2.2 Soils and Alluvial Valley Floors

2.2.1 Study Area

The cumulative effects study area for soils and AVFs includes the following subwatersheds in portions of Sheridan, Johnson, Campbell, and Converse counties: Upper Powder River, Little Powder River, Upper Belle Fourche River, Upper Cheyenne River, Antelope Creek, and Dry Fork Cheyenne River (**Figure 1-1**). It includes portions of the area administered by the BLM Buffalo and Casper field offices and a portion of the TBNG, which is administered by the FS (**Figure 1-2**).

2.2.2 Cumulative Impacts

2.2.2.1 General Impacts

Soils

As described in Section 2.2.3 of the Task 1D Report of the PRB Coal Review, Current Environmental Conditions (ENRS 2005b), soils information for the study area is available from published and ongoing soil surveys conducted predominantly at a county level by the Natural Resources Conservation Service. Detailed soils information from project-specific (e.g., coal mines and other industrial activities) state and federal permit applications, 1:24,000 scale soil survey maps, general soils maps from the Wyoming STATSGO, and SSURGO databases provide further documentation of soil resources within the study area. The occurrence and extent of STATSGO soil mapping units within the six study area subwatersheds are identified in **Table 2.2-1**. Additional information for these mapping units is presented in the Task 1D report.

Cumulative impacts to soils as a result of RFD activities in the study area primarily would result from increased vehicle traffic, vegetation removal, soil salvage and redistribution (including stripping, stockpiling, and redistribution), discharge of CBNG produced groundwater, and construction and maintenance of project-specific components (e.g., roads and rights-of-way, well pads, industrial sites, and associated ancillary facilities). In general, soil disturbance and handling from these activities would generate both long-term and short-term impacts to soil resources through accelerated wind or water erosion, other declining soil quality factors, compaction, or the essentially permanent removal of soil resources at industrial sites.

Impact minimization approaches, best management practices, and restrictions on activities as defined through project-specific NEPA assessments and permitting requirements would reduce the level of RFD-related cumulative impacts to soil resources and AVFs in the study area. There are regulatory requirements from state and federal permitting agencies (e.g., WDEQ, BLM, Federal Energy Regulatory Commission, U.S. Army Corps of Engineers [USACE]) that include provisions for minimizing impacts to soils through erosion control practices, soil salvage and replacement, revegetation, and monitored stabilization practices. For example, measures that either are routinely required or can be required, if necessary, to reduce soil erosion during surface coal mining operations include: salvaging of soils suitable to support plant growth and stockpiling it or placing it directly on recontoured areas; protecting soil stockpiles from disturbance and erosional influences; interim seeding of topsoil stockpiles; watering of active work areas, inactive areas, and problem

areas; watering and/or using chemical dust suppression on haul roads and exposed soils; using sediment control structures, as needed, to trap eroded soil; promptly revegetating exposed soils; and using mulching, cover crops, or other approved measures to control erosion on reclaimed lands prior to seeding with a final seed mix. Disturbances to AVFs and resources that may occur in similar settings (wetlands and waters of the U.S.) are highly regulated by WDEQ and USACE, respectively. Compliance with such regulatory provisions and implementation of suitable management and control practices would minimize cumulative impacts to soil resources and AVFs over the short and long terms.

Table 2.2-1
Soil Occurrence and Extent within Study Area Subwatersheds
(acres)

Mapping Unit	Antelope Creek	Dry Fork Cheyenne River	Little Powder River	Upper Belle Forche River	Upper Cheyenne River	Upper Powder River
WY002	--	--	10,006	--	--	--
WY004	--	--	--	21,366	15,211	--
WY042	--	--	10,169	--	--	--
WY043	--	--	3,770	--	--	--
WY044	--	--	11,547	--	--	--
WY045	--	--	39,410	--	--	--
WY046	--	--	6,118	--	--	--
WY047	--	--	32,193	--	--	--
WY048	--	--	--	--	--	84,524
WY049	--	--	--	--	--	52,463
WY050	--	--	227,789	--	--	529,809
WY051	--	--	--	--	--	28,272
WY053	--	--	176,512	52,432	--	--
WY081	--	--	--	--	--	160
WY082	148	--	--	--	--	437,200
WY086	--	--	--	--	--	7,552
WY114	43	--	--	--	715	--
WY115	--	--	--	2,378	14,341	--
WY124	--	--	57,061	--	--	43,339
WY125	8,920	--	54,008	--	--	126,708
WY126	42,521	--	86,451	240,086	--	10,997
WY127	--	--	150,459	134,459	39,254	--
WY128	--	--	--	17,331	--	231,834
WY129	--	--	--	67,747	103,641	--
WY130	138,542	--	--	309,064	7,503	42,780
WY203	7,605	11,837	--	--	--	--
WY204	--	69,192	--	--	--	--
WY205	--	3,937	--	--	--	--
WY206	68,850	15,647	--	--	26,139	--
WY207	166,674	36,288	--	--	--	--
WY208	60,143	10,033	--	--	--	259
WY209	87,852	90,559	--	--	--	6,121
WY210	21,760	36,298	--	--	--	--
WY211	48,081	35,526	--	--	--	--
WY315	9,159	--	--	--	--	1,503

Note: Based on GIS analysis of the mapped soils layer prepared for the PRB Oil and Gas Final EIS (BLM 2003).

