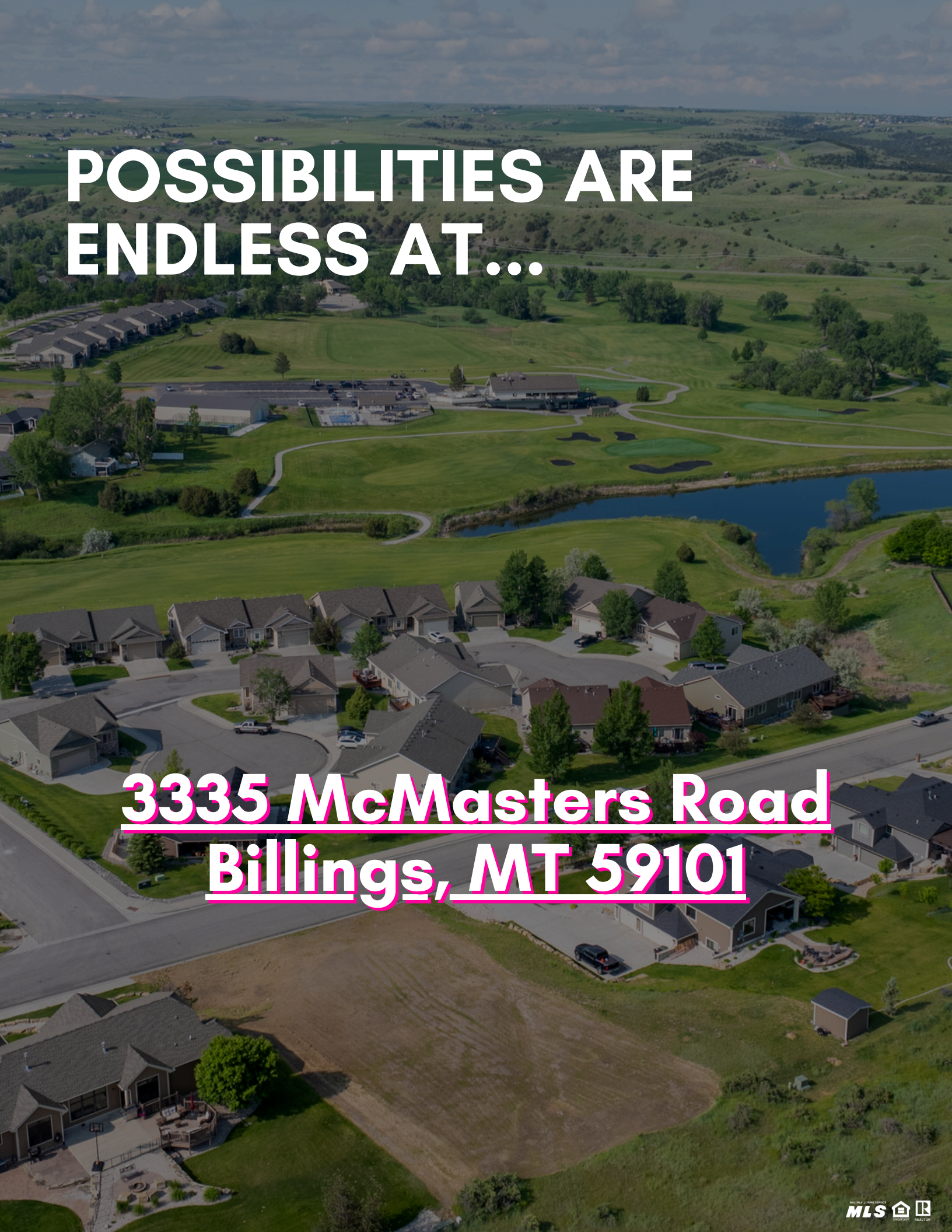
POSSIBILITIES ARE ENDLESS AT...
3335 McMasters Road
Billings, MT 59101

3335 McMasters Rd
Billings, MT 59101

18,568 SqFt Lot *(0.426 Acres)*

- **Utilities:**
  - **Water: Billings Public Works Water**
  - **Gas: Montana-Dakota Utilities Gas**
  - **Electric: Northwestern Energy Electric and Gas**


THE
BRIARWOOD
SUBDIVISION
WHERE THE LIFESTYLE IS EVERYTHING...

THE BRIARWOOD

- GOLF
  - The Briarwood offers two completely different nines. For over 30 years this has been one of the areas best layouts and premier clubs. Stretching out over 7,000 yards, the Briarwood offers a great challenge for the good player, yet we also offer five sets of tees so players of all skill levels can enjoy it.
- EAT
  - Remodeled in 2016, The Black Bunker Bar and Grill has a great modern/industrial sports bar feel. Open to the public, this is a popular hangout all the time.The Briarwood Staff does an amazing job with the menu here at the Black Bunker. Our food is the best around and our busy party and event schedule prove it!
- SWIM
  - The Briarwood Pool is a great hang out on hot summer days, not to mention our pool parties are second to none! Our refurbished pool re-opened in the summer of 2018. The new uplift is a great addition to our club. We offer an Activity Membership that gives you and your Family access all summer long.

the Briarwood

Briarwood Proprietary Memberships (Family)

Initiation Fee: $ 4200
($4200 nonrefundable payable with application)

Monthly Dues: $336

⇒ Membership inclusive of unlimited Golf, Practice Facilities, Clubhouse, & Pool amenities.
⇒ Monthly Operating Fee included.
⇒ Food minimum ($100/qtr.) still apply.

