CHAPTER VII

SOILS

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CHAPTER VII  SOILS

VII.A  ENVIRONMENTAL BASELINE DESCRIPTION

VII.A.1  SCOPE OF INVESTIGATION

U.S.D.A. Soil Conservation Service (SCS) soil mapping "Soil Survey of Carbon-Emery Area, Utah 1970" was used as the base data in this investigation. The portions of the permit area to be affected by surface disturbance were remapped to approximate an order I intensity soil survey. Some complexes mapped by the U.S.D.A. Soil Conservation Service were delineated as monotaxonomoic units. All areas in this investigation are in Township 22S, Range 6E, Emery County, Utah.

The following contractor's and/or agencies conducted the remapping:

- James P. Walsh & Associates, Inc. of Boulder, Colorado remapped approximately 1,670 acres in March of 1981 within Section 27, 28, 32, 33 and 34.

- Harner-White Ecological Consultants, Inc. of Littleton, Colorado, remapped approximately 320 acres in July of 1981 within Section 28 and 32.

- U.S.D.A. Soil Conservation Service, Carol D. Franks, Soil Scientist of Price, Utah remapped approximately 5 acres in October of 1988 within Section 30.
VII.A.2 METHODOLOGY

Soil mapping was conducted according to the standards of the National Cooperative Soil Surveys (USDA, Soil Survey Staff, 1951; USDA, SCS, 1975).

Soil mapping unit descriptions are either directly from the SCS, refined to be site specific and/or units developed specifically for the proposed surface disturbance area. New map units were developed in the case of several soil units for which no SCS map unit descriptions were appropriate. One profile for each major series was sampled and described. P vegetable cover, were done at each sample point. Soil pits were excavated to 60 inches or more; soil pedons were described and sampled according to the standards of the National Cooperative Soil Surveys.

Physical and chemical analyses of the major series were conducted by Utah State University Cooperative Soils Laboratory, Logan, Utah. All horizons were analyzed for the following: particle size distribution, textural class, saturated paste pH, percent organic carbon, percent gypsum, electrical conductivity (EC), moisture tension at saturation and 15 atmospheres, water soluble cations (Ca, Mg and Na), SAR and boron.

Soil series in the areas to be affected were evaluated as sources of reconstruction material. Soil analysis, on-site information and soil interpretation records (SCS) were used in this evaluation. The criterion used in this determination are those outlined in the National Soils Handbook (USDA, SCS, 1976). Available topsoil depth and restrictive features are given for each soil occurring in areas to be disturbed.

Water and wind erodibility in areas to be affected were evaluated. The wind erodibility group (WEG) was determined for each map unit within the area to be disturbed. The soil erodibility factors (K) of surface soils, and cropping factor (C) were calculated for major soils in the detailed mapping area. This information is needed for reclamation planning to control loss of salvaged and redressed material.
VII.A.3. SOIL SERIES/SOIL MAPPING UNIT DESCRIPTIONS

3.1 Alluvial Land (Sample Site No. 31) (J. Walsh)
   Alluvial Land 0 to 3% Slope (Aw)

3.2 Badland (Ba) (J. Walsh)

3.3 Beebe Variant (Sample Site No. 27) (J. Walsh)
   Beebe Fine Sandy Loam 0 to 3% Slope (BeB)

3.4 Billings Series (J. Walsh)
   Billings Silty Clay Loam 1 to 3% Slope (BLB)
   Billings Silty Clay Loam 1 to 6% Slope (BLC2)
   Billings Silty Clay Loam 1 to 6% (C. Franks)

3.5 Bunderson Series (J. Walsh)
   Bunderson Series (Harner-White)
   Bunderson (Bu)

3.6 Castle Valley Series (J. Walsh)
   Castle Valley Extremely Stony Very Fine Sandy Loam 0 to 20% Eroded (CeE2)

3.7 Chipeta Series (Sample No. 1) (J. Walsh)
   Chipeta Series (Harner-White)
   Chipeta-Badland Association 3 to 30% Slope, Eroded (CBF2)
   Chipeta-Persayao Complex 1 to 8% Slope Eroded (CPB2)

3.8 Disturbed Land (Sample Site No. 03) (J. Walsh)
   Disturbed Land 0 to 15% Slope (DL)

3.9 Ferron Series (Sample Site No. 19) (J. Walsh)
   Ferron Silt Loam, Heavy Variant 0 to 3% Slope (Fe)

3.10 GP Series (Sample Site No. 06) (J. Walsh)
    GP Series (Harner-White)
    GP Silt Loam 0 to 12% Slope (GP)

3.11 Gullied Land, Variable Slope (GU) (J. Walsh)

3.12 Hunting Series (Sample Site No. 10) (J. Walsh)
    Hunting Series (Harner-White)
    Hunting Clay Loam, 0 to 5% Slope (Hn)
    Hunting Clay Loam, Moderately Saline 1 to 3% Slope (Hs)

3.13 Ildefonso Series (J. Walsh)
    Ildefonso Loam 3 to 30% Slope (ILD2)
VII.A.3. SOIL SERIES/SOIL MAPPING UNIT DESCRIPTIONS (cont.)

3.14 Persayo Series (Sample Site No. 20) (J. Walsh)
   Persayo Series (Harner-White)
   Persayo-Chipeta Complex 1 to 20% Slope (PCE2)

3.15 Rafael Series (J. Walsh)
   Rafael Silty Clay Loam 1 to 3% Slope (Ra)

3.16 Ravola Series (Sample Site No. 02) (J. Walsh)
   Ravola Series (Harner-White)
   Ravola - Bunderson Complex 1 to 3% Slope Eroded (RuB2)

3.17 Rockland (RY) (J. Walsh)

3.18 Saltair Series (J. Walsh)
   Saltair Silty Clay Loam 0 to 30% Slope (Sa)

3.19 Killpack Series (J. Walsh)
   Killpack Silty Clay Loam, 0 to 3% Slope (KLB)
VII.A.3.1 Alluvial Land

Sample Site No. 31

Alluvial land is a miscellaneous land type, comprising coarse-loamy and sandy, mixed, mesic families of Typic Torrifluvents, Typic Torripsamments, Typic Fluvaquents, and Typic Salorthids. A representative profile (#31) of a coarse-loamy, mixed, mesic, Typic Salorthid, about 2,140 feet west and 865 feet north of the southeast corner of section 29, T22S, R06E, Emery County, Utah, at an elevation of 5,958 feet is:

A2 0 to 5 in. light brownish gray (2.5Y 6/2) fine sand, grayish brown (2.5Y 5/2) moist; moderate medium to coarse angular blocky structure; slightly hard, very friable, non-sticky and non-plastic; few fine and coarse roots; calcareous; moderately alkaline (pH 8.0); clear smooth boundary.

C1 5 to 20 in. light brownish gray (2.5Y 6/2) find sand, dark grayish brown (2.5Y 4/2) moist; weak coarse angular blocky parting to single grain; soft, very friable, non-sticky and non-plastic; few fine and medium roots, several coarse roots; calcareous; strongly alkaline (pH 8.8); clear smooth boundary.

C2sa 20 to 30 in. light brownish gray (2.5Y 6/2) medium sand, dark grayish brown (2.5Y 4/2) moist; weak coarse angular blocky parting to single grain; soft, very friable, non-sticky and non-plastic; few fine roots; many coarse prominent mottles on ped surfaces, root channels and pores; calcareous; moderately alkaline (pH 8.1); gradual smooth boundary.

C3sa 30 to 45 in. light brownish gray (2.5Y 6/2) sandy loam, dark grayish brown (2.5Y 4/2) moist; weak coarse angular blocky structure; friable, slightly sticky and slightly plastic; few fine roots concentrated along sandy layers; common coarse distinct mottles (5YR 4/4, N4/) on ped faces and pores; lenses of material similar to above horizon; calcareous; strongly alkaline (pH 8.6); standing water at 45 in.

There are a few salt spots on the surface and some salt crusting to a depth of 1/2 in. is visible. Salt crystals have a nodular habit. The texture of the stratified material ranges from fine to sandy depending on adjacent erosional surfaces and landscape position.

Map Unit: Aw - Alluvial Land, 0 to 3 Percent Slopes

This map unit is on nearly level to gently sloping flood plains. The slope is 0 to 3 percent. The native vegetation is mainly salt cedar (tamarisk) and greasewood.
VII.A.3.1 Alluvial Land (cont.)

Included in this map unit are about 60 percent sandy families of Typic Torripsamments, and 40 percent coarse-loamy families of Typic Salorthids, Typic Fluvaquents and Typic Torrifluvents.

The sampled soil is a deep, saline affected, medium to coarse textured, and somewhat poorly-drained Typic Salorthid. It is formed in mixed alluvium. Typically, the surface layer has about a 1/2 in. salt crust or slightly hard, medium platy structure. Below this is a light brownish gray fine sand or very fine sandy loam about 4 inches thick. The substratum to a depth of 45 inches or more is stratified and usually mottled, light grayish brown fine sandy loam, or coarse or medium sand.

Permeability of this alluvial land soil is moderately rapid. Available water capacity is moderate. Effective rooting depth is greater than 30 inches. Runoff is moderate to rapid and the erosion hazard for water is high. Wind erosion hazard is severe.

The unit is mainly used for rangeland in places where gully walls are not too steep. It is also used for wildlife habitat. This map unit is in capability unit VIw (non-irrigated); wet stream bottom range site.
VII.A.3.2  Badland

Map Unit: Ba - Badland

Badland consists of nearly bare to barren, strongly sloping to very steep, actively eroding shales. Some areas consist of erosional areas derived from interbedded shales with sandstones and occasional small sandstone-capped hills. Numerous channels of intermittent streams form a branching pattern in most places. Mapped with Badland are inclusions of Chipeta and Persayo soils in the drainageways.

The soil material is dominantly eroded clays, usually shallow, over calcareous shale. Shale colluvium or shale outcrops are distinguishing features. Vegetation is nearly non-existent; the productivity is low and therefore limited in uses. This map unit is in capability unit VIIIs (non-irrigated), and is not rated for range site.
VII.A.3.3 Beebe Variant

Sample Site No. 27

The Beebe variant is a member of the coarse-loamy, mixed, mesic family of Typic Torrifluvents. A representative profile (#27) of Beebe fine sandy loam, 645 feet west, 2,530 feet north of the southeast corner of section 32, T22S, R06E, Emery County, at an elevation of 5,936 feet is:

A1 0 to 9 in. pale brown (10YR 6/3) very fine sandy loam, light yellowish brown (10YR 6/4) moist; moderate very thin platy and fine granular structure; soft, very friable, non-sticky and non-plastic; common very fine, fine, and medium roots; moderately alkaline; (pH 8.4); clear wavy boundary.

AC 9 to 20 in. light yellowish brown (10YR 6/4) loamy sand, light yellowish brown (10YR 6/4) moist; weak very fine angular blocky parting to very fine granular and single grain structure; slightly hard, very friable, non-sticky and non-plastic; very few clay films bridge sand grains; common medium roots, few coarse roots; very strongly alkaline (pH 9.4); diffuse boundary.

C1 20 to 51 in. pale brown (10YR 6/3) loamy sand, light yellowish brown (10YR 6/4) moist; weak very fine granular structure parting to very fine single grain; slightly hard, very friable, non-sticky and non-plastic; few coarse, fine and very fine roots; pockets of coarse sand about 1 in. thick at 35 to 40 in. in depth; very strongly alkaline (pH 10.1); clear smooth boundary.

C2cas 51 to 65 in. very pale brown (10YR 7/3) sandy loam, light yellowish brown (10YR 6/4) moist; weak very fine granular structure parting to single grain; soft, very friable, non-sticky and slightly plastic; 15 to 20 percent calcareous gravels; some salt accumulations on pit walls; strongly alkaline (pH 8.8).

Some profiles have very fine sandy loam throughout. The substratum may be strongly calcareous and contain stratified layers of coarse sand and cobbly sand. The profile sampled has about 12 percent less sand than allowed for sandy families; this pedon is therefore classified as a member of the coarse-loamy family. The area was originally mapped by the SCS as the Beebe series.

Exchangeable sodium ranges from 20 to 70 percent within 20 inches of the surface in non-irrigated areas of these soils. The content of lime ranges from 3 to 20 percent. The reaction is mildly to very strongly alkaline. Unless irrigated, the soils are usually dry when not frozen. In the A1 horizon, hue ranges from 10YR to 7.5YR; value is 5 to 6 when the soils are dry and 4 to 6 when they are moist; chroma ranges from 2 to 4. In some places the A1 has been silted by irrigation water. The control section has textures ranging from fine sand to loam, but generally is loamy fine sand. In this part of the profile, the hue ranges from 10YR to 7.5YR; value is 6 or 7 when the soils are dry and 4 or 5 when they are moist; and chroma ranges from 3 to 5.
VI.3.3 Beebe Variant (Cont).

Map Unit BeB - Beebe Fine Sandy Loam, 0 to 3 Percent Slopes

This map unit is on alluvial fans and flood plains. The slope is 0 to 3 percent. The native vegetation is mainly greasewood, rabbitbrush, shadscale, some big sage and four-wing saltbush.

Included in this map unit is about 10 percent Ravola-Bunderson complex and areas where Beebe has a surface layer of loam or light sandy clay loam. Included areas make up about 12 percent of the total acreage.

Typically, the surface layer is a pale brown, slightly calcareous, very fine sandy loam about 7 inches thick. The underlying material is a light yellowish brown loamy fine sand that is weakly stratified with layers of loam, fine sand or sandy loam.

This soil is similar to the Beebe loam in use and productivity. The surface texture is more coarse; the subsoil may differ slightly in sand content.
VII.A.3.4 Billings Series

The Billings series is a member of the fine-silty, mixed (calcareous), mesic family of Typic Torrifluvents. A representative profile (Swenson et al., 1970) of a Billings silty clay loam in a nearly salt-free cultivated field, 2,000 feet west and 600 feet north of the southeast corner of section 20, T17S, R9E, in Emery County, Utah, is:

Ap1 0 to 3 in. light brownish gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; weak medium granular structure; hard, firm, sticky and plastic; plentiful medium roots; common medium pores; strongly calcareous; moderately alkaline (pH 7.9); clear smooth boundary.

AP2 3 to 11 in. light brownish gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; weak fine angular and subangular blocky structure; hard, firm, sticky and plastic; plentiful medium roots; common fine pores; strongly calcareous; moderately alkaline (pH 8.0); clear smooth boundary.

C1 11 to 18 in. light brownish gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; weak fine angular and subangular blocky structure; hard, firm, sticky and plastic; few fine roots; few fine pores; strongly calcareous; mildly alkaline (pH 7.8); gradual wavy boundary.

C2 18 to 42 in. light brownish gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; weak coarse subangular blocky structure; hard, firm, sticky and plastic; few fine roots; few fine, discontinuous pores; strongly calcareous; few soft gypsum nodules; mildly alkaline (pH 7.6); diffuse boundary.

C3 42 to 58 in. light brownish gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; massive; hard, firm, sticky and plastic; few fine roots; few fine discontinuous pores; few fine, light grayish brown (10YR 6/2) soft gypsum nodules; strongly calcareous; moderately alkaline (pH 8.0).

Salinity and alkalinity range from slight to strong, and the content of lime ranges from 5 to 25 percent. The content of gypsum in the lower C horizon ranges from 0.5 to 25 percent; gypsum nodules and crystals occur in this horizon. Clay minerals are mixed but are mainly illite and kaolinite. Unless irrigated, the soils are generally dry when not frozen. Distinct mottles occur in the moderately well drained areas at depths below 36 inches. The A1 horizon has a hue of 2.5Y to 5Y. Value in this horizon is 6 to 7 when the soils are dry and 4 or 5 when they are moist; and chroma ranges from 2 to 4. The part of the profile between 10 and 40 inches is silty clay loam to clay loam and contains 27 to 35 percent clay and 15 percent sand that is coarser than very fine sand. The color of the upper 40 inches is similar to that of the A1 horizon. Crystals, veins or soft nodules of gypsum are visible below 20 inches. There may be up to 20 percent gravels on the surface.

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VII.A.3.4 Billings Series (Cont)

Map Unit: B1B - Billings Silty Clay Loam, 1 to 3 Percent Slopes

This map unit is on level to nearly level slopes of alluvial fans, flood plains, and narrow alluvial valleys. The slope is 1 to 3 percent. The native vegetation is mainly greasewood, shadscale, galleta grass and Indian rice grass.

Included in this map unit is about 10 percent Bunderson fine sandy loam and 5 percent Hunting, strongly alkaline phase. Included areas make up about 15 percent of the total acreage.

The Billings soil is deep, well-drained, and moderately fine textured. It is formed in alluvium washed from alkaline gypsum-bearing marine shale. Typically, the surface layer is a light brownish gray, strongly calcareous, hard silty clay loam about 11 inches thick. The underlying material is a light brownish gray, gypsiferous, stratified silty clay loam, loam, or clay loam. Gypsum as veins, crystals or soft nodules is visible below 20 inches.

Permeability of the Billings soil is slow. Available water capacity is moderate to moderately high. Effective rooting depth is 40 inches or more. Runoff is medium and the erosion hazard for water is moderate. Wind erosion hazard is moderate.

The unit is mainly used for rangeland. It is in some places also used for irrigated cropland. The potential productivity is 725 and 325 pounds of air-dry vegetation in favorable and unfavorable years, respectively. This map unit is in capability unit VIIe (non-irrigated), IIIe (irrigated), desert loam range site.

Map Unit: BLC2 - Billings Silty Clay Loam, 1 to 6 Percent Slopes, Eroded

This map unit is on nearly level to gently sloping alluvial fans. In many places it is below nearly bare shale hills. Surface runoff from these shale hills is rapid and causes sheet and gully erosion. This map unit is similar to the B1B, except that it is eroded and occurs on steeper slopes. In some places gullies have formed. The slope range is 1 to 6 percent. The native vegetation is mainly greasewood, shadscale, galleta grass and Indian rice grass.
VII.A.3.4 Billings Series (Cont)

Included in this map unit is about 10 percent Bunderson fine sandy loam and some strongly saline and alkali spots. Included areas make up about 15 percent of the total acreage.

Typically, the surface layer is a light brownish gray, strongly calcareous, silty clay loam about 11 inches thick but is eroded. The underlying material is a light brownish gray, gypsiferous, stratified silty clay loam, loam, or clay loam. Gypsum as veins, crystals or soft nodules is visible below 20 inches. Gullies may be 3 to 10 feet deep and 100 to 500 feet apart.

This unit is mainly used for spring and fall range; where it is not eroded, it is used for irrigated alfalfa and grass.

The potential productivity is 725 and 325 pounds of air-dry vegetation in favorable and unfavorable years, respectively. This map unit is in capability unit VIIe (non-irrigated); desert bottom loam range site.

Map Unit:  BLC2 - Billings Silty Clay Loam, 1 to 6 Percent Slopes, Eroded (By Carol D. Franks, Soil Scientist, U.S.D.A. Soil Conservation Service, Price, Utah October 26, 1988)

The soil at the proposed pond site, T22S, R6E, Section 30 is BLC2 -- Billings silty clay loam, 1 to 6 percent slopes, eroded. The range site is Greasewood Shrubland. The range condition is poor and in a declining trend due to erosion on the site.

On-Site Investigation:

Soil

Typically, the surface layer is light brownish gray silty clay loam, nonsaline, 3 inches thick. The upper 29 inches of the substratum is light brownish gray silty clay loam, slightly saline. The lower part to a depth of 60 inches or more, is light brownish gray clay loam, slightly saline.

The topsoil is approximately 3 inches thick, which is typical of this desert soil. The substratum is the same or similar texture as the topsoil with only a slight increase in salinity (approximately 4 millimhos total) and is suitable for use as a topsoil substitute.
VII.A.3.5 Bunderson Series

The Bunderson series is a member of the fine-silty, mixed (calcareous), mesic family of Typic Torrifluvents. A representative profile (#04) of Bunderson very fine sandy loam, 1700 feet west, 530 feet south of the northeast corner of section 32, T22S, R06E, Emery County, Utah, at an elevation of 5,924 feet is:

A1  0 to 4 in. light grayish brown (2.5Y 6/2) very fine sandy loam; grayish brown (2.5Y 5/2); moderate thin platy to fine granular structure; loose, very friable, slightly sticky and slightly plastic; many very fine and fine roots; very fine cracks in surface; strongly calcareous; moderately alkaline (pH 8.3); gradual smooth boundary.

C1cacs  4 to 14 in. light brownish gray (2.5 6/2) silty clay loam, grayish brown (2.5Y 5/2) moist; moderate fine angular blocky structure parting to fine granular; soft, very friable, sticky and plastic; common coarse roots, many fine and very fine roots; strongly calcareous; secondary calcium carbonate crystals in pores and in small pockets; gypsum crystals intermixed with lime; moderately alkaline (pH 8.5); gradual smooth boundary.

C2ca  14 to 43 in. light brownish gray (2.5Y 6/2) heavy silty clay loam, grayish brown (2.5Y 5/2) moist; moderate fine angular blocky structure parting to fine granular; soft, very friable, sticky and plastic; common medium, fine, and very fine roots; white powdery lime concretions; strongly calcareous; strongly alkaline (pH 8.6); gradual smooth boundary.

C3cs  43 to 62+ in. grayish brown (2.5Y 5/2) silty clay, dark grayish brown (2.5Y 4/2) moist; moderate fine angular blocky structure; soft, friable, sticky and plastic; few very fine roots; powdery lime concretions; common gypsum crystals; strongly calcareous; few fine distinct mottles; strongly alkaline (pH 8.6).

The depth of the surface horizon ranges from 2 to 5 in. The texture ranges from very fine sandy loam to silty clay. The surface horizon has very fine cracking. Subsurface cracking is rare but may be found as deep as 22 in. and 1/2 to 3/4 in. wide. Some horizons have very gravelly veins and mottling below 15 in. The substratum is grayish brown silty clay loam, silt loam, clay loam or clay.

Exchangeable sodium is usually the greatest in the upper part of the profile and decreases with depth. Salinity ranges from moderate to strong. Lime content ranges from 5 to 25 percent. The soils are generally dry when not frozen. The A1 horizons have a hue of 2.5Y to 5Y; value of 6 or 7 when dry and 4 or 5 when moist; the chroma ranges from 2 to 4. The control section is loam or silt loam, which contains 18 to 27 percent clay and less than 15 percent sand coarser than very fine sand. Color of the upper 40 inches is about the same as that of the A1 horizons. This pedon contains a few percent more medium and coarse sands than allowed for members of the fine-silty family.
VII.A.3.5  Bunderson Series (Cont)

Bunderson

Location: 250 Feet South, 300 feet West of the North 1/4 corner of Section 32, T22S, R06E, Emery County, Utah

By (Harner-White)

A1  0-5 inches - Light greyish brown (2.5 6/2) very fine sandy loam; greyish brown (2.5Y 5/2) moderate thin platy to fine granular structure; soft dry, very friable moist, sticky, plastic; very fine cracks in surface; strongly calcareous; moderately alkaline (pH 8.3); gradual smooth boundary.

C1cacs  5-14 inches - Light brownish grey (2.5 6/2) silty clay loam, greyish brown (2.5Y 5/2) moist; moderate fine angular blocky structure parting to fine granular; soft dry, very friable moist; sticky, plastic; strongly calcareous; secondary calcium carbonate crystals in pores and in small pockets; gypsum crystals intermixed with lime; moderately alkaline (pH 8.5); gradual smooth boundary.

C2cs  14-15 inches - Light brownish grey (2.5Y 6/2) fine silty clay loam; greyish brown (2.5Y 5/2) moist; moderate fine angular blocky structure parting to fine granular; soft dry, very friable moist, sticky, plastic, white powdery lime concretions; strongly calcareous; strongly alkaline (pH 8.6); gradual smooth boundary.

C3cs  45-60 plus inches - Greyish brown (2.5Y 5/2) silty clay, dark greyish brown (2.5Y 4/2) moist; moderate fine angular blocky structure; soft dry, friable moist, sticky, plastic, powdery lime concretions; common gypsum crystals, strongly calcareous; few fine distinct mottles, strongly alkaline (pH 8.6).
The Castle Valley series is a member of the loamy, mixed, mesic family of Lithic Xerollic Haplargids. A representative profile (#35) of Castle Valley very fine sandy loam, 170 feet west, 765 feet south center of section 27, T22S R.06E, Emery County, Utah at an elevation of 6,095 feet is:

A1  0 to 4 in. light gray (10YR 7/2) fine sandy loam, light yellowish brown (10YR 6/4) moist; moderate very fine platy structure; soft, very friable, slightly sticky and slightly plastic; calcareous; strongly alkaline (pH 8.7); clear wavy boundary.

B2t  4 to 10 in. brownish yellow (10YR 6/6) loamy coarse sand, brownish yellow (10YR 6/6) moist; strong medium and coarse angular blocky structure; hard to very hard, very friable, non-sticky and non-plastic; clay bridges sand grains; calcareous; mildly alkaline (pH 8.1); abrupt wavy boundary.

C1ca  10 to 12 in. very pale brown to white (10YR 7/3, 8/1) sand, light yellowish brown (10 YR 6/4) moist; single grain; loose, very friable, non-sticky and non-plastic; calcareous; mildly alkaline (pH 8.1); abrupt wavy boundary.

Cr-R  12 to 45 in. soft rippable shale intermixed with hard fractured sandstone.

The thickness of the A1 ranges from 3 to 7 in. Depth to sandstone bedrock ranges from 10 to 20 in.; 15 to 17 in. is average for this site. Some profiles have 30 to 70 percent stones and gravels throughout. The percentage of these fragments is usually highest near rockland. The control section in some profiles is very fine sandy loam over bedrock. The surface texture ranges from loamy sand to fine sandy loam and is usually 2 to 4 in. thick. The underlying material may be gravelly very fine sandy loam to very gravelly loam. The B2t has a hue of 10YR or 2.5YR; value is 5 to 7 moist and 4 to 6 dry; chroma ranges from 3 to 6.
VII.A.3.6 Castle Valley Series (Cont.)

Map Unit: CeE2 - Castle Valley Extremely Stony Very Fine Sandy Loam, 0 to 20 Percent Slopes, Eroded

This map unit is on steep to gently sloping soils on upland benches, mesas and piedmont surfaces. The slope range is 0 to 20 percent. The native vegetation is mainly pinyon, juniper, galleta grass, and Indian ricegrass.

Included in this map unit is about 15 percent rock outcrop, rockland and areas with less than 4 inches of soil overlying bedrock, and some soils deeper than 20 inches.

The Castle Valley soil is shallow, calcareous, well-drained, and medium-to coarse-textured. It is formed in weathered material derived from interbedded shale and sandstone. The surface layer is an extremely stony very fine sandy loam about 4 inches thick. The subsoil is a brown to brownish yellow very fine sandy loam or gravelly very fine sandy loam about 8 inches thick. Sandstone bedrock is at a depth of 8 to 18 inches. In places wind erosion has removed as much as half the surface layer.

Permeability of the Castle Valley soil is moderately rapid. Available water capacity is moderately high. Effective rooting depth is about 8 to 18 inches; some roots spread horizontally above hard bedrock. Runoff is slow to moderate; in rocky areas it is high. The erosion hazard for water is slight to high. Wind erosion hazard is slight to severe.

This unit is mainly used for spring and fall range. It is also used for wildlife habitat. Fenceposts are cut from juniper in favorable sites. The potential productivity is 725/500/325 pounds of air-dry vegetation in favorable/normal/ and unfavorable years, respectively. This map unit is in capability unit VII (non-irrigated), semi-desert shallow loam range site.
VII.A.3.7 Chipeta Series

The Chipeta series is a member of the clayey, mixed (calcareous), mesic, shallow family of Typic Torriorthents. A representative profile (#01) of Chipeta gravelly silty clay loam, 400 feet east, 575 feet south of the northwest corner of section 33, T.22S R.06E, Emery County, Utah, at an elevation of 5,980 feet is:

A1 0 to 2 in. light gray (2.5Y 7/2) gravelly heavy silty clay loam, light brownish gray (2.5Y 6/2) moist; weak thin platy parting to single grain structure; loose, friable, sticky and plastic; few fine and very fine roots; 15 percent gravels; calcareous; powdery lime accumulations in matrix; mildly alkaline (pH 7.7); clear smooth boundary.

AC 2 to 11 in. light brownish gray (2.5Y 6/2) silty clay, grayish brown (2.5Y 5/2) moist; moderate fine angular blocky and thin platy structure; soft, very friable, sticky and very plastic; common medium roots, very few coarse roots; calcareous; some pockets of lime in matrix and lining pores; mottles in lower portion of horizon are few, fine faint (10YR 6/4) moderately alkaline (pH 8.4); clear smooth boundary.

Crcs 11 to 19 in. grayish brown (2.5Y 5/2) moist clay; strong thin to coarse platy structure; slightly hard, firm, sticky and plastic; common fine and very fine roots; strongly calcareous; powdery lime filaments about ped faces; abrupt smooth boundary (not sampled).

R 19+ in. shale.

In areas below Shaley Outcrop-Colluvial land or Badland, the profile is about 4 to 11 inches deep. Surface cracking is common in some places and polyhedrons may be up to 1 1/2 in. thick and 3/4 in. wide when dry. Up to 35 percent gravels may be present on the surface.

Salinity ranges from moderate to strong. Depth to shale ranges from 10 to 20 inches. Unless irrigated, the soils are generally dry when not frozen. In the A horizon, the hue ranges from 2.5Y to 5Y; value ranges from 6 to 8 dry and 4 to 6 moist; the chroma is 1 or 2. The part between 10 inches and shale is heavy silty clay loam to light clay that contains more than 35 percent clay. Hue in this part ranges from 2.5Y to 5Y; value is 5 or 6 dry and 4 or 5 moist; the chroma is 1 or 2. The content of gypsum in the Crcs horizon ranges from .5 to 11 percent. Gypsum crystals are few to common.
VII.A.3.7 Chipeta Series (Cont)

Chipeta

Location: 1280 feet West, 1190 feet North of the Center of Section 32, T22S, R06E, Emery County, Utah.

By (Harner-White)

A1 0-4 inches - Light grey (2.5Y 7/2) gravely fine silty clay loam, light brownish grey (2.5Y 6/2) moist; weak medium platy structure soft dry; friable moist; sticky, plastic; calcareous, mildly alkaline (pH 7.6); clear smooth boundary.

Ac 4-6 inches - Light brownish grey (2.5Y 6/2) silty clay, greyish brown (2.5Y 5/2) moist; moderate fine subangular blocky; soft dry; friable moist; sticky, plastic; calcareous; moderately alkaline (pH 8.4); clear smooth boundary.

Crcs 6-12 inches - Greyish brown (2.5Y 5/2) clay loam, dark greyish brown (2.5Y 4/2) moist; strong thin to thick platy structure; slightly hard dry; friable moist; sticky, plastic; strongly calcareous; moderately alkaline (pH 8.4); clear smooth boundary.

R 19 plus inches - Soft weathered shale.
VII.A.3.7  Chipeta Series (Cont.)

Map Unit: CBF2 - Chipeta-Badland Association, 3 to 30 Percent Slopes, Eroded

This map unit is on steep to strongly sloping broad fans, ridges, and sandstone and shale hills. The slope range is 3 to 30 percent. The native vegetation consists of scattered shadscale and mat saltbush.

This unit is 50 percent Chipeta channery silty clay loam, and about 40 percent Badland.

Included in this map unit is about 5 percent Shale outcrop-colluvial land and 5 percent Persayo loam. Included areas make up about 100 percent of the total acreage.

The Chipeta soil is shallow, somewhat poorly to moderately well-drained, and moderately fine textured. It is formed in residuum derived from marine shale. Typically, the surface horizons are highly eroded and severely cracked; the surface soil is thin, about 2 inches thick. Light gray and light grayish brown heavy silty clay loams and silty clays overlie soft weathered shale. A paralithic contact is encountered at about 17 to 19 inches.

Permeability of the Chipeta soil is moderately slow. Available water capacity is moderate. Effective rooting depth is about 12 to 16 inches. Runoff is rapid and the erosion hazard for water is high. Wind erosion hazard is moderate to high.

The Badland, a miscellaneous land type, consists of nearly barren, strongly sloping to very steep, actively eroding shale, interbedded sandstones and shales, and small sandstone capped-hills. Badland is in the Blue Gate shale member of the Mancos shale.

This unit is not well-suited to range. The potential productivity is 400 and 150 pounds of air-dry vegetation in favorable and unfavorable years. The Chipeta is in capability unit VIIe (non-irrigated); desert shale range site. The Badland is in capability unit VIIIIs, and is not rated for range site.

Map Unit: CPB2 - Chipeta-Persayo Complex, 1 to 8 Percent Slopes, Eroded

This map unit is on gently sloping to moderately steep slopes on broad fans and ridges. The slope range is 1 to 8 percent. The native vegetation is mainly shadscale, mat saltbush, and galleta grass.

This unit is 60 percent Chipeta very gravelly silty clay loam, and 25 percent Persayo very fine sandy clay loam. The two soils are intermingled and do not occur in any identifiable pattern on the landscape.
VII.A.3.7 Chipeta Series (Cont.)

Included in the mapping are some areas of very shallow unnamed soils. Also included are other soils that are 20 to 40 inches thick over shale and small areas, generally less than 1 acre in extent, of strongly saline/alkalai soils. Included areas make up about 15 percent of the total acreage.

The Persayo soil is shallow, well-drained and moderately fine textured. It is formed in residuum weathered from shale. Typically, the surface layer is a very fine sandy clay loam about 12 to 20 inches thick. The Persayo soil has a paralithic contact between 10 and 20 inches. Surface horizons may be eroded on the gently to moderately sloping landscapes.

Permeability of the Persayo soil is moderate. Available water holding capacity is moderate. Effective rooting depth is about 12 inches or to paralithic contact. Runoff is medium, and the erosion hazard for water is moderate. Wind erosion hazard is moderate.

This unit is mainly used for spring and fall range. The potential productivity is 400 and 150 pounds of air-dry vegetation in favorable and unfavorable years, respectively. The Chipeta is in capability unit VIIe and VIIIs (non-irrigated); desert shale range site. The Persayo is in capability unit VIIe (non-irrigated); desert shallow shale range site.
VII.A.3.8 Disturbed Land

Sample Site No. 03

Disturbed land is a miscellaneous land type comprised of various soils. A profile (#O3) of a disturbed land soil, a member of the mixed, mesic family of Ustic Torripsammets, 625 feet east and 330 feet south of the center of section 33, T22S, R06E, Emery County, Utah, is:

11C1 0 to 11 in. coal waste (not sampled).

1C1 11 to 53 in. light brownish gray (2.5Y 6/2) loamy sand, light olive brown (2.5Y 5/4) moist; weak fine subangular blocky structure; soft, very friable, non-sticky and non-plastic; few fine roots; few fragments of wood and coal, pockets and discontinuous lenses of very fine sandy loam; calcareous; moderately alkaline (pH 7.9); gradual smooth boundary.

1C2b 53 to 65 in. light brownish gray (2.5Y 6/2) loamy sand, olive brown (2.5Y 4/4) moist; massive structure; slightly hard, very friable, non-sticky, and non-plastic; common fine and medium roots; mildly alkaline (pH 7.7).

This profile was sampled at the Emery Mine office near a coal stockpile. Other disturbed land soils included in mapping will have different morphologies. Disturbed soils mapped have either mixed surface soils and subsoils, have surface and/or subsoils salvaged, or have coal material at the surface.

Map Unit: DL - Disturbed Land, 0 to 15 Percent Slopes

This map unit is on level to strongly sloping areas previously disturbed by mining activities. Surface facilities, gravel pits, haul roads, stockpiles, and surfaces disturbed by burning coal beds are included in this map unit.

Surface soils have either been salvaged, buried under coal dust, or heavily mixed with subsoils.

This map unit occurs at the Emery Mine portal and facilities area and in scattered areas above burned coal beds.
The Ferron series is a member of the coarse-silty, mixed (calcareous), mesic family of Fluventic Hapluderts. A representative profile (#19) of Ferron silt loam, 430 feet west, 1530 feet north of the center of section 27, T22S, R06E, Emery County, Utah, at an elevation of 6,069 feet is:

O1 2 to 0 in. roots and grass mat.

A1 0 to 4 in. pale brown (10YR 6/3) fine sandy clay loam, dark grayish brown (10YR 4/2) moist; weak thin platy structure; slightly hard, very friable, slightly sticky and plastic; many very fine, fine and medium roots, few coarse roots; few fine faint (10YR 6/6) mottles; calcareous; moderately alkaline (pH 7.9); distinct smooth boundary.

AC 4 to 15 in. light yellowish brown (10 YR 6/3) moist silty clay loam; weak thin platy and fine subangular blocky structure; very friable, slightly sticky and plastic; many very fine, fine, and medium roots; calcareous; moderately alkaline (pH 8.0); diffuse boundary.

C1 15 to 35+ in. light yellowish brown (10YR 6/3) moist silty clay loam; very friable, slightly sticky and plastic; common very fine, fine and medium roots; moderately alkaline (pH 7.9); standing water at 35 in.

The content of lime ranges from 10 to 25 percent, salinity ranges from slight to strong and the reaction ranges from mildly to strongly alkaline. Ferron soils are mottled within 20 inches of the surface. The water table is at a depth between 6 and 36 inches below the surface, depending on the season. In the A1g horizon, hue ranges from 2.5Y to 5Y; value is 5 or 6 dry and 4 or 5 when they are moist; chroma is 1 or 2. The control section is 18 percent fine sandy loam to light silt loam that contains less than 18 percent clay and less than 15 percent sand coarser than very fine sand. Hue in this part ranges from 2.5Y to 5Y; value is 5 or 6 dry and 4 or 5 when moist; the chroma is 2. The described pedon may contain more coarse sand in the control section (10 in. to 40 in.) than is allowed in coarse-silty families.

Map Unit Fe - Ferron Silt Loam, 0 to 3 Percent Slopes

This map unit is on nearly level to gently sloping alluvial fans, floodplains, and bottoms of narrow valleys. The slope range is 0 to 3 percent. The native vegetation is mainly wiregrass, sedges, redtop grass and saltgrass.

Included in this map unit is about 10 percent Abbott fine sandy clay loam and 5 percent small areas of very strongly saline/alkali soils and soils in which the water table is at a moderate depth. Inclusions make up about 15 percent of this map unit.

This soil is as described for Ferron heavy variant, except that the surface texture is a silt loam, and it does not receive irrigation waste water.
Sample Site No. 06

The GP series (not an established series) is a member of the fine-loamy, mixed, mesic family of Typic Gypsiorthids. A representative profile (#06) of GP silt loam, 1,700 feet east and 1,190 feet north of the southwest corner of section 28, T22S, R06E, Emery County, Utah, at an elevation of 6,083 feet is:

A11 0 to 2 in. pale yellow (2.5Y 7/4) silt loam, light olive brown (2.5Y 5/4) moist; moderate medium to thin platy structure; slightly hard, very friable, slightly sticky and slightly plastic; 5 percent gravels; 1 percent cobbles; calcareous; mildly alkaline (pH 7.8); clear smooth boundary.

A12 2 to 6 in. pale yellow (2.5Y 7/4) silt loam, light olive brown (2.5Y 5/4) moist; moderate medium and coarse subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; 2 percent gravels; calcareous; strongly alkaline (pH 8.7); clear smooth boundary.

C1cs 6 to 28 in. pale yellow (2.5Y 7/4) coarse silt loam, light olive brown (2.5Y 5/4) moist; weak medium angular blocky structure; soft, very friable, slightly sticky and slightly plastic; 2 percent gravels; calcareous; many fine gypsum crystals and threads of lime; moderately alkaline (pH 8.3); clear smooth boundary.

C2cs 28 to 60 in. light brownish gray (2.5Y 6/2) gravelly sandy clay loam, olive brown (2.5Y 4/4) moist; weak fine angular blocky structure; slightly hard, very friable, sticky and plastic; 30 percent gravels; calcareous; many large (5 mm) pockets of gypsum crystals; moderately alkaline (pH 8.3).

The gypsic horizon is between 13 and 30 in. below the surface. A gravelly horizon is at about 25 to 35 in. Weathered soft shale may be encountered below 40 in. In some landscape positions, mottling may be visible below 30 in.

GP Series

Location: 380 feet North, 380 feet West of the East & corner of Section 28, T22S, R06E, Emery County, Utah.

By (Harner-White)

A2 0-4 inches - Pale yellow (2.5 7/4) silt loam, light olive brown (2.5Y 5/4) moist; moderate medium crumb structure, hard dry, friable moist, slightly sticky, slightly plastic; calcareous; mildly alkaline (pH 7.8); clear smooth boundary.
VII.A.3.10  GP Series (Cont)

A12  4-6 inches - Pale yellow (2.5Y 7/4) silt loam, light olive brown (2.5Y 5/4) moist; weak coarse subangular blocky structure; hard dry, friable moist, slightly sticky, plastic; calcareous; strongly alkaline (pH 8.7); clear smooth boundary.

C1cs  6-32 inches - Pale yellow (2.5Y 7/4) coarse silt loam, light olive brown (2.5Y 5/4) moist; weak medium angular blocky structure; slightly hard dry, friable moist, slightly sticky, slightly plastic, 5 percent gravels; calcareous, many fine gypsum crystals and threads of lime; moderately alkaline (pH 8.3); clear smooth boundary.

C2cs  32-60 plus inches - Light brownish grey (2.5Y 6/2) gravelly sandy clay loam, olive brown (2.5Y 4/4) moist; weak fine angular blocky structure; slightly hard dry, friable moist, sticky, plastic; 15 percent gravels; calcareous; many large (5mm) pockets of gypsum crystals; moderately alkaline (pH 8.3)

Map Unit: GP - Silt Loam, 0 to 12 Percent Slopes

This map is on level to moderately sloping alluvial fans and mesa surfaces. The slope range is 0 to 12 percent. The native vegetation is mainly greasewood, big sage, four-wing slatbush, mat sage and mixed forbs.

Included in this map unit is about 10 percent Sanpete sandy clay loam, and 10 percent Ildefonso soils. Included areas make up about 20 percent of the total acreage.

The GP soil is deep, well-drained, and medium to moderately fine textured. It is formed in alluvium and glacial outwash material. Typically, the surface layer is a pale yellow to light gray silt loam about 6 inches thick. The underlying material is a light yellowish brown, pale yellow, or light brownish gray, gypisiferous silt loam, silty clay, or gravelly sandy clay loam. Weathered, soft shale may be encountered below 40 inches.

Permeability of the GP soil is moderately rapid. Available water capacity is moderate. Effective rooting depth is about 30 to 35 inches. Runoff is moderately slow and the erosion hazard for water is slight to moderate. Wind erosion hazard is high.

The unit is mainly used for spring and fall range. It is also used for wildlife habitat. The SCS has not rated this soil for capability unit or range site.

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VII.A.3.11 Gullied Land

Map Unit: GU - Gullied Land, Variable Slopes

Gullied Land is widely distributed on a range of slopes and land forms. The vegetation is mainly greasewood.

Gullied Land is adjacent to Christensen Wash, Quitchupah Creek, below rock outcrops/rockland, and areas adjacent to (Aw) Alluvial Lands. The unit is mapped where gulling is severe or where gullies occur at closer than 100 feet.

Gullied Land has little or no value for farming. It is used by wildlife and, in places, for limited grazing. It also provides drainage outlets for adjacent soils. This soil is in the capability unit VIIIe (non-irrigated); wet meadow range site.
VII.A.3.12 (Hunting Series)

Sample Site No. 10

The Hunting series is a member of the fine-silty, mixed, mesic family of Aquic Ustifluvents. A representative profile (#10) of Hunting clay loam non-saline phase, 1400 feet east and 800 feet south of the center of section 28, T22S, R06E, Emery County, Utah, at an elevation of 6,056 feet is:

Alg  0 to 5 in. gray (10YR 6/1) heavy clay loam, grayish brown (10YR 5/2) moist; moderate thin platy structure; hard, slightly firm, sticky and plastic; many fine and very fine roots; calcareous; common fine prominent (7.5YR 5/6 dry) mottles; moderately alkaline (pH 7.9); diffuse boundary.

AC  5 to 13 in. light brownish gray (10YR 6/2) clay loam, brown (10YR 5/3) moist; moderate thin platy structure; slightly hard, very friable, slightly sticky and plastic; common fine and very fine roots, very few coarse roots; calcareous; common fine and medium prominent (10YR 5/6) moist mottles; moderately alkaline (pH 8.0); diffuse boundary.

Clg 13 to 40+ in. light yellowish brown (2.5Y 6/4) moist silty clay loam and small pockets of coarse sands; weak fine granular structure; loose, very friable, slightly sticky and slightly plastic; common fine and very fine roots to 38 in.; calcareous; few fine distinct (10YR 6/6) moist; mottles; streaks of gleyed material (10YR 6/1) moist; moderately alkaline (pH 7.9); standing water at 45 in.

The A horizon has a texture varying from loam or silty clay loam. Salinity and alkalinity range from slight to strong; the content of lime ranges from 10 to 25 percent. The hue is 2.5Y or 5YR; value is 5 or 6 dry and 4 or 5 moist; the chroma is 2. Horizons between 10 and 40 inches may be loam, silt loam, or silty clay loam that contains more than 18 percent clay and less than 15 percent sand coarser than very fine sand. There may be veins of gypsum in parts of these layers. The C horizon may be stratified with sandy loam or clay loam. Typically mottles are visible between 20 and 40 inches; the color in the upper 30 inches is about the same. Below a depth of 40 inches, the soil is stratified with sandy loam or clay loam. This profile has about 2 percent less clay in the control section than allowed for fine-silty families.
VII.A.3.12 Hunting Series (Cont)

Hunting Series
Location: 100 feet South, 940 feet West of the North ¼ corner of Section 28, T22S, R06E, Emery County, Utah

By (Harner-White)

**Alg**

0-6 inches - Grey (10YR 6/1) clay loam, greyish brown (10YR 5/3) moist; moderate medium crumb structure; hard dry, friable moist, slightly sticky, plastic; calcareous; common fine prominent (7.5YR 5/6) dry; mottles; moderately alkaline (pH 8.9) diffuse smooth boundary.

**Ac**

6-11 inches - Light brownish grey (10YR 6/2) clay loam brown moist; weak subangular blocky structure; slightly hard dry, friable moist, slightly sticky; slightly plastic; calcareous common fine and medium prominent (10YR 5/6) moist mottles; moderately alkaline (pH 8.0); diffuse smooth boundary.

**Clg**

11-60 plus inches - Light yellowish brown (2.5Y 6/4) silty clay loam with small pockets of coarse sands; light olive brown (2.5 & 5/4) massive structure; slightly hard dry, friable moist, slightly sticky, plastic; calcareous; few fine distinct (10YR 6/6) moist mottles; streaks of gleyed material (10YR 6/1) moist; moderately alkaline (pH 7.9).

Map Unit: Hn - Hunting Clay Loam, 0 to 5 Percent Slopes

This map unit is on nearly level to gently sloping alluvial fans, floodplains and narrow alluvial valleys. The slope range is 0 to 5 percent. The native vegetation is mainly saltgrass, galleta grass, and redtop. Greasewood is dominant near the map unit boundaries.

Included in this map unit are areas of Billings and Rafael soils and small spots of strongly saline/alkali soils. Included areas make up about 15 percent of the total acreage.

The Hunting soil is deep, somewhat poorly drained, and medium textured. It is formed in alluvium washed from marine shale and sandstone. Typically, the surface layer is a light brownish gray to light gray, strongly calcareous, loam or clay loam about 10 inches thick. The underlying material is a light brownish gray loam, clay loam or silty clay loam about 40 to 50 inches thick. Mottles may be visible to the surface, but are typically distinct below 20 to 40 inches. The water table is below 20 to 45 inches.

Permeability of the Hunting soil is moderate. Available water capacity is moderately high. Effective rooting depth is about 40 to 50 inches. Runoff is medium, and the erosion hazard for water is moderate. Wind erosion hazard is moderate to low.

The unit is mainly used for wet meadow pasture. It is also used for irrigated cropland or pasture. This map unit is in capability unit IIIw (irrigated) not rated for range site.
VII.A.3.12  Hunting Series (Cont)

Map Unit:  Hs - Hunting Clay Loam, Moderately Sakube, 1 to 3 Percent Slopes

This map unit is on nearly level to gently sloping alluvial fans, floodplains and narrow alluvial valleys. The slope range is 1 to 3 percent. The native vegetation is mainly saltgrass, redtop grass, galleta grass and greasewood.

Included in this map unit are areas generally smaller than one acre which are strongly saline. Included areas make up about 5 percent of the total acreage.

This map unit is similar to Hunting (Hs) clay loam except that it receives additional water through irrigation seepage and irrigation runoff. The surface may be crusted and mottled, and it is moderately saline. Wetness, depth to water table and salinity are the major limitations of this soil. Salinity has reduced the amount of water readily available to plants.

The unit is mainly used for irrigated pasture. It is also used for cropland; salt tolerant species should be selected. The potential productivity is 2,000 and 1,000 pounds of air-dry vegetation in favorable and unfavorable years, respectively. This map unit is in capability unit IVs (irrigated); not rated for range site.
VII.A.3.13 Ildefonso Series

The Ildefonso series is a member of the loamy-skeletal, mixed, mesic family of Ustollic Calcic Haplophrytic soils. A representative profile (#07) of Ildefonso sandy clay loam, 350 feet east and 445 feet south of the center of section 28, T22S, R06E, Emery County, Utah, at an elevation of 6,056 feet is:

**A1ca** 0 to 6 in. light gray (2.5Y 7/2) sandy clay loam, yellowish brown (10YR 5/6) moist; weak very thin platy structure; soft, very friable, slightly sticky and slightly plastic; calcium carbonate accumulation on underside of surface gravels; strongly calcareous; moderately alkaline (pH 8.4); diffuse boundary.

**B2** 6 to 19 in. yellowish brown (10YR 5/4) very fine sandy clay loam, yellowish brown (10YR 5/4) moist; strong medium to coarse angular blocky and prismatic structure; very hard, firm, sticky and plastic; few thin clay films line pores; calcareous; moderately alkaline (pH 8.1); abrupt smooth boundary.

**1C1ca** 19 to 33 in. which (10YR 8/1) very gravelly silty clay, white (2.5YR 8/2) moist; massive structure; very hard, friable, sticky and plastic, 30 percent gravels with calcium carbonate accumulation on undersides; strongly calcareous; moderately alkaline (pH 7.9); diffuse boundary.

**1C2ca** 33 to 51 in. light gray (10YR 7/2) cobbly very fine sand, very pale brown (10YR 7/4) moist; weak fine granular structure; soft, very friable, non-sticky and non-plastic; cobbly vein below 45 inches; strongly calcareous; 50 percent gravels and cobbles; strongly alkaline (pH 8.5); clear smooth boundary.

**1C3** 51 to 60+ in. light yellowish brown (10YR 6/4) extremely gravelly very fine sand, very pale brown (10YR 7/4) moist; single grain structure; loose, non-sticky and non-plastic; 60 percent pea gravels; calcareous; mildly alkaline (pH 7.8).

Gravel and cobble content ranges from 35 to 65 percent throughout. The surface soil may be stony in places. The A1 ranges in texture from loamy fine sands, sandy loam, to sandy clay loam; it is typically 7 to 9 inches thick.

The subsoil may be a gravelly to very gravelly sandy loam, fine sandy loam to very fine sand to depths greater than 60 inches.
VII.A.3.13 Ildefonso Series (Cont)

Map Unit: IID2 - Ildefonso Loam, 3 to 30 Percent Slopes, Eroded

This map unit is on nearly level to moderately steep fans. The slope range is 3 to 30 percent. The native vegetation is mainly greasewood, halogeton, shadscale, galleta grass and clumps of cacti.

Included in this map unit is about 5 percent Hunting clay loam, 5 percent Typic Hapludands of fine and fine-loamy families, and 5 percent Sanpete sandy clay loam. Included areas make up about 15 percent of the total acreage.

This soil is similar to Ildefonso loam (ILB), except that it is steeper and eroded.

This map unit is in capability unit VIIIs (non-irrigated); not rated for range site.
Sample Site No. 20

The Persayo series is a member of the loamy, mixed (calcareous), mesic, shallow family of Typic Torriorthents. A representative profile (#20) of Persayo very fine sandy clay loam, 1,060 feet east and 185 feet north of the southwest corner of section 22, T22S, R06E, Emery County, Utah, at an elevation of 6,087 feet is:

A1 0 to 4 in. light brownish gray (2.5Y 6/2) very fine sandy clay loam, pale brown (10YR 6/3) moist; moderate very thin platy structure; loose, very friable, slightly sticky and slightly plastic; few fine and very fine roots; strongly calcareous; mildly alkaline (pH 8.0); gradual smooth boundary.

AC 4 to 11 in. pale brown (10YR 6/3) heavy silty clay loam, brown (10YR 5/3) moist; weak thin platy structure; soft, very friable, sticky and plastic; common very fine and fine roots, few medium and coarse roots; calcareous; mildly alkaline (pH 8.1); abrupt smooth boundary.

Crcs 11 to 19 in. light brownish gray (10YR 6/2) very gravelly clay, light brownish gray (2.5Y 6/2) moist; strong medium platy structure; slight hard, friable, sticky and plastic; pockets of gypsum crystals, some as streaks or threads below 15 in.; calcareous; slightly alkaline (pH 7.8); abrupt boundary.

R 19+ in. soft weathered shale.

Persayo soils are dry when not frozen, unless they are irrigated. The A1 ranges from hue of 2.5Y to 5Y; value of 6 or 7 when soils are dry and is 4 or 5 when moist; chroma is 2. The control section is silty clay loam and contains less than 35 percent clay. Soft weathered shale is encountered between 10 and 20 in. Weathered fragments of shale make up 5 to 70 percent of the material below 10 inches; shale fragments increase with depth. Some profiles have more gypsum crystals occurring directly above the bedrock; the content ranges from 0.5 to 10 percent. All of the upper 20 inches is about the same color.
Persayo Series (Cont)

Persayo Series
Location: 1190 feet South, 880 feet West from the North \( \frac{1}{4} \) corner of Section 32, T22S, R06E, Emery County, Utah.

By (Harner-White)

Al 0-4 inches - Light brown grey (2.5Y 6/2) fine sandy clay loam, pale brown (10YR 6/3) moist, moderate fine platy structure, soft dry very friable moist; slightly sticky, slightly plastic; strongly calcareous; mildly alkaline (pH 8.0); gradual smooth boundary.

Ac 4-11 inches - Pale brown (10YR 6/3) silty clay loam, brown (10YR 5/3) moist; weak fine platy structure; slightly hard dry, very friable moist, slightly sticky, plastic; calcareous; mildly alkaline (pH 8.0) abrupt smooth boundary.

Crsa 11-20 inches - Light brownish grey (10YR 6/2) gravely clay, light olive brown (2.5Y 6/2) moist; strong medium platy structure; hard dry, friable moist, sticky, plastic; pockets of gypsum crystals; some as streaks or threads below 15 inches; calcareous; slightly alkaline (pH 7.8); abrupt smooth boundary.

R 20 plus inches - Soft weathered shale.
VII.A.3.14 Persayo Series (Cont)

Map Unit: PCE2 - Persayo-Chipeta Complex, 1 to 20 Percent Slopes
Eroded

This map unit is on nearly level to steep fans, terraces, uplands, and shale knolls. The slope range is 1 to 20 percent. The native vegetation is mat saltbush, shadscale, Indian rice grass and galleta grass.

This unit is 40 percent Persayo eroded and non-eroded very fine sandy clay loams and sandy clay loams and 40 percent Chipeta silty clay loam. The two soils are intermingled and occur in an unidentifiable pattern on the landscape. Persayo is usually in the depression areas and draws, but occurs on the broad fans with the Chipeta soil. Included in this map unit is about 20 percent Badland.

The Persayo soil is shallow, well-drained, and moderately fine-textured. It is formed in residuum that weathered from shale. Typically, the surface layer is a light brownish gray loam to very fine sandy clay loam about 1 to 4 inches thick. The underlying material is a light brownish gray or pale brown silty clay loam, loam, or clay overlying soft, weathered shale at a depth of 10 to 20 inches. This is a weak to moderately strong gypsic horizon.

Permeability of the Persayo soil is moderate. Available water holding capacity is moderately high. Effective rooting depth is dependent on depth to bedrock. Runoff is medium to rapid, and the erosion hazard for water is moderate to high. Wind erosion hazard is moderate.

The Chipeta soil is shallow, somewhat poorly to moderately well-drained, and moderately fine-textured. It is formed in residuum derived from marine gypsum-bearing shale. Typically, a paralithic contact is encountered at about 17 to 19 inches. The surface horizons are highly eroded and severely cracked when dry; the surface soil is thin, about 2 inches thick. Light gray and light grayish brown heavy silty clay loams and silty clays overlie soft weathered shale.

Permeability of the Chipeta soil is moderately slow. Available water capacity is moderate. Effective rooting depth is about 12 to 16 inches. Runoff is rapid, and the erosion hazard for water is high and active. Wind erosion hazard is moderate to high.

The unit is mainly used for spring and fall range. The Chipeta soil is in the VIIe (non-irrigated) capability unit; the Persayo soil is in the VIIe (non-irrigated) capability unit. The Chipeta is in the desert shallow range site. The Persayo is in the desert loamy shale range site.
### VII.A.3.15 Rafael Series

The Rafael series is a member of the fine-silty, mixed (calcareous), mesic family of Typic Haplaquepts. A representative profile (Swenson et al., 1970) of Rafael silty clay loam, 600 feet north and 1,300 feet west of the southeast corner of section 29, T.22S R.06E, Emery County, Utah, is:

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A11</td>
<td>0 to 3 in. light brownish gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; common medium distinct, strong brown (7.5Y 5/6) mottles; weak thin platy structure; slightly hard, firm, sticky and plastic; plentiful medium and fine roots; few fine and medium pores; strongly calcareous; moderately alkaline (pH 8.0); clear smooth boundary.</td>
</tr>
<tr>
<td>A12</td>
<td>3 to 11 in. light brownish gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; common medium distinct, yellowish red (5YR 5/8) mottles; weak moderately thick platy structure; hard, firm, sticky and plastic; plentiful medium and few fine roots; common medium and few fine pores; moderately calcareous; moderately alkaline (pH 8.4); clear wavy boundary.</td>
</tr>
<tr>
<td>C1g</td>
<td>11 to 17 in. grayish brown (2.5Y 5/2) loam, dark grayish brown (2.5Y 4/2) moist; common medium distinct strong brown (7.5YR 5/6) and few fine faint gray (N 6/0) mottles; weak coarse subangular blocky structure; slightly hard or hard, firm, slightly sticky and plastic; plentiful medium and fine roots; common medium and fine pores; strongly calcareous; strongly alkaline (pH 8.6) clear wavy boundary.</td>
</tr>
<tr>
<td>C2g</td>
<td>17 to 33 in. grayish brown (2.5Y 5/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; few fine distinct strong brown (7.5Y 5/6) mottles and common medium distinct gray (N 6/0) mottles; weak coarse prismatic structure breaking to weak, coarse subangular blocky structure; very hard, very firm, sticky and very plastic; plentiful medium and fine roots; few medium and common fine pores; numerous gypsum mycelia; strongly calcareous; strongly alkaline (pH 8.6) clear wavy boundary.</td>
</tr>
<tr>
<td>C3g</td>
<td>33 to 43 in. grayish brown (2.5Y 5/2) heavy loam, dark grayish brown (2.5Y 4/2) moist; fine distinct strong brown (7.5YR 5/6) mottles and common medium distinct gray (N 6/0) mottles; massive; hard, firm, slightly sticky and plastic; few medium and fine roots; common fine and few medium pores; moderately calcareous; moderately alkaline (pH 8.3) gradual wavy boundary.</td>
</tr>
<tr>
<td>C4g</td>
<td>43 to 70 in. light brownish gray (2.5Y 6/2) heavy loam, dark grayish brown (2.5Y 4/2) moist; common medium gray (N 6/0) mottles; massive; hard, firm, slightly sticky and plastic; few medium and fine roots; common fine and few medium pores; strongly calcareous; moderately alkaline (pH 8.2).</td>
</tr>
</tbody>
</table>
The content of lime ranges from 10 to 30 percent and is greatest near the surface. In the A1 horizons, hue is 2.5Y to 5Y; value ranges from 5 to 7 when the soils are dry and is 4 or 5 when they are moist; and chroma is 2 or 3. Distinct to prominent mottles are at depths of less than 20 inches. Gley colors are common in some areas at some depth below 36 inches. Thin layers of peaty material are on the surface in some areas. The part of the profile between 10 and 40 inches is silty clay loam and heavy loam, and contains 22 to 38 percent clay and contains less than 15 percent sand that is coarser than very fine sand. All of the upper 40 inches is about the same color.

Map Unit Ra - Rafael Silty clay Loam, 1 to 3 Percent Slopes

This map unit is on nearly level to gently sloping alluvial fans, flood plains and narrow alluvial valleys. The slope range is 1 to 3 percent. The native vegetation is mainly sedge, wire grass, redtop grass, and saltgrass.

Included in this map unit is about 10 percent Ferron soils and small areas of strongly saline spots totalling about 2 percent of the acreage. Included areas make up about 12 percent of the total acreage.

The Rafael soil is deep, moderately fine-textured, and poorly drained. It is formed in alluvium derived from marine shale. Typically, the surface layer is light brownish gray silty clay loam or loam about 11 inches thick. The underlying material is a grayish brown silty clay loam with stratified layers of loams and clay loams. Mottling may be visible above 20 inches. Gleying increases below 36 inches.

Permeability of the Rafael soil is slow. Available water capacity is moderate to moderately high. Effective rooting depth is about 60 inches. Runoff is slow and the erosion hazard for water is slight. Wind erosion hazard is moderate.

The unit is mainly used for pastureland. It is also used for hay production. The potential productivity is 4,000 and 2,000 pounds of air-dry vegetation in favorable and unfavorable years, respectively. This map unit is in capability unit VIIw (non-irrigated); wet meadow range site.
VII.A.3.16 Ravola Series

The Ravola series is a member of the fine-silty, mixed (calcareous), mesic family of Typic Torrifluvents. A representative profile (#02) of Ravola loam, 380 feet east and 820 feet south of the northwest corner of section 33, T22S, R06E, Emery County, Utah, at an elevation of 5,958 feet is:

A11 0 to 3 in. grayish brown (2.5Y 5/2) silty clay, dark grayish brown (2.5Y 4/2) moist; moderate thick platy structure; soft, very friable, sticky and plastic; few fine roots; calcareous; slightly alkaline (pH 7.7); clear smooth boundary.

A12 3 to 15 in. grayish brown (2.5Y 5/2) silt loam, dark grayish brown (2.5Y 4/2) moist; moderate medium angular blocky structure; soft, very friable, slightly sticky and plastic; common fine roots; 2 percent gravels, 1 percent cobbles; few thin lime threads; calcareous, slightly alkaline (pH 7.7); abrupt smooth boundary.

C1ca 15 to 30 in. grayish brown (10YR 5/2) extremely gravelly clay loam, dark grayish brown (10YR 4/2) moist; weak medium subangular blocky structure; loose dry, loose moist, sticky and plastic; few medium roots; few distinct mottles (10YR 5/6) many pockets of lime; very strongly calcareous; 40 percent gravels; moderately alkaline (pH 8.1); gradual smooth boundary.

C2 30 to 50 in. light brownish gray (10YR 6/2) sandy clay loam, dark grayish brown (10YR 4/2) moist; weak medium subangular blocky; soft, very friable, slightly sticky and slightly plastic; few fine roots; few distinct mottles (10YR 5/6); 5 percent gravels; calcareous; moderately alkaline (pH 8.0); clear smooth boundary.

C3 50 to 70 in. light brownish gray (10YR 6/2) silty clay loam, dark grayish brown (10YR 4/2) moist; weak coarse angular blocky structure; slightly hard, firm, sticky and plastic; few fine roots; many threads of lime; calcareous; moderately alkaline (pH 8.4).

This profile is found below a gravelly Typic Gypsorthid and therefore, exhibits more gravels than the typical Ravola profile. This profile is located in an alluvium-filled swale and depth of the A horizons range to 15 in. Salinity is generally slight to moderate; reaction ranges from slightly to moderately alkaline. Gypsum occurring as veins is common below 20 to 30 inches.
The content of calcium carbonate ranges from 5 to 25 percent. Reaction is mildly to strongly alkaline. Ravola soils are generally dry when not frozen, unless they are irrigated. Clay mineralogy is mixed; but the clay is mainly illite (Swensen et al., 1970).

In some places the surface horizon may be silty clay loam. The hue is 2.5Y to 5Y, the value is 6 or 7 dry and 4 or 5 when moist; the chroma ranges from 2 to 4. Between 20 and 40 inches, the texture is a heavy loam, silt loam, clay loam or very fine sandy loam that contains 18 to 27 percent clay and less than 15 percent sand coarser than very fine sand. Below a depth of 40 inches, the soil may be sandy loam to silty clay loam.

Ravola Series
Location: 940 feet South, 560 feet West from the North corner of Section 32, T22S, R06E, Emery County, Utah

By (Harner-White)

A11 0-4 inches - Greyish brown (2.5Y 5/2) silt clay, dark greyish brown (2.5Y 4/2) moist; moderate thick platy structure; soft dry, friable moist, slightly sticky, plastic; calcareous; mildly alkaline (pH 7.6); abrupt clean smooth boundary.

A12 4-10 inches - Greyish brown (2.5Y 5/2) silt loam, dark greyish brown (2.5Y 4/2) moist; moderate medium subangular blocky structure; soft dry, friable moist, slightly sticky, plastic; 2 percent gravels; few thin lime treads; calcareous; slightly alkaline (pH 7.6); abrupt smooth boundary.

C1ca 10-28 inches - Greyish brown (10YR 5/2) gravelly clay loam, dark greyish brown (10YR 4/2) moist; weak medium subangular blocky structure; soft dry, friable moist, sticky, plastic; many lime pockets; strongly calcareous; 20 percent gravels; moderately alkaline (pH 8.0); gradual smooth boundary.

C2 28-47 inches - Light brownish grey (10YR 6/2) sandy clay loam, dark greyish brown (10YR 4/2) moist; weak medium subangular blocky structure; soft dry friable moist, slightly sticky, slightly plastic; 2 percent gravels; moderately alkaline (pH 8.0) clean smooth boundary.

C3 47-60 plus inches - Light brownish grey (10YR 6/2) silty clay loam, dark greyish brown (10YR 4/2) moist; weak coarse angular blocky structure, slightly hard dry, firm moist sticky, plastic, many threads of lime, calcareous; moderately alkaline (pH 8.4).
VII.A.3.16 Ravola Series (Cont)

Map Unit: RuB2 - Ravola-Bunderson Complex, 1 to 3 Percent Slopes Eroded

This map unit is on nearly level to level alluvial fans, floodplains and bottomlands. The landscape is hummocky in some areas within this complex. The slope range is 1 to 3 percent. The native vegetation is mainly scattered greasewood, halogeton, galleta grass and shadscale.

This unit is 60 percent Ravola silty clay, and 35 percent Bunderson fine sandy loam. Included in this map unit is about 5 percent strongly saline soils and Ravola loam or silty clay loam soils.

The Ravola soil is as described in map unit R1D2, except that it is less steep.

The Bunderson soil is deep, well-drained, calcareous, and medium textured. It is formed in alluvium washed from alkaline, sedimentary marine shale and sandstone. Typically, the surface layer is a nearly impermeable, light grayish brown very fine sandy loam about 4 inches thick. The subsoil is light grayish brown or brown silty clay loam, silt loam or fine sandy loam about 10 to 12 inches thick. The substratum to a depth of 60 inches or more may be a strongly calcareous clay or silty clay. In some profiles gypsum is visible below 40 inches.

Permeability of the Bunderson soil is slow. Available water holding capacity is low. Effective rooting depth is about 60 inches or more. Runoff is moderately rapid to rapid, and the erosion hazard for water is severe. Wind erosion hazard is moderate.

The unit is mainly used for rangeland; the dominant species have little range quality (Swenson et al, 1970). It is also used for wildlife habitat. The Bunderson soil is not rated for range; the capability unit is VIIe (non-irrigated). The Ravola soil is in capability unit VIIe (non-irrigated), I1e (irrigated); semi-desert loam range site.
VII.A.3.17 Rockland

Map Unit Ry - Rockland

This map unit is on nearly level to steep sloping broad terraces and cliffs. The native vegetation is mainly a sparse cover of pinyon, juniper and sagebrush. Elevation range is 5,900 to 6,400 feet.

This unit is a miscellaneous land type formed from sandstone. About 55 percent of the surface is covered by stones, boulders, and outcrops of sandstone. Some shale outcrops are found. About 20 percent of the land has 4 inches or less of aeolian deposited soil overlying bedrock. Most of this map unit is moderately to severely eroded.

Included in the map unit are gently sloping, moderately deep to deep, fine sandy loams intermingled with the sandstone outcrops. Inclusions of Castle Valley fine sandy loam also occur. Included areas make up about 25 percent of the total acreage.
VII.A.3.18 Saltair Series

The Saltair series is a member of the fine-silty, mixed, mesic family of Typic Salorthids. A representative profile (Swenson et al., 1970) of Saltair silty clay loam, 1,200 feet north, 500 feet west of the southeast corner of section 13, T17S, R09E, Emery County, Utah, is:

A1ls 0 to 1/2 inches; grayish brown (2.5Y 5/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; weak thin platy breaking to moderate fine granular structure; soft, firm, very sticky and plastic; strongly calcareous; plentiful medium and fine vesicular pores; thin salt crust; strongly alkaline (pH 8.9); clear smooth boundary.

A12sa 1/2 to 7 inches; light brownish gray (2.5Y 6/2) silty clay loam, grayish brown (2.5Y 5/2) moist; weak to moderate fine angular blocky structure; very hard, very firm, very sticky and very plastic; strongly calcareous; plentiful medium and fine roots; common medium and fine pores; many fine distinct (10YR 5/6) mottles; very strongly saline; efflorescent salt on many ped surfaces and in pores; moderately alkaline (pH 8.3); clear smooth boundary.

