ST. MARY DIVERSION FACILITIES GEOTECHNICAL RECONNAISSANCE FOR THE PROPOSED HYDRAULIC DROP REALIGNMENT

JUNE 2012

"Lifeline of the Hi-line"

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GEOTECHNICAL RECONNAISANCE
ST. MARY CANAL – PROPOSED DROP ALIGNMENT
ST. MARY DIVERSION AND CONVEYANCE FACILITIES

1.0 INTRODUCTION

1.1 Purpose and Scope

This report presents the results of our geotechnical investigation and study for the proposed realignment of the drop structures on the east end of the St. Mary Diversion Facilities located northeast of Babb, Montana. The purpose of the geotechnical reconnaissance study is to determine the general surface and subsurface conditions along the proposed canal alignment and to develop preliminary geotechnical engineering recommendations for consideration of earthwork parameters during conceptual grade and alignment planning. This report describes the field work and laboratory analyses conducted for this project, the surface and subsurface conditions encountered, and presents our preliminary geotechnical recommendations for the proposed canal realignment. These recommendations are to be considered preliminary in nature being as future changes to the proposed alignment used during our investigation may warrant additional investigative work and/or modifications to the recommendations provided in this report.

Our field work included drilling thirty soil borings along the proposed canal realignment. Samples were obtained from the borings and returned to our Great Falls laboratory for testing. Laboratory testing was performed on select soil samples to determine engineering properties of the subsurface materials. The information obtained during our field investigations and laboratory analyses were used to develop preliminary earthwork recommendations for the potential design of the canal realignment project.

1.2 Project Description

The new potential alignment includes the canal conveyance and energy dissipation down slope of the Hudson Bay Divide to the North Fork of the Milk River. Currently, the existing drop alignment is approximately 2.3 miles in length. The existing alignment consists of five sequential hydraulic drop structures and stilling basins which dissipate energy from the 218 foot elevation drop from the Divide to the North Fork. A new alignment would provide the opportunity to combine drops specifically designed for hydro power generation and allow for summer construction such that the existing system may remain in service without disruption of deliveries.

The proposed new alignment is 17,000 feet (3.2 miles) in length and is located to the south of the existing drop alignment. This preliminary alignment utilizes the higher natural topography to the south in order to eliminate the need for the smaller individual drop structures. The proposed system would incorporate a single 145-foot drop from the ridge to the south of drop #4 down to the existing stilling basin at drop #4. The location of drop #5 of the existing system would remain, although possibly replaced with hydropower consideration providing the final drop down to the Milk River.

The proposed realignment path will require considerable cut and fill in order to establish the necessary alignment and grade for the proposed realignment. Preliminary information estimates that cut and fill depths up to 45 feet and 12 feet, respectively, are anticipated for the proposed alignment.

2.0 SITE CONDITIONS

2.1 Geology and Physiography

The site is geologically characterized as consisting of Quaternary-aged alluvial glacial deposits of clay, sand and gravel underlain by Cretaceous-aged sedimentary bedrock possibly of the Two Medicine Formation (K_{tm}). Glacial till/drift is the most predominant soil type which blankets the slopes surrounding the proposed alignment. It is typically a clay soil with varying concentrations of sand and gravel. The glacial till/drift was most likely deposited by past widespread alpine glaciations. Sedimentary bedrock was encountered in several of the borings and exhibited varying degress of weathering throughout. Weathered bedrock was encountered at relatively shallow depths along the eastern end of the proposed alignment above existing drop #4.

The appropriate 2009 International Building Code (IBC) seismic design parameters for the site include site coefficients of 1.2 and 1.7 for F_a and F_v, respectively. The Site Class for this site is C, and the mapped spectral response accelerations at short periods (S_s) and at 1-second period (S_1) are 0.46g and 0.17g, respectively. For slope masses and embankments, risks from seismic activity include increased driving forces from lateral acceleration and a significant reduction of the resisting shear strength forces. The likelihood of seismically-induced soil liquefaction or settlement for this project is not probable and does not warrant additional evaluation.

2.2 Surface Conditions

The proposed project site is located at the east end of the existing St. Mary Diversion and Conveyance Facilities. The canal alignment is approximately one mile south of the Canadian border and located approximately 33 miles northwest of Cut Bank, Montana. The terrain along the proposed alignment presently consists of native grasses, brush, and bushes. Based on background information and site observations, the site generally slopes downward toward the north. Slopes along the alignment range from zero to approximately 12 percent. Slopes along the proposed drop from the realigned canal to the existing stilling basin at drop #4 exceed twenty percent. The topography is best described as moderately to strongly sloping with areas of moderately steep terrain.

2.3 Subsurface Conditions

3.3.1 Soils.

The subsurface soil conditions appear to be relatively consistent based on our exploratory drilling and soil sampling. In general, the subsurface soil conditions encountered within the borings consist of overburden soils comprised primarily of lean clay containing varying amounts of sand and gravel. Minor portions of clayey sand were also encountered near the ground surface sporadically and silty sand, likely severely weathered sandstone bedrock, was occasionally encountered beneath the native clay soils. The overburden soil was underlain by claystone and sandstone bedrock which exhibited varying degrees of weathering within the limits of the project. In several locations the weathered bedrock exhibited lower SPT N-values which may be indicative of dense soil; however, the material color, composition, and bedding properties were similar to the underlying bedrock and these zones are likely severally weathered portions of the underlying parent material. In most cases the borings were terminated in weathered bedrock; however, a few of the shallower borings were terminated in the lean clay.

The subsurface soils are described in detail on the enclosed boring logs and are summarized below. The stratification lines shown on the logs represent approximate boundaries between soil types and the actual in situ transition may be gradual vertically or discontinuous laterally.

CLAYEY SAND

The clayey sand encountered in the borings appears to be loose to medium dense which was confirmed by a single SPT test conducted in this material which had a penetration resistance value of 13 blows per foot (bpf). The amount of the clayey sand is minimal and appears to be limited to the surficial soils (less than 5 feet) and was encountered primarily along the western most portion of the proposed alignment. The natural moisture contents measured varied only slightly and averaged 12 percent.

LEAN CLAY

The lean clays encountered along the proposed alignment contained varying amounts of both sand and gravel. Thus, classifications ranged from lean clay to sandy/gravelly lean clay. The lean clays range from soft to hard as indicated by penetration resistance values which ranged from 3 to 33 bpf and averaged 15 bpf. The lean clays encountered in low lying moist areas were noticeably less stiff and laboratory testing showed these zones to be slightly compressible with samples exhibiting approximately three percent compressive strain under

loads up to 2,000 psf. Similar surcharges are anticipated based on the fill depths required. Reports for the consolidation tests performed are shown in Figures 43 and 44. Samples of the material obtained using split spoon samplers at various depths and locations contained between zero and 13 percent gravel, between 4 and 40 percent sand, and between 58 and 96 percent fines (clay and silt). The lean clays were of moderate to high-plasticity and exhibited liquid limits ranging from 32 to 50 percent and plasticity indices ranging from 14 to 31 percent. The natural moisture contents measured varied from 5 to 27 percent and averaged 17 percent.

Occasional thin lenses (less than 2 feet) of clayey gravels were encountered at depth within the lean clay strata on the far east end of the alignment near existing drop #4. Two samples obtained from split spoon samplers indicated that these gravel zones are comprised of 38 to 61 percent gravel, 17 to 24 percent sand, and 22 to 38 percent fines (clay and silt). A single Atterberg performed on one of the samples obtained a liquid limit of 29 percent and a plasticity index of 11 percent.

Several tests were performed to evaluate the in-situ density of the potential fill materials for construction. This testing indicated that the lean clay exhibits in-situ dry densities ranging from 107 to 119 pcf with moist densities ranging from 124 to 137 pcf. Proctors were subsequently performed on bulk samples of the clay material obtained from the same borings and at similar depths as the in-situ density test samples. Standard Proctors were performed according to ASTM D-698 to evaluate the post-construction maximum anticipated density for the material. These tests indicated that maximum dry densities range from 111 to 118 pcf and at optimum moisture, moist densities range from 128 to 133 pcf.

SILTY SAND

Silty sand was encountered in several borings between the overlying lean clays and the underlying bedrock strata. The silty sand is very loose to medium dense as indicated by penetration resistance values which ranged from 2 to 22 bpf and averaged 15 bpf. A single sample of the material obtained from B-19 contained no gravel, 72 percent sand, and 28 percent fines (silt and clay). The same sample of material exhibited a liquid limit of 30 percent and a plasticity index of 4 percent. The natural moisture contents measured varied from 7 to 12 percent and averaged 10 percent. The silty sand exhibited similar color, composition, and bedding properties as the underlying sandstone bedrock and is believed to result from the severely weathered zones of the parent sandstone.

BEDROCK – CLAYSTONE & SANDSTONE

The bedrock encountered on this project exhibited varying degrees of weathering and was medium dense to hard as indicated by penetration resistance values which ranged from 13 to greater than 100 bpf and averaged 60 bpf. The natural moisture contents measured varied from 6 to 19 percent and averaged 13 percent. The bedrock was comprised of interbedded layers of sandstone and claystone. The claystone lenses ranged in thickness up to several feet and appeared to contain a significant sand fraction. The sandstone lenses appeared to be significantly thinner and exhibited a higher degree of weathering than the claystone. The sandstone also appeared to contain a significant fraction of fine-grained material believed to be primarily silt.

3.3.2 Ground Water

Ground water was encountered within the a few borings at depths ranging from 6.4 to 23.0 feet below the ground surface. Based on measured ground surface elevations, this equates to water level elevations ranging from 4,261 to 4,409 feet. Water levels were measured at the time of drilling. Due to the nature of the fine-grained overburden soils and frequent sand and gravel lenses, ground water is anticipated to be sporadic, discontinuous, and confined to the granular interbeds. Ground water may also be encountered in the fractured sedimentary bedrock and confined by the overlying fine-grained overburden. The presence or absence of observed ground water may also be directly related to the time of the subsurface investigation. Numerous factors contribute to seasonal ground water occurrences and fluctuations, and the evaluation of such factors is beyond the scope of this report.

3.0 SUMMARY OF FIELD AND LABORATORY STUDIES

3.1 Field Explorations

The field exploration program was conducted between September 19 and October 21, 2011. A total of thirty soil borings were drilled to depths ranging from 15.0 to 51.9 feet at the locations shown on Figure 1 to observe subsurface soil and ground water conditions. The first round of drilling, performed in September 2011, (B-1 through B-11) was drilled using a truck-mounted CME-55 with 8-inch O.D. hollowstem augers. Due to access issues associated with the truck-mounted drill rig, the remainder of the investigation was performed in October 2011 using a track-mounted CME 850 drill rig also equipped with 8-inch O.D. hollowstem augers. The subsurface exploration and sampling methods used are indicated on the attached boring logs. The soil borings were logged by either Mr. Craig Nadeau, P.E. or Mr. Bill Colenso, E.I. of Thomas, Dean & Hoskins, Inc. (TD&H). The location and surface elevations of the exploratory borings shown on Figure 1 were determined in the field by TD&H survey personnel. The locations were selected based on their accessibility, with assistance provided by Mr. John Sanders, P.E. of the DNRC. Two borings (B-27 and B-28) were not surveyed at the time of our field investigation. The locations of these borings were established by Mr. Sanders in the field and elevations were estimated based on a previous topographic survey of the area.

Samples of the subsurface materials were taken using 1⅜-inch split spoon samplers. The samplers were driven 18 inches, when possible, into the various strata using a 140-pound drop hammer falling 30 inches onto the drill rods. For each sample, the number of blows required to advance the sampler each successive six-inch increment was recorded, and the total number of blows required to advance the sampler the final 12 inches is termed the penetration resistance ("N-value"). This test is known as the Standard Penetration Test (SPT) described by ASTM D-1586. When the sampler is driven more than 18 inches, the number of blows required to advance the sampler the second and third six-inch increments are used to determine the N-value. Penetration resistance values indicate the relative density of granular soils and the relative consistency of fine-grained soils. Samples were also obtained by hydraulically pushing a 3-inch I.D., thin-walled Shelby tube sampler into the subsoils. Logs of all soil borings, which include soil descriptions, sample depths, and penetration resistance values, are presented on the Figures 2 though 31.

Measurements to determine the presence and depth of ground water were made in the borings by lowering an electronic water sounder through the open boring or auger shortly after the completion of drilling. The depths or elevation of the water levels measured, if encountered, and the date of measurement are shown on the boring logs.

3.2 Laboratory Testing

Samples obtained during the field exploration were returned to our materials laboratory where they were observed and visually classified in general accordance with ASTM D2487, which is based on the Unified Soil Classification System. Representative samples were selected for testing to determine the engineering and physical properties of the soils in general accordance with ASTM or other approved procedures.

Tests Conducted:	To determine:
Natural Moisture Content	Representative moisture content of soil at the time of sampling.
Grain-Size Distribution	Particle size distribution of soil constituents describing the percentages of clay/silt, sand and gravel.
Atterberg Limits	A method of describing the effect of varying water content on the consistency and behavior of fine-grained soils.
Natural Dry Density	Dry unit weight of samples, representative of in-place conditions.
Consolidation/Swell	The amount that 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.
UU Shear Strength (Field)	The undrained, unconfined shear strength (s_u) of cohesive soils as determined in the field by either a pocket penetrometer or a hand torvane.
Moisture-Density Relationship	A relationship describing the effect of varying moisture content and the resulting dry unit weight at a given compactive effort. Provides the optimum moisture content and the maximum dry unit weight. Also called a Proctor Curve.

The laboratory testing program for this project consisted of 182 moisture-visual analyses, 21 sieve (grain-size distribution) analyses, and 18 Atterberg Limits analyses. The results of the water content analyses are presented on the boring logs, Figures 2 through 31. The grain-size distribution curves and Atterberg limits are presented on Figures 32 through 42. In addition, 2 consolidation-swell tests, 4 unit weight (in-situ dry density) tests, and 5 standard Proctor (moisture-density) tests were

performed. The consolidation/swell results are presented on Figures 43 and 44. The moisture density relationships and the in-situ unit weight tests are shown on Figures 45 through 50. Unconfined compressive strengths (q_u) were determined in the field using a pocket penetrometer. The results are shown on the boring logs at the depths the samples were tested.

4.0 ENGINEERING ANALYSIS

4.1 Introduction

The primary geotechnical concern regarding the proposed canal realignment is with respect to the magnitude of anticipated cut and fill sections. The preliminary grading of the proposed alignment indicates that a maximum cut and fill of 45 feet and 12 feet are anticipated. Variations in the in-situ density which is excavated and the final compacted density of the material during placement will control the balance of cut and fill volumes for the project. Cut and fill volumes should be carefully analyzed in order to minimize potential haul distances and to avoid earthwork shortages.

Cuts of the magnitude anticipated for this project create large back slopes adjacent to the proposed canal which may present slope stability concerns which need to be considered. In addition, the height of fill required at various locations can create fairly significant stress increases within the subsurface soil which may lead to settlement. The proposed canal can handle considerable settlement without impacting its operation; however, extensive movements may be considered undesirable from a maintenance perspective.

4.2 Site Grading and Excavations

The ground surface along the proposed realignment route is best described as moderately to strongly sloping with areas of moderately steep terrain. In general, slopes along the alignment range from zero to 12 percent; however, slopes in proximity to the proposed drop from the realigned canal to the existing stilling basin at drop #4 exceed 20 percent. Based on our field work and the proposed canal bottom elevation of approximately 4,412.6 feet with an average channel slope of -0.01 percent, fine-grained glacial till and portions of weathered bedrock will be encountered in canal excavations to the depths anticipated. Based on the soil borings, ground water should be below the anticipated depths of canal excavation except at locations directly adjacent to the existing canal or drop #4 stilling basin, when under operation. Ground water was encountered on or near the ground surface in low lying areas in which fill is to be placed. Depending on the time of year, occasional pockets of trapped or perched ground water within the excavation zone which are associated with recent precipitation events or annual canal operation may be encountered.

4.3 Slope Stability

Preliminary modeling of the proposed canal cross section was performed using Slope-W which is a component of the GeoStudio software package. The proposed geometry was modeled within the software and estimated soil parameters were used to evaluate the potential for slope instabilities along the proposed alignment. Both significant cut and fill slopes are anticipated for this project and both were analyzed for slope stability. Figure 51 provides a look at a typical cross section for the proposed alignment with both a cut and fill slope. The soil parameters used in our analysis are summarized in the following table:

Material Description	Moist Unit Weight (pcf)	Friction Angle (deg)	Cohesion (psf)
Native Clay Soil	120	18	200
Compacted Native Clay	132	24	200
Silty Sand / Weathered Bedrock	140	30	50

Using these soil properties, the anticipated safety factor with respect to slope stability was analyzed for both the cut and fill slopes anticipated for this project. The heights of the slopes and the soil conditions vary somewhat along the proposed alignment; thus, the most critical setup was analyzed to determine the minimum anticipated safety factor. There are several cut sections anticipated for the proposed alignment; however, the two most critical are located at the beginning and end of the proposed canal alignment. Near the beginning of the project a cut of approximately 27 feet is required to reach the proposed canal bottom elevation. Based on our investigation, soils in this location consist of native lean clay which extends to the proposed cut depth. When this slope is modeled (Figure 52), an overall safety factor of approximately 1.8 was obtained for the slope. The second critical cut slope is located at the end of the alignment above drop #4. At this location the largest cut of approximately 45 feet is anticipated. Soils in this area consist of thin deposits of surficial clay soil overlying medium dense to dense silty sands. The silty sand is likely a severely weathered horizon of the underlying weathered sandstone and claystone. Slope stability on this slope (Figure 53) gave a slightly lower safety factor of 1.4 due to the height of the slope. However, the anticipated slide plane is relatively shallow and a significant deep-seated failure is unlikely.

Fill sections are minimal along the proposed alignment; however, the maximum anticipated fill depth is approximately 12 feet. Native soil in this area consists of soft to firm lean clay. Excess native soil from the remainder of the canal excavation is anticipated to be used as fill in this zone. Clay material is recommended as fill in lieu of the sandy soils encountered near the east end of the project to minimize potential seepage losses from the canal. Thus, compacted lean clay was analyzed

overtop the softened clay subgrade (Figure 54) and an overall safety factor of 2.0 was obtained. To examine the impacts of the canal during operation, a preliminary water level was added to the model. The addition of the pore pressures within the slope dropped the safety factor slightly to a value of 1.9 (Figure 55). Overall, both the proposed cut and fill slopes for the typical cross section appear to be relatively stable based on these preliminary analyses.

5.0 RECOMMENDATIONS

5.1 Site Grading and Excavations

1. All topsoil and organic material should be removed and stock-piled for future use from the proposed canal alignment and any areas to receive site grading fill. For planning purposes, a minimum stripping thickness of 12 inches is recommended. Thicker stripping depths may be warranted to remove all detrimental organics as determined once actual stripping operations are performed.

2. Develop and maintain slope grades which will rapidly drain surface runoff away from canal slopes; both during and after construction. Minimizing the volume of water infiltration will help reduce the potential for slope stability issues.

3. For earthwork calculations, a composite volumetric shrinkage factor of 10 percent is appropriate for on-site soil conditions. Excavated and recompacted bedrock material will experience an overall volumetric swell factor on the order of 6 percent.

4. It is the responsibility of the Contractor to provide safe working conditions in connection with underground excavations. Temporary construction excavations greater than four feet in depth, which workers will enter, will be governed by OSHA guidelines given in 29 CFR, Part 1926. For planning purposes, subsoils encountered in the borings classify as Type B for the existing clay and Type C for the sandy soil and weathered bedrock. Prolonged exposure of the weathered bedrock to the elements will increase the likelihood of small scale sloughing and collapse of the excavation walls.

5.2 Slope Stability

5. Overall, no obvious signs of potential slope instabilities were observed based on our field investigation and preliminary slope modeling. Additional modeling should be performed once the final canal section geometry and the cut and fill sections for the canal alignment have been finalized.

6. All cut and fill slopes should be revegetated to protect the surface from erosion and help provide some additional stabilization to the surficial soils.

7. Consideration should be given to lining portions of the proposed canal located near the east end where sandier soil conditions were encountered. The permeability of the sands encountered will lead to increased seepage losses from the canal and may create future instabilities of the existing slope to the north. This can be further delineated and defined during the final design phase.

5.3 Continuing Services

8. Consultation between the geotechnical engineer and the design professionals during the design phases is highly recommended. This is important to ensure that the intentions of our recommendations are incorporated into the design, and that any changes in the design concept consider the geotechnical limitations dictated by the on-site subsurface soil and groundwater conditions.

6.0 LIMITATIONS

This report has been prepared in accordance with generally accepted geotechnical engineering practices in this area for use by the client for design purposes. The findings, analyses, and recommendations contained in this report are based on site conditions encountered and further assume that the results of the exploratory borings are representative of the subsurface conditions throughout the site, that is, that the subsurface conditions everywhere are not significantly different from those disclosed by the subsurface study. If during construction, subsurface conditions appear different from those encountered during our study, this office should be advised at once so we can review these conditions and reconsider our recommendations, when necessary.

Unanticipated soil conditions are commonly encountered and cannot be fully determined by a limited number of soil borings and laboratory analyses. Such unexpected conditions frequently require that additional expenditures be made to obtain a properly constructed project. Therefore, some contingency fund is recommended to accommodate such potential extra costs.

If substantial time has elapsed between the submission of this report and the start of work at the site, or if conditions have changed because of natural causes or construction operations at or adjacent to the site, we recommend that this report be reviewed to determine the applicability of the conclusions and recommendations considering the time lapse or changed conditions.

If you desire, we will review those portions of the plans and specifications which pertain to earthwork and foundations to determine if they are consistent with our recommendations. In addition, we are available to observe construction, particularly the placement and compaction of all fill, preparation of all foundations and quality control testing of Portland cement concrete.

This report was prepared for the exclusive use of the owner and architect and/or engineer in the design of the subject facility. It should be made available to prospective contractors and/or the contractor for information on factual data only and not as a warranty of subsurface conditions such as those interpreted from the boring logs and presented in discussions of subsurface conditions included in this report.

Prepared by: _____
Craig R. Nadeau, P.E.
Geotechnical Engineer

Reviewed by: _____
Erling A. Juel, P.E.
President

LEGEND

GRAVEL ROAD

MAJOR CONTOUR

CONTROL POINT

B-9 EL.=4414.1 — BORE HOLE LOCATION

0 200' 400' 600'
SCALE

B-1 EL.=4423.7
B-2 EL.=4429.7
B-3 EL.=4436.4
B-4 EL.=4419.1
B-5 EL.=4419.8
B-6 EL.=4428.8
B-7 EL.=4401.6
B-8 EL.=4408.0
B-9 EL.=4414.1
B-10 EL.=4415.3
B-11 EL.=4405.5
B-12 EL.=4445.5
B-13 EL.=4433.4
B-14 EL.=4428.7
B-15 EL.=4427.0
B-16 EL.=4418.9
B-17 EL.=4421.4

MATCH LINE

FIGURE 1A

REVISIONS

BY	DESCR	DATE
BY	DESCR	DATE
BY	DESCR	DATE

TD&H Engineering
tdhengineering.com
MONTANA WASHINGTON IDAHO
GREAT FALLS-BOZEMAN-KALISPELL SPOKANE LEWISTON

DRAWN BY:	TWC
DESIGNED BY:	CN
QUALITY CHECK:	
DATE:	12/11
JOB NO.	04-167
FIELDBOOK	

DNRC - CARDD
ST. MARY CANAL REHABILITATION

ST. MARY DIVERSION FACILITIES GEOTECHNICAL STUDIES
PROPOSED HYFRAULIC DROP REALIGNMENT
BORING LOCATION MAP

04167 BASEMAP 3D EAST END

SHEET 1A

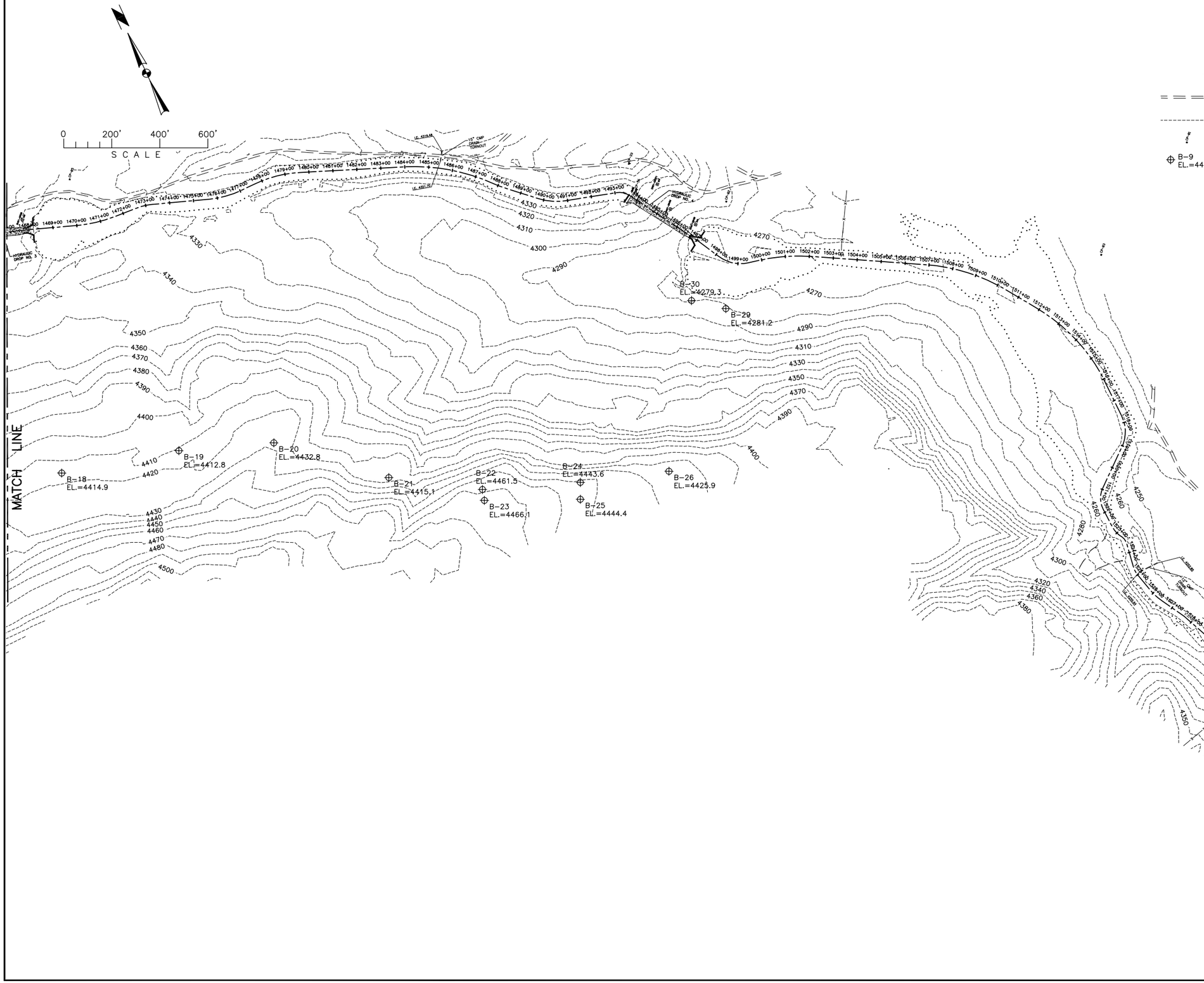


FIGURE 1B

REVISIONS

BY	DESCR	DATE
BY	DESCR	DATE
BY	DESCR	DATE

TD&H Engineering
tdhengineering.com
GREAT FALLS-BOZEMAN-KALISPELL
SPOKANE
LEWISTON
MONTANA
WASHINGTON
IDAHO

DRAWN BY:	TWC
DESIGNED BY:	CN
QUALITY CHECK:	
DATE:	12/11
JOB NO.	04-167
FIELDBOOK	

DNRC - CARDD
ST. MARY CANAL REHABILITATION

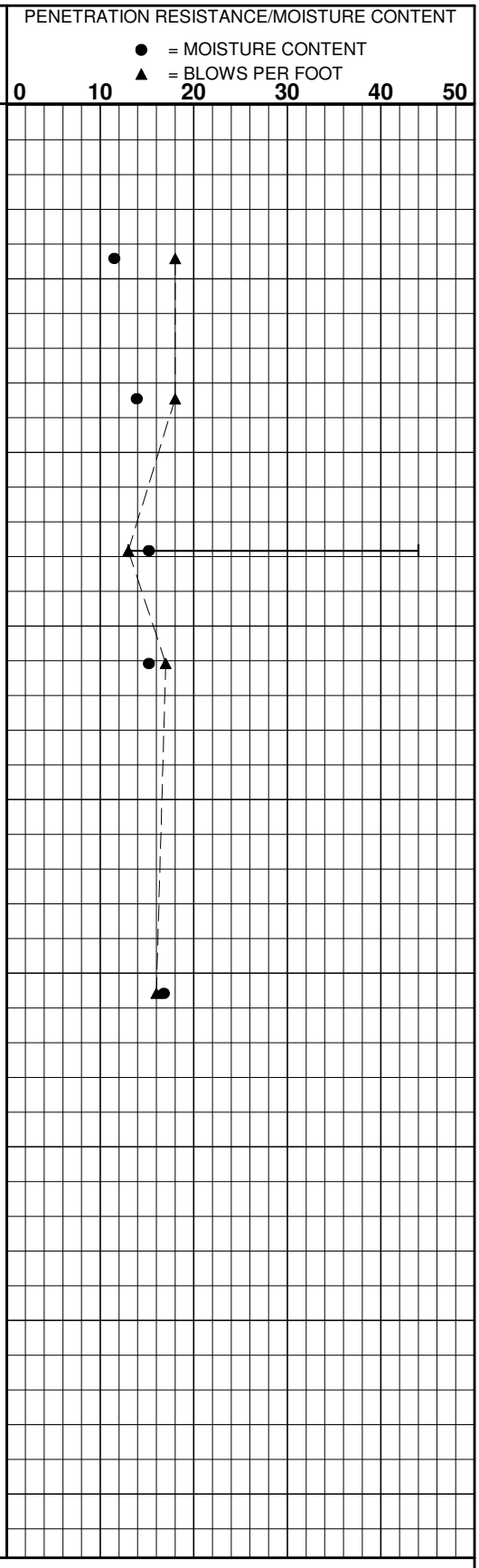
ST. MARY DIVERSION FACILITIES GEOTECHNICAL STUDIES
PROPOSED HYFRAULIC DROP REALIGNMENT
BORING LOCATION MAP

04167 BASEMAP 3D EAST END

SHEET 1B

SURFACE: Native Grasses
SURFACE ELEVATION: 4,423.7 ft

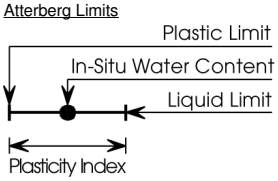
GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER
	Clayey SAND, appears loose to medium dense, brown, slightly moist	
		2.0
	Lean CLAY with Sand, stiff to very stiff, brown, slightly moist to moist, trace gravel, high-plasticity, minor mottling below 5.0 feet	
	qu > 4.5 tsf	
	qu > 4.5 tsf	
	qu > 4.5 tsf	
	qu = 3.0 - 4.5 tsf	
		16.2
	Bottom of Boring	Ground water not encountered



LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-1

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

Drilled by: Big Sky Subsurface
Truck-mounted CME-55 with 8-inch HSA

September 19, 2011 04-167-002

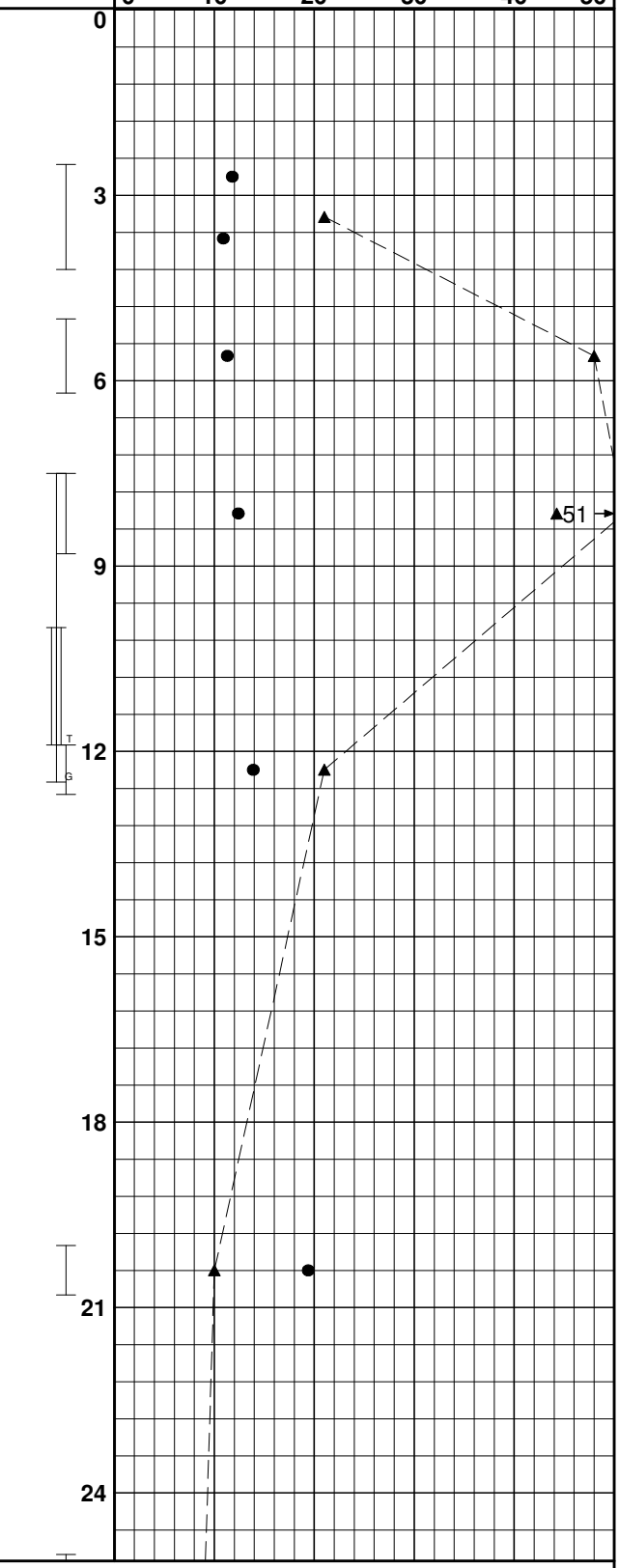
TD&H THOMAS, DEAN & HOSKINS, INC.
ENGINEERING CONSULTANTS
GREAT FALLS–BOZEMAN–KALISPELL–HELENA
SPOKANE LEWISTON
MONTANA WASHINGTON IDAHO

