West of Missoula - NW
UPN 614100
STPS 263 – 1(28)6

ACTIVITY 442: **Geotechnical and Materials Report Review**

DEFINITION: Review of Geotechnical and Materials Report from Consultant Designed Project.

TASKS:

1. Prepare Final Surfacing Sections (604)	**Yes**	**No**	**N/A**	**Initial**
a. Have 3 alternate typical sections been recommended?	X			MF
b. Is there an economic analysis for each alternate?	X			MF
c. Is the method of design satisfactory?	X			MF
d. Are the designs based on subgrade R-Value? Other?___CBR_____	X			MF
Is this acceptable?	X			MF
e. Are the design ESAL's current?	X			MF
f. Are the proposed surfacing layer thicknesses reasonable?	X			MF
g. Is the recommended typical alternate satisfactory?	X			MF

2) Primary Soils Survey (490) **(Soils Survey Report Form 111)**	**Yes**	**No**	**N/A**	**Initial**
a. Log of each test hole.	X			MF
b. Location of each test hole noted.	X			MF
c. Soil Class shown for each sample (AASHTO).	X			MF
d. Moisture/Density curve fore each soil sample. **(Moisture density testing performed on representative samples of base-subbase and subgrade layers).**		X		MF
e. In place density at each location. **(Relative densities obtained at each location from SPT sampling).**	X			MF
f. Natural moisture shown for each soil sample.	X			MF
g. R-Value for each soil sample. **(CBR testing performed on representative samples of subgrade materials).**	X			MF
h. soil survey represents entire project.	X			MF
i. Chemical and corrosion samples taken at each pipe installation. **In Activity 106 Investigation.**	X			MF
j. Report submitted describing in-place pipe condition. **In Activity 106 Investigation.**	X			MF
k. Test holes plotted on plan and profile sheets.	X			MF
l. Additional test holes represent areas of changed grade or alignment?	X			MF

3) Geotechnical Surveys and Reports (462)

a. Field and Laboratory Data	**Yes**	**No**	**N/A**	**Initial**
(1) Exploration Plan.	X			MF
(2) Boring Logs – MDT Format ? Soil & Rock.	X			MF
(3) Geophysical Methods.			X	MF
(4) Groundwater Elevations.	X			MF
(5) Structural Geology Mapping.			X	MF
(6) Soil & Rock Lab Testing Results- M/C, PI, Consol & Strength Parameters, etc.	X			MF
b. Geotechnical Engineering – Alignment and Structures (464 and 466)				
(1) Geologic Setting.	X			MF
(2) Settlement Calculations.	X			MF
(3) Slope Ratios.			X	MF
(4) Embankment Foundation Treatments.	X			MF
(5) Shrink/Swell Factors.			X	MF
(6) Digout Recommendations.	X			MF
(7) Geotextile Recommendations.	X			MF
(8) Surface & Subgrade Drainage Recommendations.			X	MF
(9) Culvert Foundation Preparation and Bedding Recommendations.			X	MF
(10) Structural Foundation Recommendations and Alternatives.	X			MF
(11) Retaining Structure Recommendations and Alternatives.			X	MF

	Yes	No	N/A	Initial
(12) Instrumentation and Monitoring Recommendations.			X	MF
(13) Special Provisions for Materials and Construction Methods. **Will provide for final construction documents.**		X		MF
(14) Have Design Methodology and Calculations Been Submitted.	X			MF

Date Received: _____ Date Approved: _____

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

START
DEPENDENCIES: Completion of Activity 130.

Consultant Activity 130 – Final 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
July 20, 2022

PRESENTED TO

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July 13, 2022

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1.0 PROJECT DESCRIPTION

The West of Missoula – NW (Mullan Rd) 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. In addition to roadway improvements, a pedestrian path will be constructed parallel to the improved roadway along the project length. The pedestrian path will be 10 feet wide and located 20 to 50 feet from roadway centerline. 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 approximate 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 farmland. 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 9 inches of asphalt concrete underlain with 1.5 to 8 feet of granular base and subbase course.

Figures 1A through 9A in Appendix A show the approximate project limits, boring locations, and other pertinent site features.

2.0 SUBSURFACE FIELD INVESTIGATIONS

Tetra Tech completed two subsurface field investigations for the project, summarized below:

Year	Task	Boring	Drilling Rig
2017	Preliminary Soil Survey	SS-1 to SS-26	Mobile B-61
2021	Geotechnical Investigation	BH-1 to BH-7	Mobile B-61

In June 2017, 26 borings were completed as part of the Activity 106 field investigation. Tetra Tech conducted a field exploration from November 10 to 16, 2021 for the Activity 130 Report. Seven additional borings were drilled along the project to explore subsurface conditions. The locations of the Activity 106 and 130 borings are shown on Figures 1A through 9A in Appendix A.

Prior to mobilization for the 2021 study, Tetra Tech contacted Montana One-Call to request the location and clearance of public underground utilities before performing drilling. Locations of the borings were

initially marked in the field by Tetra Tech utilizing the project location map provided by HDR. The boring locations were surveyed with a hand-held GPS unit. Mile posts, coordinates, and elevations of the borehole locations listed on the boring logs were determined by an HDR survey. 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. The depth at which the samples were taken, and the penetration resistance values are shown on the log of exploration boring.

Boring logs were prepared noting the borehole location and elevation, equipment and drill methods used, subsurface profile and descriptions per ASTM D2487, and groundwater conditions. Depths at which the samples were obtained along with the penetration resistance values are shown on the logs of exploratory borings. The logs of the exploratory borings for Activities 130 and 106 are presented in Appendix B1 (Figures 1B through 7B), and Appendix B2 (Figures 2A-1 through 2A-26, which were the Figures presented in the Activity 106 report), respectively.

3.0 LABORATORY TESTING

Samples obtained from the borings were taken to Tetra Tech's Missoula laboratory and were observed and visually classified in accordance with ASTM Method D2488, 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. The following list describes laboratory testing performed for this Activity 130 investigation, and their purpose:

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 C-1 in Appendix C and presented graphically on Figures 1C through 14C. These data, along with the field information, were used to prepare the exploration boring logs in Appendix B1 for the Activity 130 investigation.

4.0 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 Appendix B for each soil sample. Tetra Tech's Activity 106 Report should be referenced for more detailed soil information along the proposed alignment. The following soil types were encountered in borings BH-1 through BH-7.

4.1.1 Pavement Section

Measurements obtained by Tetra Tech during the Activity 130 field investigation consist of approximately 5 to 9 inches of asphaltic concrete. Fill was encountered in all of the borings directly below the pavement section extending to depths ranging from 1.5 to 8 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.

4.1.2 A-1 Fill Soils

Sand and gravel fill was encountered in borings BH-2 and BH-3 beneath the topsoil extending to depths on the order of 1.5 to 5 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 8 to 27 blows per foot which indicates a loose to medium soil stratum. The natural moisture content of samples obtained in the fill ranged from 4 to 5 percent at the time of drilling.

4.1.3 A-2 Fill Soils

A-2 fill soils were encountered in borings BH-4, BH-6 and BH-7 beneath the pavement or topsoil extending to depths on the order of 2.5 to 8.0 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 5 to 28 blows per foot which indicates a loose to medium soil stratum. The natural moisture content of samples obtained in the fill above the water table ranged from 2 to 18 percent at the time of drilling.

4.1.4 A-6 Fill Soils

A-6 soils were encountered in borings BH-1 and BH-5 at depths ranging from 0.5 to 0.8 feet and extending to depths ranging from 4.2 to 5.5 feet. The fill material classified as sandy lean clay. Penetration resistance values in the A-6 soils ranged from 6 to 15 blows per foot, indicating a loose to medium soil stratum.

The natural moisture content varied from 10 to 18 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. Laboratory testing performed on A-6 soils indicate a rock-corrected maximum dry density of 114.9 pcf, and rock-corrected optimum moisture content of 13.5 percent. The result of California Bearing Ratio test on the A-6 fill soils was a California Bearing Ratio on the order of 5, indicative of a poor to medium strength subgrade.

Direct shear strength testing performed on a sample of the A-6 soil indicates a friction angle on the order of 31 degrees, and a cohesion value on the order of 420 psf.

The combination of pH (7.89) and resistivity (2,050 ohm-cm) indicates the potential of corrosion of buried metal in the fill material is mild. Sulfate content was 0.0018% means sulfate attack is low.

4.1.5 A-1 Native Soils

Natural sand and gravel were encountered in all borings at depths ranging from 1.2 to 12.0 feet extending to depths of 9 to 15.5 feet. The natural granular layer visually classified as poorly graded gravel with sand and 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 6 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 and gravel above the water table ranged from 1 to 34 percent at the time of drilling. Laboratory testing indicates the A-1 soils were non-plastic with 4 to 6 percent passing the #200 sieve. Laboratory testing performed on two bulk samples of A-1 soil indicate rock-corrected maximum dry densities ranging from 139.2 to 140.5 pcf, and rock-corrected optimum moisture contents ranging from 7.6 to 8.0 percent.

4.1.6 A-2 Native Soils

Natural A-2 soils were encountered in borings BH-1 BH-2, BH-4 and BH-5 at depths ranging from 6.0 to 12.0 feet and extending to depths ranging from 15.5 to 25.5 feet. The A-2 soils classified as silty sand, clayey gravel and clayey gravel with sand. Penetration resistance values in the A-2 soils ranged from 7 to 37 blows per foot, indicating a medium stiff to hard soil stratum. The natural moisture content varied from 18 to 28 percent at the time of drilling.

4.1.7 A-4 Native Soils

Natural A-4 soils were encountered in BH-6 at a depth 2.0 feet and extending to a depth of 3.8 to feet. The A-4 soil classified as a sandy silt. Penetration resistance values in the A-4 soil were 11 blows per foot, indicating a stiff soil stratum.

The natural moisture content was 11 percent at the time of drilling. Laboratory testing indicates the A-4 soils have a plasticity index on the order of 0 to 7 percent. Laboratory testing performed on a bulk sample from BH-4 indicate a maximum dry density of 120.2 pcf, and an optimum moisture content of 10.5 percent. Results of California Bearing Ratio test on the A-4 soil indicates a California Bearing Ratio on the order of 6, or a medium strength subgrade.

4.1.8 A-6 Native Soils

A-6 soils were encountered in borings BH-1, BH-2 and BH-3 at depths ranging from 1.5 to 9.0 feet and extending to depths ranging from 2.5 to 12.0 feet. The A-6 soils classified as lean clay, lean clay with sand and sandy lean clay. Penetration resistance values in the A-6 soils ranged from 7 to 37 blows per foot, indicating a medium stiff to hard soil stratum. The natural moisture content varied from 18 to 28 percent at the time of drilling.

4.1.9 Groundwater

Subsurface water was encountered in all of the borings except for BH-2 at the time of the field investigation. Groundwater levels were measured immediately after drilling and varied from as shallow as 6.5 feet in boring BH-6 to as deep as 14.8 feet below existing grade in boring BH-1 at the time of drilling, with an average depth of 10.4 feet. The groundwater data is indicated on the boring logs.

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.

5.0 SITE CONDITIONS

5.1 GENERAL 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.

5.2 SEISMIC DESIGN PARAMETERS

National Seismic Hazard Maps prepared by the USGS depict probabilistic strong ground motions and spectral accelerations with 10, 5, and 2 percent probabilities of exceedance in any 50-year period for the conterminous United States. IBC 2015 design criteria are based on a 2 percent probability of exceedance, or in other words, a 98 percent probability of not being exceeded in a 50-year period. Based on the Applied Technology Council (ATC) Hazards by Location application (Applied Technology Council, 2022) which queries applicable data from USGS, the peak ground acceleration having a 2 percent probability of exceedance in any 50-year period is estimated to be 0.187g for Missoula, Montana.

The USGS database presents spectral response acceleration data in bedrock for short (0.2 second) periods (S_s) and for long (1 second) periods (S_1) for similar probability and 50-year return periods. According to IBC design procedures, these acceleration data are then adjusted upward or amplified depending on soil classification to reflect magnification effects as the earthquake wave energies pass from bedrock into soil. The values are then reduced by a factor that accounts for partial damping of the wave energy by the structure. The final values obtained (known as S_{DS} and S_{D1}) become the basis for the structural design and in this case are estimated as 0.411g (S_{DS}) and 0.142 (S_{D1}). The data is summarized in the table below.

The methods of IBC 2015 require that the properties of the soil at the proposed building site be classified as one of several site classes. The seismic design parameters for this site include a seismic zone soil profile type of (D), in accordance with the above referenced standard. Site Class D corresponds to a stiff soil profile with average undrained shear strengths between 1,000 and 2,000 psf and average standard penetration resistance values ranging from 15 to 50 blows per foot in the upper 100 feet. This classification is based on the laboratory test data, exploratory boring information, and knowledge of the local geology.

Earthquake and Seismic Design Parameters

Site	Latitude (North)	Longitude (West)	PGA	S_s	S_1	Site Class	F_{PGA}	F_a	F_v	PGA_M	S_{DS}	S_{D1}
Mullan	46.926367	-114.166883	0.187	0.421	0.142	D	1.426	1.463	2.316	0.266	0.411	0.219

Notes:
PGA = Peak Ground Acceleration
S_1 = 1.0 sec. Spectral Acceleration Coefficient
F_v = 1.0 sec. Spectral Acceleration Site Coefficient
A_s = Acceleration Coefficient
Time period = 50 years
S_s = 0.2 sec. Spectral Acceleration Coefficient
F_a = 0.2 sec. Spectral Acceleration Site Coefficient
F_{PGA} = Peak Ground Acceleration Site Coefficient
Return period = 2%

6.0 GEOTECHNICAL ENGINEERING – ALIGNMENT – ACTIVITY 464

This section discusses geotechnical analyses and recommendations for fill placement and embankment foundations, including; embankment construction, and subexcavation and embankment foundation treatment where necessary. Recommendations are included for slope ratios, foundation treatments, shrink/swell factors, and slope stability. A Special Provision will be included in the final project documents for Embankment Foundation Treatment and Culvert Foundation Treatment. References to applicable specifications by section number as outlined in the MDT Standard Specifications for Road and Bridge Construction, (2020 Edition) are noted in parentheses within the text.

6.1 CULVERTS

Seven large culvert crossings were identified throughout the project and are listed in the table below.

Crossing ID	Station	Number of Barrels	Size & Material	Total Length (ft)
LaValle Crossing 1	214+15.75	1	42” CSP	142
LaValle Crossing 2	203+90.55	1	40” X 65” RCPA	72
LaValle Crossing 3	178+17.27	1	42” CSP	86
		1	42” CSP	41
O’Keefe Creek Crossing	140+97.40	1	5’ x 9’ RCB	78
	133+63.00	1	24” RCP	76

Borings from both investigations (2017 and 2021) were used to analyze foundation treatments for culverts. Foundation soils were variable throughout the project, and consisted of intermixed and discontinuous layers of clay, sand and gravel with varying percentages of silt.

All culverts should be placed on granular bedding material per MDT Standard Specifications. Two feet of granular foundation material is recommended to be placed below all culverts to limit potential differential settlement due to varying low to moderate strenth subgrade materials. A high strength separation/stabilization geotextile fabric should be placed between the clay subgrade and granular foundation material. A Special Provision for Culvert Foundation Treatment will be included in the final project documents.

For all culverts, granluar materials from required excavations can be re-used to backfill above the top of the required bedding. Using silt and clay as backfill materilal above culverts is not recommended due to their low strength characterisitics and the likely difficulty in obtaining compaction.

Depending on the season of construction, surface water may be present around the existing culverts. Where ponded surface water is present, the water should be drained or pumped prior to excavating. Water should not be allowed to wet excavations for foundation treatment, and drainage water should be diverted as necessary to allow dry construction. A special provision for dewatering will be included in the final project documents.

6.2 EMBANKMENT CONSTRUCTION

The majority of the project will include fill sections on the order of 1 to 3 feet in thickness with some fills up to 6 to 8 feet on the slopes both left and right of centerline. The fills will flatten the existing approximate 3H to 4H:1V slopes to 6H:1V and will allow slight to moderate widening to achieve the proposed 4-foot shoulders. Where the slopes are too steep to flatten to 6H:1V, and where guardrail already exists, guardrail will be replaced following the shoulder widening. The pedestrian path mainly consists of thin 1- to 2-foot-thick embankment fills with some areas of fill up to 5 feet with slopes ranging from 2H:1V to 5H:1V.

6.2.1 Settlement

Based on the current design cross sections provided by HDR, the maximum roadway fill heights on the project range from approximately 8 feet at Station 144+00, to 7 feet at Station 256+00+00, and 6 feet at Station 324+50 and the maximum pedestrian path fill heights on the project range from approximately 5 feet at Station 140+00, to 5 feet at Station 326+00. Modeling of the settlement below the roadway and path was performed using the computer program Settle3 V5.005 by Rocscience, Inc, a 3D modeling program. The outputs from the models for the cross sections are included in Appendix E. Using the anticipated fill heights, total foundation soil settlements on the order of 0.5 to 3 inches are anticipated. The estimated settlements are summarized in the table below.

Station	Fill Height	Estimated Settlement
144+00 (Roadway)	8 feet	2.8 inches
256+00 (Roadway	7 feet	0.4 Inches
324+50 (Roadway)	6 feet	1.9 inches
140+00 (Ped Path)	5 feet	1.9 inches
326+00 (Ped Path)	5 feet	1.4 inches

The variability in settlement amounts is attributed to the variability in subgrade soils and fill heights along the project length. Areas with higher settlements encountered higher clay thicknesses at the embankment foundation elevation while areas with low settlements are underlain primarily by granular soils.

Based on time-rate settlement calculations performed by Settle3, 90 percent of the estimated settlement of the clay layers will occur within 30 days of fill placement. This is due to the relatively shallow fills and thin clay layers encountered across the site. In addition, the clay layers are typically underlain by granular soils that allow for rapid drainage and pore pressure dissipation.

6.2.2 Fill Placement

Fill section recommendations, including suitable material, clearing, and compaction, are included in the MDT Standard Specifications for Road and Bridge Construction, Section 203.03.2. We recommend the contractor make note of the following items specifically for this project:

Section C:

- Bench all embankments placed and compacted on hillsides, against existing embankments, built one-half width at a time, or on slopes 6H:1V or steeper when measured at right angles to the roadway centerline. Construct benches in minimum 4-foot widths, if possible, per the Standard Specification. Maintain the horizontal inclination within 5% of horizontal.
- Clear the full width of subgrade of sod and vegetative matter. Scarify the top 8 inches of the embankment foundation and compact in relatively uniform horizontal layers not exceeding 8 inches in accordance with Subsection 203.03 before constructing embankments 4 feet high or less.

It is recommended that all new fills consist of A-1-a Special Borrow or on soils, as the existing clay and clayey sand soils will be difficult to process and compact and will not provide uniform subgrade support for the roadway section.

In the fill widening areas, unclassified excavation may be necessary due to soft or saturated clay or organic subgrade soils. Specific estimated limits have been identified that are estimated to require Embankment Foundation Treatment (2 feet of subexcavation and replacement with separation/stabilization geotextile and A-1-a gravel, the A-1-a will be completely wrapped in geotextile), as follows:

Station	Feature	Comments
140+00 to 142+00 RT	Wetland / Channelized Flow	O'keefe Creek Crossing
177+00 to 181+00 RT	Wetland / Channelized Flow	Moccasin Ditch, Wetland Area
203+00 to 206+00 LT and RT	Wetland / Channelized Flow	LaVelle Creek, Wetland Area
214+00 to 216+00 RT	Wetland / Channelized Flow	Lavelle Creek, Wetland Area
277+00 to 284+00 RT	Wetland / Organics	Wetland Area, Wetland Vegetation
309+00 to 310+00 LT	Soft Subgrade Soils / Organics	Culvert Outlet, Wetland Vegetation

These areas were observed to contain channelized flow, ponded water, or water-aphyllic vegetation on one or both sides of the road during our field investigation or were near culvert locations or low topographic zones. The foundation treatment is recommended to ensure the new fills remain stable under saturated conditions. Given that the fill height in some of these areas is shallow, and a 2-foot subgrade cap is proposed as the preferred pavement section alternative, the 2 foot subgrade cap will serve the same

purpose as the Embankment Foundation Treatment layer within some of the estimated Embankment Foundation Treatment areas.

6.3 FINAL PAVEMENT SECTIONS

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 report:

1. AASHTO Guide for Design of Pavement Structures, 1993
2. *MDT Asphalt Pavement Design Manual*, November, 2018
3. 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.

6.3.1 Subgrade Soils

As discussed in the Activity 106 report, 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. To be considered a subgrade layer per MDT design, a layer must be a minimum of 2 feet thick. Per the current plan and cross section set obtained from HDR, the centerline grade will remain similar, or even lowered due to the amount of driveway and road approaches on the project. There is also a significant amount of area where the existing roadway section will be moved left or right of the existing centerline, or be filled on both sides of the existing centerline.

As discussed in Section 2 of the Activity 106 report, 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 for the subgrade soils 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 be a reasonable subgrade resilient modulus for the soils encountered in the geotechnical investigation.

Six subgrade samples were tested in the lab for CBR during the Activity 106 and 130 investigations, with the following results:

Boring	Depth (ft)	Subgrade Classification	CBR Value
Activity 106			
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
Activity 130			
BH-4	0.5-5	Silty, Clayey Sand with Gravel	6
BH-5	0.5-5	Sandy Lean Clay	5

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. As discussed in the Activity 106 report, Tetra Tech chose a CBR value of 5,000 for the clay subgrade based on both the laboratory data as well as the laboratory equivalent backcalcluated resilient modulus value.

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

6.3.2 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: 562,100

6.3.3 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 562,100.

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.

6.3.4 Final Pavement Section Alternatives

Based on Surfacing Design Guideline from MDT (2018), 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
101 to 200	0.3-0.4
0 to 100	0.3

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 and the project ESAL value of 77 per day. The design printouts were included in the Activity 106 report, and are not duplicated here.

Table 6-1. Pavement Section Alternatives

Design Section	Asphalt Concrete Surfacing Thickness (in)	Granular Base Thickness (inches)	Treated Base (inches)	Assumed Subgrade Type
Alternative 1 – 2-foot subgrade cap	3.6	8.5	0	Two-Foot Pit Run Subgrade Cap
Alternative 2 - CAC	3.6	16.0	0	Lean Clay with separation geotextile.
Alternative 3 – Cement Treated Base	3.6	0	11.0	Lean Clay with separation geotextile.

6.3.5 Cost Analysis

A cost analysis was performed using the pavement sections in Table 6-1. Average unit rate costs for each cost item were obtained from the MDT Internet web page for projects constructed in Montana in 2021. The plant mix costs are assumed to include mixing, placing, and compacting the asphalt concrete. Figure 1F in Appendix F summarizes the cost analysis for each pavement section utilizing the MDT average price units.

