

APPENDIX

SUPPORTING DATA

SOILS

Arvada Series

The Arvada series is a member of the fine, montmorillonitic, mesic family of Ustollic Natrargids. Typically, Arvada soils have thin platy A2 horizons, fine-textured B2t horizons having columnar to blocky structure, and moderate accumulations of calcium carbonate, calcium sulfate, and other salts.

Typifying Pedon. Arvada fine sandy loam—grassland. (Colors are for dry soil unless otherwise noted.)

A2 0-4"—Light gray (10YR 7/2) fine sandy loam, grayish brown (10YR 5/2) moist; moderate very thin platy structure that parts to moderate fine granules; soft; very friable; vesicular; noncalcareous; mildly alkaline (pH 7.8); abrupt smooth boundary; 0 to 6 inches thick.

B2t 4-14"—Brown (10YR 5/3) clay, dark brown (10YR 4/3) moist; moderate medium columnar structure that parts to moderate medium angular blocks; extremely hard, firm, very plastic; moderate continuous waxlike coatings on faces of peds and in root channels; strongly alkaline (pH 9.2); 20% exchangeable sodium; clear smooth boundary; 8 to 14 inches thick.

B3casa 14-20"—Brown (10YR 5/3) heavy clay loam, dark brown (10YR 4/3) moist; weak medium subangular blocky structure; extremely hard, firm, very plastic; weak visible accumulation of calcium carbonate and other salts as crystals, in concretions, and in thin seams and streaks; few thin glossy patches on faces of peds; some waxlike fillings in root channels; calcareous; very strongly alkaline (pH 9.0); 20% exchangeable sodium; gradual smooth boundary; 5 to 10 inches thick.

Ccasa 20-60"—Light yellowish brown (2.5Y 6/3) heavy clay loam, light olive brown (2.5Y 5/3) moist; massive; hard, friable; moderate accumulation of visible calcium carbonate and other soluble salts as crystals, in thin seams and streaks, and in concretions; strongly alkaline (pH 8.8); 20% exchangeable sodium.

Type Location. Sheridan County, Wyoming; 650 feet south and 200 feet west of the NE corner of Section 29, T. 55 N., R. 87 W.

Range in Characteristics. Depth to calcareous material ranges from 0 to 12 inches, thickness of solum ranges from 15 to 30 inches. Average content of organic carbon in the upper 15 inches exceeds .6%. Thin A1 horizons occur in some pedons. Light-colored platy A2 horizons are generally present but are absent in some pedons. Content of coarse fragments is typically less than 5%

and ranges from 0% to 15%. Mean annual soil temperature ranges from 47° to 58°F, and mean summer soil temperature ranges from 59° to 78°F. Length of time the soil temperature at 20 inches exceeds 41°F normally ranges from 230 to 305 days. Length of time (cumulative) the soil is moist in some part of the moisture control section while the soil temperature at 20 inches is above 41°F normally ranges from 56 days to 152 days, but in most years it should not be less than one-fourth or more than one-half of the time the soil is above 41°F. The A horizon has hue of 2.5Y to 10YR, value of 5 or 6 dry and 4 or 5 moist, and chroma of 2 through 4. It is typically clay but the percent of clay ranges from 35% to 60%, of silt from 10% to 50%, and of sand from 5% to 50%. It ranges from strongly alkaline to very strongly alkaline (pH 8.8 to 10.0) and has from 15% to 34% exchangeable sodium. Its cation exchange capacity ranges from 70 to 100 milliequivalents per 100 grams of clay. The C horizon has hue of 2.5Y to 10YR. It ranges from strongly alkaline to very strongly alkaline (pH 8.6 to 10.0) and contains 4% to 12% calcium carbonate equivalent. Exchangeable sodium typically ranges from 10% to 30% but generally decreases with depth.

Principal Associated Soils. These are the Absted, Renohill, and Ulm soils. Absted soils have less than 15% sodium in the upper part of the argillic horizon. Renohill and Ulm soils lack natric horizons.

Bankard Series

The Bankard series is a member of the sandy, mixed family of Ustic Torrifluents. Typically, Bankard soils have calcareous, granular A horizons and strongly stratified but predominantly sandy, calcareous C horizons.

Typifying Pedon. Bankard loamy sand—grassland. (Colors are for dry soil unless otherwise noted.)

A1 0-5"—Light brownish gray (2.5Y 6/2) loamy fine sand, grayish brown (2.5Y 5/2) moist; weak fine granular structure; soft, very friable; calcareous; moderately alkaline (pH 8.0); clear smooth boundary; 4 to 8 inches thick.

C 5-60"—Light yellowish brown (2.5Y 6/3) fine sand stratified with thin lenses of sandy loam and loam, light olive brown (2.5Y 5/3) moist; the weighed average texture is loamy fine sand; single grained; soft, very friable; calcareous; moderately alkaline (pH 8.2).

Type Location. Morgan County, Colorado; 100 feet south and 210 feet east of the NW corner Section 30, T. 4 N., R. 56 W.

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Range in Characteristics. The soils are typically calcareous throughout but are noncalcareous in the upper few inches in some pedons. Organic carbon in the A horizon ranges from .6% to 1.5%, but is typically less than 5%. Weak accumulations of secondary carbonate as soft concretions or seams are present in some pedons. Mean annual soil temperature ranges from 47° to 58°F, and mean summer soil temperature ranges from 60° to 78°F. The A horizon has hue of 2.5Y through 7.5YR, value of 5 or 6 dry, 3 through 5 moist, and chroma of 2 through 4. Typically the horizon has granular or crumb structure but is subangular blocky in some pedons. It is soft to slightly hard and is moderately alkaline. The C horizon has hue of 2.5Y through 7.5YR. It is moderately or strongly alkaline. Calcium carbonate equivalent ranges from less than 1% to 10% depending upon character of individual strata, but there is no distinct continuous horizon of calcium carbonate accumulation.

