RIMROCK ENGINEERING, INC.

GEOTECHNICAL ENGINEERING REPORT

Alkali Creek Subdivision
Alkali Creek Road
Billings, Montana

October 11, 2021
Project No. G21112

Prepared for:

IMEG Corp.
175 N 27th Street, Suite 1312
Billings, Montana 59101

Prepared by:

Rimrock Engineering, Inc.
5440 Holiday Avenue
Billings, Montana 59101

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October 11, 2021

Mr. Kolten Knatterud, P.E.
IMEG Corp.
175 N 27th Street, Suite 1312
Billings, Montana 59101

Re: Geotechnical Engineering Report
Alkali Creek Subdivision
Alkali Creek Road
Billings, Montana

Dear Kolten:

Rimrock Engineering, Inc. has completed the geotechnical engineering services for the referenced project. The attached report presents the results of our findings. Our work consisted of subsurface exploration, laboratory testing, engineering analyses, and preparation of this report.

We appreciate this opportunity to be of service to you and are prepared to provide construction materials testing services during the construction phase of the project. If you have any questions regarding this report or need additional information or services, please contact us.

Sincerely,
RIMROCK ENGINEERING, INC.

MONTANA
MATTHEW R. GEERING
No. 17038 PE
LICENSED
PROFESSIONAL ENGINEER

Matt Geering, P.E.	Wade Reynolds
Principal/Vice President	Principal/President

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EXECUTIVE SUMMARY

Rimrock Engineering has completed the geotechnical engineering services for Alkali Creek Subdivision located along Alkali Creek Road in Billings, Montana. Based on the results of our geotechnical investigation, the site can be developed for the proposed project consistent with the recommendations provided in this report. The following geotechnical conditions and considerations were identified:

- The subsurface profile consists of varying layers of sandy lean clay (CL), silty/clayey sand (SC-SM), and silty sand (SM) soils which extended to the maximum depths explored of 50 feet. Groundwater was encountered at approximate depths ranging from 5 to 17 feet below existing grades while drilling.

- There is a significant potential for consolidation settlement under nominal loading conditions and hydro collapse with increased moisture. Based on our calculations, settlements greater than 1 inch are possible if structures are founded on conventional spread footing foundations bearing on the site soils in their existing condition, even with bearing pressures as low as 1,500 psf. Due to these conditions and concerns, deep foundations should be considered for foundation support. In our opinion, drilled friction piers, rammed aggregate piers, or helical piers are viable options at this site.

- Another viable, yet lower level of assurance against settlement, foundation alternative would be to support the structures using a shallow spread footing foundation system bearing on a zone of geotextile-reinforced structural fill. In our opinion, deep foundation systems provide the highest level of assurance against movement related distress to the completed structures. The Owner should be made aware of and accept the risk of bearing on compressible soils and the potential for movements of shallow foundations are to be considered.

- To reduce the potential for movement related distress to concrete slabs over subgrade soils, we recommend that the subgrade soils below the anticipated concrete slab elevation be excavated to allow for the placement of at least 12 inches of geotextile-reinforced (Mirafi RS580i) structural fill.

It should be noted that specific project details were not fully developed or included in this section. The information provided in this executive summary should be used in conjunction with the entire report for design purposes.

GEOTECHNICAL ENGINEERING REPORT

Alkali Creek Subdivision
Alkali Creek Road
Billings, Montana

1.0 INTRODUCTION AND SCOPE

1.1 Project Description

The project consists of the new Alkali Creek Subdivision to be located along Alkali Creek Road in Billings, Montana. The project will include residential lots, new streets, and associated utilities. Based on the preliminary plat, Phase 1 of the subdivision will consist of 72 lots. We understand preliminary information is desired for the remaining property.

1.2 Purpose and Scope of Work

The purpose of this study is to evaluate the feasibility of the proposed development with respect to the observed subsurface conditions and to provide information, opinions, and geotechnical engineering recommendations relative to:

- General soil and groundwater conditions
- Site and subgrade preparation
- Recommended foundation type(s) and design parameters
- Estimated settlement of foundations
- Basement construction considerations
- Utility trench considerations
- Pavement thickness design
- Potential for site soils to adversely react with concrete
- General earthwork and site drainage
- Preliminary findings for remaining area

Our scope of services consisted of background review, site reconnaissance, field exploration, laboratory testing, engineering analyses, and preparation of this report.

2.0 INVESTIGATION

2.1 Field Exploration

The subsurface exploration consisted of drilling a total of eighteen (18) borings from August 30 to 31, 2021 to approximate depths ranging from 20 to 50 feet below existing grades. Several borings were unable to be drilled at this time due to restricted access. The borings were drilled using our truck mounted drill rig equipped with solid flight augers. Groundwater levels were measured during drilling operations, if encountered. Upon completion of drilling and/or groundwater measurements, the borings were backfilled with drill cuttings and compacted with the equipment at hand.

Logs of the borings along with a Vicinity/Site Map are included in Appendix A. The borings were located in the field by IMEG. Estimated ground surface elevations were provided by IMEG. The locations and elevations of the borings should be considered accurate only to the degree implied by the means and methods used to define them.

Rimrock Engineering personnel logged the soil conditions encountered in the borings. At selected intervals, samples of the subsurface materials were taken by driving split-spoon samplers, pushing Shelby tube samplers, and collecting auger cuttings. Penetration resistance measurements were obtained by driving the samplers into the subsurface materials with a 140-pound automatic hammer falling 30 inches. The penetration resistance value is a useful index in estimating the relative density, or consistency, of the materials encountered. The samples were tagged for identification, sealed to reduce moisture loss, and taken to our laboratory for further examination, testing, and classification.

2.2 Laboratory Testing

The purpose of the laboratory testing is to assess the physical and engineering properties of the soil samples collected in the field to be used in our geotechnical evaluations and analyses. Laboratory testing was performed on selected soil samples to assess the following:

- Visual classification (USCS)
- Moisture content
- Sieve analysis
- Atterberg limits
- Consolidation/swell
- Moisture/density relationship
- California Bearing Ratio (CBR)
- Water soluble sulfate, pH & resistivity

The soil descriptions presented on the boring logs are in accordance with the Unified Soil Classification System (USCS). Individual laboratory test results can be found in Appendix B at the end of this report.

3.0 SITE & SUBSURFACE CONDITIONS

3.1 Site Conditions

At the time of our investigation, the project site consists of undeveloped property located along the south side of Alkali Creek Road in Billings, Montana. The site is situated along the Alkali creek drainage with several small drainages flowing towards the site. Cliff forming sandstone is present around the property as well. The property generally slopes from northwest to southeast with about 30 feet of elevation differenced estimated between the borings. The surrounding areas consist mainly of agricultural pasture land.

3.2 Subsurface Soil Conditions

Based on materials encountered in our borings, underlying a vegetative layer, the subsurface profile consists of varying layers of sandy lean clay (CL), silty/clayey sand (SC-SM), and silty sand (SM) soils which extended to the maximum depths explored of 50 feet. For a more detailed description of the subsurface conditions, please refer to the logs provided in Appendix A.

The subsurface clay and sand soils had Standard Penetration Test (SPT) N-values in the range of 1 to 20 blows per foot with values usually less than 10. This indicates the fine grained soils to be very soft to stiff in consistency and the sand soils to be very loose to loose in relative density, have high compressibility, and relatively low shear strength characteristics.

3.3 Groundwater Conditions

The borings were observed while drilling and after completion for the presence and level of groundwater. Groundwater was encountered at approximate depths ranging from 5 to 17 feet below existing grades while drilling. These observations represent groundwater conditions at the time of the field exploration and may not be indicative of other times, or at other locations. Groundwater can be expected to fluctuate with varying seasonal, weather and irrigation conditions. Evaluation of the factors that affect groundwater fluctuations is beyond the scope of this report.

3.4 Laboratory Test Results

The site soils were tested for grain size distribution (sieve analysis) and Atterberg Limits. Atterberg limits are a basic measure of the critical water contents of a fine-grained soils. The site soils encountered in the borings generally have low plasticity. Results are summarized below:

Location	Depth (ft)	USCS	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Gravel (%)	Sand (%)	Clay/Silt (%)
B-1	4.5	SC-SM	24	18	6	0.0	56.1	43.9
B-1	9.5	SM	NP	NP	NP	0.0	65.6	34.4
B-1	35.0	SM	NP	NP	NP	0.0	72.0	28.0
B-2	4.5	CL	29	21	8	0.0	38.6	61.4
B-15	4.5	SM	NP	NP	NP	0.0	67.4	32.6
B-15	14.5	SM	23	20	3	0.0	66.4	33.6

Samples of the site soils were tested for consolidation/swell potential. The samples were allowed to consolidate under a confining pressure of 1,000 pounds per square foot (psf). Once consolidation under the surcharge load was complete, the samples were inundated with water and allowed to swell/collapse. After movement from the addition of water ceased, incremental loads were then applied to further consolidate the samples.

Consolidation/swell test results indicate that the site soils exhibit high compressibility (See Consolidation Tests in Appendix B). Results are summarized below:

Location	Depth (ft)	Material	Dry Unit Weight (pcf)	Strain @ 2,000 psf (%)	Collapse(-)/Swell(+) (%)
B-2	4.5	CL	101	3.7	-0.2
B-9	7.5	SM	99	4.8	-0.2

A representative sample of the near surface fine grained soils was collected for Moisture-Density Relationship (M/D) and California Bearing Ratio (CBR) testing. The results are summarized in the following table:

Location	Depth, (ft)	Material	Maximum Dry Density (pcf)	Optimum Moisture Content (%)	CBR
B-1 to B-18	1-3	SC-SM	107.3	15.9	5.7

4.0 RECOMMENDATIONS

4.1 Geotechnical Concerns/Considerations

Lean clay and silty/clayey sand soils will be encountered at foundation and concrete slab elevations across the site. Field and laboratory test results indicate that the site clay soils are medium stiff. The sand soils are loose to very loose in relative density. The site soils generally are highly compressible and potentially susceptible to collapse with increase moisture which can be detrimental to lightly loaded structures. Additionally, shallow groundwater will likely be encountered across portions of the site, especially near Alkali Creek. Basement construction may not be feasible in some locations.

There is a significant potential for consolidation settlement under nominal loading conditions and hydro collapse with increased moisture. Based on our calculations, settlements greater than 1 inch are possible if structures are founded on conventional spread footing foundations bearing on the site soils in their existing condition, even with bearing pressures as low as 1,500 psf. Due to these conditions and concerns, deep foundations should be considered for foundation support. In our opinion, drilled friction piers, rammed aggregate piers, or helical piers are viable options at this site. However, competent bearing materials are expected to be quite deep for helical pier installation near the drainage bottoms. Based on nearby well log data, more competent soils are expected near 80 feet. Shallow depths are likely possible closer to exposed sandstone areas. Additional exploration may be needed to identify pier depths.

Another viable, yet lower level of assurance against settlement, foundation alternative would be to support the structures using shallow foundations or a thickened edge monolithic slab bearing on a zone of geotextile-reinforced structural fill. In our opinion, deep foundation systems provide the highest level of assurance against movement related distress to the completed structures.

The Owner should be made aware of and accept the risk of bearing on compressible soils and the potential for movements if shallow foundations are to be considered.

Based on topography of the site, cut and fill balances on the order of ±5 feet or more may be required for some sloping lots. If fills greater than 5 feet are expected, Rimrock Engineering should be contacted to re-evaluate the site and provide additional recommendations, if needed.