Accelerated Wind Erosion. As indicated in Appendix A of the Task 1D Report of the PRB Coal Review, Current Environmental Conditions (ENSR 2005b), severe wind erosion hazards are associated with STATSGO mapping units WY126 (Hiland-Vonalee-Maysdorf), WY203 (Clarkelen-Draknab-Haverdad), WY207 (Hiland-Bowbac-Tassel), WY209 (Hiland-Shingle-Tassel), and WY211 (Shingle-Tassel-Rock Outcrop). Related impacts would include the loss of topsoil resources. Accelerated wind erosion would occur as soil is denuded and soil structure is degraded during vegetation clearing and soil handling on these mapping units. Impacts would be particularly likely on windward slopes and where relatively extensive areas of these soils are disturbed. The five STATSGO soil associations identified as most susceptible to wind erosion are located primarily in the southeastern portion of the cumulative effects study area. They occupy approximately 56 percent of the Dry Fork Cheyenne River subwatershed, 47 percent of the Antelope Creek subwatershed, and 28 percent of the Upper Belle Fourche subwatershed. In addition, soil mapping unit WY 126 (Hiland-Vonalle-Maysdorf) occupies 10 percent of the Little Powder River subwatershed.

Impacts from accelerated wind erosion typically would be controlled by dust abatement practices (including water and/or tackifier applications); minimizing soil handling and the extent of bare ground; and the use of suitable cover crops, mulches, and revegetation species during concurrent and final reclamation.

Accelerated Water Erosion. Severe water erosion hazards, as indicated in Appendix A of Task 1D Report of the PRB Coal Review, Current Environmental Conditions (ENRS 2005b), are associated with STATSGO mapping units WY050 (Shingle-Taluce-Kishona), WY053 (Shingle-Cushman-Taluce), WY206 (Wibaux-Rock Outcrop-Shingle), WY208 (Shingle-Samday-Hiland), WY209 (Hiland-Shingle-Tassel), WY210 (Ulm-Renohill-Shingle), and WY211 (Shingle-Tassel-Rock Outcrop). In all of these cases, the hazard is associated with the Shingle soil component of the mapping unit. The Shingle soil is poorly developed, less than 20 inches deep over interbedded shale and sandstone, and typically has a clay loam texture throughout. Slopes can be steep for this soil component, ranging up to 60 percent, although more typically the slopes range from approximately 3 to 45 percent.

In a manner similar to that described for wind erosion, accelerated water erosion would occur as soil is denuded and soil structure is degraded during vegetation clearing, soil handling, and stockpiling of these materials. Sheet, rill, and gully erosion would occur on disturbed areas and nearby sites, with the type and severity of erosion depending on the slope steepness and length, soil texture and structure, organic matter content, plant cover and root density, and erosion control practices. Related impacts would include the loss of topsoil and subsoil resources and sediment deposition in downslope positions.

Potential impacts from accelerated water erosion would be most severe on moderately-coarse to moderately-fine textured soils that occur on steep slopes or on gentler but longer, unbroken slopes. The seven STATSGO soil associations identified as most susceptible to water erosion are not concentrated in any particular region of the cumulative effects study area. They occupy approximately 61 percent of the Dry Fork Cheyenne River subwatershed, approximately 47 percent of the Little Powder River subwatershed, 43 percent of the Antelope Creek subwatershed, and 34 percent of the Upper Powder River subwatershed. In addition, soil mapping unit WY 206 (Wibaux-Rock Outcrop-Shingle) occupies approximately 13 percent of the Upper Cheyenne River subwatershed.

Water discharged as a result of CBNG development would augment flows in drainages where releases are made near or directly to channels. In the case of direct discharges to channels, which are expected to account for between 35 and 55 percent of all CBNG water discharges, local channel bed degradation may occur due to the additional flow. In some cases, downcutting may lead to bank caving as well as gullying on uplands. Additional channel geometry changes may occur downstream due to bed aggradation from sediment deposition. However, due to high conveyance losses as discussed in the Task 1B Report for the PRB Coal Review, Current Water Resources Conditions (ENSR 2005d), the areal extent of potential down channel impacts would be minor.

Impacts from accelerated water erosion typically would be controlled by minimizing soil handling and the extent of bare ground; controlling the length and degree of recontoured slopes; temporary runoff controls such as silt fencing and hay bales; long-term drainage and runoff controls such as ditches and retention ponds; and the use of suitable cover crops, mulches, and revegetation species during concurrent and final reclamation. Control practices, including management of CBNG produced waters, would be determined on a project-specific basis during permitting.

