ADDENDUM NO. 1 - OUTLINE AND SUMMARY INFORMATION

<table>
<thead>
<tr>
<th>Project Name: BART Farm Ag Storage Building</th>
<th>PPA No.: 16-0054</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location: Bozeman, Montana 59717</td>
<td>Date: February 9, 2017</td>
</tr>
</tbody>
</table>

To: All Plan Holders of Record

The Plans and Specification prepared by Dennis Rafensperger Architect dated January 23, 2017, shall be clarified and added as follow. The bidder proposes to perform all the following clarifications or changes. It is understood that the Base Bid shall include any modification of Work or Additional Work that may be required by reason of the following change or clarifications.

The Bidders are to acknowledge the receipt of this Addendum by inserting its number and date into their Bid Forms. Failure to acknowledge may subject the Bidder to disqualification and rejection of the bid. This Addendum forms part of the Contract Documents as if bound therein and modifies them as follows:

I. GENERAL INFORMATION
   A. …Request for Geotechnical Report

II. ATTACHMENTS
   A. ….MSU BART Building Geotech Report July 2016 (TDH Engineering)
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♦ Test Pit Location Map (Figure 1)
♦ Logs of Exploratory Test Pits (Figures 2 through 4)
♦ Laboratory Test Data (Figures 5 and 6)
♦ Soil Classification and Sampling Terminology for Engineering Purposes
♦ Classification of Soils for Engineering Purposes
GEOTECHNICAL REPORT
MSU BART FARM BUILDING
BOZEMAN, MONTANA

1.0 EXECUTIVE SUMMARY

The geotechnical investigation for the pre-engineered metal building to be located at the Bozeman Agricultural Research and Teaching (BART) Farm in Bozeman, Montana encountered three to four feet of surficial lean clay underlain by poorly-graded gravel with clay and sand. The seismic site class is D, and the risk of seismically-induced liquefaction or soil settlement is considered low and does not warrant additional evaluation. The primary geotechnical concern regarding this project is the presence of weak, compressible surficial soils; however, necessary improvements will be minor with standard frost depth footings. The site is suitable for conventional shallow foundations bearing on native gravel or structural fill extending to native gravel with a recommended allowable bearing of 4,000 pounds per square foot (psf) provided the recommendations included in this report are followed.
2.0 INTRODUCTION

2.1 Purpose and Scope

This report presents the results of our geotechnical study for the pre-engineered metal building to be located at the Bozeman Agricultural Research and Teaching (BART) Farm in Bozeman, Montana. The purpose of the geotechnical study is to determine the general surface and subsurface conditions at the proposed site and to develop geotechnical engineering recommendations for support of the proposed structure. This report describes the field work and laboratory analyses conducted for this project, the surface and subsurface conditions encountered, and presents our recommendations for the proposed foundations and related site development.

Our field work included excavating three test pits across the proposed site. Samples were obtained from the test pits and returned to our Great Falls laboratory for testing. Laboratory testing was performed on selected soil samples to determine engineering properties of the subsurface materials. The information obtained during our field investigations and laboratory analyses was used to develop recommendations for the design of the proposed foundation systems.

This study is in general accordance with the proposal submitted by Kyle Scarr, P.E. of our firm dated May 10, 2016. Our work was authorized to proceed by Mr. Dennis Raffensperger by his signed acceptance of our proposal.

2.2 Project Description

It is our understanding that the proposed project consists of, in part, a pre-engineered metal framed structure being approximately 60 by 80 feet in plan. The structure is proposed to be supported on conventional shallow foundations incorporating slab-on-grade construction. Structural loads had not been developed at the time of this report. However, for the purpose of our analysis, we have assumed that column loads will be less than 100 kips and wall loads, if any, will be less than 5,000 pounds per lineal foot. If the assumed design values presented above vary from the actual project parameters, the recommendations presented in this report should be reevaluated. Site development will most likely include landscaping and exterior concrete flatwork.
3.0 SITE CONDITIONS

3.1 Geology and Physiography

The site is geologically characterized as containing upper tertiary sediment according to the Montana Bureau of Mines and Geology (MBMG), Geologic Map of Montana. Generally, the surface is composed of varying thicknesses of silt and/or clay deposits overlying alluvial fan deposits of well-graded gravel with sand. The gravel is predominantly subrounded to angular and contains cobbles and minor amounts of silt and/or clay. Reportedly, the local alluvial fan deposits extend down to depths of at least 165 feet.