Competing Series and Their Differentiae. These are the Ellicott and Dwyer series. Ellicott soils are noncalcareous and formed in alluvial sediments derived from arkose formations containing a high proportion of medium and coarse angular granite sand and fine and very fine angular granite gravel. Dwyer soils have uniform texture in which organic carbon decreases uniformly with depth.

Setting. These soils are on gently sloping to nearly level floodplains and low terraces. Slope gradients typically range from 0% to about 6%. The soils are formed in calcareous, highly stratified but predominantly coarse-textured recent alluvium derived from a variety of rocks. At the type location, the average annual temperature is 48°F, the average summer temperature is 70°F. Average annual precipitation is 14 inches with peak periods of precipitation in the spring and early summer months.

Principal Associated Soils. These are the Glenberg and Haverson soils. Glenberg soils have coarse-loamy control sections. Haverson soils have finoamy control sections.

Drainage and Permeability. Well to somewhat excessively drained; slow or very slow runoff; rapid or very rapid permeability.

Use and Vegetation. These soils are used chiefly as native pastureland, however, they are tilled in some localities. Native vegetation is scattered cottonwood, grass, and brush.

Distribution and Extent. The floodplains and low terraces of the major streams in Colorado, Wyoming, New Mexico, and parts of Montana, South Dakota, and Nebraska.

Series Established. Red Willow County, Nebraska, 1965.

Bowbac Series

Typifying Pedon. Bowbac sandy loam—rangeland. (Colors are for dry soil unless otherwise noted.)

A1 0-4"—Grayish brown (10YR 5/2) sandy loam, dark grayish brown (10YR 4/2) moist; moderate very fine and fine crumb structure; soft, very friable, slightly sticky, slightly plastic; many very fine and fine, common

medium roots; mildly alkaline (pH 7.4); clear smooth boundary; 3 to 6 inches thick.

B21t 4-10"—Brown (10YR 5/3) sandy clay loam, dark brown (10YR 4/3) moist; weak medium and fine prismatic that parts to moderate medium and fine subangular blocky structure; hard, friable, slightly sticky, slightly plastic; common very fine and fine, few medium roots; thin, nearly continuous, thick patchy glossy coatings on faces of peds; mildly alkaline (pH 7.5); clear smooth boundary; 0 to 6 inches thick.

B22t 10-16"—Brown (10YR 5/3) sandy clay loam, dark brown (10YR 4/3) moist; strong medium and fine prismatic that parts to moderate medium subangular blocky structure; hard, firm, sticky, plastic; few very fine and fine roots; moderately thick continuous glossy coatings on vertical faces of peds and thin nearly continuous glossy coatings on horizontal faces of peds; mildly alkaline (pH 7.6); clear smooth boundary; 5 to 10 inches thick.

B3ca 16-22"—Light yellowish brown (10YR 6/4) sandy clay loam, brown (10YR 5/3) moist; weak medium and fine subangular blocky structure; slightly hard, very friable, slightly sticky; few thin patches of glossy coatings on faces of peds; calcareous; fine soft rounded masses of secondary calcium carbonate; moderately alkaline (pH 8.2); gradual wavy boundary; 4 to 8 inches thick.

C1 22-32"—Light yellowish brown (10YR 6/4) sandy loam, brown (10YR 5/3) moist; single grained; soft, very friable; calcareous; moderately alkaline (pH 8.2); gradual wavy boundary; 8 to 12 inches thick.

Cr 32-40"—Soft, partially weathered, calcareous sandstone.

Type Location. Converse County, Wyoming; SE $\frac{1}{4}$, SW $\frac{1}{4}$ of Section 8, T. 36 N., R. 72 W.

Range in Characteristics. Depth to paralithic contact is 20 to 40 inches; depth to calcareous material is 10 to 20 inches. The solum is 15 to 22 inches thick. Coarse fragments range from 0% to 15%. The A horizon has hue of 2.5Y or 10YR, value of 5 or 6 dry and 4 or 5 moist, and chroma of 2 or 3. It is neutral or mildly alkaline. The B2t horizon has hue of 2.5Y through 7.5YR, value of 5 or 6 dry and 4 or 5 moist, and chroma of 3 or 4. It averages between 18% and 35% clay and more than 35% fine sand or coarser. It is neutral or mildly alkaline. The C horizon has hue of 2.5Y or 10YR. It is moderately or strongly alkaline.

Principal Associated Soils. These are the Olney soils. Olney soils lack bedrock above 40 inches.

Haverson Series

Typifying Pedon. Haverson sandy loam—rangeland. (Colors are for dry soil unless otherwise noted.)

A1 0-6"—Grayish brown (10YR 5/2) sandy loam, dark grayish brown (10YR 4/2) moderate fine crumb structure; soft, very friable, slightly sticky, slightly plastic; many very fine and fine roots; mildly alkaline (pH 7.6); abrupt smooth boundary; 3 to 6 inches thick.

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C1 6-10"—Light brownish gray (10YR 6/2) clay loam, dark grayish brown (10YR 4/2) moist; weak medium and fine subangular blocky structure; slightly hard, friable, sticky, plastic; common fine and very fine roots; calcareous; moderately alkaline (pH 8.0); abrupt smooth boundary; 0 to 10 inches thick.

C2 10-60"—Grayish brown (10YR 5/2) loam, dark grayish brown (10YR 4/2) clay loam, and pale brown (10YR 6/3) sandy loam and sandy clay loam; massive; soft, very friable; few very fine and fine roots to 20 inches; common medium and fine pockets of organic stains throughout; calcareous; strongly alkaline (pH 8.5).