Silty soils can be problematic in regards to earthwork and road constructability. Silty soils tend to be moisture sensitive and pump under load, especially with increased moisture levels. In our opinion, repetitive construction traffic and subgrade processing should be limited during construction operations when silty soils are encountered. Subgrade stability tends to decrease with increased disturbance and moisture.

Subsurface conditions vary from one location to another and the structural characteristics may also vary from one structure to another. Since specific structure types and locations have not been identified, performing site specific geotechnical investigations would be beneficial and should be considered.

4.2 Earthwork

The following sections present recommendations for site and subgrade preparation and placement of fill materials on the project. Earthwork on the project should be observed and tested by Rimrock Engineering.

4.2.1 Site and Subgrade Preparation

Vegetation, topsoil, fill materials, existing utilities (if present), and other unsuitable materials (e.g. debris, desiccated soil, frozen soil, etc.) should be removed from the proposed construction area. It is anticipated that general excavations for the proposed construction can be accomplished with conventional earthmoving equipment such as tractor mounted backhoes and tracked excavators. The excavated site soils, cleaned of all organic/deleterious material, construction debris, and rock greater than 3 inches in nominal size (if encountered), may be stockpiled on-site and re-used as trench and wall backfill.

Moisture contents of the site soils varied across the site. Depending on the depth and location of subsurface soils, the addition of water may be necessary, or drying may be required depending on the construction season. Compaction of the site soils may be difficult due to the variation in moisture content.

Due to concerns stated above, if shallow foundations are to be utilized, at a minimum we recommend spread footing foundation excavations allow for the placement of at least 2.5 feet of geotextile-reinforced structural fill. Excavations below floor slabs also should allow for placement of at least 12 inches of geotextile-reinforced structural fill. Over-excavation for structural fill placement below footings should extend laterally beyond all edges of the footings at least 12 inches per foot of over-excavation depth below footing base elevation.

Excavations should be scarified a minimum of 12 inches, moisture conditioned and recompacted prior to placement of geotextile and structural fill. The geotextile and structural fill should then be quickly placed directly over the compacted subgrade soils.

Once the over-excavations have been completed, we recommend separation/stabilization geotextile such as Mirafi RS580i, or approved alternate, be placed at the interface between the site soils and the structural fill to help stabilize the subgrade as well as keep the subgrade soils from intruding into the structural fill. Two layers of geotextile (one at the base and one at mid height) should be utilized. Geotextile lengths should extend a distance of ½ times the footing width beyond the edge of the foundations or the total width of the excavation, whichever is greater.

Within the proposed areas to receive pavement, scarification, re-compaction and proof-rolling of the site subgrade soils is recommended. Subgrade soils beneath pavement areas should be scarified to a depth of at least 12 inches, moisture conditioned to within 3 percent of optimum and compacted to a minimum of 95 percent of the maximum dry density, as determined by ASTM D698. The moisture content and compaction of subgrade soils should be maintained until pavement construction.

The prepared subgrade should be proof-rolled by a standard, tandem axle dump truck loaded to its capacity. The proof-rolling should be observed by our geotechnical engineer to identify areas of soft subgrade. Any areas that become unstable or "pump" under the loaded dump truck should be excavated to a depth to be determined by our geotechnical engineer and replaced with a dense graded gravel/sand mixture to stabilize the subgrade. Additionally, a geogrid or geotextile separation fabric may be required to stabilize soft subgrade soils, if encountered. Once the subgrade has been proof-rolled and approved by the geotechnical engineer, base course may be placed.

4.2.2 Excavation and Trench Construction

Excavations into the on-site soils will likely encounter medium stiff clay soils and loose to very loose silty/clayey sand soils. The excavated materials will generally be suitable for use as trench backfill above the utility line bedding. It is anticipated that excavations for the proposed construction can be accomplished with conventional earthmoving equipment. The contractor is responsible for designing and constructing stable, temporary excavations and ultimately the safety of workers. All excavations should be sloped or shored in the interest of safety following local and federal regulations, including current OSHA excavation and trench safety standards.

Depending on the depth of excavations, groundwater may be encountered. Groundwater was encountered at depths ranging from about 5 to 17 feet. If groundwater is encountered, it should be promptly removed using a dewatering technique designed by a dewatering consultant that lowers and keeps the groundwater surface at least 2 feet below the trench bottom throughout installation and backfilling operations.

If trenches are extended deeper than five feet or are allowed to dry out, the excavations will likely become unstable and should be evaluated to verify their stability prior to occupation by construction personnel. Shoring or sloping of any deep trench walls may be necessary to protect personnel and provide temporary stability.

We anticipate the trench bottoms to be relatively stable if construction disturbance is minimized and groundwater is absent or properly controlled. Stability will likely decrease near groundwater elevations. Design and construction of the utility construction should conform to the specifications as set forth in Montana Public Works Standard Specifications. Enough separation geotextile should be placed so that the geotextile can be wrapped around the bedding material prior to placing backfill or backfilling above the utility. Only light weight compaction equipment should be used to compact the first foot of bedding and/or backfill above the trench bottom. If unstable subgrade conditions are encountered, overexcavation and 1 to 2 feet of Type II trench stabilization gravel may be required in order to provide a working platform.

As a safety measure, vehicles and stockpiles should be kept away from the excavation crest a distance at least equal to the slope height. The exposed slope face should be protected against the elements.

All trench excavations should be made with sufficient working space to permit construction including backfill placement and compaction. Utility trenches are a common source of water infiltration and migration. All utility trenches that penetrate beneath the structures should be effectively sealed to restrict water intrusion and flow through the trenches that could migrate beneath the structures. We recommend constructing an effective clay “trench plug” that extends at least 5 feet out from the structures. The plug material should consist of clay compacted at a water content at or above the optimum water content. The clay fill should be placed to completely surround the utility line above the bedding zone and be compacted in accordance with recommendations in this report. Trench plug material should conform to MPW specifications.

4.2.3 Material Requirements

It is anticipated that excavated materials will be used to the extent practical as engineered fill, wall/trench backfill, and/or lot fill. The material suitability should be evaluated by our geotechnical engineer prior to use. Moisture conditioning and processing of on-site soils will likely be required.

Structural fill should meet the criteria outlined below:

Gradation	Percent finer by weight (ASTM C136)
3"	100
No. 4 Sieve	30-75
No. 200 Sieve	15 (max)
Liquid Limit	25 (max)
Plasticity Index	6 (max)

4.2.4 Compaction Requirements

Fill materials should be placed and compacted in loose lift thicknesses of 8 inches or less when heavy, self-propelled compaction equipment is used. When hand-guided equipment such as jumping jack or plate compactor is used, loose lift thicknesses should be on the order of 4 to 6 inches.

The following table lists the compaction requirements for the different types of fill recommended in this report.

Item	Description
Compaction Requirement (ASTM D698)	**Structural Fill:** 98% **Aggregate Base (beneath slabs & pavements):** 95% **Scarified Subgrade Soils:** 95% **Wall/Trench Backfill:** 97% beneath pavements, 95% elsewhere **Drainage aggregate:** Tamp to stable condition (if required)
Moisture Content (ASTM D698)	±3 % of optimum

The Contractor shall provide and use sufficient equipment of a type and weight suitable for the conditions encountered in the field. The equipment shall be capable of obtaining the required compaction in all areas, including those that are inaccessible to ordinary rolling equipment.

4.2.5 Site Drainage

Positive drainage should be provided during construction and maintained throughout the life of the proposed project. Infiltration of water into utility or foundation excavations must be prevented during construction. All grades must provide effective drainage away from the structures during and after construction. Water permitted to pond next to the structures can result in greater soil movements than those discussed in this report. Estimated movements described in this report are based on effective drainage for the life of the structures and cannot be relied upon if effective drainage is not maintained.

In areas where sidewalks or paving do not immediately adjoin the structures, we recommend that protective slopes be provided with a minimum grade of approximately 10 percent for at least 10 feet from perimeter walls. Backfill against footings, exterior walls, and in utility and sprinkler line trenches should be well compacted and free of all construction debris to reduce the possibility of moisture infiltration.

Downspouts, roof drains or scuppers should be extended and discharged beyond the backfill zone when the ground surface beneath such features is not protected by exterior slabs or paving. Landscaped irrigation adjacent to the foundation system should be minimized, eliminated, or strictly regulated.

4.2.6 Construction Considerations

Although the exposed subgrade is anticipated to be relatively stable upon initial exposure, unstable subgrade conditions could develop during general construction operations, particularly if the soils are wetted and/or subjected to repetitive construction traffic. The use of light, rubber-tracked construction equipment would aid in reducing subgrade disturbance. Should unstable subgrade conditions develop, Rimrock Engineering should review conditions and provide recommendations for stabilization.

The site should be graded to prevent ponding of surface water on, or direction of runoff toward, the prepared subgrades or excavations. If the subgrade should become frozen, desiccated, saturated, or disturbed, the affected material should be removed.

As a minimum, all temporary excavations should be sloped or braced as required by Occupational Health and Safety Administration (OSHA) regulations to provide stability and safe working conditions. The grading contractor, by his contract, is usually responsible for designing and constructing stable, temporary excavations and should shore, slope or bench the sides of the excavations, as required, to maintain stability of both the excavation sides and bottom. All excavations should comply with applicable local, state and federal safety regulations, including the current OSHA Excavation and Trench Safety Standards.

Rimrock Engineering should be retained during the construction phase of the project to observe earthwork and to perform necessary tests and observations during construction of the project.

4.3 Drilled Pier Foundation System

This section provides design parameters and construction considerations for the deep foundation support using concrete drilled friction piers.

The geotechnical resistance for drilled piers within the depths explored for this investigation can be estimated using the following ultimate values:

Material	Ultimate Skin Friction (psf)	Ultimate End Bearing (psf)
Sand/Clay	1,000 250*	4,500 2,500*

*Below Groundwater

Piers should be sized for axial compressive loading using a Factor of Safety (FS=3) applied to the ultimate parameters provided. All piers should be reinforced full-depth for the applied axial, lateral, and uplift stresses imposed.

A minimum pier diameter of 24 inches is recommended to facilitate proper cleaning and observation of the pier hole. A minimum practical horizontal spacing between piers of at least three diameters should be maintained, and adjacent piers should bear at the same elevation. Should closer pier spacing be required, group effects on total axial (and lateral) capacity should be evaluated by further interaction with our geotechnical engineer and the structural engineer as design proceeds. Foundation elements such as pier caps should extend at least 3.5 feet below final grade for frost protection.

Provided the piers are properly designed and constructed, the total movement is estimated to be on the order of 1 inch or less. Additional foundation movements could occur if excessive water from any source infiltrates the foundation materials causing moisture increases to depths greater than the design assumption. Therefore, proper drainage should be provided in the final design, during construction and for the life of the project.

Single pile lateral load capacity can be estimated using the following design parameters for the soil profile in a p-y analysis such as conducted using the computer program LPile:

Material	Unit Weight (pcf)	Cohesion (psf)	Friction Angle (degrees)	K_h (pci)	ε_{50}
Sand/Clay	115	-	30	25	-

Soil modulus parameters in the table should be reduced by 50% for seismic analysis. Lateral load capacity will also be diminished in pile groups depending on pile spacing. Our geotechnical engineer should be contacted to provide further design assistance in this regard once pile load/type and configuration are known.

Based on available information, drilling to design depths should be possible with conventional drilled shaft/pier auger equipment. A contingency should be provided in the construction budget/planning to allow for drill hole stabilization. This may include, but not be limited to, such means as casing, drilling mud, and tremie placement of concrete if required.