Briarwood Single Memberships

Initiation Fee: $ 3400
($3400 nonrefundable payable with application)

Monthly Dues: $288

⇒ Membership inclusive of unlimited Golf, Practice Facilities, Clubhouse & Pool amenities.
⇒ Monthly Operating Fee included.
⇒ Food minimum ($100/qtr.) still apply.

Briarwood Young Professional Memberships

Initiation fee: Additional fee due at age 32 $ 2250
($2250 nonrefundable payable with application)

Monthly Dues: $234
Ages 21-31

Must be between the ages of 21 - 31 to take advantage of this offer

⇒ Membership inclusive of unlimited Golf, Practice Facilities, Clubhouse & Pool amenities.
⇒ Membership includes the entire immediate family.
⇒ Upon the 32nd birthday of either adult, the Membership status changes. Additional fee due.
⇒ No voting rights.
⇒ Monthly Operating Fee included.
⇒ Food minimum ($100/qtr.) still apply.

Briarwood Elite Activity Memberships

Initiation fee: $ 1600
($1600 nonrefundable payable with application)

Monthly Dues: $142

This membership is inclusive of all amenities (Clubhouse, Pool & inclusive of limited golf). Range included.

- ⇒ Members can access the golf course (2) times a month weekday after 1PM and weekends after 2PM. Each new Elite Activity Member will initially receive (4) guest passes. These guest passes are designed for new potential members that have not experienced the Briarwood Golf Club. The same Guest should not be invited more than once annually.
- ⇒ Limited number of Memberships available.
- ⇒ Food minimum ($100/qtr.) still apply.

Briarwood Activity Memberships

Initiation fee: $ 900
($900 nonrefundable payable with application)

Monthly Dues: $50

This Membership is inclusive of the following amenities (Clubhouse, Pool, and other future activities).

- ⇒ Access for any approved Private party, Wedding, or other event.
- ⇒ Food minimum ($100/qtr.) still apply.
- ⇒ Limited number of Memberships available.

Briarwood Social Memberships (Not available currently)

Initiation fee: $
($ nonrefundable payable with application)

Monthly Dues: $

This Membership is inclusive of the following amenities:

- ⇒ Access for dining (Breakfast, Lunch, & Dinner)
- ⇒ Access for any approved Private party, Wedding, or other social events.
- ⇒ Food minimum ($100/qtr.) still apply.
- ⇒ Limited number of Memberships available.

Briarwood Non-Resident Memberships

Initiation fee: $ 1100
($1100 nonrefundable payable with application)

Monthly Dues: $135

This membership is inclusive of all amenities (Clubhouse, inclusive of limited golf). Range included.

⇒ Available to those who neither resides nor has a regular place of Business within 80 paved road miles of Billings, MT. Members can access the golf course (4) times a month. Each new Non-Resident Member will receive (4) guest passes annually. These guest passes are designed for new potential Members that have not experienced the Briarwood Golf Club Family. The same Guest should not be invited more than once annually.

Briarwood Business Memberships

Initiation fee: $ 6900
($6900 nonrefundable payable with application)

Initiation fee includes all employees that join the Briarwood Golf Club under the Business.

Monthly Dues:	$336 (Proprietary)
	$288 (Single)
	$234 (Young Professional)
	$142 (Elite Activity)
	$ 50 (Activity)
	$ (Social - not available)

⇒ The Business will receive (10) guest passes for the first year.
⇒ The individual Business employee will be held responsible for monthly dues. One Member of the Business will be designated to have voting rights.
⇒ Unlimited number of employees may apply for Membership.
⇒ Monthly Operating Fund Fee included
⇒ Food minimum ($100/qtr.) still apply per Member!

This Membership is for Businesses that fall under the guidelines set by the Briarwood Golf Club Board of Directors and the current by-laws of the Briarwood Golf Club:

Business Qualifications:

A Small business eligible for such Membership must be deemed a single, legal entity, e.g., ABC Small Business, not ABC Business and its sub-contracting vendors.

Small Businesses must have minimum of 10 employees.

May not have held Membership at Briarwood in the past (2) years to qualify for any promotions

All Members of the Briarwood Golf Club will be responsible for any investments/assessments that are approved by the Board of Directors.


JUST OUTSIDE
OF BRIARWOOD...

UNDER 10 MIN DRIVE:

- BLUE CREEK ELEMENTARY
- RIVERSIDE MIDDLE SCHOOL
- SENIOR HIGH SCHOOL
- HIGHWAY ACCESS
- SOUTH SIDE NEIGHBORHOOD
  - MCDONALDS, SUBWAY, DAIRY QUEEN, DOMINOS, WENDYS, TACO JOHNS, TACO BELL, CITY BREW, STARBUCKS, ETC.
  - AMEND PARK
  - LAVA ISLAND
  - SAMS CLUB
  - CABELAS
  - COMING SOON...NEW REC CENTER!

