BUCKHORN GEOTECH

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GEOTECHNICAL REPORT
LERMAN BUILDING
2984 BLACK CANYON ROAD
CRAWFORD, COLORADO

August 1, 2014

Prepared for:

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Prepared by:

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Introduction

Buckhorn Geotech, Inc. conducted an evaluation of shallow subsurface and site conditions on June 25, 2014 at the proposed building envelope on 2984 Black Canyon Road of Majestic Subdivision near Crawford, Colorado. Our services were performed at the request of the owner, Ruvin Lerman. The purpose of our services was to evaluate a preliminary building envelope for construction of a steel building that will serve as a garage with living space. The evaluation consisted of a site reconnaissance, excavation of four test pits, observation, logging and testing of representative materials found, and analysis of available data. Our services did not include an evaluation of deep subsurface conditions. A more comprehensive scope of services would be required for such an evaluation. This report presents the findings of our evaluation and our geotechnical engineering recommendations for site preparation, foundation design, and management of drainage.

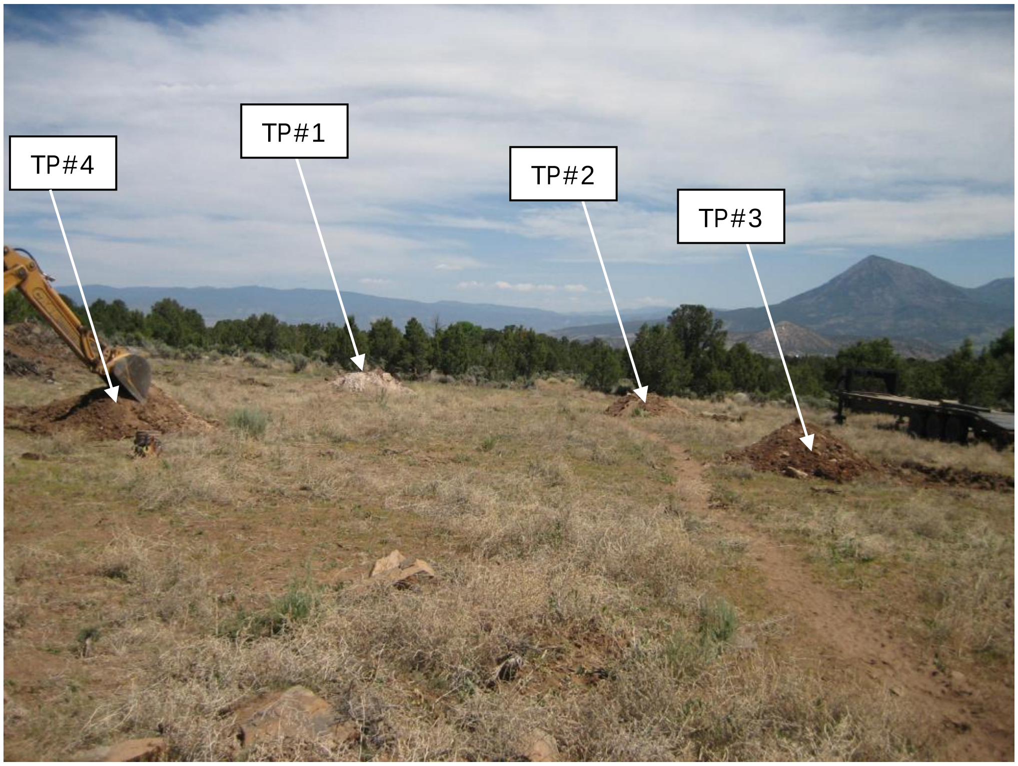
Construction Plans

Based on building plans provided to us by the owner, we understand the structure will consist of a 44' by 60' steel building on a slab on-grade. Roughly half of the structure will be used as a garage and half will be framed for living space. It will be a steel framed structure with metal sides and roof. The interior apartment will have wood framing. Buckhorn Geotech is performing the foundation and structural design work for this project and we have determined the structure will transfer approximately 1,000 pounds per linear foot to the foundation level with concentrated loads of up to 30,000 pounds. The site will need to be served by an on-site wastewater system and we understand one has been already designed by others.

Site Conditions

The subject property (2984 Black Canyon Road) is located on the east side of Black Canyon Road, roughly 7 miles southwest of Crawford in Montrose County (see Vicinity Map, Map 1). As seen on the Vicinity Map, Gould Canal is located in the northeast quadrant of the square parcel and a natural drainage swale crosses the property from the southwest corner to near the northeast corner. Most of the property is vegetated with native dry upland species such as sagebrush, rabbitbrush and an open pinion and juniper forest. The building site is located in the southwest corner of the property, which is accessed via a gravel driveway from the west. The attached Site Plan (Map 2) is an aerial photograph that shows the cleared building site and the approximate locations of our four test pits (TP#1-TP#4) with respect to the proposed building footprint.

According to the *Grand View Mesa USGS Topographic Map* (Terrain Navigator Pro Ver 8.71), the approximate elevation of the building site is 7,250 feet and it is located in an area locally known as Fruitland Mesa. The building site was not staked at the time of our field testing, but we visually approximated the building footprint based on dimensions provided by the owner on an aerial photograph. Terrain across the building site slopes gently down to the northeast at an approximate grade of 3-5%. The aforementioned natural drainage swale is east of the building site. The following photograph was taken of the building site at the time of our field evaluation.



Looking roughly north across the building site, shows the vegetative cover, the local topography, the relative locations of our test pits, and the conditions at the time of our site visit.

We excavated four test pits just outside of the designated building envelope (TP#1-TP#4), as indicated on the Site Plan and on the photograph above. The results of our field and laboratory testing are discussed in the *Soil Characteristics* Section of this report.

Geology

According to the *Reconnaissance Geologic Map of the Hotchkiss Area, Delta and Montrose Counties, Colorado* (1:48,000 scale USGS Map I-698, by W.J. Hail, 1972), the subject property is mapped as the Dakota Sandstone Formation (*Kdb*). The Dakota Sandstone is a light gray to brown resistant quartzose sandstone with some dark gray carbonaceous shale. Chert-pebble conglomerate is locally present in the lower part of the formation as it transitions to the Burro Canyon Formation, a conglomeratic sandstone. Virtually all of Fruitland Mesa, which is the northeast sloping mesa located from the south rim of the Black Canyon northeast to the Smith Fork canyon and Crawford, is mapped as being capped by the Dakota Sandstone. It is a hard, well-cemented unit that resists erosion and forms cliffs, mesa tops and canyon rims in the region. The soil and rock materials found in the test pits at the Lerman building site are consistent with the mapped geology and consist of the in-situ weathered Dakota Sandstone formation.

Geologic Hazards

This section of the report is included so that the potential building owner is aware that construction in the area comes with certain risks. Modern development in the region can be considered to be only about 40 years old, with most occurring in the past 25 years. Because of this relatively short period of time, useful empirical data are limited. Some buildings and roadways throughout the local mountains and valleys have experienced negative impacts due to slope movement, sensitive soils, and shallow groundwater. Typical accepted structural engineering practice for design and construction of buildings and roadways can be used to reduce the potential for undesirable performance related to troublesome climate and soil conditions. However, because of the overall dynamic characteristics of the area, almost every structure is subject to at least some degree of potential risk. These risks are discussed below.

Runoff & Erosion

Surface runoff from rainfall and snowmelt drains as sheetflow across the building site down to the northeast towards an unnamed drainage that crosses the property and drains to the northeast. The slopes are gentle in the vicinity of the building site and vegetation is mature, so erosion is minimal. However, it is our experience that sheetflow flooding on this type of terrain is common during intense summer thunderstorms, which can cause erosion and gullying. Care should be taken to protect the structure from this type of flooding by elevating the slab above grade. Additionally, the site grading and drainage plan should not concentrate runoff which would accelerate erosion and soil loss.