Depending on design pier depths, subsurface conditions indicate that temporary steel casing may be required on this project. The bottom of the pier excavations should be substantially free of loose material and water to affect placement of concrete in the “dry”. Pier concrete should be placed immediately after completion of drilling and cleaning. If pier concrete cannot be placed in dry conditions, or if groundwater and sloughing soils present difficulties that casing cannot adequately support, mud slurry and tremie methods may be required for concrete placement.

Temporary casing, if needed for pier construction, should be withdrawn in a slow continuous manner maintaining a sufficient head of concrete to prevent infiltration of water or the creation of voids in pier concrete. Pier concrete should have a relatively high fluidity when placed in cased pier holes or through a tremie. Pier concrete with slump in the range of 6 to 8 inches is recommended.

The pier foundation excavations and construction should be observed on a full-time basis by Rimrock Engineering. If the ground conditions encountered differ significantly from those presented in this report, supplemental recommendations will be required.

Drilled shaft construction should be constructed in accordance with applicable portions of ACI 336.3R-93 or other similar, approved specification. Concrete mix should be designed utilizing Type I-II cement to have a minimum 28-day compressive strength of 4,000 psi and a maximum water cement ratio of 0.45. A superplasticizer may be necessary to increase concrete slump/flow temporarily for drilled shaft placement.

4.4 Helical Pier Foundation System

Helical piers offer a deep foundation alternative for supporting the proposed structure. These consist of a steel helix welded to a solid steel shank. They are screwed through the soils using a hydraulic motor, usually attached to a skid-steer loader. Shank extensions are added, as needed, to reach the required bearing depth. Installation torque is monitored and has been shown to be a reliable method for estimating the individual pier capacity. This alternative avoids the potentially compressible/collapsible soil by extending loads to less compressible/collapsible bearing soils. Since helical piers do not require an open hole; no casing, drilling slurry, reinforcing steel or special concrete placement is required, nor is there any waste material requiring disposal.

For the conditions at this site, it is advisable to install helical piers to the maximum allowable installation torque to obtain the maximum capacity from each pier. We recommend design of the piers be performed by a licensed installer. Settlement of a helical pier foundation system should be about ½-inch, or less, when designed in accordance with the recommended allowable capacities. At least one load test should be performed to verify the helical piers develop the design capacity with less than ½-inch vertical deflection. Foundation elements such as pier caps or footings should extend at least 3.5 feet below final grade to provide frost protection.

4.5 Rammed Aggregate Piers

In our opinion, rammed aggregate piers may be a viable foundation alterative at the site due to the subgrade conditions. This foundation system has been used on similar soil conditions with success. Structures can be supported by shallow spread footings bearing on rammed aggregate piers constructed on a design spacing determined by a specialty contractor using proprietary drilling/installation methods.

Stone column foundation systems or rammed aggregate piers are accomplished by down-hole vibratory methods. The technique involves the installation of backfill material into the soil so that dense and sometimes deep stone columns are formed that are tightly interlocked with the surrounding overburden soils. This system improves the subgrade below conventional spread footings, grade beams, and floor slabs and reduces the compressibility of the underlying soil.

Stone column soil reinforcement elements are typically constructed at 24 or 30-inch diameters. Shaft lengths typically range from 8 and 20 feet as measured from footing subgrade; however, deeper shafts are achievable. The result of construction is a reinforced zone of soil directly under footings that allows for the construction of shallow spread footings proportioned for a relatively high bearing pressure. It is reasonable to assume that allowable bearing pressures in the range of 3,000 to 4,500 psf can be expected pending analysis with actual construction and structural load information.

Stone column elements are spaced singly or in close groups beneath interior footings to support concentrated column loads. Beneath continuous footings, stone column elements typically are spaced at 6 to 12 feet on center depending on loads, soil conditions, and other design requirements.

Stone column soil reinforcement should be designed and constructed by a licensed installer. The installer should provide a stone column layout and detailed design calculations sealed by a professional engineer licensed in the State of Montana. The design parameters should be verified by a full-scale modulus test (similar to a pile load test) performed in the field. Rimrock Engineering should be retained to monitor the modulus test and subsequent installation of production stone column elements. Foundation elements such as pier caps or footings should extend at least 3.5 feet below final grade to provide frost protection.

4.6 Shallow Footing Foundation System

In our opinion, structures can be supported by a shallow spread footing foundation system or thickened edge monolithic slab bearing on a zone of at least 2.5 feet of geotextile (Mirafi RS580i) reinforced structural fill over reconditioned site soils.

The spread footing foundation system constructed on geotextile and/or geogrid-reinforced structural fill may be designed for a maximum allowable bearing pressure of 2,000 pounds per square foot (psf). A minimum footing width of 16 inches should be maintained. The design bearing pressure applies to dead load plus design live load conditions. The design bearing pressure may be increased by one-third when considering total loads that include wind or seismic conditions. A coefficient of friction value of 0.45 can be used for footings bearing on structural fill.

Provided the structures are properly constructed, the total movement resulting from the anticipated structural loads is estimated to be on the order of 1 inch. Additional foundation movements could occur if water from any source infiltrates the foundation soils; therefore, proper drainage should be provided in the final design, during construction and for the life of the project.

Exterior foundations should be embedded a minimum of 3.5 feet below lowest adjacent exterior finish grade for frost protection and confinement. Interior footings should be bottomed at least 12 inches below lowest adjacent finish grade for confinement. Wall foundation dimensions should satisfy the requirements listed in the latest edition of the International Building Code. Reinforcing steel requirements for foundations should be provided by the design engineer.

The base of all foundation excavations should be free of water and loose material prior to placing structural fill. Concrete should be placed soon after structural fill placement to reduce the potential for bearing surface disturbance. Should the soil bearing levels become excessively dry, disturbed, saturated, or frozen, the affected material should be removed and replaced with suitable material prior to placing concrete. It is recommended that our geotechnical engineer be retained to observe and approve the foundation materials and their preparation for compliance with our recommendations and design assumptions.

The structural fill zone design and associated settlements are a function of footing width to structural fill thickness ratio. Foundation movements depend upon the variations within the subsurface soil profile, the structural loading conditions, the embedment depth of the footings, the thickness of compacted structural fill, and quality of earthwork operations. Due to this and because subsurface conditions vary from one location to another and the structural characteristics may also vary from one structure to another, home owners should consider performing site specific geotechnical investigations.

It should be noted that granular structural fill, if used, is a pervious material and the existing clay subgrade is relatively impervious compared to granular materials. When placing structural fill in less pervious soils, there is potential for water to pond within the pervious materials. Therefore, in order to intercept potential water infiltration from impacting the foundation bearing stratum, an exterior perimeter drain should be considered due to the moisture-sensitive clay subgrade materials. Perimeter drain construction details are provided in Section 4.5.

4.7 Concrete Slabs

To reduce the potential for movement related distress to concrete slabs over subgrade soils, we recommend a minimum of 12 inches of structural fill reinforced with a layer of Mirafi RS580i be used for slab support. A leveling course, typically 4 to 6 inches of sand/gravel, should be provided below the concrete slabs and can be considered part of the zone of structural fill. A structural floor on grade beams should be considered if deep foundations are used.

Additional floor slab design and construction recommendations are as follows:

- Positive separations and/or isolation joints should be provided between slabs and all foundations, columns or utility lines to allow independent movement.
- Contraction joints should be provided in slabs to control the location and extent of cracking.
- The use of a vapor retarder should be considered beneath concrete slabs-on-grade that will be covered with wood, tile, carpet or other moisture sensitive or impervious coverings, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer and slab contractor should refer to ACI 302 for procedures and cautions regarding the use and placement of a vapor retarder.
- Floor slabs should not be constructed on frozen subgrade.
- Other design and construction considerations, as outlined in Section 302.1R of the ACI Design Manual, are recommended.

Exterior slabs-on-grade founded on the site soils may experience some movement due to the volume change of the near surface materials through moisture variation or freeze-thaw cycles. This movement may lead to loss of positive drainage away from the buildings and could present a tripping hazard where slab sections move independently. Potential movement could be reduced by:

- Placing slabs on a minimum of one (1) foot of imported non-frost susceptible granular fill
- Minimizing moisture variations in the subgrade
- Controlling moisture-density during placement
- Using designs which allow vertical movement between the exterior features and adjoining structural elements
- Placing effective control joints on relatively close centers

4.8 Basement and Crawlspace Construction

Basement construction may not be feasible on some lots due to shallow groundwater concerns. To reduce the potential for surface water and/or groundwater infiltration into residential basements, installation of a perimeter drainage system should be considered when slabs are expected near groundwater elevations. The drainage system should be constructed around the exterior perimeter of the foundation, and sloped at a minimum 1/8 inch per foot to a suitable outlet such as a sump and pump system or day-lighted.

The exterior drainage system should consist of a properly sized perforated pipe (typically 4-inch pipe), embedded in free-draining gravel, placed in a trench at least 12-inches in width. The crown of the drain should be placed 12 inches below the top of the floor elevation. Gravel should extend a minimum of 3-inches beneath the bottom of the pipe, and at least 1 foot above the bottom of the foundation wall/grade beam. The gravel should be wrapped with geotextile fabric such as Mirafi 140N.

To reduce the potential for groundwater fluctuation to impact foundation bearing soils and/or enter the residential basements, installation of an interior dewatering system, in addition to the exterior perimeter system, should be considered when slabs are placed within 3 feet of the estimated groundwater levels. In our opinion, slabs should not be placed closer than 2 vertical feet to the groundwater contact. The interior dewatering system should, at a minimum, include an underslab gravel drainage layer sloped to an interior perimeter drainage system.

The interior drainage system should consist of a properly sized perforated pipe, embedded in free-draining gravel, placed in a trench at least 12 inches in width. The trench should be inset from the interior edge of the nearest foundation a minimum of 12 inches. In addition, the trench should be located such that an imaginary line extending downward at a 45-degree angle from the foundation does not intersect the nearest edge of the trench. Gravel should extend a minimum of 3 inches beneath the bottom of the pipe. The drainage system should be sloped at a minimum 1/8 inch per foot to a suitable outlet, such as a sump and pump system.

The underslab drainage layer should consist of a minimum 8-inch thickness of free-draining gravel. Cross-connecting drainage pipes should be provided beneath the slab at 10-foot intervals, and should discharge to the perimeter drainage system. In addition, a water stop is recommended at the junction of basement slabs and foundation walls, or at other locations where groundwater could enter the basement should it rise above the present level.

4.9 Lateral Earth Pressures

The basement walls will be subject to lateral earth pressure from the backfill. Basement walls are normally designed for the “at-rest” earth pressure condition, because the walls are restrained from rotating. Assuming the site clay, silt, and sand soils will be re-used as backfill material, a value of 90 pounds per square foot, per foot of depth, should be used for the at-rest lateral earth pressure against the basement walls. The lateral earth pressure does not include any factor of safety and is not applicable for submerged conditions or hydrostatic loading.

Compaction of each lift of backfill adjacent to the basement walls should be accomplished with hand-operated tampers or other lightweight compactors. Over-compaction may cause excessive lateral earth pressures which could result in wall damage.

4.10 Dewatering

Depending on the depth and time of year that the excavations take place, groundwater may be encountered for residential construction. Contractors working on the project should be aware of this and be prepared to dewater. If groundwater is encountered, it should be promptly removed using a dewatering technique that lowers and keeps the groundwater surface at least 2 feet below the trench bottom.

A potential side effect of any dewatering effort is settlement (consolidation) of the soils, resulting in surface settlements, which can adversely impact structures, pavements or underground facilities. If dewatering is required, the contractor should consult with a dewatering consultant to design a dewatering system that will limit the cone of groundwater depression to the immediate construction area.