10 - 20 MIN DRIVE:

- HOSPITALS
- COSTCO
- AIRPORT
- DOWNTOWN BILLINGS
- WEST END BILLINGS
- BILLINGS HEIGHTS - METRA PARK


SOILS TEST

RIMROCK
ENGINEERING, INC.
5440 Holiday Avenue · Billings, Montana 59101: · Phone: 406.294.8400 · www.rimrock.biz

GEOTECHNICAL ENGINEERING REPORT

Single Family Residence
3335 McMasters Road
Billings, Montana

October 7, 2024
Project No. G24135

Prepared for:

Tia Scansen
3335 McMasters Boulevard
Billings, Montana 59105

Prepared by:

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

RIMROCK ENGINEERING, INC.

5440 Holiday Avenue · Billings, Montana 59101: · Phone: 406.294.8400 · www.rimrock.biz

October 7, 2024

Tia Scansen
3335 McMasters Boulevard
Billings, Montana 59105

Re: Geotechnical Engineering Report
Single Family Residence
3335 McMasters Road
Billings, Montana

Dear Tia:

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.

Matt Geering, P.E.
Senior Engineer/Vice President

Wade Reynolds
Office Manager/President

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APPENDICES

EXECUTIVE SUMMARY

Rimrock Engineering has completed the geotechnical engineering services for the Single Family Residence to be located at 3335 McMasters Road within Briarwood Estates 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 soils consist of about 18 feet of stiff, high plasticity sandy lean to fat clay soils (completely weathered shale) overlying weathered, poorly indurated shale bedrock which extended to the maximum depths explored. Groundwater was not encountered within the depths explored while drilling or for the short duration the borings were allowed to remain open.

- Lean to fat clay soils were encountered at anticipated foundation and slab elevations. Based on field and laboratory testing, the clay soils are relatively weak, have high plasticity, and compressible. Although, consolidation/swell testing did not indicate swell, Plasticity Index properties suggest some swell potential.

- In our opinion, the proposed residence can be supported by a shallow spread footing foundation system bearing on a zone of at least three (3) feet of geotextile-reinforced (Mirafi RS580i), structural fill over prepared subgrade. It is imperative that positive drainage be maintained for the life of the structure.

- A higher level of assurance against movement related distress would be supporting the structure using a deep foundation system such as drilled concrete piers. Deep foundation alternatives are typically more expensive and often cost prohibitive in residential construction.

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

Single Family Residence
3335 McMasters Road Estates
Billings, Montana

1.0 INTRODUCTION AND SCOPE

1.1 Project Description

The project consists of a new Single Family Residence to be located at 3335 McMasters Road within Briarwood Estates in Billings, Montana. At this time, we have not been provided with anticipated structural loads. Based upon previous experience with similar projects, we estimate relatively light loadings for structure of this type. Therefore, we have assumed that wall loads will be less than 2 kips per lineal foot. Additionally, we estimate that floor slab loads will be less than 150 pounds per square foot. Please notify us if these assumptions are not valid so that we may re-evaluate and, if necessary, revise our geotechnical recommendations.

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
- Corrosion of concrete and cement type
- General earthwork and site drainage

Our scope of services consisted of background review, site reconnaissance, field exploration, laboratory testing, engineering analyses, and preparation of this report. This study did not include evaluations of site seismicity, liquefaction, faulting, slope stability, or other potential geologic or environmental hazards.

2.0 EXPLORATION

2.1 Field Exploration

The subsurface exploration consisted of drilling two borings on October 21, 2024 to approximately 20 to 24 feet below existing grades. The borings were drilled using our truck mounted drill rig equipped with solid flight augers. Groundwater levels were measured during drilling operations when 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 Rimrock Engineering based on information provided. Ground surface elevation was set at 100 for purposes of this report. 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 boring. At selected intervals, samples of the subsurface materials were taken by driving split-spoon samplers, pushing thin-walled 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
- 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

The project site is situated along the north side of McMasters Boulevard within Briarwood Estates in Billings, Montana. The site slopes from north to south towards McMasters Boulevard. The surrounding areas consist of undeveloped property, residential development, and the Briarwood Golf Course.

3.2 Subsurface Profile

The subsurface soils consist of about 18 feet of stiff, high plasticity sandy lean to fat clay soils (completely weathered shale) overlying weathered, poorly indurated shale bedrock which extended to the maximum depths explored. The clay soils had Standard Penetration Test (SPT) N-values in the range of 10 to 13 blows per foot which indicates the soils are stiff in consistency,

compressible, and low in shear strength characteristics. For a more detailed description of the subsurface conditions, please refer to the logs provided in Appendix A

3.3 Groundwater Conditions

The borings were observed while drilling and after completion for the presence and level of groundwater. Groundwater was not encountered within the depths explored while drilling or for the short duration the borings were allowed to remain open. Due to the relatively low permeability of the clay soils encountered in the boring, a relatively long period of time may be needed for a groundwater level to develop and/or stabilize in the boring. 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 and weather 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 fine-grained soils encountered in the borings generally have high plasticity. Results are summarized below:

Location	Depth (ft)	USCS	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Gravel (%)	Sand (%)	Clay/Silt (%)
B-1	2.5	CL	39	15	24	7.0	24.4	68.6
B-2	7.5	CH	51	17	34	0.0	11.0	89.0

A sample of the fine-grained soils was tested for consolidation/swell potential. The sample was allowed to consolidate under a confining pressure of 1,000 pounds per square foot (psf). Once consolidation under the surcharge load was complete, the sample was 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 sample.