Expansive and Compressible Soil and Rock

Soil materials containing some types of clay, especially bentonite (montmorillonite), can expand in volume with water absorption and then shrink upon drying. In some areas of Colorado these expansive soils cause serious damage to foundations, roadways, pavements, and embankments. The geology of swelling soils, the effects of moisture on these soils, and construction and landscaping on swelling soils are discussed in the Colorado Geological Survey publication, *A Guide to Swelling Soils for Colorado Homebuyers and Homeowners* (Special Publication #43: Noe et al., 2nd Ed. 2007). In the Crawford area, these clays are derived from such parent material as Mancos Shale, Dakota Sandstone, Morrison Formation, and volcanic material.

The potential hazard from expansive and compressible soil is the differential movement of foundation soils under loads applied through the foundation. This hazard can be partly reduced by managing on-site drainage so that water accumulation, ponding or penetration into the soil in the vicinity of foundations and slab/pavement areas is reduced to as great a degree as practical. Further reduction of hazards can be attained through design of foundation systems that extend to firmer material or which have sufficient strength to resist differential movements. The removal of problematic soil and replacement with structural fill is another option. These methods are discussed in further detail below in the *Recommendations* Section. Colorado Geologic Survey Special Publication #43 gives general explanations and illustrations of design and drainage options on swelling soils.

Seismicity

Crawford is located in the Colorado Plateau Seismotectonic Province in Colorado, where maximum credible earthquakes are estimated to be on the order of magnitude 5.5 to 6.5, which is equivalent to Modified Mercalli (MM) V to VIII (CGS Bulletin #43). Please refer to the *Seismic Design Criteria* Section of the *Recommendations* section for site-specific seismic design recommendations interpreted from the *2009 International Building Code* (IBC).

Radon Gas

Radon gas is produced by decay of radioactive minerals contained in subsurface rock and soil. The U.S. Environmental Protection Agency (EPA) has determined that radon is the second leading cause of lung cancer and that radon can accumulate in buildings and homes if the gas is not properly ventilated. The EPA map of Radon Zones indicates that virtually all of western Colorado, including Montrose County, is in Zone 1 (*www.epa.gov/radon/zonemap.html*). Although there is no known safe level of radon, Zone 1 is the zone of highest risk for exposure to radon gas [i.e., greater than 4 picoCuries per Liter (pCi/L)].

The EPA recommends testing radon levels in existing homes, however, neither they nor any other agency has developed methodology that can be used to estimate potential indoor radon levels from in-situ ground sampling and testing prior to construction. This is due to the many factors that affect the movement of radon through soils, such as soil moisture, soil types, weather patterns, and wind. The Colorado Department of Public Health and Environment (CDPHE) Radiation Management Division recommends that all new homes constructed in Colorado should include at least passive radon-resistant features. After the building is constructed, radon should be measured in the home and if the results are greater than 4 pCi/L, the system should be upgraded from passive to active (usually by installing a fan). The EPA publication entitled, *Building Radon Out: A Step-by-Step Guide on How to Build Radon-Resistant Homes* (available from CDPHE at 303-692-3420), presents alternatives for radon mitigation. Additional information about radon gas can be found on the EPA radon website *www.epa.gov/radon/* or the CDPHE radon website *www.cdphe.state.co.us/hm/rad/radon*.

Other geologic hazards are not known to be present in the vicinity of 2984 Black Canyon Road.

Soil Characteristics

Four test pits were excavated within the proposed building envelope using a backhoe. Test Pit #1 (TP#1) was located at the northwest corner of the building envelope, TP#2 was located at the northeast corner, TP#3 was located at the southeast corner, and TP#4 was located at the southwest corner at locations shown on the attached Site Plan. The soil and groundwater conditions were observed and logged, and representative samples of soils were tested in our laboratory. The subsurface conditions found in the test pits and laboratory results are shown on the attached Test Pit Logs. The contents of the four building site test pits are similar, with minor variations, and are described together below.

Our test pits reached depths of 2.5 to 4.5 feet. Our findings and recommendations are based on materials found within these profile depths. Soil conditions may change between test pits and below these depths. Buckhorn should be called to verify soil continuity and validity of our recommendations when the excavation for the foundation is complete.

In the building site test pits, we found 1 to 1.5 feet of red-brown, silt and clay underlain by brown silty/clayey sand that transitions to weathered tan, white to light brown sandstone. The sandstone became less weathered with depth until refusal was reached at depths of 2.5 to 4 feet in formational Dakota Sandstone bedrock, locally referred to as "ledge rock." The unweathered ledge rock is competent, well-cemented and very dense. The following photograph was taken of the native soil and weathered sandstone excavated from TP#4.

Native soils excavated from TP#4, shows the nature of the soil and rock at this site.

Laboratory tests were performed on the predominant native soils to evaluate the plasticity and particle size characteristics (see attached Sieve Analysis and Atterberg Limits laboratory results). An Atterberg limits test was performed on a bulk soil sample collected at a depth of 0 to 1 foot in TP#4 and 2 to 2.5 feet in TP#1 (samples GS3 and GS1, respectively). The samples had liquid limits (LL) of 36 and 41, plastic limits (PL) of 17, and plasticity indices (PI) of 19 and 24. A soil with a PI of between 15 and 30 is considered to have moderate potential for swelling or shrinking. A gradation analysis performed on the sample from TP#4 indicates that the soil is composed of 80% fines (silt and clay), 16% sand, and 4% gravel (sample GS3). Based on these laboratory test results, these soils classify as a lean clay with sand (CL) for the shallower sample (GS3) and a clayey sand (SC) for the deeper sample (GS1) according to the Unified Soil Classification System (USCS). Due to the high rock content in the soil, we were not able to obtain a drive sample for swell/consolidation testing.

Samples of the sandstone of various sizes, obtained during this evaluation in TP#1 at a depth of 3.5 to 4 feet were subjected to a soak test. After being exposed to water for 4 days, the rock was observed to have no reaction. The sandstone did not expand or delaminate during this period.

A series of geochemical tests were conducted on bulk soil sample GS2, taken from a depth of 3.5 to 4 feet in TP#1. The soil sample was tested for water soluble sulfates content, chloride content, pH, and electro-conductivity to evaluate the corrosivity of the soil. Sample GS2 had a water soluble sulfate concentration of 0.220%, a chloride content of 160 mg/L, an electro-conductivity of 181 µS/cm, and a pH of 6.9. The water soluble sulfates content and chlorides are indicative of corrosive soil. Recommendations for addressing the corrosive nature of the soil are presented in the *Recommendations* Section of this report.

In summary, the soils and rock materials found in the test pits are similar in composition, color, and physical properties. The field observations and laboratory testing indicates that the soils to the depths explored have moderate plasticity, moderate density, and become less weathered, less clayey, and denser with depth. The soil to the depths explored contains sufficient rocky material to provide a suitable bearing surface for conventional spread footings on the bedrock surface. Management of surface and subsurface water will be important to the long-term performance of the foundation soils.

RECOMMENDATIONS

Based upon our limited site evaluation and results of our subsurface testing, it appears that the proposed building site on 2984 Black Canyon Road is suitable for the construction of the intended garage with living space with special attention to foundation design, general site preparation and drainage design. The following recommendations are offered to enhance the long-term performance of the foundation soils, foundations and site improvements. It should be noted that the measures offered address only the construction at the proposed building site. They cannot and will not arrest or prevent large-scale geologic processes that may be on-going elsewhere on the property and within the Crawford area.

This report does not contain project specifications. The recommendations given are provided to guide the design process. We anticipate these recommendations, together with site-specific geotechnical information, will be used by the design team to formulate specifications for construction of buildings, infrastructure, and grading.

General Design Criteria

1. Based on the elevation of 7,250 feet, the Structural Engineers Association of Colorado recommends that the Basic Roof Snow Design Load be a minimum of 43 psf. It is recommended that the local building official be contacted to verify the required snow design load for this property.

2. Bearing foundation components on the underlying unweathered bedrock will not require attaining the typical minimum depth of embedment to reduce the negative effects of frost heave.

Seismic Design Criteria

In accordance with Section 1613.5 of the *2009 International Building Code* (IBC) and our limited knowledge of the site, we conservatively recommend that this site be designated as Site Class A. This classification is based on limited shallow exploratory data and assumes that subsurface conditions similar to those encountered during our site evaluation extend to a depth of 100 feet. For Site Class A, the maximum spectral response acceleration at short periods (0.2 second, $\mathbf{S_{MS}}$) is 0.331g and at one second ($\mathbf{S_{M1}}$) is 0.068g. These values are taken from the USGS website based on the latitude and longitude coordinates for the site.

