GEOTECHNICAL AND GEOLOGIC HAZARDS INVESTIGATION
22 ROAD CORRIDOR STUDY
GRAND JUNCTION, COLORADO
PROJECT#01042-0006

ROLLAND ENGINEERING
405 RIDGES BOULEVARD
GRAND JUNCTION, COLORADO 81507

MAY 1, 2014
SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

A geologic hazards and geotechnical investigation was conducted for the 22 Road Corridor Study in Grand Junction, Colorado. The purpose of the investigation was to evaluate the surface and subsurface conditions at the site with respect to geologic hazards, pavement design, foundation design, and earthwork for the proposed construction. This summary has been prepared to include the information required by civil engineers, structural engineers, and contractors involved in the project.

Subsurface Conditions (p. 2)

The subsurface investigation consisted of three borings during a previous investigation and sixteen borings during the current investigation. The borings generally encountered pavements above native clay soils. Groundwater was encountered in the borings at depths of between 6.5 and 20.0 feet at the time of the investigation. The native clay soils are slightly to highly plastic and slightly collapsible to slightly expansible.

Geologic Hazards and Constraints (p. 4)

No geologic hazards were identified which would preclude construction. However, moisture sensitive soils and bedrock were encountered at the site.

Summary of Foundation Recommendations

- Foundation Type – Shallow – Footings or Culvert (p. 4)
- Structural Fill – Minimum of 24-inches below foundations from canal south of H Road to canal south of J Road. Minimum 36-inches below foundations from J Road to K Road. Imported structural fill should consist of pit-run, CDOT Class 6 base course, or other granular material approved by the engineer.(p. 5)
- Lateral Earth Pressure – 55 pcf (p. 9)

Summary of Pavement Recommendations (p. 6)

22 Road – Highway 6 & 50 to H Road

Flexible ESAL’s = 2,969,640; SN = 5.0; Rigid ESAL’s = 4,147,860

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## 22 Road – H Road to I Road

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## 22 Road – I Road to J Road

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## 22 Road – J Road to K Road

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  Appendix D – Previous Lab Testing Results
  Appendix E – Current Lab Testing Results
  Appendix F – ESAL Calculations
1.0 INTRODUCTION

As part of continued improvements to infrastructure in Western Colorado, Mesa County sought to evaluate 22 Road with regard to future growth in the vicinity. As part of the evaluation 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 22 Road Corridor Study 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 and bedrock samples and conducting laboratory testing to determine the engineering properties of the soils and bedrock at the site.
- Providing recommendations for general earthwork.
- Providing recommendations for roadway pavements.
- Providing recommendations for bridge/culvert structures.
- 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 project area includes 22 Road from Highway 6 & 50 north to K Road in Grand Junction. At the southern end of the project area, from Highway 6 & 50 to H Road, the land use was primarily commercial/industrial. From H Road to H½ Road, the land use was mixed with primarily commercial/industrial facilities on the west side of the road and primarily residential properties on the east side of the road. North of H½ Road to K Road, the land use was primarily residential.

22 Road crosses Persigo Wash in the southern portion of the project area. In addition, 22 Road crosses drainage ditches at four locations and irrigation canals at three locations within the project area.

1.3 Existing Pavements

22 Road was asphalt paved within the entire project area. The roadway consisted of one lane in each direction with gravel shoulders along most of the length. However, new pavements were present near Highway 6 & 50 as part of the Love’s Truck Stop construction. In addition, curb-and-gutter was present on the east side of 22 Road in front of the Love’s facility.
In general, the existing pavements were in fairly good condition with transverse cracking as the primary observed distress. However, some longitudinal cracks were observed along the roadway. Some very small areas of alligator cracking was also observed. In addition, shoving of the asphalt was observed at the intersection of H Road.

1.4 Previous Work

A geotechnical investigation was previously completed for the southern portion of 22 Road from Highway 6 & 50 to Persigo Wash. The investigation was summarized in a report titled Geotechnical and Geologic Hazards Investigation, 22 Road at Highway 6 Realignment, Grand Junction, Colorado by Huddleston-Berry Engineering & Testing, LC for the City of Grand Junction, December 19, 2012.

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 numerous soil types exist along 22 Road within the project area. Soil survey data is included in Appendix A.

2.2 Geology

According to the Geologic Map of Colorado by Ogden Tweto (1979), the southern approximately 2/3 of the project area is underlain by Quaternary gravels. The remainder of the project area, and the gravels, are underlain by Mancos shale bedrock. The Mancos shale unit is thick in the Grand Valley and has a low to moderate potential for expansion.

2.3 Groundwater

Groundwater was encountered in the borings at depths of between 6.5 and 20.0 feet at the time of the investigation.

3.0 FIELD INVESTIGATION

3.1 Previous Subsurface Investigation

As indicated in the referenced report, the previous subsurface investigation was conducted on November 15th and 16th, 2012, and included three borings along 22 Road from Highway 6 & 50 to the Persigo Wash bridge. The locations of the borings are shown on Figure 1. Typed boring logs are included in Appendix B.
As shown on the logs, the subsurface conditions along the roadway were slightly variable. However, the borings generally encountered 7.0 to 10.0-inches of asphalt pavement above gravel base course to depths of between 12.0 and 18.0-inches. One of the borings encountered subbase material to a depth of 3.5 feet. Below the pavement section, brown to gray, moist to wet, medium stiff to very stiff lean clay extended to depths of between 9.0 and 18.0 feet. The clay was underlain by brown, moist to wet, very loose to medium dense silty or clayey sand. Dense gravel soils were encountered in two of the borings at depths of 14.5 and 17.5 feet, respectively.

3.2 Current Subsurface Investigation

The current subsurface investigation was conducted on December 5th and 11th, 2014, and included sixteen borings along 22 Road from the canal crossing south of H Road to K Road. The locations of the borings are shown on Figures 2 through 4. Typed boring logs are included in Appendix C.

As shown on the logs, the subsurface conditions along the roadway were slightly variable. However, the borings generally encountered 5.0 to 13.0-inches of asphalt pavement above gravel base course to depths of between 12.0 and 25.0-inches. Below the pavement section, brown, moist to wet, very soft to very stiff lean clay, lean clay with sand, and/or sandy silty clay soils were encountered. The clay soils extended to the bottoms of most of the borings. However, in Borings B-12 and B-16, north of J Road, the clay extended to a depth of 5.0 feet and was underlain by grayish brown, soft, highly weathered shale bedrock to the bottoms of the borings.

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 and density, grain size analysis, Atterberg limits, maximum dry density and optimum moisture (Proctor), swell/consolidation, California Bearing Ratio (CBR), and soluble sulfates content. The laboratory testing results from the previous investigation are included in Appendix D and the laboratory testing results from the current investigation are included in Appendix E.

The laboratory testing results indicate that the native clay soils are slightly to highly plastic. In addition, the native clay soils were shown to range from collapsible to expansive at their existing density with between approximately 3.5% collapse and 0.8% expansion measured during swell/consolidation testing. The CBR results indicate that the native clay soils may expand as much as 0.9% when compacted and introduced to excess moisture.

The native shale bedrock was shown to be moderately plastic. The shale is anticipated to range from slightly to moderately expansive. Water soluble sulfates were encountered in the site soils in concentrations as high as 0.3%.
5.0 GEOLOGIC INTERPRETATION

5.1 Geologic Hazards

The primary geologic hazard identified along the proposed roadway alignment is the presence of moisture sensitive soils and bedrock. However, flooding of Persigo Wash, the drainage ditches, and/or the canals in the project area may also impact the roadway.

5.2 Geologic Constraints

In general, the primary geologic constraint to construction at the site is the presence of moisture sensitive soils and bedrock.

5.3 Water Resources

As discussed previously, 22 Road crosses Persigo Wash, irrigation canals, and drainage ditches within the project area and these are the primary water features in the area. In general, with proper design and construction, the proposed work is not anticipated to adversely impact surface water or groundwater in the vicinity of the site.

5.4 Mineral Resources

Potential mineral resources in western Colorado generally include gravel, uranium ore, and commercial rock products such as flagstone. A small portion of 22 Road, just north of the canal south of J Road, is mapped on the Mesa County GIS database as containing potential gravel resources. In addition, gravels were encountered in the southern portion of the project area. However, HBET does not believe that any gravels present within the 22 Road right-of-way represent an economically recoverable resource.

