1.0 INTRODUCTION

The Powder River Basin (PRB) of Wyoming is a major energy development area with diverse environmental values. The PRB is the largest coal-producing region in the United States (U.S.); PRB coal is used to generate electricity within and outside of the region. The PRB also has produced large amounts of oil and gas resources. Within the last decade, this region has experienced nationally significant development of natural gas from coal seams.

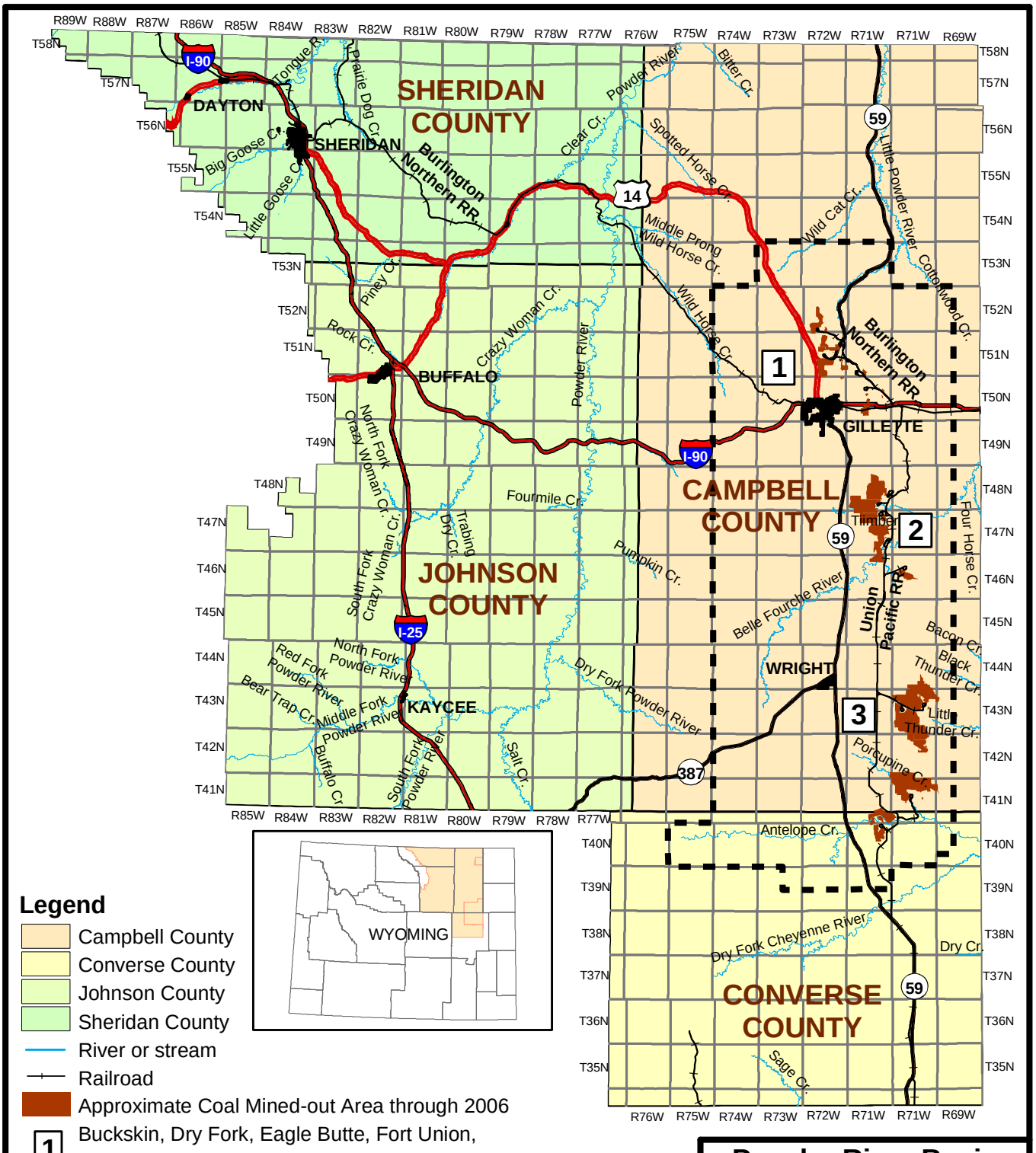
For the purpose of this study, the Wyoming PRB study area (**Figure 1-1**) comprises all of Campbell County, all of Sheridan and Johnson counties less the Bighorn National Forest lands to the west of the PRB, and the northern portion of Converse County. It includes all of the area administered by the Bureau of Land Management (BLM) Buffalo Field Office, a portion of the area administered by the BLM High Plains District Office, and a portion of the Thunder Basin National Grasslands, which is administered by the U.S. Forest Service (**Figure 1-2**). State and private lands also are included in the study area. For water resources, the cumulative effects study area encompasses the groundwater model domain (**Figure 1-1**), with emphasis placed on the overlap in the coal mine- and coal bed natural gas (CBNG)-related groundwater drawdown area.

