
SS-2	6/19/2017				3 - 6	A-4(1)	27	7	79	73	50			116.1	14.1	11	11.1	0.4			
SS-2	6/19/2017				4 - 5.5								23				11.1				
SS-2	6/19/2017				9 - 9.9												11.1				
SS-2	6/19/2017				9.9 - 11.4								1				11.1				
SS-2	6/19/2017				14 - 15.5												11.1				
SS-3	6/19/2017				0.6 - 2.1								5				11.0				
SS-3	6/19/2017				0.7 - 4	A-1-a(0)	17	2	31	22	10			146.2	3.7	45	11.0	-5.0			
SS-3	6/19/2017				4 - 5.5								1				11.0				
SS-3	6/19/2017				9 - 9.4												11.0				
SS-3	6/19/2017				14 - 15.5												11.0				
SS-4	6/19/2017				0.6 - 2.1								7				10.0				
SS-4	6/19/2017				2 - 4												10.0				
SS-4	6/19/2017				4 - 5.4												10.0				
SS-4	6/19/2017				5.4 - 6.9								1				10.0				
SS-4	6/19/2017				9 - 10.5								4				10.0				
SS-4	6/19/2017				14 - 15.5												10.0				
SS-5	6/19/2017				0.7 - 2.2								3				8.0				
SS-5	6/19/2017				0.8 - 4	A-1-a(0)	17	1	38	29	12			139.7	5.1	13	8.0	-13.0			

Table 2.1.1
Montana Department of Highways (Form 111)

Summary of Laboratory Testing

Project Number STPS 263 - 1(28)6 / UPN 6141000 Designation West of Missoula - NW (Mullan Rd) Length 5.1 miles Date August 2017

Submitted by Tetra Tech Title Consultant County Missoula

Boring Number	Date Drilled	Northing (feet)	Easting (feet)	Elevation (feet)	Depth (feet)	Soil Class (MT 214)	LL (%)	PI (%)	10 Mesh (%)	40 Mesh (%)	200 Mesh (%)	In-place Density (pcf)	Percent Natural Moisture	Maximum Dry Density (pcf)	Percent Optimum Moisture	California Bearing Ratio	Depth to Water Table (feet)	Liquidity Index	Cc	Friction Angle	Cohesion (psf)
SS-5	6/19/2017				4 - 5.5								14				8.0				
SS-5	6/19/2017				9 - 10.5								5				8.0				
SS-5	6/19/2017				14 - 15.5												8.0				
SS-6	6/20/2017				0.7 - 2.2								1				6.5				
SS-6	6/20/2017				0.8 - 3												6.5				
SS-6	6/20/2017				4 - 5.5								19				6.5				
SS-6	6/20/2017				9 - 10.5												6.5				
SS-6	6/20/2017				14 - 15.0												6.5				
SS-7	6/20/2017				0.8 - 2.3								13				7.4				
SS-7	6/20/2017				4.5 - 6								2				7.4				
SS-7	6/20/2017				9 - 10.5												7.4				
SS-7	6/20/2017				14 - 15.5												7.4				
SS-8	6/20/2017				1 - 2.5								1				7.4				
SS-8	6/20/2017				1.5 - 4												7.4				
SS-8	6/20/2017				2 - 3.4												7.4				
SS-8	6/20/2017				4 - 5.5								12				7.4				
SS-8	6/20/2017				8 - 10.5												7.4				
SS-8	6/20/2017				9 - 10.5												7.4				
SS-8	6/20/2017				14 - 15.5												7.4				
SS-9	6/20/2017				0.8 - 2.3								12				6.1				
SS-9	6/20/2017				0.8 - 1.7												6.1				
SS-9	6/20/2017				3 - 7	A-4(0)	23	5	98	97	54			114.9	12.8	10	6.1	1.0			
SS-9	6/20/2017				4 - 5.5								23				6.1				
SS-9	6/20/2017				9 - 10.5												6.1				
SS-9	6/20/2017				14 - 15.5												6.1				

Table 2.1.1
Montana Department of Highways (Form 111)

Summary of Laboratory Testing

Project Number STPS 263 - 1(28)6 / UPN 6141000 Designation West of Missoula - NW (Mullan Rd) Length 5.1 miles Date August 2017

Submitted by Tetra Tech Title Consultant County Missoula

Boring Number	Date Drilled	Northing (feet)	Easting (feet)	Elevation (feet)	Depth (feet)	Soil Class (MT 214)	LL (%)	PI (%)	10 Mesh (%)	40 Mesh (%)	200 Mesh (%)	In-place Density (pcf)	Percent Natural Moisture	Maximum Dry Density (pcf)	Percent Optimum Moisture	California Bearing Ratio	Depth to Water Table (feet)	Liquidity Index	Cc	Friction Angle	Cohesion (psf)
SS-10	6/20/2017				0.8 - 2.3								11				6.3				
SS-10	6/20/2017				0.8 - 2	A-2-4(0)	23	6	64	58	32						6.3	-1.0			
SS-10	6/20/2017				4 - 6	A-4(0)	NV	NP	100	93	37	102.2	14				6.3	0.0	0.19	24.7	800
SS-10	6/20/2017				6 - 7.5								16				6.3				
SS-10	6/20/2017				9 - 10.5												6.3				
SS-10	6/20/2017				14 - 15.5												6.3				
SS-11	6/20/2017				0.9 - 2.4								8				6.2				
SS-11	6/20/2017				1 - 1.8												6.2				
SS-11	6/20/2017				4 - 5.5								4				6.2				
SS-11	6/20/2017				7 - 14	A-1-a(1)	NV	NP	23	17	6						6.2	0.0			
SS-11	6/20/2017				9 - 10.5												6.2				
SS-11	6/20/2017				14 - 15.5												6.2				
SS-12	6/21/2017				0.9 - 2.4								12				5.0				
SS-12	6/21/2017				1 - 1.4												5.0				
SS-12	6/21/2017				4 - 5.5								10				5.0				
SS-12	6/21/2017				9 - 10.5												5.0				
SS-12	6/21/2017				14 - 15.5												5.0				
SS-13	6/21/2017				0.8 - 2.3								18				7.0				
SS-13	6/21/2017				0.8 - 1.1												7.0				
SS-13	6/21/2017				4 - 5.5								25				7.0				
SS-13	6/21/2017				5.5 - 12												7.0				
SS-13	6/21/2017				9 - 10.5												7.0				
SS-13	6/21/2017				14 - 15.5												7.0				
SS-13	6/21/2017				19 - 20.2												7.0				
SS-13	6/21/2017				24 - 24.8												7.0				

Table 2.1.1
Montana Department of Highways (Form 111)

Summary of Laboratory Testing

Project Number STPS 263 - 1(28)6 / UPN 6141000 Designation West of Missoula - NW (Mullan Rd) Length 5.1 miles Date August 2017

Submitted by Tetra Tech Title Consultant County Missoula

Boring Number	Date Drilled	Northing (feet)	Easting (feet)	Elevation (feet)	Depth (feet)	Soil Class (MT 214)	LL (%)	PI (%)	10 Mesh (%)	40 Mesh (%)	200 Mesh (%)	In-place Density (pcf)	Percent Natural Moisture	Maximum Dry Density (pcf)	Percent Optimum Moisture	California Bearing Ratio	Depth to Water Table (feet)	Liquidity Index	Cc	Friction Angle	Cohesion (psf)
SS-14	6/21/2017				0.8-1.5								23				5.5				
SS-14	6/21/2017				3 - 9	A-4(4)	28	8	98	97	75			108.5	14.3	4	5.5	1.5			
SS-14	6/21/2017				4 - 5.5								32				5.5				
SS-14	6/21/2017				9 - 10.4												5.5				
SS-14	6/21/2017				10.4 - 11.9												5.5				
SS-14	6/21/2017				14 - 15.5												5.5				
SS-15	6/21/2017				0.7 - 2.2								5				7.8				
SS-15	6/21/2017				0.8 - 2	A-1-b(0)	17	2	53	46	20			137.6	5.5		7.8	-5.0			
SS-15	6/21/2017				4 - 5.0								2				7.8				
SS-15	6/21/2017				5 - 10												7.8				
SS-15	6/21/2017				9 - 10.5												7.8				
SS-15	6/21/2017				14 - 15.4												7.8				
SS-16	6/21/2017				0.8 - 2.3								17				12.0				
SS-16	6/21/2017				3 - 9	A-6(4)	29	13	93	90	57			111.1	12.6		12.0	0.5			
SS-16	6/21/2017				4 - 5.5								22				12.0				
SS-16	6/21/2017				9 - 10	A-7-6(17)	41	23	99	96	79	93.5	26				12.0	0.3		29.9	350
SS-16	6/21/2017				10 - 10.8												12.0				
SS-16	6/21/2017				14 - 15.5												12.0				
SS-16	6/21/2017				19 - 20.5												12.0				
SS-16	6/21/2017				24 - 25.5												12.0				
SS-17	6/22/2017				0.5 - 2								6				13.4				
SS-17	6/22/2017				0.6 - 1.2												13.4				
SS-17	6/22/2017				1.2 - 5	A-1-b	18	3	46	36	19			136.6	6.0		13.4	-2.0			
SS-17	6/22/2017				4 - 5.5								12				13.4				
SS-17	6/22/2017				9 - 10.5								2				13.4				