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 rehabilitation of the existing roadway, new roadway construction, and/or new bridge/culvert construction within the project area.

7.0 RECOMMENDATIONS

7.1 Bridges/Culverts

As discussed previously, 22 Road crosses Persigo Wash, drainage ditches, and canals within the project area. With regard to the Persigo Wash bridge, recommendations for this structure are included in the referenced report. The scope of the current investigation did not outline specific structures which may be replaced along 22 Road within the project area, with the exception of the Persigo Wash bridge already addressed in the referenced report. As a result, HBET includes general recommendations for foundation type and subgrade preparation for bridges and/or culverts along 22 Road.
However, HBET should be contacted to provide specific recommendations for individual structures proposed to be replaced along 22 Road within the project area.

Based upon our observations at the site, the existing structures consist of either culverts or single-span bridges. While the foundations of the existing structures are unknown, the results of the subsurface investigation indicate that the depth to bearing ranges from 29 feet south of H Road to greater than 55 feet between H Road and J Road. In general, due to the significant depth to bearing and small size of the structures, HBET generally believes that shallow foundations would be more cost effective for any new culverts and/or bridges for the canal crossing south of H Road to the canal crossing south of J Road. However, due to the presence of soft soils in the shallow subsurface, HBET recommends that bridge footings or culverts from the canal crossing south of H Road to the canal crossing south of J Road be underlain by a minimum of 24-inches of structural fill.

With regard to the crossings between J Road and K Road, shale bedrock was encountered at a depth of 5.0 feet. As a result, shallow foundations are also recommended for any new bridges or culverts at these crossings. However, due to the presence of expansive shale bedrock, HBET recommends that bridge footings or culverts from J Road to K Road be underlain by a minimum of 36-inches of structural fill.

In general, the native clay soils are not suitable for reuse as structural fill. Imported structural fill should consist of a granular, non-expansive, non-free draining material such as crusher fines, pit-run, or CDOT Class 6 base course. However, if pit-run is used for structural fill, a minimum of six inches of crusher fines or Class 6 base course should be placed on top of the pit run to prevent large point stresses on the bottoms of the footings due to large particles in the pit-run.

Prior to placement of structural fill, it is recommended that the bottoms of the foundation excavations be scarified to a depth of 6 to 8 inches, moisture conditioned, and compacted to a minimum of 95% of the standard Proctor maximum dry density, within ± 2% of the optimum moisture content as determined in accordance with ASTM D698. However, due to the presence of soft soils and/or groundwater, compaction of the subgrade may be difficult. It may be necessary to utilize geotextile and/or geogrid in conjunction with additional granular fill to stabilize the subgrade. HBET should be contacted to provide specific recommendations for subgrade stabilization based upon the actual conditions in the bottom of the foundation excavations.

Structural fill should extend laterally beyond the edges of the foundation a distance equal to the thickness of structural fill. Structural fill should be moisture conditioned, placed in maximum 8-inch loose lifts, and compacted to a minimum of 95% of the standard Proctor maximum dry density for fine grained soils and modified Proctor maximum dry density for coarse grained soils, within ± 2% of the optimum moisture content as determined in accordance with ASTM D698 and D1557C, respectively. Pit-run materials should be proofrolled to the Engineer’s satisfaction.
7.2 Pavements

The results of the subsurface investigations indicate that the pavement subgrade soils along 22 Road consist primarily of native clays soils. The 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 used for the pavement evaluation/design.

Based upon the subgrade conditions and anticipated traffic loading, the existing pavements were evaluated and new pavements were designed in accordance with the Guideline for the Design and Use of Asphalt Pavements for Colorado Roadways by the Colorado Asphalt Pavement Association and CDOT Pavement Design Manual. Rigid pavement section alternatives were developed using the AASHTO Rigid Pavement Design spreadsheet and CDOT Pavement Design Manual. ESAL calculations are included in Appendix F.

22 Road – Highway 6 & 50 to H Road

As indicated on the boring logs, with the exception of the new pavements at the southern end of 22 Road, the critical existing pavement section along this stretch of roadway consists of 7.0-inches of asphalt above 7.0-inches of base course. Given the condition of the existing roadway, the existing roadway is adequate for an ESAL value of approximately 500,000. However, ESAL calculations for this stretch of roadway indicate a design ESAL value of nearly 3,000,000 for a 20 year design life. To achieve this capacity, an overlay of approximately 3.0-inches would be required. Pavement alternatives are included below.

Flexible ESAL’s = 2,969,640; SN = 5.0; Rigid ESAL’s = 4,147,860

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22 Road – H Road to I Road

As indicated on the boring logs, the critical existing pavement section along this stretch of roadway consists of 7.0-inches of asphalt above 9.0-inches of base course. Given the condition of the existing roadway, the existing roadway is adequate for an ESAL value of approximately 800,000. However, ESAL calculations for this stretch of roadway indicate a design ESAL value of just over 900,000 for a 20 year design life. Therefore, it will likely be necessary to overlay the pavement to achieve a design life of 20 additional years. An overlay of at least 2.0-inches is recommended. Pavement alternatives are included below.
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22 Road – J Road to J Road

As indicated on the boring logs, the critical existing pavement section along this stretch of roadway consists of 6.0-inches of asphalt above 6.0-inches of base course. Given the condition of the existing roadway, the existing roadway is adequate for an ESAL value of approximately 180,000. However, ESAL calculations for this stretch of roadway indicate a design ESAL value of just over 324,000 for a 20 year design life. Therefore, it will likely be necessary to overlay the pavement to achieve a design life of 20 additional years. An overlay of at least 2.0-inches is recommended. Pavement alternatives are included below.

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22 Road – J Road to K Road

As indicated on the boring logs, the critical existing pavement section along this stretch of roadway consists of 7.0-inches of asphalt above 9.0-inches of base course. Given the condition of the existing roadway, the existing roadway is adequate for an ESAL value of approximately 800,000. ESAL calculations for this stretch of roadway indicate a design ESAL value of approximately 145,000 for a 20 year design life. Based upon the calculations and results of the subsurface investigation, the existing roadway is adequate for the proposed design traffic. However, due to the condition of the existing roadway, it will likely be necessary to overlay the pavement to achieve a design life of 20 additional years. An overlay of at least 2.0-inches is recommended. Pavement alternatives are included below.
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**General Pavement Recommendations**

Prior to 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 0 to -2% of optimum moisture content as determined by AASHTO T-99.

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 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.

Rigid pavements should consist of CDOT Class P concrete or alternative approved by the Engineer. It is recommended that concrete pavements be continuously reinforced.

The long-term performance of the pavements is critically 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 and to prevent excess moisture from infiltrating into the subgrade below the pavements. All pavements should conform to applicable local specifications.

**7.3 Corrosion of Concrete**

As discussed previously, water soluble sulfates were detected in the site soils in concentrations as high as 0.3%. These concentrations represent a severe degree of potential sulfate attack on concrete exposed to the native soils. Therefore, Type V sulfate resistant cement is recommended for construction at this site in accordance with the International Building Code (IBC). However, Type V cement can be difficult to obtain in Western Colorado. Where Type V cement is unavailable, Type I-II cement is recommended.
7.4 Lateral Earth Pressures

Wingwalls and/or 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 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.

7.5 Engineering Properties of Soil

HBET recommends the following engineering parameters be utilized for the native soils:

Clay/Weathered Shale
- $\phi' = 18^\circ$
- $c = 200$ psf
- $\gamma = 110$ pcf

7.6 Excavations

Excavations in the soils at the site may stand for short periods of time but should not be considered to be stable. The native soils generally classify as Type C soil with regard to OSHA’s Construction Standards for Excavations. In general, for Type C soils, the maximum allowable slope in temporary cuts is 1.5H:1V. However, depending upon evaluation of specific trenches during construction, HBET may be able to classify some of the site soils as Type B.