4.11 Corrosion Protection

Soil samples were submitted for water soluble sulfate, pH and resistivity testing. The results are summarized in the following table:

Location	Depth (ft)	Material	Soluble Sulfate Content (%)	Resistivity (ohm-cm)	pH
B-2	4.5	CL	0.05	556	7.9
B-9	7.5	SM	0.03	985	7.8

Water soluble sulfate values less than 0.10 are considered to have negligible attack potential on normal strength concrete. As a result, Type I-II Portland cement can be specified for all project concrete. However, if additional protection in this regard is desired, Type V cement should be specified.

Resistivity values less than 1,000 are considered to be very strongly aggressive with regard to corrosion of buried metals. If corrosion of buried metal is critical, it should be protected using a non-corrosive backfill, wrapping, coating, sacrificial anodes, or a combination of these methods, as designed by a qualified corrosion engineer.

4.12 Pavements

Pavement section alternatives for this project were designed based on the procedures outlined in the 1993 Guideline for Design of Pavement Structures by the American Association of State Highway and Transportation Officials (AASHTO).

For purposes of this design analysis, a terminal serviceability index of 2.0, an inherent reliability of 85 percent, and a subgrade drainage coefficient of 0.9 were used. It is anticipated that pavement subgrade soils will consist of clay and sand soils which are typically considered poor to fair materials for pavement support. A California Bearing Ratio (CBR) value of 5.7 was used in the pavement design analysis. Please note that this CBR value and the pavement section alternatives provided assume that the site soils will be re-compacted and left in-place within the pavement areas. If this is not the case, Rimrock Engineering should be notified to provide additional pavement design recommendations based on the subgrade soils which will be present below the pavement sections.

Specific traffic data was not provided for this project. Therefore, we have assumed an equivalent 18-kip single axle load (ESAL) of 150,000 to represent the design traffic intensity for the proposed interior roads over a 20-year design period. Please notify us if any of the parameters used in the pavement design do not adequately define the anticipated conditions.

Select from the following pavement alternative, or an approved equivalent.

Traffic Area	Asphalt Concrete	Base Course*	Total
Residential Sub-Collector	3	10	13
	4	8	12

Base course thicknesses can typically be reduced by about 20 to 30 percent or more if a stabilization/separation geotextile such as Mirafi RS580i. Additional geotechnical input and design will be required if geosynthetics are to be used.

Asphalt concrete should be composed of a mixture of aggregate, filler and additives (if required), and approved bituminous material. The asphalt concrete should conform to approved mix designs which include volumetrics, Marshall properties, optimum asphalt cement content, job mix formula, and recommended mixing and placing temperatures. The asphalt concrete should be consistent with an approved mix design conforming to Montana Public Works (MPW). Mix designs should be submitted prior to construction to verify their adequacy. Aggregate used in the asphalt should meet MPW specifications for quality and gradation.

Asphalt material should be placed in maximum 3-inch lifts (compacted thickness) and should be compacted to the minimum standards outlined in the MPW specifications. Aggregate base course should consist of a blend of sand and gravel which meets MPW specifications for quality and gradation. Aggregate base course should be compacted to a minimum of 95 percent of the maximum dry density, as determined by ASTM D 698.

Each pavement alternative should be evaluated with respect to current material availability and economic conditions. The pavement sections presented herein are based on design parameters selected by Rimrock Engineering based on experience with similar projects and soil conditions. Design parameters may vary with the specific project and material source. Variation of these parameters may change the thickness of the pavement sections presented. Rimrock Engineering is prepared to discuss the details of these parameters and their effects on pavement design and reevaluate pavement design as appropriate.

Pavements should be sloped to provide rapid drainage of surface water. Water allowed to pond on or adjacent to the pavements could saturate the subgrade and contribute to premature pavement deterioration. In addition, the pavement subgrade should be graded to provide positive drainage within the granular base section. If heavy construction traffic is allowed on unfinished pavement sections or sections not designed for such traffic, premature rutting and/or failure may occur.

The pavement sections provided in this report represent minimum recommended thicknesses and, as such, periodic maintenance should be anticipated. Therefore, preventive maintenance should be planned and provided for through an on-going pavement management program. Preventive maintenance activities are intended to slow the rate of pavement deterioration and to preserve the pavement investment. Preventive maintenance consists of both localized maintenance (e.g. crack and joint sealing and patching) and global maintenance (e.g. surface sealing). Preventive maintenance is usually the first priority when implementing a planned pavement maintenance program and provides the highest return on investment for pavements. Prior to implementing any maintenance program, additional engineering input is recommended to determine the type and extent of preventive maintenance appropriate. Even with periodic maintenance, some movements and related cracking may still occur and repairs may be required.

5.0 ADDITIONAL SERVICES

5.1 Project Bid Documents

It has been our experience during the bidding process, that contractors often contact us to discuss the geotechnical aspects of the project. Informal contacts between Rimrock Engineering and an individual contractor could result in incorrect or incomplete information being provided to the contractor. Therefore, we recommend a pre-bid meeting be held to answer any questions about the report prior to submittal of bids. If this is not possible, questions or clarifications regarding this report should be directed to the project Owner or his designated representative. After consultation with Rimrock Engineering, the project Owner (or his representative) should provide clarifications or additional information to all contractors bidding the job.

5.2 Construction Observation/Testing and Plan Review

The recommendations made in this report are based on the assumption that an adequate program of tests and observations will be made during construction to verify compliance with these recommendations. We recommend that project plans and specifications be reviewed by Rimrock Engineering to verify compatibility with our findings and recommendations. Additional information concerning the scope and cost of these services can be obtained from our office.

The review of plans and specifications and the field observation and testing by Rimrock Engineering are an integral part of the conclusions and recommendations made in this report. If we are not retained for these services, the Client agrees to assume Rimrock Engineering's responsibility for any potential claims that may arise during construction.

6.0 LIMITATIONS

Recommendations contained in this report are based on our field explorations, laboratory tests, and our understanding of the proposed construction. The study was performed using a mutually agreed upon scope of work. It is our opinion that this study was a cost-effective method to evaluate the subject site and evaluate some of the potential geotechnical concerns. More detailed, focused, and/or thorough investigations can be conducted. Further studies will tend to increase the level of assurance; however, such efforts will result in increased costs. If the Client wishes to reduce the uncertainties beyond the level associated with this study, Rimrock Engineering should be contacted for additional consultation.

The soils data used in the preparation of this report were obtained from borings made for this investigation. It is possible that variations in soils exist between the points explored. The nature and extent of soil variations may not be evident until construction occurs. If any soil conditions are encountered at this site which is different from those described in this report, our firm should be immediately notified so that we may make any necessary revisions to our recommendations. In addition, if the scope of the proposed project changes, our firm should be notified. This report has been prepared for design purposes for specific application to this project in accordance with the generally accepted standards of practice at the time the report was written. No warranty, express or implied, is made.

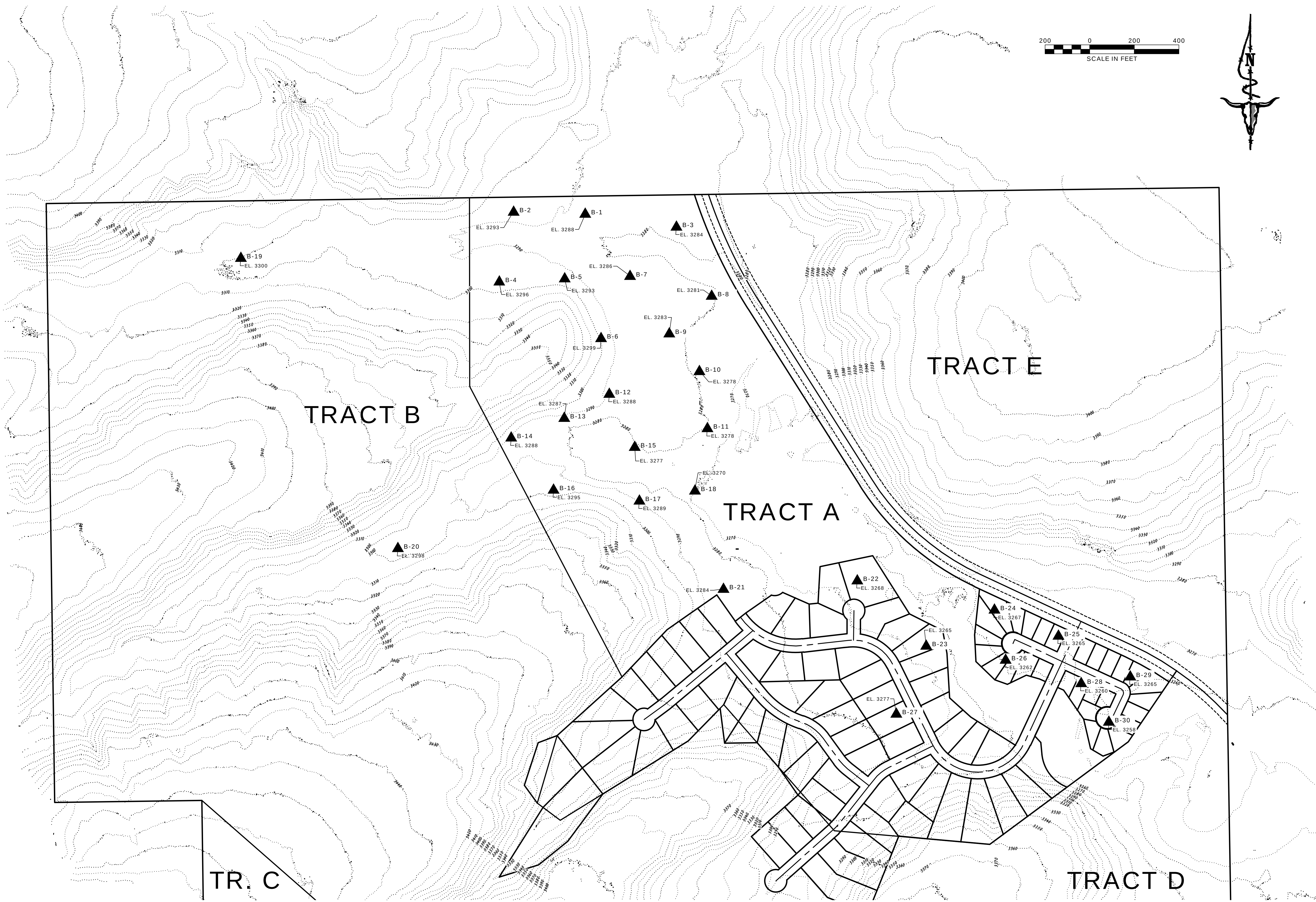
Other standards or documents referenced in any given standard cited in this report, or otherwise relied upon by the authors of this report, are only mentioned in the given standard; they are not incorporated into it or “included by reference,” as that latter term is used relative to contracts or other matters of law.

This report may be used only by the Client and for the purposes stated, within a reasonable time from its issuance. Land use, site conditions (both on- and off-site), or other factors including advances in man’s understanding of applied science may change over time and could materially affect our findings. Therefore, this report should not be relied upon after 36 months from its issue. Rimrock Engineering should be notified if the project is delayed by more than 24 months from the date of this report so that a review of site conditions can be made, and recommendations revised if appropriate.

It is the Client’s responsibility to see that all parties to the project including the designer, contractor, subcontractors, etc., are made aware of this report in its entirety. The use of information contained in this report for bidding purposes should be done at the Contractor’s option and risk. Any party other than the Client who wishes to use this report shall notify Rimrock Engineering of such intended use. Based on the intended use of the report, Rimrock Engineering may require that additional work be performed and that an updated report be issued. Non-compliance with any of these requirements by the Client or anyone else will release Rimrock Engineering from any liability resulting from the use of this report by any unauthorized party.

