2.2 Soils and Alluvial Valley Floors

2.2.1 Key Issues

The key issues related to soils and AVFs include:

- The maintenance, improvement, or restoration of soil quality while supporting multiple use; and
- The maintenance of long-term hydrologic function of AVFs for the continuation of important subirrigation and flood irrigation practices for agricultural production.

2.2.2 Study Area

The study area for soils and AVFs includes all or portions of Sheridan, Johnson, Campbell, and Converse counties (**Figure 1-1**). This includes all or portions of 18 subwatersheds (fourth order). It includes most of the area administered by the BLM Buffalo Field Office, a portion of the area administered by the BLM Casper Field Office, and a portion of the TBNG, which is administered by the FS (**Figure 1-2**). State and private lands also are included in the study area (**Figure 1-3**).

2.2.3 Current Conditions

A variety of data sources were used to identify the baseline soil characteristics in the Wyoming PRB study area. Information on major land resource areas (MLRAs) and soil types was obtained from Natural Resources Conservation Service (NRCS) literature or databases, including the Land Resource Regions and MLRAs of the U.S., the Caribbean, and the Pacific Basin, U.S. Department of Agriculture (USDA) Handbook 296 (USDA 2006) and the Soil Survey Geographic Database (SSURGO).

2.2.3.1 Soils

Regional Overview

The majority of the Wyoming PRB study area is located within two MLRAs of soil resources. Generally, from north to south, these include the following (USDA 2006):

- Pierre Shale Plains, Northern Part; and
- Southern Part of the Northern Rolling High Plains.

The Northern Pierre Shale Plains is in the Missouri Plateau, Unglaciated, Section of the Great Plains Province of the Interior Plains and occurs in the northeastern portion of the Wyoming PRB study area. It is an area of old plateaus and terraces that have been deeply eroded. Marine and continental sediments of the Cretaceous underlie most of this MLRA, generally at the higher elevations. Cretaceous shale and chalk beds occur at the higher elevations in the southeast corner of this MLRA. The dominant soil order in this MLRA is Entisols. They are shallow to very deep and generally well drained.

The Southern Part of the Northern Rolling High Plains MLRA is in the Missouri Plateau, Unglaciated Section of the Great Plains Province of the Interior Plains and makes up the largest proportion of the PRB study area. This MLRA is an area of old plateaus and terraces that have been deeply eroded. Slopes generally are gently rolling to steep, and wide belts of steeply sloping badlands border a few of the larger river valleys. Terraces are common along most of the major river systems in the area. In places, flat-topped, steep-sided buttes rise sharply above the plains. The dominant soil orders in this MLRA are Aridisols and Entisols. Soils have developed in alluvium and residuum derived mainly from the Wasatch Formation. Lithology consists of light to dark yellow and tan siltstone and sandstones with minor coal seams.

The most extensive soils in the Wyoming PRB study area are Entisols, which are recent soils occurring mainly on sloping topography where geologic erosion outpaces soil profile development or organic

matter accumulation. The physical and chemical characteristics of Entisol soils largely depend on the soil parent materials and the bedrock on which they occur. These soils generally are low in plant nutrients and commonly have clay textures.

The Wyoming PRB study area also has extensive areas of gently sloping to nearly level, more stable, topography. Soils on these surfaces commonly are identified as Aridisols. Aridisols form in an arid or semi-arid climate and commonly have low to moderate organic matter content and plant nutrients in the surface layer. They also have moderate to strong structural development within the surface and subsoil layers. This generally means that carbonates and salts have been leached by water to depths of 1 to 2 feet, or more. This produces a more fertile rooting zone, particularly when soil textures are loamy rather than sandy or clayey.

Mollisols and fluvial soils also occur to a minor extent within the Wyoming PRB study area. Mollisols are the most fertile and have higher levels of organic matter and nutrients, particularly in the surface layer. These soils are the best source of soil for reclaiming disturbance areas. Fluvial soil types are found on gently sloping to nearly level drainage bottoms. Fluvial soils vary considerably in fertility, depending on the source of alluvium. Fluvial soils typically are low in salts and sodium, tend to be very fertile, and are the most productive in the basin (BLM 1984).

Soil baseline characterization is based on SSURGO review and analyses. SSURGO is the most detailed level of county soil mapping done by the NRCS (NRCS 2012).

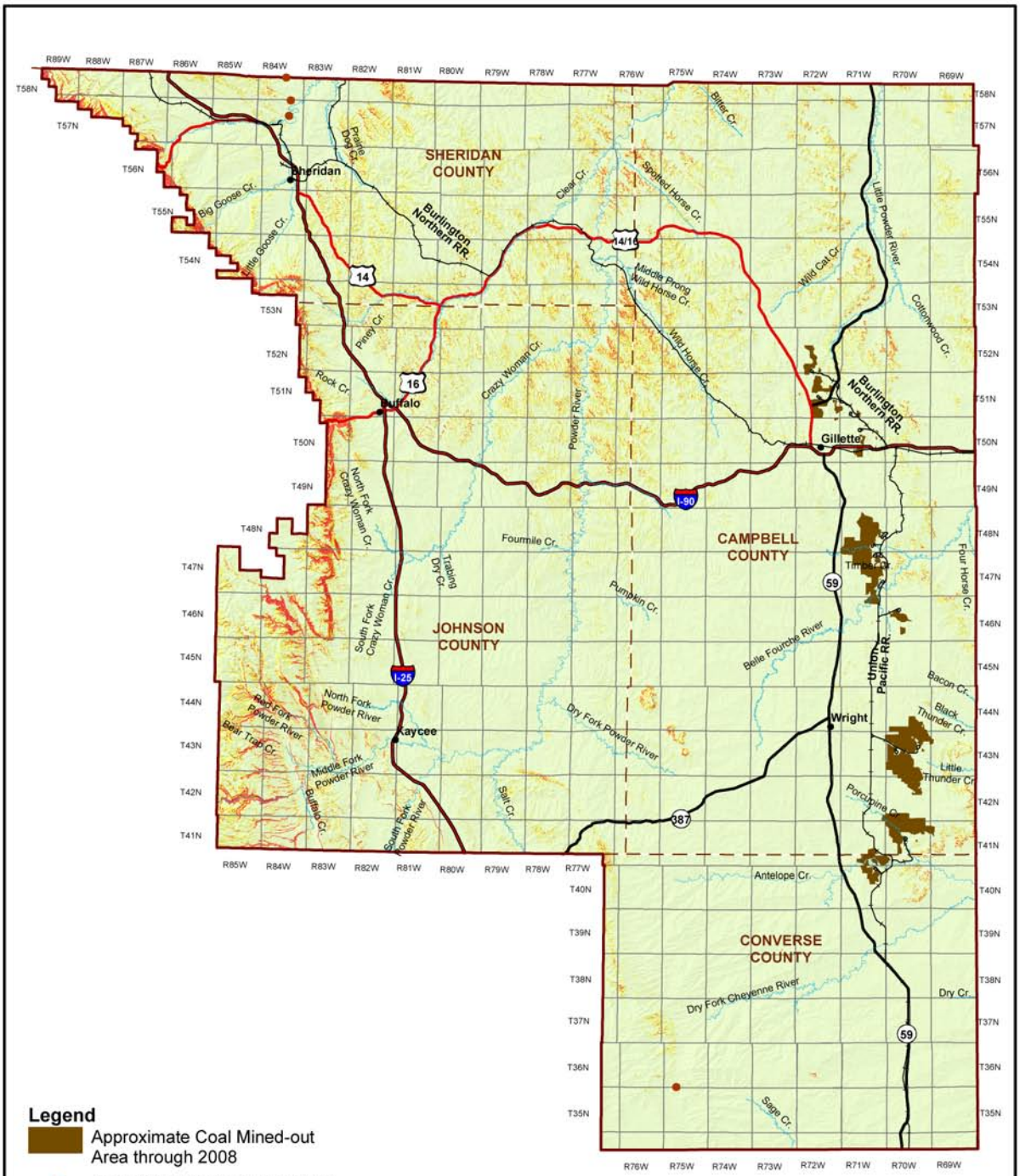
The county soil surveys generally are mapped at the Order 3 level of intensity on a photo base at the scale of the USGS 7.5-minute topographic quadrangle maps (1 inch equals 2,000 feet). The NRCS maintains current files for all of these soils, and all soil survey data and Official Soil Series Descriptions are available on the NRCS website.

More detailed soils information is available for the major coal mine permit areas associated with the 13 active coal mines located primarily in a line beginning north of Gillette and continuing southward to northern Converse County, as well as in the area northeast of Sheridan where three former coal mines are in final reclamation or awaiting bond release. The soils mapping for these coal permit areas was done at a more detailed (Order 1-2) level of intensity on photo base maps at a scale of approximately 1 inch equals 400 feet. These surveys also included substantial soil sampling for laboratory analysis and interpretation. These surveys were reviewed and approved by the Wyoming Department of Environmental Quality (WDEQ), Land Quality Division (LQD) as part of the mine permitting process.

The three slope gradient categories in the Wyoming PRB study area are presented in **Figure 2.2-1**. The slope categories are: less than 25 percent slope, between 25 and 40 percent slope, and greater than 40 percent slope.

For project-related disturbances, soils often are not recommended for salvage on slopes greater than 30 percent. In the Wyoming PRB study area, steep slopes primarily occur along the southwestern corner of Johnson County and in small scattered areas throughout the basin as shown in **Figure 2.2-1**.

The soils information was based on current published NRCS surveys. The slope information was used in combination with the soils information to assess areas with high potential for water erosion. **Table 2.2-1** also identifies the soils that have severe wind and water erosion hazards, high compaction potential and high shrink swell capacity (based on clay type and content), limited reclamation potential (LRP) (based on high or low pH, high salinity, and sodicity), and prime or otherwise valuable agricultural soils.



Sources: BLM 2010a; Gesch 2007; Gesch et al. 2002.