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. Although HBET believes that the investigation was sufficient to adequately characterize the range of subsurface conditions at the site, the precise nature and extent of subsurface variability may not become evident until construction. Therefore, it is recommended that a representative of HBET be retained to provide engineering oversight and construction materials testing services during the construction. This is to verify compliance with the recommendations included in this report or permit identification of significant variations in the subsurface conditions which may require modification of the recommendations.
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
APPENDIX A
Soil Survey Data
The soil surveys that comprise your Area of Interest (AOI) were mapped at 1:24,000. Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
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 4, Jan 2, 2014

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 22, 2010—Sep 2, 2010

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>Av</td>
<td>Avalon sandy loam, gravelly substratum, 2 to 5 percent slopes</td>
<td>4.5</td>
<td>1.0%</td>
</tr>
<tr>
<td>AvC</td>
<td>Avalon loam, gravelly substratum, 5 to 25 percent slopes</td>
<td>27.4</td>
<td>6.3%</td>
</tr>
<tr>
<td>Ba</td>
<td>Massadona silty clay loam, 0 to 2 percent slopes</td>
<td>40.9</td>
<td>9.3%</td>
</tr>
<tr>
<td>BaS</td>
<td>Massadona silty clay loam, saline, 0 to 2 percent slopes</td>
<td>8.5</td>
<td>1.9%</td>
</tr>
<tr>
<td>Bc</td>
<td>Sagers silty clay loam, 0 to 2 percent slopes</td>
<td>113.4</td>
<td>25.9%</td>
</tr>
<tr>
<td>BcS</td>
<td>Sagers silty clay loam, saline, 0 to 2 percent slopes</td>
<td>134.3</td>
<td>30.7%</td>
</tr>
<tr>
<td>BcW</td>
<td>Cojam loam, 0 to 2 percent slopes</td>
<td>9.3</td>
<td>2.1%</td>
</tr>
<tr>
<td>Fe</td>
<td>Fruita clay loam, 0 to 2 percent slopes</td>
<td>27.2</td>
<td>6.2%</td>
</tr>
<tr>
<td>Ff</td>
<td>Fruita clay loam, 2 to 5 percent slopes</td>
<td>4.9</td>
<td>1.1%</td>
</tr>
<tr>
<td>Hk</td>
<td>Killpack silty clay, 0 to 2 percent slopes</td>
<td>3.9</td>
<td>0.9%</td>
</tr>
<tr>
<td>Re</td>
<td>Sagrlite loam, 0 to 2 percent slopes</td>
<td>19.8</td>
<td>4.5%</td>
</tr>
<tr>
<td>Rp</td>
<td>Persayo silty clay loam, 12 to 40 percent slopes</td>
<td>4.0</td>
<td>0.9%</td>
</tr>
<tr>
<td>Tr</td>
<td>Turley clay loam, 0 to 2 percent slopes</td>
<td>40.2</td>
<td>9.2%</td>
</tr>
<tr>
<td><strong>Totals for Area of Interest</strong></td>
<td></td>
<td><strong>438.1</strong></td>
<td><strong>100.0%</strong></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 and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils 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. Other minor components, however, have properties and behavioral 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

Av—Avalon sandy loam, gravelly substratum, 2 to 5 percent slopes

Map Unit Setting

Elevation: 4,600 to 4,800 feet
Mean annual precipitation: 7 to 10 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 150 to 190 days
Map Unit Composition
Avalon, gravelly substratum, and similar soils: 90 percent

Description of Avalon, Gravelly Substratum

Setting
- Landform: Terraces
- Landform position (three-dimensional): Tread
- Down-slope shape: Convex
- Across-slope shape: Linear
- Parent material: Alluvium and/or slope alluvium derived from sandstone and shale

Properties and qualities
- Slope: 2 to 5 percent
- Depth to restrictive feature: More than 80 inches
- Drainage class: Well drained
- Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
- Depth to water table: More than 80 inches
- Frequency of flooding: None
- Frequency of ponding: None
- Calcium carbonate, maximum content: 40 percent
- Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
- Sodium adsorption ratio, maximum: 10.0
- Available water capacity: High (about 9.6 inches)

Interpretive groups
- Farmland classification: Prime farmland if irrigated
- Land capability classification (irrigated): 3e
- Land capability (nonirrigated): 7c
- Hydrologic Soil Group: B

Typical profile
- 0 to 3 inches: Sandy loam
- 3 to 17 inches: Loam
- 17 to 42 inches: Clay loam
- 42 to 60 inches: Gravelly loam

AvC—Avalon loam, gravelly substratum, 5 to 25 percent slopes

Map Unit Setting
- Elevation: 4,500 to 4,900 feet
- Mean annual precipitation: 7 to 10 inches
- Mean annual air temperature: 50 to 54 degrees F
- Frost-free period: 150 to 190 days

Map Unit Composition
Avalon, gravelly substratum, and similar soils: 80 percent
Description of Avalon, Gravelly Substratum

Setting

Landform: Terraces
Landform position (three-dimensional): Riser
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Alluvium and/or slope alluvium derived from sandstone and shale

Properties and qualities

Slope: 5 to 25 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 40 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 10.0
Available water capacity: High (about 9.6 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability classification (irrigated): 6e
Land capability (nonirrigated): 7c
Hydrologic Soil Group: B

Typical profile

0 to 3 inches: Sandy loam
3 to 17 inches: Loam
17 to 42 inches: Clay loam
42 to 60 inches: Gravelly loam

Ba—Massadona silty clay loam, 0 to 2 percent slopes

Map Unit Setting

Elevation: 4,500 to 4,900 feet
Mean annual precipitation: 7 to 10 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 150 to 190 days

Map Unit Composition

Massadona and similar soils: 70 percent

Description of Massadona

Setting

Landform: Fan terraces
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Alluvium derived from clayey shale

Properties and qualities
Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water
(Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Gypsum, maximum content: 2 percent
Maximum salinity: Moderately saline to strongly saline (10.0 to 32.0 mmhos/cm)
Available water capacity: High (about 10.0 inches)

Interpretive groups
Farmland classification: Not prime farmland
Land capability classification (irrigated): 3s
Land capability (nonirrigated): 7s
Hydrologic Soil Group: D

Typical profile
0 to 2 inches: Silty clay loam
2 to 12 inches: Silty clay
12 to 24 inches: Silty clay
24 to 48 inches: Stratified silty clay loam to fine sandy loam
48 to 60 inches: Stratified silty clay loam to fine sandy loam

BaS—Massadona silty clay loam, saline, 0 to 2 percent slopes

Map Unit Setting
Elevation: 4,500 to 4,890 feet
Mean annual precipitation: 7 to 10 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 150 to 190 days

Map Unit Composition
Massadona, saline, and similar soils: 70 percent

Description of Massadona, Saline
Setting
Landform: Fan terraces
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from clayey shale

Properties and qualities
Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Gypsum, maximum content: 2 percent
Maximum salinity: Strongly saline (20.0 to 40.0 mmhos/cm)
Available water capacity: High (about 10.0 inches)

Interpretive groups
Farmland classification: Not prime farmland
Land capability classification (irrigated): 4s
Land capability (nonirrigated): 7s
Hydrologic Soil Group: D

Typical profile
0 to 2 inches: Silty clay loam
2 to 12 inches: Silty clay
12 to 24 inches: Silty clay
24 to 48 inches: Stratified silty clay loam to fine sandy loam
48 to 60 inches: Stratified silty clay loam to fine sandy loam

Bc—Sagers silty clay loam, 0 to 2 percent slopes

Map Unit Setting
Elevation: 4,500 to 5,900 feet
Mean annual precipitation: 5 to 8 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 150 to 190 days

Map Unit Composition
Sagers and similar soils: 90 percent

Description of Sagers
Setting
Landform: Alluvial fans, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Alluvium and slope alluvium derived from calcareous shale and sandstone

Properties and qualities
Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Gypsum, maximum content: 5 percent
Maximum salinity: Nonsaline to slightly saline (2.0 to 8.0 mmhos/cm)
Available water capacity: High (about 9.8 inches)

Interpretive groups
Farmland classification: Prime farmland if irrigated
Land capability classification (irrigated): 2e
Land capability (nonirrigated): 7c
Hydrologic Soil Group: B

Typical profile
0 to 12 inches: Silty clay loam
12 to 25 inches: Silty clay loam
25 to 60 inches: Silty clay loam

BcS—Sagers silty clay loam, saline, 0 to 2 percent slopes

Map Unit Setting
Elevation: 4,500 to 4,900 feet
Mean annual precipitation: 5 to 8 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 150 to 190 days

Map Unit Composition
Sagers, saline, and similar soils: 90 percent

Description of Sagers, Saline
Setting
Landform: Alluvial fans, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Alluvium and slope alluvium derived from calcareous shale and sandstone

Properties and qualities
Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Gypsum, maximum content: 5 percent
Maximum salinity: Moderately saline to strongly saline (16.0 to 32.0 mmhos/cm)
Available water capacity: Very low (about 3.0 inches)
Interpretive groups