Foundation

The shallow spread footing foundation components should rest upon the competent weathered sandstone or unweathered sandstone bedrock. The following recommendations are provided to guide foundation design and construction.

1. The footings, bearing pads, and retaining walls to be placed on the prepared native soil should be designed using an allowable bearing capacity ($\mathbf{q_a}$) of 4,000 psf.

2. Once the excavation is complete to unweathered, competent sandstone, but prior to placement of any fill or footing forms, a representative of Buckhorn Geotech must be called out to verify the nature and density of the foundation excavations, to ensure that relatively uniform rock conditions are present and to confirm that our recommendations are consistent with actual conditions. If we do not verify the soil conditions, Buckhorn Geotech cannot be held responsible for recommendations that may be inconsistent with actual conditions.

3. Observation and testing during construction is essential to ensure that the geotechnical recommendations are consistent with conditions and that the project is constructed in general conformance with project design and specifications. Any geotechnical observations or testing will be provided at additional charge and we should be contacted at least 2 days in advance for scheduling site visits. In addition to excavation observations, we can provide observation and testing of soil density, concrete and grout, foundation forms and rebar, pile installation, steel, welds, grading features, and drain systems.

4. Foundation stemwalls should be designed with sufficient strength to resist lateral earth pressures and to bridge an unsupported span of at least 10 feet. The components of the foundations should be sufficiently interconnected to ensure that they act as a unit. This will provide some degree of resistance to the forces associated with some unanticipated minor soil movement and will provide some degree of unity to the foundation systems.

5. All concrete used in foundation components at this site in contact with native soil should comply with the recommendations in the *Concrete* Section of these recommendations.

Floor Systems

Slabs on-grade may be used at the site for garage and interior floor slabs if the slab will not be susceptible to groundwater seepage and/or hydraulic forces.

1. To provide an adequate bearing surface, topsoil and organic material (estimated at 6-12 inches based on test pits) should be removed. The subgrade material should be proof-compacted and soft spots removed and replaced with washed rock or structural fill. If any fill is needed to elevate the slab area to the desired foundation grade, this can be accomplished using structural fill.

2. To provide a capillary break and/or radon under-slab mitigation collection, slabs on-grade should be placed on 4 inches of ¾-inch to 1½-inch washed rock on the prepared subgrade. Where moisture-sensitive interior floor finishes are applied to the slab, an unpunctured vapor barrier between the gravel and the floor slab is also recommended.

3. Under-slab plumbing should be avoided to minimize the potential for leakage under the slab. When necessary, under-slab plumbing should be provided with flexible couplings and should be leak-tested prior to concrete floor construction.

4. Slab sections constructed upon the native non-expansive subgrade soils should be designed using a vertical subgrade modulus of 100 pci. A 25 pci increase in the subgrade modulus may be applied for each 6 inches of structural fill placed under the slab.

5. All concrete slabs used at this site in contact with native soil should comply with the recommendations in the *Concrete* Section of these recommendations.

6. Suspended floors are not planned for this structure.

Retaining Structures

1. Retaining walls are not planned for this site. However for design of the foundation stemwalls the following earth pressures may be used for design as appropriate.

Table 1. Lateral Earth Pressures

	Native Soil	
Active Earth Pressure	---	pcf*
Passive Earth Pressure	300	pcf*
At-Rest Earth Pressure	---	pcf*
Unit weight of soil	125	pcf**
Coefficient of Friction	0.32	***

* pounds per cubic foot (fluid equivalent)
** pounds per cubic foot
*** concrete on dry soil conditions

2. Excavations for foundation walls should be laid back in accordance with OSHA Regulations 29 CFR 1926. Consequently, gentler excavation faces may be required.

3. Fill material placed behind the walls may consist of clean native soil material (less than 10% passing the #200 sieve and rocks larger than 6-inches removed) compacted per the structural design engineer's specifications. Compaction of 85 to 90% of Standard Proctor maximum dry density is typically used to minimize post-construction settlement of the backfill.

4. All concrete used for retaining structures at this site in contact with native soil should comply with the recommendations in the *Concrete* Section of these recommendations.

Foundation Drainage and Ventilation

It is important to minimize moisture penetration into the soil beneath or adjacent to the structure. Moisture can accumulate as a result of such items as: poor surface drainage, drywell and infiltration systems, over-irrigation of landscaped areas, waterline leaks, melting snow, subsurface seepage, or condensation from vapor transport.

1. Provisions should be made to direct water away from foundations and under slabs. This may be accomplished using conventional footing drains in tandem with a positively-vented moisture and radon control system. Alternatively, consideration may be given to using concrete forms that facilitate both dewatering and the removal of radon gases and vapors.

2. Perimeter foundation drains should be constructed (including a discharge to daylight) as soon as the foundation excavation is completed. This will minimize the accumulation of standing water in the excavation which can create damp conditions below slab areas.

3. Roof drainage should be captured by eave gutters. Downspouts should be fitted with extensions to discharge a minimum of 10 feet away from the structure or piped into a closed underground drain system and evacuated off-site. In no case should the downspouts be directed into the perforated foundation drain system. These points of discharge should be identified in the site drainage plan so that water is readily removed from the site.

4. All foundation drains should be integrated into the site drainage plan as discussed below for final disposal from the building site. In no case should surface or roof drainage be introduced into the foundation drain system.

5. Floor systems and confined areas above concrete floor slabs should be properly ventilated to allow for the release of radon gas. See the *Radon Gas* Section of this report for more radon information.

Site Preparation and Grading

1. The site drainage plan, in tandem with the landscape and grading plans, should ensure that the construction does not impede natural drainage patterns. Surface water should be directed away from the building foundations either during or after completion of construction. This includes water from landscaped areas, patios, decks, drywell systems, infiltration galleries and roofs. Drainage plans should ensure that precipitation, snowmelt, and runoff are conveyed around and away from the building as well as the driveway. This runoff should be dispersed (not concentrated) in a manner consistent with the natural, pre-construction drainage pattern.

2. Final grading around the perimeter of the foundation should slope downward with at least one foot of drop within the first 10 feet of horizontal distance. Concrete flatwork adjacent to the foundation should slope away at a grade of at least ¼-inch per foot. If this cannot be accomplished due to site constraints, such features as berms, diversion swales, concrete interceptor ditches topped with a grate, should be used to direct surface waters away from the structure.

3. As a precaution against potential sheetflow flooding, the main floor of the proposed structure should be elevated at least one foot above finished grade.

4. Development should utilize "best practices" for design and construction so that on-site erosion is minimized. This may include selective thinning of vegetation, construction of temporary diversion ditches, silt fencing, and/or dust suppression. If the cumulative area of disturbance equals or exceeds one acre, on-site erosion management should be planned and executed in conformance with Colorado Department of Public Health and Environment (Water Quality Control Division) stormwater discharge regulations. The local building official will be able to provide specific details regarding these requirements.

5. Irrigation of lawn and landscaped areas should be kept at a distance of at least 5 feet from the perimeter of the building and sprinkler heads should be set to spray away from and not towards the foundation. Xeriscape landscaping practices are recommended for this site.

6. Backfill placed in utility trenches leading to the structure should be densely compacted in accordance with project specifications to inhibit surface water infiltration and migration towards the foundation, as well as minimize post-construction settlement of the trench backfill.

7. Disturbed areas should be revegetated as soon as practical to reduce soil erosion.

8. Fill used at this site should meet the gradational and compaction requirements listed in Tables 2 and 3 below. Fill should be placed and compacted in **maximum 6-inch lifts**, unless otherwise directed by the structural design engineer. Structural fill should not be placed on frozen or wet existing soil or fill material. It is recommended that the foundation excavation be open a minimal amount of time to avoid degradation of the foundation soils. Clean native soil material with all deleterious material and over-size

rock removed may be used as structural fill if approved by the structural design engineer.

