Geotechnical Investigation Report
Hugo Roundhouse Interior Renovation
Hugo, Lincoln County, Colorado

RockSol Project No. 813.01
April 26, 2024

Prepared for:

Lincoln County
103 3rd Avenue
Hugo, Colorado, 80821

Attention: Mr. Jacob Piper
Lincoln County Administrator

Prepared by:

RockSol Consulting Group, Inc.
12076 Grant Street
Thornton, Colorado 80241
(303) 962-9300

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Senior Geotechnical Engineer

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1.0 PROJECT PURPOSE AND DESCRIPTION

This report documents the geotechnical soil investigation performed by RockSol Consulting Group, Inc. (RockSol) to assist with evaluating the subsurface conditions for proposed interior improvements to the Hugo Roundhouse in Hugo, Colorado (see Image 1). The Hugo Roundhouse building is an historic Union Pacific Railroad Roundhouse. Based on information provided by Lincoln County (County) in a Geotechnical Scope Letter dated January 25, 2024 prepared by Bret Johnson Architecture and preliminary plan sets prepared by Martin/Martin, the proposed construction includes a new one-story mezzanine structure within Bays 5 and 6 of the existing Roundhouse Building. We understand the existing building foundations are shallow footings and are not to be altered. At completion of the improvements, the facility will have an occupant load capacity in excess of 300 people.

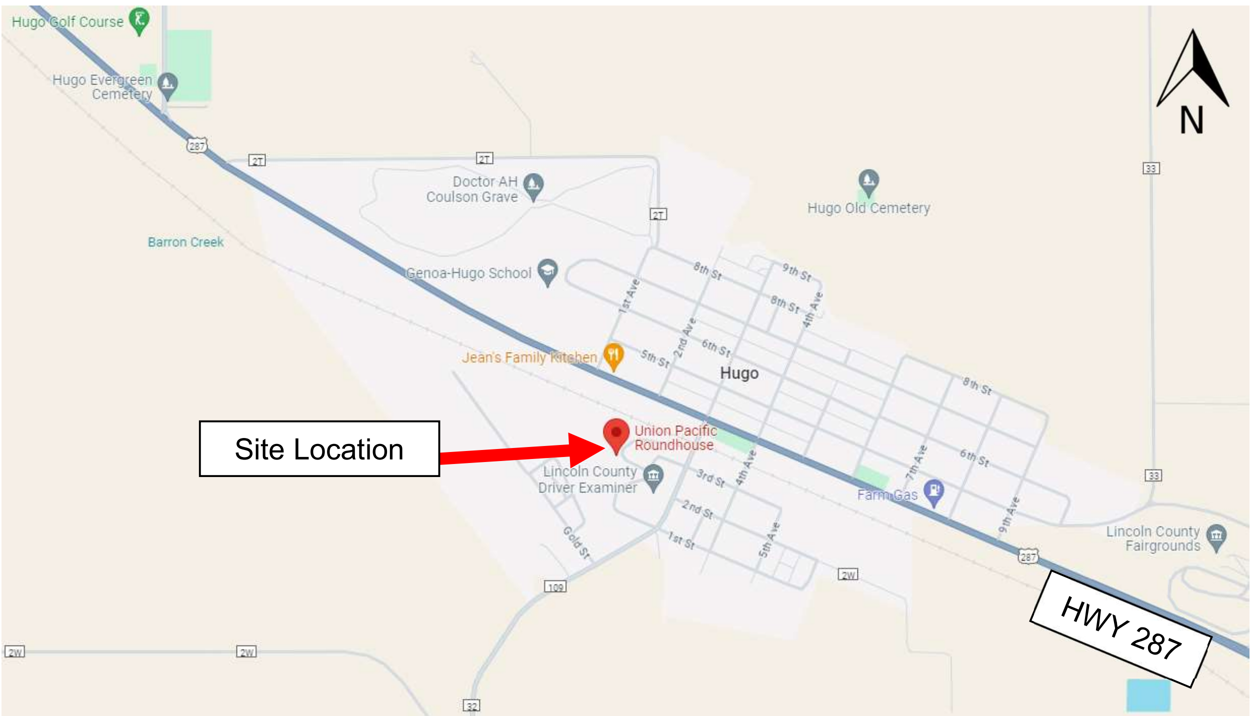


Image 1 – Site Vicinity Map (Google Maps)

The scope of work for this geotechnical investigation included:

- Formulating a drilling plan and performing the necessary subsurface investigation including the collection of samples as required.
- Performing appropriate laboratory tests and analyzing the data to determine strength properties, allowable bearing capacity, settlement potential, and corrosiveness of existing soils.
- Providing a Geotechnical Investigation Report summarizing the subsurface conditions encountered, the results of laboratory testing, groundwater and bedrock conditions, geologic hazards including any known subsurface obstructions, soil and bedrock corrosion potential, seismic design parameters, geotechnical parameters for foundation design, slab-on-grade subgrade recommendations, settlement mitigation, and earthwork recommendations.

2.0 PROJECT SITE CONDITIONS

The project site is located in Section 31, Township 10 South, Range 54, west of the 6th Principal Meridian in the City of Hugo in Lincoln County, Colorado. Developments near or adjacent to the site include Lincoln County facilities, commercial properties, and residential properties to the south and east of the project site and undeveloped land to the north and west of the project site. Big Sandy Creek flows approximately 2,000 feet to the southwest of the Hugo Roundhouse. Topography at the site is generally flat.

3.0 GEOLOGICAL SETTING

Based on information presented in the *Geologic Map of the Limon 1 Degree x 2 Degree Quadrangle, Colorado and Kansas* by J.A. Sharps, dated 1980 (See Image 2 – Site Geology Map), the site is underlain by slope wash (Qsw) which consists of slope sheetwash deposited sandy silt, alluvium (Qa) which consists of silt, sand, and gravel, and eolian sand (Qe) which consists of very fine to medium grain wind-deposited sand. Pierre Shale (Kp) is noted at or near the surface to the north and east of the project site. No geologic hazards, including subsurface obstructions, are expected to be encountered at the project site.