Powder River Basin Coal Review

Figure 2.2-1
Percent Slope

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Table 2.2-1 Soil Limitations and Characteristics in the Wyoming PRB Study Area

Subwatershed	Characteristic (acres)								
	Depth to Bedrock[1]	Hydric[2]	Wind Erodible	Water Erodible	Compaction Prone	High Shrink-Swell Potential	Droughty	LRP[3]	Prime Farmland (if irrigated)
Antelope Creek	0	85,283	116,113	8,309	241,375	214,456	329,467	0	0
Clear Creek	547,385	24,427	1,775	78,870	156,700	249,426	195,076	3,947	8,452
Crazy Woman	548,299	6,718	178	53,858	207,948	59,038	107,792	2,674	1,124
Dry Fork Cheyenne River	0	11,742	59,999	5,376	137,554	117,380	141,958	0	0
Lightning Creek	23,823	10,106	57,463	410	126,142	134,671	139,860	457	0
Little Bighorn River	50,564	3,776	0	15,512	26,782	16,253	1,712	211	4
Little Missouri River	39,065	820	0	1,268	15,831	8,633	8,056	0	0
Little Powder River	830,943	127,389	528	61,467	320,016	220,485	140,934	3,724	0
Middle Fork Powder River	463,958	10,227	3,302	101,856	155,329	119,236	82,478	8,978	8,924
Middle North Platte River	50,383	4,709	73,928	807	41,506	51,413	118,114	0	0
Middle Powder River	224,200	13,738	60	23,343	97,898	78,207	22,032	272	7
North Fork Powder River	20,179	161	44	3,587	4,754	4,034	1,601	0	0
Salt Creek	125,065	6,302	6,009	16,806	45,167	62,201	67,269	1,460	167
South Fork Powder River	114,327	4,489	2,344	12,862	65,759	40,536	25,050	1,028	248
Upper Belle Fourche River	5,126	187,302	22,009	16,837	484,344	381,952	203,085	0	0
Upper Cheyenne River	0	69,692	4,091	6,882	134,589	94,021	74,395	0	0
Upper Powder River	1,173,807	151,251	14,050	166,962	815,159	559,942	314,848	9,131	11,513
Upper Tongue River	740,031	50,651	575	121,442	405,818	407,289	115,118	3,243	37,967
Total[4]	**4,957,153**	**768,784**	**362,468**	**696,457**	**3,482,671**	**2,819,175**	**2,088,845**	**35,124**	**68,407**

[1] Soils with lithic bedrock contact less than 60 inches deep.

[2] Includes map unit acreages for partially hydric soils (map units that contain both hydric and nonhydric soils). Due to the scale of mapping, actual acreages of hydric soils may not be adequately depicted.

[3] LRP = Limited Reclamation Potential.

[4] Slight differences in totals may occur due to rounding.

Source: NRCS 2012.

Severe wind erosion hazards were identified by using the soil wind erodibility group (WEG). The WEG rating is a numerical value indicating the susceptibility of soil to wind erosion. There is a close correlation between wind erosion and the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture, frozen soil layers, slope and other factors also may influence erosion. There are nine WEG groupings: 1, 2, 3, 4, 4L, 5, 6, 7, and 8. The lower the number, the greater the risk of wind erosion. Soils with a WEG of 2 and less are considered susceptible to wind erosion. (USDA 2012b). Soils in the Wyoming PRB study area range from fine sand with severe wind erosion hazard to very wet or stony soils with only slight or no erosion hazard. Soils that are prone to wind erosion primarily occur in the southern portion of the Wyoming PRB study area, as shown in **Figure 2.2-2**.

Water erosion hazard is determined by several factors including organic matter content, K factor (the higher the number the higher the hazard), permeability class, and slope. Soils on steep slopes are highly prone to water erosion. Water erosion prone soils were determined to have a K factor greater than 0.32 and a slope greater than 20 percent. Additionally, all soils on slopes over 30 percent were determined to be water erosion prone. Erosion prone soils occur along the western portions of the basin. Severe water erosion hazard soils also occur along the northeastern border of the basin, as well as scattered areas along the Powder River. Water erodible soils are shown in **Figure 2.2-3**.

Compaction and shrink/swell potential are related to the amount and type of clay in a soil and affect the soil's ability to support construction and be reclaimed. In soils with a high shrink/swell potential, rapid changes in volume can damage structures and roads. Soils with montmorillonite (smectite or bentonite) clays are considered to have a high shrink/swell potential. Linear extensibility was used to determine soils prone to shrink/swell. The higher the number, the more prone the soil is to expansion. Further information on soils prone to shrink/swell can be found in the National Soil Survey Handbook (Part 618.37) (USDA 2012a). Compaction prone soils are common and are scattered throughout the Wyoming PRB study area. Soils with 28 percent or greater clay content are classified as compaction prone, specifically when moist or wet. Soils with high shrink/swell potential occur along the northern and western borders of the basin, on both sides of the Powder River, down the center of Johnson County, in the eastern portion and entire southern half of Campbell County, and in small scattered areas of Converse County. Compaction prone soils are shown in **Figure 2.2-4**, and shrink-swell soils are shown in **Figure 2.2-5**.

Soils that are droughty have physical characteristics that may limit plant growth due to low water holding capacity. Droughty soils in the Wyoming PRB study area were determined by identifying soils with a surface texture of sandy loam or coarser and a drainage class of moderately well to excessively drained. In addition, the success of stabilization and restoration efforts in these areas may be limited unless additional treatments and practices are employed to offset the adverse physical characteristics of the soils. As shown in **Figure 2.2-6**, droughty soils are scattered throughout the Wyoming PRB study area.

The BLM statewide reclamation policy defines LRP areas as possessing unique landscape characteristics (e.g., sensitive geologic formations, extremely limiting soil conditions, biological soil crusts, badlands, rock-outcrops, etc.) that often make reclamation success impractical and/or unrealistic due to physical, biological, and/or chemical challenges. Some LRP areas currently are identified as miscellaneous areas including, but not limited to, badlands, rock outcrop, and gullied lands in the current SSURGO soils data (see **Figure 2.2-7**). Other potential LRP areas may include areas susceptible to mass movement, very shallow soils, blown-out areas, areas with chemical properties rated unsuitable in WDEQ topsoil and overburden criteria, or other areas identified through on-site investigation as having properties that make meeting all of the reclamation requirements unrealistic or impossible.

Soils with LRP are identified by two methods. The first method uses the data contained in the county soil surveys. The second method is through on-site investigation to identify individual soil series or miscellaneous components. This site-specific analysis may include lab analysis and detailed soil mapping. Topsoils characterized as saline, sodic, and/or strongly acidic or alkaline were determined to

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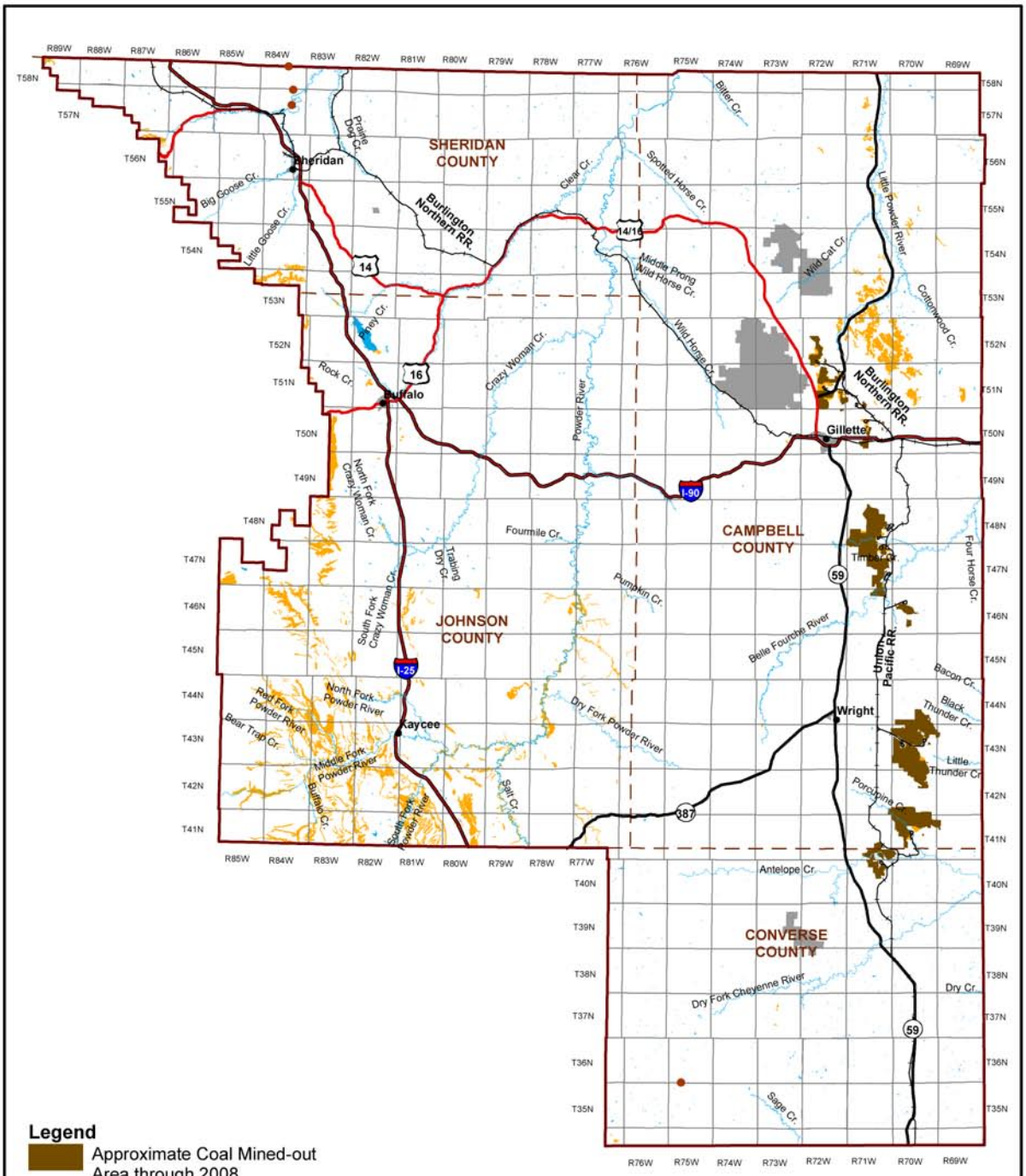
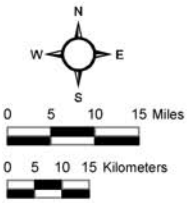


Legend

- Approximate Coal Mined-out Area through 2008
- Former Surface Coal Mine Site
- Soils Prone to Severe Wind Erosion
- Miscellaneous Units (e.g., rock outcrop, gullies, etc.)
- No NRCS Data
- County
- River or Stream
- Railroad



Sources: BLM 2010a; NRCS 2012.