Table 2. Gradation Requirements for Fill Material

Type	Sieve	%Passing, by weight
Structural Fill (CDOT Class 6 roadbase)	3/4" (19.0 mm)	100
	#4 (4.75 mm)	30-65
	#8 (2.36 mm)	25-55
	#200 (0.075 mm)	3-12
Structural Fill (CDOT Class 1)	2.5" (63.5 mm)	100
	2" (50 mm)	95-100
	#4 (4.75 mm)	30-65
	#200 (0.075 mm)	3-15
Fill under exterior concrete flatwork	3" (75 mm)	100
	#200 (0.075 mm)	0-5
Free-draining fill	3" (75 mm)	100
	¾" (19 mm)	20-90
	#4 (4.75 mm)	0-20
	#200 (0.075 mm)	0-3

Note: The Plasticity Index for all fill soils should be less than 6.

Table 3. Compaction Requirements for Fill Material

Application	Compaction Requirement	Proctor	Moisture
Under footings and slabs	95% max. dry density	Modified	±2% of optimum
Under exterior flatwork	90% max. dry density	Modified	±2% of optimum
Road Subgrade	95% max. dry density	Standard	0-4% above optimum
Road Subbase	95% max. dry density	Modified	±2% of optimum
Road base course	95% max. dry density	Modified	±2% of optimum
Behind retaining walls	Per project specifications*		
Utility Trenches	Per project specifications*		
General landscaping	Per project specifications*		

*As specified by the structural design engineer on project documents or in accordance with local municipal requirements.

9. Any soils containing organics, debris, topsoil, frozen soil, snow, ice, and other deleterious materials shall not be used for anything other than landscaping.

10. A representative of Buckhorn Geotech should be called out to the site to observe placement of structural fill and verify the compacted density. The owner should contact Buckhorn Geotech in advance of the excavations to discuss the specific testing requirements, budget, and scheduling needed for these services.

Concrete

Because of the tested sulfate and chloride contents in the soil and their corrosive qualities, Type II sulfate-resistant cement with class 'F' flyash should be used for all concrete in contact with native soil or bedrock at this site.

Exterior Concrete Flatwork

1. Flatwork may be placed on undisturbed native soil with the topsoil and organic material removed. If fill is needed, it should consist of washed rock or structural fill (see Tables 2 and 3), placed and compacted in accordance with project specifications.

2. Flatwork adjacent to buildings should be placed on properly compacted fill. To minimize future settlement and damage to the flatwork and/or adjacent foundations, the fill should consist of approved material placed and compacted per project specifications.

3. Flatwork adjacent to exterior doorways should be dowelled into the foundation to reduce long-term differential movement between the flatwork and structure.

4. Exterior concrete flatwork should be designed and constructed so that it drains freely away from the structure. Concrete flatwork adjacent to the foundation should slope away at a grade of at least ¼-inch per foot.

5. All concrete used at this site in contact with native soil should comply with the recommendations in the *Concrete* Section of these recommendations.

Excavation and Shoring

1. Temporary excavations should be in accordance with Occupational Safety and Health Administration (OSHA) regulations and with worker safety in mind.

2. Construction equipment, materials, and soil stockpiles should be located a minimum horizontal distance equal to the height of the excavation from the crest of the excavation unless otherwise approved by the structural design engineer.

3. Based upon our evaluation, the silty/clayey sand found in our test pits would be most nearly represented by an OSHA Type A soil. Our assessment is based upon the soil and groundwater conditions found in our limited evaluation and sampling. The contractor's "competent person" (defined by OSHA as "an individual capable of identifying existing and predictable hazards…and who has the authorization to take prompt corrective

measures to eliminate or manage these hazards and conditions) should evaluate the soil materials exposed during excavation based on composition, structure, and environmental conditions per 29 CFR 1926 and recommend appropriate slope laybacks or shoring, as required. Refer to OSHA's Technical Manual Section V: Chapter 2 on *Excavations: Hazard Recognition in Trenching and Shoring* (available on-line at: *www.osha.gov*) for further excavation guidelines. We can provide these services, as requested.

4. If the excavations will be made or remain open during wet weather, it is recommended that polyethylene sheeting be secured over the excavation face to minimize sediment runoff and deterioration of the foundation soils. Surface runoff above the cuts should be directed away from the excavation using berms or diversion ditches. Large rocks exposed in the excavation face should be removed for worker safety.

5. We anticipate that the excavation of the site soils can be accomplished by conventional excavating equipment. Removal of the sandstone, if needed, may require the use of a pneumatic or hydraulic hammer.

Closing Considerations

Standard of Care and Interpretation of Subsurface Data

This report has been prepared in a manner consistent with local standards of professional geotechnical engineering practice. The recommendations herein are subject to revision based on review of final site grading and structural plans. As previously noted, we did not perform an evaluation of deep subsurface conditions. Evaluation of environmental contaminants was not part of our scope of services performed at this site. The classification of soils and interpretation of subsurface conditions is based on our training and years of experience, but is necessarily based on limited subsurface observation and testing. As such, inferred ground conditions cannot be guaranteed to be exact. No other warranty, express or implied, is made.

Observations of the excavation(s) subgrade by Buckhorn Geotech prior to erection of the foundation system are integral parts of these recommendations. If subsurface conditions differing from those described herein are discovered during excavation, construction should be stopped until the situation has been assessed by a representative of Buckhorn Geotech. Construction should be resumed only when remedies or design adjustments, as necessary, have been prescribed.

Use of This Report

This report is intended for use by the design team specifically to address the site and subsurface conditions as they relate to the proposed structure(s) described in the *Construction Plans* Section. Changes to the site or proposed development plans may alter or invalidate the recommendations contained herein.

Buckhorn Geotech retains an ownership and property interest in this report. Consistent with the industry, copies of this document that may be relied upon by the design team are limited to those that are signed and sealed by the Geotechnical Engineer (*Standard Form of Agreement Between Owner and Geotechnical Engineer for Professional Services*, Engineer's Joint Contract Documents Committee, 1996). This report together with ancillary data, analyses, test results, and other components and/or supporting parts are not intended or represented to be suitable for reuse by the design team or others on extensions to this project or on any other project. Any such reuse or modification invalidates all aspects of the report and excuses the Geotechnical Engineer for all responsibility and liability or legal exposure.

This report is considered valid for a period of two years from the date of issue provided the site conditions and development plans have not changed from what is referenced in this report. Changes to the site may occur due to development or natural processes. Additionally, technological advances made in construction and changes in legislation may alter the recommendations made herein. Depending upon the site and proposed development changes, Buckhorn Geotech may require additional evaluation (at additional cost) to update the recommendations contained herein.

Retention of Samples

Samples of soil and rock collected during the course of our geotechnical evaluation(s) are routinely held in our laboratory for a period of three months from the date of the evaluation and then are discarded. A written request by the client or design team is required for samples to be stored for a longer period.

Additional Services

To provide continuity and consistency from project start to finish, we should be retained to make observations and carry out material testing as a service to the owner. As noted above, we recommend the owner contact us to discuss required services and scheduling in advance of the construction phase.

Buckhorn Geotech is a full-service engineering firm providing foundation, on-site wastewater system, site drainage, structural and retaining structure design services, as well as surveying, construction materials testing, and inspections. Please visit **www.buckhorngeo.com** for a full description of our services.

Thank you for the opportunity to perform this geotechnical evaluation for you. If you require any of the above services or have any questions regarding this report, please contact us.

Respectfully Submitted
ELECTRONICALLY,
Buckhorn Geotech, Inc.