Farmland classification: Not prime farmland
Land capability (nonirrigated): 8s
Hydrologic Soil Group: B

Typical profile

0 to 12 inches: Silty clay loam
12 to 25 inches: Silty clay loam
25 to 60 inches: Silty clay loam

BcW—Cojam loam, 0 to 2 percent slopes

Map Unit Setting

Elevation: 4,470 to 4,870 feet
Mean annual precipitation: 7 to 10 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 150 to 190 days

Map Unit Composition

Cojam and similar soils: 90 percent

Description of Cojam

Setting

Landform: Drainageways, alluvial fans
Down-slope shape: Linear, concave
Across-slope shape: Concave, linear
Parent material: Alluvium derived from sandstone and shale

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: About 12 to 24 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Gypsum, maximum content: 5 percent
Maximum salinity: Nonsaline to slightly saline (2.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum: 5.0
Available water capacity: High (about 9.9 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability classification (irrigated): 7w
Land capability (nonirrigated): 7w
Hydrologic Soil Group: D

Typical profile

0 to 4 inches: Loam
4 to 12 inches: Silt loam
12 to 24 inches: Silty clay loam
24 to 35 inches: Silty clay loam
35 to 59 inches: Stratified sandy loam to silty clay loam

Fe—Fruita clay loam, 0 to 2 percent slopes

Map Unit Setting
- **Elevation:** 4,500 to 4,900 feet
- **Mean annual precipitation:** 7 to 10 inches
- **Mean annual air temperature:** 50 to 54 degrees F
- **Frost-free period:** 150 to 190 days

Map Unit Composition
- **Fruita and similar soils:** 90 percent

Description of Fruita

Setting
- **Landform:** Terraces
- **Landform position (three-dimensional):** Tread
- **Down-slope shape:** Linear
- **Across-slope shape:** Linear
- **Parent material:** Slope alluvium derived from shale over alluvium
  derived from sandstone and shale

Properties and qualities
- **Slope:** 0 to 2 percent
- **Depth to restrictive feature:** More than 80 inches
- **Drainage class:** Well drained
- **Capacity of the most limiting layer to transmit water (Ksat):** Moderately high (0.20 to 0.60 in/hr)
- **Depth to water table:** More than 80 inches
- **Frequency of flooding:** None
- **Frequency of ponding:** None
- **Calcium carbonate, maximum content:** 10 percent
- **Gypsum, maximum content:** 50 percent
- **Maximum salinity:** Very slightly saline to moderately saline (4.0 to 16.0 mmhos/cm)
- **Sodium adsorption ratio, maximum:** 10.0
- **Available water capacity:** High (about 9.1 inches)

Interpretive groups
- **Farmland classification:** Prime farmland if irrigated
- **Land capability classification (irrigated):** 2e
- **Land capability (nonirrigated):** 7c
- **Hydrologic Soil Group:** B

Typical profile
- 0 to 2 inches: Clay loam
- 2 to 6 inches: Clay loam
- 6 to 16 inches: Clay loam
- 16 to 22 inches: Clay loam
- 22 to 32 inches: Loam
32 to 60 inches: Gypsiferous sandy loam

**Ff—Fruita clay loam, 2 to 5 percent slopes**

**Map Unit Setting**
- *Elevation:* 4,500 to 4,900 feet
- *Mean annual precipitation:* 7 to 10 inches
- *Mean annual air temperature:* 50 to 54 degrees F
- *Frost-free period:* 150 to 190 days

**Map Unit Composition**
- *Fruita and similar soils:* 90 percent

**Description of Fruita**

**Setting**
- *Landform:* Terraces
- *Landform position (three-dimensional):* Tread
- *Down-slope shape:* Linear
- *Across-slope shape:* Linear
- *Parent material:* Slope alluvium derived from shale over alluvium derived from sandstone and shale

**Properties and qualities**
- *Slope:* 2 to 5 percent
- *Depth to restrictive feature:* More than 80 inches
- *Drainage class:* Well drained
- *Capacity of the most limiting layer to transmit water (Ksat):* Moderately high (0.20 to 0.60 in/hr)
- *Depth to water table:* More than 80 inches
- *Frequency of flooding:* None
- *Frequency of ponding:* None
- *Calcium carbonate, maximum content:* 10 percent
- *Gypsum, maximum content:* 50 percent
- *Maximum salinity:* Very slightly saline to moderately saline (4.0 to 16.0 mmhos/cm)
- *Sodium adsorption ratio, maximum:* 10.0
- *Available water capacity:* High (about 9.1 inches)

**Interpretive groups**
- *Farmland classification:* Prime farmland if irrigated
- *Land capability classification (irrigated):* 3e
- *Land capability (nonirrigated):* 7c
- *Hydrologic Soil Group:* B

**Typical profile**
- 0 to 2 inches: Clay loam
- 2 to 6 inches: Clay loam
- 6 to 16 inches: Clay loam
- 16 to 22 inches: Clay loam
- 22 to 32 inches: Loam
- 32 to 60 inches: Gypsiferous sandy loam
Hk—Killpack silty clay, 0 to 2 percent slopes

Map Unit Setting
Elevation: 4,500 to 4,900 feet
Mean annual precipitation: 7 to 10 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 150 to 190 days

Map Unit Composition
Killpack and similar soils: 85 percent

Description of Killpack

Setting
Landform: Hills
Landform position (two-dimensional): Toeslope
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Residuum weathered from clayey shale

Properties and qualities
Slope: 0 to 2 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 40 percent
Gypsum, maximum content: 15 percent
Maximum salinity: Nonsaline to slightly saline (0.0 to 7.0 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water capacity: Low (about 4.7 inches)

Interpretive groups
Farmland classification: Not prime farmland
Land capability classification (irrigated): 3s
Land capability (nonirrigated): 7c
Hydrologic Soil Group: C

Typical profile
0 to 6 inches: Silty clay
6 to 17 inches: Silty clay
17 to 21 inches: Silty clay
21 to 24 inches: Silty clay
24 to 38 inches: Silty clay loam
38 to 60 inches: Weathered bedrock
Re—Sagrlite loam, 0 to 2 percent slopes

Map Unit Setting
   *Elevation:* 4,500 to 4,900 feet
   *Mean annual precipitation:* 7 to 10 inches
   *Mean annual air temperature:* 50 to 54 degrees F
   *Frost-free period:* 150 to 190 days

Map Unit Composition
   *Sagrlite and similar soils:* 90 percent

Description of Sagrlite

Setting
   *Landform:* Terraces, alluvial fans
   *Landform position (three-dimensional):* Tread
   *Down-slope shape:* Linear
   *Across-slope shape:* Linear
   *Parent material:* Alluvium derived from sandstone and shale

Properties and qualities
   *Slope:* 0 to 2 percent
   *Depth to restrictive feature:* More than 80 inches
   *Drainage class:* Well drained
   *Capacity of the most limiting layer to transmit water (Ksat):* Moderately high to high (0.60 to 2.00 in/hr)
   *Depth to water table:* More than 80 inches
   *Frequency of flooding:* None
   *Frequency of ponding:* None
   *Calcium carbonate, maximum content:* 20 percent
   *Gypsum, maximum content:* 1 percent
   *Maximum salinity:* Nonsaline to slightly saline (2.0 to 8.0 mmhos/cm)
   *Sodium adsorption ratio, maximum:* 10.0
   *Available water capacity:* High (about 9.4 inches)

Interpretive groups
   *Farmland classification:* Prime farmland if irrigated
   *Land capability classification (irrigated):* 2s
   *Land capability (nonirrigated):* 7c
   *Hydrologic Soil Group:* B

Typical profile
   0 to 13 inches: Loam
   13 to 60 inches: Silt loam

Rp—Persayo silty clay loam, 12 to 40 percent slopes

Map Unit Setting
   *Elevation:* 4,500 to 5,200 feet
   *Mean annual precipitation:* 7 to 10 inches
   *Mean annual air temperature:* 50 to 54 degrees F
Frost-free period: 150 to 190 days

Map Unit Composition
Persayo and similar soils: 70 percent

Description of Persayo

Setting
Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Residuum weathered from clayey shale

