GEOTECHNICAL AND GEOLOGIC HAZARDS INVESTIGATION
ORCHARD AVENUE IMPROVEMENTS
NORMANDY DR. TO 29 RD.
GRAND JUNCTION, COLORADO
PROJECT#01042-0011

ROLLAND ENGINEERING
405 RIDGES BOULEVARD
GRAND JUNCTION, COLORADO 81507

OCTOBER 30, 2018
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1.0 INTRODUCTION

As part of continued infrastructure improvements, Orchard Avenue is proposed to be reconstructed between Normandy Drive and 29 Road. As part of the design development process, Huddleston-Berry Engineering and Testing, LLC (HBET) was retained by Rolland Engineering to conduct a geologic hazards and geotechnical investigation at the site.

1.1 Scope

As discussed above, a geologic hazards and geotechnical investigation was conducted for the Orchard Avenue Improvements project in Grand Junction, Colorado. The scope of the investigation included the following components:

- Conducting a subsurface investigation to evaluate the subsurface conditions at the site.
- Collecting soil samples and conducting laboratory testing to determine the engineering properties of the soils at the site.
- Providing recommendations for excavations, subgrade preparation, and pavements.
- Evaluating potential geologic hazards at the site.

The investigation and report were completed by a Colorado registered professional engineer in accordance with generally accepted geotechnical and geological engineering practices. This report has been prepared for the exclusive use of Rolland Engineering and Mesa County.

1.2 Site Location and Description

The site includes Orchard Avenue, between Normandy Drive and 29 Road, in Grand Junction, Colorado. The project location is shown on Figure 1 – Site Location Map.

At the time of the investigation, Orchard Avenue consisted of one lane in each direction with no center turn lane. The area includes primarily residential properties. The roadway was fairly flat.

1.3 Proposed Construction

The proposed construction is anticipated to include new pavements and curb-gutter-sidewalk along Orchard Avenue between Normandy Drive and 29 Road.
2.0 GEOLOGIC SETTING

2.1 Soils

Soils data was obtained from the USDA Natural Resource Conservation Service Web Soil Survey. The data indicates that the site is underlain by Sagers Urban Land complex, 0 to 2 percent slopes. Soil survey data is included in Appendix A.

Road construction in the site soils is described as being very limited due to frost action, low strength, and/or shrink-swell. Excavation in the site soils is described as being somewhat limited due to dust and/or unstable excavation walls. The site soils are indicated to have a moderate potential for frost action, moderate risk of corrosion of uncoated steel, and moderate risk of corrosion of concrete.

2.2 Geology

According to the Geologic Map of the Grand Junction Quadrangle, Mesa County, Colorado (2002), the project area is underlain by undivided alluvium and colluvium.

2.3 Groundwater

Groundwater was encountered in three of the five borings at depths of between 8.5 and 11.5 feet below the ground surface at the time of the investigation.

3.0 FIELD INVESTIGATION

3.1 Subsurface Investigation

The subsurface investigation was conducted on August 30th, 2018 and consisted of five geotechnical borings. The borings were drilled to a depth of 16.5 feet below the existing ground surface. Boring locations are shown on Figures 2 through 4. Typed boring logs are included in Appendix B. Samples of the native soils were collected during Standard Penetration Testing (SPT) and using bulk sampling methods at the locations shown on the logs.

As shown on the logs, the subsurface conditions were slightly variable. However, the borings generally encountered 6 to 9 inches of asphalt above granular base course to depths of between 2.0 and 3.0 feet. The base course was underlain by brown, moist to wet, stiff to very soft lean clay, lean clay with sand, and/or silty clay soils. The clays extended to the bottoms of most of the borings. However, in B-1, a layer of brown, wet, very loose silty sand was encountered between 12.5 and 15.5 feet. As previously discussed, ground water was encountered in three of the borings at depths of between 8.5 and 11.5 feet.
4.0 LABORATORY TESTING

Selected native soil samples collected from the borings were tested in the Huddleston-Berry Engineering and Testing LLC geotechnical laboratory for natural moisture content, grain size analysis, Atterberg limits, maximum dry density and optimum moisture (Proctor), California Bearing Ratio (CBR), and water soluble sulfates content. The laboratory testing results are included in Appendix C.