APPENDIX A

Field Exploration



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FAX: 406.721.5224
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REVISIONS | DATE

DESIGNED: KK
DRAFTED: GW
CHECKED: KK
DATE: OCT. 2021

LOCATION: ALL OF SECTION 19, SECT. 19, T1N, R26E, P.M.M., BILLINGS MONTANA, YELLOWSTONE COUNTY

PREPARED FOR: DAVID MITCHELL

PROJECT NAME: THE TIMBERS SUBDIVISION

SHEET TITLE: BORE LOCATION EXHIBIT

PROJECT NO.: 20006040

SHEET: 1 OF 1

BORING NUMBER B-1

Rimrock Engineering, Inc.

CLIENT IMEG
PROJECT NAME Alkali Creek Subdivision
PROJECT NUMBER G21112
PROJECT LOCATION Billings, MT
DATE STARTED 8/30/21 **COMPLETED** 8/30/21
GROUND ELEVATION 3288 ft **HOLE SIZE** 5 inches
DRILLING CONTRACTOR Rimrock Engineering, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Solid Stem Auger
∇ **AT TIME OF DRILLING** 12.50 ft / Elev 3275.50 ft
LOGGED BY W.R. **CHECKED BY** M.G.
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	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	TOPSOIL										
	(CL) SANDY LEAN CLAY Light brown, medium stiff, low plasticity, fine sand, silty/clayey sand lenses.	SPT	100	2-2-2 (4)			11				
	(SC-SM) SILTY, CLAYEY SAND Grayish brown/light brown, loose, fine sand, low plasticity.	SPT	100	1-4-4 (8)			22	24	18	6	44
10	(SM) SILTY SAND Grayish brown/light brown, loose, fine sand, sandy silt lenses. ∇	SPT	100	2-2-3 (5)			25	NP	NP	NP	34
		SPT	100	0-2-2 (4)			25				
20		SPT	100	1-2-2 (4)			24				
30		AU	100				32	NP	NP	NP	28
40											
	(CL) LEAN CLAY with SAND Dark gray, medium stiff, medium plasticity, fine sand, possibly completely weathered shale/mudstone.	AU	100				32				
50	Bottom of borehole at 50.0 feet.										

GEOTECH BH COLUMNS - GINT STD US LAB.GDT - 10/11/21 11:05 - G:\PROJECTS\2021\G21112.GPJ

BORING NUMBER B-2

Rimrock Engineering, Inc.

CLIENT IMEG
PROJECT NAME Alkali Creek Subdivision
PROJECT NUMBER G21112
PROJECT LOCATION Billings, MT
DATE STARTED 8/30/21 **COMPLETED** 8/30/21
GROUND ELEVATION 3293 ft **HOLE SIZE** 5 inches
DRILLING CONTRACTOR Rimrock Engineering, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Solid Stem Auger
∇ **AT TIME OF DRILLING** 10.00 ft / Elev 3283.00 ft
LOGGED BY W.R. **CHECKED BY** M.G.
AT END OF DRILLING ---
NOTES
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		TOPSOIL										
		(CL) SANDY LEAN CLAY Light brown, medium stiff, low plasticity, fine sand, silty/clayey sand lenses.										
5			ST	100			101	19	29	21	8	61
		(SM) SILTY SAND Grayish brown/light brown, very loose, fine sand, sandy silt lenses.										
			SPT	100	1-1-2 (3)			25				
10		∇	SPT	100	2-2-1 (3)							
15			AU									
20												

Bottom of borehole at 20.0 feet.

BORING NUMBER B-3

Rimrock Engineering, Inc.

CLIENT IMEG

PROJECT NAME Alkali Creek Subdivision

PROJECT NUMBER G21112

PROJECT LOCATION Billings, MT

DATE STARTED 8/30/21 **COMPLETED** 8/30/21

GROUND ELEVATION 3284 ft **HOLE SIZE** 5 inches

DRILLING CONTRACTOR Rimrock Engineering, Inc.

GROUND WATER LEVELS:

DRILLING METHOD Solid Stem Auger

AT TIME OF DRILLING ---

LOGGED BY W.R. **CHECKED BY** M.G.

AT END OF DRILLING ---

NOTES

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		TOPSOIL										
		(CL) SANDY LEAN CLAY Light brown, medium stiff, low plasticity, fine sand, silty/clayey sand lenses.										
5		(SC-SM) SILTY, CLAYEY SAND Grayish brown/light brown, loose, fine sand, low plasticity.										
10		(SM) SILTY SAND Grayish brown/light brown, loose, fine sand, sandy silt lenses.	AU									
15												
20												

Bottom of borehole at 20.0 feet.

BORING NUMBER B-4

Rimrock Engineering, Inc.

CLIENT IMEG
PROJECT NAME Alkali Creek Subdivision
PROJECT NUMBER G21112
PROJECT LOCATION Billings, MT
DATE STARTED 8/30/21 **COMPLETED** 8/30/21
GROUND ELEVATION 3296 ft **HOLE SIZE** 5 inches
DRILLING CONTRACTOR Rimrock Engineering, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Solid Stem Auger
∇ **AT TIME OF DRILLING** 10.00 ft / Elev 3286.00 ft
LOGGED BY W.R. **CHECKED BY** M.G.
AT END OF DRILLING ---
NOTES
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		TOPSOIL										
		(SC-SM) SILTY, CLAYEY SAND Brown, loose, fine sand, low plasticity.										
5			SPT	100	3-2-3 (5)			5				
10		∇	SPT	100	3-3-3 (6)			23				
		(CL) LEAN CLAY with SAND Brown/gray, very soft, medium to high plasticity.										
15			SPT	100	0-0-0 (0)			27				
20												

Bottom of borehole at 20.0 feet.

BORING NUMBER B-5

Rimrock Engineering, Inc.

CLIENT IMEG	**PROJECT NAME** Alkali Creek Subdivision
PROJECT NUMBER G21112	**PROJECT LOCATION** Billings, MT
DATE STARTED 8/30/21 **COMPLETED** 8/30/21	**GROUND ELEVATION** 3293 ft **HOLE SIZE** 5 inches
DRILLING CONTRACTOR Rimrock Engineering, Inc.	**GROUND WATER LEVELS:**
DRILLING METHOD Solid Stem Auger	∇ **AT TIME OF DRILLING** 16.00 ft / Elev 3277.00 ft
LOGGED BY W.R. **CHECKED BY** M.G.	**AT END OF DRILLING** ---
NOTES	**AFTER DRILLING** ---

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (%)
0	TOPSOIL										
0.5	(SC-SM) SILTY, CLAYEY SAND Brown, loose to very loose, fine sand, low plasticity.										
5		SPT	33	4-4-1 (5)			4				
7	(SM) SILTY SAND Grayish brown/brown, medium dense, fine sand, sandy silt lenses, some sandstone gravel.										
10		SPT	100	7-9-11 (20)			11				
15		SPT	100	9-6-7 (13)			18				
16	∇										
20											

Bottom of borehole at 20.0 feet.

BORING NUMBER B-6

Rimrock Engineering, Inc.

CLIENT IMEG
PROJECT NAME Alkali Creek Subdivision
PROJECT NUMBER G21112
PROJECT LOCATION Billings, MT
DATE STARTED 8/30/21 **COMPLETED** 8/30/21
GROUND ELEVATION 3299 ft **HOLE SIZE** 5 inches
DRILLING CONTRACTOR Rimrock Engineering, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Solid Stem Auger
∇ **AT TIME OF DRILLING** 16.00 ft / Elev 3283.00 ft
LOGGED BY W.R. **CHECKED BY** M.G.
AT END OF DRILLING ---
NOTES
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		TOPSOIL										
		(SC-SM) SILTY, CLAYEY SAND Brown, loose to very loose, fine sand, low plasticity.										
5												
		(SM) SILTY SAND Grayish brown/brown, medium dense, fine sand, sandy silt lenses, some sandstone gravel.										
10			AU									
15												
16		∇										
20												

Bottom of borehole at 20.0 feet.

BORING NUMBER B-7

Rimrock Engineering, Inc.

CLIENT IMEG

PROJECT NAME Alkali Creek Subdivision

PROJECT NUMBER G21112

PROJECT LOCATION Billings, MT

DATE STARTED 8/30/21 **COMPLETED** 8/30/21

GROUND ELEVATION 3286 ft **HOLE SIZE** 5 inches

DRILLING CONTRACTOR Rimrock Engineering, Inc.

GROUND WATER LEVELS:

DRILLING METHOD Solid Stem Auger

▽ **AT TIME OF DRILLING** 12.00 ft / Elev 3274.00 ft

LOGGED BY W.R. **CHECKED BY** M.G.

AT END OF DRILLING ---

NOTES

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		TOPSOIL										
		(CL) SANDY LEAN CLAY Light brown, medium stiff, low plasticity, fine sand, silty/clayey sand lenses.										
5		(SC-SM) SILTY, CLAYEY SAND Grayish brown/light brown, loose, fine sand, low plasticity.										
10		(SM) SILTY SAND Grayish brown/light brown, loose, fine sand, sandy silt lenses.	AU									
	▽ (12 ft)											
15												
20		Bottom of borehole at 20.0 feet.										

BORING NUMBER B-8

Rimrock Engineering, Inc.

CLIENT IMEG
PROJECT NAME Alkali Creek Subdivision
PROJECT NUMBER G21112
PROJECT LOCATION Billings, MT
DATE STARTED 8/30/21 **COMPLETED** 8/30/21
GROUND ELEVATION 3281 ft **HOLE SIZE** 5 inches
DRILLING CONTRACTOR Rimrock Engineering, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Solid Stem Auger
▽ **AT TIME OF DRILLING** 9.00 ft / Elev 3272.00 ft
LOGGED BY W.R. **CHECKED BY** M.G.
AT END OF DRILLING ---
NOTES
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		TOPSOIL										
		(CL) SANDY LEAN CLAY Light brown, medium stiff, low plasticity, fine sand, silty/clayey sand lenses.										
5		(SC-SM) SILTY, CLAYEY SAND Grayish brown/light brown, loose, fine sand, low plasticity.	SPT	100	2-3-4 (7)			24				
9	▽											
10												
15												
20		Bottom of borehole at 20.0 feet.										

BORING NUMBER B-9

Rimrock Engineering, Inc.

CLIENT IMEG
PROJECT NAME Alkali Creek Subdivision
PROJECT NUMBER G21112
PROJECT LOCATION Billings, MT
DATE STARTED 8/30/21 **COMPLETED** 8/30/21
GROUND ELEVATION 3283 ft **HOLE SIZE** 5 inches
DRILLING CONTRACTOR Rimrock Engineering, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Solid Stem Auger
▽ **AT TIME OF DRILLING** 14.00 ft / Elev 3269.00 ft
LOGGED BY W.R. **CHECKED BY** M.G.
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (%)
0	TOPSOIL										
	(SM) SILTY SAND Grayish brown/light brown, loose to very loose, fine sand, sandy silt lenses.										
5		SPT	100	4-4-4 (8)			6				
		ST	100			99	8				
10		SPT	100	4-4-5 (9)			8				
14	▽										
15		SPT	100	2-3-2 (5)			18				
20		SPT	67	2-2-1 (3)							

Bottom of borehole at 20.0 feet.

BORING NUMBER B-10

Rimrock Engineering, Inc.