C1gsa 7 to 14 inches; light brownish gray (2.5Y 6/2) heavy silt loam, grayish brown (10YR 5/2) moist; weak fine angular blocky structure; very hard, very strong, very sticky and very plastic; strongly calcareous; few fine roots; common medium pores; common fine distinct (10YR 5/4) mottles and common fine faint (N 5/0) mottles; very strongly saline; efflorescent salt on many ped surfaces and in pores; strongly alkaline (pH 8.5); gradual wavy boundary.

C2gsa 14 to 32 inches; light brownish gray (2.5Y 6/2) heavy silt loam, grayish brown (2.5Y 5/2) moist; massive structure; very hard, firm, sticky and plastic; strongly calcareous; few fine roots; common medium and fine pores; many fine distinct (10YR 5/4) mottles and common fine faint (N 5/0) mottles; very strongly saline; efflorescent salt on the surfaces of many peds and in pores; strongly alkaline (pH 8.5); gradual wavy boundary.

C3g 32 to 60 inches; light gray (2.5Y 7/2) heavy silt loam, grayish brown (2.5Y 5/2) moist; massive structure; hard, firm, sticky and plastic; strongly calcareous; few fine roots; common fine pores; few fine distinct (10YR 5/4) mottles and medium faint gray (N 5/0) mottles; strongly alkaline (pH 8.5).

The content of salt is 2.0 percent or more in the upper 20 inches of the profile; the rest of the profile also contains salt. Platy crusts of salt on the surface are also common. The content of exchangeable sodium ranges from 15 to 70 percent. The A1 horizons have a hue of 2.5Y of 5Y, value of 4 to 6 dry, 5 to 7 moist; the chroma is 1 or 2. The control section is heavy silt loam, silty clay loam, or clay loam that contains less than 35 percent clay. The same color prevails throughout the upper 40 inches.
VII.A.3.18 Saltair Series (Cont)

Saltair Series
Location: 500 feet South, 250 feet West from the North \ corner of Section 28, T22S, R06E, Emery County, Utah

By (Harner-White)

Alsa 0-1 inches - Greyish brown (2.5Y 5/2) silty clay loam, dark greyish brown (2.5Y 4/2) moist; weak medium platy breaking to moderate fine granular structure; hard dry, firm most, very sticky, plastic; thin salt crusts; strongly alkaline (pH 8.4); clear smooth boundary.

Al2sa 1-8 inches - Light brownish grey (2.5Y 6/2) silty clay loam, greyish brown (2.5Y 5/2) moist; moderate fine subangular blocky; very hard dry, very firm moist, sticky, plastic, strongly calcareous; many fine distinct (10YR 5/6) mottles; very strong saline; efflorescent salt on many ped surfaces and in pores; moderately alkaline (pH 8.2); clear smooth boundary.

Clgsa 8-15 inches - Light brownish grey (2.5Y 6/2) fine silt loam, grey brown (10YR 5/2) moist; weak fine angular blocky structure; very hard dry, firm moist, sticky plastic; strongly calcareous; many fine distinct (10YR 5/4) mottles and common fine faint (2.5YR 5/0) mottles; very strongly saline; efflorescent salt on the surfaces of many peds and in pores; strongly alkaline (pH 8.5); gradual wavy boundary.

C2gsa 15-30 inches - Light brownish grey (2.5Y 6/2) silt loam, greyish brown (2.5Y 5/2) moist; massive structure; very hard dry, firm moist, sticky, plastic; strongly calcareous; many fine distinct (10YR 5/4) mottles and common fine faint (2.5N 5/0) mottles; very strongly saline; efflorescent salt on the surface of many peds and in pores; strongly alkaline (pH 8.5); gradual wavy boundary.

C3g 30-60 plus inches - Light grey (2.5Y 7/2) fine silt loam, greyish brown (2.5Y 5/2) moist; massive structure; hard dry, firm moist, sticky, plastic; strongly calcareous; few fine distinct (10YR 5/4) mottles and medium faint grey (2.5N 5/0) mottles; strongly alkaline (pH 8.5).
VII.A.3.18 Saltair Series (Cont)

Map Unit: Sa - Saltair Silty Clay Loam, 0 to 3 Percent Slopes

This map unit is on level to nearly level alluvial fans, floodplains, and narrow alluvial valleys. The slope range is 0 to 3 percent. The native vegetation is mainly greasewood, saltgrass, and kochia. Barren spots and surface salt crusting are common.

The Saltair soil is deep, very strongly saline, moderately fine-textured, and poorly drained. It is formed in alluvium derived from marine shale and sandstone. Typically, the surface layer is light brownish gray, strongly calcareous, very strongly saline, hard, silty clay loam about 7 inches thick. Platy salt crusting on the surface is common. The underlying material is a light brownish gray to light gray, very strongly saline, mottled, heavy silt loam.

Permeability of the Saltair soil is slow. Available water capacity is very low to moderately low. Roots generally concentrate near the surface, but usually penetrate to a depth of 60 inches. Runoff is slow and the erosion hazard for water is slight to moderate. Some shrubs have a pedestal-like appearance. Wind erosion hazard is slight.

The unit is mainly used for rangeland; the quality of forage is poor (Swenson et al, 1970). The potential productivity is 2,500/1,750/1,000 pounds of air-dry vegetation in favorable/normal/unfavorable years, respectively. This map unit is in capability unit VIIw (non-irrigated), salt meadow range site.
VII.A.3.19  Killpack Series

The Killpack series consists of moderately deep, slightly to moderately saline, well-drained, moderately fine textured soils. These soils formed in residuum that weathered from clayey, marine shale bedrock. Annual precipitation is 7 to 10 inches. The mean annual soil temperature ranges from 47° to 50°F, and the frost free period is 110 to 130 days. The native vegetation is shadscale, big sage and galleta grass. The elevation range is 6,000 to 6,150 feet.

The available water capacity is moderate to high, and permeability is slow. These soils are used for rangeland and wildlife habitat.

The Killpack series is a member of the fine-silty, mixed (calcareous), mesic family of Typic Torriorthents. A representative profile (Swenson et al., 1970) of Killpack clay loam in a cultivated field about 2,450 feet north and 300 feet east of the southwest corner of section 30, T.16S R.10E, Emery County, Utah, is:

Ap  0 to 9 in. grayish brown (2.5Y5/2) clay loam, dark grayish brown (2.5Y4/2) moist; weak medium and fine granular structure; hard, firm, slightly sticky and slightly plastic; plentiful fine roots; common fine pores; strongly calcareous; mildly alkaline (pH 7.8); clear smooth boundary.

C1  9 to 23 in. light brownish gray (2.5Y6/2) clay loam, grayish brown (2.5Y5/2) moist; moderate coarse angular blocky structure breaking to weak fine subangular blocky structure; hard, firm, sticky and plastic; few fine roots; few fine pores; strongly calcareous; mildly alkaline (pH 7.7); gradual wavy boundary.

C2cs 23 to 29 in. light brownish gray (2.5Y6/2) shaly silty clay loam, grayish brown (2.5Y5/2) moist; massive; hard, very firm, sticky and plastic; few fine roots; no pores; strongly calcareous; many gypsum crystals 5 to 15 mm in diameter; mildly alkaline (pH 7.7); gradual wavy boundary.

R  29 in.+ light brownish gray (2.5Y6/2) weathered shale.

Killpack soils are generally dry when frozen, except where they are irrigated. Clay minerals are mixed, but dominantly they are illite and kaolinite. In the A1 horizon, hue ranges from 10YR to 5Y; value is 5 or 6 when the soils are dry and 4 or 5 when moist; and chroma is 2 or 3. The control section is silty clay loam to clay loam and contains less than 35 percent clay. The hue in this section ranges from 10YR to 5Y; value is 6 or 7 when the soils are dry and ranges from 4 to 6 moist; the chroma is 2 or 3. The C2cs horizon contains 5 to 20 percent shale fragments. A slight to moderate accumulation of gypsum overlies the shale.
VII.A.3.19 Killpack Series (Cont)

This map unit is on nearly level to gently sloping fans and shale hills generally below the Chipeta and/or Persayo soils. The slope range is 0 to 3 percent. The native vegetation is mainly shadscale, big sage and galleta grass.

Included in this map unit are small units of strongly and very strongly saline soils, and 5 percent Billings silty clay loam. Included areas make up about 10 percent of the total acreage.

The Killpack soil is moderately deep, well-drained. It is formed in residuum that weathered from clayey marine shale bedrock. Typically, the material overlying soft, calcareous shale is light gray to light grayish brown clay loam, silt loam, or silty clay loam to a depth of 20 to 40 inches.

Permeability of the Killpack soil is slow. Available water capacity is moderate to high. Effective rooting depth is about 40 inches. Runoff is medium and the erosion hazard for water is moderate to high. Wind erosion hazard is slight to moderate.

This unit is mainly used for spring and fall range. It is also used for wildlife habitat. The potential productivity is 400 and 150 pounds of air-dry vegetation in favorable and unfavorable years, respectively. This map unit is in capability unit VII (non-irrigated), IVe (irrigated); desert loamy shale range site.
VII.A.4 PRODUCTIVITY INFORMATION

The attached productivity information was photocopied from U.S.D.A. Soil Conservation Services's "Soil Survey of Carbon-Emery Area, Utah" issued December 1970, pages 16-23.
SOIL SURVEY
Carbon-Emery Area, Utah

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
and
UNITED STATES DEPARTMENT OF THE INTERIOR
Bureau of Land Management
in cooperation with
UTAH AGRICULTURAL EXPERIMENT STATION
Use and Management of the Soils for Range

This part gives information about livestock operations in the survey area. It also describes the grouping of soils in range sites and the management of range sites. Some soils were not placed in a range site, because they are not suitable for range or they are used only for crops or tame pasture.

Both cattle and sheep graze the rangelands of the survey area. Most of the range is better suited to winter use than to use in other seasons, but some of it is grazed year long. Grazing has no set patterns. Many livestock owners have permits to graze small numbers of sheep or cattle on the Manti-LaSal National Forest in summer. In September livestock are brought from summer range to graze crop aftermath in irrigated fields. In November operators who have the privilege of grazing livestock on the public domain move their animals to winter range on the east side of the valley.

In years of drought, cattle generally are returned to the farms in January and then are fed hay and concentrates. As soon as the range plants green up in spring, these cattle are turned out to graze on adjacent range land. Rangeland near irrigated farmland generally is in poor condition because livestock come to the irrigation ditches or canals for water. The forage around watering places is heavily grazed and usually is grazed at a critical growth period.

Seventy-five percent of the livestock producers in the survey area own less than 50 head of cattle. The producers own the largest number of cattle have less than 150 to 200 head. Most of those who own sheep have 50 head or less. To reduce the expense of herding, owners join their herds when grazing on National Forest or other public land. About three-fourths of the ranchers supplement their income from livestock by working in local coal mines or for county and State Governments.

When the first livestock producers brought cattle into the survey area, they found lush forage along the river bottoms and adequate grazing on the benches to support a livestock industry. Water was diverted from streams and applied on the soils that were best suited to cultivation. The numbers of livestock increased as the population increased. All livestock depended on the open ranges for most of their forage.

In a few years native plants showed signs of grazing pressure. Many of the most palatable plants weakened, did not produce much forage even in years of adequate moisture, and eventually died. They were replaced by less palatable plants, which died under continued grazing pressure, and were replaced by plants of little or no value for grazing.

Range sites and condition classes

To manage his range well and to use the range to best advantage, the rancher should know the different kinds of soil in his holdings, the location of each kind of soil, and the kinds and amounts of vegetation that can be grown on each. He can then regulate grazing so that the vigor and abundance of the best plants are increased.

The basic unit on which management of the range is determined is the range site. A range site is an area of range uniform enough in climate, soils, drainage, exposure, and topography that it produces a specific kind and amount of vegetation. The kind of vegetation, in most instances, is the combination of plants that grew on the site before the range was affected by grazing or cultivation and is called the potential vegetation. Generally, the potential vegetation is the most productive combination of range plants that a site can support. The potential vegetation, or plant community, remains on the site if it is not disturbed by fire, excessive grazing, insects, or plant diseases.

If the range is grazed heavily or at the wrong time, the most valuable forage plants on the range, called increasers, become more scarce and eventually disappear. Their place is taken by increasers, or less palatable plants that made up only a small part of the original vegetation. These increasers, in turn, become less abundant where excessive or untimely grazing is continued, or where fire or insects seriously damage the range. Then, other kinds of plants, called invaders, find room to grow. Invaders were not a part of the original vegetation. They are the least desirable of the plants on the range and are practically worthless. Allowing livestock to graze only about half of each season's growth of the potential vegetation, or key forage species, keeps the range from deteriorating and increases the amount of forage produced annually.

The condition of the range is determined by comparing, in kind and number, the plants of the present vegetation with those of the potential vegetation. Condition of the range is related to the amount of increasers, decreasers, and invaders on the site. Four classes of range condition have been recognized. A range in excellent condition has from 70 to 100 percent of the vegetation characteristic of the potential vegetation, or that on the site originally; one in good condition has 51 to 75 percent; one in fair condition has 26 to 50 percent; and one in poor condition has less than 26 percent. Most of the range sites in the Carbon-Emery Area are in poor to fair condition.

Distinguishing one range site from another by examining vegetation alone is not always easy, particularly when the present vegetation differs from the original vegetation. Several different range sites can be covered by the same kinds of increaser and invader plants, and to the casual observer they appear to be the same site. Information obtained from a soil survey generally is needed to help identify a range site.

Estimates of forage yields and plot clippings are needed from an area for several years to determine yields of herbage by site condition. Records of precipitation help to evaluate such yields. The amount of precipitation and the season in which it falls affect the vigor and growth of plants. For example, plot clippings on a Desert Loam range site in poor condition indicate that vegetation production can vary as much as 300 percent between dry years and wet years. Yields of herbage on a site in poor or fair condition fluctuate more than those on a site in good or excellent condition. The production from
perennial plants is less variable than that from annual plants.

Similar soils in different parts of the survey area can produce distinctly different plant communities, and yet the sites can be considered to be in the same condition class. This can be caused by past grazing.

In some places the range sites can be easily distinguished. In others the boundaries are not distinct because gradual changes in relief have caused differences in the amount of precipitation and in the kinds of soils. Areas grazed by domestic livestock were not found in the Carbon-Emery survey area. There were several areas from which livestock had been excluded for many years or that had been lightly grazed in recent years. The vegetation potential of the range sites in these areas was studied.

The average annual precipitation on each range site, and the acreage and proportionate extent of each site are shown in table 2. The range sites in the survey area are described on the following pages.

**DESSERT RED SHALE RANGE SITE**

This site is along the foothills of Cedar Mountain on the east side of the survey area. It is on hills where the slopes are mainly between 5 and 13 percent but range from 3 to 30 percent. In the survey area, this site is always in poor condition. The average annual precipitation is 7 to 9 inches.

The soil in this range site is Cedar Mountain shaly clay loam, 3 to 30 percent slopes, eroded. It formed in local alluvium or residuum from the Cedar Mountain geologic formation. This soil is very strongly alkaline and typically is 10 to 20 inches deep over red shale. Its surface layer contains 25 to 50 percent shale fragments.

Galletagrass makes up 60 to 80 percent of the plant cover, and this gives the site the aspect of rolling grassland (fig. 3). There are scattered patches of juniper, and needle crops out in places. Most of the other potentially productive vegetation is Indian ricegrass and squirreltail growing in association with shadecase, Nutall saltbush, and a variety of forbs. All of the other potential plants grow in small amounts on this site.

Several forbs that have fleshy roots—Indian-potato, desertlily, evening-primrose, and locoweed—grow on this site. These plants can store moisture when it is available and use it during the frequent dry periods.

In its present or potential condition, the production of plants on this range site fluctuates greatly, according to the amount of precipitation. Many annual and perennial flowering plants that are difficult or impossible to find in dry years appear in years of good moisture. This range site has an estimated total potential production of 500 pounds of air-dry forage per acre in favorable years, and of 200 pounds per acre in less favorable years.

**DESSERT SHALE RANGE SITE**

This range site is common throughout the survey area. It is on hills that have slopes up to 30 percent, and it is easily recognized by the gray-green color of mat saltbush, the dominant plant, and by the light-gray color of the soil. It is mostly in poor to fair condition. The annual precipitation is 7 to 9 inches.

Soils of the Chipeta series make up this range site (fig. 4). They are silty clays, are less than 20 inches thick.
forage per acre, air dry, in favorable years, and of 150 pounds in less favorable years.

DESSERT LOAMY SHALE RANGE SITE

This range site is on round, shaly knolls and shaly slopes, above and interspersed with gently sloping plains. As a rule, this site is situated on slopes above the Desert Loam Bottom range site, and in many places it occurs with the Desert Shale range site. The average annual precipitation is 7 to 9 inches.

Soils of the Persayon series make up this range site (fig. 5). The surface layer is brownish-gray loam about 1 inch thick, and it absorbs moisture readily. Runoff is medium. Gully erosion is active.

All condition classes of this range site have a wide variety of plants, but no mat saltbush. Where this site is in fair to poor condition, galletagrass, blue gram, bullgrass, winterfat, bud sagebrush, shadscale, and yellow rabbitbrush are common plants. Dececer grasses are Indian ricegrass, squirreltail, and sand dropseed. The increaser grasses are galletagrass, bullgrass, and blue grama. The decreaser shrubs are winterfat, bud sagebrush, and Nuttall saltbush. Increaser shrubs are yellow rabbitbrush, shadscale, gray moly, pricklypear, broom snakeweed, and horsebrush.

Figure 4.—Cattle grazing mat saltbush on Chipeta silty clay loam, 3 to 30 percent slopes, eroded.

over gray shale bedrock, and have slopes of up to 30 percent. Accumulations of salts are on the surface. In dry, hot weather a crust one-eighth of an inch thick forms on the surface and retards the infiltration of water. Cracks in the crust divide it into wafers about 2 to 5 inches in diameter, and these are easily crushed under foot. Sheet erosion is active. Runoff from this site causes gullying in range sites lower on the slopes.

The vegetation on this site is 90 to 100 percent mat saltbush. Indian ricegrass, squirreltail, Nuttaill saltbush, winterfat, and bud sagebrush are the important decreaser plants. Other important plants, classed as increasers, are bullgrass, galletagrass, mat saltbush, and shadscale. Nuttall saltbush, known locally as Castle Valley clover, and mat saltbush produce most of the forage on this site. Invader plants are foxglove, common sunflower, silver sage, and broom snakeweed. In years of adequate moisture, annual buckweed and annual bladderpod buckwheat (popweed) grow in large amounts. Sand dropseed is present in trace amounts, but it is doubtful that this plant ever was plentiful enough to be important. It is classed as a decreaser.

Drougthiness and the content of salts in the soil are the causes of the small amount of forage production, even when the site is in its best condition. This range site has a total potential production of 285 pounds of

Figure 5.—Galletagrass, blue grama, winterfat, shadscale, and bud sagebrush on Persayon loam, 3 to 20 percent slopes, eroded. Desert Loamy Shale range site.
This range site has a total potential production of 600 pounds of forage per acre, air dry, in favorable years, and of 250 pounds in less favorable years.

DESSERT LOAM BOTTOM RANGE SITE

This site is in narrow valleys and on broad alluvial plains throughout the survey area. It is near irrigated fields. In most places the site is in poor condition. Livestock tend to congregate on this range site because it is near water (fig. 6). The annual precipitation is 7 to 9 inches, but additional water runs in from adjacent areas. This range site is composed of deep, medium-textured and moderately fine textured soils of the Billings, Killpack, Penoyer, Ravola, and Woodrow series. These soils have slopes of 0 to 6 percent, but the dominant slopes are between 1 and 3 percent. In some places these soils are saline. Deep gullies, some of which are 20 to 30 feet deep and 50 to 100 feet wide, are common at the lower elevations. Most of the water that runs in from higher areas flows down the gullies, and this makes the range site drier than it was originally. Vegetation that once held the soil in place and helped to spread runoff water is now difficult to find.

Remnants of Great Basin wildrye, alkali sacaton, Indian ricegrass, squirreltail, and sand dropseed indicate that these are the important decrease grasses on this range site. Together they make up 50 to 60 percent of the potential vegetation.

Galleta, blue grama, bullgrass, and three-awn are the increaser grasses. They make up 15 to 20 percent of the potential vegetation. Other plants are scarlet globemallow, desert plantain, aster, locoweed, bud sagebrush, Nuttall saltbush, greasewood, and winterfat. The less important plants are shadscale, fringed sagebrush, big sagebrush, and rubber rabbitbrush. Invaders are broom snakeweed, pricklypear, Russian-thistle, and annuals.

Erosion has changed the potential plant composition and has lowered the production of forage. To restore the cut-tilled areas to productivity requires diversion terraces and water spreading to reduce further gulling and to make use of water that runs in from higher areas. A method for safely disposing of waste irrigation water may also be needed. To achieve proper results, mechanical treatments need to be followed by good range management.

This range site has a total potential production of 750 pounds of forage per acre, air dry, in favorable years, and of 325 pounds in less favorable years.

DESSERT COBBLY LOAM RANGE SITE

This range site consists of Shaly colluvial land on steep breaks or scarps below benches or mesas that are as much as 200 feet high. The soil material is a mixture of cobblestones, stones, and finer materials that have fallen and rolled downslope from cobble glacial outwash caps on benches. This material is as much as 36 inches thick. Slopes range from 1 to 70 percent, but mainly they are about 30 percent. Outcrops of shale are common on the steep slopes. The annual precipitation is 7 to 9 inches.

In a few places, these colluvial slopes extend for more than a mile to form a long cobbly fan. In addition, a few isolated hills that rise from the valley floor are covered by a thin mantle of cobbly loam over Mancos shale. The cobbly loam over shale provides good soil and plant-moisture relations and produces a much different type of vegetation than grows on the Desert Shale range site. The surface layer of the soil material on this range site ranges from gray to light brown, but as a rule it is brown. Under this is blue-gray shale. Fragmented brown sandstone rocks and gravel make up about 30 percent of the surface layer.

Western wheatgrass and black sagebrush grow on this site, but evidently they were never important plants. The potentially important plants are Indian ricegrass, needle-and-thread, squirreltail, bud sagebrush, winterfat, Mormon-tea, and cliftrose. These are choice plants for livestock. Also important are bullgrass, galletagras, western wheatgrass, blue grama, sand dropseed, shadscale, black sagebrush, yellow rabbitbrush, and scarlet globe-

Figure 6.—Annual weeds, mainly Russian-thistle, are dominant on Ravola loam, 1 to 3 percent slopes, when the range is in poor condition. Desert Loam Bottom range site.
mallow. In years that moisture is above normal in quantity, the other important plants are Indian-potato, phlox, evening-primrose, and desertlily.

This site has a total potential production of 550 pounds of forage per acre, air dry, in favorable years, and of 250 pounds in less favorable years.

DESSERT SANDY LOAM RANGE SITE

The largest and most representative single area of this site is on Walker Flat, south of Emery, Utah. Small areas are also in the northern and eastern parts of the survey area. This site occupies alluvial fans and flood plains. Slopes range from 0 to 6 percent but mainly are 3 to 4 percent.

Soils of the Beebe and Penoyer series make up this range site. They are deep loamy fine sands and very fine sandy loams. They absorb moisture readily, and because of this plants respond quickly to light summer showers. These soils are highly susceptible to wind erosion.

The potential plant cover on this site is winterfat, four-wing saltbush, Indian ricegrass, sand dropseed, squirrel-tail, scarlet globemallow, and Sandberg bluegrass. Where this range site is in excellent condition, four-wing saltbush makes up a large proportion of the forage.

Blue grama is an increaser on this range site, but it makes up 30 to 50 percent of the total herbage when this site is in fair or good condition. Less than 10 percent of the vegetation is greasewood and big sagebrush. Common invaders are cheatgrass, broom snakeweed, pricklypear, and annual weeds. Where this site is in excellent condition, less than 20 percent of the vegetation is galletagrass, fringed sagebrush, shadscale, and Nuttall saltbush.

This range site has a total potential production of 800 pounds of forage per acre, air dry, in favorable years, and of 100 pounds in less favorable years.

SEMI-DESERT LOAM BENCH RANGE SITE

This site is along the west side of the survey area, where long benches project from the eastern foothills of the Wasatch Mountains. These benches lie in an east-west direction, slope gradually to the east, and are dissected by numerous draws and a few intermittent streams. This range site is also on a few isolated mesas in the central part of the survey area. The average annual precipitation is 8 to 10 inches.

The Semi-Desert Loam Bench range site consists of Minchey and Palisade loams and clay loams that have slopes of 1 to 10 percent. As a rule, these soils are more than 30 inches deep over gravel. A moderate amount of lime generally is in the surface layer. Low or black sagebrush does not grow on these soils (fig. 7). The Price airport bench and Prophesy bench, both dominantly covered by big sagebrush, are included in this range site.

Benchlands grazed by sheep in winter have a grassland aspect; those grazed by cattle in spring have a browse aspect. For example, the bench south of Ivy Creek, grazed by sheep in winter, is dominantly galletagrass; the one north of Castle Dale, grazed by cattle in spring, is dominantly browse. Both benches have similar soils and are in the same range condition class.

Important increaser plants in this range site are Indian ricegrass, needle-and-thread, squirrel-tail, winterfat, bud sagebrush, and Nuttall saltbush. The common invaders of this site are broom snakeweed and annual weeds.

This range site has a total potential production of 950 pounds per acre, air dry, in favorable years, and of 350 pounds in less favorable years.

SEMI-DESERT LIMY LOAM RANGE SITE

This range site occupies the ridges on benchlands. The bench above Castle Dale and the benches between Emery and Moore are mainly in this range site. In most places this range site occurs with the Semi-Desert Loam Bench range site, but it is easily distinguished by the presence of low-growing black sagebrush. Pygmy sagebrush is common on the Harding soil. In some places the vegetation on these two associated range sites tends to merge and form a transitional zone. The annual precipitation is 8 to 10 inches.

Soils in the Harding, Minchey, and Sanpete series made up this range site. The surface layer is moderately fine textured, and the profile has a high content of lime. As a rule, a concentration of lime is between 10 and 30 inches. Roots are somewhat restricted but penetrate this limy
layer. This restriction in rooting causes the vegetation on this range site to be slightly less productive and to show the effects of drought earlier than on the Semi-Desert Loam Bench range site.

The potential vegetation on the Semi-Desert Limy Loam range site is Indian ricegrass, needle-and-thread, squirreltail, winterfat, bud sagebrush, Nuttall saltbush, black sagebrush, low sagebrush, gray molly, and Mormon tea. These plants make up about 15 to 20 percent of the total vegetation. Galletagrass makes up more of the potential vegetation on this range site than it does on the less drouthy Semi-Desert Loam Bench range site.

The potential production on the Semi-Desert Limy Loam range site is 750 pounds of forage per acre, air dry, in favorable years, and 350 pounds in less favorable years.

**SEMI-DESERT STONY LOAM (PINE-JUNIPER) RANGE SITE**

This range site is on mesas and benches in the foothills and lower breaks of the Wasatch Mountains. Slopes range from 2 to 60 percent but mainly are 3 to 10 percent. Juniper trees make up from 60 to 50 percent of the overstory; the rest is pinon. The annual precipitation is 10 to 15 inches.

Stony alluvial land and Kenilworth very stony sandy loam, 0 to 20 percent slopes, eroded, make up this range site. Gravel, cobblestones, and stones comprise most of the profile. In places there are large boulders.

The original vegetation in the understory is so badly depleted that remnants of grass are hard to find in most places. Erosion is active as indicated by weak pedicled shrubs and exposed roots of juniper and pinon trees. Roots of the present vegetation spread through the soil and use moisture that once was available to palatable range plants. This site has been damaged to the extent that it may never recover and produce the kinds of plants that once grew there (fig. 8). If domestic livestock are excluded, deer utilize all forage produced. Some deer live here the year around and consume whatever forage is available. Deep snow in the high country causes deer to concentrate on this site, and they consume even the juniper branches within their reach.

This site is in excellent condition on Wood Hill north of Price. Here, Indian ricegrass is 85 percent of the understory vegetation. Squirreltail, needle-and-thread, bullgrass, and sand dropseed make up 5 percent; phlox, scarlet globemallow, penstemon, locoweed, and aster make up 5 percent; and birchleaf mahogany, bitterbrush, cliffrose, dwarf mahogany, Mormon-tea, and mockorange make up 5 percent.

On Wood Hill this site produced 1,250 pounds of forage per acre, air dry, in 1957; it produced 900 pounds in 1961. The annual needle and twig growth of juniper and pinon was estimated to be 40 to 50 percent of the total production. Firewood, posts, pine nuts, and Christmas trees are other products taken from this site.

**SEMI-DESERT STONY HILLS (PINE-JUNIPER) RANGE SITE**

This range site is on the east and west sides of the survey area. It occurs with steep rock outcrops, which make up as much as 40 percent of the site in some places.

The soil in this site is Castle Valley extremely rocky very fine sandy loam, 0 to 20 percent slopes, eroded. It is medium textured, gravelly, and 10 to 20 inches thick over bedrock. The content of organic matter is low. The susceptibility to wind erosion is high in places where the range is in poor condition. The forage potential is low because this soil is shallow and has a low moisture-retaining capacity. Where pinon and juniper are dominant on the site, few plants are in the understory and improvement of range condition is slow.

In 1981 production of forage on this site was measured on a mesa in an adjoining area that had been grazed by deer but never by domestic livestock. It produced a total of 327 pounds of air-dry forage per acre from the following plants: 34 pounds, or 29 percent, from bullgrass; 185 pounds, or 55 percent, from pinon and juniper; and 48 pounds, or 16 percent, from all of the following plants combined: dryland sedge, bluebunch wheatgrass, penstemon, mat buckwheat, hairy golden-aster, rock goldenrod, woody phlox, and shadscale.

The potential plant cover on this site is about 37 percent pinon and juniper. Other species making up about 40 percent are Indian ricegrass, blue grama, galletagrass, perennial mustard, sanecio, milkweed, birchleaf mahogany, pricklypear, Mormon-tea, and winterfat.

This range site has a total potential production of 450 pounds of forage per acre, air dry, in favorable years, and of 100 pounds in less favorable years. Pinon and juniper trees are scrubby and they grow slowly. The firewood and posts produced on the site have little economic value.

**SALT MEADOW RANGE SITE**

This range site consists of saltgrass meadows on lower elevations to which seepage and irrigation waste water flow to supply additional moisture. The amount of water this site gets each year is variable, and because of this the content of salts in the soil is variable.

Soils of the Abbott, Libbings, and Saltair series make up this site (fig. 9). They are strongly saline, deep and moderately deep silty clays and silty clay loams. The water table fluctuates and may be below the root zone part of the year.

Alkali sacaton, alkali bluegrass, and tufted hairgrass are the decreaser plants. Poor management will result in a 100-percent stand of saltgrass. Foxtail, sedges, and wiregrass are the increasers. Greasewood and willow make up less than 5 percent of the total vegetation. Saltcedar (tamarisk), basia, and alkaliweed are invader plants.

This range site has a total potential production of 1,700 pounds of forage per acre, air dry, in favorable years, and of 900 pounds in less favorable years. These estimates do not include forage produced in slightly elevated, highly saline areas in which only greasewood and other salt-tolerant plants can survive.

**WET MEADOW RANGE SITE**

This range site is on alluvial bottom lands and flood plains and is wet during the growing season. Soils of the Abbott, Ferron, Killpack variant, Palisade variant, and Rafael series make up this site. They are deep, and their texture ranges from clay to loam.

The decreaser plants are tufted hairgrass, redtop, and native clover. Sedges, wiregrass, cinquefoil, goldenrod, buttercup, plantain, and arrowgrass are the increasers.
Figure 8—Top, Kenilworth very stony sandy loam, 0 to 20 percent slopes, eroded, in poor range condition. Bottom, another area of the same kind of soil in excellent range condition. Semi-Desert Stony Loam (Pinyon-Juniper) range site.
The potential forage production on this site depends on the fertility of the soils and on the length of the growing season. It ranges from 2,000 to 2,500 pounds per acre, air dry.

**WET STREAM BOTTOM RANGE SITE**

This range site consists of bottom lands of streams between the channel banks and the steep side slopes of adjacent higher land. It occurs mainly along the Price River and Muddy, Huntington, Cottonwood, and Ferron Creeks. The site is flooded in spring and is later flooded by runoff from summer thundershowers of high intensity.

Mixed alluvial land makes up this site. This material is deep, is stratified, and ranges in texture from clays to sands. In some places gravel is within 10 inches of the surface. The water table is near the surface in most places, but the depth to it depends on seasonal fluctuations of the stream level. Some areas are not affected by salt, and some are moderately affected. A good sod on the surface helps prevent gully ing.

The decrease plants are slender wheatgrass, alkali bluegrass, and native and tame clovers. The important increasers are alkali sacaton, squirreltail, wiregrass, saltgrass, giantreed, willow, cottonwood, buffaloberry, and squawbrush. Common invaders are povertyweed, rubber rabbitbrush, saltcedar (tamarisk), and annual weeds.

This range site has a total potential production of 2,500 pounds of forage per acre, air dry, in favorable years, and of 1,500 pounds in less favorable years.

**Use of the Soils for Wildlife**

All kinds of wildlife require suitable habitat that provides enough food, water, and living space to support their daily activity. If the landowner insures that these elements of wildlife habitat are plentiful, the wildlife population in an area will increase.

The kinds of wildlife that live in a given area and the number of each kind are closely related to land use and the resulting kinds and patterns of vegetation. These, in turn, are generally related to the kinds of soils. The agricultural uses of the soils are correlated with their suitability for wildlife. Nonirrigated land in farms may provide living space and cover but little food or water; irrigated land provides the food and water, especially during summer and fall.

In the following paragraphs wildlife and fish are discussed in two categories because the distribution of wildlife depends on kinds of landscapes, or soil associations, but the distribution of fish depends on locations of water sources and suitable farm ponds.

**Wildlife**—The survey area is divided into three wildlife suitability groups, according to soil associations. Several soil associations have been grouped because of similarities in land use, or plant cover, or both. The colored general soil map at the back of this survey outlines the boundaries of the different soil associations. More complete descriptions of the associations are given in the section "General Soil Map."

**WILDLIFE SUITABILITY GROUP 1**

This group consists of irrigated soils, wet soils, and soils in stream channels. These are the Chipeta and Killpeck soils in association 1; the Ravola, Billings, and Penoyer soils in association 2; the Saltair and Libbings soils in association 3; and the Sanpete and Minchey soils in association 4. Kinds of wildlife adapted to these soils are Chinese pheasant, mourning dove, cottontail rabbit, ducks, geese, muskrat, and beaver. The Chinese pheasant is the most important bird in this suitability group.

**WILDLIFE SUITABILITY GROUP 2**

This group consists of the nonirrigated soils in associations listed in wildlife suitability group 1, and of the Chipeta and Persay soils and Badland of association 5. Kinds of wildlife suited to these soils are chukar partridge and cottontail rabbit. Pheasant and mourning dove nest and seek cover here. Mule deer cross these soils when migrating, or they temporarily live here in winters of deep snow.

**WILDLIFE SUITABILITY GROUP 3**

This group consists of the rest of the survey area, mainly foothills covered by pinon and juniper. In this group are the Castle Valley and Kenilworth soils and Rock land of association 6. Kinds of wildlife suited to these soils are mule deer, chukar partridge, and cottontail rabbit. Mule deer summer in the forest adjacent to the survey area.

**Fish**—In addition to wildlife on land, fish are important in the survey area. Some trout are in the Price and Muddy Rivers and in Ferron, Huntington, and Cottonwood Creeks above the main diversions for irrigation water. These streams, however, are subject to flooding, and the lower reaches near diversions are not managed as fisheries by the State government.

Below points of diversion, permanent watercourses are adversely affected by salty seepage water and are inhabited only by trash fish. The Green River has no management program, yet 14 species of fish live in it. Of these, the channel catfish is the only game fish.

A number of farm ponds have been stocked in the past with bass and bluegill. Current practice is to stock farm...
VII.A.5  LAND CAPABILITY UNITS

Information from Carbon-Emery Area Soil Survey (Swenson et al., 1970).

Capability Groups of Soils

Capability classification is a grouping of soils to show, in a general way, their suitability for most kinds of farming. It is a practical classification based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment. The classification does not apply to most horticultural crops, or to rice and other crops that have special requirements. The soils are classified according to degree and kind of permanent limitations, but without consideration of major and generally expensive landforming that would change the slope, depth, or other characteristics of the soils; and without consideration of possible but unlikely major reclamation projects.

In the capability system, all kinds of soils are grouped at three levels, the capability class, subclass, and unit. These are discussed in the following paragraphs.

CAPABILITY CLASSES, the broadest grouping, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use. Classes are defined as follows:

Class I soils have few limitations that restrict their use.

Class II soils have some limitations that reduce the choice of plants or require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require very careful management, or both.

Class IV soils have very severe limitations that restrict the choice of plants, require very careful management, or both.

Class V soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife food and cover.

Class VI soils have severe limitations that generally make them unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife food and cover.
Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to grazing, woodland, or wildlife.

Class VIII soils and landforms have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, or water supply, or to esthetic purposes.

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter, e, w, s, or c, to the class numeral, for example, IIe-2, irrigated. The letter e shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; w shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); s shows that the soil is limited mainly because it is shallow, droughty, or stony; and c shows that the chief limitation is climate that is too cold or dry.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about the management of soils. Capability units are generally designated by adding numbers, or numbers and letters, assigned locally, for example, VIIe-D3X or Vw-2W. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation, and the small letter immediately following, the subclass, or kind of limitation as defined in the foregoing paragraph. The part of the symbol following the hyphen identifies the capability unit in the State system.

In the Utah system a number or letter is used to suggest the chief kinds of limitation. The numbers 1 or 2 in the first position show the climate, as 1 - climate with 150 to 190 frost-free days, and 2 - climate with 100 to 150 frost-free days. The letters D and S in the first position are for the nonirrigated capability units and show the range of average annual rainfall. D is 4 to 8 inches, S is 8 to 12 inches. Additional numbers or letters are used to show limitations as follows.

3 - inhibiting layer
4 - low water holding capacity (gravelly or cobbly soils)
5 - slow permeability
6 - low water holding capacity (sandy soils)
7 - salinity
8 - alkali
X - coarse fragments on the surface
W - a beneficial water table

Management by Capability Units

In this subsection each capability unit in the Carbon-Emery Area is described and the use and management are briefly discussed. To find the names of all the soils in any given capability unit, refer to the "Guide to Mapping Units".
GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which the mapping unit belongs. In referring to a capability unit or a range site, read the introduction to the section it is in for general information about its management. Other information is given in tables as follows:

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(1) Per J. Walsh  
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<tr>
<td>PCE2</td>
<td>Persayo-Chipeta association, 1 to 20 percent slopes, eroded Persayo soil</td>
<td>VIIe-D4</td>
<td>Desert Loamy Shale</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Desert Shale</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VIIe-D3</td>
<td>--</td>
</tr>
<tr>
<td>Ra</td>
<td>Rafael silty clay loam</td>
<td>VIIw-28</td>
<td>Wet Meadow</td>
</tr>
<tr>
<td>RuB2</td>
<td>Ravola-Bunderson complex, 1 to 3 percent slopes, eroded Ravola soil</td>
<td>VIIe-D</td>
<td>Desert Loam Bottom</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>--</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VIIe-D</td>
<td>--</td>
</tr>
<tr>
<td>Ry</td>
<td>Rock land</td>
<td>VIIIs-3</td>
<td>--</td>
</tr>
<tr>
<td>Sa</td>
<td>Saltair silty clay loam</td>
<td>VIIw-28</td>
<td>Salt Meadow</td>
</tr>
</tbody>
</table>

(1) Per J. Walsh  
(2) No Information Available
Capability Unit Vw-2W (Nonirrigated)

This capability unit consists of deep and moderately deep, poorly drained or somewhat poorly drained, nearly level and gently sloping soils on alluvial fans and flood plains. The texture of the surface layer ranges from loam to silty clay loam. These soils are in the Ferron and Palisade series.

Permeability ranges from moderate to slow. In most places salinity is moderate, but in some places it is none to slight. The water table typically is within 20 to 30 inches of the surface, but it is lower in some seasons of the year. These soils are suited to pasture and meadow hay and are used for those purposes. They can be reseeded, fertilized, and given other management to increase the production of forage.

Capability Unit VIIe-D (Nonirrigated)

This capability unit consists of well-drained, nearly level to sloping, eroded soils and of some soils that are moderately deep over shale. The surface layer is silty clay loam to loam. The soils are on alluvial fans and flood plains and in narrow alluvial valleys. They are in the Billings, Killpack, Penoyer, Ravola, and Bunderson series. Some irregularly shaped slickspots consisting of Bunderson loam are within areas of Ravola soils.

The soils of this unit retain from 5.5 to 11 inches of moisture. They are seldom moistened to a depth of 3 feet by precipitation. Fertility and the content of organic matter are naturally low.

These soils are moderately to highly susceptible to erosion. Gullies are 3 to 10 feet deep and about 100 to 500 feet apart. Without irrigation, these soils are suited only to range. Reseeding of grasses, clearing of brush, or other practices are not feasible, because of the limited amount of precipitation.

Capability Unit VIIe-D3 (Nonirrigated)

In this capability unit are the Chipeta soils that are intermingled with and were mapped with areas of Badland and with Persayo soils. These Chipeta soils are rolling to steep and are less than 20 inches deep over shale bedrock. The surface layer is silty clay loam. Shale outcrops are common, and in places they cover 20 percent of the surface.

These Chipeta soils are slowly permeable and have a slow rate of infiltration. They are moderately eroded and are highly susceptible to further erosion. Rills and gullies are common. The soils retain 2 to 3 inches of water that is available to plants, but they are usually dry because of the limited rainfall. Salinity is moderate.

These soils are used only for range and are suited to that purpose. Reseeding of grasses and clearing of brush or other mechanical practices that would improve the range are not feasible.
Capability Unit VII-e-D4 (Nonirrigated)

In this capability unit are the Persayo soils that are intermingled with Chipeta soils and were mapped with those soils. These Persayo soils are generally less than 20 inches deep over shale bedrock, but in some places they are deeper than 20 inches.

The Persayo soils have a loam surface layer. They are slowly permeable and are highly susceptible to further erosion. Most areas are eroded. In some places gullies 3 to 6 feet deep and 100 to 300 feet apart have cut through the underlying shale. These soils retain about 2.5 inches of water that is available to plants, but they are usually dry because of the limited rainfall. Salinity ranges from slight to moderate.

These soils are used only for range and are suited to that purpose. Reseeding of grasses and clearing of brush or other mechanical practices that would improve the range are not feasible.

Capability Unit VII-e-D6 (Nonirrigated)

This capability unit consists of sandy, deep, well-drained, gently to moderately sloping soils of the Beebe and Penoyer series. These soils are on alluvial fans and flood plains and in narrow valleys. The surface layer is very fine sandy loam, loam, and loamy fine sand. Some of the soils are eroded and contain shallow gullies and rills.

These soils hold 4.0 to 7.5 inches of water available to plants. Runoff is slow to medium, and permeability is moderate. The susceptibility to erosion is moderate to high. The frost-free season is 110 to 160 days.

The soils are used for range.

Capability Unit VII-w-28 (Nonirrigated)

This capability unit consists of deep and moderately deep, nearly level and gently sloping, poorly drained, strongly saline and alkali soils on alluvial fans and flood plains. The surface layer is silty clay loam. These soils are in the Abbott, Libbings, Saltair, and Rafael series.

Permeability typically is slow. Platy crusts of salt on the surface, underlain by layers of soft, granular material, are common. The water table generally is 30 to 60 inches beneath the surface, but it may be within 20 inches of the surface early in summer.

These soils are used for and are suited to range. Because they are strongly saline, they are not suitable for reseeding or other practices intended to increase the production of forage. The dominant vegetation is greasewood and saltgrass.
In this capability unit are deep, well-drained, nearly level silty clay loams and clay loams on alluvial fans and flood plains and in narrow alluvial valleys. Some areas are moderately deep over shale. The soils are in the Billings, Killpack, Penoyer, Ravola, and Woodrow series.

Permeability is slow, and fertility and the content of organic matter are low. The soils retain 5.5 to 11 inches of water. The susceptibility to erosion is slight to moderate. Unless these soils are irrigated, they are suited only to range. Reseeding, clearing of brush, and similar practices that would improve the range are not feasible.

The only soil in this capability unit is Castle Valley extremely rocky very fine sandy loam, 0 to 20 percent slopes, eroded. It consists of medium-textured to coarse-textured material that typically is less than 20 inches deep over sandstone bedrock.

Permeability is moderate to rapid. The susceptibility to erosion is slight to high. This soil retains 3 to 4 inches of water but is generally dry because of the limited amount of rainfall.

This soil is used for range and is suited to that purpose. Reseeding of grasses and clearing of brush or other mechanical practices that would improve the range are not feasible.

This capability unit consists only of Gullied land. This land type is the source of the high content of silt in runoff, and it has little potential for the production of vegetation. Small areas are used for grazing, but the main use of this land type is for wildlife habitat.

This capability unit consists only of bare, steep ledges of Rock land on which plants do not grow. The only use is for wildlife habitat, water supply, and esthetic purposes.

This capability unit consists of rough, broken, and nearly bare areas of Badland and of a Bunderson soil. These areas have little potential for the production of plants and are sources of silt carried by runoff.

Small areas are used for a limited amount of grazing. The areas are used mainly, however, as a habitat for wildlife, for water supply, and for esthetic purposes.
VII.A.6 WATER EROSION

The Universal Soil Loss Equation (USLE) is a tool for soil conservation and erosion control planning (SCSA, 1976). The equation is used to predict the magnitude of a soil's inherent erosion potential caused by rainfall and associated runoff, commonly referred to as sheet and rill erosion.

The USLE is subject to many assumptions and constraints, especially important in the western lands, on steep slopes, rangelands and forest lands (USDA, SCS, 1978). The USLE was devised primarily for cropland east of the Rocky Mountains, although most of the soil series established within the continental U.S. have predicted erodibility factors (K) estimated. In this report the USLE parameters (K and C) are listed. The factors are to be used as an aid to reclamation planning and not to predict volumes of soil loss through erosion. It is best used when comparing potential erosion of soils within the project area.

The USLE can be used to estimate pre-disturbance soil loss. Soil erodibility factor (K) and cropping factor (C) for the soils to be disturbed are listed below. Erodibility factors (K) for most soils are calculated using soil particle size analysis, on-site information, pedon descriptions and soil erodibility nomograph (Wischmeier et al., 1971) The cropping or vegetation factor (C) is computed from pace transect data collected at each sampled pedon; an estimation of canopy cover and height were used in the determination of C.
VII.A.7 WIND EROSION

Refer to table below for wind erodibility groups (WEG) from SCS Soil Interpretation Records. For some soils, when data was insufficient, the WEG was estimated using textural analysis and WEG (USDA, SCS, Wy-2 Wind Erodibility, 1978).

Most of the soils delineated are primarily in groups 3, 4 and 4L. A soil with high wind erosion hazard is the Beebe. Wind erosion hazard is lowest for wet and stony soils; included wet soils are the Ferron and Saltair.

<table>
<thead>
<tr>
<th>Soil Series And Map Unit/Slope</th>
<th>Erodibility (K)</th>
<th>Crop Factor (C)</th>
<th>Wind Erodibility Group (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atluval Land (2)</td>
<td>.48</td>
<td>.63</td>
<td>3</td>
</tr>
<tr>
<td>Badland</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beebe Variant</td>
<td>.48</td>
<td>.52</td>
<td>2</td>
</tr>
<tr>
<td>Billings</td>
<td>.43e</td>
<td>.50d</td>
<td>4L</td>
</tr>
<tr>
<td>Bunderson (2)</td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Castle Valley</td>
<td>.42</td>
<td>.65</td>
<td>3</td>
</tr>
<tr>
<td>Chipeta-Badland</td>
<td>.44</td>
<td>.77</td>
<td></td>
</tr>
<tr>
<td>Chipeta-Persayo</td>
<td>.44-.47</td>
<td>.64-.77</td>
<td>4L</td>
</tr>
<tr>
<td>Disturbed Land (3)</td>
<td>.51f</td>
<td>1.0</td>
<td>3</td>
</tr>
<tr>
<td>Ferron</td>
<td>.43</td>
<td>.21</td>
<td>8</td>
</tr>
<tr>
<td>GP Silt Loam (4)</td>
<td>.48c</td>
<td>.72</td>
<td>5.6</td>
</tr>
<tr>
<td>Gullied Land</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hunting</td>
<td>.40</td>
<td>.24</td>
<td>4L</td>
</tr>
<tr>
<td>Ildefonso</td>
<td>.44</td>
<td>.53</td>
<td>3</td>
</tr>
<tr>
<td>Persayo-Chipeta</td>
<td>.44-.47</td>
<td>.54-.77</td>
<td>4L</td>
</tr>
<tr>
<td>Rafael</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ravola-Bunderson</td>
<td>.41-.53</td>
<td>.50-.62</td>
<td></td>
</tr>
<tr>
<td>Rockland</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saltair</td>
<td>.55</td>
<td>.80-.83</td>
<td>8</td>
</tr>
</tbody>
</table>

(a) Estimated using textural analysis and soil erodibility nomograph (Wischmeier, et al., 1971).

(b) Factor estimated using vegetative canopy cover, from pace transect data and approximate height of average fall from canopy (USDA, SEA, 1978).

(c) Data insufficient; estimated using first approximation of K (Wischmeier, et al, 1971) with 58 percent silt and very fine sand, 25 percent clay and 17 percent sand.

(d) Cropping factor estimated from range data supplied by soil interpretation records (SCS).

(e) Information from SCS Soil Interpretation Records.

(f) K factor estimated for soil layer 11 to 53 in.

(1) surface texture estimated only

(2) estimated using laboratory textural analysis and WEG (USDA, SCS, 1978)

(3) estimated using laboratory textural analysis of subsoil, 11 to 53 inches, and WEG (USDA, SCS, 1978)

(4) estimated using field textures and WEG (USDA, SCS, 1978)
VII.B  DETAILED DESIGNS AND CALCULATIONS -  
EVALUATION OF SOIL MATERIAL AS A PLANT GROWTH MEDIA

VII.B.1  METHOD OF EVALUATION

The criteria for evaluating soil as a plant growth media are given in the Table below. The criteria include sodium adsorption ratio (SAR), electrical conductivity or salinity (EC), toxic materials, soil reaction (pH), available water capacity, erosion factor, wind erosion group, texture, and percent coarse fragments.

Limits of each parameter are those of SCS, National Soils Handbook (NSH) or Wyoming Dept. of Environmental Quality (DEQ), Guideline No. 3 (revised March 1980). Criteria are given for good, fair or poor sources of reconstruction material. A good rating means vegetation is relatively easy to establish and maintain, the surface is stable and resists erosion, and the reconstructed soil has good potential productivity. Material rated fair can be vegetated and stabilized by modifying one or more properties. Top dressing with better material or application of soil amendments may be necessary for satisfactory performance. Material rated poor/unsuitable has such severe problems that revegetation and stabilization is very difficult and costly. Some material rated poor by NSH and not unsuitable by DEQ is noted in Table 8-5 as being marginally suitable material. Top dressing with better material may be necessary to establish and maintain vegetation.

<table>
<thead>
<tr>
<th>Property</th>
<th>Limits</th>
<th>Restrictive Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Good</td>
<td>Fair</td>
</tr>
<tr>
<td>1. Sodium Adsorption Ratio (SAR)</td>
<td>$&lt; 6^c$</td>
<td>6-10</td>
</tr>
<tr>
<td>2. Salinity (MMHOS/CM)$^c$</td>
<td>4</td>
<td>4-8</td>
</tr>
<tr>
<td>3. Toxic Materials (boron)</td>
<td>$&lt; 5$</td>
<td>$&lt; 5$</td>
</tr>
<tr>
<td>4. Soil Reaction (pH)$^b$</td>
<td>5.6-7.8</td>
<td>4.5-5.5</td>
</tr>
<tr>
<td>5. Soil Reaction (pH)$^c$</td>
<td>7.9</td>
<td>7.9-8.4</td>
</tr>
<tr>
<td>6. Available Water Capacity (IN/IN)$^2$</td>
<td>&gt;.10</td>
<td>.05-.10</td>
</tr>
</tbody>
</table>

-63-
VII.B.1. METHOD OF EVALUATION (Cont)

<table>
<thead>
<tr>
<th>Property</th>
<th>Limits</th>
<th>Restrictive Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Good</td>
<td>Fair</td>
</tr>
<tr>
<td>7. Erosion Factor (K)</td>
<td>&lt; .37</td>
<td>&lt; .37</td>
</tr>
<tr>
<td>8. Wind Erod. Group</td>
<td>&gt; 3</td>
<td>&gt; 3</td>
</tr>
<tr>
<td>9. USDA Texture</td>
<td>---</td>
<td>SCL, CL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SICL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SC</td>
</tr>
<tr>
<td>10. USDA Texture</td>
<td>---</td>
<td>LCOS, LS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LFS, LVFS</td>
</tr>
<tr>
<td>11. Coarse Frag. (WT PCT)</td>
<td>&lt; 15</td>
<td>15-35</td>
</tr>
<tr>
<td>3-10 in.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 10 in.</td>
<td>&lt; 3</td>
<td>3-10</td>
</tr>
</tbody>
</table>

Adapted from National Soils Handbook, NSH - Part II [403.6(a)], unless otherwise noted.

(a) Layers with high potential acidity should be rated poor.
(b) If in kaolinitic family, rate one class better if experience confirms.
(c) Wyoming Dept. of Environmental Quality (WDEQ), Guideline No. 3 (revised March 1980).
(1) 10-12 for heavy textured soils (WDEQ, 1980)
VII.B.2 SOIL CHEMICAL AND PHYSICAL PROPERTIES

Chemical and physical data for project area soils were collected to evaluate the soils as reconstruction material for disturbed lands. Sources of information include analysis by Utah State University Soils Laboratory, Carbon-Emery Area Soil Survey (Swenson, et al., 1970), and SCS Soil Interpretation Records. Refer to the attached soil chemical and physical data for the major soils groups.

Soils were sampled by horizon and analyzed by Utah State University Soils Laboratory. The parameters determined were particle size distribution, texture class, paste pH, organic carbon, gypsum, boron, electrical conductivity, saturation percent, atmosphere moisture tensions, cation exchange capacity, SAR and classification. The techniques used were those of USDA Handbook 60, with the exception of organic carbon, which was determined using the University of Colorado, Agronomy Series No. 13, Method 90-3. Particle size analysis was determined using a sieve and hydrometer technique.

TECHNIQUES USED IN SOIL ANALYSIS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Reported As</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductivity</td>
<td>mmhos/cm @ 25°C</td>
<td>USDA Handbook 60, method (31), p. 84 and method (4b), p. 89-90, or A.S.A. Mono. No. 9, Part 2, pp. 937-940.</td>
</tr>
<tr>
<td>Soluble Ca, Mg &amp; Na</td>
<td>meq/l</td>
<td>Extraction of Ca, Mg, and Na by USDA Handbook 60, Method (3a) p. 84, Analysis by atomic absorption spectrophotometry.</td>
</tr>
<tr>
<td>Sodium Adsorption-Ratio</td>
<td>SAR calculated from soluble Ca, Mg &amp; Na concentration.</td>
<td>USDA Handbook 60, p. 26.</td>
</tr>
<tr>
<td>Texture</td>
<td>USDA textural class</td>
<td>USDA Handbook 18, p. 205-233</td>
</tr>
</tbody>
</table>

Compiled from Table 1-1: WDEQ, Guideline No. 1, revised Feb. 1980.
### Physical and Chemical Properties of Selected Soils

<table>
<thead>
<tr>
<th>Soil Series</th>
<th>Depth (in.)</th>
<th>V. Coarse to Medium sand 2.0-25mm (%)</th>
<th>Fine to V. Fine sand .25-.05mm (%)</th>
<th>Sand 2.0-.05mm (%)</th>
<th>Silt (.05-.002mm) (%)</th>
<th>Clay (less than .002mm) (%)</th>
<th>Organic Matter (%)</th>
<th>pH paste</th>
<th>ESP (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beebe loamy</td>
<td>0 - 2</td>
<td>1.9</td>
<td>54.5</td>
<td>56.4</td>
<td>35.0</td>
<td>8.6</td>
<td>2.25</td>
<td>8.0</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2 - 12</td>
<td>4.0</td>
<td>77.6</td>
<td>81.6</td>
<td>12.3</td>
<td>6.1</td>
<td>0.38</td>
<td>9.7</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>12 - 16</td>
<td>36.3</td>
<td>53.9</td>
<td>90.2</td>
<td>6.1</td>
<td>3.7</td>
<td>0.14</td>
<td>9.6</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>16 - 34</td>
<td>3.7</td>
<td>76.6</td>
<td>80.3</td>
<td>13.9</td>
<td>5.8</td>
<td>0.83</td>
<td>8.5</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>34 - 56</td>
<td>5.1</td>
<td>41.9</td>
<td>47.0</td>
<td>34.8</td>
<td>18.2</td>
<td>0.83</td>
<td>7.9</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>39 - 70</td>
<td>8.3</td>
<td>72.5</td>
<td>80.8</td>
<td>12.6</td>
<td>6.8</td>
<td>0.24</td>
<td>8.2</td>
<td>8</td>
</tr>
<tr>
<td>Billings silty</td>
<td>0 - 3</td>
<td>-</td>
<td>25.0</td>
<td>48.0</td>
<td>29.0</td>
<td>2.92</td>
<td>7.9</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>clay loam</td>
<td>3 - 11</td>
<td>-</td>
<td>17.0</td>
<td>50.0</td>
<td>33.0</td>
<td>2.22</td>
<td>8.0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11 - 18</td>
<td>-</td>
<td>14.0</td>
<td>52.0</td>
<td>34.0</td>
<td>1.08</td>
<td>7.8</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>18 - 42</td>
<td>-</td>
<td>11.0</td>
<td>51.0</td>
<td>38.0</td>
<td>0.81</td>
<td>7.6</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>42 - 58</td>
<td>-</td>
<td>10.0</td>
<td>52.0</td>
<td>38.0</td>
<td>0.81</td>
<td>8.0</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Bundyson loam</td>
<td>0 - 1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.21</td>
<td>9.3</td>
<td>79</td>
</tr>
<tr>
<td></td>
<td>1 - 4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.34</td>
<td>10.0</td>
<td>98</td>
</tr>
<tr>
<td></td>
<td>4 - 11</td>
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<td>0.59</td>
<td>8.7</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>11 - 18</td>
<td>-</td>
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<td>-</td>
<td>0.60</td>
<td>8.4</td>
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</tr>
<tr>
<td></td>
<td>18 - 31</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.41</td>
<td>8.0</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>31 - 38</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.41</td>
<td>7.9</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>38 - 72</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.51</td>
<td>7.9</td>
<td>15</td>
</tr>
<tr>
<td>Castle Valley</td>
<td>0 - 2</td>
<td>0.9</td>
<td>79.6</td>
<td>80.5</td>
<td>13.5</td>
<td>6.0</td>
<td>0.77</td>
<td>7.6</td>
<td>4</td>
</tr>
<tr>
<td>very fine sandy</td>
<td>2 - 5</td>
<td>1.3</td>
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<td>70.5</td>
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<td>39.6</td>
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<td>45.9</td>
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<td>13.9</td>
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<td>25.4</td>
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<td>8.5</td>
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**NOTE** *value is high because roots were matted above the horizon*
VII.

B.

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**VII.B.4 EVALUATION OF SOIL RECONSTRUCTION MATERIAL**

The table below is an evaluation of soil reconstruction material for each horizon of each soil type. The evaluation is based on the soil chemical and physical data.

The soils are rated good, fair, marginally suitable or poor/unsuitable sources of reconstruction material. The overall rating given for each horizon is the rating for the most limiting criteria.

<table>
<thead>
<tr>
<th>Series And Phase</th>
<th>Sample No.</th>
<th>Horizon (in)</th>
<th>SAR</th>
<th>Salinity</th>
<th>Toxic Materials (Boron)</th>
<th>Soil Reaction</th>
<th>Available Water Cap</th>
<th>Erosion Factor (K)</th>
<th>Wind Erodibility Group</th>
<th>USDA Texture</th>
<th>Coarse Frag</th>
<th>Overall Rating</th>
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<td>good</td>
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<td>poor</td>
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<tr>
<td>(Typic Salorthid)</td>
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<td>C1</td>
<td>5-20</td>
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<td>good</td>
<td>fair</td>
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<td>poor</td>
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<td>poor</td>
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<td>good</td>
<td>fair</td>
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<td>C1ca</td>
<td>4-14</td>
<td>poor</td>
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<td>marg.</td>
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<td>C2ca</td>
<td>14-43</td>
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<td>C3cs</td>
<td>43-63</td>
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-68-
### Table 8-6 (Continued)

Evaluation of Soil Reconstruction Material for Areas to be Disturbed

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<tr>
<th>Series And Phase</th>
<th>Sample No.</th>
<th>Horizon</th>
<th>Depth (in)</th>
<th>Toxic Materials (Boron)</th>
<th>Soil Reaction</th>
<th>Available Water Cap</th>
<th>Erosion Factor (K)</th>
<th>Wind Erodibility Group</th>
<th>USDA Texture</th>
<th>Coarse Frags</th>
<th>Overall Rating</th>
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### Table 8-6 (Continued)

**Evaluation of Soil Reconstruction Material for Areas to be Disturbed**

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<th>Sample No.</th>
<th>Horizon</th>
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<th>Salinity</th>
<th>Toxic Materials (Boron)</th>
<th>Soil Reaction</th>
<th>Available Water Cap</th>
<th>Erosion Factor (K)</th>
<th>Wind Erodibility Group</th>
<th>USDA Texture</th>
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<th>Overall Rating</th>
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<td>Persayo fine sandy clay loam, eroded</td>
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<td>--</td>
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<td>marg.</td>
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<td>marg.</td>
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VII.B.4  EVALUATION OF SOIL RECONSTRUCTION MATERIAL (Cont.)

Table 8-6 (Continued)

Evaluation of Soil Reconstruction Material
for Areas to be Disturbed

| Series And Sample No. | Depth (in) | SAR | Salinity | Toxic Materials (Boron) | Soil Reaction | Available Water Cap | Erosion Factor (K) | Wind Erodibility Group | USDA Texture | Coarse Frags | Overall Rating |
|------------------------|-----------|-----|----------|------------------------|---------------|---------------------|-------------------|------------------------|--------------|-------------|----------------|------|

1. pedon information taken from: SCS soil interpretation records, established series descriptions, Carbon-Emery Area Soil Survey (Senson, et al., 1970), and Coal Creek portion of Carbon Area Survey (SCS, 1978).

2. calculated from textural analysis, saturation percentage, and laboratory determination of fragments 2.0 mm (USDA, USFS, 1974).

3. calculated from Wischmeier's soil erodibility nomograph and particle size determination (Wischmeier, 1978).

4. calculated from SCS wind erodibility group (WEG) and textural analysis (USDA, SCS, 1978).

5. Coarse fragments determined from laboratory analysis.

6. not sampled; waste coal layer

7. rating from field observations

8. rated one class better since field evidence indicates roots are not resisted in this layer.

9. marg. = marginally unsuitable, useable material

10. -- information not available.
VII.B.5 DEPTHS OF SUITABLE TOPSOIL MATERIAL

The depths of material available for reclamation of areas of proposed surface disturbance are listed below by map unit. The table includes the map unit, soil type, depth of horizon, rating and percent of map unit, as well as the recommended depth of stripping and the restrictive features. Some map units are not rated because of insufficient data. Others are not rated due to the variability of the map unit.

Soils rated good or fair are suitable for use in reclamation. Some soils considered marginally suitable may be used. Soils rated poor/unsuitable are not suitable for use in reclamation.

Recommendations for use have been rounded to 3-in. intervals. Those soils rated fair or good to 3 inches or less are considered too thin for salvage.

<table>
<thead>
<tr>
<th>Map Unit</th>
<th>Components</th>
<th>Depth (in)</th>
<th>Rating</th>
<th>Percent of Map Unit</th>
<th>Recommended Depth Suitable Material</th>
<th>Restrictive Feature</th>
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<td>(erodible)</td>
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<td>95</td>
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<td>Various Inclusions</td>
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<td>(too variable)</td>
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<td>(erodible, texture)</td>
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<td>Bunderson</td>
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<td>POOR</td>
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<td>0 in.</td>
<td>(SAR, salinity, pH)</td>
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<td>0-15</td>
<td>41-42 in.</td>
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### VII.B.5 DEPTHS OF SUITABLE TOPSIOI MATERIAL (Cont)⁷

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### VII.B.5 DEPTHS OF SUITABLE TOPSOIL MATERIAL (Cont)²

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<td>(erodible, texture)</td>
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<td>FAIR</td>
<td>0-15</td>
<td>12 in.</td>
<td>(salinity, pH, texture)</td>
</tr>
<tr>
<td></td>
<td>Saline/Alkali Soils</td>
<td>--</td>
<td>--</td>
<td>0-15</td>
<td>N/R</td>
<td></td>
</tr>
<tr>
<td>Hs</td>
<td>Hunting, moderately</td>
<td>0-45±</td>
<td>FAIR-MARG.</td>
<td>95</td>
<td>6 in. (1)</td>
<td>(wetness, pH, erosion, salinity)</td>
</tr>
<tr>
<td></td>
<td>saline phase 0-45+</td>
<td></td>
<td>*</td>
<td>5</td>
<td>N/R</td>
<td></td>
</tr>
</tbody>
</table>

---

*(1)*: For moderately to strongly saline soils.
### VII.B.5 DEPTHS OF SUITABLE TOPSOIL MATERIAL (Cont.)

<table>
<thead>
<tr>
<th>Map Unit</th>
<th>Components</th>
<th>Depth (in)</th>
<th>Rating</th>
<th>Percent of Map Unit</th>
<th>Recommended Depth Suitable Material</th>
<th>Restrictive Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>IID2</td>
<td>Ildefonso</td>
<td>0-6</td>
<td>POOR</td>
<td>85</td>
<td>24 in. (1)</td>
<td>(SAR, pH, AWAC)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6-33±</td>
<td>MARG.-FAIR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hunting</td>
<td>0-45</td>
<td>FAIR-MARG.</td>
<td>0-15</td>
<td>40 in.</td>
<td>(wetness, pH, erosion)</td>
</tr>
<tr>
<td></td>
<td>Sanpete²</td>
<td>0-30</td>
<td>GOOD-FAIR</td>
<td>0-15</td>
<td>30 in.</td>
<td>(pH, texture)</td>
</tr>
<tr>
<td></td>
<td>Harding</td>
<td>0-57</td>
<td>POOR</td>
<td>0-15</td>
<td>0 in.</td>
<td>(SAR, salinity, pH)</td>
</tr>
<tr>
<td>PCE2</td>
<td>Persayo</td>
<td>0-19</td>
<td>FAIR</td>
<td>40</td>
<td>18 in.</td>
<td>(erosion, pH)</td>
</tr>
<tr>
<td></td>
<td>Chipeta</td>
<td>0-11</td>
<td>POOR</td>
<td>40</td>
<td>0 in.</td>
<td>(erosion, SAR, salinity)</td>
</tr>
<tr>
<td></td>
<td>Badland</td>
<td>*</td>
<td>20</td>
<td></td>
<td></td>
<td>N/R</td>
</tr>
<tr>
<td>RuB2</td>
<td>Ravola</td>
<td>0-30</td>
<td>FAIR</td>
<td>60</td>
<td>30 in.</td>
<td>(SAR, salinity, erosion)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30-71</td>
<td>MARG.-POOR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bunderson</td>
<td>0-63</td>
<td>POOR</td>
<td>35</td>
<td>0 in.</td>
<td>(SAR, salinity, pH)</td>
</tr>
<tr>
<td></td>
<td>Strongly saline soils</td>
<td>N/T</td>
<td>5</td>
<td></td>
<td></td>
<td>N/R</td>
</tr>
<tr>
<td>Ry</td>
<td>Rockland</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td>N/R</td>
</tr>
<tr>
<td>Sa</td>
<td>Saltair²</td>
<td>0-60</td>
<td>POOR</td>
<td>100</td>
<td>0 in.</td>
<td>(SAR, pH, erosion)</td>
</tr>
</tbody>
</table>

1 excluding surface soil
2 evaluations and recommendations made from SCS information
N/R - Not Recommended
N/T - Not Tested or Sampled
MARG. - Marginal
* - too variable, but salvage of soil material on gentle sloping areas is recommended
VII.B.6 SUMMARY

Vegetation is difficult to establish on soils with high SAR; SAR indicates potential instability and water transmission problems. SAR was determined for all samples. A number of soils are rated poor/unsuitable in some of the horizons. Some are rated marginally suitable. Others are good or fair. The factors are not more limiting. Adequate mixing of this material may decrease the sodicity of this material. A judicious selection of sodic-tolerant species may also aid in reclamation success.

Salinity [electrical conductivity (EC)] tests were run on most soils in the detailed mapping area. Highly saline soils inhibit seed germination and plant growth, thus reducing reclamation success and increasing susceptibility to erosion. The Beebe variant, Bunderson, Chipeta, GP, Alluvial Lands, and Saltair soils are rated poor/unsuitable or marginally suitable in one or more horizons. Other soils are rated good or fair throughout.

Some elements, such as boron and selenium, can be deleterious to plants or the animals that feed on them. Boron was tested in all samples and most soils are rated good for boron (less than 5 ppm, Wyo. DEQ, Guideline No. 3). Boron does not seem to be a major problem in the soils. Boron exceeded 5 ppm in the substratum of the GP series; it is, therefore, rated poor for toxic material. No selenium indicators (astragalus) were found at the site. Therefore, selenium was not tested.

Paste pH was determined for all samples tested. For soils for which no site-specific data were available, pH values from Carbon-Emery Area Soil Survey (Swenson, et al., 1970) were used. Excessively high or low pH causes problems in establishing vegetation and as a result influence erosion and stability of the surface. Values of pH ranged from mildly alkaline to very strongly alkaline (7.7 to 10.1). The Beebe variant, Bunderson, GP Series, Rafael, Saltair, and Alluvial Land soils are rated poor-unsuitable, or marginally suitable in portions or all of the substratum. High pH values can be made more neutral by the addition of a soil amendment. Plant species selection may be made according to degree of alkalinity.