6.3.6 Summary

Based on the soils encountered during the Activity 106 and 130 investigations, the pavement section alternatives presented in the Activity 106 report will not change and are repeated here. Per HDR, the EAL of 77 presented in the Activity 106 report applies to the Activity 130 analysis. The Activity 106 pavement design summary language will be repeated here for clarity:

Since the roadway width will increase in most cases by 10 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 percentages 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 multiple times to get it back into place for use as subbase or the subgrade cap. It would seem to be most economical to reclaim or rip the existing asphalt layer in place, then grade or haul

the reclaimed layer into adjacent fill areas as needed. 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 estimates in 1F indicate that placing a 2-foot subgrade cap would be the most economical pavement section, by about $640,000 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 importing material that needs to be placed in the shoulder fills. And, since A-1-a Special Borrow gravel is being specified for all 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 from placing a 2-foot subgrade cap, placing a 2-foot gravel subgrade cap will serve several other functions:

1) *Provide a homogenous subgrade throughout the project length, which will 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 final design.

7.0 GEOTECHNICAL ENGINEERING – STRUCTURES – ACTIVITY 466

The following sections discuss the proposed bridge foundation design for Primrose Creek. At this point of design, the structure height and configuration are preliminary. The design data presented below is based on the soil conditions encountered in the geotechnical borings.

7.1 PROPOSED BRIDGE DESIGN

The preliminary bridge design consists of a 29.5-foot long, two-lane, single-span structure with a dedicated pedestrian walkway. The deck will consist of nine tri-deck girders and will be on the order of 53 feet wide to accommodate a 24-foot-wide roadway, 10-foot-wide walkway, pedestrian rail and safety barrier. The proposed low-chord elevation at the bottom of the Tri-deck girders is approximately 3,075.23 feet. With a proposed 3-foot by 3-foot pile cap, the bottom of pile cap elevation is approximately 3,072.23 feet.

The new bridge structure will be designed to meet current standards in accordance with Montana Department of Transportation (MDT) Bridge design and AASHTO LRFD criteria. The specific design codes utilized for the bridge and foundation design are in the current AASHTO LRFD Bridge Design Specifications and the AASHTO Guide Specifications for LRFD Seismic Bridge Design.

Preliminary LRFD structural loads obtained from HDR for each abutment, including the self-weight of the 3-foot by 3-foot pile cap and nominal wingwalls for the 29.5-foot-long bridge, are as follows:

Service I	425 kips
Strength I	625 kips

Assuming nine Tri-deck girders at about 6 feet wide each, and 1 pile per girder, HDR estimated a Strength I axial load of 70 kips per pile for a deep foundation option.

7.2 BRIDGE FOUNDATION ANALYSIS

Options for both spread footings and driven pile foundations are being considered as viable foundations to support the abutment structural loads. Since either or both foundation types could eventually be recommended due to cost, constructability, time constraints or aesthetics, preliminary recommendations for each foundation type will be provided in this report.

7.2.1 Spread Footing Foundation

Per discussions with HDR, scour is not a concern at this site because it is a controlled-flow channel. Based on the subsurface conditions encountered within the exploration borings at this location (B-4 and B-5), coupled with the assumption that scour is not a concern, conventional spread footings bearing on the natural gravel is a suitable foundation alternative to support the structural loads of the proposed bridge structure.

The native gravel layer based on the borings drilled at either end of the proposed bridge structure is at an elevation ranging from approximately 3,069 feet to 3,071 feet. The approximate groundwater elevation at the time of drilling in November 2021 was approximately 3,065 to 3,066 feet.

The native gravel layer has an in-place relative density on the order of medium dense to very dense, with a few looser zones encountered.

The spread footing geotechnical design parameters for the abutment were calculated or obtained per the current AASHTO LRFD design specifications. The parameters are as follows:

Effective passive unit weight for assumed submerged gravel layer at bearing depth: 68 pcf

Dry unit weight of backfill material over heel of footing (assume clay): 110 pcf

Saturated unit weight of backfill material over heel of footing (assume clay): 48 pcf

Factored Bearing Pressure: 4.5 ksf assuming LRFD resistance factor of 0.45

Angle of internal friction for the predominant medium dense native gravel layer: 34 degrees for sliding.

LRFD resistance factor for sliding: 0.80

LRFD resistance factor for passive pressure: 0.50

Settlement analysis using a Service Load demand of 4,500 pounds per square foot, an estimated footing width of 8 feet, and theory of elasticity principles determined the total settlement for footings supported on the natural gravel layer to be approximately 1 inch or less, which is within the tolerable limit for the type of construction proposed. Differential settlement across the new structure is estimated to be approximately one-half of the total settlement.

The following design and construction criteria should be observed for a conventional spread footing foundation. Construction details should be considered when preparing project documents.

1. Based on the site soils, footings should be placed at least 36 inches below grade for frost protection. In addition, footings should be provided with at least 36 inches of lateral frost protection where footings are adjacent to the existing channel.

2. Concrete in contact with the soil should be designed using Type I-II cement.

3. Subexcavate to an elevation of 3,068.0 or until the native gravel layer is encountered. Dewater as necessary.

4. Compact the native gravel subgrade to a dry density of 95 percent of the maximum dry density.

5. Place a high-survivability separation geotextile on the subgrade along the bottom and sides of the excavation leaving enough extra to wrap the geoxtextile under the footing.

6. Place a minimum of 2 feet of crushed ¾ to ½ inch clean drain rock over the separation geotextile and compact with a minimum of 8 passes of a large vibratory steel drum roller.

7. Construct the spread footing over the top of the crushed rock.

8. Tetra Tech's geotechnical engineer should observe all footing excavations prior to placement of concrete forms and a representative of the geotechnical engineer should test the placement of all fill and backfill.

7.2.2 Driven Pipe Pile Foundation

Should a deep foundation alternative be chosen to support the bridge structural loads, open-ended, steel pipe piles with driving shoes and a ½-inch wall thickness are recommended for the site conditions encountered in the exploration borings. Pipe pile will provide adequate support at the abutment locations provided they can be driven to a sufficient depth for lateral capacity. Open-ended pile are expected to plug in the clay, sand and gravel soils during driving.

Estimations of axial pile capacity were calculated for pipe pile diameter of 16 inches using the software program APILE for Windows, Version 2014.6.4. Graphs of ultimate axial pile capacity versus depth for the various pile diameters are shown on Figure 1D in Appendix D. The piles should be driven to a minimum depth of 25 feet into the gravel layer, or an approximate minimum tip elevation of 3,043.0 feet.

The MDT geotechnical section or their representative are recommended to perform a wave equation analysis to determine whether the contractor has selected a suitable pile hammer for production driving. In addition, one test pile should be driven at each abutment location using a pile driving analyzer (PDA). The software program CAPWAP should be used to evaluate the PDA results. The Geotechnical Section or their representative will use the PDA results to establish the driving criteria for installation of the production piles.

Based on laboratory testing of the clay soils at the site and laboratory test data, the resistivity is less than 2,000 ohm-cm. According to Section 10.7.5 of the AASHTO LRFD Bridge Design Specifications, 2020, a resistivity of less than 2,000 ohm-cm is indicative of potential pile deterioration or corrosion. The potential deterioration of steel piles may be reduced by several methods, including; protective coatings, concrete encasement, cathodic protection, use of special steel alloys, or through increased steel area to account for

the sacrificial area loss over time by corrosion. The corrosion potential should be reviewed by the structural engineer to determine the appropriate corrosion mitigation.

The following design and construction details should be observed for a driven pile foundation system should be considered when preparing project documents.

1. Steel pipe piles driven to a minimum 25 feet into the gravel layer should be used to support structural loads. Steel 16-inch pipe piles driven to 25 feet into the gravel layer, or elevation 3,043.0 feet, should be designed for a factored vertical load capacity of 78 kips.

2. The contractor should select a driving hammer and cushion combination capable of installing the selected piling without overstressing the pile material. The contractor should submit the pile-driving plan and the pile hammer-cushion combination to the MDT Geotechnical Section well in advance of pile installation for evaluation of the driving stresses using a wave equation analysis. After a pile hammer is selected, the MDT Geotechnical Section should establish the initial driving criteria using wave equation analysis.

3. Piles should have a center-to-center spacing of at least three pile diameters when accounting for vertical loading conditions, or they should be designed as a pile group. Piles aligned in the direction of lateral forces should have a center-to-center spacing of at least six pile diameters. If closer spacing is required, Tetra Tech should be contacted to recommend reduction factors.

4. Dynamic analysis should be performed during pile installation at each bent using a PDA to evaluate the driving resistance required to obtain the predicted design load and establish the final driving criteria. The software program CAPWAP should be used to evaluate the PDA results.

5. An MDT Geotechnical Section representative should observe pile driving operations on a full-time basis. Each pile should be observed and checked for buckling and crimping, in addition to recording penetration resistance, depth of penetration, and general pile driving operations.

7.2.3 L-Pile Parameters

The following soil types and parameters should be used for lateral L-pile analyses conducted by HDR, assuming the bottom of pile cap is at approximate elevation 3,072.0 feet.

Soil Type	Top of Layer Elevation (ft)	Bottom of Layer Elevation (ft)	Effective Unit Weight (pcf)	Angle of Internal Friction	Undrained Shear Strength (psf)	Strain Factor (E50)	Soil Modulus (k = pci)
Sandy Clay, Clayey Sand	3,072.0	3,068.0	125	0	750	0.01	100
Submerged Native Gravel	3,068.0	Below 3,050.5	72	34	0	NA	125

*for unit weight calculations, water table elevation = 3,068.0 feet

7.2.4 Lateral Earth Pressures for Abutment Walls

Below-grade abutment walls will be subjected to horizontal loading due to lateral earth pressure and, in some cases, additional pressure due to traffic loading. The lateral earth pressure is a function of the natural and backfill soil types and acceptable wall movements, which affect soil strain and mobilize the shear strength of the soil. More soil movement is required to develop greater internal shear strength and lower the lateral pressure on the wall. Soil strain and allowable wall rotation must be greater to mobilize full strength and reduce lateral pressures for clay soils than for cohesionless granular soils.

Distribution of the lateral earth pressures on the structure depends on soil type and wall movements or deflection. In most cases, a triangular pressure distribution is satisfactory for design and is usually represented as an at-rest equivalent fluid unit weight or pressure.

The design and construction criteria presented below should be observed for abutment and retaining walls/wing walls.

1. Abutment walls that act as retaining walls should be designed using an at-rest equivalent earth pressure of 65 pounds per cubic foot for the clayey sand and sandy clay backfill.

2. It is imperative that heavy compaction equipment is not used any closer than 4 feet from the below grade walls. In addition, care should be taken not to over-compact the backfill as it could cause excessive lateral pressure on the walls.

APPENDIX A

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

Figures A1 through A9 – Location of Exploratory Borings - Activities 106 and 130

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.

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THE ASSOCIATION OF ENGINEERING FIRMS PRACTICING IN THE GEOSCIENCES

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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

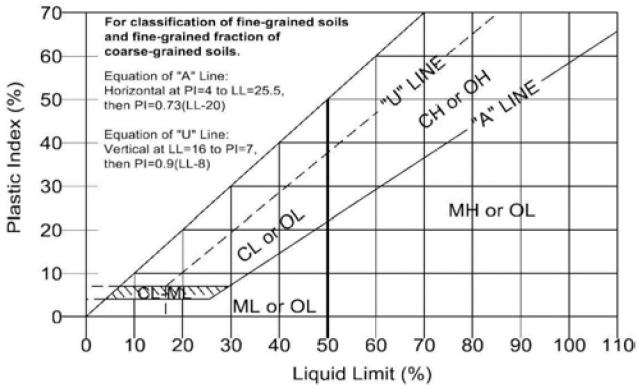
Moisture Condition

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

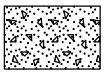
Very Soft	-Can be carved with knife. Can be excavated readily with point of rock hammer. Can be scratched readily by fingernail.
Soft	-Can be grooved or gouged readily by knife or point of rock hammer. Can be excavated in fragments from chips to several inches in size by moderate blows of the point of 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:

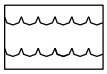
UCS = Unconfined Compressive Strength obtained from laboratory testing at the given depth.

See Soil Boring Information Special Provision.

Miscellaneous Soil/Rock Symbols and Terms

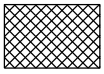

Concrete

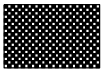

Asphalt

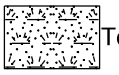

Water


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.

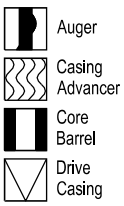
Unless stated on logs as being surveyed by district survey, all locations are considered approximate.

General Notes

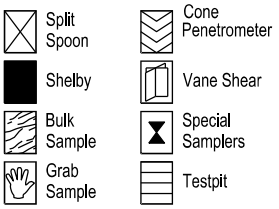
- Descriptions on these boring logs apply only at the specific boring, and at the time the time the borings were made. These logs are not warranted to be representative of subsurface conditions at other locations or times.
- Water level observations apply only at the specific boring, and at the time 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	Pl > 7 and plots on or above "A" line	CL	Lean clay [K L M]
			Pl < 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	Pl plots on or above "A" line	CH	Fat clay [K L M]
			Pl 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.

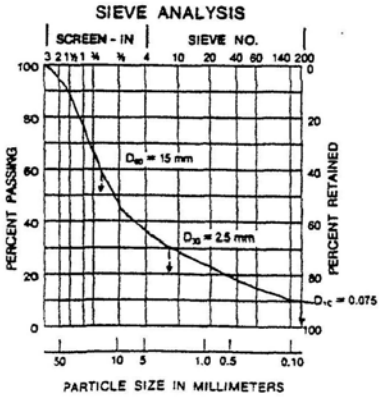
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

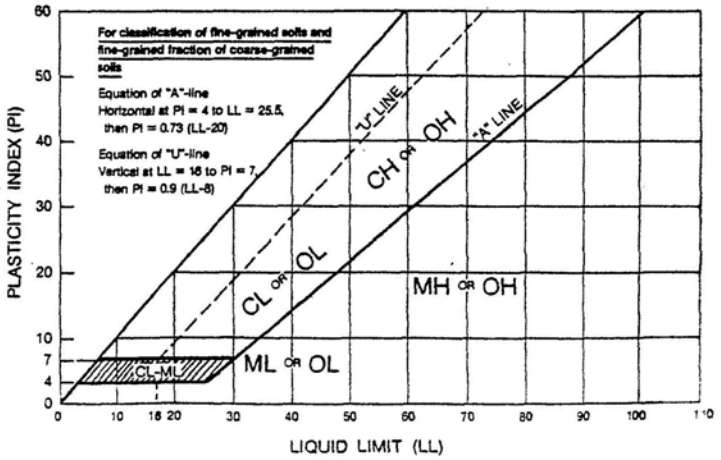
[N] Pl ≥ 4 and plots on or above "A" line.

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

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

[Q] Pl plots below "A: line.





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

UTILITY CROSSINGS	
101+11	O.H. PWR. X-ING – UNKNOWN CLR.
102+40	U.G. F.O. X-ING – UNKNOWN DEPTH
102+55	U.G. TEL. X-ING – UNKNOWN DEPTH
105+26	O.H. PWR. X-ING – UNKNOWN CLR.
105+28	O.H. PWR. X-ING – UNKNOWN CLR.
107+61	N.G. X-ING – UNKNOWN DEPTH
113+21	O.H. PWR. X-ING – UNKNOWN CLR.
115+29	U.G. TEL. X-ING – UNKNOWN DEPTH
119+22	O.H. PWR. X-ING – UNKNOWN CLR.
119+34	O.H. PWR. X-ING – UNKNOWN CLR.
121+24	O.H. PWR. X-ING – UNKNOWN CLR.

UTILITIES		UTILITIES	
99+57	F.H. RT.	99+00 to 102+54	U.G. F.O. RT.
100+68	F.H. RT.	99+00 to 129+76	U.G. TEL. RT.
102+53	F.H. RT.	99+00 to 102+25	O.H. PWR. LT.
102+57	M.H. F.O. RT.	99+00 to 107+35	N.G. LT.
103+37	M.H. RT.	103+58 to 104+77	O.H. PWR. LT.
103+48	M.H. S.D. RT.	105+36 to 124+89	U.G. TEL. LT.
104+18	WELL RT.	107+50 to 113+14	N.G. RT.
105+01	F.H. RT.	110+90 to 117+45	O.H. PWR. LT.
107+00	F.H. RT.	120+83 to 124+11	O.H. PWR. LT.
108+41	W.H. LT.	127+19 to 130+00	O.H. PWR. LT.
125+90	R.R. X-ING SIGNAL	129+34 to 130+00	U.G. PWR. LT.
126+81	R.R. X-ING SIGNAL	129+60 to 130+00	U.G. TEL. LT.

PI =96+63.83
Δ =8° 29' 51" (RT)
R =5,000'
T =371.46'
L =741.55'
E =13.78'
e = 4%

PT 100+33.92

100+00 110+00 120+00

PULP MILL RD

WETLAND-11

EX. R/W

PROP. R/W

SS-26

SS-25

S 2° 15' 36" E

BORING

MULLAN RD

STA. 101+00.00
BEGIN PROJECT
STPS 263-1(29)6

101+86 14" STL. PIPE IN PL. RT. REMOVE NEW 18" APP. PIPE RT.

103+32 14" CSP W/ HDWL. IN PL. LT. REMOVE

103+51 NEW 24" APP. PIPE LT.

103+93 12" CSP W/ HDWL. IN PL. LT. REMOVE NEW 18" APP. PIPE LT.

104+65 CONC. BOX W/ GRATE W/8" PVC DR. IN PL. LT. REMOVE NEW CONC. BOX W/ GRATE W/8" PVC DR.

105+10 12" x 18" CSP W/ HDWL. IN PL. LT. REMOVE NEW 18" APP. PIPE LT.

106+90 18" CSP W/ HDWL. IN PL. LT. REMOVE NEW 18" APP. PIPE LT.

107+38 14" STL. PIPE IN PL. LT. REMOVE NEW 18" APP. PIPE LT.

123+81 24" CSP IN PL. REMOVE NEW 24" DR.

MULLAN ROAD

102+94 26' PUBLIC APP. LT.
103+18 40' PRIVATE APP. RT.

105+14 36' PRIVATE APP. LT.

107+40 16' PRIVATE APP. LT.
106+89 PRIVATE APP. LT.

111+12 16' PRIVATE APP. RT.
111+24 34' PRIVATE APP. LT.
112+24 PRIVATE APP. LT.

115+14 PRIVATE APP. RT.
115+21 16' PRIVATE APP. LT.

121+21 PRIVATE APP. LT.
121+36 34' PRIVATE APP. RT.

3100 3090 3080 3070 3060 3050 3040 3030 3020

95+00 100+00 105+00 110+00 115+00 120+00 125+00

3,066.44

180' VC

-0.200% +0.348%

103+50.00 EL.3,065.91

EXISTING GROUND

113+00.00 EL.3,069.24

+0.348% -0.200%

200' VC

FINISHED GRADE

180' VC

-0.200% +0.288%

118+56.00 EL.3,063.14

HDR

3	MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\6141000\RD\6141000RDPL.DGN	DESIGNED BY		ROAD PLANS	WEST OF MISSOULA – NW / STPS 263-1(29)6
2		6/29/2021	REVIEWED BY		MISSOULA COUNTY	UPN 6141000 / FIGURE A1
		10:10:58 AM LFISCHER	CHECKED BY		PRELIMINARY PIH	

UTILITY CROSSINGS

129+75	U.G. TEL. X-ING - UNKNOWN DEPTH
129+78	U.G. TEL. X-ING - UNKNOWN DEPTH
129+88	O.H. PWR. X-ING - UNKNOWN CLR.

UTILITIES

125+90	R.R. X-ING SIGNAL
126+81	R.R. X-ING SIGNAL
134+59	F.H. RT.

UTILITIES

125+00 to 129+76	U.G. TEL. RT.
125+00 to 155+00	O.H. PWR. LT.
125+00 to 155+00	U.G. PWR. LT.
125+00 to 155+00	U.G. TEL. LT.
135+96 to 155+00	O.H. PWR. RT.

PI =137+03.15
Δ =16° 34' 20" (LT)
Rc =1,200'
Ls =216'
Δc =6° 15' 32" (LT)
Ts =282.97'
Lc =131.09'
Es =14.30'
e = 8%

LACASSE LN
30' WIDE PUBLIC ROAD EAS.
130+00
TS 134+20.18
SC 136+36.18
CS 137+67.27
ST 139+83.27
140+00
O'KEEFE CREEK
150+00
SS-24
SS-23
SS-22
EX. R/W
PROP. R/W
S 2° 15' 36" E
S 18° 49' 56" E
90'
100'
MULLAN RD
WETLAND-2B
WETLAND-3A
133+63
24" CSP IN PL.
REMOVE
NEW 24" DR.
140+92
TRIPLE 36" CSP IN PL.
REMOVE
NEW TRIPLE 36" DR.
149+82
14" STL. PIPE IN PL. LT.
REMOVE
NEW 18" APP. PIPE LT.

MULLAN ROAD

129+50
PUBLIC APP. LT.

149+72
16' FARM FIELD APP. LT.

126+50.00
EL.3,077.44
+0.288%
-0.394%
250' VC
FINISHED GRADE
EXISTING GROUND
180' VC
141+00.00
EL.3,064.73
-0.394%
+0.200%
149+50.00
EL.3,066.43
+0.200%
-0.200%
180' VC

3100 3090 3080 3070 3060 3050 3040 3030 3020

125+00 130+00 135+00 140+00 145+00 150+00 155+00

HDR

3 / 1 MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\6141000\RD\6141000RDPLOT.DGN 6/29/2021 10:10:59 AM LFISCHER	DESIGNED BY DRAWN BY REVIEWED BY CHECKED BY	ROAD PLANS MISSOULA COUNTY	PRELIMINARY PIH	WEST OF MISSOULA - NW UPN 6141000	STPS 263-1(29)6 FIGURE A2

UTILITIES

155+00 to 166+43	O.H. PWR. LT.
155+00 to 166+56	O.H. PWR. RT.
155+00 to 166+92	U.G. PWR. LT.
155+00 to 185+00	U.G. TEL. LT.
168+04 to 170+27	O.H. PWR. RT.
170+27 to 185+00	O.H. PWR. LT.

UTILITY CROSSINGS

166+56	O.H. PWR. X-ING - UNKNOWN CLR.
167+37	U.G. PWR. X-ING - UNKNOWN DEPTH
170+27	O.H. PWR. X-ING - UNKNOWN CLR.
177+39	O.H. TEL. X-ING - UNKNOWN CLR.
179+19	O.H. PWR. X-ING - UNKNOWN CLR.

160+00
170+00
180+00
MOCASSIN LN
TS 162+47.99
SC 164+43.99
CS 165+62.85
ST 167+18.85
TS 169+03.46
SC 171+19.46
CS 172+19.00
ST 174+35.00
WETLAND-4
WETLAND-5A
WETLAND-5B
WETLAND-3A
WETLAND-3B
WETLAND-3C
MOCCASIN DITCH
SS-21
SS-20
SS-19
EX. R/W
PROP. R/W
EX. EASE.
PROP. LINE
PROPERTY LINE
MULLAN RD
MULLAN ROAD
S 18° 49' 56" E
S 18° 51' 51" E
100'
60'

PI =165+14.51
Δ =15° 02' 01" (RT)
Rc =1,200'
Ls =216'
Δc =4° 43' 13" (RT)
Ts =266.53'
Lc =98.86'
Es =12.04'
e = 8%

PI =171+70.33
Δ =15° 03' 56" (LT)
Rc =1,200'
Ls =216'
Δc =4° 45' 08" (LT)
Ts =266.87'
Lc =99.53'
Es =12.08'
e = 8%

171+25±
6" STL. IRR. IN PL.
REMOVE

171+25
NEW 6" IRR.

