


Lorenzen Soil Mechanics, Inc.

# Lolo Street Bridge
# Missoula, Montana
## Geotechnical Engineering Report

Prepared for:
DJ&A
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Missoula, MT  59808

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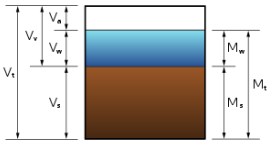
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# 1 INTRODUCTION

DJ&A of Missoula has requested Lorenzen Soil Mechanics, Inc. (LSM) to complete a geotechnical investigation for a bridge replacement over Rattlesnake Creek on Lolo Street in Missoula, Montana. LSM agreed to take the geotechnical portion of the bridge design project from Tetra-Tech after an apparent contract issue. Tetra-Tech had arranged for the drilling to be completed by O'Keefe Drilling of Butte, Montana. LSM completed the logging, sampling, and testing for two boreholes which culminated in this geotechnical design report.

The bridge replacement will be a wider bridge measuring at 44.15 feet and will include two 10-foot wide shared used concrete pathways. The length of the bridge will be 93 feet from center-of- bearing to center-of-bearing. LSM understands there will be 2.5 feet of design freeboard. There will 100 feet of new asphalt pavement as part of the project.

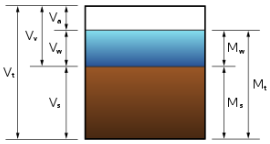
The primary purpose of the investigation was to evaluate the subgrade materials and to use that information to provide foundation design and subgrade preparation recommendations for the bridge replacement.

# 2 SITE EVALUATION

Lolo Street and the Rattlesnake Creek are within a residential section of Missoula. Lolo Street makes an 'S-curve' coming in to and out of the bridge over Rattlesnake Creek. A placard at the bridge's abutment indicates the concrete structure was constructed in 1966. A short distance upstream, older concrete abutments predate the 1966 bridge construction. The concrete side railing and a number of the concrete beams exhibit cracking, with some exposing reinforcement steel. The bridge abutments are on spread footing foundations. The fill between the creek and the abutments is typically boulders and cobbles, which are likely native.

Geologically, the general area is mapped on the Montana Bureau of Mines and Geology (MBMG) Open File Report 593 '*Geologic Map of the Missoula East 30' x 60' Quadrangle, Montana*', 2010. Rattlesnake Creek divides what is mapped as Holocene and Pleistocene epochs Alluvium of Stream Terraces (Qat) off its right bank and Holocene and Pleistocene epochs Older Alluvium of Tributaries (Qao) off its left bank. Figure 1 depicts a portion of the geologic map.

The Qat materials are characterized in the Open File Report as "Well-sorted (*poorly graded*) gravel and sand underlying flat benches perched above present river level. Thickness typically 1 – 10 m (*3 – 33 feet*)." The Qao materials are described in the Open File Report as "Moderately sorted gravel, sand, and silt underlying benches perched above modern side streams. Typically not as well-sorted (*poorly graded*) as Qat. Up to 10 m (*33 ft*) thick." LSM suspects the gravels and sands extend much deeper at this location and includes frequent cobbles and an occasional boulder. The Belt Supergroup Snowslip (Ysn) and Wallace (Yw) Formations likely underlie the Qat and Qao materials at depth.




The subsurface investigation was conducted February 27 – 28, 2025. O'Keefe Drilling of Butte, Montana completed two boreholes with their track-mounted Geoprobe 8150 LS sonic drill. Figure 2 is a Google Earth image depicting the borehole locations. A sonic drill allows the collection of a continuous sample inside a 4-inch diameter core barrel by using high frequency vibrations by oscillators through the drill string. The high frequency, resonant sonic energy is transferred to the drill bit, where the surrounding particles are fractured. Depending on conditions, a 6-inch diameter casing follows the 4-inch diameter core barrel to provide an annular space and keep the core barrel from becoming bound-up in large cobbles. The core run is retrieved and extruded into a plastic sack for logging and testing purposes. Between the core runs, generally 5 feet, a Standard Penetration Test (SPT) was conducted to evaluate the relative density of the soil materials. Horizontal coordinates were obtained using a Garmin eTrex® 10 GPS unit.

The sonic coring and SPT data yielded very dense, poorly graded gravel with silt and sand (GP-GM), silty gravel with sand (GM), and silty sand with gravel (SM). These soils are in agreement with the Open File Report for the Qao and Qat materials.

The creek channel is lined with coarse gravel, cobbles, and boulders. It was not practical to enter the swiftly moving creek to collect representative particles for a gradation analysis. Photographs are included showing the channel and exposed boulders in February during the subsurface investigation. For scour design purposes, LSM suggests a $d_{50}$ of 12 inches.

The logs of boring and seismic design information are presented in Appendix A. Photographs of the drilling operations and the soil samples are provided in Appendix B.

# 3 RECOMMENDATIONS

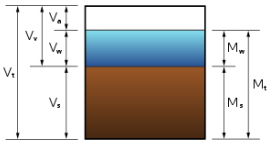
The current and previous Lolo Street bridges are single-span bridges with abutments sitting on shallow foundations. LSM agrees with this foundation type, given the very coarse aggregates at, and below, the foundation subgrade. The Rattlesnake Creek channel bottom is across cobbles and boulders.

## *3.1 Shallow Foundations*

Due to the coarseness of the subgrade soils, LSM recommends over-excavating by at least 6 inches and replacing with a 1 1/2-minus structural backfill compacted across a structural geogrid. The structural backfill is intended to provide a uniform surface on which to construct the abutments and wingwalls.

After removing the existing superstructure and foundations, prepare the shallow foundation subgrades by:

1. Providing dewatering as needed and protecting the foundation excavations from the Rattlesnake Creek channel.
2. Over-excavating by at least 6 inches below the bottom of the foundation elevation.




3. Leveling and compacting the bottom of the over-excavation to a standard relative compaction (ASTM D698) of at least 98 percent. The subgrade will be too coarse to have a relevant Proctor moisture/density curve. The maximum dry density can be established in the field by making repeated passes with a vibratory roller compactor having an operating weight of at least 20,000 pounds and a centrifugal force of at least 35,000 pounds. The maximum dry density is obtained when after making 'n passes', the dry density value from a nuclear densometer gauge no longer increases.
4. Providing a structural geogrid meeting the engineering characteristics of InterAx® NX750™ and placing it across the compacted surface.
5. Providing a 1 1/2-inch structural backfill meeting the gradation in Table 1.

**TABLE 1: 1 1/2" Structural Backfill**

| Sieve Size | Percent Passing |
|---|---|
| 1 1/2" | 100 |
| 3/4" | 74 - 96 |
| 3/8" | 40 - 76 |
| No. 4 | 24 - 60 |
| No. 40 | 6 - 34 |
| No. 200 | 0 - 8 |

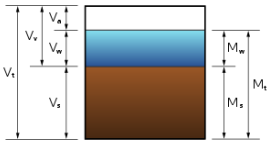
6. Placing the structural backfill and compacting it to a standard relative compaction of at least 98 percent.
7. Leveling the foundation footprint to ensure there are no visible high or low areas.

Provided the foundation subgrade is prepared as described, the allowable soil bearing capacity can be taken as 4,000 pounds per square foot (psf) or a nominal soil bearing capacity of 12,000 psf. An internal angle of friction ($\phi$) of 30 degrees and a moist unit weight ($\gamma_m$) of 120 pounds per cubic foot (pcf) can be used for the foundation subgrade's rounded to subrounded particles. A coefficient of friction ($\mu$) of 0.58 can be used for sliding resistance.

## *3.2 Abutment and Wing Wall Backfill*

The excavated granular spoils can be re-used as backfill against the walls, provided all the +3-inch sized particles are removed. LSM suspects there will be an over-abundance of +3-inch particles and that imported material will be needed. The structural backfill gradation presented in Table 1 can be used as compacted backfill behind the abutments and wing walls. Prepare the abutments and wing walls for backfilling by:

1. Providing a drain tile system at the base of the abutment wall and wing wall. The drain tile system includes a 4-inch diameter corrugated slotted pipe meeting the engineering characteristics for Duraslot® ADS™ wrapped in a filter fabric sock meeting the engineering characteristics of Geotex® 111F, at least 6 inches of 3/4-inch drain rock cover, and all wrapped in a non-woven geotextile meeting the engineering characteristics of Geotex® 401.
2. Including rodent guards at each of the drain tile outlets and landmarks such as riprap at the outlets.




3. Providing 3-inch minus stockpiled native material or imported structural fill meeting the gradation in Table 1.
4. Placing each of the backfill lifts in 12-inch (maximum) thick, loose lifts and compacting each lift to a standard relative compaction of at least 95 percent and at a moisture content within 2 percent of its optimum moisture content.