Based on the subsurface conditions encountered within the limited depth of investigation, the site is considered to fall under seismic Site Class D. The appropriate 2012 International Building Code (IBC) seismic design parameters for the site include site coefficients of 1.22 and 1.98 for $F_a$ and $F_v$, respectively. The recommended design spectral response accelerations at short periods ($SD_s$) and at 1-second period ($SD_1$) are 0.590g and 0.279g, respectively. These values represent two-thirds of the mapped response accelerations following correction for the appropriate site classification. The likelihood of seismically-induced soil liquefaction or settlement for this project is low and does not warrant additional evaluation.
3.2 Surface Conditions

The proposed project site presently consists of agricultural fields with native grasses. Based on background information and site observations, the site slopes downward toward the northwest at slopes ranging from one to three percent. The topography is best described as gently sloping.

3.3 Subsurface Conditions

3.3.1 Soils

The subsurface soil conditions appear to be relatively consistent based on our exploratory excavating and soil sampling. In general, the subsurface soil conditions encountered within the test pits consist of approximately three to four feet of surficial lean clay underlain by poorly-graded gravel with clay and sand extending to at least 8.2 feet, the maximum depth investigated.

The subsurface soils are described in detail on the enclosed test pit 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.

**LEAN CLAY**
Classifications range from lean clay to gravelly lean clay with sand. These materials appear to be soft to stiff based on the field investigation and the excavation effort required. Samples of the material contained between 4.0 and 27.4 percent gravel, between 13.3 and 20.0 percent sand, and between 52.6 and 82.7 percent fines (clay and silt). The lean clays exhibit liquid limits ranging from 33 to 35 percent and plasticity indices ranging from 11 to 14 percent. The natural moisture contents varied from 9 to 16 percent and averaged 12 percent.

**ALLUVIAL GRAVELS**
The native alluvial gravel deposits were field classified as poorly-graded gravel with clay and sand and are considered to be relatively dense based on the excavation effort required during our field investigation. No samples were taken of this soil for laboratory testing.

3.3.2 Ground Water

Ground water was encountered within the test pits at depths ranging from 5.5 to 6.0 feet below the ground surface. Based on the ground surface elevations, this equates to water level elevations ranging from 4,905.5 to 4,906.6 feet. Water levels were measured at the
time of excavation. The presence or absence of observed ground water may 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.
4.0 ENGINEERING ANALYSIS

4.1 Introduction

The primary geotechnical concern regarding this project is the presence of weak, compressible soils at the ground surface. Due to the close proximity of the gravel layer the anticipated depth for conventional frost depth footings, we recommend removal of the surficial lean clay and replacement with compacted structural fill beneath all load bearing footings for the proposed structure. Structural fill should be placed and compacted per our recommendations to reach the design footing elevation. This improvement will reduce the potential for settlement and help to reduce construction costs by provided improved bearing compared to the native clays.

4.2 Site Grading and Excavations

The ground surface at the proposed site is gently sloping down toward the northwest. Based on our field work and a proposed finished floor elevation of approximately 4,912.5 feet, lean clay will be encountered in foundation excavations to the depths anticipated. Based on the test pits, ground water should be below the anticipated depths of footing and utility excavations; however, depending on the time of year, occasional pockets of trapped or perched ground water associated with recent precipitation events should be anticipated.

4.3 Conventional Shallow Foundations

Considering the subsurface conditions encountered and the nature of the proposed construction, the structure can be supported on conventional shallow foundations bearing on properly compacted native gravels or compacted structural fill extending down to native gravel. Based on our experience, the theory of elasticity, and using an allowable bearing pressure of 4,000 psf, we estimate the total settlement for footings will be less than ¾-inch. Differential settlement across the building should be on the order of one-half this magnitude. During design, a one-third increase in the design bearing pressure provided is permitted for the evaluation of load cases which include dynamic, short-term loading conditions (i.e. wind, seismic, etc.).

The lateral resistance of spread footings is controlled by a combination of sliding resistance between the footing and the foundation material at the base of the footing and the passive earth pressure against the side of the footing in the direction of movement. Design parameters are given in the recommendations section of this report.
4.4 **Floor Slabs and Exterior Flatwork**

The natural on-site soils, exclusive of topsoil, are suitable to support lightly to moderately loaded, slab-on-grade construction. At a minimum, a leveling course of granular fill should be placed directly beneath the slab to provide a structural cushion, a capillary-break from the subgrade, and a drainage medium. Recommendations for suitable leveling course materials and thicknesses are provided below. Similar construction could realize vertical slab displacements of up to \( \frac{3}{4} \)-inch with differential movements generally being less than \( \frac{3}{8} \)-inch.

