CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

GEOTECHNICAL EVALUATION

Cinnamon Mountain Road
Mount Crested Butte, Colorado

Report Prepared for:

Ms. Isa Reeb
Town Manager
Town of Mount Crested Butte
P.O. Box 5800
Mount Crested Butte, CO 81225

Project No. 21.6065
January 28, 2022

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Report Prepared by:

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Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, you can benefit from a lowered exposure to problems associated with subsurface conditions at project sites and development of them that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed herein, contact your GBA-member geotechnical engineer. Active engagement in GBA exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Understand the Geotechnical-Engineering Services Provided for this Report

Geotechnical-engineering services typically include the planning, collection, interpretation, and analysis of exploratory data from widely spaced borings and/or test pits. Field data are combined with results from laboratory tests of soil and rock samples obtained from field exploration (if applicable), observations made during site reconnaissance, and historical information to form one or more models of the expected subsurface conditions beneath the site. Local geology and alterations of the site surface and subsurface by previous and proposed construction are also important considerations. Geotechnical engineers apply their engineering training, experience, and judgment to adapt the requirements of the prospective project to the subsurface model(s). Estimates are made of the subsurface conditions that will likely be exposed during construction as well as the expected performance of foundations and other structures being planned and/or affected by construction activities.

The culmination of these geotechnical-engineering services is typically a geotechnical-engineering report providing the data obtained, a discussion of the subsurface model(s), the engineering and geologic engineering assessments and analyses made, and the recommendations developed to satisfy the given requirements of the project. These reports may be titled investigations, explorations, studies, assessments, or evaluations. Regardless of the title used, the geotechnical-engineering report is an engineering interpretation of the subsurface conditions within the context of the project and does not represent a close examination, systematic inquiry, or thorough investigation of all site and subsurface conditions.

Geotechnical-Engineering Services are Performed for Specific Purposes, Persons, and Projects, and At Specific Times

Geotechnical engineers structure their services to meet the specific needs, goals, and risk management preferences of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client.

Likewise, geotechnical-engineering services are performed for a specific project and purpose. For example, it is unlikely that a geotechnical-engineering study for a refrigerated warehouse will be the same as one prepared for a parking garage; and a few borings drilled during a preliminary study to evaluate site feasibility will not be adequate to develop geotechnical design recommendations for the project.

Do not rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project or purpose;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, the reliability of a geotechnical-engineering report can be affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying the recommendations in it. A minor amount of additional testing or analysis after the passage of time – if any is required at all – could prevent major problems.

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read the report in its entirety. Do not rely on an executive summary. Do not read selective elements only. *Read and refer to the report in full.*

You Need to Inform Your Geotechnical Engineer About Change

Your geotechnical engineer considered unique, project-specific factors when developing the scope of study behind this report and developing the confirmation-dependent recommendations the report conveys. Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the elevation, configuration, location, orientation, function or weight of the proposed structure and the desired performance criteria;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project or site changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept* *responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.*

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface using various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing is performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgement to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team through project completion to obtain informed guidance quickly, whenever needed.

This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, they are not final, because the geotechnical engineer who developed them relied heavily on judgement and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* exposed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a continuing member of the design team, to:

- confer with other design-team members;
- help develop specifications;
- review pertinent elements of other design professionals' plans and specifications; and
- be available whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction-phase observations.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for information purposes only.* To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. This happens in part because soil and rock on project sites are typically heterogeneous and not manufactured materials with well-defined engineering properties like steel and concrete. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually provide environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures.* If you have not obtained your own environmental information about the project site, ask your geotechnical consultant for a recommendation on how to find environmental risk-management guidance.

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, the engineer's services were not designed, conducted, or intended to prevent migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration. Confront the risk of moisture infiltration*** by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are not building-envelope or mold specialists.***

GEOPROFESSIONAL
BUSINESS
ASSOCIATION

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1. PURPOSE

Cesare, Inc. (Cesare) performed a geotechnical evaluation at the existing landslide located between about 50 and 400 feet south of the intersection of Cinnamon Mountain Road and Anthracite Drive in Mount Crested Butte, Colorado. The landslide has been a cause of distress to Cinnamon Mountain Road for about 40 years. Cesare understands the distress to Cinnamon Mountain Road from the landslide occurs frequently enough that an about 300 foot long section of Cinnamon Mountain Road is unpaved to avoid the costs of frequent pavement damage.

The evaluation was made to develop a design concept study for the stabilization of Cinnamon Mountain Road, such that preliminary or relative estimates of costs for remediation could be evaluated. After a review of the estimated costs and selecting an overall plan for remediation, additional exploration and analysis should be performed to optimize the design and develop final remediation plans. The scope of services performed is detailed in Cesare's Proposal Agreement No. SC210314, executed on April 20, 2021.

Cesare's opinions and recommendations presented in this report are based on the data generated during this evaluation and its experience with similar type projects.

2. BACKGROUND AND PREVIOUS EVALUATIONS

On April 7, 2021 the client provided Cesare with 23 electronic documents pertaining to the landslide. Based on a cursory review of the documents, the first known formal evaluation of the landslide was provided in a letter dated June 30, 1978 by Lincoln DeVore Testing Laboratory (DeVore). Seven professional firms have evaluated the landslide to some extent at various times since June 1978:

- DeVore;
- F.M. Fox & Associates, Inc. (Fox);
- Chen & Associates, Inc. (Chen);
- Western Colorado Testing, Inc. (WCT);
- Lambert and Associates (Lambert);
- Buckhorn Geotech (Buckhorn); and
- DOWL.

Some of the firms have indicated that the landslide movement may encompass a much larger area than Cinnamon Mountain Road and slope immediately downhill. Lambert provided a letter dated November 1, 1995 that stated:

> "*The total area of the soil mass movement may include the area upslope from Cinnamon Mountain Road and downhill to beyond Whetstone Road as discussed above.*"

Subsurface exploration has not been performed uphill or downhill of Cinnamon Mountain Road. All known borings have been advanced within about 30 feet of the limits of Cinnamon Mountain Road.

Based on the documents provided, DOWL has been providing monitoring reports on the surface displacement of the slope since October 2016, which provides some concept of the extent of the landslide within the limits of monitoring. Based on a review of DOWL's monitoring data, it appears the landslide extends down near Whetstone Road to the west. This is consistent with Cesare's observations in the field. DOWL appears to have developed some topographic information near Cinnamon Mountain Road, however, Cesare is unaware of an overall topographic survey uphill and downhill of Cinnamon Mountain Road developed for previous evaluations.

3. SITE CONDITIONS

The site is located between about 50 and 400 feet south of the intersection of Cinnamon Mountain Road and Anthracite Drive, and between about Whetstone Road to the west and the federal boundary line to the east (see Exhibit 1). The topography of the site is steeply sloping down from east to west at grades between about 20% and 70%. Cinnamon Mountain Road is unpaved at the site. A ditch lies along the eastern side of the road (see Exhibit 2). Vegetation onsite consists of native grass and shrubs. The terrain west (downslope) of Cinnamon Mountain Road was observed to be hummocky and contains a series of natural rills and swales (see Exhibit 3). The hummocky terrain downslope from the roadway indicates past landslide movement, which is consistent with the findings of the other firms.

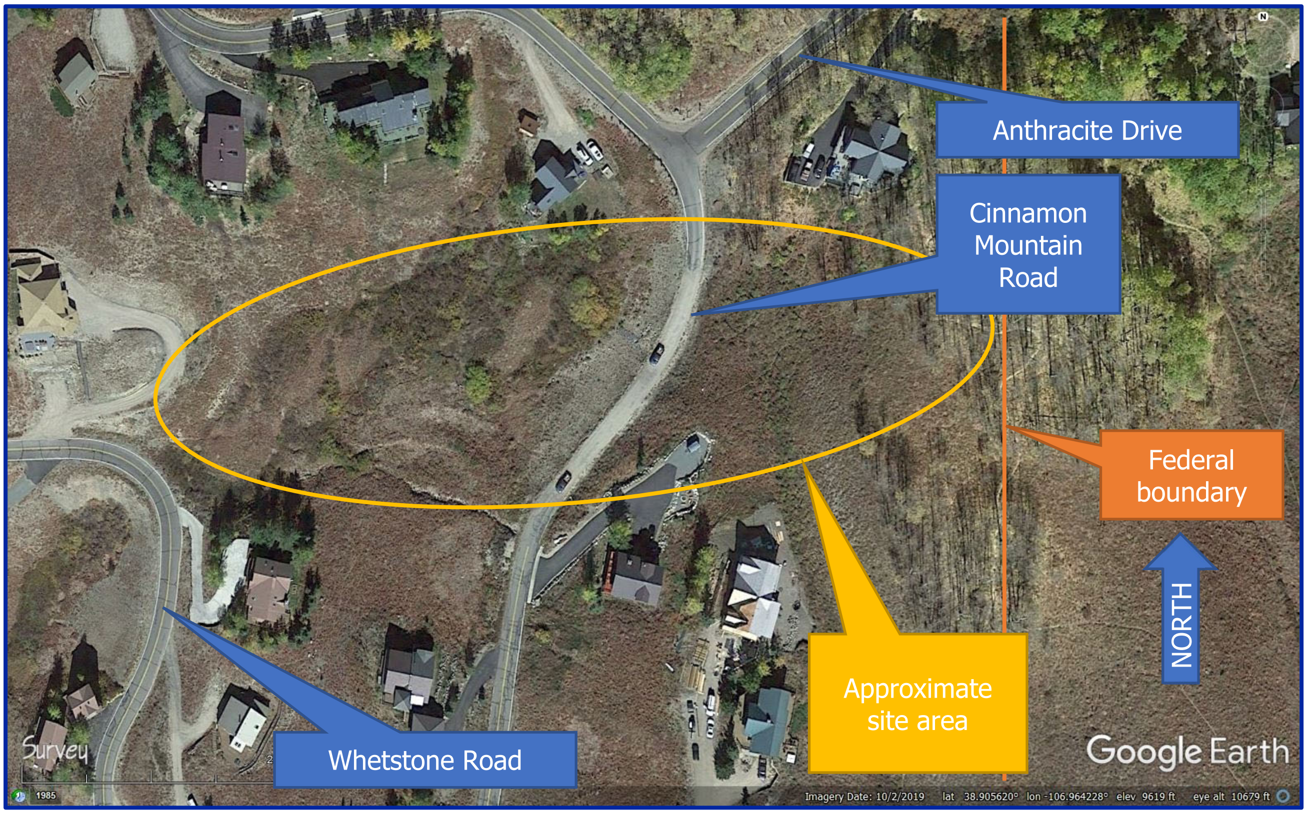


EXHIBIT 1. Aerial image of site by Google Earth October 2, 2019.

EXHIBIT 2. View looking south along Cinnamon Mountain Road on May 1, 2021.

EXHIBIT 3. View looking east from Whetstone Road at hummocky terrain below Cinnamon Mountain Road on May 1, 2021.

4. SURFACE GEOMETRY

4.1 TOPOGRAPHIC SURVEY AND SECTIONS

In order to perform the subject design concept study, Cesare recommended that more complete and accurate cross sections be developed from a topographic survey. Cesare was primarily interested in obtaining more accurate topographic information further upslope and downslope of Cinnamon Mountain Road to explore the possibilities of a larger encompassing landslide, as discussed in a letter provided by Lambert, dated November 1, 1995.

The Town of Mount Crested Butte provided Cesare an updated topographic survey of the site on November 11, 2021. The survey was performed by Landmark Surveying & Mapping (Landmark) on October 21 and 22, 2021. The topographic map provided by Landmark is included in Appendix B.

4.2 TOPOGRAPHIC SURVEY AND CROSS SECTIONS

Cesare reviewed the topographic map and developed eight cross sections over the site designated as XS-1 through XS-8. The cross sections were made at about 20 to 60 foot intervals along Cinnamon Mountain Road as indicated by Exhibit 4.

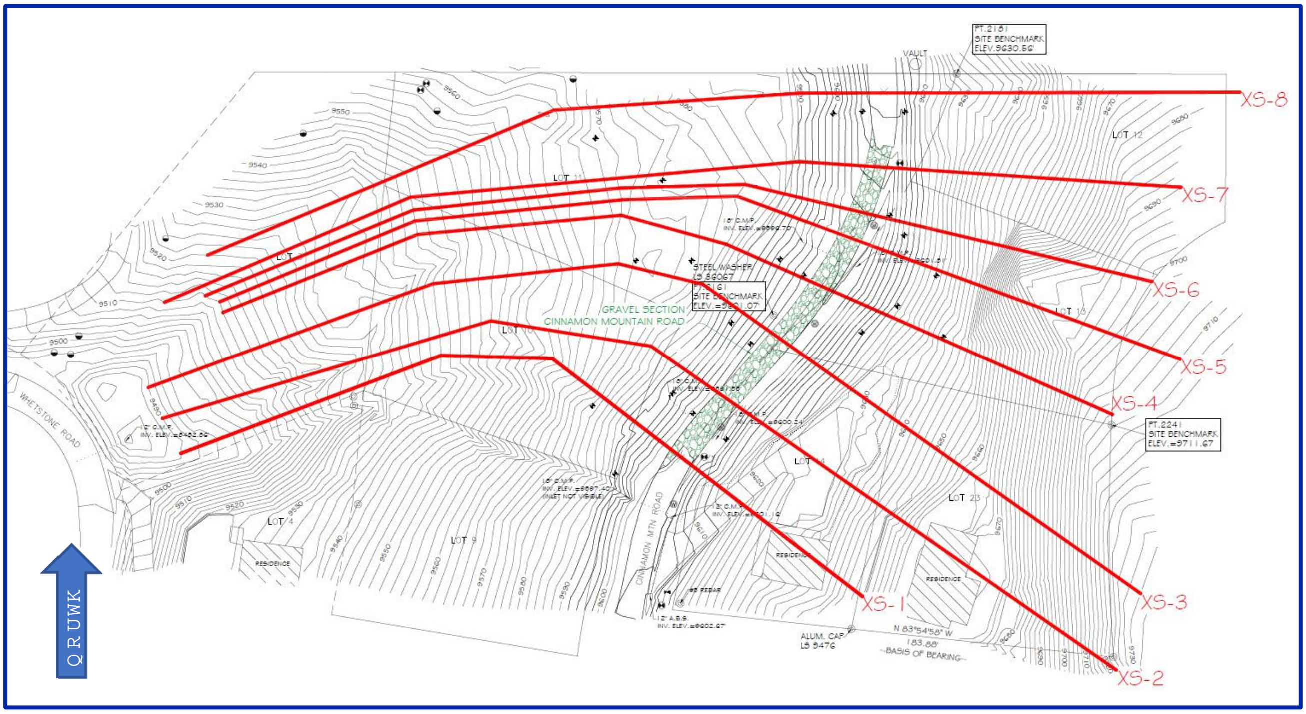


EXHIBIT 4. Cesare cross sections superimposed on Landmark topographic map.