Compacting these materials as backfill will offer an internal angle of friction ($\phi$) of 34°, and a moist unit weight ($\gamma_m$) of at least 120 pcf. For the on-site soils being used as backfill, LSM recommends using an active equivalent fluid unit weight ($\gamma_{fa}$) of 33.9 pounds per cubic foot (pcf) for wall designs where the tops of the walls are allowed to rotate, such as for wing walls. Where the walls are rigid, such as for bridge abutments, LSM recommends an at-rest $\gamma_{f0}$ of 52.9 pcf. With a level backfill, the following Rankine equations can be used to obtain a resultant lateral force (pounds per lineal foot) acting at the lower one-third of the wall heights (H in feet):

Active Pressure, $P_a$: $17.0 \times H^2$
Passive Pressure, $P_p$: $212.2 \times H^2$
At-rest Pressure, $P_0$: $26.5 \times H^2$
Seismic Pressure, $P_E$: $9.7 \times H^2$
Seismic Active Pressure, $P_{(E+a)}$: $26.7 \times H^2$

## 3.3 Seismic Considerations

The Missoula area is within the Northern Intermountain Seismic Belt. The AASHTO/LRFD Bridge Design Specifications manual was used to develop seismic design criteria as follows:

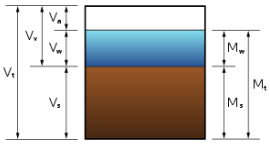
**TABLE 2: Seismic Coefficients**

| AASHTO LRFD 2009 | |
|---|---|
| Soil Profile | Type 1 |
| Seismic Design Category | B |
| Acceleration Coefficient, $A_s$ | 0.178g |
| Mapped Spectral Response Acceleration Parameter, $S_S$ for 0.2 second | 0.354g |
| Mapped Spectral Response Acceleration Parameter, $S_1$ for 1.0 second | 0.107g |
| Design Spectral Response Acceleration Parameter, $S_{DS}$ | 0.425g |
| Design Spectral Response Acceleration Parameter, $S_{D1}$ | 0.181g |
| Peak Ground Acceleration, PGA | 0.148g |
| Peak Ground Acceleration Coefficient, $F_{PGA}$ | 1.200g |

Due to the very coarse nature of the subgrade materials, liquefaction within 10 feet below the abutment elevations is considered a low concern at this site during a major earthquake.

## 3.4 Underground Utilities

An existing sewer main is located downstream of the Lolo Street bridge. It is to remain in place and is to be protected during the abutment excavation operations.



## 3.5 Typical Section

Lolo Street will have 50 feet on new pavement on each side of the new bridge deck. Lolo Street's typical section in to and out of the bridge deck will include:

| | |
|---|---|
| Asphalt Plant Mix | 4 inches |
| 3/4-inch Minus Crushed Base Course | 10 inches |
| 3-inch Minus Subbase | 8 inches |
| Woven Geotextile (as needed) | Mirifi® RS280i |
| Scarified and Wetted Subgrade | 6 inches |

LSM recommends preparing the typical section by:

1. Grading to the subgrade depth, extending the typical section to at least 1 horizontal foot beyond any curb and gutter.
2. Scarifying to a depth of at least 6 inches and wetting the scarified surface.
3. Compacting the wetted, scarified surface to a standard relative compaction of at least 95 percent. The subgrade may be too coarse to have a relevant Proctor moisture density curve and, similar to abutment subgrades, the maximum dry density may need to be established in the field. LSM recommends using a roller compactor having an operating weight of at least 20,000 pounds and a centrifugal force of at least 35,000 pounds. Conversely, the subgrade may be fine-grained silty sand/sandy silt. For the fine-grained soil subgrade, provide a woven geotextile meeting the engineering characteristics of Mirifi® RS280i. For material estimating purposes, LSM suggests including the woven geotextile across 50 percent of the paved areas.

4. Providing an 8-inch compacted thickness of 3-inch subbase course meeting the gradation in Table 3. Recycled materials such as asphalt and concrete can be blended and used as the base, provided they meet the gradation recommendation.

**TABLE 3: 3" Subbase Course**

| Sieve Size | Percent Passing |
|---|---|
| 3" | 90 - 100 |
| 2.5" | 85 - 95 |
| 1.5" | 75 - 95 |
| 3/4" | 65 - 85 |
| No. 4 | 25 - 60 |
| No. 200 | 3 - 10 |

5. Placing the subbase course and compacting it to a standard relative compaction of at least 95 percent and to a moisture content within 2 percent of its optimum moisture content.
6. Providing a 10-inch compacted thickness of 3/4-inch crushed base course meeting the gradation in Table 4. Recycled materials such as asphalt and concrete can be blended and used as the base, provided they meet the gradation recommendation.

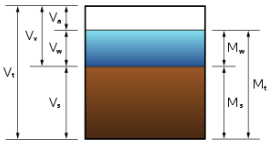


**TABLE 4: 3/4" Crushed Base Course**

| Sieve Size | Percent Passing |
|---|---|
| 1.5" | 100 |
| 3/4" | 90 - 100 |
| 3/8" | 70 - 90 |
| No. 4 | 40 - 70 |
| No. 10 | 25 - 55 |
| No. 200 | 2 - 8 |

7. Placing the crushed base course and compacting it to a standard relative compaction of at least 95 percent and to a moisture content within 2 percent of its optimum moisture content.
8. Grading the final surface to include a 2 percent crown.
9. Providing a plant mix and its aggregates meeting the following paragraphs:

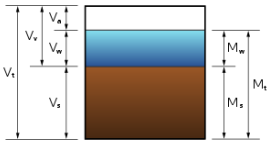
LSM recommends a performance graded PG 58-28 binder for the asphalt concrete and the plant mix surfacing aggregate meeting the Montana Public Work's gradation presented in Table 5. The gradation bands in Table 5 represent the job mix target limits, which determine the suitability of aggregate. Provide the final job mix target gradation within the specified bands and uniformly graded from coarse to fine, not to vary from the low limit on one sieve to the high limit on the adjacent sieve, or vice-versa. For example, using the 3/8" and No. 4 sieves, a gradation of 73 percent and 48 percent passing their respective sieves is acceptable, 73 percent and 62 percent passing their respective sieves is not.

**TABLE 5: Plant Mix Surfacing Gradation**

| Sieve Size | % Passing Job Mix Target Bands | Job Mix Tolerances |
|---|---|---|
| 3/4" | 100 | --- |
| 1/2" | 83 - 93 | +/- 7 |
| 3/8" | 73 - 87 | +/- 7 |
| No. 4 | 47 - 63 | +/- 6 |
| No. 10 | 32 - 43 | +/- 6 |
| No. 40 | 15 - 25 | +/- 5 |
| No. 200 | 5 - 7 | +/- 2 |

The job mix formula establishes target values. During mix production, the gradations are to fall within the job mix limits presented in Table 5, i.e. if a QA job mix target of 6 has been selected for the No. 200 sieve and since the tolerance is ±2, the job mix gradation for production would be 4 - 8.

Placing the asphalt concrete plant mix surfacing in two 2-inch thick lifts and compacting each lift at an average relative compaction (ASTM D2041) of at least 93 percent. No individual sample is to be compacted to less than 92 percent.




## 3.6 Compaction and Fresh Concrete Testing Frequency

LSM recommends a compaction testing frequency presented in Table 6 for the bridge abutment and wing wall subgrades, wall backfill, and typical section compaction as well as fresh concrete sampling and testing. The bridge construction will be performed according to the Montana Departments of Transportation and the Montana Public Works Specifications.

**TABLE 6: Testing Frequency**

| **Compaction Testing** | |
|---|---|
| Beneath Abutment and Wing Wall Subgrades | 1 Test per 25 Lineal Feet of Wall |
| Abutment and Wing Wall Structural Fill | 1 Test per 25 Lineal Feet of Wall |
| Roadway Subgrade and Aggregates | 1 Test per 1,000 Square Feet |
| **Concrete Testing** | |
| Structural Concrete[1] | 1 Test per 50 Cubic Yards per Day |
| Non-Structural Concrete | 1 Test per Day |

[1.] Structural concrete includes all footings, foundation walls, slabs, and other load bearing elements.

# 4 BASIS OF RECOMMENDATIONS

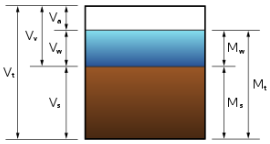
The analyses and recommendations submitted in this report are based upon the subsurface investigation. Often, variations occur within the subgrade, the nature and extent of which do not become evident until additional exploration or construction is conducted.

## 4.1 Use of Report

This report is for the exclusive use of DJ&A and their design team. In the absence of LSM's written approval, LSM makes no representation and assumes no responsibility to other parties regarding this report. The data, analyses, and recommendations may not be appropriate for other structures or purposes. Other parties contemplating other structures or purposes other than what this report was written are directed to contact LSM.

## 4.2 Level of Care

Services performed by LSM's personnel for this project have been conducted with the level of care and skill ordinarily exercised by members of the profession currently practicing in this area under similar budget and time restraints. No warranty, expressed or implied, is made.




**Professional Certification**

I hereby certify that this report was prepared by me and that I am a duly Licensed Professional Engineer under the laws of the State of Montana.