During the 1970s and early 1980s, the PRB emerged as a major coal production region. Federal coal leasing was a high profile activity as over 90 percent of the PRB's coal is federally owned. Between 1974 and 1982, the BLM issued three and started a fourth separate regional coal environmental impact statement (EIS), all addressing federal coal leasing and development, as well as other regional development.

In 1982, the BLM temporarily halted further coal leasing. However, mining continued on existing leases. When leasing resumed in 1990, the existing mines were mature operations, and there was no need for regional leasing to open new mines. However, many of the mines were depleting their original reserves, so there was a need for maintenance leasing to provide reserves to enable existing mines to meet the expanding demand. The Powder River Regional Coal Team decertified the region, allowing BLM to use the lease by application (LBA) process to meet this need.

BLM is required to complete a National Environmental Policy Act (NEPA) analysis (EIS or environmental assessment [EA]) for each coal lease application as part of the leasing process. In the coal leasing EAs and EISs that have been prepared since decertification, cumulative impacts have been addressed in a separate section of the chapter that describes the expected environmental impacts of the proposed action. This approach was designated to highlight the distinction between site-specific and cumulative impacts.

In the mid-1990s, the BLM conducted a study called the PRB Coal Development Status Check (Status Check) (BLM 1996) to evaluate how actual development levels compared to the development levels predicted in the earlier regional EISs. At the time the Status Check was prepared, the actual levels of cumulative development generally were within the levels that had been predicted. BLM continued updating key portions of the Status Check and used the results in the cumulative impact section of the coal-leasing EAs and EISs. The Status Check update indicated that the actual levels of coal development and associated impacts began to approach the predicted