In summary, based on STATSGO soil maps, the Dry Fork Cheyenne River and the Antelope Creek subwatersheds are the most severely susceptible to potential impacts from an overall combination of accelerated wind and water erosion. However, these areas are comparatively small (less than 1.0 million acres total) in relation to the cumulative effects study area. In addition, the Upper Belle Fourche subwatershed has a significant portion of land area that is severely susceptible to wind erosion. The Upper Powder River and Little Powder River subwatersheds have significant portions that are severely susceptible to water erosion. These last three subwatersheds are comparatively large (approximately 3.3 million acres) in relation to the cumulative effects study area, and thus, the actual acreage extent of accelerated erosion impacts may be greater in these areas.

Other Soil Quality Considerations. Additional cumulative impacts to soil resources would result from disturbance or modification of inherent soil characteristics such as salinity and alkalinity, microbial populations, organic matter and fertility, and soil texture and structure. The latter two characteristics particularly influence water infiltration, permeability, and aeration. Impacts to soil quality would result from increased root zone salinity or alkalinity from mixing of soil layers during salvage and redistribution; compaction or other disturbance to soil structure; and reductions in microbial populations, organic matter, and fertility from long-term soil stockpiling. In some cases (notably on Shingle soils), slope, depth to rock, and the presence of rock fragments limit the overall potential for reclamation use. In turn, these soil quality impacts may create impacts on vegetation establishment, crop growth and rangeland productivity, and surface water quality.

The control practices that typically mitigate such soil quality impacts generally include suitable soil salvage, stockpiling and redistribution practices, timely implementation of reclamation activities, and suitable seedbed preparation and amendment practices.

As indicated in Appendix E of the Task 2 Report for the PRB Coal Review, Past and Present and Reasonably Foreseeable Development Activities (ENSR 2005c), a variety of CBNG water disposal methods may be employed. As stated in the Task 1B Report, Current Water Resources Conditions (ENSR 2005d), Section 3.5.3 (CBNG Water Discharge), the major water quality issues pertaining to CBNG water discharges are sodium adsorption ratio (SAR) and total dissolved solids (TDS) which

generally may be indicated through field measurements of electrical conductivity (EC). Since these water quality constituents may occur at high levels, disposal of groundwater produced during CBNG recovery may generate impacts on soil resources. The potential impacts to soils would depend on the water treatment method (if any) and the nature of the disposal method.

Per Appendix E of the Task 2 Report, land application is anticipated to comprise approximately 5 percent of the CBNG water disposal in the Upper Powder River subwatershed, approximately 15 percent of the disposal in the Dry Fork Cheyenne River subwatershed, and approximately 10 percent of the disposal in the Little Powder River subwatershed. Impoundment disposal (via infiltration or containment and evaporation) is anticipated to comprise approximately 40 to 45 percent of the CBNG water disposal in these subwatersheds, as well as in the Antelope Creek and Upper Belle Fourche subwatersheds. Other disposal methods, including discharges to surface drainages, would account for approximately 45 to 55 percent of the CBNG water production in most of the subwatersheds (ENSR 2005d).

For agricultural uses, the Wyoming water quality standard for SAR is 8.0 (WDEQ 2005). The pH standard for agricultural water use is 4.5 to 9.0 standard units, and the TDS concentration is 2,000 milligrams per liter (mg/L). Depending on soil texture, chemistry, water availability, and plant adaptation, the growth of plants typically is severely restricted at soil SAR values of approximately 12 or more. As indicated in the Task 1B Report, Figure 3.5-1, the agricultural water quality standard for SAR typically is exceeded in Wyodak-Anderson coal zone waters produced in the Little Powder River subwatershed (mean SAR of 11.1), the Upper Belle Fourche subwatershed (mean SAR of 8.2), and the Upper Powder River subwatershed (mean SAR of 19.5). Land applications of CBNG water in the Upper Powder River and Little Powder River subwatersheds (estimated at 5 and 10 percent of CBNG water production, respectively) could reduce plant productivity by increasing soil alkalinity on areas where such applications are conducted. Such impacts would be long term and difficult to mitigate.

For agricultural uses, the Wyoming water quality standard for TDS is 2,000 mg/L (WDEQ 2005). EC, while not equivalent to TDS, may be used as a general TDS indicator and typically can be related to TDS through a highly-correlated statistical line of best fit. In water quality assessments, EC typically is measured in micromhos or microSiemens per centimeter at 25 degrees Centigrade (ºC). In addition, EC commonly is used as a salinity measure for soils and agricultural assessments. In such investigations, the common units of measure are millimhos per centimeter (mmhos/cm) (or deciSiemens per meter) at 25º C.

As a general working set of indicators, salinity effects on crop yields are mostly negligible at EC values of 0 to 2 mmhos/cm, and between 2 and 4 mmhos/cm, yields of very sensitive crops may be restricted. At EC of 4 to 8 mmhos/cm, yields of many crops are restricted, and with EC between 8 and 16 mmhos/cm, only tolerant crops yield satisfactorily. Above EC values of 16 mmhos/cm, only a very few tolerant crops yield satisfactorily (Salinity Laboratory Staff 1954). These classes are only general indicators; the actual growth and establishment of plants or crops under different salinity levels also varies with soil waterholding capacity, the actual amount of water supplied, plant adaptation (e.g., native range vegetation versus wheat) and other factors.