Properties and qualities
Slope: 12 to 40 percent
Depth to restrictive feature: 10 to 20 inches to paralithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 40 percent
Gypsum, maximum content: 10 percent
Maximum salinity: Nonsaline to slightly saline (2.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum: 5.0
Available water capacity: Very low (about 2.5 inches)

Interpretive groups
Farmland classification: Not prime farmland
Land capability (nonirrigated): 7c
Hydrologic Soil Group: D
Ecological site: Silty Saltdesert (R034XY410CO)

Typical profile
0 to 4 inches: Silty clay loam
4 to 15 inches: Silty clay loam
15 to 19 inches: Weathered bedrock

Tr—Turley clay loam, 0 to 2 percent slopes

Map Unit Setting
Elevation: 4,500 to 4,800 feet
Mean annual precipitation: 7 to 10 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 150 to 190 days

Map Unit Composition
Turley and similar soils: 90 percent
Description of Turley

Setting

Landform: Fan remnants
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from sandstone and shale

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water
(Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Gypsum, maximum content: 4 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: High (about 10.6 inches)

Interpretive groups

Farmland classification: Prime farmland if irrigated
Land capability classification (irrigated): 2e
Land capability (nonirrigated): 7c
Hydrologic Soil Group: B

Typical profile

0 to 10 inches: Clay loam
10 to 20 inches: Fine sandy loam
20 to 30 inches: Clay loam
30 to 60 inches: Stratified loam to silty clay loam

Data Source Information

Soil Survey Area: Mesa County Area, Colorado
Survey Area Data: Version 4, Jan 2, 2014
APPENDIX B
Previous Boring Logs
<table>
<thead>
<tr>
<th>DEPTH</th>
<th>GRAPHIC LOG</th>
<th>MATERIAL DESCRIPTION</th>
<th>SAMPLE TYPE NUMBER</th>
<th>RECOVERY%</th>
<th>BLOW COUNTS</th>
<th>POCKET PEN</th>
<th>DRY UNIT WT.</th>
<th>MOISTURE CONTENT%</th>
<th>LIQUID LIMIT</th>
<th>PLASTIC LIMIT</th>
<th>PLASTICITY INDEX</th>
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<td>Sandy GRAVEL (BASE COURSE), brown, dry to moist, medium dense</td>
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<td>GO 3 71 3-4-5-5 (9)</td>
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Bottom of hole at 18.0 feet.
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<th>BLOW COUNTS ( (N \text{ VAL}) )</th>
<th>POCKET PEN ( (\text{ts}) )</th>
<th>DRY UNIT WT ( \text{ (pc}) )</th>
<th>MOISTURE CONTENT (%)</th>
<th>LIQUID LIMIT</th>
<th>PLASTIC LIMIT</th>
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<tr>
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<td>Sandy GRAVEL (BASE COURSE), brown, dry to moist, medium dense</td>
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<td>SS 1</td>
<td>67</td>
<td>3-3-4-5</td>
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<tr>
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<td>Silty SAND (sm), brown, wet, medium dense</td>
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<td>Sandy GRAVEL (gw), brown, wet, medium dense</td>
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<td>Bottom of hole at 18.0 feet.</td>
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</table>
Huddleston-Berry Engineering & Testing, LLC  
640 White Avenue, Unit B  
Grand Junction, CO 81501  
970-255-8005  
970-255-6818

BORE NUMBER B-12  

CLIENT  City of GJ  
PROJECT NAME  Highway 6 & 22 Road Realignment  
PROJECT NUMBER  00208-0041  
PROJECT LOCATION  Grand Junction, CO

DATE STARTED  11/16/12  
COMPLETED  11/15/12  
GROUND ELEVATION  
HOLE SIZE  4"  
GROUND WATER LEVELS:
AT TIME OF DRILLING  dry  
AT END OF DRILLING  dry

DRILLING CONTRACTOR  S. McCracken  
DRILLING METHOD  Simco 2000 Truck Rig  
LOGGED BY  MAB  
CHECKED BY  MAB

NOTES

<table>
<thead>
<tr>
<th>DEPTH (ft)</th>
<th>GRAPHIC LOG</th>
<th>MATERIAL DESCRIPTION</th>
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<td>5</td>
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<td>Sandy GRAVEL (BASE COURSE), brown, dry to moist, medium dense</td>
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<tr>
<td>10</td>
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<td>LEAN CLAY (cl), with fat clay layers and thin sand lenses, brown, moist, medium stiff to stiff, abundant sulfates</td>
</tr>
<tr>
<td>15</td>
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<tr>
<td>Bottom of hole at 18.0 feet.</td>
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<table>
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<th>SAMPLE TYPE</th>
<th>RECOVERY% (ROD)</th>
<th>BLOW COUNTS (N VALUE)</th>
<th>POCKET PEN (ts)</th>
<th>DRY UNIT WT (pct)</th>
<th>MOISTURE CONTENT (%)</th>
<th>PLASTIC LIMIT</th>
<th>CLAY LIMIT</th>
<th>ATTERBERG LIMIT</th>
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Bottom of hole at 18.0 feet.
APPENDIX C
Current Boring Logs
### Geotechnical Boring Log

**Boring Number B-1**

**Client:** Rolland Engineering  
**Project Name:** 22 Road Improvements  
**Project Number:** 01042-0006  
**Project Location:** Grand Junction, CO  
**Date Started:** 12/5/13  
**Date Completed:** 12/5/13  
**Drilling Contractor:** S. McKieken  
**Drilling Method:** Simco 2000 Truck Rig  
**Logged By:** NWB  
**Checked By:** MAB  
**Notes:** 39.117, -108.646

---

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<th>Material Description</th>
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<tbody>
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</tr>
<tr>
<td></td>
<td>Gravel BASE COURSE</td>
</tr>
<tr>
<td></td>
<td>Lean CLAY (CL), brown, moist to wet, very soft to stiff</td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
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<tr>
<td>20</td>
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**Sample Type Number**

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<th>Type</th>
<th>Recovery % (RQD)</th>
<th>Blows</th>
<th>Moisture Content (%)</th>
<th>Plastic Limit (%)</th>
<th>Atterberg Limits (%)</th>
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---

* ***Bearing at 29 ft***

* Bottom of hole at 28.0 feet.
**BORING NUMBER B-2**

**CLIENT** Rolland Engineering  
**PROJECT NAME** 22 Road Improvements  
**PROJECT NUMBER** 01042-0006  
**PROJECT LOCATION** Grand Junction, CO  
**DATE STARTED** 12/5/13  
**COMPLETED** 12/5/13  
**GROUND ELEVATION**  
**GROUND WATER LEVELS:**  
- **AT TIME OF DRILLING**: 7.0 ft  
- **AT END OF DRILLING**: 7.0 ft  
**DRILLING CONTRACTOR** S. McKracken  
**DRILLING METHOD** Simco 2000 Truck Rig  
**LOGGED BY** NWB  
**CHECKED BY** MAB  
**NOTES** 39.117, -108.845  

### DEPTH (ft) GRAPHIC LOG

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<tr>
<td></td>
<td>Gravel BASE COURSE</td>
</tr>
<tr>
<td></td>
<td>Lean CLAY (c), dark brown, wet, very soft to medium stiff</td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
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### MATERIAL DESCRIPTION

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<th>RECOVERY % (ROD)</th>
<th>BLOW COUNTS (N VALUE)</th>
<th>POCKET PEN (ft)</th>
<th>DRY UNIT WT. (pcf)</th>
<th>MOISTURE CONTENT (%)</th>
<th>LIQUID LIMIT</th>
<th>PLASTIC LIMIT</th>
<th>ATTERBERG LIMIT</th>
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<th>FINES CONTENT (%)</th>
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***Bearing at 29 ft***  
Bottom of hole at 29.0 feet.
**BORING NUMBER B-3**

**CLIENT** Rolland Engineering

**PROJECT NUMBER** 01042-0006

**PROJECT NAME** 22 Road Improvements

**DATE STARTED** 12/5/13  **COMPLETED** 12/5/13

**GROUND ELEVATION**  **HOLE SIZE** 4 inch

**GROUND WATER LEVELS:**

**DRILLING CONTRACTOR** S. McKecken

**DRILLING METHOD** Simco 2000 Truck Rig

**LOGGED BY** NWB  **CHECKED BY** MAB

**NOTES** 39.121, -106.645

---

**DEPTH (ft)**  **GRAPHIC LOG**  **MATERIAL DESCRIPTION**  **SAMPLE TYPE**  **RECOVERY % (RQD)**  **BLOW COUNTS (N VALUE)**  **POCKET PEN (ft)**  **DRY UNIT WT (pcf)**  **MOISTURE CONTENT (%)**  **LIQUID LIMIT**  **PLASTIC LIMIT**  **PLASTICITY INDEX (%)**  **ATTERBERG LIMITS**  **FINES CONTENT (%)**