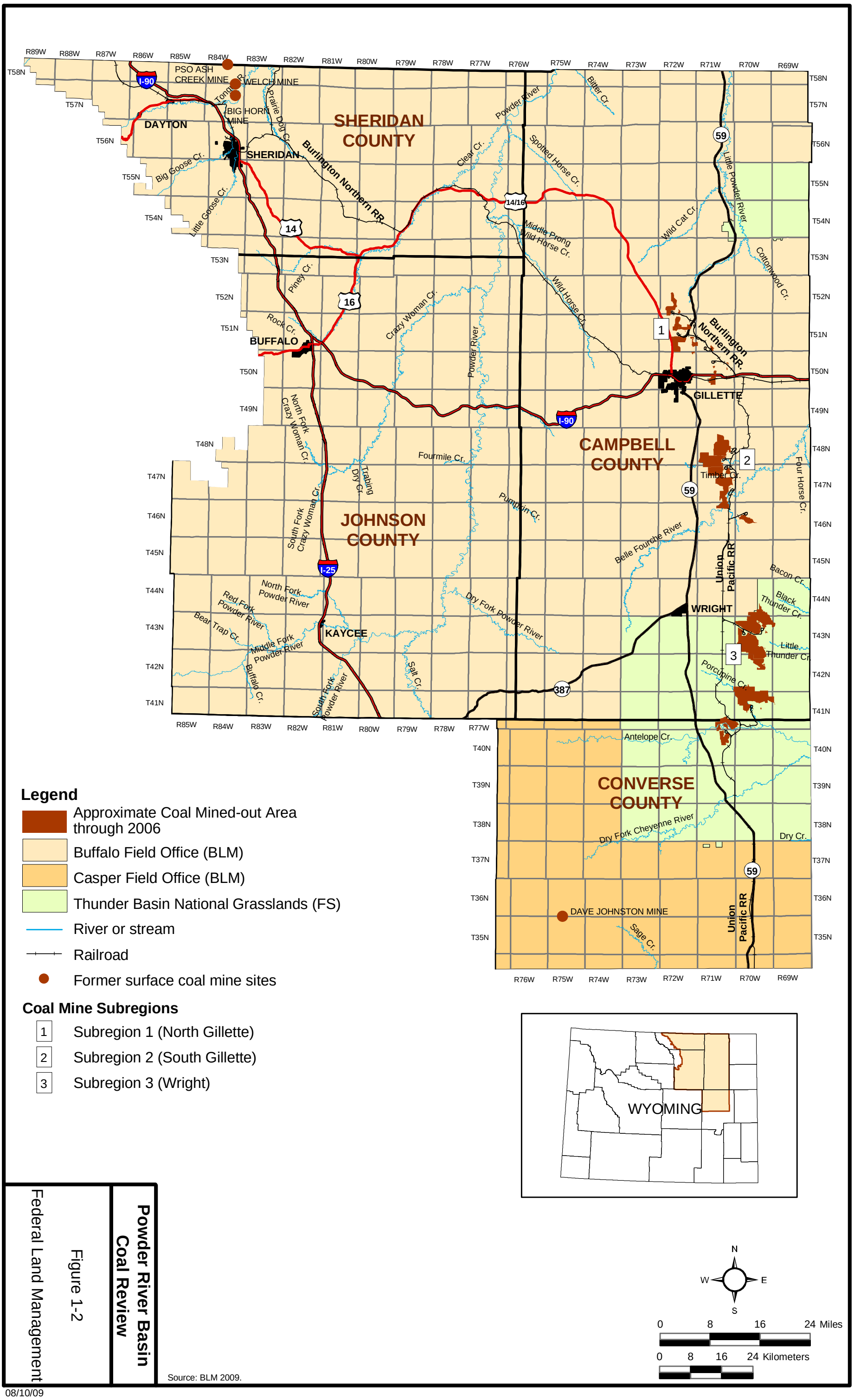


Powder River Basin Coal Review

Figure 1-1

Study Area

11/04/09



Source: BLM 2009.

Powder River Basin Coal Review

Figure 1-2

Federal Land Management

08/10/09

levels in the late 1990s. Around the same time, impacts related to oil and gas development began increasing due to development of CBNG in the PRB.

BLM prepared the Wyodak EIS (BLM 1999) and PRB Oil and Gas EIS (BLM 2003) to address the impacts of projected CBNG development in the Wyoming PRB. Modeling was used to quantify potential cumulative impacts to air and water resources in these two EISs. Surface coal mining operations in the PRB were included in the modeling analyses as reasonably foreseeable future, non-project sources of impacts. For these analyses, future levels of coal development were estimated using market demand projections. BLM used these cumulative impact analyses in the coal leasing EISs as well as in the CBNG EISs.

In early 2003, BLM completed a study of PRB coal demand through 2020 (Montgomery Watson Harza 2003). The study projected production to increase at a steady pace with current mines able to meet the demand as long as the existing mines continue to have access to additional coal reserves; therefore, the need for leasing using LBAs will continue into the foreseeable future. As part of processing these LBAs, BLM will need to maintain a current cumulative impact analysis. An initial step in that direction is this PRB Coal Review, which includes the identification of current conditions (Task 1 reports), identification of reasonably foreseeable development (RFD) actions and future coal production scenarios (Task 2 report), and predicted future cumulative impacts (Task 3 reports) in the PRB.