Todd Lorenzen 5/19/25

Todd Lorenzen, P.E.
Geotechnical Engineer

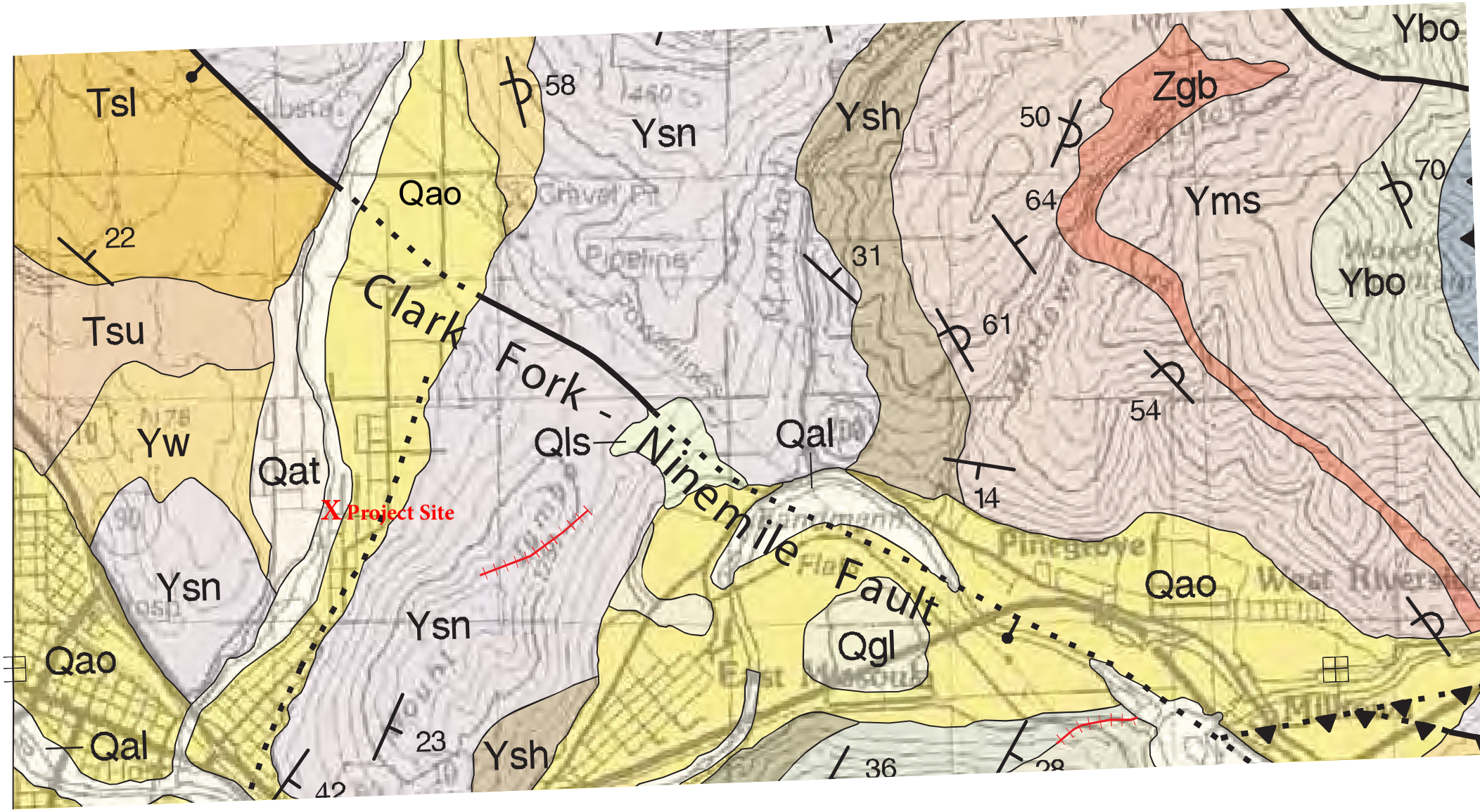
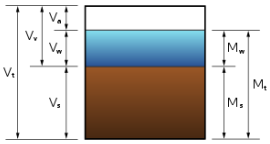



**Figure 1: Portion of the MBMG Open File Report 593, "Geologic Map of the Missoula East 30' x 60' Quadrangle", 2010; by Jeffrey Lonn, Catherine McDonald, James Sears, and Larry Smith.**




**Figure 2: Borehole Locations**




# APPENDIX A. LOGS OF BOREHOLE AND TESTING RESULTS

# GENERAL NOTES

**DRILLING & SAMPLING SYMBOLS:**

| | | | |
|---|---|---|---|
| SS: | Split Spoon - 1-3/8" I.D., 2" O.D., unless otherwise noted | CA: | Casing Advancer |
| ST: | Thin-Walled Tube - 2" O.D., unless otherwise noted | DA: | Drill Auger |
| CB: | California Sampler - 2" I.D., 2.5" O.D., unless otherwise noted | HA: | Hand Auger |
| DB: | Diamond Bit Coring - 4", NX, unless otherwise noted | RB: | Rock Bit |
| BS: | Bulk Sample or Auger Sample | GS: | Grab Sample |

The number of blows required to advance a standard 2-inch O.D. split-spoon sampler (SS) the last 12 inches of the total 18-inch penetration with a 140-pound hammer falling 30 inches is considered the "Standard Penetration" or "N-value". The field blow counts are reported for each 6-inch interval, or portion thereof if greater than 50 blows are required to advance the full 6-inch interval. For over-sized split spoon samplers, non-standard hammers, or non-standard drop heights, the field penetration values are reported on the bore log. The values must be corrected to obtain the N-value.

| | | | | | |
|---|---|---|---|---|---|
| WL: | Water Level | WS: | While Sampling | NE: | Not Encountered |
| WCl: | Wet Cave-In | WD: | While Drilling | | |
| DCI: | Dry Cave-In | BCR: | Before Casing Removal | | |
| AB: | After Boring | ACR: | After Casing Removal | | |

Groundwater table levels indicated on the boring logs are the levels measured in the borings at the times indicated. Groundwater table levels at other times and other locations across the site could vary. In pervious soils, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater table levels may not be possible with only short-term observations.

**DESCRIPTIVE SOIL CLASSIFICATION:** Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: gravel or sand. Cobbles and boulders are not part of the USCS system but are included, when present, as percentages. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; depending on their plasticity, they are described as clay or silt. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils are defined on the basis of their consistency.

**CONSISTENCY OF FINE-GRAINED SOILS**

| Unconfined Compressive Strength, Qu, psf | Standard Penetration or N-value (SS) Blows/Ft. | Consistency |
|---|---|---|
| < 500 | 0 - 1 | Very Soft |
| 500 - 1,000 | 2 - 4 | Soft |
| 1,001 - 2,000 | 5 - 8 | Medium Stiff |
| 2,001 - 4,000 | 9 - 15 | Stiff |
| 4,001 - 8,000 | 16 - 30 | Very Stiff |
| 8,000 + | 30 + | Hard |

**RELATIVE DENSITY OF COARSE-GRAINED SOILS**

| Standard Penetration or N-value (SS) Blows/Ft. | California Barrel (CB) Blows/Ft. | Relative Density |
|---|---|---|
| 0 - 4 | 0 - 6 | Very Loose |
| 5 - 10 | 7 - 18 | Loose |
| 11 - 30 | 19 - 58 | Medium Dense |
| 31 - 50 | 59 - 98 | Dense |
| 50 + | 99 + | Very Dense |

**RELATIVE PROPORTIONS OF SAND AND GRAVEL**

| Descriptive Term(s) of Other Constituents | Percent of Dry Weight |
|---|---|
| Trace | < 15 |
| With | 15 - 30 |
| Modifier | > 30 |

**USCS* GRAIN SIZE TERMINOLOGY**

| Major Component of Sample | Particle Size |
|---|---|
| Boulders | Over 12 in. (300mm) |
| Cobbles | 12 in. to 3 in. (300mm to 75 mm) |
| Gravel | 3 in. to #4 sieve (75mm to 4.75 mm) |
| Sand | #4 to #200 sieve (4.75mm to 0.075mm) |
| Silt or Clay | Passing #200 Sieve (0.075mm) |

*For AASHTO grain size the #4 sieve is replaced with the #10 sieve

**RELATIVE PROPORTIONS OF FINES**

| Descriptive Term(s) of Other Constituents | Percent of Dry Weight |
|---|---|
| Trace | < 5 |
| With | 5 - 12 |
| Modifiers | > 12 |

**PLASTICITY DESCRIPTION**

| Term | Plasticity Index |
|---|---|
| Non-Plastic | 0 |
| Slightly | 1 - 5 |
| Low | 6 - 10 |
| Medium | 11 - 20 |
| Highly | 21 - 40 |
| Very Highly | > 40 |

# GENERAL NOTES

Description of Rock Properties

**WEATHERING**

| | |
|---|---|
| Fresh | Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline. |
| Very Slight | Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline. |
| Slight | Rock generally fresh, joints stained, and discoloration extends into rock up to 1 in. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer. |
| Moderate | Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock. |
| Moderately Severe | All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick. |
| Highly | All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of strong rock usually left. |
| Very Highly | All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining. |
| Complete/Residual Soil | Rock reduced to "soil". Rock "fabric" not discernible or discernible only in small, scattered locations. Quartz may be present as dikes or stringers. |

**FIELD HARDNESS (for engineering description of rock not to be confused with Moh's scale for minerals)**

| | |
|---|---|
| Very Hard | Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist's pick. |
| Hard | Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen. |
| Moderately Hard | Can be scratched with knife or pick. Gouges or grooves to 1/4 in. deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow. |
| Medium | Can be grooved or gouged 1/16 in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1-in. maximum size by hard blows of the point of a geologist's pick. |
| Soft | Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure. |
| Very Soft | Can be carved with knife. Can be excavated readily with point of pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail. |

**Joint, Bedding and Foliation Spacing in Rock [a]**

| Spacing | Joints | Bedding/Foliation |
|---|---|---|
| Less than 2 in. | Very Close | Very Thin |
| 2 in. - 1 ft. | Close | Thin |
| 1 ft. - 3 ft. | Moderately Close | Medium |
| 3 ft.-10 ft. | Wide | Thick |
| More than 10 ft. | Very Wide | Very thick |

| Rock Quality Designation (RQD)[b] | | Joint Openness Descriptors | |
|---|---|---|---|
| ROD, as a percentage | Diagnostic description | Openness | Descriptor |
| Exceeding 90 | Excellent | No Visible Separation | Tight |
| 90 - 75 | Good | Less than 1/32 in. | Slightly Open |
| 74 - 50 | Fair | 1/32 to 1/8 in. | Moderately Open |
| 49 - 25 | Poor | 1/8 to 3/8 in. | Open |
| Less than 25 | Very poor | 1/2 in. to 1 1/4 in. | Moderately Wide |
| | | Greater than 1 1/4 in. | Wide |

a. Spacing refers to the distance normal to the planes of the described feature, which are parallel to each other or nearly so.

b. RQD (given as a percentage) = (Σ of core 4 in. and longer) / (length of run).