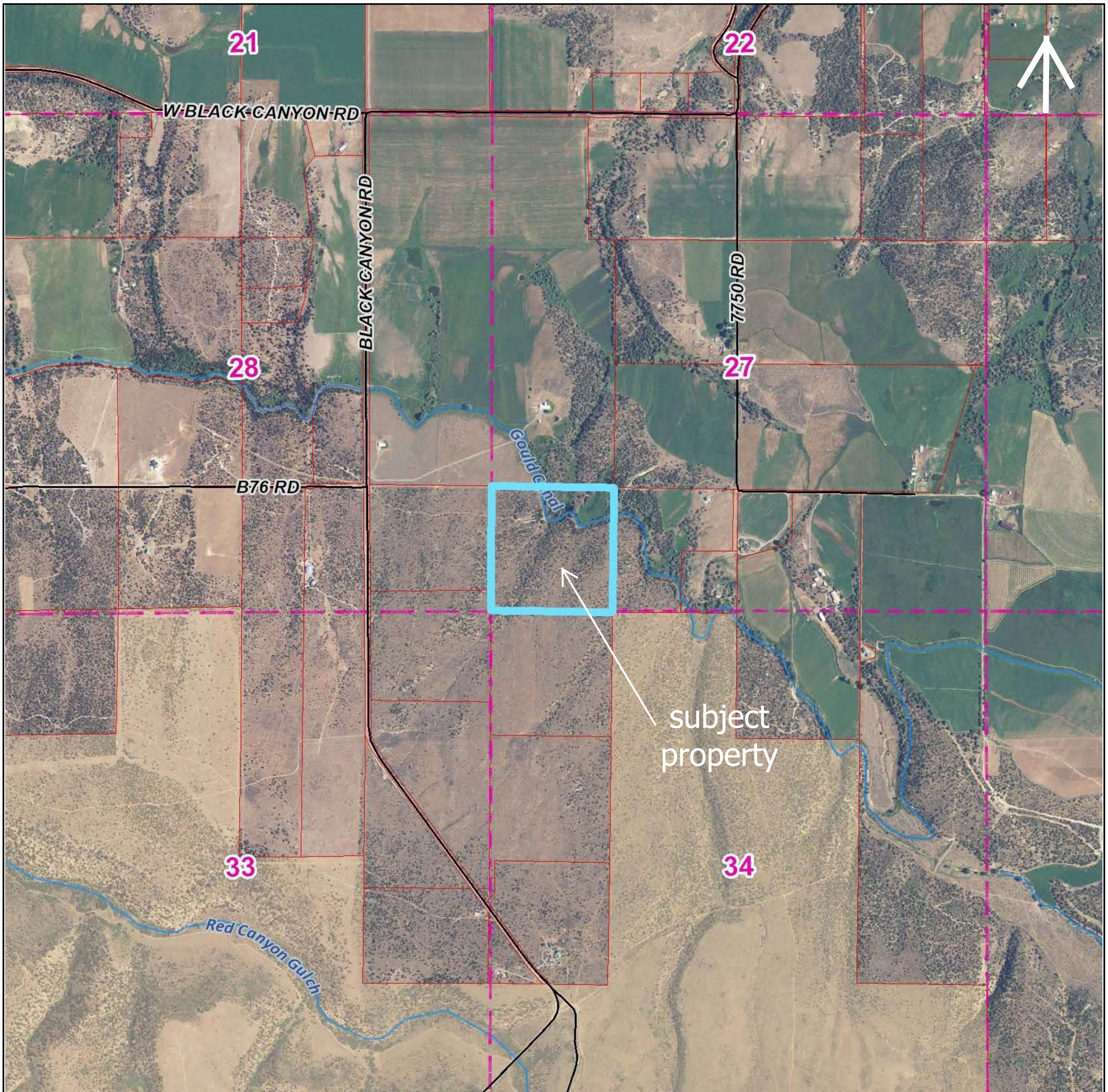
Laurie J. Brandt, P.G.
Professional Geologist

Reviewed by:

Wayne Pandorf, P.E.
Professional Engineer

Enclosures: Vicinity Map, Site Plan, Test Pit Logs, Sieve Analysis and Atterberg Limits results, Soak Test and Corrosivity Series results

VICINITY MAP



(scale unknown)

Map source: Montrose County Assessor's website

MAP NUMBER		Lerman 2984 Black Canyon Road Crawford, Colorado	BUCKHORN GEOTECH Civil, Structural & Geotechnical Engineers 222 So. Park Ave. Montrose, Colorado 81401 970-249-6828 Fax. No. 970-249-0945 www.buckhorngeo.com
1	FIELD STAFF LB		
OF 2	DRAFTING STAFF LB		
	FIELD DATE 6/25/14		
	PROJECT # 14-160-GEO		

SITE PLAN

(scale unknown)

Map source: supplied by Mr. Lerman

MAP NUMBER 2 OF 2	FIELD STAFF LB DRAFTING STAFF LB FIELD DATE 6/25/14 PROJECT # 14-160-GEO	Lerman 2984 Black Canyon Road Crawford, Colorado	BUCKHORN GEOTECH Civil, Structural & Geotechnical Engineers 222 So. Park Ave. Montrose, Colorado 81401 970-249-6828 Fax. No. 970-249-0945 www.buckhorngeo.com

TEST PIT LOG - TEST PIT #1 & #2 (TP#1 & TP#2)

TEST PIT LOCATION: TP#1 @ northwest corner. TP#2 @ northeast corner

SURFACE ELEVATION:

NOTES:

EXCAVATION COMPANY: TSM Construction

OPERATOR: Ryan

EQUIPMENT: Case Backhoe

TP#1

DEPTH (ft.)	SAMPLE TYPE	SAMPLE NUMBER	SUBSURFACE DESCRIPTION TP#1	FIELD AND LABORATORY TEST RESULTS
0-1			red-brown clay/silt; rootlets upper 12 inches (0-1')	
1-2.5			brown silty/clayey fine sand transitions to weathered sandstone (1-2.5')	
2-2.5	bulk	GS1	bulk sample GS1 @2-2.5'	GS1 @2-2.5' (CL) LL=41 PL=17 PI=24
2.5-4.5			tan/white sandstone with some silty/clayey sand (2.5-4.5')	
3.5-4	bulk	GS2	bulk sample GS2 @3.5-4' hard digging	GS2 @3.5-4' Soak Test of rock: No reaction water soluble sulfates=0.220% chlorides=160 ppm pH=6.9 Electro-conductivity=181 µS/cm
4.5			refusal @4.5' in sandstone ledge rock (bedrock); no groundwater	

TP#2

DEPTH (ft.)	SAMPLE TYPE	SAMPLE NUMBER	SUBSURFACE DESCRIPTION TP#2	FIELD AND LABORATORY TEST RESULTS
0-1			red-brown clay/silt; rootlets in upper 6" with small rock below 6" (0-1')	
1-1.5			brown silty/clayey fine sand transitions to weathered sandstone (1-1.5')	
1.5-2.5			light brown sandstone with some silty/clayey sand (1.5-2.5')	
2.5			refusal @2.5' on sandstone ledge rock (bedrock); no groundwater	

TEST PIT LOG 1&2 OF 4		
FIELD STAFF	WP	Lerman 2984 Black Canyon Rd Crawford, Colorado
DRAFTING STAFF	JLH	
FIELD DATE	6/25/2014	
PROJECT #	14-160-GEO	

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TEST PIT LOG - TEST PIT #3 & #4 (TP#3 & TP#4)

TEST PIT LOCATION: TP#3 @ southwest corner. TP#4 @ southeast corner	EXCAVATION COMPANY: TSM Construction
SURFACE ELEVATION:	OPERATOR: Ryan
NOTES:	EQUIPMENT: Case Backhoe

DEPTH (ft.) | GRAPHIC | SAMPLE TYPE | SAMPLE NUMBER

SUBSURFACE DESCRIPTION TP#3

FIELD AND LABORATORY TEST RESULTS

Depth (ft.)	Sample Number	Subsurface Description	Field and Laboratory Test Results
0–1.5		red-brown, silt/clay; rootlets upper 6 inches (0-1/1.5')	
1.5–3		brown silty/clayey fine sand transitions to weathered tan/white sandstone then ledge rock (1/1.5-3')	GS1 @2-2.5' (CL)
3		refusal @3' on sandstone ledge rock (bedrock); no groundwater	GS2 @3.5-4'

Depth scale: 0, 1, 2, 3, 4, 5

SUBSURFACE DESCRIPTION TP#4

FIELD AND LABORATORY TEST RESULTS

Depth (ft.)	Sample Number	Subsurface Description	Field and Laboratory Test Results
0–1	GS3	bulk sample GS3 @0-1' red-brown, silt/clay; rootlets in upper 6-12 inches (0-1')	GS3 @0-1' (CL) LL=36 PL=17 PI=19 gravel=3.4% sand=16.4% silt/clay=80.2%
1–2		brown silty/clayey fine sand transitions to weathered sandstone (1-2')	
2–4		light brown weathered sandstone (2-4')	
3–4	GS4	bulk sample GS4 @3-4'	
4		refusal @4' on sandstone ledge rock (bedrock); no groundwater	