The available water-holding capacity (AWHC) also is important in establishing vegetation. Soils with low available water capacity may require irrigation for establishment of vegetation. AWHC was estimated by using saturation percentage, laboratory textural analysis and coarse fragments from site-specific data (USDA, USFS, 1974). All soils are rated good or fair throughout. The Alluvial Land soil is rated poor in the surface layer only. AWHC is not a limiting factor in any of the soils recommended.
VII.B.6 SUMMARY (Cont)

The stability of the soil depends upon its erodibility by water and wind and its strength. Water erodibility is indicated by the K factor; wind erodibility is rated according to the wind erodibility group. For soils at the Emery Mine erodibility factors (K) were calculated based on the soil erodibility nomograph (Wischmeier, 1971). K factors were corrected to include the effects of coarse fragments. K values for other soils of the project area are from the best data available in the SCS Soil Survey Interpretation Records. Most soils are rated good or fair throughout. The Alluvial Land soil and the Chipeta soil are rated poor since field observations indicate active erosion.

Wind erodibility is based on textural data and wind erodibility group (WEG) (USDA, USFS, 1979). The ratings for WEG ranged from good to poor; most soils are rated good or fair in most horizons. The surface horizon of the Beebe soil is rated poor; it is a loamy sand. The substratum of the Alluvial Land soils is rated poor; these horizons are also in the textural class loamy sand. Some soils are rated one class lower since field observations indicate active wind erosion.

USDA texture influences available water capacity and erodibility by wind or water. Texture also influences soil structure, consistence, water intake rate, runoff, fertility, workability, and trafficability. Potential slippage hazard is related to soil texture, and although other factors also contribute, the ratings of soil texture represent one important factor. Soil texture is rated fair or good. No soils tested high for sand. The subsoil of the Chipeta is high in clay.

Coarse fragments influence the ease of excavation, stockpiling and respreading, and suitability for the final use of the land. A certain amount of coarse fragments can be tolerated depending upon the size and the intended use of the reclaimed area. If the size of rock fragments exceeds 10 inches, the problems are more severe. Coarse fragments do not present a limiting factor in the use of most soils. Shallow, skeletal soils such as the Castle Valley have increasing coarse fragments with depth. Some soils are gravelly or very gravelly in the subsoils; fragments greater than 3 inches (stones) tend to increase limitations of use.

Overall, the major restrictive features limiting the use of on-site soils for reclamation includes high SAR, high ESP, high EC values, strongly to very strongly alkaline conditions, and some boron toxicities. The addition of soil amendments, burial or mixing of toxic materials, and leaching salts are recommendations for handling these soils. Field investigations include observations of active gullying on some landscapes and wind erodibility hazards with coarse textured soils. Some additional measures may need to be incorporated during stripping, handling, stockpiling, and redressing of these erodible soils.
VII.B.7 LITERATURE CITED


USDA, US Salinity Laboratory Staff, 1969. Diagnosis and Improvement of Saline and Alkaline Soils. USDA Agricultural Handbook No. 60.


Wyoming Department of Environmental Quality, Guideline No. 3, revised March 1980.
VII.C.1 UMC 783.21 SOIL RESOURCES INFORMATION

Soil survey information for portions of the permit area to be affected by surface operations is provided in Chapter VII-SOILS.

Refer to the attached Soil Map which delineates the different soil mapping units for the surface operations area.

Refer to Chapter VII.A.1 Scope of Investigation and Chapter VII.A.2 Methodology concerning soil identification.

Refer to Chapter VII.A.3 Soil Description concerning soil descriptions.

Refer to Chapter VII.A.4 Estimated Yields concerning present and potential productivity of existing soils.

Refer to Chapter VII.B.5 Depth of Suitable Topsoil Material with soil analysis provided in Chapter VII.B.3 Soil Data.

Refer to Chapter VII.B.5 Depth of Suitable Topsoil Material for the depths of selected overburden material that would be suitable for topsoil material. Refer to Chapter VII.B.2 Soil Data for the results of analysis, trials and tests required under UMC 817.22.
VII.C.2 UMC 783.27 PRIME FARMLAND INVESTIGATION

A pre-application investigation of the area proposed to be affected by surface operations indicates that there are no lands historically used as cropland.
A pre-application investigation of the area proposed to be affected by surface operations indicates that there are no lands historically used as cropland.
VII.C.4  UMC 817.21 TOPSOIL: GENERAL REQUIREMENTS

Before any additional disturbance (Post September 1, 1990), topsoil thickness will be determined and mapped in the field. At each sample site a soil sample will be bagged and labeled for shipment to a laboratory for analyses.

In the laboratory the following soil analysis determinations will be performed: soil pH, available phosphorus, extractable potassium, percent sand, percent silt and percent clay.

Refer to Chapter III.A.2 - TIMING, SEQUENCE AND BONDING for the reclamation time table concerning the stockpiling of topsoil.
VII.C.5 UMC 817.22 TOPSOIL REMOVAL

Any vegetative cover that would interfere with the use of the topsoil post-mining will be cleared prior to topsoil removal. Topsoil will only be removed from areas to be affected by surface operations or major structures. Topsoil ("A" Horizon) shall be removed in a separate layer.

If the topsoil is less than six inches, a six-inch layer that includes the A horizon and the unconsolidated materials immediately below the A horizon or the A horizon and all unconsolidated material if the total available is less than six inches, shall be removed and the mixture segregated and redistributed as the surface soil layer.

No soil segregation is proposed at this time.

Each non-toxic cover and/or substitute material plan will be proposed and stand on its own merit. Our current approved proposals are listed below:

1) All areas affected prior to August 3, 1977 will have all toxic material removed or will be covered with 4 feet of non-toxic cover. If the area requires cover, a proposal with soil analysis will be submitted to the Division for approval of both the cover as non-toxic and the surface 6 inches as topsoil substitute. If the area does not require cover, the in-place graded surface material will be used in lieu of topsoil. Refer to our revegetation demonstration site plan attached as Appendix VII-1.

2) Topsoil substitution plan underground development waste disposal site, attached as Appendix VII-2.

3) All areas affected after August 3, 1977 had topsoil removed prior to disturbance. We do not anticipate a topsoil deficiency; however, if one exists following the survey of the Stockpile, the Division will be notified and a plan will be developed.

No additional topsoil substitutes are proposed at this time.

The size of the area from which topsoil will be removed will be limited at any one time to minimize erosion. Surface soil redistribution will be done at a time to also minimize erosion.

No adverse conditions are foreseen at this time for the removal of all the topsoil. If at the time of soil sampling and prior to the disturbance a problem arises, the Division will be contacted and a site by site proposal will be presented for approval.
VII.C.6  UMC 817.23 TOPSOIL: STORAGE

Refer to Chapter III.A.2 - TIMING, SEQUENCE AND BONDING for the reclamation time table concerning the stockpiling of topsoil.

Stockpiled materials shall be selectively placed on a stable surface area within the surface operations area, not disturbed, and protected from wind and water erosion, unnecessary compaction, and contaminants which lessen the capability of the materials to support vegetation when redistributed.

The topsoil stockpile and disturbed area will be seeded the first normal period after removal using the contemporaneous reclamation seed mix in Chapter VIII.C.3. Unless approved by the Division, stockpiled topsoil will not be moved or disturbed until required for redistribution on a disturbed area.

It should be noted that a portion of the existing subsoil stockpile S-1 overlaps the proposed clean coal storage area of the preparation plant area on the operations plan map. This conflict will be resolved prior to construction of the preparation plant facility by utilizing the stockpile in reclamation at the earliest possible time. The respread depth and respread location will be provided to the Division prior to initiating any reclamation. If it is not possible to utilize the stockpile prior to construction of the preparation plant facility, final disposition of the stockpile will be determined in consultation with the Division.
VII.C.7 UMC 817.24 TOPSOIL: REDISTRIBUTION

After final grading and before the replacement of topsoil and other materials segregated in accordance with Section UMC 817.23, regraded land shall be treated as required by the Division to eliminate slippage surfaces and to promote root penetration.

Topsoil and other materials shall be redistributed in a manner that--

(1) Achieves an approximate uniform, stable thickness consistent with the postmining land uses, slopes, and surface drainage system.;

(2) Prevents excess compaction of the topsoil; and

(3) Protects the topsoil from wind and water erosion before and after it is seeded and planted.
VIIC.8  UMC 817.25 TOPSOIL: NUTRIENTS AND SOIL AMENDMENTS

Nutrients and soil amendments if shown to be required by soil tests will be applied to the redistributed surface soil layer so that it supports the postmining land use approved by the Division and meets the revegetation requirements of Sections UMC 817.111-817.117. All soil tests shall be performed by a qualified laboratory using standard methods approved by the Division.
There are no prime farmlands in the surface operations area.
APPENDIX VII-1

TOPSOIL SUBSTITUTION PLAN

REVEGETATION DEMONSTRATION PLAN FOR AREAS

AFFECTED PRIOR TO AUGUST 3, 1977

Three revegetation demonstration sites were established at the Emery Mine in 1984 (see Plate II-1) in response to the Division's Apparent Completeness Review issued regarding justifying alternate topsoiling materials. Initial plot establishment and 1985 and 1986 vegetation monitoring have followed the specifications outlined in the document "Final Plans for the Emery Demonstration Sites, April, 1984".

In 1987, portions of all three demonstration sites were reconstructed in order to comply with the March 11, 1987 deficiency letter received by Consol and to evaluate some innovative techniques described in the Intermountain Forest and Range Experiment Station Research Report INT335 dated June, 1985. These reconstruction plans were conditionally approved by UDOGM on April 8, 1987 and finally approved following the June 30, 1987 submission of the soil test results by Consol. Details concerning the reconstruction of these plots along with monitoring proposals are contained in these approved plans. Copies of the 1984 and 1987 plans are found on the following pages.
FINAL PLANS FOR
THE EMERY REVEGETATION DEMONSTRATION SITES

April, 1984
3rd Submittal
INTRODUCTION

The Emery Revegetation demonstration sites are made up by 3 separate areas: (1) the borehole access road area, (2) the flume site disturbance area, and (3) the original demo. site area (identified in the plans submitted to DOGM on March 12, 1984). The borehole access road area is located just north of the mine facilities site up on top above the canyon. This is an old access road which has recently been abandoned. The flume site disturbance area is located alongside the creek just south of the mine facilities area. This site is where an old flume was located for taking water measurements but has also been abandoned and removed. The original demo. site is located just east of the scale house on the alluvial walsh soils.

The borehole access road represents the most arid site of the 3 and will give a good indication of revegetation capabilities under very dry conditions. This site will be seeded with one seed mix. Half the site will be mulched and half will not be mulched. No irrigation water will be used here. The old road is about 20' wide and 300' long.

The flume site disturbance area represents the most mesic site of the 3 and will give a good indication of revegetation possibilities under riparian conditions. This site will also be seeded with one seed mix, mulched half and half, and not irrigated. The flume site is about ¼ of an acre in size.

The original demo. site will represent a wide variety of plot variables. These plots were designed to demonstrate that revegetation can be accomplished on the topsoil materials available in the existing facilities area of the Emery underground mine site. The "original" demo. site will be approximately ¼ of an acre in size and will include seeding, transplanting, topsoiling, mulching, and irrigation plot variables. The "original" demo. plot will contain 20 sub-plots. There will be 20 seed mix sub-plots, 8 of those having transplants as well. Ten of the sub-plots will be on the original topsoil of the site. Ten will be on 4" of topsoil that has been brought onto the site from the embankment of the sediment pond that controls the runoff from the coal stockpile area. These soils are alluvial walsh soils that, because they have been in an embankment, are thought to not contain any (or very little) soil fungi or bacteria, thus simulating the topsoils underneath the buildings, roads, yard area, etc. of the mine facilities area. Half of the sub-plots will be irrigated and half will not receive irrigation. Refer to the following discussions and to Table 1 and Figure 1 for detailed illustrations.
THE BOREHOLE ACCESS ROAD SITE

Plot Variables

Seed Bed Preparation

The existing topsoils of this site will be disked up and cultivated to prepare a good firm clod-free seed bed prior to seeding.

Mulching

Half of the 20' x 300' site will be mulched with straw hay at a rate of 2,000 lbs./acre. After the mulch is applied to the surface, a disk will be used to incorporate the mulch into the soil. The other half of the road will not receive any mulch.

Soil Amendments

Fertilizer will be added to the soil according to the needs dictated by prior N-P-K testing.

Seeding

One seed mix will be used. This is an arid site seed mix as is illustrated below:

Borehole Access Road Seed Mix

<table>
<thead>
<tr>
<th>Species</th>
<th>Ounces of PLS Per Plot (6,000 Sq. Ft.)</th>
<th>PLS/Sq. Ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>streambank wheatgrass</td>
<td>3.9</td>
<td>7</td>
</tr>
<tr>
<td>western wheatgrass</td>
<td>3.9</td>
<td>5</td>
</tr>
<tr>
<td>blue grama</td>
<td>1.1</td>
<td>8</td>
</tr>
<tr>
<td>indian ricegrass</td>
<td>3.9</td>
<td>8</td>
</tr>
<tr>
<td>alkali sacaton</td>
<td>0.5</td>
<td>9</td>
</tr>
<tr>
<td>sand dropseed</td>
<td>0.5</td>
<td>26</td>
</tr>
<tr>
<td>4-wing saltbush</td>
<td>11.9</td>
<td>9</td>
</tr>
<tr>
<td>shadscale</td>
<td>7.9</td>
<td>5</td>
</tr>
<tr>
<td>gardner saltbush</td>
<td>3.9</td>
<td>5</td>
</tr>
<tr>
<td>green Mormons tea</td>
<td>16.0</td>
<td>4</td>
</tr>
<tr>
<td>yellow sweetclover</td>
<td>3.3</td>
<td>9</td>
</tr>
<tr>
<td>desert globemallow</td>
<td>1.1</td>
<td>6</td>
</tr>
<tr>
<td>blueleaf aster</td>
<td>1.1</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>59.0</td>
<td>107</td>
</tr>
</tbody>
</table>
THE FLUME SITE DISTURBANCE AREA

Plot Variables

Seedbed Preparation, Mulching and Soil Amendments

Same as for the Borehole access road site.

Seeding

One seed mix will be used. This is a mesic site seed mix as is illustrated below:

The Flume Site Seed Mix

<table>
<thead>
<tr>
<th>Species</th>
<th>Ounces of PLS/Plot (10,000 Sq. Ft.)</th>
<th>PLS/Sq. Ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>western wheatgrass</td>
<td>18.5</td>
<td>13</td>
</tr>
<tr>
<td>slender wheatgrass</td>
<td>11.1</td>
<td>11</td>
</tr>
<tr>
<td>alkali sacaton</td>
<td>0.9</td>
<td>10</td>
</tr>
<tr>
<td>spike muhly</td>
<td>0.9</td>
<td>9</td>
</tr>
<tr>
<td>alkali grass</td>
<td>1.8</td>
<td>13</td>
</tr>
<tr>
<td>yellow sweetclover</td>
<td>5.5</td>
<td>9</td>
</tr>
<tr>
<td>blueleaf aster</td>
<td>1.8</td>
<td>6</td>
</tr>
<tr>
<td>indian blanket</td>
<td>3.7</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>44.2</strong></td>
<td><strong>75</strong></td>
</tr>
</tbody>
</table>
**THE "ORIGINAL" DEMO. SITE**

**Plot Variables**

**Seed Bed Preparation**

The topsoils of the demonstration site will be mechanically worked to prepare a good firm clod-free seed bed just prior to seeding.

**Mulching**

All plots (except D3, D3A, D4, and D4A) will be mulched with straw or hay at a rate of approximately 2,000 lbs./acre. After the mulch is applied to the surface, a disk will be used to incorporate the mulch into the soil.

**Soil Amendments**

Fertilizer will be added to the soil according to the needs dictated by N-P-K testing.

**Seeding**

*Three seed mixes will be used, seed mixes A, B, and C. These are the same mixes which are proposed in the Emery underground permit (Nov. 11, 1983 response letter). These mixes were developed theoretically on a moisture gradient. Seed mix A is the most arid site mix, followed by seed mix B, with the most mesic being seed mix C. The seed plans are listed below.*

**Seed Mix A**

<table>
<thead>
<tr>
<th>Species</th>
<th>Life Form</th>
<th>Ounces of PLS Per Plot (1,352 Sq.Ft.)*</th>
<th>PLS/Sq.Ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indian ricegrass</td>
<td>cool season bunchgrass</td>
<td>1.5</td>
<td>13</td>
</tr>
<tr>
<td>alkali sacaton</td>
<td>warm season bunchgrass</td>
<td>0.25</td>
<td>20</td>
</tr>
<tr>
<td>galleta</td>
<td>warm season bunchgrass-sodformer</td>
<td>1.2</td>
<td>9</td>
</tr>
<tr>
<td>western wheatgrass</td>
<td>cool season sod-forming grass</td>
<td>1.5</td>
<td>9</td>
</tr>
<tr>
<td>winterfat</td>
<td>shrub</td>
<td>2.0</td>
<td>5</td>
</tr>
<tr>
<td>4-wing saltbush</td>
<td>shrub</td>
<td>2.0</td>
<td>6</td>
</tr>
<tr>
<td>rubber rabbitbrush</td>
<td>shrub</td>
<td>0.5</td>
<td>8</td>
</tr>
<tr>
<td>yellow sweetclover</td>
<td>forb- legume</td>
<td>0.74</td>
<td>9</td>
</tr>
<tr>
<td>desert globemallow</td>
<td>forb</td>
<td>0.25</td>
<td>6</td>
</tr>
<tr>
<td>blueleaf aster</td>
<td>forb</td>
<td>0.25</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>10.2</strong></td>
<td><strong>91</strong></td>
</tr>
</tbody>
</table>

*In irrigated and non-irrigated plots combines

PLS = pure live seeds
Seed Mix B

<table>
<thead>
<tr>
<th>Species</th>
<th>Life Form</th>
<th>Ounces of PLS Per Plot (1,352 Sq.Ft.)*</th>
<th>PLS/Sq.Ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>blue grama</td>
<td>warm season bunchgrass-sodformer</td>
<td>0.37</td>
<td>12</td>
</tr>
<tr>
<td>streambank wheatgrass</td>
<td>cool season sod-forming grass</td>
<td>1.5</td>
<td>11</td>
</tr>
<tr>
<td>sand dropseed</td>
<td>warm season bunchgrass</td>
<td>0.12</td>
<td>28</td>
</tr>
<tr>
<td>winterfat</td>
<td>shrub</td>
<td>2.0</td>
<td>5</td>
</tr>
<tr>
<td>4-wing saltbush</td>
<td>shrub</td>
<td>2.0</td>
<td>6</td>
</tr>
<tr>
<td>rubber rabbitbrush</td>
<td>shrub</td>
<td>0.5</td>
<td>8</td>
</tr>
<tr>
<td>big sagebrush</td>
<td>shrub</td>
<td>0.12</td>
<td>14</td>
</tr>
<tr>
<td>greasewood</td>
<td>shrub</td>
<td>1.24</td>
<td>16</td>
</tr>
<tr>
<td>yellow sweetclover</td>
<td>forb-legume</td>
<td>0.5</td>
<td>6</td>
</tr>
<tr>
<td>blue flax</td>
<td>forb</td>
<td>0.5</td>
<td>7</td>
</tr>
<tr>
<td>evening primrose</td>
<td>forb</td>
<td>0.25</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.1</td>
<td>119</td>
</tr>
</tbody>
</table>

Seed Mix C

<table>
<thead>
<tr>
<th>Species</th>
<th>Life Form</th>
<th>Ounces of PLS Per Plot (1,352 Sq.Ft.)*</th>
<th>PLS/Sq.Ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>western wheatgrass</td>
<td>cool season sod-forming grass</td>
<td>2.5</td>
<td>13</td>
</tr>
<tr>
<td>slender wheatgrass</td>
<td>cool season bunchgrass</td>
<td>1.5</td>
<td>11</td>
</tr>
<tr>
<td>alkali sacaton</td>
<td>warm season bunchgrass</td>
<td>0.12</td>
<td>10</td>
</tr>
<tr>
<td>spike muhly</td>
<td>warm season bunchgrass</td>
<td>0.12</td>
<td>9</td>
</tr>
<tr>
<td>alkali grass</td>
<td>cool season bunchgrass</td>
<td>0.25</td>
<td>13</td>
</tr>
<tr>
<td>yellow sweetclover</td>
<td>forb-legume</td>
<td>0.74</td>
<td>9</td>
</tr>
<tr>
<td>blueleaf aster</td>
<td>forb</td>
<td>0.25</td>
<td>6</td>
</tr>
<tr>
<td>indian blanket</td>
<td>forb</td>
<td>0.5</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.9</td>
<td>4</td>
</tr>
</tbody>
</table>

Seed Mix A will be used on plots A1, A1A, A2, and A2A, seed mix B will be used on plots B1, B1A, B2A, and B2, while seed mix C will be used on plots C1, C1A, C2A, and C2. Seed mix B will also be used on the D plots.

The seed will be hand broadcast into the plots. Afterwards the seed will be worked into the soil by cultivation.

Transplanting

Live shrub transplants will be installed into the D plots. Plots D1, D2, D3, and D4 will contain 16 transplants each. Plots D1A, D2A, D3A, and D4A will contain 8 transplants each. Species to be used and numbers needed are listed below:

<table>
<thead>
<tr>
<th>Species*</th>
<th>Total For D Plots</th>
</tr>
</thead>
<tbody>
<tr>
<td>fourwing saltbush</td>
<td>32</td>
</tr>
<tr>
<td>shadescalre</td>
<td>32</td>
</tr>
<tr>
<td>Big sagebrush</td>
<td>32</td>
</tr>
</tbody>
</table>

* Based on what species are available this spring.

Prior to transplanting, the D plots will be seeded to seed mix B.
Irrigation

Ten of the twenty sub-plots will be irrigated roughly every two weeks with two inches of supplemental water beginning in the Spring of 1987 when the plots are to be reconstructed and continuing through the growing season for the first year. The other ten sub-plots will receive no irrigation water. A small stationary sprinkler type irrigation system will be used. Irrigation will take place during later afternoon hours or at night.

MEASUREMENTS

Vegetation Monitoring

The vegetation on the demonstration sites (all 3 included) will be monitored annually starting in 1985 and continuing until the termination of the project in 1991. Parameters to be measured in the seeded plots will be:

1985 - Vegetative density and frequency
1986 - Vegetative density and frequency
1987 - Vegetative density and frequency
1988 - Vegetative density and frequency
1989 - Vegetative density and frequency
1990 - Vegetative density and frequency
1991 - Vegetative density, frequency, production and foliar cover

Survival rates and crown width will be measured on the transplants annually.

Soil Sampling

- Original Demo. Site -

Two core hole samples will be taken from the irrigated plots side and two from the non-irrigated plots side at the initiation time of the plots. Samples will again be taken at the same locations at the end of the project in 1991. Samples will be taken at 6" intervals from the surface down to 12". Parameters to be analyzed for in 1984 will be EC's, Na, Ca, Mg, pH, and N-P-K. SAR's will be calculated. The measurement parameters will be the same in 1991 except for the N-P-K analysis.

- Borehole Access Road Site and Flume Site Areas -

One core hole will be taken from each site prior to seeding. Samples will be taken from the 0 - 6" and 6" - 12" depths and analyzed for N-P-K, EC's, Na, Ca, Mg, pH, and SAR's. These sites will also be sampled again in 1991. Note: A core hole sample will also be taken from the topsoil embankment site prior to soil spreading.

Revised - April 19, 1988
# TABLE 1

**EXPERIMENTAL DESIGN TABLE FOR THE EMERY REVEGETATION DEMO SITE**

<table>
<thead>
<tr>
<th>Plot</th>
<th>Seed Mix</th>
<th>Irrigation</th>
<th>Shrub Transplants</th>
<th>Mulch Added</th>
<th>Embankment</th>
<th>Topsoil Added</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>A</td>
<td>present</td>
<td>none</td>
<td>yes</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>A1A</td>
<td>A</td>
<td>present</td>
<td>none</td>
<td>yes</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td>A</td>
<td>none</td>
<td>none</td>
<td>yes</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>A2A</td>
<td>A</td>
<td>none</td>
<td>none</td>
<td>yes</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>B1</td>
<td>B</td>
<td>present</td>
<td>none</td>
<td>yes</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>B1A</td>
<td>B</td>
<td>present</td>
<td>none</td>
<td>yes</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>B2</td>
<td>B</td>
<td>none</td>
<td>none</td>
<td>yes</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>B2A</td>
<td>B</td>
<td>none</td>
<td>none</td>
<td>yes</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td>C</td>
<td>present</td>
<td>none</td>
<td>yes</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>C1A</td>
<td>C</td>
<td>present</td>
<td>none</td>
<td>yes</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td>C</td>
<td>none</td>
<td>none</td>
<td>yes</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>C2A</td>
<td>C</td>
<td>none</td>
<td>none</td>
<td>yes</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>D1</td>
<td>A</td>
<td>present</td>
<td>present</td>
<td>yes</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>D1A</td>
<td>B</td>
<td>present</td>
<td>present</td>
<td>yes</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>D2</td>
<td>B</td>
<td>none</td>
<td>present</td>
<td>yes</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>D2A</td>
<td>B</td>
<td>none</td>
<td>present</td>
<td>yes</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>D3</td>
<td>B</td>
<td>present</td>
<td>present</td>
<td>no</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>D3A</td>
<td>B</td>
<td>present</td>
<td>present</td>
<td>no</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>D4</td>
<td>B</td>
<td>none</td>
<td>present</td>
<td>no</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>D4A</td>
<td>B</td>
<td>none</td>
<td>present</td>
<td>no</td>
<td>yes</td>
<td></td>
</tr>
</tbody>
</table>
Figure 1

EMERY REVEGETATION DEMONSTRATION SITE

PLOT LAYOUT

104 feet

A1  A1A  A2A  A2

B1  B1A  B2A  B2

C1  C1A  C2A  C2

D1  D1A  D2A  D2

D3  D3A  D4A  D4

irrigated  not irrigated
RECONSTRUCTION PLAN

FOR

EMERY REVEGETATION DEMONSTRATION SITES

February 1987
Revised April 29, 1987

Emery Deep Mine
Permit ACT/015/015

Prepared By: Gary Goodrich
Dave Larson
Rich Hiller
Evaluate: Natural reseeding from locally adapted mature transplants.

This plot will be roto-tilled to eliminate existing vegetation and break up surface crusting. No other surface treatments are proposed, as a rough-clopped surface is desirable for water infiltration. Fourteen holes with a minimum diameter of 30" and minimum depth of 24" will be hand-dug at locations equidistant from the plot borders and each other hole (minimize competitive stress). Each hole will be filled with water and allowed to drain twice immediately prior to transplanting. Three slow release fertilizer tablets will be placed in each hole.

Three mature fourwing saltbush shrubs, two rubber rabbitbrush, four shadscale shrubs, four black greasewood shrubs and one black sagebush plant were located at accessible locations on the mine property. These shrubs will be excavated with a front-end loader to obtain a minimum root-ball of 24". The shrubs will be immediately moved to the demo plot and transplanted directly from the front-end loader bucket. The hole will be backfilled to within a few inches of the predisturbance surface and excess soil materials will be distributed within the plot. A slight depression will thus be created around each shrub to enhance water retention. The transplanted shrub will be immediately irrigated to saturate the rooting zone.
Reconstructed Plot Al & AlA (Continued)

No mulching is proposed for this plot. The plot will be irrigated to supply one inch of water to the shrub rooting zone every other week during the first growing season following transplanting.* This plot will be monitored during subsequent years for survival and growth of the transplants, and more importantly, for naturally-seeded shrub starts in the vicinity of the mature transplants.

As a large scale transplanting program would be cost prohibitive for mine reclamation, the major objective of this plot is not to demonstrate transplant survival, but to monitor seedling starts from the natural reseeding from the mature transplants. If reseeding does occur, select transplants could be placed in key locations in the reclaimed areas to aid in shrub reestablishment.

* Pending favorable soil tests.
Reconstructed Plot B1 & B1A

Evaluate: Survival and growth rate of containerized shrubs.

This plot will be roto-tilled to eliminate existing vegetation and to break up surface crusting. No other surface treatments are proposed, as a rough-closhed surface is desirable for water infiltration. Twenty five containerized plants of each of the following five species will be obtained from a commercial nursery growing stock adapted to south-central Utah:

* Fourwing Saltbush
* Shadscale Saltbush
* Gardner Saltbush
* Rubber Rabbitbrush
* Greasewood

* In order of planting sequence.

Individual plants will be evenly spaced within the plot with each species being widely distributed throughout the plot to minimize the possibility of pockets of undesirable soil properties eliminating any one species. Planting will be done using a hand auger or small tilling spade. Prior to planting, the holes will
be filled with water and allowed to drain. On the north half of the plot, fertilizer tablets will be placed in the holes in order to evaluate growth response of fertilized seedlings compared to unfertilized seedings. The slow release tablet, with an analysis of 20-10-5, will be placed at the bottom of the hole and covered with 1" of soil prior to placement of the containerized shrub. Following planting, the entire plot will be immediately irrigated to saturate the rooting zone (minimum 1" over 4 hours). The plot will then be irrigated to supply one inch of water every other week during the first growing season only.* This plot will be monitored during subsequent years for survival and growth rates of the shrubs. No attempt will be made to control invading vegetation in order to better simulate an actual reclamation effort.

Consol recognizes that planting containerized shrubs is more expensive than seeding, assuming that shrub seeding will be successful. Containerized shrubs would be used in the reclamation plan only to augment the shrub seeding program to produce clumps of shrubs early in the reclamation process. Consol estimates 200-300 containerized shrubs per acre of reclaimed land would cost between $150-$250 per acre, which would be economically practical.

* Pending favorable soil tests.
Reconstructed Plots A2 and A2A

Evaluate: Customized shrub seed mix and water harvesting furrows.

Existing plots A2 and A2A will be roto-tilled to eliminate existing vegetation and to break up surface crusting. On ½ of the new plot, 2-3 inch deep north to south furrows (approximately 1' wide) will be created on 2' centers. Check dams will be placed every 5 feet in ½ of the furrows to increase water retention. The other ½ of the plot will not have furrows constructed. No other surface amendments, such as fertilizers or mulching, will be used at this plot.

Based upon the repeated failure of several species in the standard DOGM seed mixes at the Emery plots and observations of successfully seeded species and naturally invading ones at the plots, the DOGM seed mix will be simplified to those species currently observed growing at the site. A seed mixture of fourwing saltbush, greasewood, winterfat, and rubber rabbitbrush will be obtained from a local source and broadcast seeded at 2 times the normal drilling rate (to ensure sufficient germination). No grasses or forbs will be seeded.

Seed will be broadcast in early spring, no later than April 30. The seed will be lightly raked in, if conditions permit. Seeding rates will be: fourwing saltbush 4 lb/ac, greasewood 2 lbs/ac, winterfat 4 lbs/ac, and rubber rabbitbrush 2 lbs/ac.
Reconstructed Plots A2 and A2A (Continued)

The plot will be monitored for increased establishment and growth rates in the furrows compared to a level surface, overall establishment, survival, and growth rate of the four seeded shrubs, and invasion of desirable grasses and forbs over time.
Reconstructed Plots B2 and B2A

Evaluate: Customized grass-shrub seed mix and organic amendment to reduce surface crusting.

Existing plots B2 and B2A will be roto-tilled to eliminate existing vegetation and to break up surface crusting. Following the initial roto-tilling, native hay will be spread on the entire plot at a rate of 2.5 tons/acre. Following the hay application, the plot will be roto-tilled twice (second time at 90° to initial direction) to incorporate the hay into the upper few inches of the soil. Ammonium Nitrate will be added at the rate of 35 lbs/ac to maintain an appropriate carbon nitrogen balance in the soil. The entire plot will be broadcast seeded at the recommended DOGM rates with the following seed mixture obtained from a local source:

- Slender Wheatgrass - 5 lbs/ac
- Blue Grama - 1 lb/ac
- Sand Dropseed - .2 lb/ac
- Fourwing Saltbush - 2 lbs/ac
- Greasewood - 1 lb/ac
- Mat Saltbush - 2 lbs/ac
- Winterfat - 2 lbs/ac
- Rubber Rabbitbrush - 1/4 lb/ac

Seeding will be accomplished in early spring (no later than April 30). The seed will be broadcast and, if conditions permit, will be lightly raked in. No other amendments, such as fertilizer or mulch, are proposed. The plot will be monitored for germination, survival, and growth rate of the seeded species.
Reconstructed Plots C2 and C2A

Evaluate: Customized grass-shrub mix.

Existing plots C2 and C2A will be roto-tilled to eliminate existing vegetation and left in a rough-clodded surface condition to promote water infiltration. Following roto-tilling, the entire plot will be broadcast seeded at the recommended DOGM rates with the following seed mixture obtained from a local source:

<table>
<thead>
<tr>
<th>Seed Type</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slender Wheatgrass</td>
<td>5 lbs/ac</td>
</tr>
<tr>
<td>Blue Grama</td>
<td>1 lb/ac</td>
</tr>
<tr>
<td>Sand Dropseed</td>
<td>.2 lb/ac</td>
</tr>
<tr>
<td>Fourwing Saltbush</td>
<td>2 lb/ac</td>
</tr>
<tr>
<td>Greasewood</td>
<td>1 lb/ac</td>
</tr>
<tr>
<td>Mat Saltbush</td>
<td>2 lbs/ac</td>
</tr>
<tr>
<td>Winterfat</td>
<td>2 lbs/ac</td>
</tr>
<tr>
<td>Rubber Rabbitbrush</td>
<td>½ lb/ac</td>
</tr>
</tbody>
</table>

Seeding will be accomplished in early spring (no later than April 30). The seed will be broadcast and, if conditions permit, will be lightly raked in. No other amendments, such as fertilizer or mulch, are proposed. The plot will be monitored for germination, survival, and growth rate of the seeded species.
Reconstructed Borehole Plot

**Evaluate:** Establishment of mat saltbrush from seed and transplants.

Approximately ¼ of the borehole demonstration plot occurs on Bluegate shale, a geologic formation which has chemical and physical properties hostile to plant growth and which locally supports a very limited number and diversity of plants. Adjacent to the borehole site, the Blue Gate shale areas are dominated almost exclusively by mat saltbush. Accordingly, the highly diverse seed mixes proposed by DOGM and seeded in 1984 were especially unsuited for these areas.

A 25' x 25' block of the Bluegate shale portion of the borehole site will be roto-tilled to eliminate existing vegetation and to leave the surface in a rough-clodded condition. The roto-tilled area will be broadcast seeded with mat saltbush obtained from a locally available source. Seeding will be done in early spring (prior to April 30) and the seed will be lightly raked into the surface if conditions permit. The plot will be prepared for transplants by digging twenty holes (12" deep x 18" diameter) spaced equidistantly in the subplot. Each hole will be filled with water and allowed to drain just prior to transplanting.
Reconstructed Borehole Plot (Continued)

Twenty mat saltbush specimens of various size and ages will be hand dug from the Bluegate shale areas adjacent to the borehole site and immediately transplanted in the prepared holes.

This plot will be monitored for survival and growth rate of mat saltbush.
Reconstructed Flume Plot

Evaluate: Tree establishment in floodplain areas.

Observation suggest that occasional flooding of the flume site washed the previous seed from the plot and, therefore, that seeding is an unreliable method of establishing vegetation on flood prone areas. In addition, salt cedar and rubber rabbitbrush are naturally invading the site and are therefore probably the best suited species for reclamation. As an attempt to introduce more desirable species into this floodplain site, 25 containerized Freemont poplar and 25 containerized willows will be planted at the site.
All Plots

1. Composite soil samples will be taken at all reconstructed plots; one set for the 0-6" layer and one set for the 6-12" layer. Each composite sample will be analyzed for the following parameters:

   Saturation Percentage
   Electrical Conductivity
   SAR
   pH
   Potassium
   Texture
   Available Phosphorus

   using procedures applicable to Utah soils. Results of the 1987 soil analyses will be submitted to DOGM as soon as they are received from the lab.

2. For all seeds, a T-Z test will be performed within six weeks of planting. Results of the T-Z tests will be included with the 1987 monitoring report. Appropriate seeds will be stratified prior to spring planting. If available, blue grama seed will be obtained from a Utah source or other northern state. If shrub establishment from spring seeding is unacceptable (based upon 1987 monitoring in August) new shrub seed will be obtained and reseeded in the fall (August-September) of 1987. Results of the seed test will be provided to DOGM with the soil results.
3. The minor quantities of irrigation water required for the demonstration plots will be obtained from Quitchupak Creek. Water quality parameters considered pertinent to irrigation water quality are included on the attached laboratory sheets.

4. Once a schedule is established for developing the sites, DOGM will be contacted in order that they can visit the sites when the fieldwork is being done.
EMERY REVEGETATION DEMONSTRATION SITE

REVISED PLOT LAYOUT (1987)

<table>
<thead>
<tr>
<th>104 Feet</th>
<th>104 Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revised Al (mature transplants)</td>
<td>Revised A2 (trenching)</td>
</tr>
<tr>
<td>Revised B1 (containerized seedlings)</td>
<td>Revised B2 (organic matter)</td>
</tr>
<tr>
<td>C1</td>
<td>C1A</td>
</tr>
<tr>
<td>D1</td>
<td>D1A</td>
</tr>
<tr>
<td>D3</td>
<td>D3A</td>
</tr>
</tbody>
</table>

Irrigated | Not Irrigated
APPENDIX VII-2

TOPSOIL SUBSTITUTION PLAN

PERMANENT UNDERGROUND DEVELOPMENT WASTE DISPOSAL SITE

The permanent underground development waste disposal site will involve the burial of wastes presently located on the northwest coal stockpile (existing coal mine waste disposal site) and of wastes generated in the future. The disposal site is located on the hilltop adjacent to the northwest coal stockpile area and has been previously disturbed. The disturbances involved the removal of a gravel subsoil layer for use as fill material during construction of the northwest coal stockpile site and as fill outside the mine area. These activities created borrow pits on both sides of the access road that crosses the proposed disposal site. The site will be developed in two stages with the area south of the road used first. The existing pit will be enlarged and deepened by removing the gravel layer down to the underlying bluegate shale, if necessary, to provide sufficient storage volume. The cut material will be stockpiled on the north side of the road to be used as non-toxic cover material for the waste. Excess cut material will be placed in the bermed depression west of the office. A safety berm will be built on the south side of the access road as the pit advances toward the road. The road will be temporarily relocated to the north to allow for disposal underneath. The road will then be returned to its original location and grade after that part of the disposal site is filled. The north portion of the site will be similarly developed. The wastes will be placed and compacted using tracked and rubber tired equipment.

Wastes - Characterization

The mine development wastes are generally produced from roof falls and projects that enlarge entries near the portal areas. The decision to remove these materials from the mine is based on the safety hazard that they present. In order to identify any toxic materials, the wastes that are currently stored on the northwest coal stockpile location (existing coal mine waste disposal site) were sampled on September 15, 1986. The laboratory results given in Table A show that these materials have a pH range of 4.2 - 8.2 and a net neutralization potential range of -54.8 to 121.0 gCaCO3/Kg soil.

The fifteen (15) samples taken in 1986 were randomly collected from the waste pile. The sum of the analytical results yield a net positive 24.2 grams of calcium carbonate per kilogram of soil. Future wastes are not expected to differ significantly from those presently stored since no changes in the mining methods or operation are planned. Refer to CH II, pg 20 and CH V Section V.A.4 for a discussion on roof and floor characteristics (underground development waste) and Section V.A.5 for a discussion of acid, alkaline, toxic potential. Also refer to CH VI section VI.2.8.3 (PHC) for a similar discussion. Refer to CHIV pg. 21 for waste characterization of the original material, and CH IV, App IV-9 for current analysis.
Cover Material

Based upon differences in soil quality shown in Table V, Consol proposes to segregate the cover material into two stockpiles according to the following procedures. Topsoil materials found in the top zone of the project area and identified by soil sample #3 will be mixed and stored with the middle zone materials identified by soil sample #2. Materials from the bottom zone that are identified by soil sample #1 will be stored apart from the top and middle zone materials. The stockpile consisting of the top and middle zone materials will be identified as a topsoil stockpile while the stockpile of bottom zone materials will be identified as a subsoil stockpile. Prior to construction of the Permanent Waste Disposal Site, Consol will resample the site for topsoil substitute quality and quantity, and cover material quality. The site will be sampled on one sample per acre grid, with analysis on one foot intervals for the first five feet and five foot intervals for the remaining depth.

Operations and Reclamation

Excess cut material will be conveyed and placed in the bermed depression west of the office building. This material will be used to fill in and extend the parking area next to the office. The excess fill will be compacted and stabilized.

The stored wastes (existing coal mine waste disposal site) will then be conveyed from the northwest coal storage area to the excavated disposal site (permanent underground development waste disposal site), placed in the southwest end of the site, compacted and covered with four feet of stockpiled cut material.

During backfill operations, the lower zone soil material will be backfilled over the disposed underground development waste first. Then the mixed upper and middle zone soil material will be placed over the lower zone soil material. Placement of the wastes will proceed from the southwest end towards the service road until all of the temporarily stored wastes have been buried. The completed fill will then be covered, graded to its final contour and seeded. Sufficient disposal capacity will remain active to accommodate about 500 cu. yds. (approximately one year's volume) of future wastes. Consol will treat and/or otherwise place all potentially acid or toxic forming underground development waste in the disposal site within 30 days after it is first exposed on the mine site. The remaining site will be developed on an as needed basis with the road being temporarily relocated to the north and returned to its original location and graded when the site has been completed through that point. In order to reclaim the active site sufficient cover material will be maintained in a stockpile either ahead of or behind the fill.

Revised 2/08

CH VII, APP VII-2, page 2
<table>
<thead>
<tr>
<th>Lab No.</th>
<th>Sample ID</th>
<th>pH</th>
<th>Ca (meq/l)</th>
<th>Mg (meq/l)</th>
<th>Na (meq/l)</th>
<th>SAR</th>
<th>SAR (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F3563</td>
<td>M1</td>
<td>8.2</td>
<td>27.1</td>
<td>18.4</td>
<td>24.3</td>
<td>5.27</td>
<td></td>
</tr>
<tr>
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(2) Acid-Base calculated using total sulfur analysis.
(3) Grams calcium carbonate per kilogram soil.
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<th>K ppe</th>
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<th>Alkalinity PE meq/l</th>
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Abbreviations for extractants: PE= Saturated Paste Extract, H20Sol= water soluble, ABPTA= Ammonium Bicarbonate-OPTA, AAO= Acid Ammonium Oxalate
### Table B

**Underground Development Wasteshie Soil Samples**

![IML Logo]

**Inter-Mountain Laboratories, Inc.**

2506 West Main Street

Farmington, New Mexico 87401

Tel. (505) 326-4737

**CONSOLIDATION COAL COMPANY**

**EMERY, UTAH**

**MINE: EMERY MINE**

<table>
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<th>Lab No.</th>
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<th>Texture</th>
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Dates:
- **Date Received:** March 21, 1989
- **Date Reported:** March 31, 1989

Samples from excavated pit embankments. *pg 20, Chap IV.*
APPENDIX VII-3

BIOLOGICAL & SOIL RESOURCES
AT THE 4th EAST PORTAL AREA
SOIL RESOURCES REPORT
AT THE
4TH EAST PORTAL AREA

AT THE
EMERY DEEP MINE
Prepared by

MT. NEBO SCIENTIFIC, INC.
330 East 400 South, Suite 6
Springville, Utah 84663
(801) 489-6937

James Nyenhuis
Certified Professional Soil Scientist
(ARCPACS #2753)

for

CONSOLIDATION COAL COMPANY
P.O. Box 527
Emery, Utah 84522

May 2002
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INCORPORATED

JUN 03 2002

DIV OF OIL GAS & MINING
The identification and proper management of the soil resources in the proposed Emery 4th East Portal Area is essential for the success of reclamation in the mine portal area and the achievement of the post-mining land use. The information presented in this report is designed to aid in formulating a practical and successful reclamation plan.

This report is prepared to characterize the soil resources, and to determine the potential soil salvage depths of the proposed Emery 4th East Portal Area at the Consolidation Coal Company's Emery Deep Mine southeast of Emery in Emery County, Utah. The proposed 4th East Portal Area (study area) is approximately 22.55 acres in size and is located in the central portion of Section 27, T.22S., R.6E., about 2.5 miles south and 0.5 miles east of the town of Emery. Approximately 15.05 acres of the portal area is designated as the affected area.

The study area was previously investigated as part of a larger soil survey conducted in 1981 on approximately 1,670 acres within portions of Sections 27, 28, 32, 33, and 34, T.22S., R.6E. The Order 1 soil survey was conducted by James P. Walsh & Associates, Inc. of Boulder, Colorado, and was reported in Chapter VII (SOILS) of the Mine & Reclamation Plan (MRP) of the Emery Mine. The Emery Mine MRP has been previously submitted to UDOGM and the Chapter VII soils information is in the Emery project file.

The purpose of the current report is to present and evaluate soils information for the 22.5 acre study area as contained in the Emery MRP and current Natural Resources Conservation Service
(NRCS) information for the soil series mapped on the study area. The soil map units on the study area are listed and described, and soil series typical profile descriptions are presented although some of their locations are from within the larger soil survey area.

The five soil series mapped on the 22.55 acre study area (Castle Valley, Chipeta, Ferron, Killpack, and Persayo) were each sampled one time for laboratory characterization, except Killpack which was described at a typical location but not sampled. Soil suitability evaluations were originally conducted, and have been reevaluated as part of the current report.

Soil salvage depth recommendations are provided for each soil type and map unit based on a review of existing information. A site visit will be conducted prior to soil salvage operations and salvage depth recommendations will be refined and staked for all proposed disturbance areas.

Soils information for the Emery 4th East Portal Area is initially presented in the general format outlined in the UDOGM draft "Guidelines for Management of Topsoil and Overburden" (Burton and Davidson, January 2002). More detailed information is presented in Chapter 3.0, Soil Results and Discussion. Information concerning other aspects of the Emery Mine and Reclamation Plan is found in the Emery MRP.
Prime Farmland Determination (R645-301-221)

The proposed Emery 4th East Portal Area (22.55 acres) does not contain "prime farmland", "important farmland", nor any croplands at all. The source document, a map depicting "Important Farmlands of Parts of Carbon, Emery, Grand, and Sevier Counties" (Southard et al. 1981) was viewed and no farmlands are present on the 22.55 acre study area.

The previously noted Emery Chapter VII (Soils) also states "A pre-application investigation of the area proposed to be affected by surface operations indicates that there are no lands historically used as cropland" (Emery MRP, sections VII.C.2 and VII.C.3).

Soil Survey and Map (R645-301-222 and 223)

As noted above, the proposed Emery 4th East Portal Area was mapped to an Order 1 level of intensity by James P. Walsh & Associates in 1981 as part of their survey of approximately 1,670 acres associated with the Emery Coal Mine (Emery MRP, section VII.A.1). Soil mapping was conducted according to standards of the National Cooperative Soil Survey (NCSS) in effect at the time of mapping.

The Order 1 soils map of the 4th East Portal Area presented in the report was created using the Walsh soil survey map. The original map scale was 1:6000 (1" = 500 ft.). The extent
of each soil type is outlined on the map. Soil profile description and sampling sites for the Castle Valley and Ferron soil series are near the middle of Section 27 (within or very near to the 22.55 acre study area). Profile description and sampling sites for Persayo, Chipeta, and Killpack soil series are within Sections 22 and 30.

Five soil mapping units are present within the proposed 4th East Portal Area:

- **Map Unit CeE2**  
  Castle Valley extremely stony very fine sandy loam, 0 to 20% slopes, eroded

- **Map Unit Fe**  
  Ferron silt loam, heavy variant, 0 to 3% slopes

- **Map Unit KLB**  
  Killpack silty clay loam, 0 to 3% slopes

- **Map Unit PCE2**  
  Persayo-Chipeta complex, 1 to 20% slopes

- **Map Unit RY**  
  Rock Land

The study area is within a "mesic" soil temperature regime, and near the boundary between a "typic-aridic" and an "ustic-aridic" soil moisture regime (Sasser, 2002). In addition, the Castle Valley soil type has been recorrelated to the Hideout soil series (Sasser, 2002), and more information on this change is provided in section 3.1.2.

**Soil Characterization (R645-301-222, 223, 224)**

Castle Valley, Ferron, and Persayo soils were sampled for laboratory analysis as part of the Walsh soil survey. These samples were sent to the Utah State University Cooperative Soils Laboratory in Logan, Utah for analysis under the supervision of Dr. A.R. Southard.
A total of nine soil samples were analyzed for the following: particle size distribution, textural class, saturated paste pH, percent organic carbon, percent gypsum, electrical conductivity (EC), moisture tension at saturation and 15 atmospheres, water soluble cations (Ca, Mg, and Na), SAR, and boron.

In addition, laboratory data for Chipeta, Persayo, and Castle Valley soils was also obtained from the Carbon-Emery Area soil survey (Swenson et al., 1970). No samples were collected for analysis from the Killpack soil as part of the Walsh soil survey.

All laboratory results for Castle Valley, Persayo, Chipeta, and Ferron soils are included in Appendix B of this report.
SOIL RESULTS AND DISCUSSION

Each map unit is described in the following section based on information contained in the Emery MRP. Typical soil profile descriptions, obtained from the portal area or the larger Walsh survey area, are included in Appendix A and have been taken from applicable sections of the Emery MRP.

A copy of the most recent, official NRCS soil series description for each of the soils on the portal study area is included as Appendix C of this report. These current descriptions and taxonomic classifications have been obtained from the NRCS web site, "http://www.statlab.iastate.edu/soils/osd".

A soil suitability evaluation and soil salvage depth recommendation is also provided by soil type in the following section. The evaluation and recommendation is based on a review of the original evaluation and recommendation for each soil type and mapping unit contained in the Emery MRP but has been reevaluated for this report.

The original suitability evaluation was based on criteria presented in the Wyoming Department of Environmental Quality (WDEQ) soils guideline (WDEQ, 1980), and the SCS National Soils Handbook. The current evaluation also considers the revised, but not yet officially released, DOGM "Guidelines for Management of Topsoil and Overburden" (Burton and Davidson, 2002).

Parameters and threshold values contained in Table 4 (Soil and Spoil Suitability/Unsuitability
Evaluation) of the DOGM guideline were used in the reevaluation of soil suitability and salvage depth determination.

Soil laboratory data is discussed in the soil suitability evaluation and is attached to this report as Appendix B.

Table 1 (Map Unit Summary and Portal Area Soil Salvage Summary) includes the following information for each of the five map units in the 22.55 acre 4th East Portal Area:

- the soil map unit name and symbol,
- the profile description and sample location numbers,
- the recommended salvage depth and limitations to deeper salvage, and
- total potential cubic yards of available suitable soil, and overall salvage depth for the entire portal area on an inches-per-acre basis.

Map Unit CeE2, Castle Valley extremely stony very fine sandy loam, 0 to 20% slopes, eroded

Map Unit Description

The following map unit description is taken verbatim from section VII.A.3.6 of the Emery MRP.

This map unit is on steep to gently sloping soils on upland benches, mesas and piedmont surfaces. The slope range is 0 to 20 percent. The native vegetation is mainly pinyon, juniper, galleta grass, and Indian ricegrass.

Included in this map unit is about 15 percent rock outcrop, rockland and areas with less
than 4 inches of soil overlying bedrock, and some soils deeper than 20 inches.

The Castle Valley soil is shallow, calcareous, well drained, and medium to coarse textured. It is formed in weathered material derived from interbedded shale and sandstone. The surface layer is an extremely stony very fine sandy loam about 4 inches thick. The subsoil is a brown to brownish yellow very fine sandy loam or gravelly very fine sandy loam about 8 inches thick. Sandstone bedrock is at a depth of 8 to 18 inches. In places wind erosion has removed as much as half the surface layer.

Permeability of the Castle Valley soil is moderately rapid. Available water capacity is moderately high. Effective rooting depth is about 8 to 18 inches; some roots spread horizontally above hard bedrock. Runoff is slow to moderate; in rocky areas it is high. The erosion hazard for water is slight to high. Wind erosion hazard is slight to severe.

The unit is mainly used for spring and fall range. It is also used for wildlife habitat. Fenceposts are cut from juniper in favorable sites. The potential productivity is 725/500/325 pounds of air-dry vegetation in favorable/normal/ and unfavorable years, respectively. This map unit is in capability unit VIIIs (non-irrigated), semi-desert shallow loam range site

**Castle Valley Typical Soil Profile Description**

The Castle Valley typical soil profile, as described at site #35, is included in Appendix A, and is taken from section VII.A.3.6 of the Emery MRP. Castle Valley, as a soil type, has been recorrelated to the Hideout soil series (Sasser, 2002).

The Castle Valley soil name is retained for this report because it was the name used at the time of the Walsh soil survey. However, the Hideout soil series is the more accurate soil name and the most recent, official NRCS soil series description for Hideout, dated August 1998, is included in Appendix C. The Hideout soil is classified as a "Loamy, mixed, superactive, calcareous, mesic Lithic Ustic Torriorthent".

**Castle Valley Soil Suitability Evaluation & Salvage Depth Recommendation**

A detailed soil suitability evaluation and salvage depth recommendation for Castle Valley was included in sections VII.B.4 and VII.B.5 of the Emery MRP. All parameters were rated good, fair, or marginal with only coarse fragment content below 10 inches in depth rated poor. The overall rating was considered "marginal to fair", and the recommended salvage depth of suitable
material was 6 inches.

The current reevaluation rates the entire profile as generally fair to good with a possible poor rated SAR for the surface layer in some pedons. Rock fragment content is not considered poor rated. The entire soil profile to the lithic (generally sandstone) contact can be salvaged for use in reclamation. The average soil depth to sandstone is about 12 inches, with a general range of 8 to 18 inches.

The total recommended salvage depth for Castle Valley is 12 inches. As stated in the Castle Valley map unit description, about 15 percent of the map unit contains areas with rock outcrop, rockland, and areas with less than 4 inches of soil overlying bedrock, and some soils deeper than 20 inches.

Map Unit Fe, Ferron silt loam, heavy variant, 0 to 3% slopes

Map Unit Description

The following map unit description is taken verbatim from section VII.A.3.9 of the Emery MRP.

This map unit is on nearly level to gently sloping alluvial fans, floodplains, and bottoms of narrow valleys. The slope range is 0 to 3 percent. The native vegetation is mainly wiregrass, sedges, reedtop grass and saltgrass.

Included in this map unit is about 10 percent Abbott fine sandy clay loam and 5 percent small areas of very strongly saline/alkaline soils and soils in which the water table is at moderate depth. Inclusions make up about 15 percent of this map unit.

This soil is as described for Ferron heavy variant, except that the surface texture is a silt loam, and it does not receive irrigation waste water. It should be noted that Ferron is currently considered a "hydric" soil and is on the NRCS list of hydric soils for Emery County (Sasser, 2002).

Ferron Typical Soil Profile Description

The typical Ferron soil profile, as described at site #19, is included in Appendix A of this report, and is taken from section VII.A.3.9 of the Emery MRP. The Ferron soil series is currently
classified as a "Coarse-silty, mixed, calcareous, mesic Aeric Fluvaquent". A copy of the most recent, official NRCS soil series description for Ferron, dated February 1997, is contained in Appendix C of this report.

Ferron Soil Suitability Evaluation & Salvage Depth Recommendation

A detailed soil suitability evaluation and salvage depth recommendation was included in sections VII.B.4 and VII.B.5 of the Emery MRP. All parameters were rated good to fair with an overall rating of fair. The original salvage depth recommendation was 30 inches, and the reevaluation supports this conclusion. Electrical conductivity (EC) and sodium adsorption ratio (SAR) are low, soil textures are good, and there are no limiting factors except wetness at some depth in the profile. Therefore, the total recommended suitable salvage depth is 30 inches.

Map Unit KLB, Killpack silty clay loam, 0 to 3% slopes

Map Unit Description

The following map unit description is taken verbatim from section VII.A.3.19 of the Emery MRP.

This map unit is on nearly level to gently sloping fans and shale hills generally below the Chipeta and/or Persayo soils. The slope range is 0 to 3 percent. The native vegetation is mainly shadscale, big sage and galleta grass.

Included in this map unit are small units of strongly to very strongly saline soils, and 5 percent Billings silty clay loam. Included areas make up about 10 percent of the total acreage.

The Killpack soil is moderately deep and well drained. It is formed in residuum that weathered from clayey marine shale bedrock. Typically, the material overlying soft, calcareous shale is light gray to light grayish brown clay loam, silt loam, or silty clay loam to a depth of 20 to 40 inches.

Permeability of the Killpack soil is slow. Available water capacity is moderate to high. Effective rooting depth is about 40 inches. Runoff is medium and the erosion hazard for water is moderate to high. Wind erosion hazard is slight to moderate.
This unit is mainly used for spring and fall range. It is also used for wildlife habitat. The potential productivity is 400 and 150 pounds of air-dry vegetation in favorable and unfavorable years, respectively. This map unit is in capability unit VIIa (non-irrigated), IVe (irrigated); desert loamy shale range site.

_killpack typical soil profile description_

The typical Killpack soil profile, as described in the Soil Survey of Carbon-Emery Area (Swenson et al., 1970), is included in Appendix A of this report. The Killpack soil series is currently classified as a "Fine-silty, mixed, calcareous, mesic Typic Torriorthent". A copy of the most recent, official NRCS soil series description for Killpack is contained in Appendix C of this report.

_killpack soil suitability evaluation and salvage depth recommendation_

Killpack was not evaluated for soil suitability in the Emery MRP, and no soil samples were collected for laboratory analysis. Killpack occupies only a small portion of the overall portal area site, 1.35 acres (5.9%), and is not present in the affected area. Killpack is a moderately deep, slightly to moderately saline, well drained, moderately fine textured soil developing in residuum weathered from clayey, marine shale bedrock.

Based on a review of the typical Killpack profile description and discussion with NRCS soil scientist Leland Sasser, it is apparent that Killpack has no significant limiting factors for suitability and nearly the entire profile could be salvaged for use in reclamation (Sasser, 2002). The average soil depth for Killpack is 29 inches. As a result, the total recommended salvage depth for Killpack is 28 inches.

_map unit PCE2, Persayo-Chipeta complex, 1 to 20% slopes_

_map unit description_

The following map unit description is taken verbatim from section VII.A.3.14 of the Emery MRP.

This map unit is on nearly level to steep fans, terraces, uplands, and shale knolls. The slope range is 1 to 20 percent. The native vegetation is mat saltbush, shadscale, Indian rice grass and galleta grass.
This unit is 40 percent Persayo eroded and non-eroded very fine sandy clay loams and sandy clay loams and 40 percent Chipeta silty clay loam. The two soils are intermingled and occur in an unidentifiable pattern on the landscape. Persayo is usually in the depression areas and draws, but occurs on the broad fans with the Chipeta soil. Included in this map unit is about 20 percent Badland.

The Persayo soil is shallow, well drained, and moderately fine-textured. It is formed in residuum that weathered from shale. Typically, the surface layer is a light brownish gray loam to very fine sandy clay loam about 1 to 4 inches thick. The underlying material is a light brownish gray or pale brown silty clay loam, loam, or clay overlying soft, weathered shale at a depth of 10 to 20 inches. This is a weak to moderately strong gyspic horizon.

Permeability of the Persayo soil is moderate. Available water holding capacity is moderately high. Effective rooting depth is dependent on depth to bedrock. Runoff is medium to rapid, and the erosion hazard for water is moderate to high. Wind erosion hazard is moderate.

The Chipeta soil is shallow, somewhat poorly to moderately well drained, and moderately fine-textured. It is formed in residuum derived from marine gypsum-bearing shale. Typically, a paralithic contact is encountered at about 17 to 19 inches. The surface horizons are highly eroded and severely cracked when dry; the surface soil is thin, about 2 inches thick. Light gray and light grayish brown heavy silty clay loams and silty clays overlie soft weathered shale.

Permeability of the Chipeta soil is moderately slow. Available water capacity is moderate. Effective rooting depth is about 12 to 16 inches. Runoff is rapid, and the erosion hazard for water is high and active. Wind erosion hazard is moderate to high.

The unit is mainly used for spring and fall range. The Chipeta soil is in the VIIe (non-irrigated) capability unit; the Persayo soil in the VIIe (non-irrigated) capability unit. The Chipeta soil is in the desert shallow range site. The Persayo is in the desert loamy shale range site.

Persayo and Chipeta Typical Soil Profile Description

The Persayo and Chipeta typical soil profile descriptions, as described at site #20 for Persayo and at site #01 for Chipeta, are included in Appendix A of this report. The Persayo soil series is currently classified as a "Loamy, mixed, calcareous, mesic, shallow Typic Torriorthent". The Chipeta soil series is currently classified as a "Clayey, mixed, active, calcareous, mesic, shallow Typic Torriorthent". The most recent official NRCS soil series description for Persayo, dated February 1997, and for Chipeta, dated July 1998, is included in Appendix C of this report.
Persayo and Chipeta Soil Suitability Evaluation and Salvage Depth Recommendation

Persayo and Chipeta are mapped together in a soil complex. Although they are intermingled together on the landscape, most often Chipeta occupies slightly higher positions as low hills with very shallow to shallow soil over the underlying shale bedrock. Persayo occupies fans, upland draws, or slightly concave areas where soil has accumulated as local, slopewash alluvium. Persayo and Chipeta each occupy about 40 percent of the map unit. Badland constitutes the remaining 20 percent as an inclusion.

The Persayo soil was previously evaluated for soil suitability in section VII.B.4 and salvage depth recommendation in section VII.B.5. No limiting factors were present, and the soil was rated good to fair for salvage. Nearly the entire soil profile can be salvaged, an average of about 18 inches to bedrock. As a result, the total recommended salvage depth for Persayo is 18 inches.

The Chipeta soil was previously evaluated for salvage depth recommendation in section VII.B.5. Chipeta was rated poor based on salinity (EC) and sodicity (SAR) concerns. In addition, it can have a heavy clay texture, especially at depth approaching the shale bedrock. The previous salvage recommendation was 0 inches. However, the upper part of Chipeta can be suitable for salvage in many locations. The laboratory results for Chipeta (section VII.B.3) included a low ESP (no sodicity hazard). For this project it is reasonable to recommend a soil salvage depth for Chipeta of 6 inches.

Most of the proposed Soil Stockpile will be placed in these soils (see Soils Map included with this report). Soils will not be salvaged from the Soil Stockpile area – they will be left in-place and covered with other salvaged soil material. The soil salvage summaries in Table 1 does not subtract this small acreage in the estimates. In other words, soil salvage was based on salvaging the entire area (where salvable) within the proposed disturbed boundaries shown on the map. Because a field evaluation prior to salvaging will separate those areas within map unit PCE2 that receive 6 inches of salvage (Chipeta) from those that receive 18 inches (Persayo), the field evaluation will also refine the salvage depths regarding the Soil Stockpile.

Map Unit RY, Rock Land

Map Unit Description

The following map unit description is taken verbatim from section VII.A.3.17 of the Emery MRP.
This map unit is on nearly level to steep sloping broad terraces and cliffs. The native vegetation is mainly a sparse cover of pinyon, juniper and sagebrush. Elevation range is 5,900 to 6,400 feet.

This unit is a miscellaneous land type formed from sandstone. About 55 percent of the surface is covered by stones, boulders, and outcrops of sandstone. Some shale outcrops are found. About 20 percent of the land has 4 inches or less of aeolian deposited soil overlying bedrock. Most of this map unit is moderately to severely eroded.

Included in the map unit are gently sloping, moderately deep to deep, fine sandy loams intermingled with the sandstone outcrops. Inclusions of Castle Valley fine sandy loam also occur. Included areas make up about 25 percent of the total acreage.

*Rock Land Typical Soil Profile Description*

Rock Land is not a soil type, and does not have a typical soil profile description.

*Rock Land Soil Suitability Evaluation and Salvage Depth Recommendation.*

Rock Land has no soil available for salvage, and the recommended salvage depth is 0 inches.
SOIL SUITABILITY AND SALVAGE RECOMMENDATION SUMMARY

Table 1 summarizes all pertinent information concerning soil suitability and salvage depth recommendations for each map unit on the Emery 4th East Portal Area. Concerning the 15.05 acre affected area, there is a potential total volume of suitable soil of 12,952 cubic yards. This results in a weight-average total of approximately 6.4 inches of suitable soil per acre available for salvage, stockpiling, and reapplication during reclamation activities.
REFERENCES


**TABLE 1**

**EMERY 4TH EAST PORTAL AREA**

**MAP UNIT SUMMARY AND PORTAL AREA SOIL SALVAGE SUMMARY**

<table>
<thead>
<tr>
<th>Map Unit Symbol</th>
<th>Map Unit Name</th>
<th>Soil Sample/Description Number</th>
<th>Total Soil Depth (in.)</th>
<th>Total Salvage Depth (in.)</th>
<th>Limitations to Deeper Salvage</th>
<th>Total Acres within Portal Area (Percent of Total)</th>
<th>Acres within Affected Area (Percent of Total)</th>
<th>Potential Total Cubic Yards of Suitable Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>CeE2</td>
<td>Castle Valley extremely stony very fine sandy loam, 0 to 20% slopes, eroded</td>
<td>#35</td>
<td>12</td>
<td>12</td>
<td>Bedrock</td>
<td>5.99 (26.6%)</td>
<td>3.76 (25.0%)</td>
<td>5,156³</td>
</tr>
<tr>
<td>Fe</td>
<td>Ferron silt loam, heavy variant, 0 to 3% slopes</td>
<td>#19</td>
<td>35+</td>
<td>30</td>
<td>Wetness</td>
<td>2.41 (10.7%)</td>
<td>0.00 (0.0%)</td>
<td>0</td>
</tr>
<tr>
<td>KL8</td>
<td>Killpack silty clay loam, 0 to 3% slopes</td>
<td>*</td>
<td>29</td>
<td>28</td>
<td>Bedrock</td>
<td>1.33 (5.9%)</td>
<td>0.00 (0.0%)</td>
<td>0</td>
</tr>
<tr>
<td>PCE2</td>
<td>Persayo-Chipeta complex, 1 to 20% slopes</td>
<td>P: #20, C: #01</td>
<td></td>
<td></td>
<td>P: Bedrock, C: Salinity, sodicity, heavy clay texture</td>
<td>6.48 (28.7%)</td>
<td>6.04 (40.1%)</td>
<td>P: 5,847⁴, C: 1,949⁴</td>
</tr>
<tr>
<td>RY</td>
<td>Rock Land</td>
<td>--</td>
<td>--</td>
<td>0</td>
<td>Bedrock</td>
<td>6.34 (28.1%)</td>
<td>5.25 (34.9%)</td>
<td>0</td>
</tr>
</tbody>
</table>

*Profile description is unnumbered and described in Section VII.A.3.18 of the Emery MRP.*

¹ Soil profile descriptions are included in Appendix A.

² Cubic yards of suitable soil are for Affected Area only. Cubic yards for each map unit are rounded to the nearest cubic yard.

³ Potential total volume of suitable soil (cubic yards) has been reduced by 15% due to 15% Rock Outcrop and Rockland in Map Unit CeE2.

⁴ Persayo and Chipeta each occupy about 40% of Map Unit PCE2. Badland occupies the remaining 20% of the map unit.

⁵ 9.7 inches rounded to the nearest tenth inch.
APPENDIX A

TYPICAL SOIL PROFILE DESCRIPTIONS
(taken from the Emery MRP)

CASTLE VALLEY (Now correlated to HIDEOUT)
CHIPETA
FERRON
PERSAYO
KILLPACK
The Castle Valley series is a member of the loamy, mixed, mesic family of Lithic Xerollic Haplargids. A representative profile (#35) of Castle Valley very fine sandy loam, 170 feet west, 765 feet south center of section 27, T22S R.06E, Emery County, Utah at an elevation of 6,095 feet is:

A11 0 to 4 in. light gray (10YR 7/2) fine sandy loam, light yellowish brown (10YR 6/4) moist; moderate very fine platy structure; soft, very friable, slightly sticky and slightly plastic; calcareous; strongly alkaline (pH 8.7); clear wavy boundary.

B2t 4 to 10 in. brownish yellow (10YR 6/6) loamy coarse sand, brownish yellow (10YR 6/6) moist; strong medium and coarse angular blocky structure; hard to very hard, very friable, non-sticky and non-plastic; clay bridges sand grains; calcareous; mildly alkaline (pH 8.1); abrupt wavy boundary.

C1ca 10 to 12 in. very pale brown to white (10YR 7/3, 8/1) sand, light yellowish brown (10 YR 6/4) moist; single grain; loose, very friable, non-sticky and non-plastic; calcareous; mildly alkaline (pH 8.1); abrupt wavy boundary.

Cr-R 12 to 45 in. soft rippable shale intermixed with hard fractured sandstone.

The thickness of the A1 ranges from 3 to 7 in. Depth to sandstone bedrock ranges from 10 to 20 in.; 15 to 17 in. is average for this site. Some profiles have 30 to 70 percent stones and gravels throughout. The percentage of these fragments is usually highest near rockland. The control section in some profiles is very fine sandy loam over bedrock. The surface texture ranges from loamy sand to fine sandy loam and is usually 2 to 4 in. thick. The underlying material may be gravelly very fine sandy loam to very gravelly loam. The B2t has a hue of 10YR or 2.5YR; value is 5 to 7 moist and 4 to 6 dry; chroma ranges from 3 to 6.
VII.A.3.7 Chipeta Series

The Chipeta series is a member of the clayey, mixed (calcareous), mesic, shallow family of Typic Torriorthents. A representative profile (#01) of Chipeta gravelly silty clay loam, 400 feet east, 575 feet south of the northwest corner of section 33, T.22S R.06E, Emery County, Utah, at an elevation of 5,980 feet is:

A1 0 to 2 in. light gray (2.5Y 7/2) gravelly heavy silty clay loam, light brownish gray (2.5Y 6/2) moist; weak thin platy parting to single grain structure; loose, friable, sticky and plastic; few fine and very fine roots; 15 percent gravels; calcareous; powdery lime accumulations in matrix; mildly alkaline (pH 7.7); clear smooth boundary.