Based on the laboratory testing performed, the native clay soils are considered only slightly expansive and are not anticipated to result in detrimental amounts of slab displacements using conventional slab-on-grade methods. However, due to the relatively weak, compressible and slightly expansive properties of the native clay, any slab systems which are sensitive to vertical displacements or which will realize large applied loads should consider the removal and replacement of this layer with compacted structural fill.
5.0 RECOMMENDATIONS

5.1 Site Grading and Excavations

1. All topsoil and organic material should be removed from the proposed building and pavement areas 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. All fill and backfill should be non-expansive, free of organics and debris. The on-site soils, exclusive of topsoil, are suitable for use as backfill and general site grading fill on this project. All fill should be placed in uniform lifts not exceeding 8 inches in thickness for fine-grained soils and not exceeding 12 inches for granular soils. All materials compacted using hand compaction methods or small walk-behind units should utilize a maximum lift thickness of 6 inches to ensure adequate compaction throughout the lift. All fill and backfill shall be compacted to the following percentages of the maximum dry density determined by a standard proctor test which is outlined by ASTM D698 or equivalent (e.g. ASTM D4253-D4254).

a) Below Spread Footings ................................................................. 95%
b) Below Slab-on-Grade Construction ............................................ 95%
c) Foundation Wall Backfill............................................................... 95%
d) General Landscaping or Nonstructural Areas ................................. 90%
e) Utility Trench Backfill, To Within 2 Feet of Surface ..................... 95%

For your consideration, verification of compaction requires laboratory proctor tests to be performed on a representative sample of the soil prior to construction. These tests can require up to one week to complete (depending on laboratory backlog) and this should be considered when coordinating the construction schedule to ensure that delays in construction or additional testing expense is not required due to laboratory processing times or rush processing fees.

3. Imported structural fill should be non-expansive, free of organics and debris, and selected per the following gradation requirements:
<table>
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<th>Screen or Sieve Size</th>
<th>Percent Passing by Weight</th>
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<tr>
<td>3-inch</td>
<td>100</td>
</tr>
<tr>
<td>1½-inch</td>
<td>80 – 100</td>
</tr>
<tr>
<td>¾-inch</td>
<td>60 – 100</td>
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<tr>
<td>No. 4</td>
<td>25 – 60</td>
</tr>
<tr>
<td>No. 200</td>
<td>12 maximum</td>
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</table>

4. Develop and maintain site grades which will rapidly drain surface and roof runoff away from foundation and subgrade soils; both during and after construction.

5. At a minimum, downspouts from roof drains should discharge at least six feet away from the foundation or beyond the limits of foundation backfill, whichever is greater. All downspout discharge areas should be properly graded away from the structure to promote drainage and prevent ponding.

6. 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 test pits are considered Type B for the lean clay and lean clay with sand and Type C for the sandy lean clay and poorly-graded gravel with clay and sand. The soil conditions on site can change due to changes in soils moisture or disturbances to the site prior to construction. Thus, the contractor is responsible to provide an OSHA knowledgeable individual during all excavation activities to regularly assess the soil conditions and ensure that all necessary safety precautions are implemented and followed.

5.2 Conventional Shallow Foundations

The design and construction criteria below should be observed for a spread footing foundation system. The construction details should be considered when preparing the project documents.

7. Both interior and exterior footings should bear on compacted native gravel or structural fill extending down to the native gravel and should be designed for a maximum allowable soil bearing pressure of 4,000 psf provided settlements as outlined in the Engineering Analysis are acceptable. The limits of over-excavation and replacement with compacted structural fill should extend downward and outward laterally from the bottom edges of the footings at a 1:1 (horizontal to vertical) projection.
During design the use of a one-third increase in the design bearing pressure provided is permitted for evaluation of dynamic short-term loading conditions (i.e. seismic, wind, etc).

8. Soils disturbed below the planned depths of footing excavations should either be re-compacted or be replaced with suitable compacted backfill.

9. Footings shall be sized to satisfy the minimum requirements of the applicable building codes while not exceeding the maximum allowable bearing pressure provided in Item 7 above.

10. Exterior footings and footings beneath unheated areas should be placed at least 48 inches below finished exterior grade for frost protection.

11. The bottom of the footing excavations should be free of cobbles and boulders to avoid stress concentrations acting on the base of the footings.