Depth scale: 0, 1, 2, 3, 4, 5

TEST PIT LOG 3&4 OF 4			Lerman 2984 Black Canyon Rd Crawford, Colorado
	FIELD STAFF	WP	
	DRAFTING STAFF	JLH	
	FIELD DATE	6/25/2014	
	PROJECT #	14-160-GEO	

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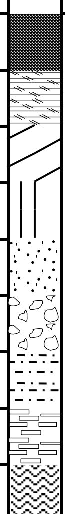
TEST PIT LOG KEY

TEST PIT LOCATION:
SURFACE ELEVATION:
NOTES:

EXCAVATION COMPANY:
OPERATOR:
EQUIPMENT:

DEPTH (ft.)	WATER LEVEL	GRAPHIC	SAMPLE TYPE	SAMPLE NUMBER	SUBSURFACE DESCRIPTION	FIELD AND LABORATORY TEST RESULTS
0					dark gray, moist, firm to stiff, sandy CLAY with gravel (CL) (2-4')	Notes in this column indicate tests performed and test results:
					Unified Soil Classification (see definitions below)	DD: dry density, pcf
1				DS1	drive sample	MC: moisture content, %
					range in depth of soil unit	LL: liquid limit
2						PL: plastic limit
				GS1	bulk sample	GS1 @2-2.5' (CL)
						GF: gravel fraction, %
						SF: sand fraction, %
						Fines: silt/clay, %
						Sh: Shear resistance
3	▽				location of free subsurface water	GS2 @3.5-4'
						CBR: California Bearing Ratio
						SP: swelling pressure
						TM: total movement
4						UCS: unconfined compressive strength
						psf: pounds per square foot
						pcf: pounds per cubic foot
						psi: pounds per square inch

Depth scale (ft.): 5, 6, 7, 8, 9, 10, 11, 12



- FILL
- TOPSOIL
- CLAY
- SILT
- SAND
- GRAVEL
- SHALE
- SANDSTONE
- HARD BEDROCK

Unified Soil Classification System (ASTM D-2487)
CL = lean clay to sandy/gravelly lean clay
ML = silt to sandy/gravelly silt
CH = high plasticity clay to sandy/gravelly high plasticity
MH = high elasticity silt to sandy/gravelly high elasticity silt
SW = well-graded sand or well-graded sand with gravel
SP = poorly-graded sand or poorly-graded sand with gravel
SM = silty sand to silty sand with gravel
SC = clayey sand to clayey sand with gravel
GW = well-graded gravel or well-graded gravel with sand
GP = poorly-graded gravel or poorly-graded gravel with
GM = silty gravel or silty gravel with sand
GC = clayey gravel or clayey gravel with sand

Rock Weathering Classification
W1 = Fresh
W2 = Slightly weathered
W3 = Moderately weathered
W4 = Highly weathered
W5 = Completely weathered
W6 = Residual soil, no structure
RQD = Rock Quality Deisgnation

Intact Rock Strength Classification
R0 = Extremely weak rock, 35 - 150 psi
R1 = Very weak rock, 150 - 725 psi
R2 = Weak rock, 725 - 3625 psi
R3 = Medium strong rock, 3625 - 7250 psi
R4 = Strong Rock, 7250 - 14500 psi
R5 = Very strong rock, 14500 - 36000 psi
R6 = Extremely strong rock, >36000 psi

Test Pit Log of	Field Staff Drafting Staff Field Date Project #	Test Pit Log Key	BUCKHORN GEOTECH Civil, Structural & Geotechnical Engineers 222 So. Park Ave. Montrose, Colorado 81401 970-249-6828 Fax. No. 970-249-0945 www.buckhorngeo.com

FIELD SOIL IDENTIFICATION TERMS

Relative Density of Cohesionless Soils

Description	Field Identification	N Value
Very Loose	Easily penetrated with hand shovel	0-4
Loose	Easily penetrated with 1/2" rebar pushed by hand; easily excavated with hand shovel	4-10
Moderately Dense	Easily penetrated with 1/2" rebar driven with 5 lb. hammer; difficult to excavate with hand shovel	10-30
Dense	Penetrated 1 ft. with driven rebar; must be loosened with pick to excavate	30-50
Very Dense	Penetrated only a few inches with driven rebar; very difficult to excavate even with pick	>50

Consistency & Relative Density of Cohesive Soils

Description	Field Identification	Undrained Shear Strength (psf)	N Value (Approx.)
Very Soft	Extrudes between fingers when squeezed	<250	0-2
Soft	Molded by light finger pressure	250-500	2-4
Firm	Molded by strong finger pressure	500-1,000	4-8
Stiff	Indented by thumb	1,000-2,000	8-15
Very Stiff	Indented by thumbnail	2,000-4,000	15-30
Hard	Difficult to indent with thumbnail	>4,000	>30

Soil Constituents

Modifier	trace	little	some	-ey or -y	and
% (by weight)	0 - 5	5 - 12	12 - 20	20 - 30	>30

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Atterberg Limits

ASTM D4318

Project Name	Lerman Building	Date	7/2/2014
Project Location	2984 Black Canyon Rd, Crawford	Project #	14-160-GEO
Client	Lerman	Sample by	WP
Sample Location	TP#1 @2-2.5'	Tested by	LC
Sample #	GS1		
Soil Description	light reddish brown clayey SAND	ASTM D2488	

Liquid Limit (LL) 41

Plastic Limit (PL) 17

Plasticity Index (PI) 24

CL = Clay

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Sieve Analysis and Atterberg Limits

Project Name	Lerman Building	Date	7/2/2014
Project Location	2984 Black Canyon Rd, Crawford	Project #	14-160-GEO
Client	Lerman	Sample by	WP
Test Location	TP#4 @ 0-1'	Tested by	BK
Sample #	GS3		

Sieve Analysis
ASTM C136 / C117

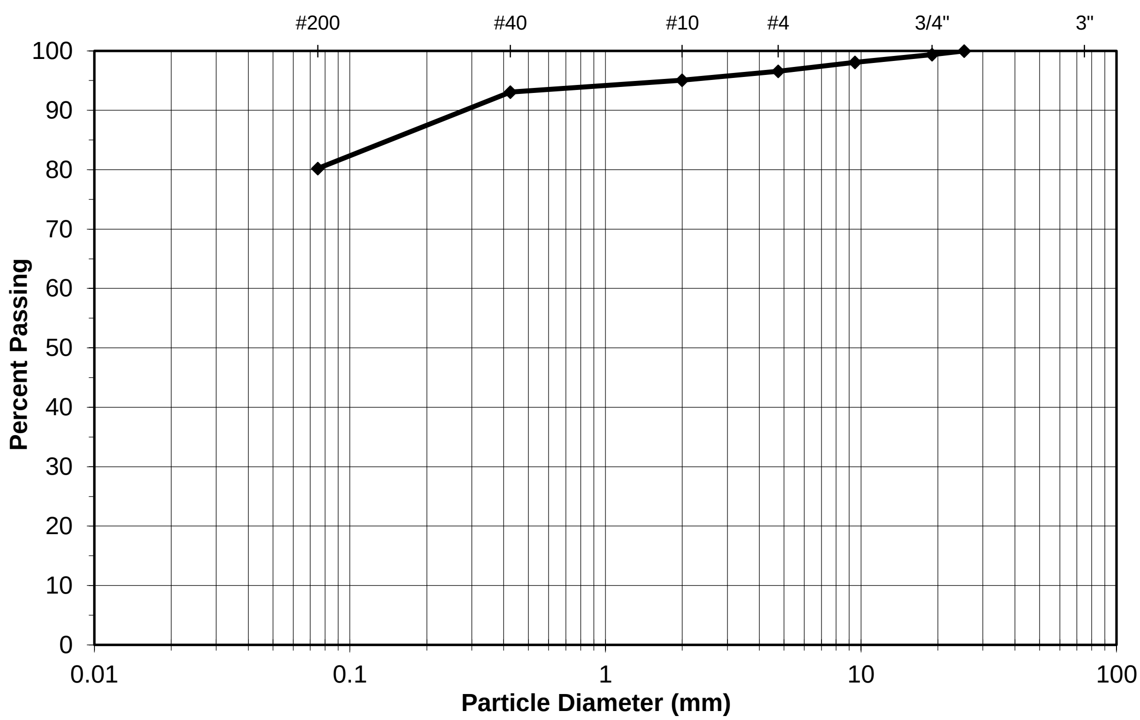
Sieve	Opening (mm)	% Passing
3"	76.2	100.0
3/4"	19.0	99.4
3/8"	9.5	98.1
#4	4.750	96.6
#10	2.000	95.1
#40	0.425	93.1
#200	0.075	80.2