References: American Society of Civil Engineers Manuals and Reports on Engineering Practice - No. 56, American Society of Civil Engineers, 1976.
U.S. Department of the Interior, Bureau of Reclamation, Engineering Geology Field Manual.
AASHTO M145, 2010.

# UNIFIED SOIL CLASSIFICATION SYSTEM

| Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A] | | | | Soil Classification | |
|---|---|---|---|---|---|
| | | | | Group Symbol | Group Name [B] |
| Coarse Grained Soils More than 50% retained on No. 200 sieve | Gravels More than 50% of coarse fraction retained on No. 4 sieve | Clean Gravels Less than 5% fines | Cu ≥ 4 and 1≤ Cc ≤ 3 | GW | Well-graded Gravel [F] |
| | | | Cu < 4 and/or 1 > Cc > 3 | GP | Poorly graded gravel [F] |
| | | Gravels with Fines More than 12% fines | Fines classify as ML or MH | GM | Silty Gravel [F,G,H] |
| | | | Fines classify as CL or CH | GC | Clayey Gravel [F,G,H] |
| | Sands 50% or more of coarse fraction passes No. 4 sieve | Clean Sands Less than 5% fines | Cu ≥ 6 and 1 ≤ Cc ≤ 3 | SW | Well-graded Sand [I] |
| | | | Cu < 6 and/or 1 > Cc > 3 | SP | Poorly graded Sand [I] |
| | | Sands with Fines More than 12% fines | Fines classify as ML or MH | SM | Silty Sand [G,H,I] |
| | | | Fines classify as CL or CH | SC | Clayey Sand [G,H,I] |
| Fine-Grained Soils 50% or more passes the No. 200 sieve | Silts and Clays Liquid limit less than 50 | inorganic | PI > 7 and plots on or above "A" line | CL | Lean Clay [K,L,M] |
| | | | PI < 4 or plots below "A" line | ML | Silt [K,L,M] |
| | | organic | Liquid limit - oven dried / Liquid limit - not dried < 0.75 | OL | Organic Clay [K,L,M,N] |
| | | | | | Organic Silt [K,L,M,O] |
| | Silts and Clays Liquid Limit 50 or more | inorganic | PI plots on or above "A" Line | CH | Fat Clay [K,L,M] |
| | | | PI plots below "A" line | MH | Elastic Silt [K,L,M] |
| | | organic | Liquid limit - oven dried / Liquid limit - not dried < 0.75 | OH | Organic Clay [K,L,M,P] |
| | | | | | Organic Silt [K,L,M,Q] |
| Highly organic soils | Primarily organic matter, dark in color, and organic odor | | | PT | Peat |

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

[B] If field sample contains cobbles and/or boulders, add "with cobbles or boulders, or both" as necessary to group name.

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

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

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

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

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

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

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

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

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

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

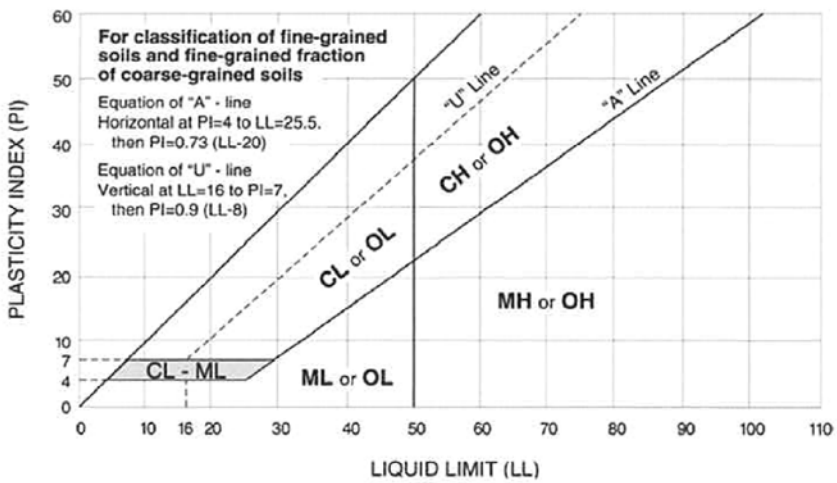
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

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

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

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

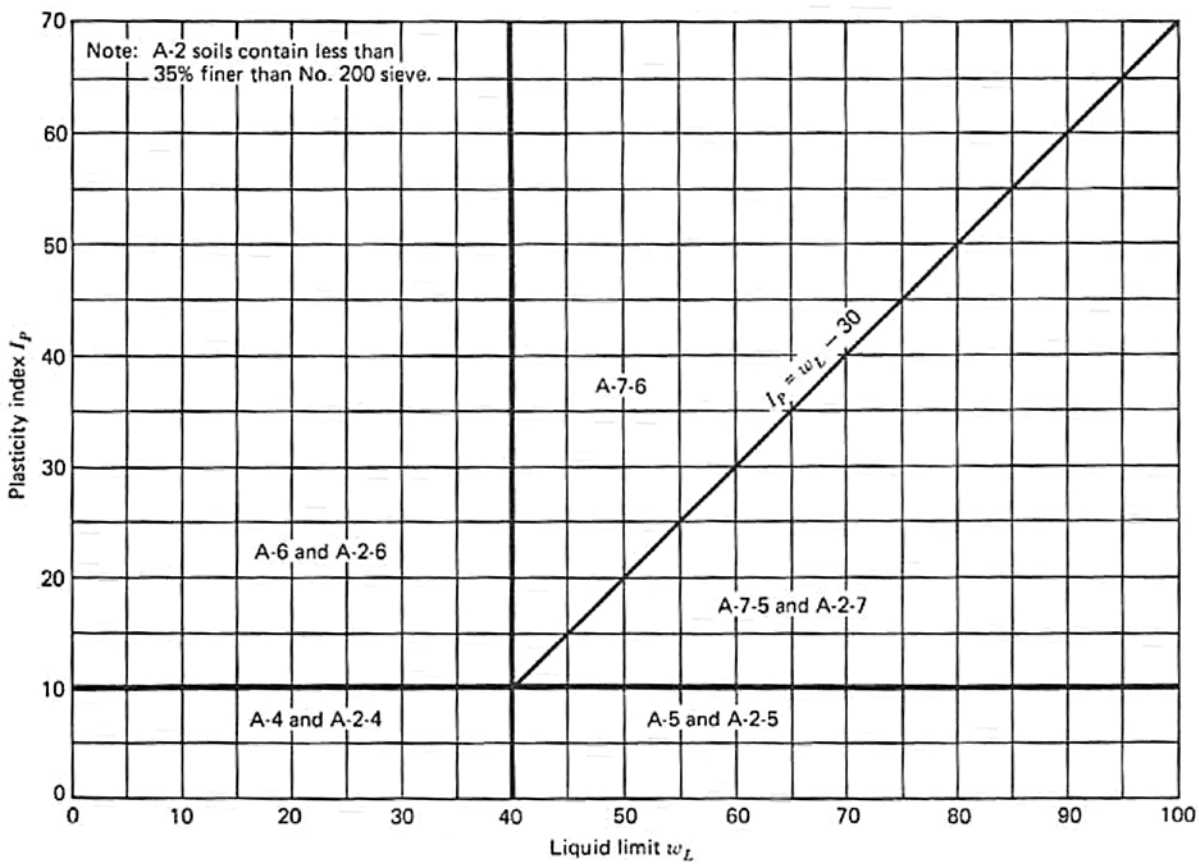
[Q] PI plots below "A" line.



# AASHTO SOIL CLASSIFICATION SYSTEM

| **General classification** | **Granular materials** (35 percent or less of total sample passing No. 200) | | | | | | | **Silt-clay material** (More than 35 percent of total sample passing No. 200) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Group classification | A-1 | | A-3 | A-2 | | | | A-4 | A-5 | A-6 | A-7 [1] |
| | A-1-a | A-1-b | | A-2-4 | A-2-5 | A-2-6 | A-2-7 | | | | A-7-5<br>A-7-6 |
| Sieve analysis percent passing<br>No. 10<br>No. 40<br>No. 200 | <br>50 max<br>30 max<br>15 max | <br><br>50 max<br>25 max | <br><br>51 max<br>10 max | <br><br><br>35 max | <br><br><br>35 max | <br><br><br>35 max | <br><br><br>35 max | <br><br><br>36 min | <br><br><br>36 min | <br><br><br>36 min | <br><br><br>36 min |
| Characteristics of fraction passing No. 40<br>Liquid limit, $w_L$<br>Plastic Index, $I_P$ | <br><br>6 max | | <br><br>NP | <br>40 max<br>10 max | <br>41 min<br>10 max | <br>40 max<br>11 min | <br>41 min<br>11 min | <br>40 max<br>10 max | <br>41 min<br>10 max | <br>40 max<br>11 min | <br>41 min<br>11 min |
| Significant constituent materials | gravel and sand | | fine sand | silty and clayey gravel and sand | | | | silty soils | | clayey soils | |

[1] Plasticity index of A-7-5 subgroup is equal to or less than LL minus 30. Plasticity index of A-7-6 subgroup is greater than LL minus 30.