AC 2 to 11 in. light brownish gray (2.5Y 6/2) silty clay, grayish brown (2.5Y 5/2) moist; moderate fine angular blocky and thin platy structure; soft, very friable, sticky and very plastic; common medium roots, very few coarse roots; calcareous; some pockets of lime in matrix and lining pores; mottles in lower portion of horizon are few, fine faint (10YR 6/4) moderately alkaline (pH 8.4); clear smooth boundary.

Crcs 11 to 19 in. grayish brown (2.5Y 5/2) moist clay; strong thin to coarse platy structure; slightly hard, firm, sticky and plastic; common fine and very fine roots; strongly calcareous; powdery lime filaments about ped faces; abrupt smooth boundary (not sampled).

R 19+ in. shale.

In areas below Shaley Outcrop-Colluvial land or Badland, the profile is about 4 to 11 inches deep. Surface cracking is common in some places and polyhedrons may be up to 1 1/2 in. thick and 3/4 in. wide when dry. Up to 35 percent gravels may be present on the surface.

Salinity ranges from moderate to strong. Depth to shale ranges from 10 to 20 inches. Unless irrigated, the soils are generally dry when not frozen. In the A horizon, the hue ranges from 2.5Y to 5Y; value ranges from 6 to 8 dry and 4 to 6 moist; the chroma is 1 or 2. The part between 10 inches and shale is heavy silty clay loam to light clay that contains more than 35 percent clay. Hue in this part ranges from 2.5Y to 5Y; value is 5 or 6 dry and 4 or 5 moist; the chroma is 1 or 2. The content of gypsum in the Crcs horizon ranges from .5 to 11 percent. Gypsum crystals are few to common.
Ferron Series

Sample Site No. 19

The Ferron series is a member of the coarse-silty, mixed (calcareous), mesic family of Fluventic Haplaquepts. A representative profile (#19) of Ferron silt loam, 430 feet west, 1530 feet north of the center of section 27, T22S, R06E, Emery County, Utah, at an elevation of 6,069 feet is:

01  2 to 0 in. roots and grass mat.

A1  0 to 4 in. pale brown (10YR 6/3) fine sandy clay loam, dark grayish brown (10YR 4/2) moist; weak thin platy structure; slightly hard, very friable, slightly sticky and plastic; many very fine, fine and medium roots, few coarse roots; few fine faint (10 YR 6/6) mottles; calcareous; moderately alkaline (pH 7.9); distinct smooth boundary.

AC  4 to 15 in. light yellowish brown (10YR 6/3) moist silty clay loam; weak thin platy and fine subangular blocky structure; very friable, slightly sticky and plastic; many very fine, fine, and medium roots; calcareous; moderately alkaline (pH 8.0); diffuse boundary.

C1  15 to 35+ in. light yellowish brown (10YR 6/3) moist silty clay loam; very friable, slightly sticky and plastic; common very fine, fine and medium roots; calcareous; moderately alkaline (pH 7.9); standing water at 35 in.

The content of lime ranges from 10 to 25 percent, salinity ranges from slight to strong and the reaction ranges from mildly to strongly alkaline. Ferron soils are mottled within 20 inches of the surface. The water table is at a depth between 6 and 36 inches below the surface, depending on the season. In the A1g horizon, hue ranges from 2.5Y to 5Y; value is 5 or 6 dry and 4 or 5 when they are moist; chroma is 1 or 2. The control section is very fine sandy loam to light silt loam that contains less than 18 percent clay and less than 15 percent sand coarser than very fine sand. Hue in this part ranges from 2.5Y to 5Y; value is 5 or 6 dry and 4 or 5 when moist; the chroma is 2. The described pedon may contain more coarse sand in the control section (10 in. to 40 in.) than is allowed in coarse-silty families.

Map Unit Fe - Ferron Silt Loam, 0 to 3 Percent Slopes

This map unit is on nearly level to gently sloping alluvial fans, floodplains, and bottoms of narrow valleys. The slope range is 0 to 3 percent. The native vegetation is mainly wiregrass, sedges, redtop grass and saltgrass.

Included in this map unit is about 10 percent Abbott fine sandy clay loam and 5 percent small areas of very strongly saline/alkali soils and soils in which the water table is at a moderate depth. Inclusions make up about 15 percent of this map unit.

This soil is as described for Ferron heavy variant, except that the surface texture is a silt loam, and it does not receive irrigation waste water.

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DIV OF OIL GAS & MINING
VII.A.3.14 Persayo Series

Sample Site No. 20

The Persayo series is a member of the loamy, mixed (calcareous), mesic, shallow family of Typic Torriorthents. A representative profile (#20) of Persayo very fine sandy clay loam, 1,060 feet east and 185 feet north of the southwest corner of section 22, T22S, R06E, Emery County, Utah, at an elevation of 6,087 feet is:

A1  0 to 4 in. light brownish gray (2.5Y 6/2) very fine sandy clay loam, pale brown (10YR 6/3) moist; moderate very thin platy structure; loose, very friable, slightly sticky and slightly plastic; few fine and very fine roots; strongly calcareous; mildly alkaline (pH 8.0); gradual smooth boundary.

AC  4 to 11 in. pale brown (10YR 6/3) heavy silty clay loam, brown (10YR 5/3) moist; weak thin platy structure; soft, very friable, sticky and plastic; common very fine and fine roots, few medium and coarse roots; calcareous; mildly alkaline (pH 8.1); abrupt smooth boundary.

Crcs 11 to 19 in. light brownish gray (10YR 6/2) very gravelly clay, light brownish gray (2.5Y 6/2) moist; strong medium platy structure; slight hard, friable, sticky and plastic; pockets of gypsum crystals, some as streaks or threads below 15 in.; calcareous; slightly alkaline (pH 7.8); abrupt boundary.

R  19+ in. soft weathered shale.

Persayo soils are dry when not frozen, unless they are irrigated. The A1 ranges from hue of 2.5Y to 5Y; value of 6 or 7 when soils are dry and is 4 or 5 when moist; chroma is 2. The control section is silty clay loam and contains less than 35 percent clay. Soft weathered shale is encountered between 10 and 20 in. Weathered fragments of shale make up 5 to 70 percent of the material below 10 inches; shale fragments increase with depth. Some profiles have more gypsum crystals occurring directly above the bedrock; the content ranges from 0.5 to 10 percent. All of the upper 20 inches is about the same color.
The Killpack series consists of moderately deep, slightly to moderately saline, well-drained, moderately fine textured soils. These soils formed in residuum that weathered from clayey, marine shale bedrock. Annual precipitation is 7 to 10 inches. The mean annual soil temperature ranges from 47° to 50°F, and the frost free period is 110 to 130 days. The native vegetation is shadscale, big sage and galleta grass. The elevation range is 6,000 to 6,150 feet.

The available water capacity is moderate to high, and permeability is slow. These soils are used for rangeland and wildlife habitat.

The Killpack series is a member of the fine-silty, mixed (calcareous), mesic family of Typic Torriorthents. A representative profile (Swenson et al., 1970) of Killpack clay loam in a cultivated field about 2,450 feet north and 300 feet east of the southwest corner of section 30, T.16S R.10E, Emery County, Utah, is:

**Ap**
0 to 9 in. grayish brown (2.5Y5/2) clay loam, dark grayish brown (2.5Y4/2) moist; weak medium and fine granular structure; hard, firm, slightly sticky and slightly plastic; plentiful fine roots; common fine pores; strongly calcareous; mildly alkaline (pH 7.8); clear smooth boundary.

**C1**
9 to 23 in. light brownish gray (2.5Y6/2) clay loam, grayish brown (2.5Y5/2) moist; moderate coarse angular blocky structure breaking to weak fine subangular blocky structure; hard, firm, sticky and plastic; few fine roots; few fine pores; strongly calcareous; mildly alkaline (pH 7.7); gradual wavy boundary.

**C2cs**
23 to 29 in. light brownish gray (2.5Y6/2) shaly sily clay loam, grayish brown (2.5Y5/2) moist; massive; hard, very firm, sticky and plastic; few fine roots; no pores; strongly calcareous; many gypsum crystals 5 to 15 mm in diameter; mildly alkaline (pH 7.7); gradual wavy boundary.

**R**
29 in.+ light brownish gray (2.5Y6/2) weathered shale.

Killpack soils are generally dry when frozen, except where they are irrigated. Clay minerals are mixed, but dominantly they are illite and kaolinite. In the A1 horizon, hue ranges from 10YR to 5Y; value is 5 or 6 when the soils are dry and 4 or 5 when moist; and chroma is 2 or 3. The control section is sily clay loam to clay loam and contains less than 35 percent clay. The hue in this section ranges from 10YR to 5Y; value is 6 or 7 when the soils are dry and ranges from 4 to 6 moist; the chroma is 2 or 3. The C2cs horizon contains 5 to 20 percent shale fragments. A slight to moderate accumulation of gypsum overlies the shale.
APPENDIX B

SOIL LABORATORY DATA
### VII.B.3 SOIL DATA

**USDA Soil Conservation Service (Carbon - Emery area, Utah)**

**Physical and Chemical Properties of Selected Soils**

<table>
<thead>
<tr>
<th>Soil Series</th>
<th>Depth (in.)</th>
<th>V. Coarse to Medium sand (2.0–2.5mm) (%)</th>
<th>Fine to V. Fine sand (0.25–0.05mm) (%)</th>
<th>Sand (2.0–0.05mm) (%)</th>
<th>Silt (0.05–0.002mm) (%)</th>
<th>Clay (less than 0.002mm) (%)</th>
<th>Organic Matter (%)</th>
<th>pH paste (%)</th>
<th>ESP (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** *value is high because roots were matted above the horizon*
<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Sample #</th>
<th>Depth (m)</th>
<th>Particle Size Distribution (in % mm)</th>
<th>%&lt;2mm</th>
<th>pH</th>
<th>Organic Carbon</th>
<th>Electrical Conductivity (mhos/cm)</th>
<th>CeO2 equipment</th>
<th>Moisture Tensions</th>
<th>Water Soluble Caions</th>
<th>Boron ppm</th>
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</thead>
<tbody>
<tr>
<td>Alluvial Land</td>
<td>31</td>
<td>0-5</td>
<td>silt: 32 clay: 9 sand: 59</td>
<td>0</td>
<td>6</td>
<td>0.45%</td>
<td>0.9</td>
<td>12</td>
<td>2.58%</td>
<td>2%</td>
<td>2.2%</td>
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<tr>
<td></td>
<td>80-1253</td>
<td>5-20</td>
<td>silt: 46 clay: 8 sand: 40</td>
<td>0</td>
<td>8</td>
<td>0.31%</td>
<td>0.6</td>
<td>22.6</td>
<td>12</td>
<td>2%</td>
<td>2.2%</td>
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<td></td>
<td>80-1254</td>
<td>20-30</td>
<td>silt: 40 clay: 15 sand: 45</td>
<td>0</td>
<td>1</td>
<td>0.24%</td>
<td>0.6</td>
<td>23.6</td>
<td>12</td>
<td>2%</td>
<td>2.2%</td>
</tr>
<tr>
<td></td>
<td>80-1255</td>
<td>20-45</td>
<td>silt: 38 clay: 16 sand: 52</td>
<td>0</td>
<td>2</td>
<td>0.36%</td>
<td>0.6</td>
<td>34.4</td>
<td>11.5</td>
<td>2%</td>
<td>2.2%</td>
</tr>
<tr>
<td>BEEBE</td>
<td>27</td>
<td>0-9</td>
<td>silt: 47 clay: 18 sand: 76</td>
<td>0</td>
<td>3</td>
<td>0.50%</td>
<td>0.6</td>
<td>13.2</td>
<td>2%</td>
<td>1%</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>80-1236</td>
<td>0-20</td>
<td>silt: 35 clay: 16 sand: 54</td>
<td>0.1</td>
<td>3</td>
<td>0.36%</td>
<td>0.6</td>
<td>26.5</td>
<td>12</td>
<td>2%</td>
<td>2.2%</td>
</tr>
<tr>
<td></td>
<td>80-1237</td>
<td>20-30</td>
<td>silt: 32 clay: 11 sand: 51</td>
<td>0.1</td>
<td>3</td>
<td>0.36%</td>
<td>0.6</td>
<td>26.5</td>
<td>12</td>
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</tr>
<tr>
<td></td>
<td>80-1238</td>
<td>30-45</td>
<td>silt: 26 clay: 16 sand: 56</td>
<td>0.1</td>
<td>3</td>
<td>0.41%</td>
<td>0.6</td>
<td>21.2</td>
<td>12</td>
<td>2%</td>
<td>2.2%</td>
</tr>
<tr>
<td>Sundcrson</td>
<td>04</td>
<td>0-4</td>
<td>silt: 37 clay: 17 sand: 44</td>
<td>0.3</td>
<td>3</td>
<td>0.34%</td>
<td>0.6</td>
<td>18.2</td>
<td>12</td>
<td>2%</td>
<td>2.2%</td>
</tr>
<tr>
<td></td>
<td>80-1260</td>
<td>4-14</td>
<td>silt: 31 clay: 15 sand: 45</td>
<td>0.5</td>
<td>3</td>
<td>0.48%</td>
<td>2.4</td>
<td>28.6</td>
<td>12</td>
<td>2%</td>
<td>2.2%</td>
</tr>
<tr>
<td></td>
<td>80-1262</td>
<td>14-40</td>
<td>silt: 23 clay: 17 sand: 58</td>
<td>0.5</td>
<td>3</td>
<td>0.48%</td>
<td>2.4</td>
<td>28.6</td>
<td>12</td>
<td>2%</td>
<td>2.2%</td>
</tr>
<tr>
<td></td>
<td>80-1263</td>
<td>40-60</td>
<td>silt: 31 clay: 17 sand: 58</td>
<td>0.5</td>
<td>3</td>
<td>0.48%</td>
<td>2.4</td>
<td>28.6</td>
<td>12</td>
<td>2%</td>
<td>2.2%</td>
</tr>
<tr>
<td></td>
<td>80-1264</td>
<td>60-80</td>
<td>silt: 31 clay: 17 sand: 58</td>
<td>0.5</td>
<td>3</td>
<td>0.48%</td>
<td>2.4</td>
<td>28.6</td>
<td>12</td>
<td>2%</td>
<td>2.2%</td>
</tr>
<tr>
<td>Castle Valley</td>
<td>35</td>
<td>0-4</td>
<td>silt: 30 clay: 17 sand: 78</td>
<td>0.8</td>
<td>3</td>
<td>0.34%</td>
<td>0.4</td>
<td>4.6</td>
<td>11.5</td>
<td>2%</td>
<td>2.2%</td>
</tr>
<tr>
<td></td>
<td>80-1276</td>
<td>0-10</td>
<td>silt: 13 clay: 20 sand: 65</td>
<td>0.8</td>
<td>3</td>
<td>0.34%</td>
<td>0.4</td>
<td>4.6</td>
<td>11.5</td>
<td>2%</td>
<td>2.2%</td>
</tr>
<tr>
<td></td>
<td>80-1279</td>
<td>10-12</td>
<td>silt: 18 clay: 10 sand: 71</td>
<td>0.8</td>
<td>3</td>
<td>0.34%</td>
<td>0.4</td>
<td>4.6</td>
<td>11.5</td>
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<td>2.2%</td>
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<tr>
<td>Disturbed Land</td>
<td>03</td>
<td>11-53</td>
<td>silt: 69 clay: 17 sand: 60</td>
<td>0.7</td>
<td>3</td>
<td>0.34%</td>
<td>0.4</td>
<td>4.6</td>
<td>11.5</td>
<td>2%</td>
<td>2.2%</td>
</tr>
<tr>
<td>Ferion</td>
<td>35</td>
<td>0-4</td>
<td>silt: 37 clay: 21 sand: 63</td>
<td>0.7</td>
<td>3</td>
<td>0.34%</td>
<td>0.4</td>
<td>4.6</td>
<td>11.5</td>
<td>2%</td>
<td>2.2%</td>
</tr>
<tr>
<td></td>
<td>80-1277</td>
<td>4-10</td>
<td>silt: 37 clay: 21 sand: 63</td>
<td>0.7</td>
<td>3</td>
<td>0.34%</td>
<td>0.4</td>
<td>4.6</td>
<td>11.5</td>
<td>2%</td>
<td>2.2%</td>
</tr>
<tr>
<td>GS Series</td>
<td>06</td>
<td>0-6</td>
<td>silt: 24 clay: 24 sand: 56</td>
<td>0.7</td>
<td>3</td>
<td>0.34%</td>
<td>0.4</td>
<td>4.6</td>
<td>11.5</td>
<td>2%</td>
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<tr>
<td></td>
<td>80-1295</td>
<td>6-28</td>
<td>silt: 24 clay: 24 sand: 56</td>
<td>0.7</td>
<td>3</td>
<td>0.34%</td>
<td>0.4</td>
<td>4.6</td>
<td>11.5</td>
<td>2%</td>
<td>2.2%</td>
</tr>
<tr>
<td>Hunting</td>
<td>10</td>
<td>0-6</td>
<td>silt: 24 clay: 24 sand: 56</td>
<td>0.7</td>
<td>3</td>
<td>0.34%</td>
<td>0.4</td>
<td>4.6</td>
<td>11.5</td>
<td>2%</td>
<td>2.2%</td>
</tr>
<tr>
<td>Ildefonso</td>
<td>07</td>
<td>0-6</td>
<td>silt: 24 clay: 24 sand: 56</td>
<td>0.7</td>
<td>3</td>
<td>0.34%</td>
<td>0.4</td>
<td>4.6</td>
<td>11.5</td>
<td>2%</td>
<td>2.2%</td>
</tr>
<tr>
<td>Persayo</td>
<td>20</td>
<td>0-4</td>
<td>silt: 24 clay: 24 sand: 56</td>
<td>0.7</td>
<td>3</td>
<td>0.34%</td>
<td>0.4</td>
<td>4.6</td>
<td>11.5</td>
<td>2%</td>
<td>2.2%</td>
</tr>
<tr>
<td>Ravola</td>
<td>02</td>
<td>0-3</td>
<td>silt: 38 clay: 17 sand: 44</td>
<td>0.7</td>
<td>3</td>
<td>0.34%</td>
<td>0.4</td>
<td>4.6</td>
<td>11.5</td>
<td>2%</td>
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</tr>
</tbody>
</table>
APPENDIX C

OFFICIAL NRCS SOIL SERIES DESCRIPTIONS

CHIPETA SERIES
FERRON SERIES
HIDEOUT (CASTLE VALLEY) SERIES
KILLPACK SERIES
PERSAYO SERIES
CHIPETA SERIES

The Chipeta series consists of very shallow and shallow, well drained, slowly permeable soils that formed in residuum and colluvium from shale. Chipeta soils are on upland pediments and hills and have slopes of 0 to 35 percent. The average annual precipitation is about 7 inches and the mean annual temperature is about 50 degrees F.

TAXONOMIC CLASS: Clayey, mixed, active, calcareous, mesic, shallow Typic Torriorthents

TYPICAL PEDON: Chipeta silty clay loam -cultivated. (Colors are for air-dry soil unless otherwise noted.)

Ap—0 to 5 inches; light brownish gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; weak fine subangular blocky structure; hard, firm, sticky and plastic; few fine and medium roots; few fine discontinuous pores; violently effervescent; slightly alkaline (pH 7.7); clear smooth boundary. (1 to 5 inches thick)

C—5 to 13 inches; light brownish gray (2.5Y 6/2) silty clay, dark grayish brown (2.5Y 4/2) moist; moderate medium and fine subangular blocky structure; hard, very firm, sticky and plastic; few fine and medium roots; few large continuous pores, few fine discontinuous pores; violently effervescent; slightly alkaline (pH 7.6); clear wavy boundary. (6 to 10 inches thick)

Cv—13 to 17 inches; light brownish gray (2.5Y 6/2) silty clay, dark grayish brown (2.5Y 4/2) moist; weak, moderately thick platy structure parting to weak medium blocky; hard, very firm, sticky and plastic; few fine and medium roots; many fine crystals and mycelia-like veins of gypsum; 20 percent unweathered shale fragments; violently effervescent; slightly alkaline (pH 7.4); gradual irregular boundary. (3 to 5 inches thick)

Cr—17 inches; weathered marine shale.

TYPE LOCATION: Emery County, Utah; 1 mile south and 1-1/2 miles east of Castle Dale, 1,000 feet south and 20 feet east of the northwest corner, sec. 11, T. 19 S., R. 8 E.

RANGE IN CHARACTERISTICS:
Soil moisture regime: Typic Aridic.
Soil temperature regime: Mesic.
Depth to shale: 5 to 20 inches.
Salinity: moderate to strong.
Particle-size control section: 35 to 50 percent clay.
Mean annual soil temperatures: 49 to 57 degrees F.
Reaction: slightly alkaline to strongly alkaline.
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A horizon:
Hue: 10YR to 5Y
Value: 5 to 8 dry, 3 to 6 moist
Chroma: 2 to 4
Texture: loam or silty clay loam

C horizon:
Hue: 10YR to 5Y
Value: 4 to 6 dry, 3 to 5 moist
Chroma: 1 to 4
Textures: silty clay loam or silty clay
Gypsum: 0.5 to 10 percent and gypsum crystal ranges from few to many.

COMPETING SERIES: This is the Chipenhill series. Chipenhill soils have more than 10 percent gypsum.

GEOGRAPHIC SETTING: These soils are on gently sloping to steep upland pediments and hills. Slopes are complex and range from 0 to 35 percent. These soils formed in residuum from alkaline marine shales containing gypsum. The climate is semiarid. The mean annual temperature is 45 to 55 degrees F. The freeze-free period ranges from 90 to 160 days. Mean annual precipitation ranges from 5 to 11 inches.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Killpack, Persayo, and Libnings soils.
Killpack soils: have fine-silty particle-size control sections.
Persayo soils: have loamy particle-size control sections.
Libnings soils: have a salic horizon.

DRAINAGE AND PERMEABILITY: Well drained; medium to very high runoff; slow permeability.

USE AND VEGETATION: A few of the smoother areas of deeper soil are irrigated and used for growing grain and hay crops. Potential vegetation is mat saltbush and galleta.

DISTRIBUTION AND EXTENT: Western Colorado, Wyoming, eastern Utah, and New Mexico. LRR D, MLRA 34. The series is extensive.

MLRA OFFICE RESPONSIBLE: Lakewood, Colorado


REMARKS:
All pH values given are of soil paste.
Diagnostic horizons and features recognized in this pedon are:
Ochric epipedon-the zone from the surface to 5 inches (Ap horizon)
Shallow feature-weathered shale at 17 inches (Cr horizon)

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Official Series Description - FERRON Series

LOCATION FERRON UT

Established Series
Rev. JLS/LDS/MJD 02/97

FERRON SERIES

The Ferron series consists of very deep, poorly drained, moderately permeable soils that formed in alluvium on flood plains. Slopes are 0 to 3 percent. The average annual precipitation is about 8 inches and mean annual temperature is about 49 degrees F.

TAXONOMIC CLASS: Coarse-silty, mixed, calcareous, mesic Aeric Fluvaquents

TYPICAL PEDON: Ferron silt loam. (Colors are for air-dry soil unless otherwise noted.)

0i—1 inch to 0; undecomposed organic material, mainly grass roots; strongly calcareous, moderately alkaline (pH 8.3); abrupt smooth boundary. (0 to 3 inches thick)

Agy—0 to 3 inches; light brownish gray (2.5Y 6/2) silt loam, dark grayish brown (2.5Y 4/2) moist, common fine prominent yellowish red (5YR 4/8) redoximorphic and common medium faint dark gray (4/0) redoximorphic depletions; weak thick platy structure parting to weak medium granular; slightly hard, friable, slightly sticky and slightly plastic; many fine and few medium roots; few medium and fine pores; moderately calcareous; moderately alkaline (pH 8.3); clear smooth boundary. (3 to 8 inches thick)

Cgy—3 to 15 inches; light brownish gray (2.5Y 6/2) loam, grayish brown (2.5Y 5/2) moist, many medium distinct olive brown (2.5Y 5/6) redoximorphic concentrations; weak moderately thick platy structure parting to weak medium granular, soft, friable, slightly plastic; many medium and fine roots; common fine pores; many gypsum mycelia; moderately calcareous; mildly alkaline (pH 7.8); gradual wavy boundary. (6 to 12 inches thick)

Cg—15 to 60 inches; light brownish gray (2.5Y 6/2) very fine sandy loam, brownish gray (2.5Y 5/2) moist, many medium and faint light olive brown (2.5Y 5/6) redoximorphic concentrations; massive; soft, friable; common medium and few fine roots; few fine pores; strongly calcareous; mildly alkaline (pH 7.7).

TYPE LOCATION: Emery County, Utah; 2 miles northwest of Huntington, 350 feet north and 20 feet west of the southeast corner of sec. 11, T. 17 S., R. 8 E.

RANGE IN CHARACTERISTICS: Mean annual soil temperatures range from 49 to 54 degrees F.
strata of fine sandy loams.

The A horizon has hues of 2.5Y through 5Y, values of 5 or 6 dry, 4 or 5 moist, and chromas of 1 or 2.

The C horizon has hues of 2.5Y through 5Y, values of 5 or 6 dry, and 4 or 5 moist, and chromas of 2. There is a subhorizon in the upper C horizon between 10 and 30 inches that has hue of 2.5Y, value 4 or 5 moist, and a chroma of 2.

**COMPETING SERIES:** There are no competing series. The Las Animas and Shoshone series are in similar families. The Las Animas and Shoshone soils have a coarse-loamy particle-size control section.

**GEOGRAPHIC SETTING:** These soils are on flood plains and in the bottoms of narrow alluvial valleys. Slopes are 0 to 3 percent. Parent material is alluvium derived from marine shale and sandstone. The climate is semiarid. Mean annual temperatures is 47 to 52 degrees F. Mean annual precipitation ranges from 6 to 10 inches. The freeze-free period is from 100 to 140 days.

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are Hunting, Rafael and Ravola soils. Hunting soils have mottles at some depth between 20 and 40 inches. Rafael soils have a fine-silty particle-size control section. Ravola soils lack mottles.

**DRAINAGE AND PERMEABILITY:** Poorly drained. Runoff slow; permeability moderate.

**USE AND VEGETATION:** Used for pasture. Potential vegetation is tufted hairgrass, redtop, native clover, and sedges.

**DISTRIBUTION AND EXTENT:** Mainly in eastern Utah. The series is inextensive. MLRA 34

**MLRA OFFICE RESPONSIBLE:** Lakewood, Colorado

**SERIES ESTABLISHED:** Green River Soil Conservation District, Emery and Grand Counties, Utah, 1940.

**REMARKS:** Diagnostic horizons and features in this pedon include:

Ochric epipedon - the zone from 0 to 3 inches (Agy horizon).

Aquic feature - 2 chroma matrix and reductomorph concentrations from 3 to 20 inches (Agy and upper Cgy horizons).

There is an irregular decrease in organic matter with depth.

All pH values given are of soil paste.

The classification was changed from Typic Fluvaquent to Aeric Fluvaquent in 9/94.

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3/19/02
HIDEOUT SERIES

The Hideout series consists of very shallow and shallow, well drained soils that formed in eolian deposits and slope alluvium derived from sandstone. Hideout soils are on hillslopes and structural benches. Slopes range from 2 to 50 percent. Mean annual precipitation is about 10 inches and the mean annual temperature is about 47 degrees F.

TAXONOMIC CLASS: Loamy, mixed, superactive, calcareous, mesic Lithic Ustic Torriorthents

TYPICAL PEDON: Hideout fine sandy loam, on a northwest-facing, linear, 18 percent slope in a Utah juniper rangeland at an elevation of 5,000 feet. (Colors are for dry soil unless otherwise noted.)

A—0 to 2 inches; brown (7.5YR 5/4) fine sandy loam, dark brown (7.5YR 4/4) moist; weak fine blocky structure parting to single grain; soft, very friable, nonsticky and nonplastic; few very fine roots; common very fine, few fine tubular and interstitial pores; very slightly effervescent, carbonates are disseminated; moderately alkaline (pH 8.2); abrupt smooth boundary. (1 to 3 inches thick)

C—2 to 10 inches; brown (7.5YR 5/4) fine sandy loam, dark brown (7.5YR 4/4) moist; weak fine and medium subangular blocky structure; soft, very friable, nonsticky and nonplastic; common very fine, few fine and medium roots; common very fine, few fine tubular and interstitial pores; very slightly effervescent, carbonates are disseminated; moderately alkaline (pH 8.4); abrupt smooth boundary. (6 to 18 inches thick)

R—10 inches; sandstone bedrock with fractures greater than 4 inches apart.

TYPE LOCATION: Uintah County, Utah; about 4.5 miles south of Split Mountain; located about 2,500 feet north and 1,500 feet west of the southeast corner of sec. 8, T. 5 S., R. 24 E., SLBM; Split Mountain, Utah USGS quad; lat. 40 degrees 23 minutes 57 seconds N. and long. 109 degrees 14 minutes 7 seconds W., NAD 27

RANGE IN CHARACTERISTICS:

Soil moisture: The soil moisture control section is affected by precipitation that has an even distribution through the year with a slight increase in late summer and early fall. Aridic moisture regime bordering on ustic.
Mean annual soil temperature: 47 to 50 degrees F.
Depth to lithic contact: 7 to 20 inches to sandstone bedrock

Particle-size control section: 5 to 18 percent clay

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Hue: 7.5YR or 10YR
Value: 4 to 6 dry, 3 to 5 moist
Chroma: 3 to 6 dry or moist
Texture: fine sandy loam or sandy loam
Reaction: slightly alkaline or moderately alkaline

C horizon:
Hue: 7.5YR or 10YR
Value: 4 to 7 dry, 3 to 6 moist
Chroma: 3 to 6 dry or moist
Texture: fine sandy loam or sandy loam
Reaction: slightly alkaline or moderately alkaline


Farview: has soil temperatures greater than 50 degrees F.

Lazear: have more than 18 percent clay in the particle size control section.

Redspear, Rizno, and Rizozo: have hue redder than 7.5YR.

Skyvillage: Do not have soil moisture control sections affected by an even distribution of precipitation throughout the year. The soil moisture control sections is dry mid-February through June and periodically moist November to mid-February.

Travson: has dry periods of precipitation in late summer and early fall, receives most of its precipitation during April, May, and June, and includes rock fragments up to 35 percent

Travessilla and Zukan: have mean annual soil temperatures greater than 50 degrees F. Zukan also has secondary calcium carbonate accumulations.

GEOGRAPHIC SETTING:
Parent material: eolian deposits and slope alluvium derived from sandstone
Landform: hillslopes and structural benches
Slopes: 2 to 50 percent
Elevation: 4,900 to 5,800 feet
Mean annual air temperature: 45 to 49 degrees F.
Mean annual precipitation: 8 to 12 inches
Frost-free period: 110 to 140 days

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Begay, Mespun, and Montwel series.

Begay soils are on fan remnants and are very deep.

Mespun soils are on ridges and are very deep.

Montwel soils are hillslopes and are moderately deep.

http://www.statlab.iastate.edu/cgi-bin/osd/osdname.cgi?P
DRAINAGE AND PERMEABILITY: Well drained, low and medium runoff, moderately rapid permeability.

USE AND VEGETATION: The major uses are wildlife habitat, rangeland, and recreation. The potential native plant community is Utah juniper, black sagebrush, Indian ricegrass, galleta, and bluebunch wheatgrass. This soil has been correlated to Semidesert Shallow Loam (Utah Juniper-Pinyon) - 034XY233UT range site in Utah.

DISTRIBUTION AND EXTENT: Northeast Utah. LRR D, MLRA 34. This series is of small extent.

MLRA OFFICE RESPONSIBLE: Lakewood, Colorado

SERIES ESTABLISHED: Uintah County, Uintah Area Soil Survey, Utah. 1998. The name is taken from a geographic location in the area.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Particle-size control section: The zone from the surface to 10 inches. (A and C horizons)
Ochric epipedon: The zone from 0 to 2 inches. (A horizon)
Lithic contact: The contact with unweathered sandstone bedrock at 10 inches. (R layer)

The cation exchange activity class was inferred from laboratory data from similar soils in the Uintah Area Soil Survey.

LOCATION KILLPACK

Established Series
REV: JLS/TBH/RLM
02/97

KILLPACK SERIES

The Killpack series consists of moderately deep, well drained, slowly permeable soils that formed in alluvium and residuum from saline marine shale. Killpack soils are on sideslopes and toeslopes of rolling shale hills. Slopes are 1 to 25 percent. Average annual precipitation is about 7 inches and mean annual temperature is about 52 degrees F.

TAXONOMIC CLASS: Fine-silty, mixed, calcareous, mesic Typic Torriorthents

TYPICAL PEDON: Killpack clay loam, cropland. (Colors are for air-dry soil unless otherwise noted.)

Ap--0 to 9 inches; brownish gray (2.5Y 5/2) clay loam, dark grayish brown (2.5Y 4/2) moist; weak medium and fine granular structure; hard, firm, slightly sticky and slightly plastic; common fine roots; common fine pores; strongly calcareous; mildly alkaline (pH 7.8); clear smooth boundary. (6 to 9 inches thick)

C--9 to 23 inches; light brownish gray (2.5Y 6/2) clay loam, grayish brown (2.5Y 5/2) moist; moderate coarse subangular blocky parting to weak fine subangular blocky structure; hard, firm, sticky and plastic; few fine roots; few fine pores; strongly calcareous; mildly alkaline (pH 7.7); gradual wavy boundary. (8 to 21 inches thick)

Cy--23 to 29 inches; light brownish gray (2.5Y 6/2) silty clay loam, grayish brown (2.5Y 5/2) moist; massive; hard, very firm, sticky and plastic; few fine roots; strongly calcareous; mildly alkaline (pH 7.7); many gypsum crystals 5 to 15mm in diameter; gradual wavy boundary. (6 to 10 inches thick)

Cr--29 inches; light brownish gray weathered shale.

TYPE LOCATION: Emery County, Utah; 2 miles northwest of Elmo, northeast of the Elmo road and the Cleveland-Price road; 2,450 feet north and 300 feet east of the SW corner of sec. 30, T. 16 S., R. 10 E.

RANGE IN CHARACTERISTICS: Soil temperatures are more than 47 degrees F. Depth to shale bedrock ranges from 20 to 40 inches. There is a few to common gypsum crystals accumulated immediately above the shale. Clay minerals are mixed but dominantly illite and kaolinite. The particle-size control section ranges from silty clay loam to silt loam with 18 to 35 percent clay. The A horizon has hue of 10YR through 5Y, dry value of 5 or 6, moist value of 4 or 5, and chroma of 2 through 4.

The C horizon has hue of 10YR through 5Y, value of 5 through 7 dry, 3 through 7 moist, and chroma of 2 through 4.

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C-8
The Cy horizon has the same color as the C horizon and contains 5 to 15 percent shale channers.

**COMPETING SERIES:** These are the Rosney, Sagers and Swingler series. Rosney, Sagers and Swingler soils are deeper than 40 inches to bedrock.

**GEOGRAPHIC SETTING:** These soils are on the gentle sideslopes of rolling shale hills. Slope gradients range from 1 to 25 percent. Killpack soils formed in alluvium and residuum from saline marine shale. The climate is semiarid with mean annual temperature of 47 to 55 degrees F. Mean annual precipitation ranges from 5 to 11 inches.

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are the Chipeta, Persayo, Billings and Libbings soils. Chipeta and Persayo soils are less than 20 inches deep over shale. Billings soils are very deep and developed in alluvium. Libbings soils have salic horizons above a depth of 20 inches.

**DRAINAGE AND PERMEABILITY:** Well drained; medium to rapid runoff; slow permeability.

**USE AND VEGETATION:** Cultivated areas are used for grain, alfalfa hay, and irrigated pasture. The remaining areas are used for rangeland. Potential vegetation is shadscale, greasewood, galleta grass, and gardner saltbush.

**DISTRIBUTION AND EXTENT:** Eastern Utah and western Colorado. The series is moderately extensive.

**MLRA OFFICE RESPONSIBLE:** Lakewood, Colorado

**SERIES ESTABLISHED:** Emery County, Utah, 1972.

**REMARKS:** The pH values were determined of soil paste.

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PERSAYO SERIES

The Persayo series consists of shallow, well drained soils on hills, terraces, and ridges. These soils formed in thin sediments weathered from underlying soft sedimentary bedrock. Slopes are 1 to 45 percent. The mean annual precipitation is about 9 inches and the mean annual temperature is about 51 degrees F.

TAXONOMIC CLASS: Loamy, mixed, calcareous, mesic, shallow Typic Torriorthents

TYPICAL PEDON: Persayo silty clay loam - grassland. (Colors are for dry soil unless otherwise noted.)

A--0 to 4 inches; light yellowish brown (2.5Y 6/3) silty clay loam, light olive brown (2.5Y 5/3) moist; moderate fine granular structure, weak platy in the upper 1/2 inch; soft, very friable; calcareous; moderately alkaline (pH 8.2); gradual smooth boundary. (3 to 7 inches thick)

C--4 to 14 inches; light yellowish brown (2.5Y 6/4) silty clay loam, light olive brown (2.5Y 5/4) moist; weak medium subangular blocky structure parting to moderate fine granules; hard, very friable; few small calcium sulfate crystals; calcareous; moderately alkaline (pH 8.2) gradual smooth boundary. (7 to 14 inches thick)

Cr--14 inches; calcareous; gray and yellow shales and siltstones.

TYPE LOCATION: Montrose County, Colorado; 0.1 mile north of the southeast corner of Sec. 22, T. 51 N., R. 10 W.

RANGE IN CHARACTERISTICS: Mean annual soil temperature ranges from 47 to 58 degrees F., and mean summer soil temperature ranges from 60 to 75 degrees F. Depth to the underlying paralithic contact ranges from 4 to 20 inches. Organic carbon in the surface 15 inches or in the soil above the bedrock is approximately .4 percent. The sand/clay ratio ranges from less than 1 to about 3. Exchangeable sodium is typically less than 3 percent, but tends to increase as depth increases and differs among pedons. Calcium carbonate equivalent ranges from about 5 to 14 percent and calcium sulfate ranges from less than 1 to about 10 percent. The series control section is typically heavy silt loam, loam, clay loam, or silty clay loam, but clay ranges from 18 to 35 percent, silt from 30 to 65 percent, and sand from 5 to 45 percent. Coarse fragments are usually less than 5 percent and range from 0 to 15 percent. These soils are dry in all parts of the moisture control section for more than three-fourths of the time that the soil temperature is above 41 degrees F.

The A horizon has hue of 10YR through 5Y, value of 5 through 7 dry, and 4 through 6 moist, with chroma of 2 through 4. It is mildly through strongly alkaline and is soft to slightly hard.

http://www.statlab.rastate.edu/cgi-bin/osd/osdname.cgi?-P

3/19/02
The C horizon has hue of 10YR through 5Y, value of 5 or 6 dry, and 4 or 5 moist, with chroma of 2 through 4. It is mildly alkaline through strongly alkaline. It contains some visible calcium carbonate and calcium sulfate which are not concentrated into a definite horizon of secondary accumulation and are considered to be characteristics of the parent sediments rather than pedogenic.

COMPETING SERIES: These are the Birdsley, Celeton, Goldyke, Oceanet, Perlor, Roic, Shalet, and Slatery series. Birdsley soils have over 15 percent exchangeable sodium in the particle-size control section. Celeton, Goldyke, Oceanet, Perlor, and Slatery soils have less than 18 percent clay in the particle-size control section. Shalet soils have hues redder than 7.5YR.

GEOGRAPHIC SETTING: These soils are on upland hills, terraces, and ridges. Slopes range from 1 to 45 percent. The soil formed in thin sediments weathered from underlying soft sedimentary bedrock. Elevation ranges from 5,000 to 6,800 feet. At the type location mean annual precipitation is 7 to 11 inches with peak periods of precipitation occurring during the late summer. Mean annual temperature ranges from 47 to 53 degrees F., and mean summer temperature is about 66 to 70 degrees F. Frost-free period ranges from 95 to 150 days. In Utah this soil has a mean annual precipitation of 6 to 8 inches, mean annual temperature of 48 to 50 degrees, and a frost-free season of 115 to 140 days at an elevation of 5,300 to 6,200 feet.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Chipeta and Menoken soils. Chipeta soils have more than 35 percent clay in the series control section. Menoken soils lack bedrock above a depth of 20 inches and have cambic horizons.

DRAINAGE AND PERMEABILITY: Well drained; medium to rapid runoff; moderate or moderately slow permeability.

USE AND VEGETATION: These soils are used almost exclusively for native pastureland. Native vegetation is salt sage, greasewood, shadscale, and scattered grasses.

DISTRIBUTION AND EXTENT: Western Colorado and Wyoming, northwestern New Mexico, and eastern Utah. The series is of large extent.

MLRA OFFICE RESPONSIBLE: Phoenix, Arizona

SERIES ESTABLISHED: Western Colorado Reconnaissance, W95, 1939.

REMARKS: Diagnostic horizons and features recognized in this pedon are: Paralithic contact - at about 14 inches. Moisture regime is Typic Aridic. Last updated by the state 12/90.
LOCATION MONTWEL

Established Series
REV: GWL/RLM/SSP
07/1999

MONTWEL SERIES

The Montwel series consists of moderately deep to shale, well drained, moderately slowly permeable soils that formed in slope alluvium and colluvium over residuum from variegated shale, siltstone, and sandstone. These soils are on hillslopes. Slopes are 2 to 90 percent. The average annual precipitation is about 8 inches and mean annual temperature is about 46 degrees F.

TAXONOMIC CLASS: Fine-loamy, mixed, superactive, calcareous, mesic Typic Torriorthents

TYPICAL PEDON: Montwel loam, on an northeast facing 42 percent slope under Mormon-tea, shadscale, galleta, and snakeweed -rangeland at an elevation of 5,350 feet. (Colors are for air-dry soil unless otherwise noted)

A--0 to 2 inches; brown (7.5YR 5/4) clay loam, strong brown (7.5YR 4/6) moist; weak very fine, fine, and medium subangular blocky structure; soft, friable, moderately sticky and moderately plastic; few fine and very fine roots; few fine and common very fine tubular pores; slightly effervescent, (10 percent calcium carbonate equivalent), carbonates are disseminated; moderately alkaline (pH 8.4); abrupt smooth boundary. (2 to 4 inches thick)

Cy1--2 to 9 inches; pale brown (10YR 6/3) clay loam, yellowish brown (10YR 5/4) moist; massive; soft, friable, slightly sticky and slightly plastic; few fine and very fine roots; few fine and very fine tubular pores; few fine geogenic gypsum crystals; slightly effervescent, (3 percent calcium carbonate equivalent), carbonates are disseminated; moderately alkaline (pH 8.2); abrupt smooth boundary. (3 to 13 inches thick).

Cy2--9 to 24 inches; reddish brown (5YR 5/4) clay loam, reddish brown (5YR 4/4) moist; massive; slightly hard, firm, moderately sticky and moderately plastic; common fine and very fine roots; few very fine tubular pores; few fine geogenic gypsum crystals; very slightly effervescent, (6 percent calcium carbonate equivalent), carbonates are disseminated; moderately alkaline (pH 8.2); abrupt smooth boundary. (5 to 19 inches thick)

Cy3--24 to 36 inches; pinkish gray (7.5YR 7/2) silty clay loam, brown (7.5YR 5/4) moist; massive; hard, firm, slightly sticky and slightly plastic; few fine geogenic gypsum crystals; slightly effervescent, (5 percent calcium carbonate equivalent), carbonates are disseminated; moderately alkaline (pH 8.4); abrupt smooth boundary. (5 to 15 inches thick).

Cr--36 inches; fractured shale.

TYPE LOCATION: Uintah County, Utah; about 10 miles south of Jensen near Red Wash; 1,700 feet south and 1,800 feet east of the northwest corner of sec. 11, T. 7 S., R. 23 E., SLBM; USGS Red

http://ortho.ftw.nrcs.usda.gov/cgi-bin/osd/osdname.cgi?-P

10/7/03
Wash, Utah quadrangle; 40 degrees, 13 minutes, 38 seconds north latitude, 109 degrees, 17 minutes, 47 seconds west longitude; NAD 27.

RANGE IN CHARACTERISTICS:

Soil moisture: The soil moisture control section is affected by precipitation that falls evenly through the year with a slight increase in the late summer and fall. This soil crosses precipitation zones that are considered to be Typic Aridic and Ustic Aridic. However, the drier aspects and steep slopes offset the additional moisture in the Ustic Aridic zone. The soil moisture regime is typic aridic.

Mean annual soil temperature: 47 to 51 degrees F.
Depth to paralithic contact: 20 to 40 inches to shale
The surface is covered with 0 to 60 percent gravel and cobbles.
Calcium carbonate equivalent: 5 to 15 percent.

Particle-size control section: 27 to 35 percent clay, 15 to 35 percent fine sand or coarser, and 0 to 15 percent parachannlers

A horizon:
Hue: 2.5YR through 7.5YR
Value: 5 or 6 dry, 4 or 5 moist
Chroma: 2 through 6
Texture: clay loam or cobbly clay loam
Rock fragments: 0 to 25 percent gravel and cobbles
Reaction: moderately alkaline or strongly alkaline

C horizon:
The C horizon is horizontal beds of variegated, stratified weathered shale, siltstone and fine grained sandstone that slakes in water.
Hue: dominantly 2.5YR through 7.5YR with thin layers of 10YR, 2.5Y, or 5Y
Value: 4 through 7 dry, 4 or 5 moist
Chroma: 2 through 6
Texture: clay loam, or silty clay loam
Reaction: moderately alkaline or strongly alkaline
Gypsum: 1 to 10 percent

COMPETING SERIES: These are the Gotho, Greybull, Hostage (T), Norland (T), Ohtog, Teapo, and Turzo series.

Gotho, Hostage, Norland, Ohtog and Turzo soils lack a paralithic contact within 40 inches of the surface.
Greybull soils have soil moisture control sections that are influenced by half the yearly precipitation falling during the months of April through June. They also have lithochromic hues that are dominantly more yellow than 7.5YR.
Teapo soils have more than 35 percent fine sand or coarser and have hue more yellow than 7.5YR.

GEOGRAPHIC SETTING:

Parent material: slope alluvium and colluvium over residuum derived from variegated shale interbedded with sandstone and siltstone

http://ortho.ftw.nrcs.usda.gov/cgi-bin/osd/osdname.cgi?P

10/7/03

Inserted 10/03
Landform: hillslopes  
Slope: 2 to 90 percent  
Elevation: 4,600 to 6,400 feet  
Mean annual temperature: 45 to 49 degrees F  
Mean annual precipitation: 5 to 12 inches  
Freeze-free period: 110 to 140 days

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Clapper, Denco, Hideout, and Milok soils.

Denco soils are on hillslopes and have a fine, smectitic particle size control section.  
Clapper and Milok soils are on fan remnants and have a calcic horizon.  
Hideout soils are on hillslopes and have a lithic contact within 20 inches of the surface.

DRAINAGE AND PERMEABILITY: Well drained, low to high runoff; moderately slowly permeable.

USE AND VEGETATION: These soils are used mainly for rangeland, wildlife habitat, and recreation. Potential vegetation is shadscale, bud sagebrush, galleta, and Indian ricegrass. This soil has been correlated to the Desert Very Steep Shallow Loam (Shadscale) - 034XY133UT range site at the type location in Utah.

DISTRIBUTION AND EXTENT: Northeastern Utah. The series is of moderate extent. LLR D. MLRA 34.

MLRA OFFICE RESPONSIBLE: Lakewood, Colorado

SERIES ESTABLISHED: Duchesne County, Utah, 1948.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Particle-size control section: The zone from 10 to 36 inches. (Cy2 and Cy3 horizons)  
Ochric epipedon: The zone from the surface to a depth of 2 inches. (A horizon)  
Gypsum: The presence of geogenic gypsum in the zone from 2 to 36 inches. (Cy1, Cy2, and Cy3 horizons)  
Paralithic contact: The contact with shale at 36 inches. (Cr horizon)

These soils are located in an area that range up to 12 inches of precipitation, typically an ustic aridic zone. However, the interaction of physical conditions (i.e., dry aspects and steep slopes) and moisture only allow desert plant communities to predominate. Thus, the soil moisture is more reflective of Typic Aridic.

Type location moved to Uintah County because of vague original location description.

The type location profile description was reviewed, updated, and revised to meet current standards on 2/1999.


http://ortho.ftw.nrcs.usda.gov/cgi-bin/osd/osdname.cgi?
Jim Nyenhuis has been a Certified Professional Soil Scientist/Soil Classifier (ARCPACS# 2753) since 1986, having been re-certified every two years (as required) since then. He has been continuously employed as a consulting soil scientist for the mining industry since 1979, having successfully completed over 100 soil projects. He has been a subconsultant to Mt. Nebo Scientific, Inc. since about 1994, and has performed soil mapping, sampling, data evaluation, and report preparation for at least 10 coal projects in the Carbon and Emery Counties area since that time. A detailed resume is available upon request.
Jim Nyenhuis and Patrick Collins visited the Emery Mine 4th East Portal Site study area on the afternoon of May 30, 2002 and subsequently conducted field work at the site on May 31, 2002. A meeting was also held late on May 31st with Seth McCourt of Consolidation Coal Company to discuss the findings of the field work. At the time of this meeting, a telephone conversation was also held with Ms. Priscilla Burton (UDOGM) concerning the findings of the field work, recommended salvage depths, and other reclamation issues. Ms. Burton had been unable to visit the site on the day of field work, May 31st.

The soils field work on May 31st involved a revision and refinement of the previous mapping by James P. Walsh & Associates in March of 1981. The Walsh survey was of a much larger area, and it is not known how much field time was actually expended on the original 22.5 acre site. A total of 39 backhoe pits were dug on May 31, 2002 on the 15 acres of the site proposed for disturbance. The soil series and depth to bedrock was noted for each backhoe site, although individual soil horizons were not described except for a deep pit in Ferron which was fully described. A copy of the Ferron profile description is included with this response. The location of each backhoe pit is identified on the revised soils map with an alphabetic letter symbol for the soil series, and the number (in inches) of the depth to bedrock (P= Persayo, CV= Castle Valley, RY=Rock Outcrop, B= Begay, Mw= Montwell, and F= Ferron).

Several revisions and refinements to the original soils map were made on May 31 including: the area mapped as rock outcrop (RY) was reduced, the area mapped as Castle Valley (recently renamed “Hideout” by NRCS) was enlarged, and two new map units were identified (map unit B, Begay; and map unit Mw, Montwell). Two delineations of the deep, coarse-loamy Begay soil were drawn on the revised map, as well as one delineation of the moderately deep, fine-loamy Montwell soil. The Revised Soils Map of the site was copied and given to Patrick Collins and Seth McCourt on May 31st. Based on previous discussion with Priscilla Burton, no soil samples for laboratory characterization were collected on May 31st.

Appendix VII-3

Addendum 1 to Appendix VII-3
Based on the soils and soil depths identified in the 39 backhoe pits, it was recommended that all soil down to the sandstone contact could be salvaged and stockpiled for later reuse in reclamation activities. A revision of soil volume available for salvage was not requested and was not calculated.

Based on the telephone conversation with Priscilla Burton on May 31st, it was decided to salvage soil from the Persayo-Chipeta (map unit PCE2) area first, and subsequently from the Castle Valley (Hideout) (map unit CeE2) and Montwell (map unit Mw) areas. This would provide soil stockpiles with the coarser-textured Castle Valley (Hideout) soil on top of the finer textured Persayo and Chipeta soils. This "sequencing" of soil salvage by soil series/map unit would provide a similar result as the "soil segregation" by soil horizons that Priscilla Burton had suggested. Based on the phone conversation on May 31st, Priscilla was in agreement with this sequencing approach to soil salvage.

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* Control section average
APPENDICE VII-4

LETTER FROM MT. NEBO CONSULTANTS -
APPEND 1.5 AC. AREA to 4th EAST PORTAL AREA
March 26, 2003

Tim Kirschbaum, P.E.
Consolidation Coal Company
P.O. Box 566
Sesser, Illinois 62884

Dear Mr. Kirschbaum:

You requested from us additional vegetation and soils information within the proposed increased area of the 4th East Portal permit boundary.

Vegetation

I have revised the current plant community boundary lines within the 4th East Portal permit area. Although I did not visit the site specifically to revise the current vegetation map, I do have a collection of good color photographs of the area. Because the proposed new permit area extension was relatively small, I used my photographs to extend the existing plant community boundary lines. A revised vegetation map has been included with this letter.

The proposed new area, however, should be surveyed for threatened, endangered or rare plant species. Plans should be made to do this study in late April or early May 2003.

Soils

I asked Mr. James Nyenhuis, Certified Professional Soil Scientist, to respond to your request regarding soils. Mr. Nyenhuis visited the site. His response is shown below. A revised soils map based on Mr. Nyenhuis' visit has also been included in this letter.

From James Nyenhuis letter-report (March 2003):

"At your request, I visited the Emery Deep 4th East Portal Area site on March 14, 2003 for the purpose of extending the previous detailed soil survey to include a small strip of land between the northeast border of the permit area and the closely adjacent northwest/southeast trending dirt road. The area to be surveyed was outlined (cross hatched) on a site map emailed to me on March 6. The intent of the new survey is to support the request to include the small strip in the Disturbance Area of the permit area. The small strip has been impacted by wind-blown coal fines from adjacent mining activities. Prior to the survey, I spoke by telephone with Mr. Tim Kirshbaum (Consol P.E.) and meet with Mr. Seth McCourt (Consol Project Manager) at the site."
The small strip had been traversed by foot during the previous soil survey of the 4th East Portal Area last year although no backhoe pits had been dug on the strip itself. This time, the strip was again traversed by foot and numerous shallow spade holes were dug to confirm and/or revise the previous mapping extension. Results indicate that the previous map unit lines can be extended along contour lines over to the dirt road. From north to south, three map units delineations were extended to the dirt road to the east: (1) map unit PCE2: Persayo-Chipeta complex, (2) map unit CeE2: Castle Valley extremely stony very fine sandy loam, and (3) map unit RY: Rock Land. Map Unit RY (Rock Land) is present along or just south of the south boundary of the small strip area. The attached soil map includes the new soil mapping, and it can be digitized for acreage determination. No soil samples were collected because no new soil series were identified.

Please contact me if you have questions or comments. Also, let me know if you want me to conduct a sensitive plant survey in the new area at the appropriate time.

Sincerely,

Patrick D. Collins, Ph.D.

Enclosures
CHAPTER VII, APPENDIX VII-5
Order 2 Soil Survey of Emery 2 Mine Permit
Order 2 Soil Survey

of

Emery 2 Mine Permit Area

Located near Emery, Utah

Prepared for

Bronco Utah Operations, LLC

By

Long Resource Consultants, Inc.

Morgan, Utah

December 9, 2016
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Introduction

Purpose of Soil Survey

The purpose of this report is to summarize the results of an order 2 soils inventory conducted for Bronco Utah Operations LLC (BUOLLC) in an area south and west of the existing Emery Mine in Emery County, Utah. The Emery 2 Soil Survey area is adjacent to the existing Emery Mine surface facilities.

BUOLLC is proposing to expand the underground operations of the Emery Mine to the southwest, which will require construction of new roads and surface facilities. This soil survey was prepared so that BUOLLC could: 1) identify suitable sources of topsoil and subsoil; 2) determine topsoil and subsoil salvage depths and quantities; and, 3) develop a post mining reclamation plan using salvaged soil materials. This soil survey covers approximately 189.7 acres.

The proposed Emery 2 permit area is approximately 28.9 with proposed disturbance of 10.3 acres. These areas are shown on Figure 3, Emery 2 Mine Order 2 Soil Survey Map.

Project Area

The Emery 2 Soil Survey area is on Walker Flat, approximately 4.7 miles south of the town of Emery, Utah, Figure 1. It is bounded on the west by the Old Woman Plateau, on south by the San Rafael Swell, and on the north and east by Quitchapah Creek. The area is located in portions of the east half of section 32 and the west half of section 33, Township 27 South, Range 6 East, Salt Lake Base Meridian.

The Emery 2 Soil Survey area drains north to Quitchapah Creek which crosses the north portion of the survey area and forms part of the boundary along the northeast part of the area. Quitchapah Creek flows into Ivie Creek about 4 miles south of the soil survey area. Ivie Creek flows into Muddy Creek about 4.5 miles southeast of the soil survey area. Then Muddy Creek flows southeast approximately 50 miles to its confluence with the Fremont River which forms the Dirty Devil River that flows into the Colorado River near Hite Crossing, Utah.

The soil survey area is accessed from the north by following State Route (SR) 10 south 5.5 miles from Emery, Utah to a dirt surface road. It is accessed from the south by following SR 10 Fremont Junction on Interstate 70 (exit 89) north 6.75 miles to the dirt surface road. The distance along the dirt surface road to the southwest corner of the Emery 2 Soil Survey Area is approximately 2.4 miles. The survey area can be accessed on foot through the canyon from a parking area south of the Emery mine office.
Native vegetation in the Emery 2 Soil Survey Area consists of shadscale, black greasewood, black sage in the northwest portion; and Utah juniper, pinyon pine, big sagebrush, and black greasewood in the southeast portion.

Climate

An official U.S. Weather Bureau station is located in Emery, Utah. The period of available records for this station is January 1, 1901 through April 30, 2006 (Western Regional Climate Center, May 2016). Average annual precipitation at Emery is 7.33 inches and is evenly distributed throughout the year. The average annual air temperature is 46.0 °F.

The precipitation pattern is aridic and the soil temperature regime is mesic (USDA-NRCS 2009). Table 1 contains a summary of weather data for Emery, Utah. Summers are warm with cool nights.

Table 1. Summary of weather data for Emery, Utah (1901-1970). Summary of Emery, Utah weather records for 1971 to 2000 have similar values.

<table>
<thead>
<tr>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ave Max Temp °F</td>
<td>37.1</td>
<td>42.0</td>
<td>50.0</td>
<td>59.3</td>
<td>68.8</td>
<td>77.6</td>
<td>83.4</td>
<td>81.3</td>
<td>74.4</td>
<td>63.4</td>
<td>50.1</td>
<td>39.6</td>
</tr>
<tr>
<td>Ave Min Temp °F</td>
<td>10.9</td>
<td>16.1</td>
<td>22.8</td>
<td>30.0</td>
<td>37.8</td>
<td>45.5</td>
<td>52.2</td>
<td>50.7</td>
<td>42.0</td>
<td>32.3</td>
<td>21.7</td>
<td>13.5</td>
</tr>
<tr>
<td>Ave Total Precip. Inches</td>
<td>0.47</td>
<td>0.50</td>
<td>0.43</td>
<td>0.39</td>
<td>0.60</td>
<td>0.51</td>
<td>0.83</td>
<td>1.12</td>
<td>0.90</td>
<td>0.81</td>
<td>0.33</td>
<td>0.44</td>
</tr>
<tr>
<td>Average Total Snowfall (Inches)</td>
<td>5.3</td>
<td>5.0</td>
<td>2.8</td>
<td>0.6</td>
<td>0.4</td>
<td>0.0</td>
<td>0.1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.6</td>
<td>1.7</td>
<td>4.4</td>
</tr>
<tr>
<td>Average Total Snow Depth (Inches)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Western Regional Climate Center, May 2016.

The Emery Area soil survey identified the area as transitioning from Typic aridic (Desert 5 to 9 inches) to Ustic aridic (Semi-Desert 10 to 16 inches) precipitation patterns (USDA-NRCS 2016). The NRCS precipitation break is along the southeast rim of the canyon that cuts through the soil survey area. This transition is identified in the field with dominantly shadscale vegetation northwest of the canyon and Utah juniper, pinyon pine, and big sagebrush on the plateau southeast of the canyon. Tamarisk and black greasewood are present in the alluvial floodplain at Quitchapah Creek.
Fig. 1. Location of Emery 2 Soil Survey Area

Fig. 1. General location of Emery 2 soil survey area.
How This Soil Survey was Conducted

This soil survey was made in accordance with the guidelines for an order 2 soil survey as detailed in the Soil Survey Manual (USDA 1993). Soils were classified using the Keys to Soil Taxonomy, Twelfth Edition (USDA 2014). The dominant soil sub-groups identified in the Emery 2 Soil Survey area are Lithic Ustic Torriorthents, shallow Ustic Torriorthents, Lithic Torriorthents, and Typic Torriorthents. Tables of the taxonomic classification and field descriptions of the soil profiles are contained in appendix B.

Field Evaluation of Soils

Soil pedon descriptions were completed for representative hand pits dug in September, October, and November 2009. Two soil profiles were examined and described in June 2016. Pits in very deep soils were dug or augured to a minimum 150 cm (60 inches), unless bedrock was encountered. Sandstone or shale bedrock was encountered in most of the pits between 25 to 100 cm (10 and 40 inches). Shallow and moderately deep pits were hand dug. A hand soil auger was used to examine soils deeper than 100 cm (60 inches) Soil pedon log sheets were completed for each soil pit using the methods detailed in the Field Book for Describing and Sampling Soils, version 3.0 (Schoeneberger et. al., 2012). Soil colors were determined using Munsell Soil Color Charts (Munsell 2000 and 2013). Soil pits were described by Robert Long, Certified Professional Soil Scientist. Field description sheets are in Appendix B. Taxonomic classification of soil profiles was completed by using Keys to Soil Taxonomy, Twelfth Edition (USDA 2014). Soils were correlated to established soil series used in Emery County, Utah (USDA 2016a).

Aerial photographs (NAIP 2006 and 2014, 1 meter) and U.S.G.S. topographic maps were used to delineate soil map unit boundaries based on slope gradient, geomorphic features, and vegetation. The aerial photography was taken in 2014 (Utah AGRC 2016). Samples of soil horizons were collected in gallon size plastic bags and in micromonolith boxes. The box samples were used for further determination of soil profile characteristics. Soil lines and sample locations were delineated on the aerial photography using ARC-Map software, version 10.2, in NAD 1983.

Analysis of Soil Samples

Soil samples (32) collected during September 29-30, 2009 from eight soil profiles were shipped to Intermountain Labs in Sheridan, Wyoming for analysis on September 24, 2009. Each of the soil samples were analyzed for the topsoil suitability parameters outlined by the Utah Division of Oil Gas and Mining’s (DOGM) Guidelines for Management of Topsoil and Overburden (DOGM, 2008), Table 2.
Soil samples (19) collected on October 8, 2009 from five soil profiles were shipped to Intermountain Labs in Sheridan, Wyoming for analysis on 20, 2009. Each of the soil samples were analyzed for the topsoil suitability parameters outlined by the Utah Division of Oil Gas and Mining's (DOGM) Guidelines for Management of Topsoil and Overburden (DOGM 2008), Table 2.

Soil samples (6) collected November 12, 2009 from one soil profile were shipped to Intermountain Labs in Sheridan, Wyoming for analysis on December 3, 2006. Each of the soil samples were analyzed for the topsoil suitability parameters outlined by the Utah Division of Oil Gas and Mining's (DOGM) Guidelines for Management of Topsoil and Overburden (DOGM 2008), Table 2.

Laboratory data reports of the soil sample analyses are in Appendix C.

Table 2. Soil analysis parameters for topsoil and overburden (Utah DOGM, 2008).

<table>
<thead>
<tr>
<th>Topsoil Suitability Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paste pH</td>
</tr>
<tr>
<td>Saturation percent</td>
</tr>
<tr>
<td>Electrical Conductivity (ECE)</td>
</tr>
<tr>
<td>Soluble Na, K, Mg, and Ca</td>
</tr>
<tr>
<td>Sodium Adsorption Ratio</td>
</tr>
<tr>
<td>Additional Analyses for Topsoil and Overburden</td>
</tr>
<tr>
<td>Soluble Selenium</td>
</tr>
<tr>
<td>Alkalinity</td>
</tr>
</tbody>
</table>

**Geology and Setting**

Ferron sandstone (Kmf), Blue Gate shale (Kmb), Quaternary stream and wash alluvium (Qa), and Quaternary mixed wind-blown sand and alluvium are the primary sources of parent material in the soil survey area. Ferron sandstone and Blue Gate shale are members of the Upper Cretaceous Mancos formation (Utah Geological Survey 2004).
Ferron sandstone (Kmf) is a member of the Upper Cretaceous Mancos formation. It is alternating yellow-gray, light-brown, and white sandstone, sandy gray shale, gray and carbonaceous shale, and coal; mostly fine to medium grained sandstone, commonly calcareous (Utah Geological Survey 2004). Shallow and moderately deep soils have developed in the Ferron sandstone area.

Blue Gate (Kmb) shale is a member of the Upper Cretaceous Mancos formation that occurs above the Ferron sandstone. It is a “pale blue-gray marine shale, nodular and irregularly bedded mudstone and siltstone...” that “weathers into low rolling hills and badlands (Utah Geological Survey, 2004). Shallow sodic saline soils have developed in Blue Gate shale in the southwest portion of the soil survey area. Blue Gate shale is also present on the upper slopes in the canyon area.

Quaternary alluvium (Qa) consists of unconsolidated clay, silt, sand, and gravel deposits along more active streams and washes of Holocene age (Utah Geological Survey, 2004). Very deep soils have developed in the Quaternary alluvium along Quitchapah Creek.

Quaternary mixed wind-blown sand and alluvium (shown as Qed on geology map, but Qea is closest symbol in geology report) “consists of sand and silt of eolian origin interspersed with silt, sand, and gravel of fluvial origin; generally dominated by eolian deposits (Utah Geological Survey, 2004)”. Moderately deep coarse-loamy soils have developed in these wind-blown deposits.

**NRCS Soil Survey**

The Emery 2 soil survey is within the Emery Area, Utah, Parts of Emery, Carbon, and Sevier Counties soil survey published by the Natural Resource Conservation (USDA – NRCS June 2016b), Figure 2. Table 3 lists the NRCS soil map units that occur within the Emery 2 soil survey area.

The only significant differences between soils mapped by the NRCS and those identified by the Emery 2 soil survey were:

- Soils on the plateau east of the canyon are dominated by coarse-loamy textures, while NRCS map unit 103 is dominated by fine-loamy soils. The other soil characteristics in the survey area are similar.
- The very deep soils in the bottom of the canyon and along Quitchapah Creek are coarse-loamy and have horizons with SAR values ranging from less than 1.0 to 48.7.
Table 3. NRCS soil map units occurring within the Emery 2 soil survey area.

<table>
<thead>
<tr>
<th>NRCS Map Unit</th>
<th>Map Unit Name</th>
<th>Acres Within Emery 2 Soil Survey Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>005</td>
<td>Badland-Persayo-Rock Outcrop Complex, 35 to 80 percent slopes</td>
<td>10.3</td>
</tr>
<tr>
<td>008</td>
<td>Beebe loamy fine sand, 1 to 3 percent slopes</td>
<td>4.9</td>
</tr>
<tr>
<td>015</td>
<td>Braf-Persayo-Casmos complex, 3 to 20 percent slopes</td>
<td>82.8</td>
</tr>
<tr>
<td>017</td>
<td>Briny silty clay loam, 0 to 3 percent slopes</td>
<td>4.3</td>
</tr>
<tr>
<td>041</td>
<td>Ferron peaty silt loam, 0 to 3 percent slopes</td>
<td>1.6</td>
</tr>
<tr>
<td>073</td>
<td>Hunting-Gullied land-Libbings complex, 0 to 5 percent slopes</td>
<td>8.3</td>
</tr>
<tr>
<td>083</td>
<td>Lazear-Gerst-Pacon complex, 3 to 35 percent slopes</td>
<td>18.0</td>
</tr>
<tr>
<td>103</td>
<td>Molen-Lazear-Gerst complex, 2 to 8 percent slopes</td>
<td>45.4</td>
</tr>
<tr>
<td>127</td>
<td>Persayo-Chipeta association, 3 to 20 percent</td>
<td>13.9</td>
</tr>
<tr>
<td>144</td>
<td>Ravola-Homko complex, 1 to 3 percent slopes</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>189.7</td>
</tr>
</tbody>
</table>


**Prime Farmland**

The Natural Resource Conservation Service (NRCS) conducted an evaluation of potential Prime Farmlands within the Emery 2 soil survey area and determined that it "contains no Prime or Unique farmlands of farmlands of Statewide importance (Sasser 2010)." The NRCS letter detailing this assessment is in Appendix A.

NRCS soil map unit 144 is designated as *Prime Farmland if Irrigated*. This soil map unit is of very limited extent in the Emery 2 soil survey area and no evidence of irrigation is present in the survey area. The surface area of 144 soil map unit is 0.2 acres within the Emery 2 soil survey area and it is not located within the proposed permit area.
Figure 2. NRCS - Emery County Area Soil Survey

Legend
- Emery 2 Permit Boundary
- Emery 2 Disturbance Area
- Emery Mine Permit Boundary
- Emery Survey Area

Map Unit, Soil Survey of Emery Co. Area, UT (USDA 2016b)

- 005 Badland-Persay-Rock Outcrop, 35-80% slopes
- 008 Beebeloamy fine sand, 1-3% slopes
- 015 Braf-Persay-Camos, 3-20% slopes
- 017 Briny silty clay loam, 0-3% slopes
- 041 Ferron peaty silt loam, 0-3% slopes
- 073 Hunting-Gullied land-Libbings, 0-5% slopes
- 083 Lazeair-Berst-Pacon, 3-35% slopes
- 103 Molen-Lazear-Gerst, 2-8% slopes
- 127 Persayp-Chipeta, 3-20% slopes
- 144 Ravola-Homko, 1-3% slopes

Base map NAIP 2014 UTM NAD 83 1 inch = 400 feet

Prepared By:
Long Resource Consultants, Inc.
Morgan, Utah
Soil Survey Map Units

Soil Survey Legend

Native soils in the Emery 2 Soil Survey area were identified with nine map units based on the taxonomic classification (USDA – NRCS, 2010) of the soils and slope. One additional soil map unit is included to identify a previously disturbed area. The composition of these map units is described in Table 4. Detailed descriptions of each soil map unit are included in this section. Topsoil and subsoil suitability classifications of Good, Fair, Poor, and Unacceptable are based on Guidelines for Management of Topsoil and Overburden (Utah DOGM 2008).

Soil map unit delineations are shown in Figure 3. Map unit boundaries are based on:

- Field traverses and transects within the soil survey area;
- Interpretation of GIS slope maps, and;
- Interpretation of vegetation patterns on aerial photography using GIS software.

In some cases, site specific evaluation of the soils and vegetation will be necessary for delineation of map unit boundaries in the field.