178+26
30" CSP IN PL. LT.
REMOVE
NEW 30" DR.

157+46
16' FARM FIELD APP. RT.
157+69
PUBLIC APP. LT.
168+03
20' PRIVATE APP. LT.
168+41
16' FARM FIELD APP. RT.
176+57
16' PRIVATE APP. LT.
176+82
16' PRIVATE APP. RT.
176+89
16' PRIVATE APP. LT.
182+07
PRIVATE APP. LT.

3100
3090
3080
3070
3060
3050
3040
3030
3020

180' V.C
-0.200%
+0.205%
157+50.00
EL.3,064.83
EXISTING GROUND
168+50.00
EL.3,064.08
+0.205%
-0.200%
180' VC
180' VC
-0.200%
±0.200%
176+00.00
E..3,065.58
FINISHED GRADE
169+45.74
RELOCATE IRR. LATERAL M1A DITCH RT.
REFER TO IRR. DETAILS

155+00
160+00
165+00
170+00
175+00
180+00
185+00

HDR

2	MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\6141000\RD\6141000RDPLN.DGN	DESIGNED BY	ROAD PLANS	PRELIMINARY PIH	WEST OF MISSOULA - NW / STPS 263-1(29)6
1		6/29/2021	REVIEWED BY	MISSOULA COUNTY		UPN 6141000 / FIGURE A3
		10:11:00 AM LFISCHER	CHECKED BY			

UTILITIES		UTILITY CROSSINGS		UTILITIES	
185+00 to 206+22	U.G. TEL. LT.	185+42	O.H. PWR. X-ING - UNKNOWN CLR.	186+35	WELL LT.
185+00 to 206+93	O.H. PWR. LT.	185+86	U.G. TEL. X-ING - UNKNOWN DEPTH		
188+39 to 188+54	U.G. PWR. LT.	188+39	O.H. PWR. X-ING - UNKNOWN CLR.		
188+42 to 189+53	U.G. PWR. RT.	199+49	U.G. PWR. X-ING - UNKNOWN DEPTH		
206+14 to 211+99	O.H. PWR. RT.	202+68	O.H. PWR. X-ING - UNKNOWN CLR.		
206+21 to 208+18	U.T. TEL. ALONG C/L	206+14	O.H. PWR. X-ING - UNKNOWN CLR.		
208+18 to 215+00	U.G. TEL. RT.	207+77	U.G. TEL. X-ING - UNKNOWN DEPTH		

BISSON PL
190+00
PROPERTY LINE
LAVALLE CREEK
200+00
PC 200+06.21
PI =203+29.31
Δ =7° 46' 58" (LT)
R =4,750'
T =323.10'
L =645.21'
E =10.98'
e = 4%
PT 206+51.42
210+00
PC 209+79.33
PI =211+12.96
Δ =6° 35' 35" (RT)
R =2,320'
T =133.63'
L =266.96'
E =3.85'
e = 6%
PT 212+46.29
TS 214+81.00
EX. EASE.
EX. R/W
PROP. R/W
60'
SS-18
SS-17
SS-16
BH-1
S 18° 51' 51" E
S 26° 38' 49" E
S 20° 03' 14" E
WETLAND-3C
WETLAND-3D
WETLAND-3E
WETLAND-6A
WETLAND-6B
WETLAND-7A
WETLAND-7B
FAIRBANKS LN
MULLAN RD
MULLAN ROAD
189+48 16" STL PIPE IN PL. LT. REMOVE NEW 18" APP. PIPE LT.
203+76 48" CSP IN PL. REMOVE NEW 48" DR.
206+04 DBL. 18" CSP W/ HDWL. IN PL. LT. REMOVE NEW DBL. 18" APP. PIPE LT.
214+67 36" CSP IN PL. REMOVE NEW 36" DR.

185+58 PUBLIC APP. LT.
185+68 PUBLIC APP. RT.
189+49 16' PRIVATE APP. LT.
189+71 20' PRIVATE APP. RT.
189+93 16' PRIVATE APP. LT.
191+46 PRIVATE APP. RT.
194+35 16' PRIVATE APP. LT.
195+91 16' PRIVATE APP. LT.
197+76 16' PRIVATE APP. LT.
197+85 16' PRIVATE APP. LT.
198+38 16' PRIVATE APP. LT.
199+19 16' PRIVATE APP. RT.
199+50 16' PRIVATE APP. LT.
200+57 16' PRIVATE APP. LT.
206+05 16' PRIVATE APP. LT.
211+44 16' FARM FIELD APP. LT.

3100 3090 3080 3070 3060 3050 3040 3030 3020

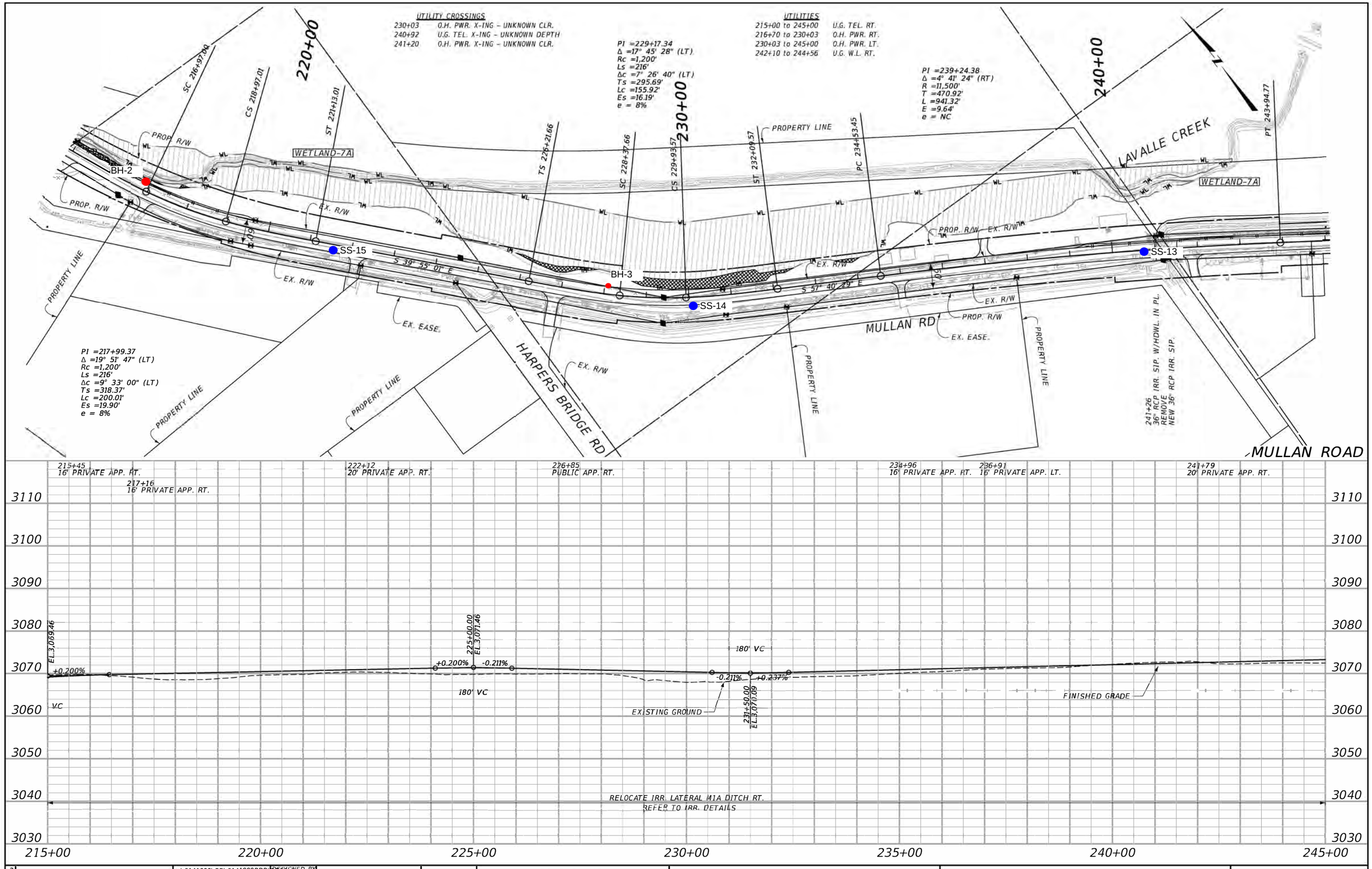
187+00.00 EL.3,067.78
+0.200% -0.200%
180' VC
191+00.00 EL.3,066.98
-0.200% +0.429%
FINISHED GRADE
EXISTING GROUND
199+00.00 EL.3,070.41
+0.429% -0.200%
230' VC
206+00.00 EL.3,069.01
0.200% -0.700%
180' VC
211+00.00 EL.3,065.51
-0.700% +0.988%
215+00.00
+0.988%
290'

RELOCATE IRR. LATERAL M1A DITCH RT.
REFER TO IRR. DETAILS

185+00 190+00 195+00 200+00 205+00 210+00 215+00

3	MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\6141000\RD\6141000RDPLN01.dgn	DESIGNED BY		ROAD PLANS	WEST OF MISSOULA - NW	STPS 263-1(29)6
2		6/29/2021	REVIEWED BY		MISSOULA COUNTY	UPN 6141000	FIGURE A4
		10:11:13 AM LFISCHER	CHECKED BY		PRELIMINARY PIH		

HDR



3 / 1	MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\6141000\RD\6141000RDPLN01.dgn 6/29/2021 10:11:14 AM LFISCHER	DESIGNED BY DRAWN BY REVIEWED BY CHECKED BY		ROAD PLANS MISSOULA COUNTY	PRELIMINARY PIH	WEST OF MISSOULA – NW UPN 6141000	STPS 263-1(29)6 FIGURE A5

HDR

250+00

260+00

270+00

PC 251+77.85

PT 257+04.67

PC 265+32.25

PT 268+97.11

PI =254+41.28
Δ =1° 40' 37" (RT)
R =18,000'
T =263.43'
L =526.82'
E =1.93'
e = NC

PI =267+14.70
Δ =1° 49' 04" (LT)
R =11,500'
T =182.45'
L =364.86'
E =1.45'
e = NC

UTILITY CROSSINGS

246+57	O.H. PWR. X-ING - UNKNOWN CLR.
256+96	U.G. TEL. X-ING - UNKNOWN DEPTH
257+65	O.H. GUY WIRE X-ING - UNKNOWN CLR.
273+25	O.H. PWR. X-ING - UNKNOWN CLR.
273+26	O.H. TEL. X-ING - UNKNOWN CLR.
273+32	O.H. PWR. X-ING - UNKNOWN CLR.

UTILITIES

245+00 to 275+00	U.G. TEL. RT.
245+00 to 275+00	O.H. PWR. LT.
246+46 to 246+55	U.G. W.L. RT.
246+97 to 247+06	U.G. W.L. RT.
257+65 to 277+16	O.H. PWR. RT.
256+97 to 257+19	U.G. TEL. LT.
265+19 to 273+13	O.H. TEL. LT.

UTILITIES

251+13	WELL RT.
271+19	W.V. RT.
273+81	W.V. LT.

PROPERTY LINE

EX. EASE.

EX. R/W

PROP. R/W

S 52° 59' 05" E

S 51° 18' 28" E

S 53° 07' 33" E

60'

SS-12

SS-11

SS-10

BH-4

BH-5

MULLAN RD

PRIMROSE DR

PRIMROSE LN

MALLARD WAY

STA. 272+18.77
BEGIN BRIDGE

STA. 272+46.82
END BRIDGE

246+89
18" CSP IRR. IN PL.
REMOVE

247+02
12" CONC. IRR TURNOUT
12" CSP W/ HG. IN PL. LT.
ABANDON

253+37
PVT. IRR. BR. IN PL. LT.
PROTECT IN PLACE

MULLAN ROAD

246+65
16' PRIVATE APP. RT.

246+69
16' PRIVATE APP. LT.

251+28
20' PRIVATE APP. RT.

252+82
32' PRIVATE APP. RT.

253+37
16' PRIVATE APP. LT.

256+71
16' FARM FIELD APP. RT.

257+08
16' PRIVATE APP. RT.

257+95
16' PRIVATE APP. RT.

264+64
16' PRIVATE APP. RT.

266+86
16' PRIVATE APP. RT.

269+83
PUBLIC APP. RT.

272+99
PUBLIC APP. LT.

272+99
PUBLIC APP. RT.

3110
3100
3090
3080
3070
3060
3050
3040
3030

246+50.00
EL.3,073.64

251+50.00
EL.3,072.64

258+50.00
EL.3,075.34

262+00.00
EL.3,074.64

+0.237%
-0.200%
+0.385%
-0.200%
-0.200%
+0.200%

180' VC
180' VC
210' VC

FINISHED GRADE

EXISTING GROUND

RELOCATE IRR.
LATERAL M1A DITCH RT.
REFER TO IRR. DETAILS
241+47.36

271+84.92
272+73.09
REMOVE
GUARDRAIL LT.

271+24.96
272+12.16
272+47.67
272+53.97
NEW MGS
GUARDRAIL LT

272+50.00
EL.3,076.91
MGS INTERSECTING
ROADWAY TERMINAL
SECTION LT.

270+47.10
272+22.70
272+57.33
NEW MGS
GUARDRAIL RT.

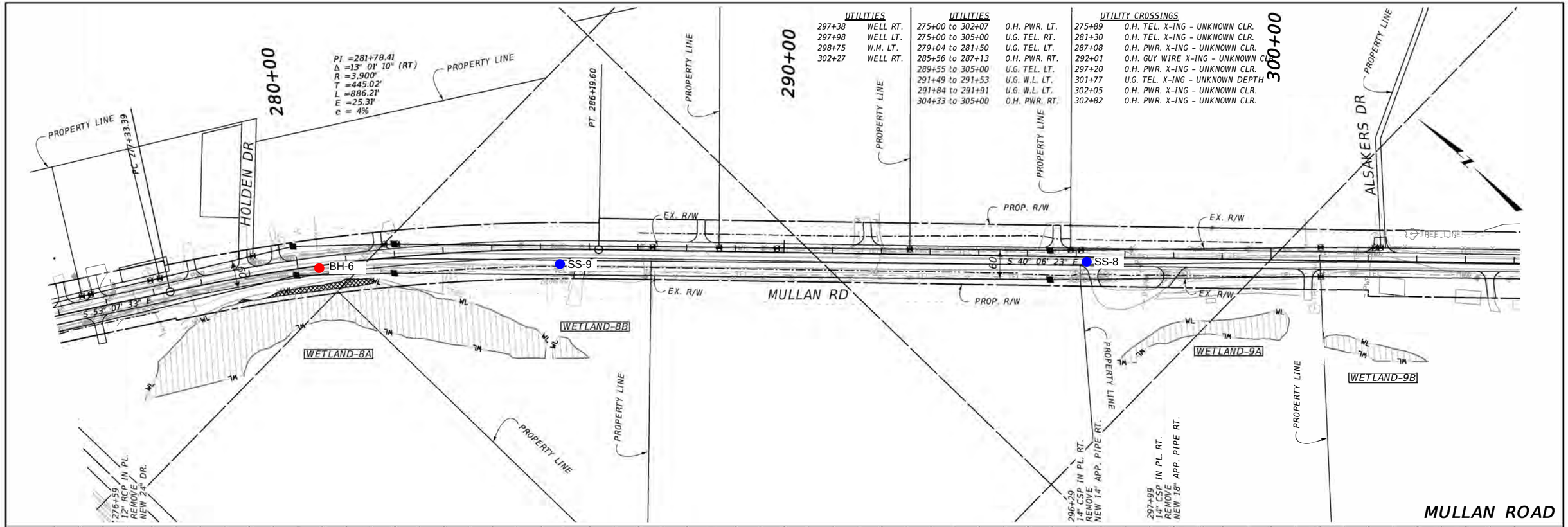
273+02.63
MGS INTERSECTING
ROADWAY TERMINAL
SECTION RT.

271+84.95
272+87.03
REMOVE
GUARDR AIL RT.

245+00
250+00
255+00
260+00
265+00
270+00
275+00

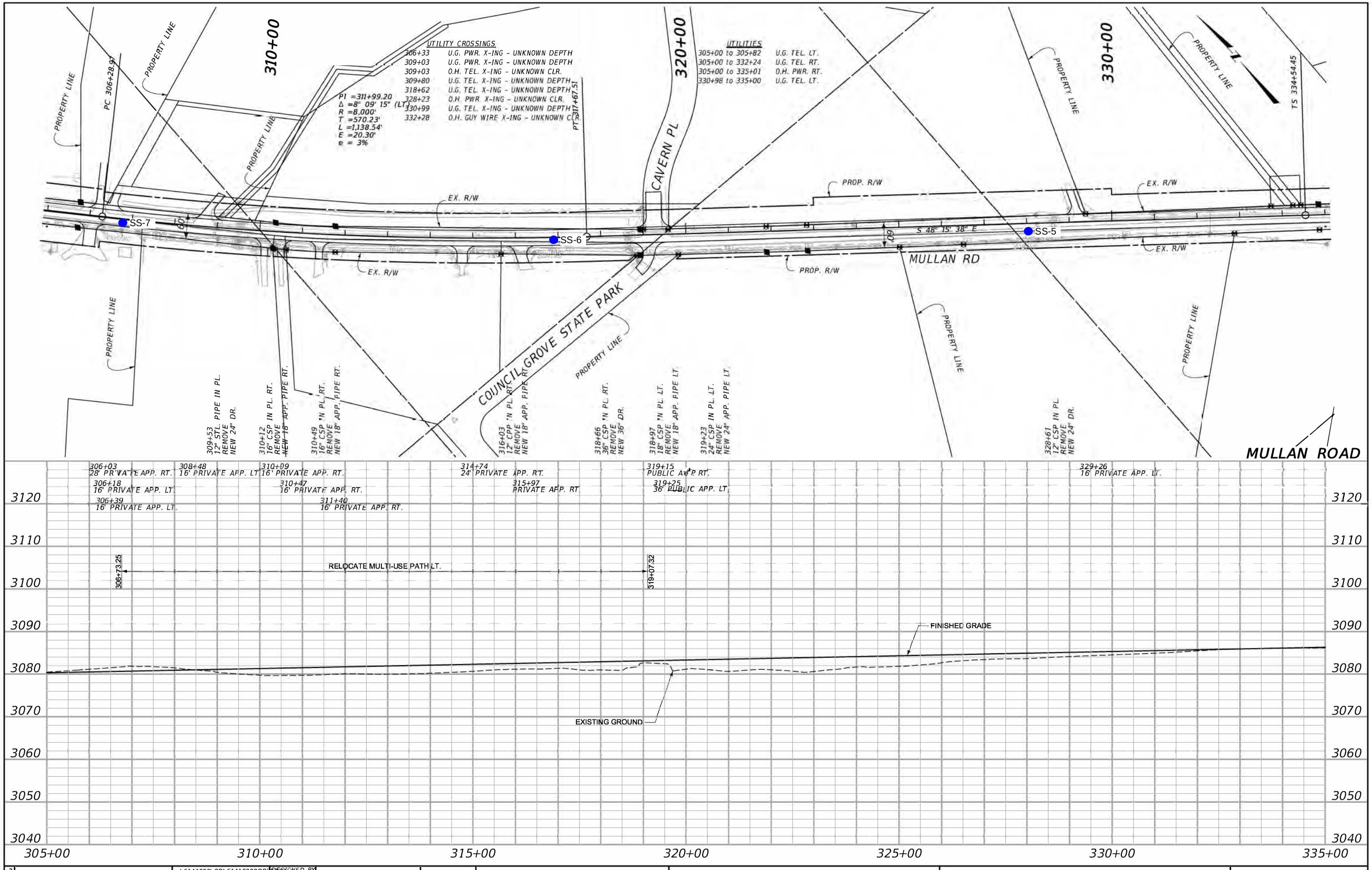
HDR

2	MDT	MONTANA DEPARTMENT OF TRANSPORTATION	...\6141000\RD\6141000RDPLN01.dgn	DESIGNED BY	ROAD PLANS	PRELIMINARY PIH	WEST OF MISSOULA - NW	STPS 263-1(29)6
1			6/29/2021	REVIEWED BY			UPN 6141000	FIGURE A6
			10:11:15 AM LFISCHER	CHECKED BY	MISSOULA COUNTY			



3	MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\6141000\RD\6141000RDPLN.dgn	DESIGNED BY	ROAD PLANS	WEST OF MISSOULA – NW	STPS 263-1(29)6
2		6/29/2021	REVIEWED BY			
		10:11:27 AM LFISCHER	CHECKED BY	MISSOULA COUNTY	PRELIMINARY PIH	UPN 6141000 FIGURE A7

HDR



3 / 1 MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\6141000\RD\6141000RDPLSH01.dgn 6/29/2021 10:11:28 AM L'FISCHER	DESIGNED BY REVIEWED BY CHECKED BY	ROAD PLANS MISSOULA COUNTY	PRELIMINARY PIH	WEST OF MISSOULA - NW UPN 6141000	STPS 263-1(29)6 FIGURE A8

HDR

UTILITY CROSSINGS:
338+26 O.H. TEL. X-ING - UNKNOWN CLR.
350+18 O.H. PWR. X-ING - UNKNOWN CLR.
353+80 U.G. TEL. X-ING - UNKNOWN DEPTH.

UTILITIES
335+00 to STA.
342+38 to 350+20
355+43 to 360+05
359+74 to STA.
U.G. TEL. LT.
O.H. PWR. LT.
U.G. W.L. LT.
O.H. PWR. RT.

UTILITIES
356+93 W.V. LT.

PI =352+57.13
Δ =15° 08' 29" (LT)
Rc =1,200'
Ls =216'
Δc =4° 49' 41" (LT)
Ts =267.68'
Lc =101.12'
Es =12.19'
e = 6%

PI =342+03.99
Δ =39° 34' 22" (RT)
Rc =1,820'
Ls =189'
Δc =33° 37' 23" (RT)
Ts =749.54'
Lc =1,068.03'
Es =115.06'
e = 7%

340+00
350+00
360+00
DESCHAMPS LN
MULLAN RD
MULLAN ROAD
PROPERTY LINE
EX. R/W
PROP. R/W
BH-7
SS-4
SS-3
SS-2
WETLAND-10A
WETLAND-10B
S 8° 41' 18" E
S 23° 49' 44" E
90'
120'
SC 338+43
CS 347+41.29
ST 349+00.49
TS 349+89.46
SC 352+05.46
CS 353+06.58
ST 355+22.58
342+77 18" CSP IN PL. RT. PROTECT IN PL.
353+43 18" CSP IN PL. RT. REMOVE NEW 18" APP. PIPE RT.
STA. 358+30.00
END PROJECT
STPS 263-1(29)6

337+06 16' PRIVATE APP. RT.
337+10 16' FARM FIELD APP. LT.
342+72 16' PRIVATE APP. RT.
348+21 26' PUBLIC APP. LT.
353+63 16' PRIVATE APP. RT.
355+09 16' PRIVATE APP. LT.
357+99 16' PRIVATE APP. RT.