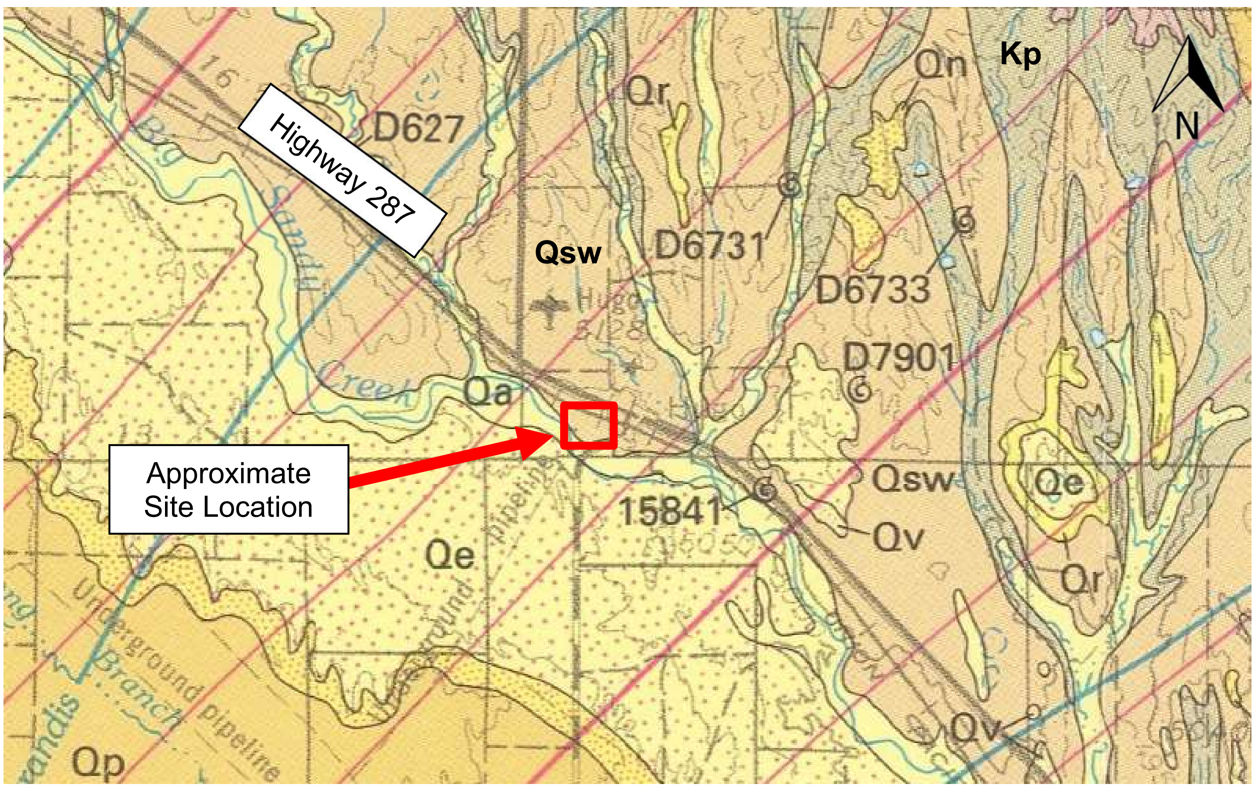


Image 2 – Site Geology Map (USGS)

4.0 SUBSURFACE EXPLORATION

On March 20, 2024, RockSol completed two soil boreholes to evaluate subsurface conditions in the interior of the Hugo Roundhouse, identified as B-1 and B-2. Borehole B-1 was completed in Bay 5 and Borehole B-2 was completed in Bay 6. Borehole locations were selected to be within proposed improvement areas and avoid existing structural elements. Top of borehole elevations were not surveyed as part of this project. Borehole elevations shown on the borehole logs were estimated using the USGS Limon, Colorado; Kansas Topographic Map, dated 1954 and are not represented to be exact elevations. Image 3 shows the borehole locations overlayed on the preliminary foundation plan provided by Lincoln County.

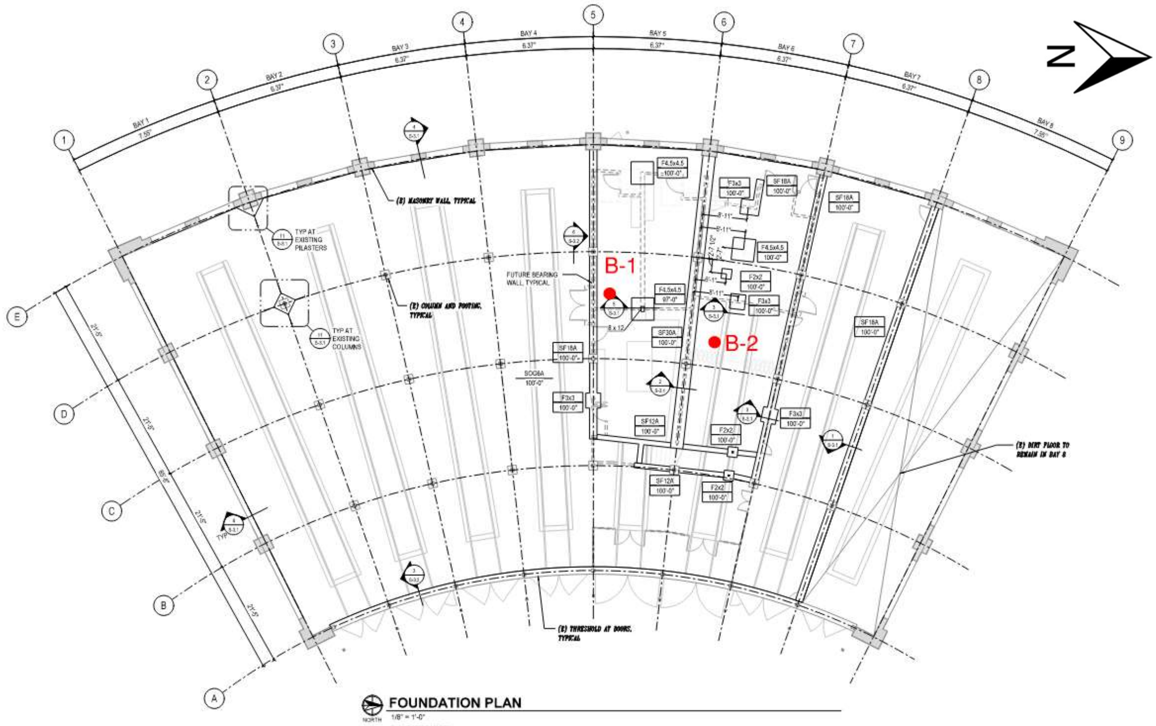


Image 3 – Borehole Location Plan

Boreholes were advanced using a CASE mini-drill rig using 3-inch outside diameter solid stem augers to maximum depths ranging from approximately 24 feet to 27 feet below existing grades. The boreholes were logged in the field by a representative of RockSol per ASTM D-2488 with the depth to groundwater, if encountered, noted at the time of drilling. The boreholes were backfilled at the completion of sampling activities.

Subsurface materials were sampled and resistance of the soil to penetration of the sampler was performed using modified California barrel and standard split spoon samplers. Penetration Tests were performed using a manual lift system and a hammer weighing 140 pounds falling 30 inches.

The modified California barrel sampler has an outside diameter of approximately 2.5 inches and an inside diameter of 2 inches. The standard split spoon sampler used had an outside diameter of 2 inches and an inside diameter of 1⅜-inches. Brass tube liners were used with the modified California barrel sampler. Brass tube liners are not used with the standard split spoon sampler.

The standard split spoon sampling method is the Standard Penetration Test (SPT) described by ASTM Method D-1586.

The modified California Barrel sampling method is similar to the SPT test with the difference being the sampler dimensions and the number of 6-inch intervals driven with the hammer per ASTM D3550. It is RockSol's experience that blow counts obtained with the modified California sampler tend to be slightly greater than a standard split spoon sampler.

Penetration resistance values (blow counts) were recorded for each sampling event. Blow counts, when properly evaluated, indicate the relative density or consistency of the soils. Depths at which the samples were taken, the type of sampler used, and the blow counts that were obtained are shown on the Borehole Logs (See Appendix A).