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Missoula, MT 59808
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# BORING NUMBER BH-01



**CLIENT** DJ&A
**PROJECT NAME** Lolo Street Bridge
**PROJECT NUMBER** E25
**PROJECT LOCATION** Missola
**DATE STARTED** 2/27/25 **COMPLETED** 2/27/25
**GROUND ELEVATION** 3311 ft **HOLE SIZE** 6 inches
**DRILLING CONTRACTOR** O'Keefe Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Geoprobe 8150 LS Sonic Drill
**AT TIME OF DRILLING** 18.00 ft / Elev 3293.00 ft
**LOGGED BY** Lorenzen **CHECKED BY** Lorenzen
**AT END OF DRILLING** 18.00 ft / Elev 3293.00 ft
**NOTES** N46° 53.096' W113° 58.266'
**AFTER DRILLING** ---

| DEPTH (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN. (tsf) | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS: LIQUID LIMIT | ATTERBERG LIMITS: PLASTIC LIMIT | ATTERBERG LIMITS: PLASTICITY INDEX | FINES CONTENT (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | (GM) Silty GRAVEL with Sand; rounded to subangular; moist; dark brown (10YR 3/3) matrix; no reaction to 10% HCl solution. Fines are non-plastic. | | | | | | | | | | |
| | | Drilling rate from 0 to 5 feet = 125 ft/hr. | RC | | | | | 5 | | | | |
| 2.5 | | (GP-GM) Poorly Graded Gravel with Silt and Sand, frequent Cobbles; subangular; dry; light gray (2.5Y 7/1) matrix; no reaction to10% HCl solution. Fines are non-plastic. | RC | | | | | 2 | | | | |
| 5.0 | | (GP-GM) Poorly Graded Gravel with Silt and Sand, frequent Cobbles, trace white Coatings; rounded; dry; brown (10YR 5/3) matrix; very dense; no to very weak reaction to 10% HCl solution. Fines are non-plastic. Cylinder Clamp weld broke at the 5-foot depth. Approximately 4 hours to repair from a local shop. | SPT | 44 | 7-26-27 (53) | | | 2 | | | | |
| 7.5 | | Drilling rate from 5 to 10 feet = 130 ft/hr. | RC | | | | | 3 | | | | |
| 10.0 | | (GP-GM) Poorly Graded Gravel with Silt and Sand, frequent Cobbles; rounded to subrounded; dry; dark yellowish brown (10YR 4/4) to light gray (10YR 7/1) and grayish brown (10YR 5/2) matrices; very dense; medium reaction to 10% HCl solution. Fines are non-plastic. | RC<br>SPT | 100 | 41-50/5" | | | 5<br>2 | | | | |
| | | | RC | | | | | 1 | | | | |
| 12.5 | | Drilling rate from 10 to 15 feet = 30 ft/hr. | RC | | | | | 3 | | | | |
| 15.0 | | | | | | | | | | | | |

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Lorenzen Soil Mechanics, Inc.
5730 Exprressway Unit H
Missoula, MT 59808
Telephone: 406-830-0633

# BORING NUMBER BH-01



**CLIENT** DJ&A **PROJECT NAME** Lolo Street Bridge

**PROJECT NUMBER** E25 **PROJECT LOCATION** Missola

| DEPTH (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN. (tsf) | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS: LIQUID LIMIT | ATTERBERG LIMITS: PLASTIC LIMIT | ATTERBERG LIMITS: PLASTICITY INDEX | FINES CONTENT (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15.0 | | (GP-GM) Poorly Graded Gravel with Silt and Sand, frequent Cobbles, occasional Boulder, trace white Coatings; rounded to subrounded; dry; brown (10YR 5/3) matrix; very dense; weak reaction to10% HCl solution. Fines are non-plastic. Drilling rate from 15 to 17.5 feet = 20 ft/hr. | SPT | 100 | 50/4" | | | 4 | | | | |
| | | | RC | | | | | | | | | |
| 17.5 | | (SP-SM) Silty SAND with Gravel, frequent Cobbles; wet; grayish brown (10YR 5/2) to brown (10YR 5/3) matrices; very dense; no reaction to 10% HCl solution. Fines are non-plastic. Gravels and Cobbles are rounded to subrounded. Drilling rate from 17.5 to 20 feet = 15 ft/hr. | RC | | | | | 4 | | | | |
| 20.0 | | | SPT | 100 | 50/6" | | | 13 | | | | |
| | | | RC | | | | | 5 | | | | |
| 22.5 | | Drilling rate from 20 to 25 feet = 100 ft/hr. | RC | | | | | 5 | | | | |
| | | | RC | | | | | 7 | | | | |
| 25.0 | | | SPT | 100 | 50/5" | | | 15 | | | | |

Rattlesnake Creek water surface ~ 12.7 below the top of bridge deck.

Bottom of borehole at 25.4 feet.

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Telephone: 406-830-0633

# BORING NUMBER BH-02



**CLIENT** DJ&A
**PROJECT NAME** Lolo Street Bridge
**PROJECT NUMBER** E25
**PROJECT LOCATION** Missola
**DATE STARTED** 2/28/25 **COMPLETED** 2/28/25
**GROUND ELEVATION** 3316 ft **HOLE SIZE** 6 inches
**DRILLING CONTRACTOR** O'Keefe Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Geoprobe 8150 LS Sonic Drill
▽ **AT TIME OF DRILLING** 14.50 ft / Elev 3301.50 ft
**LOGGED BY** Lorenzen **CHECKED BY** Lorenzen
▼ **AT END OF DRILLING** 14.50 ft / Elev 3301.50 ft
**NOTES** N46° 53.108' W113° 58.298'
**AFTER DRILLING** ---

| DEPTH (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN. (tsf) | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS: LIQUID LIMIT | ATTERBERG LIMITS: PLASTIC LIMIT | ATTERBERG LIMITS: PLASTICITY INDEX | FINES CONTENT (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | ASPHALT - 5 inches thick | | | | | | | | | | |
| | | (GW) BASE COURSE ~ 1 foot thick | | | | | | | | | | |
| | | (GP-GM) Poorly-Graded GRAVEL with Silt and Sand, frequent Cobbles; subangular to angular; dry; yellowish brown (10YR 5/4) matrix; medium reaction to 10% HCl solution; | | | | | | | | | | |
| 2.5 | | Drilling rate from 0 to 5 feet = 35 ft/hr. | RC | | | | | 5 | | | | |
| 5.0 | | (GP-GM) Poorly-Graded GRAVEL with Silt and Sand; subangular to angular; dry; brown (10YR 4/3) matrix; dense; medium reaction to 10% HCl solution. Fines are non-plastic. | SPT | 100 | 41-22-18 (40) | | | 3 | | | | |
| 7.5 | | Drilling rate from 5 to 10 feet = 170 ft/hr. | RC | | | | | 3 | | | | |
| 10.0 | | (SP-SM) Poorly-Graded SAND with Silt and Gravel frequent Cobbles; dry; brown (7.5YR 4/2); medium dense; medium reaction to 10% HCl solution. Gravels are rounded to subrounded. | SPT | 39 | 8-9-7 (16) | | | 3<br>3 | | | | |
| 12.5 | | Drilling rate from 10 to 15 feet = 25 ft/hr. | RC | | | | | | | | | |
| 15.0 | | ▼ | | | | | | | | | | |

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Lorenzen Soil Mechanics, Inc.
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Missoula, MT 59808
Telephone: 406-830-0633

# BORING NUMBER BH-02



**CLIENT** DJ&A **PROJECT NAME** Lolo Street Bridge

**PROJECT NUMBER** E25 **PROJECT LOCATION** Missola

| DEPTH (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN. (tsf) | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS: LIQUID LIMIT | ATTERBERG LIMITS: PLASTIC LIMIT | ATTERBERG LIMITS: PLASTICITY INDEX | FINES CONTENT (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15.0 | | (SP-SM) Poorly-Graded SAND with Silt and Gravel frequent Cobbles; dry; brown (7.5YR 4/2); medium dense; medium reaction to 10% HCl solution. Gravels are rounded to subrounded. *(continued)* | SPT | 35 | 3-28-50/0" | | | 22 | NP | NP | NP | 12 |
| | | | RC | | | | | 21 | | | | |
| | | (GP-GM) Poorly-Graded GRAVEL with Silt and Sand, frequent Cobbles; subangular to angular; wet; very dark grayish brown (10YR 3/2) matrix; very dense; medium reaction to 10% HCl solution. Fines are non-plastic. | | | | | | | | | | |
| 17.5 | | Drilling rate from 15 to 20 feet = 35 ft/hr. | RC | | | | | 6 | | | | |
| 20.0 | | (SM) Silty SAND with Gravel, occasional Cobble; damp; grayish brown (10YR 5/2) to light grayish brwon (10YR 6/2); very dense; no reaction to 10% HCl solution. Fines are non-plastic. Gravels are rounded to subrounded. | SPT | 94 | 30-39-39 (78) | | | 5 | NP | NP | NP | 24 |
| | | | RC | | | | | 7 | | | | |
| 22.5 | | Drilling rate from 25 to 30 feet = 20 ft/hr. | RC | | | | | 5 | NP | NP | NP | 28 |
| 25.0 | | (SM) Silty SAND with Gravel; wet; dark gray (2.5Y 4/1); very dense; no reaction to 10% HCl solution. Fines are non-plastic. Gravels are rounded to subrounded. | SPT | 100 | 50/5" | | | 15 | NP | NP | NP | 13 |
| | | | RC | | | | | 5 | | | | |
| 27.5 | | (GM) Silty GRAVEL with Sand; rounded to subrounded; wet; grayish brown (2.5Y 5/2) matrix; very dense; no reaction to 10% Cl solution. Fines are non-plastic. | RC | | | | | 8 | NP | NP | NP | 25 |
| | | (GM) Silty GRAVEL with Sand; frequent Cobbles; rounded to subrounded; dry; white (2.5Y 8/2) matrix; very dense; no reaction to 10% Cl solution. Fines are non-plastic. | | | | | | | | | | |
| 30.0 | | Drilling rate from 30 to 35 feet = 40 ft/hr. | RC | | | | | 3 | NP | NP | NP | 31 |
| | | (GM) Silty GRAVEL with Sand, frequent Cobbles; rounded to subrounded; wet; grayish brown (2.5Y 5/2) matrix; very dense; no reaction to 10% Cl solution. Fines are non-plastic. | SPT | 100 | 47-50/6" | | | 5 | | | | |