From the cross sections:

- the angle of the terrain upslope of Cinnamon Mountain Road was found to vary between about 18 and 35 degrees,
- the angle of the roadway fill embankment between about 50 and 100 feet downslope of Cinnamon Mountain Road was found to vary between about 18 and 27 degrees, and
- the angle of the overall slope downslope of the roadway fill embankment was found to vary between about 9 and 15 degrees (see Exhibit 5).

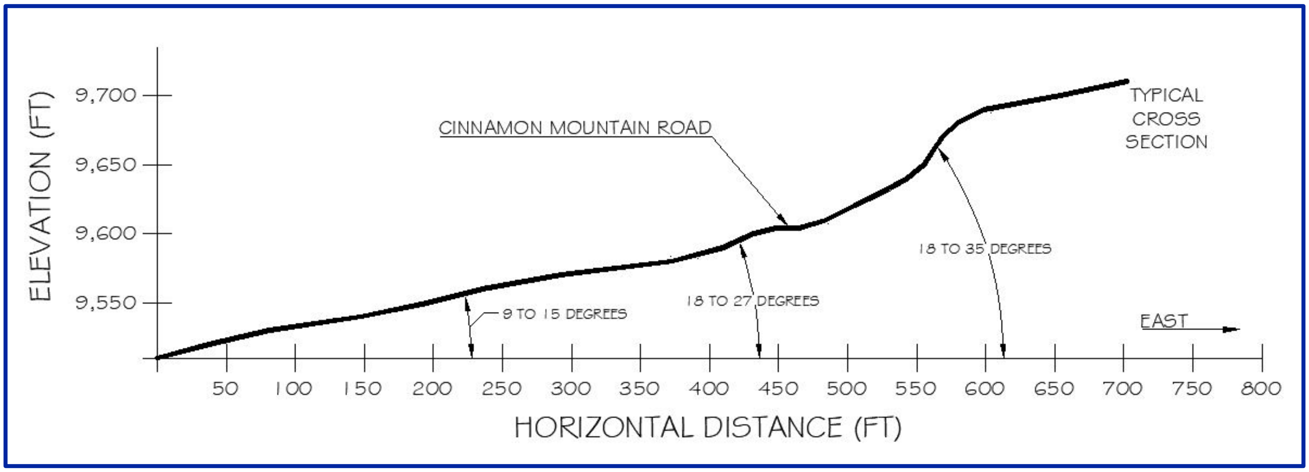


EXHIBIT 5. Typical cross section developed from topographic map.

5. SUBSURFACE EXPLORATION

5.1 SUBSURFACE EXPLORATION BY FOX

Fox advanced two exploratory borings through Cinnamon Mountain Road and one exploratory pit downslope of the roadway on May 17, 1982. The two exploratory borings were designated by Fox as "Test Hole #1" and "Test Hole #2". The exploratory pit was designated as "Test Pit #1". Cesare redesignated Test Hole #1, Test Hole #2, and Test Pit #1 as FOX-1, FOX-2, and FOX-1P, respectively. Borings FOX-1 and FOX-2 were advanced nearer the southern and northern end of the gravel roadway section, respectively. FOX-1P was advanced "*approximately 33 feet on downslope*" from FOX-1. The approximate locations of Fox's exploratory borings and pit are shown in Exhibit 6. Fox's exploratory location map and exploratory boring/pit logs are included in Appendix C.

5.2 SUBSURFACE EXPLORATION BY BUCKHORN

Buckhorn advanced eight borings through or near Cinnamon Mountain Road between July 16 and 18, 2008. The borings are designated as BH-1 through BH-8 and the approximate locations are shown in Exhibit 6. Borings BH-1 and BH-2 were advanced downslope of the roadway. Boring BH-8 was advanced through the roadway near Fox's Boring FOX-1. Borings BH-3 through BH-7 were advanced adjacent to the roadway on the uphill (east) side. Buckhorn's boring location map and logs are included in Appendix D.

Buckhorn installed a full depth inclinometer in Boring BH-1 to monitor slope movement and open standpipe piezometers in Borings BH-2 through BH-8 to monitor groundwater levels.

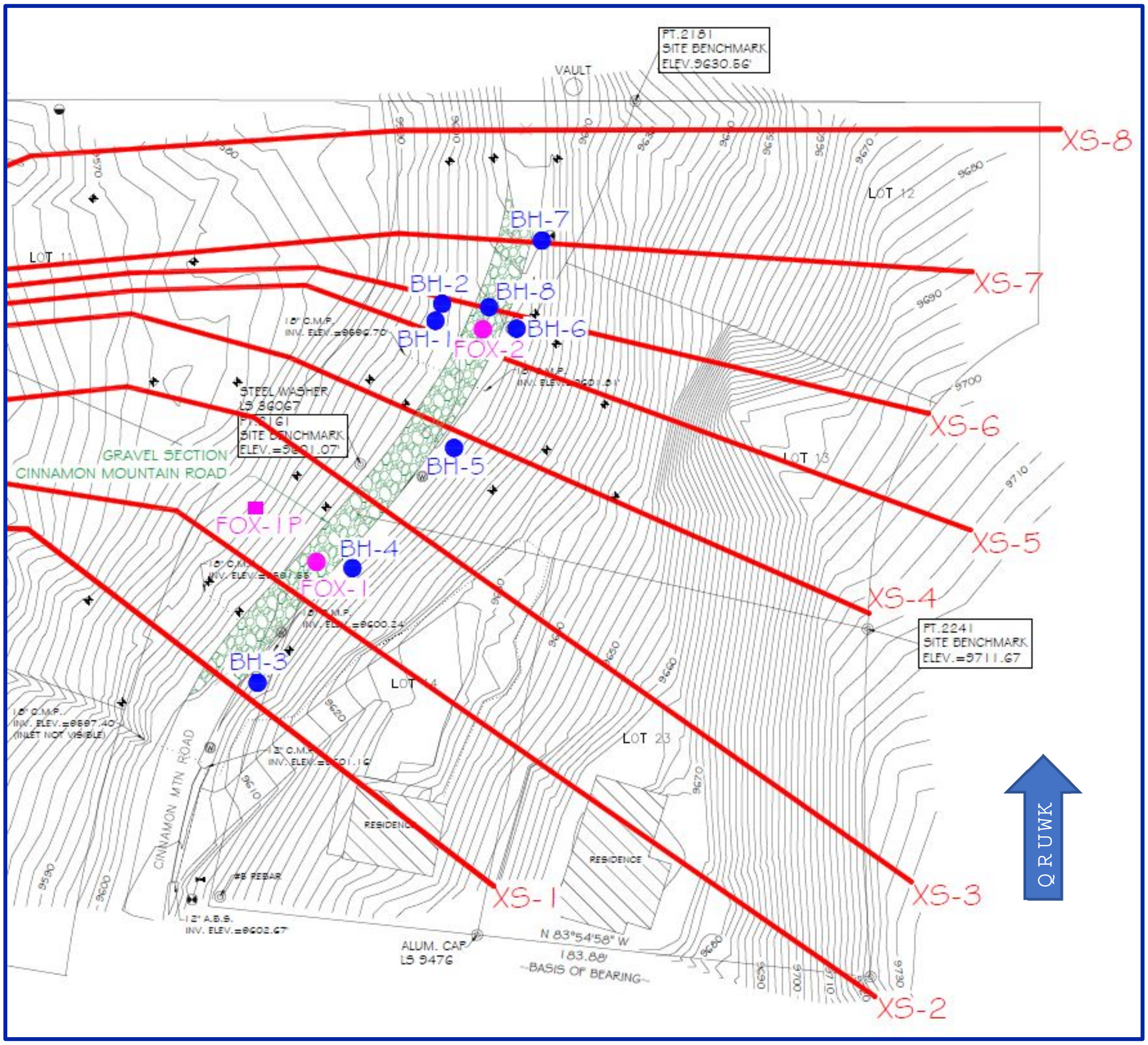


EXHIBIT 6. Approximate exploratory boring and pit locations by Fox and Buckhorn.

6. SUBSURFACE CONDITIONS

Based on review of the exploratory boring/pit logs provided by Fox and Buckhorn, the subsurface appears to consist of:

- sand and gravel fill and native material; over
- native, silty, clay with shale fragments; over
- weathered, shale; over
- hard shale bedrock.

Based on the boring logs:

- weathered shale was encountered between about 5 and 25 feet deep, and
- hard shale was encountered between 10 and 35 feet deep.

The weathered shale to hard shale bedrock is identified as Mancos shale which is known to have a very low frictional resistance in the residual state (after significant movements have occurred).

The last known full inclinometer reading for Boring BH-1 was taken on May 18, 2009, which indicated about 3.5 inches of movement on a slide plane between about 20 and 25 feet below the ground surface at BH-1. Based on a letter by DOWL, dated February 9, 2021, with subject "Slope Movement Summary Report, Winter Survey 2020, Cinnamon Mountain Road & Slope Monitoring, Mt. Crested Butte, CO", Cesare understands that the inclinometer sheared off at a depth of about 24 feet.

Based on the boring logs and inclinometer data provided by the preceding firms, the landslide appears to be passing through the interface between the native clay and weathered Mancos shale bedrock at a depth of about 23 to 28 feet below Cinnamon Mountain Road.

7. GROUNDWATER

According to most of the firms that have studied this landslide, high groundwater conditions are identified as either a contributor or primary cause for the slope instability. According to Buckhorn and DOWL, most of the recent landslide movements have occurred during spring snowmelt. Cesare understands that some remediation involving installation of subsurface drains has been attempted, with limited to no success in mitigating the landslide movement.

Buckhorn and DOWL provided records of groundwater measurements for each of the piezometers installed in Borings BH-2 through BH-6 since July 18, 2008. It appears that DOWL renamed the piezometers in Borings BH-3 through BH-6 as P1 through P4, respectively. Also, DOWL renamed the piezometer in either BH-1 or BH-2 as P5. The piezometers in Borings BH-7 and BH-8 were reportedly damaged after July 2009 and September 2008, respectively, preventing future measurements which were not recorded.

TABLE 7.1. Groundwater Measurements by Buckhorn and DOWL

Depth to Groundwater Measurements in Feet							
Buckhorn Boring ID		**BH-1/ BH-2**	**BH-3**	**BH-4**	**BH-5**	**BH-6**	**BH-7**	**BH-8**
DOWL Piezometer ID		**P5**	**P1**	**P2**	**P3**	**P4**		
07/18/08 to 07/09/09	Shallowest	8.0	0.0	0.7	1.1	3.4	6.6	9.8
	Deepest	10.7	5.8	18.8	>15	>15	>15	11.1
06/15/17		12.3/13.5	13.4	4.4	9.7	10.6		
12/11/17		14.0/13.6	14.1	8.9	12.9	14.9		
06/15/18		13.1/14.9	15.2	7.1	11.5	11.1		
12/05/18		15.8/14.9	16.9	9.3	13.8	17.4		
07/09/19		13.4/12.9	13.4	5.0	9.9	10.5		
12/18/19		15.3/12.3	17.2	9.5	12.6	14.7		
07/07/20		13.8	15.4	7.1	11.5	11.2		
12/22/20		16.8	16.8	9.4	13.9	16.9		

8. LABORATORY TESTING

Fox and Buckhorn present laboratory test results on specific samples recovered from field exploration. Thirteen moisture and density tests were presented that indicated the in-place moisture content and density of the selected samples. Eight gradation analysis and Atterberg limits test results were presented that indicated the grain size distribution and plasticity of the selected samples and eight unconfined compression test results were presented that indicated the unconfined shear strength of the selected samples. The laboratory testing by Fox and Buckhorn was summarized by Cesare and is presented in Appendix A.

9. SURFACE MOVEMENT

DOWL has been providing surface monitoring reports twice a year since 2016. The monitoring reports include displacement maps that reference baseline measurements from 2012 and 2016. The latest displacement map provided to Cesare was developed from readings taken on December 22, 2020 and is included in Appendix E.

The map includes monitoring data for points beginning slightly above (less than 20 feet east) of Cinnamon Mountain Road and extending downslope to near Whetstone Road. The data indicates movement of about:

- 1 to 2 inches along the eastern side of Cinnamon Mountain Road since 2016,
- 1 to 7 inches along the western side of Cinnamon Mountain Road since 2016,
- 6 to 16 inches along Cinnamon Mountain Road since 2012, and
- 4 to 22 inches downslope of the roadway embankment since 2012.

Based on the survey data, the landslide movement extends down near Whetstone Road. No movement data further than about 20 feet upslope of Cinnamon Mountain Road appears to have been provided; however, DOWL set monitoring pins further upslope on December 22, 2020 for additional slope monitoring.

10. PROPOSED REMEDIATION OPTION

Based on the potential failure surfaces from Cesare's stability analyses and the weak nature of the native soil, Cesare agrees with Buckhorn's assessment in its "Geotechnical Report, Town of Mt. Crested Butte, Cinnamon Mountain Landslide, Mt. Crested Butte, Colorado", dated 2009, which states "*We consider tie-back anchors to be best alternative for full remediation of the CMR landslide*".

