TABLE OF CONTENTS

CHAPTER 1 - PURPOSE OF, AND NEED FOR, THE PROPOSED ACTION 1-1
INTRODUCTION 1-1
PURPOSE AND NEED 1-2
LOCATION OF THE PROPOSED ACTION 1-2
AUTHORIZING ACTIONS 1-5
PUBLIC PARTICIPATION 1-14

CHAPTER 2 - PROPOSED ACTION AND ALTERNATIVES 2-1
THE PROPOSED ACTION 2-1
Summary 2-1
Road Access for Drilling Operations 2-8
Drilling Operations 2-10
Well Production Facilities 2-11
Electrical Distribution Lines 2-11
Power Generation 2-12
Production Pods 2-12
Pipelines 2-12
Gas-Gathering System 2-12
Produced Water-Gathering System and Discharge Facilities 2-13
Gas Delivery System 2-14
Pipeline Compression 2-14
Anticipated Level of Activity and Project Life 2-15
Hydrologic Monitoring and Mitigation 2-15
Specific Monitoring Activities 2-17
Groundwater 2-17
Additional Monitoring Wells 2-20
Cost Share on Wells to be Monitored by BLM 2-20
Implementation of Monitoring 2-20
Surface Water 2-22
ALTERNATIVE 1 - EXPANDED PROJECT AREA 2-23
Anticipated Level of Activity and Project Life 2-24
NO ACTION ALTERNATIVE 2-24
ALTERNATIVES CONSIDERED BUT NOT ANALYZED IN DETAIL 2-26
Restrict Timing on Approval of Federal Wells 2-26
Reduce the Number of Federal Wells Approved 2-26
Inject Produced Water Underground 2-26

CHAPTER 3 - THE AFFECTED ENVIRONMENT 3-1
INTRODUCTION 3-1
LOCATION 3-2
PHYSIOGRAPHY AND TOPOGRAPHY 3-2
GEOLOGY AND MINERAL RESOURCES 3-2
WATER RESOURCES 3-7
Surface Water 3-7
Groundwater 3-19
Alluvial Aquifers 3-19
Wasatch Aquifer 3-19
Fort Union Formation 3-21
Tongue River/Lebo Aquitard 3-23
Tullock Aquifer 3-23
Water Use 3-24
CLIMATE 3-26

AIR QUALITY 3-26
SOILS 3-29
VEGETATION RESOURCES 3-36
WETLANDS 3-36
WILDLIFE AND FISHERIES 3-37
SPECIAL STATUS SPECIES 3-40
Black-footed ferret 3-41
Bald eagle 3-41
Peregrine falcon 3-42
Ute Ladies'-Tresses 3-42
Swift fox 3-42
Mountain plover 3-43
Sturgeon chub 3-43
Other Species, Including FS Sensitive Species 3-44
CULTURAL RESOURCES 3-44
Overview of Known Cultural Resources 3-44
Results of File Search 3-47
Native American Consultation 3-48
LAND USE AND TRANSPORTATION 3-48
RECREATION 3-51
VISUAL RESOURCES 3-52
NOISE 3-53
SOCIOECONOMICS 3-54

CHAPTER 4 - ENVIRONMENTAL CONSEQUENCES 4-1
INTRODUCTION 4-1
GEOLOGY AND MINERAL RESOURCES 4-1
Proposed Action 4-1
Alternative 1 4-3
No Action 4-3
SURFACE WATER 4-4
Proposed Action 4-4
Water Flow 4-5
Water Quality 4-9
Water Use 4-11
Ecosystems 4-11
Wildlife and Fisheries 4-12
Land Use 4-13
Socioeconomics 4-13
Mitigating Measures 4-14
Alternative 1 4-16
No Action 4-17
GROUNDWATER 4-17
Hydrogeologic Framework 4-18
Proposed Action 4-22
Alternative 1 4-51
No Action 4-52
AIR QUALITY 4-62
Near-Range Dispersion Modeling 4-63
Far-Range Modeling 4-65
Alternative 1 4-67
Construction Impacts 4-67
Operational Impacts 4-67
Natural Gas Compressors 4-67

Air Quality Impacts 4-69
Hazardous Air Pollutant Impacts 4-71
Vehicle Operational Impacts 4-71
Far-Range Impacts 4-72
Far-Range Air Quality Impacts 4-73
Regional Haze Impacts 4-73
AQRV Impact (Acid Deposition) 4-76
Proposed Action 4-77
Construction Impacts 4-77
Operational Impacts 4-78
Visibility Impacts 4-78
AQRV Impacts 4-78
No Action 4-78
Construction Impacts 4-78
Operational Impacts 4-78
Visibility Impacts 4-78
AQRV Impacts 4-79
SOILS 4-79
Proposed Action 4-79
Alternative 1 4-81
No Action 4-81
VEGETATION RESOURCES 4-82
Proposed Action 4-82
Alternative 1 4-84
No Action 4-84
WETLANDS 4-84
Proposed Action 4-84
Alternative 1 4-86
No Action 4-86
WILDLIFE AND FISHERIES 4-87
Proposed Action 4-87
Big Game 4-88
Upland Birds 4-89
Raptors 4-89
Waterfowl, Shorebirds, and Other Species 4-90
Fish 4-90
Alternative 1 4-91
No Action 4-91
SPECIAL STATUS SPECIES 4-91
Proposed Action 4-91
Bald Eagle 4-92
Black-Footed Ferret 4-92
Peregrine Falcon 4-92
Swift Fox 4-92
Mountain Plover 4-92
Sturgeon Chub 4-93
Ute-Ladies Tresses 4-93
Other Species, Including FS Sensitive Species 4-93
Alternative 1 4-93
No Action 4-94
CULTURAL RESOURCES 4-94
Proposed Action 4-94
Alternative 1 4-101
No Action 4-102

LAND USE AND TRANSPORTATION 4-102
Proposed Action 4-102
Land Use 4-102
Transportation 4-105
Alternative 1 4-107
No Action 4-108
RECREATION 4-109
Proposed Action 4-109
Alternative 1 4-110
No Action 4-110
VISUAL RESOURCES 4-111
Proposed Action 4-111
Visual Resource Management 4-112
Alternative 1 4-113
No Action 4-113
NOISE 4-113
Proposed Action and Alternative 1 4-113
No Action 4-114
SOCIOECONOMICS 4-114
Proposed Action 4-114
Employment and Personal Income 4-115
Federal Royalty and Production Taxes 4-117
Sales and Use Taxes 4-118
Housing and Community Resources 4-119
Local Economic Impact 4-119
Environmental Justice 4-120
Alternative 1 4-121
Employment and Personal Income 4-121
Federal Royalty and Production Taxes 4-122
Sales and Use Taxes 4-123
Housing and Community Resources 4-123
Local Economic Impact 4-123
No Action 4-124
Employment and Personal Income 4-124
Federal Royalty and Production Taxes 4-125
Sales and Use Taxes 4-125
Local Economic Impact 4-126
CUMULATIVE IMPACTS 4-126
Proposed Action 4-129
Geology and Mineral Resources 4-129
Surface Water 4-132
Groundwater 4-134
Existing Monitoring Programs 4-136
Proposed Monitoring Program 4-140
Air Quality 4-140
Near-Range Cumulative Emission Inventory 4-140
Far-Range Cumulative Emissions Inventory 4-145
Near-Range Cumulative Air Quality Impacts 4-146
Far-Range Air Quality Impacts 4-147
Regional Haze Impacts 4-149
AQRV Impact (Acid Deposition) 4-149
Soils 4-153
Vegetation Resources 4-153
Wetlands 4-155

Wildlife and Fisheries 4-155
Special Status Species 4-158
Cultural Resources 4-159
Land Use and Transportation 4-159
Recreation 4-160
Visual Resources 4-161
Noise 4-162
Socioeconomics 4-162
Alternative 1 4-163
No Action 4-164

CHAPTER 5 - CONSULTATION AND COORDINATION 5-1
SCOPING PROCESS 5-1
CONSULTATION AND COORDINATION 5-1
Federal Agencies 5-1
Tribes/Native American Representatives 5-1
State of Wyoming 5-2
Citizens' Groups and Regional Societies 5-2
Companies 5-2
LIST OF PREPARERS 5-3

CHAPTER 6 - REFERENCES 6-1

CHAPTER 7 - ACRONYMS 7-1

Maps

Map 1-1 Wyodak CBM Project Location 1-3
Map 1-2 Surface Ownership 1-7
Map 1-3 Oil and Gas Ownership 1-9
Map 1-4 Coal Ownership 1-11
Map 2-1 Proposed Action and Alternative 1 2-3
Map 3-1 Soils 3-33

Figures

Figure 3-1 Representative Windrose Wyodak CBM Project - Hampshire Energy 3-27
Figure 3-2 NO2 Monitoring at Gillette, Wyoming - March 1996 to April 1997 3-30
Figure 4-1 GAGMO Coal Drawdown, 1995, Area 1 4-23
Figure 4-2 GAGMO Coal Drawdown, 1995, Area 2 4-25
Figure 4-3 Modeled Existing Drawdown, 1975 - 1995, Proposed Action, Upper Wyodak Coal 4-27
Figure 4-4 Modeled Existing Drawdown, 1975 - 1995, Proposed Action, Lower Wyodak Coal 4-29
Figure 4-5 Maximum Modeled Drawdown 1975 - 2015, Proposed Action, Upper Wyodak Coal 4-31
Figure 4-6 Maximum Modeled Drawdown 1975 - 2015, Proposed Action, Lower Wyodak Coal 4-33
Figure 4-7 Locations of Monitoring Wells, Wyodak Coal 4-37
Figure 4-8 Comparison of Alternatives for Maximum Drawdown Over Time, Upper Wyodak Coal 4-39
Figure 4-9 Drawdown vs. Time Graphs for Selected BLM Monitoring Wells 4-40
Figure 4-10 Maximum Modeled Drawdown 1975 - 2182, Proposed Action,

Wasatch Sand 4-45
Figure 4-11 Maximum Modeled Drawdown 1975 - 2182, Alternative 1,
Wasatch Sand 4-47
Figure 4-12 Maximum Modeled Drawdown 1975 - 2182, No Action, Wasatch Sand 4-49
Figure 4-13 Maximum Modeled Drawdown 1975 - 2014, Alternative 1,
Upper Wyodak Coal 4-53
Figure 4-14 Maximum Modeled Drawdown 1975 - 2014, Alternative 1,
Lower Wyodak Coal 4-55
Figure 4-15 Maximum Modeled Drawdown 1975 - 2012, No Action,
Upper Wyodak Coal 4-57
Figure 4-16 Maximum Modeled Drawdown 1975 - 2012, No Action,
Lower Wyodak Coal 4-59
Figure 4-17 NO2 Annual Air Quality Impacts - Proposed Action and Alternative 1 4-70
Figure 4-18 Comparison Between the 1995 Cumulative Drawdowns and the Mines'
Worst-Case Drawdown and the USGS Predicted Cumulative Drawdowns
in the Coal Aquifer 4-137
Figure 4-19 Maximum Modeled Drawdown 1975 - 2015, Proposed Action-CBM
Only, Upper Wyodak Coal 4-141
Figure 4-20 Maximum Modeled Drawdown 1975 - 2015, Proposed Action, CBM
Only, Lower Wyodak Coal 4-143
Figure 4-21 NO2 Air Quality Impacts - Cumulative Effects 4-148