Table 2.1.1
Montana Department of Highways (Form 111)

Summary of Laboratory Testing

Project Number STPS 263 - 1(28)6 / UPN 6141000 Designation West of Missoula - NW (Mullan Rd) Length 5.1 miles Date August 2017

Submitted by Tetra Tech Title Consultant County Missoula

Boring Number	Date Drilled	Northing (feet)	Easting (feet)	Elevation (feet)	Depth (feet)	Soil Class (MT 214)	LL (%)	PI (%)	10 Mesh (%)	40 Mesh (%)	200 Mesh (%)	In-place Density (pcf)	Percent Natural Moisture	Maximum Dry Density (pcf)	Percent Optimum Moisture	California Bearing Ratio	Depth to Water Table (feet)	Liquidity Index	Cc	Friction Angle	Cohesion (psf)
SS-17	6/22/2017				14 - 15.5												13.4				
SS-18	6/22/2017				0.7 - 2.2								12				11.0				
SS-18	6/22/2017				0.8 - 1.3												11.0				
SS-18	6/22/2017				1.3 - 4.5	A-4(0)	18	2	98	90	38						11.0	-2.5			
SS-18	6/22/2017				4 - 5.5								10				11.0				
SS-18	6/22/2017				9 - 10.5								9				11.0				
SS-18	6/22/2017				14 - 15.5												11.0				
SS-19	6/22/2017				0.7 - 2.2								13				10.6				
SS-19	6/22/2017				1.3 - 3.5												10.6				
SS-19	6/22/2017				4 - 5.4								2				10.6				
SS-19	6/22/2017				9 - 10.5								10				10.6				
SS-19	6/22/2017				14 - 15.5												10.6				
SS-20	6/22/2017				0.6 - 1												12.5				
SS-20	6/22/2017				0.8 - 2.3								6				12.5				
SS-20	6/22/2017				3.5 - 6												12.5				
SS-20	6/22/2017				4 - 5.5								6				12.5				
SS-20	6/22/2017				9 - 10.5								5				12.5				
SS-20	6/22/2017				14 - 15.5												12.5				
SS-21	6/22/2017				0.6 - 2.2												10.7				
SS-21	6/22/2017				0.7 - 2.2								5				10.7				
SS-21	6/22/2017				4 - 5.5								1				10.7				
SS-21	6/22/2017				5 - 10	A-1-a(0)	16	1	16	12	5						10.7	-13.0			
SS-21	6/22/2017				9 - 10.5								3				10.7				
SS-21	6/22/2017				14 - 15.5												10.7				

Table 2.1.1
Montana Department of Highways (Form 111)

Summary of Laboratory Testing

Project Number STPS 263 - 1(28)6 / UPN 6141000 Designation West of Missoula - NW (Mullan Rd) Length 5.1 miles Date August 2017

Submitted by Tetra Tech Title Consultant County Missoula

Boring Number	Date Drilled	Northing (feet)	Easting (feet)	Elevation (feet)	Depth (feet)	Soil Class (MT 214)	LL (%)	PI (%)	10 Mesh (%)	40 Mesh (%)	200 Mesh (%)	In-place Density (pcf)	Percent Natural Moisture	Maximum Dry Density (pcf)	Percent Optimum Moisture	California Bearing Ratio	Depth to Water Table (feet)	Liquidity Index	Cc	Friction Angle	Cohesion (psf)
SS-22	6/22/2017				0.6 - 2.1								9				11.3				
SS-22	6/22/2017				1.1 - 4	A-4(0)	18	2	93	89	40						11.3	-3.5			
SS-22	6/22/2017				4 - 5.5								18				11.3				
SS-22	6/22/2017				6 - 8	A-6(7)	33	15	100	98	63	102.7	18				11.3	0.0	0.1	30.9	400
SS-22	6/22/2017				9 - 10.5								3				11.3				
SS-22	6/22/2017				14 - 15.5												11.3				
SS-23	6/22/2017				0.9 - 2.4								3				12.5				
SS-23	6/22/2017				4 - 5.5								25				12.5				
SS-23	6/22/2017				6 - 9												12.5				
SS-23	6/22/2017				9 - 10.5								33				12.5				
SS-23	6/22/2017				14 - 15.5												12.5				
SS-23	6/22/2017				19 - 20.5												12.5				
SS-23	6/22/2017				24 - 25.4												12.5				
SS-24	6/23/2017				0.8 - 1.6	A-1-a(0)	17	2	40	30	13			140.0	5.8		NE	-3.0			
SS-24	6/23/2017				0.8 - 2.3								9				NE				
SS-24	6/23/2017				2 - 5	A-6(8)	34	14	92	90	68			105.3	17.6		NE	-1.1			
SS-24	6/23/2017				4 - 5.5								22				NE				
SS-24	6/23/2017				6 - 8	A-7-6(44)	63	39	100	100	98	97.7	28				NE	0.1		9.8	370
SS-24	6/23/2017				9 - 10.5								19				NE				
SS-24	6/23/2017				14 - 15.5								3				NE				
SS-25	6/23/2017				0.8 - 2.3								11				NE				
SS-25	6/23/2017				1 - 4												NE				
SS-25	6/23/2017				3 - 6												NE				
SS-25	6/23/2017				4 - 5.5								41				NE				
SS-25	6/23/2017				9 - 10.5								7				NE				
SS-25	6/23/2017				14 - 15.5								4				NE				

Table 2.1.1
Montana Department of Highways (Form 111)

Summary of Laboratory Testing

Project Number STPS 263 - 1(28)6 / UPN 6141000 Designation West of Missoula - NW (Mullan Rd) Length 5.1 miles Date August 2017

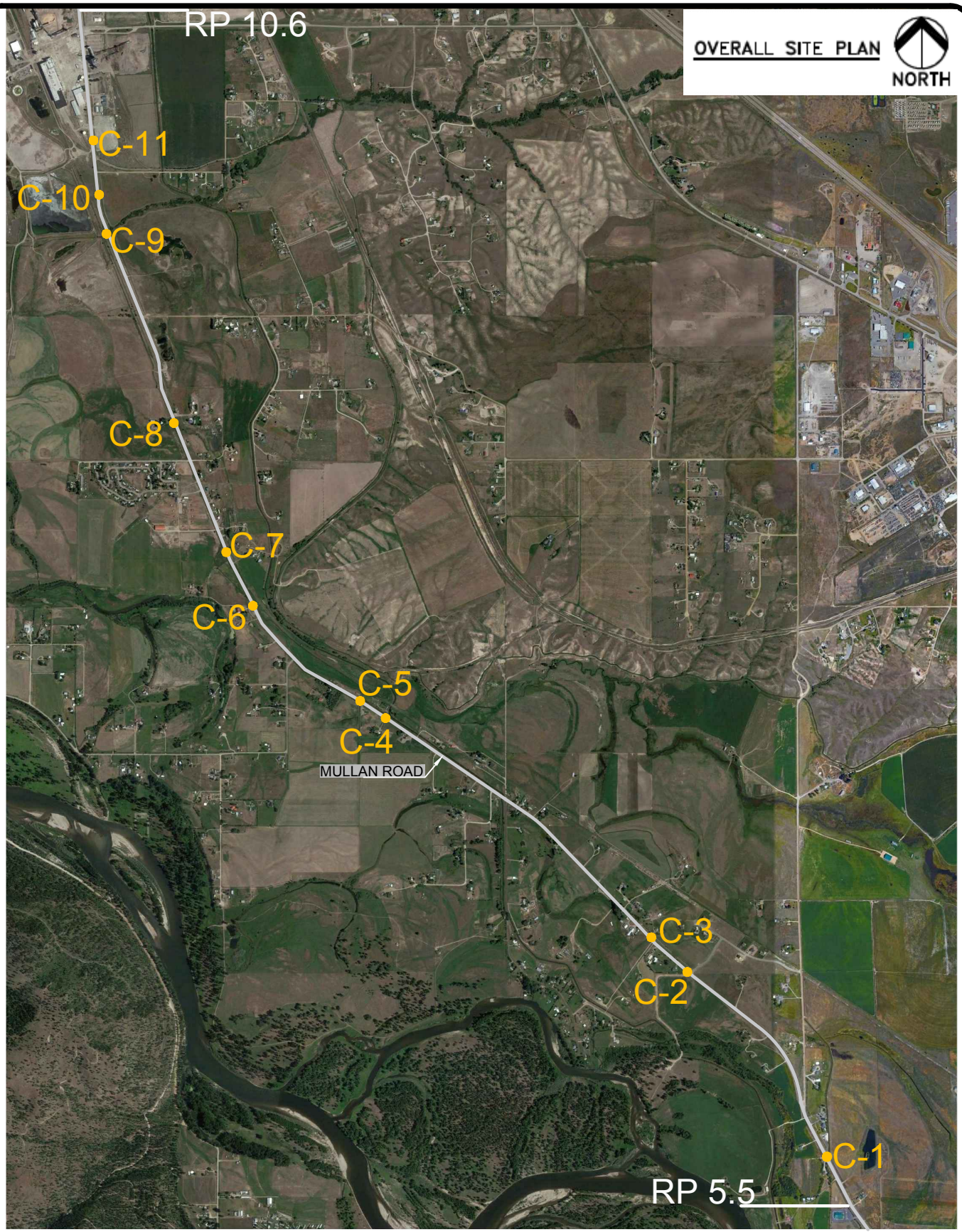
Submitted by Tetra Tech Title Consultant County Missoula