Type Location. Converse County, Wyoming; NW $\frac{1}{4}$ NW $\frac{1}{4}$ of Section 31, T. 40 N., R. 68 W.

Range in Characteristics. The soils are usually calcareous throughout but some pedons are leached a few inches. The control section is stratified with strata ranging in texture from sandy loam to clay loam. Weighed average clay ranges from 18% to 35%. It has more than 15% but less than 35% fine or coarser sand. Coarse fragments range from 0% to 15%. The A horizon has hue of 2.5Y or 10YR, value of 5 or 6 dry and 3 through 5 moist, and chroma of 2 or 3. It is mildly or moderately alkaline. The C horizon has hue of 2.5Y through 7.5YR. Degree of stratification is variable. It is moderately or strongly alkaline.

Principal Associated Soils. These are the Glenberg and Lohmiller soils. Glenberg soils have less than 18% clay in the control section. Lohmiller soils have more than 35% clay in the control section.

Olney Series

Typifying Pedon. Olney sandy loam—rangeland. (Colors are for dry soil unless otherwise noted.)

A1 0-5"—Pale brown (10YR 6/3) sandy loam, brown (10YR 5/3) moist; moderate fine crumb structure; soft, very friable; common fine and very fine, few medium roots; neutral (pH 7.2); clear smooth boundary; 4 to 6 inches thick.

B1 5-10"—Pale brown (10YR 6/3) sandy clay loam, brown (10YR 5/3) moist; weak medium prismatic that parts to moderate medium and fine subangular blocky structure; slightly hard, very friable, slightly sticky, slightly plastic; common very fine and fine, few medium roots; thin patchy glossy coatings on vertical faces of peds; neutral (pH 7.2); clear smooth boundary; 3 to 6 inches thick.

B2t 10-24"—Light yellowish brown (10YR 6/4) sandy clay loam, brown, (10YR 5/3) moist; moderate medium prismatic that parts to moderate medium and fine subangular blocky structure; hard, friable, sticky, plastic; few very fine and fine roots; thin nearly continuous glossy coatings; alkaline (pH 7.4); clear smooth boundary; 5 to 15 inches thick.

B3ca 24-30"—Light yellowish brown (10YR 6/4) sandy clay loam, brown (10YR 5/3) moist; weak medium and fine subangular blocky structure; few patchy glossy coatings on faces of peds; few soft rounded masses and

seams of secondary calcium carbonate; moderately alkaline (pH 8.0); gradual wavy boundary.

Cca 30-60"—Very pale brown (10YR 7/4) sandy loam, light yellowish brown (10YR 6/4) moist; massive; slightly hard, very friable; moderately alkaline (pH 8.2).

Type Location. Converse County, Wyoming; SE $\frac{1}{4}$ of NW $\frac{1}{4}$ of Section 14, T. 36 N., R. 72 W.

Range in Characteristics. Depth to calcareous material ranges from 10 to 24 inches. Thickness of the solum ranges from 15 to 30 inches. Coarse fragments range from 0% to 15%. The A horizon has hue of 2.5Y or 10YR, value on 5 or 6 dry and 3 through 5 moist, and chroma of 2 or 3. It is neutral or mildly alkaline. The B2t horizon averages between 18% and 35% clay and more than 35% fine sand or coarser. It is neutral or mildly alkaline. The C horizon has hue of 2.5Y or 10YR. It is moderately or strongly alkaline.

Principal Associated Soils. These are the Bowbac and Renohill soils. Bowbac soils have a paralithic contact at depths of 20 to 40 inches. Renohill soils have more than 35% clay in the B2t horizon.

Renohill Series

Typifying Pedon. Renohill clay loam—rangeland. (Colors are for dry soil unless otherwise noted.)

A1 0-5"—Light brownish gray (10YR 6/2) clay loam, grayish brown (10YR 5/2) moist; moderate fine and very fine subangular blocky structure; slightly hard, friable, sticky, plastic; common very fine and fine, few medium roots; moderately alkaline (pH 7.6); clear smooth boundary 3 to 6 inches thick.

B2t 5-16"—Light brownish gray (2.5Y 6/2) clay loam, grayish brown (2.5Y 5/2) moist; weak coarse prismatic that parts to moderate coarse and medium angular blocky structure; hard, firm, sticky, plastic; few fine and very fine roots; moderately thick continuous glossy coatings on faces of peds; some pockets of olive brown (2.5Y 4/4) sandy material; mildly alkaline (pH 7.6); clear smooth boundary; 3 to 14 inches thick.

B3ca 16-25"—Light brownish gray (2.5Y 6/2) sandy clay loam, grayish brown (2.5Y 5/2) moist; weak medium and fine angular blocky structure; hard friable sticky, plastic; patches of thin glossy coatings on faces of peds; calcareous; few fine soft rounded masses of secondary calcium carbonate; mildly alkaline (pH 7.8); gradual smooth boundary.

Cr 25-30"—Calcareous sandy shale.

Type Location. Converse County, Wyoming; SW $\frac{1}{4}$ of NE $\frac{1}{4}$ of Section 14, T. 36 N., R. 73 W.

Range in Characteristics. Depth to calcareous material ranges from 6 to 20 inches. Thickness of the solum ranges from 15 to 30 inches. Depth to bedrock ranges from 20 to 40 inches. The A horizon has hue of 2.5Y or 10YR, value of 5 or 6 dry and 4 or 5 moist, and chroma of 2 or 3. It is neutral or mildly alkaline. The B2t horizon has hue of 2.5Y or 10YR, value of 5 or 6 dry and 4 or 5 moist, and chroma of 2 through 5. It has 35% to 50% clay and more than 15% fine or coarser sand. It is

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neutral or mildly alkaline. The C horizon has hue of 2.5Y or 10YR. It is moderately or strongly alkaline.