Land applications of CBNG water in the Upper Powder River and Little Powder River subwatersheds (estimated at 5 and 10 percent of CBNG water production, respectively), could reduce plant productivity by increasing soil salinity on areas where such applications are conducted.

Such impacts may be long term or costly to mitigate. As indicated in the Task 1B Report, Figure 3.5-1, Wyodak-Anderson coal zone waters typically produced EC values approaching or exceeding 1,000 micromhos per centimeter (µmhos/cm) (1 mmhos/cm) in the Little Powder River subwatershed (mean EC of 1,271 µmhos/cm), the Upper Belle Fourche subwatershed (mean EC of 970 µmhos/cm), and the Upper Powder River subwatershed (mean EC of 2,163 µmhos/cm). Per the information in Appendix E of the Task 2 Report, land applications of CBNG water are not anticipated in the Upper Belle Fourche River subwatershed (ENSR 2005c).

The occurrence of impacts and their potential severity would depend on a number of factors, including the number of discharges to a particular area as well as other soil, plant, and meteorological factors. Concentration of salts in the root zone may occur over time with repeated land applications, as a result of storage in the soil, water uptake by plants, and capillary rise. These interactions are complex. For example, repeated land applications of slightly saline and/or alkaline CBNG discharges to soils with restricted drainage may rapidly build up salts in the root zone. In contrast, more limited applications of severely saline and/or alkaline CBNG water may have much less impact if they are dispersed over a large, well-drained area or conducted during runoff events. Although the subwatersheds mentioned above may be the most susceptible to soil impacts from CNBG water discharges by land application, impacts may also occur on other areas depending on the management and timing of specific applications themselves. The specific approaches to CBNG water discharges, the resource conditions and locations in which they occur, the timing of discharges, and discharge permit stipulations from regulatory and land management agencies would determine the extent and degree of potential impacts.

Other CBNG water disposal methods may generate impacts on soils as well. Impoundments, whether for containment or infiltration, would disturb soils where they are built. In addition, soil liners or underlying soil materials may receive repeated discharges. Over time these materials would become increasingly saline and/or alkaline. Maintenance or closure of the facility may require removal and disposal of such materials in accordance with applicable regulations and/or agency guidelines.

Untreated discharges of CBNG waters to receiving streams is regulated in various PRB subwatersheds by WDEQ and agreements with the state of Montana. It is possible that soils in lower geomorphic positions (such as alluvial terraces) may receive additional inputs of salinity and/or alkalinity as a result of discharges during high flows. If they occur, the extent and degree of these impacts would vary according to other factors as discussed above.

Alluvial Valley Floors

In the semi-arid West, the soils, topography, and hydrologic capabilities of AVFs provide the conditions for valuable agricultural land uses and wildlife habitats. This prompted Congress to protect these areas with the passage of Surface Mine Control and Reclamation Act (SMCRA) in 1977. In the PRB, agricultural land use is primarily cattle or sheep ranching with some grain (typically wheat) being grown commercially (Rusmore et al. 1985). For most ranching operations, herd size and related economic conditions usually are limited by the land base or cash available to provide hay for winter feed. In the northern part of the study area, irrigated or subirrigated valley bottomlands produce almost all of this hay. (South of Gillette, upland pastures often are clear throughout the winter.) AVF also provide generally better stock water, shelter from adverse weather,

and the most suitable locations for calving, lambing, and feeding (Rusmore et al. 1985). In addition, AVFs provide habitat diversity, food, cover, and water for a variety of wildlife species.

As described in the Task 1D Report for the PRB Coal Review, Current Environmental Conditions (ENSR 2005b), AVF regulatory determinations are made on a site-specific basis for coal mining activities. These detailed determinations consider a number of geomorphic, hydrologic, soil, and land use factors. Although soil surveys may serve as broad indicators of potential AVF occurrence, and reconnaissance investigations have been conducted to assist in identifying AVFs (Rusmore, et. al. 1985), regulatory determinations of AVF occurrence and location are part of coal mine permitting activities. As such, the locations and extent of AVFs have not been determined for the study area overall. However, AVFs do occur within the study area as has been documented in existing coal mining permits and described in the Task 1D report. Discussion of the potential occurrence of AVFs in the study area is based on the regional reconnaissance conducted in the early 1980s (Rusmore et al. 1985). However, actual AVF occurrence has not been verified except in limited areas of more detailed permit investigations. Potential cumulative impacts are qualitatively discussed on the basis of these permit investigations and the reconnaissance study.

Cumulative impacts to AVFs that are deemed significant to agriculture would be restricted by SMCRA rules and regulations as administered by WDEQ and the Office of Surface Mining. The determination of significance to agriculture is made by WDEQ/Land Quality Division (LQD), and it is based on specific calculations related to the production of crops or forage on the AVF and the size of the existing agricultural operations on the land of which the AVF is a part. Impacts generally are not permitted if the AVF is determined to be significant to agriculture. 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 date of SMCRA, the AVF can be disturbed during mining but must be restored as part of the reclamation process. As a result, cumulative impacts to AVFs that are deemed not significant to agriculture would be minimized by reclamation requirements, including restoration of the hydrologic balance.