180' VC
410' VC
250' VC
+0.200%
+0.739%
-0.400%
+1.091%
FINISHED GRADE
EXISTING GROUND
336+10.10 EL. 3,086.62
342+50.00 EL. 3,094.05
354+50.00 EL. 3,088.25
3,090.40

3120
3110
3100
3090
3080
3070
3060
3050
3040
335+00
340+00
345+00
350+00
355+00
360+00
365+00

HDR

2 1 MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\6141000\RD\6141000RDPL...	DESIGNED BY	ROAD PLANS	PRELIMINARY PIH	WEST OF MISSOULA - NW	STPS 263-1(29)6
	6/29/2021	REVIEWED BY	MISSOULA COUNTY		UPN 6141000	FIGURE A9
	10:11:30 AM LFISCHER	CHECKED BY				

APPENDIX B1

Logs of Exploratory Borings - Activity 130 (Figures 1B through 7B)

2525 Palmer St
59808
Phone: 406-543-3045
Fax:

Figure No. 1B

LOG OF BORING

Boring 614100-BH-1

TETRA TECH

Project: Mullan Road		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 714104 ft **Coordinates** E: 5202153 ft	**Station:** 204 + 75 **Offset:** 26 ft R
Project Number: 114-571120	**UPN:** 614100	**Boring Diameter:** 8"	**System:** Local Coordinates **Datum:** NAD83	**Top of Boring Elevation:** 3064.6 ft
Date Started: 11/16/21	**Date Finished:** 11/16/21	**Drilling Fluid:** None	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Plans
Driller: O'Keefe Drilling **Logger:** Sara Dalen		**Abandonment Method:** Backfilled and Compacted	**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, dry.	0.8						
			67		4 - 3 - 3		FILL, Lean CLAY (CL), [A-6]. stiff, slightly moist, dark brown to black, scattered gravel.	*3063.9*	18					
5 *3059.6*							Sandy Lean CLAY (CL), [A-6]. medium stiff, slightly moist, brown.	5.0 *3059.6*						
			83		2 - 3 - 4				18					
							Silty SAND with gravel (SM), [A-2]. very dense to very loose, slightly moist to wet, light brown, fine to coarse grained, subangular to rounded.	9.0 *3055.6*	7					
10 *3054.6*			61		11 - 50/0.3ft					NV	NP	36		
15 *3049.6*			78		23 - 36 - 50/0.4ft		▽							
20 *3044.6*			50		1 - 1 - 1									
							Boring Depth:20.5 ft, *Elevation:3044.1 ft*	20.5 *3044.1*						

Water Level Observations		Remarks:
▽ During Drilling: 14.8 ft *(3049.8 ft)*	▽ After Drilling: Not Recorded	
▽ After Drilling: Not Recorded		

2525 Palmer St
59808
Phone: 406-543-3045
Fax:

Figure No. 2B

LOG OF BORING

Boring 614100-BH-2

TETRA TECH

Project: Mullan Road		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 714273 ft **Coordinates** E: 5201882 ft	**Station:** 215 + 18 **Offset:** 36 ft L
Project Number: 114-571120	**UPN:** 614100	**Boring Diameter:** 8"	**System:** Local Coordinates **Datum:** NAD83	**Top of Boring Elevation:** 3066.6 ft
Date Started: 11/16/21	**Date Finished:** 11/16/21	**Drilling Fluid:** None	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Plans
Driller: O'Keefe Drilling **Logger:** Sara Dalen		**Abandonment Method:** Backfilled with Cuttings	**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
			67		8 - 9 - 9		FILL, Poorly-Graded GRAVEL with clay and sand (GP), [A-1]. medium dense, slightly moist to very moist, light brown, fine to coarse grained.		5					
			39		11 - 15 - 12									
5 3061.6			22		6 - 7 - 10				5					
							Poorly-Graded GRAVEL with sand (GP), [A-1]. medium dense, very moist, brown, fine to coarse grained, rounded to subangular.	5.0 3061.6		NV	NP	4		
			100		1 - 3 - 3				34					
							Lean CLAY (CL), [A-6]. soft to very stiff, very moist to wet, black, high plasticity.	9.0 3057.6	28					
10 3056.6			95		4 - 5 - 32									
							Clayey GRAVEL (GC), [A-2]. medium dense, wet, angular to subangular.	12.0 3054.6						
			39		15 - 17 - 10				10					
15 3051.6														
							Boring Depth:15.5 ft, *Elevation:3051.1 ft*	15.5 3051.1						

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

2525 Palmer St
59808
Phone: 406-543-3045
Fax:

Figure No. 3B

LOG OF BORING

Boring 614100-BH-3

TETRA TECH

Project: Mullan Road		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 714528 ft **Coordinates** E: 5201590 ft	**Station:** 228 + 14 **Offset:** 29 ft L
Project Number: 114-571120	**UPN:** 614100	**Boring Diameter:** 8"	**System:** Local Coordinates **Datum:** NAD83	**Top of Boring Elevation:** 3068.7 ft
Date Started: 11/15/21	**Date Finished:** 11/15/21	**Drilling Fluid:** None	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Plans
Driller: O'Keefe Drilling **Logger:** Sara Dalen		**Abandonment Method:** Backfilled with Cuttings	**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
			67		4 - 5 - 3		TOPSOIL, slightly moist, dark brown.	0.5 / 3068.2	4					
							FILL, Poorly-Graded SAND with gravel (SP), [A-1]. loose, slightly moist, tan/brown, fine to coarse grained, angular to subrounded.	1.5 / 3067.2						
			55		4 - 10 - 15			2.5 / 3066.2	4					
							Lean CLAY with sand (CL), [A-6]. very stiff, slightly moist, dark brown.		1					
5 / 3063.7			39		8 - 17 - 41		Poorly-Graded SAND with gravel (SP), [A-1]. loose, slightly moist, tan/brown, fine to coarse grained, angular to subrounded.	5.0 / 3063.7		NV	NP	6		
			39		3 - 3 - 4		Poorly-Graded GRAVEL with silt and sand (GP-GM), [A-1]. Cobbles, loose to dense, slightly moist to wet, brown, subangular to subrounded.		2					
10 / 3058.7			61		9 - 18 - 18				2					
15 / 3053.7			78		8 - 21 - 26			15.5 / 3053.2						

Boring Depth:15.5 ft, *Elevation:3053.2 ft*

Water Level Observations		Remarks:
During Drilling: 10.8 ft *(3057.9 ft)*		
After Drilling: Not Recorded	After Drilling: Not Recorded	

2525 Palmer St
59808
Phone: 406-543-3045
Fax:

Figure No. 4B

LOG OF BORING

Boring 614100-BH-4

TETRA TECH

Project: Mullan Road		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 715668 ft **Coordinates** E: 5200889 ft	**Station:** 272 + 09 **Offset:** 6 ft R
Project Number: 114-571120	**UPN:** 614100	**Boring Diameter:** 8"	**System:** Local Coordinates **Datum:** NAD83	**Top of Boring Elevation:** 3076.8 ft
Date Started: 11/15/21	**Date Finished:** 11/15/21	**Drilling Fluid:** None	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Plans
Driller: O'Keefe Drilling **Logger:** Sara Dalen		**Abandonment Method:** Backfilled with Cuttings	**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, dry.	0.4 *3076.4*						
			83		18 - 11 - 17		FILL, Silty, Clayey SAND with gravel (SC-SM), [A-4]. soft to very stiff, slightly moist, dark brown, fine to coarse grained, rounded to subangular.		9	23	16	36		pH= 8.15 Resistivity= 1700 ohm-cm Sulfate Content= 0.0021 % CBR= 6
			83		4 - 9 - 14				9					
5 *3071.8*			72		1 - 1 - 4				18					
			44		8 - 9 - 6				1					
							Poorly-Graded GRAVEL with clay and sand (GP-GC), [A-2]. medium dense to very dense, moist to wet, brown, fine to coarse grained, angular to rounded, Tip of final SS contained moist, pale red, hightly plastic clay. ▽	8.0 *3068.8*						
10 *3066.8*			67		10 - 10 - 12				2					
15 *3061.8*			89		5 - 24 - 35									
20 *3056.8*			61		22 - 50/0.4ft									
25 *3051.8*			100		5 - 13 - 26			25.5 *3051.3*						

Boring Depth:25.5 ft, *Elevation:3051.3 ft*

Water Level Observations		Remarks:
▽ During Drilling: 11.0 ft *(3065.8 ft)*	▽ After Drilling: Not Recorded	
▽ After Drilling: Not Recorded		

2525 Palmer St
59808
Phone: 406-543-3045
Fax:

Figure No. 5B

LOG OF BORING

Boring 614100-BH-5

TETRA TECH

Project: Mullan Road		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 715683 ft **Coordinates** E: 5200877 ft	**Station:** 272 + 71 **Offset:** 12 ft R
Project Number: 114-571120	**UPN:** 614100	**Boring Diameter:** 8"	**System:** Local Coordinates **Datum:** NAD83	**Top of Boring Elevation:** 3076.8 ft
Date Started: 11/15/21	**Date Finished:** 11/15/21	**Drilling Fluid:** None	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Plans
Driller: O'Keefe Drilling **Logger:** Sara Dalen		**Abandonment Method:** Backfilled with Cuttings	**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, dry.	0.5						
			83		7-5-5		FILL, Sandy Lean CLAY (CL), [A-6]. stiff, slightly moist, dark brown, occasional sand.	3076.2	8	26	12	59		pH= 7.89 Resistivity= 2050 ohm-cm Sulfate Content= 0.0018 % Friction Angle= 31.2 degrees Cohesion= 0.42 ksf CBR= 5 Cc= 0.2
			78		4-10-5				10					
5 3071.8			96											
			61		11-10-7		Poorly-Graded GRAVEL with clay and sand (GP-GC), [A-2]. very loose to very dense, slightly moist to wet, light tan/brown, fine to coarse grained.	6.0 3070.8	0					
10 3066.8			67		4-7-7		▽							
15 3061.8			39		3-1-2									
20 3056.8			67		30-43-34									
25 3051.8			100		5-15-50/0.3ft									
							Boring Depth:25.5 ft, *Elevation:3051.3 ft*	25.5 3051.3						

Water Level Observations		Remarks:
▽ During Drilling: 10.2 ft *(3066.6 ft)*	▽ After Drilling: Not Recorded	
▼ After Drilling: Not Recorded		

2525 Palmer St
59808
Phone: 406-543-3045
Fax:

Figure No. 6B

LOG OF BORING

Boring 614100-BH-6

TETRA TECH

Project: Mullan Road		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 715879 ft **Coordinates** E: 5200753 ft	**Station:** 280 + 36 **Offset:** 15 ft R
Project Number: 114-571120	**UPN:** 614100	**Boring Diameter:** 8"	**System:** Local Coordinates **Datum:** NAD83	**Top of Boring Elevation:** 3075.0 ft
Date Started: 11/10/21	**Date Finished:** 11/10/21	**Drilling Fluid:** None	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Plans
Driller: O'Keefe Drilling **Logger:** Tetra Tech		**Abandonment Method:** Backfilled with Cuttings	**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
			33		3 - 5 - 4		TOPSOIL, slightly moist.	0.2 *3074.8*	2					
							FILL, Poorly-Graded SAND with silt and gravel (SP-SM), [A-2]. loose, slightly moist, brown.	2.0 *3073.0*						
			53		3 - 1 - 10		Sandy SILT with gravel (ML), [A-4]. stiff, slightly moist, dark brown to black.	3.8 *3071.2*	11					
5 *3070.0*			667		8 - 16 - 18		Poorly-Graded SAND with gravel (SP), [A-1]. dense, slightly moist, angular to subangular.		0					
			60		13 - 16 - 17		Poorly-Graded GRAVEL with sand (GP), [A-1]. dense to very dense, wet, tan, subangular to subrounded.	7.0 *3068.0*						
10 *3065.0*			80		18 - 19 - 36		Poorly-Graded SAND with gravel (SP), [A-1]. dense to very dense, wet, tan, fine to coarse grained, angular to subangular.	9.0 *3066.0*						
15 *3060.0*			100		16 - 50		Poorly-Graded SAND with gravel (SP), [A-1]. wet, multi-colored, coarse grained, angular to subangular.	15.0 *3060.0* 15.5 *3059.5*						

Boring Depth:15.5 ft, *Elevation:3059.5 ft*

Water Level Observations		Remarks:
During Drilling: 6.5 ft *(3068.5 ft)*	After Drilling: Not Recorded	
After Drilling: Not Recorded		

2525 Palmer St
59808
Phone: 406-543-3045
Fax:

Figure No. 7B

LOG OF BORING

Boring 614100-BH-7

TETRA TECH

Project: Mullan Road		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 717303 ft **Coordinates** E: 5199496 ft	**Station:** 342 + 93 **Offset:** 31 ft R
Project Number: 114-571120	**UPN:** 614100	**Boring Diameter:** 8"	**System:** Local Coordinates **Datum:** NAD83	**Top of Boring Elevation:** 3085.7 ft
Date Started: 11/10/21	**Date Finished:** 11/10/21	**Drilling Fluid:** None	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Plans
Driller: O'Keefe Drilling **Logger:** Tetra Tech		**Abandonment Method:** Backfilled with Cuttings	**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
			47		5 - 3 - 2		FILL, Silty SAND (SM), [A-2]. moist, dark brown, subangular.		6					
			60		8 - 10 - 11		Poorly-Graded GRAVEL with sand (GP), [A-1]. medium dense to very dense, moist to dry, dark brown to tan, angular to subangular.	2.5 *3083.2*	2					
5 *3080.7*			67		8 - 8 - 12				2	NV	NP	4		
			67		17 - 30 - 36				1					
10 *3075.7*			47		12 - 13 - 27		Poorly-Graded SAND (SP), [A-1]. dense, wet, tan to gray, angular.	9.7 *3076.0*						
15 *3070.7*			100		11 - 50		Poorly-Graded GRAVEL with sand (GP), [A-1]. dense, wet, coarse grained, angular to subangular.	15.0 *3070.7* 15.5 *3070.2*						

Boring Depth:15.5 ft, *Elevation:3070.2 ft*

Water Level Observations		Remarks:
After Drilling: Not Recorded	During Drilling: 9.1 ft *(3076.6 ft)*	
	After Drilling: Not Recorded	

APPENDIX B2

Logs of Exploratory Borings - Activity 106 (Figures 2A-1 through 2A-26)

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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.	0.5 / 3093.0	1	NV	NP	6		
							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.							
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	

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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
			80		25 - 29 - 30		Asphalt.	0.4 *3090.0*	1					
							FILL, Poorly-Graded SAND with gravel (SP), [A-1]. very dense, slightly moist, tan/brown, fine to coarse grained, subrounded.							
							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:
After Drilling: Not Recorded	During Drilling: 11.1 ft *(3079.3 ft)*	
	After Drilling: Not Recorded	

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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*						
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.	4.0 *3084.2*	1					
10 *3078.2*			0		50/0.4ft									
15 *3073.2*			13		26 - 27 - 22									
							Boring Depth: 15.5 ft, *Elevation: 3072.7 ft*	15.5 *3072.7*						

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

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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
							Asphalt, Top 2 inches are recent overlay.	0.6	7					
			67		6 - 7 - 10		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					5.0						
3081.2							Poorly-Graded SAND with gravel (SP), [A-1]. dense, moist to wet, tan/brown, fine to coarse grained, subrounded to subangular.	3081.2	1					
			67		12 - 19 - 21									
									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

- During Drilling: 10.0 ft *(3076.2 ft)*
- After Drilling: Not Recorded
- After Drilling: Not Recorded

Remarks:

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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	3	17	15	12		
			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*						
5			87		14 - 9 - 8		Silty CLAY with sand (CL-ML), [A-4]. very stiff, slightly moist, gray to black, low plasticity.	4.7	14					
3079.0								*3079.3*						
							▽	8.0						
							Poorly-Graded SAND with gravel (SP), [A-1]. medium dense, moist to wet, tan/brown, fine to coarse grained, subrounded to subangular.	*3076.0*	5					
10			60		13 - 15 - 15									
3074.0														
15			60		7 - 10 - 10									
3069.0														
								15.5						
							Boring Depth: 15.5 ft, *Elevation: 3068.5 ft*	*3068.5*						

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

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LOG OF BORING

Boring 614100-SS-6

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 1007229.8 ft **Coordinates** 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	1					
			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*						
								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								5.0						
							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.	*3076.6*						
10			47		9 - 19 - 14									
3071.6														
15			80		8 - 50/0.5ft			15.0						
3066.6							Boring Depth: 15.0 ft, *Elevation: 3066.6 ft*	*3066.6*						

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

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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:
▽ After Drilling: Not Recorded	▽ During Drilling: 7.4 ft *(3074.3 ft)*	
	▼ After Drilling: Not Recorded	

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

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

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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	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.	*3076.6* 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:
During Drilling: 6.1 ft *(3071.2 ft)*		
After Drilling: Not Recorded	After Drilling: Not Recorded	

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LOG OF BORING

Boring 614100-SS-10

TETRA TECH

Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 1010355.84 ft **Coordinates** 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									
							Boring Depth: 15.5 ft, *Elevation: 3060.8 ft*	15.5 *3060.8*						

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

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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		

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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	

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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		

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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.			28	20	75		
5 *3064.5*			100		0 - 0 - 0				32					SS @ 4 ft. Advanced by weight of hammer.
10 *3059.5*			100					10.4 *3059.1*						
			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.							
15 *3054.5*			53		22 - 24 - 40			15.5 *3054.0*						

Boring Depth: 15.5 ft, *Elevation: 3054.0 ft*

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

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

Water Level Observations

- During Drilling: 7.8 ft *(3062.7 ft)*
- After Drilling: Not Recorded
- After Drilling: Not Recorded

Remarks:

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

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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
			60		9 - 18 - 12		Asphalt, Top 2 inches are recent overlay.	0.5 *3069.5*	6					
							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									
							Boring Depth: 15.5 ft, *Elevation: 3054.5 ft*	15.5 *3054.5*						

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

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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	

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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	

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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:
After Drilling: Not Recorded	During Drilling: 12.5 ft *(3054.5 ft)*	
	After Drilling: Not Recorded	

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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:
▽ During Drilling: 10.7 ft *(3054.5 ft)*	▼ After Drilling: Not Recorded	
▼ After Drilling: Not Recorded		

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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	

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

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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						
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	33					
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 REPORTLOGS\MULLAN RD.GPJ

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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			15.5 3053.2						

Boring Depth: 15.5 ft, *Elevation: 3053.2 ft*

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

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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	

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LOG OF BORING

Boring 614100-SS-26

TETRA TECH

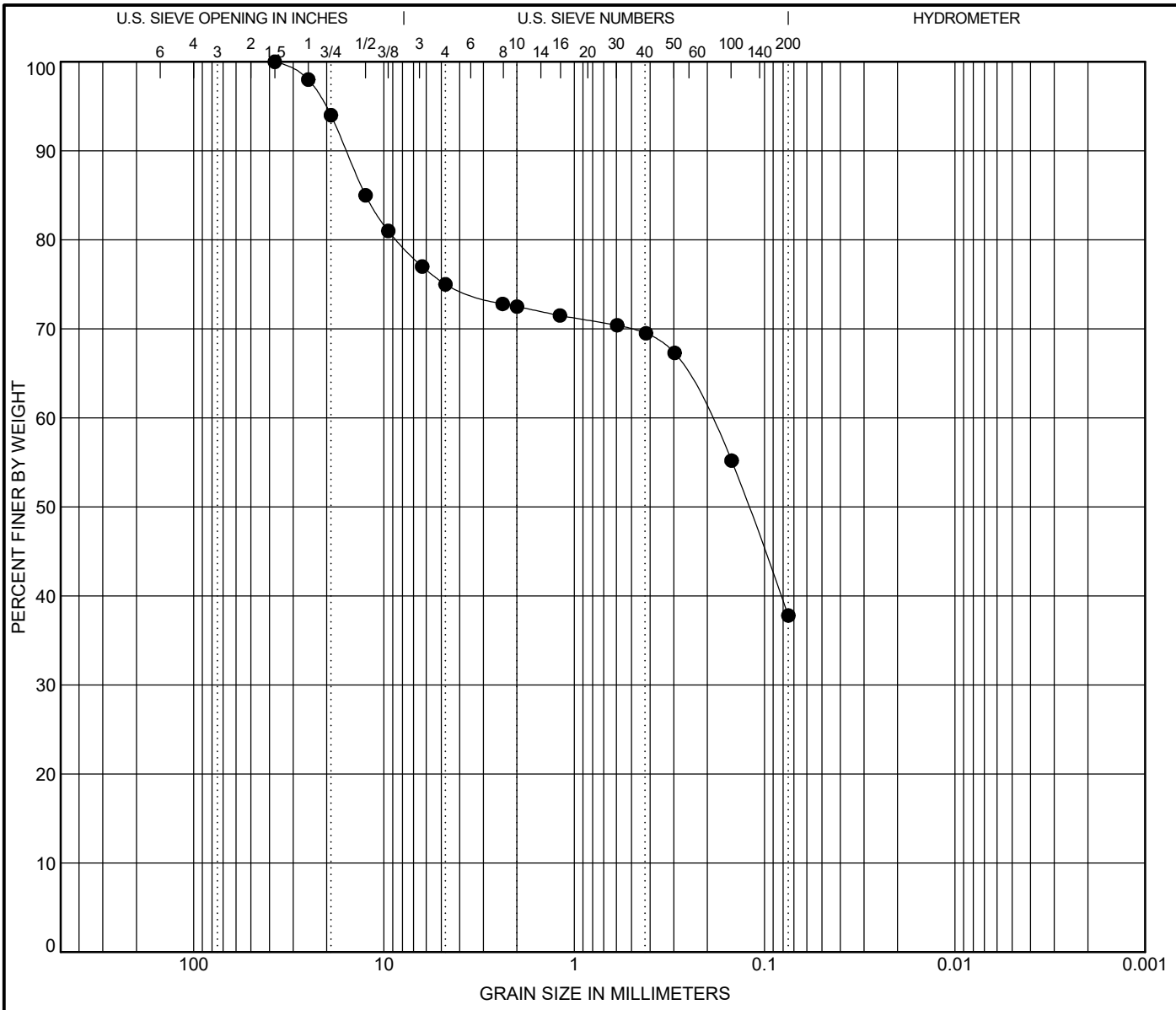
Project: West of Missoula - NW (Mullan Rd)		**Rig:** Mobile B-61 **Hammer:** Auto	**Boring Location** N: 1024801.75 ft **Coordinates** E: 796900.89 ft	**Station:** **Offset:**
Project Number: STPS 263 - 1(28)6	**UPN:** 614100	**Boring Diameter:** 8 in	**System:** MT S.P. (E) **Datum:** WGS84	**Top of 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.	0.9 / 3065.4	1					
			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.			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					
15 / 3051.3			53		5 - 10 - 7				1					
							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 C