Principal Associated Soils. These are the Briggsdale, Cushman, Olney, Shingle, and Ulm soils. Briggsdale soils have more than 15% (absolute) clay increase in the argillic. Cushman and Olney soils have 18% to 35% clay in the argillic. Olney soils also have bedrock above 40 inches. Shingle soils lack argillic horizons and have bedrock above 20 inches. Ulm soils lack bedrock above 40 inches.

Samsil Series

The samsil series is a clayey, montmorillonitic (calcareous), mesic, shallow Ustic Torriorthent. Typically, the Samsil soils have light brownish gray friable clay A horizons about 2 inches thick, light brownish gray friable clay AC horizons about 5 inches thick, and light brownish gray and light olive gray friable shaly C horizons underlain by light gray shale at a depth of about 17 inches.

Typifying Pedon. Samsil clay—on a convex, SSW facing slope of 15% under native grass. (Colors are for dry soil unless otherwise stated. When described, the soil was moist to 12 inches, dry from 12 to 21 inches, and moist below 21 inches.)

A1 0-2"—Light brownish gray (2.5Y 6/2) clay, dark grayish brown (2.5Y 4/2) moist; moderate fine granular structure; slightly hard, friable, sticky, plastic; common roots; few very fine fragments of shale; slight effervescence; mildly alkaline; clear wavy boundary; 2 to 4 inches thick.

AC 2-7"—Light brownish gray (2.5Y 6/2) clay, dark grayish brown (2.5Y 4/2) moist; weak medium subangular blocky structure parting to weak medium granular structure; hard, friable, sticky, plastic; common roots; common fine fragments of shale; slight effervescence; mildly alkaline; clear wavy boundary; 0 to 6 inches thick.

C1 7-11"—Light brownish gray (2.5Y 6/2) shaly clay, dark grayish brown (2.5Y 4/2) crushing to grayish brown (2.5Y 5/2) moist; massive; hard, friable sticky, plastic; common roots; fine and medium fragments of shale make up about 30% by volume of mass; few fine faint stains of olive yellow (2.5Y 6/6); slight effervescence; mildly alkaline; gradual wavy boundary.

C2 11-17"—Light olive gray (5Y 6/2) shaly clay, olive gray (5Y 5/2) moist; massive; hard, friable, sticky, plastic; common roots; fine, medium, and coarse fragments of shale make up about 50% by volume of mass; common distinct stains of olive yellow (2.5Y 6/6) on faces of shale fragments; few fine and medium segregations of lime; slight effervescence; moderately alkaline; gradual wavy boundary. (Combined C1 and C2 horizons are 2 to 10 inches thick.)

C3 17-40"—Light gray (5Y 7.2) bedded shale; olive gray (5Y 5/2) moist; soft when moist but hard and brittle when dry; few roots; few iron and manganese stains in upper part.

Type Location. Pennington County, South Dakota; about 3 miles east of Wasta; 1,515 feet east and 1,120 feet

south of the NW corner of Section 12, T. 1 N., R. 14 E.; 24 feet south of C & GS BM J381 (1962) on west side of Jensen Road.

Range in Characteristics. Depth to bedded shale ranges from 4 to 20 inches. Horizon above the shale ranges from loose to hard when dry, friable or firm when moist, and slightly sticky or sticky and plastic or slightly plastic when wet. These horizons contain free lime; effervescence ranges from slight to strong and from mildly alkaline through strongly alkaline. The C1 and C2 horizons and upper part of the C3 horizon commonly have segregations of lime, gypsum, and other salts. The horizons above the shale average between 45% and 65% clay. Colors throughout, including mottles and stains, are inherited from the shale. The A1 horizon has hue of 5Y, 2.5Y, or 10YR, value of 5 through 7 dry and 3 through 5 moist, and chroma of 2 through 4. It is clay or silty clay and commonly contains few or common fragments of shale ranging from 2 to 25 millimeters in diameter. It has fine or medium subangular blocky or fine or very fine granular structure. The upper $\frac{1}{4}$ to $\frac{1}{2}$ inches commonly is a fragile crust or mulch of very fine granules when dry. The AC and C horizons have hue of 5Y, 2.5Y, or 10YR, value of 5 through 7 dry and 3 through 5 moist, and chroma of 1 through 4. The C1 and C2 horizons contain from 5% to more than 50% fragments of shale that range from less than 2 to 35 millimeters in diameter. The C3 horizon or bedded shale has the same range in color as the overlying C horizons. It ranges from medium acid to moderately alkaline. The upper part or weathered zone is platy and contains free carbonates. The lower part separates to angular blocks and commonly lacks free carbonates except from segregations of lime as coatings or masses between fracture faces.

Competing Series and Their Differentiae. These are Chantier, Danko, Epsie, Lismas, and Midway soils in the family, and Conata, Grummit, Lisam, Louviers, Orella, Sansarc, and Yawdim soils. Chantier soils have B horizons. Lismas soils have harder consistence throughout. Midway soils contain less than 45% clay. Grummit soils are acid. Lisam and Yawdim soils are frigid. Louviers soils are nonacid. Orella soils are strongly or very strongly alkaline and contain from 8% to 30% exchangeable sodium. Sansarc soils are dry for a shorter period.