Tieback anchors consist of high capacity steel rods or tendons that are typically drilled and anchored back into hard rock with grout. The head of the anchors are typically tied to either discrete concrete panels or a continuous shotcrete facing that act as washers and spread the anchor load over a prepared face of the slope. Exhibit 7 is an excerpt from "Geotechnical Engineering Circular No. 4, Ground Anchors and Anchored Systems" by the Federal Highway Administration (June 1999) that shows the typical components of a tieback anchor. Tieback anchors are typically post-tensioned against the concrete panels or shotcrete facing with hydraulic rams and "locked off" at a predetermined load. Panels or shotcrete facings for tieback anchors typically vary between 1 and 2 feet thick. Discrete panels are typically square and vary in size between 6 and 10 feet. The height of a continuous shotcrete facing will typically be of a similar size.

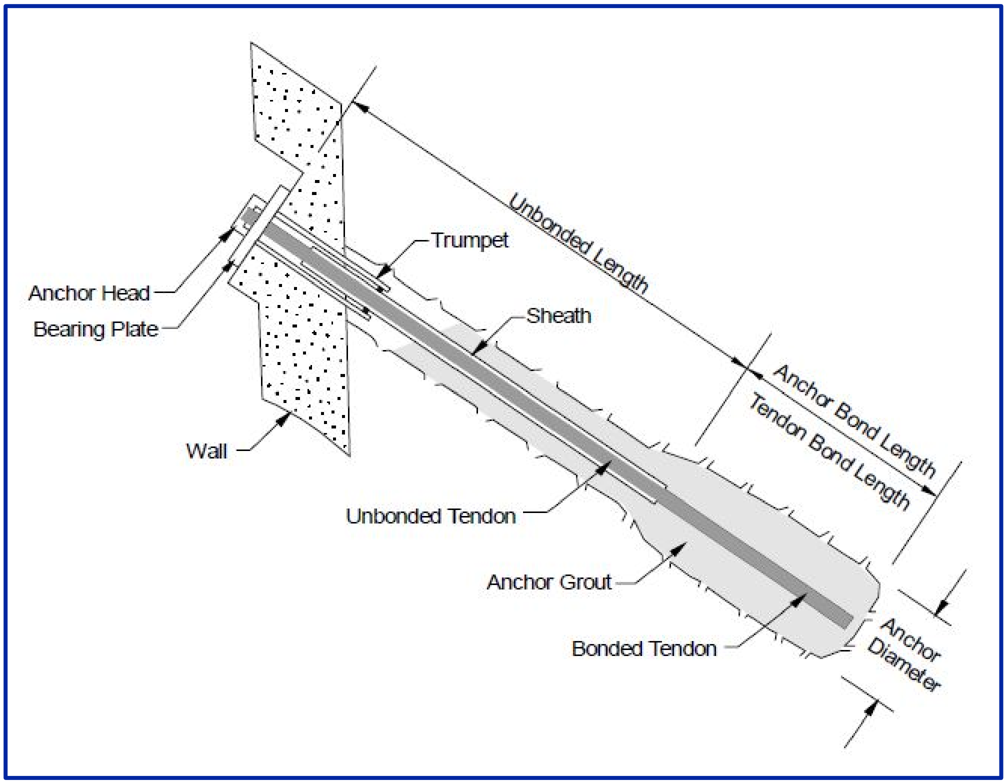


EXHIBIT 7. Typical components of a tieback anchor (FHWA, 1999)

11. GLOBAL STABILITY ANALYSES

Cesare reviewed the cross sections developed and selected Cross Sections XS-2 and XS-5 to represent the slope for global stability analyses (GSA) (see Section **4.2 TOPOGRAPHIC SURVEY AND CROSS SECTIONS**). Cross Section XS-5 was selected as a critical cross section due to its steep uphill slope, which is about 35 degrees overall but steeper than 50 degrees at the location of a possible, historic, head scarp. The cross sections were analyzed with SLOPE/W, Version 11.2.0.22838, by Geoslope International Ltd. The Spencer method of slices was used for all analyses.

Depths of subsurface soil and rock layers and depths to groundwater were assigned below Cinnamon Mountain Road based on the exploratory pit and boring logs provided by Fox and Buckhorn. Because the only known exploratory pits and borings were advanced near the roadway, the depths of subsurface layers and groundwater upslope and downslope from the roadway were extrapolated based on surface topography. These extrapolations may not represent the actual depths of the various layers and should be verified by additional subsurface exploration.

Material parameters for the various soil and rock layers were selected based on:

- laboratory data provided by Fox and Buckhorn,
- Cesare's experience with similar materials, and
- Back calculation based on the presumption that the factor of safety (FS) for the existing condition is close to unity (i.e., the driving load and resistance to sliding are about equivalent).

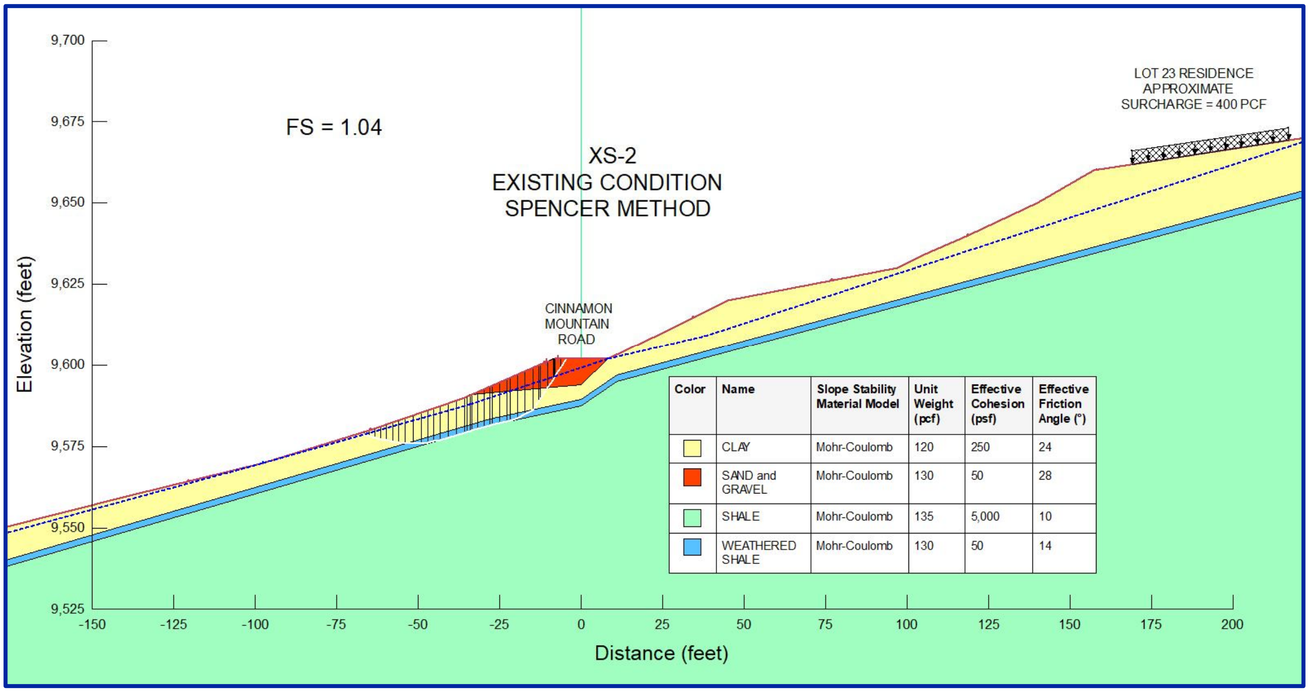
The selected material parameters for the soil and rock layers are presented in Table 11.1.

TABLE 11.1. Material Characterization of Soil and Rock

Material	Unit Weight (pcf)	Cohesion (psf)	Friction Angle (deg)
Sand and gravel roadway fill	130	50	28
Native clay overburden	120	250	24
Weakened weathered shale	130	50	14
Shale bedrock	135	5,000	10

11.1 EXISTING CONDITION

Because the existing slope of the site is actively failing at a slow rate, the actual overall resistance to sliding was presumed to be slightly less than the driving load or self weight of the slope. FS is defined as the ratio of resistance to load. Since the resistance is slightly less than the load, the overall FS should be slightly less than about 1.0. Exhibits 8 through 10 show the results of GSA performed for the existing condition at Cross Sections XS-2 and XS-5.

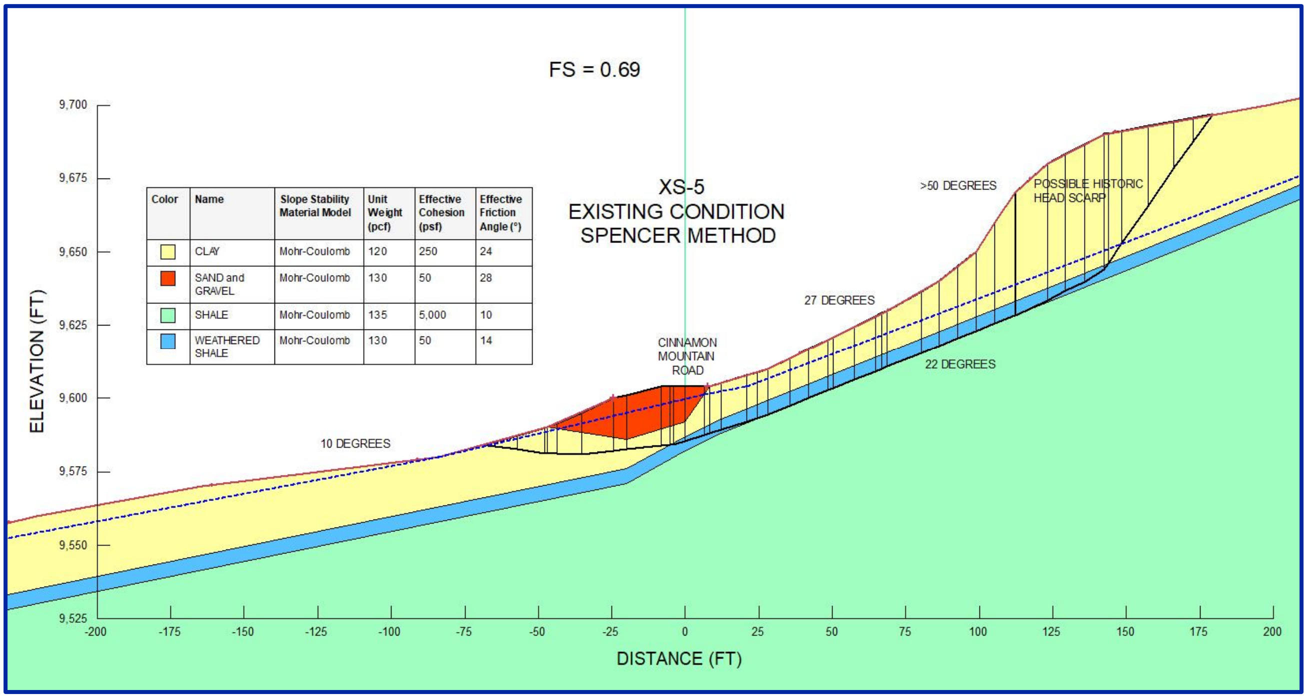


Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟨	CLAY	Mohr-Coulomb	120	250	24
🟥	SAND and GRAVEL	Mohr-Coulomb	130	50	28
🟩	SHALE	Mohr-Coulomb	135	5,000	10
🟦	WEATHERED SHALE	Mohr-Coulomb	130	50	14

EXHIBIT 8. Results of GSA for the existing condition at Cross Section XS-2.

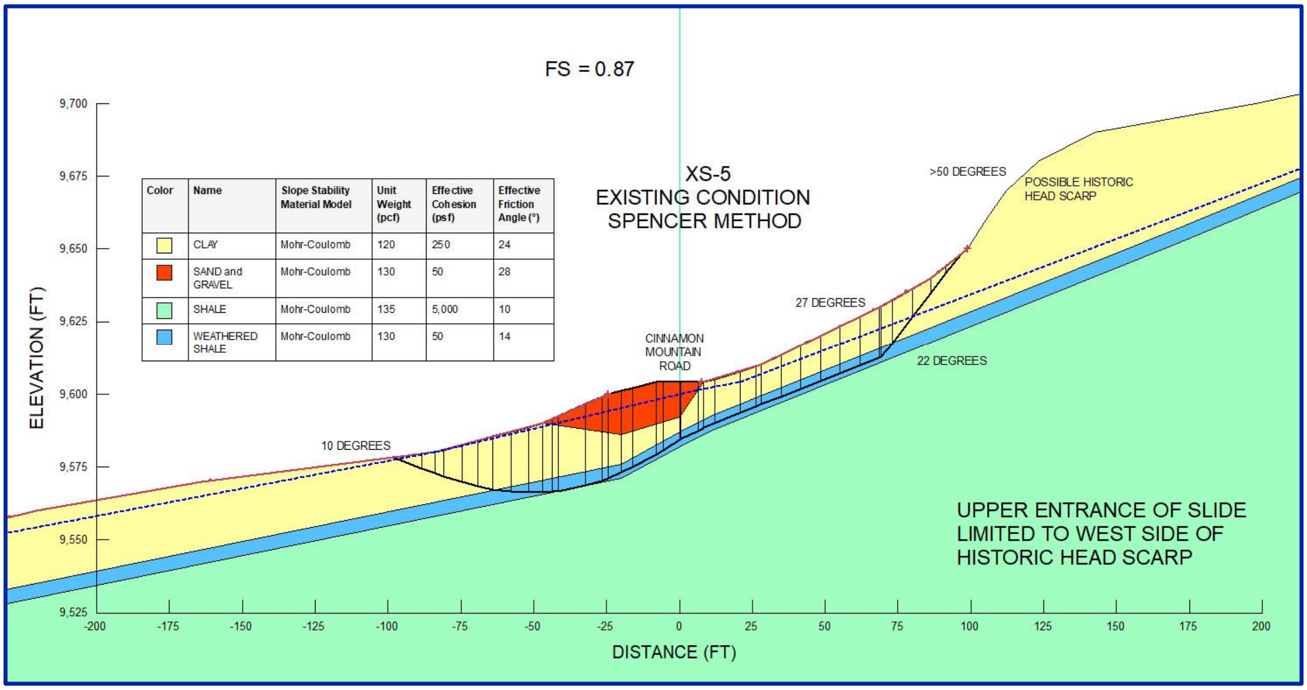
The results of the analyses were sensitive to:

- the depth of the weathered bedrock and hard bedrock uphill and downhill of the roadway,
- the strength of the native overburden material, and
- the limits of analysis (entrance and exit boundaries for the slip surfaces).