Although the formal AVF definition and related regulatory programs pertain specifically to coal mining, impacts on AVF resources could result from other development-related activities in the study area. These activities may affect irrigated or subirrigated agricultural lands, jurisdictional waters of the U.S. (including wetlands), or floodplains. Minimization and/or mitigation of potential impacts to specific resources occurring in or along streams and floodplains would be required by the federal or state authorizing agencies (e.g., BLM, FS, USACE, WDEQ) at the time of permitting.

2.2.2.2 Year 2010 – Lower Production Scenario

Soils

Under this scenario, approximately 119,224 additional acres of soil in the study area would be disturbed as a result of RFD activities from 2004 through 2010, resulting in approximately 339,912 total cumulative acres of soil disturbances (or disturbance to approximately 7.6 percent of the soils in the study area). Of this total, it is projected that by 2010 approximately 205,113 acres would be permanently reclaimed. In the Dry Fork Cheyenne River and Upper Powder River subwatersheds (**Figure 1-1**), the permanently reclaimed acreage would be substantially greater than the unreclaimed acreage, and cumulative impacts to soil resources are expected to be less than in other subwatersheds. In the Little Powder River and Upper Belle Fourche subwatersheds, the cumulative reclaimed area would be roughly equal to the cumulative unreclaimed areas. In the

remaining subwatersheds (Antelope Creek and the Upper Cheyenne River), the unreclaimed acreage is projected to be greater than the permanently reclaimed acreage, with correspondingly greater impacts expected. In all subwatersheds, reclamation and stabilization activities are expected to minimize the severity and extent of disturbance-related impacts to soils and AVFs until successful permanent reclamation occurs.

The Antelope Creek subwatershed is dominated by STATSGO mapping units WY130 (Renohill-Bidman-Ulm) and WY207 (Hiland-Bowbac-Tassel). These units are subject to impacts from compaction and severe wind erosion hazards, respectively. The WY130 unit consists of moderately deep and deep clayey soils. The WY207 units consist of shallow to deep loamy soils. Prime farmlands may occur on the Hiland soil, and the Tassel soil has poor reclamation potential due to depth to rock, rock fragments, and slopes. All the soils have calcium carbonate accumulations at depth, which may create soil quality impacts from salinity in some locations. Additional mapping units that are extensive in the subwatershed include WY206 (Wibaux-Rock Outcrop- Shingle), WY208 (Shingle-Samday-Hiland), and WY209 (Hiland-Shingle-Tassel). Combined, these five mapping units occupy approximately 79 percent of the subwatershed area. Shingle and Tassel soils are shallow and occur on slopes. The Wibaux soil contains high volumes of hard rock fragments. These three soils have poor reclamation potential, which may create cumulative impacts in RFD-related disturbance areas due to limited availability of suitable soil materials for reclamation.

Major drainages in the Antelope Creek subwatershed are occupied by the WY203 (Clarkelen-Draknab-Haverdad) mapping unit. These soils are formed in calcareous sandy to moderately fine textured unconsolidated streamlain alluvium, and AVFs may occur along valleys or drainages with these or other soils. In some areas, soil salinity may be a concern relative to reclamation of disturbance areas. The WY203 mapping unit occupies approximately 1.2 percent of the subwatershed.

The Dry Fork Cheyenne River subwatershed is dominated by the WY204 (Hiland-Ustic Torriorthents-Bowbac) and WY209 (Hiland-Shingle-Tassel) STATSGO mapping units. These are shallow to deep loamy soils. The Shingle and Tassel soils are shallow over bedrock, may occur on steep slopes, and have limited potential for reclamation uses. Additional soil mapping units that are extensive in the subwatershed include WY207 (Hiland-Bowbac-Tassel), WY210 (Ulm-Renohill-Shingle), and WY211 (Shingle-Tassel-Rock Outcrop). Combined, these five mapping units occupy approximately 87 percent of the subwatershed. Hiland soils are deep, loamy soils with few limitations for reclamation uses, but are subject to accelerated water erosion. Bowbac, Ulm, and Renohill soils are moderately deep and deep, as well as clayey. They are subject to soil quality impacts from compaction. Bowbac and Tassel soils have severe wind erosion hazards, and the Shingle soil has severe water erosion hazard. RFD-related disturbance may result in cumulative impacts from accelerated erosion and limited availability of suitable soil materials for reclamation.

Major drainages in the Dry Fork Cheyenne River subwatershed are occupied by the WY203 (Clarkelen-Draknab-Haverdad) mapping unit, as described previously for the Antelope Creek subwatershed. The mapping unit occupies approximately 3.8 percent of this subwatershed.