Setting. Samsil soils are on slope breaks of dissected shale plains. Surfaces mainly are convex, and slope gradients range from 2% to 45% or more. The soil formed in residuum weathered from shale. Mean annual temperature ranges from about 45 to 54°F; mean annual precipitation ranges from 12 to 17 inches, most of which falls in the spring and summer.

Principal Associated Soils. These are the Kyle, Pierre, and Swanboy soils, which are greater than 20 inches to shale. They are on the smoother parts of nearby landscapes.

Drainage and Permeability. Well-drained, somewhat excessively drained, and excessively drained. Surface runoff is slow on gently sloping areas and very rapid on steep areas. Permeability is slow.

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Use and Vegetation. Rangeland. Native vegetation is little bluestem needle-and-thread, sideoats grama, blue grama, green needlegrass, sedges, and forbs.

Distribution and Extent. Southwestern South Dakota and parts of Nebraska, Wyoming, and Colorado. The soil is extensive.

Series Established. Stanley County, South Dakota, 1967.

Remarks. Samsil soils were classified as Lithosols in the modified 1938 yearbook classification system.

Shingle Series

Typifying Pedon. Shingle sandy clay loam—rangeland. (Colors are for dry soil unless otherwise noted.)

A1 0-4"—Pale brown (10YR 6/3) sandy clay loam, brown (10YR 5/3) moist; weak medium and fine crumb structure; soft, very friable, slightly sticky, slightly plastic; common medium fine roots; moderately alkaline (pH 7.9); clear smooth boundary; 3 to 6 inches thick.

C1 4-19"—Pale brown (10YR 6/3) sandy clay loam, brown (10YR 5/3) moist; massive; slightly hard, friable, slightly plastic; few fine roots; 15% fine shale and sandstone fragments easily crushed; calcareous; moderately alkaline (pH 7.9); clear smooth boundary; 6 to 15 inches thick.

Type Location. Converse County, Wyoming NW $\frac{1}{4}$ of Section 15, T. 40 N., R. 70 W.

Range in Characteristics. Depth to soft bedrock is 10 to 20 inches. Depth to calcareous materials is 0 to 10 inches. The control section averages between 18% and 35% clay and has more than 15% but less than 35% fine or coarser sand. It has 0% to 15% fine shale or sandstone fragments. The A horizon has hue of 5Y through 7.5YR, value of 5 through 7 and 3 through 6 moist, and chroma of 1 through 4. It is mildly through strongly alkaline. The C horizon has hue of 5Y through 7.5YR. It is moderately or strongly alkaline.

Principal Associated Soils. These are the Renohill, Samsil, and Tassel soils. Renohill soils have an argillic horizon. Samsil soils have more than 35% clay in the control section. Tassel soils have less than 18% clay in the control section.

Rough Broken Land/Rock Outcrop

The rock outcrop consists of multicolored, calcareous to noncalcareous, coarse to fine-textured, soft to hard sandstone, shales, and siltstone.

TABLE BUA-1

GENERAL WATER ANALYSES FROM WELL SAMPLES COLLECTED ON NOVEMBER 25, 1975
(Values in mg/l except as indicated.)

ION	P-2 Overburden		P-4 Overburden		P-4 (Duplicate) Overburden		P-6 Overburden		P-7 Overburden		P-10 Overburden	
	Diss.	Total	Diss.	Total	Diss.	Total	Diss.	Total	Diss.	Total	Diss.	Total
Calcium	88	101	76	87	64	82	71	86	58	510	300	540
Magnesium	20	30	29	20	30	28	27	27	59	270	80	205
Sodium	8	10	150	165	155	145	355	310	365	370	34	87
Potassium	1.8	2.3	9.3	9.0	9.3	8.8	11	12	12	445	4.5	205
Bicarbonate	165	-	425	-	425	-	530	-	1,075	-	340	-
Carbonate	0	-	0	-	0	-	0	-	0	-	0	-
Hydroxyl	0	-	0	-	0	-	0	-	0	-	0	-
Sulfate	264	303	213	189	216	198	483	447	138	132	600	567
Chloride	5	-	7	-	5	-	17	-	8	-	5	-
Total Phosphorus	0.18	0.25	0.034	0.071	0.067	0.33	0.054	0.26	0.12	23	0.21	18
Nitrate as Nitrogen	1.8	-	<0.1	-	<0.1	-	<0.1	-	<0.1	-	<0.1	-
Temperature at Collection (°C)	8.5	-	8.0	-	8.0	-	11.5	-	6.0	-	7.5	-
pH	6.20	-	7.60	-	7.60	-	7.85	-	7.85	-	7.30	-

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TABLE BUA-1
(cont'd)

GENERAL WATER ANALYSES FROM WELL SAMPLES COLLECTED ON NOVEMBER 25, 1975
(Values in mg/l except as indicated.)

ION	P-2 Overburden		P-4 Overburden		P-4 (Duplicate) Overburden		P-6 Overburden		P-7 Overburden		P-10 Overburden	
	Diss.	Total	Diss.	Total	Diss.	Total	Diss.	Total	Diss.	Total	Diss.	Total
Total Dissolved Solids	374	-	704	-	684	-	1,120	-	1,260	-	944	-
Total Suspended Solids	-	22	-	34	-	16	-	130	-	20,600	-	10,520
Total Solids	-	396	-	738	-	700	-	1,250	-	21,900	-	11,400

Source: Shell Oil Company 1977.

TABLE BUA-2

TRACE ELEMENT CONCENTRATIONS IN WELL WATER SAMPLES COLLECTED ON THE BUCKSKIN MINE SITE, NOVEMBER 25, 1976
(All values are in mg/l.)