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Lorenzen Soil Mechanics, Inc.
5730 Exprressway Unit H
Missoula, MT 59808
Telephone: 406-830-0633

# BORING NUMBER BH-02



**CLIENT** DJ&A **PROJECT NAME** Lolo Street Bridge

**PROJECT NUMBER** E25 **PROJECT LOCATION** Missola

| DEPTH (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN. (tsf) | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS: LIQUID LIMIT | ATTERBERG LIMITS: PLASTIC LIMIT | ATTERBERG LIMITS: PLASTICITY INDEX | FINES CONTENT (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 32.5 | | (GM) Silty GRAVEL with Sand, frequent Cobbles; rounded to subrounded; wet; grayish brown (2.5Y 5/2) matrix; very dense; no reaction to 10% Cl solution. Fines are non-plastic. *(continued)* Drilling rate from 35 to 40 feet = 40 ft/hr. | RC | | | | | 8 | | | | |
| 35.0 | | (GM) Silty GRAVEL with Sand, frequent Cobbles; rounded to subrounded; wet; yellowish brown (10YR 5/4) matrix; very dense; no reaction to 10% Cl solution. Fines are non-plastic. | SPT | 100 | 50/4" | | | 16 | | | | |
| | | | RC | | | | | 9 | | | | |
| 37.5 | | | RC | | | | | 10 | | | | |
| | | | RC | | | | | 7 | | | | |
| 40.0 | | | SPT | 61 | 13-38-32 (70) | | | 9 | | | | |

Rattlesnake Creek water surface ~ 12.7 below the top of bridge deck.

Bottom of borehole at 41.5 feet.

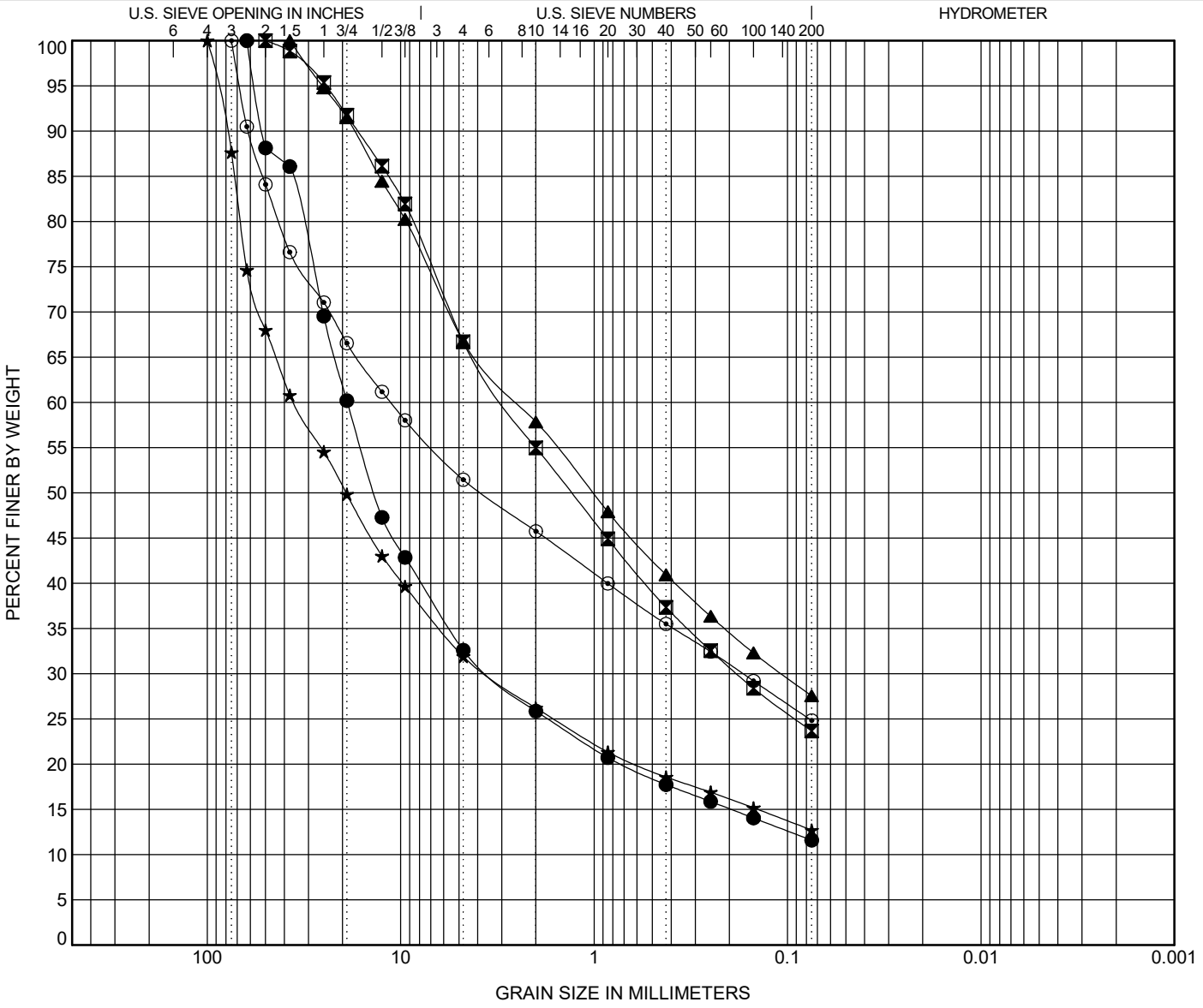
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# GRAIN SIZE DISTRIBUTION

Lorenzen Soil Mechanics, Inc.
5730 Exprressway Unit H
Missoula, MT 59808
Telephone: 406-830-0633

**CLIENT** DJ&A **PROJECT NAME** Lolo Street Bridge

**PROJECT NUMBER** E25 **PROJECT LOCATION** Missola




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| | BOREHOLE | DEPTH | Classification | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **BH-02** | **15.0** | **POORLY GRADED GRAVEL with SILT and SAND(GP-GM)** | **NP** | **NP** | **NP** | **12.82** | **394.77** |
| ⊠ | **BH-02** | **20.0** | **SILTY SAND with GRAVEL(SM)** | **NP** | **NP** | **NP** | | |
| ▲ | **BH-02** | **22.5** | **SILTY SAND with GRAVEL(SM)** | **NP** | **NP** | **NP** | | |
| ★ | **BH-02** | **25.0** | **SILTY GRAVEL with SAND(GM)** | **NP** | **NP** | **NP** | | |
| ⊙ | **BH-02** | **26.6** | **SILTY GRAVEL with SAND(GM)** | **NP** | **NP** | **NP** | | |

| | BOREHOLE | DEPTH | D100 | D60 | D30 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **BH-02** | **15.0** | **62.5** | **18.881** | **3.403** | | **67.4** | **21.0** | **11.6** | |
| ⊠ | **BH-02** | **20.0** | **50** | **2.898** | **0.183** | | **33.3** | **43.0** | **23.7** | |
| ▲ | **BH-02** | **22.5** | **37.5** | **2.467** | **0.107** | | **33.2** | **39.2** | **27.6** | |
| ★ | **BH-02** | **25.0** | **100** | **35.609** | **3.557** | | **55.7** | **19.2** | **12.7** | |
| ⊙ | **BH-02** | **26.6** | **75** | **11.287** | **0.17** | | **48.5** | **26.6** | **24.8** | |

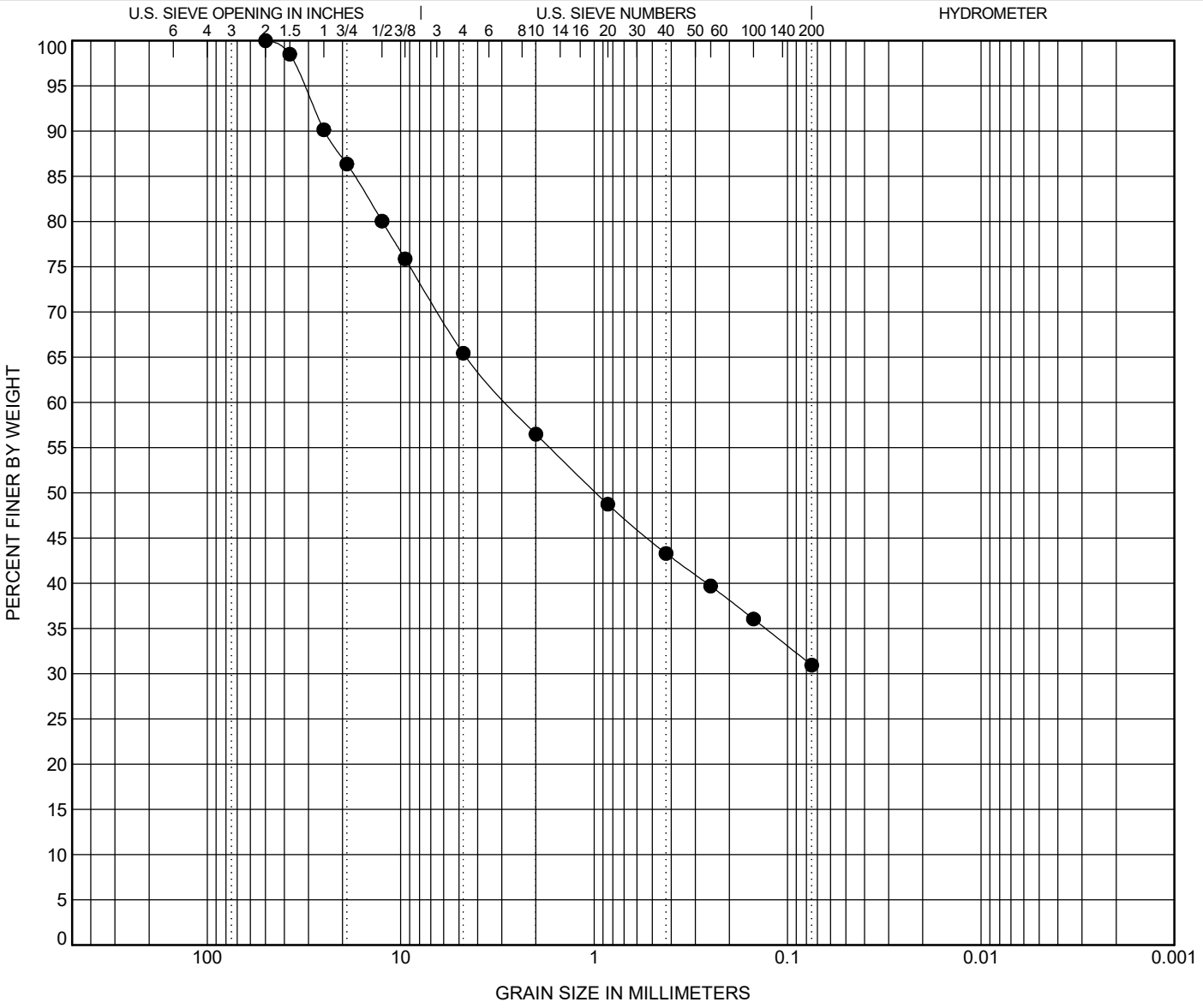
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# GRAIN SIZE DISTRIBUTION