12. Lateral loads are resisted by sliding friction between the footing base and the supporting soil and by lateral pressure against the footings opposing movement. For design purposes, a friction coefficient of 0.55 and a lateral resistance pressure of 150 psf per foot of depth are appropriate for footings bearing on compacted native gravel or structural fill and backfilled with properly compacted native lean clay.

13. A representative of the project geotechnical engineer should be retained observe all footing excavations and backfill phases prior to the placement of concrete formwork to verify that adequate compaction has been achieved at all bearing locations and the soil conditions conform to the general requirements above.

14. Backfill adjacent to foundation stem walls should be placed in lifts of equal thickness which alternative between the interior and exterior of the structure. To minimize the potential for damage to the foundation stem walls during fill placement, only hand operated compaction equipment should be used within five feet of foundation walls.

15. Based on the site conditions encountered and the proposed use of slab-on-grade construction, the incorporation of a foundation drain system is not required by the applicable building codes.
5.3 Floor Slabs and Exterior Flatwork

16. For normally loaded, slab-on-grade construction, a minimum 12-inch cushion course consisting of free-draining, crushed gravel should be placed beneath the slabs and compacted to the requirements of Item 2 above. This material should conform to the requirements outlined in Section 02235 of the Montana Public Works Standard Specifications (MPWSS) and incorporate a maximum particle size of ¾-inch. Prior to placing the cushion course, the upper six inches of subgrade should be compacted per Item 2.

17. Concrete floor slabs designed and constructed per Item 15 above should be designed using a modulus of vertical subgrade reaction no greater than 150 pci. For heavily loaded slabs or those which are considered sensitive to vertical displacements, consideration should be given to the complete removal and replacement of the native clay with compacted structural fill. Using this approach, similar slab systems may be designed using a modulus of vertical subgrade reaction not exceeding 450 pci.

18. Geotechnically, an underslab vapor barrier is not required for this project. A vapor barrier is normally used to limit the migration of soil gas and moisture into occupied spaces through floor slabs. The need for a vapor barrier should be determined by the architect and/or structural engineer based on interior improvements and/or moisture and gas control requirements.

19. If no acceptable risk can be assumed by the Owner for slab displacements of the magnitude described in the Engineering Analysis section of this report, conventional slab-on-grade methods as discussed in Item 15 are considered appropriate for this project. Under these conditions, the native clay should be completely removed and replaced with compacted structural fill to alleviate potential for vertical displacements associated with the potentially compressible/slightly expansive clay soil.

5.4 Continuing Services

Three additional elements of geotechnical engineering service are important to the successful completion of this project.

20. 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 ground water conditions.

21. Observation, monitoring, and testing during construction is required to document the successful completion of all earthwork and foundation phases. A geotechnical engineer from our firm should be retained to observe the excavation, earthwork, and foundation phases of the work to determine that subsurface conditions are compatible with those used in the analysis and design.

22. During site grading, placement of all fill and backfill should be observed and tested to confirm that the specified density has been achieved. We recommend that the Owner maintain control of the construction quality control by retaining the services of an experienced construction materials testing laboratory. We are available to provide construction inspection services as well as materials testing of compacted soils and the placement of Portland cement concrete. In the absence of project specific testing frequencies, TD&H recommends the following minimum testing frequencies by used:

**Compaction Testing**

- Beneath Column Footings 1 Test per Footing per Lift
- Beneath Wall Footings 1 Test per 25 LF of Wall per Lift
- Beneath Slabs 1 Test per 600 SF per Lift
- Foundation Backfill 1 Test per 50 LF of Wall per Lift

LF = Lineal Feet  SF = Square Feet

**Concrete Testing**

- Structural Concrete† 1 Test per 50 CY per Day
- Non-Structural Concrete 1 Test per Day

† Structural concrete includes all footings, stem walls, slabs, and other load bearing elements

CY = Cubic Yards
6.0 SUMMARY OF FIELD AND LABORATORY STUDIES

6.1 Field Explorations

The field exploration program was conducted on July 12, 2016. A total of three test pits were excavated to depths ranging from 8.0 to 8.2 feet at the locations shown on Figure 1 to observe subsurface soil and ground water conditions. The tests pits were excavated using a John Deere 410C Backhoe. The subsurface exploration and sampling methods used are indicated on the attached test pit logs. The test pits were logged by Mr. Ahren Hastings, P.E. of TD&H Engineering. The location and elevation of the test pits were determined by TD&H surveying personnel.