ELEMENT	WELL DESIGNATIONS											
	P-2		P-4		P-4 (Duplicate)		P-6		P-7		P-10	
	Overburden	Overburden	Overburden	Overburden	Overburden	Overburden	Overburden	Overburden	Overburden	Overburden	Overburden	Overburden
	Diss.*	Total**	Diss.*	Total**	Diss.*	Total**	Diss.*	Total**	Diss.*	Total**	Diss.*	Total**
Aluminum	0.22	0.78	0.89	7.7	4.1	4.1	0.66	7.4	1.6	≈3,000	1.0	510
Antimony	-	-	-	-	-	0.001	-	-	-	0.012	-	0.005
Arsenic	-	-	-	-	-	-	0.001	0.037	0.001	0.037	0.005	0.016
Barium	0.067	0.024	0.22	0.23	0.062	0.063	0.020	0.048	0.023	12.0	0.42	1.9
Beryllium	-	-	-	-	-	-	-	-	-	0.14	-	-
Bismuth	-	-	-	-	-	-	-	-	-	0.017	-	0.003
Boron	<0.1	***	<0.10	***	<0.10	***	<0.17	***	<0.14	***	<0.1	***
Bromine	0.002	0.032	0.004	0.044	0.002	0.032	0.029	0.075	0.008	0.062	0.28	0.027
Cadmium	-	-	-	-	-	-	-	-	-	0.026	0.002	0.011
Cerium	-	-	-	0.003	0.001	0.003	-	0.002	-	2.0	-	0.86
Cesium	-	-	-	-	-	-	-	-	-	0.10	-	0.019
Chromium	-	-	-	0.005	0.001	0.001	-	0.004	-	1.7	-	0.68
Cobalt	-	0.002	-	-	0.001	-	-	-	-	0.36	0.001	0.079
Copper	0.004	0.006	0.015	0.003	0.002	0.003	0.011	0.012	0.002	0.53	0.001	0.23

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TABLE BUA-2
(cont'd)

TRACE ELEMENT CONCENTRATIONS IN WELL SAMPLES COLLECTED IN THE BUCKSKIN MINE SITE, NOVEMBER 25, 1976
(All values are in mg/l.)

ELEMENT	WELL DESIGNATIONS											
	P-2		P-4		P-4 (Duplicate)		P-6		P-7		P-10	
	Overburden		Overburden		Overburden		Overburden		Overburden		Overburden	
	Diss.*	Total**	Diss.*	Total**	Diss.*	Total**	Diss.*	Total**	Diss.*	Total**	Diss.*	Total**
Dysprosium	-	-	-	-	-	-	-	-	-	0.092	-	0.040
Erbium	-	-	-	-	-	-	-	-	-	0.010	-	0.004
Europium	-	-	-	-	-	-	-	-	-	0.009	-	0.005
Gadolinium	-	-	-	-	-	-	-	-	-	0.014	-	0.007
Gallium	-	-	-	0.001	-	-	-	0.001	-	0.16	0.002	0.14
Germanium	-	0.002	-	-	-	-	-	-	-	0.034	-	0.014
Gold	-	-	-	-	-	-	-	-	-	-	-	-
Hafnium	-	-	-	-	-	-	-	-	-	0.066	-	0.029
Holmium	-	-	-	-	-	-	-	-	-	0.006	-	0.003
Indium	****	****	****	****	****	****	****	****	****	****	****	****
Iodine	-	-	0.005	0.01	0.001	0.009	0.003	0.017	-	0.024	0.004	0.030
Iridium	-	-	-	-	-	-	-	-	-	-	-	-
Iron	0.046	0.33	0.035	0.46	0.18	0.19	0.019	0.78	0.33	800	0.96	640
Lanthanum	-	-	-	0.003	-	0.001	-	0.001	-	0.98	-	0.42
Lead	0.026	0.002	0.001	0.005	0.005	0.002	-	0.009	-	0.34	0.001	0.14

BUA-9

TABLE BUA-2
(cont'd)

TRACE ELEMENT CONCENTRATIONS IN WELL SAMPLES COLLECTED IN THE BUCKSKIN MINE SITE, NOVEMBER 25, 1976
(All values are in mg/l.)

ELEMENT	WELL DESIGNATIONS											
	P-2		P-4		P-4 (Duplicate)		P-6		P-7		P-10	
	Overburden		Overburden		Overburden		Overburden		Overburden		Overburden	
	Diss.*	Total**	Diss.*	Total**	Diss.*	Total**	Diss.*	Total**	Diss.*	Total**	Diss.*	Total**
Lithium	0.016	0.02	0.006	0.007	0.080	0.053	-	0.054	0.15	5.2	0.18	0.45
Lutetium	-	-	-	-	-	-	-	-	-	0.014	-	0.006
Manganese	0.037	0.026	0.008	0.007	0.007	0.003	0.007	0.012	0.33	4.2	1.0	2.8
Mercury	.0003	.0003	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Molybdenum	0.004	0.003	0.009	0.019	0.008	0.018	0.003	0.003	0.015	0.062	0.004	0.009
Neodymium	-	-	-	-	-	-	-	-	-	0.24	-	0.11
Nickel	-	-	-	0.002	-	0.002	-	-	-	0.67	0.002	0.057
Niobium	-	-	-	-	-	-	-	0.001	-	0.33	-	0.14
Osmium	-	-	-	-	-	-	-	-	-	-	-	-
Palladium	-	-	-	-	-	-	-	-	-	-	-	-
Platinum	-	-	-	-	-	-	-	-	-	-	-	-
Praseodymium	-	-	-	-	-	-	-	-	-	0.096	-	0.089
Rhenium	****	****	****	****	****	****	****	****	****	****	****	****
Rhodium	-	-	-	-	-	-	-	-	-	-	-	-

BUA-10

TABLE BUA-2
(cont'd)

TRACE ELEMENT CONCENTRATIONS IN WELL WATER SAMPLES COLLECTED ON THE BUCKSKIN MINE SITE, NOVEMBER 25, 1976
(All values are in mg/l.)