Powder River Basin Coal Review

Figure 2.2-2

Soils Prone to Severe Wind Erosion

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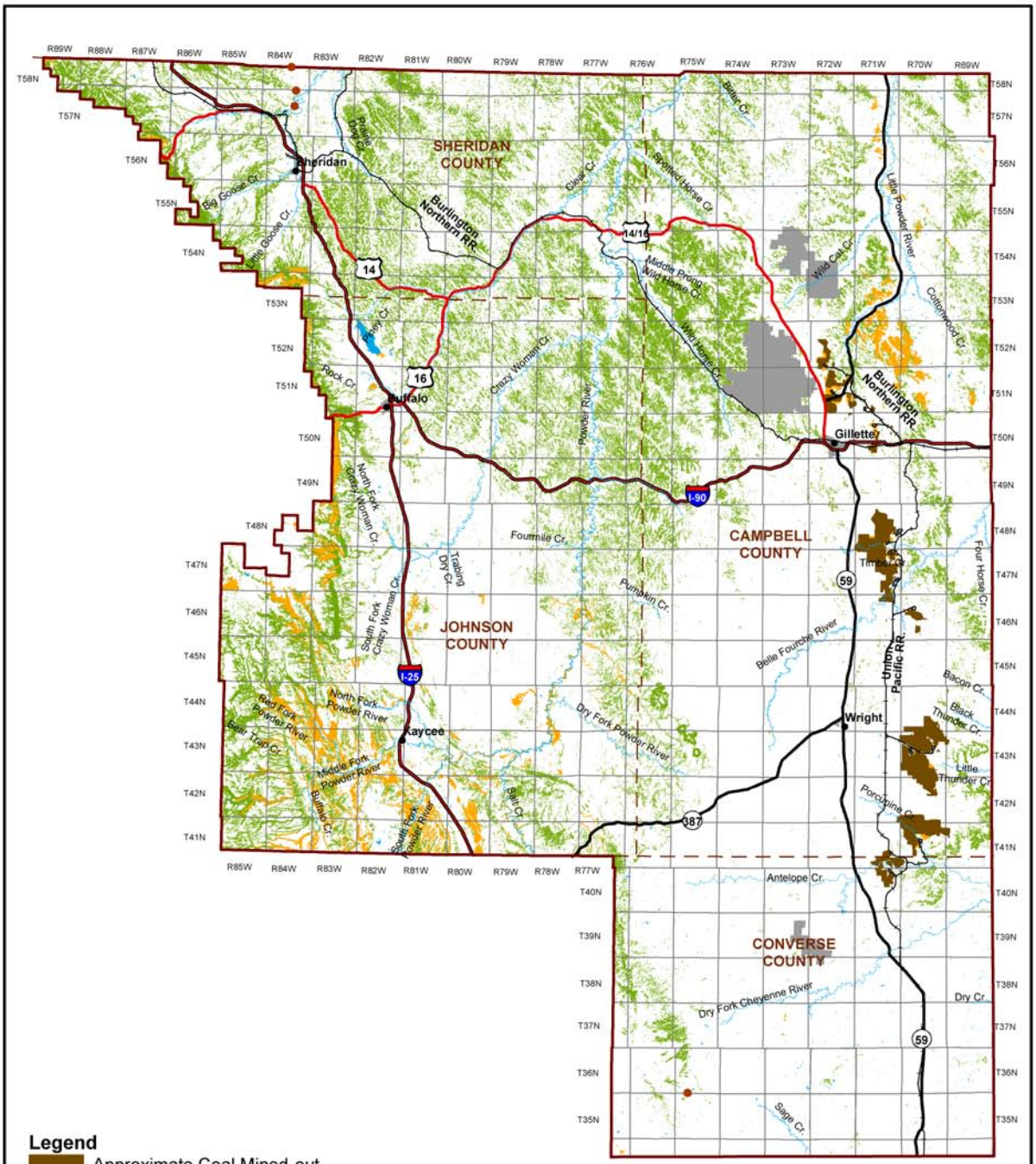

Sources: BLM 2010a; Gesch 2007; Gesch et al. 2002; NRCS 2012.

Powder River Basin Coal Review

Figure 2.2-3

Soils Prone to Severe Water Erosion

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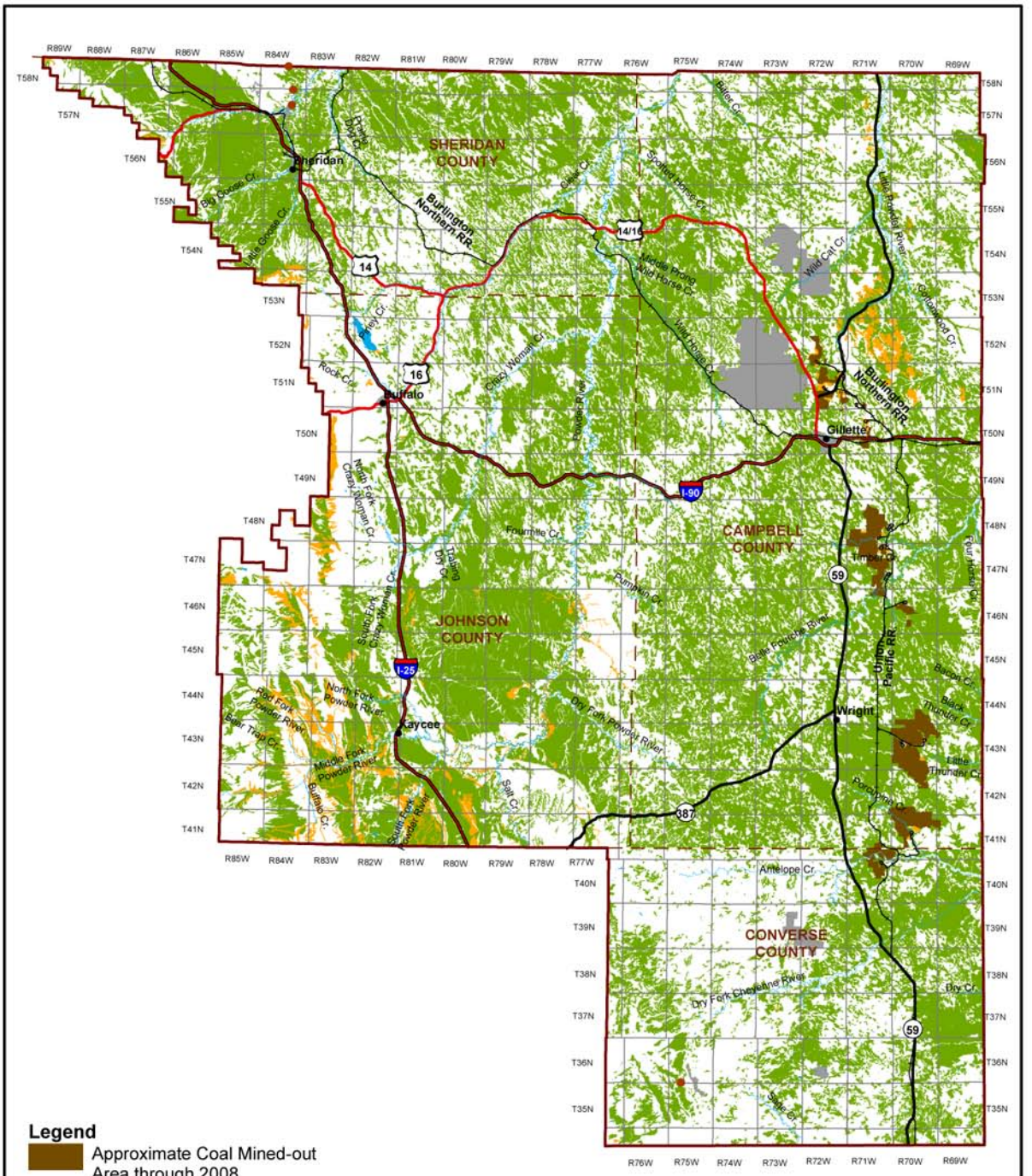
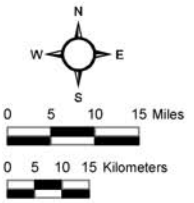


Legend

- Approximate Coal Mined-out Area through 2008
- Former Surface Coal Mine Site
- Soils Prone to Compaction
- Miscellaneous Units (e.g., rock outcrop, gullies, etc.)
- No NRCS Data
- County
- Railroad
- River or Stream



Sources: BLM 2010a; NRCS 2012.