Laboratory Testing
Table C-1: Summary of Laboratory Results
Gradations: Figures 1C through 6C
Proctors: Figures 7C through 10C
Consolidation Curve: Figure 11C
Direct Shear Test: Figure 12C
CBR Tests: Figures 13C and 14C



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	85
3/8 in	81
1/4 in	77
No. 4	75
No. 8	72.8
No. 10	72.5
No. 16	71.5
No. 30	70.4
No. 40	69.5
No. 50	67.3
No. 100	55.2
No. 200	37.8

Specimen Identification
BH-1 - (10 - 14 ft)

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

% Gravel	% Sand	% Silt	% Clay
25	37	38	

D100	D60	D30	D10
37.5	0.196		

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: Mullan Road

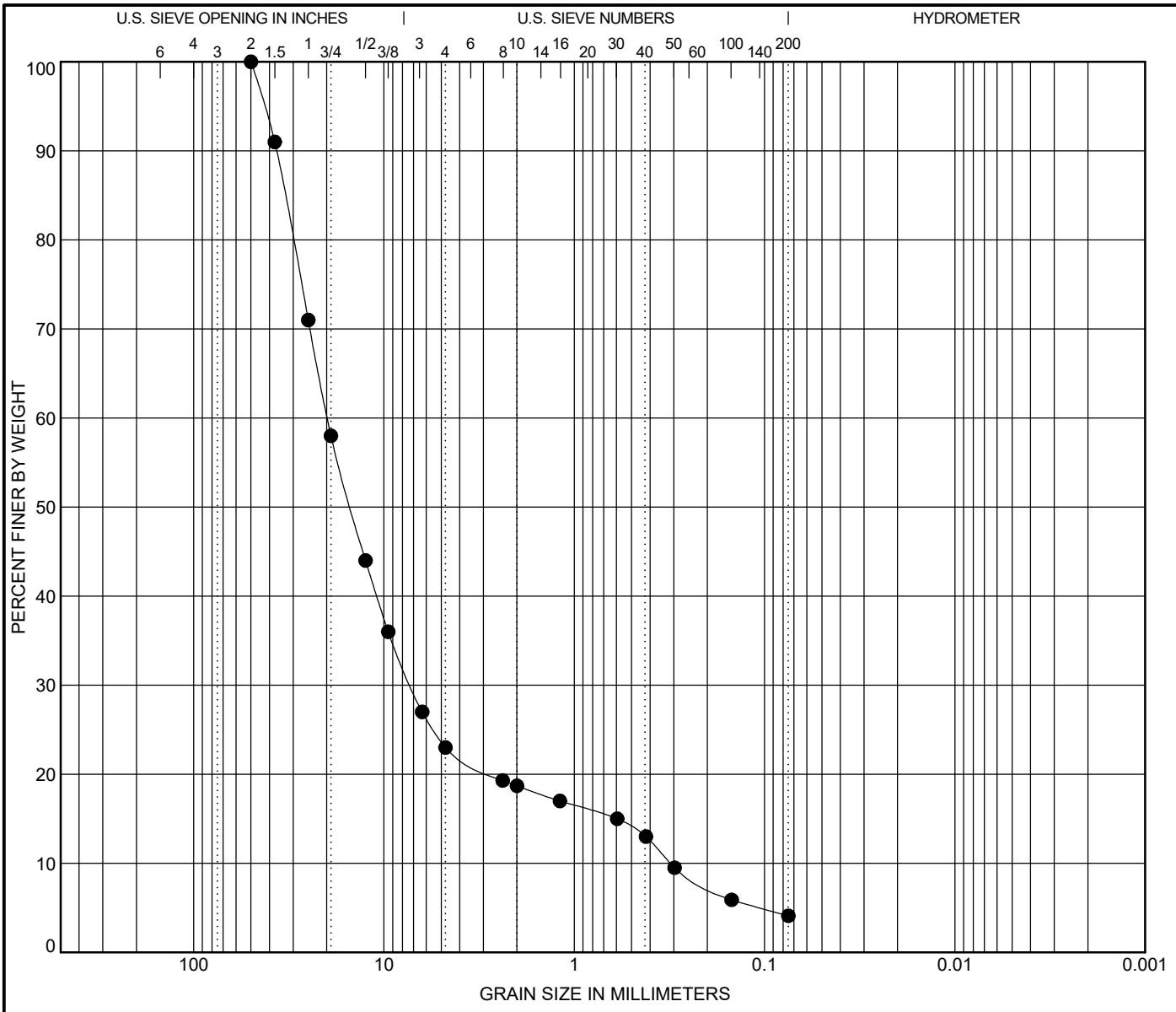
Location: Refer to Site Map

Number: 114-571120

Figure No. 1C

MULLAN ROAD BORING LOGS.GPJ ` 6-22-22 ` ` 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	91
1 in	71
3/4 in	58
1/2 in	44
3/8 in	36
1/4 in	27
No. 4	23
No. 8	19.3
No. 10	18.7
No. 16	17
No. 30	15
No. 40	13
No. 50	9.5
No. 100	5.9
No. 200	4.1

Specimen Identification
BH-2 - (5 - 9 ft)

Classification	LL	PL	PI	Cc	Cu
POORLY GRADED GRAVEL with SAND(GP)	**NV**	**NV**	**NP**	**8.44**	**63.51**
AASHTO : A-1-a (1)					

% Gravel	% Sand	% Silt	% Clay
77	19	4	

D100	D60	D30	D10
50	19.819	7.224	0.312

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: Mullan Road

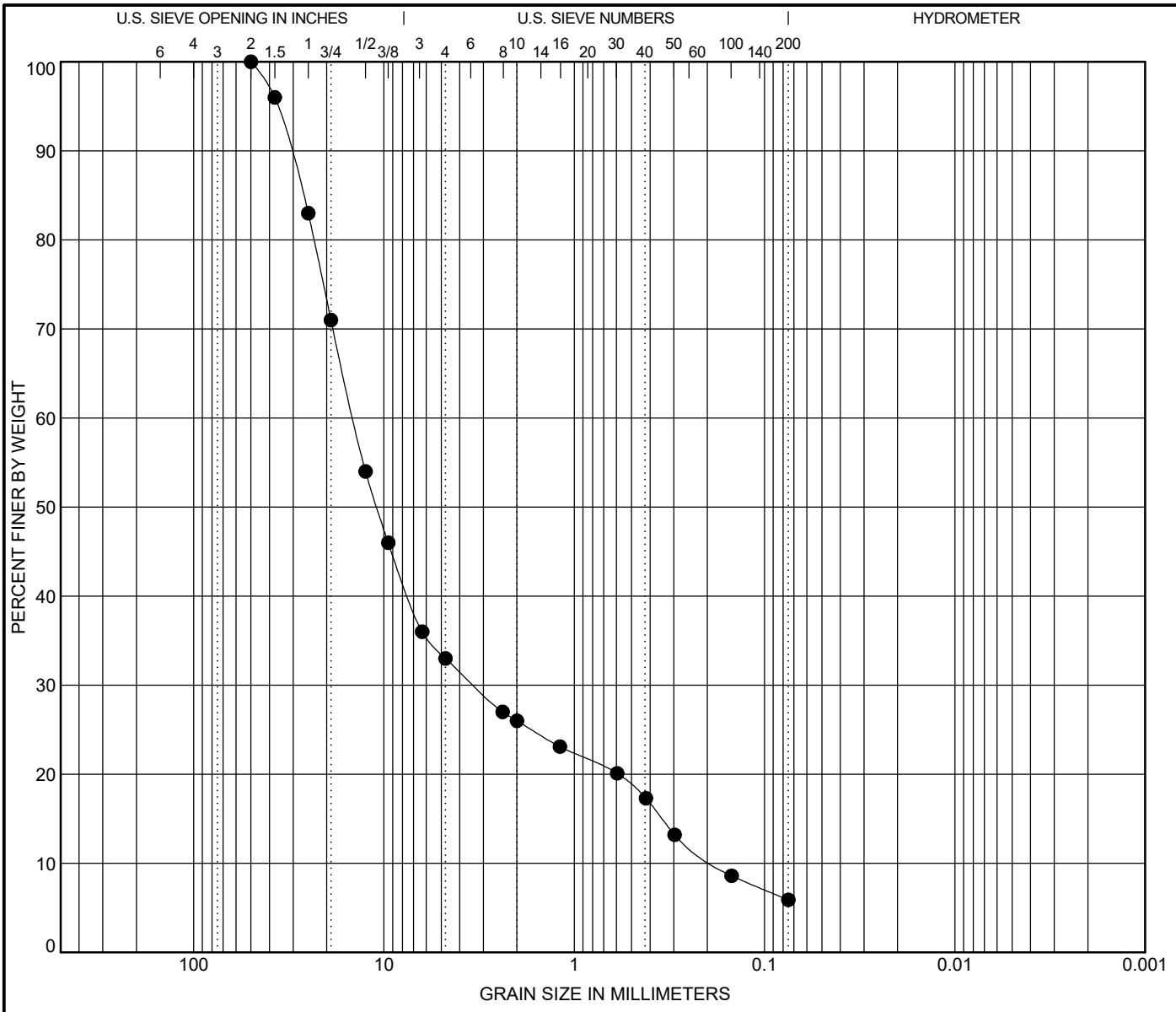
Location: Refer to Site Map

Number: 114-571120

Figure No. 2C

MULLAN ROAD BORING LOGS.GPJ ` 6-22-22 ` ` 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	83
3/4 in	71
1/2 in	54
3/8 in	46
1/4 in	36
No. 4	33
No. 8	27
No. 10	26
No. 16	23.1
No. 30	20.1
No. 40	17.3
No. 50	13.2
No. 100	8.6
No. 200	5.9

Specimen Identification
BH-3 - (5 - 9 ft)

Classification	LL	PL	PI	Cc	Cu
POORLY GRADED GRAVEL with SILT and SAND(GP-GM)	**NV**	**NV**	**NP**	**4.24**	**78.84**
AASHTO : A-1-a (1)					

% Gravel	% Sand	% Silt	% Clay
67	27	6	

D100	D60	D30	D10
50	14.491	3.362	0.184

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: Mullan Road

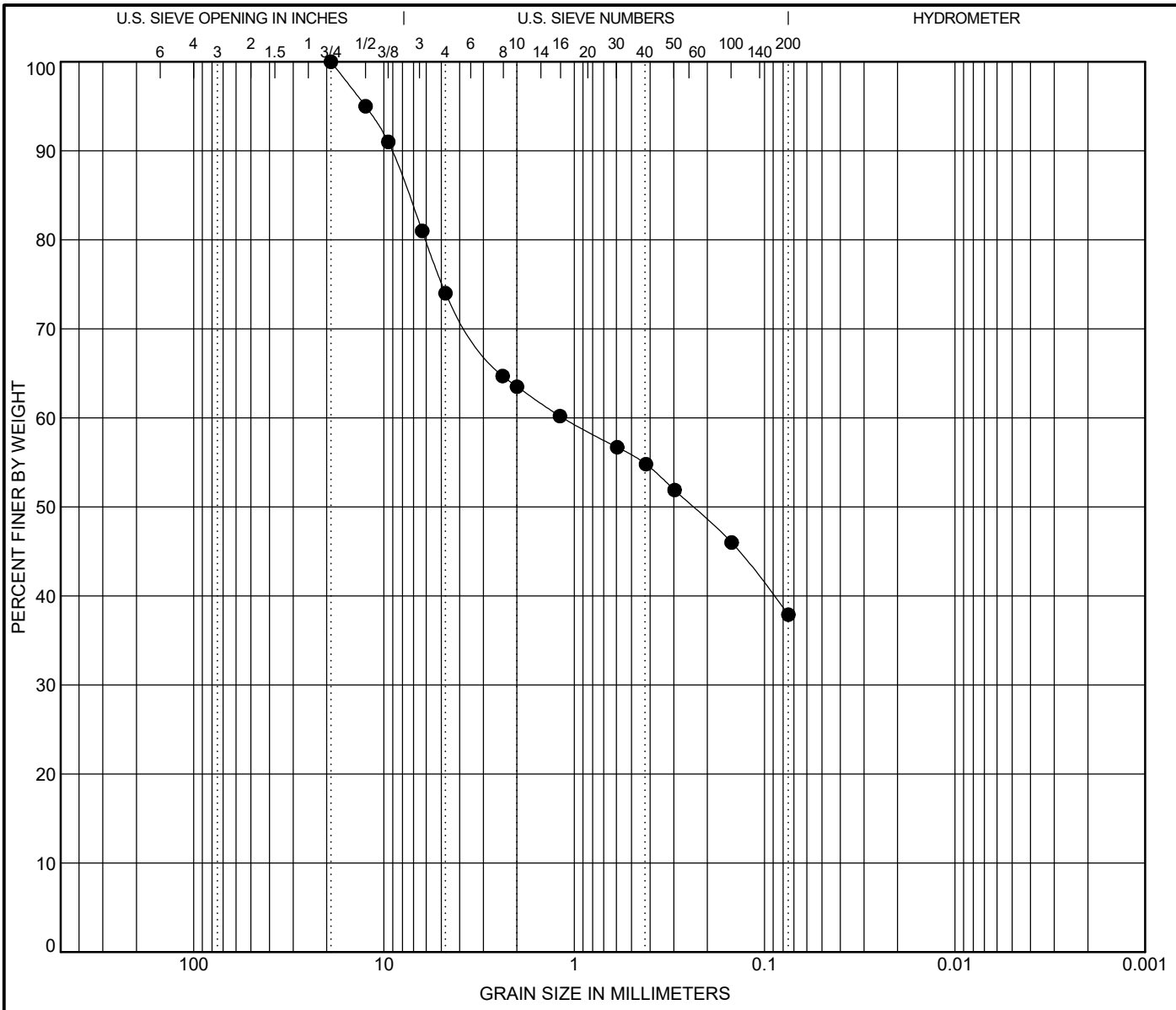
Location: Refer to Site Map

Number: 114-571120

Figure No. 3C

MULLAN ROAD BORING LOGS.GPJ ` 6-22-22 ` ` 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	95
3/8 in	91
1/4 in	81
No. 4	74
No. 8	64.7
No. 10	63.5
No. 16	60.2
No. 30	56.7
No. 40	54.8
No. 50	51.9
No. 100	46
No. 200	37.9

Specimen Identification
BH-4 - (0.4 - 5 ft)

Classification	LL	PL	PI	Cc	Cu
SILTY, CLAYEY SAND with GRAVEL(SC-SM)	**23**	**16**	**7**		
AASHTO : A-4 (0)					

% Gravel	% Sand	% Silt	% Clay
26	36	38	

D100	D60	D30	D10
19	1.144		

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: Mullan Road

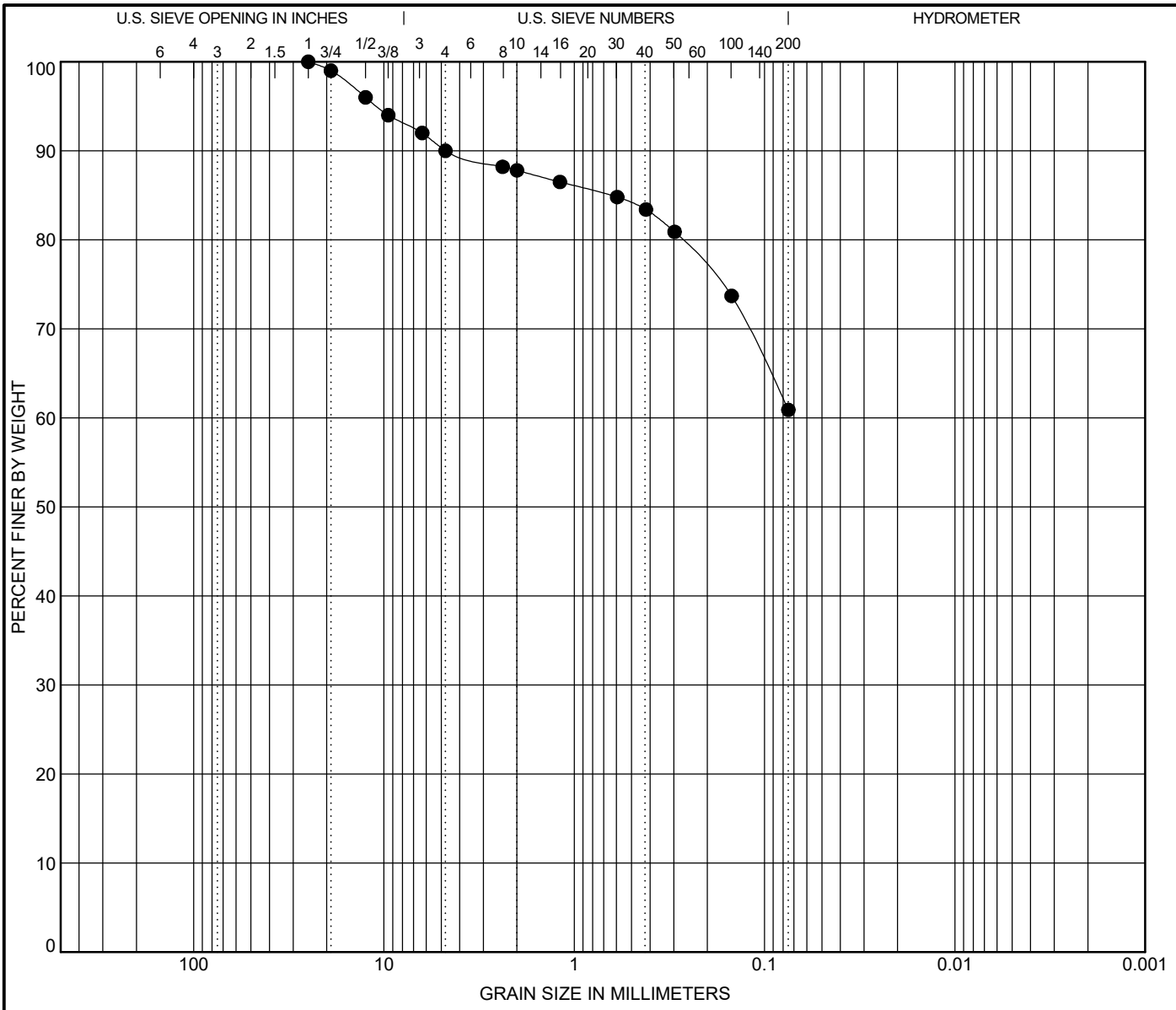
Location: Refer to Site Map. Primrose Bridge

Number: 114-571120

Figure No. 4C

MULLAN ROAD BORING LOGS.GPJ ` 6-22-22 ` ` 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	96
3/8 in	94
1/4 in	92
No. 4	90
No. 8	88.2
No. 10	87.8
No. 16	86.5
No. 30	84.8
No. 40	83.4
No. 50	80.9
No. 100	73.7
No. 200	60.9

Specimen Identification
BH-5 - (0.5 - 5 ft)

Classification	LL	PL	PI	Cc	Cu
SANDY LEAN CLAY(CL)					
AASHTO : A-6 (5)	**26**	**12**	**14**		

% Gravel	% Sand	% Silt	% Clay
10	29	61	

D100	D60	D30	D10
25			

GRAIN SIZE DISTRIBUTION

TETRA TECH

Project: Mullan Road

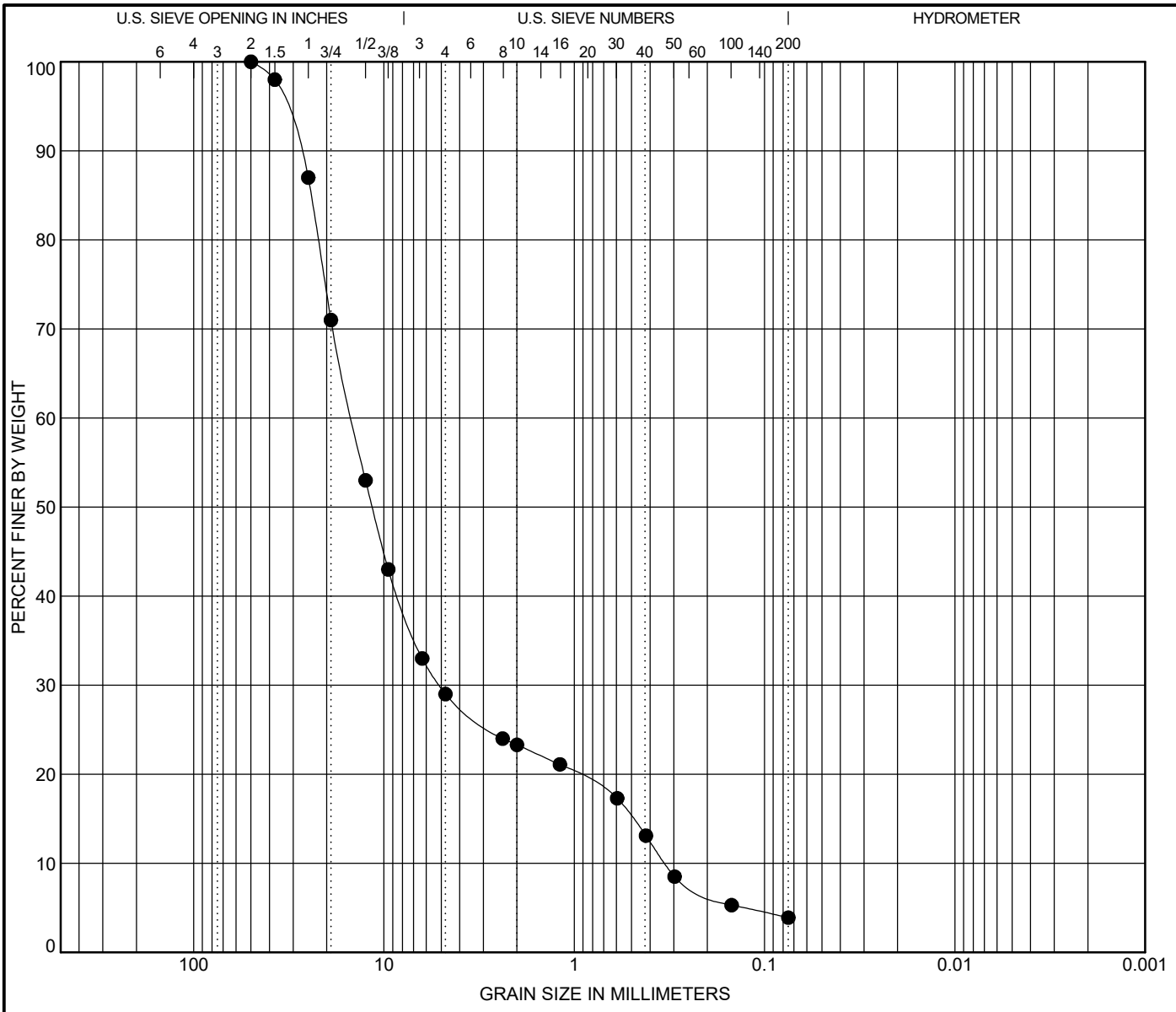
Location: Refer to Site Map. Primrose Bridge