Boring Number	Date Drilled	Northing (feet)	Easting (feet)	Elevation (feet)	Depth (feet)	Soil Class (MT 214)	LL (%)	PI (%)	10 Mesh (%)	40 Mesh (%)	200 Mesh (%)	In-place Density (pcf)	Percent Natural Moisture	Maximum Dry Density (pcf)	Percent Optimum Moisture	California Bearing Ratio	Depth to Water Table (feet)	Liquidity Index	Cc	Friction Angle	Cohesion (psf)
SS-26	6/23/2017				0.9 - 1.7								1				NE				
SS-26	6/23/2017				1 - 1.5												NE				
SS-26	6/23/2017				1.5 - 4	A-2-6(0)	30	13	17	15	12						NE	-1.2			
SS-26	6/23/2017				4 - 5.5								22				NE				
SS-26	6/23/2017				4.1 - 6	A-7-6(19)	46	27	95	91	73						NE	0.1			
SS-26	6/23/2017				9 - 10.5								2				NE				
SS-26	6/23/2017				14 - 15.5								1				NE				

APPENDIX 2H

Culvert Locations (Figure 2H-1)

Culvert Drainage Evaluation Form
and Culvert Condition Form (Table 2H-1)



TETRA TECH
www.tetratech.com
2525 Palmer St. Suite 2
Missoula, MT 59808
Phone: (406) 543-3045

Client: HDR, Inc.

West of Missoula - NW (Mullan Road)
RP 5.5 to RP 10.6
Missoula, MT
CULVERT LOCATIONS

Project No.:	STPS 263 - 1(28)6
Date:	October 2017
Drawn By:	A. Hotaling

Drawing Number
2H-1

Table 2H-1
CULVERT INSPECTION REPORT

DATE: 6/30/2017
PROJECT: West of Missoula - NW (Mullan Road) MDT PROJECT NUMBER: STPS 263 - 1(28)6 UPN: 6141000

INSPECTED BY: Tetra Tech, Inc. TETRA TECH PROJECT NO: 114-571120
DATE(S): June 29 and 30, 2017

Culvert Location	Approximate Location	Culvert Condition	Culvert Diameter (inches)	Culvert Type *	Photo at Invert of Pipe	Observed Flow Condition	Comments
C1		Good	48 - 36	PCC	Yes	3/4 full	48" inlet and 36" outlet. Concrete aprons on both ends of culvert. Debris gate located at inlet.
C2		Poor	36	CSP	Yes	None	3/4 full of sediment. Ends of culvert damaged and collapsed.
C3		Fair - Poor	12	Solid Steel	Yes	None	12" solid steel pipe. On the south side of the embankment there was a 24" CSP around the 12" steel pipe. The 24" CSP ended or was collapsed approximately 4 feet into the embankment. 2" of sediment in pipe.
C4		Poor	24	PCC	Yes	None	Both ends blocked with debris and sediment. 1/4 - 1/2 full of sediment. Cracks in concrete.
C5		Good	36	PCC	Yes	Full - 3" above top of culvert	Irrigation canal crossing under road. Concrete aprons on both ends of culvert. Water levels 3.3 feet deep at inlet and outlet.
C6		Good	36	CSP	Yes	1/2 Full	Irrigation canal crossing under road. Ends of pipe are bent.
C7		Good	36	CSP	Yes	1/2 Full	Irrigation canal crossing under road.
C8		Good	32	CSP	Yes	None	1/4 full of sediment. Wetland vegetation at both ends of pipe. Depression on west side of road over top of culvert. Depression filled with asphalt.
C9		Good - Fair	36	CSP	Yes	1/8 - 1/4 Full	3 CSP pipes at O'Keefe Creek crossing. 1" of sediment in pipe. Bottom of center pipe damaged at outlet. Center pipe was 1/4 full, outside pipes were 1/8 full.
C10		Fair	24	CSP	Yes	None	Collapsed on west end. Standing water in pipe near middle of pipe.
C11		Poor	24	CSP	Yes	None	Collapsed. 1/2 full of sediment. Transverse crack in asphalt pavement directly above pipe location.

CSP: Corregated Steel Pipe
PCC: Potland Cement Concrete
PVC: Plastic

DRAINAGE EVALUATION FORM
MT 207

This form should be submitted with each soil survey. Each area of concern on the project should be noted.

Project No. STPS 263 - 1(28)6 Designation: Mullan Road

Date 6/29/2017 Submitted by: Tetra Tech, Inc. - Aric Hotaling

Station(s) RP 5.5 - RP 7.9

Are the ditch lines clear of standing water? Yes.

Are the ditch lines and pavement edges free from weed growth that may indicate a moisture concentration? Yes.

After a rain,

a) Is there moisture standing in the joints or cracks?

b) Is there any evidence of pumping?

c) Is there water standing at the outer edge of the shoulder?

d) Is there evidence that the water may pond on the shoulder?

Are joint sealants or crack sealants in good condition and preventing water from entering the pavement?

Recent overlay from RP 5.8 to RP 7.9, RP 5.5 to RP 5.8 had some cracking with no sealant.

Are the cross drainage conduits closed by debris? Culverts near RP 7.8 and RP 6.5 were blocked by sediment and debris. The culvert near RP 5.7 had a debris grate that was full, but still allowing water to flow.

AC Pavements

Is there moisture related distress evident such as; Stripping, Rutting, Cracking in Wheelpath, Shoulder Dropoff/Heave, Pumping, Water Bleeding, Swelling?

Recent overlay from RP 5.8 to RP 7.9.

RP 5.5 to RP 5.8 showed little to no signs of moisture related distress.

PCC Pavements

Is there moisture related distress evident such as; Pumping, Faulting, Corner Break, D-Cracking, Edge Joint Opening, Shoulder Dropoff/Heave, Punchout (CRCP only), Swelling, Slab Cracking?

N/A

Is there evidence of springs and excessively wet areas? No, with the exception of the irrigation canal intersecting the road near RP 5.7.

Are there slides or slumps noted along the alignment? No.

Specific surface/subsurface drainage recommendations

DRAINAGE EVALUATION FORM
MT 207

This form should be submitted with each soil survey. Each area of concern on the project should be noted.

Project No. STPS 263 - 1(28)6 Designation: Mullan Road

Date 6/29/2017 Submitted by: Tetra Tech, Inc. - Aric Hotaling

Station(s) RP 7.9 - RP 9

Are the ditch lines clear of standing water? Irrigation canals parallel roadway.

Are the ditch lines and pavement edges free from weed growth that may indicate a moisture concentration? Due to irrigation canals parallel to road and crossing under road, there is higher vegetation growth in this section.

After a rain,

a) Is there moisture standing in the joints or cracks?

b) Is there any evidence of pumping?

c) Is there water standing at the outer edge of the shoulder?

d) Is there evidence that the water may pond on the shoulder?

Are joint sealants or crack sealants in good condition and preventing water from entering the pavement?

Recent overlay from RP 7.9 to RP 9.

Are the cross drainage conduits closed by debris? No.

AC Pavements

Is there moisture related distress evident such as; Stripping, Rutting, Cracking in Wheelpath, Shoulder Dropoff/Heave, Pumping, Water Bleeding, Swelling?

Recent overlay from RP 7.9 to RP 9.

PCC Pavements

Is there moisture related distress evident such as; Pumping, Faulting, Corner Break, D-Cracking, Edge Joint Opening, Shoulder Dropoff/Heave, Punchout (CRCP only), Swelling, Slab Cracking?