Tables

Table 2-1 Proposed Coal Bed Methane Development Alternatives 2-5
Table 2-2 Acres of Potential Surface Disturbance Associated with Proposed
CBM Development 2-9
Table 2-3 Required Constituents for Water Quality Sampling from Monitoring Wells 2-19
Table 2-4 Completed CBM Monitor Wells 2-21
Table 2-5 Proposed CBM Monitor Wells 2-22
Table 3-1 Generalized Description of the Shallow Geology Within the Wyodak CBM
Study Area 3-3
Table 3-2 Flow Statistics from USGS Gaging Stations in Wyodak Study Area 3-9
Table 3-3 Average Annual Runoff from Selected USGS Sites 3-10
Table 3-4 Predicted Storm Flows from USGS Gaging Stations 3-11
Table 3-5 Water Quality Criteria 3-14
Table 3-6 Chemical Analyses of Waters from the Belle Fourche River below Rattlesnake Creek near Piney,
Wyoming 3-15
Table 3-7 1990 Water Uses1 within the WYODAK Study Area 3-17
Table 3-8 Statistical Summary of WDEQ Discharge Monitoring Report Data (12/31/93 - 12/31/97) 3-23
Table 3-9 Trace Metal Concentrations of Groundwater In Coal Area 50 3-24
Table 3-10 1998-1999 Data on Type and Number of Wells in the Wyodak Study Area (T40-58 N R70-75 W;
T45-56N R76W; and T48-52N R77W) 3-25
Table 3-11 National and Wyoming Air Quality Standards 3-28
Table 3-12 Wyodak Study Area Gillette Ambient Pollutant Concentration Data 3-29
Table 3-13 General Soils Information - Areal Extent of Soil Units 3-32
Table 3-14 Study Area Soil Series Characteristics 3-35
Table 3-15a 1998 Nest Status 3-39
Table 3-15b 1997 Nest Status 3-39
Table 3-15c 1996 Nest Status 3-39
Table 3-16 U.S. Forest Service Sensitive Species 3-45
Table 3-17 Site Types Known for Wyodak Study Area 3-49
Table 3-18 Visual Resource Management in the Wyodak Study Area 3-52
Table 3-19 Population in Campbell, Converse, Johnson, and Sheridan Counties 3-54
Table 3-20 Taxable Valuation of Mineral Production for Fiscal Year 1997, Based on

1996 Production Campbell, Converse, Johnson, and Sheridan Counties 3-56
Table 4-1 Projected Outflow at Project Boundary for Existing and Proposed CBM Well Scenarios 4-7
Table 4-2 CBM Annual Runoff Compared with Average Annual Runoff by Drainage Basin 4-8
Table 4-3 Comparison of Extent and Depth of Maximum Drawdown by Alternatives 4-61
Table 4-4 Wyodak Compressor Emissions 4-64
Table 4-5 Class I and Sensitive Class II Areas 4-66
Table 4-6 Wyodak CBM Project Near-Range Air Quality Impacts 4-69
Table 4-7 Wyodak CBM Project Far-Range Air Quality Impacts (g/m3) 4-73
Table 4-8 IMPROVE3 Baseline Visibility Data For 20 Percent Cleanest Conditions 4-75
Table 4-9 Predicted Annual Days of Regional Haze Visibility Reductions At Class I and Sensitive Class II Areas from Wyodak CBM Project 4-75
Table 4-10 Predicted Levels of Acid Deposition from Wyodak CBM Project 4-77
Table 4-11 Predicted Acidification Neutralization Capacity (ANC) Analysis for Florence Lake, WY 4-77
Table 4-12 Eligible and National Register Sites in the Proposed Action Area 4-96
Table 4-13 Additional Eligible and National Register Sites in the Alternate 1 Area 4-101
Table 4-14 Proposed Project Employees 4-106
Table 4-15 Coal Production and Disturbance for Mines in the Wyodak Study Area 4-127
Table 4-16 Cumulative NOx Emissions for Near-Range Air Quality Analysis 4-145
Table 4-17 Cumulative Pollutant Emissions for Far-Range Air Quality/AQRV Analysis 4-147
Table 4-18 Wyodak NO2 Cumulative Near-Range Air Quality Impacts 4-147
Table 4-19 Results of Air Quality Impact Analysis (g/m3) 4-150
Table 4-20 Predicted Annual Days of Visibility Reductions At Class I and Class II Sensitive Areas from Wyodak CBM Project and Cumulative Sources 4-151
Table 4-21 Predicted Levels of Acid Deposition from Cumulative Sources and Wyodak CBM Project 4-152
Table 4-22 Acidification Neutralization Capacity (ANC) Analysis for Florence Lake, WY 4-153

Appendices

Appendix A Wetlands Management Guidance
Appendix B Standard "Conditions of Approval" for APDs
Appendix C Summary of Public Scoping Issues
Appendix D Water Well Agreement CHAPTER 1
PURPOSE OF, AND NEED FOR, THE PROPOSED ACTION

INTRODUCTION
Barrett Resources Corporation and Lance Oil and Gas Company representing themselves and a number of additional coal bed methane (CBM) developers (hereafter referred to as the Companies) have notified the USDI Bureau of Land Management (BLM), Buffalo Field Office, of their intent to expand CBM development on lands in the Powder River Basin (PRB). This expansion would include federal lands administered by the BLM and USDA Forest Service (FS), and is known as the Wyodak CBM Project. Development scenarios of 3,000 and 5,000 new productive wells were analyzed in combination with 640 productive wells previously addressed in the Gillette South CBM Project Environmental Impact Statement (EIS) and 250 productive wells previously analyzed in the Gillette North CBM Project Environmental Assessment (EA). In total, this EIS documents the analysis of the cumulative effects of 3,890 productive wells (Proposed Action), 5,890 productive wells (Alternative 1), 2,890 productive wells (No Action Alternative), and associated facilities, including roads, pipelines, and CBM compressors (**Map 1-1**).

Shortly after the Record of Decision (ROD) for the Gillette South CBM Project EIS was signed in October

1997, a meeting was held by the BLM to discuss the implications of this ROD regarding mitigation measures, monitoring requirements, and the potential and direction of additional development. Information provided subsequently by industry in 1998 regarding development plans indicated an additional 2,250 CBM wells could be drilled and operated in the PRB south of Gillette, Wyoming. Continued interest by industry added the potential for 750 wells north of Gillette. This Wyodak CBM Project EIS uses information developed in the analyses for previous CBM EAs in the area, including the Gillette North, Lighthouse, and Marquiss EAs, and it considers the effects of changes in environmental conditions and development procedures that have occurred since the Gillette South CBM Project EIS was completed.

Drilling CBM wells on lands where mineral rights are owned and controlled by the federal government must be conducted under an approved application for permit to drill (APD) issued by the BLM. In considering whether to approve APDs, the BLM must consider the possible project-specific and cumulative environmental impacts to ensure compliance with the National Environmental Policy Act of 1969 (NEPA). This draft EIS was prepared to meet that requirement. An additional analysis, which will look at the site-specific impacts of the drilling location and its relationship to the range of impacts documented in this analysis, will be completed in response to the filing of an APD and prior to approval by BLM.

When the location and operational requirements for gas compression facilities that are needed for CBM development are determined, permit applications would be submitted to the Air Quality Division (AQD) of the Wyoming Department of Environmental Quality (WDEQ). At that time a complete analysis of Prevention of Significant Deterioration (PSD) increments and Best Available Control Technology (BACT) would be prepared. The analysis contained in this draft EIS is not intended as an air quality regulatory determination. PSD increments are used here only to evaluate air quality impacts. PURPOSE AND NEED

The purpose of, and need for, the proposed CBM development is to allow for the orderly development of the resource to meet the energy needs of the nation. Development of federally-owned CBM also would reduce the possibility of drainage from the federal mineral estate and loss of royalties to the U.S. Treasury and the State of Wyoming. The leaseholders will be able to exercise their rights within the project area to drill for, extract, remove, and market CBM within conditions stipulated in the lease. Also included in these lease rights is the right to build and maintain necessary improvements. These rights continue throughout the lease term and any extensions or renewals granted by the appropriate authority.

The purpose of the Proposed Action is to analyze the impact of additional development of federal CBM properties within the Wyodak project area that were not analyzed in the Gillette South EIS and the Gillette North EA. This project area includes new developments within the Gillette South EIS and Gillette North EA areas and locations now being developed exclusively on state and private oil and gas leases outside these original assessment areas. An estimated 890 productive CBM wells were in place within the Wyodak project area by the end of 1998. Production statistics for 420 productive CBM wells were available for February 1998 (PI/Dwight's, 1998). Production statistics for 638 productive CBM wells were available for November 1998 (PI/Dwight's, 1999).

For the purpose of this analysis, the BLM estimates the following conditions: 1) up to one-half of all new CBM wells that would be drilled within the project area would be located on lands where these mineral rights are owned privately or by the State of Wyoming; and 2) up to one-half of all the new CBM wells that would be drilled within the project area would be located on lands where CBM mineral rights are federally owned. Drilling wells under an approved APD is the only way to determine the potential for CBM production on federal lands. The private- and state-owned gas will be developed regardless of the outcome of this decision, but under the Proposed Action the project would include development of private, state, and federal CBM properties.

The operators propose to develop CBM within the project area by increasing the total number of wells and ancillary facilities where economically feasible. This proposal would enhance recovery of methane from the project area by increasing the availability of gas supplies, thus allowing operators to provide more gas to companies distributing and supplying methane to consumers.

LOCATION OF THE PROPOSED ACTION

The proposed CBM projects are located in central Campbell and northern Converse Counties, Wyoming, within the eastern portion of the PRB. The proposals include additional development within the Gillette South EIS assessment area and the Gillette North EA assessment area, and in surrounding areas (**Map 1-1**). The wells would be located within a project boundary extending from approximately 33 miles north of Gillette, Wyoming to 24 miles south of Wright, Wyoming. Wells would be located on lands adjacent to the coal mines along the eastern project boundary, and would extend to a western boundary located about 18 to 36 miles to the west. For reference, Map 1-1 Wyodak CBM Project Location This page intentionally left blank this roughly rectangular area has been named the Wyodak CBM project area. The project area includes portions of the Thunder Basin National Grassland (TBNG), which is under surface administration of the FS; drilling activity currently is proposed on FS-administered federal lands. The project boundary was delineated by industry interest. There is no legal requirement for the Companies to confine drilling to this area other than their federal leases. It is significant to note that although approximately 8.1 percent of the project area is federal surface (4.5 percent BLM-administered federal lands and 3.6 percent FS-administered federal lands) (**Map 1-2**), federal ownership of oil and gas rights constitutes about 50 percent of the project area (**Map 1-3**). Federal ownership of coal rights totals about 88 percent of the project area (**Map 1-4**) (USDI BLM, 1998f).

AUTHORIZING ACTIONS

The BLM's Buffalo Field Office (BFO) administers oil and gas leases for all federally-owned minerals within the project area. Coal bed gas (or CBM) currently is leased by the federal government as an oil and gas right. CBM development is regulated in accordance with federal oil and gas regulations and onshore oil and gas orders. The applicability of this regulatory framework to CBM currently is under review.

The Solicitor of the Interior Department recently has withdrawn a 1981 opinion that concluded coal bed gas was disposable under the oil and gas leasing provisions of the 1920 Mineral Leasing Act. The appeal to the U.S. Supreme Court of a recent 10th Circuit Court decision, in Southern Ute Indian Tribe vs. Amoco Production Company et al. involving CBM development in Colorado, prompted the issuance of the Solicitor's written brief. The U.S. Supreme Court announced on January 23, 1999 that it will decide the ownership of CBM in the 10th Circuit Court case.

On November 10, 1998 P.L. 105-367 was signed into law. This statute protects the integrity of CBM leases entered into on or before November 10, 1998, where CBM leases were issued by surface patent holders as an oil and gas right. This statute also ratifies pending APDs from mineral owners developing their own minerals. Under this statute, the U.S. recognizes as not infringing upon any ownership right of the U.S., any contract or lease involving 1909 or 1910 Coal Act lands where the U.S. is the owner of coal rights reserved to the U.S.