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟨	CLAY	Mohr-Coulomb	120	250	24
🟥	SAND and GRAVEL	Mohr-Coulomb	130	50	28
🟩	SHALE	Mohr-Coulomb	135	5,000	10
🟦	WEATHERED SHALE	Mohr-Coulomb	130	50	14

EXHIBIT 9. Results of GSA for the existing condition at Cross Section XS-5.



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟨	CLAY	Mohr-Coulomb	120	250	24
🟥	SAND and GRAVEL	Mohr-Coulomb	130	50	28
🟩	SHALE	Mohr-Coulomb	135	5,000	10
🟦	WEATHERED SHALE	Mohr-Coulomb	130	50	14

EXHIBIT 10. Results of GSA for the existing condition at Cross Section XS-5 with slide entrance limited to the western side of the possible historic scarp.

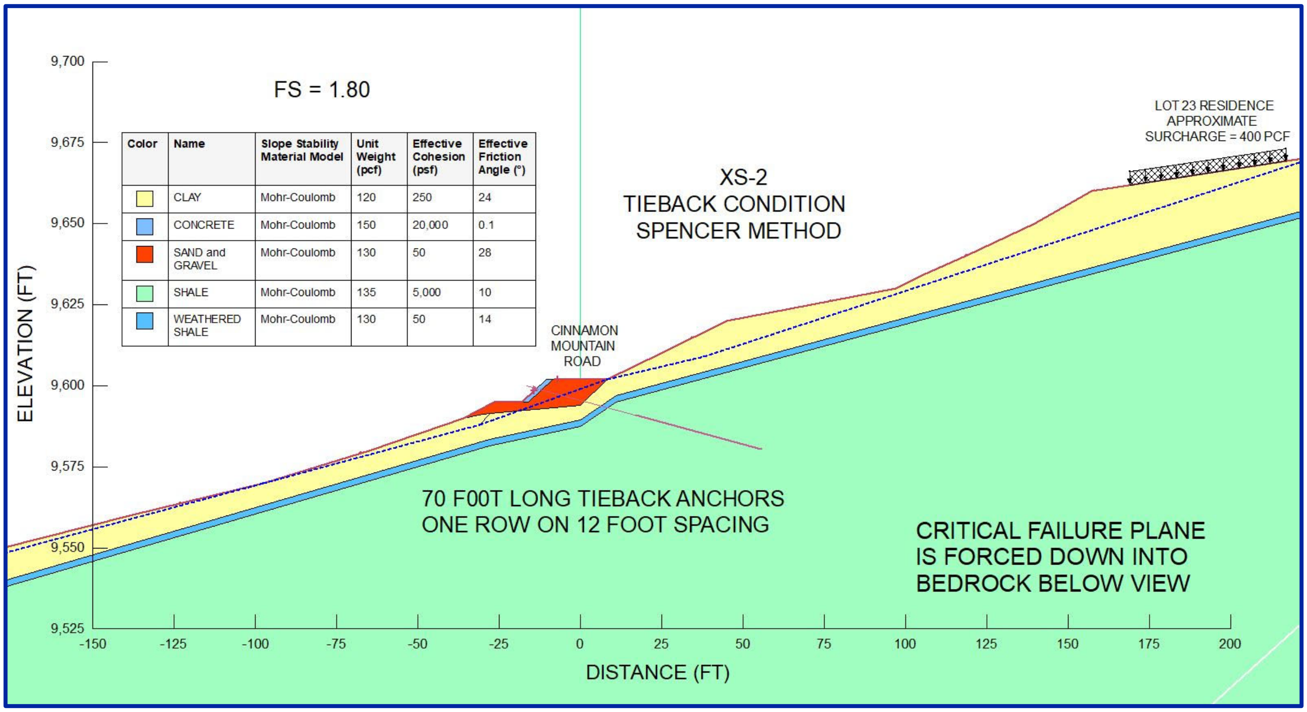
The results of the analysis indicate an FS of 1.04 for Cross Section XS-2 and an FS between 0.69 and 0.87 for the critical Cross Section XS-5, depending on the limits of analyses. The result shown in Exhibit 8 was given by nearly unbounded limits of analysis (i.e., the possible range in entrance of the slip surface extended as far upslope as the Landmark topographic survey provided). The result shown in Exhibit 10 was given by a slip surface entrance that was limited to the downslope (western) side of the prominent, possible, historic scarp. The difference in the FS is significant with a value of 0.69 for the unbounded case and a value of 0.87 where the slip surface entrance was limited to the downslope of the historic scarp. Such limitations on the range of analyses may be justifiable if they are based on the movement history of the site (e.g., signs of movement were not observed by Cesare near the prominent, possible, historic scarp of Exhibit 10). However, limitations on the range of analyses are typically not needed when the subsurface profiles are better known across the site. Cesare recommends that updated GSA for the existing condition be performed based on additional subsurface exploration downslope and especially upslope of Cinnamon Mountain Road, rather than the assumed subsurface profiles presented herein.

Because the subsurface profiles and topography varies, the FS is expected to vary with the cross sections across the site. Typically, lower FS's are given by steeper cross sections. If the result of Exhibit 10 (the analysis limited to the western side of the historic scarp) is taken to be representative of the critical cross section then the average FS between XS-2 and XS-5 is 0.96, which is slightly less than 1.0 inch and considered a reasonable representation of the existing conditions.

11.2 TIEBACK CONDITION

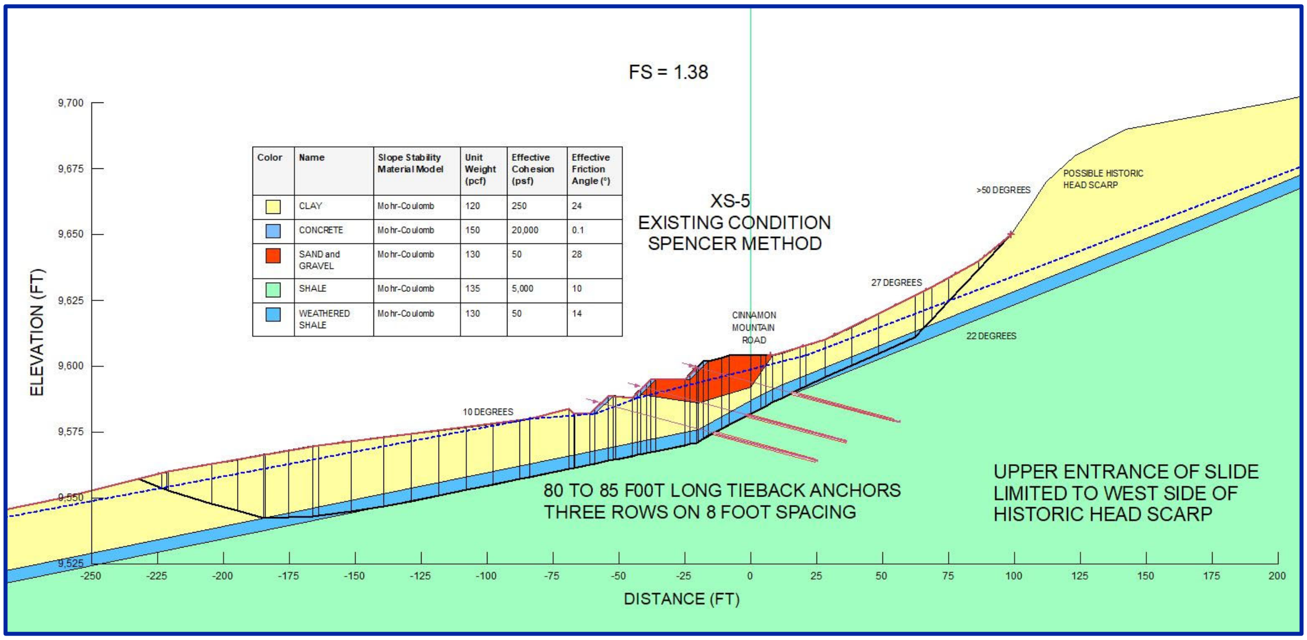
Cesare performed a series of analyses to evaluate the number of tiebacks that would be required to stabilize the slope. For the conditions of the site and presuming additional laboratory strength testing will be performed prior to final design for remediation, an FS of 1.35 is considered adequate. Exhibits 10 through 12 present the results of GSA for various tieback conditions. Exhibit 11 indicates that adequate stability of Cinnamon Mountain Road can be achieved for a single row of tiebacks with a 12 foot spacing at Cross Section XS-2. Exhibit 12 indicates that three rows of tiebacks on an 8 foot spacing would be required at Cross Section XS-5 to achieve adequate stability if the limits of analysis are kept to the western side of the historic scarp. Exhibit 13 indicates that three rows of tiebacks on a 5 foot spacing would be required at Cross Section XS-5 if the limits of analysis are unbounded.

There are practical limits to the lengths of tiebacks. Strain compatibility between the deformation of the tieback and the rock it is bonded to prevent additional resistance contributions beyond a bond length of about 40 feet into the hard rock. Based on the exploratory pit and boring logs provided by Fox and Buckhorn, hard bedrock is presumed to be about 30 to 45 feet from the starting point of installation, so the practical limit on the length of the tiebacks may be assumed to be about 70 to 85 long. For these analyses Cesare assumed that an ultimate grout-to-ground bond strength of 35 pounds per square inch will be achievable in the hard shale.



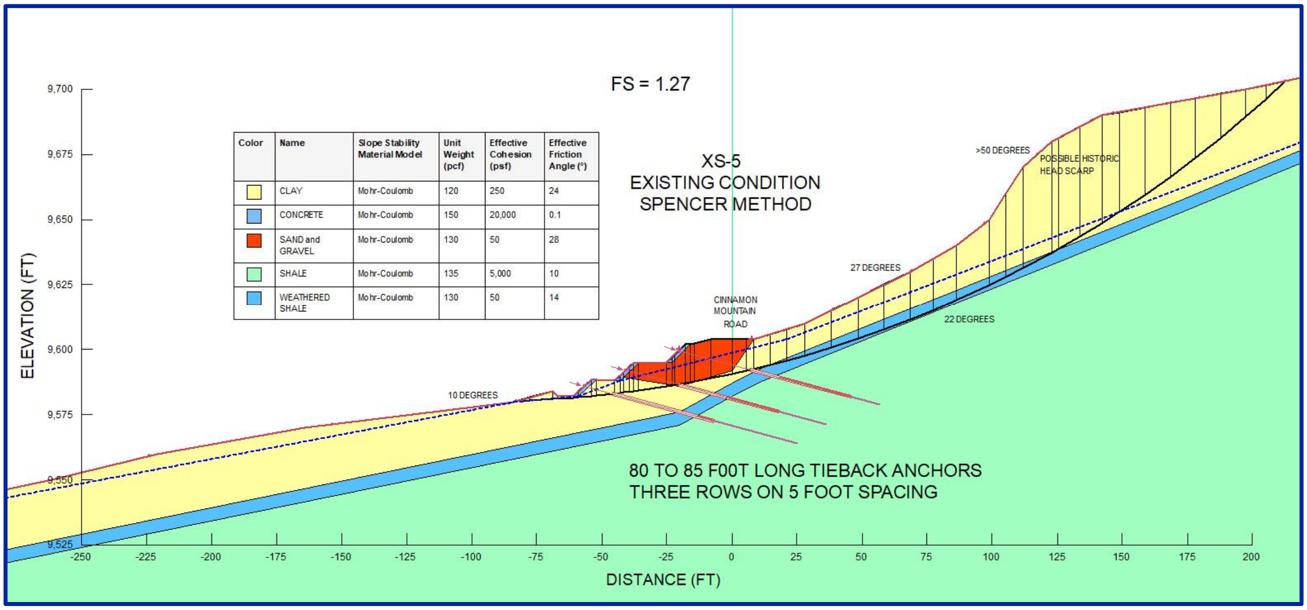
Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟨	CLAY	Mohr-Coulomb	120	250	24
🟦	CONCRETE	Mohr-Coulomb	150	20,000	0.1
🟥	SAND and GRAVEL	Mohr-Coulomb	130	50	28
🟩	SHALE	Mohr-Coulomb	135	5,000	10
🟦	WEATHERED SHALE	Mohr-Coulomb	130	50	14

EXHIBIT 11. Results of GSA for a proposed tieback condition at Cross Section XS-2.



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟨	CLAY	Mohr-Coulomb	120	250	24
🟦	CONCRETE	Mohr-Coulomb	150	20,000	0.1
🟥	SAND and GRAVEL	Mohr-Coulomb	130	50	28
🟩	SHALE	Mohr-Coulomb	135	5,000	10
🟦	WEATHERED SHALE	Mohr-Coulomb	130	50	14

EXHIBIT 12. Results of GSA for the existing condition at Cross section XS-5 with slide entrance limited to the western side of the possible historic scarp.



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟨	CLAY	Mohr-Coulomb	120	250	24
🟦	CONCRETE	Mohr-Coulomb	150	20,000	0.1
🟥	SAND and GRAVEL	Mohr-Coulomb	130	50	28
🟩	SHALE	Mohr-Coulomb	135	5,000	10
🟦	WEATHERED SHALE	Mohr-Coulomb	130	50	14

EXHIBIT 13. Results of GSA for a proposed tieback condition at Cross Section XS-5 with unbounded limits of analysis (i.e., the entrance of the slip surface extends beyond the historic scarp).