Number: 114-571120

Figure No. 5C

MULLAN ROAD BORING LOGS.GPJ ` 6-22-22 ` ` 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	87
3/4 in	71
1/2 in	53
3/8 in	43
1/4 in	33
No. 4	29
No. 8	24
No. 10	23.3
No. 16	21.1
No. 30	17.3
No. 40	13.1
No. 50	8.5
No. 100	5.3
No. 200	3.9

Specimen Identification
BH-7 - (5 - 7 ft)

Classification	LL	PL	PI	Cc	Cu
POORLY GRADED GRAVEL with SAND(GP)	**NV**	**NV**	**NP**	**5.31**	**44.24**
AASHTO : A-1-a (1)					

% Gravel	% Sand	% Silt	% Clay
71	25	4	

D100	D60	D30	D10
50	14.71	5.097	0.333

TETRA TECH

GRAIN SIZE DISTRIBUTION

Project: Mullan Road

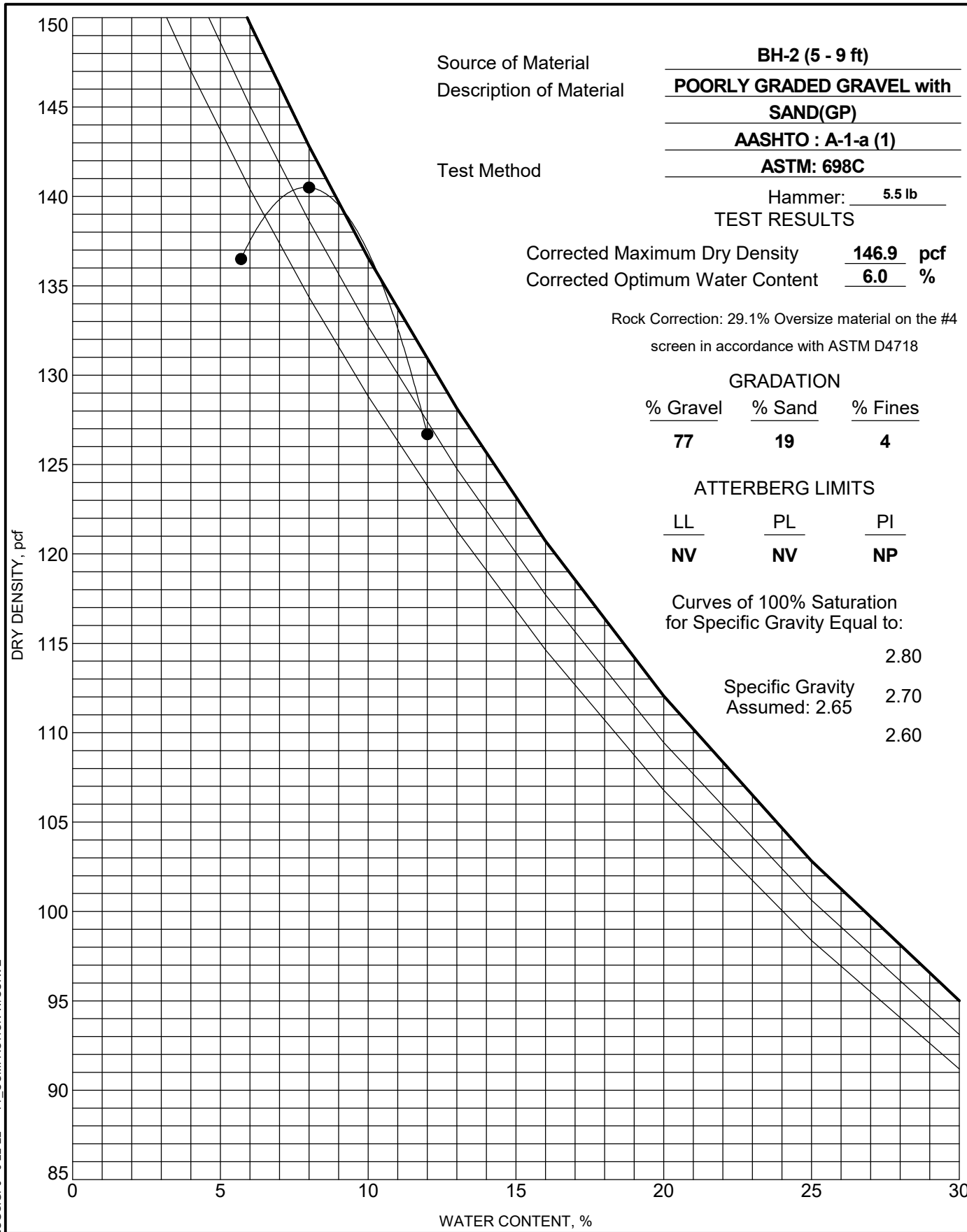
Location: Refer to Site Map

Number: 114-571120

Figure No. 6C

MULLAN ROAD BORING LOGS.GPJ ` 6-22-22 ` ` TT_US GRAIN SIZE (SIEVE DATA)

Revised 1-23-08 (MAT)



Source of Material: **BH-2 (5 - 9 ft)**

Description of Material: **POORLY GRADED GRAVEL with SAND(GP)**

AASHTO : A-1-a (1)

Test Method: **ASTM: 698C**

Hammer: **5.5 lb**

TEST RESULTS

Corrected Maximum Dry Density	**146.9**	**pcf**
Corrected Optimum Water Content	**6.0**	**%**

Rock Correction: 29.1% Oversize material on the #4 screen in accordance with ASTM D4718

GRADATION

% Gravel	% Sand	% Fines
77	**19**	**4**

ATTERBERG LIMITS

LL	PL	PI
NV	**NV**	**NP**

Curves of 100% Saturation for Specific Gravity Equal to:

Specific Gravity Assumed: 2.65

2.80

2.70

2.60

MOISTURE-DENSITY RELATIONSHIP

TETRA TECH

Project: Mullan Road

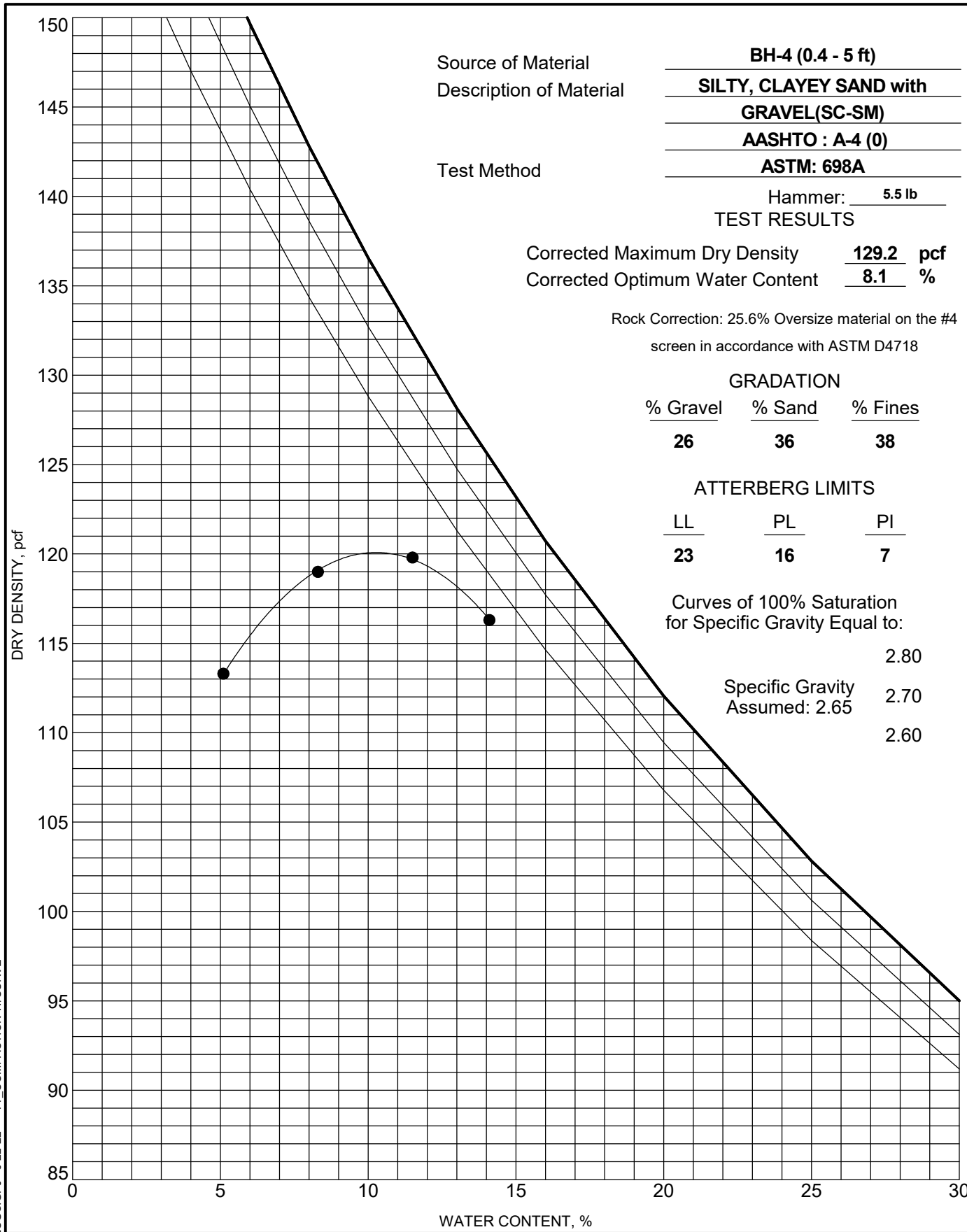
Location: Refer to Site Map

Number: 114-571120

Figure No. 7C

MULLAN ROAD BORING LOGS.GPJ ` 6-22-22 ` ` TT_COMPACTION W/CURVE

Revised 1-23-08 (MAT)



Source of Material: **BH-4 (0.4 - 5 ft)**

Description of Material: **SILTY, CLAYEY SAND with GRAVEL(SC-SM)**

AASHTO : A-4 (0)

Test Method: **ASTM: 698A**

Hammer: **5.5 lb**

TEST RESULTS

Corrected Maximum Dry Density	**129.2**	**pcf**
Corrected Optimum Water Content	**8.1**	**%**

Rock Correction: 25.6% Oversize material on the #4 screen in accordance with ASTM D4718

GRADATION

% Gravel	% Sand	% Fines
26	**36**	**38**

ATTERBERG LIMITS

LL	PL	PI
23	**16**	**7**

Curves of 100% Saturation for Specific Gravity Equal to:

Specific Gravity Assumed: 2.65

2.80

2.70

2.60

MOISTURE-DENSITY RELATIONSHIP

TETRA TECH

Project: Mullan Road

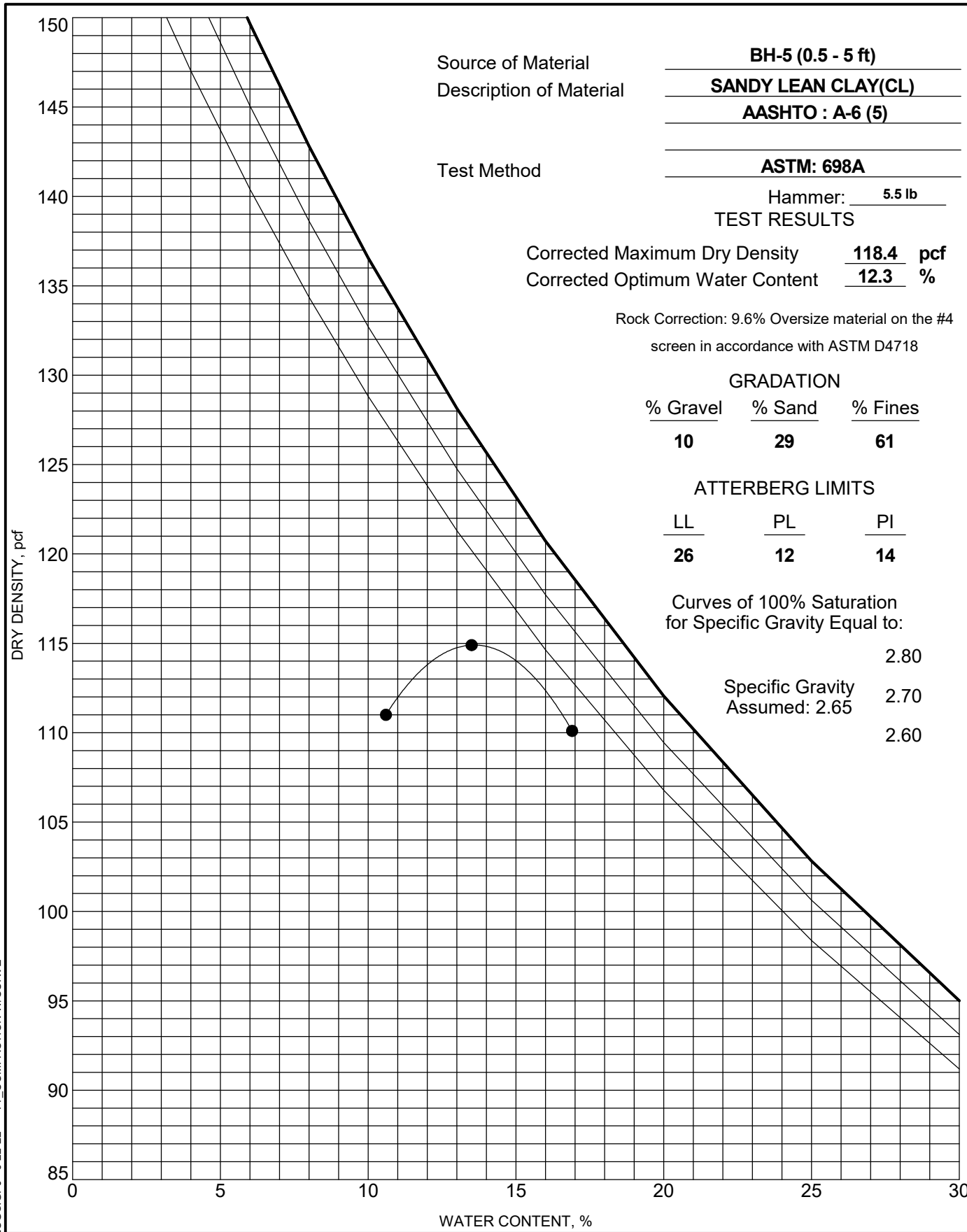
Location: Refer to Site Map. Primrose Bridge

Number: 114-571120

Figure No. 8C

MULLAN ROAD BORING LOGS.GPJ ` 6-22-22 ` ` TT_COMPACTION W/CURVE

Revised 1-23-08 (MAT)



Source of Material: **BH-5 (0.5 - 5 ft)**

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

AASHTO : A-6 (5)

Test Method: **ASTM: 698A**

Hammer: **5.5 lb**

TEST RESULTS

Corrected Maximum Dry Density	**118.4**	**pcf**
Corrected Optimum Water Content	**12.3**	**%**

Rock Correction: 9.6% Oversize material on the #4 screen in accordance with ASTM D4718

GRADATION

% Gravel	% Sand	% Fines
10	**29**	**61**

ATTERBERG LIMITS

LL	PL	PI
26	**12**	**14**

Curves of 100% Saturation for Specific Gravity Equal to:

Specific Gravity Assumed: 2.65

2.80

2.70

2.60

MOISTURE-DENSITY RELATIONSHIP

TETRA TECH

Project: Mullan Road

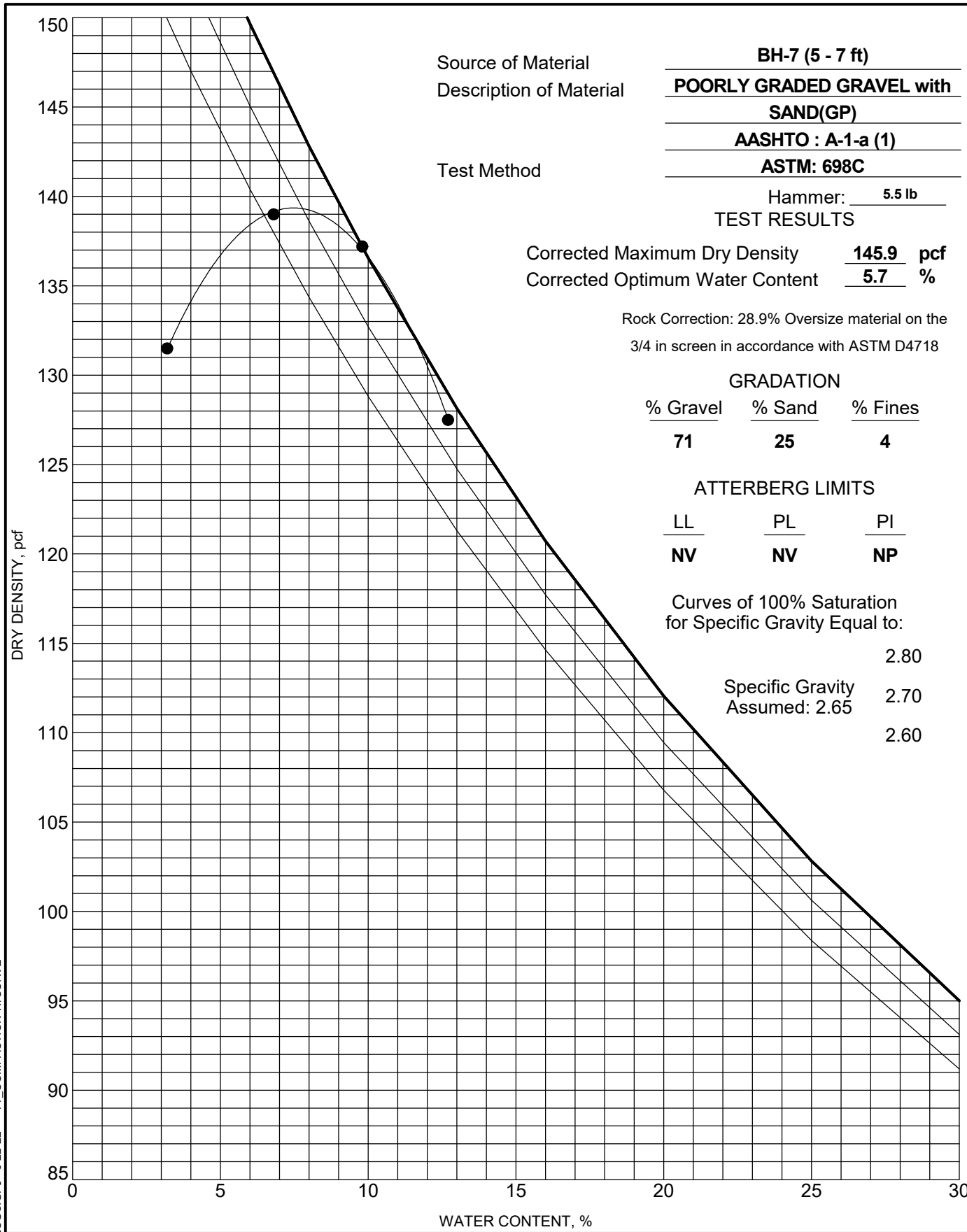
Location: Refer to Site Map. Primrose Bridge

Number: 114-571120

Figure No. 9C

MULLAN ROAD BORING LOGS.GPJ ` 6-22-22 ` ` TT_COMPACTION W/CURVE

Revised 1-23-08 (MAT)



Source of Material: **BH-7 (5 - 7 ft)**

Description of Material: **POORLY GRADED GRAVEL with SAND(GP)**

AASHTO : A-1-a (1)

Test Method: **ASTM: 698C**

Hammer: **5.5 lb**

TEST RESULTS

Corrected Maximum Dry Density	**145.9**	**pcf**
Corrected Optimum Water Content	**5.7**	**%**

Rock Correction: 28.9% Oversize material on the 3/4 in screen in accordance with ASTM D4718

GRADATION

% Gravel	% Sand	% Fines
71	**25**	**4**

ATTERBERG LIMITS

LL	PL	PI
NV	**NV**	**NP**

Curves of 100% Saturation for Specific Gravity Equal to:

Specific Gravity Assumed: 2.65

2.80

2.70

2.60

MOISTURE-DENSITY RELATIONSHIP

TETRA TECH

Project: Mullan Road

Location: Refer to Site Map

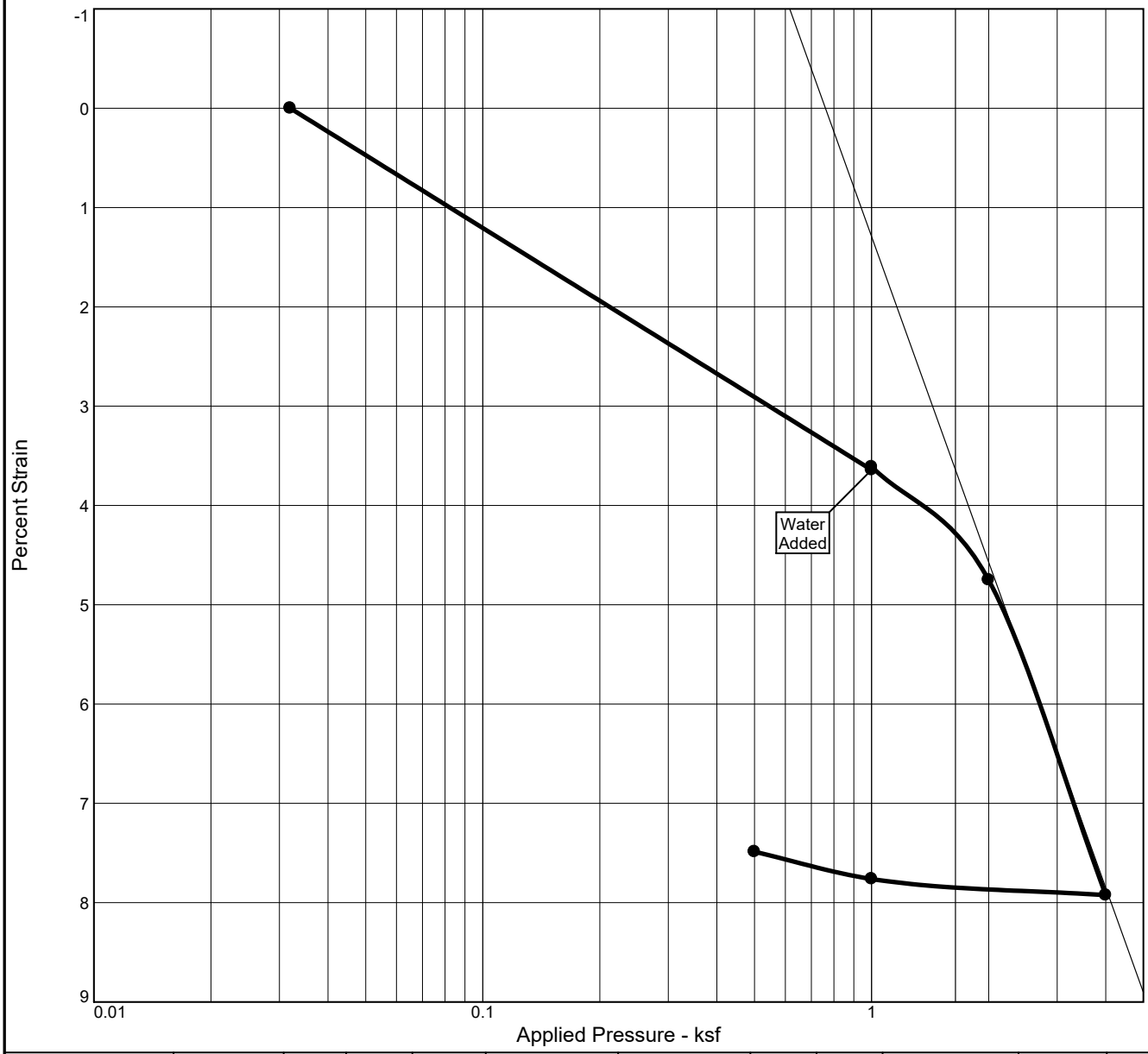
Number: 114-571120

Figure No. 10C

MULLAN ROAD BORING LOGS.GPJ ` 6-22-22 ` ` TT_COMPACTION W/CURVE

Revised 1-23-08 (MAT)