Figure No. 2
Sheet 1 of 1

SURFACE: Dry Stubble Field
SURFACE ELEVATION: 4,429.7 ft

SOIL DESCRIPTION	DEPTH GROUND WATER
qu > 4.5 tsf Clayey SAND, appears medium dense, brown, slightly moist	
	2.9
Lean CLAY with Sand, firm to hard, brown, slightly moist, trace sand and gravel, high-plasticity, mineral deposits	
qu > 4.5 tsf	
qu > 4.5 tsf * Maximum compacted density (moist) = 131.6 pcf	
* In-situ density (moist) = 124.4 pcf	
qu = 2.5 - 3.0 tsf	

PENETRATION RESISTANCE/MOISTURE CONTENT
● = MOISTURE CONTENT
▲ = BLOWS PER FOOT



LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
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- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
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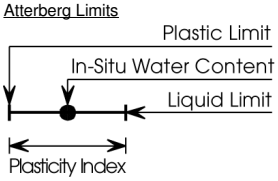
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-2

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

Drilled by: Big Sky Subsurface
Truck-mounted CME-55 with 8-inch HSA

September 19, 2011 04-167-002

TD&H THOMAS, DEAN & HOSKINS, INC.
ENGINEERING CONSULTANTS
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SPOKANE LEWISTON
MONTANA WASHINGTON IDAHO

Figure No. 3
Sheet 1 of 2

GRAPHIC LOG	SURFACE: Dry Stubble Field SURFACE ELEVATION: 4,429.7 ft SOIL DESCRIPTION	DEPTH GROUND WATER	SAMPLE DEPTH
	qu = 2.0 - 2.5 tsf - Saturated sand seam approx. 4 inches thick at 30.1 feet	31.5	
	Bottom of Boring	Ground water not encoun-tered	

PENETRATION RESISTANCE/MOISTURE CONTENT

● = MOISTURE CONTENT

▲ = BLOWS PER FOOT

0 10 20 30 40 50

27 30 33 36 39 42 45 48

LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits

Plastic Limit

In-Situ Water Content

Liquid Limit

Plasticity Index

GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-2

Proposed Drop Realignment
St. Mary River Siphon

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September 19, 2011 04-167-002

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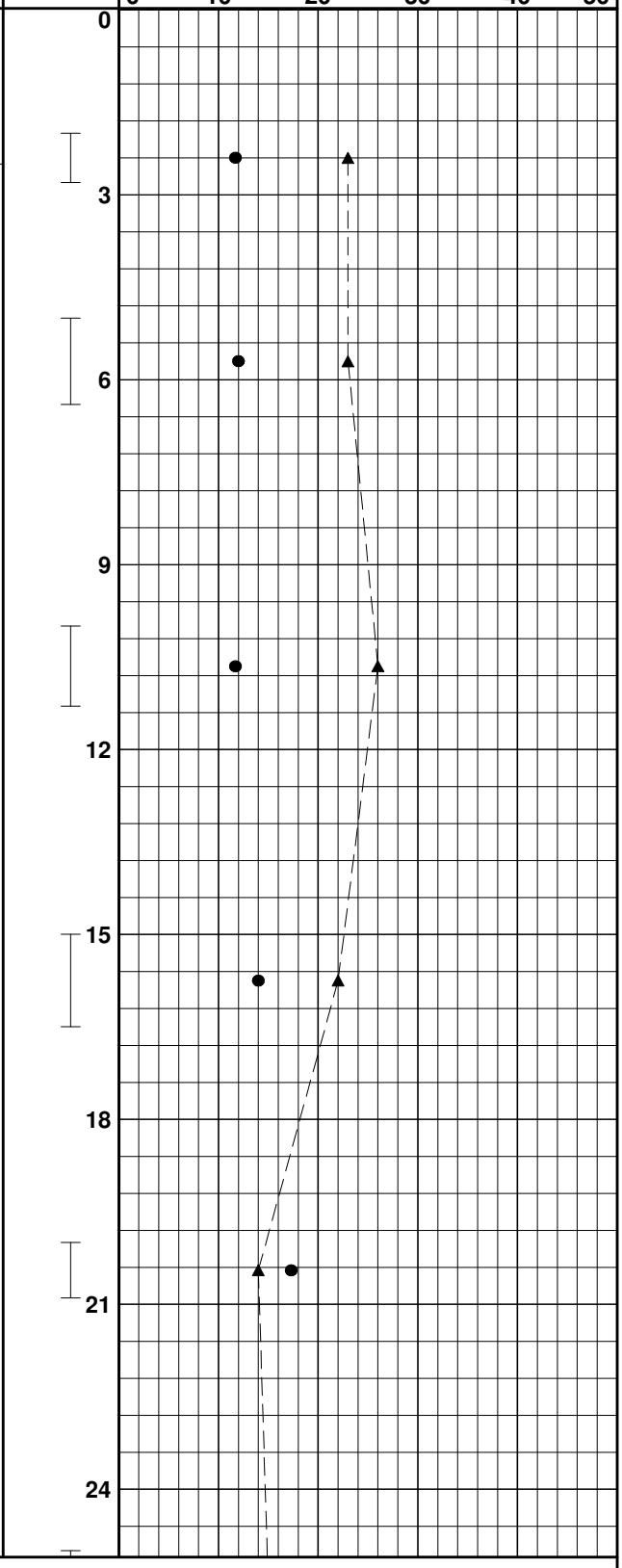
Figure No. 3

Sheet 2 of 2

SURFACE: Dry Stubble Field
SURFACE ELEVATION: 4,438.4 ft

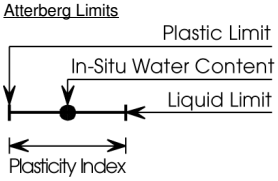
GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER
	Clayey SAND, appears medium dense, brown, slightly moist	2.5
	Lean CLAY, stiff to very stiff, brown, slightly moist to moist, high-plasticity	
	- Difficult drilling in tight clay from 12.0 to 14.0 feet. Sand content increases below 13.0 feet	
	- Thin gravel lense approx. 2 inches thick at 16.3 feet	



LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-3

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

Drilled by: Big Sky Subsurface
Truck-mounted CME-55 with 8-inch HSA

September 19, 2011 04-167-002

TD&H THOMAS, DEAN & HOSKINS, INC.
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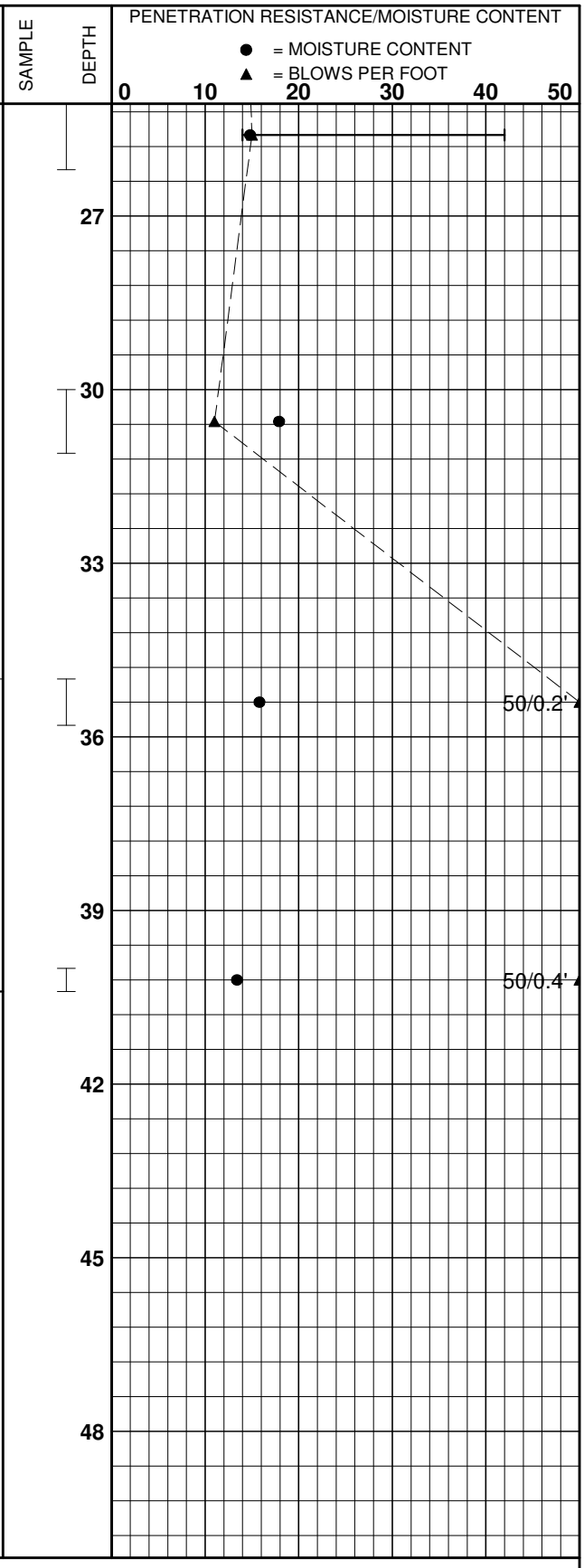
MONTANA WASHINGTON IDAHO

Figure No. 4
Sheet 1 of 2

SURFACE: Dry Stubble Field
SURFACE ELEVATION: 4,438.4 ft

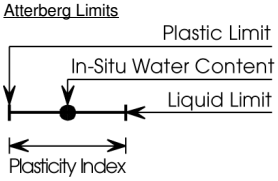
GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER
		35.0
	CLAYSTONE, hard, grayish tan, slightly moist, sandy	
	- 50 blows within first six inches of test	40.4
	Bottom of Boring	Ground water not encoun-tered



LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-3

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

Drilled by: Big Sky Subsurface
Truck-mounted CME-55 with 8-inch HSA

September 19, 2011 04-167-002

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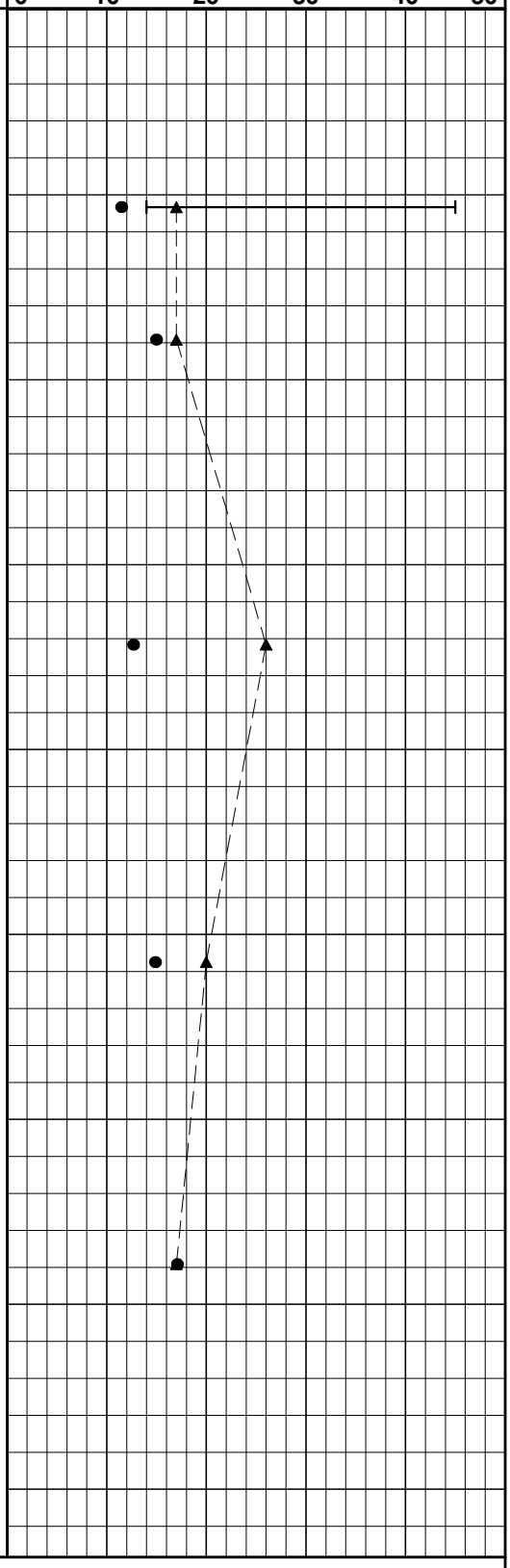
Figure No. 4
Sheet 2 of 2

SURFACE: Native Grasses
SURFACE ELEVATION: 4,419.1 ft

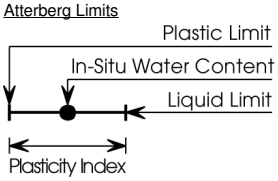
GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER
	Lean CLAY with Sand, very stiff, brown, moist, trace gravel, high-plasticity	
	- Sand content appears to decrease with depth	
		5.0
	Lean CLAY, very stiff, brown, moist, trace gravel, white salts in laminations, high-plasticity	
	qu > 4.5 tsf	
	- Roots growing through vertical laminations of white salts at 10.0 to 11.5 ft	
	qu > 4.5 tsf	
	qu > 4.5 tsf	
	qu = 2.5 - 3.0 tsf	
		21.5
	Bottom of Boring	Ground water not encountered



LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-4

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

Drilled by: Big Sky Subsurface
Truck-mounted CME-55 with 8-inch HSA

September 19, 2011 04-167-002

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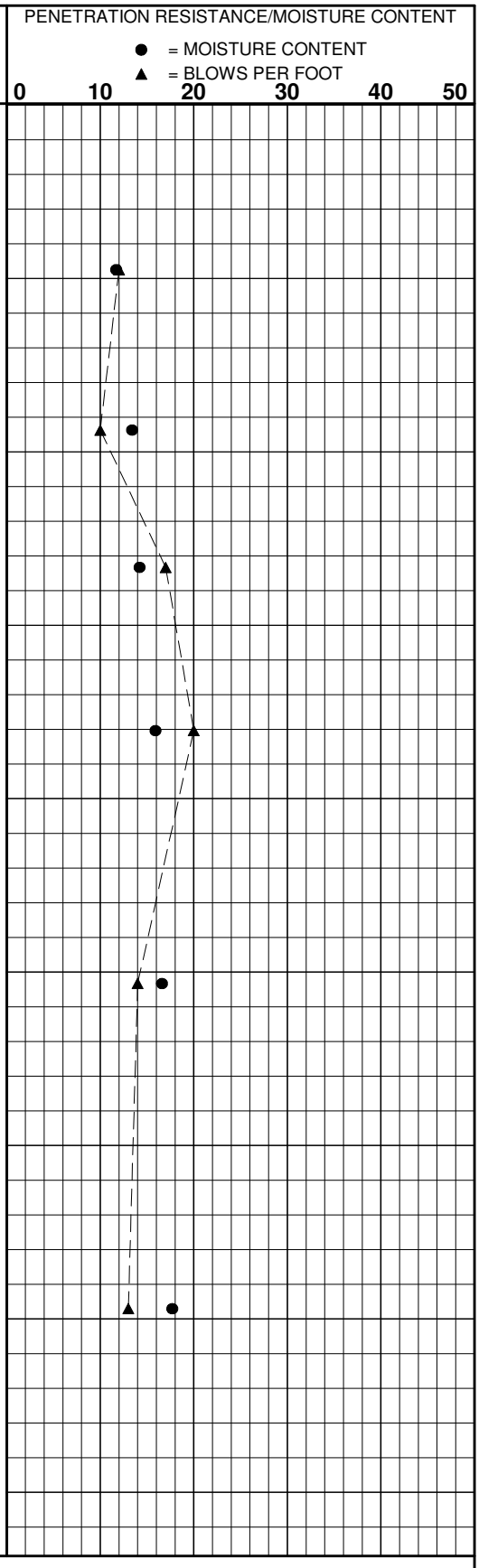
MONTANA WASHINGTON IDAHO

Figure No. 5
Sheet 1 of 1

SURFACE: Native Grasses & Shrubs
SURFACE ELEVATION: 4,419.8 ft

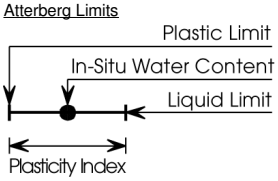
GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER
	Clayey SAND, appears medium dense, brown, slightly moist	
		2.0
	Lean CLAY, stiff to very stiff, brown, slightly moist, trace gravel and white salts, high-plasticity	
	qu > 4.5 tsf	
	qu > 4.5 tsf	
	- Vertical laminations of white salts below 9.0 feet	
	qu = 3.5 - 4.5 tsf	
	qu = 2.0 - 2.5 tsf	
	qu = 1.5 - 2.5 tsf	
		21.7
	Bottom of Boring	Ground water not encountered



LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-5

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

Drilled by: Big Sky Subsurface
Truck-mounted CME-55 with 8-inch HSA

September 20, 2011 04-167-002

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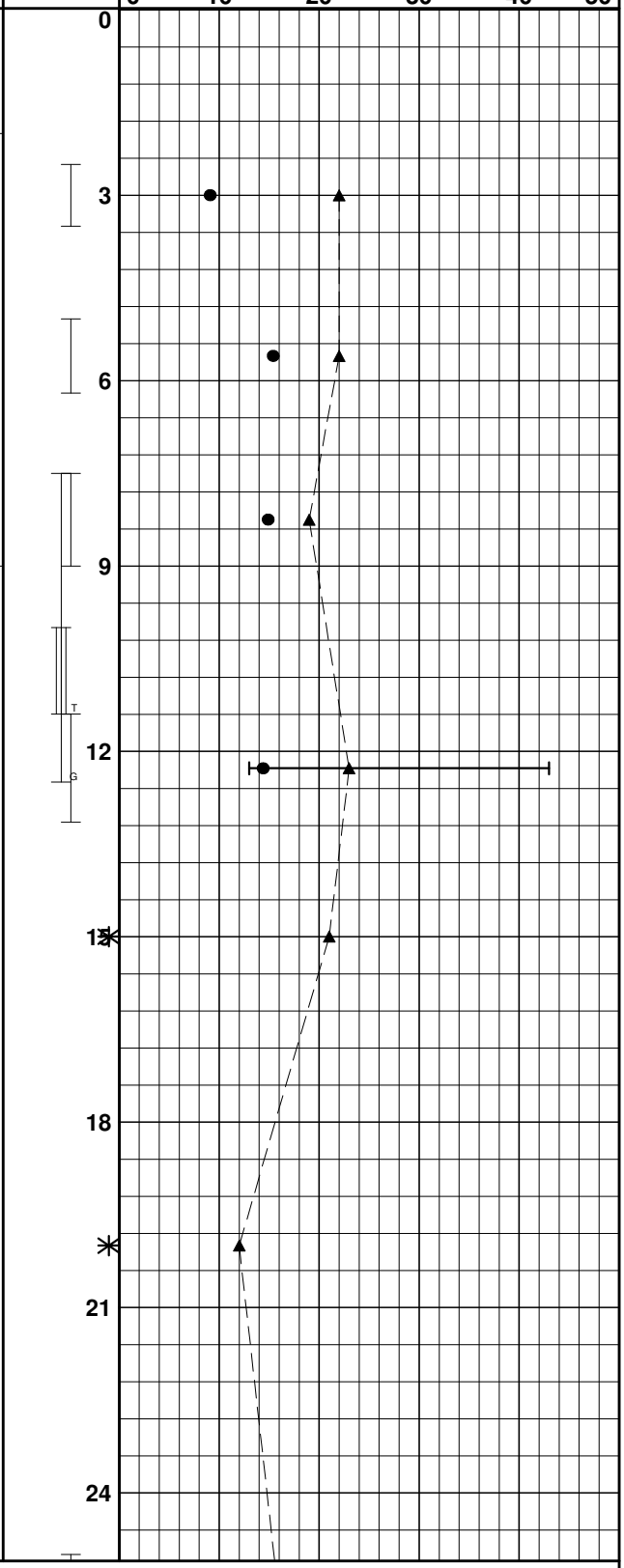
Figure No. 6
Sheet 1 of 1

SURFACE: Native Grasses & Shrubs
SURFACE ELEVATION: 4,428.8 ft

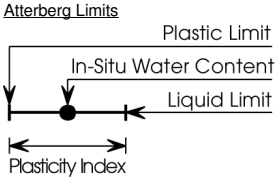
GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER
	Sandy Lean CLAY, relatively firm, brown, dry	
		2.0
	Lean CLAY with Sand, stiff to very stiff, brown, slightly moist, trace gravel and white salts, high-plasticity	
	qu > 4.5 tsf	
	* Maximum compacted density (moist) = 128.5 pcf	
	qu > 4.5 tsf	
		9.0
	Sandy Lean CLAY, very stiff, brown, moist	
	* In-situ density (moist) = 137.0 pcf	
	qu > 4.5 tsf	
	- Minor gypsum encountered at approximately 12.7 feet.	
	- Occasional auger chatter and increasing gravel below 14.0 feet	
	- No sample recovered in spoon at 15.0 ft	
	- No sample recovered in spoon at 20.0 ft. Catcher added to spoon	



LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- * No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-6

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

Drilled by: Big Sky Subsurface
Truck-mounted CME-55 with 8-inch HSA

September 20, 2011 04-167-002

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Figure No. 7
Sheet 1 of 2

GRAPHIC LOG	SURFACE: Native Grasses & Shrubs SURFACE ELEVATION: 4,428.8 ft SOIL DESCRIPTION	DEPTH GROUND WATER	SAMPLE DEPTH
	qu = 2.0 - 3.0 tsf		27
	qu = 2.5 - 3.0 tsf		30
		31.5	
	Bottom of Boring	Ground water not encoun-tered	33

PENETRATION RESISTANCE/MOISTURE CONTENT

● = MOISTURE CONTENT

▲ = BLOWS PER FOOT

0 10 20 30 40 50

27 30 33 36 39 42 45 48

LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits

Plastic Limit

In-Situ Water Content

Liquid Limit

Plasticity Index

GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-6

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

Drilled by: Big Sky Subsurface
Truck-mounted CME-55 with 8-inch HSA

September 20, 2011 04-167-002

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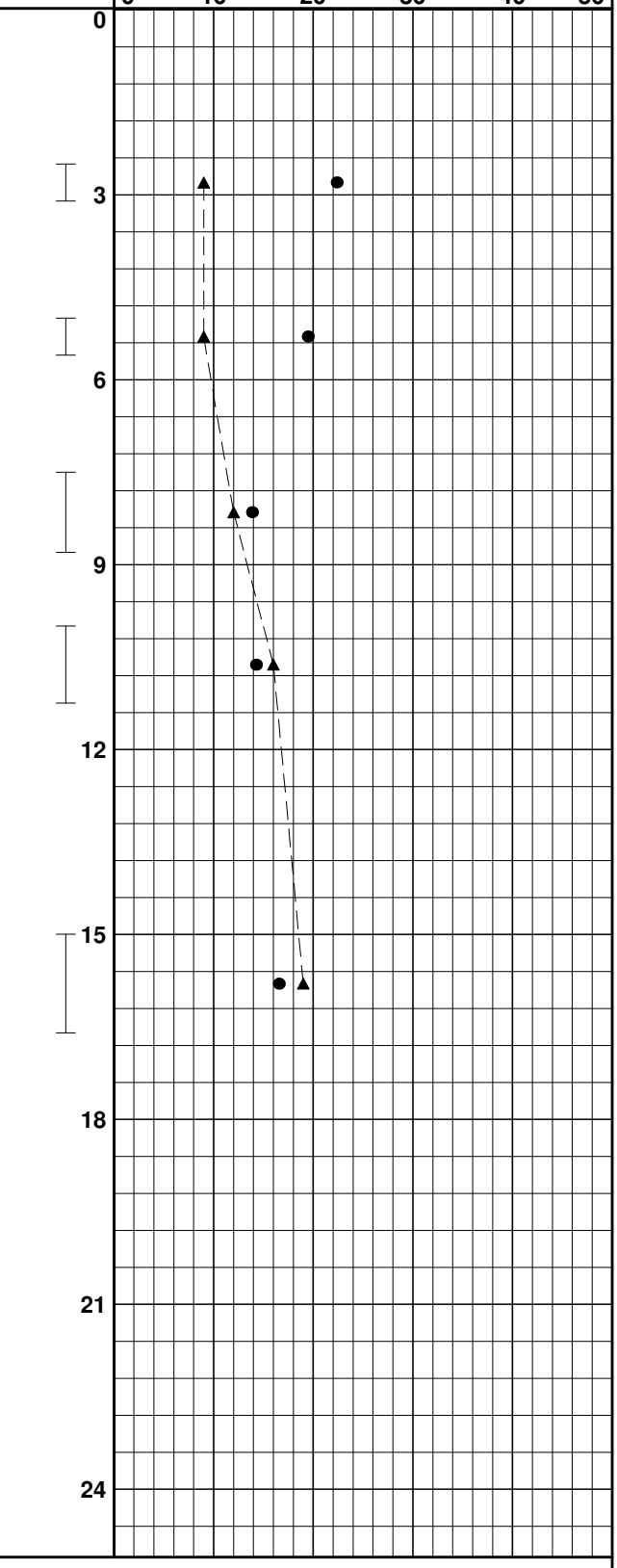
MONTANA WASHINGTON IDAHO

SURFACE: Native Grasses & Shrubs
SURFACE ELEVATION: 4,401.6 ft

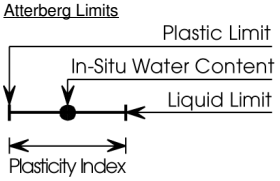
GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER
	Lean CLAY, stiff to very stiff, light brown and gray, slightly moist to moist, trace gravel, high-plasticity, minor oxidation	
	qu = 1.0 tsf	
	qu = 2.5 - 3.0 tsf	
	- Samples become less gray and less oxidized below 12.0 ft qu = 3.0 - 4.5 tsf	
	qu = 3.5 - 4.5 tsf	16.6
	Bottom of Boring	Ground water not encoun-tered



LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-7

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

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Truck-mounted CME-55 with 8-inch HSA

September 20, 2011 04-167-002

TD&H THOMAS, DEAN & HOSKINS, INC.
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GREAT FALLS–BOZEMAN–KALISPELL–HELENA
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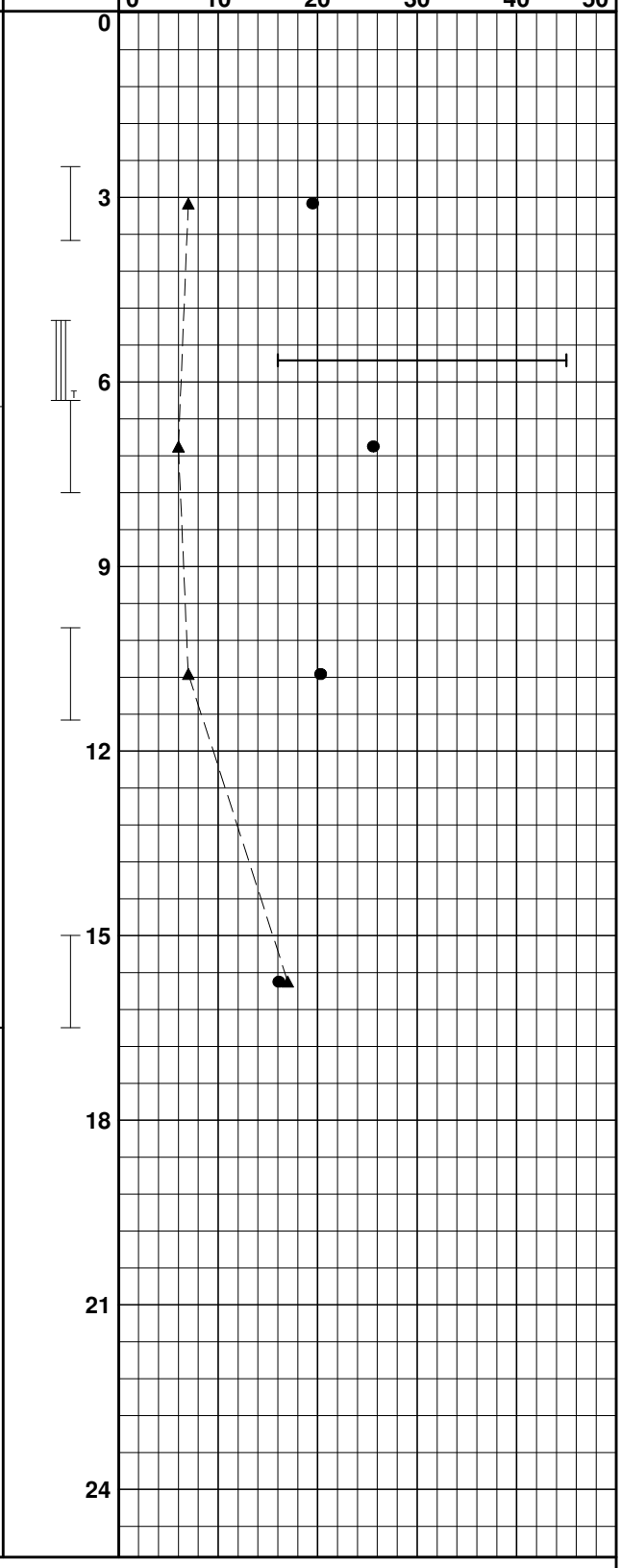
Figure No. 8
Sheet 1 of 1

SURFACE: Native Grasses & Shrubs
SURFACE ELEVATION: 4,408.0 ft

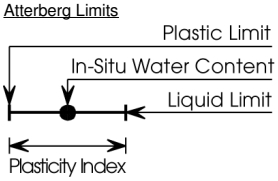
GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER
	Lean CLAY, firm to very stiff, grayish brown, moist to wet, occasional saturated sand seams	
	qu = 0.5 - 1.5 tsf	
	- Zone of saturated sand at 6.4 feet. Free water on spoon and sample	
	qu = 1.0 tsf	
	- Occasional gravel below 13.0 feet	
	qu = 2.0 - 2.5 tsf	16.5
	Bottom of Boring	



LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



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Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-8

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

Drilled by: Big Sky Subsurface
Truck-mounted CME-55 with 8-inch HSA

September 20, 2011 04-167-002

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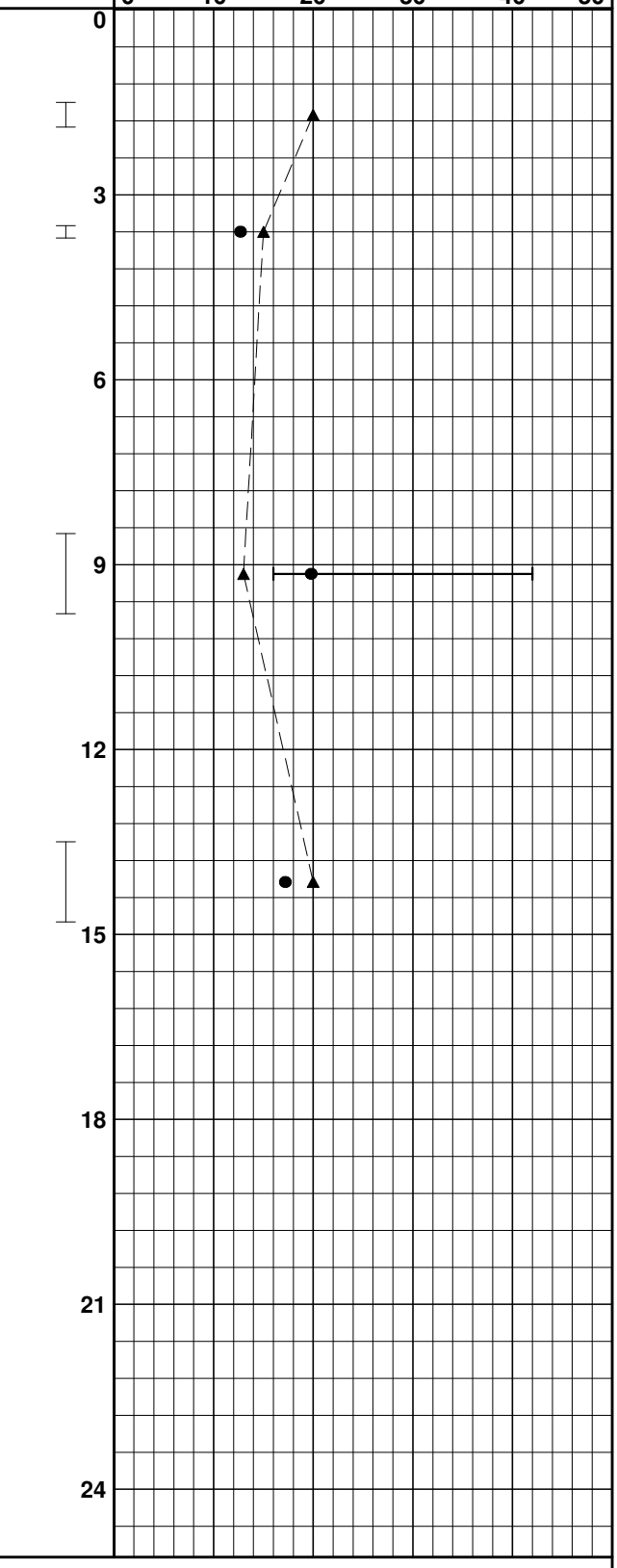
SPOKANE LEWISTON
MONTANA WASHINGTON IDAHO

Figure No. 9
Sheet 1 of 1

SURFACE: Native Grasses & Shrubs
SURFACE ELEVATION: 4,414.1 ft

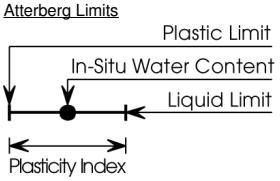
GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER
	Clayey SAND, appears medium dense, dark brown, slightly moist, organics	1.0
	Lean CLAY with Sand, stiff to very stiff, brown, slightly moist	
	- Material changes to maroon in color around 7.0 feet. Possible transition into weathered claystone	
	qu = 1.5 - 2.0 tsf	
	qu > 4.5 tsf	
		15.0
	Bottom of Boring	Ground water not encountered



LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-9

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

Drilled by: Big Sky Subsurface
Truck-mounted CME-55 with 8-inch HSA

September 20, 2011 04-167-002

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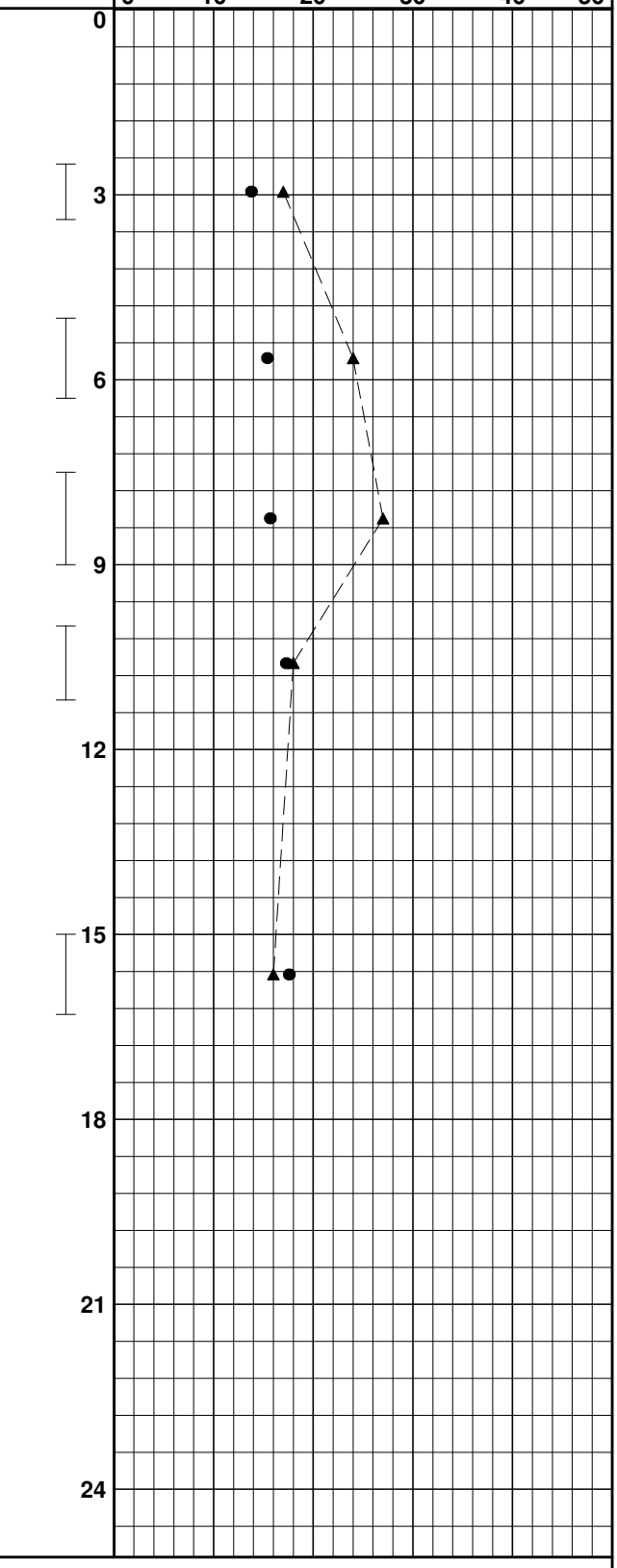
SPOKANE LEWISTON
MONTANA WASHINGTON IDAHO

Figure No. 10
Sheet 1 of 1

SURFACE: Native Grasses & Shrubs
SURFACE ELEVATION: 4,415.3 ft

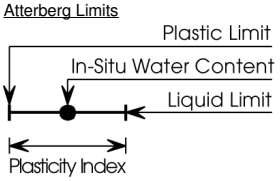
GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER
	Sandy Lean CLAY, appears firm, dark brown, slightly moist, contains organics	
		2.0
	Lean CLAY with Sand, very stiff, reddish brown, slightly moist, white salts present, moderate to high-plasticity	
	qu > 4.5 tsf	
	qu > 4.5 tsf	
	- Lenses of clayey sand up to 3 inches thick below 7.0 feet	
	qu > 4.0 tsf	
	- Zones of gray material below 13.0 ft	
	qu > 4.0 tsf	
		16.5
	Bottom of Boring	Ground water not encountered



LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-10

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

Drilled by: Big Sky Subsurface
Truck-mounted CME-55 with 8-inch HSA

September 20, 2011 04-167-002

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GREAT FALLS–BOZEMAN–KALISPELL–HELENA
SPOKANE LEWISTON
MONTANA WASHINGTON IDAHO

Figure No. 11
Sheet 1 of 1

SURFACE: Native Grasses & Shrubs
SURFACE ELEVATION: 4,405.5 ft

GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER	SAMPLE DEPTH
	Lean CLAY, firm to stiff, maroon and gray, moist, laminated with lenses of sand		0
	qu < 1.0 tsf		3
			6
			9
		9.5	
	Weathered CLAYSTONE, hard, gray, slightly moist, sandy		12
		13.0	
	Weathered SANDSTONE, hard, gray, slightly moist		15
	- 50 blows within first six inches of test		
		16.1	18
	Bottom of Boring	Ground water not encountered	21
			24

PENETRATION RESISTANCE/MOISTURE CONTENT
● = MOISTURE CONTENT
▲ = BLOWS PER FOOT
0 10 20 30 40 50

99/0.7'
50/0.5'

LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits

Plastic Limit
In-Situ Water Content
Liquid Limit
Plasticity Index

GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-11

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

Drilled by: Big Sky Subsurface
Truck-mounted CME-55 with 8-inch HSA

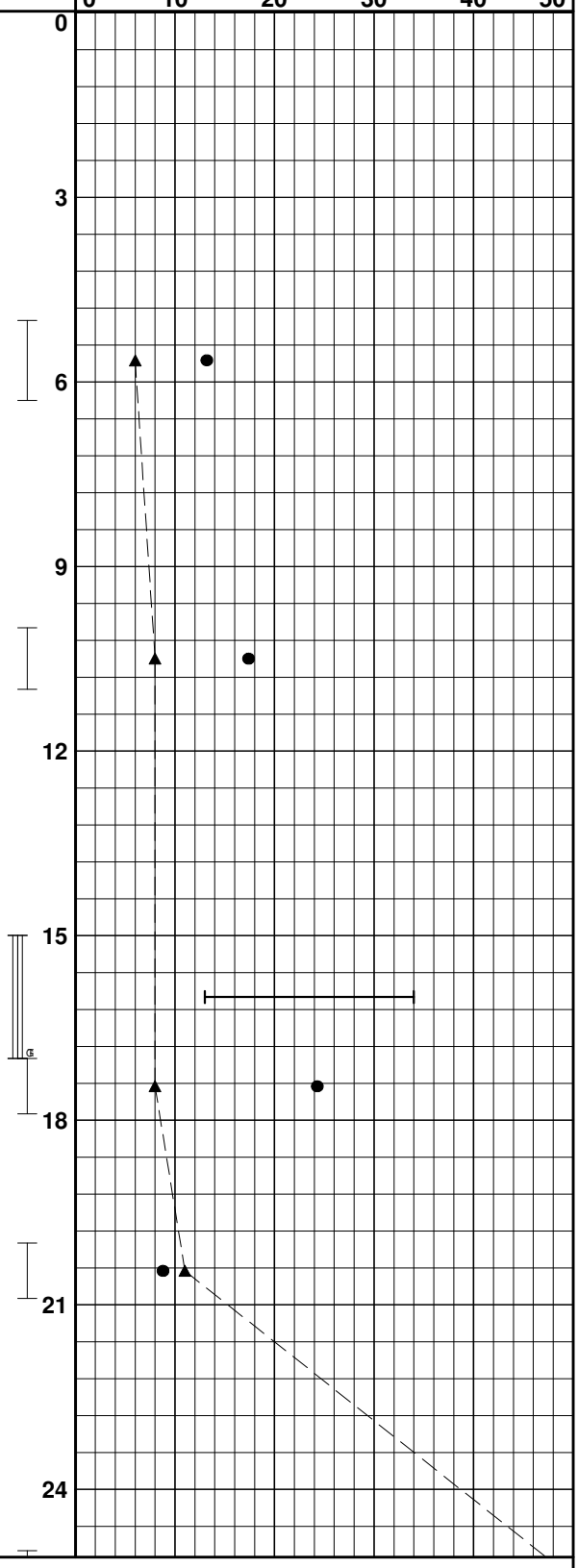
September 20, 2011 04-167-002

TD&H THOMAS, DEAN & HOSKINS, INC.
ENGINEERING CONSULTANTS
GREAT FALLS–BOZEMAN–KALISPELL–HELENA
SPOKANE LEWISTON
MONTANA WASHINGTON IDAHO

Figure No. 12
Sheet 1 of 1

SURFACE: Native Grasses & Shrubs
SURFACE ELEVATION: 4,445.5 ft

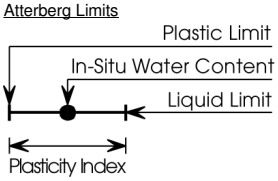
GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER
	Lean CLAY with Sand, firm, brown, moist	
		8.0
	Lean CLAY, firm, maroon, moist	
		12.5
	Sandy Lean CLAY, firm to stiff, brown, moist * Maximum compacted density (moist) = 132.5 pcf * In-situ density (moist) = 130.2 pcf - Free water at 17.0 feet. No additional water observed below and all samples appear dry. Likely perched water.	
		21.3
	Weathered CLAYSTONE, hard, gray and maroon, moist	



LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-12

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Bill Colenso, E.I.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

October 21, 2011 04-167-002

TD&H THOMAS, DEAN & HOSKINS, INC.
ENGINEERING CONSULTANTS
GREAT FALLS–BOZEMAN–KALISPELL–HELENA
SPOKANE LEWISTON
MONTANA WASHINGTON IDAHO

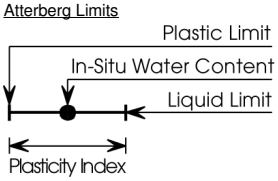
Figure No. 13
Sheet 1 of 2

GRAPHIC LOG	SURFACE: Native Grasses & Shrubs SURFACE ELEVATION: 4,445.5 ft SOIL DESCRIPTION	DEPTH GROUND WATER	SAMPLE	DEPTH	PENETRATION RESISTANCE/MOISTURE CONTENT ● = MOISTURE CONTENT ▲ = BLOWS PER FOOT 0 10 20 30 40 50
	- Water added to help bring cuttings to the surface				50/0.3'
				27	
				30	▲74
				33	
		34.0			
	SANDSTONE, very dense to hard, gray, dry to slightly moist - 50 blows within first six inches of test				50/0.3'
				36	
		37.5			
	CLAYSTONE, hard, gray to dark gray, dry to slightly moist				
				39	
		41.0			50/0.48'
	Bottom of Boring	Ground water not encoun-tered		42	
				45	
				48	

LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-12

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Bill Colenso, E.I.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

October 21, 2011 04-167-002

TD&H THOMAS, DEAN & HOSKINS, INC.
ENGINEERING CONSULTANTS
GREAT FALLS–BOZEMAN–KALISPELL–HELENA
SPOKANE LEWISTON
MONTANA WASHINGTON IDAHO

Figure No. 13

Sheet 2 of 2

SURFACE: Native Grasses & Shrubs
SURFACE ELEVATION: 4,433.4 ft

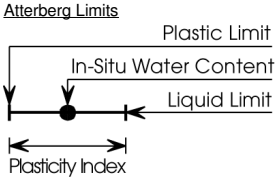
GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER	SAMPLE DEPTH
	Lean CLAY with Sand, appears medium dense, light brown, moist		0
		5.0	3
	Clayey SAND, medium dense, light brown, moist		6
	* In-situ density (moist) = 132.5 pcf * Maximum compacted density (moist) = 130.0 pcf	11.0	9
	Weathered CLAYSTONE, very stiff, gray, slightly moist, degree of weathering appears to decrease with depth		12
	- Sand mixed with claystone from 15.0 - 16.5 feet		15
	- Thin lenses of gray sand below 19.0 ft		18
			21
			24

PENETRATION RESISTANCE/MOISTURE CONTENT
● = MOISTURE CONTENT
▲ = BLOWS PER FOOT
0 10 20 30 40 50

LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-13

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Bill Colenso, E.I.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

October 20, 2011 04-167-002

THOMAS, DEAN & HOSKINS, INC.
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SPOKANE LEWISTON
MONTANA WASHINGTON IDAHO

Figure No. 14
Sheet 1 of 2

GRAPHIC LOG	SURFACE: Native Grasses & Shrubs SURFACE ELEVATION: 4,433.4 ft SOIL DESCRIPTION	DEPTH GROUND WATER	SAMPLE DEPTH
		29.0	
	Weathered SANDSTONE, medium dense, gray, moist		
		31.5	
	Bottom of Boring	Ground water not encoun-tered	

PENETRATION RESISTANCE/MOISTURE CONTENT

● = MOISTURE CONTENT

▲ = BLOWS PER FOOT

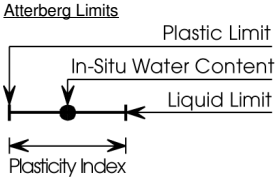
0 10 20 30 40 50

27 30 33 36 39 42 45 48

LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-13

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Bill Colenso, E.I.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

October 20, 2011 04-167-002

THOMAS, DEAN & HOSKINS, INC.
ENGINEERING CONSULTANTS
GREAT FALLS–BOZEMAN–KALISPELL–HELENA
SPOKANE LEWISTON
MONTANA WASHINGTON IDAHO

Figure No. 14

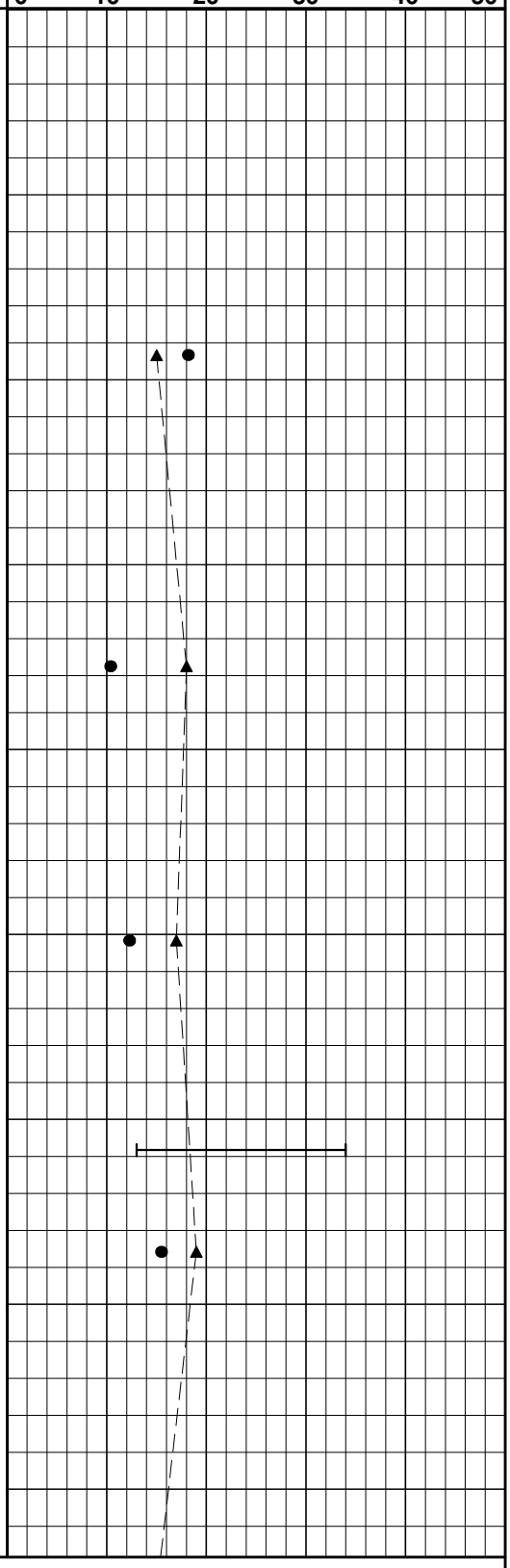
Sheet 2 of 2

SURFACE: Native Grasses & Shrubs
SURFACE ELEVATION: 4,428.7 ft

GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER
	Lean CLAY with Sand, appears firm to stiff, light brown, slightly moist	
		2.5
	Lean CLAY, stiff, maroon to brown, dry to slightly moist	
		7.0
	Lean CLAY with Gravel, very stiff, brown, moist	
	- Sandstone fragments from 11.0 - 11.2 ft	
		13.0
	Sandy Lean CLAY, very stiff, light brown, moist	
	* Maximum compacted density (moist) = 133.0 pcf	

SAMPLE DEPTH

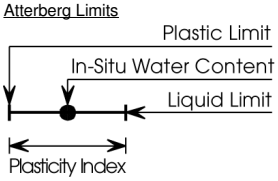
PENETRATION RESISTANCE/MOISTURE CONTENT
● = MOISTURE CONTENT
▲ = BLOWS PER FOOT



LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-14

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Bill Colenso, E.I.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

October 20, 2011 04-167-002

TD&H THOMAS, DEAN & HOSKINS, INC.
ENGINEERING CONSULTANTS
GREAT FALLS–BOZEMAN–KALISPELL–HELENA
SPOKANE LEWISTON
MONTANA WASHINGTON IDAHO

Figure No. 15
Sheet 1 of 2

GRAPHIC LOG	SURFACE: Native Grasses & Shrubs SURFACE ELEVATION: 4,428.7 ft SOIL DESCRIPTION	DEPTH GROUND WATER	SAMPLE DEPTH
	- Sand lense from 30.7 - 30.8 ft		
		31.5	
	Bottom of Boring	Ground water not encoun-tered	

PENETRATION RESISTANCE/MOISTURE CONTENT

● = MOISTURE CONTENT

▲ = BLOWS PER FOOT

0 10 20 30 40 50

27 30 33 36 39 42 45 48

LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits

Plastic Limit

In-Situ Water Content

Liquid Limit

Plasticity Index

GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-14

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Bill Colenso, E.I.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

October 20, 2011 04-167-002

TD&H THOMAS, DEAN & HOSKINS, INC.
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GREAT FALLS–BOZEMAN–KALISPELL–HELENA MONTANA
SPOKANE WASHINGTON
LEWISTON IDAHO

Figure No. 15

Sheet 2 of 2

SURFACE: Native Grasses & Shrubs
SURFACE ELEVATION: 4,427.0 ft

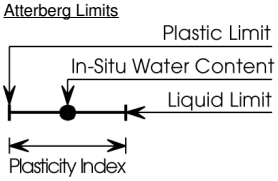
GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER	SAMPLE DEPTH
	Lean CLAY with Sand, appears soft, light brown, moist		0
		3.0	3
	Silty SAND, very loose, gray, moist		
		7.0	6
	Weathered CLAYSTONE, stiff to very stiff, gray and maroon, slightly moist, lenses of sand		9
			12
			15
	- Less maroon coloring below 18.0 feet		18
			21
		24.0	24
	Weathered SANDSTONE, medium dense, gray, slightly moist		

PENETRATION RESISTANCE/MOISTURE CONTENT
● = MOISTURE CONTENT
▲ = BLOWS PER FOOT
0 10 20 30 40 50

LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- ▼ Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-15

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Bill Colenso, E.I.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

October 19, 2011 04-167-002

TD&H THOMAS, DEAN & HOSKINS, INC.
ENGINEERING CONSULTANTS
GREAT FALLS–BOZEMAN–KALISPELL–HELENA
SPOKANE LEWISTON
MONTANA WASHINGTON IDAHO

Figure No. 16
Sheet 1 of 2

GRAPHIC LOG	SURFACE: Native Grasses & Shrubs SURFACE ELEVATION: 4,427.0 ft SOIL DESCRIPTION	DEPTH GROUND WATER	SAMPLE DEPTH
		26.5	
	CLAYSTONE, very stiff, maroon and gray, slightly moist		27
			30
		31.5	
	Bottom of Boring		33
			36
			39
			42
			45
			48

PENETRATION RESISTANCE/MOISTURE CONTENT

● = MOISTURE CONTENT

▲ = BLOWS PER FOOT

0 10 20 30 40 50

LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits

Plastic Limit

In-Situ Water Content

Liquid Limit

Plasticity Index

GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-15

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Bill Colenso, E.I.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

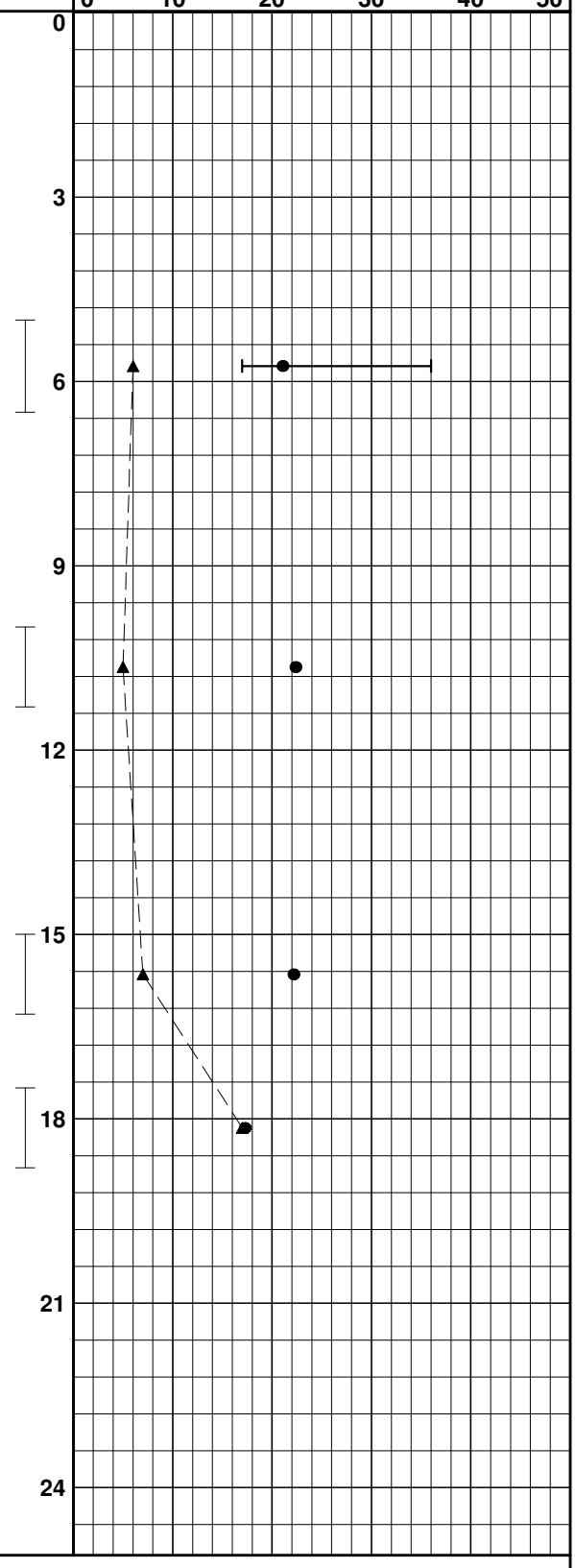
October 19, 2011 04-167-002

TD&H THOMAS, DEAN & HOSKINS, INC.
ENGINEERING CONSULTANTS
GREAT FALLS–BOZEMAN–KALISPELL–HELENA
SPOKANE LEWISTON
MONTANA WASHINGTON IDAHO

Figure No. 16

SURFACE: Native Grasses & Shrubs - Surface Water Nearby
SURFACE ELEVATION: 4,418.9 ft

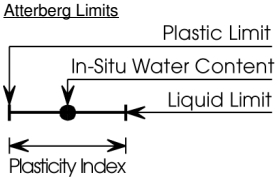
GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER
	Lean CLAY, appears soft, light brown, moist to very moist	
		3.0
	Sandy Lean CLAY, firm, light brown, very moist, minor salts	
	- Lense of clayey sand from 10.2 to 10.5 feet	
		13.0
	Lean CLAY with Sand (Severely weathered claystone), firm, gray, moist	
		17.0
	Weathered SANDSTONE, medium dense, gray, moist, severely weathered	
		19.0
	Bottom of Boring	



LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-16

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Bill Colenso, E.I.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

October 19, 2011 04-167-002

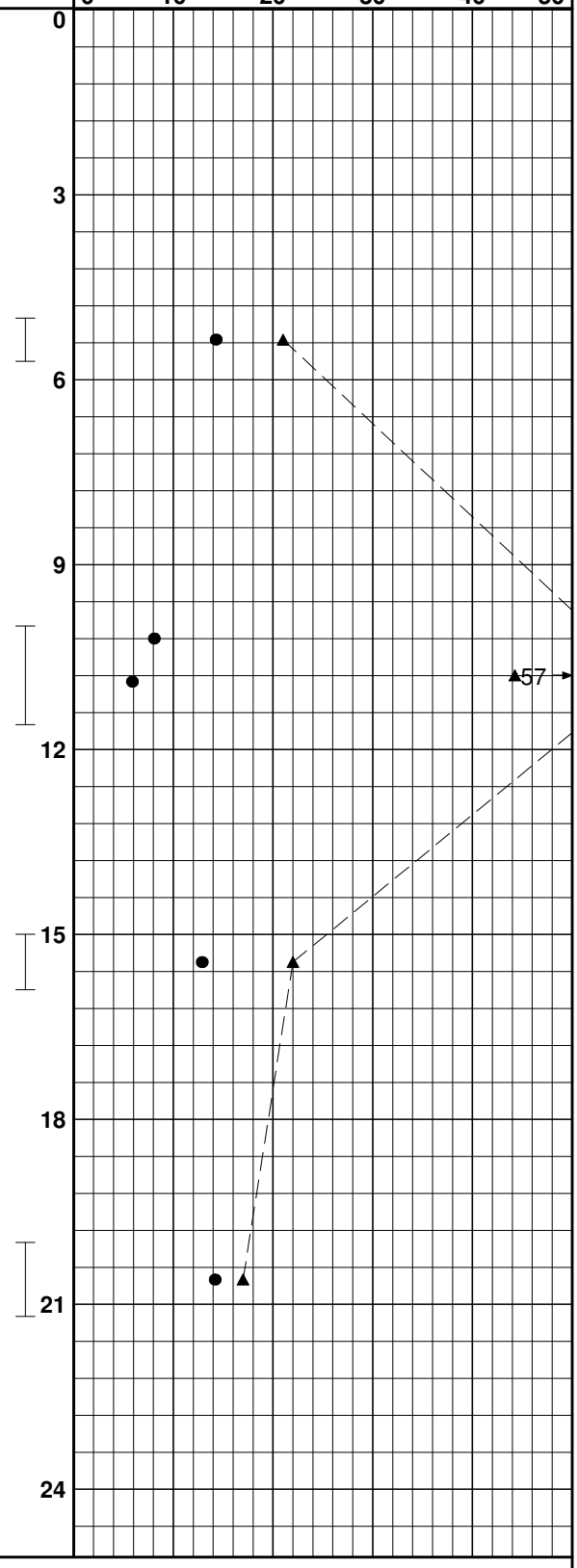
TD&H THOMAS, DEAN & HOSKINS, INC.
ENGINEERING CONSULTANTS
GREAT FALLS–BOZEMAN–KALISPELL–HELENA
SPOKANE LEWISTON
MONTANA WASHINGTON IDAHO

Figure No. 17
Sheet 1 of 1

SURFACE: Native Grasses & Shrubs
SURFACE ELEVATION: 4,421.4 ft

GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER
	Lean CLAY with Sand, appears firm, brown, slightly moist	
		4.5
	Weathered CLAYSTONE, very stiff, gray and maroon, slightly moist	
		10.4
	Weathered SANDSTONE, very dense, gray, dry	
		13.0
	Weathered CLAYSTONE, very stiff, maroon and gray, moist, small lenses of sand	
		21.5
	Bottom of Boring	Ground water not encountered

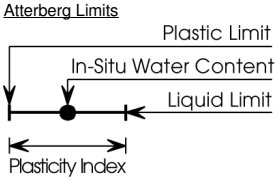
PENETRATION RESISTANCE/MOISTURE CONTENT
● = MOISTURE CONTENT
▲ = BLOWS PER FOOT



LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-17

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Bill Colenso, E.I.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

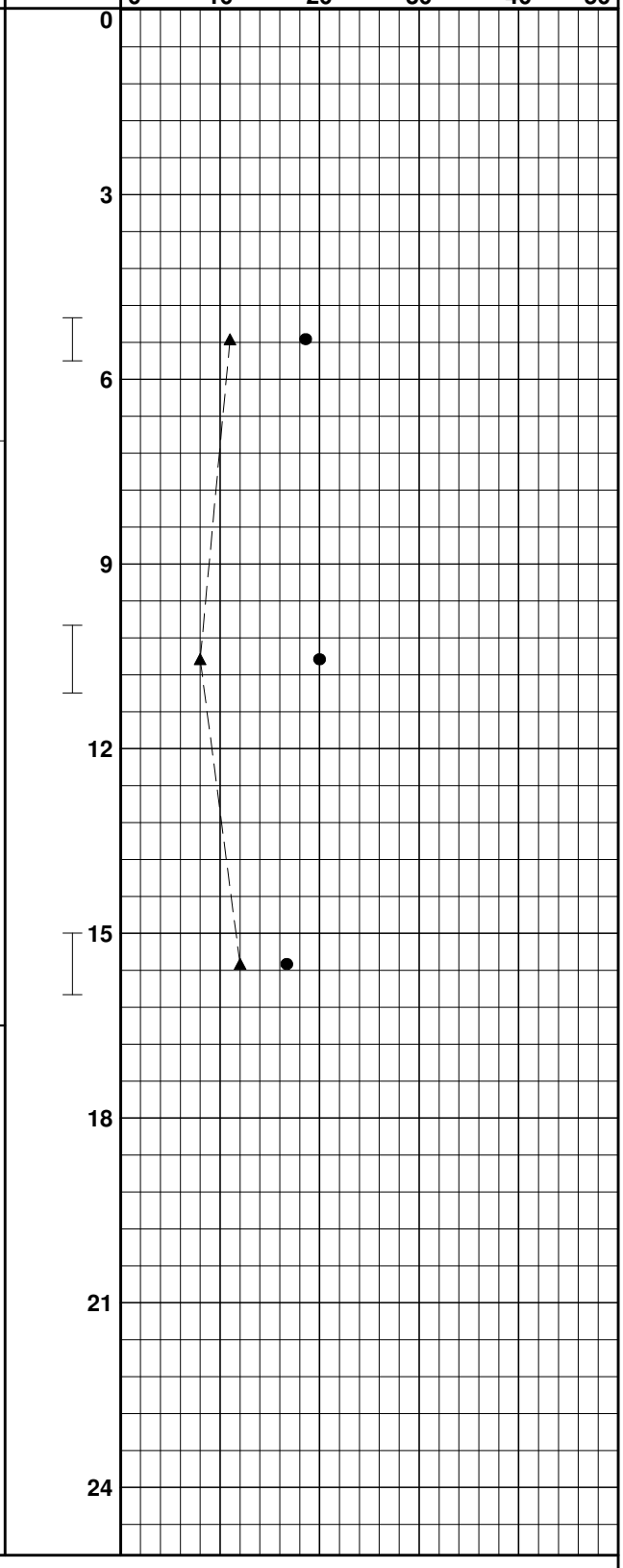
October 19, 2011 04-167-002

TD&H THOMAS, DEAN & HOSKINS, INC.
ENGINEERING CONSULTANTS
GREAT FALLS–BOZEMAN–KALISPELL–HELENA
SPOKANE LEWISTON
MONTANA WASHINGTON IDAHO

Figure No. 18
Sheet 1 of 1

SURFACE: Native Grasses & Shrubs
SURFACE ELEVATION: 4,414.9 ft

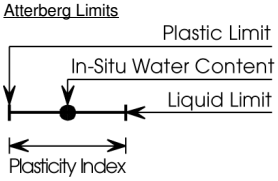
GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER
	Lean CLAY with Sand, stiff, brown, slightly moist	
		7.0
	Lean CLAY with Sand (Severely Weathered CLAYSTONE), firm to stiff, gray and maroon, moist	
		16.5
	Bottom of Boring	Ground water not encountered



LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-18

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Bill Colenso, E.I.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

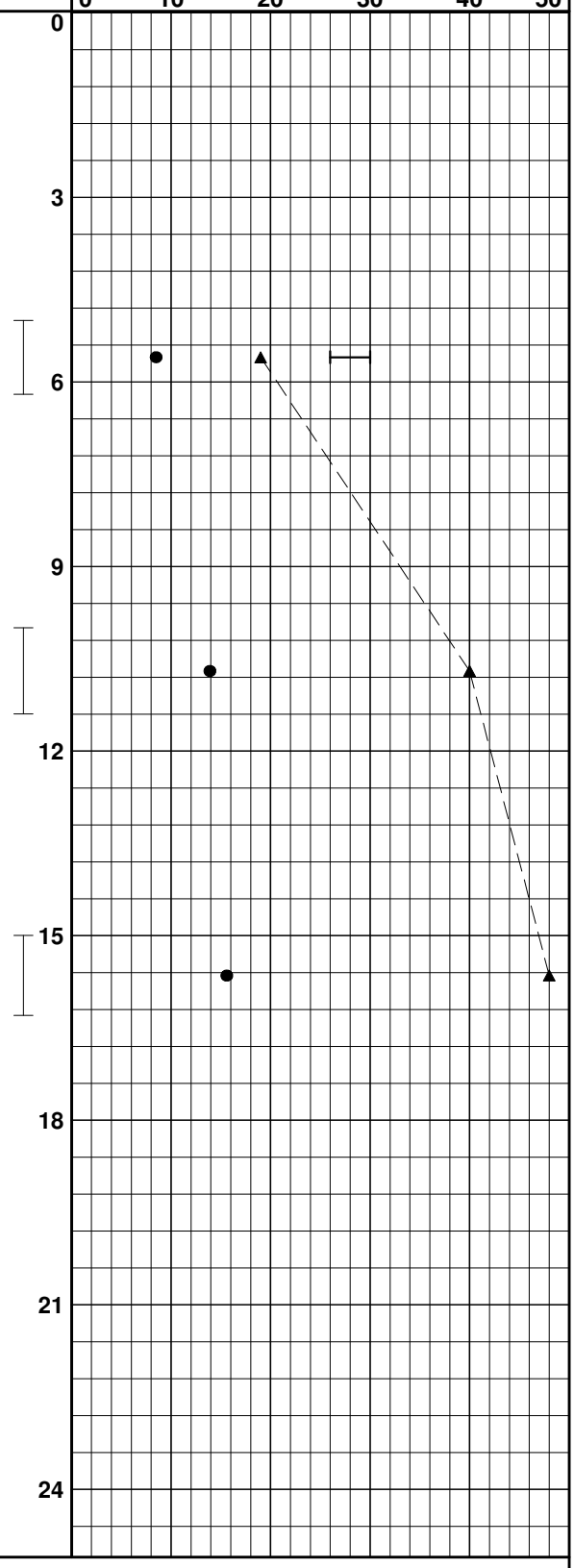
October 19, 2011 04-167-002

TD&H THOMAS, DEAN & HOSKINS, INC.
ENGINEERING CONSULTANTS
GREAT FALLS–BOZEMAN–KALISPELL–HELENA
SPOKANE LEWISTON
MONTANA WASHINGTON IDAHO