The laboratory testing results indicate that the native clay soils are slightly to moderately plastic. In addition, the CBR results indicate that the native clay soils are slightly expansive with up to approximately 0.7% expansion measured in the laboratory. Water soluble sulfates were detected in the site soils in a concentration of 0.03%.

5.0 GEOLOGIC INTERPRETATION

5.1 Geologic Hazards

The most critical geologic hazard identified on the site is the presence of moisture sensitive soils. However, shallow groundwater was also encountered in some portions of the project area.

5.2 Geologic Constraints

In general, the primary geologic constraint to construction at the site is the presence of moisture sensitive soils. However, shallow groundwater and associated soft soil conditions may impact the construction in some areas of the site.

5.3 Water Resources

No water supply wells were observed in the project area. As discussed previously, shallow groundwater was encountered in some areas of the site. In general, with proper design and construction, the proposed construction is not anticipated to adversely impact surface water or groundwater.

5.4 Mineral Resources

Potential mineral resources in western Colorado generally include gravel, uranium ore, and commercial rock products such as flagstone. As discussed previously, the site is mapped as being underlain by alluvium and colluvium. However, gravels were not encountered in the subsurface to the depth explored. In general, based upon the existing land use, HBET does not believe that any mineral resources which may exist at the site are economically recoverable.
6.0 CONCLUSIONS

Based upon the available data sources, field investigation, and nature of the proposed construction, HBET does not believe that there are any geologic conditions which should preclude construction at this site. However, pavements, utility installation, and/or earthwork may have to consider the impacts of moisture sensitive soils. In addition, shallow groundwater and associated soft soil conditions may impact the construction.

7.0 RECOMMENDATIONS

7.1 Corrosion of Concrete

As indicated previously, water soluble sulfates were encountered in the site soils in a concentration of 0.03%. This concentration of sulfates represents a negligible degree of potential sulfate attack on concrete. However, the USDA Soil Survey data suggests that the site soils have a moderate potential for sulfate attack on concrete. Therefore, at a minimum, Type I-II sulfate resistant cement is recommended for construction at this site.

7.2 Corrosion of Steel

As discussed previously, the USDA Soil Survey data indicate that the native soils are moderately corrosive to uncoated steel. As a result, corrosion should be considered in design of any buried steel elements proposed to be used as part of the construction.

7.3 Lateral Earth Pressures

Any retaining walls should be designed to resist lateral earth pressures. For backfill consisting of the native soils or imported granular, non-free draining, non-expansive material, we recommend that the walls be designed for an active equivalent fluid unit weight of 55 pcf in areas where no surcharge loads are present. Lateral earth pressures should be increased as necessary to reflect any surcharge loading behind the walls.

7.4 Excavations

Excavations in the soils at the site may stand for short periods of time but should not be considered to be stable. In general, the site soils classify as Type C soil with regard to OSHA’s Construction Standards for Excavations. For Type C soils, the maximum allowable slope in temporary cuts is 1.5H:1V. However, very soft soils were encountered near the water table and these will likely be unstable. As a result, it may be necessary to utilize shoring in utility trench excavations. In addition, dewatering may be required in some areas where deeper excavations are proposed.
7.5 Subgrade Preparation

In general, it is recommended that concrete flatwork, utility lines, etc. be placed above well compacted subgrade soils. However, as indicated previously, soft soils were encountered in most of the borings and compaction of the subgrade may be difficult depending upon the subgrade elevation. It may be necessary to utilize geotextile and/or geogrid in conjunction with up to 30-inches of granular fill to stabilize the subgrade. HBET should be contacted to provide specific recommendations for subgrade stabilization based upon the actual subgrade conditions during construction.