Leasing of federal lands and federal minerals administered by the BLM is subject to the limitations imposed by the *Buffalo Resource Management Plan/Record of Decision* (RMP) (USDI BLM, 1985); current policy; and local, state, and federal laws. The FS's Douglas Ranger District of the Medicine Bow-Routt National Forest administers oil and gas leasing and development activities within the TBNG. Leasing and development activities on FS-administered federal lands are subject to the limitations imposed by the *Land and Resource Management Plan for the Medicine Bow National Forest and Thunder Basin National Grassland* (LRMP) (USDA FS, 1985 as amended) and the EIS for *Oil and Gas Leasing on the TBNG* (USDA FS, 1994).
Before any surface disturbance can occur on federal lands and/or federal minerals administered by the BLM, a company must have an APD approved by the BLM Field Manager for on-lease drilling. A right-of-way must be approved by the BLM for off-lease disturbance of federal surface. Securing necessary legal access to and/or across any state- or privately-owned lands also is part of the APD approval process. The Wyoming Office of State Lands and Investments is responsible for easements and temporary uses of state lands that are required for off-lease activities. Before any surface disturbance can occur on FS-administered federal lands, a company must have a surface use plan approved by the FS District Ranger for on-lease activities, which is part of the APD that must be approved by the BLM Field Manager. A special-use permit is issued by the FS to manage off-lease activities on FS-administered federal lands. On-lease production facilities are authorized by Sundry Notices.

The Wyoming Oil and Gas Conservation Commission (WOGCC) regulates drilling and well spacing, and requires an approved APD for all oil and gas wells drilled in the state, including federal wells. The WOGCC also regulates reserve pits and water encountered (surface flows) or produced during drilling operations.

The State of Wyoming requires water produced in conjunction with CBM development to be put to subsequent beneficial use and requires approved permits from the Wyoming State Engineer's Office (WSEO) to appropriate groundwater or surface water or to impound produced water. Stream channel modification, construction of new reservoirs, and some types of dam modification on existing reservoirs also require permits from the WSEO.

The Water Quality Division (WQD) of the WDEQ regulates increasing sedimentation, erosion, and other issues affecting the quality of water. WQD also is responsible for granting a National Pollution Discharge Elimination System (NPDES) permit for surface discharge of produced waters from CBM wells. The WQD also issues NPDES permits for pipeline construction activities that disturb five or more acres or involve temporary discharge to "Waters of the State" during hydrostatic testing.

The WQD also administers a voluntary State Wetland Bank where landowners can temporarily "bank" newly-created wetlands as a wetlands credit. The existence of a non-wetland use is recorded to facilitate reversal of the decision creating the banked wetlands (if desired, as long as the wetland credit was not used as mitigation for another wetland impact). Where the U.S. Army Corps of Engineers (COE) exerts federal jurisdiction over banked wetlands, the outcome of decisions involving these wetlands will be in accordance with the federal regulations administered by the COE.

Federal agencies are directed to take action to minimize the destruction, loss, or degradation of wetlands, and to preserve and enhance the natural and beneficial value of wetlands by Executive Order (EO) 11990, May 24, 1977, (Protection of Wetlands). A BLM instructional memorandum summarizing the operating procedures used to implement this federal policy for all Wyoming wetlands administered by the BLM is included in **Appendix A**.
Map 1-2 Surface Ownership This page intentionally left blank Map 1-3 Oil and Gas Ownership This page intentionally left blank Map 1-4 Coal Ownership This page intentionally left blank The COE authorizes activities that would impact navigable waters and waters of the U.S. through individual permits or nationwide permits for categories of activities, and also receives pre-construction notification of activities. "Waters of the U.S." is a collective term for all areas subject to regulation by the COE under Section 404 of the Clean Water Act. COE will require a permit when dredge or fill activities are planned in waters of the United States. A February 19, 1998 letter describing COE jurisdictional areas, regulated activities, and permitting requirements in relation to CBM production activities in northeastern Wyoming is included in **Appendix A**.

The AQD of the WDEQ enforces U.S. and Wyoming Air Quality Standards and Regulations, and authorizes the construction and operation of compression facilities. A Section 21 permit application is required prior to the construction, modification, or operation of any site, equipment, source, facility, or process that may cause or increase the emissions of an air contaminant into the atmosphere. All operations would be required to comply with WDEQ rules regarding noise limits. No permits would be required for the proposed project from the affected counties, the City of Gillette, or the City of Wright.

As part of the APD approval process for federal lands and/or federal minerals it administers, the BLM reviews the surface use and drilling plans submitted by a company. For CBM development, BLM also is asking operators to submit a water management plan (**Appendix B**). After the BLM receives a Notice of Staking (NOS) or an APD and before approval, an onsite inspection is made of the proposed drilling locations, access roads, water management, and other potentially-disturbed areas. BLM personnel, company representatives, and the surface owner(s) usually attend the inspection to determine site-specific conditions for approving the APD. As part of the APD-approval process, BLM requires standard and, in some cases, special site-specific protective measures in design and operation of the proposed project and may require establishment of additional monitoring wells.

Before construction, the Companies would be required to follow BLM land management guidance and decisions, and comply with existing laws for threatened and endangered species; cultural, historical, and paleontological resources; and federally-protected raptor nests. The actions proposed within the project area must be in conformance with the BLM's Buffalo RMP (USDI BLM, 1985). The BLM would apply any appropriate conditions of approval to protect site-specific resources. A plan for monitoring and mitigating potential adverse impacts to groundwater and surface water would be detailed as part of this project design (Chapter 2). Standard *Conditions of Approval* for APDs used by BLM's Buffalo Field Office are contained in **Appendix B**.

As part of the APD approval process for FS-administered federal lands, the FS reviews the surface use plan and BLM reviews the drilling plan submitted by a company. After the FS and BLM receive the NOS or APD and before approval, an onsite inspection is made of the proposed drilling locations, access roads, and other potentially-disturbed areas. Agency personnel and company representatives attend the inspection to determine site-specific conditions for approving the APD. As part of the APD approval process, the FS and BLM require standard and, in some cases, special site-specific protective measures for design and operation of the proposed project, and the FS may require additional baseline information on water resources or the establishment of additional monitoring wells.

Before construction, the Companies would be required to follow FS land management guidance and comply with existing laws. The actions proposed within the project area must be in conformance with the management goals within the FS LRMP (USDA FS, 1985 as amended). The management goal for the TBNG is to demonstrate grassland management and utilization of resources and values that are in harmony with nature's requirements and behavior, and to foster long-term economic stability and productivity of the land base and quality of life for the people and communities in the area. The TBNG is managed to provide for multiple land uses, including oil and gas development; a broad spectrum of dispersed recreation opportunities; characteristic landscapes that satisfy the adopted visual quality objectives; increased public access; wildlife and fish habitats that maintain viable populations; and water quality and increased water quantity where possible (USDA FS, 1985).

All of the TBNG is available for oil and gas leasing. Many leasing restrictions were developed by the FS in 1994 for use within the TBNG. Any restrictions applicable to drilling or production activities may be included as conditions of approval for activities on post-1994 leases. These restrictions can be reviewed to provide insight regarding conditions of approval that may be applied to future APDs within the TBNG (USDA FS, 1994). The FS would apply any appropriate conditions of approval to APDs that are needed to protect site-specific resources or conditions.

PUBLIC PARTICIPATION
The Council on Environmental Quality (CEQ) regulations require an "early and open process for determining the scope of issues to be addressed and for identifying significant issues related to a Proposed Action" (40 CFR 1501.7). Scoping was conducted through a direct mail process and a public meeting. The mailing list included landowners, business groups, environmental groups, and other interested members of the public.

The Notice of Intent (NOI) for this EIS was published in the *Federal Register* on January 29, 1998, and a public meeting was held on February 5, 1998 at the Holiday Inn in Gillette. All substantive comments the BLM received during these meetings have been used to direct the scope and analysis of this EIS. Public scoping comments were accepted through March 2, 1998. A letter that summarizes both the issues raised at the public scoping meeting and contained in written comments is presented as **Appendix C** (3/19/98 BLM letter to "Partner"). CHAPTER 2
PROPOSED ACTION AND ALTERNATIVES

This section describes the proposed Wyodak CBM project and the alternatives that were developed for consideration in this EIS. Three alternatives are analyzed comparatively in the EIS: 1) the Proposed Action (project area); 2) Alternative 1 (expanded project area); and 3) the No Action Alternative. In addition, other alternatives that were considered but not analyzed in detail, also are discussed.

THE PROPOSED ACTION

Summary

The Proposed Action consists of drilling, completing, operating, and reclaiming approximately 3,000 new productive CBM wells and related production facilities. The project area is located in the eastern PRB within central Campbell County and northern Converse County, Wyoming (**Map 2-1)**. The Companies base this proposed activity on the preliminary development plans that were submitted to the BLM in 1998.

Development of natural gas (coal bed methane) wells and related facilities associated with the Wyodak CBM Project would be included. Proposed CBM development is based on an assumed 40-acre well spacing pattern. The exact well locations will be determined subsequent to this EIS during the environmental analysis conducted for each well's APD, which would be reviewed and approved on a case-by-case basis. The APD process allows conditions of approval to be developed for each well on the basis of site-specific water monitoring requirements and environmental constraints. In addition to well sites, other facilities, such as access roads, gas gathering and water disposal pipelines, electrical utilities, and compressors, would be developed to facilitate natural gas (methane) production in the well fields.

Coal bed methane is owned by the federal government for approximately 50 percent of the project area. For the purpose of this analysis, the following conditions were assumed: One-half of the 3,000 new productive wells are estimated to be federal wells; an estimated 400 wells would be drilled by 20 different companies, on average, each year during the initial development period of five to ten years; most drilling activity would occur within the initial development period; and the actual rate of development would depend on the productivity of the wells and the ability to compress and market the methane. Currently, interest in immediate CBM development is high. More than 40 companies filed APDs with the WOGCC through 1998, for CBM well locations on federal, state, and private lands within the PRB (WOGCC, 1999).

In addition to the proposed new wells, the Proposed Action also includes increased rates of development, CBM production, and surface water discharge and an increased area of disturbance within areas previously analyzed in the Gillette North CBM Project EA and the Gillette South CBM Project EIS (**Map 1-1**). Both the Gillette North CBM Project EA and Gillette South CBM Project EIS assessment areas are contained within the project area boundary for this EIS.

The proposed CBM wells would be located from approximately 33 miles north of Gillette to approximately 24 miles south of Wright, Wyoming. As stated under the "Location of the Proposed Action" in Chapter 1, the project boundary was delineated by industry interest but there is no legal requirement for companies to confine drilling to this area, other than the location of their federal leases. Under the Proposed Action, the project would include well development and production from private, state, and federal properties. However, CBM development likely would continue on private and state mineral estates, even if development of federal mineral estates were denied by the BLM.

The area analyzed under the Proposed Action (the project area) totals approximately 2,400 square miles (1,538,000 acres). Well spacing, combined with a preferred approach to locating wells, results in grouping of most wells into "pods" of about ten wells, depending on the structure of the coal seam. Developed areas may have up to 16 wells per square mile based on an assumed 40-acre spacing. Development typically would result in wells drilled within productive portions of the project area on a spacing determined by the WOGCC. The remaining less productive portions of the project area may never have any activity. As a result, the average density of new wells, if all 3,000 productive wells were drilled, would be approximately 1.3 wells per square mile. Refer to **Table 2-1** for additional information.