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

Location	Depth (ft)	Material	Dry Unit Weight (pcf)	Strain at 2,000 psf (%)	Collapse (-) / Swell (+) (%)
B-2	7.5	CH	114	2.7	-

4.0 RECOMMENDATIONS

4.1 Geotechnical Concerns/Considerations

Lean to fat clay soils were encountered at anticipated foundation and slab elevations. Based on field and laboratory testing, the clay soils are relatively weak, have high plasticity, and compressible. Although, consolidation/swell testing did not indicate swell, Plasticity Index properties suggest some swell potential.

Due to these concerns, if a shallow foundation system is desirable, we recommend the structure be supported on a zone of geotextile-reinforced structure fill over reconditioned materials. Performance of this system is directly related to the proper treatment and re-compaction of the native soils, placement and control of geotextiles and structural fill, and good positive drainage for the life of the structure.

In addition to the structural fill system, treatment of the existing expansive materials should be considered in order to reduce swell tendencies of the site materials. CST Concrete Stabilization Technologies, Inc. offers expansive soil remediation treatment. This option involves injecting a stabilizing agent called AGSS-ICS into the soil through small injection probes. This chemical reduces swell potential and minimizing shrinkage potential of expansive soils. This would provide an added level of protection against swell potential.

A higher level of assurance against movement related distress would be supporting the structure using a deep foundation system such as drilled concrete piers extending into the underlying shale formation with a structural floor. Deep foundation alternatives are typically more expensive and sometimes cost prohibitive in residential construction. In our opinion, a deep foundation system provides the highest level of assurance against movement related distress to the completed structure. The Owner should be made aware of and accept the risk of bearing on compressible and/or expansive soils and the potential for movements if shallow foundations are used.

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, 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.

If shallow foundations are utilized, in order to limit consolidation and/or swell potential of the site subgrade soils, foundation preparation should allow for the placement of at least 3 feet of geotextile-reinforced structural fill. Excavation for structural fill placement should extend laterally beyond all edges of the foundation at least 8 inches per foot of over-excavation depth.

Prior to placing the geotextile and structural fill, the exposed subgrade soils should be tightened with a roller or similar equipment to provide a stable surface. Rimrock Engineering should observe the subgrade surface to ascertain integrity consistent with the design assumptions. Prior to the placement of structural fill, we recommend the separation/stabilization geotextile Mirafi RS580i be placed at the interface between the prepared subgrade and the structural fill zone to help stabilize the subgrade as well as keep the subgrade soils from intruding into the structural fill. A second layer of this geotextile or geogrid Mirafi BXG120 is recommended in the middle of the structural fill section for additional stability and reinforcement.

The excavated site soils, cleaned of all organic/deleterious material, construction debris, and rock greater than 4 inches in nominal size (if encountered), may be stockpiled on-site and re-used as wall/trench backfill or for landscaping purposes. The processed, on-site clayey soils will provide some advantage as wall/trench backfill to limit potential for surface water infiltration. An impermeable liner should be considered around the perimeter of the structure and extend out past the backfill/trench zone to reduce potential for surface water infiltration into foundation bearing soils.

4.2.2 Material Requirements

It is anticipated that excavated materials will be used to the extent practical as wall and trench backfill. The material suitability should be evaluated by the 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)

4.2.3 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% **Subgrade Soils:** 95% **Aggregate Base (beneath slabs):** 95% **Wall/Trench Backfill:** 95% **Drainage Aggregate:** Tamp to Stable Condition
Moisture Content (ASTM D698)	**Structural Fill:** ±3 % of optimum **Site Clayey Soils:** 0 to +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.

4.2.4 Utility Trench Backfill

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 structure should be effectively sealed to restrict water intrusion and flow through the trenches that could migrate beneath the structure. We recommend constructing an effective clay “trench plug” that extends at least 5 feet out from the structure. 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.

4.2.5 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 structure during and after construction. Water permitted to pond next to the structure 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 structure and cannot be relied upon if effective drainage is not maintained.

In areas where sidewalks or paving do not immediately adjoin the structure, 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. Sprinkler systems should not be installed within 10 feet of foundation walls. Landscaped irrigation adjacent to the foundation system should be minimized, eliminated, or strictly regulated.

4.2.6 Construction Considerations

Although the exposed subgrade soils are 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, our geotechnical engineer 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 foundation preparation, structural fill placement, compaction of backfill, and final preparation for construction of the structure.

4.3 Drilled Pier Foundation System

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

4.3.1 Axial/Uplift Design Capacity

The site soils are expected to have some expansive potential and design should provide allowance for uplift resistance. Based on field and lab test results, we believe a nominal active zone of 5 feet should be assumed as a minimum. The geotechnical resistance for drilled piers can be estimated using the following ultimate values:

Material	Ultimate Skin Friction (psf)	Ultimate End Bearing (psf)
Clay	1,000*	-
Shale	1,000	18,000

*Consider as ultimate adhesion in upper 5 feet of profile for uplift analysis.