5.0 LABORATORY TESTING

Soil samples retrieved from the borehole locations were examined by the project geotechnical engineer in the RockSol laboratory. Selected samples were tested and classified according to the Unified Soil Classification System (USCS). The following laboratory tests were performed in accordance with the American Society for Testing and Materials (ASTM), American Association of State Highway and Transportation Officials (AASHTO), and current local practices:

- Natural Moisture Content (ASTM D-2216)
- Percent Passing No. 200 Sieve (ASTM D-1140)
- Liquid and Plastic Limits (ASTM D-4318)
- Dry Density (ASTM D-2937)
- Soil Classification (ASTM D-2487 and AASHTO M145)
- Gradation (ASTM D6913)
- Water-Soluble Sulfate Content (CDOT CP-L 2103)
- Water-Soluble Chloride Content (CDOT CP-L 2104)
- Swell Test (Denver Swell Test, modified from ASTM D-4546)

Laboratory test results were used to characterize the engineering properties of the subsurface material. For soil classification, RockSol conducted sieve analyses and Atterberg Limits tests. Lab testing was also performed on selected samples to determine the water-soluble sulfate content of subsurface materials to assist with cement type recommendations. Laboratory test results are presented in Appendix B and are also summarized on the Borehole Logs found in Appendix A.

6.0 SURFACE AND SUBGRADE CHARACTERIZATION

6.1 Existing Surface Materials

Surface materials encountered in our boreholes generally consisted of loose silty sand fill material with minor amounts of concrete, wood, ceramic, plastic, and glass debris. The debris is likely due to historic building usage and recent renovation work within the building. It appears that the interior was previously surfaced, at least partially, with wood block pavers. The silty sand fill material is likely a bedding material placed below the wood block pavers. All debris should be removed prior to construction of the proposed improvements. An example of debris on the ground surface is shown in Image 4.

Image 4: Hugo Roundhouse Surface Material Conditions

6.2 Subsurface Materials

Subsurface materials generally consisted of fine-grained fill material overlying native clay and sand. Pierre Shale bedrock was encountered approximately 23 to 23.5 feet below existing grades. Groundwater was encountered at an approximate depth of 9 feet below existing grades during drilling operations at both boreholes. Descriptions of the subsurface conditions encountered in the boreholes are provided below and are also summarized on the Borehole Logs presented in Appendix A.

Fill Material

Fill material was encountered directly below the surface materials described in Section 6.1 at both borehole locations and generally consisted of brown, medium stiff to stiff sandy clay with iron staining and intermittent debris. The fill material extended to depths of approximately 3 to 3.5 feet below existing grades. The fill material is likely the result of grading required during original construction of the Roundhouse.

Native Soils

Native soils were encountered below the fill material in both boreholes. A layer of stiff, brown to gray, moist to very moist, calcareous sandy clay was noted that extended to a depth ranging from 8 to 8.5 feet below existing grades. Below the clay, loose to medium dense, brown, very moist to wet, slightly silty to gravelly sand was encountered and extended to the underlying bedrock surface.

Bedrock

Bedrock was encountered at approximate depths of 23 feet and 23.5 feet at borehole locations B-1 and B-2, respectively. Bedrock was identified as the Pierre Shale formation and classified as hard to very hard based on blow count data.

Groundwater

Groundwater was encountered at both borehole locations at a depth of approximately 9 feet below existing grades at the time of drilling. Groundwater levels at the site may vary and are subject to seasonal change and long-term precipitation trends.

6.3 Swell Potential of Subgrade Soils

RockSol performed one swell test on a sample of the native clay in Borehole B-1 at a depth of 4 feet below existing grade. Based on swell test results, the subgrade soils encountered within the upper 9 feet of the existing subgrade at the project site exhibit low representative swell potential (0.7 percent swell under 1,000 pounds per square foot (psf) surcharge pressure). Representative swell potential descriptions are based on Colorado Association of Geotechnical Engineers (CAGE) Guideline for Slab Performance Risk Evaluation and Table 4.9 of the CDOT 2024 Pavement Design Manual Addendum. RockSol does not recommend any special mitigation for swell.

6.4 Cement Type/Sulfate Resistance Discussion

Lincoln County has adopted the 2018 International Building Code (IBC 2018) as the building code standard, including development of concrete resistance parameters. The IBC 2018 references the American Concrete Institute (ACI) for such parameters. Cementitious material requirements for concrete in contact with site soils or groundwater are based on the percentage of water-soluble sulfate in either soil or groundwater that will be in contact with concrete constructed for this project. Mix design requirements for concrete exposed to water-soluble sulfates in soils or water are considered by the ACI as shown in Table 6.1 and in the Building Code Requirements for Structural

Concrete (ACI 318-14) (ACI Table 19.3.2.1). A summary of our water-soluble sulfate testing of on-site soils is shown in Table 6.2.

Table 6.1 – Requirements to Protect Against Damage to Concrete by Sulfate Attack from External Sources of Sulfate

Exposure Class	Water-soluble sulfate (SO_4), in dry soil, percent	Sulfate (SO_4), in water, ppm	Water Cementitious Ratio, maximum	Cementitious Material Requirements (ASTM C150)
S0	0.00 to <0.10	0 to <150	Not Applicable	No Restriction
S1	0.10 to < 0.20	151 to <1,500	0.50	Type II
S2	0.20 to 2.0	1,500 to 10,000	0.45	Type V
S3	2.01 or greater	10,001 or greater	0.45	Type V plus pozzolan

Table 6.2 – Water-Soluble Sulfate Testing Summary

Borehole I.D.	Sample Depth (Feet)	Water-Soluble Sulfate (SO_4) in dry soil, percent	Exposure Class
B-1	1 – 9	0.00	S0
B-2	4	0.01	S0
B-2	9	0.01	S0
B-2	24 – 27	0.13	S1

The concentration of water-soluble sulfates measured in soil samples obtained from RockSol's exploratory boreholes resulted in sulfate content ranging from 0.00 to 0.01 percent by weight. One sample of bedrock material was tested for water-soluble sulfate content and resulted in a sulfate content of 0.13 percent by weight. Based on the results of the water-soluble sulfate testing, Exposure Class S0 is recommended for concrete in contact with subgrade soils and Exposure Class S1 is recommended for concrete in contact with bedrock for the project. For Exposure Class S0, there are no restrictions on the type of cement used at this site.

7.0 SEISMICITY DISCUSSION

Lincoln County uses the 2018 International Building Code (IBC 2018) for development of seismic design parameters. The IBC 2018 references the American Society of Civil Engineers 7-16 (ASCE 7-16) seismic design code. Based on the terminal depths of our boreholes and the subsurface conditions encountered, it is our opinion that the subject site meets criteria for Seismic Site Class D. Site Class E and F conditions were not encountered. Shear wave velocity testing was not performed by RockSol. Seismic design parameters for Seismic Site Class D are discussed below.

7.1 Seismic Design Parameters

Seismic design parameters were obtained from the United States Geological Survey (USGS) Earthquake Design Maps using the 2018 International Building Code specifications which reference ASCE 7-16. Values were obtained using the USGS site: https://seismicmaps.org. The Hugo Roundhouse qualifies as risk category III per Table 1604.5 of the *IBC-2018* based on the occupant loading capacity exceeding 300 after completion of the Roundhouse improvements. Interpolated values for Peak Ground Acceleration Coefficient (PGA), Spectral Acceleration Coefficient at Period 0.2 sec (S_s), and Spectral Acceleration Coefficient at Period 1.0 sec (S_1) were obtained using the latitude and longitude for the site. The seismic acceleration coefficients obtained (data based on 0.05-degree grid spacing) are presented in Table 7.1.

Table 7.1 – Seismic Acceleration Coefficients

Project Location (Latitude°/Longitude°)	Peak Ground Acceleration (PGA)	Spectral Acceleration Coefficient - S_s (Period 0.2 sec)	Spectral Acceleration Coefficient - S_1 (Period 1.0 sec)
Hugo Roundhouse (39.1338 N/ -103.4746 W)	0.058	0.12	0.044

The acceleration coefficients are then used to obtain Site Factors F_a, and F_v based on the defined Site Class as shown in Tables 1613.2.3(1) and 1613.2.3(2) of the *IBC-2018*. A summary of the Site Factor values obtained are shown in Table 7.2.