The Little Powder River subwatershed is dominated by STATSGO mapping units WY050 (Shingle-Taluce-Kishona), WY053 (Shingle-Cushman-Taluce), WY127 (Kishona-Shingle-Theedle), and WY126 (Hiland-Vonalee-Maysdorf). In combination, these units occupy approximately

74 percent of the subwatershed. All of these soils have medium to moderately fine textures, and range from shallow to deep. Taluce and Shingle soils are loamy and shallow over sandstone and interbedded sedimentary rocks, respectively. Both are poorly suited to reclamation uses, and are extensive in the subwatershed. This may affect soil material availability and overall reclamation success in the region. In addition, accelerated water erosion may occur on areas occupied by these soils due to their geographic position on ridges and hills. Kishona, Maysdorf, Vonalee, and Hiland soils are deep with loamy textures. Cushman soils also are loamy, but are moderately deep over shale. These soils have few limitations for use as reclamation materials; however, Hiland and Vonalee soils have severe water erosion hazards, which may generate accelerated water erosion in RFD-related disturbance areas in this subwatershed.

Major drainages in the Little Powder River subwatershed are dominated by STATSGO mapping unit WY044 (Havre-Hanly-Glendive). This unit occupies approximately 1.3 percent of the subwatershed area. These soils are formed in calcareous sandy to moderately fine textured unconsolidated streamlain alluvium, and AVFs may occur along valleys or drainages with these or other soils. In some areas, cumulative impacts to soil quality as a result of soil salinity may be a concern relative to reclamation of disturbance areas.

The Upper Belle Fourche River subwatershed is expected to undergo the largest cumulative extent of disturbance under this scenario. The area is dominated by the WY126 (Hiland-Vonalee-Maysdorf), WY127 (Kishona-Shingle-Theedle), and WY130 (Renohill-Bidman-Ulm) mapping units. Combined, these STATSGO mapping units occupy approximately 81 percent of the subwatershed. Cumulative impacts from accelerated wind erosion are anticipated on Hiland and Vonalee soils in this subwatershed, as are soil quality impacts from compaction on the WY130 unit. However, these units generally are well suited to soil salvage and reconstruction with best management practices and compliance with regulatory programs. Major drainages in the Upper Belle Fourche River subwatershed are dominated by STATSGO mapping unit WY004 (Haverson-Glenberg-Bone). This unit occupies approximately 2.5 percent of the subwatershed area, and formed in calcareous unconsolidated streamlain alluvium. Cumulative impacts to soil quality as a result of soil salinity may be a concern relative to reclamation of disturbance areas.

The Upper Cheyenne River subwatershed is dominated by the WY127 (Kishona-Shingle-Theedle), WY129 (Bidman-Parmaleed-Renohill) and WY206 (Wibaux-Rock Outcrop-Shingle) mapping units. Combined, these STATSGO mapping units occupy approximately 82 percent of the subwatershed. Cumulative soil quality impacts from compaction on the WY129 unit may be anticipated as a result of the clayey nature of these soils. On steeper slopes, accelerated water erosion also may create cumulative impacts. In addition, the WY126 unit is poorly suited to reclamation uses due to shallow depth to rock, rock outcrops, and slope. This may make permanent reclamation of RFD-related disturbance areas more difficult in some areas.

Major drainages in the Upper Cheyenne River subwatershed are dominated by STATSGO mapping unit WY004 (Haverson-Glenberg-Bone). This unit occupies approximately 2.5 percent of the subwatershed area, and its soils formed in calcareous unconsolidated streamlain alluvium. Cumulative impacts to soil quality as a result of soil salinity may be a concern relative to reclamation of disturbance areas.

The Upper Powder River subwatershed is dominated by STATSGO mapping units WY050 (Shingle-Taluce-Kishona), WY082 (Renohill-Shingle-Parmaleed) and WY128 (Renohill-Cushman-

Cambria). Combined, these units occupy approximately 75 percent of the subwatershed area. Accelerated water erosion and soil quality declines from compaction are likely to be RFD disturbance-related impacts within this subwatershed, due to the extent of Shingle soils and clayey materials from the Renohill and Parmaleed soils.

Major drainages in the Upper Powder River subwatershed are dominated by STATSGO mapping unit WY048 (Riverwash-Haverdad-Clarkelen). This unit occupies approximately 5.3 percent of the subwatershed area, and its soils and land types formed in calcareous unconsolidated streamlain alluvium. Cumulative impacts to soil quality as a result of soil salinity may be a concern relative to reclamation of disturbance areas.

Of the approximately 339,912 total cumulative acres of soil disturbance under this scenario, approximately 98,662 acres would be associated with coal mining activities. By year 2010, approximately 44,938 acres (46 percent) of the coal mine-related disturbance would be permanently reclaimed. Of the remaining 53,724 acres of coal mining-related disturbance, it is estimated that approximately 26,338 acres would be unavailable for reclamation due to the presence of long-term facilities which would be reclaimed near the end of each mine's life. Reclamation of the remaining 27,386 acres of disturbance would proceed concurrently with mining operations.

Of the types of RFD projects in the study area, coal mining activities would create the most concentrated cumulative impacts to soils. This is due to the large acreages involved and the relatively contiguous, block nature of the anticipated mining activities. These factors would encourage widespread accelerated wind and water erosion, and extensive soil handling would reduce soil quality through compaction and corresponding loss of permeability to water and air; declining microbial populations, fertility, and organic matter; potential mixing of saline and/or alkaline soil zones into seedbeds; and the limited availability of suitable soil resources for reclamation uses in some areas. Potential measures that would be implemented to minimize these impacts are discussed in Section 2.2.2.1.