Table 4. Soil map unit composition for the Emery 2 Soil Survey area.

<table>
<thead>
<tr>
<th>Map Unit</th>
<th>Percent</th>
<th>Soil Series or Taxonomic Family</th>
<th>Modal Pedon</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rock Outcrop – Hideout complex, 3 to 8 percent slopes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>Sandstone Outcrop</td>
<td>EM-4-09</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>Hideout</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Begay family</td>
<td></td>
</tr>
<tr>
<td>Ba</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Begay family – Lazear complex, 3 to 12 percent slopes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>Begay family</td>
<td>EM-1-09</td>
</tr>
<tr>
<td></td>
<td>35</td>
<td>Lazear</td>
<td>EM-5-09</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Hideout</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Sandstone Outcrop</td>
<td></td>
</tr>
<tr>
<td>Bd</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Disturbed Lands, 3 to 15 percent slopes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>85</td>
<td>Previously disturbed soils</td>
<td>EM-3-09</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Begay family</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Hideout</td>
<td></td>
</tr>
</tbody>
</table>
Table 4. Soil map unit composition for the Emery 2 Soil Survey area.

<table>
<thead>
<tr>
<th>Map Unit</th>
<th>Percent</th>
<th>Soil Series or Taxonomic Family</th>
<th>Modal Pedon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca</td>
<td>50</td>
<td>Persayo family</td>
<td>EM-6-09</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>Sandstone Outcrop</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>Hideout</td>
<td>EM-17-09</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Garley</td>
<td>EM-8-09</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Monue family</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Persayo family – Rock Outcrop - Hideout complex, 3 to 80 percent slopes</td>
<td></td>
</tr>
<tr>
<td>Cb</td>
<td>60</td>
<td>Monue Family</td>
<td>EM-16-09</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>Garley</td>
<td>EM-9-09</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Begay family</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Monue Family – Garley complex, 3 to 12 percent slopes</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>85</td>
<td>Braf</td>
<td>EM-10-09</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Sandstone Outcrop</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Persayo family</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Braf sandy loam, 2 to 8 percent slopes</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>50</td>
<td>Sandstone Outcrop</td>
<td>EM-11-09</td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>Braf</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Persayo family</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rock Outcrop – Braf complex, 6 to 15 percent slopes</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>85</td>
<td>Persayo</td>
<td>EM-13-09</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Braf</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Sandstone Outcrop</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Persayo very gravelly clay loam, 15 to 45 percent slopes</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>85</td>
<td>Garley, moderately well drained</td>
<td>EM-12-09</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Green river</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Braf</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Garley loam, moderately well drained, 2 to 5 percent slopes</td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>90</td>
<td>Green River</td>
<td>EM-7-09</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Garley, moderately well drained</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Green River sandy clay loam, 1 to 3 percent slopes</td>
<td></td>
</tr>
</tbody>
</table>
Emery 2 Permit Boundary
Emery 2 Disturbance Area
Emery Mine Permit Boundary
Emery 2 Soil Survey Area
Soil Profiles

Emery 2 Soil Map Units
A  Rock Outcrop-Hideout, 3-8%
Ba Begay family-Lazear, 3-12%
Bd Disturbed Lands, 3-15%
Ca Persayo family-Rock Outcrop-Hideout, 3-80%
Cb Monue family-Garley, 3-12%
D Braa, 2-8%
E  Rock Outcrop-Braf, 6-15%
F  Persayo, 15-45%
G  Garley, mod well drained, 2-5%
H  Green River, 1-3%

Figure 3. Emery 2 Mine
Order 2 Soil Survey Map

Prepared By:
Long Resource Consultants, Inc.
Morgan, Utah
A  Rock Outcrop — Hideout complex, 3 to 8 percent slopes

General
Map unit A is characterized by Ferron sandstone outcrops and shallow soils on a plateau in the southeast portion of the soil survey area. Inclusions of moderately deep Begay family soils also occur in this soil map unit. Component distribution is based on a 10 point transect (Appendix B). Hideout soils are dominated by Utah juniper and pinyon pine. Big sagebrush and black greasewood are on the Begay family soils. Grasses are of very limited extent in this map unit. Table 5 lists the taxonomic classification of the soil components in map unit A.

Table 5. Taxonomic classification of soil components in map unit A.

<table>
<thead>
<tr>
<th>Percent of Soil Series or Map Unit</th>
<th>Family</th>
<th>Taxonomic Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>Sandstone outcrop</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>Hideout Lithic Ustic Torriorthents, loamy, mixed, superactive, calcareous, mesic</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Begay family Ustic Haplocambids, coarse-loamy, mixed, superactive, mesic</td>
<td></td>
</tr>
</tbody>
</table>

Typifying Soil Pedon Descriptions
Soils colors are for dry soil unless specified otherwise.

The typifying soil pedon for Hideout soils in map unit A is EM-4-09, The surface 4 cm (2 inches) is very pale brown loamy sand. The lower surface is pale brown sandy loam to 20 cm (8 inches). Ferron sandstone is at 20 cm (8 inches).

Limiting Features
The large amount of Ferron sandstone outcrop and shallow depth to sandstone will be limiting to excavation and topsoil salvage in this map unit.

Available water capacity is Fair (DOGM 2008) in these coarse textured soils.

Reclamation of this map unit will be limited by the amount of topsoil salvage from shallow soils.
**Ba  Begay family — Lazear complex, 3 to 12 percent slopes**

**General**

Map unit Ba is dominated by moderately deep, Begay family, and shallow, Lazear, soils over Ferron sandstone. Minor inclusions of shallow Hideout soils also occur in this map unit. Wyoming big sagebrush, black greasewood, and shadscale dominate the Begay family soils. Shadscale is the dominant vegetation on Lazear soils. Grasses are of very limited extent in this map unit. Table 6 lists the taxonomic classification of the soil components in map unit Ba.

<table>
<thead>
<tr>
<th>Percent of</th>
<th>Soil Series or Family</th>
<th>Taxonomic Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Map Unit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>Begay family</td>
<td>Ustic Haplocambids, coarse-loamy, mixed, superactive, mesic</td>
</tr>
<tr>
<td>35</td>
<td>Lazear</td>
<td>Lithic Ustic Torriorthents, loamy, mixed, superactive, calcareous, mesic</td>
</tr>
<tr>
<td>10</td>
<td>Hideout</td>
<td>Lithic Ustic Torriorthents, loamy, mixed, superactive, calcareous, mesic</td>
</tr>
<tr>
<td>5</td>
<td>Sandstone outcrop</td>
<td></td>
</tr>
</tbody>
</table>

**Typifying Soil Pedon Descriptions**

The typifying pedon for Begay family soils in map unit Ba is EM-1-09. The surface is pale yellow sandy loam to 8 cm (3 inches). The sub-surface is light yellowish brown sandy loam to 50 cm (20 inches). The subsoil is pale yellow channery sandy loam to 80 cm (32 inches). Ferron sandstone is at 80 cm (32 inches).

The typifying pedon for Lazear soils in map unit Ba is EM-5-09. The surface is pale brown channery sandy loam to 7 cm (3 inches). The sub-surface is light yellowish brown channery sandy clay loam to 20 cm (8 inches). Ferron sandstone is at 20 cm (8 inches).

Hideout soils are similar to Lazear soils, but textures are coarse-loamy (5 to 18 percent clay).
Limiting Features

The moderately deep (50 to 100 cm) and shallow (less than 50 cm) depths to Ferron sandstone will be limiting to excavations.

Available water capacity is *Fair* (DOGM 2008) in these coarse textured soils.

Calcium carbonates in the Lazear subsoil will be limiting (*Fair*) to reclamation success. Topsoil salvage will be limited by the depth to Ferron sandstone.

Reclamation potential in this map unit ranges from fair to good depending on depth to sandstone.
**Bd  Disturbed Lands, 3 to 15 percent slopes**

**General**
Map unit Bd is characterized by soils which have been previously disturbed for construction of roads and drill locations. The specific date and origin of this disturbance could not be determined. This disturbance did not appear to be recent when field work was conducted in the fall of 2009. Shadscale and black greasewood had become well established in the area by the time the soil survey field work was conducted in 2009.

Disturbed soils are shallow to hard shale and sandstone with characteristics similar to Lazear soils. Minor inclusions of Begay family and Hideout soils are present in non-disturbed areas. Black greasewood and shadscale are the dominant vegetation on the disturbed soils. Big sagebrush and black greasewood characterize the Begay family soils, while the small areas of Hideout soils are dominated by pinyon pine and Utah juniper. Table 7 lists the taxonomic classification of the soil components in map unit Bd.

**Table 7. Taxonomic classification of soil components in map unit Bd.**

<table>
<thead>
<tr>
<th>Percent of</th>
<th>Soil Series or Map Unit</th>
<th>Family</th>
<th>Taxonomic Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>85</td>
<td>Previously disturbed</td>
<td></td>
<td>Lands</td>
</tr>
<tr>
<td>10</td>
<td>Begay family</td>
<td>Ustic</td>
<td>Haplocambids, coarse-loamy, mixed,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>superactive, mesic</td>
</tr>
<tr>
<td>5</td>
<td>Hideout</td>
<td>Lithic</td>
<td>Ustic Torriorthents, loamy, mixed,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>superactive, calcareous, mesic</td>
</tr>
</tbody>
</table>

**Typifying Soil Pedon Descriptions**
Soils colors are for dry soil unless specified otherwise.

The typifying soil pedon for disturbed soils in map unit Bd is EM-3-09. The surface is very pale brown channery loam to 18 cm (7 inches). The subsoil is pale brown channery sandy clay loam to 46 cm (18 inches). Hard shale is at 46 cm (18 inches).
Limiting Features
The shallow depth to hard shale and sandstone will be limiting to excavations in this map unit.

Topsoil salvage in this map unit will be limited by the previous soil disturbance.

Available water capacity is *Fair* (DOGM 2008) in these coarse textured soils.

Reclamation potential in this map unit is fair due to the previous disturbance.
Ca  Persayo family - Rock Outcrop - Hideout complex, 3 to 80 percent slopes

General
Map unit Ca is located in the narrow canyon that separates the soil survey area from south to northeast. Soils are shallow to either Mancos shale (Persayo family) or Ferron sandstone (Hideout). There is a significant amount of sandstone outcrop with large car to house sized boulders on the steep canyon sideslopes and bottom. Alluvium in the bottom of the canyon is coarse-loamy with Unacceptable saline and sodic conditions in localized areas. Shadscale and Gardner's saltbush dominate the Persayo family soils. Utah juniper and pinyon pine occur on Hideout soils. Black greasewood and shadscale are the dominant vegetation on the Garley and Monue Family soils. Table 8 lists the taxonomic classification of the soil components in map unit Ca.

Table 8. Taxonomic classification of soil components in map unit Ca.

<table>
<thead>
<tr>
<th>Percent of Soil Series or Map Unit</th>
<th>Family</th>
<th>Taxonomic Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 Persayo family</td>
<td>Typic Torriorthents, loamy, mixed, active, calcareous, mesic, shallow</td>
<td></td>
</tr>
<tr>
<td>20 Sandstone Outcrop</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 Hideout</td>
<td>Lithic Ustic Torriorthents, loamy, mixed, superactive, calcareous, mesic</td>
<td></td>
</tr>
<tr>
<td>8 Garley</td>
<td>Typic Torrifluvents, coarse-loamy, mixed, active, calcareous, mesic</td>
<td></td>
</tr>
<tr>
<td>7 Monue Family</td>
<td>Typic Haplocambids, coarse-loamy, mixed, superactive, calcareous, mesic</td>
<td></td>
</tr>
</tbody>
</table>

Typifying Soil Pedon Descriptions
Soils colors are for dry soil unless specified otherwise.

The typifying soil pedon for Persayo family soils in map unit Ca is EM-6-09. The surface is very pale brown channery loamy sand to 7 cm (3 inches). The subsoil is very pale brown channery sandy loam to 18 cm (7 inches). Decomposing shale with a few fine and very fine roots is from 18 to 34 cm (7 to 13 inches). Soft shale that restricts plant root development is at 34 cm (13
inches). Persayo family soils have less than 18 percent clay in the control section (Persayo soil series has 18 to 35 percent clay). These soils are on very steep slopes ranging from 45 to 80 percent.

The typifying soil pedon for Hideout soils in map unit Ca is EM-17-09. The surface is pale brown very channery loamy sand to 4 cm (2 inches). The subsoil is brown channery sandy loam to 19 cm (8 inches). These soils are on structural benches on the canyon sideslopes.

**Limiting Features**
Persayo family and Hideout soils in this map unit are limited by the shallow depth to shale and sandstone, respectively.

Available water capacity is *Fair to Poor* (DOGM 2008) in these coarse textured soils.

The large (car to house size) sandstone boulders will make topsoil salvage difficult in some areas.

The very steep canyon sideslopes will make topsoil salvage difficult.

Garley soils have *Poor to Unacceptable* (DOGM 2008) saline and sodic conditions.

Monue family soils have *Poor* (DOGM 2008) saline and sodic conditions in the bottom of the soil profile.

Reclamation potential in this map unit ranges from fair to poor depending on slope, depth, soil chemistry, and other localized conditions.
Cb  Monue Family — Garley complex, 3 to 12 percent slopes

General

Map unit Cb is characterized by very deep coarse-loamy soils in the upper portion of the canyon bottom. Minor inclusions of moderately deep Begay family soils occur on the footslopes of the adjacent canyon sideslopes. Black greasewood is the dominant vegetation on the Monue Family and Garley soils. Small clumps of Indian ricegrass occur on the Monue Family soils. Shadscale is found on the Garley soils. Utah juniper and pinyon pine grow on the Hideout soils. Table 9 lists the taxonomic classification of the soil components in map unit Cb.

Table 9. Taxonomic classification of soil components in map unit Cb.

<table>
<thead>
<tr>
<th>Percent of Soil Series or Map Unit Family</th>
<th>Taxonomic Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 Monue Family</td>
<td>Typic Haplocambids, coarse-loamy, mixed, superactive, mesic</td>
</tr>
<tr>
<td>30 Garley</td>
<td>Typic Torrifluvents, coarse-loamy, mixed, active, calcareous, mesic</td>
</tr>
<tr>
<td>10 Begay family</td>
<td>Ustic Haplocambids, coarse-loamy, mixed, superactive, mesic</td>
</tr>
</tbody>
</table>

Map unit Cb is the best source of topsoil and subsoil in the Emery 2 soil survey area. However, this map unit comprises less than 5 percent of the Emery 2 permit area.

Soil profiles in map unit Cb were evaluated from 43 to 67 inches. Monue family soils are a good to fair source of topsoil, but limited by Poor conductivity and SAR in the lower subsoil. Garley soils are limited by Poor salinity (conductivity) levels and Unacceptable sodium (SAR) levels. Unacceptable and Poor materials will need to be salvaged and stockpiled separately from the Good and Fair materials. This segregation of materials will require monitoring by a Certified Professional Soil Scientist. Additional laboratory analysis of soil samples may be required for site specific determination of material quality.
Typifying Soil Pedon Descriptions
Soils colors are for dry soil unless specified otherwise.

The typifying soil pedon for Monue Family soils in map unit Cb is EM-16-09. The surface is light yellowish brown gravelly sandy loam to 8 cm (3 inches). The subsurface is pale yellow sandy loam to 46 cm (18 inches). The upper subsoil is light yellowish brown sandy loam to 80 cm (32 inches). The lower subsoil is light yellowish brown sandy loam with *Fair to Poor* salinity and SAR levels (DOGM 2008) to 170 cm (67 inches).

The typifying soil pedon for Garley soils in map unit Cb is EM-8-09. The surface is pale brown loamy sand to 9 cm (3 inches). The lower surface is light yellowish brown loamy sand to 46 cm (18 inches). The upper subsoil is light yellowish brown sandy loam to 60 cm (24 inches). The lower subsoil consists of layers light yellowish brown very gravelly sandy loam and very bouldery sandy loam to 150 cm (59 inches), SAR levels are *Unacceptable* in all soil below 9 cm (3 inches). Salinity is *Poor* (DOGM 2008) in all 46 to 88 cm (18 to 35 inches).

Limiting Features
*Poor to Unacceptable* salinity and SAR levels (DOGM 2008) will be limiting to topsoil and subsoil salvage. Soil salinity and pH should be monitored during topsoil and subsoil salvage in order to minimize the amount of soils with *Poor* salinity and *Unacceptable* SAR that are salvaged. Soil samples should be collected from disturbance areas and analyzed for pH, salinity and SAR.

Available water capacity is *Fair to Poor* in these coarse textured soils (DOGM 2008).

Reclamation potential ranges from fair to good depending on the amount of non-saline and non-sodic topsoil that is salvaged.
D Braf sandy loam, 2 to 8 percent slopes

General
Map unit D is characterized by shallow coarse-loamy soils. Ferron sandstone outcrop inclusions occur on convex summits and shoulders. Minor inclusions of shallow Persayo family soils occur on hillslopes. Shadscale and black sage with Indian ricegrass are the dominant vegetation on Braf soils. Table 10 lists the taxonomic classification of the soil components in map unit D.

Table 10. Taxonomic classification of soil components in map unit D.

<table>
<thead>
<tr>
<th>Percent of</th>
<th>Soil Series or Map Unit Family</th>
<th>Taxonomic Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>85</td>
<td>Braf</td>
<td>Lithic Torriorthents, loamy, mixed, superactive, calcareous, mesic</td>
</tr>
<tr>
<td>10</td>
<td>Sandstone outcrop</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Persayo family</td>
<td>Typic Torriorthents, loamy, mixed, active, calcareous, mesic, shallow</td>
</tr>
</tbody>
</table>

Typifying Soil Pedon Descriptions
Soils colors are for dry soil unless specified otherwise.

The typifying soil pedon for Braf soils in map unit D is EM-10-09. The surface is pale brown loamy sand to 7 cm (3 inches). The upper subsoil is light yellowish brown sandy loam to 27 cm (11 inches). The lower subsoil is pale yellow flaggy sandy loam to 45 cm (18 inches). Ferron sandstone is at 45 cm (18 inches). Calcium carbonate levels are *Fair* in the subsoil (DOGM 2008).

Limiting Features
The shallow depth to Ferron sandstone will be limiting to excavations and topsoil salvage.

Calcium carbonate levels (DOGM 2008) are *Fair* in the subsoil.

Available water capacity is *Fair* (DOGM 2008).

Reclamation potential is fair based on the shallow depth to sandstone.
E   Rock Outcrop — Braf complex, 6 to 15 percent slopes

General
Map unit E is characterized by Ferron sandstone outcrops and shallow soils. The sandstone outcrops are on convex ridges and hillslopes. The shallow Braf soils are in swales on the hillslopes and on leeward hillslopes. Persayo family soils occur on the steeper shale outcrop areas. Shadscale, black sage, Indian ricegrass, and prickly pear are the dominate vegetation on the Braf soils. Widely scattered Utah juniper and pinyon pine are growing in the swales. Table 11 lists the taxonomic classification of the soil components in map unit E.

Table 11. Taxonomic classification of soil components in map unit E.

<table>
<thead>
<tr>
<th>Percent of Soil Series or Map Unit</th>
<th>Family</th>
<th>Taxonomic Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>Sandstone outcrop</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>Braf</td>
<td>Lithic Torriorthents, loamy, mixed, superactive, calcareous, mesic</td>
</tr>
<tr>
<td>5</td>
<td>Persayo family</td>
<td>Typic Torriorthents, loamy, mixed, active, calcareous, mesic, shallow</td>
</tr>
</tbody>
</table>

Typifying Soil Pedon Descriptions
Soils colors are for dry soil unless specified otherwise.

The typifying soil pedon for Braf soils in map unit E is EM-11-09. The surface is pale brown channery sandy loam to 3 cm (1 inch), The subsoil is pale brown sandy loam to 8 cm (3 inches). Ferron sandstone is at 8 cm (3 inches). The surface and subsoil horizons were sampled and analyzed together due to the limited thickness of each.

Limiting Features
Sandstone outcrops and shallow soils will be limiting to topsoil salvage.

Available water capacity is *Fair* (DOGM 2008).

Reclamation potential is fair to poor due to the very limited potential for topsoil salvage.
F Persayo very gravelly clay loam, 15 to 45 percent slopes

General
Map unit F is characterized by soils which are shallow to Mancos shale on steep to very steep slopes. There are minor inclusions of shallow coarse-loamy Braf soils over sandstone and sandstone outcrops. Shadscale is the dominant vegetation on the Persayo soils. Table 12 lists the taxonomic classification of the soil components in map unit F.

Table 12. Taxonomic classification of soil components in map unit F.

<table>
<thead>
<tr>
<th>Percent of</th>
<th>Soil Series or Map Unit Family</th>
</tr>
</thead>
<tbody>
<tr>
<td>85</td>
<td>Persayo Typic Torriorthents, loamy, mixed, active, calcareous, mesic, shallow</td>
</tr>
<tr>
<td>10</td>
<td>Braf Lithic Torriorthents, loamy, mixed, superactive, calcareous, mesic</td>
</tr>
<tr>
<td>5</td>
<td>Sandstone Outcrop</td>
</tr>
</tbody>
</table>

Typifying Soil Pedon Descriptions
Soils colors are for dry soil unless specified otherwise.

The typifying soil pedon for Persayo soils in map unit F is EM-13-09. The surface is light yellowish brown very gravelly clay loam to 10 cm (4 inches). The subsoil is light brownish gray silty clay loam to 40 cm (16 inches). Soft shale is at 40 cm (16 inches). Salinity levels are Poor and SAR levels are Unacceptable in the subsoil. Calcium carbonate levels are Fair to Poor (DOGM 2008).

Limiting Features
The shallow depth to shale and steep slopes will be limiting to topsoil salvage.

Poor salinity and Unacceptable SAR levels in the subsoil will limit topsoil salvage (DOGM 2008).

Reclamation potential will be limited by the shallow depths to shale and sandstone.
G  Garley loam, moderately well drained, 2 to 5 percent slopes

General
Map unit G is characterized by very deep coarse-loamy saline and sodic soils. This map unit occurs on the stream terrace along Quitchapah Creek. Minor inclusions of Green River soils with aquic soil conditions occur on the floodplain. Also included are small areas of shallow Braf soils on the footslopes adjacent to the stream terrace. Black greasewood is the dominant vegetation on the Garley soils. Grasses are very limited in this map unit. Table 13 lists the taxonomic classification of the soil components in map unit G.

This map unit does not occur within the Emery 2 Mine Permit area.

Table 13. Taxonomic classification of soil components in map unit G.

<table>
<thead>
<tr>
<th>Percent of</th>
<th>Soil Series or Map Unit Family</th>
<th>Taxonomic Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>85</td>
<td>Garley, moderately well drained</td>
<td>Typic Torrifluvents, coarse-loamy, mixed, active, calcareous, mesic</td>
</tr>
<tr>
<td>10</td>
<td>Green River</td>
<td>Oxyaquic Torrifluvents, coarse-loamy, mixed, calcareous, superactive, mesic</td>
</tr>
<tr>
<td>5</td>
<td>Braf</td>
<td>Lithic Torriorthents, loamy, mixed, superactive, calcareous, mesic</td>
</tr>
</tbody>
</table>

Typifying Soil Pedon Descriptions
Soils colors are for dry soil unless specified otherwise.

The typifying soil pedon for Garley, moderately well drained, soils in map unit G is EM-12-09. The surface is light gray loam to 15 cm (3 inches). The upper subsoil is light yellowish brown sandy loam and loam to 72 cm (28 inches). A buried surface of light yellowish brown sandy loam is from 72 to 102 cm. The lower subsoil is light yellowish brown sandy loam to 164 cm (65 inches). SAR levels are Unacceptable. Salinity levels are Fair in the surface and Poor below 15 cm (3 inches). Calcium carbonate and available water capacity range from Good to Fair in the soil profile. Soil pH is Fair below the surface horizon (DOGM 2008).
Limiting Features
The *Unacceptable* SAR levels will limit the amount of topsoil that can be salvaged (DOGM 2008). The topsoil salvaged from Garley soils should be stockpiled separately from the better quality topsoil salvaged from other map units.

Reclamation potential is poor due to the *Poor* salinity and *Unacceptable* SAR levels.
Green River sandy clay loam, 1 to 3 percent slopes

General
Map unit H soils are coarse-loamy and very deep (greater than 150 cm or 60 inches) on the floodplain along Quitchapah Creek (perennial stream). These soils are subject to flooding and high groundwater during periods of high stream flows in Quitchapah Creek. Minor inclusions of Garley soils occur on the stream terraces. Tamarisk is the dominant vegetation on Green River soils with small clumps of coyote willow along the stream channel. Black greasewood dominates the Garley soils. Table 14 lists the taxonomic classification of the soil components in map unit H.

This map unit is of very limited extent within the Emery 2 permit area. It occurs at the confluence of the canyon drainage and Quitchapah Creek in the permit area.

<table>
<thead>
<tr>
<th>Percent of</th>
<th>Soil Series or Family</th>
<th>Taxonomic Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Map Unit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>Green River</td>
<td>Oxyaquic Torrifluvents, coarse-loamy, mixed, calcareous, superactive, mesic</td>
</tr>
<tr>
<td>10</td>
<td>Garley, moderately well drained</td>
<td>Typic Torrifluvents, coarse-loamy, mixed, active, calcareous, mesic</td>
</tr>
</tbody>
</table>

Typifying Soil Pedon Descriptions
Soils colors are for dry soil unless specified otherwise.

The typifying soil pedon for Green River soils in map unit H is EM-7-09. The surface is light yellowish brown sandy clay loam to 15 cm (6 inches). A buried surface is pale yellow silty loam and barns to 28 cm (11 inches). The underlying subsoil is light gray loam and silt loam to 56 cm (22 inches). The lower subsoil is light yellowish brown sandy loam and loam to 130 cm (51 inches). The lower subsoil is light gray sandy loam to 150 cm. Fine, medium and coarse soil mottles were observed between 28 and 56 cm (11 and 22 inches). The surface 15 cm (6 inches) appeared to have been deposited when the area was flooded on September 16, 2009. The stream channel was incised ten to fifteen feet within this soil map unit at the location of the representative pedon for Green River soils.
Limiting Features
Calcium carbonate levels are *Fair* (DOGM 2008) from 15 to 102 cm (6 to 40 inches).

Flooding could be limiting to reclamation, if the stream flows are too high.

This soil map unit is a good source of topsoil for reclamation.

Map Unit Areas
The cumulative surface area for each soil map unit was calculated with ARC-Map software on the horizontal plane. Cumulative surface areas are listed for each soil map unit in Table 15.

Table 15. Cumulative surface area for soil map units in the Emery 2 soil survey area.

<table>
<thead>
<tr>
<th>Soil Map Units</th>
<th>A</th>
<th>Ba</th>
<th>Bd</th>
<th>Ca</th>
<th>Cb</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acres</td>
<td>13.8</td>
<td>20.3</td>
<td>8.4</td>
<td>18.3</td>
<td>3.2</td>
<td>64.5</td>
<td>37.4</td>
<td>5.4</td>
<td>12.0</td>
<td>6.4</td>
<td>189.7</td>
</tr>
<tr>
<td>Percent</td>
<td>7.3</td>
<td>10.7</td>
<td>4.4</td>
<td>9.6</td>
<td>1.7</td>
<td>34.0</td>
<td>19.7</td>
<td>2.9</td>
<td>6.3</td>
<td>3.4</td>
<td></td>
</tr>
</tbody>
</table>
Major Soil Types

Representative soil profiles for each of the major soil types are described in this section. Major soil types are those which comprise at least 15 percent of a soil map unit. Field description sheets are in Appendix B. Laboratory analysis data for these profiles are in Appendix C.

Soil horizon depths were measured in centimeters in the field. Depths in inches have been rounded to the nearest inch.

Major soil types were correlated to established soil series (USDA 2016a). Soils that did meet specific soil series criteria were correlated to soil families with the name of a locally used soil series in the same family (USDA 2016a and 2016b).

Begay family

Begay family soils are moderately deep (50 to 100 cm, 20 to 40 inches) to Ferron sandstone. They have developed in stabilized eolian deposits on the plateau southeast of the canyon.

Soil profile EM-1-09 is representative of Begay family soil in the Emery 2 soil survey area. Dominant vegetation on the Begay family soils is big sage, black greasewood, and shadscale.

Ustic Haplocambids, coarse-loamy, mixed, superactive, mesic

A --- 0 to 8 cm (0 to 3 inches); pale yellow (2.5Y 7/3) dry, sandy loam; light yellowish brown (2.5Y 6/4) moist; 63 percent sand; 20 percent silt; 17 percent clay; weak medium platy parting to moderate fine granular structure; very friable, slightly hard, slightly sticky, slightly plastic; common very fine roots throughout and common fine roots throughout; common very fine tubular pores; 2 percent (common) fine irregular moderately cemented carbonate concretions on bottom of rock fragments; 3 percent subangular calcareous sandstone gravels; electrical conductivity of 2.25 dS/m by EC meter, saturated paste; violently effervescent by HCl, 1 normal; neutral, pH 7.3; clear smooth boundary; CaCO3 9.1 percent.

Bw1 --- 8 to 23 cm (3 to 9 inches); light yellowish brown (2.5Y 6/4) dry, sandy loam; light olive brown (2.5Y 5/4) moist; 57 percent sand; 29 percent silt; 14 percent clay; structure; very friable, slightly hard, slightly sticky, slightly plastic; many very fine roots throughout, common fine roots throughout and common medium roots throughout; common very fine tubular pores; 2 percent (common) fine irregular moderately cemented carbonate concretions on bottom of rock fragments; 5 percent calcareous sandstone gravels; electrical conductivity of 2.32 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.4; clear smooth boundary; CaCO3 7.2 percent.
Major Soil Types

**Bw2** --- 23 to 50 cm (9 to 20 inches); light yellowish brown (10YR 6/4) dry, sandy loam; yellowish brown (10YR 5/4) moist; 73 percent sand; 14 percent silt; 13 percent clay; moderate medium subangular blocky structure; very friable, slightly hard, nonsticky, nonplastic; many very fine roots throughout, common fine roots throughout, common medium roots throughout and common coarse roots throughout; common very fine tubular pores; 3 percent (common) fine masses of carbonate on vertical faces of peds and 4 percent (common) fine irregular carbonate concretions around rock fragments; 8 percent subangular calcareous sandstone gravels; electrical conductivity of 3.94 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.7; clear smooth boundary; CaCO3 7.2 percent.

**Bk** --- 50 to 80 cm (20 to 32 inches); very pale brown (10YR 7/4) dry, channery sandy loam; yellowish brown (10YR 5/4) moist; 65 percent sand; 23 percent silt; 12 percent clay; weak medium subangular blocky structure; friable, slightly hard, slightly sticky, slightly plastic; common very fine roots throughout, common fine roots throughout, common medium roots throughout and common coarse roots throughout; common very fine tubular pores; 2 percent (common) fine masses of carbonate on vertical faces of peds and 7 percent (common) medium carbonate concretions around rock fragments; 6 percent subangular calcareous sandstone gravels and 12 percent subangular calcareous sandstone channers; electrical conductivity of 3.07 dS/m by EC meter, saturated paste; violently effervescent by HCl, 1 normal; slightly alkaline, pH 7.6; abrupt smooth boundary; CaCO3 7.8 percent.

**R** --- 80 cm (32 inches); Ferron sandstone.
Major Soil Types

Braf

Braf soils are shallow, less than 50 cm (20 inches) to sandstone bedrock. In some areas, especially map unit F, Braf soils are less than 25 cm (10 inches) deep. These soils are well drained. Braf soils have a typic aridic moisture regime and are drier than Hideout and Lazear soils which have aridic moisture regimes bordering on ustic. Braf soils have 5 to 18 percent clay in the control section. These soils are in Wind Erodibility Groups 2 and 3. Braf soils were delineated as the dominant soil (map unit 015) on the bench west of the canyon by the NRCS in the Emery Area soil survey (USDA 2016b).

Soil profile EM-10-09 is representative of Braf soils in the Emery 2 soil survey area. Shadscale, black sage, Indian ricegrass, and prickly pear cactus are the dominant vegetation on Braf soils.

Lithic Torriorthents, loamy, mixed superactive, calcareous, mesic

A --- 0 to 7 cm (0 to 3 inches); pale yellow (2.5Y 7/3) dry, loamy sand; light yellowish brown (2.5Y 6/3) moist; 84 percent sand; 8 percent silt; 8 percent clay; weak medium platy parting to single grain structure; very friable, slightly hard, nonsticky, nonplastic; many very fine roots throughout, common fine roots throughout and common medium roots throughout; common very fine tubular pores; 10 percent subangular calcareous sandstone gravels; electrical conductivity of 0.64 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; moderately alkaline, pH 7.9; clear smooth boundary; CaCO3 13.5 percent.

C1 --- 7 to 27 cm (3 to 11 inches); light yellowish brown (2.5Y 6/4) dry, sandy loam; light olive brown (2.5Y 5/3) moist; 70 percent sand; 20 percent silt; 10 percent clay; structure; very friable, moderately hard, nonsticky, nonplastic; common very fine roots throughout, common fine roots throughout and common medium roots throughout; common very fine tubular pores; 2 percent fine calcium carbonate coats on bottom of rock fragments; 10 percent subangular calcareous sandstone gravels; electrical conductivity of 0.50 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.8; clear smooth boundary; CaCO3 22.2 percent.

C2 --- 27 to 45 cm (11 to 18 inches); pale yellow (2.5Y 7/4) dry, flaggy sandy loam; light yellowish brown (2.5Y 6/4) moist; 76 percent sand; 16 percent silt; 8 percent clay; single grain; loose, loose, nonsticky, nonplastic; common very fine roots throughout and common fine roots throughout; common very fine tubular pores; 2 percent fine calcium carbonate coats on bottom of rock fragments; 20 percent subangular calcareous sandstone flags and 10 percent subangular calcareous sandstone channers; electrical conductivity of 1.97 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.6; abrupt smooth boundary; CaCO3 18.7 percent.

R --- 45 cm (18 inches); Ferron sandstone.
Disturbed Soils

The soil surfaces in map unit Bd were previously disturbed for the construction of drill holes and access roads. The area appeared to have been similar to map unit Ba prior to the disturbance. The specific date and origin of this disturbance could not be determined. This disturbance did not appear to be recent when field work was done in the fall of 2009. Shadscale and black greasewood had become well established in the area by the time the soil survey field work was conducted in 2009.

The dominant soil in the disturbed areas is shallow to sandstone or hard shale. These soils are similar to Lazear with the native A horizon removed or disturbed.

Soil profile EM-3-09 is representative of the disturbed soils in map unit Bd. Black greasewood and shadscale have partially re-vegetated these areas.

*Loamy, mixed, superactive, calcareous, mesic Lithic Ustic Torriorthents*

**A** --- 0 to 18 cm (0 to 7 inches); very pale brown (10YR 7/3) dry, channery loam; pale brown (10YR 6/3) moist; 47 percent sand; 33 percent silt; 20 percent clay; structure; friable, hard, slightly sticky, slightly plastic; common very fine roots throughout; common very fine tubular pores; 2 percent (common) fine irregular moderately cemented carbonate concretions around rock fragments; 15 percent subangular calcareous sandstone channers; electrical conductivity of 1.40 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.5; clear smooth boundary; CaCO3 13.9 percent.

**C** --- 18 to 46 cm (7 to 18 inches); pale brown (10YR 6/3) dry, channery sandy clay loam; brown (10YR 5/3) moist; 53 percent sand; 25 percent silt; 22 percent clay; medium structure; friable, hard, nonsticky, slightly plastic; common fine roots throughout and common very fine roots throughout; common very fine tubular pores; 2 percent (common) medium irregular moderately cemented carbonate concretions around rock fragments; 5 percent subangular calcareous sandstone flags and 15 percent subangular 2 calcareous sandstone channers; electrical conductivity of 4.39 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.4; abrupt smooth boundary; CaCO3 13.4 percent.

**R** --- 46 cm (18 inches); hard shale.
Garley

Garley soils are very deep, greater than 150 cm (60 inches) and are in the bottom of the canyon that crosses the Emery 2 soil survey from south to northeast. They are coarse-textured and are saline and have Unacceptable SAR levels (Utah DOGM 2008).

Soil profile EM-8-09 is representative of Garley soils in the Emery 2 soil survey area. Black greasewood, shadscale, and scattered clumps of Indian ricegrass are the dominant vegetation.

Typic Torrifluvents, coarse-loamy, mixed, active, calcareous, mesic

A --- 0 to 9 cm (0 to 4 inches); pale yellow (2.5Y 7/3) dry, loamy sand; light yellowish brown (2.5Y 6/3) moist; 79 percent sand; 13 percent silt; 8 percent clay; moderate medium platy structure; friable, hard, slightly sticky, slightly plastic; many very fine roots throughout, few fine roots throughout; common very fine tubular pores; electrical conductivity of 2.25 dS/m by EC meter, saturated paste; slightly effervescent by HCl, 1 normal; strongly alkaline, pH 8.7; clear smooth boundary; CaCO₃ 8.8 percent.

C1--- 9 to 32 cm (4 to 13 inches); pale yellow (10YR 7/4) dry, loamy sand; light yellowish brown (10YR 6/4) moist; 85 percent sand; 10 percent silt; 5 percent clay; moderate medium subangular blocky structure; friable, hard, nonsticky, nonplastic; common very fine roots throughout, few fine roots throughout, and few medium roots throughout; common very fine tubular pores; electrical conductivity of 3.82 dS/m by EC meter, saturated paste; slightly effervescent by HCl, 1 normal; very strongly alkaline, pH 9.3; abrupt smooth boundary; CaCO₃ 8.9 percent.

C2 --- 32 to 46 cm (13 to 18 inches); pale yellow (10YR 7/4) dry, very gravelly loamy sand; light yellowish brown (10YR 6/4) moist; 85 percent sand; 9 percent silt; 6 percent clay; single grain; loose, loose, nonsticky, nonplastic; common very fine roots throughout; many very fine interstitial pores; 40 percent fine calcareous sandstone gravels; 2 percent thin calcium carbonate coatings on bottom of rock fragments; electrical conductivity of 3.91 dS/m by EC meter, saturated paste; very slightly effervescent by HCl, 1 normal; strongly alkaline, pH 8.8; abrupt wavy boundary; CaCO₃ 8.9 percent.

Ab1 --- 46 to 60 cm (18 to 24 inches); pale yellow (10YR 7/4) dry, loamy sand; light yellowish brown (10YR 6/4) moist; 85 percent sand; 9 percent silt; 6 percent clay; moderate medium subangular blocky structure; friable, very hard, nonsticky, nonplastic; common very fine roots throughout; common very fine tubular pores; electrical conductivity of 8.29 dS/m by EC meter, saturated paste; slightly effervescent by HCl, 1 normal; very strongly alkaline, pH 9.3; clear smooth boundary; CaCO₃ 5.3 percent.

C3 --- 60 to 70 cm (24 to 28 inches); light yellowish brown (10YR 6/4) dry, very gravelly loam; light olive brown (10YR 5/4) moist; 50 percent sand; 40 percent silt; 10 percent clay; single grain; loose, loose, nonsticky, nonplastic; common very fine roots throughout.
common fine roots throughout, few medium roots throughout and few coarse roots throughout; many very fine interstitial pores; 40 percent fine calcareous sandstone gravels; 2 percent thin calcium carbonate coatings on bottom of rock fragments; electrical conductivity of 9.77 dS/m by EC meter, saturated paste; very slightly effervescent by HCl, 1 normal; strongly alkaline, pH 8.6; abrupt wavy boundary; CaCO₃ 8.4 percent.

C4 --- 70 to 88 cm (28 to 35 inches); pale yellow (10YR 7/4) dry, sandy loam; light yellowish brown (10YR 6/4) moist; 79 percent sand; 10 percent silt; 11 percent clay; massive; very friable, slightly hard, nonsticky, nonplastic; common very fine roots throughout, and few fine roots throughout; common very fine tubular pores; 2 percent fine masses of carbonate on faces of peds; electrical conductivity of 9.38 dS/m by EC meter, saturated paste; slightly effervescent by HCl, 1 normal; moderately alkaline, pH 7.9; abrupt wavy boundary; CaCO₃ 6.3 percent.

AB2 --- 88 to 98 cm (35 to 66 inches); light yellowish brown (10YR 6/4) dry, very gravelly loam; light olive brown (10YR 5/4) moist; 80 percent sand; 8 percent silt; 12 percent clay; single grain; loose, loose, nonsticky, nonplastic; common very fine roots throughout; many very fine interstitial pores; 50 percent calcareous sandstone boulders; electrical conductivity of 4.35 dS/m by EC meter, saturated paste; slightly effervescent by HCl, 1 normal; slightly alkaline, pH 7.4; abrupt wavy boundary; CaCO₃ 5.5 percent.

C5 --- 98 to 108 cm (35 to 43 inches); light yellowish brown (10YR 6/4) dry, very bouldery sandy loam; light olive brown (10YR 5/4) moist; 77 percent sand; 14 percent silt; 9 percent clay; very friable, slightly hard, nonsticky, nonplastic; common very fine roots throughout; few very fine tubular pores; 50 percent calcareous sandstone boulders; electrical conductivity of 5.54 dS/m by EC meter, saturated paste; slightly effervescent by HCl, 1 normal; slightly alkaline pH 7.7; abrupt smooth boundary; CaCO₃ 6.8 percent.

C6 --- 108 to 120 cm (43 to 47 inches); light yellowish brown (10YR 6/3) dry, extremely bouldery sandy loam; light olive brown (10YR 5/4) moist; 75 percent sand; 13 percent silt; 12 percent clay; very friable, slightly hard, slightly sticky, slightly plastic; many very fine and common fine roots throughout; few very fine tubular pores; 70 percent calcareous sandstone boulders; electrical conductivity of 5.59 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline pH 7.5; clear smooth boundary; CaCO₃ 3.2 percent.

C7 --- 120 to 150 cm (59 inches); light yellowish brown (10YR 6/3) dry, extremely bouldery sandy loam; olive brown (10YR 4/4) moist; 77 percent sand; 11 percent silt; 12 percent clay; very friable, slightly hard, slightly sticky, slightly plastic; common very fine roots throughout; few very fine tubular pores; 70 percent calcareous sandstone boulders; electrical conductivity of 6.17 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline pH 7.5; clear smooth boundary; CaCO₃ 6.0 percent.
Garley, moderately well drained phase

Garley, moderately well drained, soils in map unit G are on low stream terraces along Quitchapah Creek. These soils have the same unacceptable SAR levels discussed previously in the Garley soils section.

Soil profile EM-12-09 is representative of Garley, moderately well drained soils in the Emery 2 soil survey area. Black greasewood is the dominant vegetation on Garley, moderately well drained soils. Black greasewood is the dominant vegetation.

Typic Torrifluvents, coarse-loamy, mixed, active, mesic

A --- 0 to 15 cm (0 to 6 inches); light gray (2.5Y 7/2) dry, loam; light olive brown (2.5Y 5/3) moist; 48 percent sand; 38 percent silt; 14 percent clay; moderate coarse platy structure; friable, very hard, slightly sticky, nonplastic; common very fine roots throughout; common very fine tubular pores; electrical conductivity of 6.54 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; moderately alkaline, pH 8.1; clear smooth boundary; CaCO3 17.5 percent.

C1 --- 15 to 35 cm (6 to 14 inches); light yellowish brown (2.5Y 6/3) dry, sandy loam; light olive brown (2.5Y 5/3) moist; 54 percent sand; 30 percent silt; 16 percent clay; moderate medium subangular blocky structure; friable, very hard, nonsticky, nonplastic; common very fine roots throughout, common fine roots throughout and common medium roots throughout; common very fine tubular pores; electrical conductivity of 8.97 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; moderately alkaline, pH 8.1; unable to dig with shovel; clear smooth boundary; CaCO3 18.7 percent.

C2 --- 35 to 46 cm (14 to 18 inches); light yellowish brown (2.5Y 6/3) dry, sandy loam; light olive brown (2.5Y 5/3) moist; 64 percent sand; 25 percent silt; 11 percent clay; weak fine and medium subangular blocky structure; friable, hard, nonsticky, nonplastic; common very fine roots throughout, common fine roots throughout and common medium roots throughout; common very fine tubular pores; electrical conductivity of 8.60 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; moderately alkaline, pH 8.2; gradual smooth boundary; CaCO3 14.3 percent.

C3 --- 46 to 72 cm (18 to 28 inches); light yellowish brown (2.5Y 6/3) dry, loam; light olive brown (2.5Y 5/3) moist; 46 percent sand; 38 percent silt; 16 percent clay; weak medium subangular blocky structure; friable, hard, nonsticky, nonplastic; common very fine roots throughout, common fine roots throughout and common medium roots throughout; common very fine tubular pores; 5 percent (common) fine masses of carbonate on vertical faces of peds; electrical conductivity of 8.88 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; moderately alkaline, pH 8.3; gradual smooth boundary; CaCO3 16.1 percent.
Major Soil Types

**Ab** --- 72 to 102 cm (28 to 40 inches); light yellowish brown (2.5Y 6/3) dry, sandy loam; grayish brown (2.5Y 5/2) moist; 54 percent sand; 34 percent silt; 12 percent clay; weak medium subangular blocky structure; very friable, slightly hard, nonsticky, nonplastic; common very fine roots throughout, common fine roots throughout and common medium roots throughout; common very fine tubular pores; 2 percent (common) fine masses of carbonate on vertical faces of peds; electrical conductivity of 12.1 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; moderately alkaline, pH 8.4; clear smooth boundary; CaCO₃ 14.6 percent.

**C4** --- 102 to 130 cm (40 to 52 inches); light yellowish brown (2.5Y 6/3) dry, sandy loam; grayish brown (2.5Y 5/2) moist; 54 percent sand; 34 percent silt; 12 percent clay; weak medium subangular blocky structure; very friable, hard, nonsticky, nonplastic; common very fine roots throughout; common very fine tubular pores; 1 percent (few) fine masses of carbonate on vertical faces of peds; electrical conductivity of 5.55 dS/m by EC meter, saturated paste; electrical conductivity of 12.6 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; moderately alkaline, pH 8.4; clear smooth boundary; CaCO₃ 15.2 percent.

**C5** --- 130 to 164 cm (52 to 65 inches); light yellowish brown (2.5Y 6/3) dry, sandy loam; grayish brown (2.5Y 5/2) moist; 54 percent sand; 30 percent silt; 16 percent clay; 2 percent fine prominent brownish yellow (10YR 6/6) mottles; moderate medium subangular blocky structure; friable, very hard, nonsticky, nonplastic; common very fine roots throughout; common very fine tubular pores; 2 percent (common) fine prominent spherical very weakly cemented masses of oxidized iron clear in matrix; 1 percent (few) fine masses of carbonate on vertical faces of peds; electrical conductivity of 9.64 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; moderately alkaline, pH 8.3; CaCO₃ 14.8 percent.
**Major Soil Types**

**Green River**

Green River soils are very deep and are located in the floodplain along Quitchapah Creek. These soils are susceptible to flooding and a water table may be present in locations near the stream.

Soil profile EM-7-09 is representative of Green River soils in the Emery 2 soil survey area. Tamarisk is the dominant vegetation with coyote willows along streambanks.

*Oxyaquic Torrifluvents, coarse-loamy, mixed, superactive, calcareous, mesic*

**A** --- 0 to 15 cm (0 to 6 inches); light yellowish brown (2.5Y 6/3) dry, sandy clay loam; light olive brown (2.5Y 5/3) moist; 57 percent sand; 15 percent silt; 28 percent clay; medium platy structure; very friable, slightly hard, nonsticky, nonplastic; electrical conductivity of 2.43 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.5; abrupt smooth boundary; CaCO₃ 14.4 percent.

**2A** --- 15 to 28 cm (6 to 11 inches); pale yellow (2.5Y 7/3) dry, silt loam; grayish brown (2.5Y 5/2) moist; 37 percent sand; 52 percent silt; 11 percent clay; moderate medium subangular blocky structure; very friable, hard, nonsticky, nonplastic; common very fine roots throughout and common fine roots throughout; common very fine tubular pores; electrical conductivity of 1.55 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.6; clear smooth boundary; CaCO₃ 18.3 percent.

**2C** --- 28 to 43 cm (11 to 17 inches); light gray (2.5Y 7/2) dry, loam; light yellowish brown (2.5Y 6/3) moist; 43 percent sand; 48 percent silt; 9 percent clay; 2 percent medium distinct olive yellow (2.5Y 6/6) and 2 percent fine distinct olive yellow (2.5Y 6/6) mottles; moderate medium subangular blocky structure; very friable, hard, slightly sticky, nonplastic; many very fine roots throughout and common fine roots throughout; common very fine tubular pores; electrical conductivity of 1.36 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.7; clear smooth boundary; CaCO₃ 15.9 percent.

**3A** --- 43 to 56 cm (17 to 22 inches); light gray (2.5Y 7/2) dry, silt loam; light olive brown (2.5Y 5/3) moist; 23 percent sand; 56 percent silt; 21 percent clay; 6 percent coarse prominent strong brown (7.5YR 5/8) and 6 percent medium prominent strong brown (7.5YR 5/8) mottles; strong coarse platy structure; very friable, hard, slightly sticky, slightly plastic; common very fine roots throughout and common fine roots throughout; common very fine tubular pores; electrical conductivity of 3.46 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.5; abrupt smooth boundary; CaCO₃ 19.2 percent.
Major Soil Types

3C1 --- 56 to 78 cm (22 to 31 inches); light yellowish brown (2.5Y 6/3) dry, sandy loam; light olive brown (2.5Y 5/3) moist; 61 percent sand; 26 percent silt; 13 percent clay; single grain; loose, loose, nonsticky, nonplastic; many very fine interstitial pores; electrical conductivity of 3.67 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.6; clear smooth boundary; CaCO3 15.2 percent.

3C2 --- 78 to 102 cm (31 to 40 inches); light yellowish brown (2.5Y 6/3) dry, loam; dark grayish brown (2.5Y 4/2) moist; 46 percent sand; 37 percent silt; 17 percent clay; massive parting to single grain; very friable, slightly hard, slightly sticky, slightly plastic; many very fine interstitial pores; electrical conductivity of 3.93 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.5; gradual smooth boundary; CaCO3 16.5 percent.

3C3 --- 102 to 130 cm (40 to 51 inches); light yellowish brown (2.5Y 6/3) dry, sandy loam; light olive brown (2.5Y 5/3) moist; 58 percent sand; 33 percent silt; 9 percent clay; single grain and medium structure; very friable, slightly hard, slightly sticky, slightly plastic; many very fine interstitial pores; electrical conductivity of 2.21 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.6; clear smooth boundary; CaCO3 14.5 percent.

3C4 --- 130 to 150 cm (51 to 59 inches); light gray (2.5Y 7/2) dry, sandy loam; light yellowish brown (2.5Y 6/3) moist; 69 percent sand; 25 percent silt; 6 percent clay; single grain; loose, loose, nonsticky, nonplastic; many very fine interstitial pores; electrical conductivity of 1.6 dS/m by EC meter, saturated paste; slightly effervescent by HCl, 1 normal; slightly alkaline, pH 7.7; CaCO3 14.3 percent.
Major Soil Types

Hideout

Hideout soils are shallow and located on the plateau southeast of the canyon and on structural benches in the canyon. These soils have 5 to 18 percent clay in the control section while Lazear soils have 18 to 27 percent clay. Hideout soils have an aridic moisture regime that borders on ustic. Hideout soils are similar to Braf soils, but Braf soils are typic aridic (drier).

Soil profile EM-4-09 is representative of Hideout soils in the Emery 2 soil survey area. Utah juniper, pinyon pine, Birchleaf mahogany, Utah serviceberry, Wyoming big sage, black sage, broom snakeweed, and prickly pear cactus are the dominant vegetation.

Lithic Ustic Torriorthents, loamy, mixed, superactive, calcareous, mesic

A --- 0 to 6 cm (0 to 2 inches); very pale brown (10YR 7/3) dry, loamy sand; pale brown (10YR 6/3) moist; 79 percent sand; 14 percent silt; 7 percent clay; weak medium platy parting to single grain structure; very friable, slightly hard, nonsticky, nonplastic; common very fine roots throughout and common fine roots throughout; many very fine interstitial pores; electrical conductivity of 0.69 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.7; abrupt smooth boundary; CaCO3 6.1 percent.

C --- 6 to 20 cm (2 to 8 inches); pale brown (10YR 6/3) dry, sandy loam; brown (10YR 5/3) moist; 69 percent sand; 21 percent silt; 10 percent clay; weak medium subangular blocky structure; very friable, hard, nonsticky, nonplastic; many very fine roots throughout, common fine roots throughout and common medium roots throughout; common very fine tubular pores; electrical conductivity of 0.95 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.5; abrupt smooth boundary; CaCO3 6.4 percent.

R --- 20 cm (8 inches); Ferron sandstone.
Major Soil Types

Lazear

Lazear soils are shallow and located on the plateau southeast of the canyon. These soils are similar to Hideout soils, but Lazear soils have 18 to 27 percent clay in the control section while Hideout soils have 5 to 18 percent clay.

Soil profile EM-5-09 is representative of Lazear soils in the Emery 2 soil survey area. Shadscale, black sage, broom snakeweed, and bluegrass are the dominant vegetation.

Lithic Ustic Torriorthents, loamy, mixed, superactive, calcareous, mesic

A --- 0 to 7 cm (0 to 3 inches); pale brown (10YR 6/3) dry, channery sandy loam; brown (10YR 5/3) moist; 65 percent sand; 22 percent silt; 13 percent clay; moderate medium platy structure; very friable, slightly hard, slightly sticky, slightly plastic; common very fine roots throughout; common fine roots throughout and common medium roots throughout; common very fine tubular pores; 10 percent subangular calcareous sandstone channers and 10 percent subangular calcareous sandstone gravels; electrical conductivity of 0.65 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.8; clear smooth boundary; CaCO3 22.5 percent.

C --- 7 to 20 cm (23 to 8 inches); light yellowish brown (10YR 6/4) dry, channery sandy clay loam; pale brown (10YR 6/3) moist; 63 percent sand; 16 percent silt; 21 percent clay; weak medium subangular blocky structure; friable, slightly hard, slightly sticky, slightly plastic; many very fine roots throughout, common fine roots throughout and common medium roots throughout; common very fine tubular pores; 10 percent subangular calcareous sandstone gravels and 15 percent subangular calcareous sandstone channers; electrical conductivity of 0.57 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.6; abrupt smooth boundary; CaCO3 25.4 percent.

R --- 20 cm (8 inches); Ferron sandstone.
Major Soil Types

Monue Family

Monue family soils are very deep and are located on alluvial fans in the upper third of the canyon. These soils are on the same landforms in the canyon as Garley soils. Monue family soils generally have slightly more grass cover than Garley soils. These soils have *Fair* conductivity and SAR levels below 80 cm (31 inches) and poor levels below 122 cm (48 inches). Monue family soils are a good source of topsoil and subsoil within the Emery 2 permit area.

Soil profile EM-16-09 is representative of Monue family soils in the Emery 2 soil survey area. Black greasewood and Indian rice grass are the dominant vegetation.

*Typic Haplocambids, coarse-loamy, mixed, superactive, mesic*

A1 --- 0 to 8 cm (0 to 3 inches); light yellowish brown (2.5Y 6/3) dry, sandy loam gravel; light olive brown (2.5Y 5/3) moist; 64 percent sand; 28 percent silt; 8 percent clay; weak medium subangular blocky parting to single grain structure; very friable, slightly hard, nonsticky, nonplastic; common very fine roots throughout and common fine roots throughout; many very fine interstitial pores; 1 percent subangular calcareous sandstone gravels; electrical conductivity of 1.01 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.7; clear smooth boundary; CaCO3 13.4 percent.

Bw1 --- 8 to 21 cm (3 to 8 inches); pale yellow (2.5Y 7/3) dry, sandy loam; light olive brown (2.5Y 5/3) moist; 68 percent sand; 24 percent silt; 8 percent clay; structure; very friable, hard, nonsticky, nonplastic; common very fine roots throughout and common fine roots throughout; many very fine interstitial pores; electrical conductivity of 0.43 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.6; clear smooth boundary; CaCO3 (Exists in NASIS Horizon) 11.4 percent.

Bw2 --- 21 to 46 cm (8 to 18 inches); pale yellow (2.5Y 7/3) dry, sandy loam; light olive brown (2.5Y 5/3) moist; 58 percent sand; 33 percent silt; 9 percent clay; moderate medium subangular blocky structure; very friable, slightly hard, nonsticky, nonplastic; common very fine roots throughout and common fine roots throughout; many very fine interstitial pores; electrical conductivity of 0.43 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.5; clear smooth boundary; CaCO3 11.6 percent.

C2 --- 46 to 80 cm (18 to 31 inches); light yellowish brown (2.5Y 6/4) dry, sandy loam; light olive brown (2.5Y 5/3) moist; 60 percent sand; 28 percent silt; 12 percent clay; single grain; very friable, slightly hard, nonsticky, nonplastic; common very fine roots throughout; many very fine interstitial pores; 1 percent (few) carbonate concretions on bottom of rock fragments; 2 percent subangular calcareous sandstone gravels; electrical conductivity of 0.45 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.5; gradual smooth boundary; CaCO3 13 percent.
**Major Soil Types**

**C3 ---** 80 to 122 cm (31 to 48 inches); light yellowish brown (2.5Y 6/4) dry, sandy loam; light olive brown (2.5Y 5/3) moist; 70 percent sand; 22 percent silt; 8 percent clay; single grain; very friable, slightly hard, nonsticky, nonplastic; common very fine roots throughout; many very coarse interstitial pores; electrical conductivity of 5.89 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.7; gradual smooth boundary; CaCO3 12.9 percent.

**2C ---** 122 to 170 cm (48 to 67 inches); light yellowish brown (10YR 6/4) dry, sandy loam; yellowish brown (10YR 5/4) moist; 68 percent sand; 24 percent silt; 8 percent clay; single grain; very friable, slightly hard, nonsticky, nonplastic; common very fine roots throughout; many very fine interstitial pores; 1 percent (few) salt masses in matrix and 1 percent (few) carbonate concretions on bottom of rock fragments; 4 percent subangular calcareous sandstone channers; electrical conductivity of 9.6 dS/m by EC meter, saturated paste; violently effervescent by HCl, 1 normal; moderately alkaline, pH 8; CaCO3 12.3 percent.
**Persayo**

Persayo soils are shallow to Blue Gate shale member of the Mancos formation on very steep to extremely steep hillslopes, referred to locally as the “Blue Hills”. Persayo soils are medium textured and have 18 to 35 percent clay in the control section, while Persayo Family soils have less than 18 percent clay in the control section.

Soil profile EM-13-09 is representative of Persayo soils in the Emery 2 soil survey area. Widely scattered shadscale was the only vegetation observed.

*Typic Torriorthents, loamy, mixed, active, calcareous, mesic, shallow*

**A ---** 0 to 10 cm (0 to 4 inches); light yellowish brown (2.5Y 6/3) dry, very gravelly clay loam; dark grayish brown (2.5Y 4/2) moist; 32 percent sand; 41 percent silt; 27 percent clay; weak fine subangular blocky parting to moderate fine granular structure; friable, hard, slightly sticky, slightly plastic; common very fine roots throughout; common very fine tubular pores; 20 percent angular strongly cemented calcareous shale channnels and 40 percent angular strongly cemented calcareous shale gravels; electrical conductivity of 2.44 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; moderately alkaline, pH 7.9; clear smooth boundary; CaCO3 33.6 percent.

**C ---** 10 to 40 cm (4 to 16 inches); light brownish gray (2.5Y 6/2) dry, silty clay loam; grayish brown (2.5Y 5/2) moist; 18 percent sand; 50 percent silt; 32 percent clay; moderate medium subangular blocky structure; friable, hard, slightly sticky, slightly plastic; common very fine roots throughout; common very fine tubular pores; 10 percent angular very weakly cemented calcareous shale parachannlers; electrical conductivity of 8.64 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; moderately alkaline, pH 8.2; clear smooth boundary; CaCO3 16.5 percent.

**Cr ---** 40 cm (16 inches); Blue Gate member of the Mancos shale.
Major Soil Types

Persayo Family

Persayo family soils are shallow to Blue Gate shale member of the Mancos formation and located on extremely steep sideslopes in the canyon. These soils have less than 18 percent clay in the control, while Persayo soils have 18 to 27 percent clay in the control section.

Soil profile EM-6-09 is representative of Persayo Family soils in the Emery 2 soil survey area. Gardners saltbush and shadscale are the dominant vegetation. Depth to the Blue Gate member of the Mancos shale is 18 cm (7 inches). Very fine and fine roots penetrate the shale to 34 cm (13 inches). Soil textures are influenced by slope wash from the Ferron sandstone cliffs.

Typic Torriorthents, loamy, mixed, active, calcareous, mesic, shallow

A --- 0 to 7 cm (0 to 3 inches); very pale brown (10YR 7/3) dry, channery loamy sand; pale brown (10YR 6/3) moist; 79 percent sand; 12 percent silt; 9 percent clay; weak medium platy structure parting to single grain; very friable, slightly hard, non-sticky, non-plastic; common very fine and few fine roots; common very fine and few fine tubular pores; 10 percent angular strongly cemented 2 to 76 millimeters (0.1 to 3 inches) sandstone channers, 5 percent angular strongly cemented sandstone gravels, 5 percent angular strongly cemented sandstone flags, and 1 percent angular strongly cemented sandstone boulders; electrical conductivity of 2.32 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.7; clear smooth boundary; CaCO3 6.4 percent.

2C --- 7 to 18 cm (3 to 7 inches); very pale brown (10YR 7/4) dry, para-channery sandy loam; light yellowish brown (10YR 6/4) moist; 71 percent sand; 15 percent silt; 14 percent clay; weak fine and medium subangular blocky structure; very friable, slightly hard, slightly sticky, non-plastic; many very fine, few fine, few medium roots; common very fine tubular pores; 20 percent angular weakly cemented shale parachanners; electrical conductivity of 2.71 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.7; abrupt smooth boundary; CaCO3 7.5 percent.

2Cr1 --- 18 to 34 cm (7 to 13 inches); decomposing Blue Gate member of the Mancos shale; common very fine and few fine roots; clear smooth boundary.

2Cr2 --- 34 to 38 cm (13 to 15 inches); Blue Gate member of the Mancos shale.
Topsoil Salvage

Soil Limiting Features
Topsoil and subsoil salvage depths were determined by the depth to carbonates, soil pH (greater than 8.5), salinity (EC), sodicity (SAR), texture and depth to parent material (based on DOGM 2008). Clayey soils, carbonate accumulations and corresponding poor pH are the primary limiting soil features in the Emery 2 soil survey area. The depth to each of these limiting soil features varies by soil type and map unit.

The determination of Good, Fair, Poor, or Unacceptable qualities of the topsoil and subsoil is based on the soil suitability criteria established by the Utah Division of Oil Gas and Mining in Guidelines for Management of Topsoil and Overburden (Utah DOGM 2008). The Utah DOGM suitability guidelines are summarized in Table 16.

Table 16. Soil suitability and unsuitability criteria (Utah DOGM, 2005).

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturation %</td>
<td>25 to 55</td>
<td>≥56 to 80</td>
<td>&lt;25 or &gt;80</td>
</tr>
<tr>
<td>pH</td>
<td>6.5 to 8.2</td>
<td>6.0 to 6.4</td>
<td>5.5 to 6.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.2 to 8.5</td>
<td>8.6 to 9.0</td>
</tr>
<tr>
<td>EC (mS/cm 25°C)</td>
<td>0 to 4</td>
<td>4 to 8</td>
<td>8 to 15</td>
</tr>
<tr>
<td>SAR</td>
<td>0 to 4</td>
<td>5 to 10</td>
<td>10 to 14</td>
</tr>
<tr>
<td>CaCO₃ %</td>
<td>&lt;15</td>
<td>15 to 30</td>
<td>&gt;30</td>
</tr>
<tr>
<td>Texture</td>
<td>sl, l, sil, scl, vfs, fsl</td>
<td>cl, c, sicl, sc, ls, ifs</td>
<td>sic, s, sc, c, cos, fs, vfs</td>
</tr>
</tbody>
</table>
## Topsoil Salvage

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Organic Carbon</td>
<td>&lt; 10%</td>
<td></td>
<td>≥ 10%</td>
</tr>
<tr>
<td>Available Water Capacity</td>
<td>&gt; 0.10</td>
<td>0.05 to 0.10</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td></td>
<td>moderate</td>
<td>low</td>
<td>very low</td>
</tr>
<tr>
<td>K factor</td>
<td>&lt; 0.37</td>
<td>0.37</td>
<td>&gt; 0.37</td>
</tr>
<tr>
<td>Overburden</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selenium, soluble, mg/kg</td>
<td></td>
<td>≥ 0.15²</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥ 0.10³,⁴</td>
<td></td>
</tr>
<tr>
<td>Boron, available, mg/kg</td>
<td></td>
<td>≥ 5.0</td>
<td></td>
</tr>
<tr>
<td>Acid/Base Potential, tons CaCO₃/1000 tons</td>
<td></td>
<td>≤ 0</td>
<td></td>
</tr>
</tbody>
</table>

1. For clay textured soils *Unacceptable* is SAR > 14. For sandy textured soils *Unacceptable* is > 20.
2. Unacceptable level for the rooting zone (top four feet of fill) and/or ephemeral drainages with 100 year flood plains, top 4 feet fill.
3. Unacceptable level for the top 4 feet of fill in surface-water impoundments.
4. Unacceptable level for intermittent/perennial drainages including 100 year flood plains.
Topsoil Salvage by Major Soil Types

Estimated Topsoil and subsoil salvage depths are based on field examination of soil profiles and laboratory analysis of representative soil samples. Actual salvage depths will vary within soil types and map units. These estimates are provided as a guideline for determining potential salvage volumes and to determine post-mining reclamation soil profile composition. Topsoil and subsoil salvage operations should be monitored in consultation with a Certified Professional Soil Scientist. A summary of estimated average topsoil and subsoil salvage depths for each major soil type are listed in Table 17. Salvage depth estimates listed in Table 17 are based on the representative soil profile previously listed in the Major Soil Types section.

Estimations of Good, Fair, Poor, and Unacceptable sources of topsoil and subsoil are based on the Guidelines for Management of Topsoil and Overburden (DOGM 2008).

Begay family

Begay family soils are a fair source of topsoil. These soils have low available water capacities due to the sandy loam textures. These soils are in Wind Erodibility Group 3. Begay family soils are limited by the moderate depth to sandstone (less than 40 inches) and low water holding capacity.

The estimated topsoil salvage depth for Begay family soils is 23 cm (9 inches) and 57 cm (22 inches) of subsoil. Salvage depths are limited by the depth to Ferron sandstone, which is 80 cm (32 inches) in the representative soil profile (EM-1-09). The separation between topsoil and subsoil is based on decreased organic matter and increased salinity.

Braf

Limiting features of Braf soils are: 1) the low available water capacity (AWC), due to the loamy sand textures; and 2) the calcium carbonate equivalents (CCE) range from 18 to 22 in the C horizon; and 3) shallow depth to Ferron sandstone. Both the AWC and CCE for Braf soils are in the Fair range (Utah DOGM 2008). Braf soils are a fair source of topsoil, but are limited by the shallow depth to Ferron sandstone. These soils are in Wind Erodibility Groups 2 and 3.

The estimated topsoil salvage depth is 27 cm (11 inches) and 18 cm (7 inches) of subsoil in the representative soil profile (EM-10-09). Limiting soil features are increased salinity at 27 cm and Ferron sandstone at 45 cm.

Total salvage depths in the Braf soils evaluated in this survey range from as little as 8 cm (1.2 inches) in EM-11-09 to as much as 48 cm (18.9 inches) in EM-14-09.
Topsoil Salvage

Disturbed Soils
Overburden analysis (Utah DOGM 2008) was conducted on the representative soil profile in addition to standard topsoil analyses, because of the previous disturbance. The overburden analysis suite consists of acid-base potential, soluble selenium, soluble boron, and total organic carbon. None of the results for the overburden parameters exceeded the Utah DOGM suitability guidelines (Table 8 in Utah DOGM 2008).

The only limiting feature identified in these soils was an electrical conductivity of 4.39 in the C horizon, 18 to 46 cm (7-18 inches). This conductivity level is in the Fair range (Utah DOGM 2008). These soils are in Wind Erodibility Group 3. These previously disturbed lands are a fair source of topsoil due to the shallow depth to sandstone and shale, and potential for horizons with fair salinity levels. Salvage of previously disturbed materials should be monitored. The estimated salvage depths for disturbed soils in map unit Bd are 18 cm (7 inches) of topsoil and 28 cm (18 inches) of subsoil, based on the representative soil profile (EM-3-09). Separation between topsoil and subsoil is based on increased salinity at 18 cm.

Garley
Garley soils are well drained. The main limiting features of Garley soils, based on Utah DOGM Topsoil and Overburden Guidelines (Utah DOGM 2008), are: 1) Unacceptable SAR values that range from 15 to 49 (ESP 25 to 52 percent); 2) Poor electrical conductivity values ranging from 8.29 to 15.9 dS/m; 3) Poor pH values that correspond directly with the Unacceptable SAR levels; 4) loamy sand textures (Poor); and 5) Poor available water capacity due to the loamy sand textures. These soils are in Wind Erodibility Group 3.

Garley soils are a Poor source of topsoil and Unacceptable source of subsoil due to the SAR levels. The representative soil profile (EM-08-09) has 9 cm (~4 inches) of topsoil with Poor SAR value in map unit Cb based on the loamy sand texture. The Unacceptable SAR level for sandy textured soils is 20 (DOGM 2008). These soils have developed from numerous fluventic depositions, so the chemical and physical characteristics may vary between locations.

SAR levels in the subsoil range from 32.2 to 48.7 in the 9 to 88 cm zone of the representative soil profile. These SAR levels are in excess of the Unacceptable level. Garley subsoil should not be stockpiled with other salvaged subsoil materials.