Atterberg Limits
ASTM D4318

Liquid Limit (LL)	36
Plastic Limit (PL)	17
Plasticity Index (PI)	19

CL = Clay

Soil Description: dark reddish brown lean CLAY with sand
USCS Classification: CL



Clay/Silt	Fine	Medium	Coarse	Fine	Coarse
FINES	SAND			GRAVEL	

% Fines = 80.2 % Sand = 16.4 % Gravel = 3.4

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Soak Test

Project Name	Lerman Building	Start Date	7/3/2014
Project Location	2984 Black Canyon Rd, Crawford	Start Time	100p
Client	Lerman	Project #	14-160-GEO
Sample Location	TP#1 @3.5-4'	Sample by	WP
Sample #	GS2	Test by	SJ

BEFORE SOAK

Shale Description (color, size of fragments, etc):
very light brown SANDSTONE; 3" x 2-1/4" x 1"; 3-1/4" x 1-1/2" x 3/4-1"; 3-1/2" x 4" x 1/2-1"

Layers/bands visible? [X] NO [ ] YES [ ] FAINTLY [ ] DISTINCTLY

Fragments break along bedding planes? [X] NOT AT ALL
[ ] BREAKS EASILY [ ] BREAKS WITH MODERATE PRESSURE [ ] BREAKS WITH FIRM PRESSURE

Fragments break across bedding planes? [ ] NOT AT ALL
[ ] BREAKS EASILY [ ] BREAKS WITH MODERATE PRESSURE [X] BREAKS WITH VEY FIRM PRESSURE

AFTER SOAK End Date: 7/7/14 End Time: 100p

Rate of Reaction: [X] NONE [ ] IMMEDIATE (DISPERSIVE) [ ] WATER WAS CLOUDY

Level of Reaction: [X] NO REACTION

Compressability: [X] NONE [ ] LOW [ ] MODERATE [ ] HIGH

Texture: [X] NOT SLIPPERY (SILT) [ ] SLIPPERY (CLAY)

Breaks Apart:
[ ] FRAGMENTS BROKE WITHOUT PRESSURE IN CONTAINER
[ ] CAN BREAK ALONG BEDDING PLANES WITH HAND PRESSURE
[ ] CAN BREAK ACROSS BEDDING PLANES WITH HAND PRESSURE

Delamination:
[X] NONE
[ ] DELAMINATION BUT NO SEPARATION
[ ] DELAMINATION AND SEPARATION BUT REMAINS IN BEDDING PLANES
[ ] DELAMINATION, SEPARATION, AND DISORIENTATION OF FLAKES

Comments: some releasing of air pockets with the addition of water.

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Corrosivity Series

Based on HACH methods

Project Name	Lerman Building	Date Tested	7/22/2014
Project Location	Crawford, CO	Project #	14-160-GEO
Client	Lerman	Sample by	LB
Sample Location	TP#1 @3.5-4'	Tested by	SJ
Sample #	GS2		
Soil Description	very light brown SANDSTONE	ASTM D2488	

Water-soluble sulfates, dry soil basis	**0.220**	**%**
Chlorides	**160**	**ppm**
Electro-conductivity	**181**	**µS/cm**
pH	**6.9**	

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Glossary of Engineering & Soils Terms

active earth pressure	The pressure that a soil exerts against a vertical surface which is allowed a certain degree of flexure or rotational freedom.
allowable soil bearing capacity	The recommended maximum contact stress developed at the interface of the foundation and the supporting soil. Given in psf (pounds per square foot).
alluvial fan	A cone-shaped deposit of water-transported material (alluvium). They typically form at the base of topographic features where there is a distinct decrease in gradient. Consequently, alluvial fans tend to be coarse-grained near their mouths and relatively fine-grained at their edges.
alluvium	Rock and soil material deposited by moving water. Rocks are generally rounded and sorted by size as they are worked by water. Found in river channels or alluvial fans.
ASTM	American Society for Testing and Materials (a national non-profit organization which writes testing standards for materials, products, systems and services).
at-rest earth pressure	The pressure that soil exerts upon a vertical surface which is restrained from any movement.
Atterberg limits	Named for a Swedish scientist, Atterberg limits are defined by the water content that produces a specified soil consistency. See l*iquid limit* and p*lastic limit*.
auger-cast pile (ACP)	A deep foundation system that consists of an auger-advanced hole, followed by grouting of the hole through the auger during withdrawal. A reinforcement cage is lowered into the wet grout.
backfill	A specified material placed and compacted in a confined area.
backslope zone	The area in which loads applied to the ground surface or increase in slope angle will increase the total lateral force against a retaining wall.
base course	A layer of specified material placed on a subgrade or subbase.
bedrock	Sedimentary, igneous, or metamorphic rock that has not been weathered or broken down by the elements of water, ice, wind, or gravity. Also referred to as “formational” material, as bedrock is known as a particular formation for the region.
bench	A horizontal or near-horizontal surface in a sloped deposit.
calcareous	Containing calcium carbonate (lime). A distinct layer of calcium carbonate hardpan is called caliche.
clay	A fine-grained soil (<0.002 mm) composed of very small platy (flat) particles that are smaller than silt particles. Forms lumps or clods when dry and is plastic (Plasticity Index > 4) and sticky when wet.
cohesionless soil	Non-plastic granular soils (silt, sand, gravel) composed of bulky grains that are not attracted to each other with the addition of water.
cohesive soil	Soils (i.e., clays and some silts) in which adsorbed water and particle attraction work together to produce a mass which holds together and deforms plastically.

collapse	Soil Settlement due to wetting at constant vertical stress.
colluvium	Rock and soil material deposited by gravity. Rocks are generally angular to subangular, loose and not sorted. Found below steep slopes and at the mouth of canyons; talus and cliff debris are included.
compaction	The decrease in volume of an unsaturated soil mass due to a decrease in the void spaces, usually by mechanical means.
consolidation	The decrease in soil volume due to a release of water when a saturated soil is subjected to stress increase. As a soil consolidates, its void ratio decreases. Loosely, the term is used to describe time-dependent compression of a fine-grained soil.
crawlspace	The space beneath the house that has a raised stemwall foundation and is typically 18 to 36 inches in height.
creep	A slow, nearly continuous movement of soil caused by changes in soil moisture and the downhill force of gravity.
dead load	Static loads transferred to the foundation, usually the weight of building materials, but can also be the loads imposed by retained soil or a constructed slope.
debris flow	Debris flows are rapid flood-like events consisting of mud, water, rock and organic debris and that have 20 to 80% particles coarser than sand sizes. Steep slopes, weak or weathered rock, a lack of vegetative cover, and abnormal precipitation contribute to debris flows. (See mud flow)
differential settlement	Unequal settlement between or within foundation elements of a structure.
dispersive soils	Fine-grained soils whose clays have been neutralized by an abundance of cations which are then susceptible to removal (dispersion) from the soil matrix. This weakens soil strength; piping and gullying are common features in this soil.
drilled pier	A deep foundation system that consists of reinforced concrete piers cast into a drilled hole that extends into bedrock or other suitable material.
driven pile	A deep foundation system that consists of steel, concrete, or timber that is driven into bedrock or other suitable material.
existing fill	Materials placed by man prior to geotechnical exploration of the site.
existing grade	The ground surface at the time of field exploration.
expansive soil	A soil containing clay which expands (increases in volume) when exposed to an increase in moisture.
fine grained soil	Soils composed of silt and/or clay-sized particles.
flowing avalanche	The turbulent cascade of slabs and blocks of relatively high-density (>25 pcf) snow and air downslope.
fluvial	Deposited or transported by a stream or river.
fluvioglacial	Alluvial deposits derived from the rivers originating from the melting of glaciers. Glacial outwash is the term used to describe fluvioglacial deposits.
formational material	See bedrock. Also known as the "R" horizon.