7.6 Roadway Pavements

As discussed previously, the subgrade materials at the site consist primarily of native clays soils. The design CBR of the native clay soils was determined in the laboratory to be less than 2.0. Therefore, the minimum recommended Resilient Modulus of 3,000 psi was be used for the pavement design.

Based upon the subgrade conditions and anticipated traffic loading, pavement section alternatives were developed in accordance with AASHTO design procedures. ESAL calculations are included in Appendix D and indicate a design value of 2,566,680 ESAL’s. The following pavement section alternatives are recommended:

<table>
<thead>
<tr>
<th>Orchard Avenue</th>
<th>PAVEMENT SECTION (Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALTERNATIVE</td>
<td>Hot-Mix Asphalt Pavement</td>
</tr>
<tr>
<td>A</td>
<td>6.0</td>
</tr>
<tr>
<td>B</td>
<td>5.0</td>
</tr>
<tr>
<td>C</td>
<td>6.0</td>
</tr>
</tbody>
</table>

7.7 Sidewalk Pavements

As discussed previously, new curb-gutter-sidewalk is proposed at the site. In general, HBET recommends that the curb-gutter-sidewalk be a minimum of 6-inches in thickness in accordance with Mesa County standards. A minimum of 6-inches of CDOT Class 6 base course is recommended below the concrete.

7.8 General Pavement Recommendations

Prior to new street or sidewalk pavement placement, areas to be paved should be stripped of all topsoil, uncontrolled fill, or other unsuitable materials. It is recommended that the subgrade soils be scarified to a depth of 12-inches; moisture conditioned, and recompacted to a minimum of 95% of the standard Proctor maximum dry density, within ±2% of optimum moisture content as determined by AASHTO T-99.
However, as discussed previously, soft soil conditions were encountered during the subsurface investigation and this may make compaction of the subgrade difficult. It may be necessary to utilize geotextile and/or geogrid in conjunction with up to 30-inches of granular fill to stabilize the subgrade. HBET should be contacted to provide specific recommendations for stabilization based upon the actual subgrade conditions during construction.

Aggregate base course and subbase course should be placed in maximum 9-inch loose lifts, moisture conditioned, and compacted to a minimum of 95% and 93% of the maximum dry density, respectively, at -2% to +3% of optimum moisture content as determined by AASHTO T-180. In addition to density testing, base course should be proofrolled to verify subgrade stability.

It is recommended that Hot-Mix Asphaltic (HMA) pavement conform to CDOT grading SX or S specifications and consist of an approved 75 gyration Superpave method mix design. HMA pavement should be compacted to between 92% and 96% of the maximum theoretical density. An end point stress of 50 psi should be used. In addition, pavements should conform to local specifications.

The long-term performance of the pavements is dependent on positive drainage away from the pavements. Ditches, culverts, and inlet structures in the vicinity of paved areas must be maintained to prevent ponding of water on the pavement.

8.0 GENERAL

The recommendations included above are based upon the results of the subsurface investigation and on our local experience. These conclusions and recommendations are valid only for the proposed construction.

As discussed previously, the subsurface conditions at the site were slightly variable. However, the precise nature and extent of any subsurface variability may not become evident until construction. Therefore, it is recommended that a representative of HBET observe the foundation excavations prior to structural fill placement to verify that the subsurface conditions are consistent with those described herein. In addition, it is recommended that a representative of HBET test compaction of structural fill materials.

As discussed previously, moisture sensitive soils were encountered at the site. The recommendations contained herein are designed to reduce the potential for excessive differential movements; however, HBET cannot predict long-term changes in subsurface moisture conditions and/or the precise magnitude or extent of volume change. Where significant increases in subsurface moisture occur due to poor grading, improper stormwater management, utility line failure, excess irrigation, or other cause, significant movements are possible.
Huddleston-Berry Engineering and Testing, LLC is pleased to be of service to your project. Please contact us if you have any questions or comments regarding the contents of this report.