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (ksf)	P_c (ksf)	C_c	C_s	Swell Press. (ksf)	Swell %	e_o
Sat.	Moist.											
89.9 %	28.0 %	90.7	26	14	2.65		1.9	0.20	0.01	1.0	0.0	0.825

MATERIAL DESCRIPTION	USCS	AASHTO
Sandy Lean Clay	CL	A-6 (5)

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

Project: Mullan Road - MDT

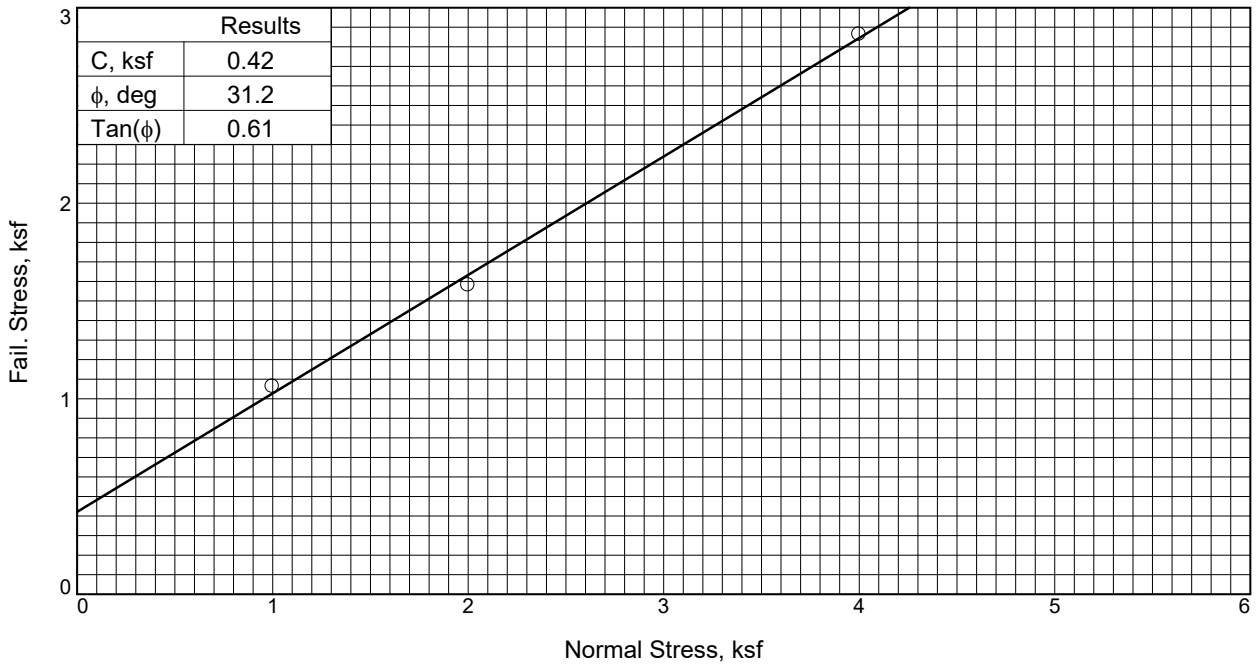
Source of Sample: BH-5 **Depth:** 4-6 ft

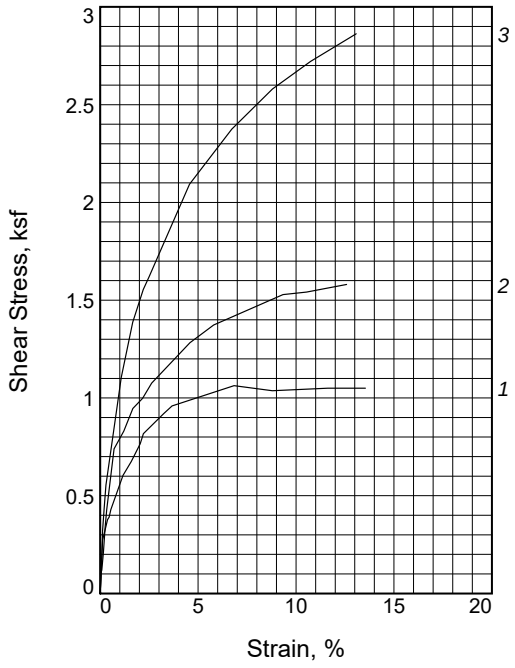
Tetra Tech

Missoula, MT

Remarks:

Figure 11C





Sample No.		1	2	3
Initial	Water Content, %	25.9	26.0	32.3
	Dry Density, pcf	98.4	90.5	91.0
	Saturation, %	100.8	83.1	104.7
	Void Ratio	0.6820	0.8280	0.8177
	Diameter, in.	2.40	2.40	2.41
	Height, in.	1.07	1.08	1.03
At Test	Water Content, %	23.8	34.6	25.1
	Dry Density, pcf	99.0	94.3	91.6
	Saturation, %	94.1	121.6	82.6
	Void Ratio	0.6710	0.7535	0.8053
	Diameter, in.	2.40	2.40	2.41
	Height, in.	1.07	1.04	1.02
Normal Stress, ksf		1.00	2.00	4.00
Fail. Stress, ksf		1.06	1.58	2.86
Strain, %		6.8	12.6	13.1
Ult. Stress, ksf				
Strain, %				
Strain rate, in./min.		0.001	0.001	0.001

Sample Type: Shelby
Description: Sandy Lean Clay (CL) - A-6 (5)

Assumed Specific Gravity= 2.65
Remarks:

Client: HDR

Project: West Missoula - Mullan Road

Source of Sample: BH-5 **Depth:** 4-6 ft

Proj. No.: 114-571120 **Date Sampled:**

DIRECT SHEAR TEST REPORT
Tetra Tech
Missoula, MT

Figure 12C

TETRA TECH

PROJECT:	Mullan Road	**PROJECT NO:**	114-571120
LOCATION:	BH-4	**WORK ORDER NO:**	1
MATERIAL:	Silty, Clayey Sand with Gravel	**LAB NO:**	1
SAMPLE SOURCE:	0.43-5 ft	**DATE SAMPLED:**	5/26/2022
REVIEWED BY:	SDD		

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

COMPACTION(%) 120.7

PERCENT SWELL 0.26%

	BEFORE SOAK	AFTER SOAK
DRY DENSITY	120.1 lbs./cu.ft	123.9 lbs./cu.ft
PERCENT MOISTURE	9.6 %	9.6 %

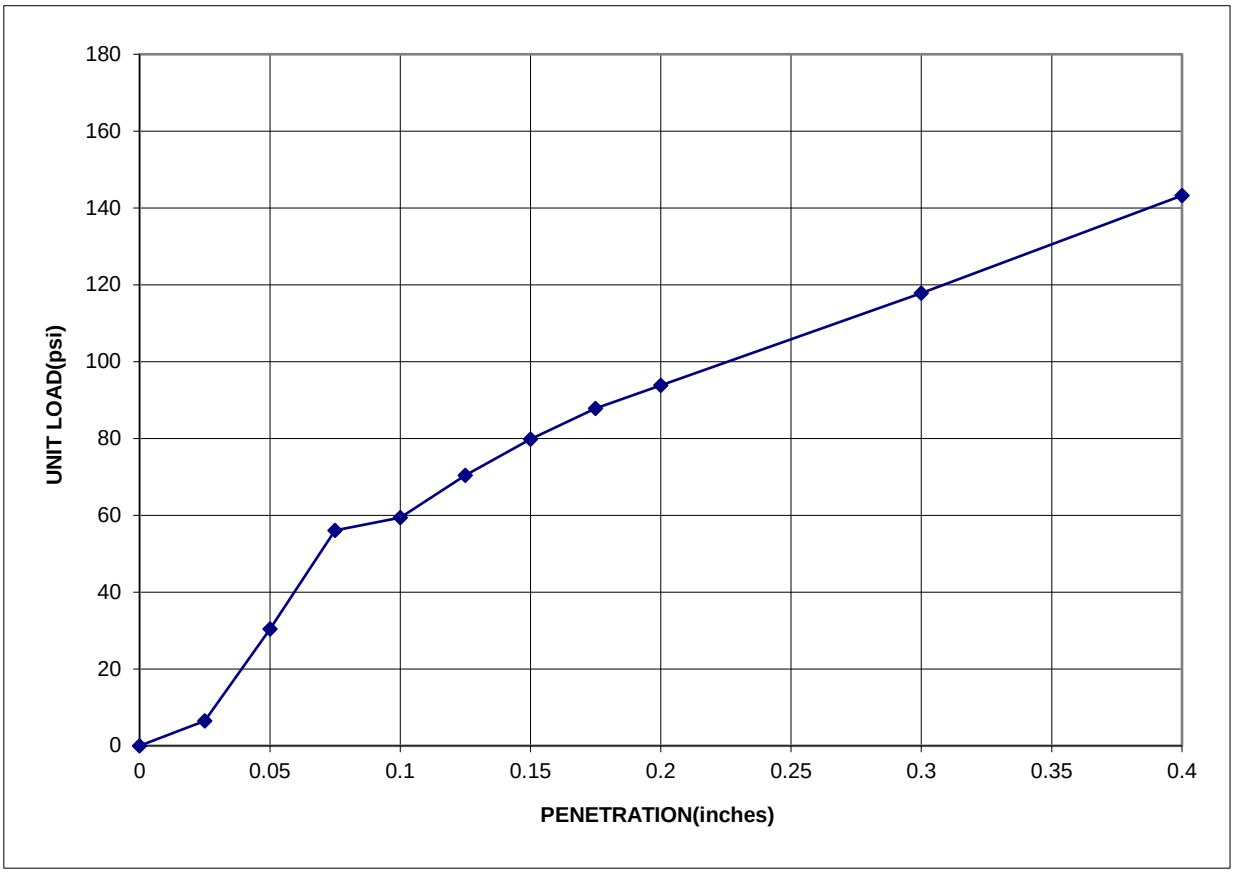
SURCHARGE WEIGHT 10 lbs.

PENETRATION	CORRECTED C B R
0.100	6
0.200	6

D 698

DRY DENSITY(pcf) 99.5

MOISTURE(%) 20.0



CBR 6

Figure 13C

TETRA TECH

PROJECT:	Mullan Road	**PROJECT NO:**	114-571120
LOCATION:	BH-5	**WORK ORDER NO:**	1
MATERIAL:	Sandy Lean Clay	**LAB NO:**	1
SAMPLE SOURCE:	(0.5-5)	**DATE SAMPLED:**	5/26/2022
REVIEWED BY:	SDD		

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

COMPACTION(%) 112.8

PERCENT SWELL -29333.12%

	BEFORE SOAK	AFTER SOAK
DRY DENSITY	112.2 lbs./cu.ft	112.8 lbs./cu.ft
PERCENT MOISTURE	12.8 %	15.3 %

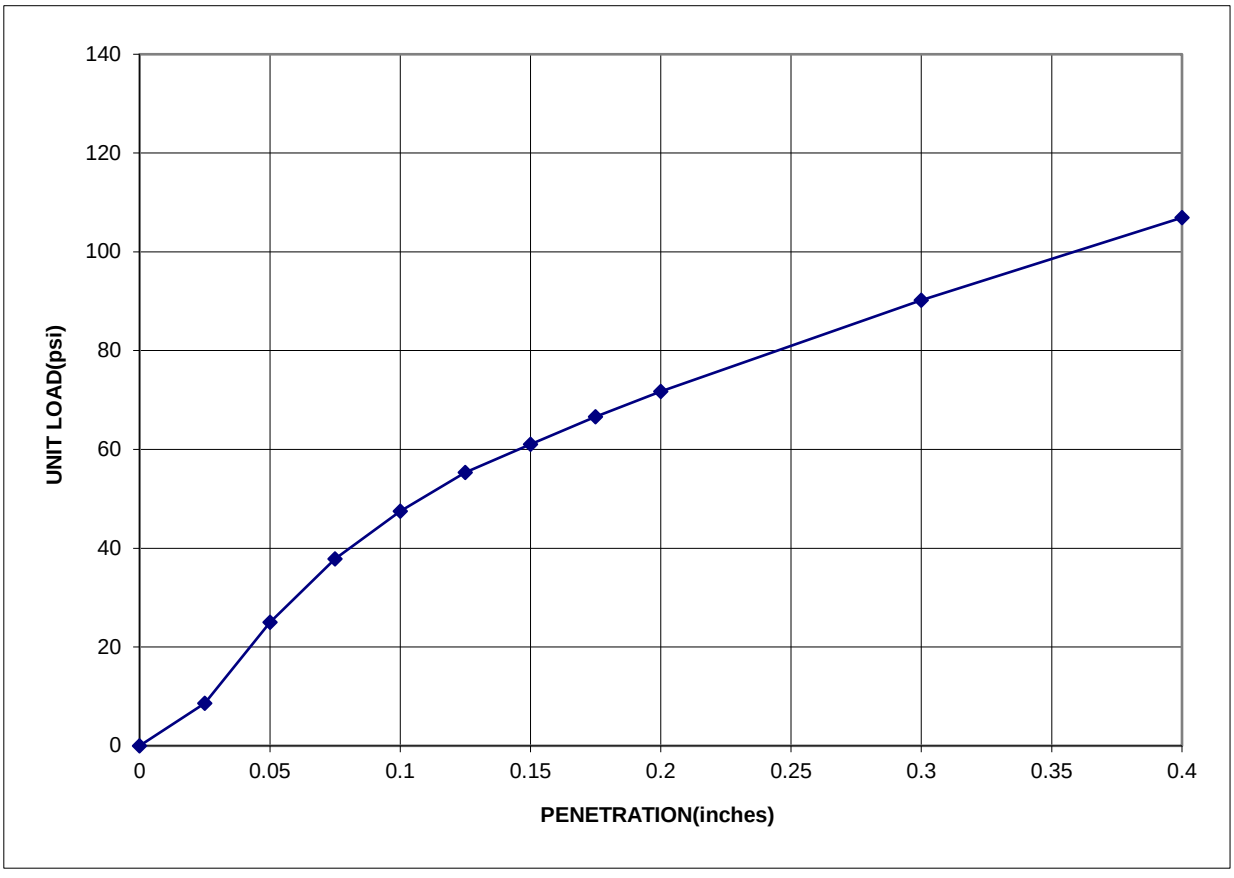
SURCHARGE WEIGHT 10 lbs.

PENETRATION	CORRECTED C B R
0.100	5
0.200	5

D 698

DRY DENSITY(pcf) 99.5

MOISTURE(%) 20.0

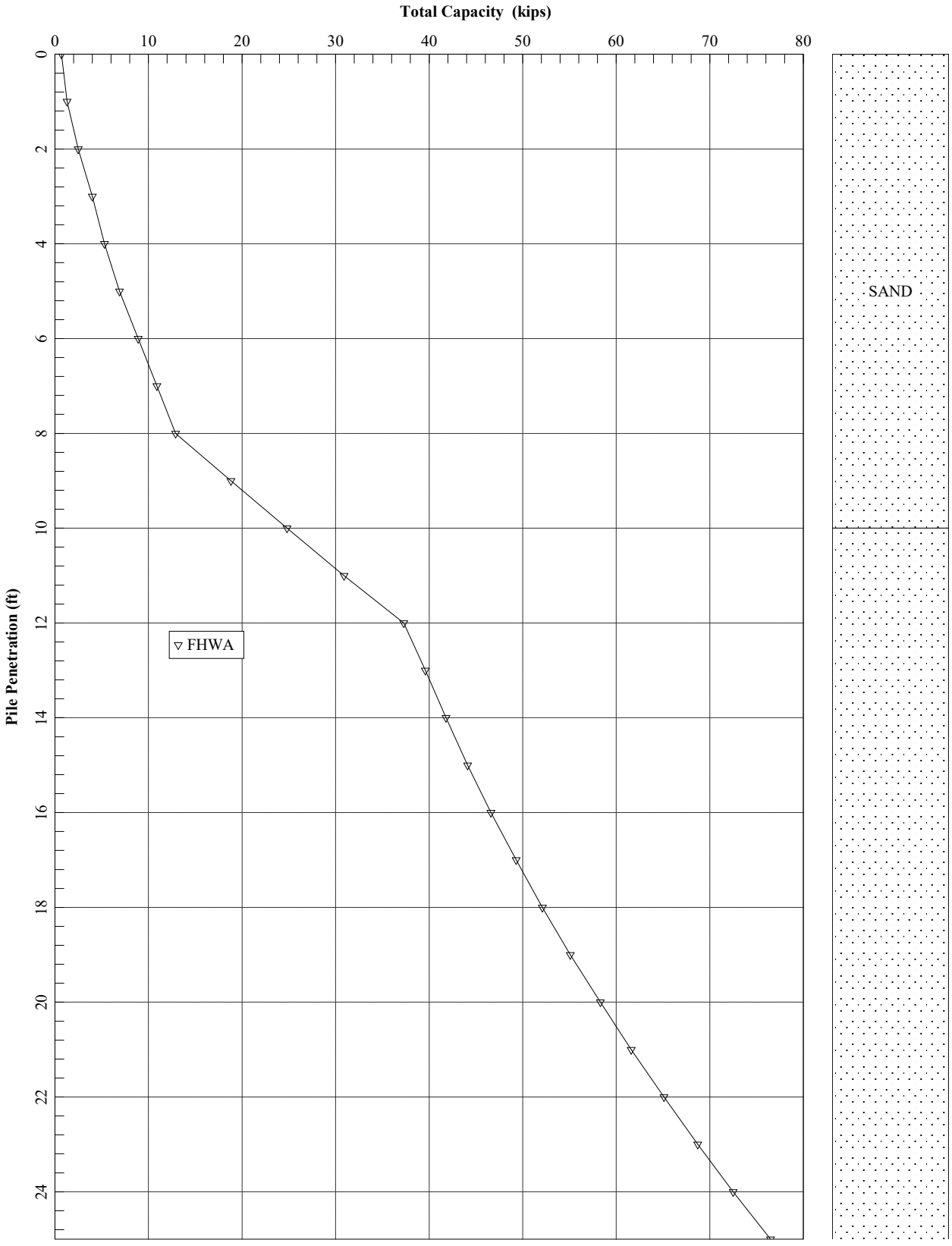


CBR 5

Figure 14C

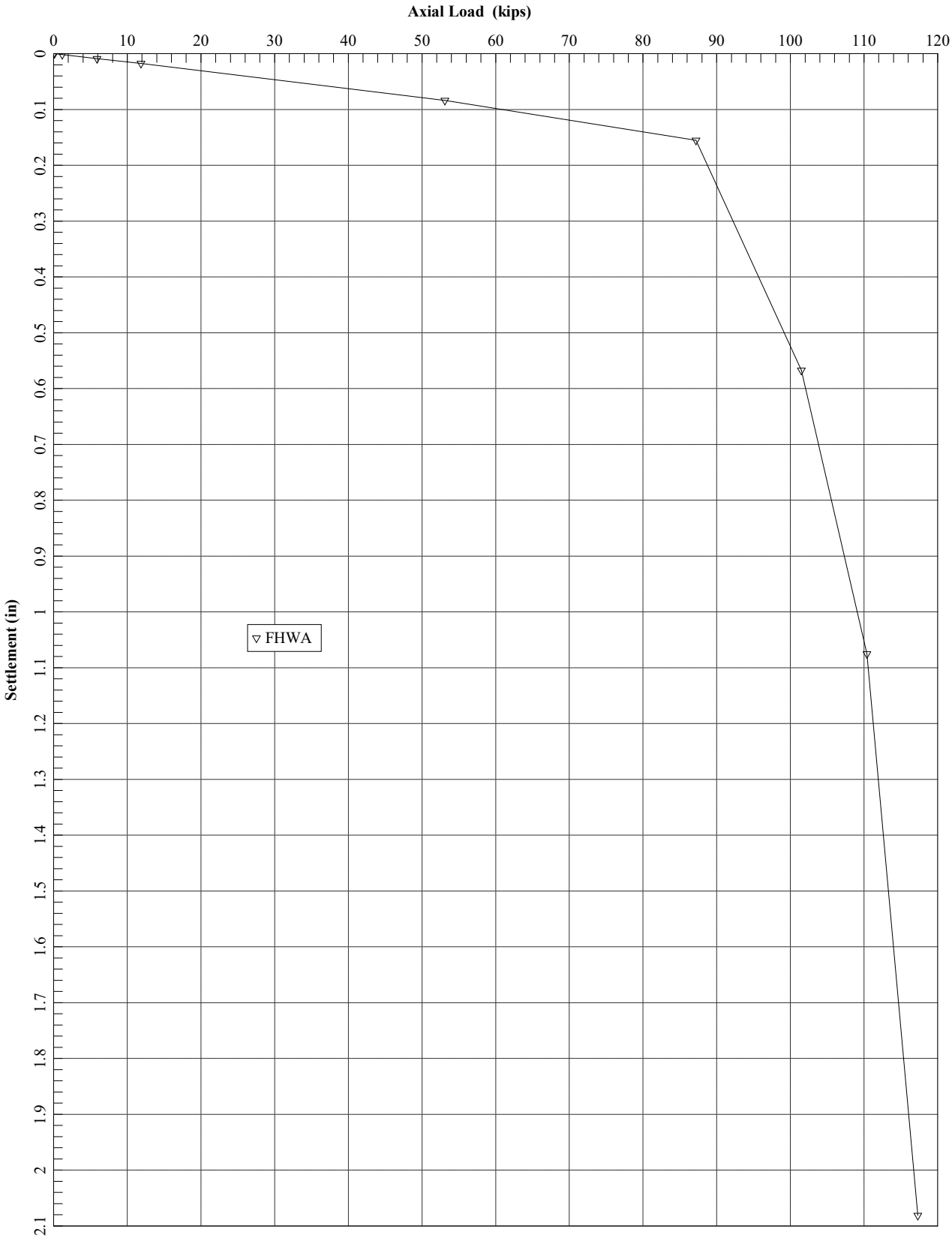
APPENDIX D

A-Pile Outputs (Figures 1D and 2D)