Based on the assumed subsurface profiles, the assumed extents of the existing slide, and the analyses performed, Cesare estimates that the number of 70 to 85 foot long tieback anchors required to stabilize the roadway will be on the order of 60 to 100, depending on the findings of additional subsurface exploration and slope monitoring. Cesare estimates that the anchors will need to be installed in one to three rows along the downhill side of Cinnamon Mountain Road with either discrete concrete panels or continuous shotcrete as indicated by Exhibits 11 through 13.

Cesare understands that horizontal drains work well to lower groundwater conditions in the Mount Crested Butte area and should be installed in combination with the tieback anchors. Horizontal drains consist of drilling an inclined hole about 4 inches in diameter, typically back to bedrock, and installing pipe (typically polyvinyl chloride (PVC) pipe). The deeper sections of pipe (beyond about 10 feet) are slotted to allow water to gather to and drain from the pipe. The section of pipe within about 10 feet of the ground surface is typically solid and surrounded by a bentonite core. Horizontal drains are typically spaced at 10 to 20 feet and would be on the order of about 100 feet long for this project.

11.3 LIMITATIONS OF ANALYSES

11.3.1 Potential for Additional Downhill Landslide Movement

The GSA for remediation by tieback anchors presented herein did not consider the existing landslide movement downhill (west) of the remediation area (location of the tieback anchors). If the proposed remediation were to be implemented, the landslide movements downhill may continue to occur. If significant downhill movement were to continue, it could negatively affect the proposed remediation work and additional stabilization efforts may be required. Cesare could further evaluate the future possibilities of additional downhill movement if additional subsurface explorations are performed downhill.

11.3.2 Potential for Uphill Landslide Movement

The GSA for remediation by tieback anchors also did not consider the possibility of slope failure uphill (east) of Cinnamon Mountain Road. That is, a potential slope failure coming down onto the roadway from above has not been evaluated. Such an evaluation should be performed and would require additional subsurface exploration uphill of the roadway, rather than the extrapolations presented herein.

12. RECOMMENDATIONS

Cesare recommends that additional surface and subsurface exploration be performed both uphill and downhill of Cinnamon Mountain Road to better define the depths of bedrock, more accurately estimate the strength of the soil, and better define the limits of analyses prior to developing final remediation design.

Cesare recommends that:

- The surface monitoring pins set by DOWL (especially the pins set uphill of Cinnamon Mountain Road) continue to be monitored and that additional pins set further uphill of the roadway be installed and monitored.
- Additional subsurface exploration be performed further uphill and downhill of Cinnamon Mountain Road by drilling borings, extracting samples for strength testing, and setting inclinometers to better define the slip surface.
- Bond strength testing on the proposed tiebacks be further evaluated, either by review of other tieback bond strength testing performed in the area or by installing and performing bond strength tests onsite.

13. GEOTECHNICAL RISK

The concept of risk is an important aspect of any geotechnical evaluation. The primary reason for this is that the analytical methods used by geotechnical engineers are generally empirical and must be tempered by engineering judgment and experience, therefore, the solutions or recommendations presented in any geotechnical evaluation should not be considered risk free, and more importantly, are not a guarantee that the interaction between the soil and the proposed construction will perform as predicted, desired, or intended. The engineering recommendations presented in the preceding sections constitute Cesare's best estimate of those measures that are necessary to stabilize Cinnamon Mountain Road based on the information generated during this and previous evaluations, and our experience in working with these conditions.

14. LIMITATIONS

This report has been prepared for the exclusive use of the Town of Mount Crested Butte for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either expressed or implied, are intended or made.

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

APPENDIX A

Summary of Laboratory Data Provided by
Fox & Associates, Inc. and Buckhorn Geotech

SUMMARY OF LABORATORY DATA PROVIDED BY FOX AND BUCKHORN

Cinnamon Mountain Road
Project No. 21.6065

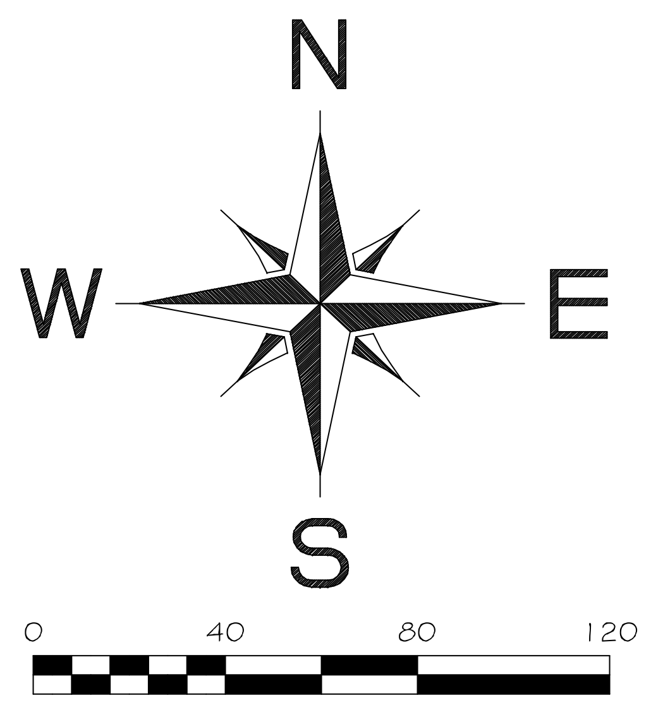
Sample Location		Natural Moisture Content (%)	Dry Density (pcf)	Wet Density (pcf)	Gradation			Atterberg Limits		Unconfined Shear Strength (psf)	Material Type
Boring	Depth (feet)				Gravel (%)	Sand (%)	Silt/ Clay (%)	Liquid Limit (%)	Plasticity Index (%)		
FOX-1	9.5	26.7	88.0	111.5						1260	CLAY, sandy, with organics
FOX-1	11.0	19.4	109.0	130.1						1580	CLAY, with organics
FOX-1	12.5	20.2	106.0	127.4						2140	WEATHERED SHALE (top of 12.5 foot sample)
FOX-1	12.5	12.9	123.0	138.9							SHALE (bottom of 12.5 foot sample)
FOX-2	15.0	27.0	93.0	118.1						850	CLAY, silty and sandy, with organics
FOX-2	16.5	25.8	96.0	120.8						1800	CLAY, with organics
FOX-2	18.0	23.8	95.0	117.6						1590	CLAY, sandy, with organics
FOX-2	21.0	21.2	105.0	127.3						1570	WEATHERED SHALE
FOX-2	22.5	28.2	95.0	121.8						530	WEATHERED SHALE
FOX-1P	1.5	16.3			25.6	36.1	38.3	29	10		SAND, clayey with gravel
FOX-1P	5.0	19.7			7.1	21.5	71.4	34	9		CLAY, sandy with gravel [SILT, with sand]
FOX-1P	7.0	20.8			5.7	43.0	51.3	29	6		CLAY [SILT], sandy
FOX-1P	12.0	51.3			35.8	11.9	52.3	47	15		CLAY [SILT], gravelly
FOX-1P	13.0	20.5			0.1	3.8	96.1	38	16		WEATHERED SHALE
BH-1	15.5	19.6	107.9	129.0	32.9	31.5	35.6	28	12		GRAVEL, clayey with sand
BH-1	21.0	18.9	108.4	128.9	3.2	28.3	68.5	37	19		CLAY, sandy
BH-1	30.0	21.1	103.9	125.8							CLAY, sandy
BH-6	5.0	11.9	102.0	114.1	30.2	43.6	26.2	34	16		SAND, clayey with gravel

APPENDIX B

Topographic Map by Landmark Surveying and Mapping
(November 11, 2021)

CINNAMON ROAD TOPOGRAPHIC SURVEY

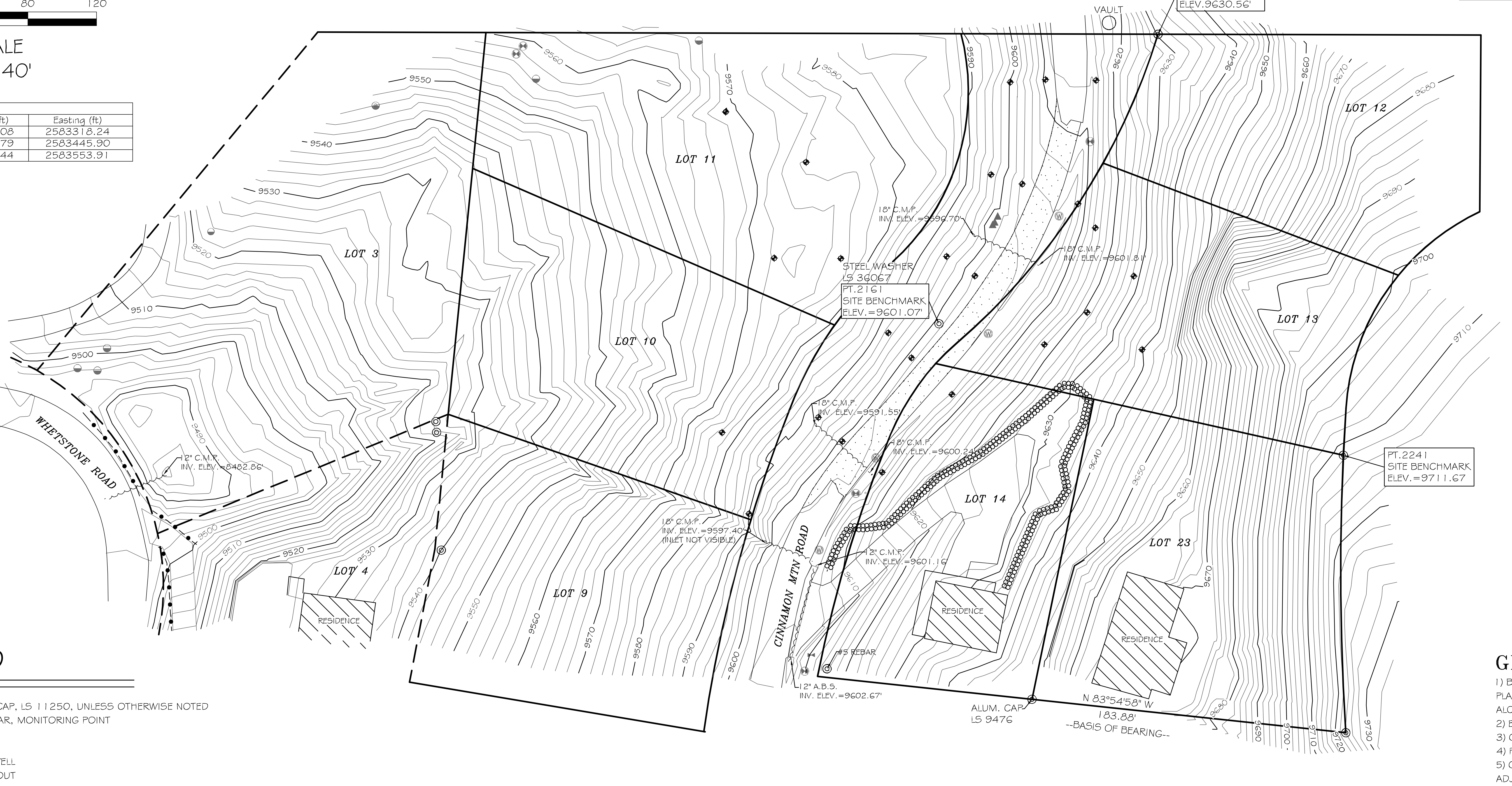
TOWN OF MT. CRESTED BUTTE
GUNNISON COUNTY, COLORADO



SCALE
1" = 40'

POINT TABLE		
Point	Northing (ft)	Easting (ft)
2161	1393894.08	2583318.24
2181	1394062.79	2583445.90
2241	1393817.44	2583553.91

VICINITY MAP
NOT TO SCALE



LEGEND

- ◎ FOUND ALUM. CAP, LS 11250, UNLESS OTHERWISE NOTED
- ⊕ FOUND #6 REBAR, MONITORING POINT
- ▲ PIEZOMETER
- ⋈ FIRE HYDRANT
- Ⓦ MONITORING WELL
- ◒ SEWER CLEAN OUT
- ⊗ TELEPHONE PEDESTAL
- ○○○○ BOULDER RETAINING WALL
- -•-•-•- GUARDRAIL
- — — — APPROXIMATE BOUNDARY
- ▨ GRAVEL

GENERAL NOTES

1) BASIS OF BEARING FOR THIS SURVEY IS GRID NORTH FROM COLORADO STATE PLANE COORDINATE SYSTEM CENTRAL ZONE, BASED ON G.P.S. OBSERVATIONS ALONG THE SOUTH LINE OF LOT 23, HAVING A BEARING OF N 83°54'58" W
2) ELEVATIONS BASED UPON N.A.V.D.88
3) CONTOUR INTERVAL = 2'
4) FIELD WORK PERFORMED ON OCTOBER 21 & 22, 2021
5) COORDINATES BASED UPON NAD 83 COLORADO STATE PLANE, CENTRAL ZONE, ADJUSTED TO GROUND WITH A SCALE FACTOR OF 1.0004939866

LAND SURVEYOR'S CERTIFICATE

I, SYDNEY A. SCHIEREN, A REGISTERED LAND SURVEYOR LICENSED TO PRACTICE IN THE STATE OF COLORADO, DO HEREBY CERTIFY THAT THIS LAND SURVEY WAS PERFORMED UNDER MY DIRECT SUPERVISION, AND THAT THE PLAT REPRESENTS THE RESULTS OF SAID SURVEY AND IS TRUE AND CORRECT TO THE BEST OF MY KNOWLEDGE.