Figure No. 19
Sheet 1 of 1

SURFACE: Native Grasses & Shrubs
SURFACE ELEVATION: 4,412.8 ft

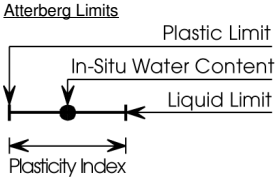
GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER
	Lean CLAY with Gravel, appears firm, brown, dry	
		3.0
	Silty SAND, medium dense, gray, slightly moist	
		7.5
	CLAYSTONE, hard, maroon, slightly moist	
	- Color change from maroon to gray near 14.0 feet with gradual transition back to maroon by 16.3 ft	
		16.5
	Bottom of Boring	Ground water not encountered



LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-19

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Bill Colenso, E.I.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

October 19, 2011 04-167-002

TD&H THOMAS, DEAN & HOSKINS, INC.
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GREAT FALLS–BOZEMAN–KALISPELL–HELENA
SPOKANE LEWISTON
MONTANA WASHINGTON IDAHO

Figure No. 20
Sheet 1 of 1

SURFACE: Native Grasses & Shrubs
SURFACE ELEVATION: 4,432.8 ft

GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER
	Lean CLAY with Sand, stiff, brown, dry to slightly moist	
		6.0
	Silty SAND, relatively loose, gray, dry	
		7.0
	Weathered SANDSTONE, medium dense, gray, slightly moist, lenses of CLAYSTONE intermixed	
		14.0
	Weathered CLAYSTONE, hard, maroon, dry, small lenses of gray sand throughout	
		23.0
	Weathered SANDSTONE, dense, gray, dry	

SAMPLE DEPTH

PENETRATION RESISTANCE/MOISTURE CONTENT

● = MOISTURE CONTENT
▲ = BLOWS PER FOOT

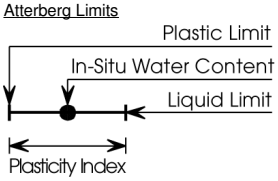
0 10 20 30 40 50

0 3 6 9 12 15 18 21 24

LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- ▼ Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-20

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Bill Colenso, E.I.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

October 19, 2011 04-167-002

TD&H THOMAS, DEAN & HOSKINS, INC.
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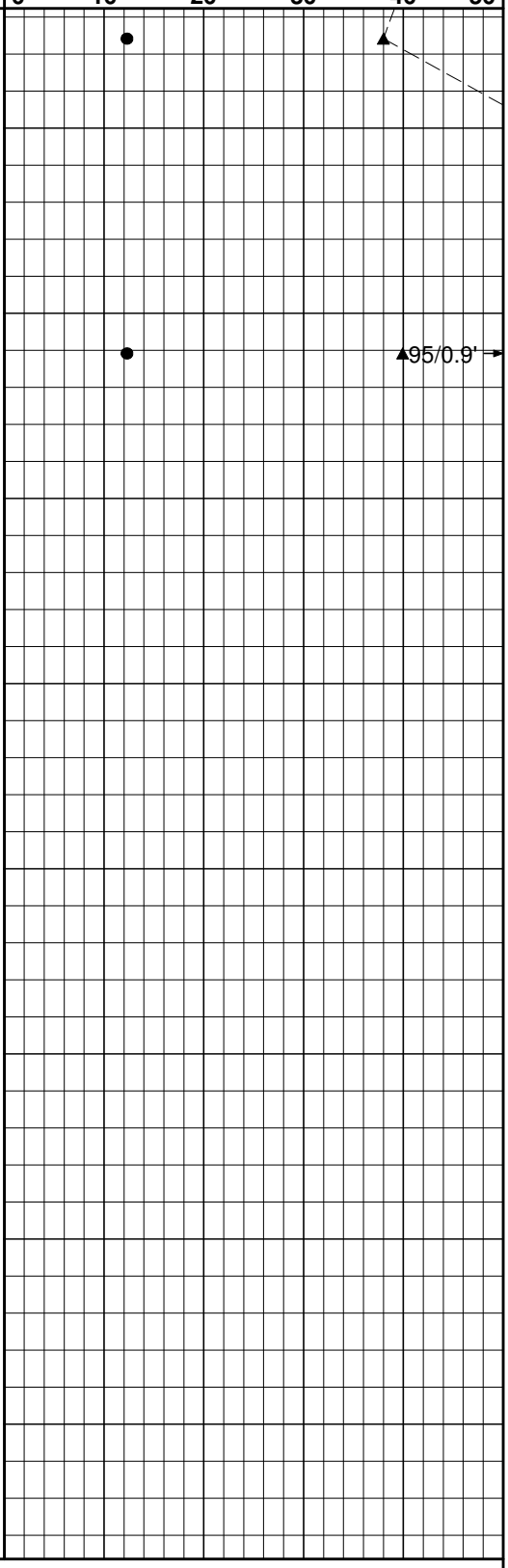
SPOKANE WASHINGTON
LEWISTON IDAHO

Figure No. 21

SURFACE: Native Grasses & Shrubs
SURFACE ELEVATION: 4,432.8 ft

GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER
		28.0
	Weathered CLAYSTONE, hard, gray and maroon, dry, lenses of gray sandstone throughout	
		31.4
	Bottom of Boring	Ground water not encoun-tered

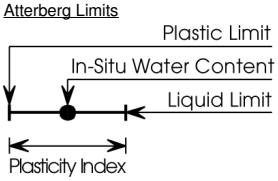
PENETRATION RESISTANCE/MOISTURE CONTENT
● = MOISTURE CONTENT
▲ = BLOWS PER FOOT



LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-20

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Bill Colenso, E.I.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

October 19, 2011 04-167-002

TD&H THOMAS, DEAN & HOSKINS, INC.
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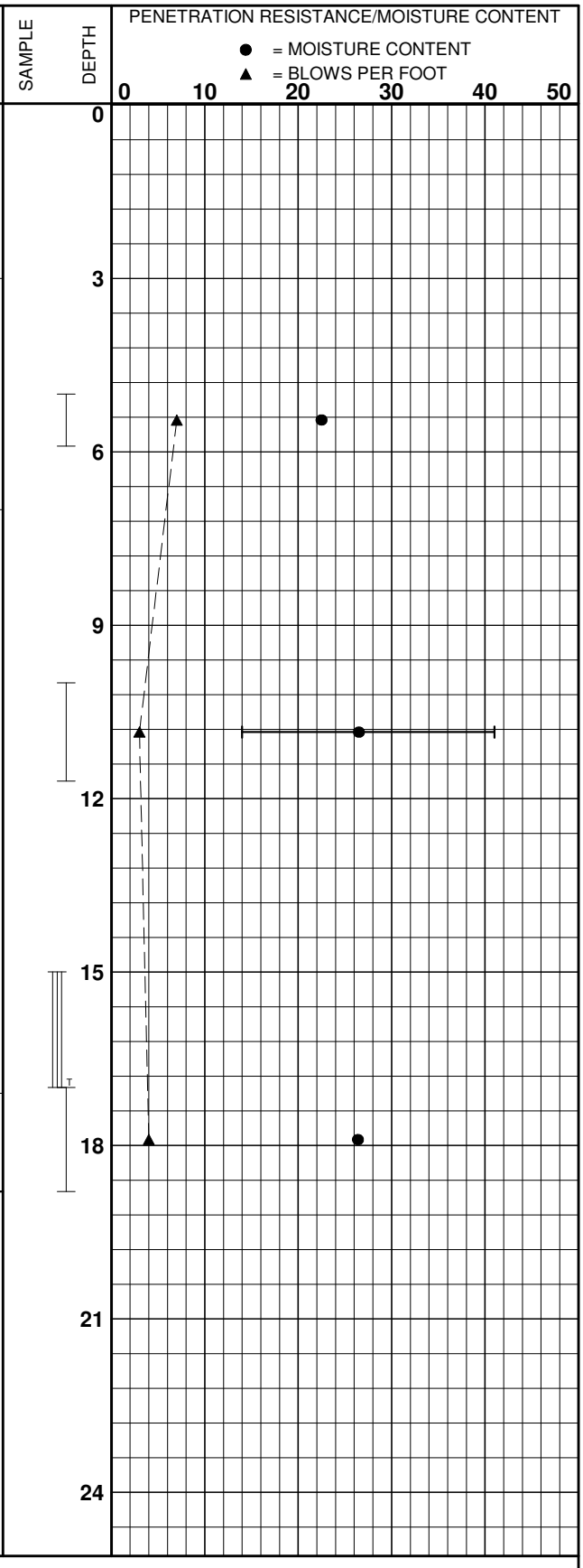
GREAT FALLS–BOZEMAN–KALISPELL–HELENA
SPOKANE LEWISTON
MONTANA WASHINGTON IDAHO

Figure No. 21
Sheet 2 of 2

SURFACE: Native Grasses & Shrubs
SURFACE ELEVATION: 4,415.1 ft

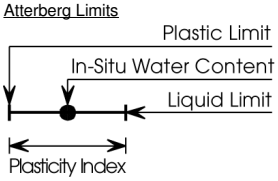
GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER
	Lean CLAY with Sand, appears firm, dark brown to black, dry	
		3.0
	Lean CLAY, firm, dark brown to black, slightly moist	
		7.0
	Sandy Lean CLAY, soft, brown, moist to very moist	
	- Lense of Sandy Lean CLAY at 17.1 to 17.4 feet, wet	
		18.8
	Bottom of Boring	



LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-21

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Bill Colenso, E.I.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

October 19, 2011 04-167-002

TD&H THOMAS, DEAN & HOSKINS, INC.
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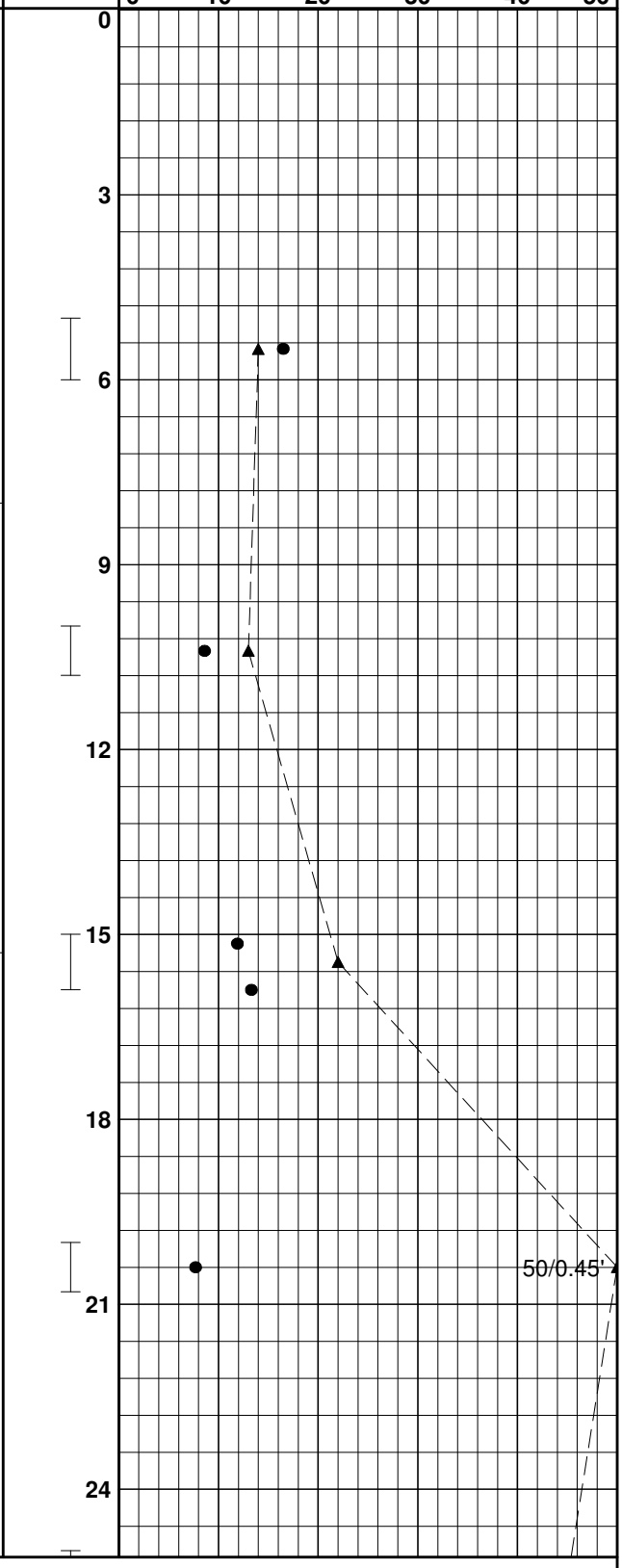
GREAT FALLS–BOZEMAN–KALISPELL–HELENA
SPOKANE LEWISTON
MONTANA WASHINGTON IDAHO

Figure No. 22
Sheet 1 of 1

SURFACE: Native Grasses & Shrubs
SURFACE ELEVATION: 4,461.5 ft

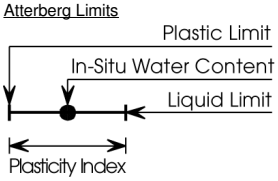
GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER
	Lean CLAY with Sand, stiff, brown to maroon, moist, high-plasticity	
		8.0
	Silty SAND, medium dense, gray, moist, possible weathered sandstone	
		15.3
	Weathered CLAYSTONE, very stiff to hard, maroon, moist to slightly moist	



LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-22

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

October 17, 2011 04-167-002

TD&H THOMAS, DEAN & HOSKINS, INC.
ENGINEERING CONSULTANTS
GREAT FALLS–BOZEMAN–KALISPELL–HELENA
SPOKANE LEWISTON
MONTANA WASHINGTON IDAHO

Figure No. 23

SURFACE: Native Grasses & Shrubs
SURFACE ELEVATION: 4,461.5 ft

GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER	SAMPLE DEPTH
	- Drilling very slow at rate less than 1 inch per minute		27, 30, 33, 36, 39, 42, 45, 48
		32.0	
	Weathered SANDSTONE, medium dense, light olive to gray, moist, noticable silt content - Water added to boring to help remove cuttings		
		38.0	
	CLAYSTONE, hard, maroon, slightly moist		

PENETRATION RESISTANCE/MOISTURE CONTENT

● = MOISTURE CONTENT
▲ = BLOWS PER FOOT

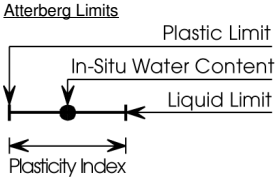
0 10 20 30 40 50

▲54 ▲58

LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-22

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

October 17, 2011 04-167-002

TD&H THOMAS, DEAN & HOSKINS, INC.
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SPOKANE LEWISTON
MONTANA WASHINGTON IDAHO

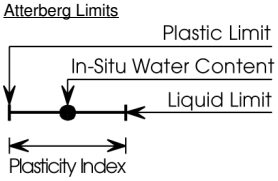
Figure No. 23
Sheet 2 of 3

GRAPHIC LOG	SURFACE: Native Grasses & Shrubs SURFACE ELEVATION: 4,461.5 ft SOIL DESCRIPTION	DEPTH GROUND WATER	SAMPLE	DEPTH	PENETRATION RESISTANCE/MOISTURE CONTENT ● = MOISTURE CONTENT ▲ = BLOWS PER FOOT 0 10 20 30 40 50
		50.9		51	50/0.4'
	Bottom of Boring	Ground water not encoun-tered		54	
				57	
				60	
				63	
				66	
				69	
				72	
				75	

LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-22

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

October 17, 2011 04-167-002

TD&H THOMAS, DEAN & HOSKINS, INC.
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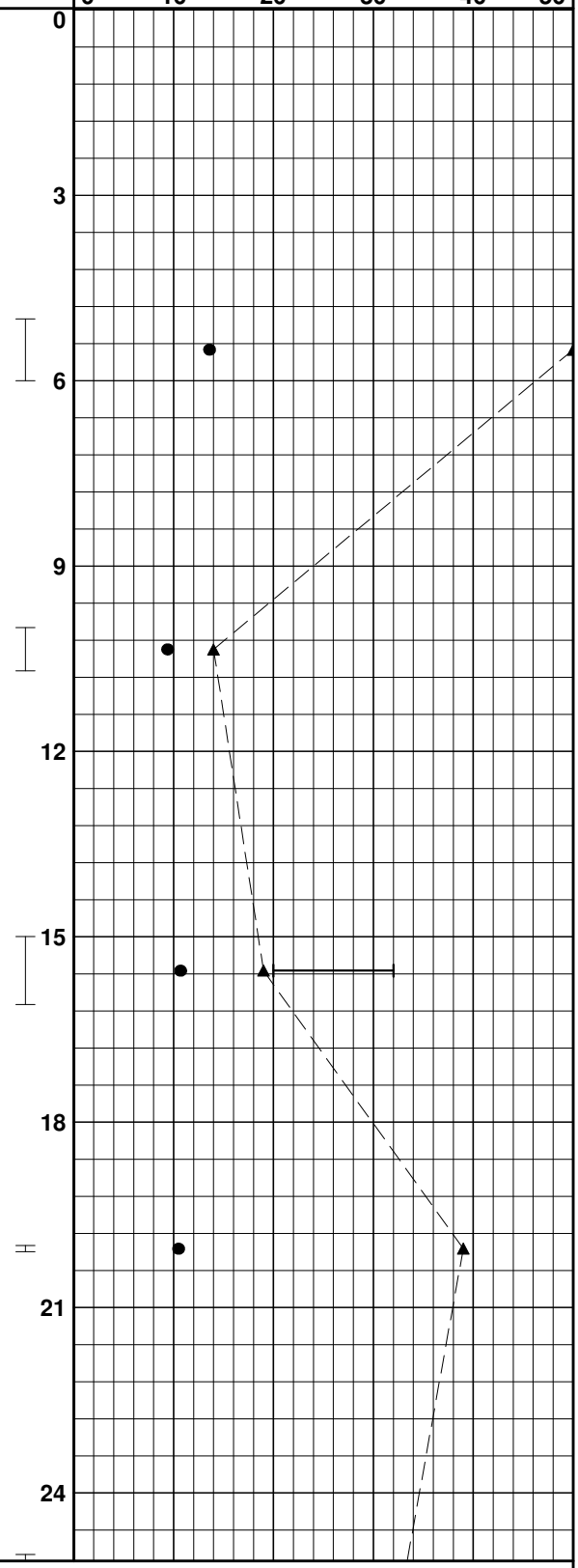
GREAT FALLS–BOZEMAN–KALISPELL–HELENA
SPOKANE LEWISTON
MONTANA WASHINGTON IDAHO

Figure No. 23

Sheet 3 of 3

SURFACE: Native Grasses & Shrubs
SURFACE ELEVATION: 4,466.1 ft

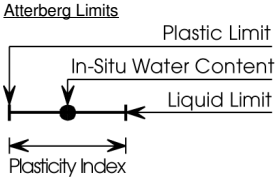
GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER
	Lean CLAY with Sand, relatively firm, brown, moist, occasional gravel, high- plasticity	
	- Hit rock with spoon	
		6.5
	Lean CLAY with Sand, medium dense, light brown, slightly moist, possible weathered CLAYSTONE - Color transitions to gray gradually	
	- Very slow drilling below 10.0 feet	
		18.0
	Weathered SANDSTONE, dense, gray, slightly moist, noticable silt content	
		23.0
	Weathered CLAYSTONE, hard, maroon, moist	



LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-23

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

October 17, 2011 04-167-002

TD&H THOMAS, DEAN & HOSKINS, INC.
ENGINEERING CONSULTANTS
GREAT FALLS–BOZEMAN–KALISPELL–HELENA
SPOKANE LEWISTON
MONTANA WASHINGTON IDAHO

Figure No. 24
Sheet 1 of 2

GRAPHIC LOG	SURFACE: Native Grasses & Shrubs SURFACE ELEVATION: 4,466.1 ft SOIL DESCRIPTION	DEPTH GROUND WATER	SAMPLE DEPTH
			27
			30
		31.3	
	Bottom of Boring - Practical Auger Refusal	Ground water not encoun-tered	33
			36
			39
			42
			45
			48

PENETRATION RESISTANCE/MOISTURE CONTENT

● = MOISTURE CONTENT

▲ = BLOWS PER FOOT

0 10 20 30 40 50

▲99/0.75'

LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits

Plastic Limit

In-Situ Water Content

Liquid Limit

Plasticity Index

GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-23

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

October 17, 2011 04-167-002

TD&H THOMAS, DEAN & HOSKINS, INC.
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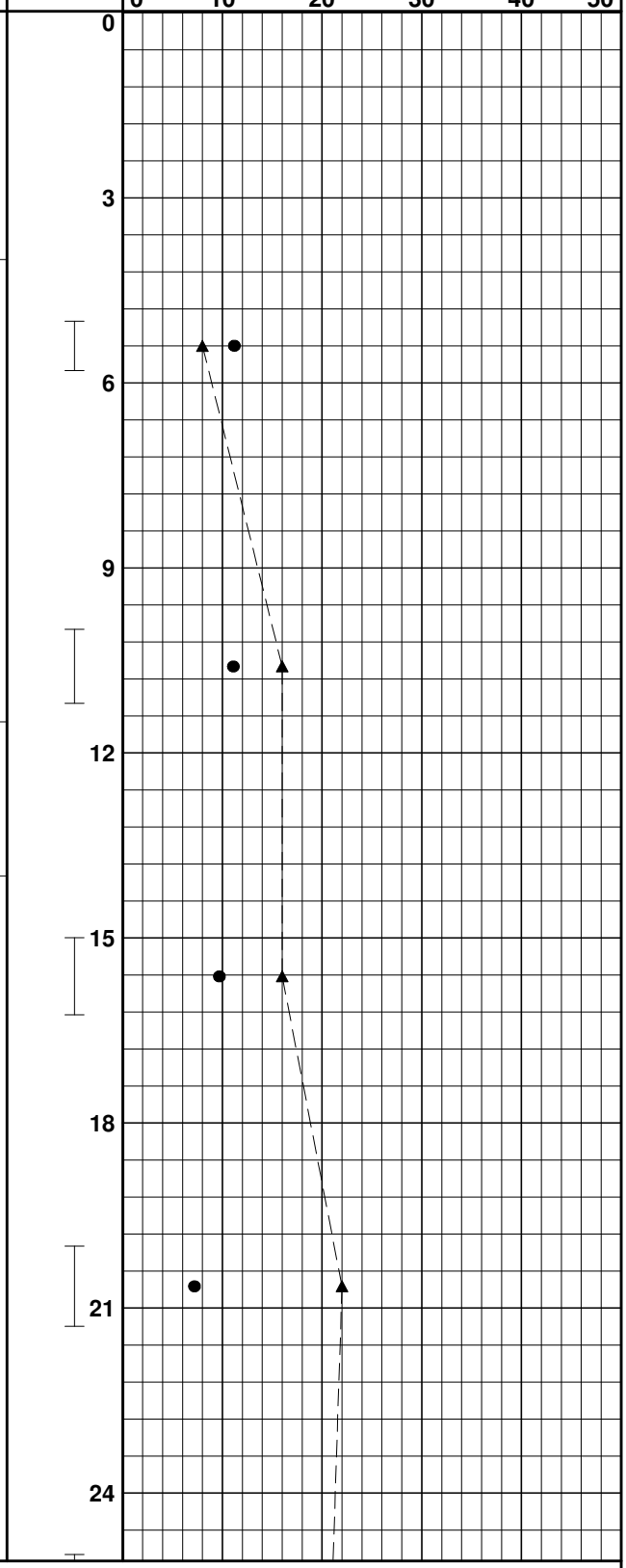
GREAT FALLS–BOZEMAN–KALISPELL–HELENA
SPOKANE LEWISTON
MONTANA WASHINGTON IDAHO

Figure No. 24

Sheet 2 of 2

SURFACE: Native Grasses & Shrubs
SURFACE ELEVATION: 4,443.6 ft

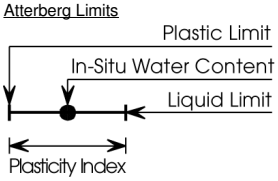
GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER
	Lean CLAY with Sand, appears firm, brown, moist	
		4.0
	Silty SAND, loose to medium dense, gray to tan, slightly moist, possible weathered sandstone	
		11.5
	Lean CLAY, very stiff, maroon, moist, possible weathered claystone	
		14.0
	Silty SAND, medium dense, gray, slightly moist, possible weathered sandstone - Occasional interbedded layers of maroon lean clay (Claystone)	



LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-24

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

October 18, 2011 04-167-002

TD&H THOMAS, DEAN & HOSKINS, INC.
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GREAT FALLS–BOZEMAN–KALISPELL–HELENA MONTANA
SPOKANE LEWISTON WASHINGTON IDAHO

Figure No. 25
Sheet 1 of 2

GRAPHIC LOG	SURFACE: Native Grasses & Shrubs SURFACE ELEVATION: 4,443.6 ft SOIL DESCRIPTION	DEPTH GROUND WATER
		28.0
	Weathered SANDSTONE, medium dense to dense, gray, slightly moist - Added water to help remove cuttings	
	Bottom of Boring	41.5 Ground water not encoun-tered

PENETRATION RESISTANCE/MOISTURE CONTENT

● = MOISTURE CONTENT

▲ = BLOWS PER FOOT

SAMPLE DEPTH: 27, 30, 33, 36, 39, 42, 45, 48

0 10 20 30 40 50

LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits

Plastic Limit

In-Situ Water Content

Liquid Limit

Plasticity Index

GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-24

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

October 18, 2011 04-167-002

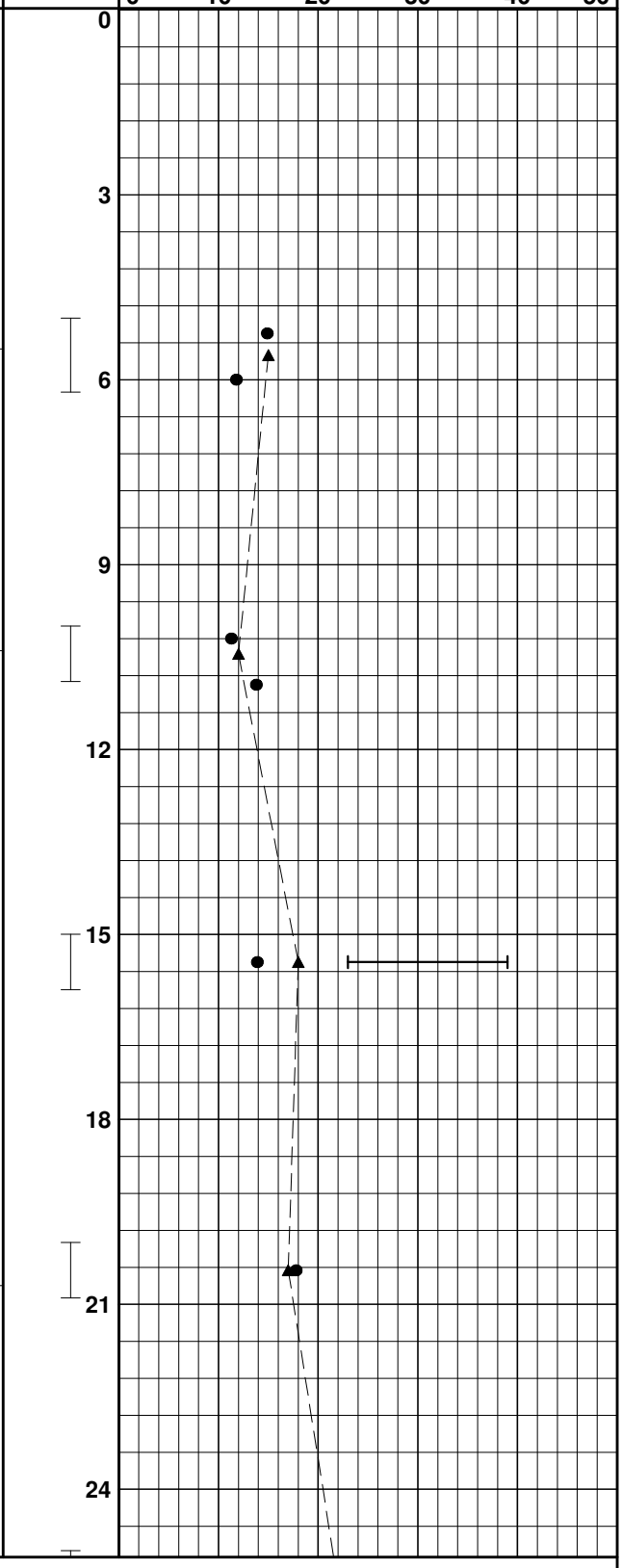
TD&H THOMAS, DEAN & HOSKINS, INC.
ENGINEERING CONSULTANTS
GREAT FALLS–BOZEMAN–KALISPELL–HELENA MONTANA
SPOKANE WASHINGTON
LEWISTON IDAHO

Figure No. 25

Sheet 2 of 2

SURFACE: Native Grasses & Shrubs
SURFACE ELEVATION: 4,444.4 ft

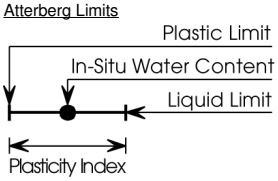
GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER
	Lean CLAY with Sand, relatively firm, brown, moist, high-plasticity	
	- Sandier zone from 2.0 to 4.0 feet	5.5
	Silty SAND, medium dense, tan, moist, possible weathered sandstone	10.4
	Lean CLAY, stiff to very stiff, maroon, moist, possible weathered claystone	20.7
	Weathered SANDSTONE, medium dense, gray, slightly moist	



LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-25

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

October 18, 2011 04-167-002

TD&H THOMAS, DEAN & HOSKINS, INC.
ENGINEERING CONSULTANTS
GREAT FALLS–BOZEMAN–KALISPELL–HELENA
SPOKANE LEWISTON
MONTANA WASHINGTON IDAHO

Figure No. 26
Sheet 1 of 2

GRAPHIC LOG	SURFACE: Native Grasses & Shrubs SURFACE ELEVATION: 4,444.4 ft SOIL DESCRIPTION	DEPTH GROUND WATER	SAMPLE DEPTH
			27
		28.0	
	Weathered CLAYSTONE, very stiff, maroon, moist		30
		31.5	
	Bottom of Boring	Ground water not encoun-tered	33
			36
			39
			42
			45
			48

PENETRATION RESISTANCE/MOISTURE CONTENT

● = MOISTURE CONTENT

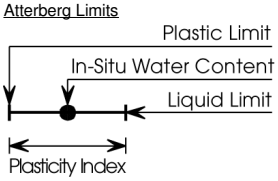
▲ = BLOWS PER FOOT

0 10 20 30 40 50

LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-25

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

October 18, 2011 04-167-002

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SPOKANE LEWISTON
MONTANA WASHINGTON IDAHO

Figure No. 26

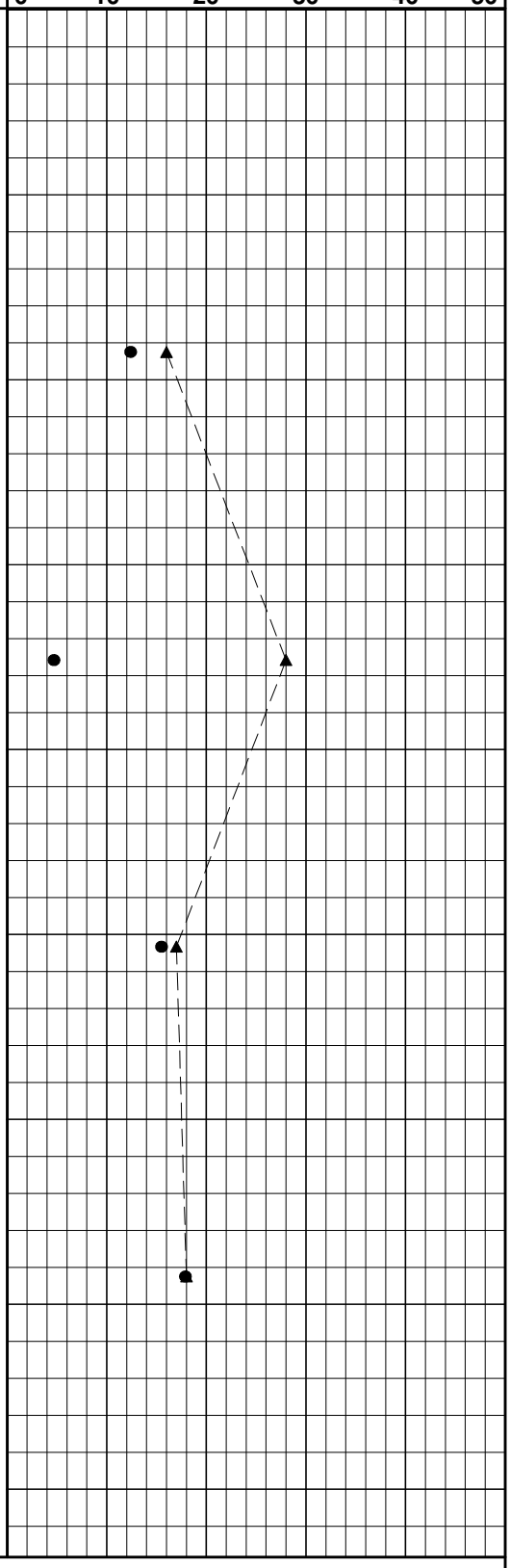
Sheet 2 of 2

SURFACE: Native Grasses & Shrubs
SURFACE ELEVATION: 4,425.9 ft

GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER
	Lean CLAY with Sand, firm to very stiff, brown, moist, high-plasticity, minor gravel	
	qu > 4.5 tsf	
		10.3
	Clayey GRAVEL with Sand, medium dense, dry to slightly moist, angular	
		12.0
	Lean CLAY with Sand, stiff, brown, moist, occasional gravel	
	- Pushed rock with spoon	
	qu = 3.0 - 3.5 tsf	
		21.5
	Bottom of Boring	Ground water not encoun-tered