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Graphic Log</th>
<th>Material Description</th>
<th>Sample Type</th>
<th>Recovery % (RQD)</th>
<th>Blow Counts (N Value)</th>
<th>Pocket Pen (ft)</th>
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<th>Moisture Content (%)</th>
<th>Liquid Limit</th>
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Bottom of hole at 9.5 feet.
Bottom of hole at 9.5 feet.
**Client:** Rolland Engineering  
**Project Name:** 22 Road Improvements  
**Project Number:** 01642-0006  
**Project Location:** Grand Junction, CO  
**Date Started:** 12/5/13  
**Completed:** 12/5/13  
**Drilling Contractor:** S. McKraken  
**Logging:** NWB  
**Checking:** MAB  
**Ground Elevation:**  
**Ground Water Levels:**  
- **At Time of Drilling:** dry  
- **At End of Drilling:** dry  
**After Drilling:**  
**Notes:** 39.125, -108.645

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<td>Lean Clay with Silt (CL), brown, moist, very stiff to soft</td>
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<td>72</td>
<td>1-2-2 (4)</td>
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Bottom of hole at 0.5 feet.
**BORING NUMBER B-6**

**CLIENT** Rolland Engineering  
**PROJECT NUMBER** 01042-0006

**DATE STARTED** 12/5/13  
**COMPLETED** 12/5/13

**DRILLING CONTRACTOR** S. McKraken

**LOGGED BY** NWB  
**CHECKED BY** MAB  
**NOTES** 39.129, -108.845

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**GROUND ELEVATION**  
**HOLE SIZE** 4 inch

**GROUND WATER LEVELS:**

**AT TIME OF DRILLING** dry  
**AT END OF DRILLING** dry  
**AFTER DRILLING** ---

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**BORING NUMBER B-7**

**CLIENT:** Rolland Engineering  
**PROJECT NUMBER:** 01042-0006

**DATE STARTED:** 12/6/13  
**COMPLETED:** 12/5/13  
**GROUND ELEVATION:**  
**HOLE SIZE:** 4 inch

**DRILLING CONTRACTOR:** S. McKracken  
**DRILLING METHOD:** Simco 2000 Tuck Rig

**LOGGED BY:** NWB  
**CHECKED BY:** MAB

**NOTES:** 39.133 -108.845

---

### MATERIAL DESCRIPTION

| DEPTH (ft) | Asphalt Gravel Base Course  
Lean CLAY with Sard (c), brown, moist to wet, stiff to very soft  
**SS 1**  
**MC 1**  
**SS 2** |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
</tr>
<tr>
<td>30</td>
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<tr>
<td>40</td>
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### Data Table

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<tbody>
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<td>1-1-2 (3)</td>
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<td>MC 1</td>
<td>89</td>
<td>2-4-5 (9)</td>
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**Bottom of hole at 45.0 feet.**  
**At Time of Drilling:** 20.0 ft  
**At End of Drilling:** 20.0 ft  
**After Drilling:** ---
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<th>MATERIAL DESCRIPTION</th>
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<td></td>
<td>Gravel BASE COURSE</td>
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<tr>
<td></td>
<td></td>
<td>Lean CLAY with Sand (ci), brown, moist, very stiff to stiff</td>
</tr>
<tr>
<td>2.5</td>
<td></td>
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<tr>
<td>5.0</td>
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Bottom of hole at 9.5 feet.
# Boring Number B-9

**CLIENT:** Rolland Engineering  
**PROJECT NAME:** 22 Road Improvements  
**PROJECT NUMBER:** 01042-0006  
**PROJECT LOCATION:** Grand Junction, CO  
**DATE STARTED:** 12/11/13  
**COMPLETED:** 12/11/13  
**GROUND ELEVATION:**  
**HOLE SIZE:** 4 inch  
**GROUND WATER LEVELS:**  
**AT TIME OF DRILLING:** dry  
**AT END OF DRILLING:** dry  
**AFTER DRILLING:** ---  
**LOGGED BY:** NWB  
**CHECKED BY:** MAB  
**NOTES:** 39.139, -108.845

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<tr>
<td>2.5</td>
<td>Gravel BASE COURSE</td>
</tr>
<tr>
<td>6.0</td>
<td>Lean CLAY (cl), brown, moist, medium stiff to very soft</td>
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<td>7.5</td>
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Bottom of hole at 9.5 feet.

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<th>SAMPLE TYPE NUMBER</th>
<th>RECOVERY % (RQD)</th>
<th>BLOW COUNTS (N VALUE)</th>
<th>POCKET PEN (lsf)</th>
<th>DRY UNIT WT. (pcf)</th>
<th>MOISTURE CONTENT (%)</th>
<th>PLASTIC LIMIT</th>
<th>LIQUID LIMIT</th>
<th>ATTERBERG LIMITS</th>
<th>PLASTICITY INDEX</th>
<th>FINES CONTENT (%)</th>
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<td>SS 2</td>
<td>39</td>
<td>4-2-2 (4)</td>
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<td>SS 3</td>
<td>61</td>
<td>0-1-0 (1)</td>
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<td>GRAPHIC LOG</td>
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<tr>
<td></td>
<td>Lean CLAY (ct), brown, moist to wet, stiff to very soft</td>
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**Notes:** 35.142, -108.645

**Log:** NWB

**Checked by:** MAB

**Client:** Rolland Engineering

**Project Name:** 22 Road Improvements

**Project Location:** Grand Junction, CO

**Date Started:** 12/11/13

**Date Completed:** 12/11/13

**Ground Elevation:** HOLE SIZE 4 inch

**Drilling Contractor:** S. McKracken

**Drilling Method:** Simco 2000 Truck Rig

**At Time of Drilling:** 15.0 ft

**At End of Drilling:** 15.0 ft

**After Drilling:** ---

**Sample Type Number:** SS

**Blow Counts (N Value):**

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<th>SAMPLE TYPE NUMBER</th>
<th>RECOVERY % (RGD)</th>
<th>BLOW COUNTS (N VALUE)</th>
<th>POCKET PENETRATION (ft)</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>
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<tbody>
<tr>
<td>SS 1</td>
<td>39</td>
<td>5-4-4</td>
<td>(8)</td>
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<tr>
<td>SS 2</td>
<td>22</td>
<td>1-2-3</td>
<td>(5)</td>
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<td></td>
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<tr>
<td>SS 3</td>
<td>61</td>
<td>1-1-2</td>
<td>(3)</td>
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<td></td>
<td></td>
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<tr>
<td>SS 4</td>
<td>67</td>
<td>1-1-1</td>
<td>(2)</td>
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<td>(0)</td>
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**Atterberg Limits:**

---

***No Bearing***

Bottom of hole at 55.0 feet.
<table>
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<th>MATERIAL DESCRIPTION</th>
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<tr>
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<td>ASPHALT Gravel BASE COURSE Sandy Silty CLAY (d), brown, moist, soft to medium stiff</td>
</tr>
<tr>
<td>10</td>
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</tr>
<tr>
<td>20</td>
<td></td>
</tr>
<tr>
<td>30</td>
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<td>40</td>
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<td>50</td>
<td>*** No Bearing *** Bottom of hole at 55.0 feet.</td>
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<table>
<thead>
<tr>
<th>SAMPLE TYPE NUMBER</th>
<th>RECOVERY %</th>
<th>BLOW COUNTERS (N VALUE)</th>
<th>POCKET PERS (lsf)</th>
<th>DRY UNIT WT. (pcf)</th>
<th>MOISTURE CONTENT (%)</th>
<th>ATTERBERG LIMITS</th>
<th>PLASTIC LIMIT</th>
<th>PLASTICITY INDEX</th>
<th>FINE CONTENT (%)</th>
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<tbody>
<tr>
<td>MC 1</td>
<td>67</td>
<td>3-2-1 (3)</td>
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<tr>
<td>SS 1</td>
<td>28</td>
<td>2-2-5 (7)</td>
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<tr>
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<td>39</td>
<td>2-3-2 (6)</td>
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<td>SS 3</td>
<td>56</td>
<td>1-2-2 (4)</td>
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<tr>
<td>SS 4</td>
<td>100</td>
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**BOURING NUMBER B-12**