SYDNEY A. SCHIEREN
COLORADO P.L.S. 37937

SYDNEY ARTHUR SCHIEREN
37937

REVISED:

JOB # 21168
DATE: NOVEMBER 11, 2021
SHEET 1 OF 1

CINNAMON ROAD
TOPOGRAPHIC SURVEY

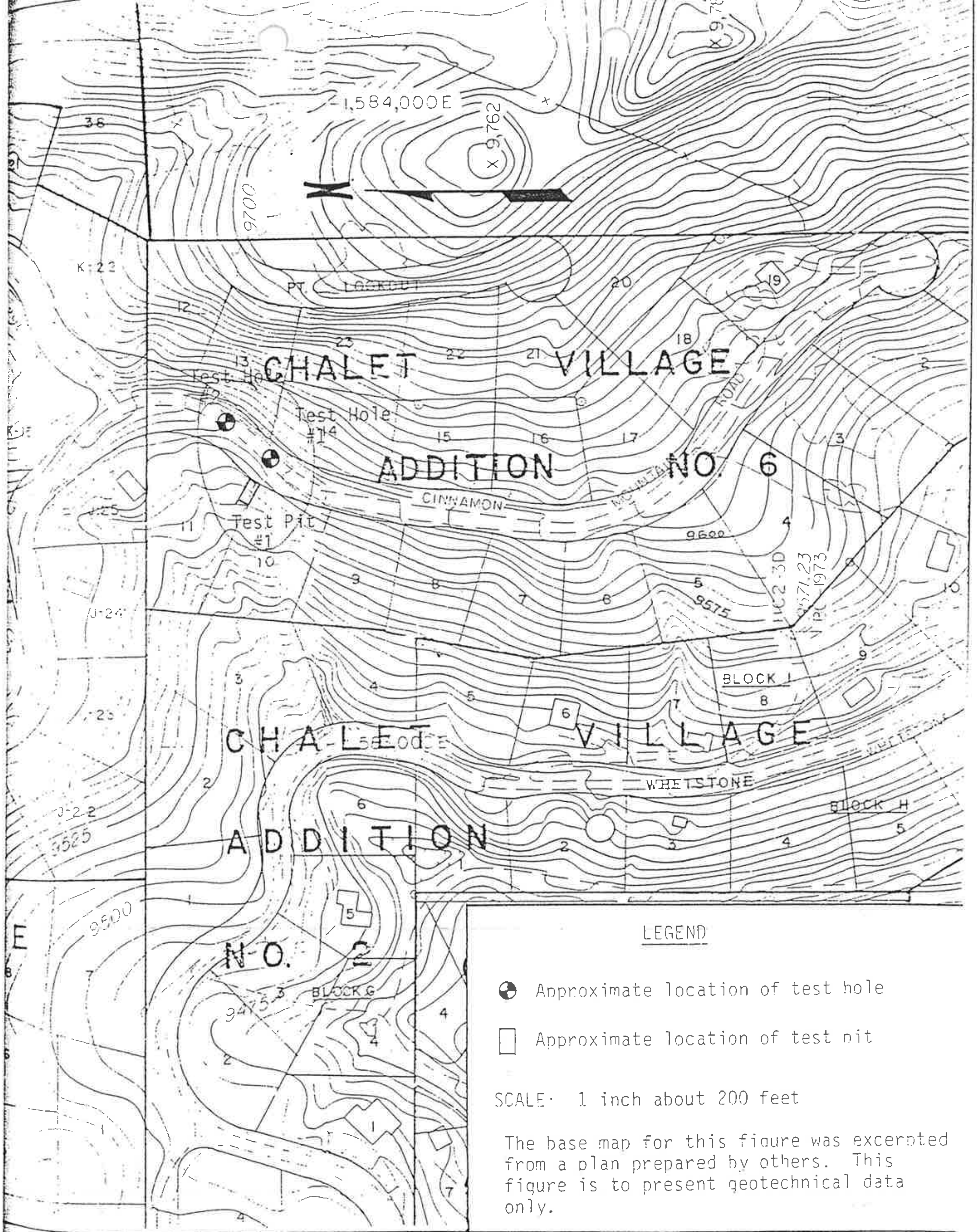
TOWN OF MT. CRESTED BUTTE
GUNNISON COUNTY, COLORADO

LANDMARK
SURVEYING & MAPPING
P.O. BOX 668 SALIDA, CO 81201
PH 719.539.4021 FAX 719.539.4031

NOTICE: ACCORDING TO COLORADO LAW YOU MUST COMMENCE ANY LEGAL ACTION BASED UPON ANY DEFECT IN THIS SURVEY WITHIN THREE YEARS AFTER YOU FIRST DISCOVER SUCH DEFECT. IN NO EVENT MAY ANY ACTION BASED UPON ANY DEFECT IN THIS SURVEY BE COMMENCED MORE THAN TEN YEARS FROM THE DATE OF THE SURVEYOR'S STATEMENT CONTAINED HEREON.

APPENDIX C

Exploratory Pit and Boring Location Map and Logs by Fox & Associates, Inc.



LEGEND

● Approximate location of test hole

▯ Approximate location of test pit

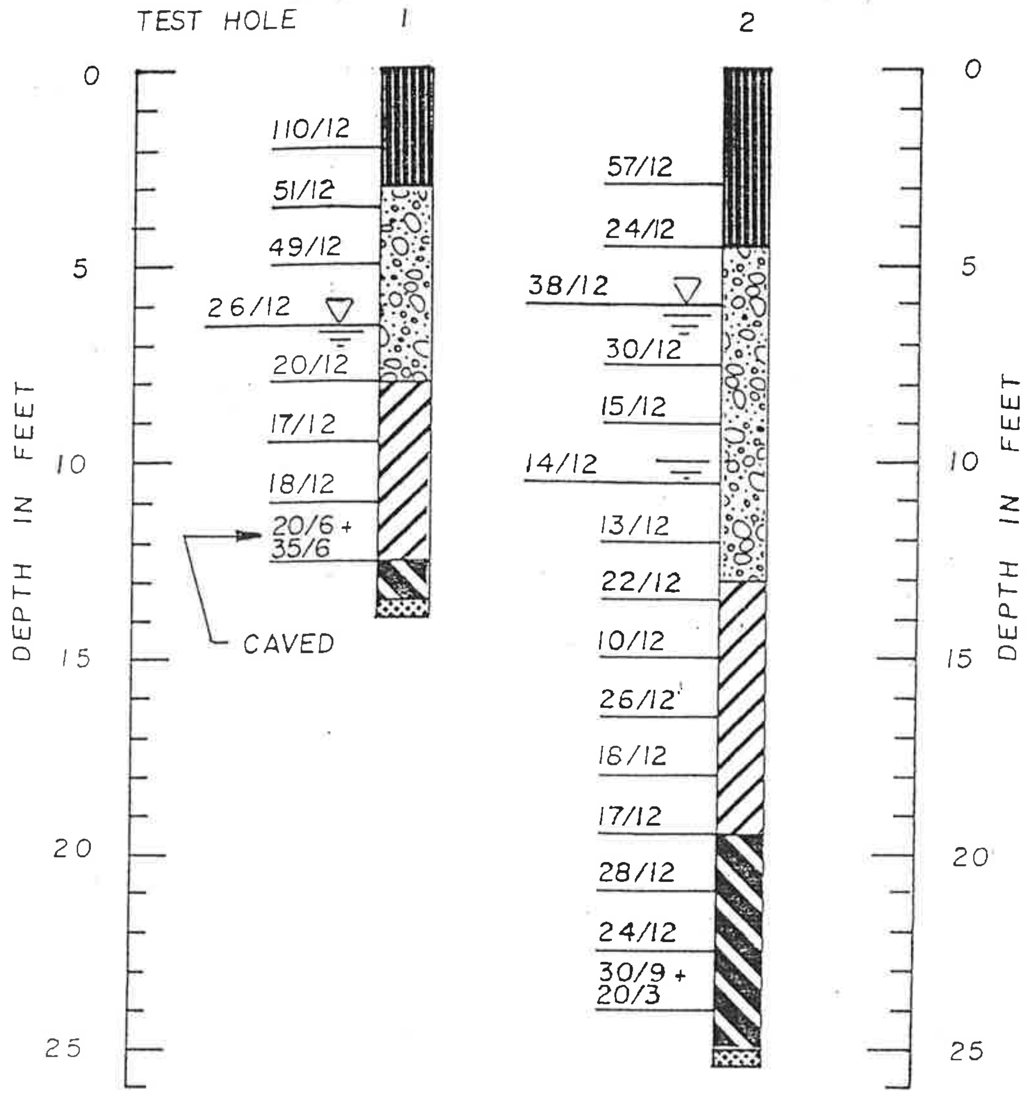
SCALE: 1 inch about 200 feet

The base map for this figure was excerpted from a plan prepared by others. This figure is to present geotechnical data only.

TEST HOLE LOCATION PLAN

FOX Consulting Engineers and Geologists

Job No: 010238
Date: 6/2/82
Figure 1



▥ ASPHALT & BASE COURSE

░ SAND & GRAVEL, slightly clayey to clayey, medium dense, moist to wet, (SC-GC)

▨ CLAY, silty and sandy, (very organic), stiff to very stiff, some low density, moist to very moist, brown to black, (CL-OL)

▧ WEATHERED SHALE, firm to medium hard, moist to very moist, brown to black, (CL-CH)

▒ CLAY - SHALE BEDROCK, silty, hard to very hard, slightly moist to medium moist, brown to black, (CL-CH)

▽ Indicates water table at time of drilling.

≡ Indicates free-water level.

CAVED Indicates depth at which hole was plugged.

NOTES

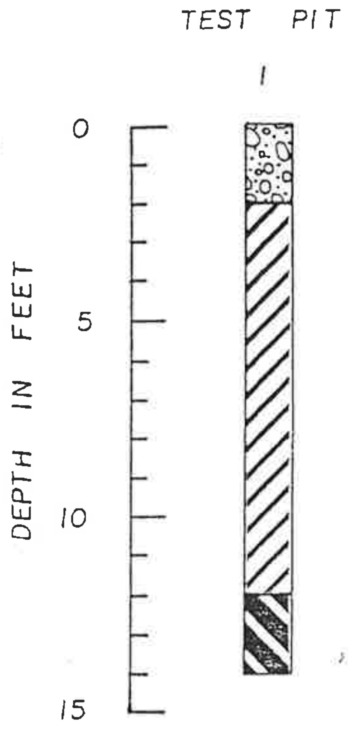
1. Test holes were drilled on 5/17/82 with a 6 inch diameter hollow stem power auger.
2. (110/12) location of Standard Penetration Test; indicates that 110 blows with a 140 pound hammer, falling 30 inches, were required to drive a ? inch diameter sampler 12 inches.

LOGS OF TEST HOLES

Job No: 010238

Date: 6-2-82

FOX Consulting Engineers and Geologists



▨ SAND & GRAVEL, slightly clayey to clayey, loose to medium dense, very moist to wet, (SC-GC)

▨ CLAY, silty and sandy (very organic), some low density, very moist to wet, brown to black, (CL-OL)

▩ WEATHERED SHALE, firm to medium hard, moist to very moist, brown to black, (CL-CH)

NOTES

1. Test pit was dug on May 17, 1982 with a backhoe.
2. No free-water was found in test pit at time of digging.
3. Location of test pit is approximately 38 feet on downslope from test hole number 1 of Cinnamon Mountain Road.

LOGS OF TEST PITS

Job No: 010238

Date: 6 - 4 - 82

Figure 3

FOX

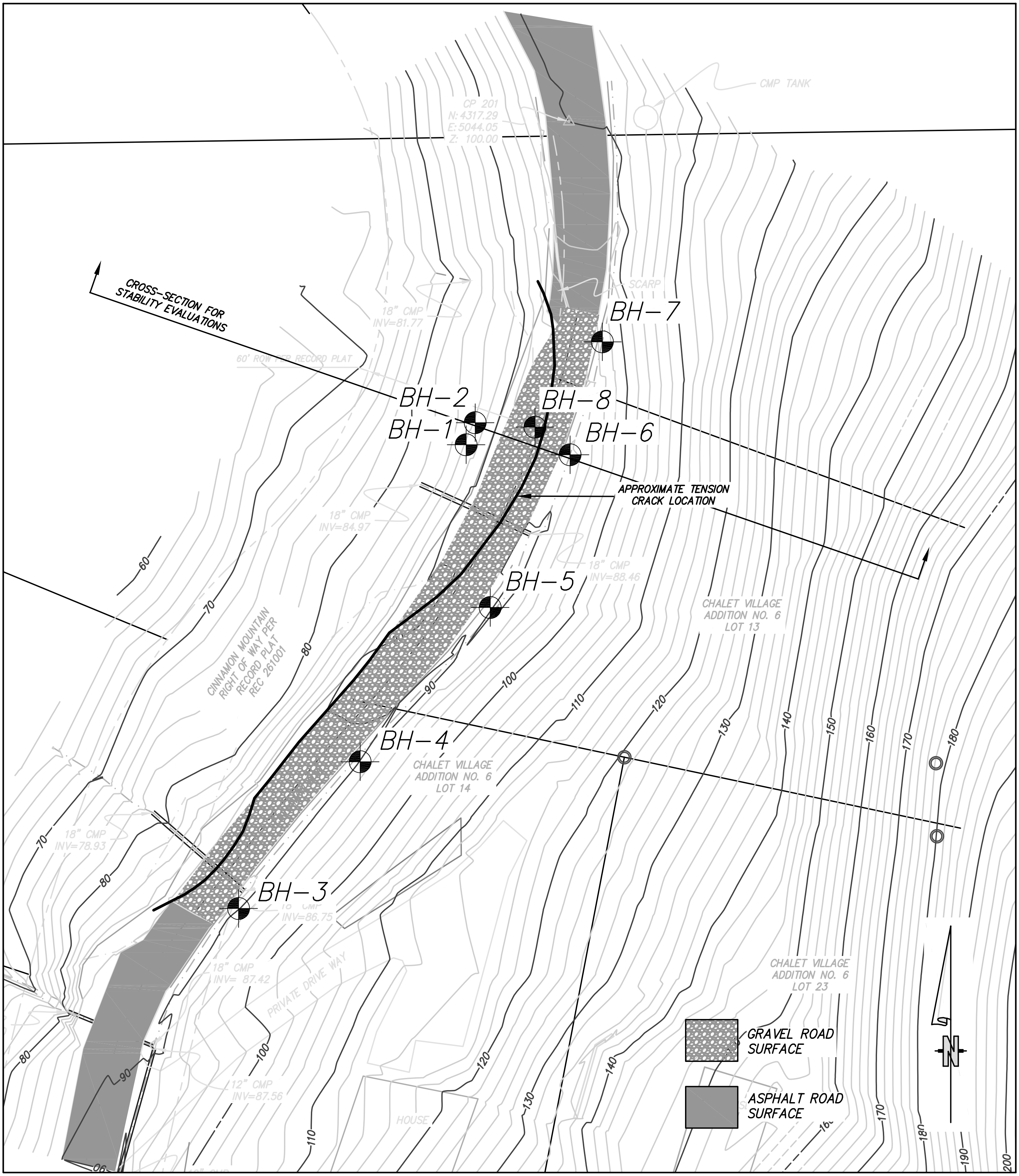
Consulting Engineers and Geologists

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

APPENDIX D

Exploratory Boring Location Map and Logs by Buckhorn Geotech

SITE PLAN



MAP NUMBER

2

OF 2

INVESTIGATION TB/KR

DRAFTING CL

FIELD DATE 7/16/08–7/18/08

JOB NO. 08–244–GEO

TOWN OF MT. CRESTED BUTTE

CINNAMON MOUNTAIN ROAD LANDSLIDE

MT. CRESTED BUTTE, COLORADO

BUCKHORN GEOTECH

Civil, Structural, and Geotechnical Engineers, Inc.
222 South Park Avenue
Montrose, Colorado 81401
Phone (970) 249-6828 Fax (970) 249-0945