N/A

Is there evidence of springs and excessively wet areas? Yes, due to irrigation canals parallel to road and crossing under road, there are multiple wet areas. A lower wetland area was observed between RP 7.9 and RP 8.4. The record water table from the soil survey was approximately 5 to 8 feet across the section.

Are there slides or slumps noted along the alignment? No.

Specific surface/subsurface drainage recommendations

DRAINAGE EVALUATION FORM
MT 207

This form should be submitted with each soil survey. Each area of concern on the project should be noted.

Project No. STPS 263 - 1(28)6 Designation: Mullan Road

Date 6/29/2017 Submitted by: Tetra Tech, Inc. - Aric Hotaling

Station(s) RP 9 - RP 10.6

Are the ditch lines clear of standing water? Yes, O'Keefe Creek crosses under road near RP 9.8.

Are the ditch lines and pavement edges free from weed growth that may indicate a moisture concentration? Yes

After a rain,

a) Is there moisture standing in the joints or cracks?

b) Is there any evidence of pumping?

c) Is there water standing at the outer edge of the shoulder?

d) Is there evidence that the water may pond on the shoulder?

Are joint sealants or crack sealants in good condition and preventing water from entering the pavement?

Recent overlay from RP 9 to RP 10, RP 10 to RP 10.6 had cracking with no sealant.

Are the cross drainage conduits closed by debris? Culvert near RP 10.2 blocked and damaged.

AC Pavements

Is there moisture related distress evident such as; Stripping, Rutting, Cracking in Wheelpath, Shoulder Dropoff/Heave, Pumping, Water Bleeding, Swelling?

Recent overlay from RP 9 to RP 10.

RP 10 to RP 10.6 showed little to no signs of moisture related distress.

PCC Pavements

Is there moisture related distress evident such as; Pumping, Faulting, Corner Break, D-Cracking, Edge Joint Opening, Shoulder Dropoff/Heave, Punchout (CRCP only), Swelling, Slab Cracking?

N/A

Is there evidence of springs and excessively wet areas? No, with the exception of O'Keefe Creek.

O'Keefe Creek crosses under road near RP 9.8.

Are there slides or slumps noted along the alignment? No.

Specific surface/subsurface drainage recommendations

APPENDIX 2I

Culvert Design Life Spreadsheet (Table 2I-1)
With Culvert Lab Results from
Tetra Tech and Energy Laboratory

Table 2I-1

PROJECT NAME WEST OF MISSOULA - NW (MULLAN ROAD) - ACTIVITY 106 Page 1 PLFSPLIT - Revised Aug. '00
PROJECT NUMBER :STPS 263 - 1(28)6 UPN: 6141000 PIPE LIFE SUMMARY
DATE 8/7/2017 As-Builts:
DESIGNER Tetra Tech, Inc. Year:

Note: Steel and aluminum pipes not available in all sizes and thicknesses. Check Chapter 9 or Fill Height Tables for availability and suitability.

STATION		Pipe	Required	Marble	pH	Conductivity	Resistivity	Sulfates	Fill Height	Galvanized Steel				Type II Aluminized Steel				Aluminum				Concrete Pipe	
Pipe	Soil Sample	Size (mm	Life (yrs)	pH		mMHOS	OHMS	%	(m)	Gage	Actual Life	Adjusted Life	Coating	Gage	Actual Life	Adjusted Life	Coating	Gage	Actual Life	Adjusted Life	OK to Use?	Cement	Coating / Wall Type
C1	C1	1219	75	8.2	8.4	0.24	4200	0.00	0.0	16 - 1.63	90	90	None	16 - 1.63	90	135	None	16 - 1.52	90	234	Yes	Type II	None / B Wall
										14 - 2.01		117	None	14 - 2.01		162	None	14 - 1.91		261			
										12 - 2.77		144	None	12 - 2.77		189	None	12 - 2.67		315			
										10 - 3.51		198	None	10 - 3.51		243	None	10 - 3.43		369			
										8 - 4.27		252	None	8 - 4.27		297	None	8 - 4.17		423			
C2	C2	914	75	7.9	7.7	0.50	2000	0.00	0.0	16 - 1.63	66	66	Note 1	16 - 1.63	66	100	None	16 - 1.52	66	172	Yes	Type II	None / B Wall
				See						14 - 2.01		86	Note 1	14 - 2.01		119	None	14 - 1.91		192			
				Note 2						12 - 2.77		106	Note 1	12 - 2.77		139	None	12 - 2.67		232			
				Below						10 - 3.51		146	Note 1	10 - 3.51		179	None	10 - 3.43		272			
										8 - 4.27		186	Note 1	8 - 4.27		219	None	8 - 4.17		312			
C3	C3	305	75	8.0	8.0	0.91	1100	0.00	0.0	16 - 1.63	52	52	Note 1	16 - 1.63	52	78	None	16 - 1.52	52	135	Yes	Type II	None / B Wall
										14 - 2.01		67	Note 1	14 - 2.01		93	None	14 - 1.91		151			
										12 - 2.77		83	Note 1	12 - 2.77		109	None	12 - 2.67		182			
										10 - 3.51		114	Note 1	10 - 3.51		140	None	10 - 3.43		213			
										8 - 4.27		145	Note 1	8 - 4.27		171	None	8 - 4.17		244			
C4	C4	610	75	8.3	8.3	0.53	1900	0.00	0.0	16 - 1.63	65	65	Note 1	16 - 1.63	65	97	None	16 - 1.52	65	169	Yes	Type II	None / B Wall
										14 - 2.01		84	Note 1	14 - 2.01		117	None	14 - 1.91		188			
										12 - 2.77		104	Note 1	12 - 2.77		136	None	12 - 2.67		227			
										10 - 3.51		143	Note 1	10 - 3.51		175	None	10 - 3.43		266			
										8 - 4.27		182	Note 1	8 - 4.27		214	None	8 - 4.17		305			
C5	C5	914	75	8.0	8.0	0.44	2250	0.00	0.0	16 - 1.63	70	70	None	16 - 1.63	70	104	None	16 - 1.52	70	181	Yes	Type II	None / B Wall
										14 - 2.01		91	None	14 - 2.01		125	None	14 - 1.91		202			
										12 - 2.77		111	None	12 - 2.77		146	None	12 - 2.67		244			
										10 - 3.51		153	None	10 - 3.51		188	None	10 - 3.43		285			
										8 - 4.27		195	None	8 - 4.27		230	None	8 - 4.17		327			
C6	C6	914	75	8.1	8.1	0.77	1300	0.00	0.0	16 - 1.63	56	56	Note 1	16 - 1.63	56	83	None	16 - 1.52	56	145	Yes	Type II	None / B Wall
										14 - 2.01		72	Note 1	14 - 2.01		100	None	14 - 1.91		161			
										12 - 2.77		89	Note 1	12 - 2.77		117	None	12 - 2.67		195			
										10 - 3.51		122	Note 1	10 - 3.51		150	None	10 - 3.43		228			
										8 - 4.27		156	Note 1	8 - 4.27		183	None	8 - 4.17		261			
C7	C7	914	75	7.5	7.7	0.59	1700	0.06	0.0	16 - 1.63	62	62	Note 1	16 - 1.63	62	93	None	16 - 1.52	62	161	Yes	Type II	None / B Wall
										14 - 2.01		81	Note 1	14 - 2.01		112	None	14 - 1.91		180			
										12 - 2.77		99	Note 1	12 - 2.77		130	None	12 - 2.67		217			
										10 - 3.51		137	Note 1	10 - 3.51		168	None	10 - 3.43		254			
										8 - 4.27		174	Note 1	8 - 4.27		205	None	8 - 4.17		292			
C8	C8	813	75	7.6	7.6	0.50	2000	0.01	0.0	16 - 1.63	66	66	Note 1	16 - 1.63	66	100	None	16 - 1.52	66	172	Yes	Type II	None / B Wall
										14 - 2.01		86	Note 1	14 - 2.01		119	None	14 - 1.91		192			
										12 - 2.77		106	Note 1	12 - 2.77		139	None	12 - 2.67		232			
										10 - 3.51		146	Note 1	10 - 3.51		179	None	10 - 3.43		272			
										8 - 4.27		186	Note 1	8 - 4.27		219	None	8 - 4.17		312			
C9	C9	914	75	7.5	7.8	0.38	2600	0.00	0.0	16 - 1.63	74	74	None	16 - 1.63	74	111	None	16 - 1.52	74	192	Yes	Type II	None / B Wall
										14 - 2.01		96	None	14 - 2.01		133	None	14 - 1.91		214			
										12 - 2.77		118	None	12 - 2.77		155	None	12 - 2.67		259			
										10 - 3.51		163	None	10 - 3.51		199	None	10 - 3.43		303			
										8 - 4.27		207	None	8 - 4.27		244	None	8 - 4.17		347			
C10	C10	610	75	7.6	7.4	0.51	1950	0.00	0.0	16 - 1.63	66	66	Note 1	16 - 1.63	66	98	None	16 - 1.52	66	171	Yes	Type II	None / B Wall
				See						14 - 2.01		85	Note 1	14 - 2.01		118	None	14 - 1.91		190			
				Note 2						12 - 2.77		105	Note 1	12 - 2.77		138	None	12 - 2.67		230			
				Below						10 - 3.51		144	Note 1	10 - 3.51		177	None	10 - 3.43		269			
										8 - 4.27		184	Note 1	8 - 4.27		217	None	8 - 4.17		309			
C11	C11	610	75	8.2	8.7	0.16	6100	0.00	0.0	16 - 1.63	105	105	Note 1	16 - 1.63	105	105	Note 5	16 - 1.52	Don't Use		Yes	Type II	None / B Wall
										14 - 2.01		136	Note 1	14 - 2.01		136	Note 5	14 - 1.91					
										12 - 2.77		168	Note 1	12 - 2.77		168	Note 5	12 - 2.67					
										10 - 3.51		231	Note 1	10 - 3.51		231	Note 5	10 - 3.43					
										8 - 4.27		293	Note 1	8 - 4.27		293	Note 5	8 - 4.17					