Samples of the subsurface materials were taken from the test pits via hand sampling. Logs of all test pits, which include soil descriptions and sample depths, are presented on Figures 2 through 4. Measurements to determine the depth of ground water in the test pits were made using a steel tape measure shortly after the completion of excavating. The depths or elevations of the water levels measured, if encountered, and the date of measurement are shown on the test pit logs.

6.2 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.

<table>
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<tr>
<th>Tests Conducted</th>
<th>To determine:</th>
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<tbody>
<tr>
<td>Natural Moisture Content</td>
<td>Representative moisture content of soil at the time of sampling.</td>
</tr>
<tr>
<td>Grain-Size Distribution</td>
<td>Particle size distribution of soil constituents describing the percentages of clay/silt, sand and gravel.</td>
</tr>
<tr>
<td>Atterberg Limits</td>
<td>A method of describing the effect of varying water content on the consistency and behavior of fine-grained soils.</td>
</tr>
<tr>
<td>UU Shear Strength (Field)</td>
<td>The undrained, unconfined shear strength ($s_u$) of cohesive soils as determined in the field by either a pocket penetrometer or a hand torvane.</td>
</tr>
</tbody>
</table>
The laboratory testing program for this project consisted of three moisture-visual analyses, two sieve (grain-size distribution) analyses, and two Atterberg Limits analyses. The results of the water content analyses are presented on the test pit logs, Figures 2 through 4. The grain-size distribution curves and Atterberg limits are presented on Figures 5 and 6. Unconfined compressive strengths ($q_u$) were determined in the field using a pocket penetrometer. The results are shown on the test pit logs at the depths the samples were tested.
7.0 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 reflect our professional opinion regarding potential impacts the subsurface conditions may have on the proposed project and are based on site conditions encountered. Our analysis assumes that the results of the exploratory test pits 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. Unanticipated soil conditions are commonly encountered and cannot be fully determined by a limited number of soil test pits and laboratory analyses. Such unexpected conditions frequently require that some additional expenditures be made to obtain a properly constructed project. Therefore, some contingency fund is recommended to accommodate such potential extra costs.

The recommendations contained within this report are based on the subsurface conditions observed in the test pits and are subject to change pending observation of the actual subsurface conditions encountered during construction. TD&H cannot assume responsibility or liability for the recommendations provided if we are not provided the opportunity to perform limited construction inspection and confirm the engineering assumptions made during our analysis. A representative of TD&H should be retained to observe all construction activities associated with subgrade preparation, foundations, and other geotechnical aspects of the project to ensure the conditions encountered are consistent with our assumptions. Unforeseen conditions or undisclosed changes to the project parameters or site conditions may warrant modification to the project recommendations.

Long delays between the geotechnical investigation and the start of construction increase the potential for changes to the site and subsurface conditions which could impact the applicability of the recommendations provided. If site conditions have changed because of natural causes or construction operations at or adjacent to the site, this report should be reviewed by TD&H to determine the applicability of the conclusions and recommendations provide considering the time lapse or changed conditions.

Misinterpretation of the geotechnical information by other design team members is possible and can result in costly issues during construction and with the final product. We strongly advise that TD&H be retained to review those portions of the plans and specifications which pertain to earthwork and foundations to determine if they are consistent with our recommendations and to suggest necessary modifications as warranted. In addition, TD&H should be involved throughout the construction process to observe construction, particularly the placement and compaction of
all fill, preparation of all foundations, and all other geotechnical aspects. Retaining the geotechnical engineer who prepared your geotechnical report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

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 test pit logs and presented in discussions of subsurface conditions included in this report.

Prepared by: Jeremy Miller, E.I.  Reviewed by: Craig Nadeau, P.E.
Geotechnical Engineer             Geotechnical Manager
LOG OF TEST PIT TP-1
MSU BART Building
Bozeman, Montana

Logged by: Ahren Hastings, PE
Excavated by: Montana State University
John Deere 410C Backhoe

July 12, 2016  B16-049

---

SURFACE: Native Grasses
SURFACE ELEVATION: 4,912.6 ft

**SOIL DESCRIPTION**

**TOPSOIL:** Lean CLAY, appears firm, brown, slightly moist

**Lean CLAY,** appears stiff, light brown, dry to slightly moist

qu = 3.5 tsf

**Poorly-Graded GRAVEL with Clay and Sand,** appears dense, red/brown/gray, slightly moist to wet

**Bottom of Test Pit**

---

**LEGEND**

- Field Moisture content
- Groundwater Level
- Grab/composite sample

**Atterberg Limits**

- Plastic Limit
- In-Situ Water Content
- Plasticity Index
- Liquid Limit

**GPN** = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.
LOG OF TEST PIT TP-2
MSU BART Building
Bozeman, Montana

Logged by: Ahren Hastings, PE
Excavated by: Montana State University
John Deere 410C Backhoe