It will be difficult to salvage 9 cm of topsoil and not have some mixing with Unacceptable SAR soils. Salvage from areas with Garley soils should be closely monitored in the field by a Certified Professional Soil Scientist. Salvaged Garley soils should be stockpiled separately from other topsoil sources. Placement of Garley topsoil and subsoil in reclamation areas should be limited to depths below four feet, whenever possible.
Garley, moderately well drained
The moderately well drained Garley soils have *Unacceptable* SAR levels (greater than 20) throughout the representative soil profile EM-12-09 (Utah DOGM 2008). These soils have *Poor* electrical conductivities, and *Poor* available water capacity due to the coarse soil texture. In addition, they are only moderately well drained due to the close proximity to Quitchapah Creek. Garley soils are described as well drained in the official series description (USDA – NRCS 2016). These soils are in Wind Erodibility Groups 3 and 4L. The Garley, moderately well drained soils are an *Unacceptable* source of topsoil and subsoil due to the SAR levels, based on the representative soil profile (EM-12-09).

The estimated topsoil and subsoil salvage depths are both 0 cm (0 inches).

Disturbance of Garley, moderately well drained, soils should be avoided or minimized. If disturbance of these soils is not avoidable, then the topsoil and subsoil from this soil type should be stockpiled separately from other sources. Placement of Garley, moderately well drained, topsoil and subsoil in reclamation areas should be limited to depths below four feet, whenever possible.

Green River
These soils are limited by *Fair* calcium carbonate levels (15.2 to 19.2 tons CaCO$_3$ per 1,000 tons) in soil horizons between 15 and 102 cm (6 and 40 inches). Occasional flooding and aquic soil conditions from 28 to 56 cm (11 to 22 inches) are also limiting features. SAR is *Fair* in the 56 to 78 cm (22 to 31 inches) horizon of the representative soil profile (EM-7-09). The calculated K factor is *Poor* (greater than 0.37) between 28 and 56 cm in the representative soil profile. These soils are in Wind Erodibility Groups 3 and 4L. Green River soils are a poor source of topsoil due to the flooding potential and *Poor* K Factor.

The estimated topsoil salvage depth for Green River soils is 15 cm (6 inches), based on an increase of carbonates below this depth. An estimated 135 cm (53 inches) of subsoil can be salvaged from Green River soils to a depth of 150 cm (60 inches), if deep disturbance of the soil is required. Green River soils are geographically associated with Garley, moderately well drained soils and their locations should be monitored (*Unacceptable* SAR levels).

Disturbance of Green River soils should be avoided due to their close proximity to Quitchapah Creek. Additional permitting may be required, if these soils are impacted.

Hideout
These soils are in Wind Erodibility Groups 2 and 3. Hideout soils are a fair source of topsoil due to the shallow depth to sandstone and low available water capacities. These soils are geographically associated with large areas of Ferron sandstone outcrops. The estimated topsoil salvage depth is limited to approximately 20 cm (8 inches) based on the representative soil profile (EM-4-09).

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Physical and chemical characteristics of Hideout topsoil and subsoil are similar. They should be salvaged and stockpiled together as topsoil due to the thinness of each.

**Lazear**

Lazear soils are a fair source of topsoil due to the calcium carbonate levels and the shallow depth. Calcium carbonate concentrations in the representative profile range from 22.5 to 25.4 percent, which are in the *Fair* range (Utah DOGM 2008). These soils are in Wind Erodibility Groups 3 and 4L.

The estimated topsoil salvage depth for Lazear soils is limited by the shallow depth to Ferron sandstone, which is 20 cm (8 inches) in the representative soil profile (EM-5-09).

Physical and chemical characteristics of Lazear topsoil and subsoil are similar. They should be salvaged and stockpiled together as topsoil due to the thinness of each.

**Monue Family**

Monue family soils are a good source of topsoil and good to fair source of subsoil. SAR and salinity levels are *Fair* from 80 cm 122 cm and *Poor* below 122 cm in the representative soil profile (EM-16-09). These soils have low available water capacities due to the sandy loam textures. Monue family soils are in Wind Erodibility Group 3.

The estimated topsoil salvage depth for Monue Family soils is 46 cm (18 inches) in the representative soil profile (EM-16-09). Subsoil salvage of 76 cm (48 inches) may occur in the Monue Family soils based on the representative soil profile, if deep disturbance is required. Monue Family soils are subject to wind erosion, so the actual topsoil salvage depth should be limited to the amount required to successfully revegetate the disturbance. The separation between topsoil and subsoil is based on the transition from the B to the C horizons in the representative soil profile.

Monue family soils are a good source of topsoil and subsoil within the Emery 2 permit area. The lower subsoil that is poor quality due to increased conductivity and SAR should not be stockpiled with the better quality topsoil and upper subsoil. Salvage of these soils should be monitored by a Certified Professional Soil Scientist.

**Persayo**

Persayo soils are a fair source of topsoil and an *Unacceptable* source of subsoil. These soils are limited by low water holding capacity in the upper 10 cm (4 inches) and *Unacceptable* SAR (15.9) below 10 cm (4 inches). Persayo soils are in Wind Erodibility Group 4L. These soils are limited by the shallow depth to shale.

The estimated topsoil salvage depth for Persayo soils is 10 cm (4 inches) in the representative soil profile (EM-13-09). The *Unacceptable* subsoil (SAR) below 10 cm to depth of 30 cm (28
inches) should only be disturbed, if deeper excavation is required. Persayo subsoil should be stockpiled separately from other subsoil materials. Disturbance of Persayo soils should be minimized.

**Persayo Family**

Persayo family soils are a good source of topsoil and subsoil, but limited by the shallow depth to shale in the representative soil profile (EM-6-09). These soils are limited by low available water capacities. Persayo family soils are in Wind Erodibility Groups 2 and 3. SAR levels were *Good* in the representative soil profile, but *Poor* to *Unacceptable* values are possible due to the shallow depth to Mancos shale. These soils are on very steep to extremely steep (45 to 80 percent) slopes which will be limiting to topsoil salvage operations.

The estimated topsoil salvage depth for Persayo family soils is limited by the depth to Mancos shale, which is 18 cm (7 inches) in the representative soil profile.

Physical and chemical characteristics of Persayo family topsoil and subsoil are similar. They should be salvaged and stockpiled together as topsoil due to the thinness of each.
Table 17. Estimated topsoil and subsoil salvage depths for each major soil type in the Emery 2 soil survey area based on the typifying or representative soil profiles. Salvage depth estimates are based on the representative soil profile listed in the Major Soil Types section.

<table>
<thead>
<tr>
<th>Soil Series/Family</th>
<th>Typifying Profile</th>
<th>Topsoil Salvage (cm)</th>
<th>Subsoil Salvage (cm)</th>
<th>Topsoil Salvage (inches)</th>
<th>Subsoil Salvage (inches)</th>
<th>Total Salvage (inches)</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Begay family</td>
<td>EM-1-09</td>
<td>23</td>
<td>57</td>
<td>9</td>
<td>22</td>
<td>31</td>
<td>Increased carbonate concentrations, increased salinity, and sandstone at 80 cm. Topsoil subsoil split based on decreased organic matter and increased soil pH and salinity.</td>
</tr>
<tr>
<td>Braf</td>
<td>EM-10-09</td>
<td>27</td>
<td>18</td>
<td>11</td>
<td>7</td>
<td>18</td>
<td>Increased salinity at 27 cm and sandstone at 45 cm.</td>
</tr>
<tr>
<td>Disturbed Soils</td>
<td>EM-3-09</td>
<td>18</td>
<td>28</td>
<td>7</td>
<td>11</td>
<td>18</td>
<td>Increased salinity at 18 cm and hard shale at 46 cm.</td>
</tr>
<tr>
<td>Garley</td>
<td>EM-8-09</td>
<td>9</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>Increase of SAR from 20.4 to 32.2 at 9 cm (SAR of 20 used for Unacceptable limit based on loamy sand texture).</td>
</tr>
<tr>
<td>Garley, mod well drained</td>
<td>EM-12-09</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Unacceptable SAR levels to the surface. Topsoil and subsoil should be salvaged and stockpiled separately from other soil due to the Unacceptable qualities, if disturbance is necessary. Topsoil salvage depth (15 cm) based on depth of A horizon.</td>
</tr>
</tbody>
</table>
Table 17. Estimated topsoil and subsoil salvage depths for each major soil type in the Emery 2 soil survey area based on the typifying or representative soil profiles. Salvage depth estimates are based on the representative soil profile listed in the Major Soil Types section.

<table>
<thead>
<tr>
<th>Soil Series/Family</th>
<th>Typifying Profile</th>
<th>Topsoil Salvage (cm)</th>
<th>Subsoil Salvage (cm)</th>
<th>Total Salvage (inches)</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green River</td>
<td>EM-7-09</td>
<td>15</td>
<td>135</td>
<td>53</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>53</td>
<td>59</td>
<td>Carbonates increase below 15 cm; redox mottles observed from 28 to 56 cm.</td>
</tr>
<tr>
<td>Hideout</td>
<td>EM-4-09</td>
<td>20</td>
<td>0</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>0</td>
<td>8</td>
<td>Sandstone at 20 cm; topsoil and subsoil should be salvaged as topsoil due to thin topsoil.</td>
</tr>
<tr>
<td>Lazear</td>
<td>EM-5-09</td>
<td>20</td>
<td>0</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>0</td>
<td>8</td>
<td>Sandstone at 20 cm; topsoil and subsoil should be salvaged as topsoil due to thin topsoil.</td>
</tr>
<tr>
<td>Monue Family</td>
<td>EM-16-09</td>
<td>46</td>
<td>76</td>
<td>30</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18</td>
<td>30</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A and B horizons comprise topsoil depth. Single grain alluvial parent material (C horizons) below 46 cm. Poor salinity below 122 cm.</td>
</tr>
<tr>
<td>Persayo</td>
<td>EM-13-09</td>
<td>10</td>
<td>30</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>12</td>
<td>16</td>
<td>Poor salinity and Unacceptable SAR below 10 cm. Thin topsoil layer should be salvaged and stockpiled separately from subsoil.</td>
</tr>
<tr>
<td>Persayo family</td>
<td>EM-6-09</td>
<td>18</td>
<td>0</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>0</td>
<td>7</td>
<td>Shale at 18 cm; topsoil and subsoil should be salvaged as topsoil. Large stones and boulders should be separated from salvaged topsoil.</td>
</tr>
</tbody>
</table>
Map Unit Salvage Depths

Table 18 identifies the weighted average depth of topsoil and subsoil that may be available for salvage based on field evaluations of soil pits and laboratory analysis of soil samples. Salvage depths may include some Poor quality materials. Field data sheets are in appendix B. Results of the laboratory analysis of soil samples are contained in appendix C.

Salvage depths will be limited by the depth to Ferron sandstone and presence of sandstone outcrops in portions of the Emery 2 permit area.

Table 18. Summary of weighted average topsoil and subsoil salvage depths for soil map units in the Emery 2 soil survey area. Actual salvage depths will vary from these estimates. Salvage operations should be monitored by a Certified Professional Soil Scientist.

<table>
<thead>
<tr>
<th>Map Unit</th>
<th>Weighted Average Topsoil Salvage Depth¹</th>
<th>Weighted Average Subsoil Salvage Depth²</th>
<th>Total Weighted Average Salvage Depth³</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.3 feet</td>
<td>0.2 feet</td>
<td>0.5 feet</td>
</tr>
<tr>
<td>Ba</td>
<td>0.7 feet</td>
<td>0.9 feet</td>
<td>1.6 feet</td>
</tr>
<tr>
<td>Bd</td>
<td>0.6 feet</td>
<td>1.0 feet</td>
<td>1.6 feet</td>
</tr>
<tr>
<td>Ca</td>
<td>0.6 feet</td>
<td>0.2 feet</td>
<td>0.8 feet</td>
</tr>
<tr>
<td>Cb</td>
<td>1.1 feet</td>
<td>1.6 feet</td>
<td>2.7 feet</td>
</tr>
<tr>
<td>D</td>
<td>0.8 feet</td>
<td>0.5 feet</td>
<td>1.3 feet</td>
</tr>
<tr>
<td>E</td>
<td>0.4 feet</td>
<td>0.3 feet</td>
<td>0.7 feet</td>
</tr>
<tr>
<td>F</td>
<td>0.3 feet</td>
<td>0.9 feet</td>
<td>1.2 feet</td>
</tr>
<tr>
<td>G</td>
<td>0.1 feet</td>
<td>0.5 feet</td>
<td>0.6 feet</td>
</tr>
<tr>
<td>H</td>
<td>0.4 feet</td>
<td>4.0 feet</td>
<td>4.4 feet</td>
</tr>
</tbody>
</table>

1. Weighted topsoil salvage depth for map unit is sum of products of map unit component percents and representative salvage depths from Table 17 (see Table F-1 for details).
2. Weighted subsoil salvage depth for map unit is sum of products of map unit component percents and representative salvage depth from Table 17 (see Table F-1 for details).
3. Sum of weighted topsoil and subsoil depths.
The estimated topsoil and subsoil salvage depths listed in Table 18 are for planning purposes. Actual depths will vary and should be monitored by a Certified Professional Soil Scientist. Salvage depth estimates are detailed in Appendix F.

Salvage of topsoil and subsoil from map unit Cb should be closely monitored due to presence of both Good and Unacceptable materials. Additional laboratory analysis may be necessary in order to identify specific topsoil and subsoil salvage depths within the Emery 2 permit area.

Potential salvage depths are listed for map unit H. However, soils in this map unit are on the floodplain of Quitchapah Creek and disturbance should be avoided. Additional studies and permitting may be necessary, if disturbance of soils in map unit H is necessary.

**Disturbance Impacts**

Soil map unit delineations within the proposed Emery 2 permit area are shown in Figure 3. The map unit areas within the Emery 2 permit area and disturbance areas are listed in Table 19. Map units Ca on the canyon sideslopes and D on the bench west of the canyon are the two most dominant within the Emery 2 permit area. Map units G and H do not occur within the Emery 2 permit area.

Estimated salvage volumes are detailed in Table 20. These estimated volumes are based on the weighted average topsoil and subsoil salvage depths listed in Table 18 and the map unit disturbance acres listed in Table 19. These volumes are the potential amounts of topsoil and subsoil that would need to be stockpiled, if all soils within the disturbance area are disturbed.

Ferron sandstone outcrops are the dominant feature in map units A and E and a major component in Ca. It is also a minor component in map units Ba, D, and F. Sandstone outcrops comprise approximately 1.70 acres of the planned disturbance area (Table 21).
Table 19. Map unit acres for Emery 2 permit and disturbance areas.

<table>
<thead>
<tr>
<th>Soil Map Units</th>
<th>A</th>
<th>Ba</th>
<th>Bd</th>
<th>Ca</th>
<th>Cb</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>acres</td>
<td>acres</td>
<td>acres</td>
<td>acres</td>
<td>acres</td>
<td>acres</td>
<td>acres</td>
<td>acres</td>
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<td>acres</td>
</tr>
<tr>
<td>Emery 2 Permit acres</td>
<td>2.9</td>
<td>4.5</td>
<td>0.3</td>
<td>10.4</td>
<td>1.3</td>
<td>8.0</td>
<td>1.3</td>
<td>0.2</td>
<td>0.0</td>
<td>0.0</td>
<td>28.9</td>
</tr>
<tr>
<td>Emery Mine Access Road(^1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.7</td>
</tr>
<tr>
<td>Emery Mine Canyon Area</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.4</td>
<td></td>
<td></td>
</tr>
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<td>Total Emery Mine Disturbance</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>Emery 2 Road &amp; Facilities(^2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emery 2 Canyon Area</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td>Emery 2 Rock Scaling Work Area</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>Emery 2 East Bench Berm(^3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td>Emery 2 Disturbance Total(^5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Total Disturbance(^6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Disturbance for west bench road to Emery 2 facilities above portal on existing Emery Mine permit area.
2. Disturbance for west bench road to Emery 2 facilities above portal on Emery 2 permit area.
3. Planned disturbance to be less than 0.01 acres.
4. Disturbance for berm on east bench to control surface runoff.
5. Total Emery 2 area is sum of Emery 2 road & facilities, canyon, rock scaling area, and east bench berm areas.
6. Total Disturbance is Total Emery Disturbance plus Emery 2 Disturbance.
### Table 20. Estimated salvage volumes for map units by disturbance areas and by mine permit.

<table>
<thead>
<tr>
<th>Map Unit</th>
<th>Disturbance Area</th>
<th>Topsoil Salvage Weighted Depth</th>
<th>Subsoil Salvage Weighted Depth</th>
<th>Estimated Topsoil Salvage Volume</th>
<th>Estimated Subsoil Salvage Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>acres</td>
<td>feet</td>
<td>feet</td>
<td>cubic yards</td>
<td>cubic yards</td>
</tr>
<tr>
<td>Road &amp; Facilities above Emery 2 Portal on Emery Mine Permit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ca</td>
<td>0.2</td>
<td>0.6</td>
<td>0.2</td>
<td>300</td>
<td>100</td>
</tr>
<tr>
<td>D</td>
<td>0.4</td>
<td>0.8</td>
<td>0.5</td>
<td>478</td>
<td>298</td>
</tr>
<tr>
<td>E</td>
<td>0.1</td>
<td>0.4</td>
<td>0.3</td>
<td>39</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>816</td>
<td>428</td>
</tr>
<tr>
<td>Road &amp; Facilities on Emery 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>0.9</td>
<td>0.8</td>
<td>0.5</td>
<td>1,162</td>
<td>726</td>
</tr>
<tr>
<td>E</td>
<td>0.6</td>
<td>0.4</td>
<td>0.3</td>
<td>374</td>
<td>281</td>
</tr>
<tr>
<td>F</td>
<td>0.1</td>
<td>0.3</td>
<td>0.9</td>
<td>29</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1,565</td>
<td>1,094</td>
</tr>
<tr>
<td>Total Salvage from Road &amp; Facilities</td>
<td></td>
<td></td>
<td></td>
<td>2,381</td>
<td>1,521</td>
</tr>
<tr>
<td>Canyon Area on Emery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ca</td>
<td>0.4</td>
<td>0.6</td>
<td>0.2</td>
<td>387</td>
<td>129</td>
</tr>
<tr>
<td>Canyon Area on Emery 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ca</td>
<td>5.6</td>
<td>0.6</td>
<td>0.2</td>
<td>5,421</td>
<td>1,807</td>
</tr>
<tr>
<td>Cb</td>
<td>1.3</td>
<td>1.1</td>
<td>1.6</td>
<td>2,307</td>
<td>3,356</td>
</tr>
<tr>
<td>Total Salvage from Emery 2</td>
<td></td>
<td></td>
<td></td>
<td>7,728</td>
<td>5,163</td>
</tr>
<tr>
<td>Total Salvage from Canyon Area</td>
<td></td>
<td></td>
<td></td>
<td>8,115</td>
<td>5,292</td>
</tr>
<tr>
<td>East Bench Berm on Emery 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>0.1</td>
<td>0.3</td>
<td>0.2</td>
<td>48</td>
<td>32</td>
</tr>
<tr>
<td>Ba</td>
<td>0.3</td>
<td>0.7</td>
<td>0.9</td>
<td>339</td>
<td>436</td>
</tr>
<tr>
<td>Total Salvage from East Bench</td>
<td></td>
<td></td>
<td></td>
<td>387</td>
<td>468</td>
</tr>
<tr>
<td>East Bench Scaling Area on Emery 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ba</td>
<td>0.3</td>
<td>0.7</td>
<td>0.9</td>
<td>339</td>
<td>436</td>
</tr>
<tr>
<td>Total Salvage on Emery Permit</td>
<td></td>
<td></td>
<td></td>
<td>1,162</td>
<td>565</td>
</tr>
<tr>
<td>Total Salvage from Emery 2 Permit</td>
<td></td>
<td></td>
<td></td>
<td>10,438</td>
<td>7,357</td>
</tr>
<tr>
<td>Total Salvage from Disturbance Area</td>
<td></td>
<td></td>
<td></td>
<td>11,600</td>
<td>7,992</td>
</tr>
</tbody>
</table>

1. Disturbance map unit area from Table 19.
2. Estimated weighted map unit topsoil salvage depths from Table 18.
3. Estimated weighted map unit subsoil salvage depths from Table 18.
4. Estimated salvage volumes are from all areas on the existing Emery Mine permit.
5. Estimated Emery 2 salvage volumes are the sum of volumes for the all Emery 2 disturbances.
6. Total Disturbance is Total Emery Disturbance plus Emery 2 Disturbance.
# Table 21. Estimate of sandstone outcrop area within the Emery 2 disturbance area.

<table>
<thead>
<tr>
<th>Area1</th>
<th>Map Unit Symbol</th>
<th>Map Unit Acres2</th>
<th>Percent Rock Outcrop3</th>
<th>Estimated Sandstone Outcrop in Map Unit Component4</th>
<th>Estimated Sandstone Outcrop Area in Map Unit5</th>
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</thead>
<tbody>
<tr>
<td>East Bench Berm</td>
<td>A</td>
<td>0.1</td>
<td>50</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>East Bench Berm</td>
<td>Ba</td>
<td>0.3</td>
<td>5</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>East Bench Berm</td>
<td>Ca</td>
<td>0.0</td>
<td>20</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>East Bench Scaling</td>
<td>Ba</td>
<td>0.3</td>
<td>5</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Emery 2 Canyon</td>
<td>A</td>
<td>0.0</td>
<td>50</td>
<td>0.00</td>
<td>0.0</td>
</tr>
<tr>
<td>Emery 2 Canyon</td>
<td>Ca</td>
<td>5.6</td>
<td>20</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Emery 2 Canyon</td>
<td>Cb</td>
<td>1.3</td>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Canyon on Emery</td>
<td>Ca</td>
<td>0.4</td>
<td>20</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Canyon on Emery</td>
<td>Cb</td>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Emery 2 Road &amp; Facilities</td>
<td>D</td>
<td>0.9</td>
<td>10</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Emery 2 Road &amp; Facilities</td>
<td>E</td>
<td>0.6</td>
<td>50</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Emery 2 Road &amp; Facilities</td>
<td>F</td>
<td>0.1</td>
<td>5</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Emery Road</td>
<td>Ca</td>
<td>0.2</td>
<td>20</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Emery Road</td>
<td>D</td>
<td>0.4</td>
<td>10</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Emery Road</td>
<td>E</td>
<td>0.1</td>
<td>50</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>10.30</td>
<td></td>
<td>1.7</td>
<td></td>
</tr>
</tbody>
</table>

1. Geographic portion of Emery 2 disturbance area.
2. Map unit acres within geographic portions of Emery 2 disturbance area from Table 19.
3. Percent rock outcrop in map unit from Table 4.
4. Map unit area (acres) multiplied by percent rock outcrop in map unit.
5. Cumulative estimated in geographic portion of Emery 2 disturbance area.
Topsoil Salvage

Topsoil and Subsoil Salvage in Canyon Area

The topsoil and subsoil identified in this report will be salvaged by an experienced contractor that has worked on several projects of this type for the Utah mining industry. The salvage operation will be monitored by a Certified Professional Soil Scientist (CPSS) capable of making field decisions and changes in conjunction with DOGM.

Large chunks of sandstone on the canyon rim have been identified as unstable and present a safety issue. They will be brought down before any topsoil or subsoil is salvaged from the canyon. Bringing down these large chunks of sandstone from the canyon rim will result in some disturbance of topsoil and subsoil in the canyon. Topsoil and subsoil removal will begin after the canyon rim has been stabilized.

Safety will be the top priority when salvaging topsoil and subsoil in the Emery 2 disturbance area. Steepness of slope, large boulders on the canyon rim or on the sideslope, and other site specific factors may preclude salvage in some areas.

Appropriate equipment for salvaging topsoil and subsoil will be utilized to salvage topsoil and subsoil from the Emery 2 disturbance areas. The type of equipment selected to complete this task is dependent on slope, access, size of work space, soil horizon depths, and amount of rock in the soil.

This soil survey identified sodic and saline soils in the canyon within the Emery 2 disturbance area. Soil samples will be collected from the Emery 2 canyon area to further identify areas with Unacceptable sodium adsorption ratios (SAR), pH, and electrical conductivities (ECe) prior to the start of salvage operations. Samples will be analyzed for pH, conductivity, sodium adsorption ratio, and texture by the methods detailed in Table 3 of the Guidelines for Management of Topsoil and Overburden (Utah DOGM 2008). Samples will be collected in the Emery 2 canyon on the basis of approximately one sample location per 1 to 2 acres as determined appropriate by the Certified Professional Soil Scientist collecting the soil samples. The canyon area has an estimated 6.3 acres of salvageable soils. The following table lists how the soil sample locations in the canyon area may be selected.

Table 22. Estimated number and location of soil sample locations in Emery 2 canyon for use during construction phase.

<table>
<thead>
<tr>
<th>Emery 2 Disturbance Area</th>
<th>Soil Families of Concerns</th>
<th>Estimated Number of Sample Locations Within Canyon¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canyon bottom</td>
<td>Monue and Garley</td>
<td>3 to 5</td>
</tr>
<tr>
<td>Canyon Sideslopes</td>
<td>Persayo</td>
<td>1 to 2</td>
</tr>
</tbody>
</table>

¹. The actual number soil sample locations will be determined in the field by the Certified Professional Soil Scientist collecting the samples.
Topsoil Salvage

Soil samples collected for construction salvage purposes will be collected by soil horizon as determined by the Certified Soil Scientist collecting the soil samples. The surface horizon sample will not exceed 12 inches in thickness and subsurface horizon samples will not exceed 18 inches in thickness.

The large rocks will be sorted out of the topsoil and subsoil as the salvage operation progresses. Sorting of rock may take place either in the canyon or at the storage location, depending on the amount of space available and the amount of sorting required. Rock will either be hauled from the canyon and stockpiled in designated storage areas or left in piles within the canyon to provide fill for building the road to the new portal site. Larger boulders will be broken down to a size that can be handled by the equipment and transported in trucks to designated storage areas.

Soil and rock will be removed in layers along the face of the work area. When all of the soil and rock have been removed from a layer, then removal of the next soil layer will begin. Layer thickness will depend on soil quality, thickness, and rock size.

Topsoil and subsoil pH and conductivity will be monitored in the field by a Certified Professional Soil Scientist (CPSS). Soil with pH greater than approximately 8.6 or conductivities greater than approximately 8 dS/m (mS/cm) will not be salvaged.

Topsoil and Subsoil Stockpiles

The coarse-loamy soil textures that dominate the Emery 2 soil survey are susceptible to wind erosion. Topsoil and subsoil stockpiles should be protected from both wind and water erosion.

Topsoil and subsoil that is salvaged from the Garley, Garley, moderately well drained, and other soils with Unacceptable properties (DOGM 2008) should be placed in stockpiles that are separate from the other topsoil or subsoil stockpiles. These soils with SAR levels in excess of 20 will require special treatment in order to establish vegetation.

Native Soil Profile Features

The combined depth of topsoil and subsoil varies in native soil profiles within the Emery 2 permit area depending on physiographic setting, depth to sandstone or shale, salinity, and sodicity (SAR).
Stockpile and Placement of Topsoil and Subsoil

Topsoil and subsoil should be salvaged and placed directly into stockpiles. Stockpiles should be identified with signs and protected from other mining activities. Stockpile locations should protect the topsoil from wind erosion, flooding, and stockpiled coal. A mixture of native grasses and shrubs should be seeded on the stockpile(s) to protect them from wind and water erosion.

Topsoil placement depths will range from a minimum of 9 cm (6 inches) up to approximately 30 cm (12 inches). Topsoil will not be available for reclamation in areas which were sandstone outcrops prior to disturbance. There is an approximately 1.70 acres of sandstone outcrops in the proposed Emery 2 disturbance area based on map unit composition and map unit acres, Table F-1.

Reclamation of Sodic Subsoil Areas

Unacceptable sodium adsorption ratios (SAR) in the Garley soils may be limiting to the establishment of grasses and shrubs during post-mining reclamation. These soils are naturally sodic within a few inches of the native surface. Black greasewood and shadscale are presently growing on these soils with scattered clumps of Indian ricegrass in localized areas. The reclamation seed mix should include grasses and shrubs that are tolerant of these SAR levels.

It is recommended that sodic subsoil be stockpiled separately to avoid mixing with other subsoil sources.

Reclamation

The primary keys to successful reclamation of disturbed areas within the Emery 2 permit area will be:

- Identification of sodic subsoil materials and stockpiling them separately from other subsoil sources;
- Replacement of sodic subsoil materials in areas less susceptible to erosion;
- Incorporation of rock outcrop areas into the final surface reclamation plan in proportions similar to native conditions prior to disturbance;
- Seeding the final surface with a mixture of native grasses and shrubs that are tolerant of the coarse-loamy, droughty, saline, and sodic conditions in the Emery 2 permit area.

Substitute Soil Materials

No sources of substitute soil material were identified during the Emery 2 soil survey.
Topsoil Salvage

Literature Cited


Utah Division of Oil Gas and Mining (DOGM), January 2008. Guidelines for Management of Topsoil and Overburden. Salt Lake City, Utah.


Appendix A

NRCS - Prime Farmland Assessment
January 8, 2010

Mr. John Gefferth
Consolidated Coal Company
P.O. Box 566
Sesser, IL 62884

Dear: Mr. Gefferth

The area south and west of the coal mine south of Emery, Utah as outlined by Robert Long CPSS in sections 32 and 33 T22S. R6E. contains no Prime or Unique farmlands or farmlands of Statewide importance because there is no developed irrigation system on these arid soils. Most of this area has soils with other limitations also, such as being shallow to bedrock or steep slopes.

If we can be of further assistance please let us know.

Leland Sasser NRCS Soil Scientist
Appendix B

Soil Profile Descriptions
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Map Unit A Transect ....................................................................................................... 44
Site ID: EM-1-09  
Description Date: 9/29/2009  
Describer: Robert Long  
Soil Name As Correlated: Begay Family  
Classification: Coarse-loamy, mixed, superactive, mesic Ustic Haplocambids  
Pedon Type: Modal pedon for map unit  
Pedon Purpose: Full pedon description  
Taxon Kind: Family  

County or Parish: UT015 - Emery  
State or Territory: UT - Utah  
7.5' Quad: Walker Flat, Utah  
UTM: 422584E, 4300701N – Datum NAD83, Zone 12  

Location Description:  
Legal Description: Section 33, Township 22 S, Range 6 E  

Landscape: plateau  
Landform: hill  
Geomorphic Component: Side Slope  
Profile Pos: Footslope  

Slope: 7 percent  
Elevation: 1847 meters (6060 feet)  
Aspect: 314°  
Shape: up/down: Concave; across: Concave  
Drainage: Well drained  
Runoff: Medium  
Permeability: Moderate  
Erosion: Class 2 - Gully erosion  

Primary Earth Cover: Grass/herbaceous cover; Secondary Earth Cover: Grassland rangeland  
Existing Vegetation: ARTRW8 - Wyoming big sagebrush (Artemisia tridentata ssp. wyomingensis); SAVE4 - greasewood (Sarcobatus vermiculatus); ATCO - shadscale (Atriplex confertifolia)  

Parent Materials: Alluvium over Sandstone  
Bedrock: Calcareous sandstone at 80 centimeters (32 inches)  
Particle Size Control Section: 25 to 80 centimeters (10 to 32 inches)  
Diagnostic Features: Lithic contact: 80 centimeters (Restrictive layer) and Cambic horizon: 8 to 50 centimeters (3 to 20 inches)  
Restrictions: Lithic bedrock: 80 centimeters
A --- 0 to 8 cm (0 to 3 inches); pale yellow (2.5Y 7/3) dry, sandy loam; light yellowish brown (2.5Y 6/4) moist; 63 percent sand; 20 percent silt; 17 percent clay; weak medium platy parting to moderate fine granular structure; very friable, slightly hard, slightly sticky, slightly plastic; common very fine roots throughout and common fine roots throughout; common very fine tubular pores; 2 percent (common) fine irregular moderately cemented carbonate concretions on bottom of rock fragments; 3 percent subangular calcareous sandstone gravels; electrical conductivity of 2.25 dS/m by EC meter, saturated paste; violently effervescent by HCl, 1 normal; neutral, pH 7.3; clear smooth boundary; CaCO₃ 9.1 percent.

Bw1 --- 8 to 23 cm (3 to 9 inches); light yellowish brown (2.5Y 6/4) dry, sandy loam; light olive brown (2.5Y 5/4) moist; 57 percent sand; 29 percent silt; 14 percent clay; structure; very friable, slightly hard, slightly sticky, slightly plastic; many very fine roots throughout, common fine roots throughout and common medium roots throughout; common very fine tubular pores; 2 percent (common) fine irregular moderately cemented carbonate concretions on bottom of rock fragments; 5 percent calcareous sandstone gravels; electrical conductivity of 2.32 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.4; clear smooth boundary; CaCO₃ 7.2 percent.

Bw2 --- 23 to 50 cm (9 to 20 inches); light yellowish brown (10YR 6/4) dry, sandy loam; yellowish brown (10YR 5/4) moist; 73 percent sand; 14 percent silt; 13 percent clay; moderate medium subangular blocky structure; very friable, slightly hard, nonsticky, nonplastic; many very fine roots throughout, common fine roots throughout, common medium roots throughout and common coarse roots throughout; common very fine tubular pores; 3 percent (common) fine masses of carbonate on vertical faces of peds and 4 percent (common) fine irregular carbonate concretions around rock fragments; 8 percent subangular calcareous sandstone gravels; electrical conductivity of 3.94 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.7; clear smooth boundary; CaCO₃ 7.2 percent.

Bk --- 50 to 80 cm (20 to 32 inches); very pale brown (10YR 7/4) dry, channery sandy loam; yellowish brown (10YR 5/4) moist; 65 percent sand; 23 percent silt; 12 percent clay; weak medium subangular blocky structure; friable, slightly hard, slightly sticky, slightly plastic; common very fine roots throughout, common fine roots throughout, common medium roots throughout and common coarse roots throughout; common very fine tubular pores; 2 percent (common) fine masses of carbonate on vertical faces of peds and 7 percent (common) medium carbonate concretions around rock fragments; 6 percent subangular calcareous sandstone gravels and 12 percent subangular calcareous...
sandstone channers; electrical conductivity of 3.07 dS/m by EC meter, saturated paste; violently effervescent by HCl, 1 normal; slightly alkaline, pH 7.6; abrupt smooth boundary; CaCO3 7.8 percent.

R --- 80 cm (32 inches); Ferron sandstone.
EM-2-09

Pedon ID: EM-2-09
Description Date: 9/29/2009
Describer: Robert Long

Soil Name As Correlated: Hideout
Current Taxonomic Class: Loamy, mixed, superactive, calcareous, mesic Lithic Ustic Torriorthents
Current Taxon Kind: Series

County or Parish: UT015 - Emery
State or Territory: UT - Utah
UTM: 477634E, 4300621N -- Datum NAD83, Zone 12
Legal Description: Section 33, Township 22 South, Range 6 East of the 29 Meridian

Landscape: plateaus or tablelands
Landform: hill
Geomorphic Component: Side Slope
Profile Pos: Backslope: on middle third
Slope: 6 percent
Elevation: 1851 meters (6070 feet)
Aspect: 10°
Shape: up/down: ; across:
Complexity: Simple

Drainage: Well drained
Runoff: Medium
Erosion: Class 1 - Sheet erosion

Primary Earth Cover: Shrub cover; Secondary Earth Cover: Shrubby rangeland
Existing Vegetation: ARTRW8 - Wyoming big sagebrush (Artemisia tridentata ssp. wyomingensis); ATCO - shadscale (Atriplex confertifolia); SAVE4 - black greasewood (Sarcobatus vermiculatus); JUOS - Utah juniper (Juniperus osteosperma); GUSA2 - broom snakeweed (Gutierrezia sarothrae); EPHED - Mormon tea (Ephedra); AMUT - Utah serviceberry (Amelanchier utahensis); PIED - twoneedle pinyon (Pinus edulis)

Parent Materials: slightly weathered, residuum weathered from calcareous sandstone
Bedrock: Strongly cemented calcareous sandstone at 19 centimeters (7.5 inches)
Particle Size Control Section: 0 to 19 centimeters (0 to 7.5 inches)
Diagnostic Features: Lithic contact: 19 centimeters (7.5 inches)
Restrictions: Lithic bedrock: 19 centimeters (7.5 inches)
A --- 0 to 5 centimeters (0 to 2 inches); pale brown (10YR 6/3) dry, sandy loam; brown (10YR 4/3) moist; 69 percent sand; 20 percent silt; 11 percent clay; moderate fine granular and weak medium platy structure; very friable, slightly hard, nonsticky, nonplastic; common very fine roots throughout; common very fine tubular pores; 5 percent subangular calcareous sandstone gravels; electrical conductivity of 0.89 mmhos/cm by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.7, pH meter; abrupt smooth boundary; CaCO₃ 5.5 Percent.

C --- 5 to 19 centimeters (2 to 7.5 inches); brown (10YR 5/3) dry, sandy loam; brown (10YR 4/3) moist; 71 percent sand; 17 percent silt; 12 percent clay; weak medium subangular blocky structure; friable, hard, slightly sticky, slightly plastic; common fine roots throughout and common very fine roots throughout; common very fine tubular pores; electrical conductivity of 0.78 mmhos/cm by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.7, pH meter; abrupt smooth boundary; CaCO₃ 4.4 Percent.

R --- 19 centimeters (7.5 inches).
Pedon ID: EM-3-09
Description Date: 9/29/2009
Describer: Robert Long

Soil Name As Correlated: Disturbed Land
Classification: Loamy, mixed, superactive, calcareous, mesic Lithic Ustic torriorthents
Kind: Series

County or Parish: UT015 - Emery
State or Territory: UT - Utah
7.5' Quad: Walker Flat, Utah
UTM: 477516E, 4300469N -- Datum NAD83, Zone 12
Legal Description: Section 33, Township 22 S, Range 6 E

Landscape: plateau
Landform: hillslope
Geomorphic Component: Side Slope
Profile Pos: Backslope
Slope: 11 percent
Elevation: 1861 meters (6105 feet)
Aspect: 350°
Shape: up/down: Linear; across: Linear

Drainage: Well drained
Runoff: Medium
Permeability: Moderately slow
Erosion: Class 2 - Sheet erosion

Primary Earth Cover: Grass/herbaceous cover; Secondary Earth Cover: Grassland rangeland
Existing Vegetation: ATCO - shadscale (Atriplex confertifolia); SAVE4 - greasewood (Sarcobatus vermiculatus)

Parent Materials: Residuum
Bedrock: Calcareous shale at 46 centimeters (18 inches)
Particle Size Control Section: 36 to 46 centimeters (7 to 18 inches)
Diagnostic Features: Lithic contact: 46 centimeters (18 inches)
Restrictions: Lithic bedrock: 46 centimeters (18 inches)
A --- 0 to 18 cm (0 to 7 inches); very pale brown (10YR 7/3) dry, channery loam; pale brown (10YR 6/3) moist; 47 percent sand; 33 percent silt; 20 percent clay; structure; friable, hard, slightly sticky, slightly plastic; common very fine roots throughout; common very fine tubular pores; 2 percent (common) fine irregular moderately cemented carbonate concretions around rock fragments; 15 percent subangular calcareous sandstone channers; electrical conductivity of 1.40 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.5; clear smooth boundary; CaCO3 13.9 percent.

C --- 18 to 46 cm (7 to 18 inches); pale brown (10YR 6/3) dry, channery sandy clay loam; brown (10YR 5/3) moist; 53 percent sand; 25 percent silt; 22 percent clay; medium structure; friable, hard, nonsticky, slightly plastic; common fine roots throughout and common very fine roots throughout; common very fine tubular pores; 2 percent (common) medium irregular moderately cemented carbonate concretions around rock fragments; 5 percent subangular calcareous sandstone flags and 15 percent subangular calcareous sandstone channers; electrical conductivity of 4.39 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.4; abrupt smooth boundary; CaCO3 13.4 percent.

R --- 46 cm (18 inches); hard shale.
Pedon ID: EM-4-09
Description Date: 9/29/2009
Describer: Robert Long

Soil Name as Correlated: Hideout
Classification: Loamy, mixed, superactive, calcareous, mesic Lithic Ustic Torriorthents
Taxon Kind: Series

County or Parish: UT015 - Emery
State or Territory: UT - Utah
7.5' Quad: Walker Flat, Utah
UTM: 477406E, 4300402N -- Datum NAD83, Zone 12
Legal Description: Section 33, Township 22 S, Range 6 E of the Salt Lake Meridian

Landscape: plateau
Landform: structural bench and plateau
Geomorphic Component: Tread
Profile Pos: Summit

Slope: 6 percent
Elevation: 1852 meters (6076.1 feet)
Aspect: 327°
Shape: up/down: Convex; across: Convex
Drainage: Well drained Runoff: Medium Permeability: Moderate
Erosion: Class 2 - Sheet erosion

Primary Earth Cover: Tree cover; Secondary Earth Cover: Conifers
Existing Vegetation: PIED - twoneedle pinyon (Pinus edulis); JUOS - Utah juniper (Juniperus osteosperma); CEMOG - birchleaf mountain mahogany (Cercocarpus montanus var. glaber); ARTRW8 - Wyoming big sagebrush (Artemisia tridentata ssp. wyomingensis); ARNO4 - black sagebrush (Artemisia nova); OPUNT - pricklypear (Opuntia); GUSA2 - broom snakeweed (Gutierrezia sarothrae)

Parent Materials: Eolian
Bedrock: Calcareous sandstone at 20 centimeters (7.9 inches)
Particle Size Control Section: 0 to 20 centimeters (0 to 7.9 inches)
Diagnostic Features: Lithic contact: 20 centimeters (7.9 inches) (Restrictive layer)
Restrictions: Lithic bedrock: 20 centimeters (7.9 inches)
A --- 0 to 6 centimeters (0 to 2.4 inches); very pale brown (10YR 7/3) dry, loamy sand; pale brown (10YR 6/3) moist; 79 percent sand; 14 percent silt; 7 percent clay; weak medium platy parting to single grain structure; very friable, slightly hard, nonsticky, nonplastic; common very fine roots throughout and common fine roots throughout; many very fine interstitial pores; electrical conductivity of 0.69 mmhos/cm by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.7; abrupt smooth boundary; CaCO₃ 6.1 Percent.

C --- 6 to 20 centimeters (2.4 to 7.9 inches); pale brown (10YR 6/3) dry, sandy loam; brown (10YR 5/3) moist; 69 percent sand; 21 percent silt; 10 percent clay; weak medium subangular blocky structure; very friable, hard, nonsticky, nonplastic; many very fine roots throughout, common fine roots throughout and common medium roots throughout; common very fine tubular pores; electrical conductivity of 0.95 mmhos/cm by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.5; abrupt smooth boundary; CaCO₃ 6.4 Percent.

R --- 20 centimeters (7.9 inches); Ferron sandstone.
Pedon ID: EM-5-2009
Description Date: 9/29/2009
Describer: Robert Long

Soil Name As Correlated: Lazear
Classification: Loamy, mixed, superactive, calcareous, mesic Lithic Ustic torriorthents
Pedon Type: Modal pedon for map unit
Pedon Purpose: Full pedon description
Taxon Kind: Series

County or Parish: UT015 - Emery
State or Territory: UT - Utah
7.5' Quad: Walker Flat, Utah
UTM: 477277E, 4300359N -- Datum NAD83, Zone 12
Legal Description: Section 33, Township 22 S, Range 6 E

Landscape: plateau
Landform: hillslope
Geomorphic Component: Side Slope
Slope: 8 percent
Elevation: 1859 meters (6100 feet)
Aspect: 0°
Shape: up/down: Linear; across: Convex

Drainage: Well drained
Runoff: Medium
Permeability: Moderate
Erosion: Class 2 - Sheet erosion

Primary Earth Cover: Grass/herbaceous cover; Secondary Earth Cover: Grassland rangeland
Existing Vegetation: ATCO - shadscale (Atriplex confertifolia); ARNO4 - black sagebrush (Artemisia nova); GUSA2 - broom snakeweed (Gutierrezia sarothrae); POA - bluegrass (Poa)

Parent Materials: Residuum
Bedrock: Calcareous sandstone at 20 centimeters (8 inches)
Particle Size Control Section: 0 to 20 centimeters (0 to 8 inches)
Diagnostic Features: Lithic contact: 20 centimeters (Restrictive layer)
Restrictions: Lithic bedrock: 20 centimeters (8 inches)
A --- 0 to 7 cm (0 to 3 inches); pale brown (10YR 6/3) dry, channery sandy loam; brown (10YR 5/3) moist; 65 percent sand; 22 percent silt; 13 percent clay; moderate medium platy structure; very friable, slightly hard, slightly sticky, slightly plastic; common very fine roots throughout, common fine roots throughout and common medium roots throughout; common very fine tubular pores; 10 percent subangular calcareous sandstone channers and 10 percent subangular calcareous sandstone gravels; electrical conductivity of 0.65 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.8; clear smooth boundary; CaCO3 22.5 percent.

C --- 7 to 20 cm (23 to 8 inches); light yellowish brown (10YR 6/4) dry, channery sandy clay loam; pale brown (10YR 6/3) moist; 63 percent sand; 16 percent silt; 21 percent clay; weak medium subangular blocky structure; friable, slightly hard, slightly sticky, slightly plastic; many very fine roots throughout, common fine roots throughout and common medium roots throughout; common very fine tubular pores; 10 percent subangular calcareous sandstone gravels and 15 percent subangular calcareous sandstone channers; electrical conductivity of 0.57 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.6; abrupt smooth boundary; CaCO3 25.4 percent.

R --- 20 cm (8 inches); Ferron sandstone.
EM-6-09

Pedon ID: EM-6-09
Description Date: 9/30/2009
Describer: Robert Long

Soil Name As Correlated: Persayo family
Current Taxonomic Class: Loamy, mixed, superactive, calcareous, mesic, shallow Typic Torriorthents
Pedon Type: Representative pedon for component
Current Taxon Kind: family

County or Parish: UT015 - Emery
State or Territory: UT - Utah
7.5' Quad: 38111-G3 - Walker Flat, Utah
UTM: 477565E, 4300903N – Datum NAD83, Zone 12
Legal Description: Section 33, Township 22 S, Range 6 E of the Salt Lake Meridian

Landscape: plateaus or tablelands
Landform: canyon
Geomorphic Component: Side Slope
Profile Pos: Backslope
Slope: 78 percent
Elevation: 1811 meters (5940 feet)
Aspect: 90°
Shape: up/down: ; across:
Complexity: Simple

Drainage: Well drained
Runoff: High
Erosion: Class 2 - Sheet erosion

Primary Earth Cover: Shrub cover; Secondary Earth Cover: Shrubby rangeland
Existing Vegetation: ATCO - shadscale (Atriplex confertifolia); ATGA - Gardner's saltbush (Atriplex gardneri)

Parent Materials: moderately weathered, residuum weathered from calcareous shale
Bedrock: Very weakly cemented calcareous shale at 18 centimeters (7.1 inches)
Particle Size Control Section: 0 to 18 centimeters (0 to 7.1 inches)
Diagnostic Features: Paralithic contact: 18 centimeters (7.1 inches)
Restrictions: Paralithic bedrock: 18 to 34 centimeters (7.1 to 13.4 inches) and Paralithic bedrock: 34 centimeters (13.4 inches)
A --- 0 to 7 cm (0 to 3 inches); very pale brown (10YR 7/3) dry, channery loamy sand; pale brown (10YR 6/3) moist; 79 percent sand; 12 percent silt; 9 percent clay; weak medium platy structure parting to single grain; very friable, slightly hard, non-sticky, non-plastic; common very fine and few fine roots; common very fine and few fine tubular pores; 10 percent angular sandstone channers, 5 percent angular strongly cemented sandstone gravels, 5 percent angular sandstone flags, and 1 percent angular sandstone boulders; electrical conductivity of 2.32 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.7; clear smooth boundary; CaCO3 6.4 percent.

2C --- 7 to 18 cm (3 to 7 inches); very pale brown (10YR 7/4) dry, para-channery sandy loam; light yellowish brown (10YR 6/4) moist; 71 percent sand; 15 percent silt; 14 percent clay; weak fine and medium subangular blocky structure; very friable, slightly hard, slightly sticky, non-plastic; many very fine, few fine, few medium roots; common very fine tubular pores; 20 percent angular weakly cemented shale parachanners; electrical conductivity of 2.71 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.7; abrupt smooth boundary; CaCO3 7.5 percent.

2Cr1 --- 18 to 34 cm (7 to 13 inches); decomposing Blue Gate member of the Mancos shale; common very fine and few fine roots; clear smooth boundary.

2Cr2 --- 34 to 38 cm (13 to 15 inches); Blue Gate member of the Mancos shale.
Pedon ID: EM-7-09
Description Date: 9/30/2009
Describer: Robert Long

Soil Name As Correlated: Green River
Classification: Coarse-loamy, mixed, calcareous, mesic Oxyaquic Torrifluvents
Pedon Type: Modal pedon for map unit
Taxon Kind: Series

County or Parish: UT015 - Emery
State or Territory: UT - Utah
7.5' Quad: 38111-G3 - Walker Flat, Utah
UTM: 477190E, 4301339N -- Datum NAD83, Zone 12
Legal Description: Section 32, Township 22 S, Range 6 E of the Salt Lake Meridian

Landscape: valley
Landform: valley floor and stream terrace
Geomorphic Component: Base Slope
Profile Pos: Toeslope
Slope: 2 percent
Elevation: 1797 meters (5895 feet)
Aspect: 152°
Shape: up/down: Convex; across: Linear
Complexity: Simple

Flooding: Occasional; very brief Ponding: Rare; very brief Drainage: Moderately well drained
Runoff: Low
Permeability: Moderate
Erosion:
Primary Earth Cover: Grass/herbaceous cover; Secondary Earth Cover: Grassland rangeland
Existing Vegetation: TAMAR2 - tamarisk (Tamarix); SALIX - willow (Salix)

Parent Materials: Alluvium
Particle Size Control Section: 25 to 100 centimeters (9.8 to 39.4 inches)

A --- 0 to 15 cm (0 to 6 inches); light yellowish brown (2.5Y 6/3) dry, sandy clay loam; light olive brown (2.5Y 5/3) moist; 57 percent sand; 15 percent silt; 28 percent clay; medium platy structure; very friable, slightly hard, nonsticky, nonplastic; electrical conductivity of 2.43 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.5; abrupt smooth boundary; CaCO3 14.4 percent.
2A --- 15 to 28 cm (6 to 11 inches); pale yellow (2.5Y 7/3) dry, silt loam; grayish brown (2.5Y 5/2) moist; 37 percent sand; 52 percent silt; 11 percent clay; moderate medium subangular blocky structure; very friable, hard, nonsticky, nonplastic; common very fine roots throughout and common fine roots throughout; common very fine tubular pores; electrical conductivity of 1.55 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.6; clear smooth boundary; CaCO3 18.3 percent.

2C --- 28 to 43 cm (11 to 17 inches); light gray (2.5Y 7/2) dry, loam; light yellowish brown (2.5Y 6/3) moist; 43 percent sand; 48 percent silt; 9 percent clay; 2 percent medium distinct olive yellow (2.5Y 6/6) and 2 percent fine distinct olive yellow (2.5Y 6/6) mottles; moderate medium subangular blocky structure; very friable, hard, slightly sticky, nonplastic; many very fine roots throughout and common fine roots throughout; common very fine tubular pores; electrical conductivity of 1.36 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.7; clear smooth boundary; CaCO3 15.9 percent.

3A --- 43 to 56 cm (17 to 22 inches); light gray (2.5Y 7/2) dry, silt loam; light olive brown (2.5Y 5/3) moist; 23 percent sand; 56 percent silt; 21 percent clay; 6 percent coarse prominent strong brown (7.5YR 5/8) and 6 percent medium prominent strong brown (7.5YR 5/8) mottles; strong coarse platy structure; very friable, hard, slightly sticky, slightly plastic; common very fine roots throughout and common fine roots throughout; common very fine tubular pores; electrical conductivity of 3.46 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.5; abrupt smooth boundary; CaCO3 19.2 percent.

3C1 --- 56 to 78 cm (22 to 31 inches); light yellowish brown (2.5Y 6/3) dry, sandy loam; light olive brown (2.5Y 5/3) moist; 61 percent sand; 26 percent silt; 13 percent clay; single grain; loose, loose, nonsticky, nonplastic; many very fine interstitial pores; electrical conductivity of 3.67 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.6; clear smooth boundary; CaCO3 19.2 percent.

3C2 --- 78 to 102 cm (31 to 40 inches); light yellowish brown (2.5Y 6/3) dry, loam; dark grayish brown (2.5Y 4/2) moist; 46 percent sand; 37 percent silt; 17 percent clay; massive parting to single grain; very friable, slightly hard, slightly sticky, slightly plastic; many very fine interstitial pores; electrical conductivity of 3.93 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.5; gradual smooth boundary; CaCO3 16.5 percent.
3C3 --- 102 to 130 cm (40 to 51 inches); light yellowish brown (2.5Y 6/3) dry, sandy loam; light olive brown (2.5Y 5/3) moist; 58 percent sand; 33 percent silt; 9 percent clay; single grain and medium structure; very friable, slightly hard, slightly sticky, slightly plastic; many very fine interstitial pores; electrical conductivity of 2.21 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.6; clear smooth boundary; CaCO3 14.5 percent.

3C4 --- 130 to 150 cm (51 to 59 inches); light gray (2.5Y 7/2) dry, sandy loam; light yellowish brown (2.5Y 6/3) moist; 69 percent sand; 25 percent silt; 6 percent clay; single grain; loose, loose, nonsticky, nonplastic; many very fine interstitial pores; electrical conductivity of 1.6 dS/m by EC meter, saturated paste; slightly effervescent by HCl, 1 normal; slightly alkaline, pH 7.7; CaCO3 14.3 percent.
EM-8-09

Pedon ID: EM-8-09  
Description Date: 9/30/2009  
Describer: Robert Long

Soil Name As Correlated: Garley  
Current Taxonomic Class: Coarse-loamy, mixed, superactive, calcareous, mesic Typic Torrifluvents  
Pedon Type: Representative pedon for component  
Current Taxon Kind: Series

County or Parish: UT015 - Emery  
State or Territory: UT - Utah  
UTM: 477585E, 4300886N -- Datum NAD83, Zone 12  
Legal Description: Section 33, Township 22 South, Range 6 East of the 29 Meridian

Landscape: plateau canyon  
Landform: stream terrace  
Geomorphic Component: Base Slope  
Profile Pos: Toeslope  
Slope: 5 percent  
Elevation: 1809 meters (5934 feet)  
Aspect: 45°  
Shape: up/down: Concave; across: Linear  
Complexity: simple

Drainage: Well drained  
Runoff: Medium  
Erosion: Class 2 - Gully erosion

Primary Earth Cover: Shrub cover; Secondary Earth Cover:  
Existing Vegetation: SAVE4 - black greasewood (Sarcobatus vermiculatus); ATCO - shadscale (Atriplex confertifolia); CHRY9 - rabbitbrush (Chrysothamnus); ARNO4 - black sagebrush (Artemisia nova); ACHY - Indian ricegrass (Achnatherum hymenoides)

Parent Materials: alluvium  
Particle Size Control Section: 25 to 100 centimeters (9.8 to 39.4 inches)  
Diagnostic Features: Secondary carbonates: 32 to 88 centimeters (12.6 to 34.6 inches)
A --- 0 to 9 cm (0 to 4 inches); pale yellow (2.5Y 7/3) dry, loamy sand; light yellowish brown (2.5Y 6/3) moist; 79 percent sand; 13 percent silt; 8 percent clay; moderate medium platy structure; friable, hard, slightly sticky, slightly plastic; many very fine roots throughout, few fine roots throughout; common very fine tubular pores; electrical conductivity of 2.25 dS/m by EC meter, saturated paste; slightly effervescent by HCl, 1 normal; strongly alkaline, pH 8.7; clear smooth boundary; CaCO₃ 8.8 percent.

C1 --- 9 to 32 cm (4 to 13 inches); pale yellow (10YR 7/4) dry, loamy sand; light yellowish brown (10YR 6/4) moist; 85 percent sand; 10 percent silt; 5 percent clay; moderate medium subangular blocky structure; friable, hard, nonsticky, nonplastic; common very fine roots throughout, few fine roots throughout, and few medium roots throughout; common very fine tubular pores; electrical conductivity of 3.82 dS/m by EC meter, saturated paste; slightly effervescent by HCl, 1 normal; very strongly alkaline, pH 9.3; abrupt smooth boundary; CaCO₃ 8.9 percent.

C2 --- 32 to 46 cm (13 to 18 inches); pale yellow (10YR 7/4) dry, very gravelly loamy sand; light yellowish brown (10YR 6/4) moist; 85 percent sand; 9 percent silt; 6 percent clay; single grain; loose, loose, nonsticky, nonplastic; common very fine roots throughout; many very fine interstitial pores; 40 percent fine calcareous sandstone gravels; 2 percent thin calcium carbonate coatings on bottom of rock fragments; electrical conductivity of 3.91 dS/m by EC meter, saturated paste; very slightly effervescent by HCl, 1 normal; strongly alkaline, pH 9.3; abrupt wavy boundary; CaCO₃ 8.9 percent.

Ab1 --- 46 to 60 cm (18 to 24 inches); pale yellow (10YR 7/4) dry, loamy sand; light yellowish brown (10YR 6/4) moist; 85 percent sand; 9 percent silt; 6 percent clay; moderate medium subangular blocky structure; friable, very hard, nonsticky, nonplastic; common very fine roots throughout; common very fine tubular pores; electrical conductivity of 8.29 dS/m by EC meter, saturated paste; slightly effervescent by HCl, 1 normal; very strongly alkaline, pH 9.3; clear smooth boundary; CaCO₃ 5.3 percent.

C3 --- 60 to 70 cm (24 to 28 inches); light yellowish brown (10YR 6/4) dry, very gravelly loam; light olive brown (10YR 5/4) moist; 50 percent sand; 40 percent silt; 10 percent clay; single grain; loose, loose, nonsticky, nonplastic; common very fine roots throughout, common fine roots throughout, few medium roots throughout and few coarse roots throughout; many very fine interstitial pores; 50 percent fine calcareous sandstone gravels; 2 percent thin calcium carbonate coatings on bottom of rock fragments; electrical conductivity of 9.77 dS/m by EC meter, saturated paste; very slightly effervescent by HCl, 1 normal; strongly alkaline, pH 8.6; abrupt wavy boundary; CaCO₃ 8.4 percent.
C4  --- 70 to 88 cm (28 to 35 inches); pale yellow (10YR 7/4) dry, sandy loam; light yellowish brown (10YR 6/4) moist; 79 percent sand; 10 percent silt; 11 percent clay; massive; very friable, slightly hard, nonsticky, nonplastic; common very fine roots throughout, and few fine roots throughout; common very fine tubular pores; 2 percent fine masses of carbonate on faces of peds; electrical conductivity of 9.38 dS/m by EC meter, saturated paste; slightly effervescent by HCl, 1 normal; moderately alkaline, pH 7.9; abrupt wavy boundary; CaCO₃ 6.3 percent.

AB2  --- 88 to 98 cm (35 to 66 inches); light yellowish brown (10YR 6/4) dry, very bouldery sandy loam; light olive brown (10YR 5/4) moist; 80 percent sand; 8 percent silt; 12 percent clay; single grain; loose, loose, nonsticky, nonplastic; common very fine roots throughout; many very fine interstitial pores; 50 percent calcareous sandstone boulders; electrical conductivity of 4.35 dS/m by EC meter, saturated paste; slightly effervescent by HCl, 1 normal; slightly alkaline, pH 7.4; abrupt wavy boundary; CaCO₃ 5.5 percent.

C5  --- 98 to 108 cm (35 to 43 inches); light yellowish brown (10YR 6/4) dry, very bouldery sandy loam; light olive brown (10YR 5/4) moist; 77 percent sand; 14 percent silt; 9 percent clay; very friable, slightly hard, nonsticky, nonplastic; common very fine roots throughout; few very fine tubular pores; 50 percent calcareous sandstone boulders; electrical conductivity of 5.54 dS/m by EC meter, saturated paste; slightly effervescent by HCl, 1 normal; slightly alkaline pH 7.7; abrupt smooth boundary; CaCO₃ 6.8 percent.

C6  --- 108 to 120 cm (43 to 47 inches); light yellowish brown (10YR 6/3) dry, extremely bouldery sandy loam; light olive brown (10YR 5/4) moist; 75 percent sand; 13 percent silt; 12 percent clay; very friable, slightly hard, slightly sticky, slightly plastic; many very fine and common fine roots throughout; few very fine tubular pores; 70 percent calcareous sandstone boulders; electrical conductivity of 5.59 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline pH 7.5; clear smooth boundary; CaCO₃ 3.2 percent.

C7  --- 120 to 150 cm (59 inches); light yellowish brown (10YR 6/3) dry, extremely bouldery sandy loam; olive brown (10YR 4/4) moist; 77 percent sand; 11 percent silt; 12 percent clay; very friable, slightly hard, slightly sticky, slightly plastic; common very fine roots throughout; few very fine tubular pores; 70 percent calcareous sandstone boulders; electrical conductivity of 6.17 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline pH 7.5; clear smooth boundary; CaCO₃ 6.0 percent.
Pedon ID: EM-9-09
Description Date: 10/8/2009
Describer: Robert Long
Soil Name As Correlated: Garley
Classification: Coarse-loamy, mixed, superactive, mesic Typic Torrifluvents
Pedon Type: Modal pedon for map unit
Pedon Purpose: Full pedon description
Taxon Kind: Series

County or Parish: UT015 - Emery
State or Territory: UT - Utah
7.5' Quad: 38111-G3 - Walker Flat, Utah
UTM: 477210E, 4300409N -- Datum NAD83, Zone 12
Location Description:
Legal Description: Section 32, Township 22 S, Range 6 E of the Uintah Meridian

Landscape: canyon
Landform: alluvial fan
Geomorphic Component: Base Slope
Profile Pos: Toeslope
Slope: 5 percent
Elevation: 1827 meters (5994 feet)
Aspect: 21°
Shape: up/down: Linear; across: Concave

Drainage: Well drained
Runoff: Medium
Permeability: Moderate
Erosion: Class 2 - Gully erosion

Primary Earth Cover: Grass/herbaceous cover; Secondary Earth Cover: Grassland rangeland
Existing Vegetation: SAVE4 - greasewood (Sarcobatus vermiculatus); ATCO - shadscale (Atriplex confertifolia); ACHY - Indian ricegrass (Achnatherum hymenoides); JUOS - Utah juniper (Juniperus osteosperma)

Parent Materials: Alluvium/ Colluvium
Particle Size Control Section: 25 to 100 centimeters (9.8 to 39.3 inches)
A --- 0 to 9 centimeters (0 to 3.5 inches); pale yellow (2.5Y 7/3) dry, sandy loam; light olive brown (2.5Y 5/3) moist; null percent sand; null percent silt; 6 percent clay; moderate medium platy structure; very friable, slightly hard, nonsticky, nonplastic; common very fine roots throughout, common fine roots throughout and common medium roots throughout; common very fine tubular pores finely disseminated salts throughout; electrical conductivity of 1.01 dS/m by EC meter, saturated paste; slightly effervescent by HCl, 1 normal; moderately alkaline, pH 8.4; clear smooth boundary; CaCO₃ 12.6 Percent.

Ac --- 9 to 25 centimeters (3.5 to 9.8 inches); light yellowish brown (10YR 6/4) dry, sandy loam; yellowish brown (10YR 5/4) moist; null percent sand; null percent silt; 9 percent clay; moderate medium subangular blocky structure; friable, hard, nonsticky, nonplastic; common very fine roots throughout, common fine roots throughout, common medium roots throughout and common coarse roots throughout; common very fine tubular pores finely disseminated salts throughout; electrical conductivity of 2.03 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; strongly alkaline, pH 8.6; clear smooth boundary; CaCO₃ 12 Percent.

C2 --- 25 to 49 centimeters (9.8 to 19.3 inches); light yellowish brown (10YR 6/4) dry, sandy loam; yellowish brown (10YR 5/4) moist; null percent sand; null percent silt; 8 percent clay; structure; friable, very hard, nonsticky, nonplastic; common very fine roots throughout, common fine roots throughout, common medium roots throughout and common coarse roots throughout; common very fine tubular pores finely disseminated salts throughout; electrical conductivity of 13.5 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; moderately alkaline, pH 8.4; clear smooth boundary; CaCO₃ 12.9 Percent.

C2 --- 49 to 75 centimeters (19.3 to 29.5 inches); light yellowish brown (10YR 6/4) dry, sandy loam; yellowish brown (10YR 5/4) moist; null percent sand; null percent silt; 10 percent clay; weak medium subangular blocky structure; very friable, moderately hard, nonsticky, nonplastic; common very fine roots throughout, common fine roots throughout, common medium roots throughout and common coarse roots throughout; common very fine tubular pores; medium distinct strongly cemented masses of carbonate on vertical faces of peds; electrical conductivity of 15.9 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; strongly alkaline, pH 8.6; gradual smooth boundary; CaCO₃ 11.7 Percent.

C3 --- 75 to 120 centimeters (29.5 to 47.2 inches); light yellowish brown (2.5Y 6/4) dry, sandy loam; light olive brown (2.5Y 5/4) moist; null percent sand; null percent silt; 10 percent clay; weak medium subangular blocky structure; very friable, slightly hard, nonsticky, nonplastic; common very fine roots throughout, common fine roots throughout, common medium roots throughout and common coarse roots throughout; common very fine tubular pores; 5 percent (common) fine faint masses of carbonate on vertical faces of peds; strongly effervescent by HCl, 1 normal; electrical conductivity of 11.3 dS/m
by EC meter, saturated paste; strongly alkaline, pH 8.5; clear smooth boundary; CaCO₃ 12.2 Percent.

2Bk --- 120 to 168 centimeters (47.2 to 66.1 inches); very pale brown (10YR 7/4) dry, very channery sandy loam; yellowish brown (10YR 5/4) moist; null percent sand; null percent silt; 8 percent clay; subangular blocky and medium structure; very friable, slightly hard, nonsticky, nonplastic; common very fine roots throughout, common fine roots throughout and common medium roots throughout; many very fine interstitial pores; 4 percent (common) faint carbonate concretions on bottom of rock fragments; 10 percent shale cobbles and 35 percent calcareous sandstone channers; electrical conductivity of 8.55 dS/m by EC meter, saturated paste; violently effervescent by HCl, 1 normal; strongly alkaline, pH 8.6; CaCO₃ 23.2 Percent.
Pedon ID: EM-10-09
Description Date: 10/8/2009
Describer: Robert Long

Soil Name As Correlated: Braf
Classification: Coarse-loamy, mixed, superactive, calcareous, mesic Lithic Torriorthents
Pedon Type: Modal pedon for map unit
Taxon Kind: Series

County or Parish: UT015 - Emery
State or Territory: UT - Utah
7.5' Quad: 38111-G3 - Walker Flat, Utah
UTM: 477094E, 4300475N -- Datum NAD83, Zone 12
Location Description:
Legal Description: Section 32, Township 22 S, Range 6 E

Landscape: plateau
Landform: hillslope
Tread Profile Pos: Summit
Slope: 7 percent
Elevation: 1840 meters (6036 feet)
Aspect: 343°
Shape: up/down: Convex; across: Convex

Drainage: Well drained
Runoff: Medium
Permeability: Moderately rapid
Erosion: Class 2 - Sheet erosion

Primary Earth Cover: Shrub cover
Existing Vegetation: ATCO - shadscale (Atriplex confertifolia); SAME3 - black sage (Salvia mellifera); ACHY - Indian ricegrass (Achnatherum hymenoides); OPUNT - pricklypear (Opuntia)

Parent Materials: Residuum
Bedrock: Calcareous sandstone at 45 centimeters (18 inches)
Particle Size Control Section: 25 to 47 centimeters (9.8 to 18 inches)
Diagnostic Features: Lithic contact: 45 centimeters (Restrictive layer)
Restrictions: Lithic bedrock: 45 centimeters (18 inches)
Notes: this profile does not meet requirements of a calcic horizon due to less than 5 percent identifiable secondary carbonates.

A --- 0 to 7 cm (0 to 3 inches); pale yellow (2.5Y 7/3) dry, loamy sand; light yellowish brown (2.5Y 6/3) moist; 84 percent sand; 8 percent silt; 8 percent clay; weak medium platy parting to single grain structure; very friable, slightly hard, nonsticky, nonplastic; many very fine roots throughout, common fine roots throughout and common medium roots throughout; common very fine tubular pores; 10 percent subangular calcareous sandstone gravels; electrical conductivity of 0.64 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; moderately alkaline, pH 7.9; clear smooth boundary; CaCO₃ 13.5 percent.

C1 --- 7 to 27 cm (3 to 11 inches); light yellowish brown (2.5Y 6/4) dry, sandy loam; light olive brown (2.5Y 5/3) moist; 70 percent sand; 20 percent silt; 10 percent clay; structure; very friable, moderately hard, nonsticky, nonplastic; common very fine roots throughout, common fine roots throughout and common medium roots throughout; common very fine tubular pores; 2 percent (very few) fine calcium carbonate coats on bottom of rock fragments; 10 percent subangular calcareous sandstone gravels; electrical conductivity of 0.50 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.8; clear smooth boundary; CaCO₃ 22.2 percent.

C2 --- 27 to 45 cm (11 to 18 inches); pale yellow (2.5Y 7/4) dry, flaggy sandy loam; light yellowish brown (2.5Y 6/4) moist; 76 percent sand; 16 percent silt; 8 percent clay; single grain; loose, loose, nonsticky, nonplastic; common very fine roots throughout and common fine roots throughout; common very fine tubular pores; 2 percent (very few) fine calcium carbonate coats on bottom of rock fragments; 20 percent subangular calcareous sandstone flags and 10 percent subangular calcareous sandstone channers; electrical conductivity of 1.97 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.6; abrupt smooth boundary; CaCO₃ 18.7 percent.