Table 7.2 – Seismic Site Factor Values

Project Location (Latitude°/Longitude°)	Fpga (at zero-period on acceleration spectrum)	Fa (for short period range of acceleration spectrum)	Fv (for long period range of acceleration spectrum)
Hugo Roundhouse (39.1338 N/ -103.4746 W)	1.6	1.6	2.4

Table 7.3 summarizes the Seismic Design Category determination and horizontal response spectral Acceleration Coefficients (S_{D1}) and (S_{DS}) obtained for the proposed structure. Seismic Performance Zone determination is based on the value of the horizontal response spectral Acceleration Coefficient at 1.0 Seconds, S_{D1}, as determined by *Eq. 16-39* of the IBC-2018 and the horizontal response spectral Acceleration Coefficient at 0.2 Seconds, S_{DS}, as determined by *Eq. 16-38.* Values for S_1 and F_v are presented in Tables 7.1 and 7.2, shown above. The seismic performance zone was determined *IBC-2018* Tables 1613.2.5(1) and (2). Seismic Design output sheets are summarized in Appendix E.

Table 7.3 – Seismic Design Category

Project Location (Latitude°/Longitude°)	Acceleration Coefficient at 1.0 seconds (S_{D1})	Acceleration Coefficient at 0.2 seconds (S_{DS})	Seismic Design Category (1)
Hugo Roundhouse (39.1338 N/ -103.4746 W)	0.07	0.128	B

Note (1): Seismic Design Category B (For Risk Categories I, II or III) is assigned when
$0.067g \le S_{D1} < 0.133g$ or $0.167g \le S_{DS} < 0.33g$ and $S_{D1} < 0.133g$ and $S_{DS} < 0.33g$

8.0 MEZZANINE STRUCTURE FOUNDATION RECOMMENDATIONS

Per Bret Johnson Architecture, a new mezzanine structure will be constructed in the existing Hugo Roundhouse Building in Bays 5 and 6. The mezzanine structure will consist primarily of wood frames with some steel elements. Loading for the mezzanine structure is estimated to be 4 kips for maximum column dead load, 20 kips for maximum column dead plus live load, and 2.6 kips per foot for maximum wall dead plus live load.

Shallow foundations are considered feasible and the most economical foundation option for the Hugo Roundhouse Interiors improvements. Deep foundations are feasible to support the proposed improvements, but it is RockSol's opinion that it is not the most economical option. Shallow foundation design parameters are presented below.

Based on conditions encountered in Boreholes B-1 and B-2, bearing resistances are presented in Table 8.1 for shallow (footing) foundations for the proposed improvements. Values for AASHTO Load and Resistance Factor Design (LRFD) strength limit state, service limit state, and Allowable Bearing Resistance (ASD) are presented. A resistance factor of 0.45 is used to determine the factored bearing resistance for LRFD strength limit state evaluation. The weight of footing below grade may be neglected for bearing capacity calculations. Service bearing resistance may not be increased for short term loading. Service limit state bearing resistance was correlated to total settlement of less than 1 inch.

Table 8.1 – Recommended Bearing Resistances

Anticipated Bearing Material	Strength Limit State (LRFD)		Service Limit State (LRFD) or Allowable Bearing Resistance (ASD)
	Ultimate (Nominal) Resistance (ksf)	Factored Resistance (ksf)	Service Limit State Bearing Resistance (LRFD) (ksf)
CLAY, sandy	4.0	1.8	1.5

Sliding Resistance

For evaluation of sliding, parameters are presented in Table 8.2 for the foundation soil. For concrete cast-in-place on clay, an LRFD sliding resistance factor of 0.80 is recommended and for concrete cast-in-place on sand, an LRFD sliding resistance factor of 0.85 is recommended. If a vapor barrier is used below footings, passive earth pressures may be used to resist sliding. A passive earth pressure coefficient of 2.198 is recommended for the existing sandy clay soils.

Table 8.2 – Sliding Resistance Parameters

Foundation Bearing Material	Foundation Soil Parameters			
	Total Unit Weight (pcf)	Effective Friction Angle ϕ' (degree's)	Ultimate Coefficient of Friction	Undrained Shear Strength (ksf)
CLAY, sandy	120	22	0.40	0.7

All loose/disturbed material at the bottom of the excavations for each foundation shall be removed and the bearing surface compacted to at least 95% of maximum dry density per ASTM D698. Additional earthwork recommendations are presented in Section 10.0.

9.0 SLAB-ON-GRADE RECOMMENDATIONS

Based on the swell test result on the existing site soils, slab-on-grade construction is considered feasible for the proposed Hugo Roundhouse Building location provided the subgrade soils are compacted to the requirements in Section 10.0. If imported material is required to establish subgrade elevation, the material must conform to specifications listed in Section 10.2 and be approved by the project engineer. Potential heave-related slab-on-grade movements are estimated to be less than ¼-inch.

For moisture-conditioned clayey soil, a modulus of subgrade reaction of 100 pci is considered appropriate. During construction, the clayey soil may deflect under heavy equipment loading. To achieve a level subgrade, a thin granular soil layer may be used as a leveling course if placed with lightweight equipment. A vapor barrier is recommended for all interior slab-on-grade floor slabs.

RockSol anticipates the existing concrete stem walls associated with the engine service pits will be removed or modified (cut) so they do not interfere with the concrete floor slab construction and future performance. RockSol recommends a minimum separation of at least 12-inches between the top of the stem walls and the bottom of the floor slab or foundation elements. See Section 10.0 for further discussion of the service pits.

10.0 EARTHWORK

To accommodate the Hugo Roundhouse Interiors improvements, some earthwork will be required. Subgrade soils used to construct interior improvements shall meet the moisture density control requirements as specified in CDOT's Standard Specifications for Road and Bridge Construction.

At a minimum, the ground surface underlying all floor slabs and structure foundations should be carefully prepared by removing all debris, scarification to a minimum depth of 6-inches, and recompacting to the requirements for maximum dry density and moisture content listed in Table 10.1 of this report.

On-site excavated material may be used as backfill provided it does not contain unsuitable material or cobble particles larger than 3 inches. Unsuitable material includes, but is not limited to, concrete, wood, ceramic, plastic, and glass debris.

The existing engine service pits include concrete stem walls in varying conditions, see Image 5.

Image 5: Engine Service Pits – Upper Portion of the Concrete Stem Walls Visible

RockSol understands that the stem walls may be removed either fully, or partially. At a minimum, RockSol recommends the upper 12-inches of soil within the service pits be excavated and stockpiled for re-use. The bottom of the excavation shall be moisture conditioned and compacted to the requirements in Table 10.1. The removed soil may be replaced in lifts of 8-inches, or less, and moisture conditioned and compacted per Table 10.1.

10.1 Compaction Specifications

Structure backfill and utility trench backfill shall be thoroughly compacted to the moisture and density specifications required for the material tested, in accordance with CDOT's Standard Specifications for Road and Bridge Construction. At a minimum, subgrade moisture conditioning and compaction should meet the compaction specifications outlined in Table 10.1.