Alluvial Valley Floors

Soils occurring in major drainages are described above for each subwatershed in the study area. The extent of cumulative impacts to AVFs in the study area as a result of coal mining activities cannot be quantified, due to the site-specific nature of AVF determinations and the current lack of information relative to the actual disturbance area footprint that would be required for mining of future reserves. However, their potential extent is described in general terms below. Past site-specific determinations are described in the Task 1D Report for the PRB Coal Review, Current Environmental Conditions (ENSR 2005a).

Earlier intensive mine permitting studies indicate that within the Antelope Creek subwatershed, AVFs are located along Antelope Creek and Horse Creek in relation to the Antelope Mine, and an AVF existed within the original North Antelope permit area. Future activities at North Antelope/Rochelle may extend into the Upper Cheyenne River subwatershed. The regional reconnaissance indicates that the potential for AVF exists within the Antelope Creek subwatershed in narrow, sinuous delineations mainly along Antelope Creek, Sand Creek, the South Fork of Bear Creek, Bates Creek, Spring Creek, Horse Creek, and Porcupine Creek. Delineations range from a few tens of feet up to approximately 0.6 mile wide. These areas are thought to be largely

subirrigated, with potential or actual surface irrigation primarily located along the South Fork of Bear Creek, Bates Creek, Spring Creek, and Porcupine Creek in the northern part of the subwatershed (Rusmore et al. 1985).

In the Dry Fork Cheyenne River subwatershed, no AVFs were identified through site-specific determinations, and no coal mining is projected to occur within the area. Reconnaissance indicates that subirrigated AVF potential exists along the Dry Fork itself and along scattered tributaries. These delineations of potential AVF occurrence follow the relatively narrow, meandering course of the streams, in widths varying from a few tens of feet to approximately 0.4 mile. Off-channel areas that are surface irrigated, or have the potential to be, are located along the downstream third of the Dry Fork (Rusmore et al. 1985). Although no coal mining is projected to occur in this subwatershed, potential impacts to resources associated with alluvial valley settings could occur from other RFD activities as discussed in Section 2.2.2.1.

In the Little Powder River subwatershed, AVFs were declared in permit areas for the Buckskin, Eagle Butte, and Rawhide mines and at the former Fort Union Mine. These were determined not to be significant to agriculture, or else have been “grandfathered” with respect to this criterion. More extensive reconnaissance information indicates that additional potential for AVFs occurs along the Little Powder River itself, as well as along Rawhide Creek, Horse Creek, and Wildcat Creek. Fairly narrow, meandering, subirrigated potential zones occur along the creeks and the upper river, whereas the Little Powder River below Rawhide Creek has existing or potential surface irrigation in alluvial zones 0.5 mile wide or more (Rusmore et al. 1985).

Within the Upper Belle Fourche River subwatershed, AVFs were determined to occur at the Wyodak, Belle Ayre, Caballo, Cordero-Rojo (Caballo Rojo and Cordero) mines. These AVFs occur mainly along Caballo Creek and Donkey Creek. In the future, the Wyodak Mine permit area may extend into the Little Powder River subwatershed. Reconnaissance investigations in the upper Belle Fourche area indicate that the potential for additional AVF determinations occurs in narrow zones along Caballo Creek and its primary tributaries (notably Tisdale Creek and Gold Mine Draw, Bone Pile Creek, Bluegate Creek, and Hoe Creek). In addition, the potential for AVFs is extensive along the Belle Fourche River and its tributaries, including Timber Creek and several others in the vicinity of Reno Junction. Most of the potential AVF zones in this subwatershed are surface irrigated or may be suited to it. Small areas are likely to be subirrigated (Rusmore et al. 1985). Potential AVFs occupy zones up to approximately 0.5 mile wide along the streams.

In the Upper Cheyenne River subwatershed, AVF declarations were made at the Black Thunder and Jacobs Ranch mines, primarily along Little Thunder Creek and its North Prong tributary. These areas were “grandfathered” due to the early dates of mining operations, and WDEQ recently removed the AVF declaration for the North Prong of Little Thunder Creek. Reconnaissance investigations indicate that AVFs may occur elsewhere along both of these streams, as well as along School Creek and Black Thunder Creek (Rusmore et al. 1985). These zones typically are narrow (less than 0.2 mile wide), sinuous, alluvial terrace systems that may be suited for surface irrigation.

Currently no site-specific AVF determinations have been made in the Upper Powder River subwatershed, and no coal mining is projected to occur within the area. However, widespread areas having the potential for positive AVF declarations exist in this subwatershed within the study area. (It should be noted that Clear Creek, Crazy Woman Creek, Salt Creek, and the upper forks of the

Powder River are not within the cumulative effects study area.) Extensive areas of potential AVFs are delineated along the Powder River in reconnaissance studies, in zones up to 1 mile wide. Many of these areas along the river are based on the existence of surface irrigation or suitability for it. Based on the reconnaissance, subirrigated zones also occur all along the river. The potential for subirrigated or surface irrigated AVFs also occurs along every major Powder River tributary and several smaller tributaries. Such streams include Bitter Creek, SA Creek, LX Bar Creek, Spotted Horse Creek, Wild Horse Creek and its prongs, Fortification Creek, Barber Creek, Dead Horse Creek, and others. Potential AVF delineations along these streams typically are 0.2 mile wide or less (Rusmore et al. 1985). Although no coal mining is projected to occur in this subwatershed, potential impacts to resources associated with alluvial valley settings could occur from other RFD activities as discussed in Section 2.2.2.1.