CLIENT IMEG
PROJECT NAME Alkali Creek Subdivision
PROJECT NUMBER G21112
PROJECT LOCATION Billings, MT
DATE STARTED 8/30/21 **COMPLETED** 8/30/21
GROUND ELEVATION 3278 ft **HOLE SIZE** 5 inches
DRILLING CONTRACTOR Rimrock Engineering, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Solid Stem Auger
AT TIME OF DRILLING 7.00 ft / Elev 3271.00 ft
LOGGED BY W.R. **CHECKED BY** M.G.
AT END OF DRILLING ---
NOTES
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		TOPSOIL										
		(SM) SILTY SAND Grayish brown/light brown, loose to very loose, fine sand, sandy silt lenses.										
5												
		▽										
10			AU									
		(SC-SM) SILTY, CLAYEY SAND Grayish brown/light brown, loose to very loose, fine sand, low plasticity.										
15												
20												

Bottom of borehole at 20.0 feet.

BORING NUMBER B-11

Rimrock Engineering, Inc.

CLIENT IMEG	**PROJECT NAME** Alkali Creek Subdivision
PROJECT NUMBER G21112	**PROJECT LOCATION** Billings, MT
DATE STARTED 8/30/21 **COMPLETED** 8/30/21	**GROUND ELEVATION** 3278 ft **HOLE SIZE** 5 inches
DRILLING CONTRACTOR Rimrock Engineering, Inc.	**GROUND WATER LEVELS:**
DRILLING METHOD Solid Stem Auger	∇ **AT TIME OF DRILLING** 8.00 ft / Elev 3270.00 ft
LOGGED BY W.R. **CHECKED BY** M.G.	**AT END OF DRILLING** ---
NOTES	**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		TOPSOIL										
		(SM) SILTY SAND Grayish brown/light brown, loose to very loose, fine sand, sandy silt lenses.										
5			SPT	100	1-1-2 (3)			9				
	∇											
10			SPT	100	2-2-3 (5)			21				
		(SC-SM) SILTY, CLAYEY SAND Grayish brown/light brown, loose to very loose, fine sand, low plasticity.										
15												
20												

Bottom of borehole at 20.0 feet.

BORING NUMBER B-12

Rimrock Engineering, Inc.

CLIENT IMEG
PROJECT NAME Alkali Creek Subdivision
PROJECT NUMBER G21112
PROJECT LOCATION Billings, MT
DATE STARTED 8/30/21 **COMPLETED** 8/30/21
GROUND ELEVATION 3288 ft **HOLE SIZE** 5 inches
DRILLING CONTRACTOR Rimrock Engineering, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Solid Stem Auger
▽ **AT TIME OF DRILLING** 9.00 ft / Elev 3279.00 ft
LOGGED BY W.R. **CHECKED BY** M.G.
AT END OF DRILLING ---
NOTES
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		TOPSOIL										
		(SM) SILTY SAND Grayish brown/light brown, loose to very loose, fine sand, sandy silt lenses.										
5												
		▽										
10			AU									
15												
20												

Bottom of borehole at 20.0 feet.

Rimrock Engineering, Inc.

CLIENT IMEG	**PROJECT NAME** Alkali Creek Subdivision
PROJECT NUMBER G21112	**PROJECT LOCATION** Billings, MT
DATE STARTED 8/30/21 **COMPLETED** 8/30/21	**GROUND ELEVATION** 3287 ft **HOLE SIZE** 5 inches
DRILLING CONTRACTOR Rimrock Engineering, Inc.	**GROUND WATER LEVELS:**
DRILLING METHOD Solid Stem Auger	∇ **AT TIME OF DRILLING** 9.00 ft / Elev 3278.00 ft
LOGGED BY W.R. **CHECKED BY** M.G.	**AT END OF DRILLING** ---
NOTES	**AFTER DRILLING** ---

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (%)
0	TOPSOIL										
	(SM) SILTY SAND Grayish brown/light brown, loose to very loose, fine sand, sandy silt lenses.										
5		SPT	100	3-3-3 (6)							
9	∇										
10		SPT	100	2-3-2 (5)							
15		SPT	100	0-1-2 (3)							
20		SPT	100	0-1-1 (2)							

Bottom of borehole at 20.0 feet.

BORING NUMBER B-14

Rimrock Engineering, Inc.

CLIENT IMEG		**PROJECT NAME** Alkali Creek Subdivision	
PROJECT NUMBER G21112		**PROJECT LOCATION** Billings, MT	
DATE STARTED 8/30/21	**COMPLETED** 8/30/21	**GROUND ELEVATION** 3288 ft	**HOLE SIZE** 5 inches
DRILLING CONTRACTOR Rimrock Engineering, Inc.		**GROUND WATER LEVELS:**	
DRILLING METHOD Solid Stem Auger		∇ **AT TIME OF DRILLING** 5.00 ft / Elev 3283.00 ft	
LOGGED BY W.R.	**CHECKED BY** M.G.	**AT END OF DRILLING** ---	
NOTES		**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		TOPSOIL										
		(SM) SILTY SAND Grayish brown/light brown, loose to very loose, fine sand, sandy silt lenses.										
5		∇										
10			AU									
15												
20												

Bottom of borehole at 20.0 feet.

BORING NUMBER B-15

Rimrock Engineering, Inc.

CLIENT IMEG
PROJECT NAME Alkali Creek Subdivision
PROJECT NUMBER G21112
PROJECT LOCATION Billings, MT
DATE STARTED 8/30/21 **COMPLETED** 8/30/21
GROUND ELEVATION 3277 ft **HOLE SIZE** 5 inches
DRILLING CONTRACTOR Rimrock Engineering, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Solid Stem Auger
∇ **AT TIME OF DRILLING** 16.00 ft / Elev 3261.00 ft
LOGGED BY W.R. **CHECKED BY** M.G.
AT END OF DRILLING ---
NOTES
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		TOPSOIL										
		(SM) SILTY SAND Grayish brown/light brown, medium dense to loose, fine sand, sandy silt lenses.										
5			SPT	100	4-5-6 (11)			5	NP	NP	NP	33
10			SPT	100	2-2-2 (4)							
15			SPT	100	3-3-2 (5)			11	23	20	3	34
16		∇										
20												

Bottom of borehole at 20.0 feet.

BORING NUMBER B-16

Rimrock Engineering, Inc.

CLIENT IMEG
PROJECT NAME Alkali Creek Subdivision
PROJECT NUMBER G21112
PROJECT LOCATION Billings, MT
DATE STARTED 8/31/21 **COMPLETED** 8/31/21
GROUND ELEVATION 3295 ft **HOLE SIZE** 5 inches
DRILLING CONTRACTOR Rimrock Engineering, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Solid Stem Auger
∇ **AT TIME OF DRILLING** 16.00 ft / Elev 3279.00 ft
LOGGED BY W.R. **CHECKED BY** M.G.
AT END OF DRILLING ---
NOTES
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		TOPSOIL										
		(SM) SILTY SAND Grayish brown/light brown, loose, fine sand, sandy silt lenses.										
5												
10			AU									
15		∇										
		(CL) SANDY LEAN CLAY Light brown, medium stiff, low plasticity, fine sand, silty/clayey sand lenses.										
20												

Bottom of borehole at 20.0 feet.

BORING NUMBER B-17

Rimrock Engineering, Inc.

CLIENT IMEG
PROJECT NAME Alkali Creek Subdivision
PROJECT NUMBER G21112
PROJECT LOCATION Billings, MT
DATE STARTED 8/31/21 **COMPLETED** 8/31/21
GROUND ELEVATION 3289 ft **HOLE SIZE** 5 inches
DRILLING CONTRACTOR Rimrock Engineering, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Solid Stem Auger
▽ **AT TIME OF DRILLING** 17.00 ft / Elev 3272.00 ft
LOGGED BY W.R. **CHECKED BY** M.G.
AT END OF DRILLING ---
NOTES
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		TOPSOIL										
		(SM) SILTY SAND Grayish brown/light brown, loose, fine sand, sandy silt lenses.										
5			SPT	100	4-5-4 (9)							
10			SPT	100	3-3-3 (6)							
15			SPT	100	2-2-2 (4)							
17 ▽		(CL) SANDY LEAN CLAY Light brown, medium stiff, low plasticity, fine sand, silty/clayey sand lenses.										
20												

Bottom of borehole at 21.0 feet.

GEOTECH BH COLUMNS - GINT STD US LAB.GDT - 10/11/21 11:05 - G:\PROJECTS\2021\G21112.GPJ

BORING NUMBER B-18

Rimrock Engineering, Inc.

CLIENT IMEG	**PROJECT NAME** Alkali Creek Subdivision
PROJECT NUMBER G21112	**PROJECT LOCATION** Billings, MT
DATE STARTED 8/31/21 **COMPLETED** 8/31/21	**GROUND ELEVATION** 3270 ft **HOLE SIZE** 5 inches
DRILLING CONTRACTOR Rimrock Engineering, Inc.	**GROUND WATER LEVELS:**
DRILLING METHOD Solid Stem Auger	∇ **AT TIME OF DRILLING** 14.00 ft / Elev 3256.00 ft
LOGGED BY W.R. **CHECKED BY** M.G.	**AT END OF DRILLING** ---
NOTES	**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		TOPSOIL										
		(SM) SILTY SAND Grayish brown/light brown, loose, fine sand, sandy silt lenses.										
5												
10			AU									
	∇											
15												
20												

Bottom of borehole at 20.0 feet.

Rimrock Engineering, Inc.

KEY TO SYMBOLS

CLIENT IMEG

PROJECT NAME Alkali Creek Subdivision

PROJECT NUMBER G21112

PROJECT LOCATION Billings, MT

LITHOLOGIC SYMBOLS (Unified Soil Classification System)

- CL: USCS Low Plasticity Clay
- CLS: USCS Low Plasticity Sandy Clay
- SC-SM: USCS Clayey Sand
- SM: USCS Silty Sand
- TOPSOIL: Topsoil

SAMPLER SYMBOLS

- Auger Cuttings
- Standard Penetration Test
- Shelby Tube

WELL CONSTRUCTION SYMBOLS

ABBREVIATIONS

LL	- LIQUID LIMIT (%)
PI	- PLASTIC INDEX (%)
W	- MOISTURE CONTENT (%)
DD	- DRY DENSITY (PCF)
NP	- NON PLASTIC
-200	- PERCENT PASSING NO. 200 SIEVE
PP	- POCKET PENETROMETER (TSF)
TV	- TORVANE
PID	- PHOTOIONIZATION DETECTOR
UC	- UNCONFINED COMPRESSION
ppm	- PARTS PER MILLION

- Water Level at Time Drilling, or as Shown
- Water Level at End of Drilling, or as Shown
- Water Level After 24 Hours, or as Shown