Lorenzen Soil Mechanics, Inc.
5730 Exprressway Unit H
Missoula, MT 59808
Telephone: 406-830-0633

**CLIENT** DJ&A **PROJECT NAME** Lolo Street Bridge

**PROJECT NUMBER** E25 **PROJECT LOCATION** Missola

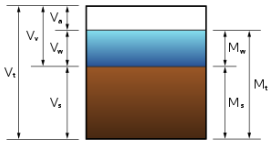



| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| | BOREHOLE | DEPTH | Classification | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **BH-02** | **27.9** | **SILTY GRAVEL with SAND(GM)** | **NP** | **NP** | **NP** | | |

| | BOREHOLE | DEPTH | D100 | D60 | D30 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **BH-02** | **27.9** | **50** | **2.809** | | | **34.6** | **34.5** | **30.9** | |

GRAIN SIZE - GINT STD US LAB.GDT - 3/24/25 18:32 - C:\USERS\TODD LORENZEN\DOCUMENTS\LORENZEN SOIL MECHANICS\DJ&A\LOLO STREET BRIDGE\5.0 DELIVERABLES\LOLO STREET BRIDGE.GPJ




# APPENDIX B. PHOTOGRAPHS



Description: BH-01 Location. View is to the northeast.




Description: BH-01 Location. View is to the northwest.

Lorenzen Soil Mechanics, Inc.

Project: Lolo Street Bridge - Missoula



Description: BH-01 Location. View is to the southwest.



Description: BH-01 Location. View is to the southeast.

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Project: Lolo Street Bridge - Missoula



Description: BH-01 Retrieving sonic drill sample from 0 to 5 feet.




Description: BH-01 SS sample from the 5- to 6.5-foot depth.

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Project: Lolo Street Bridge - Missoula



Description: BH-01 Hydraulic clamp broke. Approximately 4 hours were needed to repair and replace the clamp.




Description: BH-01 SS sample from the 10- to 10.8-foot depth.

Lorenzen Soil Mechanics, Inc.

Project: Lolo Street Bridge - Missoula



Description: BH-01 Sonic sample from 10 to 15 feet before being extruded into its plastic bag.




Description: BH-01 SS sample from the 15- to 15.33-foot depth.

Lorenzen Soil Mechanics, Inc.

Project: Lolo Street Bridge - Missoula




Description: BH-01 SS sample from the 20- to 20.45-foot depth.




Description: BH-01 SS sample from the 25- to 25.4-foot depth.

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Description: BH-02 Location. View is to the south.



Description: BH-02 Location. View is to the southeast.

Lorenzen Soil Mechanics, Inc.

Project: Lolo Street Bridge - Missoula



Description: BH-02 Location. View is to the northeast.



Description: BH-02 Location. View is to the north.

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Description: BH-02 SS sample from the 5- to 6.5-foot depth.




Description: BH-02 SS sample from the 10- to 11.5-foot depth.

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Description: BH-02 SS sample from the 15- to 16.1-foot depth.




Description: BH-02 SS sample from the 20- to 21.5-foot depth.

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Description: BH-02 SS sample from the 25- to 25.45-foot depth.




Description: BH-02 SS sample from the 30- to 31-foot depth.

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Description: BH-02 SS sample from the 35- to 35.3-foot depth.




Description: 4-inch diameter core barrel bit and its catcher cage.

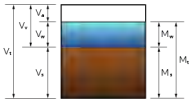
Lorenzen Soil Mechanics, Inc.

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Description: BH-02 SS sample from the 40- to 41.5-foot depth.

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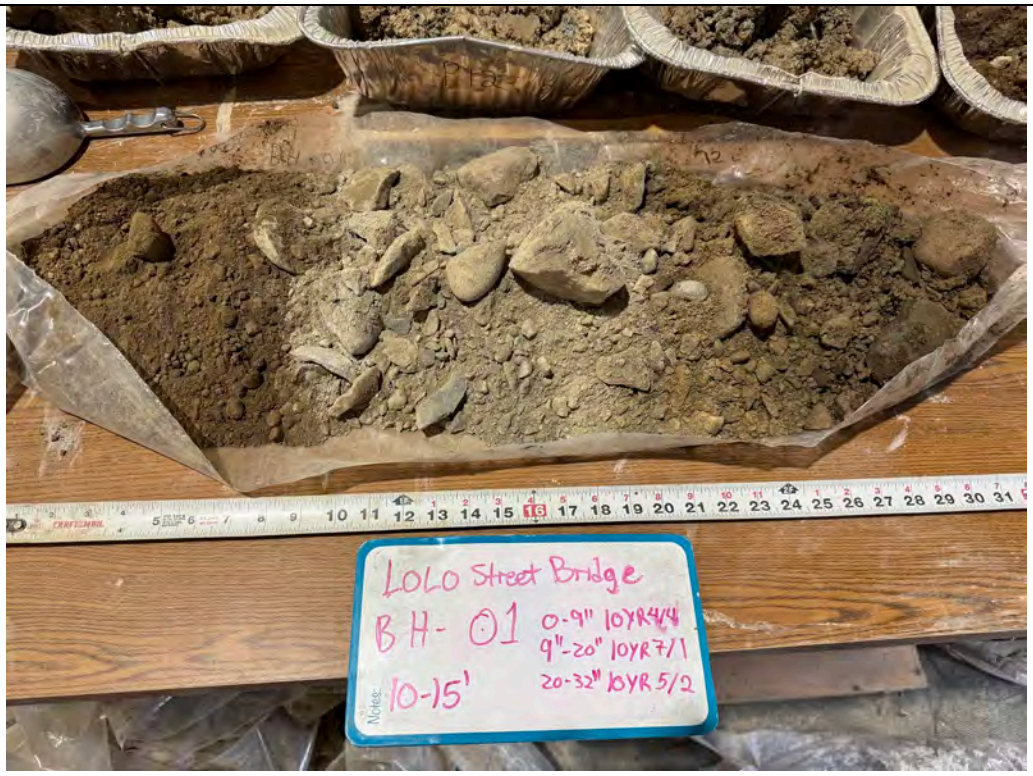

Description: BH-01 Moisture content SPT samples prior to being placed into the drying oven.



Description: BH-01 Moisture content SPT samples after being taken out of the drying oven.

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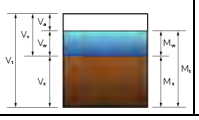



Description: BH-01 Sonic tube sample from 10 to 15 feet.




Description: BH-01 Sonic tube sample from 17.5 to 20 feet.

Lorenzen Soil Mechanics, Inc.



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Description: BH-01 Sonic tube sample from 20 to 25 feet.



Description: Various sonic tube samples prior to being placed into the drying oven.