The BLM has a general policy that requires access roads to oil and gas wells on federal lands to be crowned, ditched, and, in most cases, graveled or otherwise surfaced. The BLM's general policy is based on the typical requirements for multi-component rigs. For CBM development, an exception has been made to this policy in consideration of the following factors. A water well drilling rig would be used for both drilling and completion activities. This type of drill rig and the well servicing equipment that supports its operation are modest in size, when compared with multi-component drill rigs and equipment used to drill deeper conventional oil and gas wells. Each CBM well would be drilled within one to three days. Well completion also would occur within one to three days. Typically, wellpads would not be leveled unless steep terrain could not be avoided. For producing CBM wells, on average, well service visits would be expected to occur once a month. As a result, two-track unimproved roads or trails would be used for access to the majority of CBM wells. In some cases, roads will need to be upgraded to BLM's minimum standards due to special conditions such as rough topography or stream drainage areas.

The project would develop over time as the Companies implement their various CBM projects. Drilling activity would correspond to the estimated five-year to ten-year initial development period. A certain number of wells would be drilled and connected to pipelines each year within limited portions of the project area. Numerous companies may drill wells during the same given year. Actual well locations will be determined by the success of previous drilling, which determines where CBM can be produced efficiently. Lower numbers of wells being drilled could result from various economic factors that would cause companies to limit activity. The estimated productive life of the project is 10 to 20 years. A study conducted by the BLM projects an estimated average CBM well life of 12 years (USDI BLM, 1996a). Map 2-1 Proposed Action and Alternative 1 This page intentionally left blank

Table 2-1 (continued)
Proposed Coal Bed Methane Development Alternatives

	Proposed Action	**Alternative 1**	**No Action**
1.Proposed Project Area (estimated):	1,538,000 ac 2,400 sq mi	2,317,000 ac 3,600 sq mi	1,538,000 ac 2,400 sq mi
2.Wells (projected):			
New Productive CBM Wells (total):	3,000	5,000	2,000
New Productive CBM Wells (federal oil & gas ownership)	1,500	2,500	0
Maximum Well Density:	16 wells/sq mi	16 wells/sq mi	16 wells/sq mi
Average Density (new wells only):	1.3 wells/sq mi	1.4 wells/sq mi	0.8 wells/sq mi
Average Density (all CBM wells):	1.6 wells/sq mi	1.6 wells/sq mi	1.2 wells/sq mi
Depth:	350 to 1,200 ft	350 to 1,200 ft	350 to 1,200 ft
Average Production Rate (per well):	125 MCFD	125 MCFD	125 MCFD
3.Production Pods (estimated):	300	500	200
4.Water Discharge (estimated):			
Water Discharge Points	500 to 1,000	833 to 1,667	333 to 667
NPDES Permits	167 to 333	278 to 556	111 to 222
Maximum Annual Volume (new wells)	58,072 ac-ft/yr	96,787 ac-ft/yr	38,715 ac-ft/yr
5.Compressors (estimated): *			
Booster Compressors (at some production pods):			
Stations Operational by 5/97	13	13	13
Additional Stations	147	147	147
Total Number of Stations	160	160	160
380 HP Booster Compressor Engines Operational by 5/97	13	13	13
	220	220	220

Additional 380 HP Booster Compressor Engines	233	233	233
Total Number of 380 HP Booster Compressor	1-2	1-2	1-2
Engines	2.1 MMCFD	2.1 MMCFD	2.1 MMCFD
Number of Compressors per Station	20	20	20
Compressor (Engine) Capacity (gas volume)			
Compressor (Engine) Capacity (wells)			

5.Compressors (estimated) - continued: *

Field Compressors

Stations Operational by 5/97	15	15	15
Additional Stations	34	34	34
Total Number of Stations	49	49	49
1000 HP Field Gathering Line Engines Operational	5	5	5
by 5/97	13	13	13
Additional 1000 HP Field Gathering Line Engines	18	18	18
Total Number of 1000 HP Field Gathering Line	1-6	1-6	1-6
Engines	7 MMCFD	7 MMCFD	7 MMCFD
Number of Compressors per Station	56	56	56
Compressor Engine Capacity (Gas volume)			
Compressor Engine Capacity (Wells)	39	39	39
	43	43	43
1500 HP Field Gathering Line Engines Operational	82	82	82
by 5/97	1-4	1-4	1-4
Additional 1500 HP Field Gathering Line Engines	5 MMCFD	5 MMCFD	5 MMCFD
Total Number of 1500 HP Field Gathering Line	40	40	40
Engines			
Number of Compressors per Station			
Compressor Engine Capacity (Gas volume)	0	0	0
Compressor Engine Capacity (Wells)	5	5	5
	5	5	5

Pipeline Compressors

Stations Operational by 5/97	0	0	0
Additional Stations	18	18	18
Number of Stations	18	18	18
	22.5 MMCFD	22.5 MMCFD	22.5 MMCFD
1500 HP Transmission Pipeline Engines	N/A	N/A	N/A
Operational by 5/97			
Additional 1500 HP Transmission Pipeline Engines			
Total Number of 1500 HP Transmission Pipeline			
Engines			
Compressor Engine Capacity (Gas volume)			
Compressor Engine Capacity (Wells)			

6.Transmission Pipeline Capacity (estimated):

Available Pipeline Capacity (by the end of 1998):			
Redstone	40 MMCFD	40 MMCFD	40 MMCFD
Western Gas Resources	120 MMCFD	120 MMCFD	120 MMCFD
TOTAL	160 MMCFD	160 MMCFD	160 MMCFD
Pipeline Capacity (life of project):			
Redstone	40 MMCFD	40 MMCFD	40 MMCFD
Western Gas Resources	585 MMCFD	585 MMCFD	585 MMCFD
Thunder Creek	450 MMCFD	450 MMCFD	450 MMCFD
Misc. (wet gas line capacity for CBM gas)	20 MMCFD	20 MMCFD	20 MMCFD
TOTAL	1,095 MMCFD	1,095	1,095

		MMCFD	MMCFD

* Compression facilities were estimated based on logical field-wide development plans, and do not vary by alternative. Alternatives are based on differing well numbers considered in this analysis.

Note:
Gas production is measured in cubic feet per day.
MCFD represents 1,000 cubic feet per day; MMCFD represents 1,000,000 (one million) cubic feet per day.
ac = acres; sq mi = square miles; ac-ft/yr = acre-feet per year (1 acre-foot = 325,829 gallons). The Companies propose to develop well fields within the project area for the Wyodak CBM Project EIS, consisting of the following development activities:

€ Approximately 3,000 additional productive wells based on an assumed 40-acre well spacing pattern;
€ Associated transportation infrastructure, such as roads, pipelines, and utilities;
€ An estimated 34 additional field compressor stations (in May 1997, 15 field compressor stations were in use):
€ An estimated 147 additional booster compressor stations (in May 1997, 13 booster compressor stations were in use):
€ An estimated 5 new pipeline compressor stations (in May 1997, no pipeline compressor stations were in use); and
€ Produced water discharge facilities authorized by the State of Wyoming and other agencies, as appropriate, including an estimated 500 to 1,000 additional NPDES discharge points authorized in 167 to 333 NPDES permits.

The Proposed Action would consist of the following components proposed by any lessees or operators (operators), as defined in Onshore Order No. 1 issued under 43 CFR 3164: a) road access for drilling operations; b) drilling operations; c) well production facilities; d) electrical distribution lines; e) power generation; f) production pods; g) pipelines (gas gathering system, produced water gathering system and discharge facilities, gas delivery system); and h) pipeline compression (**Tables 2-1 and 2-2**).

Road Access for Drilling Operations
Access to drill locations from the existing road network already in place on federal, state, and private lands will be provided primarily by two-track roads traversing over natural terrain along pipeline rights-of-way whenever feasible. Travel on two-track roads would be rescheduled or postponed during infrequent periods of wet weather when vehicular traffic could cause rutting. Well access roads will be maintained in an undisturbed, two-track status, unless road upgrades are needed to alleviate safety concerns or access difficulties. Gravel or scoria may be applied in problem areas. Troublesome areas, such as stream drainage crossings, low water crossings, and rough topography would be upgraded as the need arises. In less rugged terrain, little earthwork is anticipated for well access road construction.

In more rugged terrain, BLM experience to date has shown that construction of a rough well access road to the drill location using cut and fill construction techniques may be necessary an estimated ten percent of the time. Surface disturbance associated with crowning and ditching (normally required by BLM's general policy on design and construction of oil and gas well access roads) would occur only as required for well access roads traversing steeper terrain or rough, broken topography, or in other exceptional site-specific circumstances. Use of cut and fill construction techniques for well access roads may disturb up to 1.8 acres per well located in difficult terrain. Roads not needed for production will be reclaimed, as needed, as soon as practical after the conclusion of drilling. Roads needed for production may be upgraded, as

Table 2-2
Acres of Potential Surface Disturbance Associated with Proposed CBM Development

	Proposed Action	Alternative 1	No Action
Potential Short-term Disturbance Only (until facilities completed and reclaimed)			

Drill Sites (during drilling) a	825	1,375	550
Water Discharge Pipelines	4,500	7,500	3,000
Pod Gathering Lines to Trunklines	2,910	4,850	1,940
Trunklines to Compressors	2,038	2,038	2,038
TOTAL Potential Short-term Disturbance (acres) *(percentage of area analyzed)*	*10,273* *0.7%*	*15,763* *0.7%*	*7,528* *0.5%*
Potential Long-term Disturbance (during production)			
Well Access Roads & Pipelines (gathering)	5,400	9,000	3,600
Well Sites for Productive CBM Wells	36	60	24
Production Pod Facilities	75	125	50
New Field Compressor Stations	51	51	51
New Booster Compressor Stations	37	37	37
New Transmission Pipeline Compressor Stations	15	15	15
Improved Roads to Production Pods	900	1,500	600
TOTAL Potential Long-term Disturbance (acres) *(percentage of area analyzed)*	*6,514* *0.4%*	*10,788* *0.5%*	*4,377* *0.3%*
TOTAL POTENTIAL SURFACE DISTURBANCE (acres) b **(percentage of area analyzed)**	**16,751** **1.1%**	**26,491** **1.2%**	**11,881** **0.8%**

aUp to 10% more new CBM wells may be drilled (drill sites) than are produced (as well sites). Short-term drilling disturbance from unproductive wells is included. Acreage for drill sites (during drilling) encompasses acreage for productive CBM well sites.

b Does not include acreage for productive CBM well sites. This acreage already is included under drill sites (during drilling).

Notes:

Potential Surface Disturbance is estimated in acres. (For reference: 43,560 square feet = 1 acre; 640 acres = 1 square mile).

Short-term Disturbance = Disturbance during drilling or installation of facilities, followed by reclamation, up to approximately 3 years.

Long-term Disturbance = Disturbance continuing during the life of the project, followed by reclamation, approximately 10 to 20 years. needed, to ensure safe, year-round access. At the conclusion of the project, roads and culverts that improve access to livestock pastures or calving areas, cultivated fields, ranch buildings, or other areas could be left in place with surface owner concurrence. All roads no longer needed will be reclaimed.

Drilling Operations

Typically, drilling operations will be confined within a 100 feet by 100 feet well site area that is not leveled and is not cleared of vegetation. The use of cut and fill construction techniques to level work areas will be limited to areas where the land surface is too steep to allow the drill rig to set up over natural terrain. In areas where limited cuts and fills are necessary, vegetation may be disturbed or removed. Use of cut and fill construction techniques for well sites may be necessary an estimated ten percent of the time and may disturb up to 0.25 acre per well that is located in difficult terrain. Areas disturbed, but not needed for production, will be reclaimed as soon as practical after the conclusion of drilling. At the conclusion of the project, all disturbed areas no longer needed will be reclaimed.