R --- 45 cm (18 inches); Ferron sandstone.
EM-11-09

Pedon ID: EM-11-09
Description Date: 10/8/2009
Describer: Robert Long

Soil Name As Correlated: Braf
Current Taxonomic Name: Braf
Current Taxonomic Class: Loamy, mixed, superactive, calcareous, mesic Lithic Torriorthents
Pedon Type: Confirmation description
Current Taxon Kind: Series

County or Parish: UT015 - Emery
State or Territory: UT - Utah
UTM: 477103E, 4300766N -- Datum NAD83, Zone 12
Legal Description: Section 32, Township 22 South, Range 6 East of the 29 Meridian

Landscape: plateau
Landform: hillslope
Geomorphic Component: Side Slope
Profile Pos: Backslope
Slope: 10 percent
Elevation: 1828 meters (5997 feet)
Aspect: 330°
Shape: up/down: Linear; across: Convex
Complexity: simple

Drainage: Well drained
Runoff: Medium
Erosion: Class 3 - Sheet erosion

Primary Earth Cover: Shrub cover;
Existing Vegetation: ATCO - shadscale (Atriplex confertifolia); ACHY - Indian ricegrass
(Achnatherum hymenoides); ARNO4 - black sagebrush (Artemisia nova); OPPO - plains
pricklypear (Opuntia polyacantha)

Parent Materials: residuum
Bedrock: Strongly cemented calcareous sandstone at 8 centimeters (3.1 inches)
Particle Size Control Section: 0 to 18 centimeters (0 to 7.1 inches)
Diagnostic Features: Lithic contact: 8 centimeters (3.1 inches)
Restrictions: Lithic bedrock: 8 centimeters (3.1 inches)
A --- 0 to 3 centimeters (0 to 1.2 inches); very pale brown (10YR 7/3) dry, channery sandy loam; light yellowish brown (10YR 6/4) moist; 70 percent sand; 14 percent silt; 16 percent clay; moderate medium platy structure; very friable, slightly hard, nonsticky, nonplastic; common fine roots throughout and common very fine roots throughout; common very fine tubular pores; 5 percent subangular calcareous sandstone gravels and 10 percent subangular calcareous sandstone channers; electrical conductivity of 1.55 mmhos/cm by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.6, pH meter; abrupt smooth boundary; CaCO₃ 20.5 Percent.

C --- 3 to 8 centimeters (1.2 to 3.1 inches); very pale brown (10YR 7/4) dry, sandy loam; brownish yellow (10YR 6/6) moist; 70 percent sand; 14 percent silt; 16 percent clay; moderate fine subangular blocky structure; very friable, slightly hard, slightly sticky, nonplastic; common fine roots throughout and common very fine roots throughout; common very fine tubular pores; 5 percent subangular calcareous sandstone gravels; electrical conductivity of 1.55 mmhos/cm by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.6, pH meter; abrupt smooth boundary; CaCO₃ 20.5 Percent.

R --- 8 centimeters (3.1 inches); Ferron sandstone.
EM-12-09

Pedon ID: EM-12-09
Description Date: 10/8/2009
Describer: Robert Long

Soil Name As Correlated: Garley, moderately well drained
Classification: Coarse-loamy, mixed, active, calcareous, mesic Typic Torrifuvents
Pedon Type: Modal pedon for map unit
Pedon Purpose: Full pedon description
Taxon Kind: Series

County or Parish: UT015 - Emery
State or Territory: UT - Utah
7.5' Quad: 38111-G3 - Walker Flat, Utah
UTM: 477106E, 4301242N -- Datum NAD83, Zone 12
Legal Description: Section 32, Township 22 South, Range 6 East

Landscape: valley
Landform: stream terrace
Geomorphic Component: Base Slope
Profile Pos: Toeslope
Slope: 3 percent
Elevation: 1802 meters (5912.1 feet)
Aspect: 56°
Shape: up/down: Linear; across: Linear
Complexity: Simple

Flooding: Rare; extremely brief Ponding: Rare; very brief Drainage: Moderately well drained
Runoff: Low
Permeability: Moderately rapid
Erosion: Class 3 - Tunnel erosion

Primary Earth Cover: Shrub cover; Secondary Earth Cover: Shrubby rangeland
Existing Vegetation: SAVE4 - greasewood (Sarcobatus vermiculatus)

Parent Materials: Alluvium
Particle Size Control Section: 25 to 100 centimeters (9.8 to 39.4 inches)
A --- 0 to 15 cm (0 to 6 inches); light gray (2.5Y 7/2) dry, loam; light olive brown (2.5Y 5/3) moist; 48 percent sand; 38 percent silt; 14 percent clay; moderate coarse platy structure; friable, very hard, slightly sticky, nonplastic; common very fine roots throughout; common very fine tubular pores; electrical conductivity of 6.54 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; moderately alkaline, pH 8.1; clear smooth boundary; CaCO_3 17.5 percent.

C1 --- 15 to 35 cm (6 to 14 inches); light yellowish brown (2.5Y 6/3) dry, sandy loam; light olive brown (2.5Y 5/3) moist; 54 percent sand; 30 percent silt; 16 percent clay; moderate medium subangular blocky structure; friable, very hard, nonsticky, nonplastic; common very fine roots throughout, common fine roots throughout and common medium roots throughout; common very fine tubular pores; electrical conductivity of 8.97 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; moderately alkaline, pH 8.1; unable to dig with shovel; clear smooth boundary; CaCO_3 18.7 percent.

C2 --- 35 to 46 cm (14 to 18 inches); light yellowish brown (2.5Y 6/3) dry, sandy loam; light olive brown (2.5Y 5/3) moist; 64 percent sand; 25 percent silt; 11 percent clay; weak fine and medium subangular blocky structure; friable, hard, nonsticky, nonplastic; common very fine roots throughout, common fine roots throughout and common medium roots throughout; common very fine tubular pores; electrical conductivity of 8.60 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; moderately alkaline, pH 8.2; gradual smooth boundary; CaCO_3 14.3 percent.

C3 --- 46 to 72 cm (18 to 28 inches); light yellowish brown (2.5Y 6/3) dry, loam; light olive brown (2.5Y 5/3) moist; 46 percent sand; 38 percent silt; 16 percent clay; weak medium subangular blocky structure; friable, hard, nonsticky, nonplastic; common very fine roots throughout, common fine roots throughout and common medium roots throughout; common very fine tubular pores; 5 percent (common) fine masses of carbonate on vertical faces of peds; electrical conductivity of 8.88 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; moderately alkaline, pH 8.3; gradual smooth boundary; CaCO_3 16.1 percent.

Ab --- 72 to 102 cm (28 to 40 inches); light yellowish brown (2.5Y 6/3) dry, sandy loam; grayish brown (2.5Y 5/2) moist; 54 percent sand; 34 percent silt; 12 percent clay; weak medium subangular blocky structure; very friable, slightly hard, nonsticky, nonplastic; common very fine roots throughout, common fine roots throughout and common medium roots throughout; common very fine tubular pores; 2 percent (common) fine masses of carbonate on vertical faces of peds; electrical conductivity of 12.1 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; moderately alkaline, pH 8.4; clear smooth boundary; CaCO_3 14.6 percent.
C4 --- 102 to 130 cm (40 to 52 inches); light yellowish brown (2.5Y 6/3) dry, sandy loam; grayish brown (2.5Y 5/2) moist; 54 percent sand; 34 percent silt; 12 percent clay; weak medium subangular blocky structure; very friable, hard, nonsticky, nonplastic; common very fine roots throughout; common very fine tubular pores; 1 percent (few) fine masses of carbonate on vertical faces of peds; electrical conductivity of 5.55 dS/m by EC meter, saturated paste; electrical conductivity of 12.6 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; moderately alkaline, pH 8.4; clear smooth boundary; CaCO₃ 15.2 percent.

C5 --- 130 to 164 cm (52 to 65 inches); light yellowish brown (2.5Y 6/3) dry, sandy loam; grayish brown (2.5Y 5/2) moist; 54 percent sand; 30 percent silt; 16 percent clay; 2 percent fine prominent brownish yellow (10YR 6/6) mottles; moderate medium subangular blocky structure; friable, very hard, nonsticky, nonplastic; common very fine roots throughout; common very fine tubular pores; 2 percent (common) fine prominent spherical very weakly cemented masses of oxidized iron clear in matrix; 1 percent (few) fine masses of carbonate on vertical faces of peds; electrical conductivity of 9.64 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; moderately alkaline, pH 8.3; CaCO₃ 14.8 percent.
EM-13-09

Pedon ID: EM-13-09
Description Date: 10/8/2009
Describer: Robert Long

Soil Name As Correlated: Persayo
Classification: Loamy, mixed, superactive, calcareous, mesic, shallow Typic Torriorthents
Pedon Type: Modal pedon for map unit
Taxon Kind: Series

County or Parish: UT015 - Emery
State or Territory: UT - Utah
7.5' Quad: 38111-G3 - Walker Flat, Utah
UTM: 476873E, 4300442N -- Datum NAD83, Zone 12
Legal Description: Section 32, Township 22 S, Range 6 E

Landscape: plateau
Landform: hillslope
Geomorphic Component: Side Slope
Profile Pos: Backslope
Slope: 42 percent
Elevation: 1832 meters (6012 feet)
Aspect: 230°
Shape: up/down: Linear; across: Convex

Drainage: Well drained
Runoff: High
Permeability: Moderately slow
Erosion: Class 3 - Sheet erosion

Primary Earth Cover: Grass/herbaceous cover;
Existing Vegetation: ATCO - shadscale (Atriplex confertifolia)

Parent Materials: Residuum
Bedrock: Calcareous shale at 40 centimeters
Particle Size Control Section: 25 to 40 centimeters
Diagnostic Features: Paralithic contact: 40 centimeters (Restrictive layer)

Restrictions: Paralithic bedrock: 40 centimeters (15.8 inches)
A --- 0 to 10 centimeters (0 to 3.9 inches); light yellowish brown (2.5Y 6/3) dry, very gravelly clay loam; dark grayish brown (2.5Y 4/2) moist; 33 percent sand; 40 percent silt; 27 percent clay; weak fine subangular blocky structure; friable, hard, slightly sticky, slightly plastic; common very fine roots throughout; common very fine tubular pores; 20 percent angular calcareous shale channers and 40 percent angular calcareous shale gravels; strongly effervescent by HCl, 1 normal; moderately alkaline, pH 8.4; clear smooth boundary.

C --- 10 to 40 centimeters (3.9 to 15.8 inches); light brownish gray (2.5Y 6/2) dry, silty clay loam; grayish brown (2.5Y 5/2) moist; 10 percent sand; 68 percent silt; 32 percent clay; moderate medium subangular blocky structure; friable, hard, slightly sticky, slightly plastic; common very fine roots throughout; common very fine tubular pores; 10 percent flat angular very weakly cemented calcareous shale parachanners; strongly effervescent by HCl, 1 normal; moderately alkaline, pH 8.4; clear smooth boundary.

Cr --- 40 centimeters (15.8 inches); weathered Mancos shale.
EM-14-09

Pedon ID: EM-14-09
Description Date: 11/12/2009
Describer: Robert Long

Soil Name As Correlated: Braf
Current Taxonomic Name: Braf
Current Taxonomic Class: Loamy, mixed, superactive, calcareous, mesic Lithic Torriorthents
Pedon Type: Confirmation description
Current Taxon Kind: Series

County or Parish: UT015 - Emery
State or Territory: UT - Utah
UTM: 477475E, 4300929N -- Datum NAD83, Zone 12
Legal Description: Section 33, Township 22 South, Range 6 East of the 29 Meridian

Landscape: plateaus or tablelands
Landform: hillslope
Geomorphic Component: Tread
Profile Pos: Shoulder
Slope: 8 percent
Elevation: 1855 meters (6086 feet)
Aspect: 340°
Shape: up/down: Convex; across: Linear
Complexity: Simple

Drainage: Well drained
Runoff: Medium
Erosion: Class 2 - Wind erosion

Primary Earth Cover: Shrub cover;
Existing Vegetation: ATCO - shadscale (Atriplex confertifolia); BOGR2 - blue grama (Bouteloua gracilis)

Parent Materials: residuum weathered from calcareous sandstone
Bedrock: Strongly cemented calcareous sandstone at 48 centimeters (18.9 inches)
Particle Size Control Section: 25 to 48 centimeters (9.8 to 18.9 inches)
Diagnostic Features: Lithic contact: 48 centimeters (18.9 inches)
Restrictions: Lithic bedrock: 48 centimeters (18.9 inches)
A --- 0 to 12 centimeters (0 to 4.7 inches); pale brown (10YR 6/3) dry, channery sandy loam; brown (10YR 5/3) moist; null percent sand; null percent silt; 6 percent clay; weak medium subangular blocky structure; very friable, slightly hard, moderately sticky, nonplastic; common medium roots throughout, common fine roots throughout and many very fine roots throughout; common very fine dendritic tubular and many very fine interstitial pores; 3 percent (very few) carbonate coats on bottom surfaces of rock fragments; 15 percent subangular calcareous sandstone channers and 10 percent subangular calcareous sandstone gravels; strongly effervescent by HCl, 1 normal; neutral, pH 7.3, pH meter; clear smooth boundary.

C1 --- 12 to 38 centimeters (4.7 to 15 inches); light yellowish brown (10YR 6/4) dry, gravelly sandy loam; yellowish brown (10YR 5/4) moist; null percent sand; null percent silt; 6 percent clay; moderate medium subangular blocky structure; very friable, slightly hard, nonsticky, nonplastic; common fine roots throughout and common very fine roots throughout; many very fine interstitial pores; 4 percent (very few) carbonate coats on bottom surfaces of rock fragments; 5 percent subangular calcareous sandstone channers and 15 percent subangular calcareous sandstone gravelly; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.5, pH meter; clear smooth boundary.

C2 --- 38 to 48 centimeters (15 to 18.9 inches); very pale brown (10YR 7/3) dry, gravelly loamy sand; pale brown (10YR 6/3) moist; null percent sand; null percent silt; 4 percent clay; weak medium subangular blocky structure; very friable, slightly hard, nonsticky, nonplastic; common very fine roots throughout; many very coarse interstitial pores; 2 percent (very few) carbonate coats on bottom surfaces of rock fragments; 15 percent subangular calcareous sandstone gravels; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.4, pH meter; abrupt smooth boundary.

R --- 48 centimeters (18.9 inches); Ferron sandstone.
Pedon ID: EM-15-09  
Description Date: 11/12/2009  
Describer: Robert Long

Soil Name As Correlated: Persayo  
Current Taxonomic Name: Persayo  
Current Taxonomic Class: Loamy, mixed, superactive, calcareous, mesic, shallow Typic Torriorthents  
Pedon Type: Confirmation description  
Current Taxon Kind: Series

County or Parish: UT015 - Emery  
State or Territory: UT - Utah  
Lat/Long:  
UTM: 477421E, 4300927N -- Datum NAD83, Zone 12  
Legal Description: Section 33, Township 22 South, Range 6 East of the 29 Meridian

Landscape: plateau  
Landform: hillslope  
Geomorphic Component: Side Slope  
Profile Pos: Backslope  
Slope: 12 percent  
Elevation: 1852 meters (6076.1 feet)  
Aspect: 40°  
Shape: up/down: Convex; across: Convex

Drainage: Well drained  
Runoff: High  
Erosion: Class 2 - Sheet erosion

Primary Earth Cover: Shrub cover;  
Existing Vegetation: ATCO - shadscale (Atriplex confertifolia)

Parent Materials: Residuum  
Bedrock: Calcareous shale at 48 centimeters (18.9 inches)  
Particle Size Control Section: 25 to 48 centimeters (9.8 to 18.9 inches)  
Diagnostic Features: Paralithic contact: 48 centimeters (18.9 inches)  
Restrictions: Paralithic bedrock: 48 centimeters (18.9 inches)
A --- 0 to 17 centimeters (0 to 6.7 inches); light yellowish brown (2.5Y 6/3) dry, channery loam; light olive brown (2.5Y 5/3) moist; null percent sand; null percent silt; 22 percent clay; moderate medium subangular blocky structure; friable, hard, slightly sticky, slightly plastic; common fine roots throughout and common very fine roots throughout; common fine dendritic tubular and common very fine dendritic tubular pores; 5 percent subangular calcareous sandstone gravels and 15 percent angular calcareous shale channers; strongly effervescent by HCl, 1 normal; clear smooth boundary.

Cr --- 17 to 48 centimeters (6.7 to 18.9 inches); light yellowish brown (2.5Y 6/4) dry, loam; light olive brown (2.5Y 5/3) moist; null percent sand; null percent silt; 23 percent clay; weak fine subangular blocky structure; friable, hard, slightly sticky, slightly plastic; common very fine roots throughout; common very fine dendritic tubular pores; strongly effervescent by HCl, 1 normal; gradual smooth boundary.

A --- 48 centimeters (18.9 inches); weathered Mancos shale.
EM-16-09

Pedon ID: EM-16
Site ID: EM-16
Description Date: 11/12/2009
Print Date: 1/8/2010
Describer: Robert Long
Soil Name As Described/Sampled: Monue family
Soil Name As Correlated:
Classification: Coarse-loamy, mixed, superactive, mesic Typic Haplocambids
Pedon Type: Modal pedon for map unit
Pedon Purpose: Full pedon description
Taxon Kind: Series

County or Parish: UT015 - Emery
State or Territory: UT - Utah
7.5' Quad: 38111-G3 - Walker Flat, Utah
UTM: 477110E, 4300392N -- Datum NAD83, Zone 12
Location Description:
Legal Description: Section 32, Township 22 S, Range 6 E of the Salt Lake Meridian

Landscape: canyon
Landform: alluvial fan and stream terrace
Geomorphic Component: Base Slope
Profile Pos: Toeslope
Slope: 7 percent
Elevation: 1844 meters (6050 feet)
Aspect: 120°
Shape: up/down: Concave; across: Linear
Complexity: Simple

Drainage: Well drained
Runoff: Medium
Permeability: Moderately rapid
Erosion: Class 2 - Gully erosion

Primary Earth Cover: Shrub cover; Secondary Earth Cover: Shrubby rangeland
Existing Vegetation: SAVE4 - greasewood (Sarcobatus vermiculatus); ACHY - Indian ricegrass (Achnatherum hymenoides)

Parent Materials: Alluvium
Particle Size Control Section: 25 to 100 centimeters (9.8 to 39.4 inches)
Diagnostic Features: Cambic horizon: 8 to 21 centimeters (3.1 to 8.3 inches)
**A1** --- 0 to 8 cm (0 to 3 inches); light yellowish brown (2.5Y 6/3) dry, sandy loam gravel; light olive brown (2.5Y 5/3) moist; 64 percent sand; 28 percent silt; 8 percent clay; weak medium subangular blocky parting to single grain structure; very friable, slightly hard, nonsticky, nonplastic; common very fine roots throughout and common fine roots throughout; many very fine interstitial pores; 1 percent subangular calcareous sandstone gravels; electrical conductivity of 1.01 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.7; clear smooth boundary; CaCO₃ 13.4 percent.

**Bw1** --- 8 to 21 cm (3 to 8 inches); pale yellow (2.5Y 7/3) dry, sandy loam; light olive brown (2.5Y 5/3) moist; 68 percent sand; 24 percent silt; 8 percent clay; structure; very friable, hard, nonsticky, nonplastic; common very fine roots throughout and common fine roots throughout; many very fine interstitial pores; electrical conductivity of 0.43 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.6; clear smooth boundary; CaCO₃ (Exists in NASIS Horizon) 11.4 percent.

**Bw2** --- 21 to 46 cm (8 to 18 inches); pale yellow (2.5Y 7/3) dry, sandy loam; light olive brown (2.5Y 5/3) moist; 58 percent sand; 33 percent silt; 9 percent clay; moderate medium subangular blocky structure; very friable, slightly hard, nonsticky, nonplastic; common very fine roots throughout and common fine roots throughout; many very fine interstitial pores; electrical conductivity of 0.43 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.5; clear smooth boundary; CaCO₃ 11.6 percent.

**C2** --- 46 to 80 cm (18 to 31 inches); light yellowish brown (2.5Y 6/4) dry, sandy loam; light olive brown (2.5Y 5/3) moist; 60 percent sand; 28 percent silt; 12 percent clay; single grain; very friable, slightly hard, nonsticky, nonplastic; common very fine roots throughout; many very fine interstitial pores; 1 percent (few) carbonate concretions on bottom of rock fragments; 2 percent subangular calcareous sandstone gravels; electrical conductivity of 0.45 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.5; gradual smooth boundary; CaCO₃ 13 percent.

**C3** --- 80 to 122 cm (31 to 48 inches); light yellowish brown (2.5Y 6/4) dry, sandy loam; light olive brown (2.5Y 5/3) moist; 70 percent sand; 22 percent silt; 8 percent clay; single grain; very friable, slightly hard, nonsticky, nonplastic; common very fine roots throughout; many very coarse interstitial pores; electrical conductivity of 5.89 dS/m by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.7; gradual smooth boundary; CaCO₃ 12.9 percent.
2C --- 122 to 170 cm (48 to 67 inches); light yellowish brown (10YR 6/4) dry, sandy loam; yellowish brown (10YR 5/4) moist; 68 percent sand; 24 percent silt; 8 percent clay; single grain; very friable, slightly hard, nonsticky, nonplastic; common very fine roots throughout; many very fine interstitial pores; 1 percent (few) salt masses in matrix and 1 percent (few) carbonate concretions on bottom of rock fragments; 4 percent subangular calcareous sandstone channers; electrical conductivity of 9.6 dS/m by EC meter, saturated paste; violently effervescent by HCl, 1 normal; moderately alkaline, pH 8; CaCO3 12.3 percent.
Pedon ID: EM-17-09
Description Date: 11/12/2009
Describer: Robert Long

Soil Name As Correlated: Hideout
Current Taxonomic Class: Loamy, mixed, superactive, calcareous, mesic Lithic Ustic Torriorthents
Pedon Type: Confirmation description
Current Taxon Kind: Series

County or Parish: UT015 - Emery
State or Territory: UT - Utah
UTM: 477229E, 4300406N -- Datum NAD83, Zone 12
Legal Description: Section 32, Township 22 South, Range 6 East of the 29 Meridian
Landscape: plateau

Landform: structural bench and canyon
Geomorphic Component: Free face
Profile Pos: Footslope
Slope: 10 percent
Elevation: 1843 meters (6045 feet)
Aspect: 345°
Shape: up/down: Convex; across: Linear

Drainage: Well drained
Runoff: Medium
Erosion: Class 2 - Sheet erosion

Primary Earth Cover: Tree cover; Secondary Earth Cover: Shrubby rangeland
Existing Vegetation: PIED - twoneedle pinyon (Pinus edulis); JUOS - Utah juniper (Juniperus osteosperma); AMUT - Utah serviceberry (Amelanchier utahensis); ARTRW8 - Wyoming big sagebrush (Artemisia tridentata ssp. wyomingensis)

Parent Materials: residuum weathered from calcareous sandstone
Bedrock: Moderately cemented calcareous sandstone
Particle Size Control Section: 0 to 19 centimeters (0 to 7.5 inches)
Diagnostic Features: Lithic contact: 19 centimeters (7.5 inches)
Restrictions: Lithic bedrock: 19 centimeters (7.5 inches)
A --- 0 to 4 centimeters (0 to 1.6 inches); pale brown (10YR 6/3) dry, very channery loamy sand; brown (10YR 4/3) moist; null percent sand; null percent silt; 6 percent clay; moderate fine platy structure; very friable, slightly hard, nonsticky, nonplastic; common very fine roots throughout; many very fine interstitial pores; 15 percent subangular calcareous sandstone flags and 30 percent subangular calcareous sandstone channers; strongly effervescent; abrupt smooth boundary.

C --- 4 to 19 centimeters (1.6 to 7.5 inches); brown (10YR 5/3) dry, channery sandy loam; brown (10YR 4/3) moist; null percent sand; null percent silt; 8 percent clay; weak medium subangular blocky and weak fine subangular blocky structure; very friable, slightly hard, nonsticky, nonplastic; common fine roots throughout and common very fine roots throughout; many very fine interstitial pores; 5 percent flat subangular calcareous sandstone flags and 20 percent subangular calcareous sandstone channers; strongly effervescent; abrupt smooth boundary.

R --- 19 centimeters (7.5 inches); Ferron sandstone.
Pedon ID: EM-1-16  
Description Date: 6/9/2016  
Describer: Robert Long  

Soil Name As Correlated: Monue family  
Current Taxonomic Name: Monue family  
Current Taxonomic Class: Coarse-loamy, mixed, superactive, mesic Typic Haplocambids  
Pedon Type: Confirmation description  
Current Taxon Kind: Family  

County or Parish: UT015 - Emery  
State or Territory: UT - Utah  
UTM: 477468E, 4300731N -- Datum NAD83, Zone 12  
Legal Description: Section 33, Township 22 South, Range 6 East of the 29 Meridian  

Landscape: plateau  
Landform: alluvial fan and canyon  
Geomorphic Component: Base Slope  
Profile Pos: Toeslope  
Slope: 5 percent  
Elevation: 1818 meters (5965 feet)  
Aspect: 40°  
Shape: up/down: Linear; across: Concave  
Complexity: Simple  

Drainage: Well drained  
Runoff: Low  
Erosion: Class 2 - Gully erosion  

Primary Earth Cover: Shrub cover;  
Existing Vegetation: SAVE4 - black greasewood (Sorobatus vermiculatus); ATCA2 - fourwing saltbush (Atriplex canescens); ATCO - shadscale (Atriplex confertifolia); BRTE - cheatgrass (Bromus tectorum)  

Parent Materials: slightly weathered, alluvium derived from sandstone and shale  
Particle Size Control Section: 25 to 100 centimeters (9.8 to 39.4 inches)  
Diagnostic Features: Cambic horizon: 12 to 75 centimeters (4.7 to 29.5 inches) and Secondary carbonates: 40 to 75 centimeters (15.7 to 29.5 inches)
A --- 0 to 12 centimeters (0 to 4.7 inches); pale yellow (2.5Y 7/4) dry, sandy loam; light olive brown (2.5Y 5/4) moist; null percent sand; null percent silt; 8 percent clay; weak medium platy parting to single grain structure; very friable, hard, nonsticky, nonplastic; electrical conductivity of 0.3 mmhos/cm by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; neutral, pH 7.2, pH meter; clear smooth boundary.

Bk1 --- 12 to 40 centimeters (4.7 to 15.7 inches); light yellowish brown (2.5Y 6/4) dry, sandy loam; light olive brown (2.5Y 5/4) moist; null percent sand; null percent silt; 10 percent clay; weak medium subangular blocky parting to single grain structure; very friable, slightly hard, nonsticky, nonplastic; electrical conductivity of 0.4 mmhos/cm by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; slightly alkaline, pH 7.4, pH meter; gradual smooth boundary.

Bk2 --- 40 to 75 centimeters (15.7 to 29.5 inches); pale yellow (2.5Y 7/4) dry, loamy sand; light yellowish brown (2.5Y 6/4) moist; null percent sand; null percent silt; 6 percent clay; weak medium subangular blocky parting to single grain structure; very friable, slightly hard, nonsticky, nonplastic; 2 percent (very few) discontinuous carbonate coats on bottom surfaces of rock fragments; 5 percent subangular calcareous sandstone gravels; electrical conductivity of 1.4 mmhos/cm by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; neutral, pH 7.3, pH meter; clear smooth boundary.

C --- 75 to 110 centimeters (29.5 to 43.3 inches); light yellowish brown (2.5Y 6/4) dry, sandy loam; light olive brown (2.5Y 5/4) moist; null percent sand; null percent silt; 8 percent clay; single grain; loose, loose, nonsticky, nonplastic; 2 percent subangular calcareous sandstone gravels; electrical conductivity of 2 mmhos/cm by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; neutral, pH 7.3, pH meter.
EM-2-16

Pedon ID: EM-2-16
Description Date: 6/9/2016
Describer: Robert Long

Soil Name As Described/Sampled:
Current Taxonomic Name: Hideout
Current Taxonomic Class: Loamy, mixed, superactive, calcareous, mesic Lithic Ustic
Torriorthents
Pedon Type: Confirmation description
Current Taxon Kind: Series

County or Parish: UT015 - Emery
State or Territory: UT - Utah
UTM: 477309E, 4300606N -- Datum NAD83, Zone 12
Legal Description: Section 32, Township 22 South, Range 6 East of the 29 Meridian

Landscape: plateau
Landform: structural bench and canyon
Geomorphic Component: Free face
Profile Pos: Backslope
Slope: 8 percent
Elevation: 1833 meters (6014 feet)
Aspect: 265°
Shape: up/down: Linear; across: Linear
Complexity: complex

Drainage: Well drained
Runoff: High
Erosion: Class 2 - Sheet erosion

Primary Earth Cover: Tree cover;
Existing Vegetation: PIED - twoneedle pinyon (Pinus edulis); JUOS - Utah juniper (Juniperus osteosperma); CEMOG - birchleaf mountain mahogany (Cercocarpus montanus var. glaber)

Parent Materials: slightly weathered, residuum weathered from calcareous sandstone
Particle Size Control Section: 0 to 18 centimeters (0 to 7.1 inches)
Diagnostic Features: Lithic contact: 18 centimeters (7.1 inches)
Restrictions: Lithic bedrock: 18 centimeters (7.1 inches)
A --- 0 to 18 centimeters (0 to 7.1 inches); pale brown (10YR 6/3) dry, channery sandy loam; brown (10YR 5/3) moist; null percent sand; null percent silt; 14 percent clay; weak medium subangular blocky parting to single grain structure; very friable, slightly hard, nonsticky, nonplastic; common very fine roots throughout; 10 percent subangular calcareous sandstone channers and 5 percent subangular calcareous sandstone gravels; strongly effervescent by HCl, 1 normal; moderately alkaline, pH 8, pH meter; abrupt smooth boundary.

R --- 18 centimeters (7.1 inches); Ferron sandstone.

Map Unit A Transect

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Average Soil Depth 10

Sandstone outcrop comprises 50 percent of map unit A based on this transect.
Appendix C

Laboratory Analysis
## Appendix C - Table of Contents

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<thead>
<tr>
<th>Tables</th>
<th>Contents of Table</th>
<th>Page</th>
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<td>Laboratory analysis results for Emery 2 soil samples with topsoil suitability highlights (DOGM 2008).</td>
<td>C-1</td>
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<tr>
<td>C-2</td>
<td>Available water capacity, K factor, and wind erodibility group by soil horizon.</td>
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## Laboratory Analysis Reports

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<th>Saturation (%)</th>
<th>Electrical Conductivity (dS/m)</th>
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Topsoil suitability (Utah DOGM 2008)

- **Good**
- **Fair**
- **Poor**
- **Unacceptable**
Table C-2. Available water capacity, K factor, and wind erodibility group by soil horizon

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<th>SampleID</th>
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<th>End Depth cm</th>
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Topsoil suitability (Utah DOGM 2008)  
Fair  Poor  

INCORPORATED  
FEB 10 2017  
Div. of Oil, Gas & Mining
### Soil Analysis Report

**Long Resource Consultants, Inc.**

1960 West Deep Creek Road
Morgan, UT 84050

---

**Report ID:** S0910098001

**Project:** Emery 2 Topsoil

**Date Received:** 10/7/2009

**Lab ID**

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These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H2O= water soluble, AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate


Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed by: Karen Secor, Soil Lab Supervisor
## Soil Analysis Report

### Long Resource Consultants, Inc.

**1960 West Deep Creek Road**  
**Morgan, UT 84050**

---

**Project:** Emery 2 Topsoil  
**Date Received:** 10/7/2009

**Lab ID** | **Sample ID** | **Depths cm** | **Sand %** | **Silt %** | **Clay %** | **Texture** | **Very Fine** | **CO3** | **Nitrate ppm** | **Phosphorus ppm** | **Available Potassium meq/100g**  
---|---|---|---|---|---|---|---|---|---|---|---
S0910098-001 | EM-1-09 | 0-8 | 63.0 | 20.0 | 17.0 | Sandy Loam | 18.9 | 9.1 | 5.4 | 10.7 | 0.33
S0910098-002 | EM-1-09 | 8-23 | 57.0 | 29.0 | 14.0 | Sandy Loam | 20.5 | 7.2 | <0.1 | 6.20 | 0.28
S0910098-003 | EM-1-09 | 23-50 | 73.0 | 14.0 | 13.0 | Sandy Loam | 24.1 | 7.2 | <0.1 | 4.60 | 0.23
S0910098-004 | EM-1-09 | 50-80 | 65.0 | 23.0 | 12.0 | Sandy Loam | 25.4 | 7.8 | <0.1 | 5.33 | 0.18
S0910098-005 | EM-2-09 | 0-5 | 69.0 | 20.0 | 11.0 | Sandy Loam | 24.2 | 5.5 | 1.9 | 11.7 | 0.31
S0910098-006 | EM-2-09 | 5-19 | 71.0 | 17.0 | 12.0 | Sandy Loam | 30.4 | 4.4 | 0.7 | 5.39 | 0.19
S0910098-007 | EM-4-09 | 0-6 | 79.0 | 14.0 | 7.0 | Loamy Sand | 25.0 | 6.1 | 6.8 | 9.72 | 0.35
S0910098-008 | EM-4-09 | 6-20 | 69.0 | 21.0 | 10.0 | Sandy Loam | 23.6 | 6.4 | <0.1 | 5.21 | 0.43
S0910098-009 | EM-5-09 | 0-7 | 65.0 | 22.0 | 13.0 | Sandy Loam | 21.4 | 22.5 | 3.5 | 12.5 | 0.41
S0910098-010 | EM-5-09 | 7-20 | 63.0 | 16.0 | 21.0 | Sandy Clay Loam | 18.2 | 25.4 | 1.5 | 5.94 | 0.60
S0910098-011 | EM-6-09 | 0-7 | 79.0 | 12.0 | 9.0 | Loamy Sand | 33.0 | 6.4 | <0.1 | 8.44 | 0.13
S0910098-012 | EM-6-09 | 7-18 | 71.0 | 15.0 | 14.0 | Sandy Loam | 32.2 | 7.5 | 3.4 | 5.44 | 0.17
S0910098-013 | EM-7-09 | 0-15 | 57.0 | 15.0 | 28.0 | Sandy Clay Loam | 5.6 | 14.4 | 1.8 | 5.20 | 0.16
S0910098-014 | EM-7-09 | 15-28 | 37.0 | 52.0 | 11.0 | Silty Loam | 2.7 | 18.3 | 3.9 | 16.2 | 0.44
S0910098-015 | EM-7-09 | 28-43 | 43.0 | 48.0 | 9.0 | Loam | 2.7 | 15.9 | <0.1 | 4.67 | 0.20
S0910098-016 | EM-7-09 | 43-56 | 23.0 | 56.0 | 21.0 | Silty Loam | 2.3 | 19.2 | 32.0 | 5.89 | 0.31
S0910098-017 | EM-7-09 | 56-78 | 61.0 | 26.0 | 13.0 | Sandy Loam | 14.2 | 15.2 | 8.3 | 4.26 | 0.13
S0910098-018 | EM-7-09 | 78-102 | 46.0 | 37.0 | 17.0 | Loam | 6.6 | 16.5 | 8.6 | 4.84 | 0.20
S0910098-019 | EM-7-09 | 102-130 | 58.0 | 33.0 | 9.0 | Sandy Loam | 5.4 | 14.5 | 1.6 | 4.71 | 0.13
S0910098-020 | EM-7-09 | 130-150 | 69.0 | 25.0 | 6.0 | Sandy Loam | 10.9 | 14.3 | <0.1 | 3.98 | 0.10

These results apply only to the samples tested.

Abbreviations for extractants: 
- PE= Saturated Paste Extract, 
- H2OSol= water soluble, 
- AB-DTPA= Ammonium Bicarbonate-DTPA, 
- AAO= Acid Ammonium Oxalate

Abbreviations used in acid base accounting: 
- T.S.= Total Sulfur, 
- AB= Acid Base, 
- ABP= Acid Base Potential, 
- PyrS= Pyritic Sulfur, 
- Pyr+Org= Pyritic Sulfur + Organic Sulfur, 
- Neutral. Pot.= Neutralization Potential

Miscellaneous Abbreviations: 
- SAR= Sodium Adsorption Ratio, 
- CEC= Cation Exchange Capacity, 
- ESP= Exchangeable Sodium Percentage

Reviewed by: Karen Secor, Soil Lab Supervisor
Soil Analysis Report
Long Resource Consultants, Inc.
1960 West Deep Creek Road
Morgan, UT 84050

Project: Emery 2 Topsoil
Date Received: 10/7/2009

<table>
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<th>Depths cm</th>
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These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H2OSol= water soluble, AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate
Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed by: [Signature]
Karen Secor, Soil Lab Supervisor
<table>
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These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H20Sol= water soluble, AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate
Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed by: Karen Secor, Soil Lab Supervisor
## Soil Analysis Report

**Project:** Emery 2 Topsoil  
**Date Received:** 10/7/2009

**Lab IDs:** S0910098-021 to S0910098-030  
**Sample IDs:** EM-8-09 to EM-8-09

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<th>Clay %</th>
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Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed by: [Signature]
Karen Secor, Soil Lab Supervisor
## Soil Analysis Report

**Long Resource Consultants, Inc.**

1960 West Deep Creek Road  
Morgan, UT 84050

---

### Project:
Emery 2 Topsoil

### Date Received:
10/7/2009

### Depths

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**Inter-Mountain Labs, Inc.**

1673 Terra Avenue, Sheridan, Wyoming 82801

(307) 672-8945

**Report ID:** S0910098001

**Date Reported:** 11/11/2009

**Work Order:** S0910098

---

These results apply only to the samples tested.

Abbreviations for extractants: **PE** = Saturated Paste Extract, **H20Sol** = water soluble, **AB-DTPA** = Ammonium Bicarbonate-DTPA, **AAO** = Acid Ammonium Oxalate

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Miscellaneous Abbreviations: **SAR** = Sodium Adsorption Ratio, **CEC** = Cation Exchange Capacity, **ESP** = Exchangeable Sodium Percentage

Reviewed by: [Signature]
Karen Secor, Soil Lab Supervisor

Page 6 of 6
# Soil Analysis Report

**Long Resource Consultants, Inc.**
1960 West Deep Creek Road
Morgan, UT 84050

**Project:** Emery 2 Overburden

**Date Received:** 10/7/2009

**Lab ID** | **Sample ID** | **Depths** | **pH** | **Saturation** | **Conductivity** | **Organic Matter** | **Calcium** | **Magnesium** | **Potassium** | **Sodium** | **SAR**
---|---|---|---|---|---|---|---|---|---|---|---|
S0910099-001 | EM-3-09 | 0-18 | 7.5 | 34.8 | 1.40 | 1.3 | 8.26 | 1.71 | 1.19 | 4.45 | 1.99 |
S0910099-002 | EM-3-09 | 18-46 | 7.4 | 35.7 | 4.39 | 1.4 | 31.9 | 15.7 | 0.38 | 17.9 | 3.68 |

These results apply only to the samples tested.

**Abbreviations for extractants:** PE = Saturated Paste Extract, H20Sol = water soluble, AB-DTPA = Ammonium Bicarbonate-DTPA, AAO = Acid Ammonium Oxalate

**Abbreviations used in acid base accounting:** T.S. = Total Sulfur, AB = Acid Base, ABP = Acid Base Potential, PyrS = Pyritic Sulfur, Pyr+Org = Pyritic Sulfur + Organic Sulfur, Neutral. Pot. = Neutralization Potential

**Miscellaneous Abbreviations:** SAR = Sodium Adsorption Ratio, CEC = Cation Exchange Capacity, ESP = Exchangeable Sodium Percentage

Reviewed by: [Signature]
Karen Secor, Soil Lab Supervisor
### Soil Analysis Report

**Long Resource Consultants, Inc.**

1960 West Deep Creek Road  
Morgan, UT 84050

---

**Lab ID** | **Sample ID** | **Depth (cm)** | **Sand (%)** | **Silt (%)** | **Clay (%)** | **Texture** | **Very Fine Sand (%)** | **CO3 (%)**
---|---|---|---|---|---|---|---|---
S0910099-001 | EM-3-09 | 0-18 | 47.0 | 33.0 | 20.0 | Loam | 6.6 | 13.9
S0910099-002 | EM-3-09 | 18-46 | 53.0 | 25.0 | 22.0 | Sandy Clay Loam | 6.3 | 13.4

---

**Inter-Mountain Labs, Inc.**  
1673 Terra Avenue, Sheridan, Wyoming 82801  
(307) 672-8945

---

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**Abbreviations for extractants:** PE = Saturated Paste Extract, H2OSol = water soluble, AB-DTPA = Ammonium Bicarbonate-DTPA, AAO = Acid Ammonium Oxalate

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Reviewed by:  
Karen Secor, Soil Lab Supervisor
### Soil Analysis Report

**Long Resource Consultants, Inc.**

1960 West Deep Creek Road  
Morgan, UT 84050  

**Project:** Emery 2 Overburden  
**Date Received:** 10/7/2009

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<th>Sample ID</th>
<th>Depths (cm)</th>
<th>Nitrogen Nitrate (ppm)</th>
<th>Selenium (ppm)</th>
<th>Boron (ppm)</th>
<th>Phosphorus (ppm)</th>
<th>Available Potassium (meq/100g)</th>
<th>Total Carbon (%)</th>
<th>TOC (%)</th>
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<td>S0910099-001</td>
<td>EM-3-09</td>
<td>0-18</td>
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<td>1.8</td>
<td>0.3</td>
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These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H20Sol= water soluble, AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate  
Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed by: Karen Secor, Soil Lab Supervisor
# Soil Analysis Report

**Long Resource Consultants, Inc.**

1960 West Deep Creek Road  
Morgan, UT 84050

---

**Project:** Emery 2 Overburden  
**Date Received:** 10/7/2009  
**Report ID:** S0910099001

**Work Order:** S0910099  
**Date Reported:** 11/10/2009

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**Lab ID** | **Sample ID** | **Depth** | **Total Sulfur** | **T.S. AB Potential** | **T.S. ABP**
---|---|---|---|---|---
S0910099-001 EM-3-09 | 0-18 | <0.01 | <0.01 | 131 | 131
S0910099-002 EM-3-09 | 18-46 | 0.53 | 16.4 | 127 | 111

---

These results apply only to the samples tested.

Abbreviations for extractants:  
PE = Saturated Paste Extract,  
H2OSol = water soluble,  
AB-DTPA = Ammonium Bicarbonate-DTPA,  
AAO = Acid Ammonium Oxalate

Abbreviations used in acid base accounting:  
T.S. = Total Sulfur,  
AB = Acid Base,  
ABP = Acid Base Potential,  
PyrS = Pyritic Sulfur,  
Pyr+Org = Pyritic Sulfur + Organic Sulfur,  
Neutral. Pot. = Neutralization Potential

Miscellaneous Abbreviations:  
SAR = Sodium Adsorption Ratio,  
CEC = Cation Exchange Capacity,  
ESP = Exchangeable Sodium Percentage

Reviewed by:  
Karen Secor, Soil Lab Supervisor
### Soil Analysis Report

**Long Resource Consultants, Inc.**

1960 West Deep Creek Road
Morgan, UT 84050

**Report ID:** S0910332003
(Replaces S0910332002)

**Date Reported:** 12/17/2009

**Work Order:** S0910332

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**Lab ID** | **Sample ID** | **Depths cm** | **pH** | **Saturation %** | **Electrical Conductivity dS/m** | **Organic Matter %** | **Calcium meq/L** | **Magnesium meq/L** | **Potassium meq/L** | **Sodium meq/L** | **SAR**
--- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | ---
S0910332-001 | EM-9-09 | 0-9 | 8.4 | 32.1 | 1.01 | 2.0 | 1.18 | 0.78 | 1.46 | 9.54 | 9.66
S0910332-002 | EM-9-09 | 9-25 | 8.6 | 29.9 | 2.03 | 1.0 | 1.19 | 0.74 | 0.93 | 21.9 | 22.3
S0910332-003 | EM-9-09 | 25-49 | 8.4 | 30.8 | 13.5 | 0.7 | 24.7 | 19.5 | 1.04 | 206 | 43.7
S0910332-004 | EM-9-09 | 49-75 | 8.6 | 31.4 | 15.9 | 1.3 | 24.7 | 42.4 | 0.72 | 273 | 47.2
S0910332-005 | EM-9-09 | 75-120 | 8.5 | 29.5 | 11.3 | 1.4 | 20.6 | 37.8 | 0.22 | 175 | 32.3
S0910332-006 | EM-9-09 | 120-168 | 8.6 | 27.4 | 8.55 | 1.9 | 21.0 | 24.0 | 0.17 | 120 | 25.2
S0910332-007 | EM-10-09 | 0-7 | 7.9 | 32.3 | 0.64 | 1.6 | 1.15 | 1.44 | 0.45 | 2.14 | 1.26
S0910332-008 | EM-10-09 | 7-27 | 7.8 | 32.7 | 0.50 | 1.7 | 2.96 | 1.23 | 0.32 | 1.32 | 0.91
S0910332-009 | EM-10-09 | 27-45 | 7.6 | 32.3 | 1.97 | 1.4 | 27.9 | 4.97 | 0.85 | 1.02 | 0.25
S0910332-010 | EM-11-09 | 0-8 | 7.6 | 29.9 | 1.55 | 2.0 | 7.24 | 5.01 | 0.77 | 6.88 | 2.78
S0910332-011 | EM-12-09 | 0-15 | 8.1 | 34.6 | 6.54 | 2.7 | 7.12 | 3.02 | 3.60 | 79.3 | 35.2
S0910332-012 | EM-12-09 | 15-35 | 8.1 | 33.0 | 8.97 | 1.9 | 24.0 | 7.67 | 1.90 | 139 | 34.9
S0910332-013 | EM-12-09 | 35-46 | 8.2 | 36.2 | 8.60 | 1.2 | 24.8 | 14.4 | 1.29 | 126 | 28.5
S0910332-014 | EM-12-09 | 46-72 | 8.3 | 36.2 | 8.88 | 1.2 | 21.7 | 27.7 | 0.84 | 128 | 25.8
S0910332-015 | EM-12-09 | 72-102 | 8.4 | 36.4 | 12.1 | 1.0 | 16.0 | 23.3 | 1.24 | 157 | 35.5
S0910332-016 | EM-12-09 | 102-130 | 8.4 | 35.2 | 12.6 | 1.2 | 21.0 | 31.3 | 1.42 | 167 | 32.7
S0910332-017 | EM-12-09 | 130-164 | 8.3 | 36.5 | 9.64 | 1.3 | 18.7 | 24.5 | 0.76 | 113 | 24.3
S0910332-018 | EM-13-09 | 0-10 | 7.9 | 34.2 | 2.44 | 3.2 | 27.1 | 6.37 | 1.90 | 3.69 | 0.90
S0910332-019 | EM-13-09 | 10-40 | 8.2 | 41.7 | 8.64 | 4.3 | 20.1 | 33.8 | 2.24 | 82.6 | 15.9

---

These results apply only to the samples tested.

**Abbreviations for extractions:**
- PE = Saturated Paste Extract
- H2OSol = water soluble
- AB-DTPA = Ammonium Bicarbonate-DTPA
- AAO = Acid Ammonium Oxalate

**Abbreviations used in acid-base accounting:**
- T.S. = Total Sulfur
- AB = Acid Base
- ABP = Acid Base Potential
- PyrS = Pyritic Sulfur
- Pyr+Org = Pyritic Sulfur + Organic Sulfur, Neutral
- Pot. = Neutralization Potential

**Miscellaneous Abbreviations:**
- SAR = Sodium Adsorption Ratio
- CEC = Cation Exchange Capacity
- ESP = Exchangeable Sodium Percentage

---

Reviewed by: [Signature]
Karen Secor, Soil Lab Supervisor
### Soil Analysis Report

**Long Resource Consultants, Inc.**

**Report ID:** S0910332003  
(Replaces S0910332002)  
Report Date: 12/17/2009  
Work Order: S0910332

**Project:** Emery 2 Topsoil  
**Date Received:** 10/22/2009

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<th>Depths</th>
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<th>Silt</th>
<th>Clay</th>
<th>Texture</th>
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<td></td>
<td>cm</td>
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<td>%</td>
<td>%</td>
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<td>18.7</td>
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</tbody>
</table>

*These results apply only to the samples tested.*

**Abbreviations for extractants:**  
PE = Saturated Paste Extract, H2O=S = water soluble, AB-DTPA = Ammonium Bicarbonate-DTPA, AAO = Acid Ammonium Oxalate

**Abbreviations used in acid base accounting:**  

**Miscellaneous abbreviations:**  
SAR = Sodium Adsorption Ratio, CEC = Cation Exchange Capacity, ESP = Exchangeable Sodium Percentage

Reviewed by: Karen Secor, Soil Lab Supervisor
## Soil Analysis Report

**Long Resource Consultants, Inc.**

1960 West Deep Creek Road
Morgan, UT 84050

### Available Exchangeable CEC

<table>
<thead>
<tr>
<th>Lab ID</th>
<th>Sample ID</th>
<th>Depths (cm)</th>
<th>CEC (meq/100g)</th>
<th>Potassium (meq/100g)</th>
<th>Sodium (meq/100g)</th>
<th>Exchangeable Sodium (meq/100g)</th>
<th>ESP (%)</th>
<th>Total Carbon (%)</th>
<th>Neutral. Carbon (%)</th>
<th>TOC Potential (t/1000t)</th>
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These results apply only to the samples tested.

Abbreviations for extractions: PEx = Saturated Paste Extract, H2OSol= water soluble, AB-DTPA= Ammonium Bicarbonate-DTPA, AAO = Acid Ammonium Oxalate


Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed by: Karen Secor, Soil Lab Supervisor
### Soil Analysis Report

**Long Resource Consultants, Inc.**
1960 West Deep Creek Road
Morgan, UT 84050

**Report ID:** S0912073001  
**Date Reported:** 12/17/2009  
**Work Order:** S0912073

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#### Lab ID | Sample ID | Depths (cm) | pH | Saturation (s.u.) | Electrical Conductivity (dS/m) | Organic Matter (%) | Calcium (meq/L) | Magnesium (meq/L) | Potassium (meq/L) | Sodium (meq/L) | SAR
---|---|---|---|---|---|---|---|---|---|---|---
S0912073-001 | EM-16-09 | 0-8 | 7.7 | 26.4 | 1.01 | 1.5 | 4.67 | 1.02 | 0.82 | 2.93 | 1.74
S0912073-002 | EM-16-09 | 8-21 | 7.6 | 34.4 | 0.43 | 1.1 | 2.98 | 1.05 | 0.50 | 1.20 | 0.84
S0912073-003 | EM-16-09 | 21-46 | 7.5 | 29.9 | 0.43 | 1.2 | 2.33 | 0.75 | 0.37 | 0.42 | 0.43
S0912073-004 | EM-16-09 | 46-80 | 7.5 | 32.1 | 0.45 | 1.2 | 2.63 | 0.98 | 0.20 | 0.41 | 0.30
S0912073-005 | EM-16-09 | 80-122 | 7.7 | 30.2 | 5.89 | 1.0 | 32.6 | 26.4 | 0.14 | 29.6 | 5.44
S0912073-006 | EM-16-09 | 122-170 | 8.0 | 28.3 | 9.60 | 0.8 | 31.7 | 45.0 | 0.18 | 65.5 | 10.6

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*These results apply only to the samples tested.*

**Abbreviations for extractants:** PE = Saturated Paste Extract, H2OSol= water soluble, AB-DTPA = Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate

**Abbreviations used in acid base accounting:** T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyrS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neutral. Pot.= Neutralization Potential

**Miscellaneous Abbreviations:** SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

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Reviewed by: Karen Secor, Soil Lab Supervisor

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Page 1 of 3
### Soil Analysis Report

**Project:** Emery 2 Topsoil  
**Topsoil**  
**Date Received:** 12/4/2009  
**Lab:** S0912073-001, S0912073-002, S0912073-003, S0912073-004, S0912073-005, S0912073-006  
**Sample ID:** EM-16-09

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<th>Clay %</th>
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These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H2OSol= water soluble, AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate


Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed by: Karen Secor, Soil Lab Supervisor
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These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H20Sol= water soluble, AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate


Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed by: Karen Secor, Soil Lab Supervisor
Appendix D

Site and Profile Photos
Appendix D

Site and Profile Photos

Photo D - 1. EM-1-09 soil profile of Begay family soils in map unit Ba with Wyoming big sage, black greasewood, and shadscale vegetation. Soil is moderately deep (Ferron sandstone at 80 cm) with coarse-loamy textural family.

Photo D - 2. EM-2-09 soil profile location of Hideout soils in map unit A. Vegetation includes scattered pinyon pine, Utah juniper, Utah Mormon tea, and Utah serviceberry. Depth to Ferron sandstone is 19 cm.

Photo D - 3. EM-3-09 soil profile location of Disturbed Land in map unit Bd. Depth to hard Mancos shale is 46 cm. Vegetation is limited to shadscale and black greasewood.

Photo D - 4. EM-4-09 soil profile location of Hideout soil in map unit A. Hideout soils are coarse-loamy. The surface is covered with 5 percent channers. Depth to Ferron sandstone is 20 cm. Vegetation is Utah juniper, pinyon pine, Birchleaf mahogany, and Utah serviceberry.

Photo D - 5. EM-5-09 soil profile location of Lazear soil on plateau in map unit Ba. Lazear soils are fine-loamy. Surface is covered with 10 percent gravels and 5 percent channers. Depth to Ferron sandstone is 20 cm. Vegetation is shadscale and black sage. Map unit A is in background with pinyon pine and Utah juniper.

Photo D - 6. EM-6-09 soil profile location of Persayo family soil on a very steep canyon sideslope (78 percent) in map unit Ca. The Persayo family soils in this map unit are coarse-loamy, compared to fine-loamy for the Persayo series. Depth to Mancos shale is 34 cm. Dominant vegetation is shadscale and Gardners saltbush.

Photo D - 7. EM-7-09 soil profile location of Green River soil in coarse-loamy alluvium in floodplain along Quitchapah Creek. This soil profile showed three distinct periods of deposition. The most recent deposition appeared to have been deposited during flooding on September 16, 2009. Distinct and prominent soil mottles were observed from 28 to 56 cm below the new surface. Dominant vegetation is tamarisk.

Photo D - 8. EM-8-09 soil profile location of Garley soil on cutbank in map unit Ca near northeast end of canyon. Surface is covered with 3 percent cobbles, 2 percent channers, and a few very large boulders (car to house size). SAR levels are unacceptable for use as topsoil from 0 to 88 cm and from 98 to 108 cm based on Utah DOGM Topsoil Guidelines (Utah DOGM 2005). Vegetation is dominated by black greasewood, shadscale, with small inclusions of rabbitbrush, black sage, and Indian ricegrass.

Photo D - 9. EM-9-09 soil profile location of Garley soil in alluvial toeslope in map unit Cb. Soil is coarse-loamy with unacceptable SAR levels from 8 to 168 cm (Utah DOGM 2005). Surface is covered with 3 percent gravels, 2 percent channers, 1 percent flagstones, and a few very large boulders (car to house size). Dominant vegetation is black greasewood and shadscale with scattered clumps of Indian ricegrass.

Photo D - 10. EM-10-09 soil profile location of Braf soil in map unit D. Surface is covered with 6 percent gravel, 4 percent channers, 1 percent stones, and 1 percent flagstones. Ferron sandstone is at 45 cm. Vegetation is dominated by shadscale, black sage, Indian ricegrass, and prickly pear cactus. Area slopes to the northwest at 2 to 8 percent.
Appendix D  

Site and Profile Photos

Photo D - 11. EM-11-09 soil profile location of Braf soil in map unit E. Area slopes to the northwest on broken slopes of 6 to 15 percent. Surface is covered with 10 percent channers and 5 percent gravels. This map unit is dominated by Ferron sandstone outcrops, visible in lower right corner of photo. Dominant vegetation is shadscale, black sage, Indian ricegrass, and prickly pear cactus. 

Photo D - 12. EM-12-09 soil profile location of Garley, moderately well drained, soil on stream terrace above Quitchapah Creek in map unit G. Garley, moderately well drained, soils are coarse-loamy. SAR levels are unacceptable (SAR greater than 24) for use as topsoil from 0 to 164 cm (Utah DOGM 2005). This area is dominated by black greasewood and bare soils. 

Photo D - 13. EM-13-09 soil profile location of Persayo soils on a very steep south facing slope in map unit F. Surface is covered with 40 percent gravels and 20 percent channers. Mancos shale is at 40 cm. Vegetation is limited to widely scattered shadscale. 

Photo D - 14. EM-14-09 soil profile location of Braf soil in map unit D. Surface is covered with 15 percent channers and 10 percent gravels. Depth to Ferron sandstone is 48 cm. Vegetation is dominated by shadscale and scattered grasses. Dozer push piles in map unit Bd are visible (center left) on plateau southeast side of canyon (sandstone outcrop is upper portion of canyon sideslope). 

Photo D - 15. EM-15-09 soil profile location of Persayo soil in map unit F. Surface is covered with 30 percent channers and 5 percent gravels. Depth to Mancos shale is 48 cm. This ridge slopes to the northeast at 12 percent. Vegetation is dominated by shadscale Garley (map unit G) and Green River (map unit H) soils can be seen in the alluvial stream terrace and floodplain along Quitchapah Creek. 

Photo D - 16. EM-16-09 soil profile location of Monue family soil in map unit Cb. Soil has developed from eolian deposits derived from the nearby Ferron sandstone. Surface is covered with 8 percent gravels and 3 percent channers. Vegetation is dominated by black greasewood and Indian ricegrass. The setting and vegetation for the Monue family soil is similar to the Garley soil in map unit Cb, but SAR and salinity do not become limiting in the Monue family soil until 80 cm. Monue family soils appear to have more Indian ricegrass cover than Garley soils (EM-8 and EM-9). The break between map units Ca (rock outcrop and steep shale slopes) and Cb is at the base of the Ferron sandstone outcrop. Map unit D (Farb soils) is located on the plateau above the canyon rim. 

Photo D - 17. EM-17-09 soil profile location of Hideout soil on northwest facing structural bench in map unit Ca. Surface is covered with 35 percent channers, 10 percent flags, and 1 percent boulders. Soil is corase-loamy with Ferron sandstone is at 19 cm. Pinyon pine and Utah juniper dominate this area with scattered Wyoming big sage and utah serviceberry. 

Photo D - 18. EM-01-16 soil profile location of Monue family soil in map unit Cb. Black greasewood is the dominant vegetation in the bottom of the canyon.
Photo D - 19. EM-02-16 soil profile location of Hideout soil on structural bench in canyon, map unit Ca. Pinyon pine and Utah juniper are the dominant vegetation. Surface is covered with channers and flags. Large boulders have fallen from the cliffs above the bench....
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Photo D - 14. EM-14-09 soil profile location of Braf soil in map unit D. Surface is covered with 15 percent channers and 10 percent gravels. Depth to Ferron sandstone is 48 cm. Vegetation is dominated by shadscale and scattered grasses. Dozer push piles in map unit Bd are visible (center left) on plateau southeast side of canyon (sandstone outcrop is upper portion of canyon sideslope).
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Appendix E

Profile Box Photos
# Table of Contents

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EM-1-09 - Begay family

Ustic Haplocambids, coarse-loamy, mixed, superactive, mesic

A 0-8 cm (0-3 inches)

Bw1 8-23 cm (3-9 inches)

Bw2 23-50 cm (9-20 inches)

Bk 50-80 cm (20-32 inches)

R 80 cm (32 inches)
EM-2-09 - Hideout

Lithic Ustic Torriorthents, loamy, mixed, superactive, calcareous, mesic

A  0-5 cm (0-2 inches)
C  5-19 cm (2-7 inches)
R  19 cm (7 inches)
EM-3-09 - Disturbed Land

Lithic Ustic Torriorthents, loamy, mixed, superactive, calcareous, mesic

A  0-18 cm (0-7 inches)
C  18-46 cm (7-18 inches)
R  46 cm (18 inches)
EM-4-09 - Hideout

Lithic Ustic torriorthents, loamy, mixed, superactive, calcareous, mesic

A 0-6 cm (0-2 inches)

C 6-20 cm (2-8 inches)

R 20 cm (8 inches)
Lithic Ustic Torriorthents, loamy, mixed, superactive, calcareous, mesic

A 0-7 cm (0-3 inches)

C 7-20 cm (3-8 inches)

R 20 cm (8 inches)
EM-6-09 - Persayo family

Typic Torriorthents, loamy, mixed active, calcareous, shallow, mesic

A  0-7 cm (0-3 inches)

2C  7-18 cm (3-7 inches)

Cr1  18-34 cm (7-13 inches)

Cr2  34-38+ cm (13-15+ inches)
EM-7-09 - Green River

Oxyaquic Torrifluvents, coarse-loamy, mixed, calcareous, superactive, mesic

A  0-15 cm (0-6 inches)

2A  15-28 cm (6-11 inches)

2C  28-43 cm (11-17 inches)

3A  43-56 cm (17-22 inches)

3C1  56-78 cm (22-31 inches)

3C2  78-102 cm (31-40 inches)

3C3  102-130 cm (40-51 inches)

3C4  130-150 cm (51-59 inches)
**EM-8-09 - Garley**

Typic Torrifluvents, coarse-loamy, mixed, calcareous, active, mesic

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EM-9-09 - Garley

Typic Torrifluvents, coarse-loamy, mixed, calcareous, active, mesic

<table>
<thead>
<tr>
<th>Layer</th>
<th>Depth (cm) (or inch)</th>
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<tbody>
<tr>
<td>A</td>
<td>0-9 (0-4 inches)</td>
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<tr>
<td>AC</td>
<td>9-25 (4-10 inches)</td>
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<tr>
<td>C1</td>
<td>25-49 (10-19 inches)</td>
</tr>
<tr>
<td>C2</td>
<td>49-75 (19-30 inches)</td>
</tr>
<tr>
<td>C3</td>
<td>75-120 (30-47 inches)</td>
</tr>
<tr>
<td>2Bk</td>
<td>120-168 (47-66 inches)</td>
</tr>
</tbody>
</table>
Lithic Torriorthents, loamy, mixed, superactive, calcareous, mesic

A  0-7 cm (0-3 inches)

C1  7-27 cm (3-11 inches)

C2  27-45 cm (11-18 inches)

R  45 cm (18 inches)
EM-11-09 - Braf

Lithic Torriorthents, loamy, mixed, superactive, calcareous, mesic

A  0-3 cm (0-1 inches)
C  3-8 cm (1-3 inches)
R  8 cm (3 inches)
EM-12-09 - Garley, moderately well drained

Typic Torrifluvents, coarse-loamy, mixed, calcareous, active, mesic

A  0-15 cm (0-6 inches)
C1 15-35 cm (6-14 inches)
C2 35-46 cm (14-18 inches)
C3 46-72 cm (18-28 inches)
Ab 72-102 cm (28-40 inches)
C4 102-130 cm (40-51 inches)
C5 130-164 cm (51-65 inches)
EM-13-09 - Persayo

Typic Torriorthents, loamy, mixed, active, calcareous, mesic, shallow
Appendix E

Micromonolith Box Photos

EM-14-09 - Braf

Lithic Torriorthents, loamy, mixed, superactive, calcareous, mesic

A  0-12 cm (0-5 inches)

C1  12-38 cm (5-15 inches)

C2  38-48 cm (15-19 inches)

Cr  48 cm (19 inches)
    – no sandstone sample
EM-15-09 - Persayo

Typic Torriorthents, loamy, mixed, active, calcareous, mesic, shallow

A  0-17 cm (0-7 inches)

C  17-48 cm (7-19 inches)

R  48 cm (19 inches)
EM-16-09 - Monue family

Typic Haplocambids, coarse-loamy, mixed, superactive, mesic

A  0-8 cm (0-3 inches)
Bw1  8-21 cm (3-8 inches)
Bw2  21-46 cm (8-18 inches)
C1  46-80 cm (18-32 inches)
C2  80-122 cm (32-48 inches)
2C  122-170 cm (48-67 inches)
EM-17-09 - Hideout

Lithic Ustic Torriorthents, loamy, mixed, superactive, calcareous, mesic

A  0-4 cm (0-2 inches)

C  4-19 cm (2-7 inches)

Cr 19 cm (7 inches)
   - no sandstone sample
EM-1-16

No box sample was collected.

EM-2-16

No box sample was collected.
Appendix F

Map Unit Salvage and Sandstone Estimates
Table F - 1. Estimated topsoil and subsoil salvage depths for Emery 2 map units based on representative soil profiles as listed in the Major Soil Types section of Emery 2 Soil Survey Report.

<table>
<thead>
<tr>
<th>Map Unit</th>
<th>Soil Series or Family</th>
<th>Topsoil Salvage Depth</th>
<th>Weighted Topsoil Depth</th>
<th>Total Topsoil Depth</th>
<th>Subsoil Salvage Depth</th>
<th>Weighted Subsoil Depth</th>
<th>Total Subsoil Depth</th>
<th>Total Weighted Topsoil Salvage Depth</th>
<th>Total Weighted Subsoil Salvage Depth</th>
<th>Total Weighted Topsoil Depth</th>
<th>Total Weighted Subsoil Depth</th>
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<tbody>
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<td>Ba</td>
<td>Begay family - Lazear complex, 3 to 12 percent slopes</td>
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Div. of Oil, Gas & Mining
FEB 10 2017

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<td>Soil Series or Family</td>
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1. Topsoil salvage depth based on physical and chemical characteristics of the representative soil profile from Table 17.
2. Weighted topsoil depth is the product of multiplying the topsoil salvage depth by the component percent.
3. Total weighted topsoil depth is the sum of weighted topsoil depths for map unit.
4. Subsoil salvage depth based on physical and chemical characteristics of the representative soil profile from Table 17.
5. Weighted subsoil depth is the product of multiplying the subsoil salvage depth by the component percent.
6. Total weighted subsoil depth is the sum of weighted subsoil depths for map unit.
7. Total weighted topsoil depth for map unit converted to inches.
8. Total weighted subsoil depth for map unit converted to inches.
9. Sum of weighted topsoil depths for map unit (total estimated depth of topsoil and subsoil salvage).
Soil Survey

of the

Emery Deep Mine - Canyon Disturbance Area

Located near Emery, Utah

Prepared for

Bronco Utah Operations, LLC

By

Long Resource Consultants, Inc.

Morgan, Utah

January 18, 2017
Revised February 16, 2017
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B Soil Profile Descriptions
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Introduction

Purpose of Soil Survey
Soils in the Emery Deep Canyon Disturbance Area (CDA) were previously identified as part of the Order 2 Soil Survey of Emery 2 Mine Permit Area (Long 2016). Soils were mapped in complexes and consociations. Alkaline (pH), saline (conductivity), sodic (SAR), and shallow soil limitations were identified by this soil survey.

The primary purpose of this soil survey was to conduct an in depth evaluation of topsoil and subsoil salvage depths within the Emery Deep CDA prior to construction. This evaluation will be used by the monitoring soil scientist and contractor during construction.

Topsoil and subsoil will be salvaged in the canyon at the commencement of construction of a new mine portal. Soils with Unacceptable pH, conductivity, or SAR levels will not be salvaged from the Emery Deep CDA. Soil pH and conductivity will be monitored in the field with a meter during construction.

This soil survey was conducted for the purpose of identifying areas of saline, sodic, and shallow soils within the Emery Deep CDA.

This soil survey does not include the proposed disturbance area on the top of the canyon within the Emery 2 Mine permit boundary (cliff scaling work area on east bench, berm on east bench, access road on west bench, and work area on west bench above the new portal).

Project Area
The Emery Deep CDA soil survey consists of 6.9 acres within the Emery 2 permit area and 0.4 acres within the existing Emery mine permit area for a total of 7.3 acres. The Emery Deep CDA is shown in Figure 1.

Climate
The climate of the soil survey is described in detail in the Order 2 Soil Survey of Emery 2 Mine Permit Area (Long 2016). Average annual precipitation at Emery, Utah is 7.33 inches and is evenly distributed throughout the year. The average annual air temperature at Emery, Utah is 46 °F.

The precipitation pattern borders between aridic and ustic aridic depending on aspect, slope, and physiographic setting. Soil temperature regime is mesic (USDA-NRCS 2016b).
How This Soil Survey was Conducted

This soil survey was made in accordance with the guidelines for soil surveys as detailed in the Soil Survey Manual (USDA 1993). Soils were classified using the Keys to Soil Taxonomy, Twelfth Edition (USDA 2014). The number of holes described and sampled within the 7.3 acre canyon area qualify as an order 1 soil survey. The dominant soil sub-groups identified in the canyon by this soil survey are Lithic Ustic Torriorthents, Typic Torriorthents, Typic Haplocambids, and Typic Torrifluvents. Soil family names were correlated to soil series of the same using official soil series descriptions (NRCS 2016a). Field descriptions of the soil profiles are in appendix B.

Field Evaluation of Soils

Seven soil profiles were hand dug, described, and sampled in the Emery Deep CDA. In addition, large areas of sandstone outcrop was identified and one soil profile was described and sampled just outside the disturbance area. These soil sample locations were dug, described, and sampled on December 13 and 14, 2016. Soil samples were placed in clean ZipLoc® freezer bags and sealed for shipment.

Soil profile descriptions were completed using the guidelines established in the Field Book for Describing and Sampling Soils (Schoenberger, et. al. 2012).

Soil color was evaluated on dry and moist samples using Munsell color charts (Munsell 2013).

Two soil profiles (EM-6-09 and EM-7-09) located within or immediately adjacent to the Emery Deep CDA soil survey were described and sampled as part of the Order 2 Soil Survey of Emery 2 Mine Permit Area (Long 2016). Soil descriptions, lab analysis, and photographs of these two locations are in the Order 2 Soil Survey of Emery 2 Mine Permit Area (Long 2016).

Two profile locations (EM-1-16 and EM-2-16) were described on June 9, 2016. Soil pH and conductivity were measured on these soils with a field instrument. Soil descriptions and photographs of these are in the Order 2 Soil Survey of Emery 2 Mine Permit Area (Long 2016).

Analysis of Soil Samples

Soil samples collected in December 2016 were shipped to Inter Mountain Laboratories in Sheridan, Wyoming for analysis of pH, conductivity, sodium adsorption ratio, and soil texture in accordance with the procedures outlined in Table 3 of the Guidelines for Management of Topsoil and Overburden (Utah DOGM 2008).

The results of the December 2016 analysis are in appendix A.

Laboratory analysis results for the 2009 soil samples can be reviewed in the Order 2 Soil Survey of Emery 2 Mine Permit Area (Long 2016).
Soils in Survey Area

Soil Types
Five soil types were identified within or immediately adjacent to the Emery Deep CDA. Five of these soils were previously identified by the *Order 2 Soil Survey of Emery 2 Mine Permit Area* (Long 2016). The sixth soil type, Cheeta, contains more than 35 percent rock fragments and is similar to Hideout soils. Table 1 lists the taxonomic soil types identified in the Emery Deep CDA soil survey. The limiting features identified in soil profiles located within or immediately adjacent to the Emery Deep CDA are listed in Table 2.