Table 10.1 – Compaction Specifications

AASHTO Classification	Minimum Relative Compaction (Percentage of MDD), %	Moisture Content (Deviation from OMC)
A-1, A-2, A-3	95% of AASHTO T180 or ASTM D1557	-2 to +2
A-4, A-5, A-6 and A-7	95% of AASHTO T99 or ASTM D698	-2 to +2

MDD = Maximum Dry Density; OMC = Optimum Moisture Content

The relatively thin layer of surficial soils encountered at our boreholes and observed within the Roundhouse likely classifies as A-2-4 or A-2-6 soils with the majority of subsurface soils classifying as A-6 and A-7 soils.

10.2 Imported Fill Material Recommendations

Fill material imported to the project site to be used within the building interior must comply with CDOT Class 1 Structural Backfill requirements per CDOT's Standard Specifications for Road and Bridge Construction Section 703.08 (a), as defined below.

- 100% passing the 2-inch sieve.
- 30-100% passing the #4 sieve.
- 10- 60% passing the #50 sieve.
- 5- 20% passing the #200 sieve.
- Maximum Liquid Limit of 35.
- Maximum Plasticity Index of 6.

All fill material must be compacted per Table 10.1.

11.0 OTHER DESIGN AND CONSTRUCTION CONSIDERATIONS

Proper construction practices and adherence to project plans and specifications should be followed during construction activities for the suitable long-term performance of the maintenance facility. For preliminary planning, existing fill material and native soils may be considered as OSHA Type C soils. Limited access excavation equipment may be required during construction due to limited access within the interior of the building.

The actual subsurface conditions between boring locations may vary from the information obtained at specific boring locations and described in this report.

The proposed improvements should not adversely affect the surface drainage inside the Hugo Roundhouse Building. All interior drains should be inspected for damage to ensure adequate performance.

Groundwater is not expected to be encountered during excavation for the shallow foundations. RockSol does not anticipate the need for dewatering systems provided construction activities stay within 5 feet of the existing ground surface elevation.

12.0 LIMITATIONS

This geotechnical investigation was conducted in general accordance with the scope of work. The geotechnical practices are similar to that used in Colorado with similar soil conditions and our understanding of the proposed work.

The subsurface investigation program was conducted to obtain information on the subsurface soil, groundwater, and bedrock conditions at the Hugo Roundhouse site. Surface and groundwater hydrology, hydraulic engineering, and environmental studies including contaminant characterization were not included in RockSol's geotechnical scope of work.

This report has been prepared by RockSol for Lincoln County exclusively for the project described in this report. The report is based on our exploratory boreholes and does not take into account variations in the subsurface conditions that may exist between boreholes. Additional investigation is required to address such variation. If during construction activities, materials or water conditions appear to be different from those described herein, RockSol should be advised at once so that a re-evaluation of the recommendations presented in this report can be made. RockSol is not responsible for liability associated with interpretation of subsurface data by others.

APPENDIX A

LEGEND AND INDIVIDUAL BOREHOLE LOGS

RockSol Consulting Group, Inc.

CLIENT Lincoln County
PROJECT NAME Hugo Roundhouse Interiors
PROJECT NUMBER 813.01
PROJECT LOCATION Hugo, Colorado

LITHOLOGY

- **Fill - CLAY, sandy**
- **Fill - SAND, silty**
- **Native - SAND, silty with gravel**
- **Native - CLAY, sandy**
- **Bedrock - PIERRE SHALE**

SAMPLE TYPE

- Auger Cuttings
- GRAB SAMPLE FROM CUTTINGS
- MODIFIED CALIFORNIA SAMPLER 2.5" O.D. AND 2" I.D. WITH BRASS LINERS INCLUDED
- SPLIT SPOON SAMPLER 2" O.D. AND 1 3/8" I.D. NO LINERS

Fines Content indicates amount of material, by weight, passing the US No 200 Sieve (%)

15/12 Indicates 15 blows of a 140 pound hammer falling 30 inches was required to drive the sampler 12 inches.

5,5,5 Indicates 5 blows, 5 blows, 5 blows of a 140 pound hammer falling 30 inches was required to drive the sampler 18 inches.

NS Indicates no sample was recovered due to borehole caving.

Borehole elevations were estimated using the USGS Limon, Colorado; Kansas Topographic Map, dated 1954 and are not exact elevations.

GROUND WATER LEVEL

Borehole Location – B-1

Photograph Taken Looking West

RockSol Consulting Group, Inc.

BORING : B-1

CLIENT Lincoln County
PROJECT NAME Hugo Roundhouse Interiors
PROJECT NUMBER 813.01
PROJECT LOCATION Hugo, Colorado
DATE STARTED 3/20/24 **COMPLETED** 3/20/24
GROUND ELEVATION 5125.0 ft **STATION NO.**
DRILLING CONTRACTOR Unlimited Access Drilling
NORTH **EAST**
DRILLING METHOD Solid Stem Auger **HOLE SIZE** 3.0
BORING LOCATION: Bay 5, South Side of Concrete Rail
LOGGED BY R. Lepro **HAMMER TYPE** Manual
GROUND WATER LEVELS:
NOTES ~35' East of West Exterior Wall Windows
▼ **WATER DEPTH** 9.0 ft on 3/20/24

ELEVATION (ft)	DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE	BLOW COUNTS	SWELL POTENTIAL (%)	SULFATE (%)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
5125.0	0	(Fill) SAND, slightly moist, brown, loose, minor amounts of concrete, wood, ceramic, plastic, and glass debris										
		(Fill) CLAY, sandy, moist, brown, medium stiff to stiff	MC	8/12			101.9	15.7				
		(Native) CLAY, with sand to sandy, moist, gray to brown, stiff, calcareous	MC	9/12	0.7		98.9	24.2				84.2
5120.0	5	**Approximate Bulk Depth 1-9** Liquid Limit= 33 Plastic Limit= 13 Plasticity Index= 20 Fines Content= 56.8 Sulfate= 0.00	BULK			0.00			33	13	20	56.8
		(Native) SAND, slightly silty to gravelly, very moist to wet, brown, medium dense, borehole caving ~19' depth										
5115.0	10		MC	13/12			102.8	12.6				4.0
5110.0	15		SS	7,7,11				12.5				2.6
5105.0	20		SS	NS								
		(Bedrock) PIERRE SHALE, moist, dark gray, hard to very hard	SS	NS								
		Bottom of hole at 24.0 feet.										

Borehole Location – B-2

Photograph Taken Looking West

RockSol Consulting Group, Inc.

BORING : B-2

CLIENT Lincoln County
PROJECT NAME Hugo Roundhouse Interiors
PROJECT NUMBER 813.01
PROJECT LOCATION Hugo, Colorado
DATE STARTED 3/20/24 **COMPLETED** 3/20/24
GROUND ELEVATION 5125.0 ft **STATION NO.**
DRILLING CONTRACTOR Unlimited Access Drilling
NORTH **EAST**
DRILLING METHOD Solid Stem Auger **HOLE SIZE** 3.0
BORING LOCATION: Bay 6, ~2' South of Concrete Rail
LOGGED BY R. Lepro **HAMMER TYPE** Manual
GROUND WATER LEVELS:
NOTES ~40' East of West Exterior Wall Windows
WATER DEPTH 9.0 ft on 3/20/24

ELEVATION (ft)	DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE	BLOW COUNTS	SWELL POTENTIAL (%)	SULFATE (%)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
5125.0	0	(Fill) SAND, silty, slightly moist, brown, loose, minor debris on ground surface										
		(Fill) CLAY, sandy, moist, brown, stiff, iron staining, minor debris noted 2'-3' depth	MC	9/12			112.3	12.5				
		(Native) CLAY, with sand to sandy, moist to very moist, brown to gray, stiff, minor iron staining, calcareous										
5120.0	5		MC	9/12		0.01	96.0	25.9	51	18	33	89.9
		(Native) SAND, silty to slightly silty with gravel, very moist to wet, brown with gray brown mix, loose to medium dense, borehole caving ~19' depth										
5115.0	10		MC	9/12		0.01	105.9	17.4				
5110.0	15		SS	3,4,6				15.4				6.5
5105.0	20		SS	8,10,13				13.9				5.2
		(Bedrock) PIERRE SHALE, moist, dark gray, hard to very hard										
5100.0	25		GB			0.13		21.6				87.4
		Bottom of hole at 27.0 feet.										