DESIGN SERVICE LIFE: New or Replacement Pipes
- Field Approach - 40 yrs.
- Mainline / Major Approach - 75 yrs.
- Storm Drains - 75 yrs.

Overlay / Minor Widening
- All In-place Pipes - 20 yrs.

Reconstruct / Major Widening
- In-place Pipes - 25 to 50 yrs. (See Chapter 9)

NOTE 1: Use approved bituminous or polymeric coating.
NOTE 2: Marble pH >pH by 0.2 or more. Use approved bituminous or polymeric coating on steel pipe.
NOTE 3: Where sulfate between 0.25% and 1.0%, use Type 5 cement. Where sulfate >1.0%, use either bituminous coating or "C Wall" pipe.
NOTE 4: Use Type 5 cement and either bituminous coating or "C Wall" pipe.
NOTE 5: Use approved bituminous coating. No gage reduction allowed for use of Type II aluminized steel in place of galvanized steel.

APPENDIX 2J

Culvert and Pavement Project Pictures (Photos 1 through 48)

Culvert Inspection Photographs
Preliminary Materials and Geotechnical Report
West of Missoula – NW (Mullan Road), STPS 263 - 1(28)6 / UPN 6141000
Tetra Tech Project # 114-571120

PHOTOGRAPH 1 Culvert C1 inlet, southwest side Mullan Road, RP 5.7.

PHOTOGRAPH 2 Culvert C1 outlet northeast side Mullan Road, RP 5.7.

PHOTOGRAPH 3 Culvert C1 outlet, looking downstream, RP 5.7.

PHOTOGRAPH 4 Mullan Road near Culvert C1, RP 5.7.

PHOTOGRAPH 5 Culvert C2 outlet, north side Mullan Road, RP 6.4.

PHOTOGRAPH 6 Culvert C2 inlet, south side Mullan Road, RP 6.4.

Culvert Inspection Photographs
Preliminary Materials and Geotechnical Report
West of Missoula – NW (Mullan Road), STPS 263 - 1(28)6 / UPN 6141000
Tetra Tech Project # 114-571120

PHOTOGRAPH 7 Looking east down Mullan Road across culvert C2 location, RP 6.4

PHOTOGRAPH 8 Culvert C2 outlet, RP 6.4.

PHOTOGRAPH 9 Culvert C3 inlet, south side Mullan Road, RP 6.6.

PHOTOGRAPH 10 Culvert C3 outlet, north side Mullan Road, RP 6.6.

PHOTOGRAPH 11 Looking through Culvert C3, RP 6.6.

PHOTOGRAPH 12 Culvert C3, looking to the south at inlet, RP 6.6.

Culvert Inspection Photographs
Preliminary Materials and Geotechnical Report
West of Missoula – NW (Mullan Road), STPS 263 - 1(28)6 / UPN 6141000
Tetra Tech Project # 114-571120

PHOTOGRAPH 13 Asphalt near culvert C3, RP 6.6.

PHOTOGRAPH 14 Culvert C4, inlet north side Mullan Road, RP 7.8.

PHOTOGRAPH 15 Culvert C4, outlet south side Mullan Road, RP 7.8.

PHOTOGRAPH 16 Crack in concrete at C4 outlet, RP 7.8.

PHOTOGRAPH 17 Looking through culvert C4, RP 7.8.

PHOTOGRAPH 18 Asphalt near culvert C4, RP 7.8.

Culvert Inspection Photographs
Preliminary Materials and Geotechnical Report
West of Missoula – NW (Mullan Road), STPS 263 - 1(28)6 / UPN 6141000
Tetra Tech Project # 114-571120

PHOTOGRAPH 19 Culvert C5, inlet north side Mullan Road, RP 7.85.

PHOTOGRAPH 20 Looking upstream from culvert C5 inlet, RP 7.85.

PHOTOGRAPH 21 Culvert C5, outlet south side Mullan Road, RP 7.85.

PHOTOGRAPH 22 Looking downstream from culvert C5 outlet, RP 7.85.

PHOTOGRAPH 23 Asphalt near culvert C5, RP 7.85.

PHOTOGRAPH 24 Culvert C6 inlet, east side Mullan Road, RP 8.4

Culvert Inspection Photographs
Preliminary Materials and Geotechnical Report
West of Missoula – NW (Mullan Road), STPS 263 - 1(28)6 / UPN 6141000
Tetra Tech Project # 114-571120

PHOTOGRAPH 25 Culvert C6 outlet, west side Mullan Road, RP 8.4.

PHOTOGRAPH 26 Looking through culvert C6, RP 8.4.

PHOTOGRAPH 27 Looking north along Mullan Road across culvert C6, RP 8.4.

PHOTOGRAPH 28 Culvert C7 inlet, west side Mullan Road, RP 8.5.

PHOTOGRAPH 29 Culvert C7 outlet, east side Mullan Road, RP 8.5.

PHOTOGRAPH 30 Looking through culvert C7, RP 8.5.

Culvert Inspection Photographs
Preliminary Materials and Geotechnical Report
West of Missoula – NW (Mullan Road), STPS 263 - 1(28)6 / UPN 6141000
Tetra Tech Project # 114-571120

PHOTOGRAPH 31 Asphalt near culvert C7, RP 8.5.

PHOTOGRAPH 32 Culvert C8 inlet, east side Mullan Road, RP 9.1.

PHOTOGRAPH 33 Culvert C8 outlet, west side Mullan Road, RP 9.1.

PHOTOGRAPH 34 Looking through culvert C8, RP 9.1.

PHOTOGRAPH 35 Pavement depression over culvert C8 outlet, RP 9.1.

PHOTOGRAPH 36 Culvert C9 inlet, east side Mullan Road, RP 9.8.

Culvert Inspection Photographs
Preliminary Materials and Geotechnical Report
West of Missoula – NW (Mullan Road), STPS 263 - 1(28)6 / UPN 6141000
Tetra Tech Project # 114-571120

PHOTOGRAPH 37 Culvert C9 outlet, west side Mullan Road, RP 9.8.

PHOTOGRAPH 38 Looking north down west side of Mullan Road across culvert C9 outlet, RP 9.8.

PHOTOGRAPH 39 Looking through middle culvert C9, RP 9.8.

PHOTOGRAPH 40 Asphalt near culvert C9, RP 9.8.

PHOTOGRAPH 41 Culvert C10 inlet, west side Mullan Road, RP 10.

PHOTOGRAPH 42 Culvert C10 outlet, east side Mullan Road, RP 10.

Culvert Inspection Photographs
Preliminary Materials and Geotechnical Report
West of Missoula – NW (Mullan Road), STPS 263 - 1(28)6 / UPN 6141000
Tetra Tech Project # 114-571120

PHOTOGRAPH 43 Looking south down west side of Mullan Road, RP 10.

PHOTOGRAPH 44 Looking through culvert C10, RP 10.

PHOTOGRAPH 45 Asphalt near culvert C10, RP 10.

PHOTOGRAPH 46 Culvert C11 inlet, west side Mullan Road, RP 10.2.

PHOTOGRAPH 47 Culvert C11 inlet, west side Mullan Road, RP 10.2.

PHOTOGRAPH 48 Crack in asphalt over top of culvert C11, RP 10.2.