Respectfully Submitted:
Huddleston-Berry Engineering and Testing, LLC

Michael A. Berry, P.E.
Vice President of Engineering
The Geographic Information System (GIS) and its components are designed as a source of reference for answering inquiries, for planning, and for modeling. GIS is not intended to replace legal description information in the chain of title and other information contained in official government records such as the County Clerk and Recorder's office or the courts. In addition, the representations of location in this GIS cannot be substitute for actual legal surveys.

The information contained herein is believed accurate and suitable for the intended uses, and subject to the limitations, set forth above. Mesa County makes no warranty as to the accuracy or suitability of any information contained herein. Users assume all risk and responsibility for any and all damages, including consequential damages, which may flow from the user's use of this information.

Mesa County Map

FIGURE 1
Site Location Map

Print Date: October 9, 2018

Mesa County, Colorado
GIS/IT Department
gis.mesacounty.us
The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.
Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)
Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.
Soil Survey Area: Mesa County Area, Colorado
Survey Area Data: Version 9, Sep 10, 2018
Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Sep 13, 2010—Aug 8, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.
## Map Unit Legend

<table>
<thead>
<tr>
<th>Map Unit Symbol</th>
<th>Map Unit Name</th>
<th>Acres in AOI</th>
<th>Percent of AOI</th>
</tr>
</thead>
<tbody>
<tr>
<td>BcU</td>
<td>Sagers-Urban land complex, 0 to 2 percent slopes</td>
<td>1.9</td>
<td>100.0%</td>
</tr>
<tr>
<td><strong>Totals for Area of Interest</strong></td>
<td></td>
<td>1.9</td>
<td>100.0%</td>
</tr>
</tbody>
</table>
Map Unit Description

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions in this report, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named, soils that are similar to the named components, and some minor components that differ in use and management from the major soils.

Most of the soils similar to the major components have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Some minor components, however, have properties and behavior characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.
Soils that have profiles that are almost alike make up a *soil series*. All the soils of a series have major horizons that are similar in composition, thickness, and arrangement. Soils of a given series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Additional information about the map units described in this report is available in other soil reports, which give properties of the soils and the limitations, capabilities, and potentials for many uses. Also, the narratives that accompany the soil reports define some of the properties included in the map unit descriptions.

**Report—Map Unit Description**

**Mesa County Area, Colorado**

**BcU—Sagers-Urban land complex, 0 to 2 percent slopes**

**Map Unit Setting**

*National map unit symbol:* k1rq  
*Elevation:* 4,490 to 4,920 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 55 degrees F
Frost-free period: 140 to 180 days
Farmland classification: Not prime farmland

Map Unit Composition
Sagers and similar soils: 55 percent
Urban land: 40 percent
Estimates are based on observations, descriptions, and transects of the map unit.

Description of Sagers
Setting
Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear, concave
Across-slope shape: Linear
Parent material: Cretaceous source alluvium derived from sandstone and shale

Typical profile
Ap - 0 to 12 inches: silty clay loam
C - 12 to 25 inches: silty clay loam
Cy - 25 to 60 inches: silty clay loam

Properties and qualities
Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat):
  Moderately high (0.21 to 0.71 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Gypsum, maximum in profile: 5 percent
Salinity, maximum in profile: Very slightly saline to moderately saline (2.0 to 8.0 mmhos/cm)
Available water storage in profile: High (about 9.7 inches)

Interpretive groups
Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 7c
Hydrologic Soil Group: C
Ecological site: Desert Loam (Shadscale) (R034BY106UT)
Hydric soil rating: No

Description of Urban Land
Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydric soil rating: No

Data Source Information

Soil Survey Area: Mesa County Area, Colorado
Survey Area Data: Version 9, Sep 10, 2018
Roads and Streets, Shallow Excavations, and Lawns and Landscaping

Soil properties influence the development of building sites, including the selection of the site, the design of the structure, construction, performance after construction, and maintenance. This table shows the degree and kind of soil limitations that affect local roads and streets, shallow excavations, and lawns and landscaping.