Although the actual occurrence of regulated AVFs has not been verified within these subwatersheds, it is likely that expanding mining activities under this scenario would encounter AVFs and related issues. Impacts on agriculture, soils, surface water and groundwater resources, and wildlife habitats would vary with the characteristics of the specific site and watershed locale, as well as with the type of disturbance. The actual extent of impacts cannot be determined at this time, since AVF determinations are site-specific. In addition to considerations at a specific project location, impacts may extend upstream and downstream from the disturbance.

In general, potential impacts on AVFs as a result of coal mining or nearby mining activities would include disturbance of supporting hydrologic regimes, physicochemical alteration of underlying geologic materials, impacts to soils (as described above), alteration of vegetation communities; and modification of existing or potential land uses. The application of best management practices for reclamation and stabilization of such disturbance, in addition to compliance with regulatory programs and project-specific permit provisions, would minimize or mitigate these cumulative impacts over both the short and long terms.

2.2.2.3 Year 2010 – Upper Production Scenario

Soils

Under this scenario, cumulative impacts to soil resources as a result of RFD activities in the study area would be similar to, but slightly more extensive than, those described under the 2010 – Lower Production Scenario, due to an approximately 3,786 additional acres of disturbance. This additional acreage would be related to increased coal production.

Alluvial Valley Floors

It is anticipated that the overall acreage of AVFs affected by coal mining and the related impacts would be similar to those described under the 2010 – Lower Production Scenario. This assumption is based on the 3,786 total additional acres of coal mine-related disturbance projected for this scenario, a portion of which may occur on AVFs.

2.2.2.4 Year 2015 – Lower Production Scenario

Soils

Under this scenario, 86,172 additional acres of soils would be disturbed as a result of RFD activities in the study area, 27 percent of which would be related to coal mining. As a result, cumulative impacts to soil resources would be similar in nature, but more extensive, than those described under the 2010 – Lower Production Scenario.

Alluvial Valley Floors

It is anticipated that the overall acreage of AVFs affected by RFD activities would be greater than under the 2010 – Lower Production Scenario. This assumption is based on the 18,574 total additional acres of coal mine-related disturbance projected for this scenario, a portion of which may occur on AVFs. Whether from coal mining or other RFD activities, the types of impacts to AVFs (or resources in similar alluvial settings) would be similar to those described in Section 2.2.2.1.

2.2.2.5 Year 2015 – Upper Production Scenario

Soils

Under this scenario, 93,480 additional acres of soils would be disturbed as a result of RFD activities in the study area, 29 percent of which would be related to coal mining. As a result, cumulative impacts to soil resources would be similar in nature, but more extensive, than those described under the 2010 – Lower Production Scenario.

Alluvial Valley Floors

It is anticipated that the overall acreage of AVFs affected by RFD activities would be greater than under the 2010 – Lower Production Scenario. This assumption is based on the 25,883 total additional acres of coal mine-related disturbance projected for this scenario, a portion of which may occur on AVFs. Whether from coal mining or other RFD activities, the types of impacts to AVFs (or resources in similar alluvial settings) would be similar to those described in Section 2.2.2.1.

2.2.2.6 Year 2020 – Lower Production Scenario

Soils

Under this scenario, 163,173 additional acres of soils would be disturbed as a result of RFD activities in the study area, 27 percent of which would be related to coal mining. As a result, cumulative impacts to soil resources would be similar in nature, but much more extensive, than those described under the 2010 – Lower Production Scenario.

Alluvial Valley Floors

It is anticipated that the overall acreage of AVFs affected by RFD activities would be greater than under the 2010 – Lower Production Scenario. This assumption is based on the 38,780 total additional acres of coal mine-related disturbance projected for this scenario, a portion of which may occur on AVFs. Whether from coal mining or other RFD activities, the types of impacts to AVFs (or resources in similar alluvial settings) would be similar to those described in Section 2.2.2.1.

2.2.2.7 Year 2020 – Upper Production Scenario

Soils

Under this scenario, 174,820 additional acres of soils would be disturbed as a result of RFD activities in the study area, 29 percent of which would be related to coal mining. As a result, cumulative impacts to soil resources would be similar in nature, but much more extensive, than those described under the 2010 – Lower Production Scenario.

Alluvial Valley Floors

It is anticipated that the overall acreage of AVFs affected by RFD activities would be greater than under the 2010 – Lower Production Scenario. This assumption is based on the 50,427 total additional acres of coal mine-related disturbance projected for this scenario, a portion of which may occur on AVFs. Whether from coal mining or other RFD activities, the types of impacts to AVFs (or resources in similar alluvial settings) would be similar to those described in Section 2.2.2.1.