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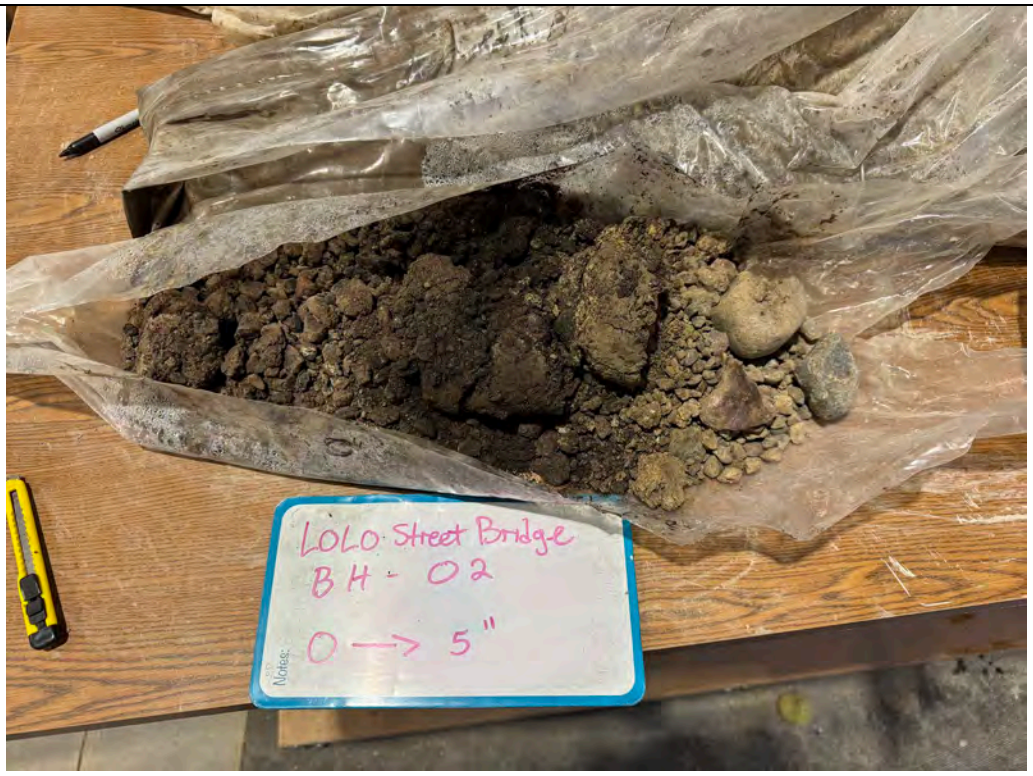
Description: BH-02 Moisture content SPT samples prior to being placed into the drying oven.



Description: BH-02 Moisture content SPT samples after being taken out the drying oven.

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Project: Lolo Street Bridge - Missoula



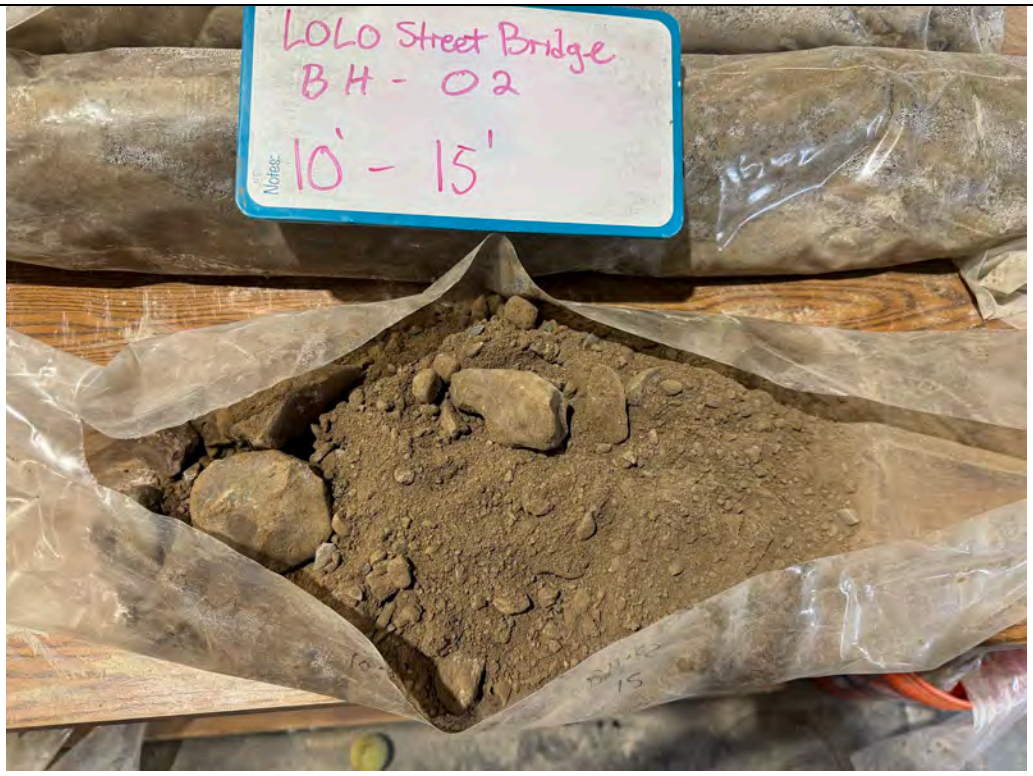

Description: BH-02 Sonic tube sample from 0 to 5 feet. Units are mislabeled as inches.




Description: BH-02 Sonic tube sample from 5 to 10 feet.

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Description: BH-02 Sonic tube sample from 10 to 15 feet.




Description: BH-02 Sonic tube sample from 15 to 20 feet.

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Project: Lolo Street Bridge - Missoula




Description: BH-02 Sonic tube sample from 20 to 25 feet.




Description: BH-02 Sonic tube sample from 25 to 30 feet.

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Project: Lolo Street Bridge - Missoula




Description: BH-02 Sonic tube sample from 30 to 35 feet.




Description: BH-02 Sonic tube sample from 35 to 40 feet.

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Project: Lolo Street Bridge - Missoula




Description: 1966 Construction plaque on the left bank's abutment.



Description: Upstream side of the Lolo Street Bridge. The channel is well-armored.

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Project: Lolo Street Bridge - Missoula

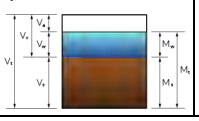


Description: Spalling concrete of the side rail on the bridge's downstream left bank.



Description: Channel is well-armored. Downstream side of the bridge. View is toward the right bank.

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Project: Lolo Street Bridge - Missoula



Description: Riprap placed as fill in front of the left bank's abutment wall. There is a gap beneath the foundation wall. The footings are likely beneath the buttress to the right.



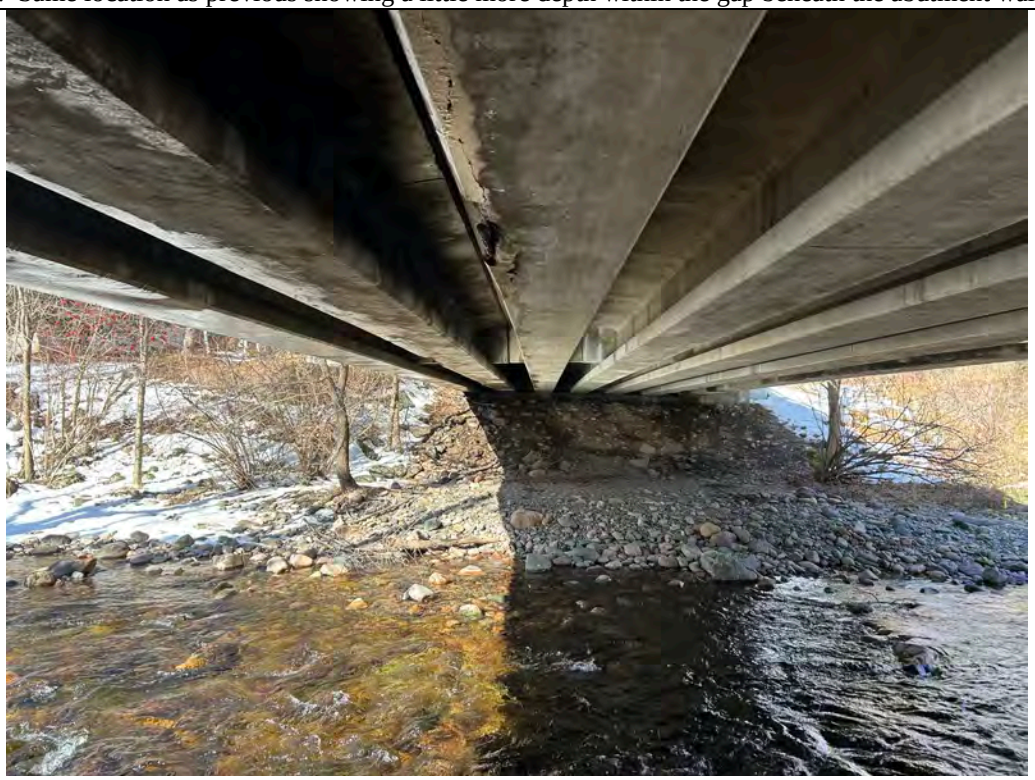
Description: Inside the gap beneath the abutment wall.

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Project: Lolo Street Bridge - Missoula

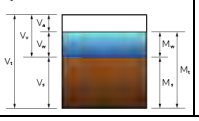


Description: Same location as previous showing a little more depth within the gap beneath the abutment wall.



Description: Concrete beams showing some distress. View is toward the right bank.

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Project: Lolo Street Bridge - Missoula



Description: Exposed rebar in one of the middle concrete beams. View is toward the right bank.



Description: Exposed rebar in one of the middle concrete beams.

Lorenzen Soil Mechanics, Inc.

Project: Lolo Street Bridge - Missoula



Description: Upstream side of the bridge. View is to the right bank. Earlier right abutment is in front of the large tree.



Description: Right abutment wall with fill placed to near the top of the wall.

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Project: Lolo Street Bridge - Missoula



Description: Fill includes occasional boulder, frequent cobbles, gravel, sand, and fines.



Description: Rattlesnake Creek's well-armored channel. View is toward the boulder/cobble fill at the left bank's abutment.

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Project: Lolo Street Bridge - Missoula



Description: Right bank – Exposed rebar on downstream concrete beam.



Description: Cracking in concrete beams near the right bank abutment.

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Project: Lolo Street Bridge - Missoula



Description: Cracking in concrete beams near the right bank abutment. View is upstream toward the left bank.



Description: Cracking in concrete beams near the right bank abutment. View is toward the left bank abutment.

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Project: Lolo Street Bridge - Missoula



Description: Earlier right bank concrete abutment. View is to the west.



Description: Earlier left bank concrete abutment. View is to the east.

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