The ratings in the table are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect building site development. Not limited indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. Somewhat limited indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. Very limited indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the table indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

Local roads and streets have an all-weather surface and carry automobile and light truck traffic all year. They have a subgrade of cut or fill soil material; a base of gravel, crushed rock, or soil material stabilized by lime or cement; and a surface of flexible material (asphalt), rigid material (concrete), or gravel with a binder. The ratings are based on the soil properties that affect the ease of excavation and grading and the traffic-supporting capacity. The properties that affect the ease of excavation and grading are depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, depth to a water table, ponding, flooding, the amount of large stones, and slope. The properties that affect the traffic-supporting capacity are soil strength (as inferred from the AASHTO group index number), subsidence, linear extensibility (shrink-swell potential), the potential for frost action, depth to a water table, and ponding.

Shallow excavations are trenches or holes dug to a maximum depth of 5 or 6 feet for graves, utility lines, open ditches, or other purposes. The ratings are based on the soil properties that influence the ease of digging and the resistance to sloughing. Depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, the amount of large stones, and dense layers influence the ease of digging, filling, and compacting. Depth to the seasonal high water table, flooding, and ponding may restrict the period when excavations can be made. Slope influences the ease of using machinery. Soil texture, depth to the water table, and linear extensibility (shrink-swell potential) influence the resistance to sloughing.
Lawns and landscaping require soils on which turf and ornamental trees and shrubs can be established and maintained. Irrigation is not considered in the ratings. The ratings are based on the soil properties that affect plant growth and trafficability after vegetation is established. The properties that affect plant growth are reaction; depth to a water table; ponding; depth to bedrock or a cemented pan; the available water capacity in the upper 40 inches; the content of salts, sodium, or calcium carbonate; and sulfidic materials. The properties that affect trafficability are flooding, depth to a water table, ponding, slope, stoniness, and the amount of sand, clay, or organic matter in the surface layer.

Information in this table is intended for land use planning, for evaluating land use alternatives, and for planning site investigations prior to design and construction. The information, however, has limitations. For example, estimates and other data generally apply only to that part of the soil between the surface and a depth of 5 to 7 feet. Because of the map scale, small areas of different soils may be included within the mapped areas of a specific soil.

The information is not site specific and does not eliminate the need for onsite investigation of the soils or for testing and analysis by personnel experienced in the design and construction of engineering works.

Government ordinances and regulations that restrict certain land uses or impose specific design criteria were not considered in preparing the information in this table. Local ordinances and regulations should be considered in planning, in site selection, and in design.

Report—Roads and Streets, Shallow Excavations, and Lawns and Landscaping

[Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the potential limitation. The table shows only the top five limitations for any given soil. The soil may have additional limitations]
Data Source Information

Soil Survey Area: Mesa County Area, Colorado
Survey Area Data: Version 9, Sep 10, 2018
Soil Features

This table gives estimates of various soil features. The estimates are used in land use planning that involves engineering considerations.

A **restrictive layer** is a nearly continuous layer that has one or more physical, chemical, or thermal properties that significantly impede the movement of water and air through the soil or that restrict roots or otherwise provide an unfavorable root environment. Examples are bedrock, cemented layers, dense layers, and frozen layers. The table indicates the hardness and thickness of the restrictive layer, both of which significantly affect the ease of excavation. **Depth to top** is the vertical distance from the soil surface to the upper boundary of the restrictive layer.

**Subsidence** is the settlement of organic soils or of saturated mineral soils of very low density. Subsidence generally results from either desiccation and shrinkage, or oxidation of organic material, or both, following drainage. Subsidence takes place gradually, usually over a period of several years. The table shows the expected initial subsidence, which usually is a result of drainage, and total subsidence, which results from a combination of factors.