Piers should be sized for axial compressive loading using a Factor of Safety (FS=3) applied to the ultimate parameters provided. Potential uplift loads should be considered due to possible swelling and adhesion in the active upper zone as noted. A minimum Factor of Safety (FS=1.5) should be provided versus uplift by considering the skin friction below the active zone and the shaft/structure dead load as resistance. All piers should be reinforced full-depth for the applied axial, lateral, and uplift stresses imposed.

A minimum pier diameter of 18 inches is recommended to facilitate proper cleaning and observation of the pier hole. We recommend a minimum pier length of 15 feet. 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.

4.3.2 Lateral Design Capacity

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}
Clay	115	500	-	100	0.010
Shale	130	1,000	-	1,000	0.005

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.

4.3.3 Design Considerations

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 will likely not 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 V or other sulfate resistant cement to have a minimum 28-day compressive strength of 4,500 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.

Foundation elements such as pier caps should extend at least 3.5 feet below final grade to provide frost protection. Downdrag is not expected to be a concern for the site soils based on limited changes in existing grade.

The clay soils may have some expansive potential and uplift on pier caps and grade beams could be generated if moisture infiltrates below the structure. This potential can be mitigated by incorporation of positive surface drainage and use of void forms or compressible filler (geo-foam beneath grade beams).

4.4 Shallow Foundation System

In our opinion, if deep foundations are not desired, the proposed residence can be supported by a shallow spread footing foundation system bearing on a zone of at least three (3) feet of geotextile-reinforced (Mirafi RS580i) structural fill over prepared subgrade.

The spread footing foundation system constructed on structural fill, as described above, may be designed for a maximum allowable bearing pressure of 2,500 pounds per square foot (psf). 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 structure is properly constructed, the total movement resulting from the assumed 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 18 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 soft/loose material prior to placing structural fill. Structural fill should be placed soon after subgrade preparation to reduce bearing surface disturbance. Should the subgrade bearing surface become excessively dry, disturbed, saturated, or frozen, the affected material should be removed and replaced with additional structural fill material prior to placing concrete. It is recommended that Rimrock Engineering 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.

It should be noted that granular structural fill is a pervious material and the existing clay/shale 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 and is recommended due to the moisture-sensitive clay/shale subgrade materials.

To intercept potential water infiltration from impacting the foundation bearing stratum, an exterior perimeter drain should be considered due to the moisture-sensitive subgrade materials. The exterior drainage system should be constructed around the outer perimeter of the over-excavation, and sloped at a minimum 1/8 inch per foot to a suitable outlet, such as a sump and pump system or day-lighted to a suitable outlet.

The exterior drainage system should consist of a 4-inch perforated pipe (minimum), embedded in free-draining gravel. Prior to placement of the drainage gravel, 20 mil (minimum) polyethylene sheeting should be placed to contain the flow of the system and be fixed to the footing. Gravel should extend a minimum of 3 inches beneath the bottom of the pipe, and at least 2 feet above the bottom of the foundation. The gravel should be wrapped with drainage fabric such as Mirafi 140N.

4.5 Concrete Slabs

Due to potential for swell, a structural floor should be considered. If a structural floor is not desired, to reduce the potential for movement related distress to concrete slabs where present, we recommend a minimum of 12 inches of geotextile-reinforced (Mirafi RS580i) structural fill be used for slab support. A leveling course, typically 4 to 6 inches of sand/gravel, should also be provided below the concrete slabs.

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
- Floor slabs should be structurally independent of any building footings or walls to reduce the possibility of floor slab cracking caused by differential movements between slab and foundation
- 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 building and could present a tripping hazard where slab sections move independently. Potential movement could be reduced by:

- Performing regular joint-sealing maintenance
- Minimizing moisture variations in the subgrade
- Minimizing moisture introduction to slab surfaces
- Rebar reinforcement on relatively close centers
- Controlling moisture-density during placement
- Placing effective control joints on relatively close centers

- Using designs which allow vertical movement between the exterior features and adjoining structural elements

4.6 Lateral Earth Pressures

Basement walls, if present, 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 soils will be re-used as backfill material, a value of 80 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.

4.7 Corrosion Protection

A soil sample was submitted for water soluble sulfate, pH and resistivity testing. The results are summarized in the following table:

Location	Depth (ft)	Material	Water Soluble Sulfate Content (%)	Resistivity (ohm/cm)	pH
B-2	4.0	CL	0.71	124	8.0

Water soluble sulfate values between 0.20 and 2.00 are considered to have severe attack potential on normal strength concrete. As a result, Type V Portland or other sulfate resistant cement with a maximum water-cementitious materials ratio of 0.45 should be specified for all project concrete placed on and below grade. Foundation concrete should be designed in accordance with the provisions of the ACI Design Manual, Section 318, Chapter 4.

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.