ELEMENT	WELL DESIGNATIONS											
	P-2		P-4		P-4 (Duplicate)		P-6		P-7		P-10	
	Overburden		Overburden		Overburden		Overburden		Overburden		Overburden	
	Diss.*	Total**	Diss.*	Total**	Diss.*	Total**	Diss.*	Total**	Diss.*	Total**	Diss.*	Total**
Rubidium	-	0.003	0.004	0.023	0.004	0.014	0.013	0.014	0.007	2.7	0.002	0.58
Ruthenium	-	-	-	-	-	-	-	-	-	-	-	-
Samarium	-	-	-	-	-	-	-	-	-	0.045	-	0.005
Scandium	-	-	-	-	-	-	-	-	-	0.013	-	0.056
Selenium	-	-	-	-	-	-	0.005	-	-	0.034	-	0.021
Silicon	18.0	26.0	6.9	13.0	18	12	2.4	2.6	2.6	≈5,000	15.0	≈2,200
Silver	0.002	-	-	-	-	-	-	-	-	0.004	-	0.005
Strontium	0.13	0.006	0.65	0.68	0.31	0.18	0.10	1.2	0.025	2.2	0.95	3.6
Tantalum	-	-	-	-	-	0.001	-	-	0.001	0.032	0.002	0.014
Tellurium	-	-	-	-	-	-	-	-	-	0.002	-	<0.001
Terbium	-	-	-	-	-	-	-	-	-	0.007	-	0.003
Thallium	-	-	-	-	-	-	-	-	-	0.027	-	0.004
Thorium	-	-	-	-	-	-	-	-	-	0.13	-	0.058
Thulium	-	-	-	-	-	-	-	-	-	0.002	-	0.001

BUA-11

TABLE BUA-2
(cont'd)

TRACE ELEMENT CONCENTRATIONS IN WELL WATER SAMPLES COLLECTED ON THE BUCKSKIN MINE SITE, NOVEMBER 25, 1976
(All values are in mg/l.)

ELEMENT	WELL DESIGNATIONS											
	P-2		P-4		P-4 (Duplicate)		P-6		P-7		P-10	
	Overburden Diss.*	Total**										
Tin	0.001	-	-	0.002	-	0.001	-	0.001	-	0.028	-	0.029
Titanium	-	0.02	<0.002	0.13	0.024	0.12	0.002	0.022	0.093	83.0	0.003	36.0
Tungsten	-	-	-	-	-	-	-	-	-	0.083	-	0.014
Uranium	0.001	0.002	-	-	0.002	0.002	-	-	0.001	0.060	0.004	0.026
Vanadium	-	0.001	0.002	0.004	0.001	0.001	-	0.006	0.003	2.4	-	1.0
Ytterbium	-	-	-	-	-	-	-	-	-	0.024	-	0.025
Yttrium	-	-	-	-	-	-	-	-	-	0.27	-	0.012
Zinc	0.045	0.086	0.002	0.019	0.041	0.018	0.007	0.074	0.007	1.4	0.040	1.2
Zirconium	-	0.001	-	0.004	-	0.004	-	0.003	-	4.7	0.001	5.7

Source: Shell Oil Company 1977.

* Dissolved. Analyses performed on sample of unfiltered, unpreserved water.

** Analyses performed on sample that was filtered then preserved with nitric acid.

*** Colorimetric method used for boron analysis.

**** Internal standard.

BUA-12

TABLE BUA-3

WATER ANALYSES FOR MAJOR DISSOLVED CONSTITUENTS AND PHYSICAL PARAMETERS FROM COAL
DECEMBER 2, 1976(All values in mg/l except as noted.)
Data furnished by the applicant.

<u>Parameter</u>	<u>Well P-4</u>
Calcium	45.2
Magnesium	21.5
Potassium	11.2
Sodium	266
Bicarbonate	845
Chloride	14
Sulfate	5.3
Nitrate (as N)	0.27
Fluoride	7.4
Silica (as SiO ₂)	4.5
Total Phosphorous (as P)	0.05
Total Dissolved Solids	843
Total Suspended Solids	39
Total Solids	882
Temperature (field) (°C)	10.0
pH (units)	7.30
Chromium	<0.03
Iron (dissolved)	0.2
Manganese	0.3
Mercury (µg/l)	0.2
Selenium (µg/l)	<2.5
Zinc	0.05

TABLE BUA-4

WATER ANALYSIS FOR TOTAL CONCENTRATIONS OF SELECTED ELEMENTS FROM COAL
DECEMBER 2, 1976

(All values in mg/l except as noted.)
Data furnished by the applicant.

<u>Parameter</u>	<u>Well P-4</u>
Aluminum	0.5
Arsenic ($\mu\text{g}/\text{l}$)	<1
Boron	<0.04
Calcium	50.5
Chromium	0.7
Copper	0.6
Iron	1.6
Lead	0.05
Magnesium	23.4
Manganese	0.3
Mercury ($\mu\text{g}/\text{l}$)	<0.5
Nickel	0.02
Potassium	12
Selenium ($\mu\text{g}/\text{l}$)	<2.5
Silica	4.7
Sodium	275
Zinc	0.15

TABLE BUA-5

RESULTS OF ANALYSES FOR MAJOR DISSOLVED CONSTITUENTS FROM ALLUVIUM
 AUGUST 13, 1976
 (All values in mg/l.)
 Data furnished by the applicant.