**Potential for frost action** is the likelihood of upward or lateral expansion of the soil caused by the formation of segregated ice lenses (frost heave) and the subsequent collapse of the soil and loss of strength on thawing. Frost action occurs when moisture moves into the freezing zone of the soil. Temperature, texture, density, saturated hydraulic conductivity (Ksat), content of organic matter, and depth to the water table are the most important factors considered in evaluating the potential for frost action. It is assumed that the soil is not insulated by vegetation or snow and is not artificially drained. Silty and highly structured, clayey soils that have a high water table in winter are the most susceptible to frost action. Well drained, very gravelly, or very sandy soils are the least susceptible. Frost heave and low soil strength during thawing cause damage to pavements and other rigid structures.

**Risk of corrosion** pertains to potential soil-induced electrochemical or chemical action that corrodes or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design may be needed if the combination of factors results in a severe hazard of corrosion. The steel or concrete in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than the steel or concrete in installations that are entirely within one kind of soil or within one soil layer.

For uncoated steel, the risk of corrosion, expressed as **low**, **moderate**, or **high**, is based on soil drainage class, total acidity, electrical resistivity near field capacity, and electrical conductivity of the saturation extract.

For concrete, the risk of corrosion also is expressed as **low**, **moderate**, or **high**. It is based on soil texture, acidity, and amount of sulfates in the saturation extract.
### Report—Soil Features

<table>
<thead>
<tr>
<th>Map symbol and soil name</th>
<th>Restrictive Layer</th>
<th>Subsidence</th>
<th>Potential for frost action</th>
<th>Risk of corrosion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Kind</td>
<td>Depth to top</td>
<td>Thickness</td>
<td>Hardness</td>
</tr>
<tr>
<td></td>
<td>Low-RV-High</td>
<td>Range</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>In</td>
<td>In</td>
<td>In</td>
<td>In</td>
</tr>
<tr>
<td>BcU—Sagers- Urban land complex, 0 to 2 percent slopes</td>
<td>—</td>
<td>—</td>
<td>0</td>
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</tbody>
</table>

### Data Source Information

Soil Survey Area: Mesa County Area, Colorado  
Survey Area Data: Version 9, Sep 10, 2018
APPENDIX B
Typed Boring Logs
<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Material Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Asphalt Granular Base Course</td>
</tr>
<tr>
<td>5</td>
<td>Lean CLAY (cl), brown, moist to wet, stiff to soft</td>
</tr>
<tr>
<td>10</td>
<td>Silty SAND with trace Gravel (sm), brown, wet, very loose</td>
</tr>
<tr>
<td>15</td>
<td>Lean CLAY (cl), brown, wet, very soft</td>
</tr>
<tr>
<td></td>
<td>Bottom of hole at 16.5 feet.</td>
</tr>
<tr>
<td>DEPTH (ft)</td>
<td>MATERIAL DESCRIPTION</td>
</tr>
<tr>
<td>------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>0</td>
<td>ASPHALT Granular Base Course</td>
</tr>
<tr>
<td>5</td>
<td>Lean CLAY with Sand (cl), to Lean CLAY (CL), brown, moist to wet, medium stiff to soft</td>
</tr>
<tr>
<td>10</td>
<td>*** Lab Classified SS4</td>
</tr>
<tr>
<td>15</td>
<td>Bottom of hole at 16.5 feet.</td>
</tr>
</tbody>
</table>
**ASPHALT**

Lean CLAY (cl), to Silty CLAY (cl-ml), brown, moist to wet, stiff to very soft

**MATERIAL DESCRIPTION**

<table>
<thead>
<tr>
<th>DEPTH (ft)</th>
<th>GRAPHIC LOG</th>
<th>MATERIAL DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>ASPHALT</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**GRAPHIC LOG AT END OF DRILLING**

**LIMITS**

- **BLOW COUNTS (N VALUE)**
  - SS 1: 83 (4-5-4 (9))
  - SS 2: 89 (0-0-0 (0))
  - SS 3: 100 (0-0-0 (0))
  - SS 4: 100 (2-1-1 (2))