July 12, 2016

LEGEND

- Field Moisture content
- Groundwater Level
- Grab/composite sample

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.
**TOPSOIL:** Lean CLAY, appears soft, brown, slightly moist, organics

**Sandy Lean CLAY,** appears firm, light brown, dry to slightly moist

**Gravelly Lean CLAY with Sand,** appears firm, light brown, slightly moist

\[ qu = 3.0 \text{ tsf} \]

**Poorly-Graded GRAVEL with Clay and Sand,** appears dense, red/brown/gray, moist to wet

---

**Bottom of Test Pit**

Monitoring well completed in open excavation.
**Particle Size Distribution Report**

### Material Description
- ○ Lean CLAY with Sand
- □ Gravelly Lean CLAY with Sand

### Remarks
- ○ Report No. A-13505-206
- □ Report No. A-13506-206

### Coefficients
- $C_c$
- $C_u$

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### GRAIN SIZE

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<td>91.8</td>
<td>59.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#100</td>
<td>90.3</td>
<td>58.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#200</td>
<td>82.7</td>
<td>52.6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### PERCENT FINER

<table>
<thead>
<tr>
<th>Location: TP-2</th>
<th>Depth: 2.0 ft</th>
<th>Sample Number: A-13505</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location: TP-3</td>
<td>Depth: 2.0 ft</td>
<td>Sample Number: A-13506</td>
</tr>
</tbody>
</table>

Client: Dennis Raffensperger Architect

Project: MSU BART Building

Bozeman, Montana

Project No.: B16-049

Figure 5

Tested By: WJC

Checked By: [Signature]
LIQUID AND PLASTIC LIMITS TEST REPORT

Dashed line indicates the approximate upper limit boundary for natural soils.

<table>
<thead>
<tr>
<th>MATERIAL DESCRIPTION</th>
<th>LL</th>
<th>PL</th>
<th>PI</th>
<th>%&lt;#40</th>
<th>%&lt;#200</th>
<th>USCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Lean CLAY with Sand</td>
<td>33</td>
<td>22</td>
<td>11</td>
<td>94.8</td>
<td>82.7</td>
<td>CL</td>
</tr>
<tr>
<td>■ Gravelly Lean CLAY with Sand</td>
<td>35</td>
<td>21</td>
<td>14</td>
<td>64.6</td>
<td>52.6</td>
<td>CL</td>
</tr>
</tbody>
</table>

Project No. B16-049  Client: Dennis Raffensperger Architect
Project: MSU BART Building  Bozeman, Montana
● Location: TP-2  Depth: 2.0 ft  Sample Number: A-13505
■ Location: TP-3  Depth: 2.0 ft  Sample Number: A-13506

Remarks:
● Report No. A-13505-207
■ Report No. A-13506-207

Figure 6

Tested By: MS  Checked By: Craig R. Nadelson
**STANDARD PENETRATION TEST (ASTM D1586)**

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

* 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**

<table>
<thead>
<tr>
<th>Sieve Openings (inches)</th>
<th>Standard Sieve Sizes</th>
</tr>
</thead>
<tbody>
<tr>
<td>12”</td>
<td>3”</td>
</tr>
<tr>
<td>3/4” No.4</td>
<td>No.10 No.40 No.200</td>
</tr>
<tr>
<td>BOULDERS</td>
<td>COBBLES</td>
</tr>
<tr>
<td>GRAVELS</td>
<td>SANDS</td>
</tr>
<tr>
<td>SILTS &amp; CLAYS</td>
<td>Coarse Fine Coarse Medium Fine</td>
</tr>
</tbody>
</table>

(Distinguished By Atterberg Limits)

**PLASTICITY CHART**

For classification of fine-grained soils and the fine-grained fraction of coarse-grained soils.

- **Equation of "A"-line**
  Horizontal at PL = 4 to LL = 25.5, then PL = 0.73 (LL-20)

- **Equation of "U"-line**
  Vertical at LL = 16 to PL = 7, then PL = 0.9 (LL-8)

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