APPENDIX B

SUMMARY OF LABORATORY TEST RESULTS

RockSol
Consulting Group, Inc.

SUMMARY OF PHYSICAL & CHEMICAL TEST RESULTS

CLIENT Lincoln County

PROJECT NUMBER 813.01

PROJECT NAME Hugo Roundhouse Interiors

PROJECT LOCATION Hugo, Colorado

Borehole	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	Swell Potential (%)	%<#200 Sieve	Classification		Water Content (%)	Dry Density (pcf)	Unconfined Compressive Strength (psi)	Sulfate (%)	Resistivity (ohm-cm)	pH	Chlorides (%)	Proctor S=Standard M=Modified		
							USCS	AASHTO								MDD	OMC	S/M
B-1	1								15.7	101.9								
B-1	1.01-9	33	13	20		57	CL	A-6 (8)				0.00	1400 @ 29.0%	8.2	0.0100			
B-1	4				0.7	84			24.2	98.9								
B-1	9					4			12.6	102.8								
B-1	14					3			12.5									
B-2	1								12.5	112.3								
B-2	4	51	18	33		90	CH	A-7-6 (31)	25.9	96.0		0.01						
B-2	9								17.4	105.9		0.01						
B-2	14					7			15.4									
B-2	19					5			13.9									
B-2	24-27					87			21.6			0.13		8.0	0.0100			

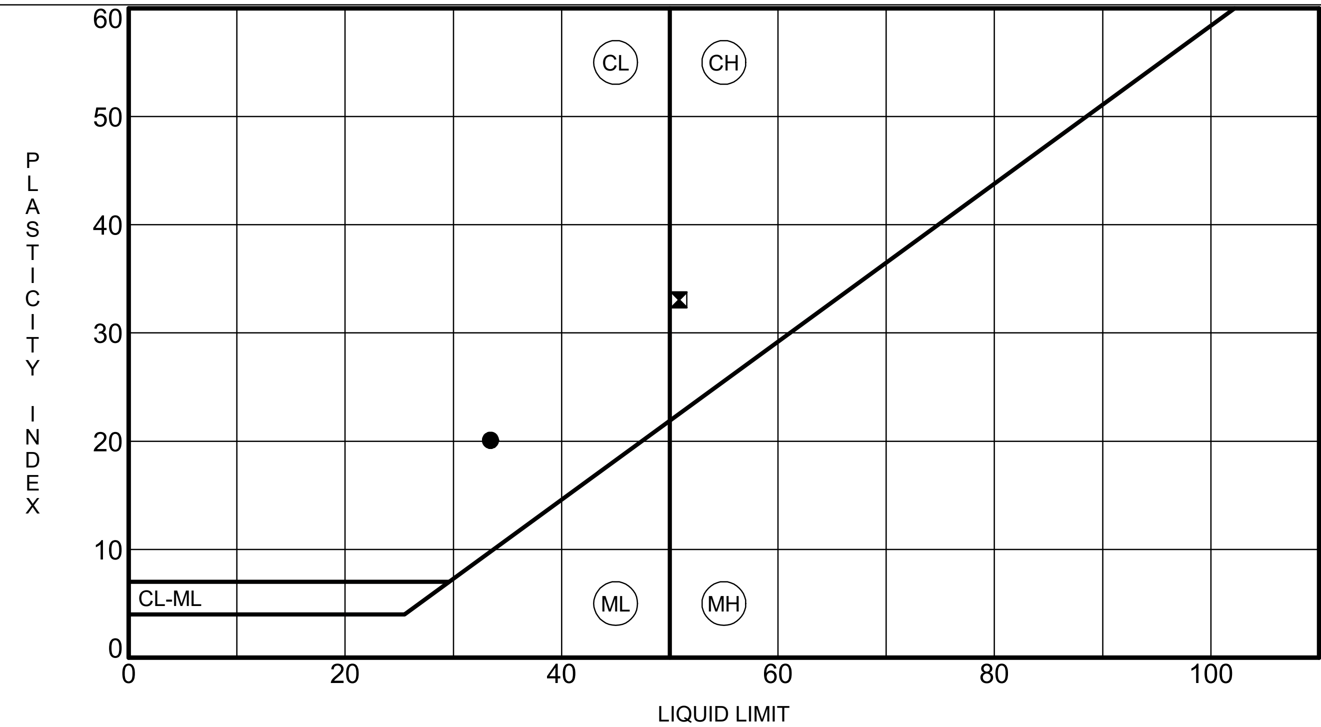
ATTERBERG LIMITS RESULTS
AASHTO T89 Method A/T90