APPENDIX 3A

MDT Backcalculated Pavement Section Modulus data

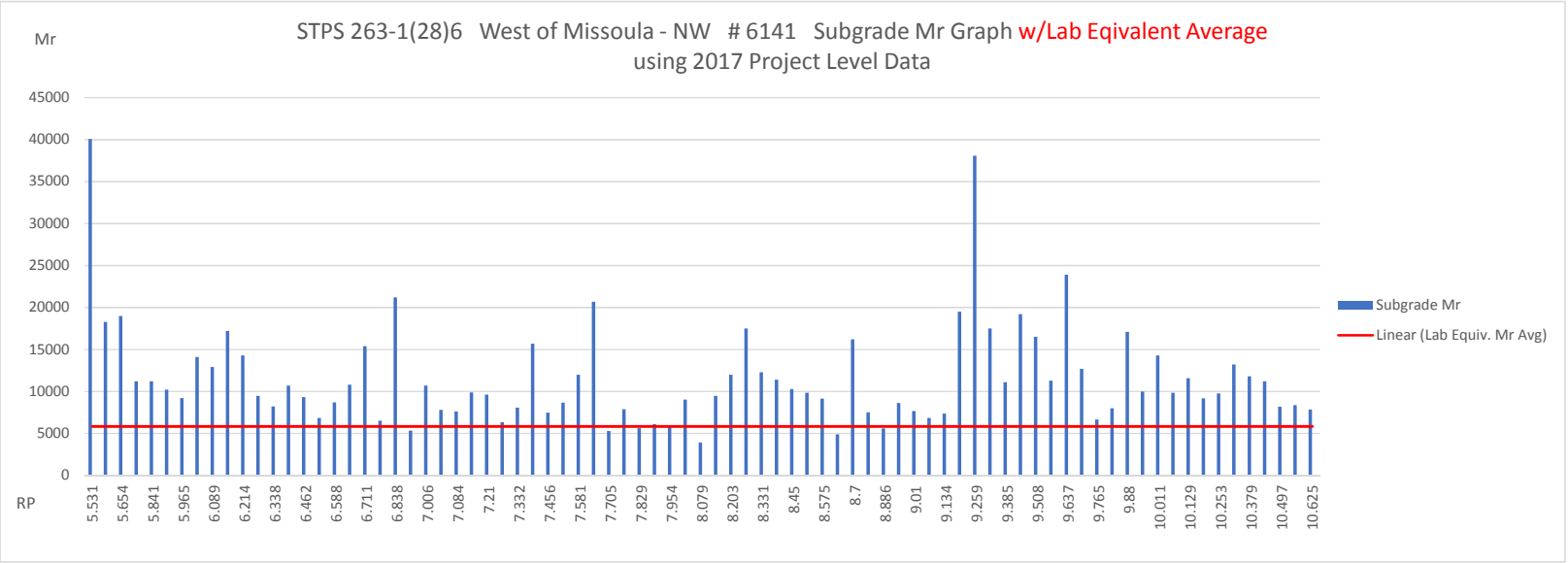


Figure 3A-1. Backcalculated Subgrade Modulus Values obtained from MDT Surfacing Section.

Montana Department of Transportation
Helena, Montana 59620

Memorandum

To: Fred Bente
Helena Consultant Design
Consultant Project Supervisor

From: Becky Duke, Supervisor
Traffic Data Collection & Analysis Section

Date: August 10, 2017

Subject: STPS 263-1(28)6
West of Missoula - NW
Control No. 6141

Attached is the traffic information requested in an email dated August 7, 2017. There are no major traffic breaks within the project. Please note that the equivalency factors used to calculate ESAL values are determined using information from our weigh-in-motion sites and reflect a five-year average.

If you have any questions or need further assistance, please contact me at 6122.

CC: Pavement Analysis and Research - Helena
Project File

RAIL TRANSIT AND PLANNING DIVISION
TRAFFIC DATA COLLECTION SECTION
Worksheet for Engineering and Planning Purposes

Project Description: Minor Flexible
STPS 263-1(28)6
West of Missoula - NW
UPN: 6141
S-263: RP 005+0.500 to 010+0.600

Date: 10-Aug-17

2017	AADT= **1,670**	PRESENT		
2021	AADT= **1,770**	LETTING YEAR		
2041	AADT= **2,390**	DESIGN YEAR		
	DHV= **250**			
	D=			
	T= **7.7%**			
	ESAL= **77**			
	AGR= **1.5%**			

*Truck Distribution**

5	9.7 %	0.7 %
6	16.6 %	1.3 %
7	4.1 %	0.3 %
8	9.0 %	0.7 %
9	46.9 %	3.6 %
10	0.7 %	0.1 %
11	9.7 %	0.7 %
12	0.0 %	0.0 %
13	3.5 %	0.3 %
	100.0 %	7.7 %

2016

AADT*=	1,640	
BUS=	1.5%	25
COM=	7.7%	126
AGR=	1.5%	
K Factor=	10.40%	

* Distribution: 2016 Vehicle Class count (Site ID: 32-3A-036)

* AADT & Growth Rate: 2016 TYC

PROJECT DESCRIPTION: STPS 263-1(28)6
West of Missoula - NW
UPN: 6141

DATE: 10-Aug-17

PAVEMENT: RIGID:
FLEXIBLE: X

LETTING YEAR AADT: 1,770 LETTING YEAR 2021
DESIGN YEAR AADT: 2,390 DESIGN YEAR 2041

LANE DESIGN FACTOR: 100 %

VEHICLE TYPE	% OF TYPE	LETTING YEAR ADT	DESIGN YEAR ADT	MEAN YEAR ADT	DIRECTIONAL ADT	DESIGN LANE ADT	18K EQUIV RATE FAC	MEAN YEAR ADL
CLASS 1 & 2	46.0	814.20	1099.4	956.8	478.4	478.4	0.007	3.14
CLASS 3	44.8	792.96	1070.7	931.8	465.9	465.9	0.004	1.77
CLASS 4	1.5	26.98	36.4	31.7	15.9	15.9	0.55278	8.76
CLASS 5	0.7	13.14	17.7	15.4	7.7	7.7	0.13246	1.02
CLASS 6	1.3	22.51	30.4	26.4	13.2	13.2	0.48572	6.42
CLASS 7	0.3	5.63	7.6	6.6	3.3	3.3	0.83396	2.76
CLASS 8	0.7	12.20	16.5	14.3	7.2	7.2	0.32904	2.36
CLASS 9	3.6	63.78	86.1	74.9	37.5	37.5	1.06434	39.89
CLASS 10	0.1	0.94	1.3	1.1	0.6	0.6	0.95152	0.52
CLASS 11	0.7	13.14	17.7	15.4	7.7	7.7	0.79718	6.15
CLASS 12	0.0	0.00	0.0	0.0	0.0	0.0	0.56674	0.00
CLASS 13	0.3	4.69	6.3	5.5	2.8	2.8	1.47776	4.07
CLASS 14		0.00	0.0	0.0	0.0	0.0		0.00
CLASS 15		0.00	0.0	0.0	0.0	0.0		0.00
CLASS 16		0.00	0.0	0.0	0.0	0.0		0.00
	7.7	136.02	183.7	159.8				
TOTAL VALUES	100.0							76.87

AVERAGE DAILY 18 KIP EQUIVALENT AXLE LOAD: 76.87

20 YEAR EQUIVALENT AXLE LOAD: 561,162

2017	AADT =	1,670
2021	AADT =	1770
2041	AADT =	2390
	DHV =	250
	Direction =	
	Com Trks =	7.7%
	ESAL =	76.87
	AGR =	1.500%

* Equivalency Factors: WIM Data (2012 to 2016)

APPENDIX 3B

Tetra Tech Pavement Design Output

Roadways And Civil Engineering (R.A.C.E.) with Geotextiles,
Version 1.3
by Propex Inc.

Designer: **Fellin**

Client: **HDR**

Project Name: **West of Missoula - NW**

Project Number: **114-571120**

Date: **October 2 - 2017**

Comments:

Pavement Section 1 - 2 feet of new gravel fill as subgrade cap.