Table 1. Taxonomic classification of soil types identified during the Emery Deep CDA soil survey.

<table>
<thead>
<tr>
<th>Soil Series of Family</th>
<th>Taxonomic Classification$^{1,2}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheeta</td>
<td>Lithic Ustic Torriorthents loamy-skeletal, mixed, superactive, calcareous, mesic</td>
</tr>
<tr>
<td>Hideout</td>
<td>Lithic Ustic Torriorthents loamy, mixed, superactive, calcareous, mesic</td>
</tr>
<tr>
<td>Garley</td>
<td>Typic Torriorthents, coarse-loamy, mixed, active, calcareous, mesic</td>
</tr>
<tr>
<td>Monue family</td>
<td>Typic Haplocambids, coarse-loamy, mixed, superactive, mesic</td>
</tr>
<tr>
<td>Persayo family</td>
<td>Typic Torriorthents loamy, mixed, active, calcareous, mesic, shallow</td>
</tr>
</tbody>
</table>

2. Series and family names obtained from Natural Resources Conservation Service web site (USDA 2016a).

Soil suitability ratings of *Good, Fair, Poor,* and *Unacceptable* used in this report to describe soils in the Emery Deep CDA are based on the *Guidelines for Management of Topsoil and Overburden* (Utah DOGM 2008).

Cheetah and Hideout soils have sandstone bedrock within 20 inches of the soil surface. These soils occur on sandstone structural benches on the very steep canyon sideslopes.

Garley and Monue family soils have depths ranging from approximately 30 to more than 60 inches. *Unacceptable* conductivity and SAR levels have been identified in both soils. These *Unacceptable* levels occur within one foot of the soil surface in Garley soils, but at depths greater than 40 inches in Monue family soils. Both soils are coarse textured. Soil pH in the *Poor* range has also been identified in both soils.
Persayo family soils have weathered shale bedrock within 20 inches of the soil surface. These soils occur on the very steep canyon sideslopes between the sandstone outcrops. Low soil pH (*Poor*) was identified in the upper subsoil in one soil profile.

Table 2. Limiting soil features in profiles located within or immediately adjacent to the Emery Deep CDA.

<table>
<thead>
<tr>
<th>Soil Profile</th>
<th>Soil Type</th>
<th>Limiting Features&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>EM-6-09</td>
<td>Persayo family</td>
<td>Weathering shale at 7 inches and very steep slope.</td>
</tr>
<tr>
<td>EM-8-09</td>
<td>Garley</td>
<td><em>Unacceptable</em> sodic, saline, and pH soils below 4 inches.</td>
</tr>
<tr>
<td>EM-1-16</td>
<td>Monue family</td>
<td>None identified in upper 43 inches.</td>
</tr>
<tr>
<td>EM-2-16</td>
<td>Hideout</td>
<td>Shallow to sandstone at 7 inches; large boulders on surface.</td>
</tr>
<tr>
<td>16-EM-03</td>
<td>Cheeta (Hideout similar)</td>
<td>Shallow to sandstone at 17 inches; boulders and stones on surface; and very steep slope.</td>
</tr>
<tr>
<td>16-EM-04</td>
<td>Monue family</td>
<td>Sandstone at 34 inches; large rocks or bedrock at 34 inches; <em>Poor</em> pH in 6 to 17 inch horizon.</td>
</tr>
<tr>
<td>16-EM-05</td>
<td>Monue family</td>
<td><em>Unacceptable</em> SAR and conductivity below 41 inches; and <em>Poor</em> pH in 8 to 19 inch horizon and below 41 inches.</td>
</tr>
<tr>
<td>16-EM-06</td>
<td>Sandstone Outcrop</td>
<td>Salvageable soil is in small pockets; shallow to sandstone; and very steep slopes.</td>
</tr>
<tr>
<td>16-EM-07</td>
<td>Monue family</td>
<td>None identified in upper 59 inches; some large boulders are present in this portion of the canyon bottom.</td>
</tr>
<tr>
<td>16-EM-08</td>
<td>Persayo family</td>
<td><em>Unacceptable</em> pH below 8 inches; boulders and stones on surface; and very steep slope.</td>
</tr>
<tr>
<td>16-EM-09</td>
<td>Monue family</td>
<td><em>Poor</em> conductivity below 9 inches; boulders stones on surface; sandstone bedrock at 31 inches; very steep slope.</td>
</tr>
<tr>
<td>16-EM-010</td>
<td>Monue family</td>
<td>Very large sandstone boulders.</td>
</tr>
<tr>
<td>16-EM-011</td>
<td>Hideout</td>
<td>Shallow to sandstone at 12 inches boulders and stones on surface; and very steep slope.</td>
</tr>
</tbody>
</table>

<sup>1</sup> Suitability based on ranges listed *Guidelines for Management of Topsoil and Overburden* (Utah DOGM 2008).
Map Units
Soils in the Emery Deep CDA were mapped in the Order 2 Soil Survey of Emery 2 Mine Permit Area (Long 2016) with map units Ca and Cb. The components of these map units are listed in Table 3. Soil map unit Ca delineated soil features on the canyon sideslopes and Cb described the canyon bottom.

Table 3. Components of soil map units mapped in the Emery Deep CDA by the Order 2 Soil Survey of Emery 2 Mine Permit Area (Long 2016).

<table>
<thead>
<tr>
<th>Map Unit</th>
<th>Component Description</th>
<th>Soil Series or Taxonomic Family</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca</td>
<td>Persayo family - Rock Outcrop - Hideout complex, 3 to 80 percent slopes</td>
<td>Persayo family, Sandstone Outcrop, Hideout, Garley, Monue family</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>Persayo family</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>Sandstone Outcrop</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>Hideout</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Garley</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Monue family</td>
</tr>
<tr>
<td>Cb</td>
<td>Monue family - Garley complex, 3 to 12 percent slopes</td>
<td>Monue family, Garley, Begay family</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>Monue family</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>Garley</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Begay family</td>
</tr>
</tbody>
</table>

The Ca and Cb soil map units have been separated into the units listed in Table 4 for the soil survey of the Emery Deep CDA. Surface area covered by the soil survey map units is listed in Table 5.

**Ca1  Persayo family, 3 to 80 percent slopes**
This map unit is dominated by Persayo family soils which are shallow to weathered shale. Soil profile 16EM08 is representative of Persayo soil in this map unit. Surface boulders, stones, and flagstones are a dominant feature of this map unit.

**Ca2  Hideout family - Cheeta family complex, 3 to 80 percent slopes**
This map unit is dominated by Hideout and Cheeta soil families. Both soils are shallow to Ferron sandstone. Surface boulders, stones, and flagstones are a dominant feature of this map unit.

**Ca3  Sandstone Outcrops, 3 to 80 percent slopes**
This map unit consists of sandstone outcrops on the very steep canyon sideslopes.
**Cb1 Monue family - Garley complex, 3 to 12 percent slopes**
This map unit occurs on the canyon bottom of the Emery Deep CDA. These soils are typically greater than 40 inches deep. *Unacceptable* conductivity, pH, and SAR levels are present in these soils. Monue family soils are deeper to the *Unacceptable* saline and sodic material. Garley soils have *Unacceptable* conductivity, pH and SAR within one foot of the soil surface.

Table 4. Soil map units in the soil survey of the Emery Deep CDA.

<table>
<thead>
<tr>
<th>Component</th>
<th>Map Unit</th>
<th>Percent</th>
<th>Soil Series or Taxonomic Family</th>
<th>Modal Soil Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca1</td>
<td>Persayo family, 3 to 80 percent slopes</td>
<td>80</td>
<td>Persayo family</td>
<td>16EM08</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>Hideout</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>Monue family</td>
<td></td>
</tr>
<tr>
<td>Ca2</td>
<td>Hideout - Cheeta complex, 3 to 80 percent slopes</td>
<td>70</td>
<td>Hideout</td>
<td>16EM11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15</td>
<td>Cheeta</td>
<td>16EM03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>Monue family</td>
<td>16EM03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>Persyao family</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>Sandstone outcrops</td>
<td></td>
</tr>
<tr>
<td>Ca3</td>
<td>Sandstone outcrops, 3 to 80 percent slopes</td>
<td>85</td>
<td>Sandstone outcrop</td>
<td>16EM06</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>Hideout family</td>
<td>EM-2-16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>Persyao family</td>
<td></td>
</tr>
<tr>
<td>Cb1</td>
<td>Monue family - Garley complex, 3 to 12 percent slopes</td>
<td>80</td>
<td>Monue family</td>
<td>16EM05</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15</td>
<td>Garley</td>
<td>EM-8-09</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>Sandstone boulders</td>
<td></td>
</tr>
</tbody>
</table>

Table 5. Map unit acres in the soil survey of the Emery Deep CDA.

<table>
<thead>
<tr>
<th>Soil Map Units</th>
<th>Ca1</th>
<th>Ca2</th>
<th>Ca3</th>
<th>Cb1</th>
<th>Cb1 Boulders</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>acres</td>
<td>2.0</td>
<td>1.4</td>
<td>2.0</td>
<td>0.8</td>
<td>1.1</td>
<td>7.3</td>
</tr>
</tbody>
</table>

**MAY 05 2017**
Topsoil and Subsoil Salvage

Limiting Soil Features
Soil pH, salinity (conductivity), and sodic soils (SAR) are the primary limiting features for soils in the Emery Deep CDA.

The presence of stones and very large boulders on the surface will need to be taken into consideration when salvaging topsoil and subsoil. Steep canyon sideslopes slopes are also a feature that needs to be taken into account during salvage operations.

All salvage operations should be monitored by a Certified Professional Soil Scientist.

Soil Profile Salvage Depths
Topsoil and subsoil salvage depths for each of the Emery Deep CDA soil profiles are listed in Table 6. These depths are based on the suitability ranges listed in Table 4 of the Guidelines for Management of Topsoil and Overburden (Utah DOGM 2008). Depths are based on not salvaging materials rated as Unacceptable. Average estimated salvage depths for the soil types are listed in Table 7.

Cheeta
Cheeta soils are a Fair source of topsoil due to the shallow depth to sandstone and low available water capacities. These soils are geographically associated with large areas of Ferron sandstone outcrops. The estimated topsoil salvage depth is approximately 6 inches and estimated subsoil salvage depth is 10 inches based on soil profile 16EM03.

Physical and chemical characteristics of the Cheeta topsoil and subsoil are similar. They should be salvaged and stockpiled together as topsoil, if the thickness of the A horizon is less than 6 inches (Utah Code R645-301-200.232.300). The lower salvage depth for Cheeta soils is normally the transition to Ferron sandstone bedrock.

Salvage of these soils should be monitored by a Certified Professional Soil Scientist.
Table 6. Topsoil and subsoil salvage depths for soil profiles located within and immediately adjacent to the Emery CDA.

<table>
<thead>
<tr>
<th>Soil Profile</th>
<th>Soil Type</th>
<th>Topsoil Salvage Depth</th>
<th>Subsoil Salvage Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Inches</td>
<td>inches</td>
</tr>
<tr>
<td>EM-6-09</td>
<td>Persayo family</td>
<td>7</td>
<td>11\textsuperscript{1}</td>
</tr>
<tr>
<td>EM-8-09</td>
<td>Garley</td>
<td>4</td>
<td>0\textsuperscript{2,3}</td>
</tr>
<tr>
<td>EM-1-16</td>
<td>Monue family</td>
<td>16</td>
<td>27\textsuperscript{4}</td>
</tr>
<tr>
<td>EM-2-16</td>
<td>Hideout</td>
<td>7</td>
<td>0\textsuperscript{5}</td>
</tr>
<tr>
<td>16-EM-03</td>
<td>Cheeta (Hideout similar)</td>
<td>6</td>
<td>10\textsuperscript{5}</td>
</tr>
<tr>
<td>16-EM-04</td>
<td>Monue family</td>
<td>7</td>
<td>27\textsuperscript{5}</td>
</tr>
<tr>
<td>16-EM-05</td>
<td>Monue family</td>
<td>8</td>
<td>33\textsuperscript{2}</td>
</tr>
<tr>
<td>16-EM-06</td>
<td>Sandstone Outcrop\textsuperscript{5,6}</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>16-EM-07</td>
<td>Monue family</td>
<td>7</td>
<td>52\textsuperscript{4}</td>
</tr>
<tr>
<td>16-EM-08</td>
<td>Persayo family</td>
<td>8</td>
<td>0\textsuperscript{14}</td>
</tr>
<tr>
<td>16-EM-09</td>
<td>Monue family</td>
<td>9</td>
<td>0\textsuperscript{5,7}</td>
</tr>
<tr>
<td>16-EM-010</td>
<td>Monue family</td>
<td>7</td>
<td>32\textsuperscript{5}</td>
</tr>
<tr>
<td>16-EM-011</td>
<td>Hideout</td>
<td>12</td>
<td>0\textsuperscript{4}</td>
</tr>
</tbody>
</table>

1. Limited by depth to weathered shale.
2. Limited by depth to Unacceptable SAR.
3. Limited by depth to Unacceptable pH.
4. Thickness of subsoil salvage depth limited by depth of profile examination.
5. Limited by depth to sandstone.
6. Small pockets of Hideout, Cheeta, or Persayo family soils with sufficient depth and volume to salvage may be present.
7. Conductivities in the subsoil are in upper end of the Poor range. Monitoring of pH and conductivity in deep soils on the canyon sideslopes may identify small areas with salvageable subsoil.
Garley
Garley soils are a Poor source of topsoil and an Unacceptable source of subsoil. The main limiting features of Garley soils, based on the Guidelines for Management of Topsoil and Overburden (Utah DOGM 2008), are: 1) Unacceptable SAR values that range from 15 to 49 (ESP 25 to 52 percent); 2) Poor electrical conductivity values ranging from 8.29 to 15.9 dS/m; 3) Poor pH values that correspond directly with the Unacceptable SAR levels in Garley soils; 4) loamy sand textures (Poor); and 5) Poor available water capacity due to the loamy sand textures.

Garley soils are a Poor source of topsoil and Unacceptable source of subsoil due to the SAR levels. The representative soil profile (EM-OS-09) has 4 inches of topsoil with Poor SAR value in map unit Cb based on the loamy sand texture. The Unacceptable SAR level for coarse textured soil is 20 (DOGM 2008). These soils have developed from numerous fluventic depositions, so the chemical and physical characteristics may vary between locations.

SAR levels in the subsoil range from 32.2 to 48.7 in the 4 to 35 inch horizon of soil profile EM-08-09. These SAR levels are in excess of the Unacceptable level. Garley subsoil should not be salvaged or stockpiled with other salvaged subsoil materials which are suitable.

It will be difficult to salvage 4 inches of topsoil and not have some mixing with Unacceptable SAR soils. Salvage from areas with Garley soils should be closely monitored in the field by a Certified Professional Soil Scientist.

Hideout
Hideout soils are a Fair source of topsoil due to the shallow depth to sandstone and low available water capacities. These soils are geographically associated with Ferron sandstone outcrops. The estimated topsoil salvage depth is limited to approximately 10 inches based on soil profiles EM-2-16 and 16EM11.

Physical and chemical characteristics of Hideout topsoil and subsoil are similar. They should be salvaged and stockpiled together as topsoil, if the A horizon is less than 6 inches thick (Utah Code R645-301-200.232.300). The lower salvage depth for Hideout soils is normally the transition to Ferron sandstone bedrock.

Salvage of these soils should be monitored by a Certified Professional Soil Scientist.

Monue family
Monue family soils are a Good source of topsoil and Good to Fair source of subsoil. SAR and salinity levels are Good to Fair in the upper 34 to 40 inches based on Monue family profiles examined in the Emery Deep CDA. These soils have low available water capacities due to the sandy loam textures.
The estimated topsoil salvage depth for Monue Family soils is 9 inches based on the average depths of profiles examined within the Emery Deep CDA.

Estimated subsoil salvage is approximately 29 inches based on the representative soil profile, if deep disturbance is required. The separation between topsoil and subsoil is the transition between the A horizon and the Bw horizon (cambic).

Monue family soils are the primary source of topsoil and subsoil within the Emery Deep CDA. All suitable topsoil and subsoil should be salvaged. The lower subsoil that is of Unacceptable quality due to increased conductivity and/or SAR should not be salvaged. Salvage of these soils should be monitored by a Certified Professional Soil Scientist.

**Persayo family**
Persayo family soils are a Good source of topsoil and subsoil; but limited by the shallow depth to weathered shale, surface stones and boulders, and steep slopes. These soils are limited by low available water capacities. SAR and conductivity levels were Good in soil profile EM-6-09 and 16EM08. Soil pH was identified as Unacceptable (4.7) in the C horizon of 16EM08 which contained a large amount of shale parachannlers. Soil with Unacceptable pH should be not be salvaged.

These soils are on very steep to extremely steep (45 to 80 percent) slopes which will be limiting to topsoil salvage operations.

The estimated topsoil salvage depth for Persayo family soils is limited by the depth to Mancos shale. The average topsoil salvage depth is 8 inches and the average subsoil salvage depth is 6 inches. If either the topsoil horizon is less than 6 inches thick, then all of the suitable soil should be salvaged as topsoil (Utah Code R645-301-200.232.300).

Salvage of these soils should be monitored by a Certified Professional Soil Scientist.

**Sandstone Outcrops**
The estimated topsoil and subsoil salvage depths for sandstone outcrop areas are zero. However, small pockets of Cheeta, Hideout, or Persayo families do occur amongst the larger Ferron sandstone outcrops. In some cases, it may be feasible to salvage soil from these areas. This determination should be made in the field between Certified Professional Soil Scientist and the construction contractor. If there are safety concerns, then the material will not be salvaged.
Table 7. Average estimated salvage depths for soil families in the Emery Deep CDA.

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Topsoil Salvage Depth</th>
<th>Subsoil Salvage Depth</th>
<th>Total Salvage Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inches</td>
<td>Inches</td>
<td>inches</td>
</tr>
<tr>
<td>Cheeta</td>
<td>6</td>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td>Garley</td>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Hideout</td>
<td>10</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Monue family</td>
<td>9</td>
<td>29</td>
<td>38</td>
</tr>
<tr>
<td>Persayo family</td>
<td>8</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td>Sandstone outcrops</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Map Unit Salvage Depths
Weighted average topsoil and subsoil salvage depth estimates are listed by soil map unit in Table 8. Estimated map unit salvage depths are based on the component percents in Table 4 and the estimated average soil depths in Table 7. These estimates take minor soil inclusions into account. They are provided for planning purposes. Actual salvage depths will vary and will be need to be monitored in the field by a Certified Professional Soil Scientist.

Table 8. Estimated average topsoil and subsoil salvage depths for map units in the Emery Deep CDA. Depths are provided for general reference, monitoring will be required.

<table>
<thead>
<tr>
<th>Map Unit</th>
<th>Estimated Average Topsoil Salvage Depth</th>
<th>Estimated Average Subsoil Salvage Depth</th>
<th>Total Salvage Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>inches</td>
<td>inches</td>
<td>inches</td>
</tr>
<tr>
<td>Ca1</td>
<td>8</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>Ca2</td>
<td>9</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>Ca3(^1)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cb1</td>
<td>8</td>
<td>27</td>
<td>35</td>
</tr>
<tr>
<td>Cb1 - Boulders(^2)</td>
<td>8</td>
<td>27</td>
<td>35</td>
</tr>
</tbody>
</table>

1. It may be possible to salvage topsoil from small pockets of soil in this map unit. For planning purposes the average depths are estimated to be zero.
2. Topsoil salvage in this unit may vary widely.
Table 9 lists estimated salvage volumes for the Emery Deep CDA based on the map unit acres from Table 5 and the estimated average map unit salvage depths in Table 8. Volume estimates could not be made for the Cb1 with boulders area, due to the amount of very large boulders.

Table 9. Estimated topsoil and subsoil salvage volumes for the Emery Deep CDA.

<table>
<thead>
<tr>
<th>Map Unit</th>
<th>Topsoil Salvage Volume(^1)</th>
<th>Subsoil Salvage volume(^2)</th>
<th>Total Salvage Volume(^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>cubic yards</td>
<td>cubic yards</td>
<td>cubic yards</td>
</tr>
<tr>
<td>Ca1</td>
<td>2,151</td>
<td>2,151</td>
<td>4,302</td>
</tr>
<tr>
<td>Ca2</td>
<td>1,694</td>
<td>376</td>
<td>2,070</td>
</tr>
<tr>
<td>Ca3</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cb1</td>
<td>860</td>
<td>2,904</td>
<td>3,764</td>
</tr>
<tr>
<td>Cb1</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Totals</td>
<td>4,706</td>
<td>5,432</td>
<td>10,137</td>
</tr>
</tbody>
</table>

1. Weighted topsoil salvage volume for map unit is sum of products of map unit acres from Table 5 and estimated average map unit salvage depths from Table 8 and converted to cubic yards.
2. Weighted subsoil salvage volume for map unit is sum of products of map unit acres from Table 5 and estimated average salvage depths from Table 8 and converted to cubic yards.
3. Sum of weighted topsoil and subsoil volumes.

NA Salvage of topsoil and subsoil is possible, but an estimated quantity cannot be made due to the large boulders.
Salvage Operations

Determination of Salvage Suitability
The Guidelines for Management of Topsoil and Overburden (DOGM 2008) states in Table 4 that the Unacceptable SAR limit for coarse textured soils is 20. Garley and Monue family soils are coarse textured soils. The goal in the Emery Deep CDA will be to only salvage soils with a SAR of 10 or less, which is the Utah DOGM limit for Fair suitability (DOGM 2008). These salvage limits will facilitate the majority of the salvaged soil having a SAR of 10 or less.

Review of the lab analysis results indicates that there is a relationship between pH, conductivity, and SAR in the Emery Deep CDA. Table 10 lists the relationships that will be used to determine salvage suitability in the Emery Deep CDA. This relationship is based on soils sampled within or immediately adjacent to the Emery Deep CDA. SAR cannot be measured in the field.

The separation of conductivity at 3 dS/m and 8 dS/m applies to two samples with an 8.8 pH. The SAR in sample 16EM04 (7 to 17 inches) is 5.7 with a conductivity of 0.70 dS/m. The SAR in sample EM-8-09 (13 to 18 inches) is 28.5 with a conductivity of 3.91 dS/m. Conductivity of 8 dS/m is the DOGM limit for Fair suitability. Soil pH of 8.6 to 8.8 is in the Poor range (DOGM 2008). The amount of soil with Poor pH is anticipated to be limited based on the lab analysis.

The majority of the Monue family soil samples that will be salvaged in the Emery Deep CDA have a pH of 8.4 or less and a conductivity less than 8 dS/m. This occurred in 13 of 16 horizon samples or 81 percent. Ten of the 16 samples have a pH of 8.2 or less and a conductivity of 3 dS/m or less. The SAR in these 16 samples ranged from range from 0.24 to 7.24 with 13 samples having an SAR less than 4.

Table 10. Relationship between pH and conductivity (EC) in the Emery Deep CDA that will be used to determine the suitability of topsoil and subsoil for salvage. This relationship only applies to soils within the Emery Deep CDA, except for the area mapped as Cb1 with boulders (see Table 11).

<table>
<thead>
<tr>
<th>Soil pH</th>
<th>EC ≤ 3 dS/m</th>
<th>EC &lt; 3 dS/m and EC &lt; 8 dS/m</th>
<th>EC ≥ 8 dS/m</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH &lt; 8.8</td>
<td>Salvage</td>
<td>Salvage</td>
<td>Reject</td>
</tr>
<tr>
<td>pH = 8.8</td>
<td>Salvage</td>
<td>Reject</td>
<td>Reject</td>
</tr>
<tr>
<td>pH &gt;8.8</td>
<td>Reject</td>
<td>Reject</td>
<td>MAY 05 2017 Reject</td>
</tr>
</tbody>
</table>
Salvage Operations

Monitoring Topsoil and Subsoil Salvage
Soil pH and conductivity will be monitored in the field for all soils salvaged in the Emery Deep CDA. A meter that measures both pH and conductivity will be used to monitor pH and conductivity. The meter will be calibrated with standard solutions on a daily basis or more often as determined necessary by the Certified Professional Soil Scientist monitoring the topsoil and subsoil salvage. If there are safety concerns, then the soil will not be salvaged.

The following information identifies soil features that may be encountered in the soil map units. Inclusions of contrasting soils occur in each mapping unit and should be monitored during the salvage operations.

**Ca1**
Persayo family soils are shallow to weathered Mancos shale. Salvage is limited to the soil above the weathered shale. The weathered shale including soil with large amounts of parachanners should not be salvaged. Low soil pH was identified in the C horizon (8 to 13 inches) at sample location 16EM08.

Topsoil and subsoil should be salvaged as a single horizon, if the A horizon is less than 6 inches thick. The soil may be too shallow to feasibly salvage in some localized pockets.

**Ca2**
Hideout and Cheeta soils are shallow to Ferron sandstone. The depth of these soils varies from a few inches up to 20 inches in localized areas. Topsoil and subsoil should be salvaged as a single horizon, if the A horizon is less than 6 inches thick. The soil may be too shallow to feasibly salvage in some localized pockets.

**Ca3**
This map unit is dominated by Ferron sandstone outcrops. Topsoil and subsoil salvage is limited to small localized pockets of soil that are shallow to weathered shale or Ferron sandstone. Salvage of shallow soils in this map unit should be handled as described in Ca1 and Ca2 above.

**Cb1**
This map unit is dominated by very deep coarse textured soils (Monue family and Garley). Three Monue family profiles were described within this map unit delineation (0.8 acres) and did not have any limitations above 41 inches, except for sandstone bedrock at one location (16EM04). One additional Monue family profile (16EM01) that meets this criteria was described (field analysis of pH and conductivity) in the Cb1 area as part of the Order 2 Soil Survey of Emery, 2 Mine Permit Area (Long 2016).

Unacceptable SAR was identified in soil profile 16EM05 below 41 inches.
Based on the lab analysis, soils in the upper canyon above the large boulder field, are acceptable for salvage to an estimated average depth of 39 inches or sandstone bedrock, whichever occurs first. All suitable Monue family soils should be salvaged.

Garley soils were not identified in the upper portion of the CDA.

Conductivity and pH should be monitored. Soils with conductivity less than 8.0 dS/m and pH of 8.8 or less will be suitable for salvage in the Cb1 area.

**Cb1 with Boulders**

Soils in the lower canyon were mapped as Cb1 with boulders. This area is dominated by very large boulders. Salvage depths are estimated to be similar to the Cb1 map unit, but limited to the Monue family soils. Volume estimates could not be made, due to the amount of very large boulders. The delineation of this map unit is approximately 1.1 acres.

Both Garley (EM-8-09) and Monue family (16EM-10) soils were identified in the lower end of the canyon. These profiles were identified on opposite sides of the draw, approximately 64 feet apart. Soil pH is less than 8.0 and conductivity is less than 5 dS/m in the Monue family profile (16EM-10) to 39 inches.

Soil in this area will only be salvaged if the pH is less than or equal to 8.5 and the conductivity is less than 8 dS/m, Table 11. These salvage restrictions are intended to reduce the amount of Garley subsoil salvaged in the lower portion of the canyon. Based on the lab results these lower limits will facilitate the majority of the salvaged soil having a SAR of 10 or less. Utah DOGM limits for Fair suitability are pH less than or equal to 8.5 and conductivity less than or equal to 8 dS/m (DOGM 2008).

**Table 11. Relationship between pH and conductivity that will be used in the area mapped as Cb1 with boulders in the Emery Deep CDA to determine the suitability of topsoil and subsoil for salvage.** This relationship only applies to soils mapped as Cb1 with boulders.

<table>
<thead>
<tr>
<th>Soil pH</th>
<th>EC &lt; 8.0 dS/m</th>
<th>EC ≥ 8.0 dS/m</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH ≤ 8.5</td>
<td>Salvage</td>
<td>Reject</td>
</tr>
<tr>
<td>pH &gt; 8.5</td>
<td>Reject</td>
<td>Reject</td>
</tr>
</tbody>
</table>

Salvage from the Cb1 with boulders area may be limited to the 16EM10 sample location. A large portion of this area has been eroded and covered with very large boulders. Monitoring of soil pH and conductivity may identify additional areas suitable for salvage. All suitable topsoil and subsoil should be salvaged.
Literature Cited


Munsell Soil Color Charts. 2013.


Appendix A

Laboratory Analysis
Table A-1. Summary of lab analysis for samples collected in Emery 2 CDA on December 13 and 14, 2016.

<table>
<thead>
<tr>
<th>SampleID</th>
<th>Begin Depth</th>
<th>Begin Depth</th>
<th>End Depth</th>
<th>End Depth</th>
<th>pH</th>
<th>Electrical Conductivity</th>
<th>SAR</th>
<th>Clay</th>
<th>Texture</th>
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</thead>
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<tr>
<td>16EM03</td>
<td>0</td>
<td>16</td>
<td>0.0</td>
<td>6.3</td>
<td>8.0</td>
<td>2.44</td>
<td>0.72</td>
<td>14.0</td>
<td>Loam</td>
</tr>
<tr>
<td>16EM03</td>
<td>16</td>
<td>43</td>
<td>6.3</td>
<td>16.9</td>
<td>8.0</td>
<td>2.56</td>
<td>0.68</td>
<td>10.0</td>
<td>Sandy Loam</td>
</tr>
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<td>17</td>
<td>0.0</td>
<td>6.7</td>
<td>8.2</td>
<td>0.77</td>
<td>1.70</td>
<td>6.0</td>
<td>Sandy Loam</td>
</tr>
<tr>
<td>16EM04</td>
<td>17</td>
<td>44</td>
<td>6.7</td>
<td>17.3</td>
<td>8.8</td>
<td>0.70</td>
<td>5.70</td>
<td>6.0</td>
<td>Loamy Sand</td>
</tr>
<tr>
<td>16EM04</td>
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<td>86</td>
<td>17.3</td>
<td>33.9</td>
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<td>7.30</td>
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<td>16EM05</td>
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<td>20</td>
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<td>7.9</td>
<td>8.0</td>
<td>1.09</td>
<td>0.38</td>
<td>10.0</td>
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<td>16EM05</td>
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<td>48</td>
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<td>18.9</td>
<td>8.7</td>
<td>0.59</td>
<td>3.87</td>
<td>10.0</td>
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<tr>
<td>16EM05</td>
<td>48</td>
<td>80</td>
<td>18.9</td>
<td>31.5</td>
<td>7.9</td>
<td>2.76</td>
<td>1.31</td>
<td>10.0</td>
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<td>105</td>
<td>31.5</td>
<td>41.3</td>
<td>8.1</td>
<td>5.05</td>
<td>5.44</td>
<td>9.0</td>
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</tr>
<tr>
<td>16EM05</td>
<td>105</td>
<td>160</td>
<td>41.3</td>
<td>63.0</td>
<td>8.4</td>
<td>9.16</td>
<td>25.0</td>
<td>6.0</td>
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</tr>
<tr>
<td>16EM07</td>
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<td>7.1</td>
<td>8.0</td>
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<td>1.18</td>
<td>6.0</td>
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<td>0.34</td>
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<tr>
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<td>150</td>
<td>39.4</td>
<td>59.1</td>
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<td>1.92</td>
<td>0.37</td>
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<td>0.59</td>
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<td>Loam</td>
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<td>Loamy Sand</td>
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<td>8.0</td>
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DOGM Suitability

| Good | Fair | Poor |

INTEGRATED

MAY 05 2017

Div. of Oil, Gas & Mining
Samples 16EM03, 16EM04, 16EM05, 16EM07, 16EM08, 16EM09, 16EM10, and 16EM11 were received on December 19, 2016.

Samples were analyzed using the methods outlined in the following references:

- U.S.E.P.A. 600/2-78-054 "Field and Laboratory Methods Applicable to Overburden and Mining Soils", 1978
- American Society of Agronomy, Number 9, Part 2, 1982
- USDA Handbook 60 "Diagnosis and Improvement of Saline and Alkali Soils", 1969
- Wyoming Department of Environmental Quality, Land Quality Division, Guideline No. 1, 1984
- New Mexico Overburden and Soils Inventory and Handling Guideline, March 1987
- State of Utah, Division of Oil, Gas, and Mining: Guidelines for Management of Topsoil and Overburden for Underground and Surface Coal Mining, April 1988
- Montana Department of State Lands, Reclamation Division: Soil, Overburden, and Regraded Spoil Guidelines, December 1994
- State of Nevada Modified Sobek Procedure
- Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW846, 3rd Edition

All Quality Control parameters met the acceptance criteria defined by EPA and Inter-Mountain Laboratories except as indicated in this case narrative.

Reviewed by: Karen Secor, Soil Lab Supervisor
# Soil Analysis Report

## Bronco Utah Operations, LLC

**P.O. Box 527**  
550 West Consol Mine Road  
Emery, UT 84522

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### Project: Emery 2 Canyon Construction  
**Date Received:** 12/19/2016  
**Date Reported:** 12/29/2016

### Work Order: S1612225

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<th>Sample ID</th>
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*These results apply only to the samples tested.*

Abbreviations for extractions: PE = Saturated Paste Extract, H2O Sol = water soluble, AB-DTPA = Ammonium Bicarbonate-DTPA, AAO = Acid Ammonium Oxalate


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Reviewed by: Karen Secor, Soil Lab Supervisor
### Soil Analysis Report

**Project:** Emery 2 Canyon Construction  
**Date Received:** 12/19/2016  
**Sample:** 16EM09, 16EM10

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Reviewed by: Karen Secor, Soil Lab Supervisor
# Soil Analysis Report

**Project:** Emery 2 Canyon Construction  
**Date Received:** 12/19/2016

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<th>Clay %</th>
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Reviewed by: Karen Secor, Soil Lab Supervisor
# Soil Analysis Report

**Project:** Emery 2 Canyon Construction  
**Date Received:** 12/19/2016

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Reviewed by: Karen Secor, Soil Lab Supervisor
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Additional Soil Profiles

Four soil profiles were described in the Emery 2 Canyon Disturbance Area (CDA) as part of the order 2 soil survey. Descriptions for these profiles are in appendix B of Order 2 Soil Survey of Emery 2 Mine Permit Area (Long 2016). These profile locations are listed below and shown on Figure 1. Lab analysis data for EM-6-09 and EM-8-09 is in appendix C of Order 2 Soil Survey of Emery 2 Mine Permit Area (Long 2008).

EM-6-09 Persayo family
EM-8-09 Garley
16EM-01 Monue family
16EM02 Hideout
16EM03 - Cheeta

Pedon ID: 16EM03  
Description Date: 12/13/2016  
Describer: Robert Long

Soil Name As Correlated: Cheeta  
Current Taxonomic Class: Loamy-skeletal, mixed, superactive, calcareous, mesic Lithic Ustic Torriorthents  
Pedon Type: Correlates to named soil  
Current Taxon Kind: Series

Pedon Notes: this soil profile is similar to the Hideout soils mapped in the canyon, except for a C horizon dominated by weathered sandstone channers. Cheeta family soils are similar to Hideout soils, but have greater than 35 percent rock fragments.

County or Parish: UT015 - Emery  
State or Territory: UT - Utah  
UTM: 477294.1E, 4300646.9N -- Datum NAD83, Zone 12  
Location Description:  
Legal Description: Section 32, Township 22 South, Range 6 East of the 29 Meridian

Landscape: canyonlands  
Landform: canyon bench  
Geomorphic Component: Side Slope  
Profile Pos: Backslope  
Slope: 69 percent  
Elevation: 1833.3 meters (6014.8 feet)  
Aspect: 130  
Shape: up/down: Convex; across: Convex  
Drainage: Well drained  
Runoff: Very high  
Erosion: Class 3 - Rill erosion

Primary Earth Cover: Shrub cover;  
Existing Vegetation: ACHY - Indian ricegrass (*Achnatherum hymenoides*); EPHED - Mormon tea (*Ephedra*); CEMOG - birchleaf mountain mahogany (*Cercocarpus montanus var. glaber*); SAVE4 - black greasewood (*Sarcobatus vermiculatus*); ATCO - shadscale saltbush (*Atriplex confertifolia*)

Parent Materials: moderately weathered, residuum weathered from sandstone and shale and/or slightly weathered, residuum weathered from sandstone over strongly weathered, colluvium derived from sandstone and shale
Bedrock: Strongly cemented sandstone at 43 centimeters (16.9 inches)

Particle Size Control Section: 25 to 43 centimeters (9.8 to 16.9 inches)
Diagnostic Features: Lithic contact: 43 centimeters (16.9 inches)
Restrictions: Lithic bedrock: 43 centimeters (16.9 inches)

Surface Fragments: 3 percent boulders, 5 percent stones, 15 percent gravels, 15 percent flags, and 5 percent channers. Fragments are sandstone.

A --- 0 to 16 centimeters (0 to 6.3 inches); pale yellow (2.5Y 7/3) dry, channery loam; light olive brown (2.5Y 5/3) moist; 44 percent sand; 42 percent silt; 14 percent clay; weak medium subangular blocky parting to single grain structure; very friable, slightly hard, nonsticky, nonplastic finely disseminated carbonates; 30 percent angular sandstone channers; electrical conductivity of 2.44 mmhos/cm by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; moderately alkaline, pH 8, pH meter; clear smooth boundary; SAR 0.72.

2C --- 16 to 43 centimeters (6.3 to 16.9 inches); pale brown (10YR 6/3) dry, extremely channery sandy loam; brown (10YR 5/3) moist; 74 percent sand; 16 percent silt; 10 percent clay; single grain; very friable, slightly hard, nonsticky, nonplastic; 5 percent (few) carbonate coats on bottom surfaces of rock fragments; 10 percent shale parachanners and 70 percent sandstone channers; electrical conductivity of 2.56 mmhos/cm by EC meter, saturated paste; slightly effervescent by HCl, 1 normal; moderately alkaline, pH 8, pH meter; alternating layers of weathered shale and sandstone; abrupt smooth boundary; SAR 0.68.

2R --- 43 centimeters (16.9 inches); sandstone.

Estimated Salvage Depth: topsoil 17 cm (6 inches) thick (A horizon); subsoil 27 cm (10 inches) thick (2C horizon).

Salvage Limitations: shallow depth to sandstone; boulders and stones on surface; and very steep slopes.
**16EM04 - Monue family**

**Pedon ID:** 16EM04  
**Description Date:** 12/30/2016 8:44:42 PM  
**Describer:** Robert Long  

**Soil Name As Correlated:** Monue family  
**Current Taxonomic Class:** Coarse-loamy, mixed, superactive, mesic Typic Haplocambids  
**Pedon Type:** Correlates to named soil  
**Current Taxon Kind:** Family  

**Pedon Notes:** moderately deep Monue family soil profile.  

**County or Parish:** UT015 - Emery  
**State or Territory:** UT - Utah  
**UTM:** 477381.9E, 4300683.1N -- Datum NAD83, Zone 12  
**Location Description:**  
**Legal Description:** Section 33, Township 22 South, Range 6 East of the 29 Meridian  

**Landscape:** canyonlands  
**Landform:** stream terrace  
**Geomorphic Component:** Base Slope  
**Profile Pos:** Toeslope  
**Slope:** 9 percent  
**Elevation:** 1820.3 meters (5972.1 feet)  
**Aspect:** 350°  
**Shape: up/down:** Convex; across: Linear  

**Drainage:** Well drained  
**Runoff:** Medium  
**Erosion:** Class 3 - Sheet erosion  

**Primary Earth Cover:** Shrub cover;  
**Existing Vegetation:** CHRY9 - rabbitbrush (*Chrysothamnus*); SAVE4 - black greasewood (*Sarcobatus vermiculatus*); ACHY - Indian ricegrass (*Achnatherum hymenoides*); GUTIE - snakeweed (*Gutierrezia*); ATCO - shadscale saltbush (*Atriplex confertifolia*); CEMOG - birchleaf mountain mahogany (*Cercocarpus montanus var. glaber*)

**Parent Materials:** slope alluvium derived from sandstone and shale  
**Bedrock:** Sandstone at 86 centimeters (33.9 inches)  

**Particle Size Control Section:** 25 to 86 centimeters (9.8 to 33.9 inches)
Diagnostic Features: Secondary carbonates: 44 to 86 centimeters (17.3 to 33.9 inches) and Lithic contact: 86 centimeters (33.9 inches)

Restrictions: Lithic bedrock: 86 centimeters (33.9 inches)

Surface Fragments: 3 percent sandstone gravels.

A --- 0 to 17 centimeters (0 to 6.7 inches); very pale brown (10YR 7/3) dry, sandy loam; brown (10YR 4/3) moist; 74 percent sand; 20 percent silt; 6 percent clay; weak medium subangular blocky structure; very friable, hard, nonsticky, nonplastic; 5 percent subangular sandstone gravels; electrical conductivity of 0.77 mmhos/cm by EC meter, saturated paste; slightly effervescent by HCl, 1 normal; moderately alkaline, pH 8.2, pH meter; clear smooth boundary; SAR 1.7.

Bw --- 17 to 44 centimeters (6.7 to 17.3 inches); very pale brown (10YR 7/3) dry, loamy sand; yellowish brown (10YR 5/4) moist; 82 percent sand; 12 percent silt; 6 percent clay; moderate medium subangular blocky structure; very friable, slightly hard, nonsticky, nonplastic; electrical conductivity of 0.7 mmhos/cm by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; strongly alkaline, pH 8.8, pH meter; clear smooth boundary; SAR 5.7.

Ck --- 44 to 86 centimeters (17.3 to 33.9 inches); very pale brown (10YR 7/4) dry, sandy loam; light yellowish brown (10YR 6/4) moist; 72 percent sand; 19 percent silt; 9 percent clay; massive parting to single grain; very friable, slightly hard, nonsticky, nonplastic; 3 percent (very few) carbonate coats on bottom surfaces of rock fragments; 5 percent (common) fine threadlike masses of carbonate in matrix; 5 percent subangular sandstone gravels; electrical conductivity of 7.3 mmhos/cm by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; moderately alkaline, pH 8.4, pH meter; abrupt smooth boundary; SAR 7.24.

R --- 86 centimeters (33.9 inches); sandstone bedrock or large boulder).

Estimated Salvage Depth: topsoil 17 cm (7 inches) thick (A horizon); and subsoil 69 cm (27 inches) thick (Bw and Ck horizons).

Salvage Limitations: pH of the cambic horizon (Bw, 17 to 44 cm) is in the Poor range and will require monitoring to ensure that Unacceptable material is not salvaged; depth to sandstone.
16EM05 - Monue family

Pedon ID: 16EM05
Description Date: 12/13/2016
Describer: Robert Long

Soil Name As Correlated: Monue family
Current Taxonomic Class: Coarse-loamy, mixed, superactive, mesic Typic Haplocambids

Pedon Type: Correlates to named soil
Current Taxon Kind: Family

Pedon Notes: this soil profile is similar to Monue family profile previously described in the Emery 2 soil survey.

County or Parish: UT015 - Emery
State or Territory: UT - Utah
UTM: 477454.7E, 4300722.4N -- Datum NAD83, Zone 12
Legal Description: Section 33, Township 22 South, Range 6 East of the 29 Meridian

Landscape: canyonlands
Landform: stream terrace
Geomorphic Component: Base Slope
Profile Pos: Toeslope
Slope: 7 percent
Elevation: 1820 meters (5971.1 feet)
Aspect: 310°
Shape: up/down: Linear; across: Convex

Drainage: Well drained
Runoff: Medium
Erosion: Class 2 - Gully erosion

Primary Earth Cover: Shrub cover
Existing Vegetation: ATCA2 - fourwing saltbush (Atriplex canescens); GUTIE - snakeweed (Gutierrezia); ACHY - Indian ricegrass (Achnatherum hymenoides);
BRTE - cheatgrass (Bromus tectorum); OPPO - plains pricklypear (Opuntia polyacantha); ARNO4 - black sagebrush (Artemisia nova)

Parent Materials: alluvium derived from sandstone and shale
Particle Size Control Section: 25 to 100 centimeters (9.8 to 39.4 inches)
Diagnostic Features: Secondary carbonates: 48 to 160 centimeters (18.9 to 63 inches)
**Surface Fragments:** 10 percent boulders, 10 percent stones, 5 percent cobbles, 15 percent gravels, and 10 percent channers. Fragments are sandstone.

A --- 0 to 20 centimeters (0 to 7.9 inches); light yellowish brown (10YR 6/4) dry, sandy loam; yellowish brown (10YR 5/4) moist; 74 percent sand; 16 percent silt; 10 percent clay; weak medium subangular blocky parting to single grain structure; very friable, slightly hard, nonsticky, nonplastic; common medium roots throughout, common fine roots throughout and common very fine roots throughout; 5 percent subangular sandstone gravels; electrical conductivity of 1.09 mmhos/cm by EC meter, saturated paste; by HCl, 1 normal; moderately alkaline, pH 8, pH meter; clear smooth boundary; SAR 0.38.

Bw --- 20 to 48 centimeters (7.9 to 18.9 inches); very pale brown (10YR 7/4) dry, gravelly sandy loam; yellowish brown (10YR 5/4) moist; 78 percent sand; 12 percent silt; 10 percent clay; moderate medium subangular blocky parting to single grain structure; very friable, slightly hard, nonsticky, nonplastic; common medium roots throughout, common fine roots throughout and many very fine roots throughout; 2 percent (very few) carbonate coats on bottom surfaces of rock fragments; 20 percent subangular sandstone gravels; electrical conductivity of 0.59 mmhos/cm by EC meter, saturated paste; by HCl, 1 normal; strongly alkaline, pH 8.7, pH meter; gradual smooth boundary; SAR 3.87.

Bk1 --- 48 to 80 centimeters (18.9 to 31.5 inches); very pale brown (10YR 7/4) dry, gravelly sandy loam; yellowish brown (10YR 5/4) moist; 78 percent sand; 12 percent silt; 10 percent clay; moderate medium subangular blocky parting to single grain structure; very friable, slightly hard, nonsticky, nonplastic; common medium roots throughout, common fine roots throughout and many very fine roots throughout; 5 percent (few) carbonate coats on bottom surfaces of rock fragments finely disseminated carbonates; 15 percent subangular sandstone gravels; electrical conductivity of 2.76 mmhos/cm by EC meter, saturated paste; by HCl, 1 normal; moderately alkaline, pH 7.9, pH meter; gradual smooth boundary; SAR 1.31.

Bk2 --- 80 to 105 centimeters (31.5 to 41.3 inches); very pale brown (10YR 7/4) dry, gravelly loamy sand; yellowish brown (10YR 5/4) moist; 82 percent sand; 9 percent silt; 9 percent clay; weak medium subangular blocky structure; very friable, slightly hard, nonsticky, nonplastic; common very fine roots throughout; 4 percent (very few) carbonate coats on bottom surfaces of rock fragments; 5 percent (common) medium masses of carbonate in matrix; 15 percent subangular sandstone gravels; electrical conductivity of 5.05 mmhos/cm by EC meter, saturated paste; by HCl, 1 normal; moderately alkaline, pH 8.1, pH meter; gradual smooth boundary; SAR 5.44.
Bk3 --- 105 to 160 centimeters (41.3 to 63 inches); very pale brown (10YR 7/3) dry, very gravelly loamy sand; pale brown (10YR 6/3) moist; 82 percent sand; 12 percent silt; 6 percent clay; single grain; very friable, soft, nonsticky, nonplastic; common very fine roots throughout; 8 percent (few) carbonate coats on bottom surfaces of rock fragments; 8 percent (common) fine threadlike masses of carbonate in matrix; 5 percent nonflat subangular 76 to 250 millimeters (3 to 10 inches) sandstone fragments and 35 percent nonflat subangular 2 to 76 millimeters (0.1 to 3 inches) sandstone fragments; electrical conductivity of 9.16 mmhos/cm by EC meter, saturated paste; by HCl, 1 normal; moderately alkaline, pH 8.4, pH meter; SAR 25.

Estimated Salvage Depth: topsoil 20 cm (8 inches) thick (A horizon); and subsoil 85 cm (33 inches) thick (Bk1 and Bk2 horizons).

Salvage Limitations: pH of the cambic horizon (Bw, 20 to 48 cm or 8 to 19 inches) is in the Poor range and will require monitoring to ensure that Unacceptable material is not salvaged; conductivity is Poor and SAR is Unacceptable below 105 cm (41 inches) and should not be salvaged; boulders and stones on surface.
16EM06 - Rock Outcrop

**Pedon ID:** 16EM06  
**Description Date:** 12/13/2016  
**Describer:** Robert Long

**Site Notes: Text:** This site is located on a very steep northwest facing canyon sideslope. The area is approximately 75 percent rock outcrop, 15 percent Hideout soils, and 10 percent Persayo family soils. It is estimated that there will be very little to no salvageable topsoil or subsoil in this area, based on the small pockets of shallow soils.

**County or Parish:** UT015 - Emery  
**State or Territory:** UT - Utah  
**UTM:** 477445.5E, 4300704.9N -- Datum NAD83, Zone 12  
**Legal Description:** Section 33, Township 22 South, Range 6 East of the 29 Meridian  
**Landscape:** canyonlands  
**Landform:** canyon wall

**Geomorphic Component:** Free face  
**Profile Pos:** Backslope  
**Slope:** 44 percent  
**Elevation:** 1827.1 meters (5994.4 feet)  
**Aspect:** 315°  
**Shape:** up/down: ; across:

**Drainage:** Well drained  
**Runoff:** Very high

**Estimated Salvage Depth:** Limited to small pockets of Hideout family soils (shallow).

**Salvage Limitations:** sandstone outcrops; and very steep slopes.
16EM07 - Monue family sandy taxadjunct

Pedon ID: 16EM07
Description Date: 12/13/2016
Describer: Robert Long

Soil Name As Correlated: Monue family sandy taxadjunct
Current Taxonomic Class: Sandy, mixed, superactive, mesic Typic Haplocambids
Current Taxon Kind: Family

Pedon Notes: profile is similar to Monue family profile, but the textures are sand and loamy sand.

County or Parish: UT015 - Emery
State or Territory: UT - Utah
UTM: 477513.7E, 4300765.5N -- Datum NAD83, Zone 12
Legal Description: Section 33, Township 22 South, Range 6 East of the 29 Meridian

Landscape: canyonlands
Landform: stream terrace
Geomorphic Component: Base Slope
Profile Pos: Toeslope
Slope: 8 percent
Elevation: 1820.7 meters (5973.4 feet)
Aspect: 300°
Shape: up/down: Concave; across: Concave

Drainage: Well drained
Runoff: High
Erosion: Class 2 - Gully erosion

Primary Earth Cover: Shrub cover;
Existing Vegetation: SAVE4 - black greasewood (Sarcobatus vermiculatus); ATCA2 - fourwing saltbush (Atriplex canescens); BRTE - cheatgrass (Bromus tectorum)

Parent Materials: alluvium derived from sandstone and shale

Particle Size Control Section: 25 to 100 centimeters (9.8 to 39.4 inches)
Diagnostic Features: Secondary carbonates: 18 to 150 centimeters (7.1 to 59.1 inches) and Cambic horizon: 18 to 38 centimeters (7.1 to 15 inches)

Surface Fragments: 15 percent gravels and 5 percent channers. Fragments are sandstone.
A -- 0 to 18 centimeters (0 to 7.1 inches); very pale brown (10YR 7/3) dry, sand; light yellowish brown (10YR 6/4) moist; 88 percent sand; 6 percent silt; 6 percent clay; weak medium subangular blocky parting to single grain structure; very friable, slightly hard, nonsticky, nonplastic; common fine roots throughout and common very fine roots throughout; 5 percent subangular sandstone gravels; electrical conductivity of 0.71 mmhos/cm by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; moderately alkaline, pH 8, pH meter; clear smooth boundary; SAR 1.18.

Bw -- 18 to 38 centimeters (7.1 to 15 inches); very pale brown (10YR 7/4) dry, sand; yellowish brown (10YR 5/4) moist; 90 percent sand; 5 percent silt; 5 percent clay; weak medium subangular blocky structure; very friable, slightly hard, nonsticky, nonplastic; common medium roots throughout, common fine roots throughout and many very fine roots throughout finely disseminated carbonates; electrical conductivity of 0.37 mmhos/cm by EC meter, saturated paste; slightly effervescent by HCl, 1 normal; moderately alkaline, pH 8, pH meter; gradual smooth boundary; SAR 0.29.

C -- 38 to 64 centimeters (15 to 25.2 inches); very pale brown (10YR 7/4) dry, sand; light yellowish brown (10YR 6/4) moist; 92 percent sand; 2 percent silt; 6 percent clay; single grain; very friable, slightly hard, nonsticky, nonplastic; common medium roots throughout, common fine roots throughout and common very fine roots throughout finely disseminated carbonates; electrical conductivity of 0.4 mmhos/cm by EC meter, saturated paste; slightly effervescent by HCl, 1 normal; moderately alkaline, pH 8.1, pH meter; clear wavy boundary; SAR 0.32.

2Ck1 -- 64 to 100 centimeters (25.2 to 39.4 inches); light yellowish brown (10YR 6/4) dry, very gravelly loamy sand; yellowish brown (10YR 5/4) moist; 82 percent sand; 10 percent silt; 8 percent clay; single grain; loose, loose, nonsticky, nonplastic; common medium roots throughout, common fine roots throughout and common very fine roots throughout; 6 percent (few) carbonate coats on bottom surfaces of rock fragments finely disseminated carbonates; 10 percent subangular sandstone channers and 30 percent subangular sandstone gravels; electrical conductivity of 2.1 mmhos/cm by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; moderately alkaline, pH 7.9, pH meter; gradual smooth boundary; SAR 0.34.

2Ck2 -- 100 to 150 centimeters (39.4 to 59.1 inches); very pale brown (10YR 7/4) dry, extremely gravelly loamy sand; yellowish brown (10YR 5/4) moist; 86 percent sand; 7 percent silt; 7 percent clay; single grain; loose, loose, nonsticky, nonplastic; common very fine roots throughout; 10 percent (few) carbonate coats on bottom surfaces of rock fragments finely disseminated carbonates; 15 percent subangular sandstone channers and 50 percent sub angular sandstone gravels; electrical conductivity of 1.92 mmhos/cm by EC meter, saturated paste; violently effervescent by HCl, 1 normal; moderately alkaline, pH 8, pH meter; SAR 0.37.
Estimated Salvage Depth: topsoil 18 cm (7 inches) thick (A horizon); and subsoil 132 cm (52 inches) thick (Bw, C, 2Ck1, and 2Ck2 horizons).

Salvage Limitations: sandy textures are in Fair range.
16EM08 - Persayo family

Pedon ID: 16EM08
Description Date: 12/14/2016
Describer: Robert Long

Soil Name As Correlated: Persayo family
Current Taxonomic Class: Loamy, mixed, active, calcareous, mesic, shallow Typic Torriorthents
Pedon Type: Correlates to named soil
Current Taxon Kind: Family

Pedon Notes: this soil profile is similar to Persayo family profile previously described in the Emery 2 soil survey.

County or Parish: UT015 - Emery
State or Territory: UT - Utah
UTM: 477606.3E, 4300862.6N -- Datum NAD83, Zone 12
Legal Description: Section 33, Township 22 South, Range 6 East of the 29 Meridian

Landscape: canyonlands
Landform: canyon
Geomorphic Component: Side Slope
Profile Pos: Backslope
Slope: 42 percent
Elevation: 1813 meters (5948.2 feet)
Aspect: 300°
Shape: up/down: Linear; across: Convex

Drainage: Well drained
Runoff: High
Erosion: Class 2 - Sheet erosion

Primary Earth Cover: Shrub cover;
Existing Vegetation: BRTE - cheatgrass (*Bromus tectorum*); PIDE4 - bud sagebrush (*Picrothamnus desertorum*); ATCO - shadscale saltbush (*Atriplex confertifolia*); ACHY - Indian ricegrass (*Achnatherum hymenoides*)

Parent Materials: residuum weathered from shale
Bedrock: Moderately cemented shale at 60 centimeters (23.6 inches)

Particle Size Control Section: 0 to 34 centimeters (0 to 13.4 inches)
Diagnostic Features: Paralithic contact: 34 centimeters (13.4 inches)
Restrictions: Paralithic bedrock: 34 to 60 centimeters (13.4 to 23.6 inches) and Paralithic bedrock: 60 centimeters (23.6 inches)
**Surface Fragments:** 10 percent boulders; 5 percent stones, 5 percent cobbles, 40 percent flags, 20 percent channers, and 10 percent gravels. Fragments are sandstone.

**A ---** 0 to 20 centimeters (0 to 7.9 inches); light brownish gray (10YR 6/2) dry, gravelly sandy loam; brown (10YR 5/3) moist; 68 percent sand; 18 percent silt; 14 percent clay; moderate medium subangular blocky parting to single grain structure; very friable, slightly hard, slightly sticky, slightly plastic; common fine roots throughout and common very fine roots throughout; 15 percent subangular sandstone gravels; electrical conductivity of 2.18 mmhos/cm by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; neutral, pH 7.3, pH meter; clear smooth boundary; SAR 0.59.

**C ---** 20 to 34 centimeters (7.9 to 13.4 inches); dark grayish brown (10YR 4/2) dry, very parachannery loam; very dark grayish brown (10YR 3/2) moist; 38 percent sand; 39 percent silt; 23 percent clay; massive; very friable, slightly hard, slightly sticky, slightly plastic; common fine roots throughout and many very fine roots throughout; 55 percent angular shale parachanners; electrical conductivity of 3.14 mmhos/cm by EC meter, saturated paste; noneffervescent by HCl, 1 normal; very strongly acid, pH 4.7, pH meter; clear smooth boundary; SAR 0.2.

**Cr1 ---** 34 to 60 centimeters (13.4 to 23.6 inches); extremely parachannery loam; 28 percent sand; 47 percent silt; 25 percent clay; common fine roots throughout and common very fine roots throughout; electrical conductivity of 4.31 mmhos/cm by EC meter, saturated paste; noneffervescent by HCl, 1 normal; slightly acid, pH 6.5, pH meter; 55 percent weathering shale parachanners; gradual smooth boundary; SAR 0.13.

**Cr2 ---** 60 centimeters (23.6 inches); slightly weathered shale.

**Estimated Salvage Depth:** topsoil 20 cm (8 inches) thick (A horizon); and no subsoil due to Unacceptable pH of C horizon.

**Salvage Limitations:** depth to Unacceptable pH (4.7) in C horizon (20 to 34 cm or 8 to 13 inches); depth to weathering shale (34 cm or 13 inches; surface boulders and stones.
16EM09 - Monue family

Pedon ID: 16EM09
Description Date: 12/14/2016
Describer: Robert Long

Soil Name As Correlated: Monue family
Current Taxonomic Class: Coarse-loamy, mixed, superactive, mesic Typic
Haplocambids
Current Taxon Kind: Family

Pedon Notes: this profile is similar to other Monue family profiles, but it is on a very steep slope.

County or Parish: UT015 - Emery
State or Territory: UT - Utah
UTM: 477533.6E, 4300868N -- Datum NAD83, Zone 12
Legal Description: Section 33, Township 22 South, Range 6 East of the 29 Meridian

Landscape: canyonlands
Landform: canyon bench
Geomorphic Component: Head Slope
Profile Pos: Backslope
Slope: 76 percent
Elevation: 1818.3 meters (5965.6 feet)
Aspect: 100°
Shape: up/down: Linear; across: Convex

Drainage: Well drained
Runoff: High
Erosion: Class 3 - Sheet erosion

Primary Earth Cover: Shrub cover;
Existing Vegetation: ATCO - shadscale saltbush (Atriplex confertifolia); SAVE4 - black greasewood (Sarcobatus vermiculatus)

Parent Materials: residuum weathered from sandstone
Bedrock: Strongly cemented sandstone at 80 centimeters (31.5 inches)

Particle Size Control Section: 25 to 80 centimeters (9.8 to 31.5 inches)
Diagnostic Features: Cambic horizon: 23 to 54 centimeters (9.1 to 21.3 inches);
Secondary carbonates: 54 to 80 centimeters (21.3 to 31.5 inches) and Lithic contact: 80 centimeters (31.5 inches)
Restrictions: Lithic bedrock: 80 centimeters (31.5 inches)
**Surface Fragments:** 20 percent boulders; 20 percent channers, 5 percent flags, and 5 percent gravels. Fragments are sandstone.

A --- 0 to 23 centimeters (0 to 9.1 inches); very pale brown (10YR 7/4) dry, channery loamy sand; yellowish brown (10YR 5/4) moist; 84 percent sand; 4 percent silt; 12 percent clay; weak medium subangular blocky parting to single grain structure; very friable, slightly hard, nonsticky, nonplastic; common medium roots throughout, common fine roots throughout and many very fine roots throughout; 10 percent subangular sandstone channers, 5 percent subangular sandstone flags and 5 percent subangular sandstone boulders; electrical conductivity of 4.1 mmhos/cm by EC meter, saturated paste; noneffervescent by HCl, 1 normal; slightly alkaline, pH 7.7, pH meter; gradual smooth boundary; SAR 3.03.

Bw --- 23 to 54 centimeters (9.1 to 21.3 inches); very pale brown (10YR 7/3) dry, gravelly sandy loam; brown (10YR 5/3) moist; 78 percent sand; 10 percent silt; 12 percent clay; weak medium subangular blocky parting to single grain structure; very friable, slightly hard, nonsticky, nonplastic; common medium roots throughout, common fine roots throughout and common very fine roots throughout; 20 percent angular sandstone gravels; electrical conductivity of 12 mmhos/cm by EC meter, saturated paste; very slightly effervescent by HCl, 1 normal; slightly alkaline, pH 7.4, pH meter; clear smooth boundary; SAR 2.78.

Bk --- 54 to 80 centimeters (21.3 to 31.5 inches); weathering sandstone and shale; extremely parachannery sandy loam; 68 percent sand; 14 percent silt; 18 percent clay; massive; friable, hard, nonsticky, nonplastic; common very fine roots throughout; 5 percent (few) carbonate coats on bottom surfaces of rock fragments; 45 percent shale parachanners and 30 percent subangular sandstone gravels; electrical conductivity of 13.3 mmhos/cm by EC meter, saturated paste; very slightly effervescent by HCl, 1 normal; slightly alkaline, pH 7.6, pH meter; abrupt smooth boundary; SAR 2.9.

R --- 80 centimeters (31.5 inches); sandstone.

**Estimated Salvage Depth:** topsoil 23 cm (9 inches) thick (A horizon); and no subsoil due to Poor conductivity below 23 cm (9 inches)

**Salvage Limitations:** boulders and stones on surface; Poor conductivity below 23 cm (9 inches); depth to sandstone; and very steep slopes.

**INTEGRATED**

**MAY 05 2017**

Div. of Oil, Gas & Mining
Pedon ID: 16EM10
Description Date: 12/14/2016
Describer: Robert Long

Soil Name As Correlated: Monue family
Current Taxonomic Class: Coarse-loamy, mixed, superactive, mesic Typic Haplocambids
Pedon Type: Correlates to named soil
Current Taxon Kind: Family

Pedon Notes: profile similar to other Monue family profiles described in area, unable to dig below 1 meter (39 inches) due large rock.

County or Parish: UT015 - Emery
State or Territory: UT - Utah
UTM: 477590.6E, 4300905N -- Datum NAD83, Zone 12
Legal Description: Section 33, Township 22 South, Range 6 East of the 29 Meridian

Landscape: canyonlands
Landform: fan apron
Geomorphic Component: Base Slope
Profile Pos: Toeslope
Slope: 5 percent
Elevation: 1809.9 meters (5938 feet)
Aspect: 15°
Shape: up/down: Linear; across: Linear

Drainage: Well drained
Runoff: Low
Erosion: Class 4 - Gully erosion

Primary Earth Cover: Shrub cover;
Existing Vegetation: PI DE4 - bud sagebrush (Picrothamnus desertorum); ACHY - Indian ricegrass (Achnatherum hymenoides); SAVE4 - black greasewood (Sarcobatus vermiculatus); SPCR - sand dropseed (Sporobolus cryptandrus)

Parent Materials: alluvium derived from sandstone and shale

Particle Size Control Section: 25 to 100 centimeters (9.8 to 39.4 inches)
Diagnostic Features: Secondary carbonates: 17 to 100 centimeters (6.7 to 39.4 inches).
**Surface Fragments:** 5 percent very large boulders (substantially more in adjacent areas), 5 percent gravels, and 3 percent channers. Fragments are sandstone.

**A** --- 0 to 17 centimeters (0 to 6.7 inches); light yellowish brown (10YR 6/4) dry, loamy sand; yellowish brown (10YR 5/4) moist; 78 percent sand; 14 percent silt; 8 percent clay; weak medium subangular blocky parting to single grain structure; very friable, slightly hard, nonsticky, nonplastic; common medium roots throughout, common fine roots throughout and many very fine roots throughout; 10 percent angular sandstone gravels; electrical conductivity of 0.64 mmhos/cm by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; moderately alkaline, pH 7.9, pH meter; clear smooth boundary; SAR 0.24.

**Bw** --- 17 to 40 centimeters (6.7 to 15.7 inches); very pale brown (10YR 7/4) dry, sandy loam; yellowish brown (10YR 5/4) moist; 74 percent sand; 18 percent silt; 8 percent clay; moderate fine subangular blocky parting to single grain structure; very friable, slightly hard, nonsticky, nonplastic; common fine roots throughout and common very fine roots throughout finely disseminated carbonates; 5 percent angular sandstone gravels; electrical conductivity of 1.13 mmhos/cm by EC meter, saturated paste; strongly effervescent by HCl, 1 normal; moderately alkaline, pH 7.9, pH meter; gradual smooth boundary; SAR 0.28.

**Bk1** --- 40 to 74 centimeters (15.7 to 29.1 inches); very pale brown (10YR 7/3) dry, gravelly sandy loam; light yellowish brown (10YR 6/4) moist; 72 percent sand; 20 percent silt; 8 percent clay; weak fine subangular blocky parting to single grain structure; very friable, slightly hard, nonsticky, nonplastic; common fine roots throughout and common very fine roots throughout finely disseminated carbonates; 15 percent angular sandstone gravels; electrical conductivity of 3.38 mmhos/cm by EC meter, saturated paste; violently effervescent by HCl, 1 normal; slightly alkaline, pH 7.8, pH meter; gradual smooth boundary; SAR 1.37.

**Bk2** --- 74 to 100 centimeters (29.1 to 39.4 inches); very pale brown (10YR 7/3) dry, gravelly sandy loam; yellowish brown (10YR 5/4) moist; 68 percent sand; 14 percent silt; 14 percent clay; weak fine subangular blocky parting to single grain structure; very friable, slightly hard, nonsticky, nonplastic; common fine roots throughout and common very fine roots throughout; 2 percent (very few) carbonate coats on bottom surfaces of rock fragments; 4 percent (common) fine masses of carbonate in matrix; 25 percent angular sandstone gravels; electrical conductivity of 4.92 mmhos/cm by EC meter, saturated paste; violently effervescent by HCl, 1 normal; slightly alkaline, pH 7.7, pH meter; stopped by large rock or boulder at 100 cm; SAR 3.53.

**Estimated Salvage Depth:** topsoil 17 cm (7 inches); and subsoil 83 cm (32 inches).

**Salvage Limitations:** very large sandstone boulders; Unacceptable SAR levels could be present below 100 cm (39 inches).
16EM11 - Hideout family

Pedon ID: 16EM11  
Description Date: 12/14/2016  
Describer: Robert Long

Soil Name As Correlated: Hideout  
Current Taxonomic Class: Loamy, mixed, superactive, calcareous, mesic Lithic Ustic Torriorthents  
Current Taxon Kind: Series

County or Parish: UT015 - Emery  
State or Territory: UT - Utah  
UTM: 477604.8E, 4300945.9N -- Datum NAD83, Zone 12  
Legal Description: Section 33, Township 22 South, Range 6 East of the 29 Meridian

Landscape: canyonlands  
Landform: canyon sideslope  
Geomorphic Component: sideslope  
Profile Pos: Backslope  
Slope: 70 percent  
Elevation: 1791.4 meters (5877.3 feet)  
Aspect: 152°  
Shape: up/down: Linear; across: Linear

Drainage: Well drained  
Runoff: Very high  
Erosion: Class 3 - Rill erosion

Primary Earth Cover: Shrub cover;  
Existing Vegetation: PIDE4 - bud sagebrush (*Piceothamnus desertorum*); SAVE4 - black greasewood (*Sarcobatus vermiculatus*); ATCO - shadscale saltbush (*Atriplex confertifolia*)

Parent Materials: residuum  
Bedrock: Sandstone at 30 centimeters (11.8 inches)

Particle Size Control Section: 0 to 30 centimeters (0 to 11.8 inches)  
Diagnostic Features: Lithic contact: 30 centimeters (11.8 inches)  
Restrictions: Lithic bedrock: 30 centimeters (11.8 inches)
Surface Fragments: 5 percent boulders, 10 percent stones, 5 percent cobbles, 15 percent gravels, and 25 percent channers. Fragments are sandstone.

AC --- 0 to 30 centimeters (0 to 11.8 inches); light brown (7.5YR 6/4) dry, very gravelly sandy loam; brown (7.5YR 5/4) moist; 72 percent sand; 16 percent silt; 12 percent clay; moderate medium subangular blocky structure; very friable, hard, nonsticky, nonplastic; common medium roots throughout, common fine roots throughout and common very fine roots throughout; 40 percent subangular sandstone gravels; electrical conductivity of 2.75 mmhos/cm by EC meter, saturated paste; slightly effervescent by HCl, 1 normal; moderately alkaline, pH 8, pH meter; clear smooth boundary; SAR 2.56.

R --- 30 centimeters (11.8 inches); sandstone.

Estimated Salvage Depth: topsoil 30 cm (12 inches).

Salvage Limitations: shallow depth to sandstone (30 cm or 12 inches); boulders and stones on surface; and very steep slope.
Appendix C

Site Photographs
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Appendix D

Profile Box Photographs
Photo D - 1. Soil profile 16EM03, Cheeta family.
Photo D - 2. Soil profile 16EM04, Monue family.
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No sample box was collected at 16EM06, because it was a sandstone outcrop site.

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