APPENDIX B

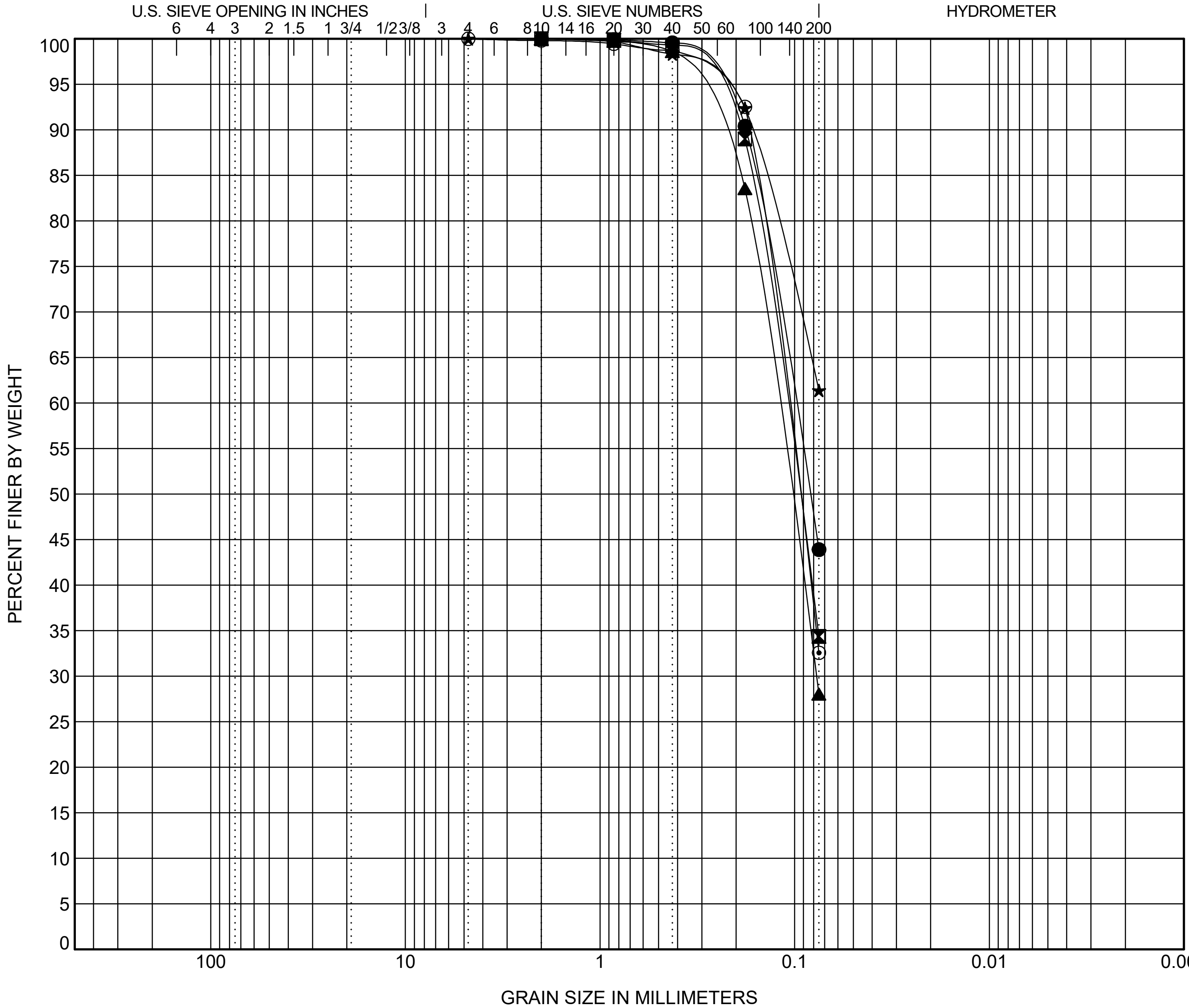
Laboratory Test Results

GRAIN SIZE DISTRIBUTION

Rimrock Engineering, Inc.

CLIENT IMEG **PROJECT NAME** Alkali Creek Subdivision

PROJECT NUMBER G21112 **PROJECT LOCATION** Billings, MT



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BOREHOLE	DEPTH	Classification	LL	PL	PI	Cc	Cu
●	B-1	4.5	SILTY, CLAYEY SAND(SC-SM)	24	18	6		
⧗	B-1	9.5	SILTY SAND(SM)	NP	NP	NP		
▲	B-1	30.0	SILTY SAND(SM)	NP	NP	NP		
★	B-2	4.5	SANDY LEAN CLAY(CL)	29	21	8		
⊙	B-15	4.5	SILTY SAND(SM)	NP	NP	NP		

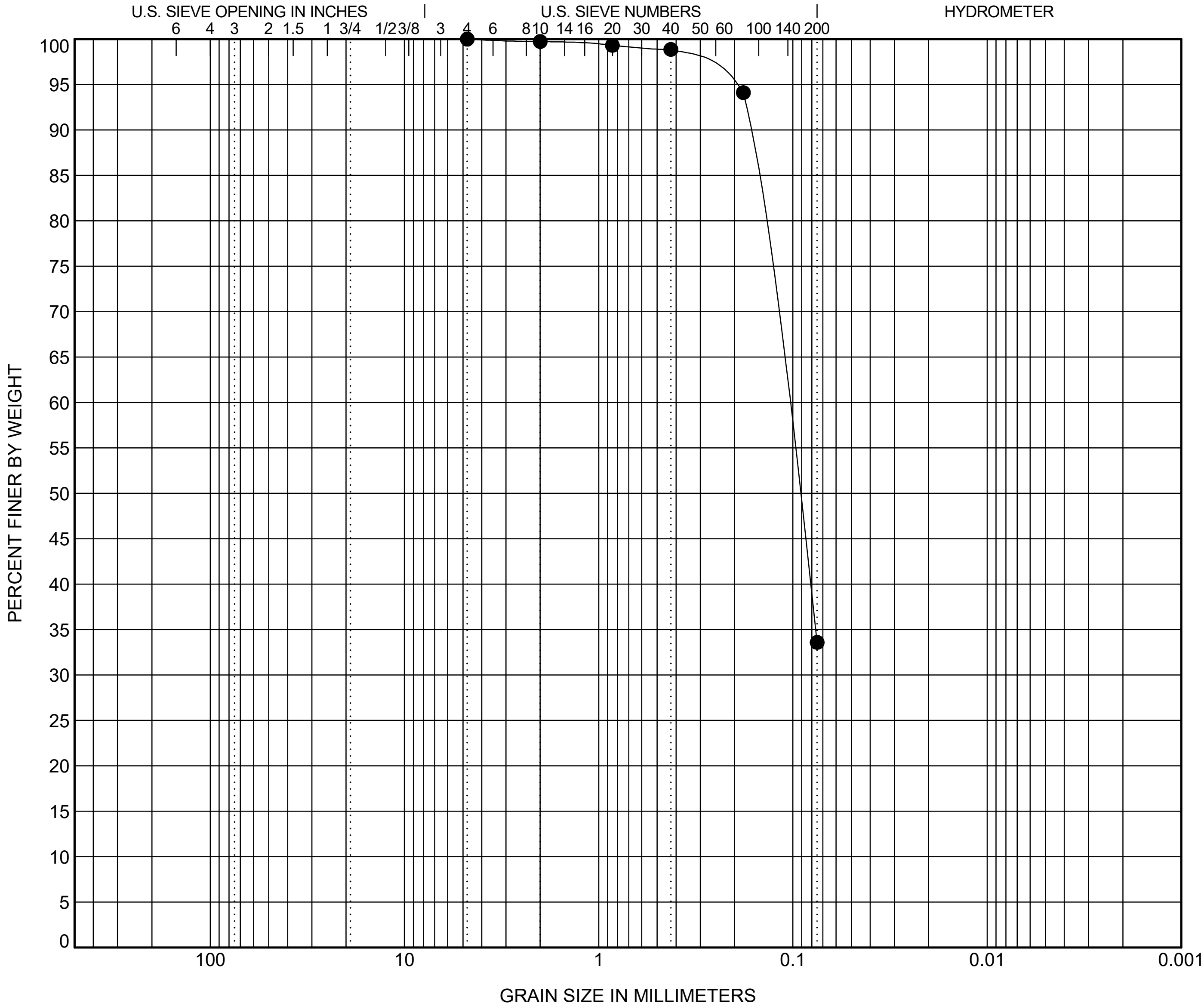
	BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-1	4.5	2	0.102			0.0	56.1	43.9	
⧗	B-1	9.5	2	0.113			0.0	65.6	34.4	
▲	B-1	30.0	2	0.124	0.077		0.0	72.0	28.0	
★	B-2	4.5	4.75				0.0	38.6	61.4	
⊙	B-15	4.5	4.75	0.112			0.0	67.4	32.6	

GRAIN SIZE DISTRIBUTION

Rimrock Engineering, Inc.

CLIENT IMEG **PROJECT NAME** Alkali Creek Subdivision

PROJECT NUMBER G21112 **PROJECT LOCATION** Billings, MT



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

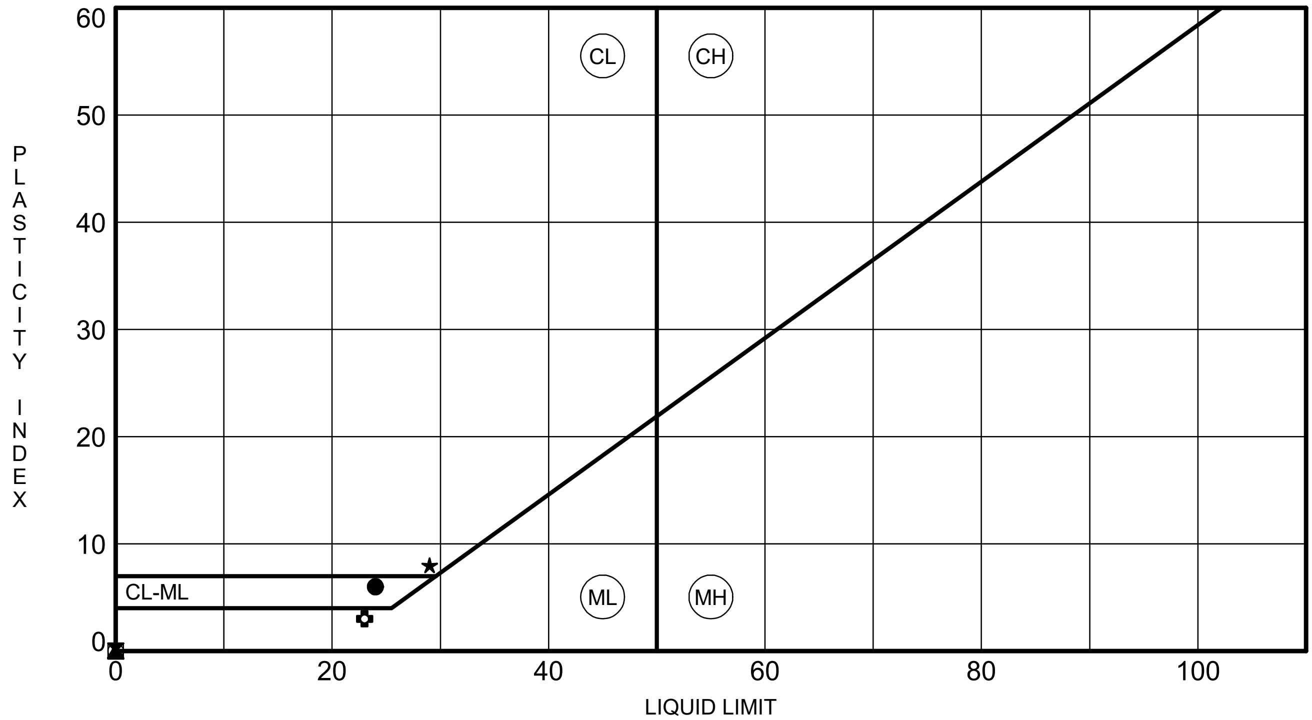
	BOREHOLE	DEPTH	Classification	LL	PL	PI	Cc	Cu
●	**B-15**	**14.5**	**SILTY SAND(SM)**	**23**	**20**	**3**		

	BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-15**	**14.5**	**4.75**	**0.11**			**0.0**	**66.4**	**33.6**	

ATTERBERG LIMITS' RESULTS

Rimrock Engineering, Inc.