Input:

Reliability:

Roadway Location: Urban
Roadway Type: Principal Arterial
Reliability: 89.5 %
Standard Deviation: 0.45
Number of Stages: 1

Traffic:

Method: Enter Value
Design Period: 20 years
Number of Lanes in one Direction: 2
Lane Factor: Auto
Directional Distribution: 0.5
ESALs: 561,162

Present Serviceability Index:

Initial Serviceability Level: 4.2
Terminal Serviceability Level: 2.5
Frost Heave Loss: 0.00
Swelling Loss: 0.00
PSI Change Due to Traffic: 1.7
PSI Change Due to Environment: 0.00
Total PSI Change: 1.70

Subgrade Resilient Modulus:

Single Value: 12,000 PSI

Required Structural Number:

Computation: AASHTO Without Environmental Effects
SN: 2.62
Performance Period: 20 years

Pavement Properties:

Length: 1 mile
Width: 12 ft
Number of Lanes in one Direction: 2
Current Grade: 0.0 ft
Top of Pavement Final Grade: 1.0 ft
Excavation Cost: 12.00 $/yd3
Fill Cost: 6.00 $/yd3

Material Cost:

Wearing Surface: 42.00 $/Ton
Base Course: 10.00 $/Ton

Geotextile Properties:

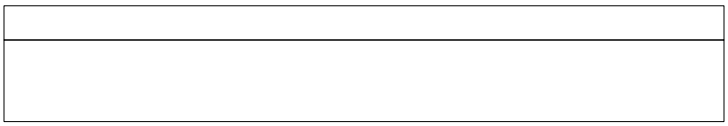
Geotextile Overlap: 2.0 ft
Unit Cost of Geotextile: 1.00 $/yd2
Roll Width: 15.0 ft
Roll Length: 300 ft

Pavement Design:

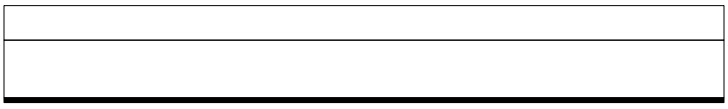
			Without Geotextile (A)		With Geotextile (B)	
Layer	a Coeff.	m Coeff.	Thickness(in)	Cost($)	Thickness(in)	Cost($)
Wearing Surface	0.41	1.00	3.60	115,759	3.60	115,759
Base Course	0.14	1.00	8.50	55,913	6.00	39,468
Geotextile						18,000
Total			12.10	171,672	9.60	173,227
Site Preparation						
Excavation			0.10	508		
Fill					2.40	6,101
Total Cost				172,180		179,328
Savings				(4.2 %) 7,148		

Required SN: 2.62 Design SN: 2.67

Design Without Geotextile (A)



Design With Geotextile (B)



Pavement Life Extension:

Life Extension if Geotextile is utilized in Design A (see Pavement Design above).

Original Design Period: 20 years New Performance Period: 20 years

Life Extension: 0 years

Cost of Geotextile Layer: $18,000 Number of Geotextile Rolls Needed: 36

Pavement Cost Without Geotextile: $172,180 Pavement Cost With Geotextile: $190,180

Discount Rate: 2 %

Annual Maintenance Cost: 5,000 $/lane-mile Annual User Cost: 3,000 $/lane-mile

Equivalent Annual Cost Without Geotextile: $26,530 Equivalent Annual Cost With Geotextile: $27,631

Recommended Geotextile Products:

Geotex 601, Geotex 250ST, AASHTO M 288 Class 2

Product Descriptions:

Geotex 601: Nonwoven polypropylene needle-punched geotextile. Advantages include better filtration with a higher water flow rate, a higher coefficient of friction against soil and road base aggregate, and a high resistance to construction damage. Meets AASHTO M 288 Class 2 Nonwoven Geotextile requirements. Maximum width is 15 feet. For a generically stated product specification in doqnloadable Rich Text format, refer to Guideline Specifications - Separation/Stabilization "AASHTO M 288 Class 2 Nonwoven Geotextile" under Applicable Documents or under R.A.C.E. Software at www.geotextile.com. It is recommended that the maximum width geotextile be used to improve installation quality control.

Geotex 250ST: Woven polypropylene geotextile made from slit tape machine direction (warp) yarns and fibrillated yarns in the cross-machine (fill) direction. Meets AASHTO M 288 Class 2 Woven Geotextile Requirements. Advantages include higher modulus and widths up to 17.5 feet. For a generically stated product specification in downloadable Rich Text format, refer to Guideline Specifications - Separation/Stabilization "AASHTO M 288 Class 2 Woven Geotextile" under Applicable Documents or under R.A.C.E. Software at www.geotextile.com. It is recommended that the maximum width geotextile be used to improve installation quality control.

Information, Availability and Cost:

For additional help with your project, such as distributor locations, geotextile properties or rough pricing; you may wish to contact your Propex Regional Manager as may be located for your area under "Contact Us" on our website, www.geotextile.com.

Roadways And Civil Engineering (R.A.C.E.) with Geotextiles,
Version 1.3
by Propex Inc.

Designer: **Fellin**

Client: **HDR**

Project Name: **West of Missoula - NW**

Project Number: **114-571120**

Date: **October 2 - 2017**

Comments:

Pavement Section 2 - Lean Clay Subgrade

Input:

Reliability:

Roadway Location: Urban
Roadway Type: Principal Arterial
Reliability: 89.5 %
Standard Deviation: 0.45
Number of Stages: 1

Traffic:

Method: Enter Value
Design Period: 20 years
Number of Lanes in one Direction: 2
Lane Factor: Auto
Directional Distribution: 0.5
ESALs: 561,162

Present Serviceability Index:

Initial Serviceability Level: 4.2
Terminal Serviceability Level: 2.5
Frost Heave Loss: 0.00
Swelling Loss: 0.00
PSI Change Due to Traffic: 1.7
PSI Change Due to Environment: 0.00
Total PSI Change: 1.70

Subgrade Resilient Modulus:

Single Value: 5,000 PSI

Required Structural Number:

Computation: AASHTO Without Environmental Effects
SN: 3.67
Performance Period: 20 years

Pavement Properties:

Length: 1 mile
Width: 12 ft
Number of Lanes in one Direction: 2
Current Grade: 0.0 ft
Top of Pavement Final Grade: 1.0 ft
Excavation Cost: 12.00 $/yd3
Fill Cost: 6.00 $/yd3

Material Cost:

Wearing Surface: 42.00 $/Ton
Base Course: 10.00 $/Ton

Geotextile Properties:

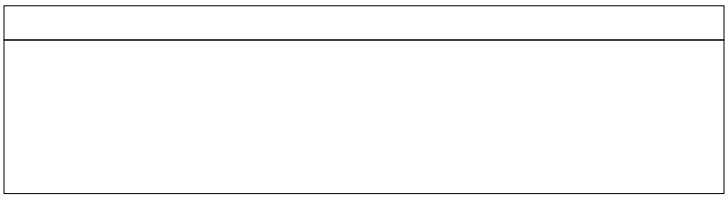
Geotextile Overlap: 2.0 ft
Unit Cost of Geotextile: 1.00 $/yd2
Roll Width: 15.0 ft
Roll Length: 300 ft

Pavement Design:

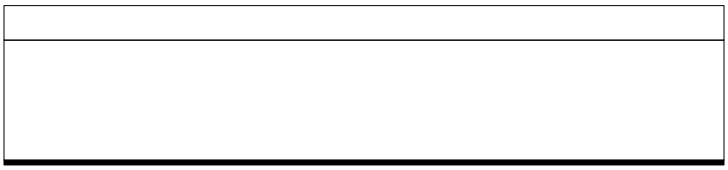
Layer	a Coeff.	m Coeff.	Without Geotextile (A) Thickness(in)	Without Geotextile (A) Cost($)	With Geotextile (B) Thickness(in)	With Geotextile (B) Cost($)
Wearing Surface	0.41	1.00	3.60	115,759	3.60	115,759
Base Course	0.14	1.00	16.00	105,248	12.50	82,225
Geotextile						18,000
Total			19.60	221,007	16.10	215,984
Site Preparation						
Excavation			7.60	38,642	4.10	20,846
Fill						
Total Cost				259,649		236,830
Savings						(8.8 %) 22,819

Required SN: 3.67 Design SN: 3.72

Design Without Geotextile (A)



Design With Geotextile (B)



Pavement Life Extension:

Life Extension if Geotextile is utilized in Design A (see Pavement Design above).

Original Design Period: 20 years New Performance Period: 20 years

Life Extension: 0 years

Cost of Geotextile Layer: $18,000 Number of Geotextile Rolls Needed: 36

Pavement Cost Without Geotextile: $259,649 Pavement Cost With Geotextile: $277,649

Discount Rate: 2 %

Annual Maintenance Cost: 5,000 $/lane-mile Annual User Cost: 3,000 $/lane-mile

Equivalent Annual Cost Without Geotextile: $31,879 Equivalent Annual Cost With Geotextile: $32,980

Recommended Geotextile Products:

Geotex 601, Geotex 250ST, AASHTO M 288 Class 2

Product Descriptions:

Geotex 601: Nonwoven polypropylene needle-punched geotextile. Advantages include better filtration with a higher water flow rate, a higher coefficient of friction against soil and road base aggregate, and a high resistance to construction damage. Meets AASHTO M 288 Class 2 Nonwoven Geotextile requirements. Maximum width is 15 feet. For a generically stated product

specification in doqnloadable Rich Text format, refer to Guideline Specifications - Separation/Stabilization "AASHTO M 288 Class 2 Nonwoven Geotextile" under Applicable Documents or under R.A.C.E. Software at www.geotextile.com. It is recommended that the maximum width geotextile be used to improve installation quality control.