grade beam	Typically, concrete beams that are constructed at or just below ground elevation that are used to transfer building loads to deep foundation elements. Walls and floor systems are then built upon the grade beams.
groundwater	Water that is resident beneath the ground surface in porous soil and rock. This level can fluctuate due to seasonal changes and irrigation.
heave	Upward movement of soil or foundation components.
helical piers	Helical piers typically consist of 5- to 10-foot long sections of solid square high-strength steel bar with the lead (deepest) section having one or more 6- or 8-inch diameter helixes welded to the bar. These piers are “screwed” into the ground using a torque head which stops driving the pier when the head reaches a design torque pre-selected by the engineer based on correlations with bearing capacity.
hinge point	Toe of excavated wall without footing or outside edge of concrete if footing is used.
hummocky	The uneven, bumpy or chaotic terrain typically resulting from a landslide or glacial deposit. The rock and soil materials are unsorted and often jumbled.
hydrocompactive soils	Soils that have considerable voids, thus making it susceptible to consolidation in the presence of water.
jumping jack	A construction machine, used to compact both cohesive and cohesionless soils, that consists of a curved shoe that tamps the soil in an up and down motion.
landslide	The general term for the downward and outward movement (flow, slide or fall) of slope-forming bedrock, rock debris and soil (fine-grained fragmental debris). See "slump," a type of landslide.
lifts	Horizontal layers of fill, generally 6 to 8-inches thick.
liquid limit (LL)	The water content above which a soil behaves as a liquid.
live load	Transient loads introduced onto a structure and its foundation due to occupancy, wind, snow and rain, earthquakes, changes in groundwater, and other environmental factors.
loam	A mixture of sand, silt and clay. It is easily crumbled when dry and has a slightly gritty, yet fairly smooth feel, and is often slightly plastic.
micropile	A deep foundation system consisting of small diameter piles, typically 1- to 4-inch diameter steel bars (solid or hollow), that are drilled and grouted into place. Micropiles are designed as friction elements and must be drilled deep enough to provide resistance to anticipated uplift pressures.
monolithic slab	A shallow foundation system that consists of a single unit of reinforced concrete with downturned edges and may include thickened ribs on the underside of the slab.
moraine	Deposits formed by direct glacial action. There are many forms of moraines, but they generally consist of unsorted, unstratified, and subrounded to subangular materials deposited by glacial ice. Also generally known as “drift” or “till.”
mottling	The discoloration of a soil due to the reaction of water with clay minerals during prolonged periods of saturation. Red colors indicate the presence of iron oxides in an oxidized state and gray indicate the removal of free iron in reducing conditions.
mud flow	Mud flows are flood-like events that have 80% or more mud and sand. Over-saturation of fine-grained soils triggers mud flows, which are a rapid failure or slippage of mud and other debris entrained in the movement. (See debris flow)

native grade	The naturally occurring ground surface (before disturbance).
native soil	Naturally occurring on-site soil.
parent material	The formational material from which a soil is derived.
passive earth pressure	The resistance of a soil against movement when a lateral force is exerted upon it.
piping	A feature in fine-grained soils whereby water preferentially follows root zones, animal burrows and surface soil cracks, and carries soil particles downwards through voids, leaving behind weak vertical planes, voids, and/or tunnels in the soil structure.
pistol butting	When the base of tree trunk is widened and bent upwards due to soil creep, snow loading, or slope movement. The tree continues to grow vertically despite the ground moving downslope, thus creating a shape like a "pistol butt" in the expanded trunk.
plastic index (PI)	The difference between Liquid and Plastic Limits (LL - PL). This represents the moisture content range that the soil is in the plastic state. The larger the PI, the more plastic a soil is.
plastic limit (PL)	The water content at which a soil becomes brittle after being in the plastic state. The soil breaks apart or crumbles when its moisture content is equal to or less than its PL.
plastic soil	A predominately silt or clay soil that exhibits plastic (deformable) behavior.
post-tensioned slab	A post-tensioned slab is a stiffened raft foundation system that has a grid of tensioned cables running through the concrete slabs and in thickened “ribs.” The cables or tendons are tightened after the concrete has partially cured. This system minimizes differential movement because it allows the foundation to act as a rigid unit.
powder avalanche	The relatively low-density (12.5 pcf), high velocity, turbulent force of snow, air and entrained debris that precedes and extends beyond a dry-snow avalanche. The powder and air blast can travel at speeds in excess of 100 mph.
Proctor compaction test (standard & modified)	A laboratory compaction procedure to determine the maximum dry density and optimum moisture content of soil. The standard Proctor procedure uses a 5.5-lb hammer and 3 lifts, while the modified Proctor procedure uses a 10-lb hammer and 5 lifts.
raft foundation	Also called “mat” foundations, these comprise a single slab that supports an entire structure. The slab is generally stiffened to resist excessive differential movement.
refusal	When very dense native material is encountered that cannot be excavated or penetrated further by whatever equipment is being used.
scarify	To mechanically loosen, roughen or break down existing soil surface, usually to improve bonding to subsequent fill.
settlement	Downward movement of foundation components due to compression of a soil mass.
shale	A thinly-bedded rock formation composed of clay or silt muds that have been solidified into rock. The Mancos Shale Formation in Colorado is of marine origin.
silt	Fine-grained soil particles measuring 0.002 to 0.075mm, which are larger than clay but smaller than sand. Silt can exhibit plastic characteristics.

slab-on-grade	A concrete layer cast directly upon a base, subbase or subgrade.
slope	The angle of a hillside, usually expressed in degrees or percent (elevation drop per given distance).
slump	A type of landslide that has a rotational slip along a concave-up surface of rupture. The resulting "main scarp" is the crescent shaped failure plane formed at the source of the slump.
soil	Any unconsolidated, excavatable earth material composed of discrete solid particles, with air or liquids between, that is the result of the chemical and mechanical weathering of rock.
soil (excavation or borehole) log	A graphic representation of a column of soil indicating textural changes and general properties of soil or rock types encountered in a test pit or boring.
spread footing	A shallow foundation system that consists of a wide (typically from 12 to 48 inches) "foot" of reinforced concrete upon which vertical wall components are built.
stemwall	A vertical concrete foundation component, normally 6 to 12 inches wide, that rests on the spread footing and extends up to the floor level.
subbase	A layer of specified material between the subgrade and base course.
subbase grade	Top of subbase elevation.
subgrade	Prepared native soil surface.
subsoil	The layer of soil below the topsoil and above the substratum that has undergone pedogenesis (soil formation). The "B" horizons.
substratum	The layer of soil below the subsoil that has not undergone soil genesis. It contains weathered parent material. The "C" horizons.
swell potential	The potential of a soil to expand (increase in volume) due to absorption of moisture.
tension cracks	Transverse cracks (linear openings) in the soil due to soil movement.
topsoil	The surface layer of soil containing organic material and roots. The "A" horizons.
transverse	A feature (like a crack or ridge) that is at right angles to the slope of a hillside or the general trend of a valley.
vesicular pores	In a fine-grained soil, the sponge-like openings that are the result of the solution and dispersal of clay particles. The pores are discontinuous and vary in size.
vibratory roller	A construction machine with a heavy vibrating drum, used to compact soil and aggregate material.
void ratio	A ratio of the volume of voids (pore spaces) to the volume of solids.
waffle slab	A waffle slab is a stiffened raft foundation system that is a monolithic slab with a tight network or grid of reinforced stemwalls that resemble a waffle from underneath. This system minimizes differential movement because it allows the foundation to act as a rigid unit.
water table	The relatively continuous and consistent level of groundwater below the ground surface.
weathering	The breakdown of intact masses of rock into smaller pieces by mechanical or chemical processes.