Powder River Basin Coal Review

Figure 2.2-4

Soils Prone to Compaction

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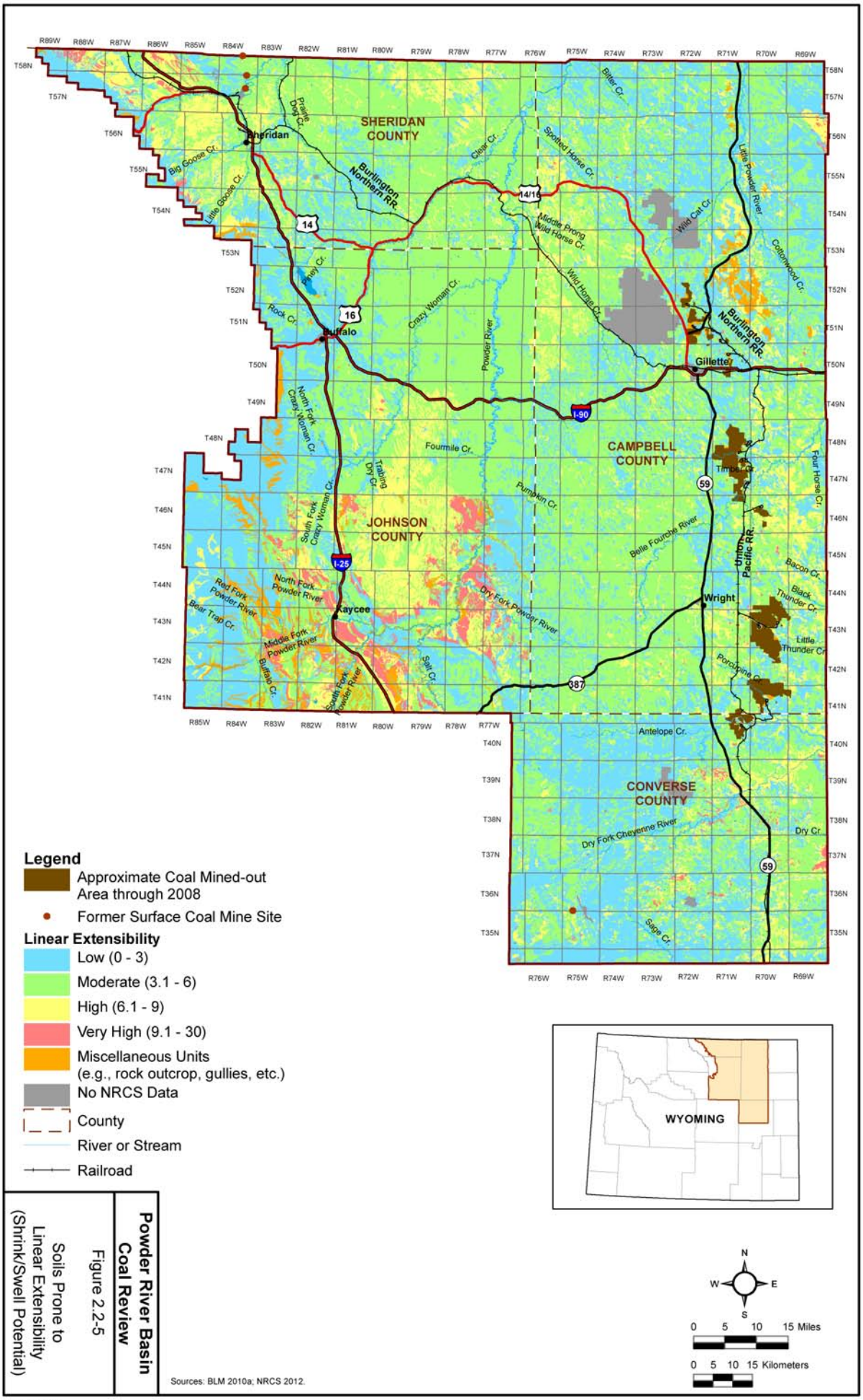

Sources: BLM 2010a; NRCS 2012.

Powder River Basin Coal Review

Figure 2.2-5

Soils Prone to Linear Extensibility (Shrink/Swell Potential)

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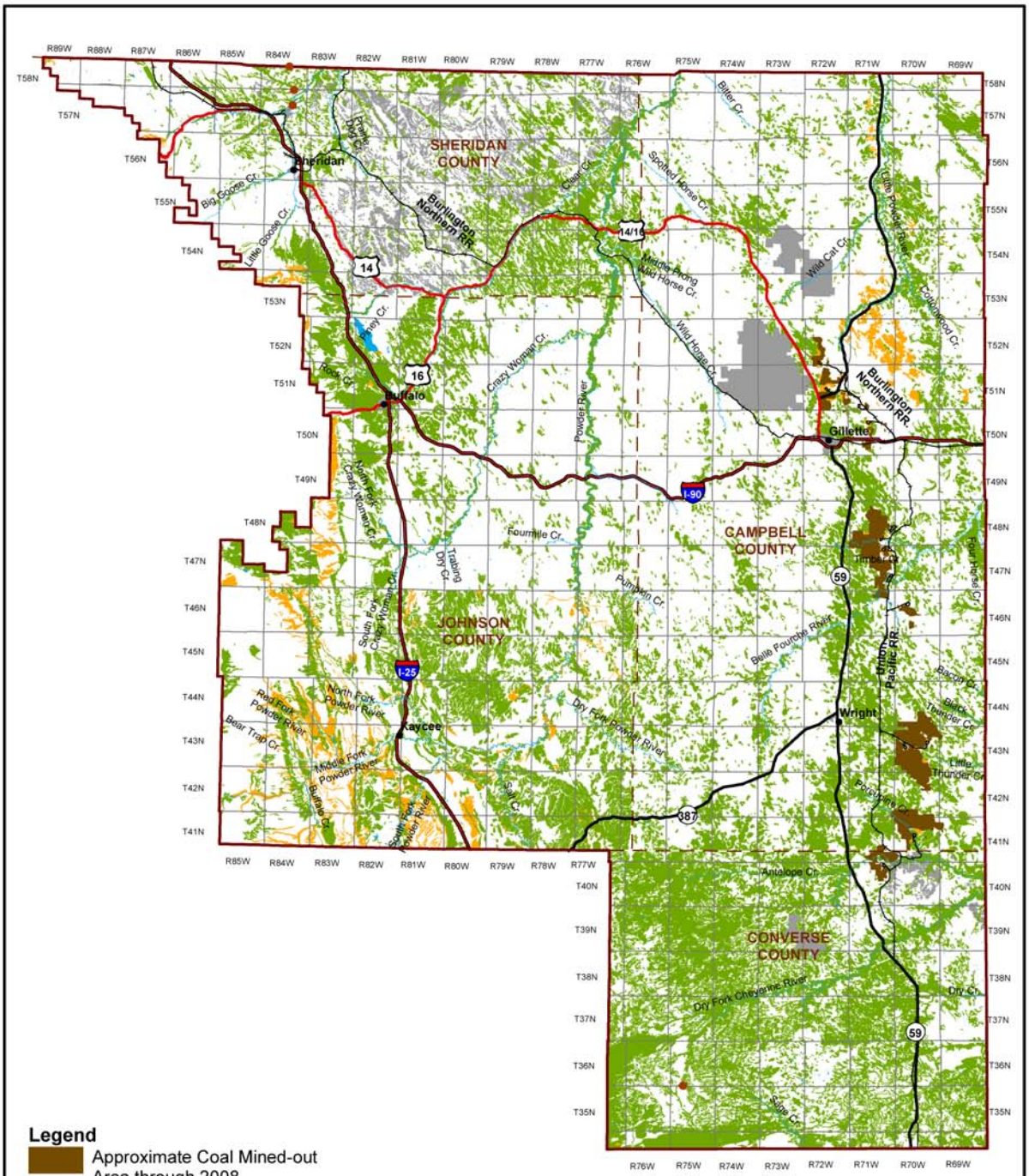

Legend

- Approximate Coal Mined-out Area through 2008
- Former Surface Coal Mine Site
- Droughty Soil
- Miscellaneous Units (e.g., rock outcrop, gullies, etc.)
- No NRCS Data
- County
- River or Stream
- Railroad

N W E S

0 5 10 15 Miles

0 5 10 15 Kilometers

Sources: BLM 2010a; NRCS 2012.

Powder River Basin Coal Review

Figure 2.2-6

Droughty Soils

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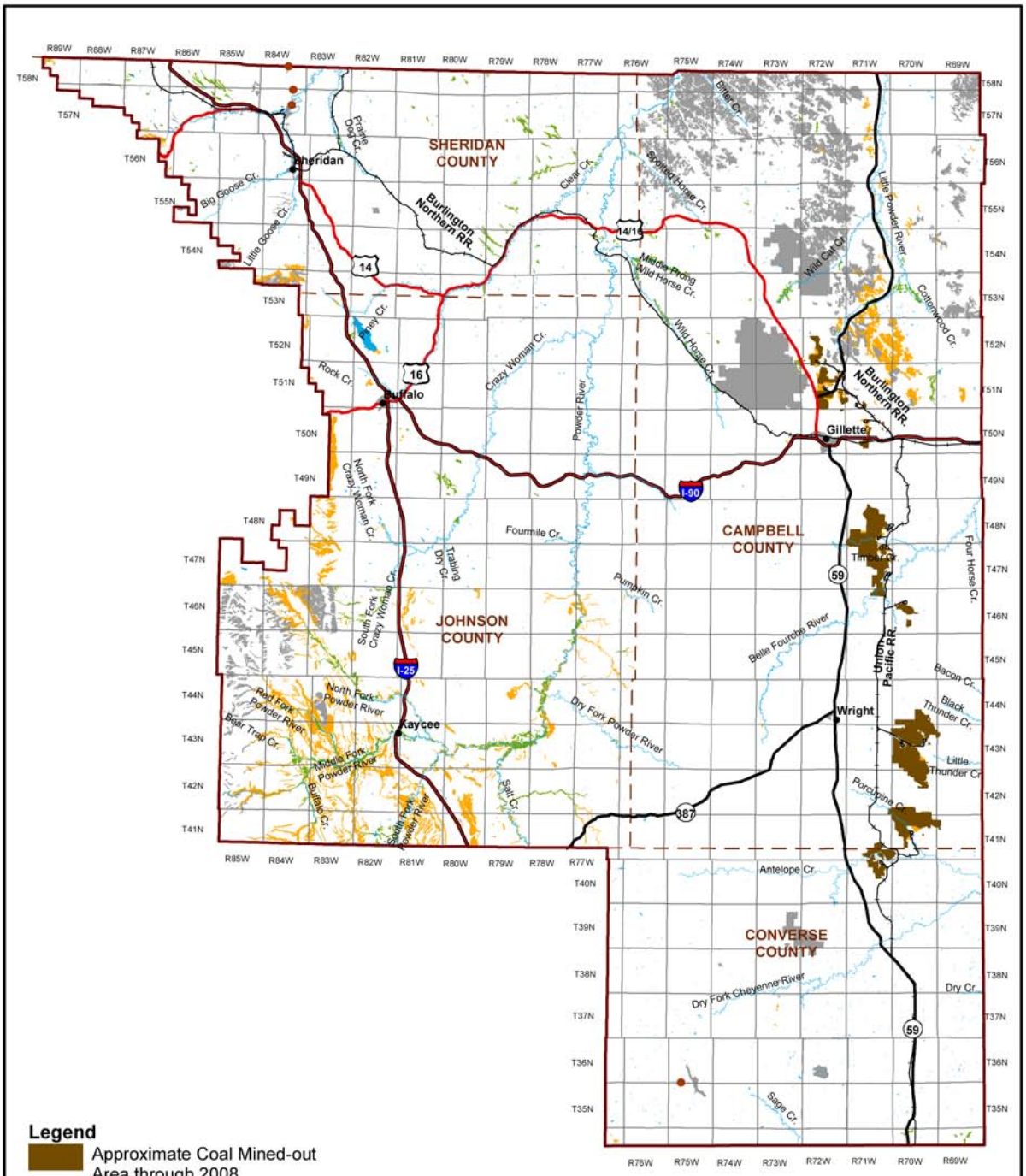