5.0 ADDITIONAL SERVICES

The recommendations made in this report assume that an adequate program of tests and observations will be made during construction to verify compliance with these recommendations. 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 boring 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

Rimrock Engineering, Inc.
5440 Holiday Avenue
Billings, MT 59101 Tel. (406) 294-8400

PROJECT NO. G24135

VICINITY/SITE MAP

SINGLE FAMILY RESIDENCE
3335 McMasters Road
Billings, Montana

N

BORING NUMBER B-1

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

CLIENT Tia Scansen
PROJECT NAME SFR 335 McMasters Rd.
PROJECT NUMBER G24135
PROJECT LOCATION Billings, MT
DATE STARTED 10/21/24 **COMPLETED** 10/21/24
GROUND ELEVATION 100 ft **HOLE SIZE** 5 inches
DRILLING CONTRACTOR Rimrock Engineering, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Solid Stem Auger
AT TIME OF DRILLING ---
LOGGED BY G.J. **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 Brown, stiff, high plasticity, coarse to fine sand.	SPT	100	6-6-6 (12)			12	39	15	24	69
5			SPT	100	5-5-5 (10)			16				
		(CH) FAT CLAY Brown, stiff, high plasticity, some sand.	SPT	100	3-6-8 (14)			17				
10			SPT	100	4-5-6 (11)			18				
15			SPT	100	5-6-7 (13)			13				
		SHALE Gray/brown, weathered, moderately hard to hard, more competent with depth.										
20			SPT	100	16-19-26 (45)			23				

Bottom of borehole at 24.0 feet.

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

BORING NUMBER B-2

CLIENT Tia Scansen
PROJECT NAME SFR 335 McMasters Rd.
PROJECT NUMBER G24135
PROJECT LOCATION Billings, MT
DATE STARTED 10/21/24 **COMPLETED** 10/21/24
GROUND ELEVATION 100 ft **HOLE SIZE** 5 inches
DRILLING CONTRACTOR Rimrock Engineering, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Solid Stem Auger
AT TIME OF DRILLING ---
LOGGED BY G.J. **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 Brown, stiff, high plasticity, coarse to fine sand.										
5			AU	100				13				
		(CH) FAT CLAY Brown, stiff, high plasticity, some sand.	ST	100		3.5	114	13	51	17	34	89
10												
15			AU	100				24				
20		SHALE Gray/brown, weathered, moderately hard to hard, more competent with depth.										

Bottom of borehole at 20.0 feet.

KEY TO SYMBOLS

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

CLIENT Tia Scansen **PROJECT NAME** SFR 335 McMasters Rd.

PROJECT NUMBER G24135 **PROJECT LOCATION** Billings, MT

LITHOLOGIC SYMBOLS
(Unified Soil Classification System)

- CH: USCS High Plasticity Clay
- CLS: USCS Low Plasticity Sandy Clay
- SHALE: Shale
- 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