**BOTTOM OF HOLE**

Bottom of hole at 16.5 feet.
<table>
<thead>
<tr>
<th>DEPTH (ft)</th>
<th>GRAPHIC LOG</th>
<th>MATERIAL DESCRIPTION</th>
<th>SAMPLE TYPE NUMBER</th>
<th>RECOVERY (%)</th>
<th>BLOW COUNTS (N-value)</th>
<th>POCKET PEN. (tsf)</th>
<th>DRY UNIT WT. (pcf)</th>
<th>MOISTURE CONTENT (%)</th>
<th>LIQUID LIMIT</th>
<th>PLASTIC LIMIT</th>
<th>PLASTICITY INDEX</th>
<th>FINES CONTENT (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>ASPHALT Granular Base Course</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Lean CLAY (cl), to Silty CLAY (cl-ml), brown, moist, medium stiff to stiff</td>
<td>SS 1</td>
<td>89</td>
<td>5-6-5 (11)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td>SS 2</td>
<td>100</td>
<td>4-4-4 (8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td>SS 3</td>
<td>78</td>
<td>5-5-5 (10)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SS 4</td>
<td>89</td>
<td>5-5-7 (12)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Bottom of hole at 16.5 feet.
**MATERIAL DESCRIPTION**

- **ASPHALT**
- **Granular Base Course**
- **Lean CLAY (cl) to Silty CLAY (CL-ML), brown, moist, medium stiff to stiff**
- **Lab Classified SS4**

**Ground Water Levels:**
- **Ground Elevation:**
- **Hole Size:** 4-inches
- **Logging Method:** Simco 2000 Truck Rig
- **Drilling Contractor:** S. McKracken
- **Drilling Method:**
  - At Time of Drilling: dry
  - At End of Drilling: dry
- **Notes:**

**Depth (ft)** | **Graphic Log** | **Material Description** | **Sample Type Number** | **Recovery (%)** | **Blow Counts (N-value)** | **Pocket Pen (tsf)** | **Dry Unit Wt (pcf)** | **Moisture Content (%)** | **Liquid Limit** | **Plastic Limit** | **Plasticity Index (%)** | **Atterberg Limits** | **Plasticity Index** |
---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
0 | | ASPHALT | | | | | | | | | | | | |
5 | | Granular Base Course | | | | | | | | | | | | |
10 | | Lean CLAY (cl) to Silty CLAY (CL-ML), brown, moist, medium stiff to stiff | SS 1 | 100 | 3-2-3 (5) | | | | | | | | | |
15 | | Lab Classified SS4 | SS 2 | 100 | 2-2-3 (5) | | | | | | | | | |
20 | | | SS 3 | 100 | 2-3-2 (5) | | | | | | | | | |
25 | | | SS 4 | 100 | 4-4-5 (9) | | | | | | | | | |
APPENDIX C
Laboratory Testing Results
Specimen Identification | LL  | PL | PI  | #200 | Classification               
------------------------|-----|----|-----|------|-------------------------------
• B-2, SS4              | 8/18| 34 | 19  | 15   | 97  LEAN CLAY (CL)            
• B-5, SS4              | 8/18| 24 | 17  | 7    | 86  SILTY CLAY (CL-ML)        
• Composite             | 8/18| 24 | 17  | 7    | 86  LEAN CLAY with SAND (CL)  

CLIENT: Rolland Engineering
PROJECT NUMBER: 01042-0011
PROJECT NAME: Orchard Avenue Improvements
PROJECT LOCATION: Grand Junction, CO

ATERBERG LIMITS' RESULTS

Huddleston-Berry Engineering & Testing, LLC
640 White Avenue, Unit B
Grand Junction, CO 81501
970-255-8005
970-255-6818
Sample Date: 8/30/2018
Sample No.: 18-0671
Composite
Sample Date: 8/30/2018
Source of Material: LEAN CLAY with SAND(CL)
Description of Material: Composite
Test Method: ASTM D698A