A mobile drilling rig will be driven to the well site and erected. Typically, a truck-mounted water well drilling rig will be used to drill CBM wells. Additional equipment and materials needed for drilling operations, including water, would be trucked to the well site. The proposed project would require approximately 8,000 gallons (or 0.03 acre-feet) of water per well for cement preparation, well stimulation, dust control, and possibly drilling (non-toxic drilling mud is required to handle certain downhole conditions). Drilling mud usually is native mud and bentonite. As hole conditions dictate, small amounts of polymer additives and/or potassium chloride salts may be added for hole cleaning and clay stabilization.

The drill rig typically will be set up over natural terrain. A temporary mud pit approximately six feet deep, ten feet wide, and up to thirty feet long, would be excavated within each well site area, used during drilling and completion operations, and then reclaimed. Each producing well would be drilled to a depth of 350 feet to 1,200 feet or deeper, and would have steel casing cemented from the top of the coal seam to the surface. The well control system would be designed to meet the conditions likely to be encountered in the hole and would be in conformance with BLM and State of Wyoming requirements.

The drilling and completion operation for a CBM well normally requires approximately seven to 25 people at a time, including personnel for logging and cementing activities. Each well would be drilled within a period of one to three days. In preparation for production of gas from a drilled, cased, and cemented well, a well completion program may be initiated to stimulate production of gas and to determine gas and water production characteristics. A mobile completion rig similar to the drill rig may be transported to the well site, erected, and used to complete a well. Completion operations are expected to average one to three days per well. Methane gas may be vented and water temporarily discharged for a very short period of time during testing to determine whether wells will be produced. Once determined to be productive, wells would be shut-in until pipelines and other production facilities are constructed.

Well Production Facilities
If wells are productive, a very small part of each well site, perhaps five or six feet square, will be leveled to install wellhead facilities. A weatherproof covering will be placed over the wellhead facilities. No additional structure will be constructed at the well site for gas-water separation facilities. A downhole pump will be utilized to produce water from the uncased open hole interval located below the steel production casing. Methane gas will flow to the surface using the space between the production casing and the water tubing. No pumpjacks will be located at the wellheads. The long-term surface disturbance (10 to 20 years) at each productive well location where no cut and fill construction techniques are utilized is likely to encompass a negligible area, much less than 0.1 acre. The long-term surface disturbance at each productive well location where cut and fill construction techniques are utilized is likely to encompass approximately 40 feet by 80 feet, or approximately 0.1 acre. Well site production facilities typically will not be fenced or otherwise removed from existing uses.

Pipeline trenches for well gathering lines are expected to disturb portions of 40-foot wide corridors temporarily and to be reclaimed as soon as practical after construction is completed. Trenches will be constructed along the two-track well access roads wherever possible. Separate gathering lines, averaging one quarter to one-half mile long each, will be buried in the trenches and will transport methane gas to production pod facilities and produced water to discharge points.

At the conclusion of the project, roads, culverts, cattleguards, pipelines, stock watering facilities, or other structures could be left in place for any beneficial purpose of the surface owner. Electrical service would be available where CBM wellhead or pod production facilities were located, at the landowner's expense. Water wells and produced water would be available to the surface landowner, with appropriations, diversion, and storage rights already properly filed with the WSEO. Ponds and reservoirs would continue to store water if surface owners elect to manage the wells and continue pumping water from them. All federally-owned surfaces that contain disturbed areas or facilities that are no longer needed will be reclaimed. All disturbed areas and facilities that are no longer needed and are located on private land also will be reclaimed, unless landowners elect to manage the wells and continue pumping water from them, or desire to keep the access roads intact.

Electrical Distribution Lines
Electricity would be used to power downhole pumps during well development and to initiate and maintain production. A limited number of newly-constructed, high-voltage distribution lines are anticipated. Electricity will be routed to well sites and ancillary facilities within the transportation corridor. Direct burial cable will be the preferred method of electrification, unless otherwise impractical. Electrical lines connecting the wells and

the production pods will be buried in the trenches excavated for well gathering lines. Overhead electrical lines will be installed along the pod access road or in a more suitable location. All overhead electrical lines will utilize raptor protection designs. At the conclusion of the project, overhead distribution systems not owned by the operators may or may not be salvaged. Operators will reclaim areas and facilities no longer needed.

Power Generation

Both natural gas-fired and diesel engine-powered generators may be used on a temporary basis at individual wells until electrical distribution lines are constructed. Either electrical motors or natural gas-fired reciprocating or microturbine engines will power booster or blower units. Future compressors are anticipated to be natural gas-fired or electrical units.

Production Pods

Typically, gas production from each well will be individually measured and mechanically or electronically recorded at a central collection point or pod building. Gas gathering lines for an average of ten wells will be tied together in a production pod, where metering for all the wells in that pod will be done. At the production pod, gas is commingled into the gas gathering system, which transports it to the compressor station. An improved road, averaging one-half mile in length, will be constructed to each production pod and will disturb an area not expected to be wider than 50 feet. Each production pod facility will disturb approximately 0.25 acre. At the conclusion of the project all disturbed areas and facilities no longer needed will be reclaimed.

Pipelines

Three types of pipelines would be constructed as part of the proposed project:

1. Gas-gathering pipeline systems (low pressure, from wellhead to pod building, and from pod building through trunkline to the compressor station)

2. Produced water-gathering pipeline systems

3. Gas-delivery pipelines (high pressure, from compressor station to existing transmission pipelines)

Reclamation of pipeline corridors will occur as soon as practical after pipeline construction is completed.

Gas-Gathering System

As part of the transportation corridor system linking the wells and ancillary facilities, gas- gathering pipelines and produced water-gathering pipelines would be constructed, placed together in the same trench/ditch, when practical, and buried. Construction and installation of pipelines would occur immediately after well drilling. Access roads typically will follow the pipeline right-of-way, except in a limited number of cases where topography dictates or as surface owners require. Separate gathering lines will transport methane gas to production pod facilities and produced water away from wells to points where water discharge will occur.

Pod gathering lines, averaging two miles long, each are expected to disturb portions of 40-foot wide corridors, and will transport gas from each production pod to a trunkline. Separate trunklines, averaging six miles long each, will disturb portions of 50-foot wide corridors, and will transport gas to compressor stations.

Produced Water-Gathering System and Discharge Facilities

Based on the production characteristics from a composite of approximately 300 CBM production wells located within the project area (PI/Dwight's, 1998), water production is expected to average 12 gallons per minute (gpm) per well. This estimate of water production was compared to updated production characteristics from a composite of 638 CBM wells in the PRB, which average 10.4 gpm of produced water (PI/Dwight's, 1999) and to WOGCC production statistics for approximately 500 Wyoming CBM wells, which average 14.6 gpm of produced water (WOGCC, 1998a). For the purposes of this analysis, water production is expected to average 12 gpm per well over the life of the well.

This value will vary within the project area and throughout the life of a well, with slightly increased values occurring in the western portion of the area and at the beginning of a well's life. Water production, on average, would not be expected to exceed an estimated of 0.05 ac-ft/day/well (17,280 gallons/day/well). As anticipated development expands toward the western portions of the project area and deeper coal beds under greater pressures are developed, water production from CBM wells likely will increase and exceed the average water production for the project. Water production may decrease with time. The approximate productive life for each CBM well is 12 years (USDI BLM, 1996a). Produced water contains an average (mean value) of 764 mg/l Total Dissolved Solids (TDS) based on WDEQ discharge monitoring report data from 577 CBM effluent (discharge) samples reported to WDEQ between 12/31/93 and 12/31/97 (WDEQ, 1998a).

Produced water may be discharged from individual wells or collected and discharged at a multi-well central point. All produced water would be discharged only at NPDES permitted points. Produced water-gathering pipelines would be constructed along the well access road wherever feasible, from the wellhead to locations where water discharge will occur. These gravity-fed water lines would be placed together in the same trench/ditch as gas gathering lines wherever practical, and buried.

Produced water is expected to be discharged into surface drainages from pipelines that average one half mile in length and disturb portions of 30-foot wide corridors. Some discharged waters may be contained near the discharge point in small impoundments. Produced water is expected to average 12 gpm throughout a 12-year (previously estimated by BLM) to 15-year (possible) production life for each CBM well. Operators will be asked to develop water management plans where multi-well projects are planned. These plans will address how large volumes of produced water would be managed on a drainage-by-drainage basis.

There is likely to be an average of one water discharge point per three to six CBM wells. Several discharge points may be combined into each NPDES permit within the project area.

Gas Delivery System

High-pressure gas delivery lines connecting compressor stations with existing transmission pipelines are expected to be located along existing roads. Disturbance related to these delivery lines is expected to be confined to areas not wider than 40 feet, located within rights-of-way already established.

The pipeline capacity for the life of the project is estimated to be 1,095 million cubic feet per day (MMCFD). As the existing capacity (160 MMCFD as of the end of 1998) of pipelines already in place is reached, the least productive wells are likely to be taken off line until additional pipeline capacity is available. Production must be established before potential additional pipeline locations can be identified for site-specific environmental analysis. Existing and proposed high- pressure gas delivery lines are shown on **Map 2-1**.

Development will be constrained by the pipeline capacity available to transport compressed gas to markets. The total gas production for the number of CBM wells projected exceeds the existing pipeline capacity. As producing areas are depleted, compressors are likely to be removed and relocated to productive areas. Up to 11.4 MMCFD of gas may be utilized locally to generate electricity if the Two Elk Power Plant is constructed. The Two Elk Power Plant also may utilize some CBM produced water in its operations.

Pipeline Compression

Produced natural gas (methane) under wellhead pressure would move through the low pressure gas gathering system to a compressor station. Typical gathering system line pressure is less than 100 pounds per square inch (psi). Gas arriving at the compressor station would be compressed from line pressure to facilitate transport and introduction of the gas into an existing transmission pipeline.

The use of low horsepower (HP) (380 HP) natural gas or electric-powered boosters or blowers may be required to enhance gas flow through certain pipelines. Individual booster compressors may be located at some production pods. As of the end of 1998, 13 booster compressors were in use within the project area. The Proposed Action will require approximately 220 additional booster compressors. An additional 0.25 acre would be disturbed at each production pod where a booster compressor station is co-located with production pod facilities.

Compression of the gas at field compressor station would increase the pressure to an estimated 700 to 1,450 psi. In May 1997, 15 natural gas-fired compressor stations, containing 39 1500-HP engines and five 1000-HP engines were in use within the project area. The Proposed Action will require an estimated 34 additional field compressor stations, containing 56 additional compressors. It is anticipated that 1,500-HP and 1,000-HP natural gas-fired engines would drive 43 and 13 new compressors, respectively. One existing field compressor station ultimately is expected to contain six 1,000-HP engines and to produce a long-term disturbance of 20 acres. The remaining 48 field compressor stations each would support one to four 1,500-HP or one to six 1000-HP engines and each station would disturb approximately 1.5 acres. The Proposed Action also will require five new transmission pipeline compressor stations, which would contain a total of 18 1500-HP engines; each station would disturb approximately 3 acres. All compressors are expected to be housed within structures. Compressor stations are expected to be built along existing roads and are not expected to require any new roads or improvements to existing roads.

Anticipated Level of Activity and Project Life

The total project life, including production, is expected to be 12 to 20 years. The estimated initial development period (drilling phase) is 5 to 10 years. APDs for up to 400 federal wells could be approved by BLM in a given year. Twenty companies, on average, may have CBM development projects operating concurrently within the project area during the initial development period. Approximately 50 to 400 wells per year may be drilled by each Company. The minimum number of drilling rigs required to drill 400 wells annually would be twelve drilling rigs conducting drilling or completion operations concurrently for an estimated 200 to 300 days within a calendar year (the estimated period when weather and soil conditions are suitable for access to the well location and drilling or well completion operations). It is likely that the Companies would utilize, on average, an estimated 25 drilling rigs to allow for poor weather conditions, mechanical problems, and scheduling concerns.