Geotex 250ST: Woven polypropylene geotextile made from slit tape machine direction (warp) yarns and fibrillated yarns in the cross-machine (fill) direction. Meets AASHTO M 288 Class 2 Woven Geotextile Requirements. Advantages include higher modulus and widths up to 17.5 feet. For a generically stated product specification in downloadable Rich Text format, refer to Guideline Specifications - Separation/Stabilization "AASHTO M 288 Class 2 Woven Geotextile" under Applicable Documents or under R.A.C.E. Software at www.geotextile.com. It is recommended that the maximum width geotextile be used to improve installation quality control.

Information, Availability and Cost:

For additional help with your project, such as distributor locations, geotextile properties or rough pricing; you may wish to contact your Propex Regional Manager as may be located for your area under "Contact Us" on our website, www.geotextile.com.

Roadways And Civil Engineering (R.A.C.E.) with Geotextiles,
Version 1.3
by Propex Inc.

Designer: **Fellin**

Client: **HDR**

Project Name: **West of Missoula - NW**

Project Number: **114-571120**

Date: **October 2 - 2017**

Comments:

Pavement Section 3 - Cement Treated Base

Input:

Reliability:

Roadway Location: Urban
Roadway Type: Principal Arterial
Reliability: 89.5 %
Standard Deviation: 0.45
Number of Stages: 1

Traffic:

Method: Enter Value
Design Period: 20 years
Number of Lanes in one Direction: 2
Lane Factor: Auto
Directional Distribution: 0.5
ESALs: 561,162

Present Serviceability Index:

Initial Serviceability Level: 4.2
Terminal Serviceability Level: 2.5
Frost Heave Loss: 0.00
Swelling Loss: 0.00
PSI Change Due to Traffic: 1.7
PSI Change Due to Environment: 0.00
Total PSI Change: 1.70

Subgrade Resilient Modulus:

Single Value: 5,000 PSI

Required Structural Number:

Computation: AASHTO Without Environmental Effects
SN: 3.67
Performance Period: 20 years

Pavement Properties:

Length: 1 mile
Width: 12 ft
Number of Lanes in one Direction: 2
Current Grade: 0.0 ft
Top of Pavement Final Grade: 1.0 ft
Excavation Cost: 12.00 $/yd3
Fill Cost: 6.00 $/yd3

Material Cost:

Wearing Surface: 42.00 $/Ton
Cement Treated Base: 22.00 $/Ton

Geotextile Properties:

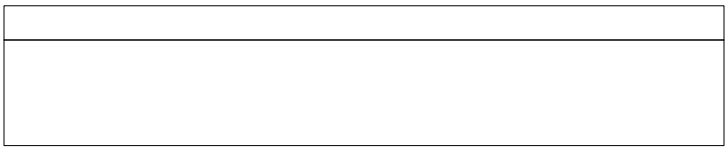
Geotextile Overlap: 2.0 ft
Unit Cost of Geotextile: 1.00 $/yd2
Roll Width: 15.0 ft
Roll Length: 300 ft

Pavement Design:

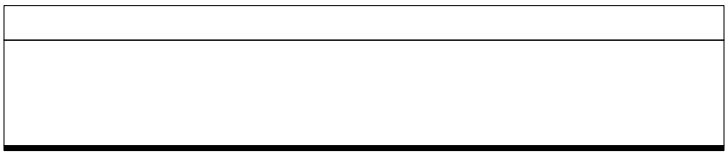
Layer	a Coeff.	m Coeff.	Without Geotextile (A) Thickness(in)	Without Geotextile (A) Cost($)	With Geotextile (B) Thickness(in)	With Geotextile (B) Cost($)
Wearing Surface	0.41	1.00	3.60	115,759	3.60	115,759
Cement Treated Base	0.20	1.00	11.00	193,794	11.00	193,794
Geotextile						18,000
Total			14.60	309,552	14.60	327,552
Site Preparation						
Excavation			2.60	13,220	2.60	13,220
Fill						
Total Cost				322,772		340,772
Savings				(5.6 %) 18,000		

Required SN: 3.67 Design SN: 3.68

Design Without Geotextile (A)



Design With Geotextile (B)



Pavement Life Extension:

Life Extension if Geotextile is utilized in Design A (see Pavement Design above).

Original Design Period: 20 years New Performance Period: 20 years

Life Extension: 0 years

Cost of Geotextile Layer: $18,000 Number of Geotextile Rolls Needed: 36

Pavement Cost Without Geotextile: $322,772 Pavement Cost With Geotextile: $340,772

Discount Rate: 2 %

Annual Maintenance Cost: 5,000 $/lane-mile Annual User Cost: 3,000 $/lane-mile

Equivalent Annual Cost Without Geotextile: $35,740 Equivalent Annual Cost With Geotextile: $36,840

Recommended Geotextile Products:

Geotex 601, Geotex 250ST, AASHTO M 288 Class 2

Product Descriptions:

Geotex 601: Nonwoven polypropylene needle-punched geotextile. Advantages include better filtration with a higher water flow rate, a higher coefficient of friction against soil and road base aggregate, and a high resistance to construction damage. Meets AASHTO M 288 Class 2 Nonwoven Geotextile requirements. Maximum width is 15 feet. For a generically stated product specification in doqnloadable Rich Text format, refer to Guideline Specifications - Separation/Stabilization "AASHTO M 288 Class

2 Nonwoven Geotextile" under Applicable Documents or under R.A.C.E. Software at www.geotextile.com. It is recommended that the maximum width geotextile be used to improve installation quality control.

Geotex 250ST: Woven polypropylene geotextile made from slit tape machine direction (warp) yarns and fibrillated yarns in the cross-machine (fill) direction. Meets AASHTO M 288 Class 2 Woven Geotextile Requirements. Advantages include higher modulus and widths up to 17.5 feet. For a generically stated product specification in downloadable Rich Text format, refer to Guideline Specifications - Separation/Stabilization "AASHTO M 288 Class 2 Woven Geotextile" under Applicable Documents or under R.A.C.E. Software at www.geotextile.com. It is recommended that the maximum width geotextile be used to improve installation quality control.

Information, Availability and Cost:

For additional help with your project, such as distributor locations, geotextile properties or rough pricing; you may wish to contact your Propex Regional Manager as may be located for your area under "Contact Us" on our website, www.geotextile.com.

APPENDIX 3C

Cost Analyses Spreadsheets

Figure 3C-1
Cost Analysis
West of Missoula - West

Alternative 1								
	Grade	Thickness (ft)/or rate	Units	Amount	Units	Cost (*)	Per Units	Total Cost
Asphalt Concrete	S - 3/4"	0.3	ft	4134	Ton	$30.91	Ton	127789
Granular Base	CAC	0.710	ft	4998	yd3	$22.35	yd3	111714
Prime Coat	CRS-2P	0.07	Gal/ft2	55	Ton	$417	Ton	23026
Tack Coat	SS-1	0.01	Gal/ft2	1901	Gallon	$2.32	Gallon	4410
Asphalt	PG 64-28	5.1	%	211	Ton	$403	Ton	84971
						Cost/Mile		351910

190080

Alternative 2								
	Grade	Thickness (ft)/or rate	Units	Amount	Units	Cost (*)	Per Units	Total Cost
Asphalt Concrete	S - 3/4"	0.3	ft	4134	Ton	$30.91	Ton	127789
Granular Base	CAC	1.330	ft	9363	yd3	$22.35	yd3	209268
Prime Coat	CRS-2P	0.07	Gal/ft2	55	Ton	$417	Ton	23026
Tack Coat	SS-1	0.01	Gal/ft2	1901	Gallon	$2.32	Gallon	4410
Asphalt	PG 64-28	5.1	%	211	Ton	$403	Ton	84971
						Cost/Mile		449464

Alternative 3								
	Grade	Thickness (ft)/or rate	Units	Amount	Units	Cost (*)	Per Units	Total Cost
Asphalt Concrete	S - 3/4"	0.3	ft	4134	Ton	$30.91	Ton	127789
Treated Base	CTB	0.920	ft	6477	yd3	$52.68	yd3	341198
Prime Coat	CRS-2P	0.07	Gal/ft2	55	Ton	$417	Ton	23026
Tack Coat	SS-1	0.01	Gal/ft2	1901	Gallon	$2.32	Gallon	4410
Asphalt	PG 64-28	5.1	%	211	Ton	$403	Ton	84971
						Cost/Mile		581394

Assumptions
36-foot wide cross section
1 mile section = 190,080 square feet of surface area.
Asphalt Concrete Unit Weight = 145 lb/cubic foot
Prime Coat Unit Weight = 63 lb/cubic foot = 8.3 lbs/gallon

5.1% Asphalt Content assumed Grade S Asphalt Mix
Costs for each item obtained from MDT Contractor Average Bid Prices for Jan-Jun 2012
0.07 gallon/square foot prime coat application
0.01 gallon/square foot tack coat application between asphalt lifts