Legend

- Approximate Coal Mined-out Area through 2008
- Former Surface Coal Mine Site
- Soils with Limited Reclamation Potential
- Miscellaneous Units (e.g., rock outcrop, gullies, etc.)
- No NRCS Data
- County
- River or Stream
- Railroad

Powder River Basin Coal Review

Figure 2.2-7

Soils with Limited Reclamation Potential

Sources: BLM 2010a; NRCS 2012.

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have limited revegetation potential for reclamation of project-related disturbances. Soil salinity and sodicity are measured by electrical conductivity (EC) and sodium adsorption ratio (SAR), respectively. Salinity impacts a plant's ability to take in water, whereas sodicity slows the movement of water through the soil. Soils with an EC greater than 4 are considered saline. Soils with an SAR greater than 13 are considered sodic. Soils with a pH of 9 or greater are considered very strongly alkaline, and soils with a pH of 4.4 or less are considered extremely acidic. Soils with LRP are scattered in isolated areas throughout the Wyoming PRB study area except in southern Campbell County. Soils with LRP are shown in **Figure 2.2-7**.

WDEQ topsoil and overburden criteria require site-specific soil sampling and description, laboratory analysis of soil samples, and a subsequent suitability evaluation and salvage depth recommendation (WDEQ 1994). This method is appropriate for project-specific land areas and usually requires the completion of a detailed (Order 1-2) soil survey. WDEQ maintains the records associated with detailed soil surveys required for mining permits.

Prime farmland is land that has the best combination of physical and chemical characteristics for producing crops and is available for these uses. It has the combination of soil properties, growing season, and moisture supply needed to produce sustained high yields of crops in an economic manner if it is treated and managed according to acceptable farming methods. These soils have the capability to be prime farmland, even if they have not yet been developed for agricultural uses. The Farmland Protection Policy Act states that federal programs that contribute to the unnecessary and irreversible conversion of farmland to non agricultural uses will be minimized and shall be administered in a manner that, as practicable, are compatible with state and local government and private programs and policies to protect farmland. Soils within the Wyoming PRB study area are only characterized as prime farmland if they are irrigated. Prime farmland soils in the Wyoming PRB study area primarily are located along the floodplains of the Powder River in southern Johnson County and in scattered locations in Sheridan County (**Figure 2.2-8**).

Based on GIS analysis, as of the end of base year 2008, the existing development-related soil disturbance in the Wyoming PRB study area was approximately 217,647 acres, of which approximately 67,242 acres of disturbance was related to coal mining activity (**Table 2.2-2**). The existing cumulative energy-related soil disturbance for each soil limitation and characteristic is shown in **Table 2.2-3**. Existing soil disturbance from coal mine-related development only is shown in **Table 2.2-4**.

Table 2.2-2 Existing Soil Disturbance in the Wyoming PRB Study Area

Subwatershed	Total Cumulative Disturbance[1,2]	Coal Mine-related Disturbance[1]
Antelope Creek	30,282	16,295
Clear Creek	6,582	0
Crazy Woman Creek	2,298	0
Dry Fork Cheyenne River	3,088	0
Lightning Creek	3,850	0
Little Bighorn River	107	0
Little Missouri River	275	0
Little Powder River	24,993	7,874
Middle North Platte River	1,045	0
Middle Powder River	827	0
Middle Fork Powder River	6,399	0

Table 2.2-2 Existing Soil Disturbance in the Wyoming PRB Study Area

Subwatershed	Total Cumulative Disturbance[1,2]	Coal Mine-related Disturbance[1]
North Fork Powder River	0	0
Salt Creek	809	0
South Fork Powder River	653	0
Upper Belle Fourche River	56,214	21,702
Upper Cheyenne River	26,295	21,371
Upper Powder River	43,259	0
Upper Tongue River	10,671	0
Total	**217,647**	**67,242**

[1] Based on GIS analysis of existing development-related disturbance as of the end of base year 2008.

[2] Inclusive of coal mine-related disturbance.

Source: NRCS 2012.

2.2.3.2 Alluvial Valley Floor

The Federal Office of Surface Mining (OSM) 1977 Surface Mining Control and Reclamation Act (SMCRA) regulations define AVFs as unconsolidated stream-laid deposits where water availability is sufficient for subirrigation or flood irrigation agricultural activities (P.L. 95-87). The WDEQ/LQD administers these AVF regulations for coal mining activities in Wyoming. Because their presence can restrict mining activities, AVFs must be determined before leasing and mining can proceed. Coal mine-related impacts to designated AVFs generally are not permitted if the AVF is determined to be significant to agriculture. Conversely, if the AVF is determined not to be significant to agriculture, or if the permit to affect the AVF was issued prior to the effective SMCRA date, the AVF can be disturbed during mining but must be restored during reclamation.

The WDEQ/LQD determines significance to agriculture based on specific calculations related to the production of crops or forage on the AVF and the size of the existing agricultural activities on the land of which the AVF is part. In addition, for any designated AVF, regardless of its significance to agriculture, it must be demonstrated that the essential hydrologic functions of the valley would be protected.

The determination of AVFs is done in accordance with the OSM and WDEQ/LQD guidelines that require detailed studies of soils, geomorphology, hydrology, vegetation, and land use. Three items must be determined as limiting criteria: 1) the possibility for artificial flood irrigation; 2) past and/or present flood irrigation; and 3) apparent subirrigated areas and the possibility for natural flood irrigation. Areas that meet these criteria are then studied for their practical use for agriculture.

The following information summarizes the current conditions for AVFs within the coal mining areas in the Wyoming PRB study area. Essential hydrologic functions and their restoration are not part of this discussion.

As discussed in the Task 2 report (AECOM 2011) and shown in **Figure 1-1**, the coal mines have been grouped into four areas based on geographic distribution within the basin including: 1) Subregion 1, those mines near Gillette and extending to the north; 2) Subregion 2, mines south of Gillette and north of Wright; 3) Subregion 3, mines east of Wright and extending to the south into the northern part of Converse County; and 4) Subregion 4, former mines northeast of Sheridan to the Wyoming/Montana state line.

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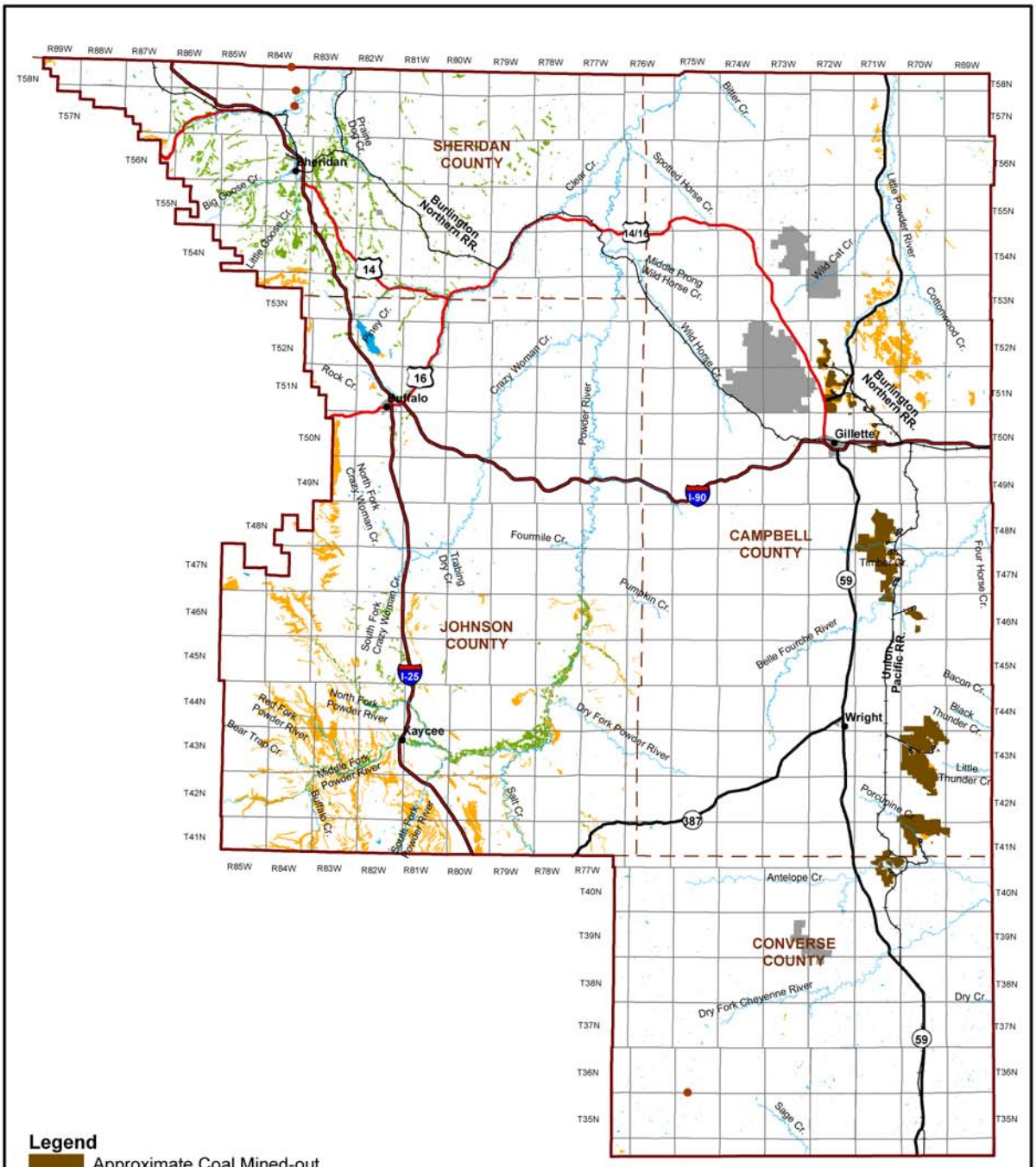