CLIENT Lincoln County

PROJECT NAME Hugo Roundhouse Interiors

PROJECT NUMBER 813.01

PROJECT LOCATION Hugo, Colorado



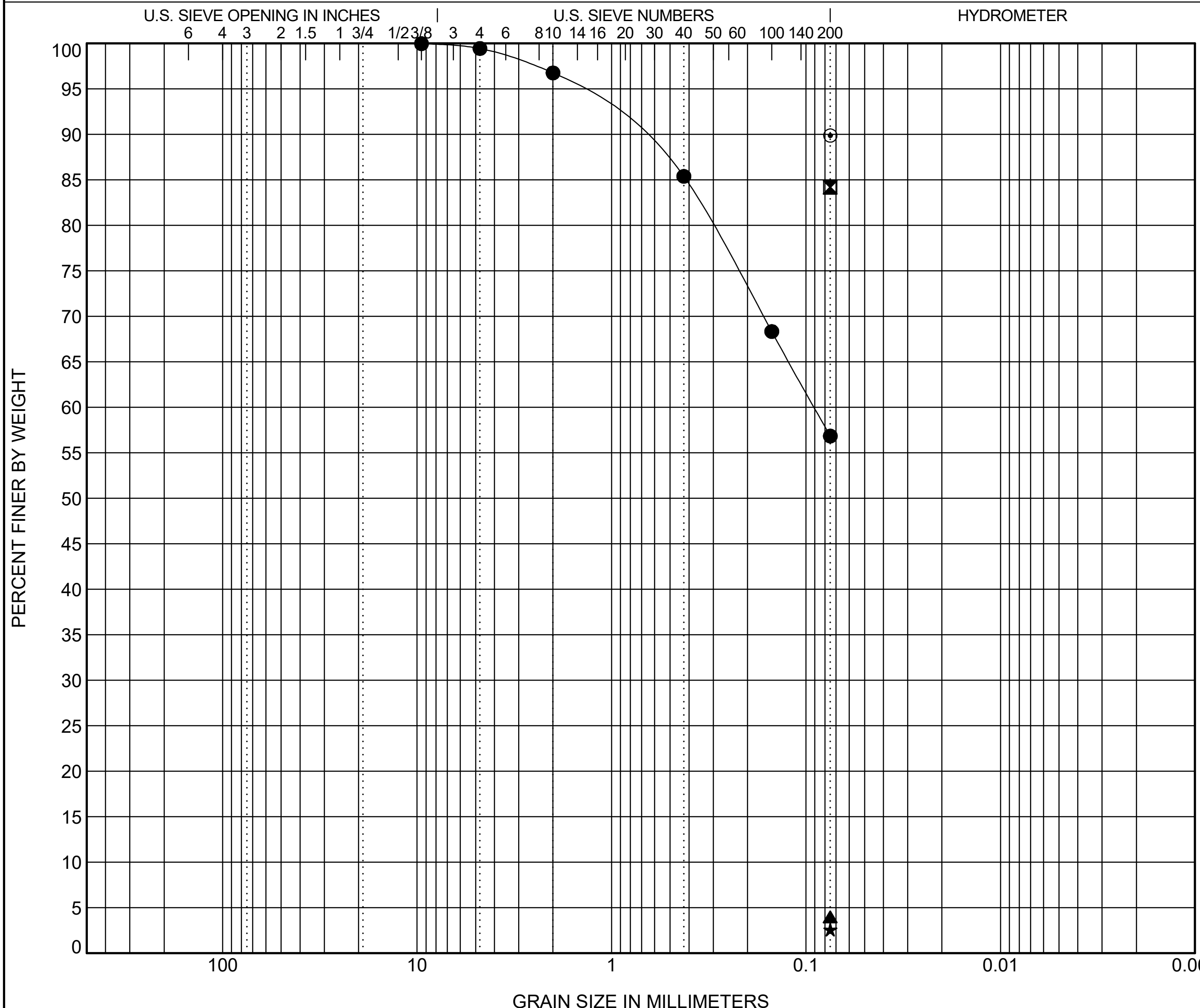
	Specimen Identification		LL	PL	PI	Fines	Classification
●	**B-1**	**1.0-9.0**	**33**	**13**	**20**	**56.8**	**SANDY LEAN CLAY (CL) (A-6)**
⧗	**B-2**	**4.0**	**51**	**18**	**33**	**89.9**	**FAT CLAY (CH) (A-7-6)**

GRAIN SIZE DISTRIBUTION

RockSol

CLIENT Lincoln County **PROJECT NAME** Hugo Roundhouse Interiors

PROJECT NUMBER 813.01 **PROJECT LOCATION** Hugo, Colorado



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	**B-1**	**1.0-9.0**	**SANDY LEAN CLAY (CL) (A-6)**	**33**	**13**	**20**		
⧗	**B-1**	**4.0**	**(Native) CLAY, with sand to sandy**					
▲	**B-1**	**9.0**	**(Native) SAND, slightly silty to gravelly**					
★	**B-1**	**14.0**	**(Native) SAND, slightly silty to gravelly**					
⊙	**B-2**	**4.0**	**FAT CLAY (CH) (A-7-6)**	**51**	**18**	**33**		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt	%Clay
●	**B-1**	**1.0-9.0**	**9.5**	**0.091**			**3.2**	**11.4**	**28.5**	**56.8**	
⧗	**B-1**	**4.0**	**0.075**							**84.2**	
▲	**B-1**	**9.0**	**0.075**							**4.0**	
★	**B-1**	**14.0**	**0.075**							**2.6**	
⊙	**B-2**	**4.0**	**0.075**							**89.9**	

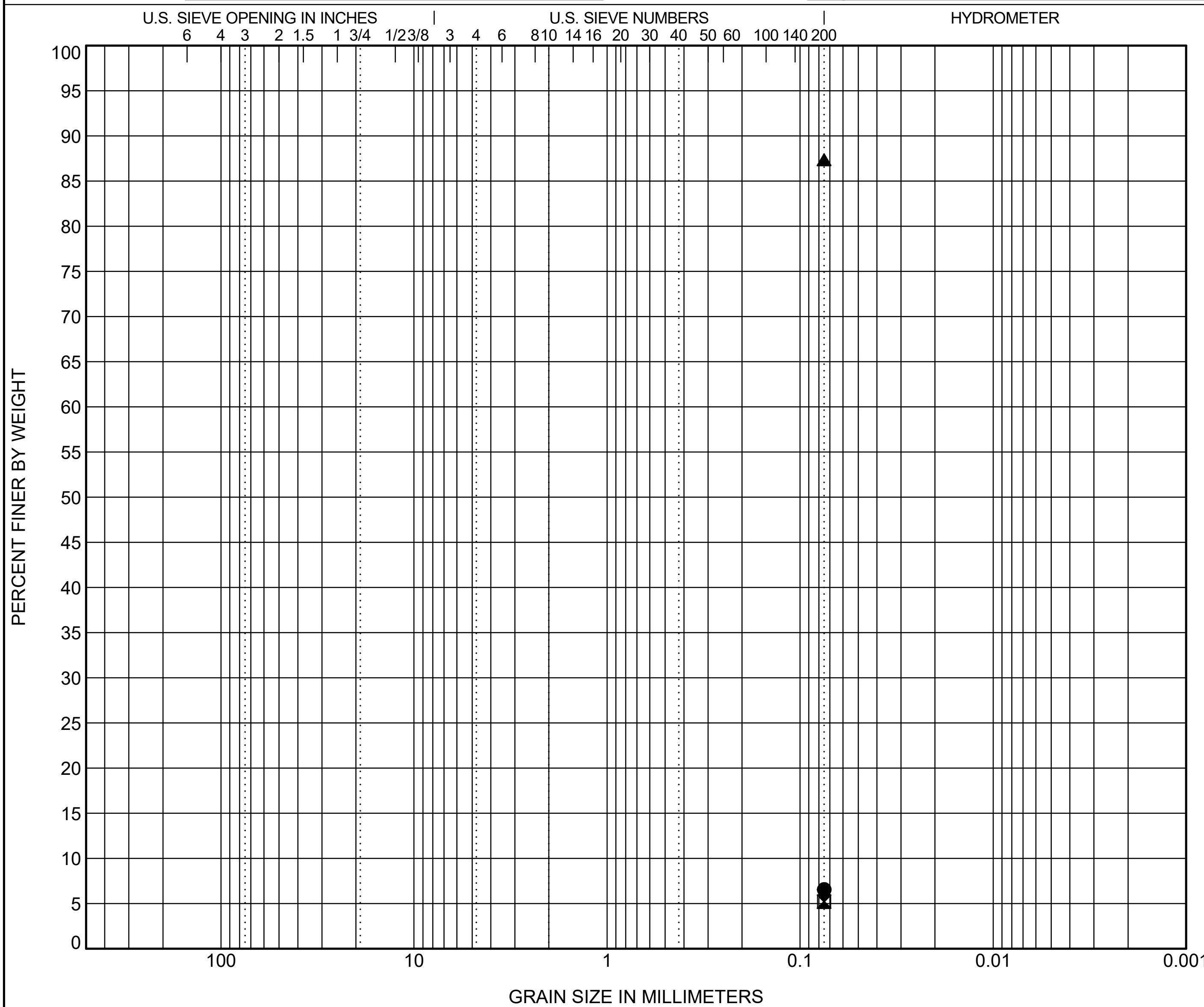
GRADATION - STANDARD 813.01_HUGO ROUNDHOUSE INTERIORS_LINCOLN COUNTY.GPJ ROCKSOL TEMPLATE.GDT 4/15/24