SAMPLE DEPTH

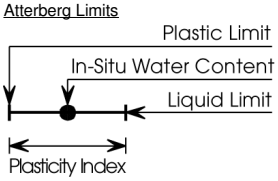
PENETRATION RESISTANCE/MOISTURE CONTENT
● = MOISTURE CONTENT
▲ = BLOWS PER FOOT



LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-26

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

October 18, 2011 04-167-002

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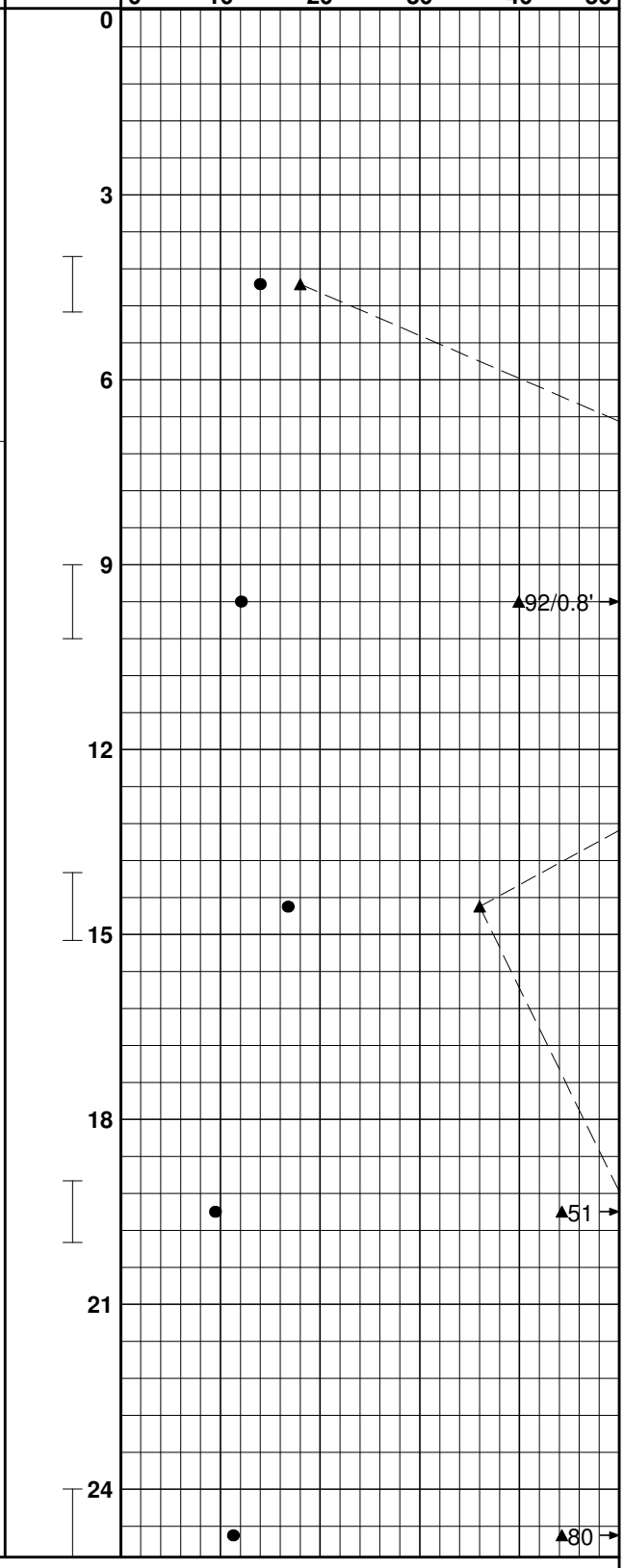
MONTANA WASHINGTON IDAHO

Figure No. 27
Sheet 1 of 1

SURFACE: Native Grasses & Shrubs
SURFACE ELEVATION: 4,261.5 ft

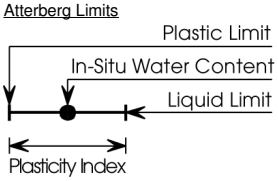
GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER
	Lean CLAY with Sand, appears firm near surface, brown, moist	
	- Changed to maroon in color and very stiff near 3.0 feet	
		7.0
	Weathered CLAYSTONE, hard, maroon and gray, slightly moist, sandy	



LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-27

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

October 18, 2011 04-167-002

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SPOKANE LEWISTON
MONTANA WASHINGTON IDAHO

Figure No. 28
Sheet 1 of 2

GRAPHIC LOG	SURFACE: Native Grasses & Shrubs SURFACE ELEVATION: 4,261.5 ft SOIL DESCRIPTION	DEPTH GROUND WATER	SAMPLE	DEPTH
		25.5		
	Bottom of Boring	Ground water not encoun-tered		

PENETRATION RESISTANCE/MOISTURE CONTENT

● = MOISTURE CONTENT

▲ = BLOWS PER FOOT

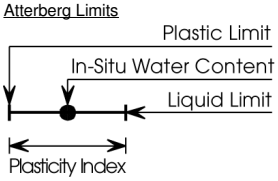
0 10 20 30 40 50

27 30 33 36 39 42 45 48

LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-27

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

October 18, 2011 04-167-002

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SPOKANE WASHINGTON
LEWISTON IDAHO

Figure No. 28

Sheet 2 of 2

SURFACE: Native Grasses & Shrubs
SURFACE ELEVATION: 4,237.7 ft

GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER	SAMPLE DEPTH
	Lean CLAY with Sand, stiff to very stiff, brown to maroon, moist, high-plasticity		0
			3
			6
			9
			12
	Weathered CLAYSTONE, hard, maroon, slightly moist	13.0	15
			18
			21
			24

PENETRATION RESISTANCE/MOISTURE CONTENT
● = MOISTURE CONTENT
▲ = BLOWS PER FOOT
0 10 20 30 40 50

LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits

Plastic Limit
In-Situ Water Content
Liquid Limit
Plasticity Index

GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-28

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

October 18, 2011 04-167-002

TD&H THOMAS, DEAN & HOSKINS, INC.
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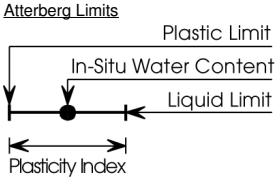
Figure No. 29
Sheet 1 of 2

GRAPHIC LOG	SURFACE: Native Grasses & Shrubs SURFACE ELEVATION: 4,237.7 ft SOIL DESCRIPTION	DEPTH GROUND WATER	SAMPLE DEPTH	PENETRATION RESISTANCE/MOISTURE CONTENT ● = MOISTURE CONTENT ▲ = BLOWS PER FOOT 0 10 20 30 40 50
	- 50 blows within first six inches of test	25.6		50/0.3'
	Bottom of Boring	Ground water not encoun-tered	27 30 33 36 39 42 45 48	

LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-28

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

October 18, 2011 04-167-002

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Figure No. 29

SURFACE: Native Grasses & Shrubs
SURFACE ELEVATION: 4,281.2 ft

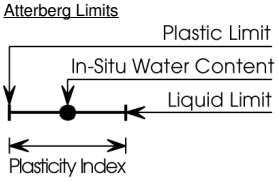
GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER	SAMPLE DEPTH
	Lean CLAY with Gravel, appears firm, brown, moist		0
		3.0	3
	Lean CLAY with Sand, firm to very stiff, brown, moist		6
			9
			12
	- Gradually increasing sand content near 15.8 feet		15
			18
	- Seam of clayey sand from 20.0 to 20.5 feet, wet		21
		23.0	
	Lean CLAY with Gravel, appears very stiff, brown, moist, fragmented sandstone particles		24

PENETRATION RESISTANCE/MOISTURE CONTENT
● = MOISTURE CONTENT
▲ = BLOWS PER FOOT
0 10 20 30 40 50

LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-29

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

Drilled by: HazTech Drilling
Truck-mounted CME 850 with 8-inch HSA

October 19, 2011 04-167-002

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Figure No. 30
Sheet 1 of 2

GRAPHIC LOG	SURFACE: Native Grasses & Shrubs SURFACE ELEVATION: 4,281.2 ft SOIL DESCRIPTION	DEPTH GROUND WATER	SAMPLE DEPTH
	- Pushing rock with spoon	26.5	
	Bottom of Boring		

PENETRATION RESISTANCE/MOISTURE CONTENT

● = MOISTURE CONTENT

▲ = BLOWS PER FOOT

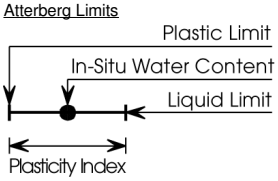
0 10 20 30 40 50

27 30 33 36 39 42 45 48

LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-29

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Craig R. Nadeau, P.E.

Drilled by: HazTech Drilling
Truck-mounted CME 850 with 8-inch HSA

October 19, 2011 04-167-002

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Figure No. 30

SURFACE: Native Grasses & Shrubs
SURFACE ELEVATION: 4,279.3 ft

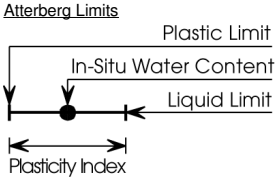
GRAPHIC LOG	SOIL DESCRIPTION	DEPTH GROUND WATER	SAMPLE DEPTH
	Lean CLAY with Sand, stiff to very stiff, light brown, slightly moist, trace amount of salts		0
			3
			6
			9
			12
		14.5 ▼	
	Sandy Lean CLAY, firm to stiff, light brown, wet		15
			18
			21
			24

PENETRATION RESISTANCE/MOISTURE CONTENT
● = MOISTURE CONTENT
▲ = BLOWS PER FOOT
0 10 20 30 40 50

LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- ▼ Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-30

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Bill Colenso, E.I.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

October 19, 2011 04-167-002

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ENGINEERING CONSULTANTS
GREAT FALLS–BOZEMAN–KALISPELL–HELENA
SPOKANE LEWISTON
MONTANA WASHINGTON IDAHO

Figure No. 31
Sheet 1 of 2

GRAPHIC LOG	SURFACE: Native Grasses & Shrubs SURFACE ELEVATION: 4,279.3 ft SOIL DESCRIPTION	DEPTH GROUND WATER	SAMPLE	DEPTH
		26.5		
	Bottom of Boring			

PENETRATION RESISTANCE/MOISTURE CONTENT

● = MOISTURE CONTENT

▲ = BLOWS PER FOOT

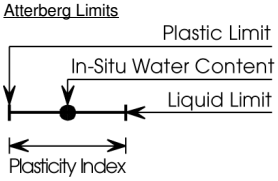
0 10 20 30 40 50

27 30 33 36 39 42 45 48

LEGEND

- ▲ SPT blows per foot
- ● Field Moisture content
- Groundwater Level
- Grab/composite sample
- 1-3/8-inch I.D. split spoon
- 2-1/2-inch I.D. split spoon
- 2-1/2-inch I.D. ring sampler
- 3-inch I.D. thin-walled sampler
- ✱ No sample recovery

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF SOIL BORING B-30

Proposed Drop Realignment
St. Mary River Siphon

Logged by: Bill Colenso, E.I.

Drilled by: HazTech Drilling
Track-mounted CME 850 with 8-inch HSA

October 19, 2011 04-167-002

TD&H THOMAS, DEAN & HOSKINS, INC.
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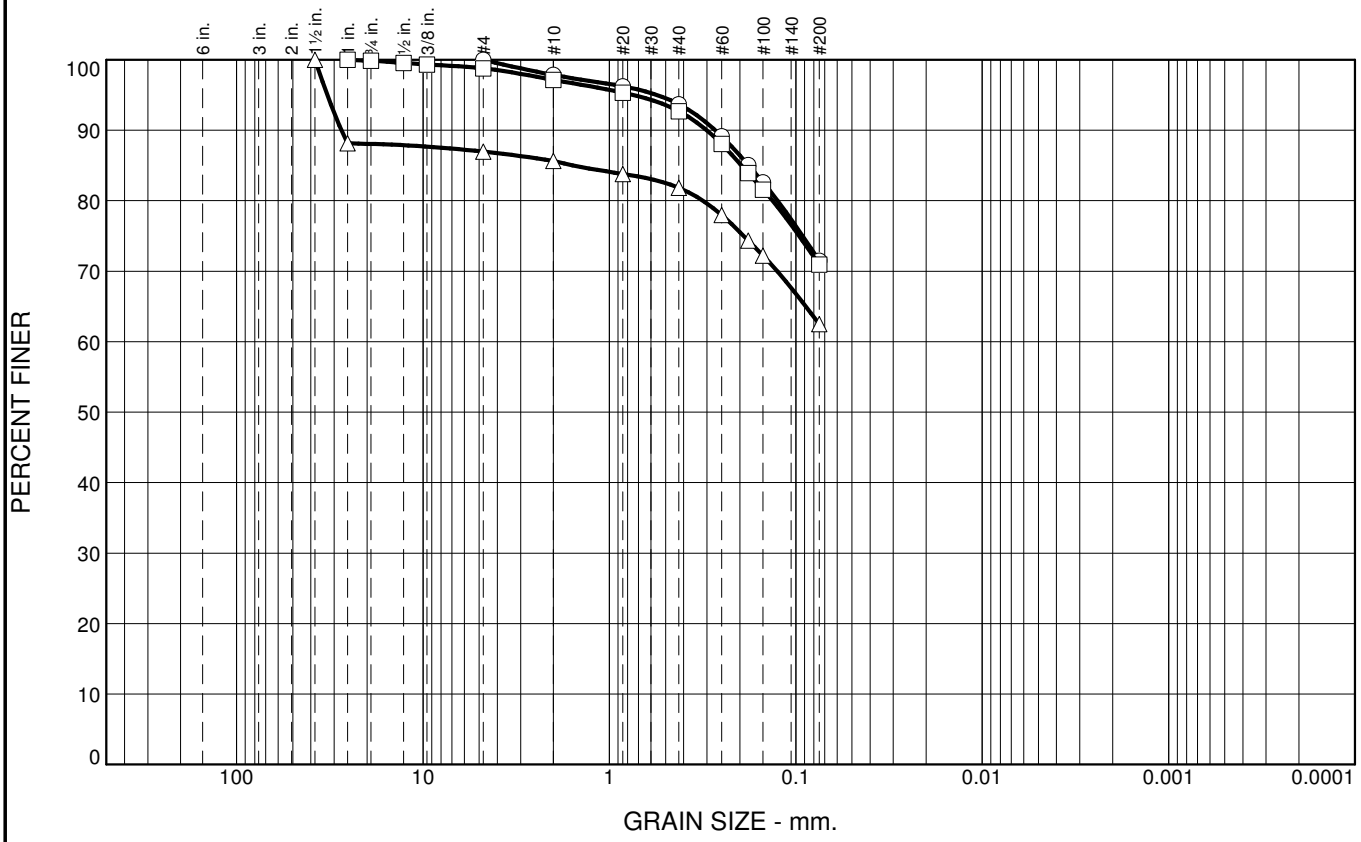
GREAT FALLS–BOZEMAN–KALISPELL–HELENA MONTANA
SPOKANE WASHINGTON
LEWISTON IDAHO

Figure No. 31

Sheet 2 of 2

Particle Size Distribution Report



	+3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PL	PI
○	0.0	0.0	28.5	71.5		CL	44	13	31
□	0.0	1.2	27.8	71.0		CL			
△	0.0	13.0	24.5	62.5		CL	42	14	28

SIEVE inches size	PERCENT FINER ○	□	△
1 1/2"			100.0
1"		100.0	88.1
3/4"		99.9	
1/2"		99.5	
3/8"		99.3	
GRAIN SIZE			
D_{60}			
D_{30}			
D_{10}			
COEFFICIENTS			
C_c			
C_u			

SIEVE number size	PERCENT FINER ○	□	△
#4	100.0	98.8	87.0
#10	97.8	97.2	85.7
#20	96.2	95.3	83.8
#40	93.7	92.7	81.8
#60	89.1	88.1	78.0
#80	85.1	83.9	74.4
#100	82.6	81.6	72.2
#200	71.5	71.0	62.5

Material Description

○ Lean CLAY with Sand

□ Lean CLAY with Sand

△ Sandy Lean CLAY

REMARKS:

○ Report No. A-4930-206

□ Report No. A-4939-206

△ Report No. A-4949-206

○ Location: B-1 Depth: 7.0 - 8.5 ft Sample Number: A-4930

□ Location: B-2 Depth: 7.5 - 12.5 ft Sample Number: A-4939

△ Location: B-3 Depth: 25.0 - 26.5 ft Sample Number: A-4949

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SPOKANE WASHINGTON
LEWISTON IDAHO

Client: DNRC - Water

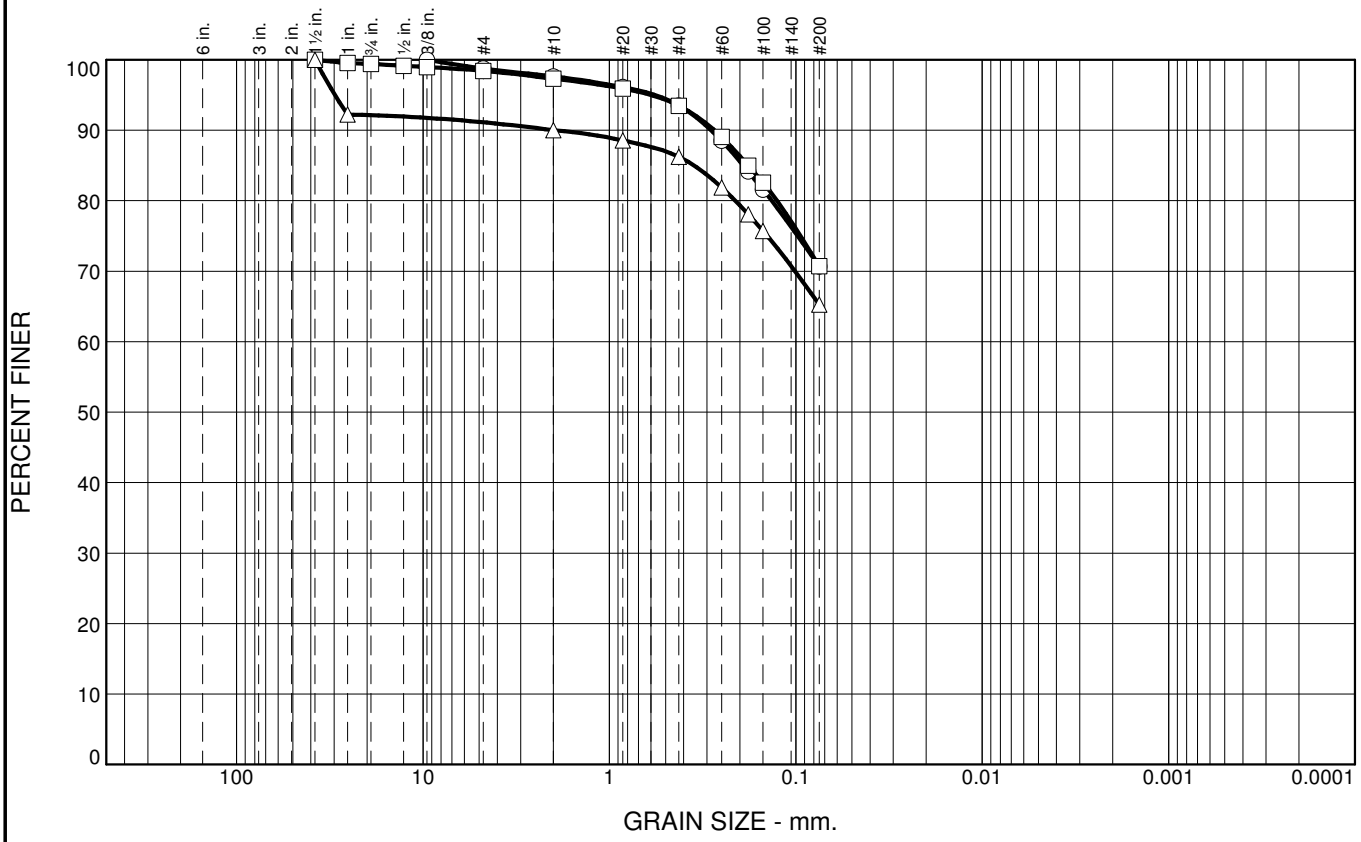
Project: Proposed Drop Realignment
St. Mary River Siphon

Project No.: 04-167-002

Figure 32

Tested By: MEJ **Checked By:** Craig R Madsen

Particle Size Distribution Report



	+3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PL	PI
○	0.0	1.2	28.1	70.7		CL	45	14	31
□	0.0	1.6	27.7	70.7		CL			
△	0.0	8.9	25.8	65.3		CL	43	13	30

SIEVE inches size	PERCENT FINER ○	□	△
1 1/2"		100.0	100.0
1"		99.6	92.2
3/4"		99.4	
1/2"		99.2	
3/8"	100.0	99.0	
GRAIN SIZE			
D_{60}			
D_{30}			
D_{10}			
COEFFICIENTS			
C_c			
C_u			

SIEVE number size	PERCENT FINER ○	□	△
#4	98.8	98.4	
#10	97.6	97.3	90.0
#20	96.1	95.9	88.5
#40	93.5	93.5	86.2
#60	88.5	89.1	81.9
#80	84.1	85.0	78.1
#100	81.6	82.6	75.7
#200	70.7	70.7	65.3

Material Description

○ Lean CLAY with Sand

□ Lean CLAY with Sand

△ Sandy Lean CLAY

REMARKS:

○ Report No. A-4953-206

□ Report No. A-4969-206
Bulk sample of cuttings obtained at ground surface

△ Report No. A-4968-206

○ Location: B-4 Depth: 2.5 - 4.0 ft Sample Number: A-4953

□ Location: B-6 Depth: 7.5 - 12.5 ft Sample Number: A-4969

△ Location: B-6 Depth: 11.4 - 12.9 ft Sample Number: A-4968

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SPOKANE WASHINGTON
LEWISTON IDAHO

Client: DNRC - Water

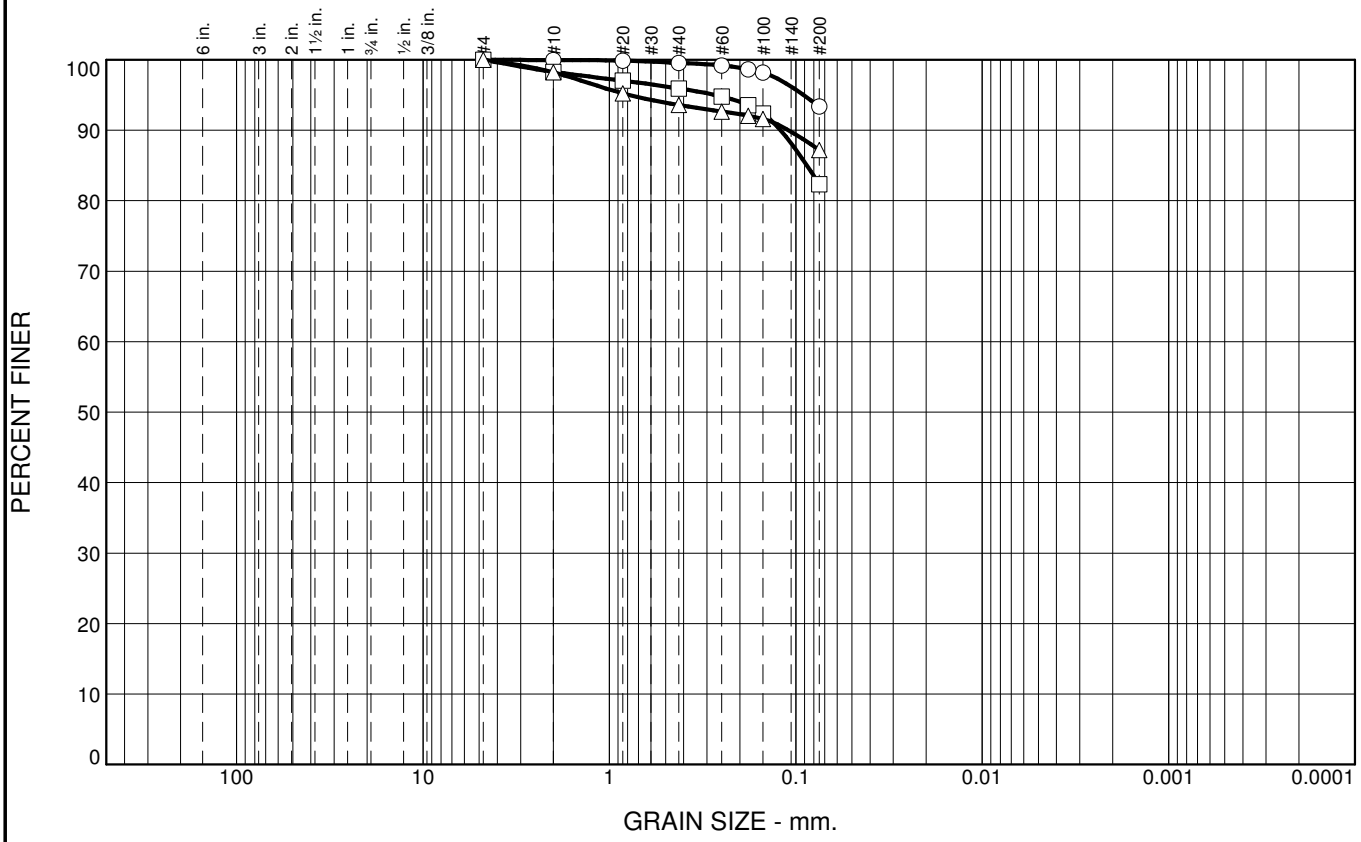
Project: Proposed Drop Realignment
St. Mary River Siphon

Project No.: 04-167-002

Figure 33

Tested By: MEJ **Checked By:** Craig R Madsen

Particle Size Distribution Report



	+3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PL	PI
○	0.0	0.0	6.6	93.4		CL	45	16	29
□	0.0	0.0	17.7	82.3		CL	42	16	26
△	0.0	0.0	12.8	87.2		CL	36	18	18

SIEVE inches size	PERCENT FINER ○	□	△
GRAIN SIZE			
D_{60}			
D_{30}			
D_{10}			
COEFFICIENTS			
C_c			
C_u			

SIEVE number size	PERCENT FINER ○	□	△
#4	100.0	100.0	100.0
#10	100.0	98.3	98.2
#20	99.9	97.0	95.2
#40	99.6	95.9	93.6
#60	99.2	94.8	92.7
#80	98.7	93.6	92.1
#100	98.2	92.4	91.6
#200	93.4	82.3	87.2

Material Description
○ Lean CLAY
□ Lean CLAY with Sand
△ Lean CLAY

REMARKS:
○ Report No. A-4978-206
□ Report No. A-4983-206
△ Report No. A-4991-206

○ Location: B-8 Depth: 5.0 - 6.3 ft Sample Number: A-4978
□ Location: B-9 Depth: 8.5 - 10.0 ft Sample Number: A-4983
△ Location: B-11 Depth: 7.5 - 9.0 ft Sample Number: A-4991

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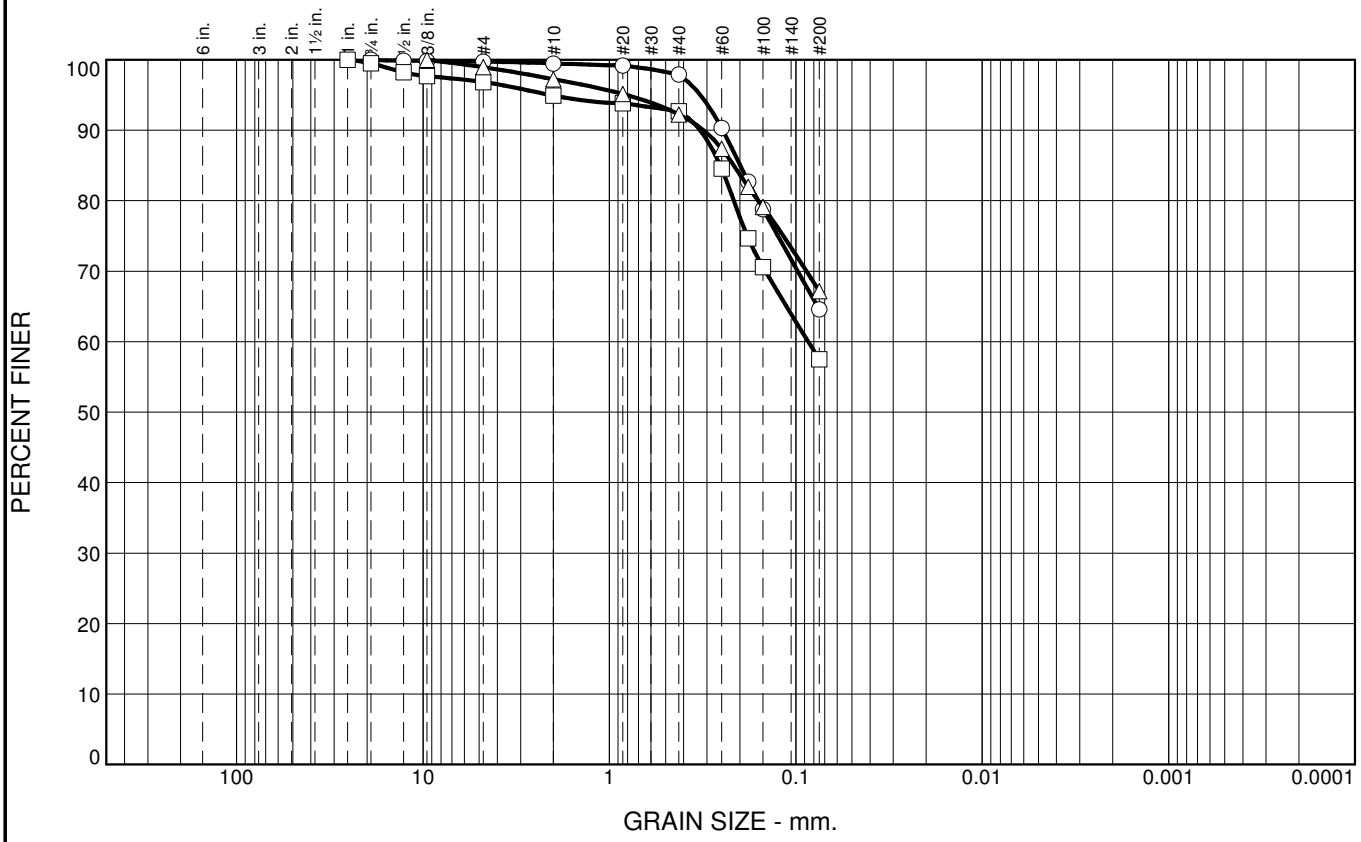
GREAT FALLS - BOZEMAN - KALISPELL MONTANA
SPOKANE WASHINGTON
LEWISTON IDAHO

Client: DNRC - Water
Project: Proposed Drop Realignment
St. Mary River Siphon
Project No.: 04-167-002
Figure 34

Tested By: ● MPJ ■ MEJ/SSS ▲ MEJ/SSS **Checked By:** Craig R Madsen

Particle Size Distribution Report



	+3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PL	PI
○	0.0	0.3	35.1	64.6		CL	34	13	21
□	0.0	3.2	39.3	57.5		CL	34	13	21
△	0.0	1.1	31.7	67.2		CL	36	17	19

SIEVE inches size	PERCENT FINER ○	□	△
1"		100.0	
3/4"	100.0	99.5	
1/2"	99.9	98.2	
3/8"	99.8	97.7	100.0
GRAIN SIZE			
D_{60}		0.0860	
D_{30}			
D_{10}			
COEFFICIENTS			
C_c			
C_u			

SIEVE number size	PERCENT FINER ○	□	△
#4	99.7	96.8	98.9
#10	99.5	94.9	97.2
#20	99.2	93.8	95.1
#40	97.9	92.7	92.2
#60	90.3	84.5	87.4
#80	82.7	74.7	82.0
#100	78.8	70.6	79.1
#200	64.6	57.5	67.2

Material Description
○ Sandy Lean CLAY
□ Sandy Lean CLAY
△ Sandy Lean CLAY

REMARKS:
○ Report No. A-5132-206
□ Report No. A-5150-206
△ Report No. A-5160-206

○ Location: B-12 Depth: 15.0 - 17.0 ft Sample Number: A-5132
□ Location: B-14 Depth: 17.0 - 20.0 ft Sample Number: A-5150
△ Location: B-16 Depth: 5.0 - 6.5 ft Sample Number: A-5160

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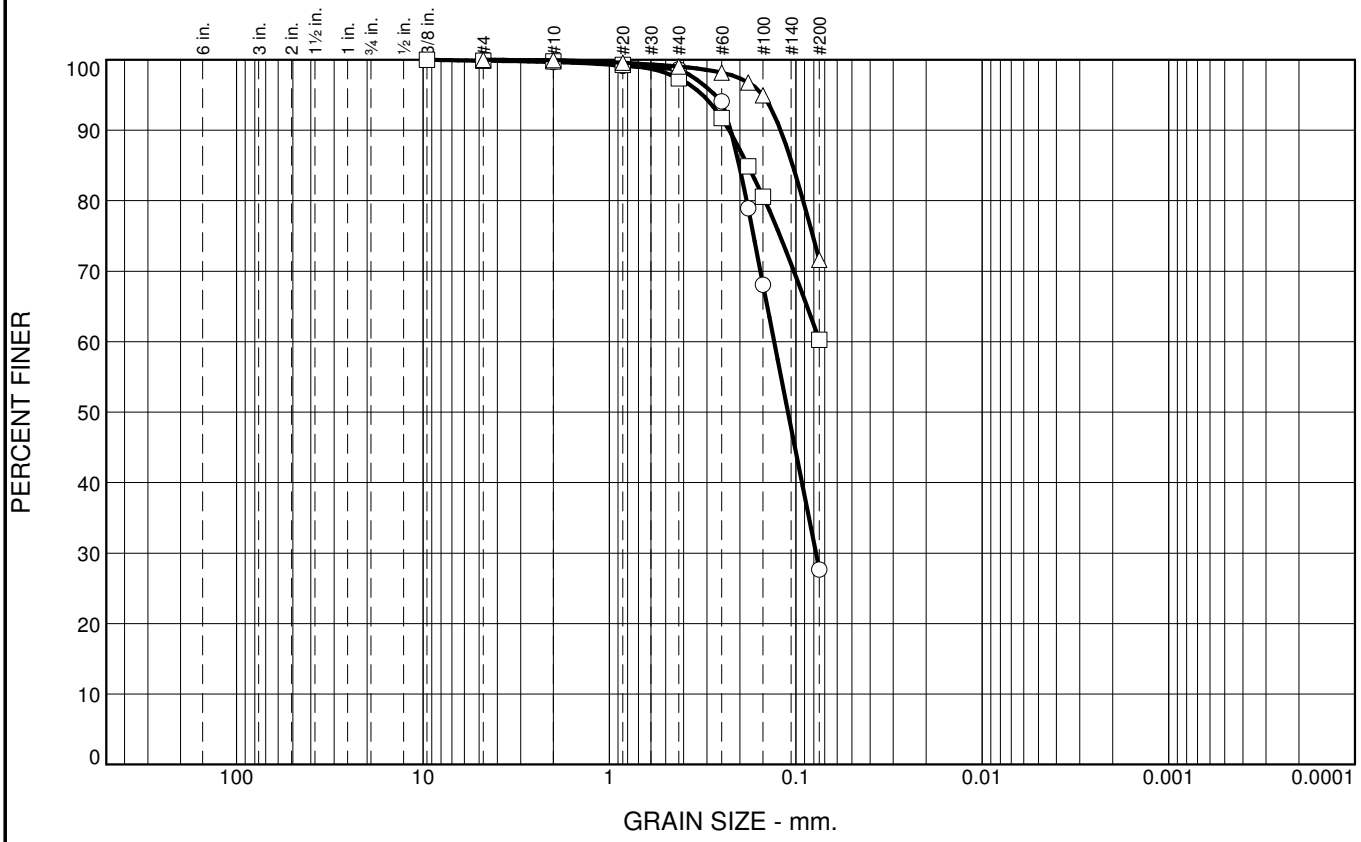
ENGINEERING CONSULTANTS
GREAT FALLS - BOZEMAN - KALISPELL MONTANA
SPOKANE WASHINGTON
LEWISTON IDAHO