Legend

- Approximate Coal Mined-out Area through 2008
- Former Surface Coal Mine Site
- Prime Farmland (if irrigated)
- Miscellaneous Units (e.g., rock outcrop, gullies, etc.)
- No NRCS Data
- County
- River or Stream
- Railroad

Powder River Basin Coal Review

Figure 2.2-8

Prime Farmland (if irrigated)

Sources: BLM 2010a; NRCS 2012.

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Table 2.2-3 Existing Cumulative Soil Disturbance by Subwatershed

Subwatershed	Characteristic (acres)[1]								
	Depth to Bedrock[2]	Hydric[3]	Wind Erodible	Water Erodible	Compaction Prone	High Shrink-Swell Potential	Droughty	LRP	Prime Farmland (if irrigated)
Antelope Creek	0	6,910	2,182	98	18,227	5,896	9,929	0	0
Clear Creek	6,582	3,039	36	199	1,032	228	1,456	62	159
Crazy Woman	2,298	39	0	71	865	195	512	13	5
Dry Fork Cheyenne River	0	98	564	19	1,139	387	1,337	0	0
Lightning Creek	355	86	837	2	1,566	839	1,858	8	0
Little Bighorn River	107	7	0	5	26	17	24	0	0
Little Missouri River	275	14	0	4	84	26	100	0	0
Little Powder River	23,084	5,370	22	729	7,994	1,169	3,704	148	0
Middle Fork Powder River	1,045	4	3	9	604	167	257	4	11
Middle North Platte River	204	24	198	1	292	64	457	0	0
Middle Powder River	6,399	381	0	394	3,299	474	785	21	0
North Fork Powder River	0	0	0	0	0	0	0	0	0
Salt Creek	792	42	3	63	224	158	391	32	0
South Fork Powder River	653	27	1	44	323	233	29	9	0
Upper Belle Fourche River	32	9,789	720	249	30,324	5,738	12,484	0	0
Upper Cheyenne River	0	8,050	139	58	18,413	5,735	8,173	0	0
Upper Powder River	30,064	3,974	433	2,317	19,303	6,140	8,622	361	54
Upper Tongue River	10,671	745	20	744	5,535	1,972	2,435	42	713
Total[4]	**82,561**	**38,600**	**5,160**	**5,004**	**109,249**	**29,437**	**52,552**	**700**	**942**

1 Based on GIS analysis of existing development-related disturbance as of the end of base year 2008 (inclusive of coal mine-related disturbance).

2 Soils with lithic bedrock contact less than 60 inches deep.

3 Includes map unit acreages for partially hydric soils (map units that contain both hydric and nonhydric soils). Due to the scale of mapping, actual acreages of hydric soils may not be adequately depicted.

4 Slight differences in totals may occur due to rounding.

Source: NRCS 2012.

Table 2.2-4 Existing Soil Disturbance from Coal Mine-related Development by Subwatershed

Subwatershed	Characteristic (acres)[1]								
	Depth to Bedrock[2]	Hydric[3]	Wind Erodible	Water Erodible	Compaction Prone	High Shrink-Swell Potential	Droughty	LRP	Prime Farmland (if irrigated)
Antelope Creek	0	4,726	307	59	11,891	4,750	3,008	0	0
Clear Creek	0	0	0	0	0	0	0	0	0
Crazy Woman	0	0	0	0	0	0	0	0	0
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0	0	0	0
Little Bighorn River	0	0	0	0	0	0	0	0	0
Little Missouri River	0	0	0	0	0	0	0	0	0
Little Powder River	7,784	111	0	112	1,967	51	603	0	0
Middle Fork Powder River	0	0	0	0	0	0	0	0	0
Middle North Platte River	0	0	0	0	0	0	0	0	0
Middle Powder River	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	0	0	0
South Fork Powder River	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	0	3,294	235	100	10,198	2,595	4,265	0	0
Upper Cheyenne River	0	6,390	61	31	14,764	4,559	5,903	0	0
Upper Powder River	0	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	0	0	0
Total[4]	**7,784**	**14,522**	**602**	**302**	**38,821**	**11,955**	**13,778**	**0**	**0**

1 Based on GIS analysis of existing development-related disturbance as of the end of base year 2008.

2 Soils with lithic bedrock contact less than 60 inches deep.

3 Includes map unit acreages for partially hydric soils (map units that contain both hydric and nonhydric soils). Due to the scale of mapping, actual acreages of hydric soils may not be adequately depicted.

4 Slight differences in totals may occur due to rounding.

Source: NRCS 2012.

AVF information obtained from various NEPA documents as well as the State Decision Documents (SDDs) prepared for each mine by the WDEQ/LQD with their attendant permit numbers is presented below. LBA tracts leased after 2008 and pending LBAs are considered future actions and are not considered part of current conditions; however, a brief summary of their current status and associated AVF information is presented below for each coal mine subregion.

Subregion 1

Subregion 1 includes the Buckskin, Dry Fork, Eagle Butte, Rawhide, and Wyodak mines. AVF areas were identified on the Buckskin Mine, Eagle Butte Mine, Dry Fork Mine (former Fort Union Mine portion), and Rawhide Mine permit areas. AVFs were not identified on the Wyodak Mine permit area or on the Hay Creek II amendment area of the Buckskin Mine. Mine plan and reclamation features to prevent long-term impacts and the maintenance of essential hydrologic functions for declared AVF areas are contained in various sections of each mine's permit document.

Buckskin Mine Including Hay Creek Amendment (SDD, Permit 500-T6-A1, Change No. 4). Declared AVF areas were identified along Rawhide Creek and Spring Draw, and are shown on Map D11-1 of the Buckskin Mine permit. Previous disturbance to the Rawhide Creek AVF is delineated on Map D11-2 of the Buckskin permit. AVF areas were identified along Rawhide Creek and lower Spring Draw, with disturbance proposed along portions of the Rawhide Creek AVF. The entire Spring Draw AVF within the permit area will be mined out. Neither of these AVF areas was determined to be significant to farming, and no AVF was identified in association with the Hay Creek Amendment.

At the end of the third permit term (T3), all identified AVFs proposed to be disturbed were disturbed. Reconstruction work was completed on the Rawhide Creek AVF, and natural flow was returned to the channel in year 2000. Reclamation work on the Little Draw AVF (the Spring Draw AVF replacement feature) was completed in 2001 at the confluence of Little Draw and Rawhide Creek.

The Buckskin Mine was awarded the West Hay Creek LBA tract through competitive bid, with an effective lease date of January 2005 (BLM 2012a). Investigations within and surrounding the Buckskin Mine and LBA tract analysis area determined there were no AFVs within that area. The WDEQ concurred with that finding. The nearest declared AVF is south of the analysis area along Rawhide Creek. Portions of that AVF area previously have been disturbed by mining and subsequently reclaimed.

Eagle Butte Mine Including the Eagle Butte LBA (SDD, Permit No. 428-T4-A1, Change No. 13, and Final Eagle Butte EA [BLM 1994]). Much of Little Rawhide Creek was declared an AVF non-significant to farming as it diagonally traverses the northern part of the permit area from west to east. Other portions of Little Rawhide Creek and its tributaries coming from the south within and adjacent to the permit area also have been declared AVF. AVF declarations are documented in Section 2.10 and Appendix 2.10-4 of the Eagle Butte mine permit. Monitoring, mitigation, and reclamation plans are presented in Subsections 3.5.8.7, 4.6.1, and 4.6.2 of the permit and are designed to prevent material damage to water supplies for the declared AVF. Reclamation features to prevent long-term impacts and to restore essential hydrologic functions to AVF areas adjacent to mining operations appear in Subsection 4.6.2.4 of the permit.

The Eagle Butte Mine was awarded the Eagle Butte West LBA tract through competitive bid, with an effective lease date of May 2008 (BLM 2012a). Based on the Final Eagle Butte West Coal Lease Application EIS (BLM 2007b), Little Rawhide Creek, a small portion of Prong Draw at its confluence with Little Rawhide Creek, and their alluvial valleys lie within the eastern portion of the Eagle Butte West LBA Tract, which is inside Eagle Butte Mine's permit area. The entire reach of Little Rawhide Creek within the BLM study area for the LBA tract was declared an AVF non-significant to farming by the WDEQ/LQD. Based on further investigation, it was determined that the undeclared portion of the Prong Draw AVF does not meet the regulatory definition of an AVF because the stream-laid deposits are very limited in areal extent and support little or no natural subirrigation or flood irrigation activities, and the quality of groundwater in the alluvial deposits is unsuitable for agricultural use. Surface water quantity is insufficient

to support agricultural activities, further supporting the contention that the portion of Prong Draw within the LBA tract is not an AVF.