Hydrologic Monitoring and Mitigation

An integral part of the Proposed Action is the hydrologic monitoring that detects impacts on other water users and provides data for control and operation of the Companies' CBM projects. Monitoring plans will address the following: objectives; standards; procedures; timeframes; data management; and groundwater and surface water monitoring.

Plans would address the following:

€ Monitoring required under the terms of NPDES discharge permits issued by the WDEQ, APDs approved by the WOGCC or surface management agency (BLM or FS) (**Appendix B**), groundwater or surface water appropriation permits approved by the WSEO, and on-location pit permits approved by the WOGCC;
€ Requirements for reporting on surface flows encountered during drilling to WOGCC; and
€ Requirements contained in any executed Water Well Agreement.

Plans for hydrologic monitoring and mitigation would be re-evaluated periodically by the authorizing agencies in collaboration with the BLM, other involved surface management agencies, WDEQ, WSEO, WOGCC, CBM operators, landowners, coal operators, and other downstream interests.

Whether production of methane occurs by encountering free gas trapped in the coal seam or by pumping water to reduce pressure and induce gas flow, it is possible that nearby water wells completed in the coal could experience a decline in hydraulic head (for example, an increase in the depth to the static water level in the well bore). If the decline in head were a significant part of the total available head at a particular water well, then that water well likely would experience a reduction in its capacity to deliver water (yield) and possibly an increase in the concentration of methane.

Monitoring has been occurring in the Gillette North CBM Project EA and Gillette South CBM Project EIS assessment areas to validate predicted impacts and to identify needed mitigation. This monitoring would be continued and expanded to cover the Wyodak CBM EIS assessment area. The Water Well Agreement, previously worked out by landowners and CBM operators as part of the Gillette North CBM Project EA and Gillette South CBM Project EIS, will be required to be offered to affected surface owners before federal APD's will be approved. BLM will continue to suggest that operators also make this agreement available to surface owners when developing private- and state-owned minerals. A copy of this agreement is contained in **Appendix D**.

The Water Well Agreement addresses monitoring of any properly-permitted water well that falls within the Circle of Influence (COI) of a CBM production well. This COI is defined as a one-half mile radius around a CBM well. The Water Well Agreement also addresses how the COI would be expanded, should there be interference with a water well within the COI. If no water well falls within the initial COI, the COI would be expanded to the next nearest water well. Impaired wells can be restored by reconfiguring, redrilling, installing a new well, or by other means.

If landowners do not accept the Water Well Agreement, a second option for water well mitigation will be used. As a second option, mitigation of these impacts in accordance with state water law will be accomplished. This would occur if water levels drop below the lowest point of diversion in the vicinity of the well and well yields are reduced below historic production levels. Mitigation under state law would be developed on a case-by-case basis, in consultation with the WSEO, the affected landowner, the operator, and the BLM. Possible ways in which mitigation could be accomplished at the cost of the operator are: temporary replacement with commercially-purchased water or water produced by the operator, or reimbursement to a well owner for increased pumping costs associated with a greater lift. Permanent replacement would be accomplished by drilling a replacement well.

Through the independent groundwater monitoring program being carried out by the BLM, information on lowered water levels (drawdown of the static water levels in wells completed within the coal seam) and on the status of the sand aquifers is being obtained and tracked. This information will enable the BLM to evaluate impacts. This information could be greatly supplemented if all monitoring information being gathered by operators were brought into one common database. The coal operators are carrying out this type of activity under the direction of the Gillette Area Groundwater Monitoring Organization (GAGMO).
The CBM operators report to the WSEO on an individual basis, but it is time restrictive for the WSEO to combine individual operator reports and plot combined drawdown curves. Combining information from CBM operators with that gathered by the BLM, the WSEO, and the coal operators would provide a comprehensive view of what is happening.

Because impacts to groundwater are of the highest concern in the project area, operators developing federal CBM will be required to join a group similar to GAGMO for the purpose of providing a common reporting method and database of their monitoring results. This group is called the Powder River Area Groundwater Monitoring Organization (PRAGMO) and was organized in April 1999 to collect and distribute CBM groundwater monitoring data. PRAGMO members will be required to provide a yearly combined drawdown map of the results of their CBM activities. This compiled and interpreted information, along with the comprehensive, uninterpreted data, will be furnished to the BLM and WSEO. The WSEO, BLM and the PRAGMO group are working to develop a coordinated set of monitoring standards, but until this work is completed, the following specific activities will be required.

Specific Monitoring Activities

Groundwater

The following monitoring would be required of the Companies. The data would be submitted to the BLM as well as the appropriate state agencies (WSEO, WDEQ, WOGCC) or BLM, as required by current permitting requirements.

€ Baseline static water levels, productive capacity, and methane concentration: for all properly- permitted water wells within the COI as defined by the Water Well Agreement in **Appendix D**.

€ Quarterly monitoring of static water levels and methane concentrations selected wells within and around the project area. The CBM operator would be required to submit a monitoring plan to the WSEO prior to pumping any water.

€ Periodic monitoring of static water levels in CBM production wells as required by the WSEO. Based on current WSEO requirements, it is expected that the WSEO would require the operator to submit monthly reports containing the following information in addition to static water level measurements for each CBM well: a) well name, permit number, and location; b) reporting dates, name of individual responsible for report, and method of measurement; c) total volumes of water and gas produced during the reporting period and cumulatively since reporting began; d) bottom of hole pressure build-up during a minimum 8-hour shut-in period once every 45 days; and, e) remarks or comments regarding data acquisition. These reporting requirements were established by the WSEO for CBM projects. If the WSEO modifies its CBM reporting requirements, then the revised WSEO requirements would apply here.

€ Monthly and cumulative monitoring of water production at each CBM production well.

€ Semi-annual monitoring or produced water discharges as required by WDEQ for NPDES permits.

€ Water quality analyses for surface flows encountered during drilling, as required by WOGCC.

The following monitoring would be continued by the BLM as a result of the Marquiss, Lighthouse, and Gillette North and Gillette South CBM projects to provide independent verification of hydrologic activities. Depending on federal budget availability, it may become necessary for the CBM operators to pay for some or all of this monitoring through cost reimbursement.

The BLM would conduct continuous monitoring of groundwater levels and gas pressure of selected wells completed in the coal and periodic (one to two months) measurement of methane concentrations at these wells. Several of these monitoring sites could include additional well(s) near the coal well completed in the next shallower sand(s) above the coal (less than 300 feet). Some of the well sets would include a coal completion well and a well completed in the next sand below the coal. If adequate existing wells are available, they may be substituted for some of the wells described in this analysis (or possibly added to the network). Additional wells would be required with the new development proposed in this EIS. The monitoring well schedule and final location of monitoring wells ultimately would be a function of the final CBM development scenario and schedule. The BLM would conduct the following sampling:

€ Periodic spot checking of measurements made by operators on their monitoring wells.

€ Periodic (one or two times per year) monitoring of additional water wells that operators are not monitoring, located farther from the project area.

€ Water quality sampling from selected monitoring wells on a semi-annual basis, analyzed for the constituents shown in **Table 2-3**.

BLM may convert additional stratigraphic test holes to monitoring wells as stratigraphic testing moves into areas that currently lack monitoring wells. Costs and scheduling would be negotiated on a well-by-well basis.

Table 2-3
Required Constituents for Water Quality Sampling from Monitoring Wells

Parameter	Unit
pH	Standard Units
Total Dissolved Solids (TDS)	mg/l

Electrical Conductivity	mhos/cm
Bicarbonate	mg/l
Chloride	mg/l
Sulfate	mg/l
Carbonate	mg/l
Fluoride	mg/l
Calcium	mg/l
Potassium	mg/l
Magnesium	mg/l
Sodium	mg/l
Arsenic	g/l
Barium	g/l
Boron	g/l
Cadmium	g/l
Chromium	g/l
Copper	g/l
Iron	g/l
Lead	g/l
Mercury	g/l
Selenium	g/l
Silica	g/l
Silver	g/l
Zinc	g/l

Notes:
mhos/cm = thousandths of unit of conductance per centimeter (2.54 centimeters = 1 inch)
mg/l = milligram per liter (1 mg = 1 ppm [part per million]; 1 liter = 0.264 gallons)
g/l = microgram per liter (1 g = one thousandth of a milligram or 0.001 mg or 1 ppb [part per billion])

Additional Monitoring Wells
In coordination with the WSEO, an adequate number of monitoring wells would be added to the existing monitoring wells that were established previously as part of the Gillette North CBM Project EA and Gillette South CBM Project EIS assessment and decision process (**Table 2-4**). Installation of the monitoring wells required under the Gillette South EIS and Gillette North EA progressed in 1998 with the addition of one new well pair and the finalization of one ongoing completion. The WSEO completed five monitoring locations (3 paired) and plans on completing a sixth in 1999. With the addition of these wells, there are few locations where the BLM is waiting on the completion of required wells (**Table 2-5**). This probably would satisfy BLM's immediate needs for monitoring wells under these two plans. The BLM still will need additional monitor wells for development outside these assessment areas. Well locations in areas north, west and south of the existing Gillette North CBM Project EA and Gillette South CBM Project EIS assessment areas (**Map 1-1**) are anticipated. The groundwater modeling used to analyze CBM development in this EIS would be used to determine specific well locations. Following is a list of general areas where additional monitoring information is needed:

- Areas north of T54N
- Areas west of R76W
- Areas south of T41N
- Areas west of R75W and north of T53N
- Areas west of R75W and south of T47N

Cost Share on Wells to be Monitored by BLM

Where suitable wells do not exist for monitoring, operators would be required to obtain access, permit, drill, and properly complete wells (including PVC casing, stainless steel screen where appropriate, sand pack where appropriate, logging, and cementing) where necessary, in relation to their projects. In addition, operators would provide and install necessary support facilities (shelter and fence) and would be responsible for the cost of the monitoring equipment as specified by the BLM. The BLM would provide requirements for instrumentation and equipment and would provide labor to monitor the wells.

Implementation of Monitoring

The monitoring well schedule and final locations ultimately would be a function of the CBM development scenario and schedule. If necessary, monitoring wells will be added as conditions of approval for APDs.

Table 2-4 (continued) Completed CBM Monitor Wells

Approximate Well Location	Target Zone of Completion	Comments
T53N R73W S21	COAL	Existing well Hall #33-2633
T53N R73W S21	OVERBURDEN SAND	Sand well of well pair.
T49N R73W S3	COAL	WSEO CBM MON #2
T49N R73W S3	OVERBURDEN SAND	WSEO CBM MON #2W
T49N R74W S36	COAL	WSEO CBM MON #1
T49N R77W S1	COAL	Gilmore O&G well acquired 3-98, plugged back and recompleted
T48N R73W S36	COAL	WSEO CBM MON #3
T48N R73W S36	OVERBURDEN SAND	WSEO CBM MON #3W
T48N R72W S22	COAL	Coal well of a set of wells completed for the Marquiss project.
T48N R72W S22	OVERBURDEN SAND	Overburden sand well of a set of wells completed for the Marquiss project.
T48N R72W S22	SHALLOW CONFINED SAND	Additional (shallower) overburden sand completed at this location to evaluate vertical leakage.
T48N R72W S22	UNCONFINED SAND	Unconfined (shallowest saturated) sand completed at this location to evaluate vertical leakage and recharge.
T48N R77W S12	COAL	Arco Federal 12-2. Drilled out bridge plug, plugged back and recompleted. (SASQUATCH)
T47N R71W S19	COAL	Existing (Cordero well).