<u>Parameters</u>	<u>OT-2B</u>
Calcium	310
Magnesium	48.5
Potassium	38.5
Sodium	1,128
Chloride	18.5
Sulfate	4,043
Bicarbonate (as CaCO ₃)	724
Silica	8.3

TABLE BUA-6

COMPARISON OF WATER QUALITY IN RAWHIDE CREEK WITH APPLICABLE STANDARDS

	Maximum (mg/l)*	Discharge (cfs)**	Minimum (mg/l)*	Discharge (cfs)**	Suggested Limits for Drinking Water (mg/l)*	Suggested Biological Limits (mg/l)*
Dissolved calcium (Ca)	400	NA	390	0.18	less than 75	± 25 (for crustaceans) needed
Dissolved magnesium (Mg)	490	NA	470	0.18	less than 30	less than 14
Dissolved sodium (Na)	685	NA	650	NA	less than 270	85 needed, 500 is toxic
Dissolved bicarbonate (HCO ₃)	638	NA	334	6.7	less than 150	more than 100 needed
Dissolved sulfate (SO ₄)	4,000	9.6	780	1.0	less than 250	less than 90
Dissolved solids	5,890	.18	1,410	6.7	less than 500	more than 400 needed

Sources: McKee and Wolf 1963, National Academy of Sciences 1972, U.S. Environmental Protection Agency 1976a.

Note: Three water samples were taken from Rawhide Creek at U.S. Highway 14/16 between March 1975 and August 1976 to obtain the figures above.

NA = Not available.

* milligrams per liter
 ** cubic feet per second

FISH AND WILDLIFE

BIRDS AND MAMMALS OBSERVED ON THE BUCKSKIN SITE
(Wyoming Game and Fish Department 1978)

BIRDS

Brewer's sparrow
Vesper sparrow
Lark bunting
Horned lark
Western meadowlark
Mourning dove
Sage grouse
Killdeer
Sage sparrow
Pintail
Shoveler
Blue-winged teal
American widgeon
Loggerhead shrike
Red-winged blackbird
Mallard
Upland plover
Marsh hawk
Ferruginous hawk
Swainson's hawk
Golden eagle
Prairie falcon
Burrowing owl
American kestrel
Red-tailed hawk
Lesser scaup
Horned grebe
Pied-billed grebe
American coot
Sharp-tailed grouse
Great horned owl
Eastern kingbird
Say's phoebe
Rock wren
Common grackle
Brewer's blackbird
Song sparrow
Barn swallow
Cliff swallow
Black-billed magpie

MAMMALS

Pronghorn
Mule deer
Black-tail prairie dog
White-tail jackrabbit
Desert cottontail
Mountain cottontail
Least chipmunk
Thirteen-lined ground squirrel
Deer mouse
Northern grasshopper mouse
Prairie vole
Meadow vole
Plains pocket gopher
Muskrat
Porcupine
Badger
Coyote

TABLE BUA-7

CONTRAST RATING FOR BUCKSKIN MINE AS SEEN FROM U.S. HIGHWAY 14/16

Short Term
(Life of the Mine)

<u>Feature</u>	<u>Element*</u>	<u>Contrast**</u>	<u>Score</u>	<u>Maximum Possible Score</u>
	Form (4)	x Moderate (2)	= 8	
	Line (3)	x Strong (3)	= 9	
<u>Land Surface</u>	Color (2)	x Strong (3)	= 6	
	Texture (1)	x Moderate (2)	= <u>2</u>	
	Feature Contrast Score		= 25 (unacceptable)	30
	Form (4)	x Weak (1)	= 4	
	Line (3)	x Moderate (2)	= 6	
<u>Vegetation</u>	Color (2)	x Moderate (2)	= 4	
	Texture (1)	x Weak (1)	= <u>1</u>	
	Feature Contrast Score		= 15 (medium)	30
	Form (4)	x Weak (1)	= 4	
	Line (3)	x Weak (1)	= 3	
<u>Structures</u>	Color (2)	x Weak (1)	= 2	
	Texture (1)	x Weak (1)	= <u>1</u>	
	Feature Contrast Score		= 10 (low)	30
	Grand Total		50 (medium)	90

TABLE BUA-7
(cont'd)

CONTRAST RATING FOR BUCKSKIN MINE AS SEEN FROM U.S. HIGHWAY 14/16

Long Term
(After Completion of Reclamation)

Feature	Element*	Contrast**	Score	Maximum Possible Score
<u>Land Surface</u>	Form (4)	x Weak (1)	= 4	
	Line (3)	x Weak (1)	= 3	
	Color (2)	x Moderate (2)	= 4	
	Texture (1)	x Weak (1)	= <u>1</u>	
	Feature Contrast Score		= 12 (medium)	30
<u>Vegetation</u>	Form (4)	x Weak (1)	= 4	
	Line (3)	x Moderate (2)	= 6	
	Color (2)	x Moderate (2)	= 4	
	Texture (1)	x Weak (1)	= <u>1</u>	
	Feature Contrast Score		= 15 (medium)	30
<u>Structures</u>	Form (4)	x None (0)	= 0	
	Line (3)	x None (0)	= 0	
	Color (2)	x None (0)	= 0	
	Texture (1)	x None (0)	= <u>0</u>	
	Feature Contrast Score		= 0 (none)	90
Grand Total			27 (low)	90

Note: The maximum allowable feature contrast score for the Buckskin site is 20 (Class IV designation). The mine would generate a short-term feature contrast score of 25 for land surface, 5 points more than an acceptable level. Bureau of Land Management Manual 632 contains a detailed description of the contrast rating procedure.

* Rated on a scale of 1 to 4 depending on how easily contrast can be detected.

** Rated on a scale of 1 to 3.