The Task 2 component of the PRB Coal Review defines the past and present development actions in the study area that have contributed to the current environmental and socioeconomic conditions in the PRB study area. This report also defines the projected RFD scenarios in the Wyoming and Montana PRB for years 2010, 2015, and 2020. For the Wyoming PRB, the past and present development and RFD scenarios include coal mine development as well as coal-related activities (i.e., railroads, coal-fired power plants, major transmission lines, and coal technology projects) and non-coal-related activities (i.e., other mines, CBNG, conventional oil and gas, major transportation pipelines, and key water storage reservoirs). Coal mine development and coal-related activities in the Montana PRB study area are included in this study to provide the basis for the analysis of cumulative air quality impacts. The past and present activities identified in this report are based on the most recent data available at the end of 2003 and provide the basis for the resource-specific descriptions of current conditions presented in the PRB Coal Review Task 1 reports.

The RFD scenarios presented in the Task 2 report provide the basis for the analysis of potential cumulative impacts in the Task 3 component of the study. The accuracy of any projected cumulative impact analysis is dependent on the adequacy and accuracy of information regarding potential future activities in the affected area. While it is impossible to identify all potential future activities over the next 15 years, it is possible and desirable to identify reasonably foreseeable future actions based on current industry announcements, agency plans, economic trends, and technological advances affecting major industry sectors. Information regarding potential new development constantly is changing; however, to facilitate development of the information in this study, the RFDs identified in the Task 2 report reflect information available through the end of 2004.

The past and present actions in the Task 2 report were identified based on information in existing NEPA documents on file with federal and state agencies and the Status Check (BLM 1996). The RFD scenarios in the Task 2 report were developed based on recent information that identifies proposed and anticipated development in the PRB, including NEPA documents; various other

technical reports and studies; federal, state, and local (county) agency management plans; and permit applications. The specific development scenarios and development activities identified in these sources were assessed as to their current status prior to inclusion in the RFD scenarios for the PRB Coal Review. In addition, potential additional projects were identified through interviews with agency and industry representatives, review of published news articles and trade publications, and discussions with community leaders.

The identified RFD activities subsequently were evaluated as to their probability for occurrence. Due to the lack of detailed information for many developments beyond the next few years, the degree of uncertainty associated with the predicted developments and trends increases as the timeframe extends further into the future.

For each of the past and present and RFD projects and activities, project-specific impact-causing parameters (e.g., disturbance acreage, emission levels, employment levels, etc.) have been compiled from the sources identified above. Where specific information was unavailable, assumptions were developed and included based on typical industry-specific standards, permit criteria for similar existing industries, and professional judgment. This information is summarized in the Task 2 report.

In order to account for the variables associated with future coal production, two detailed coal production scenarios (reflecting upper and lower production estimates) were projected for this study to bracket the most likely foreseeable regional coal production level and to provide a basis for quantification of related impact-causing parameters. These future production levels were derived from the analysis of historic production levels and current PRB coal market forecasts, public and private information sources, and input from individual PRB coal operators and are summarized in the Task 2 report.

This Task 3B report describes the modeled cumulative groundwater impacts associated with ongoing coal mine- and CBNG-related groundwater withdrawal and CBNG water discharge in the eastern PRB of Wyoming for the time periods of 2010, 2015, and 2020. The base years used for comparison of groundwater impacts were 2002 (the year used for calibration of the groundwater model for the eastern PRB) and 1990 (a time period before CBNG pumpage and before major expansion by the coal mines). The eastern PRB cumulative effects study area for water resources comprises the Coal Mine Groundwater Model (CMGM) domain as shown in **Figure 1-1**. The study area primarily includes the area encompassed by the coal mines extending from north of Gillette, Wyoming, to south of Wright, Wyoming, near Antelope Creek. Projected cumulative surface water impacts primarily include the impacts of CBNG production water discharge to ephemeral drainages and the surface disturbance and subsequent reclamation of drainages that result from coal mine expansion. The base year used for comparison of surface water quality impacts was 2003, as discussed in the surface water quality and channel stability report for the eastern PRB (Anderson Consulting Engineers [ACE] 2009) and summarized in this Task 3B report. This Task 3B report also includes a discussion of groundwater level recovery in the eastern PRB after the cessation of both CBNG development and coal mining, and the effect on groundwater flow paths associated with coal mine pit backfill and reclamation after the cessation of coal mining in the eastern PRB. For purposes of modeling groundwater recovery, it was assumed that CBNG development in the eastern PRB would cease by 2030 and surface coal mining would cease by 2050.