T47N R72W S2	COAL	Coal well of a set of wells completed for the Marquiss project.
T47N R72W S2	OVERBURDEN SAND	Overburden sand well of a set of wells completed for the Marquiss project.
T47N R72W S7	COAL	Hoe Creek DOE project.
T47N R72W S7	OVERBURDEN SAND	Hoe Creek DOE project.
T47N R72W S36	COAL	Existing (Amoco well).
T47N R73W S16	COAL	WSEO CBM MON #4
T47N R73W S16	OVERBURDEN SAND	WSEO CBM MON #4W
T46N R72W S6	COAL	Existing (Cordero well).
T46N R72W S16	COAL	Use this existing Western Gas well for monitoring until replaced or no longer needed.
T46N R72W S25	COAL	Coal well of well pair
T46N R72W S25	OVERBURDEN SAND	Sand well of well pair
T45N R71W S6	COAL	Coal well of well pair
T45N R71W S6	OVERBURDEN SAND	Sand well of well pair
T45N R73W S1	COAL	Coal completion in a dual completion well.
T45N R73W S1	OVERBURDEN SAND	Sand completion in a dual completion well.
T45N R74W S36	COAL	WSEO CBM MON #6
T45N R75W S31	COAL	Shogrin Federal #2 acquired from Exxon 11-96.
T44N R71W S31	COAL	Coal well of three well set
T44N R71W S31	OVERBURDEN SAND	Overburden sand well of three well set
T44N R71W S31	UNDERBURDEN SAND	Underburden sand well of three well set
T44N R72W S14	COAL	Coal well of well pair
T44N R72W S14	OVERBURDEN SAND	Sand well of well pair
T42N R72W S36	COAL	Bowers 4-36

Table 2-5
Proposed CBM
Monitor Wells

Approximate Well Location	Target Zone of Completion	Comments
T54N R74W	COAL	Coal 1 of well set (3 wells total)

S4,5		
T54N R74W S4,5	COAL	Coal 2 of well set (3 wells total)
T54N R74W S4,5	OVERBURDEN SAND	Sand well of 3 well set
T43N R71W S21	COAL	Coal well of well pair
T43N R71W S21	OVERBURDEN SAND	Sand well of well pair. This location and installation was discussed with Darrel Metz of Barrett Resources, Feb 19, 1998.
T46N R74W S16	COAL	WSEO CBM MON #5

Surface Water
The following would be required of the operators:

€ Monitoring of volume and quality of produced water being discharged to the surface as required by the WDEQ under the terms specified in each NPDES permit, and as required by the WOGCC for surface flows encountered during drilling. If the State of Wyoming modifies its CBM reporting requirements, then the revised requirements would apply here.

€ Additional surface water stations may be needed on the Little Powder, Powder, Belle Fourche, and Cheyenne Rivers and/or their tributaries. This will depend on the location of discharge points, availability of existing data, and magnitude of the projected impact. The cost of this monitoring would be shared by the BLM and the CBM operators. With the projected budgets, it is anticipated that the operators would have to be responsible for most of this cost. The following would be conducted by the BLM:

€ Operation of a surface water gauging station on the Belle Fourche River and additional stations, as necessary, downstream of the area to be affected by surface discharge of produced water from the project area. In addition, the Cordero-Rojo Mine complex currently is operating a station on Caballo Creek.

€ Periodic sampling of water quality would be done at project area discharge points and analyzed as above (**Table 2-3**).

€ Selected channels receiving produced water would be monitored for signs of accelerated erosion and degradation.

At the BLM operated station(s), stream flow, water temperature, and electrical conductivity of the water would be continuously recorded. In addition, periodic manually collected samples would be analyzed for the constituents listed in **Table 2-3** with the addition of total suspended sediments (TSS).

ALTERNATIVE 1 - EXPANDED PROJECT AREA
Alternative 1 to the Proposed Action consists of drilling, completing, operating, and reclaiming approximately 5,000 new productive CBM wells and related production facilities in an expanded project area that includes all of the Proposed Action's project area (**Map 2-1**). This well total would be 2,000 wells more than the 3,000 wells planned under the Proposed Action. Up to 2,500 of the proposed 5,000 wells would be located on lands where CBM rights are owned by the federal government. This alternative was developed by BLM in response to expressions of interest in CBM development within additional townships extending north of the northern boundary of the Proposed Action and additional townships located along the western boundary of the Proposed Action. The area covered by Alternative 1 would total approximately 3,600 square miles (2,317,000 acres).

The overall approach and technical procedures for CBM development under Alternative 1 would be the same as described previously for the Proposed Action. Alternative 1 also would consist of those components described in detail for the proposed Action: a) road access for drilling operations; b) drilling operations; c) well production facilities; d) electrical distribution lines; e) power generation; f) production pods; g) pipelines (gas gathering system, produced water gathering system and discharge facilities, gas delivery system); and h) pipeline compression. Because the extent of development under Alternative 1 would be greater than the Proposed Action, the extent of activity and disturbance would be proportionally increased, with the exception of gas compression.

Comparable quantities of compression facilities would be anticipated under the Proposed Action, Alternative 1, and the No Action alternative, as the Companies' field-wide plans for orderly development of CBM resources in the PRB are initiated. The Companies' field-wide compression plans, currently under development, are not constrained by the scope of this EIS analysis and the number of productive wells under consideration here. The compression facilities that would adequately handle the gas volumes anticipated as CBM development continues were estimated in **Table 2-1**. Potential surface disturbance associated with CBM development under Alternative 1 is shown in **Table 2-2**.

Anticipated Level of Activity and Project Life

The total project life, including production, is expected to be 12 to 17 years. The estimated project life of the drilling phase is 3 to 5 years. APDs for up to 400 federal wells could be approved by BLM in a given year. Twenty companies may have CBM development projects operating concurrently within the expanded project area. Approximately 50 to 400 wells per year may be drilled by each company. The minimum number of drilling rigs required to drill 800 to 1,000 wells annually would be 24 rigs conducting drilling or completion operations concurrently for an estimated 200 to 300 days within a calendar year (the estimated period when weather and soil conditions are suitable for access to the well location and drilling or well completion operations). It is likely that the Companies would utilize an estimated 50 drilling rigs to allow for poor weather conditions, mechanical problems, and scheduling concerns.

The hydrologic monitoring and mitigation and prescribed activities defined for the Proposed Action also would be implemented under Alternative 1. The offer of the Water Well Agreement (**Appendix D**) to affected surface owners would be required before federal APD's would be approved.

NO ACTION ALTERNATIVE

CBM production would be established from an estimated 2,000 coal bed methane wells drilled within the project area, excluding lands with federal CBM ownership. Construction and operation of compressors would be required to move gas to the transmission pipelines. Drilling would occur over a five year period, with as many as 400 potentially productive wells being added each year.

These wells would be drilled anywhere within the project area evaluated under the Proposed Action (2,400 square miles), but only on lands where the CBM mineral estate is not federally owned. Approximately 50 percent of the project area (1,200 square miles) contains lands with federal oil and gas ownership. The remaining 1,200 square miles (approximately) of the project area would be available for drilling under the No Action Alternative. The average well density for new non-federal wells that are likely to be drilled under the No Action Alternative is estimated to be 0.8 well per square mile. Additional information is contained in **Table 2-1**.

Federal surface lands administered by the BLM or FS would not be expected to be affected by disturbance related to CBM drilling, since CBM drilling on lands where the oil and gas estate is federally owned would not be allowed under the No Action Alternative unless potential drainage of federal CBM resources were identified by BLM. Some federally-administered lands may be affected by disturbance related to installation of production facilities or pipelines for private wells drilled under the No Action Alternative. The nature of the disturbance would be similar to the disturbance proposed under the Proposed Action and Alternative 1 (**Table 2-2**).

The No Action Alternative is defined as the rejection of all applications for federal wells that do not involve potential drainage of federally-owned CBM resources. The CEQ regulations at 40 CFR 1501.14(d) require that alternatives analysis in the EIS "include the alternative of no action." The Secretary of the Interior's authority to implement a No Action Alternative is limited. Following is an explanation of this limitation and the discretion the Department has in this regard.

An oil and gas lease grants the lessee the "right and privilege to drill for, mine, extract, remove and dispose of all oil and gas deposits" in the leased lands, subject to the terms and conditions incorporated in the federal lease. Because the Secretary of the Interior has the authority and responsibility to protect the environment within federal oil and gas leases, restrictions are imposed on the lease terms.

Leases within the project area for the Wyodak CBM Project EIS contain various stipulations concerning surface disturbance, surface occupancy, and limited surface use. In addition, the lease stipulations provide that the authorized representative of the Department of the Interior may impose "such reasonable conditions, not inconsistent with the purposes for which the lease is issued, as the BLM may require to protect the leased lands and environment." None of the stipulations imposed would empower the Secretary of the Interior to deny all drilling activity because of environmental concerns where leases have been issued with surface occupancy rights.

Provisions that expressly provide Secretarial authority to deny or restrict lease development in whole or in part would depend on an opinion provided by the U.S. Fish and Wildlife Service (USFWS) regarding impacts to endangered or threatened species or habitats of species that are listed or proposed for listing (for example, bald eagle). If the USFWS concludes that the Proposed Action and alternatives would likely jeopardize the continued existence of any endangered or threatened plant or animal species, then CBM development, including APD(s) and related Sundry Notices, may be denied in whole or in part on the affected federal leases.

Regardless of development of federal minerals, development would likely proceed on private and state leases. Under these conditions, the No Action Alternative would likely consist of drilling, completing, and operating as many as 2,000 additional productive wells, 1,000 fewer wells than the Proposed Action, in the eastern PRB. The additional wells would be not be located within the federal CBM mineral estate; wells would be located only on lands having private or state CBM mineral ownership. As development of the private and state-owned CBM mineral estate is not subject to federal approval or the NEPA process, no boundary can be assigned for activities occurring on non-federal mineral estate. For the purpose of comparative analysis, the estimated 2,000 additional wells developing private and state minerals would be located within the Proposed Action project area boundary (**Map 2-1** and **Tables 2-1** and **2-2**).

ALTERNATIVES CONSIDERED BUT NOT ANALYZED IN DETAIL

A number of additional alternatives to the Proposed Action were considered for the Wyodak CBM Project but were not carried through the full analysis in this EIS for various reasons. These alternatives and the reasons they were not considered to be feasible are listed below.

Restrict Timing on Approval of Federal Wells

This alternative considered slowing the rate of approval for the estimated 1,500 federal wells included in the Proposed Action. It was not analyzed in detail because there is enough flexibility in implementing the Proposed Action to regulate the timing of approval for the estimated 1,500 federal wells. The decision to approve each well is based on the site-specific analysis completed for each APD. The rate at which federal wells are approved could be slowed down, but the mix of mineral ownership in the project area would lead to proportionally more wells being drilled on private and state leases to make up for the reduced number of federal wells approved. This could lead to drainage of gas from the federal CBM mineral estate.

Reduce the Number of Federal Wells Approved

This alternative considered the drilling of fewer than 1,500 federal wells. It was not analyzed in detail because there is enough flexibility in the implementation of the Proposed Action to approve fewer than 1,500 federal wells. Approving fewer than 1,500 federal wells could lead to drainage of federal gas as discussed above. The decision to approve each well is based on the site-specific analysis completed for that well's APD.