**CLIENT** Rolland Engineering  
**PROJECT NAME** 22 Road Improvements  
**PROJECT NUMBER** 01042-0006  
**PROJECT LOCATION** Grand Junction, CO  
**DATE STARTED** 12/11/13  
**COMPLETED** 12/11/13  
**GROUND ELEVATION**  
**HOLE SIZE** 4 inch  
**GROUND WATER LEVELS:**  
**AT TIME OF DRILLING** dry  
**AT END OF DRILLING** dry  
**LOGGED BY** NWB  
**CHECKED BY** MAB  
**NOTES** 39.150, -108.845  

<table>
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<th>DEPTH (ft)</th>
<th>GRAPHIC LOG</th>
<th>MATERIAL DESCRIPTION</th>
<th>SAMPLE TYPE NUMBER</th>
<th>RECOVERY % (RD)</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>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2.5</td>
<td></td>
<td>Gravel BASE COURSE</td>
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</tr>
<tr>
<td>5.0</td>
<td></td>
<td>Sandy Silty CLAY (CL), brown, moist, medium stiff</td>
<td>SS 1</td>
<td>66</td>
<td>5-4-3 (7)</td>
<td>13</td>
<td>22</td>
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<td>SHALE, grayish brown, soft, highly weathered</td>
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<td>83</td>
<td>14-25</td>
<td>97</td>
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Bottom of hole at 8.0 feet.
# Boring Number B-13

**Client:** Rolland Engineering  
**Project Name:** 22 Road Improvements  
**Project Location:** Grand Junction, CO  
**Date Started:** 12/11/13  
**Completed:** 12/11/13  
**Drilling Contractor:** S. McKracken  
**Drilling Method:** Simco 2000 Truck Rig  
**Logged By:** NWB  
**Checked By:** MAB  
**Notes:** 39.153, -108.645

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<tr>
<th>Depth (ft)</th>
<th>Material Description</th>
<th>Sample Type</th>
<th>Recovery % (RQD)</th>
<th>Blows (N Value)</th>
<th>Pocket Penetration (in)</th>
<th>Liquid Limit</th>
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<th>Atterberg Limits</th>
<th>Fines Content (%)</th>
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<td>Asphalt</td>
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<td>33</td>
<td>3-4-5</td>
<td>10</td>
<td>6</td>
<td>20</td>
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<td>20</td>
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<tr>
<td>2.5</td>
<td>Gravel Base Course</td>
<td>SS 2</td>
<td>44</td>
<td>1-1-1</td>
<td>2</td>
<td>6</td>
<td>20</td>
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<td>20</td>
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<tr>
<td>5.0</td>
<td>Lean Clay with Sand (ci), brown, moist to wet, stiff to very soft</td>
<td>SS 3</td>
<td>67</td>
<td>1-2-1</td>
<td>3</td>
<td>6</td>
<td>20</td>
<td>20</td>
<td>20</td>
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</table>

Bottom of hole at 9.5 feet.
CLIENT: Rolland Engineering
PROJECT NUMBER: 01042-0006
DATE STARTED: 12/11/13
DATE COMPLETED: 12/11/13
DRILLING CONTRACTOR: S. McKracken
DRILLING METHOD: Simco 2000 Truck Rig
LOGGED BY: NWB
CHECKED BY: MAB
GROUND ELEVATION:
HOLE SIZE: 4 inch
GROUND WATER LEVELS:
\[ \text{At Time of Drilling: } 6.5 \text{ ft} \]
\[ \text{At End of Drilling: } 6.5 \text{ ft} \]
AFTER DRILLING:

<table>
<thead>
<tr>
<th>DEPTH (ft)</th>
<th>MATERIAL DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>ASPHALT</td>
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<td>Gravel BASE COURSE</td>
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<tr>
<td>2.5</td>
<td>Lean CLAY with Silt (d), brown, moist to wet, very stiff to very soft</td>
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<tr>
<td>7.5</td>
<td>Bottom of hole at 9.5 feet</td>
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</table>

Bottom of hole at 9.5 feet.
Bottom of hole at 9.5 feet.
Bottom of hole at 8.5 feet.
APPENDIX D
Previous Lab Testing Results
### GRAIN SIZE DISTRIBUTION

**CLIENT:** City of GJ  
**PROJECT NAME:** Highway B & 22 Road Realignment  
**PROJECT NUMBER:** 00208-0041  
**PROJECT LOCATION:** Grand Junction, CO

---

#### TABLE: GRAIN SIZE IN MILLIMETERS

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<th>Specimen Identification</th>
<th>Classification</th>
<th>LL</th>
<th>PL</th>
<th>PI</th>
<th>Cc</th>
<th>Cu</th>
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<tbody>
<tr>
<td>B-3 SS-1</td>
<td>LEAN CLAY(CL)</td>
<td>40</td>
<td>18</td>
<td>22</td>
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</tr>
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<td>B-8 SS-1</td>
<td>LEAN CLAY(CL)</td>
<td>37</td>
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<td>FAT CLAY(CH)</td>
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<td>Comp 10-12</td>
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<th>%Clay</th>
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<td>2.6</td>
<td>97.4</td>
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## Atterberg Limits Results

**Client:** City of GJ  
**Project Name:** Highway 6 & 22 Road Realignment  
**Project Number:** 00208-0041  
**Project Location:** Grand Junction, CO

### Plots

![Plots](image)

### Table

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<td>18</td>
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<td>B-8 SS-1</td>
<td>11/2012</td>
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<td>18</td>
<td>19</td>
<td>97 LEAN CLAY (CL)</td>
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Sample Date: 11/16/2012
Sample No.: 12-0711
Source of Material: Composite B10- B12
Description of Material: LEAN CLAY(CL)
Test Method: ASTM D698A

TEST RESULTS
Maximum Dry Density 105.8 PCF
Optimum Water Content 18.8 %

GRADATION RESULTS (% PASSING)

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ATTERBERG LIMITS

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<td>19</td>
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Curves of 100% Saturation for Specific Gravity Equal to:

- 2.80
- 2.70
- 2.60
CALIFORNIA BEARING RATIO
ASTM D1883

Project No.: 00208-0041
Project Name: Highway 6 & 22 Road Realignment
Client Name: City of GJ
Sample Number: 12-0711 Location: Composite B10-B12

Compaction Method ASTM D696A

| Maximum Dry Density (pcf): | 105.8 |
| Opt. Moisture Content (%): | 18.8 |
| Sample Condition: | Soaked |
| Remarks: | |

| Blow per Compacted Lift: | 15 | 25 | 56 |
| Surcharge Weight (lbs): | 10.0 | 10.0 | 10.0 |
| Dry Density Before Soak (pcf): | 93.2 | 93.3 | 104.0 |
| Dry Density After Soak (pcf): | 90.4 | 90.6 | 100.5 |
| Moisture Content (%) | Bottom Pre-Test | 16.8 | 15.7 | 15.5 |
| | Top Pre-Test | 17.1 | 16.1 | 15.1 |
| | Top 1" After Test | 27.7 | 27.1 | 28.1 |
| | Average After Soak | 26.3 | 26.9 | 21.9 |
| | Percent Swell After Soak | 3.1 | 3.0 | 3.5 |

Penetration Data

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Corrected CBR @ 0.1" | 0.5 | 0.6 | 0.7 |
Corrected CBR @ 0.2" | 0.4 | 0.6 | 0.6 |

Penetration Distance Correction (in) | 0.000 | 0.000 | 0.000 |

Figure: ___
APPENDIX E
Current Lab Testing Results
### ATTERBERG LIMITS' RESULTS

**CLIENT**: Rolland Engineering  
**PROJECT NAME**: 22 Road Improvements  
**PROJECT NUMBER**: 01042-0006  
**PROJECT LOCATION**: Grand Junction, CO

#### Graph
- Units: CL, CH, ML, MH
- Liquid Limit (LL) vs Plasticity Index (PI)
- Classification:
  - B-1, SS2 12/2013: LL 32, PI 14, Classification: LEAN CLAY (CL)
  - B-12, SS1 12/2013: LL 22, PI 5, Classification: SANDY SILTY CLAY (CL-ML)
  - B-16, SS2 12/2013: LL 38, PI 16
  - B-5, SS1 12/2013: LL 29, PI 11, Classification: LEAN CLAY with SAND (CL)
  - Composite 1 12/2013: LL 28, PI 11, Classification: LEAN CLAY (CL)
  - Composite 2 12/2013: LL 26, PI 10, Classification: LEAN CLAY with SAND (CL)
CONsolidation test