Coal mine and CBNG development scenarios are discussed in the Task 2 report (AECOM 2009b). For use in groundwater modeling, the estimation of future CBNG groundwater production was based on actual permitted pumping rates available from the Wyoming Oil and Gas Conservation Commission (WOGCC) for wells operating through 2004, and the scaling down of pumping rates over the 7-year life cycle of a pod of CBNG wells as estimated by the BLM (2007a). The location of CBNG wells through 2006 was based on data available from the WOGCC website and IHS Energy Services (IHS) database files (IHS 2007), with CBNG well locations from 2007 to 2020 based on estimates provided by the BLM (2007c). Therefore, pumping rates for CBNG wells beyond 2004 are approximate and based on the estimates of future CBNG development in the eastern PRB provided by the BLM (2007a) for the drainage basins (referred to as subwatersheds in this report) in the eastern PRB for the three time periods analyzed in this study. Appendix A presents the BLM report on future CBNG groundwater production in the eastern PRB (BLM 2007a); a summary of the report is presented in Section 2.3. Coal mine groundwater pumpage was developed from data provided by the coal mine operators and from data on projected locations of coal mine pits over time as provided by the BLM (2007b).

Surface water quality impacts for the target years of 2010, 2015, and 2020 were estimated using a linear mixing model developed by ACE (2009) and the projected water discharge volumes presented in the Task 2 report (AECOM 2009b). For CBNG discharge, the direct discharge to ephemeral drainages for each drainage basin was used as the guide for modeling water quality or estimating impacts to channel stability and channel properties. For the coal mines, most of the water produced was expected to be consumed, according to estimates provided by the mine operators and included in the Task 2 report. Where production of groundwater exceeded estimated consumption for the coal mines in any given drainage basin, it was assumed that the discharged water would go first to holding ponds and then to nearby ephemeral drainages in accordance with Wyoming Pollution Discharge Elimination System (WYPDES) permits, thereby minimizing the potential for degradation of water quality and impacts to channel stability.

Any estimation of water resource impacts in future years requires the use of assumptions. For CBNG development, the key assumptions were: 1) that CBNG development would proceed in the eastern PRB using methods that have been developed and used since 1995; 2) that most of the groundwater produced by CBNG wells would be discharged directly to ephemeral drainages through outfalls because the water quality has relatively low sodium absorption ratios (SAR) and electrical conductance (EC) values; and 3) that 60 to 70 percent of the water discharged to drainages by CBNG wells would infiltrate into the shallow alluvium and the upper Wasatch Formation (AECOM 2009a). For coal mine expansion, the key assumption was that the amount of water discharged to drainages would be approximately equal to the estimated amount of future discharge water provided by the mine operators. These data were presented in the Task 2 report (AECOM 2009b).

The Task 2 report (AECOM 2009b) discusses different methods for the disposal of CBNG-produced groundwater. These methods include direct discharge to drainages, the use of in-channel and off-channel impoundments, active treatment, reinjection, and land application. The predominate method of discharge in the eastern PRB is direct discharge to ephemeral drainages, with the use of impoundments being the second most common method of discharge. These two methods are expected to account for 81 percent of the CBNG-produced groundwater discharged in the study area. As both of these methods would have approximately the same amount of recharge to shallow aquifers, the CMGM developed for the eastern PRB assumed that all CBNG discharge would be to

ephemeral drainages through Wyoming Department of Environmental Quality (WDEQ) approved outfalls near the producing wells. For the purpose of estimating future impacts to groundwater levels using the CMGM, it was assumed that all water produced by the CBNG wells would be discharged to the surface and that 70 percent of all water produced would infiltrate into the top layer of the model (alluvium or shallow Wasatch Formation). It was further assumed that 10 percent of the infiltrating water would be trapped in storage, used by plants, or eventually evaporated, leaving 60 percent of the discharged water as potential recharge to the top layer. This approach attempted to incorporate and average the effects of different CBNG discharge methods. No attempt was made to specifically model infiltration ponds, active treatment of discharged water, land application, or reinjection of water. For surface water quality modeling, it was assumed that 70 percent of the CBNG discharge water would infiltrate into the shallow alluvium and the upper Wasatch Formation; 30 percent of the discharged water would flow down the drainage.