Client: DNRC - Water
Project: Proposed Drop Realignment
St. Mary River Siphon
Project No.: 04-167-002
Figure 35

Tested By: ● MEJ ■ MEJ ▲ MPJ **Checked By:** Craig R Madsen

Particle Size Distribution Report



	+3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PL	PI
○	0.0	0.0	72.3	27.7		SM	30	26	4
□	0.0	0.1	39.6	60.3		CL	41	14	27
△	0.0	0.0	28.4	71.6		CL	32	20	12

SIEVE inches size	PERCENT FINER ○	□	△
3/8"		100.0	
GRAIN SIZE			
D_{60}	0.1310		
D_{30}	0.0781		
D_{10}			
COEFFICIENTS			
C_c			
C_u			

SIEVE number size	PERCENT FINER ○	□	△
#4	100.0	99.9	100.0
#10	99.7	99.8	99.9
#20	99.1	99.3	99.6
#40	98.7	97.4	99.0
#60	94.1	91.7	98.2
#80	78.9	84.9	96.8
#100	68.1	80.6	95.0
#200	27.7	60.3	71.6

Material Description
○ Silty SAND
□ Sandy Lean CLAY
△ Lean CLAY with Sand

REMARKS:
○ Report No. A-5171-206
□ Report No. A-5182-206
△ Report No. A-5197-206

○ Location: B-19 Depth: 5.0 - 6.5 ft Sample Number: A-5171
□ Location: B-21 Depth: 10.0 - 11.5 ft Sample Number: A-5182
△ Location: B-23 Depth: 15.0 - 16.5 ft Sample Number: A-5197

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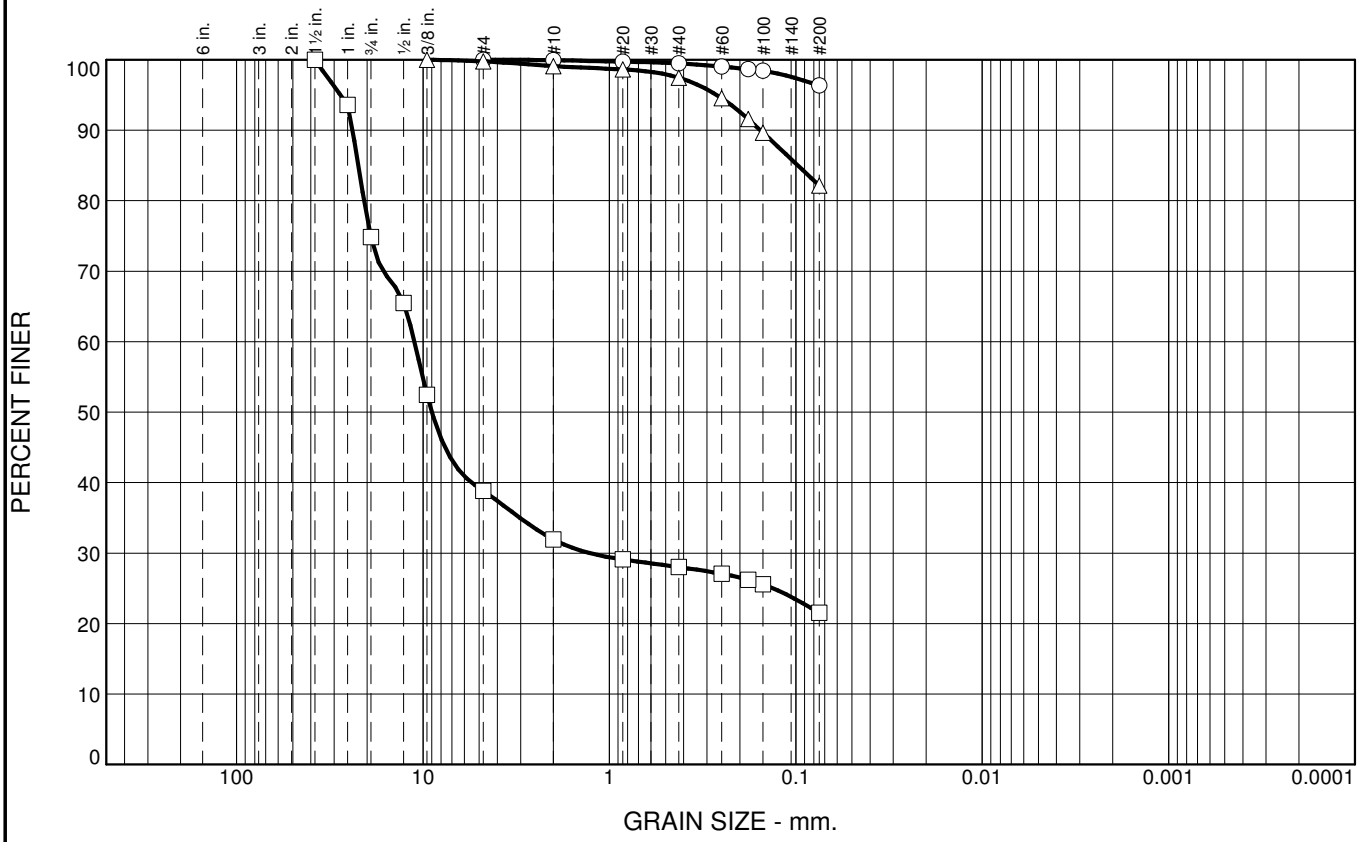
SPOKANE WASHINGTON
LEWISTON IDAHO

Client: DNRC - Water
Project: Proposed Drop Realignment
St. Mary River Siphon
Project No.: 04-167-002
Figure 36

Tested By: MPJ **Checked By:** Craig R Madsen

Particle Size Distribution Report



	+3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PL	PI
○	0.0	0.0	3.6	96.4		CL	39	23	16
□	0.0	61.2	17.3	21.5		GC			
△	0.0	0.2	17.7	82.1		CH	50	22	28

SIEVE inches size	PERCENT FINER ○	□	△
1 1/2"		100.0	
1"		93.6	
3/4"		74.9	
1/2"		65.5	
3/8"		52.5	100.0
	GRAIN SIZE		
D_{60}		11.1186	
D_{30}		1.2745	
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○	□	△
#4	100.0	38.8	99.8
#10	99.9	31.9	99.1
#20	99.7	29.1	98.6
#40	99.5	28.0	97.5
#60	99.0	27.1	94.6
#80	98.7	26.2	91.6
#100	98.4	25.6	89.6
#200	96.4	21.5	82.1

Material Description

○ Lean CLAY

□ Clayey GRAVEL with Sand

△ Fat CLAY with Sand

REMARKS:

○ Report No. A-5214-206

□ Report No. A-5219-206
Assumed Clayey Fines

△ Report No. A-5228-206

○ Location: B-25 Depth: 15.0 - 16.5 ft Sample Number: A-5214

□ Location: B-26 Depth: 10.0 - 11.5 ft Sample Number: A-5219

△ Location: B-28 Depth: 10.0 - 11.5 ft Sample Number: A-5228

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SPOKANE WASHINGTON
LEWISTON IDAHO

Client: DNRC - Water

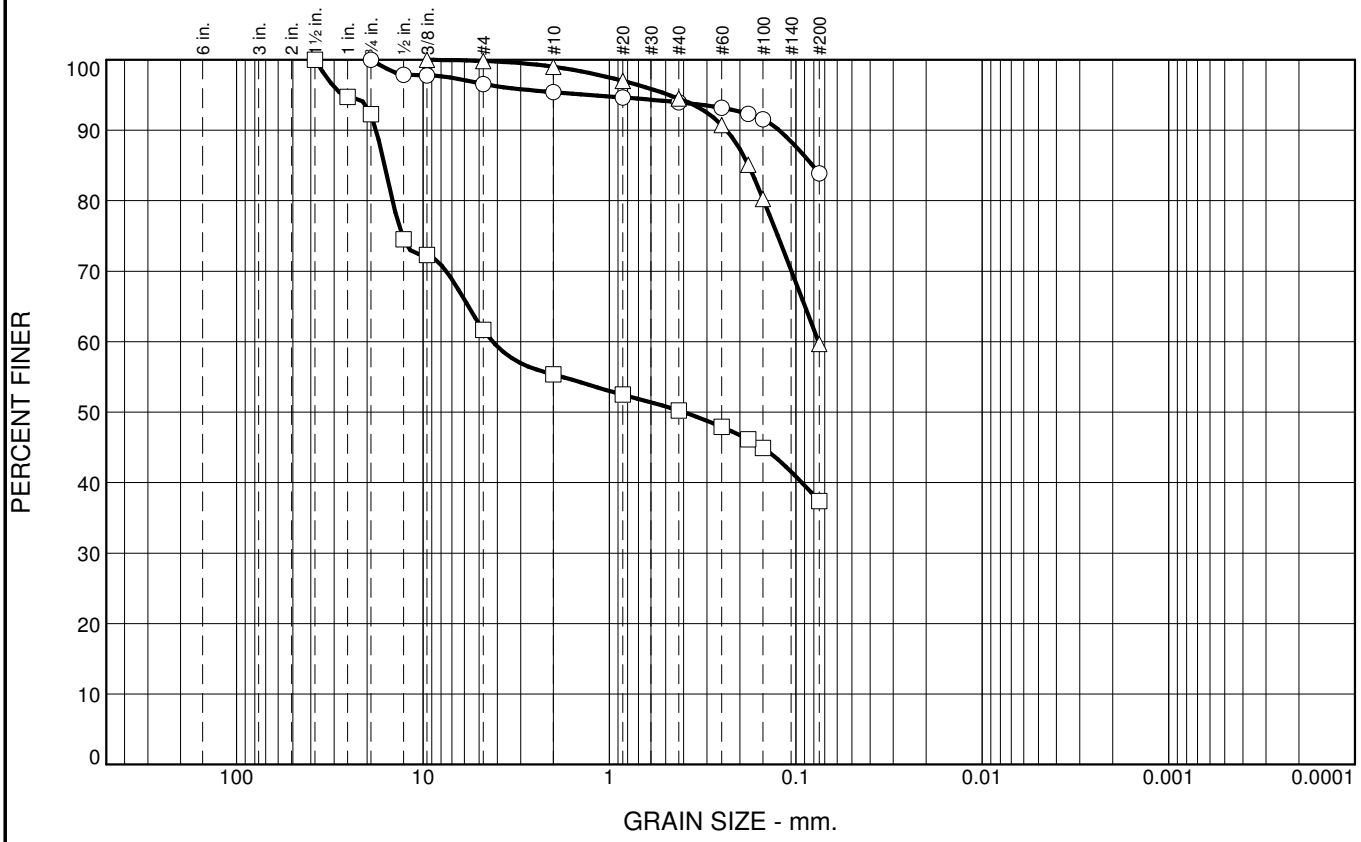
Project: Proposed Drop Realignment
St. Mary River Siphon

Project No.: 04-167-002

Figure 37

Tested By: MPJ **Checked By:** Craig R Madsen

Particle Size Distribution Report



	+3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PL	PI
○	0.0	3.4	12.7	83.9		CL	35	20	15
□	0.0	38.3	24.3	37.4		GC	29	18	11
△	0.0	0.2	40.1	59.7		CL	36	13	23

SIEVE inches size	PERCENT FINER ○	□	△
1 1/2"		100.0	
1"		94.7	
3/4"	100.0	92.3	
1/2"	97.9	74.5	
3/8"	97.8	72.3	100.0
	GRAIN SIZE		
D_{60}		4.2258	0.0758
D_{30}			
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○	□	△
#4	96.6	61.7	99.8
#10	95.4	55.4	99.0
#20	94.6	52.5	97.0
#40	94.0	50.2	94.5
#60	93.2	47.9	90.7
#80	92.3	46.2	85.1
#100	91.5	44.9	80.2
#200	83.9	37.4	59.7

Material Description

○ Lean CLAY with Sand

□ Clayey GRAVEL with Sand

△ Sandy Lean CLAY

REMARKS:

○ Report No. A-5233-206

□ Report No. A-5236-206

△ Report No. A-5241-206

○ Location: B-29 Depth: 10.0 - 11.5 ft Sample Number: A-5233

□ Location: B-29 Depth: 25.0 - 26.5 ft Sample Number: A-5236

△ Location: B-30 Depth: 20.0 - 21.5 ft Sample Number: A-5241

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GREAT FALLS - BOZEMAN - KALISPELL MONTANA
SPOKANE WASHINGTON
LEWISTON IDAHO

Client: DNRC - Water

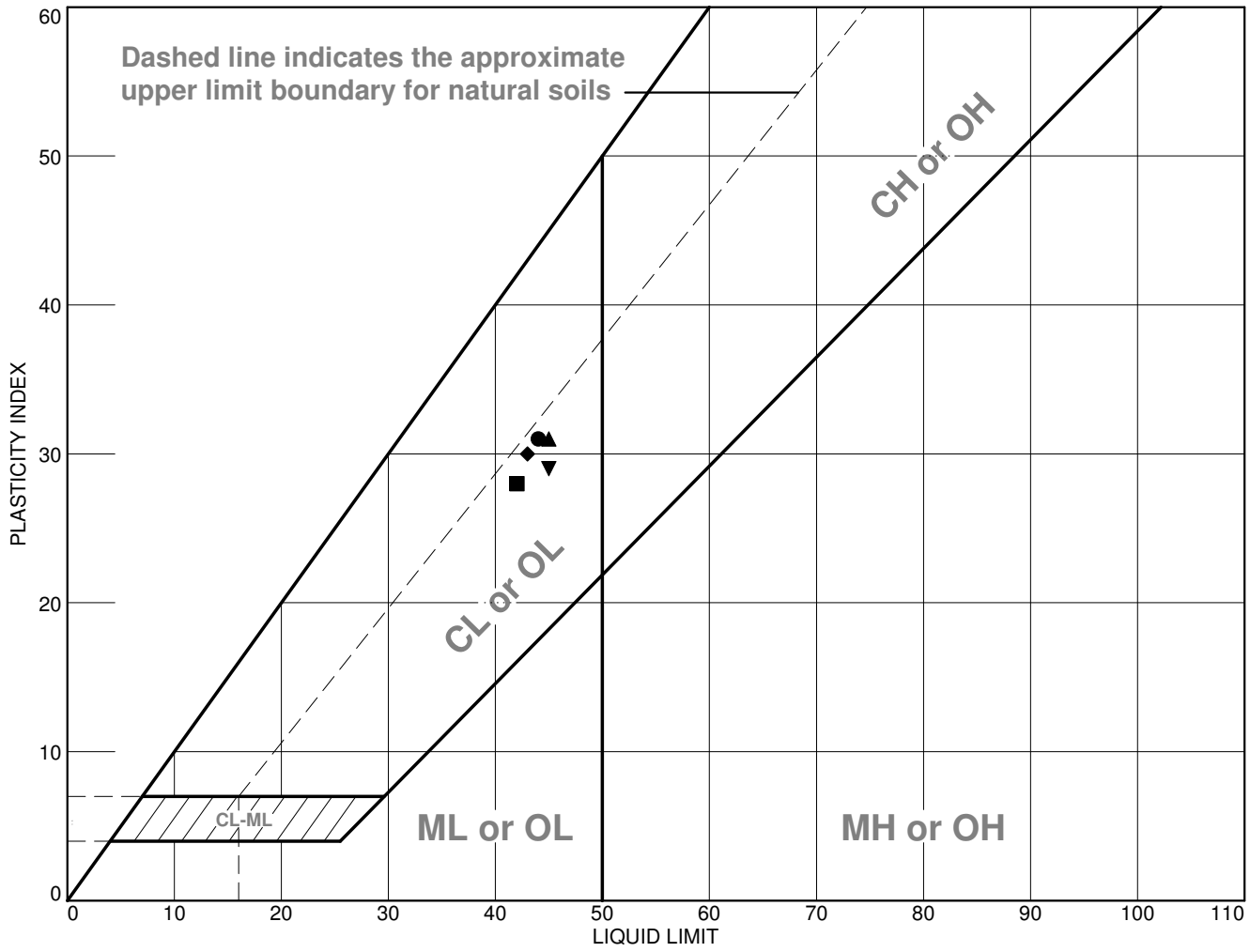
Project: Proposed Drop Realignment
St. Mary River Siphon

Project No.: 04-167-002

Figure 38

Tested By: MPJ **Checked By:** Craig R Madsen

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Lean CLAY with Sand	44	13	31	93.7	71.5	CL
■	Sandy Lean CLAY	42	14	28	81.8	62.5	CL
▲	Lean CLAY with Sand	45	14	31	93.5	70.7	CL
◆	Sandy Lean CLAY	43	13	30	86.2	65.3	CL
▼	Lean CLAY	45	16	29	99.6	93.4	CL

Project No. 04-167-002 **Client:** DNRC - Water

Project: Proposed Drop Realignment

St. Mary River Siphon

● **Location:** B-1 **Depth:** 7.0 - 8.5 ft **Sample Number:** A-4930

■ **Location:** B-3 **Depth:** 25.0 - 26.5 ft **Sample Number:** A-4949

▲ **Location:** B-4 **Depth:** 2.5 - 4.0 ft **Sample Number:** A-4953

◆ **Location:** B-6 **Depth:** 11.4 - 12.9 ft **Sample Number:** A-4968

▼ **Location:** B-8 **Depth:** 5.0 - 6.3 ft **Sample Number:** A-4978

Remarks:

● Report No. A-4930-207
■ Report No. A-4949-207
▲ Report No. A-4953-207
◆ Report No. A-4968-207
▼ Report No. A-4978-207

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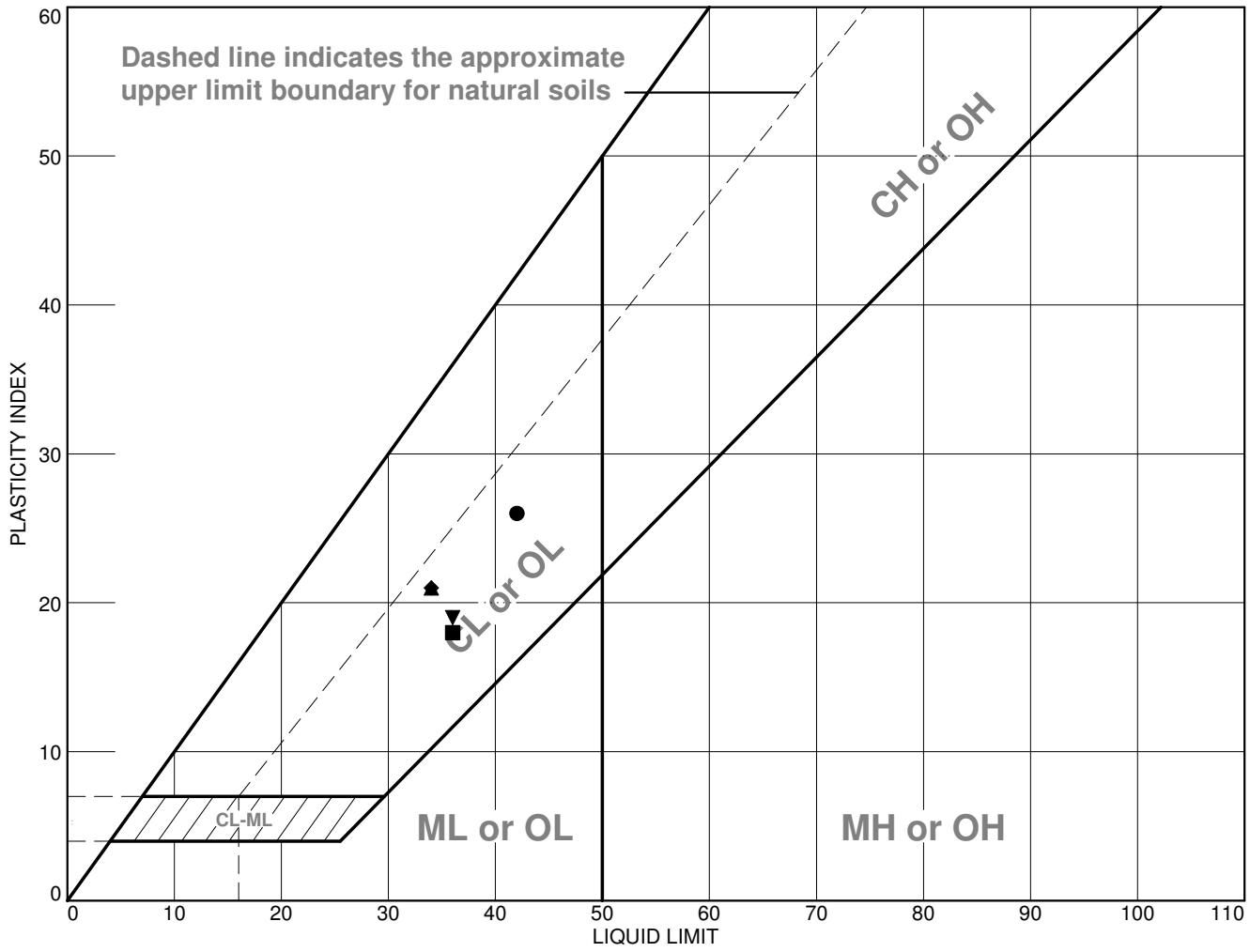
GREAT FALLS - BOZEMAN - KALISPELL
SPOKANE
LEWISTON
MONTANA
WASHINGTON
IDAHO

Figure 39

Tested By: TJR **Checked By:** Craig R Nadeau

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Lean CLAY with Sand	42	16	26	95.9	82.3	CL
■	Lean CLAY	36	18	18	93.6	87.2	CL
▲	Sandy Lean CLAY	34	13	21	97.9	64.6	CL
◆	Sandy Lean CLAY	34	13	21	92.7	57.5	CL
▼	Sandy Lean CLAY	36	17	19	92.2	67.2	CL

Project No. 04-167-002 **Client:** DNRC - Water

Project: Proposed Drop Realignment

St. Mary River Siphon

● **Location:** B-9 **Depth:** 8.5 - 10.0 ft **Sample Number:** A-4983

■ **Location:** B-11 **Depth:** 7.5 - 9.0 ft **Sample Number:** A-4991

▲ **Location:** B-12 **Depth:** 15.0 - 17.0 ft **Sample Number:** A-5132

◆ **Location:** B-14 **Depth:** 17.0 - 20.0 ft **Sample Number:** A-5150

▼ **Location:** B-16 **Depth:** 5.0 - 6.5 ft **Sample Number:** A-5160

Remarks:

● Report No. A-4983-207
■ Report No. A-4991-207
▲ Report No. A-5132-207
◆ Report No. A-5150-207
▼ Report No. A-5160-207

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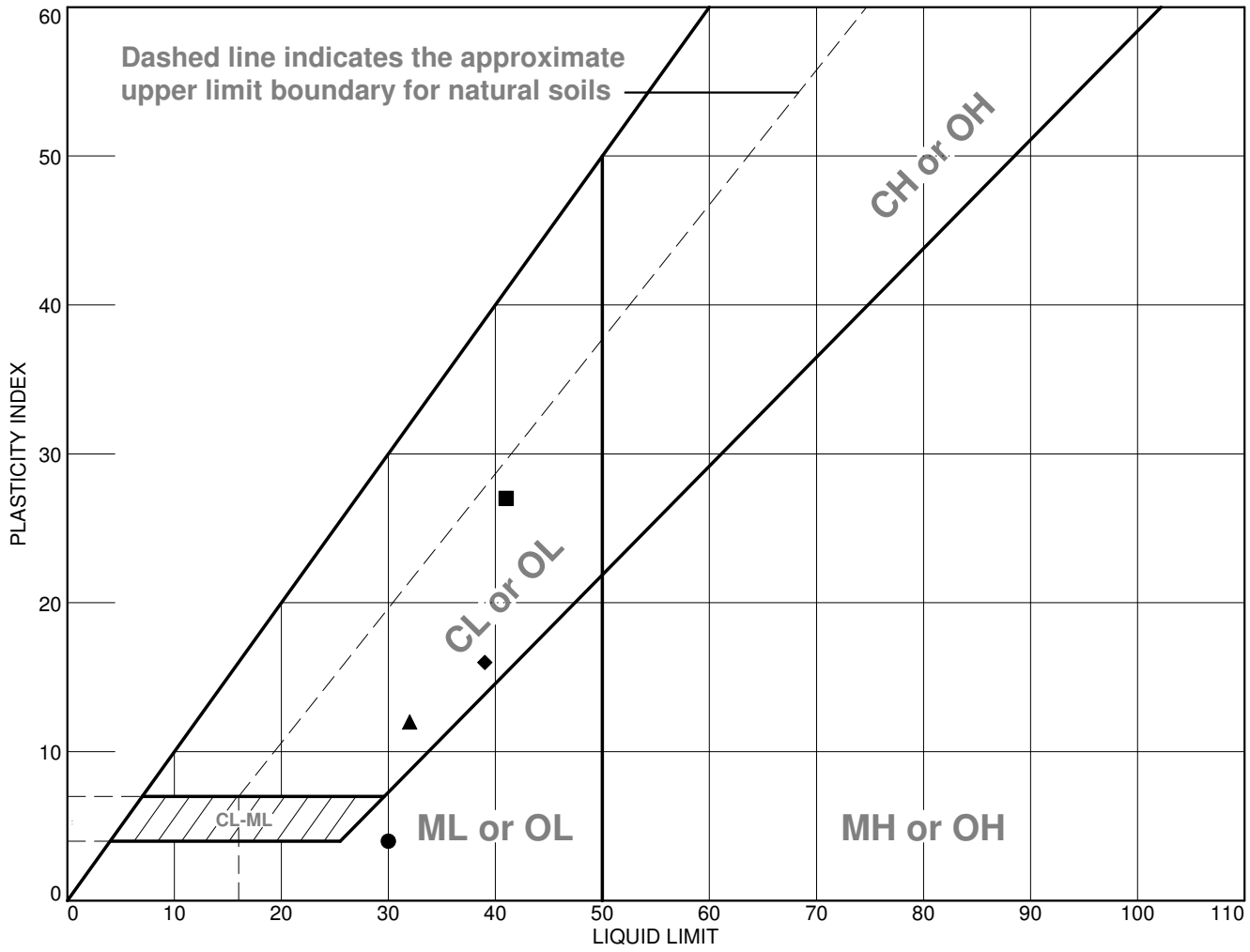
SPOKANE WASHINGTON
LEWISTON IDAHO

Figure 40

Tested By: ● TJR ■ TJR ▲ TJR ◆ MEJ ▼ MWC **Checked By:** Craig R Madsen

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Silty SAND	30	26	4	98.7	27.7	SM
■	Sandy Lean CLAY	41	14	27	97.4	60.3	CL
▲	Lean CLAY with Sand	32	20	12	99.0	71.6	CL
◆	Lean CLAY	39	23	16	99.5	96.4	CL

Project No. 04-167-002 **Client:** DNRC - Water

Project: Proposed Drop Realignment

St. Mary River Siphon

● **Location:** B-19 **Depth:** 5.0 - 6.5 ft **Sample Number:** A-5171

■ **Location:** B-21 **Depth:** 10.0 - 11.5 ft **Sample Number:** A-5182

▲ **Location:** B-23 **Depth:** 15.0 - 16.5 ft **Sample Number:** A-5197

◆ **Location:** B-25 **Depth:** 15.0 - 16.5 ft **Sample Number:** A-5214

Remarks:

● Report No. A-5171-207

■ Report No. A-5182-207

▲ Report No. A-5197-207

◆ Report No. A-5214-207

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ENGINEERING CONSULTANTS

GREAT FALLS - BOZEMAN - KALISPELL MONTANA

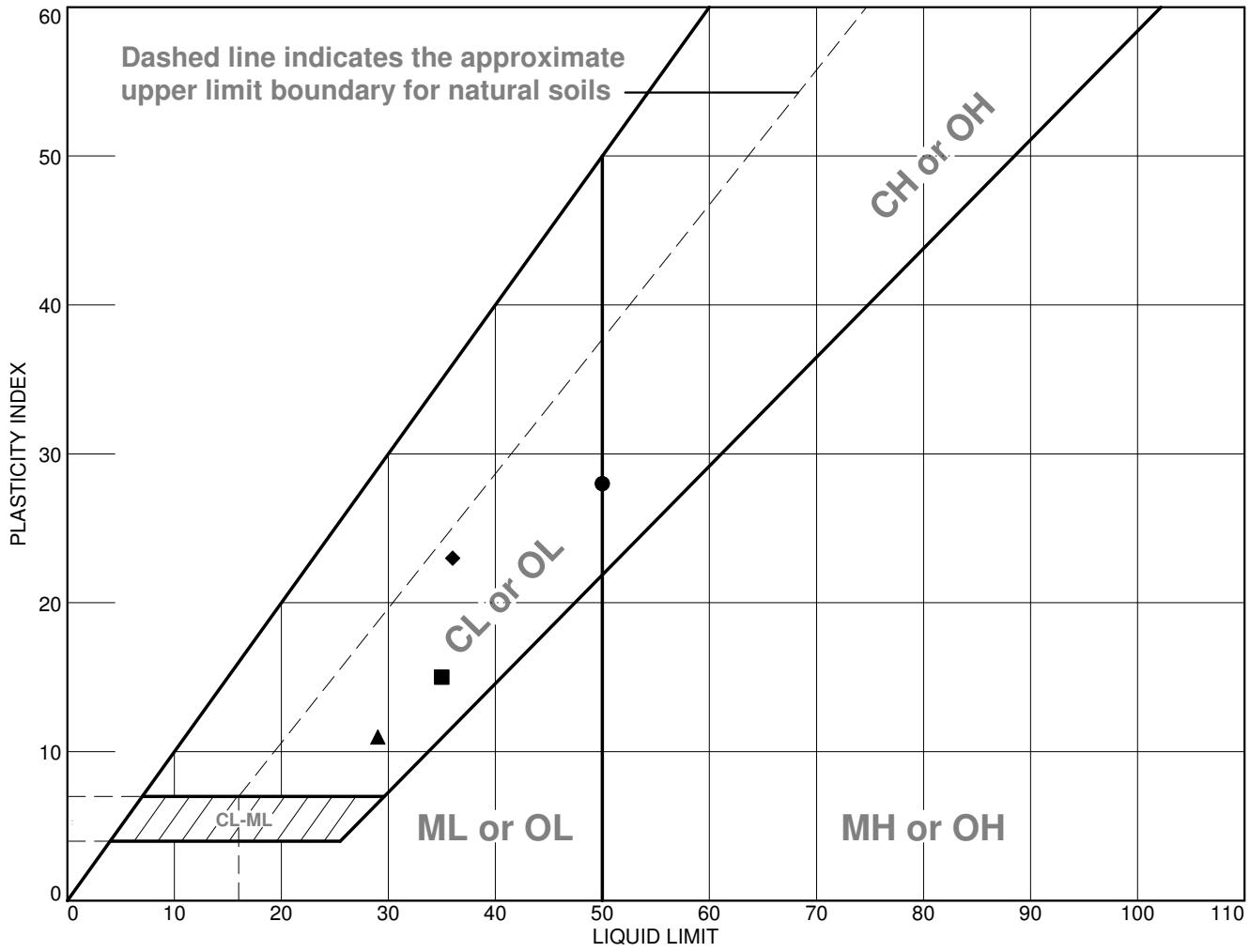
SPOKANE WASHINGTON

LEWISTON IDAHO

Figure 41

Tested By: ● MWC ■ TJR ▲ MWC ◆ MWC **Checked By:** Craig R Madsen

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY with Sand	50	22	28	97.5	82.1	CH
■	Lean CLAY with Sand	35	20	15	94.0	83.9	CL
▲	Clayey GRAVEL with Sand	29	18	11	50.2	37.4	GC
◆	Sandy Lean CLAY	36	13	23	94.5	59.7	CL

Project No. 04-167-002 **Client:** DNRC - Water

Project: Proposed Drop Realignment

St. Mary River Siphon

● **Location:** B-28 **Depth:** 10.0 - 11.5 ft **Sample Number:** A-5228

■ **Location:** B-29 **Depth:** 10.0 - 11.5 ft **Sample Number:** A-5233

▲ **Location:** B-29 **Depth:** 25.0 - 26.5 ft **Sample Number:** A-5236

◆ **Location:** B-30 **Depth:** 20.0 - 21.5 ft **Sample Number:** A-5241

Remarks:

● Report No. A-5228-207

■ Report No. A-5233-207

▲ Report No. A-5236-207

◆ Report No. A-5241-207

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GREAT FALLS - BOZEMAN - KALISPELL MONTANA