Dry Fork Mine (former Fort Union Mine portion – SDD, Permit No. 659-T2). AVF information for the Dry Fork Mine is available in the SDD and permit files for the former Fort Union Mine, which previously became part of the Dry Fork Mine. No other AVF information was available for the Dry Fork Mine. The Dry Fork of the Little Powder River is an AVF not significant to agriculture from a southwest point 1,320 feet south of the northwest corner of Township 50 North (T50N), Range 72 West (R72W), Section 1, to a point at least 660 feet southwest of its confluence with the Little Powder River in T51N, R71W, Section 6. Only a very short reach of the AVF is located within the permit area. The permit application describes how the essential hydrologic functions would be adequately restored for the AVF, if it is mined through in the future.

Rawhide Mine (SDD, Permit No. 240-T4-R4, Change No. 6). AVFs were identified in four locations within the permit area: 1) the Dry Fork Little Powder River; 2) the Little Rawhide Creek north of the section line between T51N, R73W, Sections 4 and 9; 3) Rawhide Creek downstream from the Buckskin Mine eastern permit boundary; and 4) Rawhide Creek in T51N, R72W, Section 6 from U.S. Highway 14/16 to the Buckskin Mine access road. Both upper Rawhide Creek and Little Rawhide Creek will be mined through during life-of-mine operations. As a result of revision to the mine plan, Rawhide Creek will not be mined through near its confluence with Little Rawhide Creek. In addition, the lower reaches of Little Rawhide Creek will not be mined near its confluence with Rawhide Creek.

The significance to farming has been “grandfathered” for the AVFs within the Rawhide Mine permit area. The operator is allowed to mine the AVFs but is required to restore the essential hydrologic functions associated with the AVFs that are disturbed.

Wyodak Mine (SDD, Permit No. 232-T5). The Wyodak Mine permit area is adjacent to an AVF on a portion of Donkey Creek located east of the permit area in the north half of T50N, R71W, Sections 26 and 27. The AVF begins approximately 0.25 mile east of the permit boundary, and extends at least 0.5 mile into Section 26, downstream of the permit area. No other drainages within or adjacent to the permit area contain AVFs.

The significance to farming has been “grandfathered” for any AVFs within the Wyodak Mine permit area. The AVF on Donkey Creek is not projected to be disturbed. However, should it be affected, the operator would be required to restore all essential hydrologic functions associated with the Donkey Creek AVF.

LBA Tracts. Leasing is pending for one LBA tract in Subregion 1 (BLM 2012a), as described below.

- Hay Creek II – Application submitted by the Buckskin Mine operator; Final EIS completed in 2011. Lease sale is pending. Based on the Final Buckskin Mine Hay Creek II Coal Lease Application EIS (BLM 2011), no AVFs exist within the Hay Creek valley bottom or within the mine permit area.

<u>Subregion 2</u>

Subregion 2 includes the Belle Ayr, Caballo, Cordero-Rojo, and Coal Creek mines. AVFs were identified on the Belle Ayr and Caballo mines and on the Caballo Rojo portion of the Cordero-Rojo Mine. No AVFs were identified on the Cordero portion of the Cordero-Rojo Mine, or on the Coal Creek Mine permit area.

Belle Ayr Mine (SDD, Permit 214-T6). Two areas along Caballo Creek were designated as AVFs, although no specific determinations were made regarding significance to farming. Belle Ayr contended that unsuitable soils and water quality rendered the areas insignificant to farming. More recent information included new potential AVF areas on Bone Pile, Caballo, and Duck Nest creeks within the 214-T4 permit boundary. The WDEQ has concluded, however, that no significant areas of AVFs exist within the Belle Ayr permit area. There is an area of 134 acres to the east of active mining that

historically has been used as subirrigated hayland. However, the high groundwater levels in the alluvium in this area are artificially sustained by stock dams in the Caballo Creek channel and, thus, do not meet the natural subirrigation criterion of the WDEQ guidelines.

Caballo Mine (SDD, Permit 433-T1 and T-5). There are two major alluvial systems within the Caballo Mine permit area; however, neither area will be mined under existing permits. The confluence area where theTisdale, North Tisdale, and Gold Mine draws converge has been designated as an AVF. The AVF in Gold Mine Draw in T48N, R71W, Sections 13 and 24 is considered significant to farming. Existing disturbance in this area is confined to a railroad loop and sedimentation pond. Both of these structures, “grandfathered” under a previous state permit, will be removed at the end of mining. The long-term impacts to this AVF are expected to be minimal once reclamation is complete.

Cordero-Rojo Mine (Caballo Rojo SDD, Permit No. 511-T6-R1-Change No. 2, and Cordero SDD, Permit No. 237-T6). The Caballo Rojo Mine and the Cordero Mine previously were combined into the Cordero-Rojo Mine. No AVFs exist within the former Caballo Rojo permit area. However, two AVFs do exist along Caballo Creek to the north of the former Caballo Rojo permit area. These AVFs, known as the western and eastern Caballo Creek AVFs, are located within and adjacent to the Belle Ayr Mine. The potential effects of mining within the former Caballo Rojo permit area on these somewhat distant AVFs were discussed in the Caballo Rojo Mine Plan, and are expected to be mitigated. For the former Cordero permit area, no AVFs were identified. The valleys of Kicken and Bengal draws, Coal Creek, and the Belle Fourche River in the vicinity of the former Cordero Mine are not AVFs, because they are not capable of supporting subirrigation or flood irrigation agricultural activities.

The Cordero-Rojo Mine was awarded the South Maysdorf (Mt. Logan) LBA tract through competitive bid, with an effective lease date of August 2008 (BLM 2012a). Based on the EIS analysis for this tract (BLM 2007a) and confirmation from the WDEQ/LQD (Barbula 2012), the Cordero-Rojo Mine received a negative AVF determination for lands in the Maysdorf Amendment. The WDEQ/LQD determined that the valleys of Kicken and Bengal draws, Coal Creek, and the Belle Fourche River in the vicinity of the Cordero-Rojo Mine are not AVFs because they are not capable of supporting subirrigation or flood irrigation agricultural activities. The Belle Fourche River is considered an impractical water source for artificial flood irrigation practices due to poor water quality and infrequent water availability. Historic flood irrigation attempts have not been identified along the Belle Fourche River or ephemeral drainages within the general analysis area.

LBA Tracts. The status and associated AVF information for the LBA tracts in Subregion 2 that were leased after 2008, or for which leases are pending (BLM 2012a), is presented below. In addition, one LBA in this subregion (West Coal Creek) was rejected (BLM 2012a).

- Belle Ayr North – Lease obtained by the Belle Ayr Mine operator; lease effective as of November 2011. An AVF occurs along Duck Nest Creek on the Belle Ayr North LBA tract. Approximately 14.9 acres of the total declared acreage on Duck Nest Creek are located within the Belle Ayr North general analysis area (BLM 2009).
- Caballo West – Lease obtained by the Caballo Mine operator; lease effective as of November 2011. No streams that have AVF characteristics are located within 0.5 mile of the permit amendment area because the streams are incised and contain few stream laid deposits. In addition, there are no present or historical records of agricultural use, other than undeveloped range land, of the stream channels and associated stream laid deposits within the permit amendment area. To date, no official AVF determination has been made by the WDEQ/LQD for this LBA tract (Barbula 2012). However, based on previous non-AVF declarations made on Tisdale Creek within and adjacent to this tract, and based on the lack of site-specific AVF determination factors, it is unlikely that the WDEQ/LQD would declare that an AVF is present on the LBA tract that lies outside of Caballo Mine’s existing permit boundary where the drainages are smaller and AVF characteristics are negligible (BLM 2009).

- Maysdorf II – Application submitted by the Cordero-Rojo Mine operator; Final EIS completed in 2009. Lease sale is pending. An AVF not significant to mining was declared by the WDEQ/LQD to occur in T47N, R72W, Section 1. The WDEQ/LQD has determined that there are no AVFs within the 7.4-mile segment of the Belle Fourche River through T46N, R71W, Sections 9 and 16 (BLM 2009).
- North Maysdorf – Lease obtained by the Cordero-Rojo Mine operator; lease effective as of May 2009. The WDEQ/LQD has issued a negative AVF determination for this LBA tract (Barbula 2012).

Subregion 3

The Subregion 3 area includes the Antelope, Black Thunder, Izita, Jacobs Ranch, North Antelope/Rochelle, and North Rochelle mines. AVFs were identified on mines in Subregion 3 including the Antelope, Black Thunder, Jacobs Ranch, and the North Antelope/Rochelle mines. No AVFs were identified on the North Rochelle Mine. The former Dave Johnston Mine (Glenrock Coal), currently in final reclamation, is located to the southwest of Subregion 3. No AVFs were identified on this mine.

Antelope Mine (SDD, Permit 525-T7). An area along Antelope Creek originally was designated an AVF. The area subsequently was refined to include only those areas which are delineated as “Possible Subirrigated AVF of Minor Importance to Agriculture.” An additional AVF along Horse Creek was designated and contained 61.2 acres, with 50.6 acres permitted to be disturbed by mining. The approved reclamation for this area will require replacement of the alluvial materials and restoration of the hydrologic function of the AVF.

The Antelope Mine was awarded the West Antelope LBA tract through competitive bid, with an effective lease date of March 2005 (BLM 2012a). Per WDEQ/LQD (Kunze 2012), 16.6 acres of AVF not significant to agriculture were declared on Horse Creek. A negative AVF determination was made for the remainder of the streams within this LBA tract.

Black Thunder Mine (SDD, Permit No. 233-T6). AVFs within the original State Program Permit area are “grandfathered,” because the mine was sited prior to the passage of SMCRA in 1977. AVFs disturbed by mining will be restored to their hydrologic functions. There is a large confluence area between the North Prong of Little Thunder and Little Thunder Creek immediately adjacent to the eastern permit boundary. Future mining is not expected to materially damage the quantity or water supply of the AVFs. Those AVFs that exist off-site, outside the permit boundary, will not be mined, and the operation is not expected to materially damage the quantity of water supplying them. A recent change, approved by the WDEQ, removed the AVF assessment for the North Prong of the Little Thunder Creek.