Client: Rolland Engineering

Project Name: 22 Road Improvements

Project Number: 01042-0006

Project Location: Grand Junction, CO

---

**Specimen Identification** | **Classification** | **γd** | **MC%**
--- | --- | --- | ---
B-7 | 7.0 | 100 | 20
Consolidation Test

Client: Rolland Engineering
Project Name: 22 Road Improvements
Project Number: 01042-0006
Project Location: Grand Junction, CO

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Strain, %

Stress, psf
MOISTURE-DENSITY RELATIONSHIP

Sample Date: 12/11/2013
Sample No.: 
Source of Material: Composite-1
Description of Material: LEAN CLAY(CL)
Test Method: ASTM D698A

TEST RESULTS
Maximum Dry Density 114.5 PCF
Optimum Water Content 15.0 %

GRADATION RESULTS (% PASSING):

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<td>11</td>
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Curves of 100% Saturation for Specific Gravity Equal to:

- 2.80
- 2.70
- 2.60
Sample Date: 12/11/2013
Sample No.:
Source of Material: Composite-2
Description of Material: LEAN CLAY with SAND(CL)
Test Method: ASTM D698A

TEST RESULTS
Maximum Dry Density 115.5 PCF
Optimum Water Content 13.5 %

GRADATION RESULTS (% PASSING)

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ATTERBERG LIMITS

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

Compacktion Method: ASTM D698, Method A

Maximum Dry Density (pcf): 114.5
Opt. Moisture Content (%): 15.0
Sample Condition: Soaked
Remarks:

Sample Data

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<th>Point 3</th>
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Penetration Data

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Corrected CBR @ 0.1"

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CALIFORNIA BEARING RATIO
ASTM D1883

Project No.: 01042-0006  
Project Name: 22 Road Improvements  
Client Name: Rolland Engineering  
Sample Number: 13-0728  
Location: Comp 2, B13 - B16

Compaction Method: ASTM D698, Method A

Maximum Dry Density (pcf): 115.5
Opt. Moisture Content (%): 13.5
Sample Condition: Soaked
Remarks:  

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Load Penetration Curve(s)

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Penetration Distance Correction (in)

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<th>Stress (psi)</th>
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Dry Density vs CBR

Corrected CBR @ 0.1"

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Corrected CBR @ 0.2"

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<td>2.5</td>
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Figure:
APPENDIX F
ESAL Calculations
Given: From City of SF
2010 ADT = 6885
2031 ADT = 14750
% Trucks = 17%

Assumptions:
70% of Trucks are Single Axle
30% of Trucks are Combination

Calculate Design ADT
ADT = (6885 + 14750)/2 = 10818

Calculate breakdown of vehicles and multiply by equivalency factors for flexible pavements
Cars / Trucks = (10818)(0.88)(0.003) = 79
Single Unit = (10818)(0.12)(0.7)(0.747) = 726
Combination = (10818)(0.12)(0.3)(1.087) = 423

Calculate Flexible Pavement ESHL's
ESHL's = (79)(365)(Yr)(Yr)/(260,000)(260) = 22,969.640

Calculate breakdown of vehicles and multiply by equivalency factors for rigid pavement
Cars / Trucks = (10818)(0.88)(0.003) = 79
Single Unit = (10818)(0.12)(0.7)(0.785) = 757
Combination = (10818)(0.12)(0.3)(1.679) = 659

Calculate Rigid Pavement ESHL's
ESHL's = (747)(365)(Yr)(Yr)/(260,000)(260) = 4,143,260
Given: From McDowell Engineering

2013 ABT = 1,370
2035 ABT = 11,000
% Trucks = 6%

Assumptions:
- 70% of trucks are single unit
- 30% of trucks are combination

Calculate ABT in 2015 assuming 4% growth 2013 to 2015

ABT_{2015} = (1,370)(1.04)^3 = 1,482

Calculate ABT at Midpoint

ABT = (1,482 + 11,000) / 2 = 6,241

Calculate breakdown of vehicles and multiply by equivalency factors for flexible pavements

Cars/Trucks = (6,241)(0.99)(0.003) \approx 18

Single Unit = (6,241)(0.06)(0.3)(0.29) \approx 66

Combination = (6,241)(0.06)(0.3)(1.69) \approx 172

Calculate flexible pavement ESL's

ESL's = (306)(365 days/yr)(30 yr)(0.6) \approx 902,280

1 lane each direction

Calculate breakdown of vehicles and multiply by equivalency factors for rigid pavement

Cars/Trucks = (6,241)(0.99)(0.003) \approx 18

Single Unit = (6,241)(0.06)(0.3)(0.29) \approx 78

Combination = (6,241)(0.06)(0.3)(1.69) \approx 190

Calculate rigid pavement ESL's

ESL's = (303)(365 days/yr)(30 yr)(0.6) \approx 1,239,540
Given: From McDowell Engineering

2013 ADT = 560
2035 ADT = 3,800
% Trucks = 6%

Assumptions:
- 20% of trucks are single unit
- 30% of trucks are combination

Calculate ADT in 2035 assuming 4% growth from 2013 to 2035

\[
\text{ADT}_{2035} = (560)(1.04)^3 = 606
\]

Calculate ADT at midpoint

\[
\text{ADT} = \frac{(606 + 3,800)}{2} = 2,203
\]

Calculate breakdown of vehicles and multiply by equivalency factors for flexible pavements

Cars/Trucks = \(2,203 \times (0.91)(0.003)\) = 7
Single Unit = \(2,203 \times (0.06)(0.9)(0.047)\) = 73
Combination = \(2,203 \times (0.06)(0.3)(1.067)\) = \(74\)

Calculate flexible pavement ESAL's

\[
\text{ESAL}^2 = (74)(365 \text{ days/yr})(20 \text{ yr})(0.6) = 324,120
\]

Calculated each direction

Calculate breakdown of vehicles and multiply by equivalency factors for rigid pavements

Cars/Trucks = \(2,203 \times (0.91)(0.003)\) = 7
Single Unit = \(2,203 \times (0.06)(0.9)(0.085)\) = 77
Combination = \(2,203 \times (0.06)(0.3)(1.69)\) = \(67\)

Calculate rigid pavement ESAL's

\[
\text{ESAL}^2 = (101)(365 \text{ days/yr})(20 \text{ yr})(0.6) = 443,380
\]
Given: From McDowell Engineering

2013 ADT = 400
2035 ADT = 1,500
% Trucks = 6%

Assumptions:
70% of trucks are single unit
30% of trucks are combination

Calculate ADT in 2015 assuming 4% growth 2013 to 2015

\[ \text{ADT}_{2015} = (400)(1.04)^2 = 433 \]

Calculate ADT at midpoint

\[ \text{ADT} = \frac{(433 + 1500)}{2} = 967 \]

Calculate breakdown of vehicles and multiply by equivalency factor for flexible pavements

\[ \begin{align*}
\text{LC/Trucks} &= (967)(0.79)(0.003) \approx 3 \\
\text{Single Unit} &= (967)(0.06)(0.14)(0.11) \approx 11 \\
\text{Combination} &= (967)(0.06)(0.3)(1.03) \approx \frac{19}{33}
\end{align*} \]

Calculate flexible pavement ESL’s

\[ \begin{align*}
\text{ESL}_F &= (33)(365 \text{ days/yr})(50 \text{ yr})(0.6) = 144,540 \\
\text{1 lane each direction}
\end{align*} \]

Calculate breakdown of vehicles and multiply by equivalency factors for rigid pavements

\[ \begin{align*}
\text{LC/Trucks} &= (967)(0.79)(0.003) \approx 3 \\
\text{Single Unit} &= (967)(0.06)(0.14)(0.11) \approx 11 \\
\text{Combination} &= (967)(0.06)(0.3)(1.03) \approx \frac{30}{45}
\end{align*} \]

Calculate rigid pavement ESL’s

\[ \begin{align*}
\text{ESL}_R &= (45)(365 \text{ days/yr})(50 \text{ yr})(0.6) = 19,7100
\end{align*} \]