CLIENT IMEG
PROJECT NAME Alkali Creek Subdivision
PROJECT NUMBER G21112
PROJECT LOCATION Billings, MT



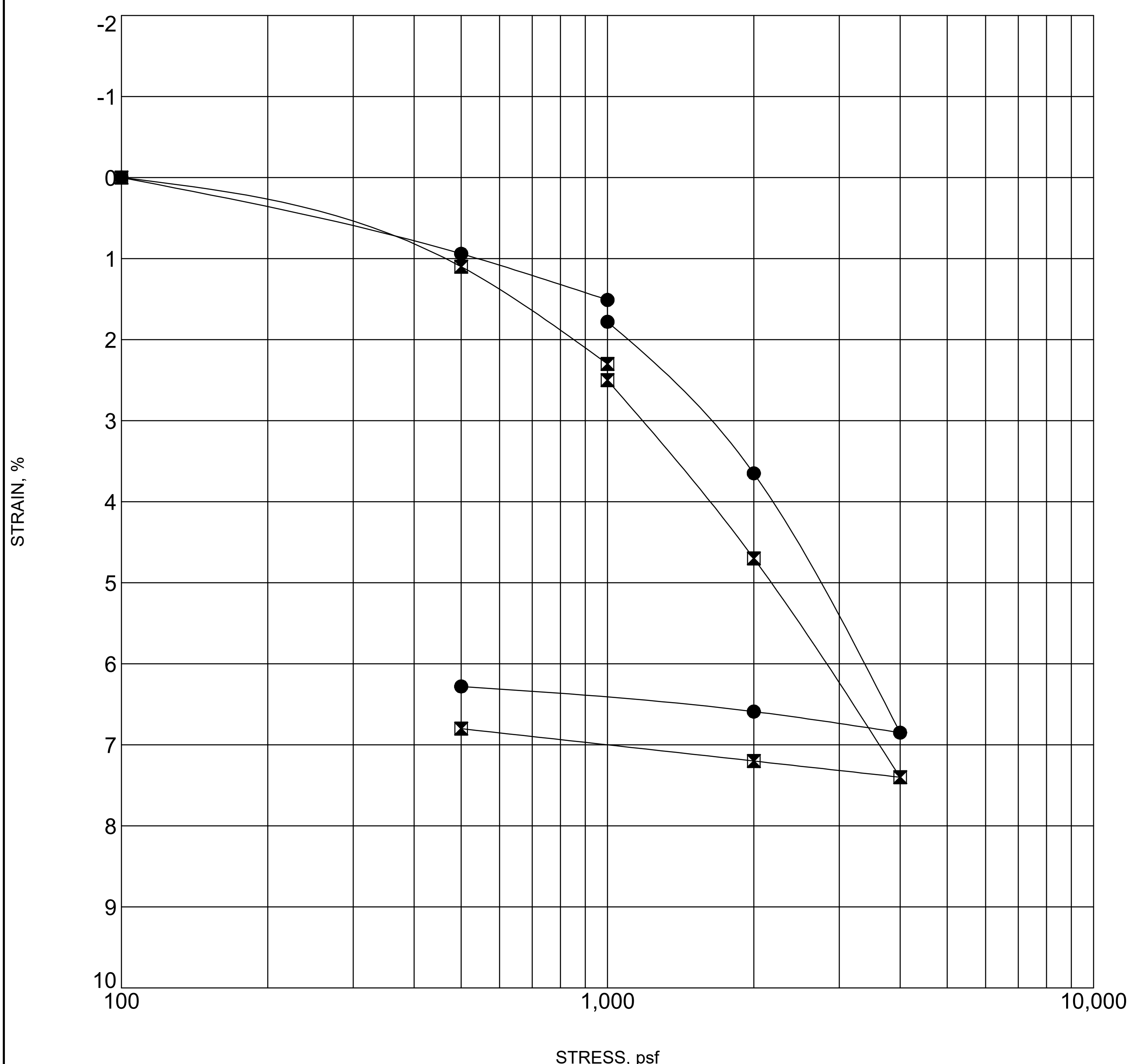
	BOREHOLE	DEPTH	LL	PL	PI	Fines	Classification
●	**B-1**	**4.5**	**24**	**18**	**6**	**44**	**SILTY, CLAYEY SAND(SC-SM)**
⧗	**B-1**	**9.5**	**NP**	**NP**	**NP**	**34**	**SILTY SAND(SM)**
▲	**B-1**	**30.0**	**NP**	**NP**	**NP**	**28**	**SILTY SAND(SM)**
★	**B-2**	**4.5**	**29**	**21**	**8**	**61**	**SANDY LEAN CLAY(CL)**
⊙	**B-15**	**4.5**	**NP**	**NP**	**NP**	**33**	**SILTY SAND(SM)**
✿	**B-15**	**14.5**	**23**	**20**	**3**	**34**	**SILTY SAND(SM)**

CONSOLIDATION TEST

Rimrock Engineering, Inc.

CLIENT IMEG **PROJECT NAME** Alkali Creek Subdivision

PROJECT NUMBER G21112 **PROJECT LOCATION** Billings, MT



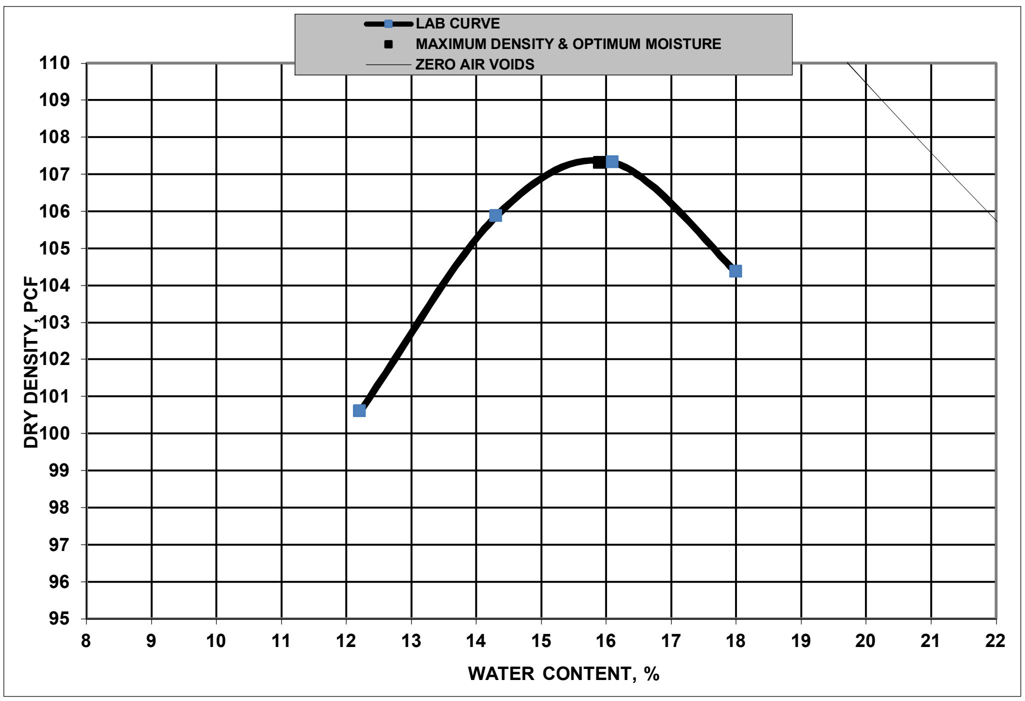
BOREHOLE		DEPTH	Classification	γ_d	MC%
●	**B-2**	**4.5**	**SANDY LEAN CLAY(CL)**	**101**	**19**
⧗	**B-9**	**7.5**	**SILTY SAND(SM)**	**99**	**10**

RIMROCK ENGINEERING, INC.

PHYSICAL PROPERTIES OF SOIL/AGGREGATE

Client Name:	IMEG	**Project No:**	G21112
		Date of Report:	10/4/2021
Project Name:	Alkali Creek Subdivision	**Sample Location:**	B-1 to B-18
Project Location:	Billings, Montana	**Sample Depth:**	1'-3'
Sampled By:	Rimrock Engineering, Inc.	**Classification:**	Silty, Clayey Sand(SC-SM)
Submitted By:	Rimrock Engineering, Inc.	**Date Sampled:**	8/30/2021

MOISTURE-DENSITY RELATIONSHIP



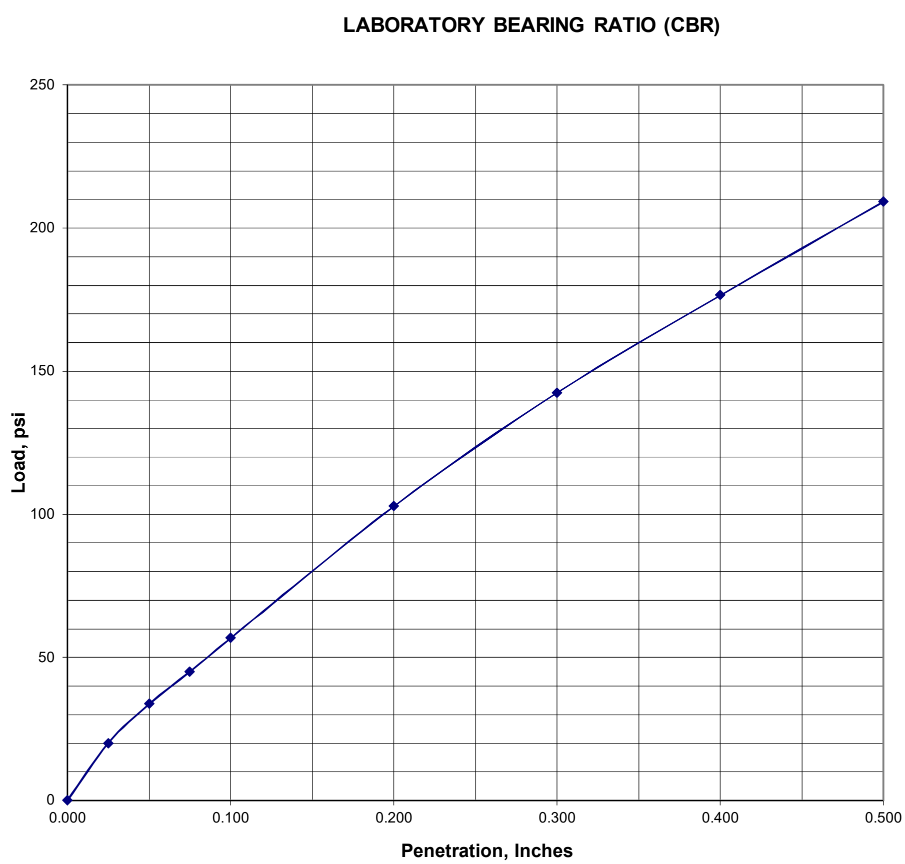
Maximum Density, PCF:	107.3
Optimum Moisture, %:	15.9
Test Method:	ASTM D698
Visual Classification:	Silty, Clayey Sand(SC-SM)

RIMROCK ENGINEERING, INC.

PHYSICAL PROPERTIES OF SOIL/AGGREGATE

Client Name:	IMEG	**Project No:**	G21112
		Date of Report:	10/4/2021
Project Name:	Alkali Creek Subdivision	**Sample Location:**	B-1 to B-18
Project Location:	Billings, Montana	**Sample Depth:**	1'-3'
Sampled By:	Rimrock Engineering, Inc.	**Classification:**	Silty, Clayey Sand(SC-SM)
Submitted By:	Rimrock Engineering, Inc.	**Date Sampled:**	8/30/2021

CALIFORNIA BEARING RATIO



% CBR @ 0.1" **5.7**