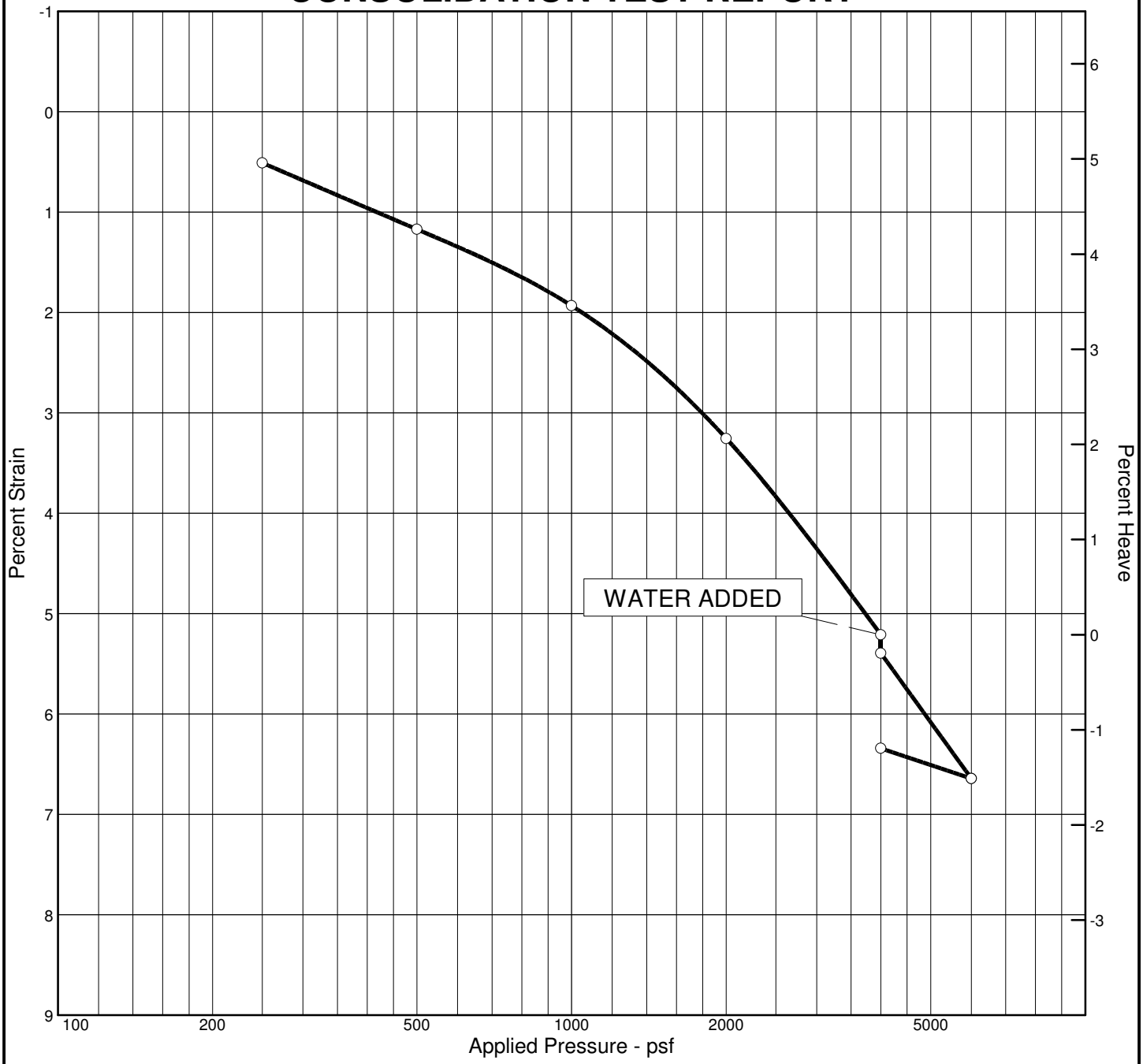
SPOKANE WASHINGTON

LEWISTON IDAHO

Figure 42

Tested By: ○ MWC □ MWC △ MWC ◇ TJR **Checked By:** Craig R Madsen

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_s	Swell Press. (psf)	Heave %	e_o
Sat.	Moist.											
117.0 %	33.4 %	94.2	45	29	2.65	650	1403	0.12	0.03		-0.2	0.755

MATERIAL DESCRIPTION	USCS	AASHTO
Lean CLAY	CL	A-7-6(28

Project No. 04-167-002 **Client:** DNRC - Water

Project: Proposed Drop Realignment
St. Mary River Siphon

Location: B-8 (5.2 - 5.4 ft)

Craig R Radtke

Remarks:
Report No. A-4978-217

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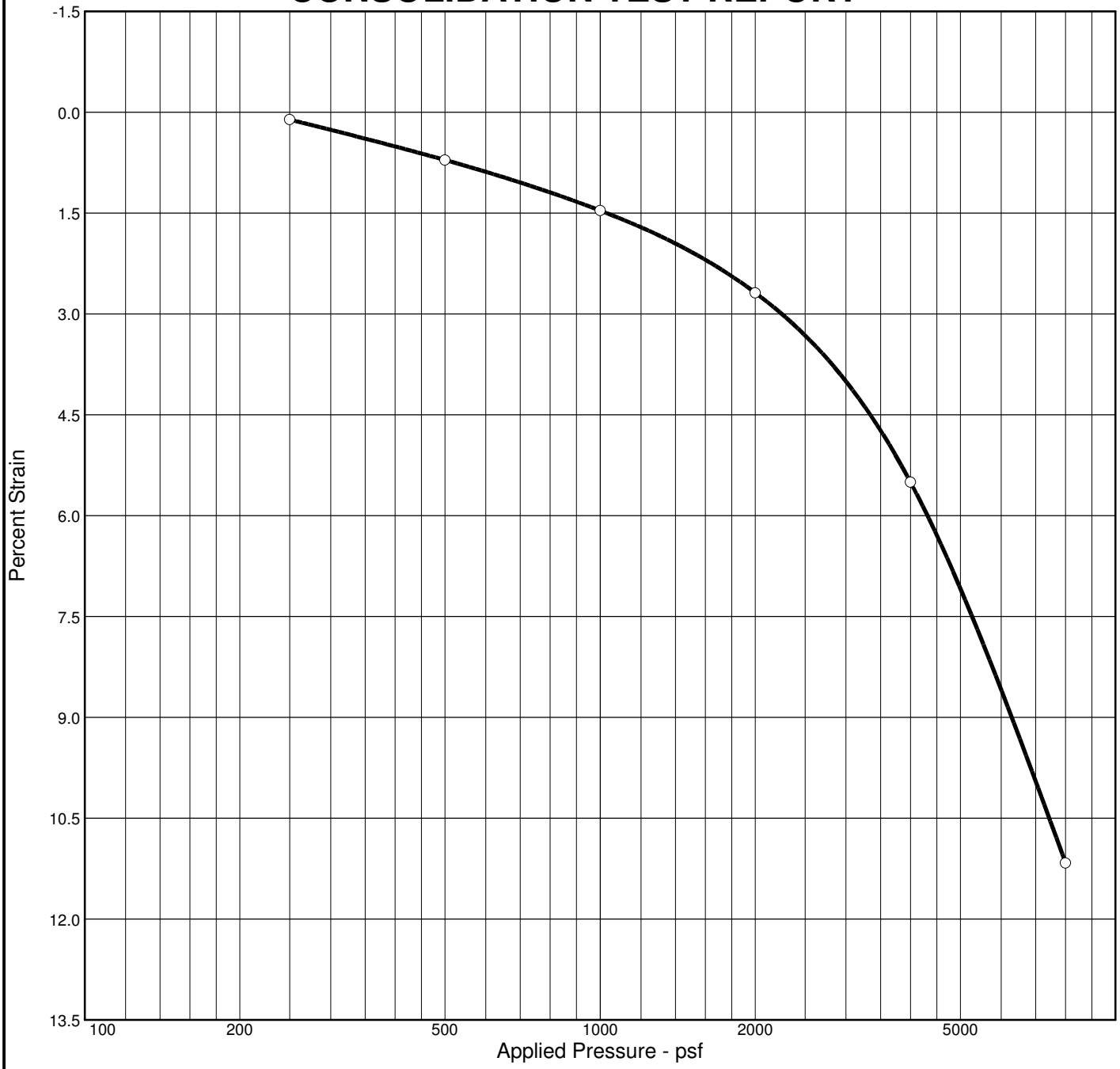
GREAT FALLS - BOZEMAN - KALISPELL MONTANA
SPOKANE WASHINGTON
LEWISTON IDAHO

Figure 43

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_r	Swell Press. (psf)	Heave %	e_o
Sat.	Moist.											
99.7 %	36.0 %	84.6			2.65	1850	3511	0.38				0.956

MATERIAL DESCRIPTION	USCS	AASHTO
Sandy Lean CLAY (Visual)	CL	

Project No. 04-167-002 **Client:** DNRC - Water

Project: Proposed Drop Realignment
St. Mary River Siphon

Location: B-21

Craig R Nadeau

Remarks:
Report No. A-5183-217

TD&H

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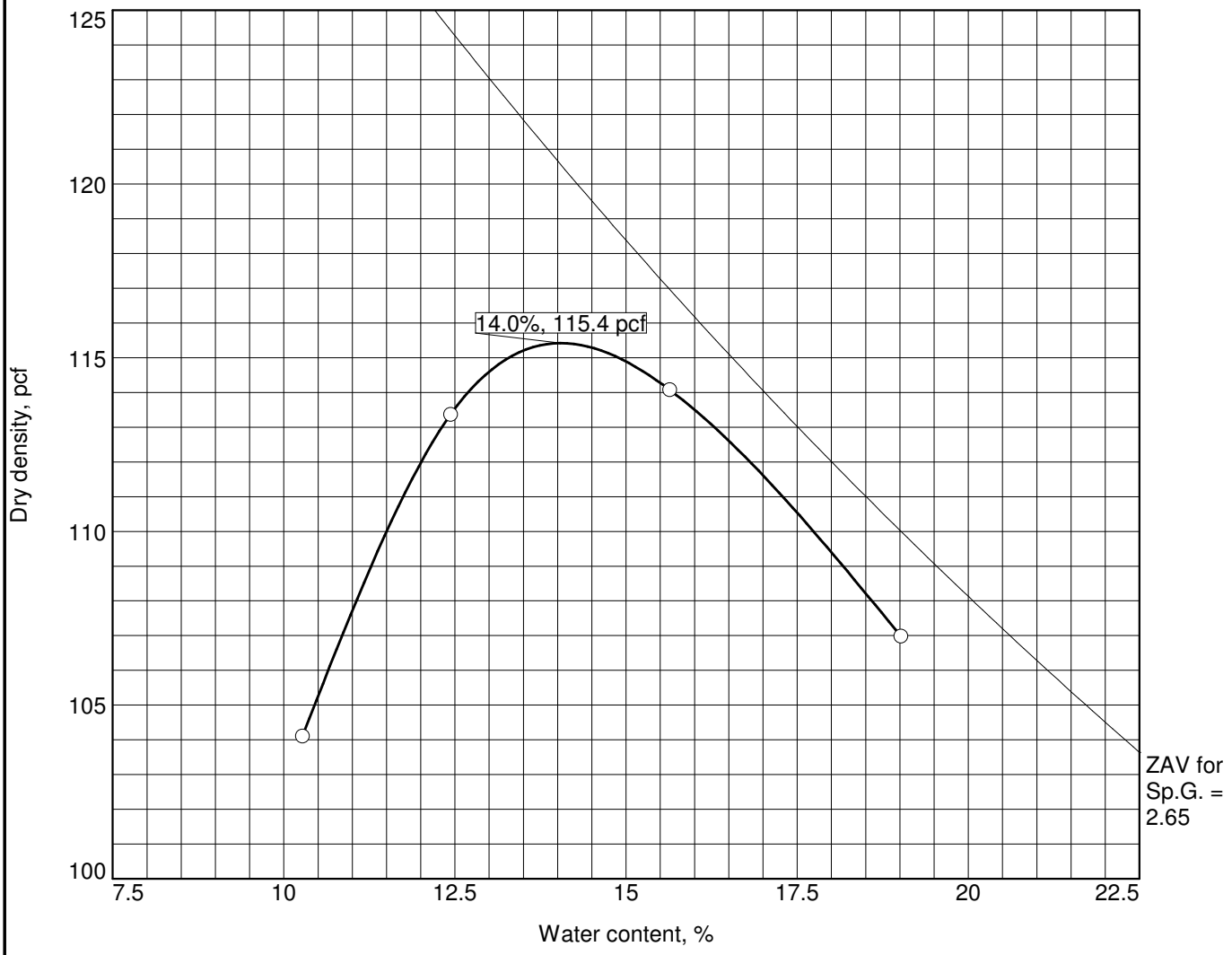
GREAT FALLS - BOZEMAN - KALISPELL MONTANA
SPOKANE WASHINGTON
LEWISTON IDAHO

Figure 44

Moisture-Density Test Report



Test specification: ASTM D 698-07 Method A

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
7.5 - 12.5 ft	CL			2.65			1.2	71.0

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 115.4 pcf Optimum moisture = 14.0 %	Lean CLAY with Sand

Project No. 04-167-002 **Client:** DNRC - Water
Project: Proposed Drop Realignment
St. Mary River Siphon
○ **Location:** B-2 **Depth:** 7.5 - 12.5 ft **Sample Number:** A-4939

Remarks:
Report No. A-4939-204

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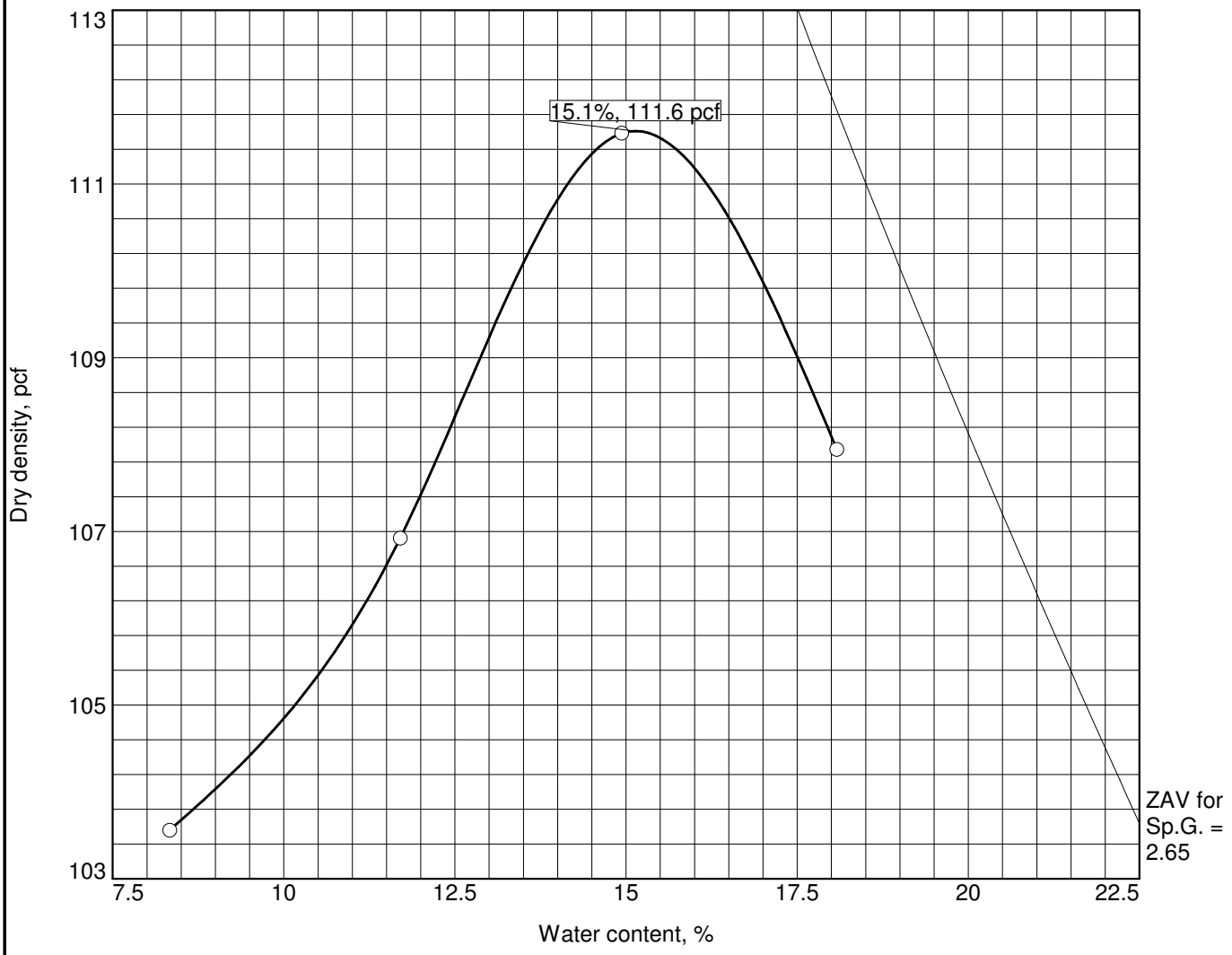
GREAT FALLS - BOZEMAN - KALISPELL MONTANA
SPOKANE WASHINGTON
LEWISTON IDAHO

Figure 45

Tested By: MEJ **Checked By:** Craig R Madsen

Moisture-Density Test Report



Test specification: ASTM D 698-07 Method A

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
7.5 - 12.5 ft	CL			2.65			1.6	70.7

TEST RESULTS

Maximum dry density = 111.6 pcf

Optimum moisture = 15.1 %

MATERIAL DESCRIPTION

Lean CLAY with Sand

Project No. 04-167-002 **Client:** DNRC - Water

Project: Proposed Drop Realignment

St. Mary River Siphon

○ **Location:** B-6 **Depth:** 7.5 - 12.5 ft **Sample Number:** A-4969

Remarks:

Report No. A-4969-204

TD&H

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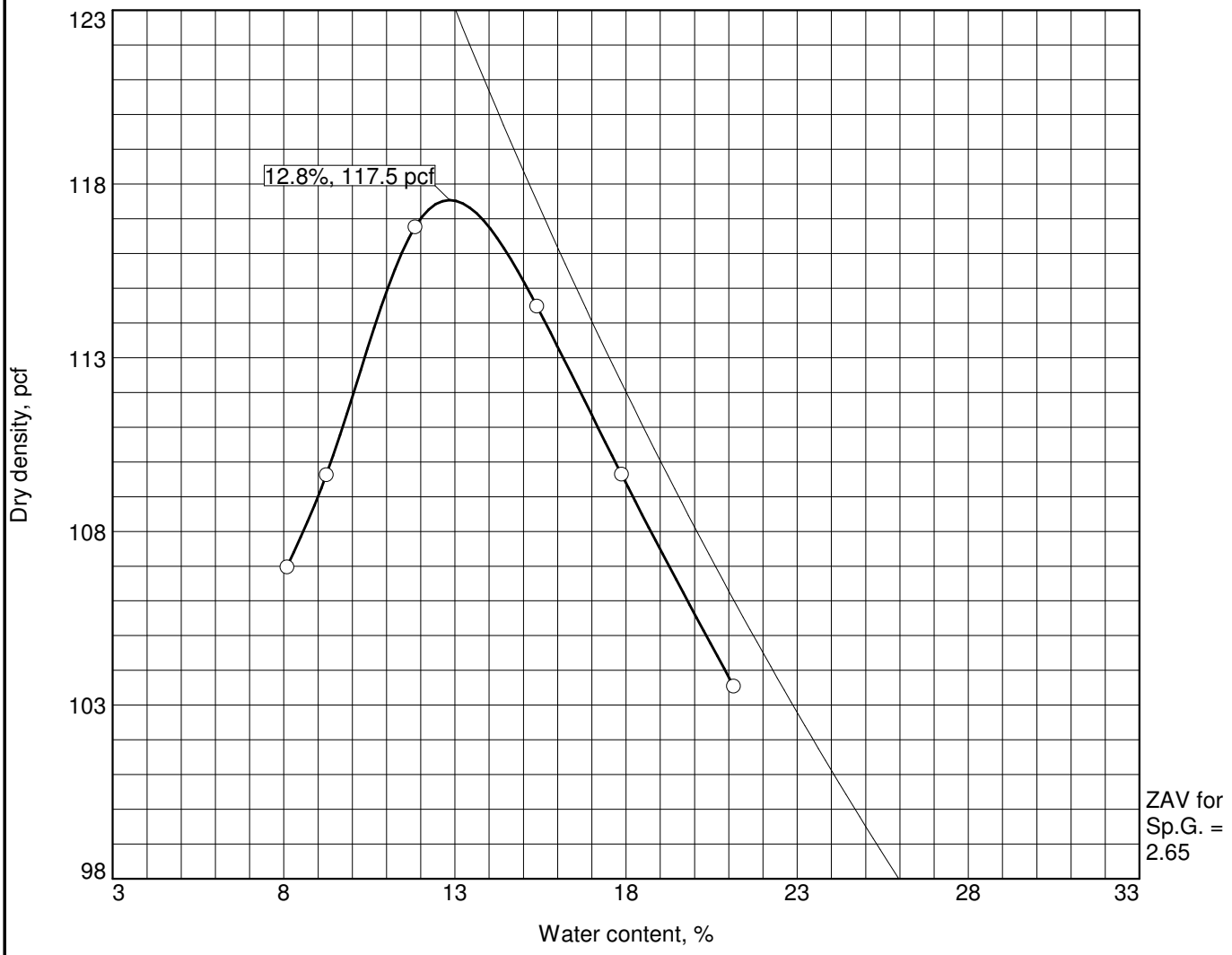
ENGINEERING CONSULTANTS

GREAT FALLS - BOZEMAN - KALISPELL MONTANA
SPOKANE WASHINGTON
LEWISTON IDAHO

Figure 46

Tested By: MEJ **Checked By:** Craig R Madsen

Moisture-Density Test Report



Test specification: ASTM D 698-07 Method A

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
15.0 - 17.0 ft	CL	A-6(11)		2.65	34	21	0.3	64.6

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 117.5 pcf Optimum moisture = 12.8 %	Sandy Lean CLAY

Project No. 04-167-002 **Client:** DNRC - Water
Project: Proposed Drop Realignment
St. Mary River Siphon
○ **Location:** B-12 **Depth:** 15.0 - 17.0 ft **Sample Number:** A-5132

Remarks:
Report No. A-5132-204

TD&H
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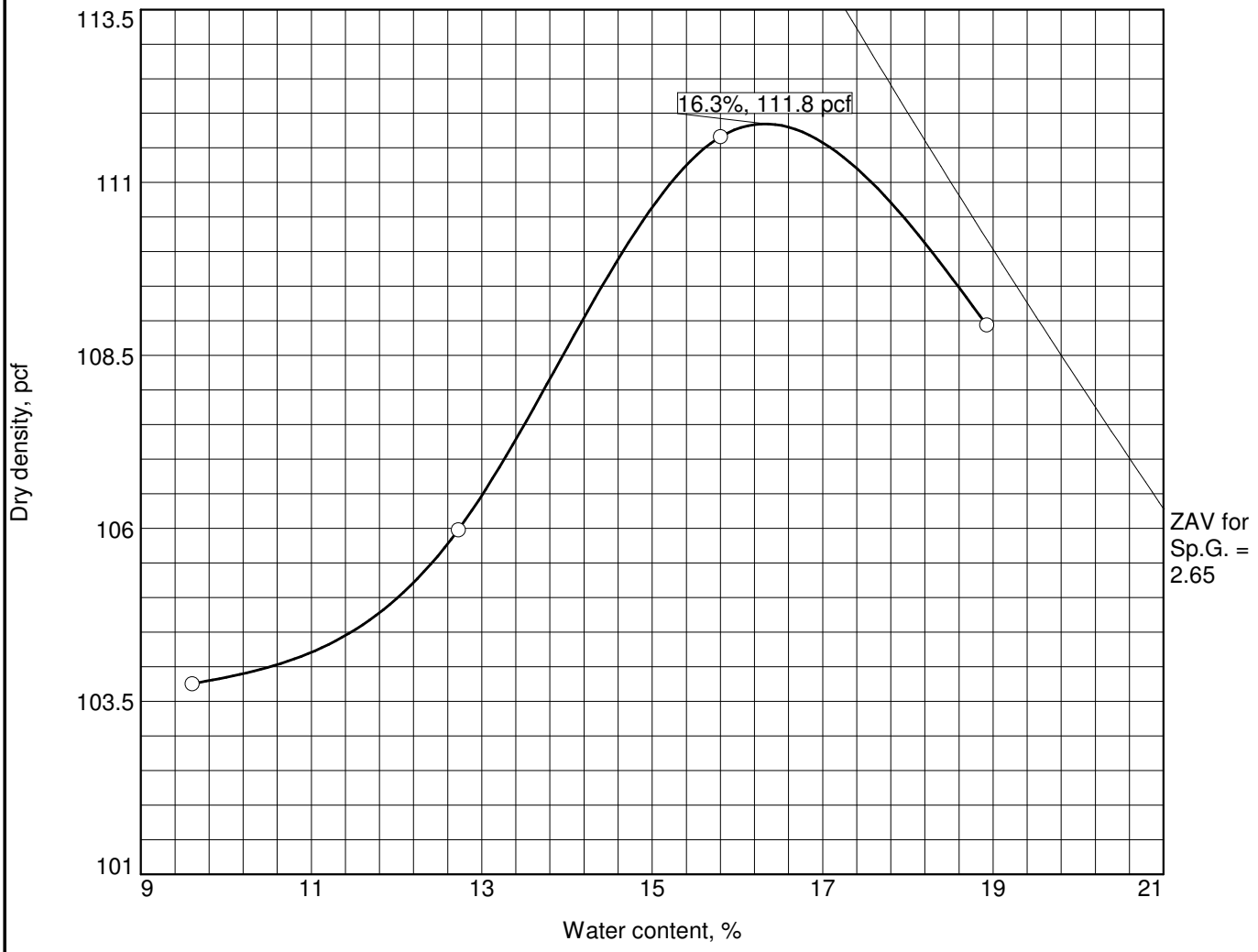
ENGINEERING CONSULTANTS
GREAT FALLS - BOZEMAN - KALISPELL MONTANA
SPOKANE WASHINGTON
LEWISTON IDAHO

Figure 47

Tested By: MEJ **Checked By:** Craig R Madsen

Moisture-Density Test Report



Test specification: ASTM D 698-07 Method A

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
10.0 - 15.0 ft	CL			2.65			0.0	

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 111.8 pcf Optimum moisture = 16.3 %	Sandy Lean CLAY (Visual)

Project No. 04-167-002 **Client:** DNRC - Water
Project: Proposed Drop Realignment
St. Mary River Siphon
○ **Location:** B-13 **Depth:** 10.0 - 15.0 ft **Sample Number:** A-5141

Remarks:
Report No. A-5141-204

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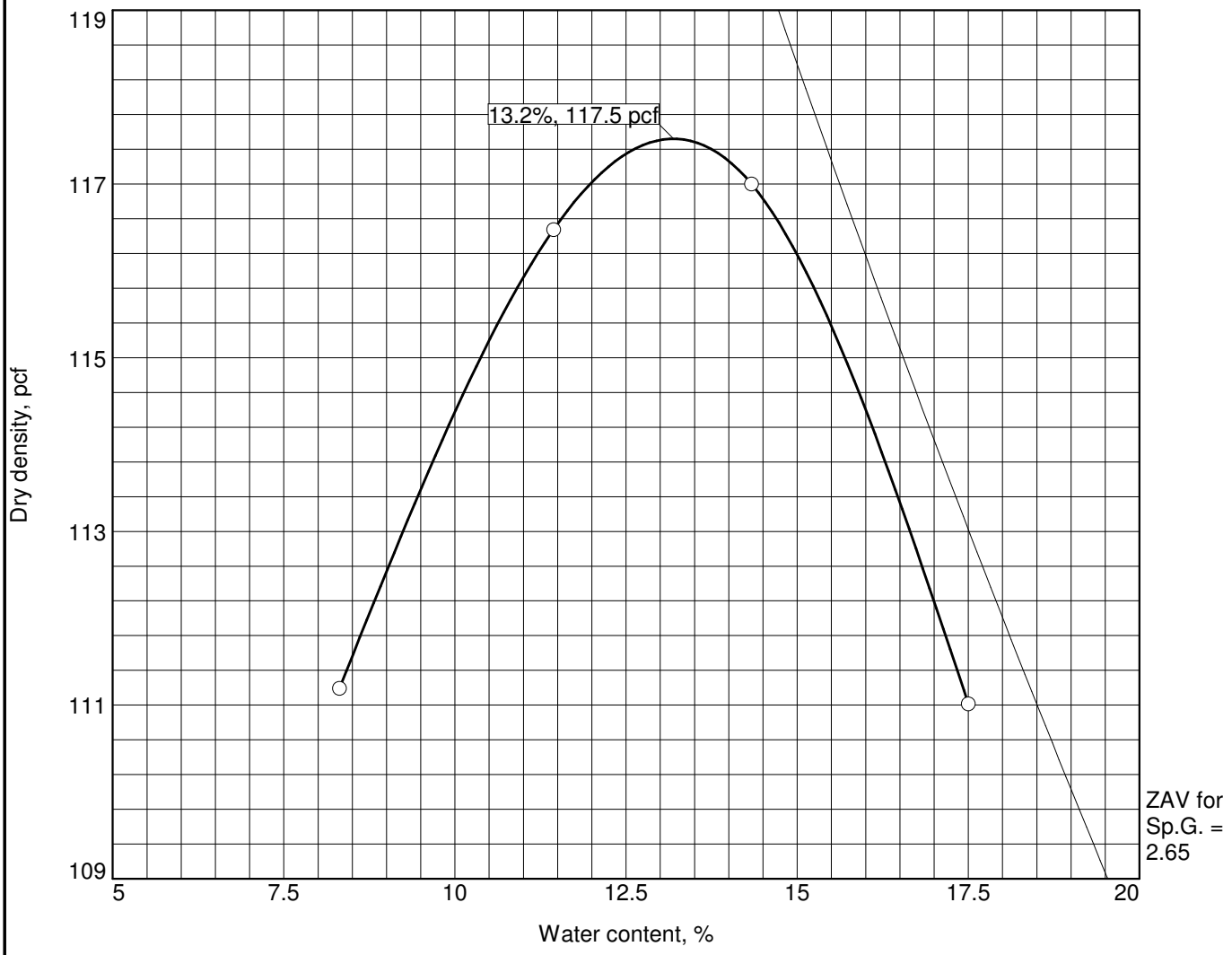
GREAT FALLS - BOZEMAN - KALISPELL MONTANA
SPOKANE WASHINGTON
LEWISTON IDAHO

Figure 48

Tested By: MEJ **Checked By:** Craig R Madsen

Moisture-Density Test Report



Test specification: ASTM D 698-07 Method A

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
17.0 - 20.0 ft	CL	A-6(9)		2.65	34	21	3.2	57.5

TEST RESULTS

Maximum dry density = 117.5 pcf

Optimum moisture = 13.2 %

MATERIAL DESCRIPTION

Sandy Lean CLAY

Project No. 04-167-002 **Client:** DNRC - Water

Project: Proposed Drop Realignment

St. Mary River Siphon

○ **Location:** B-14 **Depth:** 17.0 - 20.0 ft **Sample Number:** A-5150

Remarks:

Report No. A-5150-204

TD&H

THOMAS, DEAN & HOSKINS, INC.