BOREHOLE LOG – BOREHOLE BH#1

BOREHOLE LOCATION: West side of road

SURFACE ELEVATION:

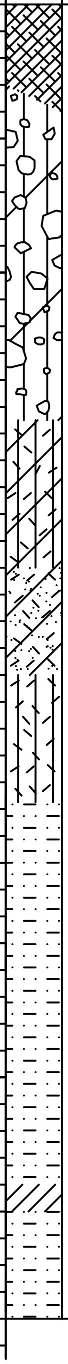
NOTES: Inclinometer installed in borehole to approx. 56'

DRILLER: Scott Drilling

DRILL RIG: Simco 2800 HS

DRILL STEM: 4" Solid-stem continuous flight auger & HQ wireline core assembly

SAMPLER: 2" I.D. California split spoon and HQ core tube



DEPTH (ft.)	WATER LEVEL	SAMPLE TYPE	SAMPLE NUMBER	SPT BLOW COUNTS	*SPT 'N' VALUE (bpf)	R.Q.D. (%)	RECOVERY (in.)	SUBSURFACE DESCRIPTION	FIELD & LABORATORY TEST RESULTS
0								sandy GRAVEL & COBBLES [FILL] (0–3/4')	
5			DS1	3 5 4	9		9/18	brown, damp to moist, loose sandy GRAVEL & COBBLES, little clay, little to some silt [FILL] (3/4–11)	
10								small boulder @10'	
			DS2	2 3 3	6		9/18	dark brown to brown, wet to moist, loose, sandy GRAVEL & COBBLES, little to some silt & clay	
15			DS3	5 5 6	11		14/18	dark gray, moist to wet, firm to stiff, silty CLAY with jumbled shale fragments; sampler is wet	DS3 (GC) LL=28 PL=16 PI=12 MC=19.6% DD=107.9 pcf GF=32.9% SF=31.5% F200=35.6%
20			DS4	3 4 5	9		12/18	dark gray, wet, stiff to very stiff, silty, sandy CLAY with some shale fragments; slightly mottled & iron oxide staining	DS4 (CL) LL=37 PL=19 PI=19 MC=18.9% DD=108.4 pcf GF=3.2% SF=28.3% F200=68.5%
25			DS5	5 8 9	17		17/18	driller notes shale @25' dark gray, wet, highly weathered & fractured, silty jumbled SHALE; possible shear zone	DS5 MC=21.1% DD=103.9 pcf
30			DS6	50/1"			1/18	dark gray SHALE start coring @30'	
		RUN 1				0	0		
35								dark gray, slightly to moderately weathered, moderately to highly fractured, weak to very weak, silty SHALE (30–49')	
		RUN 2				78	100		
		RUN 3				47	100		
40		RUN 4				44	83		
45								8" thick bentonite layer between 44 and 45'; possible shear zone	
		RUN 5				33	100		
								end of borehole @49' in SHALE	
50									

* SPT N–values not corrected for energy or depth; stratigraphic transitions are approximate and are inferred from cuttings & drillers comments

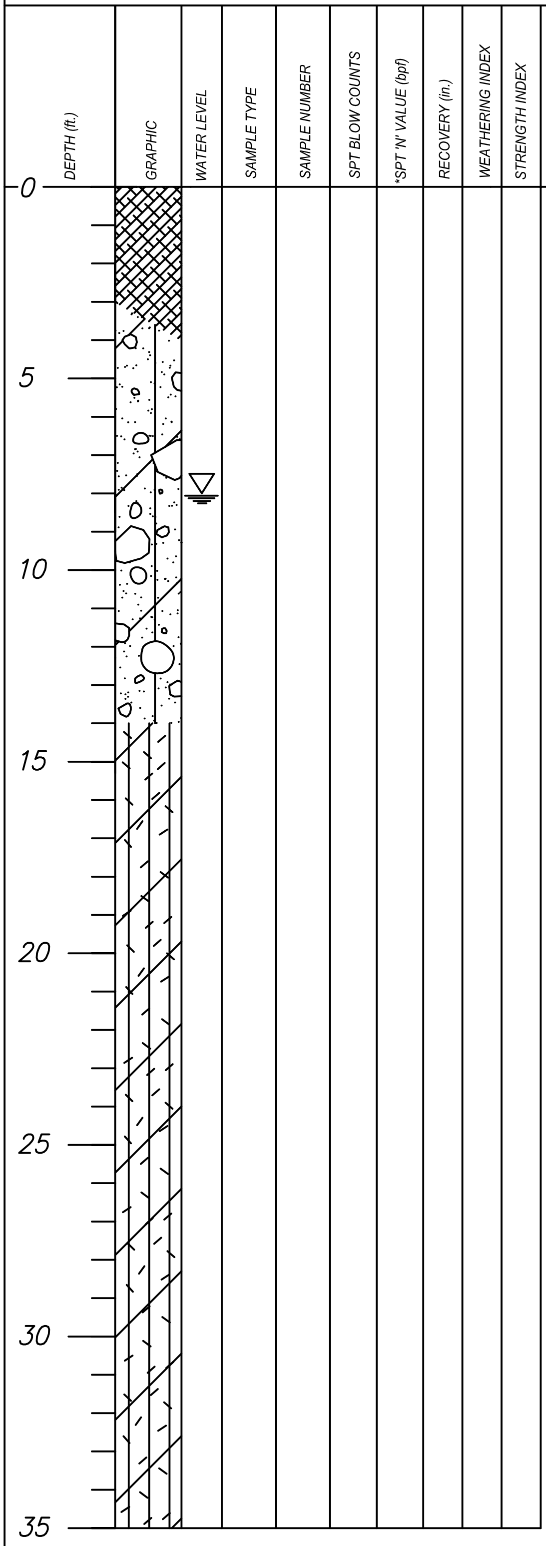
BOREHOLE LOG 1 OF 8	INVESTIGATION TB/KR DRAFTING CL FIELD DATE 7/16/08 JOB NO. 08–244–GEO	TOWN OF MT. CRESTED BUTTE CINNAMON MOUNTAIN ROAD LANDSLIDE MT. CRESTED BUTTE, COLORADO

BUCKHORN GEOTECH
Civil, Structural, and Geotechnical Engineers, Inc.
222 South Park Avenue
Montrose, Colorado 81401
Phone (970) 249-6828 Fax (970) 249-0945

BOREHOLE LOG – BOREHOLE BH#2

BOREHOLE LOCATION: West side of road, next to BH #1
SURFACE ELEVATION:
NOTES: Open standpipe installed to 35'; bottom open, not slotted

DRILLER: Scott Drilling
DRILL RIG: Simco 2800 HS
DRILL STEM: 4" Solid-stem continuous flight auger



SUBSURFACE DESCRIPTION

[FILL] (0–3/4')

Loose, sandy GRAVEL & COBBLES, little silt & clay; easy drilling (3/4–14')

shallowest groundwater at 8.0' bgs on 6/11/09 over 2008–2009 monitoring period

driller notes groundwater at 10' during drilling

Driller notes stiffening @ 14'

Silty CLAY with jumbled shale fragments (14–35')

Shelby Tube attempted @26'; No recovery

end of borehole @35' in SHALE

FIELD & LABORATORY TEST RESULTS

* SPT N–values not corrected for energy or depth; stratigraphic transitions are approximate and are inferred from cuttings & drillers comments

BOREHOLE LOG
2
OF 8

INVESTIGATION TB/KR
DRAFTING CL
FIELD DATE 7/16/08–7/17/08
JOB NO. 08–244–GEO

TOWN OF MT. CRESTED BUTTE
CINNAMON MOUNTAIN ROAD LANDSLIDE
MT. CRESTED BUTTE, COLORADO

BUCKHORN GEOTECH
Civil, Structural, and Geotechnical Engineers, Inc.
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Montrose, Colorado 81401
Phone (970) 249-6828 Fax (970) 249-0945

BOREHOLE LOG – BOREHOLE BH#3

BOREHOLE LOCATION: Cinnamon Mt. Road, east side of road, southernmost BH

SURFACE ELEVATION:

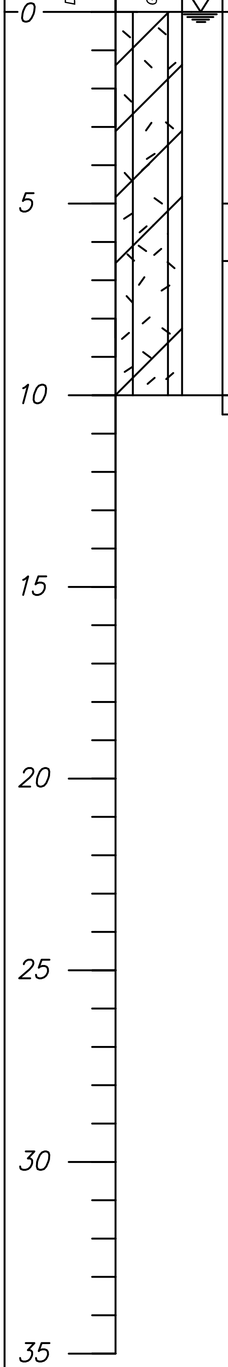
NOTES: Open standpipe installed to 10'; slotted 6-10'

DRILLER: Scott Drilling

DRILL RIG: Simco 2800 HS

DRILL STEM: 4" Solid-stem continuous flight auger

SAMPLER: 2" I.D. California split spoon



DEPTH (ft.)	GRAPHIC	WATER LEVEL	SAMPLE TYPE	SAMPLE NUMBER	SPT BLOW COUNTS	*SPT 'N' VALUE (bpf)	RECOVERY (in.)	WEATHERING INDEX	STRENGTH INDEX	SUBSURFACE DESCRIPTION	FIELD & LABORATORY TEST RESULTS
0		▽								silty CLAY, jumbled shale fragments (0–5/6')	
5			CA	DS7	7 14 20	34	18			olive gray, dry to damp jumbled SHALE, some silt & clay; highly weathered, highly fractured, oxidation stains (5/6–10')	
10			CA	DS8	50/6"		6			end of borehole @10' shallowest groundwater at 0' bgs (surface) on 8/14/08 over 2008–2009 monitoring period	

* SPT N–values not corrected for energy or depth; stratigraphic transitions are approximate and are inferred from cuttings & drillers comments

BOREHOLE LOG
3
OF 8

INVESTIGATION	TB/KR
DRAFTING	CL
FIELD DATE	7/16/08
JOB NO.	08–244–GEO

TOWN OF MT. CRESTED BUTTE
CINNAMON MOUNTAIN ROAD LANDSLIDE
MT. CRESTED BUTTE, COLORADO

BUCKHORN GEOTECH
Civil, Structural, and Geotechnical Engineers, Inc.
222 South Park Avenue
Montrose, Colorado 81401
Phone (970) 249-6828 Fax (970) 249-0945

BOREHOLE LOG – BOREHOLE BH#4

BOREHOLE LOCATION: Cinnamon Mt. Road, east side of road, 2nd BH from south end

SURFACE ELEVATION:

NOTES: Open standpipe installed to 20'; slotted 10-20'

DRILLER: Scott Drilling

DRILL RIG: Simco 2800 HS

DRILL STEM: 4" Solid-stem continuous flight auger

SAMPLER: 2" I.D. California split spoon

DEPTH (ft.)	GRAPHIC	WATER LEVEL	SAMPLE TYPE	SAMPLE NUMBER	SPT BLOW COUNTS	*SPT 'N' VALUE (bpf)	RECOVERY (in.)	WEATHERING INDEX	STRENGTH INDEX	SUBSURFACE DESCRIPTION	FIELD & LABORATORY TEST RESULTS
0		▽								dry, soft, silty CLAY, jumbled shale fragments (0–3')	
5			CA	DS9	23 28	51	12/12			olive gray, dry to damp, very stiff to hard, jumbled SHALE, some silt & clay; highly weathered, highly fractured	
10			CA	DS10	15 16 29	35	18/18			olive gray, dry to damp, very stiff to hard, jumbled SHALE, some silt & clay; highly weathered, highly fractured	
15			CA	DS11	12 11 16	27	18/18			same as above; free moisture on some fractured surfaces	
				DS12	50/2"		2/2				
20										end of borehole @20' shallowest groundwater at 0.7' bgs on 4/28/09 & 5/7/09 over 2008–2009 monitoring period	
25											
30											
35											