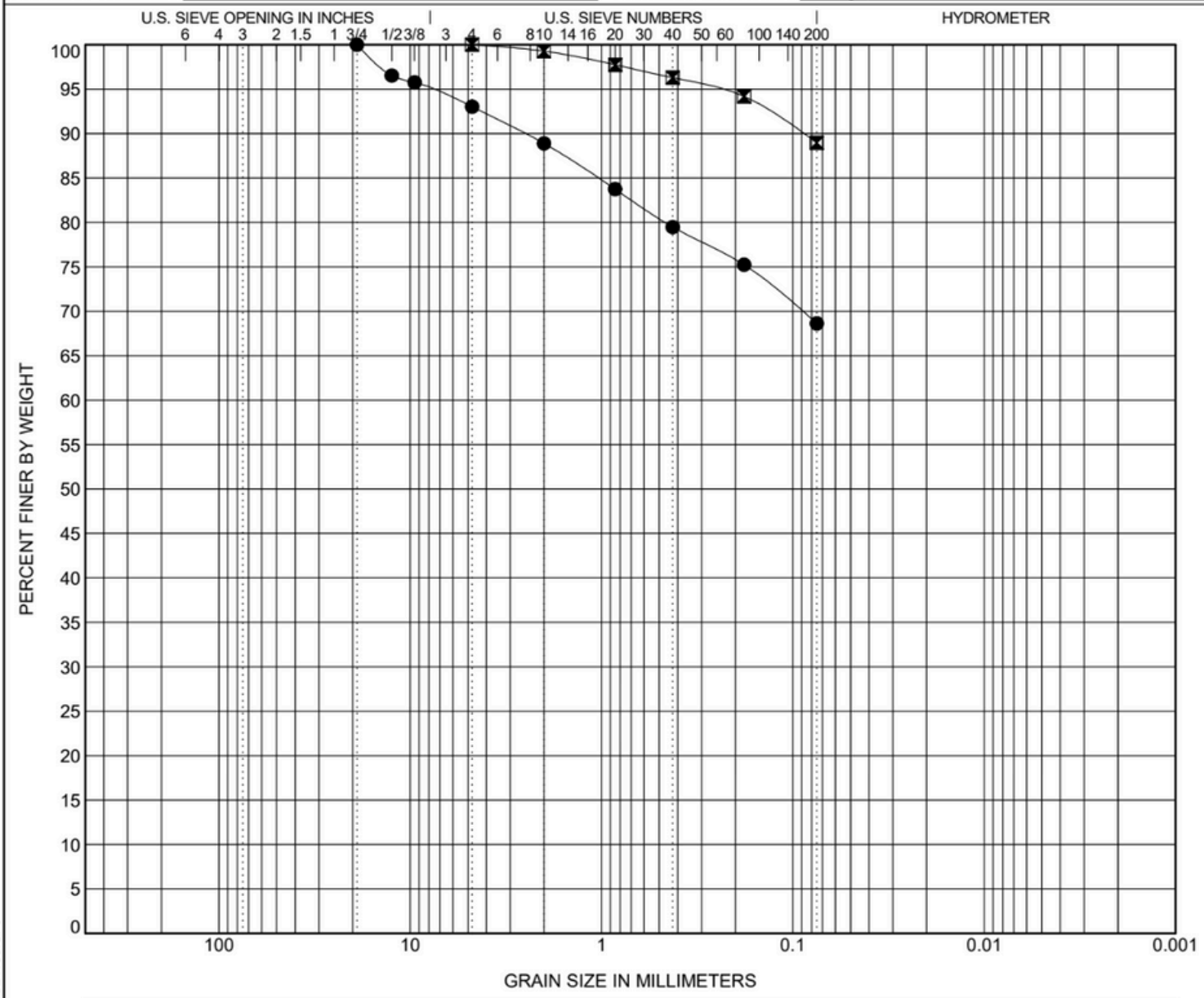
Laboratory Test Results

GRAIN SIZE DISTRIBUTION

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

CLIENT Tia Scansen **PROJECT NAME** SFR 335 McMasters Rd.

PROJECT NUMBER G24135 **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	2.5	SANDY LEAN CLAY(CL)	39	15	24		
⧓	B-2	7.5	FAT CLAY(CH)	51	17	34		

	BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-1	2.5	19				7.0	24.4	68.6	
⧓	B-2	7.5	4.75				0.0	11.0	89.0	

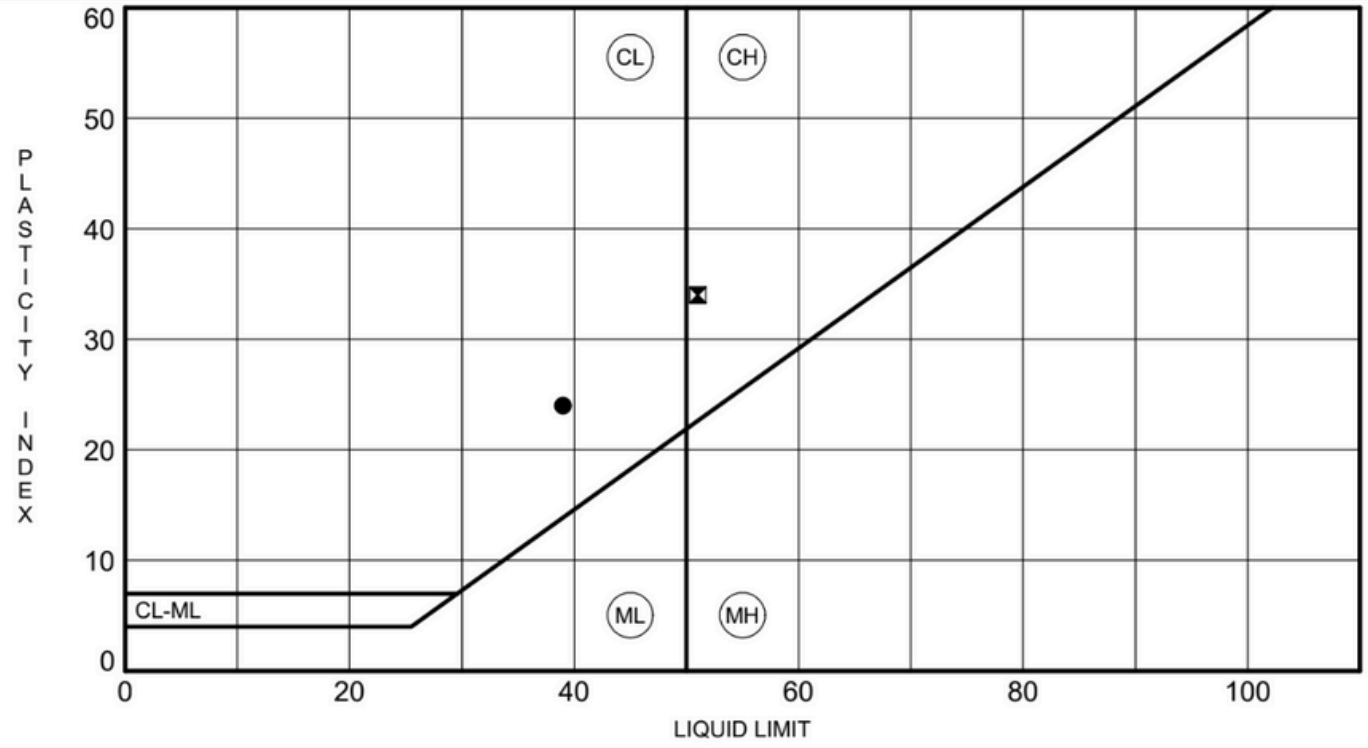
GRAIN SIZE - GINT STD US LAB.GDT - 11/7/24 13:37 - G:\PROJECTS\2024\G24135.GPJ

ATTERBERG LIMITS' RESULTS

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

CLIENT Tia Scansen **PROJECT NAME** SFR 335 McMasters Rd.