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GREAT FALLS - BOZEMAN - KALISPELL MONTANA
SPOKANE WASHINGTON
LEWISTON IDAHO

Figure 49

Tested By: MEJ **Checked By:** Craig R Madsen

Report of Unit Weight (SOP- 213)

Thomas, Dean, & Hoskins
208½ 17th Street North * 1601 2nd Ave. North Suite 226
Great Falls, Montana 59401

Client:	DNRC - Water	**Report Number:**	A-4937/4967/5131/5140-213
Address:	P.O. Box 201601	**Report Date:**	12/1/2011
	Helena, MT 59620-1601	**Project:**	St. Mary Siphon - Proposed Drop Realignment
		Project Number:	04-167-002
Attn:	Mr. John Sanders	**Test Method:**	ASTM D-2950, D-3017
		Technician:	CRN/WJC
		Test Date:	9/26/2011 & 10/27/2011

Sample #	Location	Diameter, in.	Height, in.	Volume, ft³	Container #	Container Weight, grams	Wet Soil & Container, grams	Dry Soil & Container, grams	Moisture, %	Wet Density, pcf	Dry Density, pcf
A-4937	B-2 (10.7 - 11.6 ft)	2.9	10.8	0.041	B-100	273.1	2584.6	2335.4	12.1	124.4	111.0
A-4967	B-6 (10.2 - 11.4 ft)	2.9	15.0	0.057	002	663.3	4201.2	3742.5	14.9	137.0	119.3
A-5131	B-12 (15.0 - 17.0 ft)	2.9	16.1	0.060	B-101	312.7	3865.5	3250.3	20.9	130.2	107.7
A-5140	B-13 (10.0 - 12.0 ft)	2.9	20.2	0.075	A-101	316.0	4831.1	4176.2	17.0	132.5	113.3

Deviations From Test Methods: None

Figure: 50

Remarks:

FOR Peter Klevberg, P.E.
Laboratory Manager

FIGURE 51
ST. MARY DIVERSION SYSTEM - PROPOSED DROP REALIGNMENT
GEOMETRY OF PROPOSED CANAL SECTION

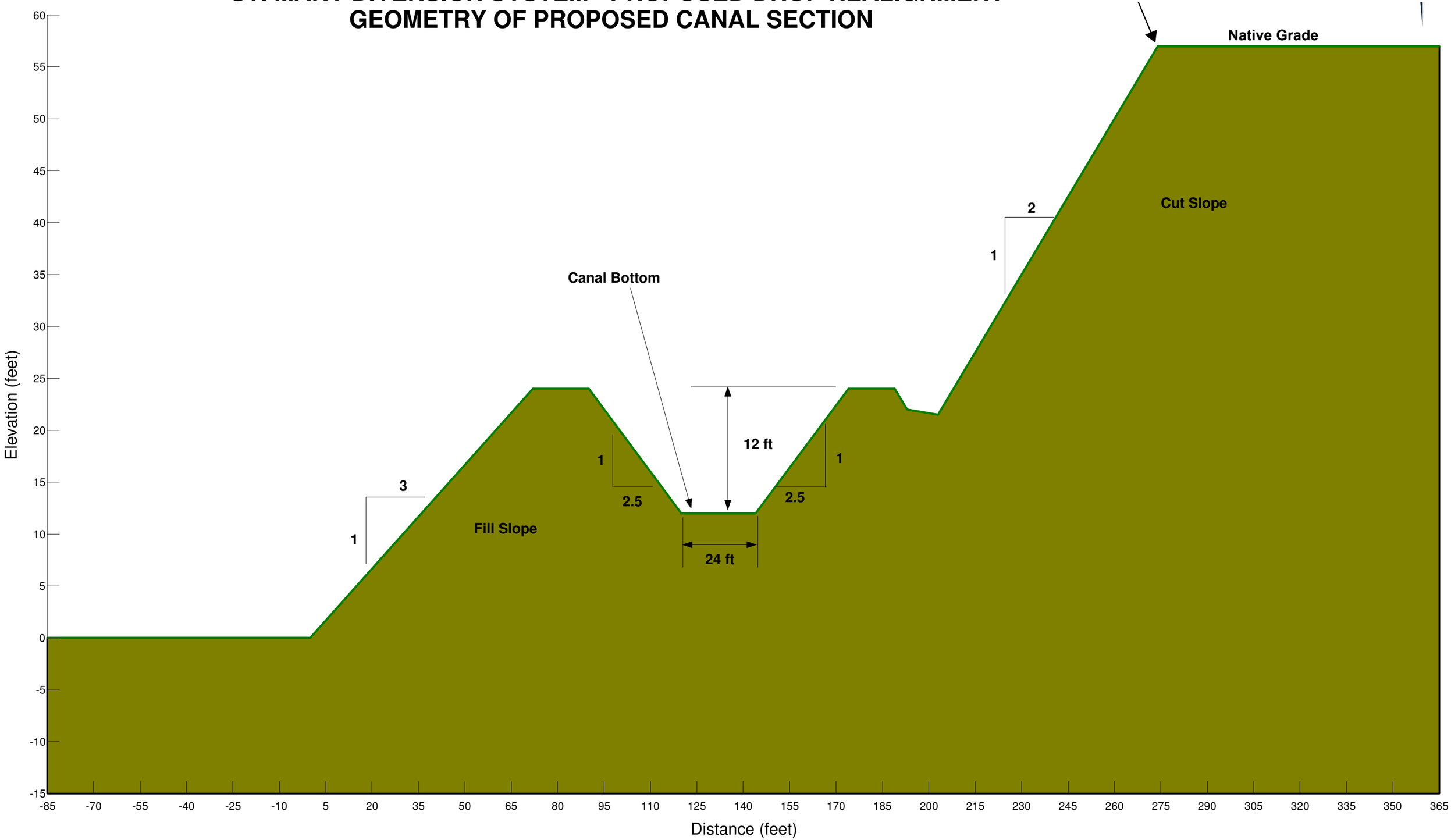


FIGURE 52
ST. MARY DIVERSION SYSTEM - PROPOSED DROP REALIGNMENT
STABILITY OF CUT SLOPE IN NATIVE CLAYS (WEST END)

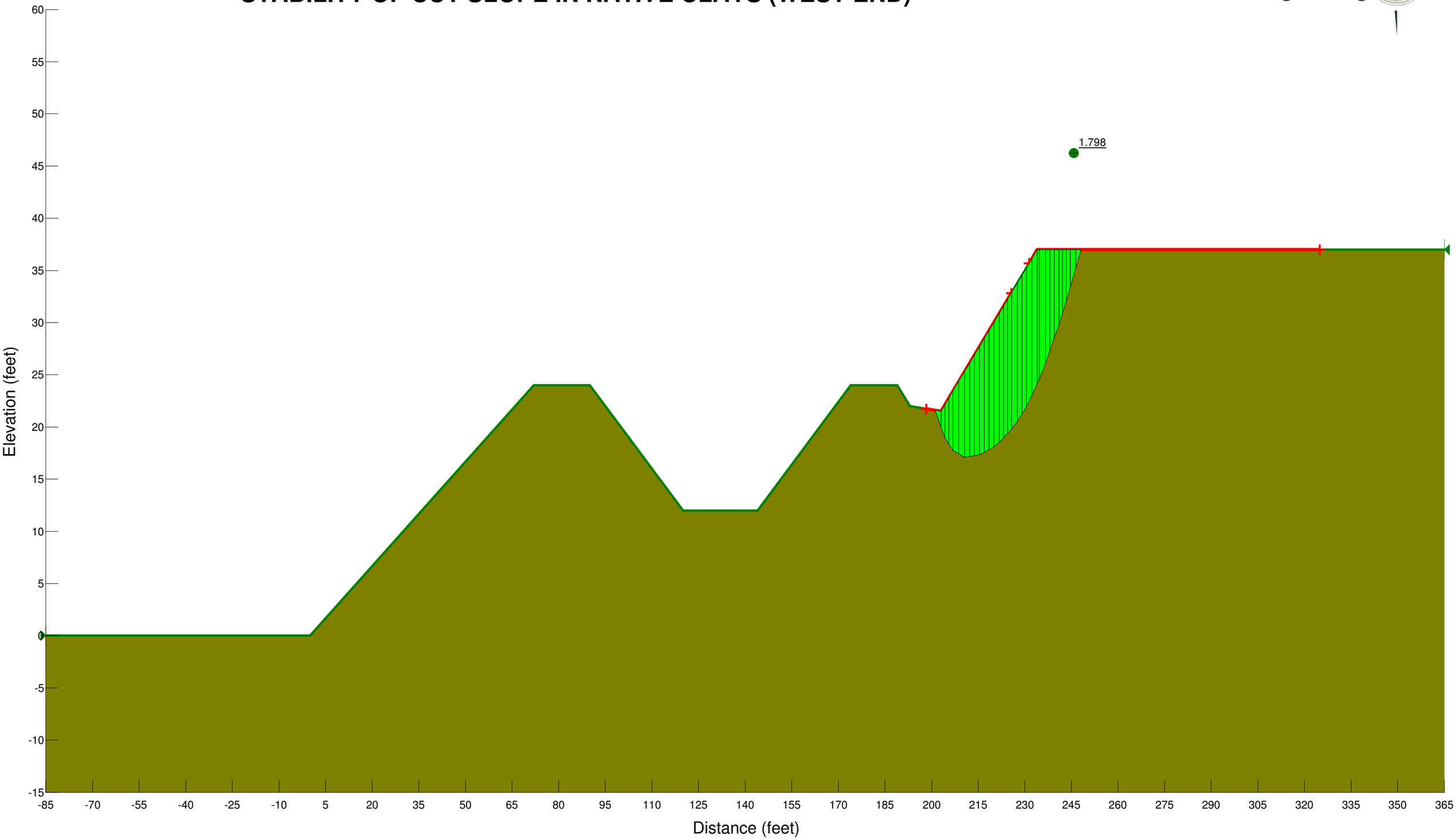
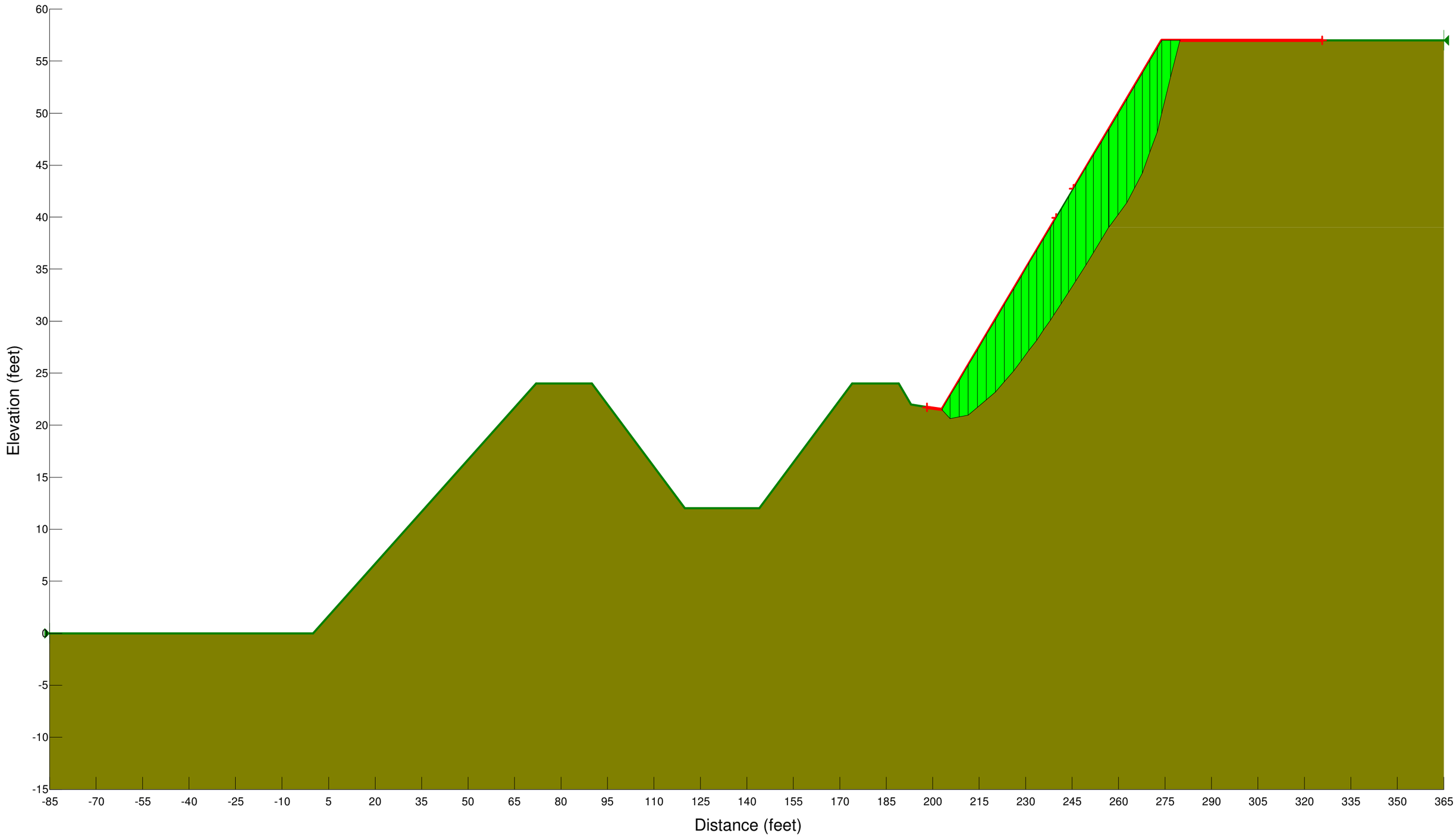


FIGURE 53
ST. MARY DIVERSION SYSTEM - PROPOSED DROP REALIGNMENT
STABILITY OF CUT SLOPE IN SANDY SOILS (EAST END)



1.980

FIGURE 54
ST. MARY DIVERSION SYSTEM - PROPOSED DROP REALIGNMENT
STABILITY OF FILL SLOPE WITHOUT PORE PRESSURES

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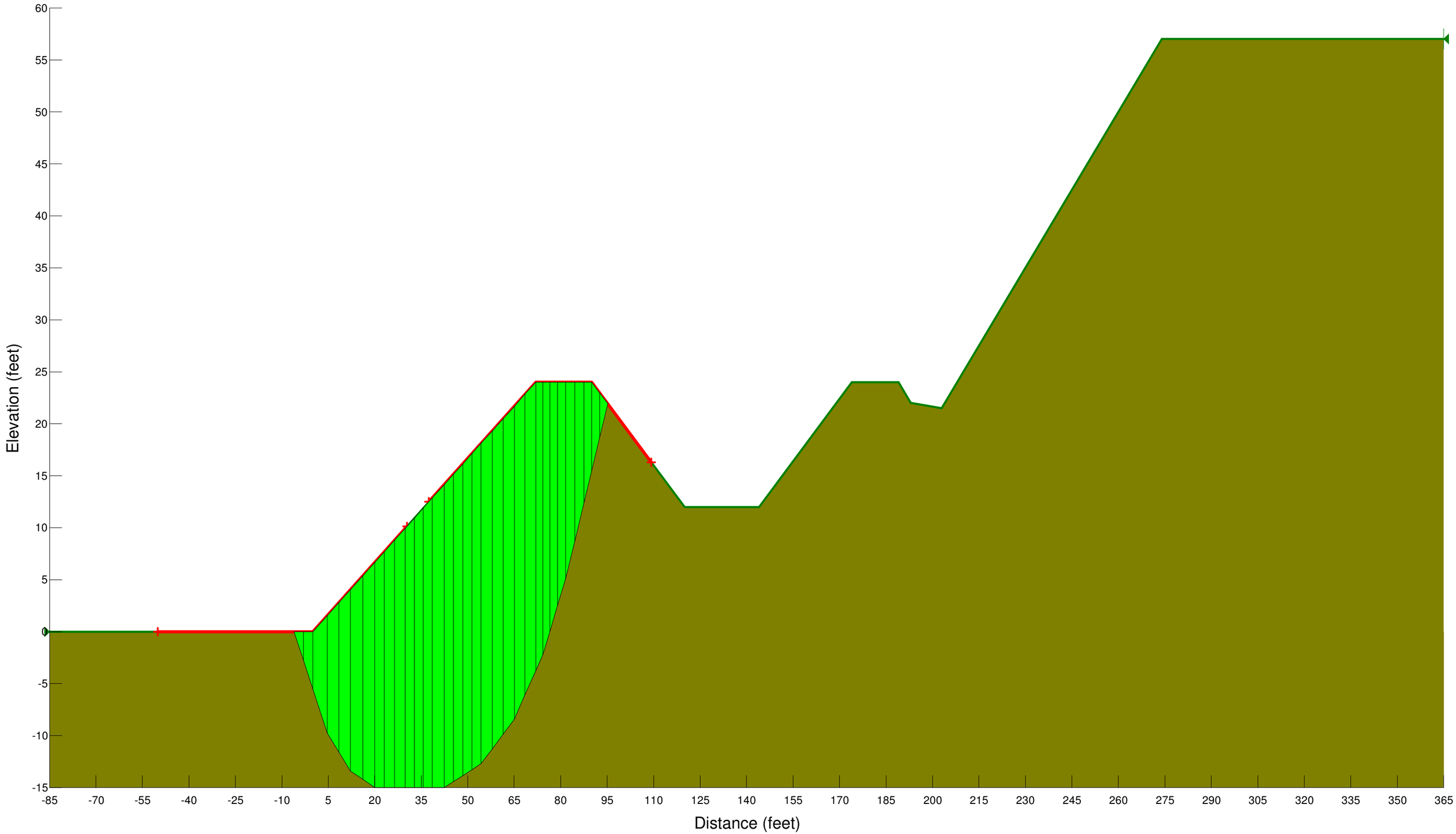
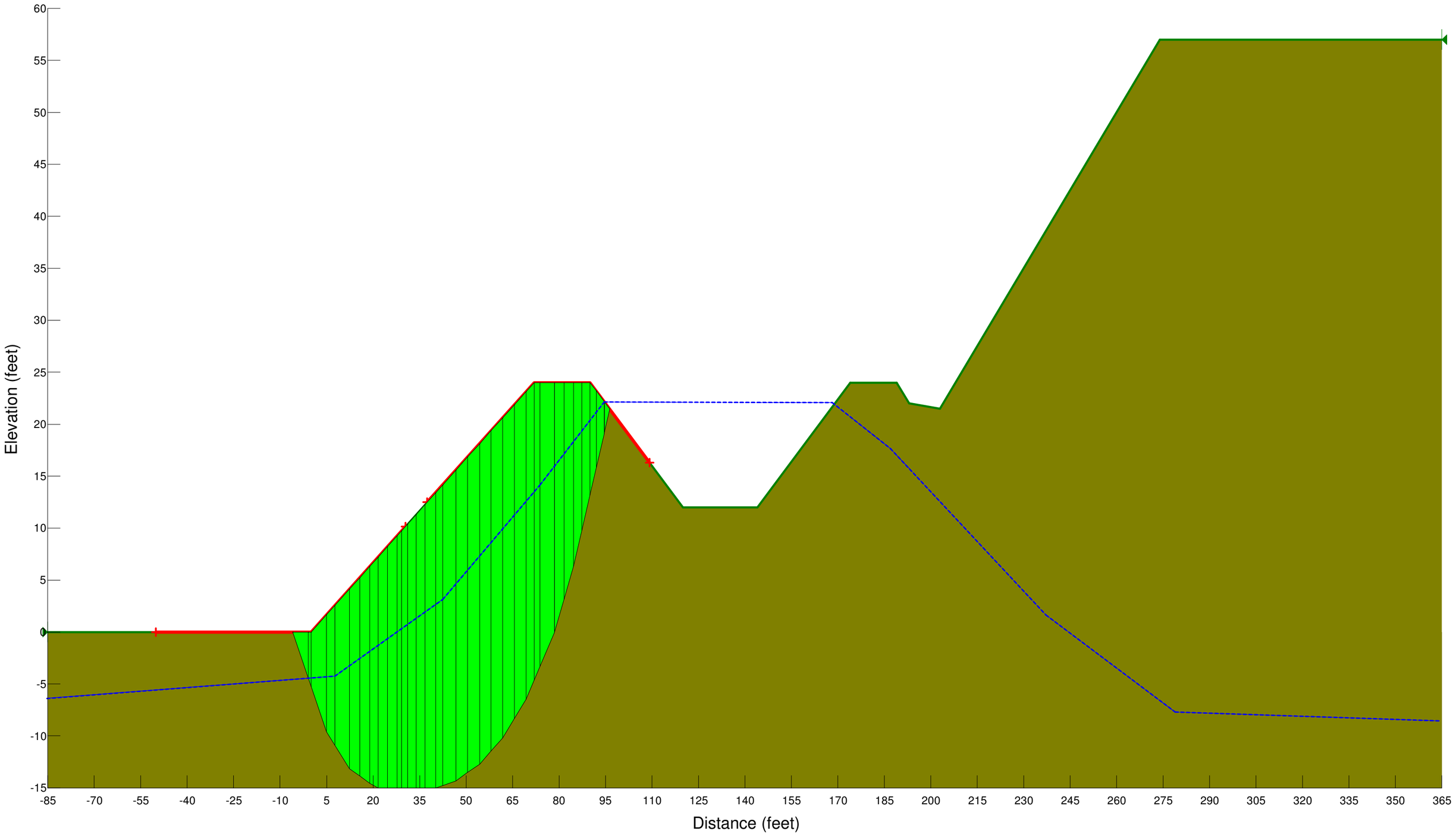
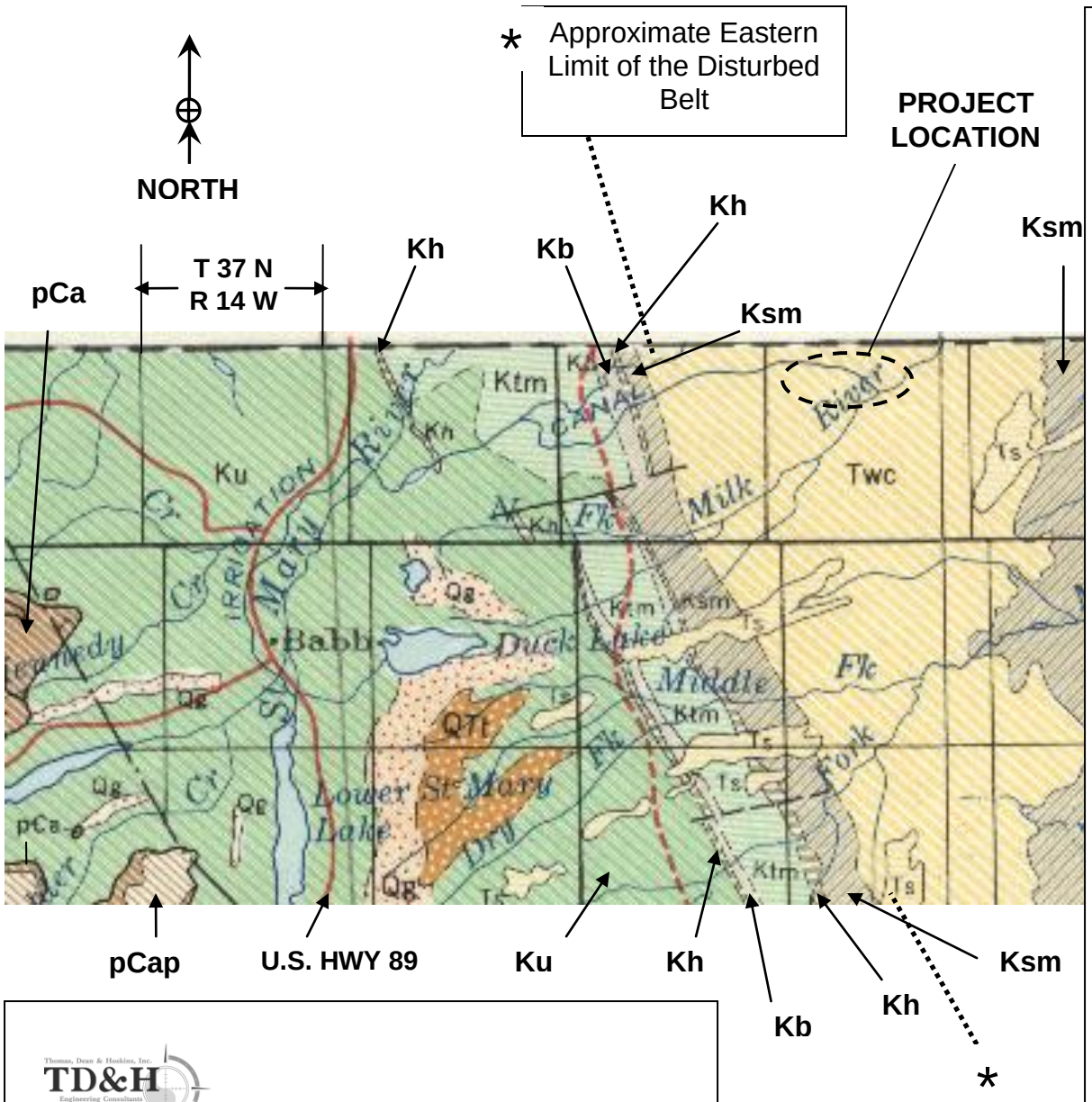


1.877

FIGURE 55
ST. MARY DIVERSION SYSTEM - PROPOSED DROP REALIGNMENT
STABILITY OF FILL SLOPE WITH PORE PRESSURES





Qg - Pleistocene Glacial Drift
Morainal and outwash plain deposits of mountain glaciers; mainly ill-sorted and poorly rounded boulders, cobbles, pebbles and sand; may include alluvium in places.

QTf – Terrace Deposits
Gravel, sand, and silt of terrace remnants

Ts - Tertiary Sedimentary Rocks Undifferentiated
Poorly consolidated gravel, sand, silt, clay and other - tuff, lignite, bentonite, deposits, in valleys.

Twc - Tertiary (Paleocene) Willow Creek Formation
Variegated clay and soft sandstone, chiefly maroon to chocolate brown; local lenses of purple-gray nodular limestone.

Ksm - Upper Cretaceous St. Mary River Formation
Greenish-gray clay with local nodular limestone and cross-bedded sandstone.

Kh - Upper Cretaceous Horsethief Sandstone
Shaley sandstone grading upward into massive brownish cliff-forming sandstone with local concentrations of magnetite in beds near top.

Kb - Upper Cretaceous Bearpaw Shale
Dark gray and brownish clay shale; thick units of non-fissile bentonitic shale; contains some thick bentonite beds.

Ktm - Upper Cretaceous Two Medicine Formation
Greenish-gray clay with local nodular limestone and cross-bedded sandstone; locally some coal in lower part.

Ku - Cretaceous Undifferentiated
(disturbed belt – subdivision difficult – contains
Kvi Virgelle formation – gray to buff massive cliff forming sandstone with iron-stained concretions in the upper part)

pCap – Appekunny Argillite
Gray quartzitic argillite and quartzite

pCa – Altyn Limestone
Dolomite and magnesian limestone

Fault observed _____ inferred ---------

THOMAS,DEAN & HOSKINS, INC.
ENGINEERING CONSULTANTS
MONTANA DEPARTMENT of TRANSPORTATION
MT 18(35) , UPN 6001 St. Mary River – North of Babb
Approx. Lat. 48°56'37"N., Long. 113°22'15"W.
SW ¼, S.19, NW ¼ , S. 30, T.37 N., R. 13 W.
November 2006
FIGURE 56 - AREA GEOLOGIC MAP

From USGS
Geologic Map of Montana
MR 2235
1955

THOMAS, DEAN & HOSKINS
Engineering Consultants
Great Falls, Kalispell, Bozeman, Montana
Spokane, Washington, Lewiston, Idaho

SOIL CLASSIFICATION AND SAMPLING TERMINOLOGY FOR ENGINEERING PURPOSES

STANDARD PENETRATION TEST (ASTM D1586)

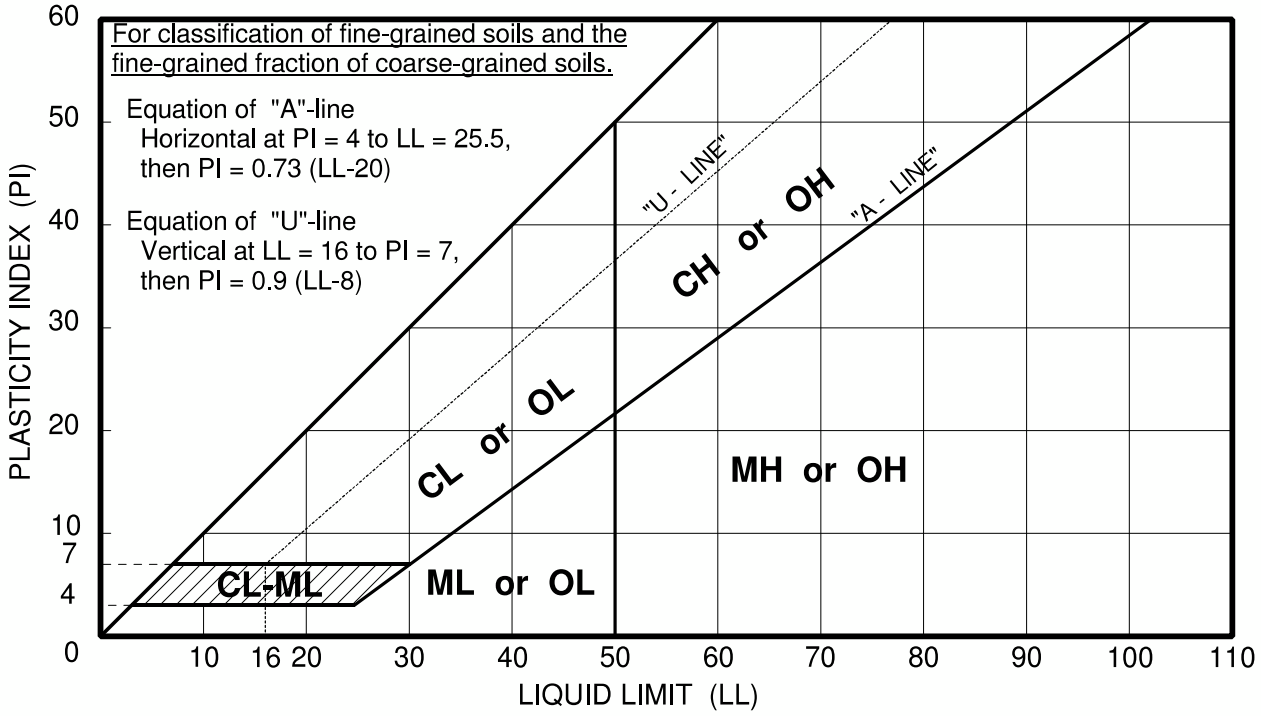
RELATIVE DENSITY*		RELATIVE CONSISTENCY*	
Granular, Noncohesive (Gravels, Sands, & Silts)	Standard Penetration Test (blows/foot)	Fine-Grained, Cohesive (Clays)	Standard Penetration Test (blows/foot)
Very Loose	0-4	Very Soft	0-2
Loose	5-10	Soft	3-4
Medium Dense	11-30	Firm	5-8
Dense	31-50	Stiff	9-15
Very Dense	+50	Very Stiff	15-30
		Hard	+30

* Based on Sampler-Hammer Ratio of 8.929 E-06 ft/lbf and 4.185 E-05 ft^2/lbf for granular and cohesive soils, respectively (Terzaghi)

PARTICLE SIZE RANGE

Sieve Openings (Inches)				Standard Sieve Sizes				
12"		3"	3/4"	No.4	No.10	No.40	No.200	<No.200
BOULDERS	COBBLES	GRAVELS		SANDS				SILTS & CLAYS
		Coarse	Fine	Coarse	Medium	Fine		(Distinguished By Atterberg Limits)

PLASTICITY CHART



GW - Well-graded GRAVEL
GP - Poorly-graded GRAVEL
GM - Silty GRAVEL
GC - Clayey GRAVEL

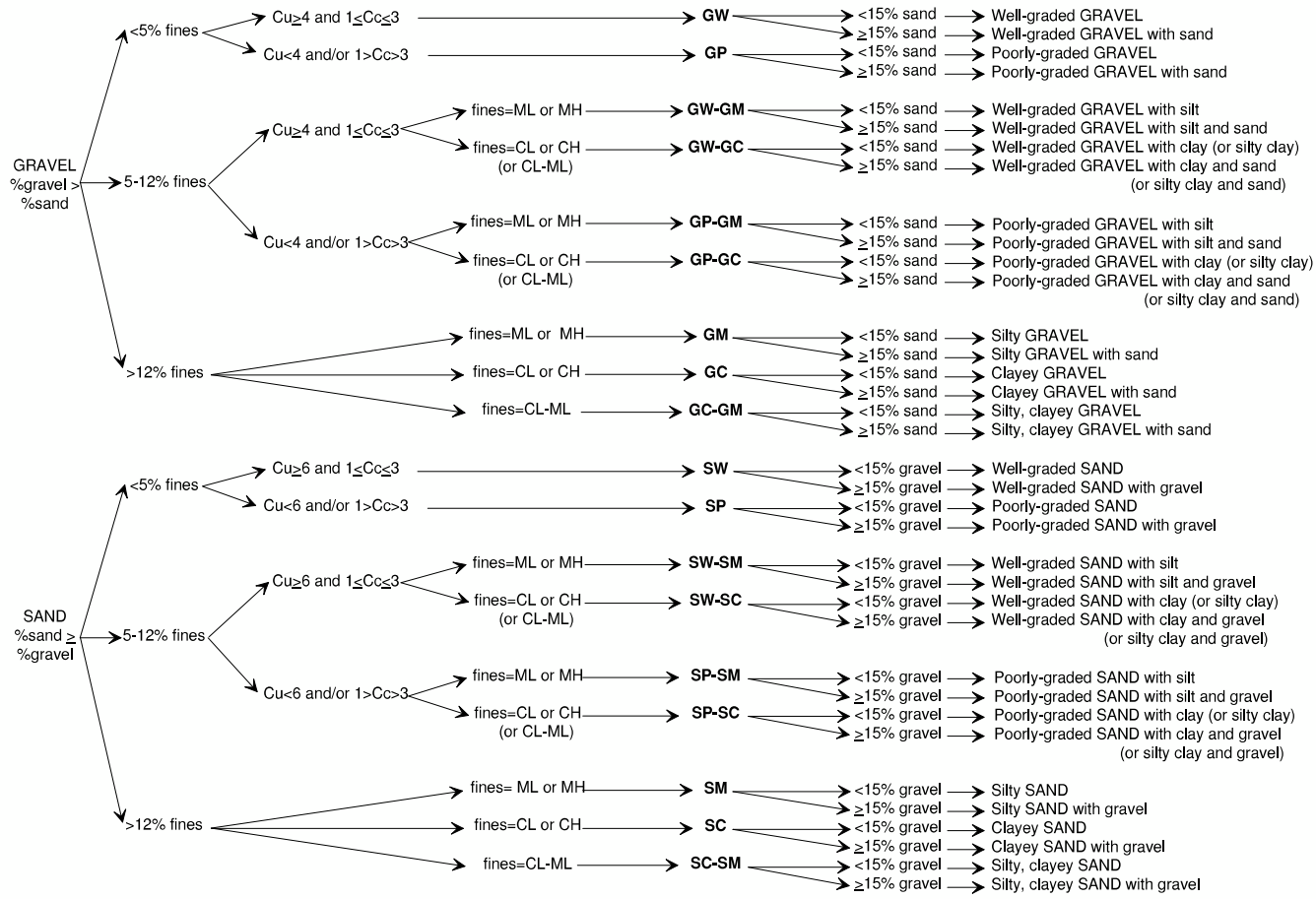
SW - Well-graded SAND
SP - Poorly-graded SAND
SM - Silty SAND
SC - Clayey SAND

CL - Lean CLAY
ML - SILT
OL - Organic SILT/CLAY
CH - Fat CLAY
MH - Elastic SILT
OH - Organic SILT/CLAY

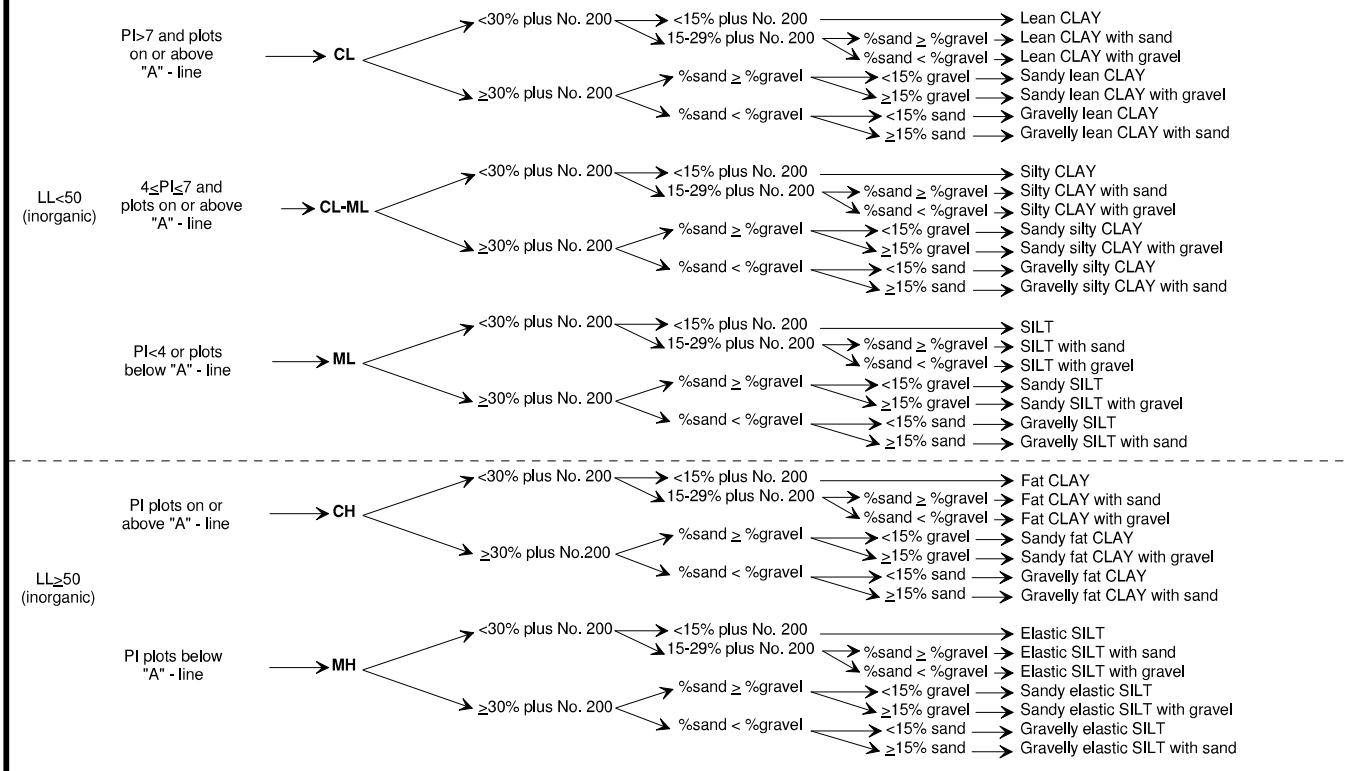
03/01

THOMAS, DEAN & HOSKINS
Engineering Consultants
Great Falls, Kalispell, Bozeman, Montana
Spokane, Washington, Lewiston, Idaho

ASTM D2487
CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES



Flow Chart For Classifying Coarse-Grained Soils (More Than 50 % Retained On The No. 200 Sieve)



Flow Chart For Classifying Fine-Grained Soils (50 % Or More Passes The No. 200 Sieve)

03/98