* SPT N–values not corrected for energy or depth; stratigraphic transitions are approximate and are inferred from cuttings & drillers comments

BOREHOLE LOG

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OF 8

INVESTIGATION TB/KR

DRAFTING CL

FIELD DATE 7/17/08

JOB NO. 08–244–GEO

TOWN OF MT. CRESTED BUTTE

CINNAMON MOUNTAIN ROAD LANDSLIDE

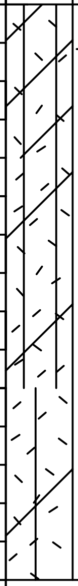
MT. CRESTED BUTTE, COLORADO

BUCKHORN GEOTECH
Civil, Structural, and Geotechnical Engineers, Inc.
222 South Park Avenue
Montrose, Colorado 81401
Phone (970) 249-6828 Fax (970) 249-0945

BOREHOLE LOG – BOREHOLE BH#5

BOREHOLE LOCATION: Cinnamon Mt. Road, east side of road, 3rd BH from south end
SURFACE ELEVATION: 9614'
NOTES: Open standpipe installed to 15'; slotted 5-15'

DRILLER: Scott Drilling
DRILL RIG: Simco 2800 HS
DRILL STEM: 4" Solid-stem continuous flight auger
SAMPLER: 2" I.D. California split spoon



DEPTH (ft.)	GRAPHIC	WATER LEVEL	SAMPLE TYPE	SAMPLE NUMBER	SPT BLOW COUNTS	*SPT 'N' VALUE (bpf)	RECOVERY (in.)	WEATHERING INDEX	STRENGTH INDEX	SUBSURFACE DESCRIPTION	FIELD & LABORATORY TEST RESULTS
0										approximately 2–3' cut below grade before drilling	
		▽									
										yellowish brown, dry to damp, silty CLAY, shale fragments (0–4')	
										driller notes hard drilling @4'	
5			CA	DS13	15 17 29	40	18/18			olive gray, dry to damp, very stiff to hard SHALE, some silt & clay; highly weathered, highly fractured (4–10')	
10			CA	DS14	50/3"					drive sample DS14 @10'; olive gray, SHALE, little silt & clay; highly weathered, highly fractured	
15										end of borehole @15'	
										shallowest groundwater at 1.1' bgs on 5/7/09 over 2008–2009 monitoring period	
20											
25											
30											
35											

* SPT N–values not corrected for energy or depth; stratigraphic transitions are approximate and are inferred from cuttings & drillers comments

BOREHOLE LOG
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OF 8

INVESTIGATION TB/KR
DRAFTING CL
FIELD DATE 7/17/08–7/18/08
JOB NO. 08–244–GEO

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CINNAMON MOUNTAIN ROAD LANDSLIDE
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BOREHOLE LOG – BOREHOLE BH#6

BOREHOLE LOCATION: Cinnamon Mt. Road, east side of road, 3rd BH from south end

SURFACE ELEVATION:

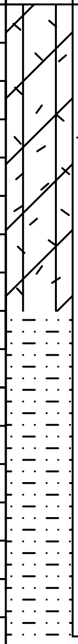
NOTES: Open standpipe installed to 15'

DRILLER: Scott Drilling

DRILL RIG: Simco 2800 HS

DRILL STEM: 4" Solid-stem continuous flight auger

SAMPLER: 2" I.D. California split spoon



DEPTH (ft.)	GRAPHIC	WATER LEVEL	SAMPLE TYPE	SAMPLE NUMBER	SPT BLOW COUNTS	*SPT 'N' VALUE (bpf)	RECOVERY (in.)	WEATHERING INDEX	STRENGTH INDEX	SUBSURFACE DESCRIPTION	FIELD & LABORATORY TEST RESULTS
0										approximately 2–3' cut below grade before drilling	
		▽									
5										driller notes hard drilling @2'	
			CA	DS15	3 6 7	13	18/18			brownish gray to dark olive gray, dry to moist, silty CLAY to clayey SILT, estimated 30–50% jumbled SHALE fragments	DS15 (SC) LL=34 PL=18 PI=16 GF=30.2% SF=43.6% F200=26.2% MC=11.9% DD=102.0 pcf
				ST1						shelby tube sample ST1 @6.5–7.8'	
										@8' possible hard shale	
10			CA	DS16	25 31	56				dark olive gray, dry to damp SHALE, little to trace silt & clay; highly weathered, highly fractured	
15			CA	DS17	30 23/3"		18/18			dark olive gray, dry to damp SHALE, little to trace silt & clay; highly weathered, highly fractured	
										end of borehole @16.5'	
										shallowest groundwater at 3.4' bgs on 5/7/09 over 2008–2009 monitoring period	
20											
25											
30											
35											

* SPT N–values not corrected for energy or depth; stratigraphic transitions are approximate and are inferred from cuttings & drillers comments

BOREHOLE LOG
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OF 8

INVESTIGATION TB/KR
DRAFTING CL
FIELD DATE 7/18/08
JOB NO. 08–244–GEO

TOWN OF MT. CRESTED BUTTE
CINNAMON MOUNTAIN ROAD LANDSLIDE
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BOREHOLE LOG – BOREHOLE BH#7

BOREHOLE LOCATION: Cinnamon Mt. Road, east side of road, northern most BH

SURFACE ELEVATION:

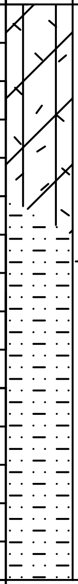
NOTES: Open standpipe installed to 15'

DRILLER: Scott Drilling

DRILL RIG: Simco 2800 HS

DRILL STEM: 4" Solid-stem continuous flight auger

SAMPLER: 2" I.D. California split spoon



DEPTH (ft.)	GRAPHIC	WATER LEVEL	SAMPLE TYPE	SAMPLE NUMBER	SPT BLOW COUNTS	*SPT 'N' VALUE (bpf)	RECOVERY (in.)	WEATHERING INDEX	STRENGTH INDEX	SUBSURFACE DESCRIPTION	FIELD & LABORATORY TEST RESULTS
0										dry to damp, silty CLAY to clayey SILT, jumbled SHALE fragments (0–5/6')	
5			CA	DS18	4 4 6	10					
		▽		ST2						shelby tube sample ST2 @6.5–7.5' @~5.5–7' mainly SHALE with less interstitial soil	
10											
										@13' harder shale and increased moisture content	
15										end of borehole @15' shallowest groundwater at 6.6' bgs on 5/7/09 over 2008–2009 monitoring period	
20											
25											
30											
35											* SPT N–values not corrected for energy or depth; stratigraphic transitions are approximate and are inferred from cuttings & drillers comments

BOREHOLE LOG
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OF 8

INVESTIGATION	TB/KR
DRAFTING	CL
FIELD DATE	7/18/08
JOB NO.	08–244–GEO

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CINNAMON MOUNTAIN ROAD LANDSLIDE
MT. CRESTED BUTTE, COLORADO

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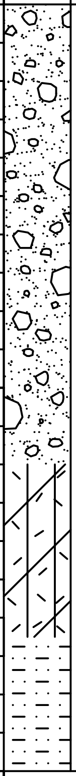
BOREHOLE LOG – BOREHOLE BH#8

BOREHOLE LOCATION: Cinnamon Mt. Road, approx. center of road, between BH#1 & BH#6
SURFACE ELEVATION:
NOTES: Open standpipe installed to 20'

DRILLER: Scott Drilling
DRILL RIG: Simco 2800 HS
DRILL STEM: 4" Solid-stem continuous flight auger
SAMPLER: 2" I.D. California split spoon



DEPTH (ft.)	GRAPHIC	WATER LEVEL	SAMPLE TYPE	SAMPLE NUMBER	SPT BLOW COUNTS	*SPT 'N' VALUE (bpf)	RECOVERY (in.)	WEATHERING INDEX	STRENGTH INDEX	SUBSURFACE DESCRIPTION	FIELD & LABORATORY TEST RESULTS
0											
										sandy GRAVEL some cobbles [FILL] (0–12’)	
5											
										@12’ driller notes native soil	
10											
15											
			CA	DS19	3 12 29	41				sampled at transition zone to shale; dark olive gray, wet, silty CLAY, shale fragments (16–16.5), dark olive gray, damp, SHALE (16.5–17.5)	
20										end of borehole @20’	
25											
30											
35											

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BOREHOLE LOG
8
OF 8

INVESTIGATION TB/KR
DRAFTING CL
FIELD DATE 7/18/08
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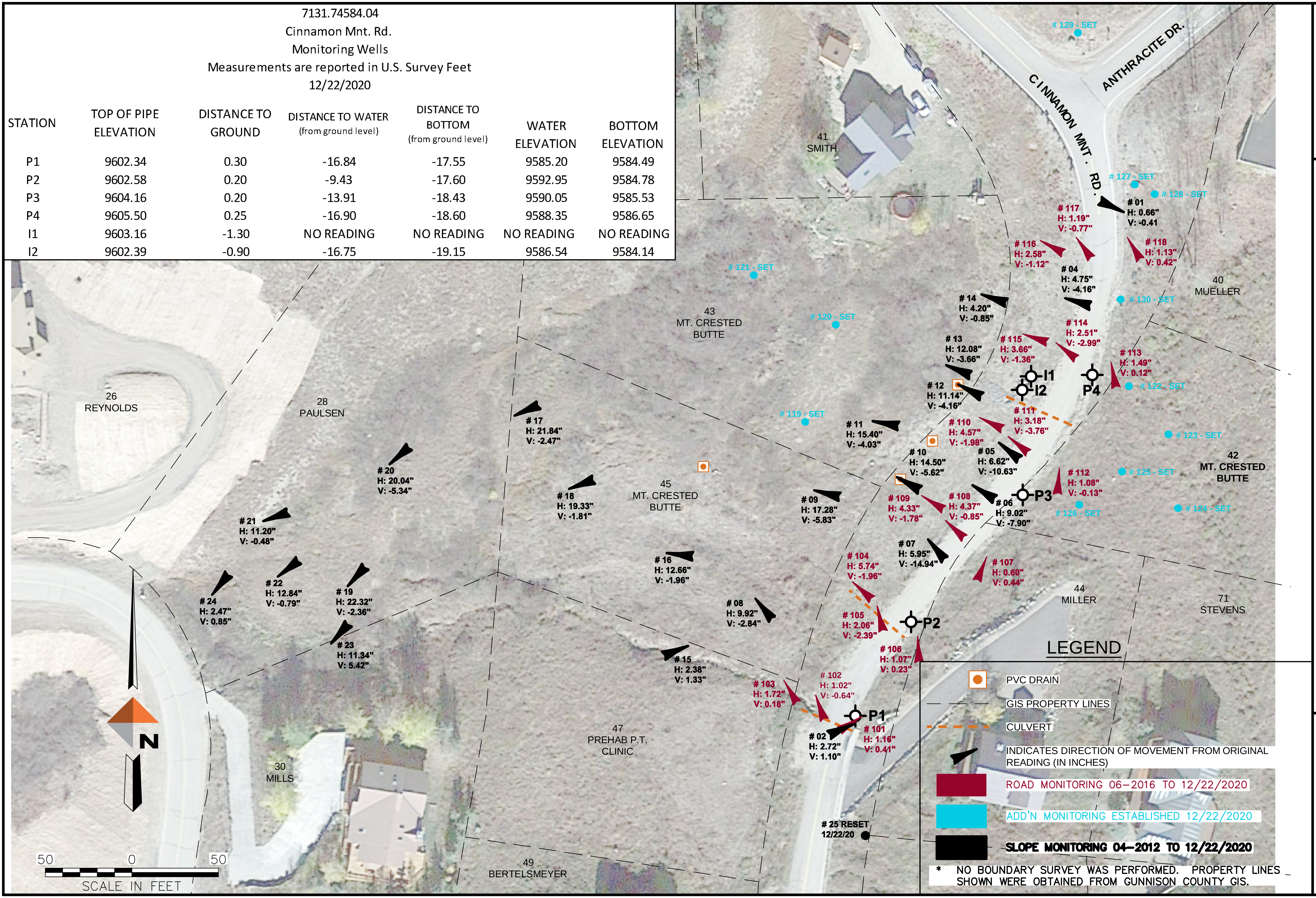
APPENDIX E

Subsurface Displacement Map by DOWL
(December 22, 2020)

7131.74584.04
Cinnamon Mnt. Rd.
Monitoring Wells
Measurements are reported in U.S. Survey Feet
12/22/2020

STATION	TOP OF PIPE ELEVATION	DISTANCE TO GROUND	DISTANCE TO WATER (from ground level)	DISTANCE TO BOTTOM (from ground level)	WATER ELEVATION	BOTTOM ELEVATION
P1	9602.34	0.30	-16.84	-17.55	9585.20	9584.49
P2	9602.58	0.20	-9.43	-17.60	9592.95	9584.78
P3	9604.16	0.20	-13.91	-18.43	9590.05	9585.53
P4	9605.50	0.25	-16.90	-18.60	9588.35	9586.65
I1	9603.16	-1.30	NO READING	NO READING	NO READING	NO READING
I2	9602.39	-0.90	-16.75	-19.15	9586.54	9584.14



PROJECT	7131.74584.04
DATE	01/13/2021

MAP 1

CINNAMON MOUNTAIN ROAD
SLOPE & OBSERVATION WELL MONITORING 12-22-2020
COMPARISON BETWEEN ORIGINAL AND LATEST DATA

DOWL
WWW.DOWL.COM

Q:\31\74584-04\70Survey\74584 Cinnamon Mnt Road Complete Monitoring 122220.dwg PLOT DATE 2021-1-19 13:52 SAVED DATE 2021-01-19 13:52 USER: jharness