PROJECT NUMBER G24135 **PROJECT LOCATION** Billings, MT



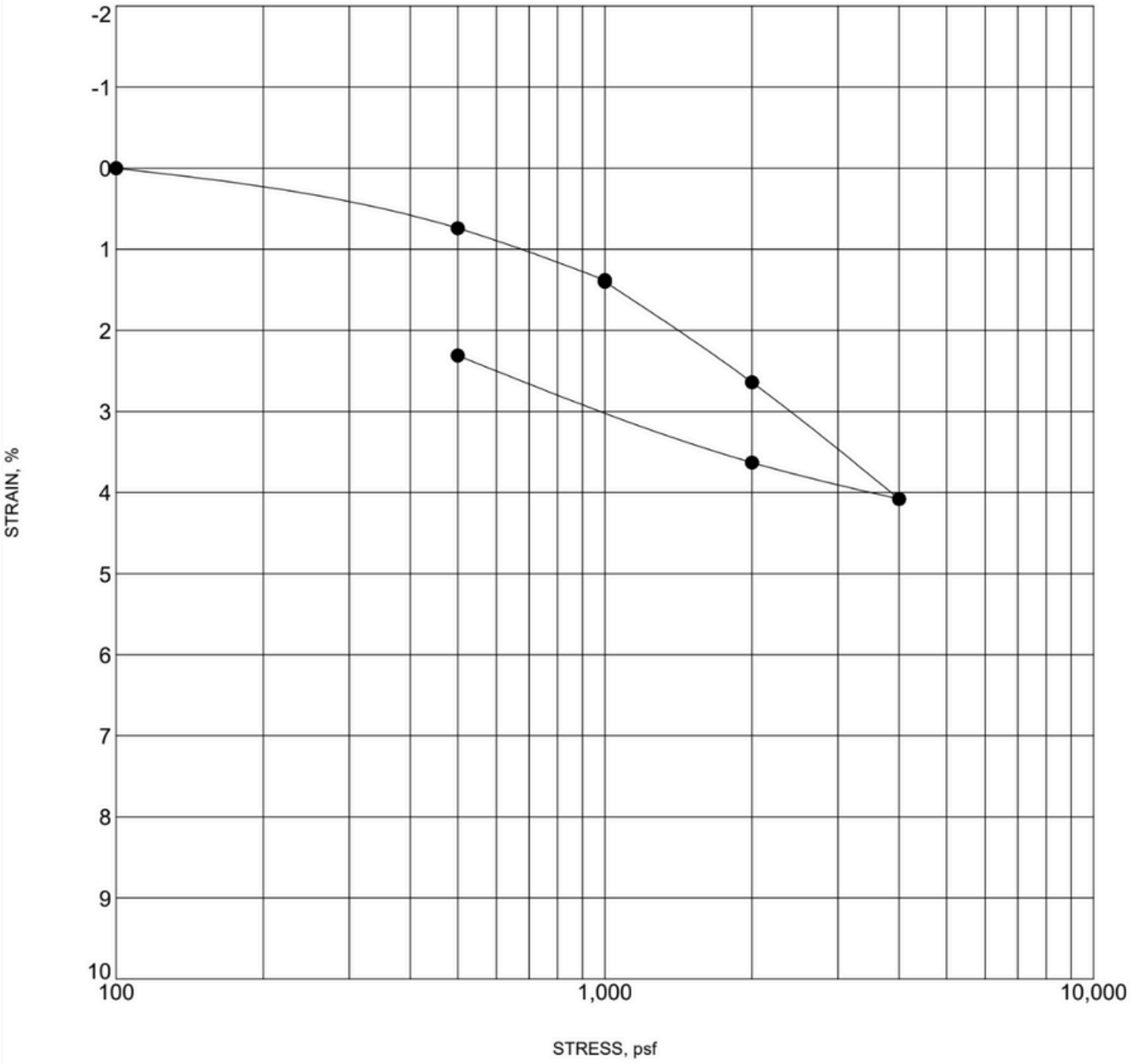
	BOREHOLE	DEPTH	LL	PL	PI	Fines	Classification
●	**B-1**	**2.5**	**39**	**15**	**24**	**69**	**SANDY LEAN CLAY(CL)**
⧓	**B-2**	**7.5**	**51**	**17**	**34**	**89**	**FAT CLAY(CH)**

CONSOLIDATION TEST

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

CLIENT Tia Scansen **PROJECT NAME** SFR 335 McMasters Rd.

PROJECT NUMBER G24135 **PROJECT LOCATION** Billings, MT



	BOREHOLE	DEPTH	Classification	γ_d	MC%
●	**B-2**	**7.5**	**FAT CLAY(CH)**	**114**	**13**