GRAIN SIZE DISTRIBUTION

RockSol Consulting Group, Inc. RockSol

CLIENT Lincoln County **PROJECT NAME** Hugo Roundhouse Interiors

PROJECT NUMBER 813.01 **PROJECT LOCATION** Hugo, Colorado



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	**B-2**	**14.0**	**(Native) SAND, slightly silty with gravel**					
⊠	**B-2**	**19.0**	**(Native) SAND, slightly silty with gravel**					
▲	**B-2**	**24.0-27.0**	**(Bedrock) PIERRE SHALE**					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt	%Clay
●	**B-2**	**14.0**	**0.075**							**6.5**	
⊠	**B-2**	**19.0**	**0.075**							**5.2**	
▲	**B-2**	**24.0-27.0**	**0.075**							**87.4**	

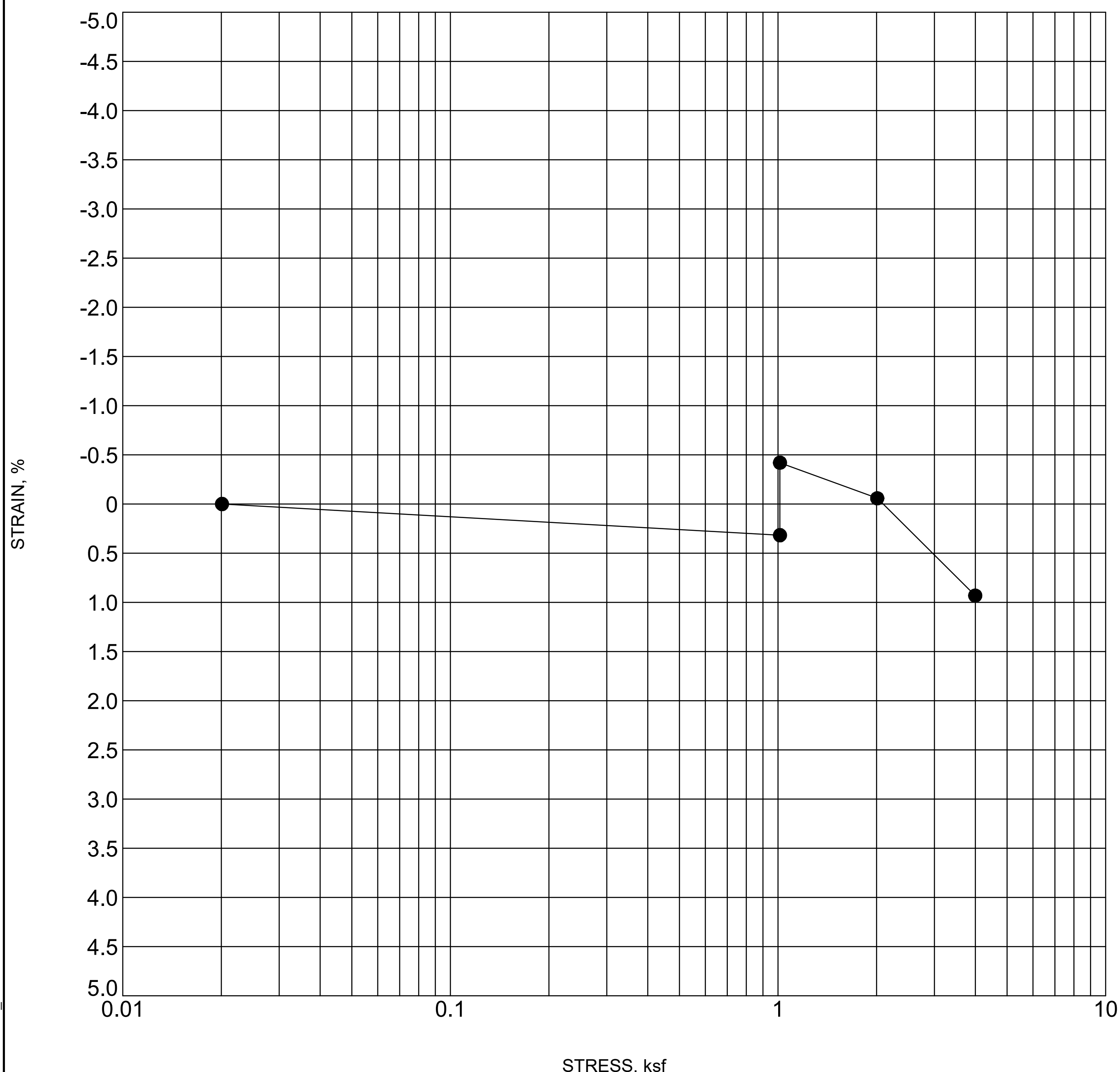
GRADATION - STANDARD 813.01_HUGO ROUNDHOUSE INTERIORS_LINCOLN COUNTY.GPJ ROCKSOL TEMPLATE.GDT 4/15/24

SWELL - CONSOLIDATION TEST

RockSol Consulting Group, Inc.

CLIENT Lincoln County **PROJECT NAME** Hugo Roundhouse Interiors

PROJECT NUMBER 813.01 **PROJECT LOCATION** Hugo, Colorado



Specimen Identification		Classification	Swell/Consol. (%)	γ_d (pcf)	MC%
● **B-1**	**4**	**(Native) CLAY, with sand to sandy**	**0.7**	**98.9**	**24.2**

APPENDIX C

SEISMIC DESIGN CRITERIA OUTPUT SHEETS

USGS web services were down for some period of time and as a result this tool wasn't operational, resulting in *timeout* error.
USGS web services are now operational so this tool should work as expected.

Hugo Roundhouse Improvements

Latitude, Longitude: 39.1338, -103.4746

Date	4/26/2024, 9:44:30 AM
Design Code Reference Document	ASCE7-16
Risk Category	III
Site Class	D - Default (See Section 11.4.3)

Type	**Value**	**Description**
S_S	0.12	MCE_R ground motion. (for 0.2 second period)
S_1	0.044	MCE_R ground motion. (for 1.0s period)
S_{MS}	0.192	Site-modified spectral acceleration value
S_{M1}	0.105	Site-modified spectral acceleration value
S_{DS}	0.128	Numeric seismic design value at 0.2 second SA
S_{D1}	0.07	Numeric seismic design value at 1.0 second SA

Type	**Value**	**Description**
SDC	B	Seismic design category
F_a	1.6	Site amplification factor at 0.2 second
F_v	2.4	Site amplification factor at 1.0 second
PGA	0.058	MCE_G peak ground acceleration
F_{PGA}	1.6	Site amplification factor at PGA
PGA_M	0.092	Site modified peak ground acceleration
T_L	4	Long-period transition period in seconds
SsRT	0.12	Probabilistic risk-targeted ground motion. (0.2 second)
SsUH	0.126	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration
SsD	1.5	Factored deterministic acceleration value. (0.2 second)
S1RT	0.044	Probabilistic risk-targeted ground motion. (1.0 second)
S1UH	0.047	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration.
S1D	0.6	Factored deterministic acceleration value. (1.0 second)
PGAd	0.5	Factored deterministic acceleration value. (Peak Ground Acceleration)

Type	Value	Description
PGA_{UH}	0.058	Uniform-hazard (2% probability of exceedance in 50 years) Peak Ground Acceleration
C_{RS}	0.953	Mapped value of the risk coefficient at short periods
C_{R1}	0.931	Mapped value of the risk coefficient at a period of 1 s
C_V	0.7	Vertical coefficient

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