The Black Thunder Mine was awarded the Little Thunder LBA tract through competitive bid, with an effective lease date of March 2005 (BLM 2012a). The Little Thunder LBA tract has been declared non-AVF by the WDEQ/LQD. Portions of Little Thunder Creek and North Prong Little Thunder Creek cross the Little Thunder LBA tract. The WDEQ/LQD declared 143 acres along the lower reach of Little Thunder Creek and 194 acres along the lower reach of North Prong Little Thunder Creek as AVFs. The declared AVFs are located several miles downstream from the Little Thunder LBA tract and would not be affected by mining.

Izita Mine (SDD, Permit No. 676-T1). Thunder Basin Coal Company received a regular mining permit for an area that would serve as an equipment transportation corridor between its Black Thunder Mine (Permit No. 233) and Coal Creek Mine (Permit No. 483), a distance of approximately 23 miles. Because no surface mining is authorized under this permit, the WDEQ/LQD did not require a formal AVF study and did not make a formal declaration

Jacobs Ranch Mine (SDD, Permit No. 271-T4-R2). A designated AVF exists within the permit area in T43N, R70W, Sections 22 and 23. Appendix D-11 of the Jacobs Ranch permit describes the AVFs within and adjacent to the permit area. The AVF is “grandfathered” with regard to significance to farming. The

mine will not materially damage the quality or quantity of surface or subsurface waters which supply the North Prong or Little Thunder Creek.

North Antelope/Rochelle Mine (SDD, Permit No. 569-T5-A2, Change 28). Four AVF studies have been completed on the North Antelope/Rochelle Mine Complex permit area over time including: 1) the Rochelle Mine, Permit No. 569-T1; 2) the North Antelope Mine, Permit No. 532-T1; 3) the North Antelope 1995 amendment, Permit No. 532-T5; and 4) the North Antelope/Rochelle Mine Complex amendment, Permit No. 569-T5.

The WDEQ/LQD determined that an AVF did not exist in the original Rochelle Mine permit area. They determined that a 622-acre AVF did exist within the original North Antelope Mine permit area based on the presence of unconsolidated streamlaid deposits and presumably enough water to potentially flood irrigate these deposits. This AVF was determined not to be significant to farming. North Antelope's T-5 permit amendment area was determined not to contain an AVF due to the presence of an incised channel, limited availability of water due to the relatively flat topography, and a relatively narrow cross sectional area which would be inundated by the predicted peak flow for the 2-year event. The North Antelope/Rochelle Mine Complex amendment area was determined not to contain an AVF because of the incised channel morphology and minimal extent of streamlaid deposits.

The North Antelope Mine was awarded the NARO North and NARO South LBA tracts through competitive bid, with effective lease dates of March 2005 and September 2004, respectively (BLM 2012a). One 250-acre flood irrigated hay meadow near the confluence of Porcupine Creek and Antelope Creek was determined to be significant to agriculture. This hay meadow is the only flood-irrigated land identified in the analysis area. No other declared AVFs or potential AVFs identified in the analysis area were determined by the WDEQ/LQD to be significant to agriculture. The NARO North LBA tract was declared non-AVF by the WDEQ/LQD. The declared AVF on Porcupine Creek is located several miles downstream of the NARO North LBA tract. A total of approximately 100 acres of declared AVF occur within the mine's railroad spur along Porcupine and Antelope creeks, east-southeast of the NARO South LBA tract. This AVF is outside the area of coal removal for the NARO South LBA tract. Special measures were designated to ensure that the mine operation would not interrupt or preclude farming on the flood irrigated lands, and Porcupine Creek downstream from the mine would not be affected by mining. The NARO South LBA tract was declared non-AVF by the WDEQ/LQD (Kunze 2012).

The North Rochelle Mine was awarded the West Roundup LBA tract through competitive bid, with an effective lease date of May 2005. The tract subsequently was obtained by the North Antelope/Rochelle Mine (BLM 2012b). The WDEQ/LQD issued a negative AVF determination for this tract (Kunze 2012).

Dave Johnston Mine (SDD, Permit No. 291-T6). Coal mining was completed at the Dave Johnston Mine on September 28, 2000, and the mine currently is in final reclamation. An AVF located along a portion of Sage Creek occurs approximately 3.5 miles east of the permit area. No mining activities took place within the Sage Creek watershed, and, therefore, there were no surface water impacts. However, groundwater impacts may be induced by mining geologic units supplying discharge to the AVF.

LBA Tracts. The status and associated AVF information for the LBA tracts in Subregion 3 that were leased after 2008, or for which leases are pending, are described below (BLM 2008, 2010b, 2012a).

- North Porcupine – Lease obtained by the North Antelope/Rochelle Mine operator in June 2012. The WDEQ/LQD has determined that no AVFs occur within the amendment area (Kunze 2012).
- South Hilight – Lease obtained by the Black Thunder Mine operator; lease effective as of May 2012. No AVFs exist along Little Thunder Creek within the South Hilight LBA tract. The WDEQ/LQD has not yet made a determination on AVFs for this LBA tract (Barbula 2012).
- South Porcupine – Lease obtained by the North Antelope/Rochelle Mine operator in May 2012. No unconsolidated stream laid deposits have been mapped within the South Porcupine LBA

tract. The WDEQ/LQD has determined that no AVFs occur within the amendment area (Kunze 2012).

- West Antelope II – Lease obtained by the Antelope Mine operator; north lease effective as of July 2011, and south lease effective as of September 2011. There are stream-laid deposits in portions of Horse Creek and Spring Creek within the LBA that are potential AVFs. The WDEQ/LQD has designated AVF in a narrow band adjacent to the Horse Creek channel and extending approximately a 0.5 mile upstream of the current permit boundary (BLM 2008). The portions of Horse Creek that have been declared an AVF were determined to be insignificant to farming by the WDEQ/LQD. No other AVFs were declared by the WDEQ/LDQ within the amendment area (Kunze 2012).
- West Hilight – Application submitted by the Black Thunder Mine operator. Record of Decision (ROD) and lease sale are pending. No AVFs exist along Little Thunder Creek within the West Hilight LBA tract.
- North Hilight – Application submitted by the Black Thunder Mine operator. Lease sale is pending. Numerous ephemeral drainages occur within the analysis area for the North Hilight LBA tract, although the stream-laid deposits associated with these drainages are very limited in areal extent and not capable of supporting subirrigation or flood irrigation agricultural activities. Surface water quantity is insufficient to support natural or artificial flood irrigation practices, and historic flood irrigation attempts have not been identified along Mills Draw, Keeline Draw, or Springen Draw. Based on previous non-AVF declarations made on Mills Draw and Springen Draw within and adjacent to the existing Jacobs Ranch Mine permit area, which includes a portion of the BLM study area for the North Hilight LBA tract, it is unlikely that the WDEQ/LQD would declare AVFs in this tract.
- West Jacob Ranch – Application submitted by the Jacobs Ranch Mine operator. ROD and lease sale are pending. Alluvial deposits only have been mapped along Dry Fork Little Thunder Creek and one of its unnamed tributaries; no stream-laid deposits have been mapped within any other drainage area for the West Jacobs Ranch LBA tract. Based on previous non-AVF declarations made on North Prong Little Thunder Creek and Dry Fork Little Thunder Creek downstream within the existing Black Thunder Mine permit area, which includes a portion of the West Jacobs Ranch LBA tract, it is unlikely that the WDEQ/LQD would declare any AVF characteristics in this tract.

Subregion 4

Subregion 4 in the northwest portion of the Wyoming PRB contains the former Public Service Company of Oklahoma (PSO) Ash Creek, Big Horn Coal, and Welch No. 1 North mines. These mines are in final reclamation or have been reclaimed, with all awaiting final bond release (AECOM 2011). The Ash Creek Mine currently is in field reclamation, and the Big Horn Mine is in final reclamation. The Welch No. 1 Mine was never developed beyond a small test pit. All of these mines contained AVFs.

PSO Ash Creek Mine (SDD, Permit No. 407-T1). Within the former PSO Ash Creek Mine permit area, one AVF was identified along Little Youngs Creek. The AVF extends across the northeastern portion of the permit boundary and across adjacent areas 0.5 mile upstream and downstream of the permit area. There are approximately 54 acres of streamlaid deposits underlying the channel, floodplain, and terraces of Little Youngs Creek. The areal extent of the alluvial gravel aquifer is approximately 66 acres. This 66-acre areal extent of potentially irrigable farmland will be restored during reclamation in accordance with permit requirements. The AVF is “grandfathered” in regard to significance to farming.

Big Horn Mine (SDD, Permit No. 213-T5). AVFs are present within the former mines’ permit area, and are described on Page MP-14 of the Mine Plan. Appendix D-11 of the permit application contains a detailed discussion of the location and characteristics of these AVFs. Portions of the alluvial systems in T57N, R84W, Sections 13 and 14 were projected to be disturbed by the Pit 3 mine plan. The permanent loss of the AVF area was addressed in the Reclamation Hydrology section of the Reclamation Plan.

Welch No. 1 North Mine (SDD, Permit No. 497-T3). There was a pre-application determination that an AVF significant to farming was present within and adjacent to the historic permit boundary. Addendum 2.11-A contains the WDEQ/LQD Administrator's June 17, 1985, pre-application determination. The associated Figure 2.11-A shows the "AVF Significant to Farming as Determined on 5-25-85." The permit boundary subsequently was reduced, resulting in the majority of the AVF residing adjacent to and outside the T3 permit area boundary.

The T3 permit has no approved Mine Plan. The Reclamation Plan details permanent reclamation or stabilization of the approximately 10 acres of surface disturbance that occurred outside of the AVF area. None of the reclamation activities have the potential to detrimentally affect the AVF within or adjacent to the permit area boundary.

LBA Tracts. There are no recently leased or pending LBAs in the Wyoming portion of Subregion 4 (BLM 2012a).