TEST RESULTS
Maximum Dry Density 116.0 PCF
Optimum Water Content 13.5 %

GRADATION RESULTS (% PASSING)
#200  #4  3/4"  85  99  100

ATTERBERG LIMITS
LL  PL  PI
30  18  12

Curves of 100% Saturation for Specific Gravity Equal to:
2.80
2.70
2.60
CALIFORNIA BEARING RATIO
ASTM D1883

Project No.: 10142-0011
Project Name: Orchard Avenue Improvements
Client Name: Rolland Engineering
Sample Number: 18-0671  Location: Composite

Compaction Method ASTM D698, Method A

Maximum Dry Density (pcf): 116.0
Opt. Moisture Content (%): 13.5
Sample Condition: Soaked
Remarks: 

<table>
<thead>
<tr>
<th>Sample Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point 1</td>
</tr>
<tr>
<td>Blows per Compacted Lift:</td>
</tr>
<tr>
<td>Surcharge Weight (lbs):</td>
</tr>
<tr>
<td>Dry Density Before Soak (pcf):</td>
</tr>
<tr>
<td>Dry Density After Soak (pcf):</td>
</tr>
<tr>
<td>Moisture Content (%) Bottom Pre-Test</td>
</tr>
<tr>
<td>Moisture Content (%) Top Pre-Test</td>
</tr>
<tr>
<td>Moisture Content (%) Top 1&quot; After Test</td>
</tr>
<tr>
<td>Average After Soak:</td>
</tr>
<tr>
<td>Percent Swell After Soak:</td>
</tr>
</tbody>
</table>

Penetration Data

<table>
<thead>
<tr>
<th>Penetration Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point 1</td>
</tr>
<tr>
<td>Dist. (in)</td>
</tr>
<tr>
<td>0.000</td>
</tr>
<tr>
<td>0.025</td>
</tr>
<tr>
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<td>0.075</td>
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<tr>
<td>0.125</td>
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<td>0.150</td>
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<td>0.175</td>
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<tr>
<td>0.200</td>
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<tr>
<td>0.225</td>
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<td>0.250</td>
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</tr>
<tr>
<td>0.300</td>
</tr>
<tr>
<td>0.325</td>
</tr>
</tbody>
</table>

Corrected CBR @ 0.1"
0.4  0.4  0.4
Corrected CBR @ 0.2"
1.9  1.8  1.9

Penetration Distance Correction (in)
0.000 0.000 0.000

Figure: __________
Project No.: 10142-0011
Project Name: Orchard Avenue Improvements
Client Name: Rolland Engineering
Completed By: MAB
Date: 10/29/2018
Current Year: 2018

GIVEN INFORMATION:
Source: City of Grand Junction GIS
Year: 2015 ADT: 8153

ASSUMPTIONS:
Growth Rate (%): 2.2
Design Life (yr): 20
Truck Traffic (%): 10
Single Axle (%): 70
Combination (%): 30

DEFINED EQUIVALENCY FACTORS:
Automobiles Flexible: 0.003
Automobiles Rigid: 0.003
Single Unit Flexible: 0.249
Single Unit Rigid: 0.285
Combination Flexible: 1.087
Combination Rigid: 1.692

CALCULATIONS:
ADT at Beginning of Design Life
ADT: 8704

ADT at End of Design Life
ADT: 13451

ADT at Midpoint of Design Life
ADT: 11078

Breakdown of Vehicles Multiplied by Equivalency Factors for Flexible Pavement
Automobiles: 30
Single Unit: 194
Combination: 362

Breakdown of Vehicles Multiplied by Equivalency Factors for Rigid Pavement
Automobiles: 30
Single Unit: 222
Combination: 563

Flexible Pavement ESAL's
ESAL's: 2566680

Rigid Pavement ESAL's
ESAL's: 3569700