1.1 Objectives

This PRB Coal Review is a regional technical study to assess cumulative impacts associated with past, present, and reasonably foreseeable development in the PRB. The PRB Coal Review:

- Describes past and present (through 2002 for water) development activities in the PRB that have affected the environmental conditions in the study area;
- Describes the current (through 2002 for water, based on data availability) environmental conditions in the study area and compares these conditions to the conditions projected in the Status Check (BLM 1996);
- Estimates RFD in the study area through the year 2020, based on available information; and
- Estimates the environmental impacts associated with RFD through the year 2020.

The PRB Coal Review provides data, models, and projections to facilitate cumulative analyses for future agency land use planning efforts and for future project-specific impact assessments for project development in compliance with NEPA. It should be noted that the PRB Coal Review itself is not a NEPA document. It is not a policy study, nor is it an analysis of regulatory actions or the impacts of project-specific development.

The primary objective of the Task 3B report is to provide an estimate of potential future cumulative impacts to water resources in the eastern PRB of Wyoming due to CBNG development and coal mining for the target years 2010, 2015, and 2020. To accomplish this objective, the following secondary objectives have been established for the Task 3B report:

- Evaluate potential groundwater impacts due only to CBNG development for 2010, 2015, and 2020. Compare groundwater levels to 1990 (the year before major initiation of CBNG activity in the PRB) and 2002 (the calibration year for the CMGM) levels.
- Evaluate potential groundwater impacts due only to coal mine dewatering for 2010, 2015, and 2020. Compare groundwater levels to 1990 (the period when coal mine dewatering began to expand) and 2002 (the calibration year for the CMGM) levels.

- Evaluate potential groundwater impacts due to combined CBNG development and coal mine dewatering for 2010, 2015, and 2020. Compare groundwater levels to 1990 and 2002 levels.

- Evaluate potential surface water quality impacts in the six major drainages of the eastern PRB due to CBNG- and coal mine-related discharge for the years 2010, 2015, and 2020.

- Evaluate groundwater level recovery following the cessation of both CBNG development and coal mining (assumed to be 2030 and 2050, respectively).

- Evaluate potential effects on channel stability in relation to potential changes in the hydrologic regime due to coal mine- and CBNG-related discharges.

- Evaluate the transport of groundwater containing elevated levels of total dissolved solids (TDS) associated with the resaturation of the pit backfill following cessation of coal mining.

The PRB Coal Review Task 3 descriptions of predicted cumulative impacts for air quality, social and economic conditions, and environmental resources are presented in separate stand-alone reports.

1.2 Agency Outreach, Coordination, and Review

The BLM directed the preparation of this PRB Coal Review. In order to ensure the technical credibility of the data, projections, interpretations, and conclusions of the study and ensure the study's usefulness for other agencies' needs, the BLM initiated contact with other federal and state agencies early in the study. This contact included meetings, periodic briefings, and written communications.

The BLM conducted an agency outreach program to solicit input from other agencies relative to their:

- Interested role and level of involvement in the study;
- Available data for use in the study; and
- Technical areas in which the agency would like to participate or review deliverables.

As part of this agency outreach and technical oversight, the BLM organized technical advisory groups for air quality, water resources, and socioeconomics. These groups were composed of agency representatives with technical expertise in the applicable resource(s). The PRB Water Resources Advisory Team has been actively involved in review of data; review of the CMGM protocol, development, and calibration; and review of the design of the linear mixing model approach for estimating effects to stream water quality.