16in Pipe Pile

Figure: 1D



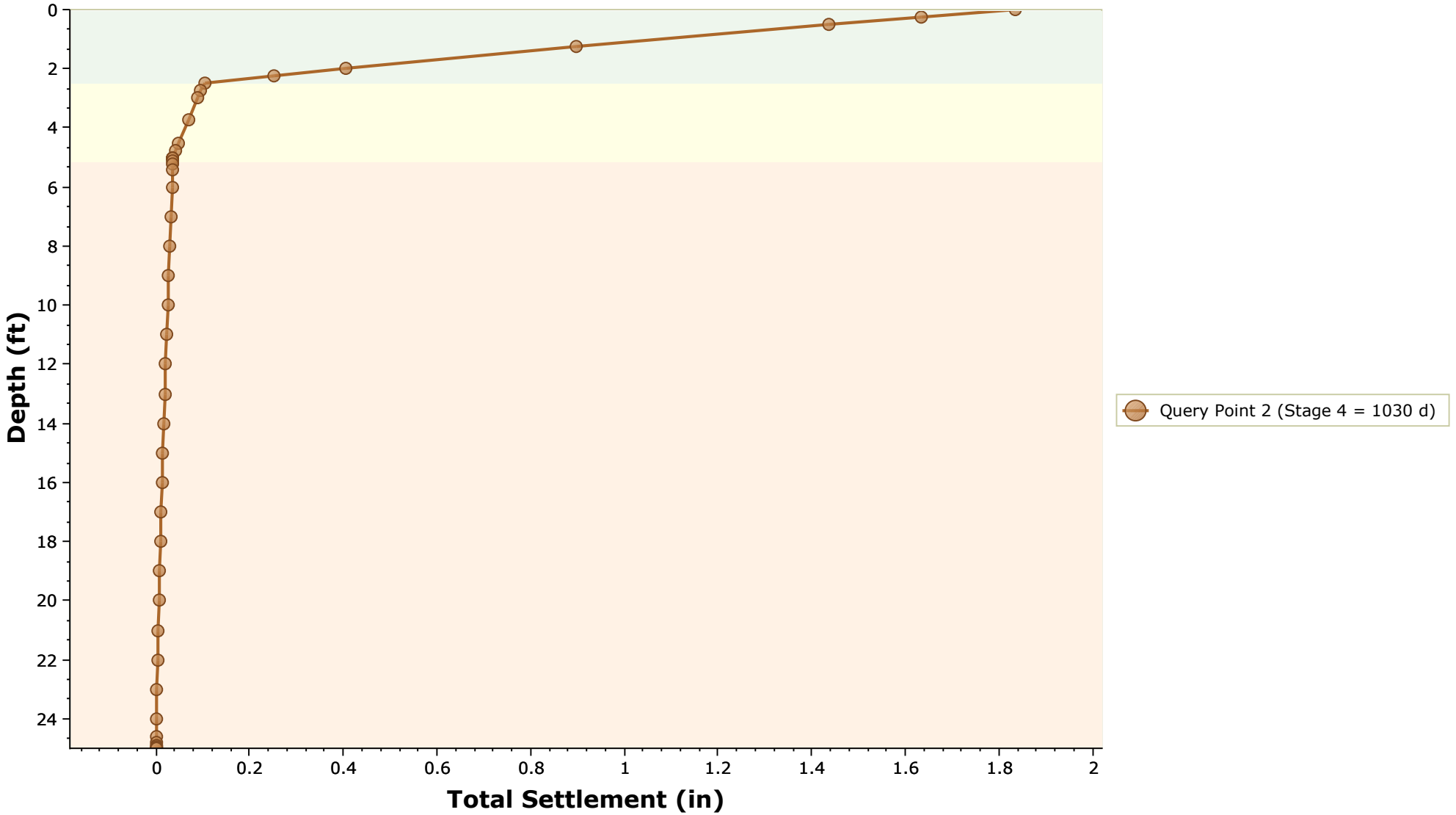
16in Pipe Pile

Figure 2D

APPENDIX E

Settle 3D Outputs (Figures 1E through 5E)

Total Settlement vs. Depth



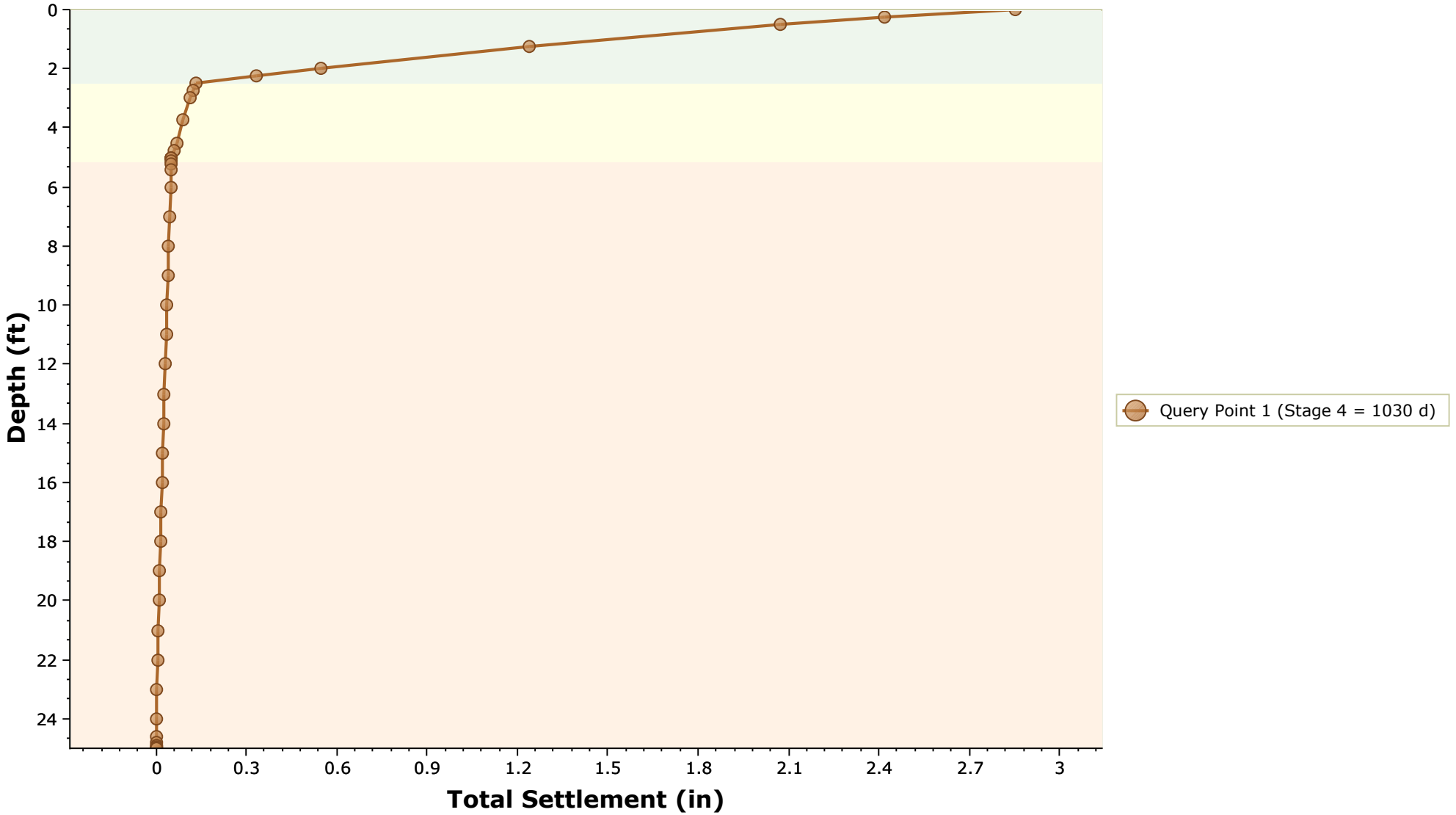
Reference Stage: Stage 2 = 1000 d

TETRA TECH	Project	West of Missoula - NW (Mullan Rd)	
	Analysis Description	Station 140+00 - Ped Path	
	Drawn By	AJH	Company Tt
	Date	6/27/2022, 11:04:05 AM	File Name 140+00 Path.s3z

SETTLE3 5.005

FIGURE 1E

Total Settlement vs. Depth



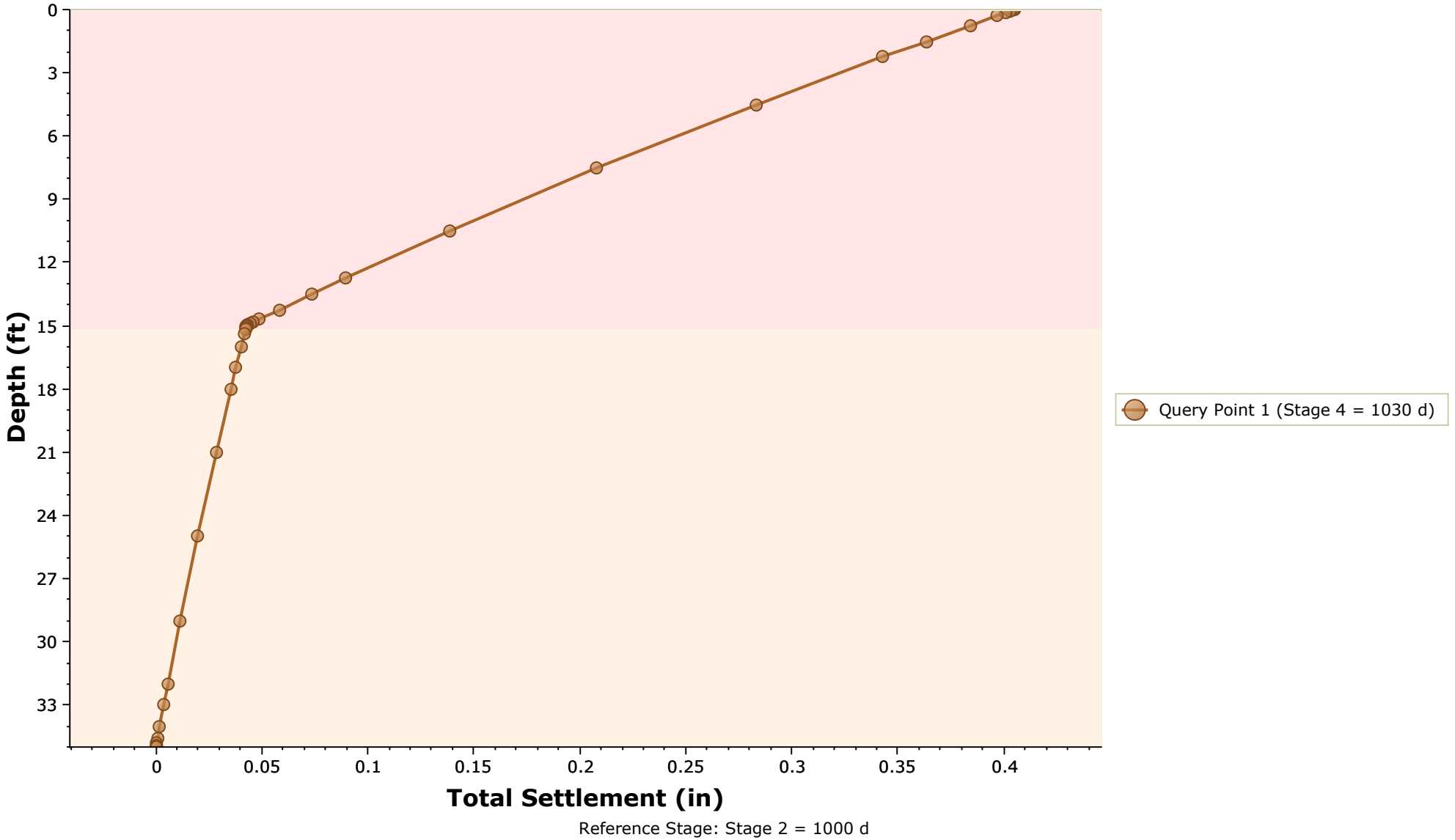
Reference Stage: Stage 2 = 1000 d

TETRA TECH	Project	West of Missoula - NW (Mullan Rd)	
	Analysis Description	Station 144+00 - Roadway	
	Drawn By	AJH	Company: Tt
	Date	6/27/2022, 11:04:05 AM	File Name: 144+00 Road.s3z

SETTLE3 5.005

FIGURE 2E

Total Settlement vs. Depth



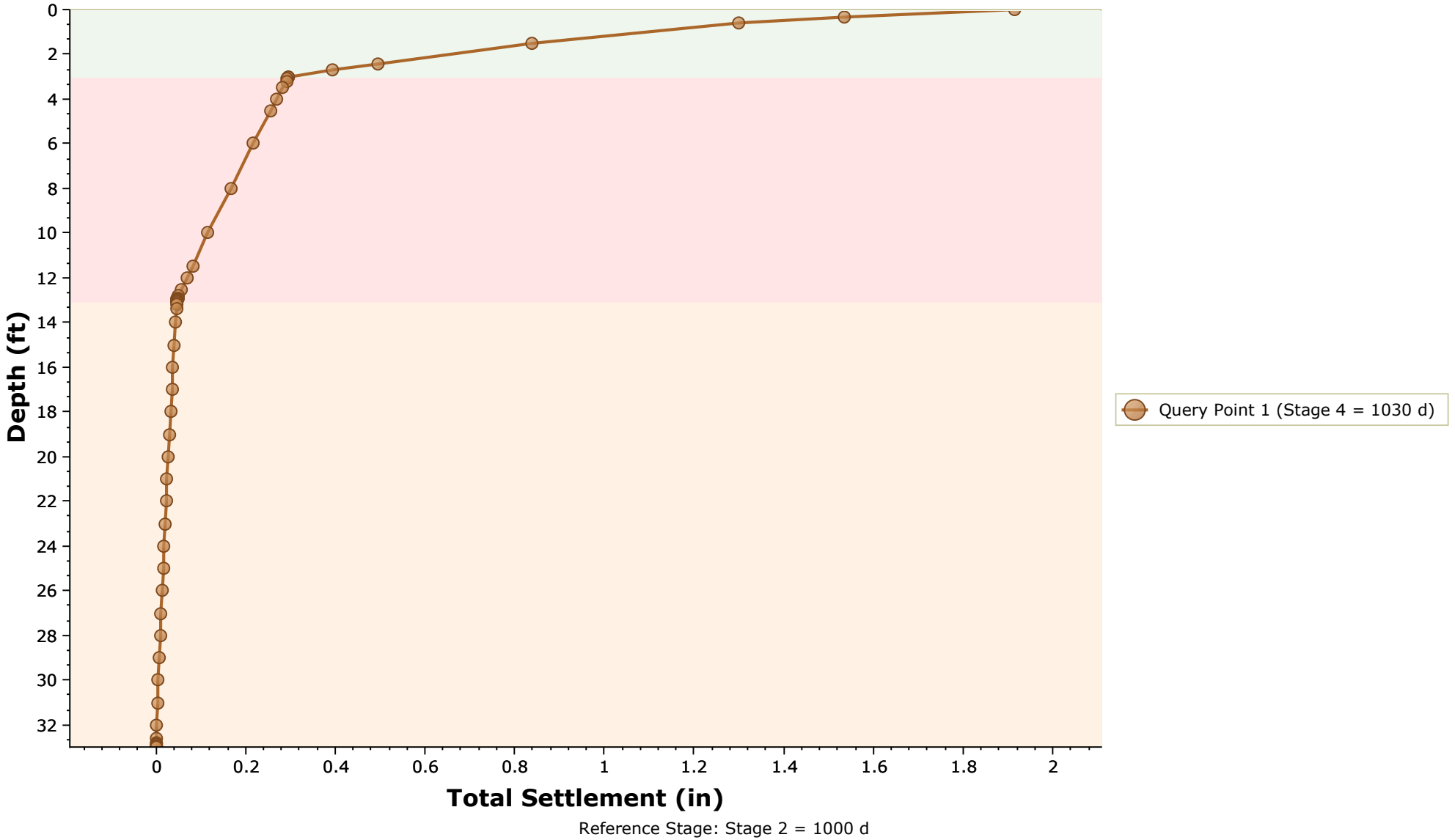
Reference Stage: Stage 2 = 1000 d

TETRA TECH	Project	West of Missoula - NW (Mullan Rd)	
	Analysis Description	Station 256+00 - Roadway	
	Drawn By	AJH	Company: Tt
	Date	6/27/2022, 11:04:05 AM	File Name: 256+00 Road.s3z

SETTLE3 5.005

FIGURE 3E

Total Settlement vs. Depth



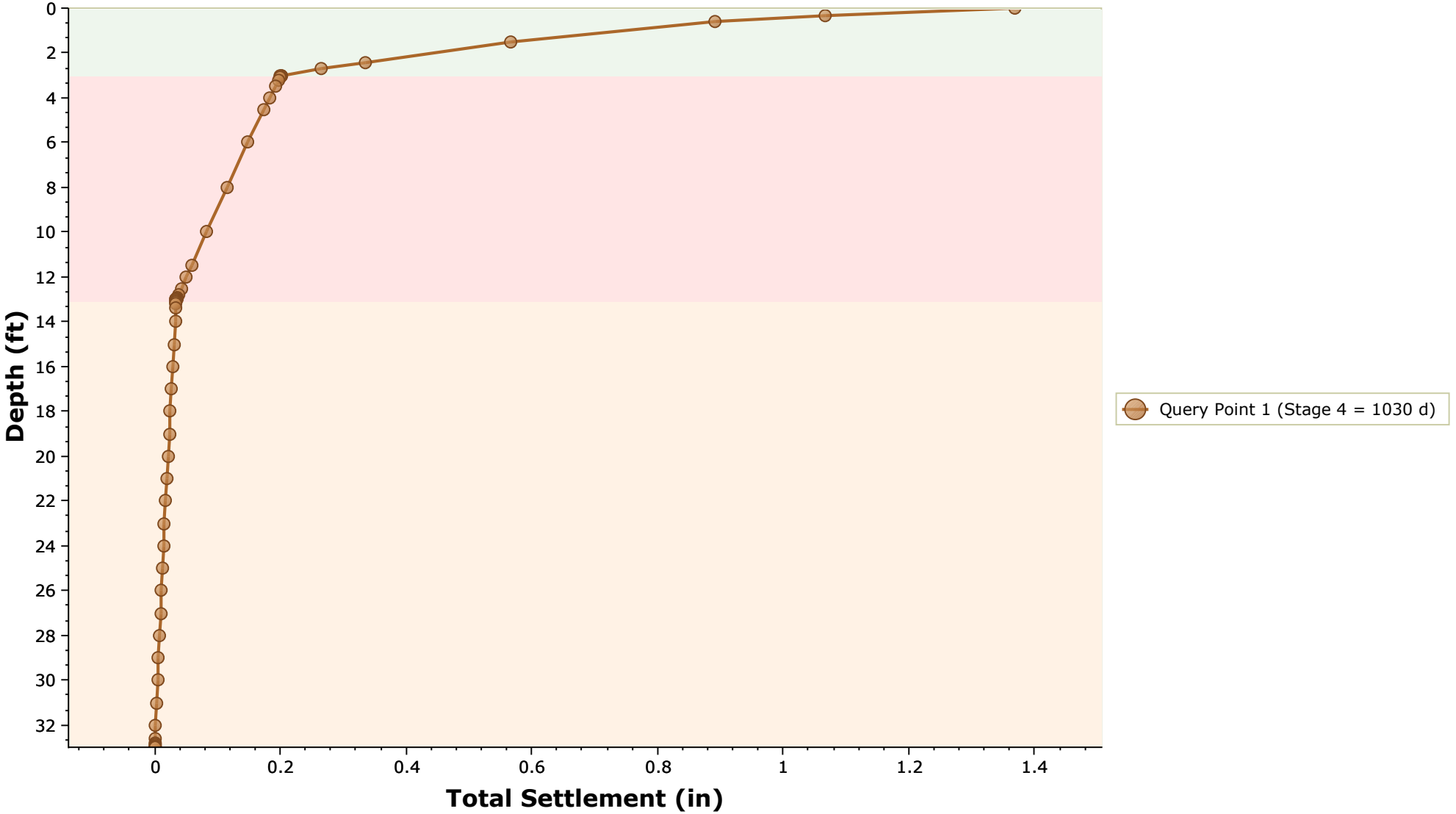
Reference Stage: Stage 2 = 1000 d

TETRA TECH	Project	West of Missoula - NW (Mullan Rd)	
	Analysis Description	Station 324+50 - Roadway	
	Drawn By	AJH	Company: Tt
	Date	6/27/2022, 11:04:05 AM	File Name: 324+50 Road.s3z

SETTLE3 5.005

FIGURE 4E

Total Settlement vs. Depth



Reference Stage: Stage 2 = 1000 d

TETRA TECH	*Project*	West of Missoula - NW (Mullan Rd)	
	Analysis Description	Station 326+00 - Ped Path	
	Drawn By	AJH	*Company* Tt
	Date	6/27/2022, 11:04:05 AM	*File Name* 326+00 Path.s3z

SETTLE3 5.005

FIGURE 5E

APPENDIX F

Table 1F - Pavement Alternatives Cost Estimate

Figure 1F
Cost Analysis
West of Missoula - Wes - Activity 130 Final Pavement Sections

Alt 1 - 2 ft Cap.

	Grade	Thickness (ft)/or rate	Units	Amount	Units	Cost (*)	Per Units	Total Cost
Asphalt Concrete	S - 3/4"	0.3	ft	4134	Ton	$43.01	Ton	177814
Granular Base	CAC	0.710	ft	4998	yd3	$29.96	yd3	149752
Prime Coat	CRS-2P	0.07	Gal/ft2	55	Ton	$590	Ton	32589
Tack Coat	SS-1	0.01	Gal/ft2	1901	Gallon	$2.20	Gallon	4182
Asphalt	PG 64-28	5.1	%	211	Ton	$606	Ton	127792
						Cost/Mile		492128

190080

Alt. 2 - Clay SG

	Grade	Thickness (ft)/or rate	Units	Amount	Units	Cost (*)	Per Units	Total Cost
Asphalt Concrete	S - 3/4"	0.3	ft	4134	Ton	$43.01	Ton	177814
Granular Base	CAC	1.330	ft	9363	yd3	$29.96	yd3	280521
Prime Coat	CRS-2P	0.07	Gal/ft2	55	Ton	$590	Ton	32589
Tack Coat	SS-1	0.01	Gal/ft2	1901	Gallon	$2.20	Gallon	4182
Asphalt	PG 64-28	5.1	%	211	Ton	$606	Ton	127792
						Cost/Mile		622897

Alt. 3 - CTB

	Grade	Thickness (ft)/or rate	Units	Amount	Units	Cost (*)	Per Units	Total Cost
Asphalt Concrete	S - 3/4"	0.3	ft	4134	Ton	$43.01	Ton	177814
Cement Treated Base	CTB	0.920	ft	6477	yd3	$67.01	yd3	434010
Prime Coat	CRS-2P	0.07	Gal/ft2	55	Ton	$590	Ton	32589
Tack Coat	SS-1	0.01	Gal/ft2	1901	Gallon	$2.20	Gallon	4182
Asphalt	PG 64-28	5.1	%	211	Ton	$606	Ton	127792
						Cost/Mile		776386

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 2021
0.07 gallon/square foot prime coat application
0.01 gallon/square foot tack coat application between asphalt lifts