Inject Produced Water Underground

Underground injection to dispose of the produced water was considered as an alternative. Produced water from existing projects has been of relatively good quality. Total Dissolved Solids (TDS) levels have averaged 764 mg/l TDS for CBM water discharges reported to WDEQ (WDEQ, 1998a), well within Wyoming standards for livestock water. Disposal of produced water is limited to aquifers exempt from the definition of fresh and potable water (WOGCC, 1998b). Injection of this water into an exempt formation would make water now suitable for irrigation and livestock unusable for any future use. This action would mitigate potential surface water impacts but would create additional potential groundwater impacts. Injection into the coal seam would defeat the purpose of removing water from the coal seam to produce methane. Also, injection would require a system of wells and pipelines that would increase the total surface disturbance. Finally, because the produced water is suitable for livestock, wildlife, and possibly irrigation, surface disposal allows it to be put to subsequent beneficial uses.

CHAPTER 3

THE AFFECTED ENVIRONMENT

INTRODUCTION

The study area for the affected environment encompasses the same area, 3,600 square miles or 2,317,000 acres, as the expanded project area for Alternative 1. The smaller Proposed Action project area, 2,400 square miles or 1,538,000 acres, is wholly contained within the study area. The portions of the study area that are included only within the Alternative 1 expanded project area, approximately 1,200 square miles or 779,000 acres, occur along the western and northern flanks of the Proposed Action project area (**Map 1-1**).

The description of the affected environment focuses primarily on air quality, hydrologic, and hydrogeologic conditions in the study area because it is believed these aspects of the environment are the most likely to be impacted by the proposal. Other aspects of the environment have been discussed in the Buffalo RMP (USDI BLM, 1985), the BRA Oil and Gas EA (USDI BLM, 1980a), the West Rocky Butte Coal Lease Application EIS (USDI BLM, 1992f), the Jacobs Ranch Coal Lease Application EA (USDI BLM, 1991), the West Black Thunder Coal Lease Application EA (USDI BLM, 1992e), the North Antelope/Rochelle Coal Lease Application EA (USDI BLM, 1992d), the EA for American Oil and Gas' Marquiss CBM Project (USDI BLM, 1992a) the Lighthouse CBM Project EA (USDI BLM, 1995c), the Eagle Butte Coal Lease Application EA (USDI BLM, 1994b), the Antelope Coal Lease Application EA (USDI BLM, 1995a), the Gillette North CBM Project EA (USDI BLM, 1996a), the Gillette South CBM Project EIS (USDI BLM, 1997a), the North Rochelle Coal Lease Application EIS (USDI BLM, 1997b), the Powder River and Thundercloud Coal Lease Application EIS (USDI BLM, 1998i), the environmental analysis project record for the Horse Creek Coal Lease Application (USDI BLM, 1998a), the Land and Resource Management Plan for the Medicine Bow National Forest and TBNG (USDA FS, 1985), and the Oil and Gas Leasing EIS for the TBNG (USDA FS, 1994). There is additional detailed information on wildlife, soils, vegetation, air quality, surface water, groundwater, and cultural resources within the existing coal mine permit areas and associated buffer zones in original mining permit applications, in subsequent mining permit amendments and renewals, and in annual mine reports for the Buckskin Mine, Rawhide Mine, Eagle Butte Mine, Dry Fork Mine, Ft. Union/Kfx Mine, Wyodak Mine, Caballo Mine, Belle Ayr Mine, Cordero-Rojo Mine complex (formerly the Caballo Rojo and Cordero Mines), Coal Creek Mine, Jacobs Ranch Mine, Black Thunder Mine, North Rochelle Mine, North Antelope Mine, Rochelle Mine, and the Antelope Mine. All of these coal permit documents are required by state law. They are submitted to and approved by the WDEQ, Land Quality Division (LQD), and are available for viewing at the WDEQ offices in Sheridan and Cheyenne.

The critical elements of the human environment that would not be affected by the project, or are not known to be present within the study area, and will not be discussed further, are the following: areas of critical environmental concern, prime or unique farmlands, hazardous wastes, wild and scenic rivers, wilderness, and paleontological resources.

LOCATION

The Wyodak Coal Bed Methane (CBM) Project study area is located in northeastern Wyoming, within

Campbell County and small portions of Converse, Johnson, and Sheridan Counties. Approximately 31 percent of the study area has been analyzed in previous environmental impact assessments for CBM projects (Gillette North and Gillette South assessment areas). The additional portions of the study area (69 percent) are within the same demographic area and contain similar physiographic features.

The study area is a long rectangular area extending up to 110 miles in a N-S direction from the Wyoming-Montana border, and covering nearly 40 miles in an E-W direction at some locations. The eastern extent is defined by the areas of major coal development in eastern Campbell County. Gillette, Wyoming is located adjacent to the eastern boundary of the study area, just outside the area's eastern limit. Wright, Wyoming is located in the southern portion of the study area. Wyoming Highway 59 passes through the study area, connecting Interstate 90 at Gillette with Interstate 25 near Douglas, Wyoming.

PHYSIOGRAPHY AND TOPOGRAPHY
The study area is a high plains area within the eastern portion of the Powder River Basin (PRB). This basin is bounded by the Black Hills on the east, the Big Horn Mountains on the west, the Hartville Uplift on the south, and the Yellowstone River on the north. The western half of the study area includes the Powder River Breaks. Landforms of the area consist of a dissected, rolling upland plain, with low relief, broken by low red-capped buttes, mesas, hills, and ridges. Elevations range from 3,600 to 5,000 feet above sea level. The major river valleys have wide, flat floors and broad floodplains. The drainages dissecting the project area are incised, typically are ephemeral or intermittent, and do not provide permanent or year-round water sources. Underground coal seams are important aquifers in many parts of the study area, feeding springs and seeps. Drainage catchments and open basins are separated by scoria hills, ridges, and buttes.

The study area forms a low divide among several drainage systems. Northwestern and western portions of the study area, generally those areas west of Highway 50 and north of Highway 387, are drained by the north-flowing Powder River. The northeastern portion of the study area is drained by tributaries of the Little Powder River. The area east of Highway 50, located between the communities of Gillette and Wright, is drained by the Belle Fourche River and its tributaries. The areas south and east of Highway 387 are drained by the Cheyenne River.

GEOLOGY AND MINERAL RESOURCES
The study area is located along the eastern limb of the Powder River structural basin. The portion of the PRB situated within Campbell County is one of the major mineral development areas in North America. Coal, oil and gas, and uranium have been the principal resources extracted from the basin.
This north-south trending syncline was formed during the Laramide Orogeny (mountain building era) of the early Tertiary period of geologic time (about 60 million years ago) (WGS, 1996a). Basin sediments were derived from the Bighorn Mountains to the west, the Laramie Mountains and Hartville uplift to the south, and the Black Hills to the east. Geologic formations exposed at the surface within the study area are Quaternary alluvial deposits, clinker deposits, and the White River, Wasatch, and Fort Union Formations (Fms) (**Table 3-1**) (WGS, 1987 and 1990).

Table 3-1 Generalized Description of the Shallow Geology Within the Wyodak CBM Study Area

Formation	Description	Aquifer Characteristics
Alluvium	Unconsolidated and poorly consolidated Quaternary	Fine-grained alluvium usually

	alluvial deposits of silt, sand, and gravel. Underlies floodplains and low terraces. Thickness generally less than 50 feet (WGS, 1974).	yields a few gallons per minute, more in coarser deposits.
Wasatch	Arkosic sandstone, siltstone, shale, and conglomerate lenses with many coal beds present in the lower part (WGS, 1990). It dates from the Eocene epoch of the Tertiary period (37 to 58 million years ago). This formation is found at the surface throughout most of the project area south of Gillette as well as the area northwest of Gillette.	Discontinuous lenticular sands, fine- to medium-grained; generally supply provides adequate quantities for stock use.
	Thick shale layer, 10 feet or more thick occurring on top of the Wyodak coal.	Aquiclude (semi-impermeable layer).
	Wasatch/Fort Union Contact	
Wyodak coal	Coal, 50 to 100 feet or more thick.	Continuous, fractured coal seam.
	Shale layer commonly present at the base of the Wyodak.	Aquiclude (semi-impermeable layer).
Upper Fort Union (Tongue River/ Lebo)	Interbedded sandstones, siltstones, shales, and coals.	Sands fine- to medium-grained; Lebo is a leaky confining layer between Upper and Lower Fort Union.
Lower Fort Union/Tullock	Interbedded sandstones, shales, and coal.	Sands somewhat coarser than Upper Fort Union; sand at base of Fort Union (Tullock) is good producer and has regular industrial use.

Unconsolidated and poorly consolidated Quaternary alluvial deposits have been accumulating since the Pleistocene Epoch (Ice Age). They are found in the floodplains and low terraces of the larger streams draining the area (WGS, 1990). These deposits are comprised of silt to gravel sized material that has been eroded from siltstone, sandstone, conglomerate, and clinker within the PRB.

The White River Fm is composed of tuffaceous claystone and siltstone with conglomerate lenses near its base (WGS, 1987). It dates from the Oligocene epoch of the Tertiary period (24 to 37 million years ago). Within the study area, this formation is only found capping the Pumpkin Buttes, located in southwestern Campbell County.

The Wasatch Fm is composed of interbedded arkosic sandstone, siltstone, shale, and conglomerate lenses, and also contains many coal beds in the lower part (WGS, 1990). It dates from the Eocene epoch of the Tertiary period (37 to 58 million years ago). This formation occurs at the surface throughout most of the study area.

The Fort Union Fm is composed of interbedded sandstones, siltstones, shales, claystones, and coal. It dates from the Paleocene epoch of the Tertiary period (58 to 66 million years ago) (WGS, 1990). It occurs throughout the study area and is exposed at the surface within the northern third of the area, and along the eastern margin of the area. This formation has been divided into three members: Tongue River, Lebo, and Tullock.

The Tongue River member (the upper member of the Fort Union Fm) consists of approximately 600 feet of sedimentary deposits. It contains the Wyodak coal bed (also known as the Wyodak- Anderson or Anderson-Canyon coal bed) (USGS, 1986a), which is the primary target zone for the proposed CBM wells associated with this project. The methane contained in this bed (or seam) is present in a free state, adsorbed on interior pore surfaces and micropores of the coal matrix, and dissolved in water contained within the seam. Reducing the hydrostatic pressure on the coal seam by pumping off the water enhances the release and production of methane previously trapped in the coal matrix as well as gas dissolved in the water.

The Wyodak seam usually is between 60 and 70 feet thick and has a maximum thickness of approximately 100 feet. Within the study area this seam occurs at depths ranging from 200 to 1,000 feet below the surface, increasing in depth from east to west. The Wyodak seam is mined extensively in open pit mines located just east of the study area. Several less significant coal seams lie above and below this seam. North of Gillette, the Wyodak coal bed separates into upper Wyodak and lower Wyodak beds. South of Gillette, it separates into the Anderson and Canyon coal beds (USGS, 1986a). South of the Belle Fourche River, the Lebo Member is equivalent to the Lebo and Tongue River members in the northern part of the study area (USGS, 1988). Therefore, the Tongue River is not identified as a separate member in the southern part of the study area.

The PRB contains some of the largest accumulations of low sulfur sub-bituminous coal in the world. The coal is exposed at the surface in north-south oriented outcrops along the eastern boundary of the study area (USDI BLM, 1985). It occurs at depth, below the surface, throughout the remainder of the study area. This coal is valued for its clean-burning properties.

In the PRB and other regions where coal occurs at or near the surface, exposures of clinker can be associated with coal outcrops, marking the locations where coal has burned in place. Burning coal in the PRB is a natural process which has been going on for the last few million years, ever since erosion began to expose the coal beds (Coates, 1991). It has long been recognized that spontaneous combustion, as well as range and forest fires and lightning, causes coal outcrops to burn naturally, producing clinker.

Clinker exposures in the eastern PRB occur primarily along the eastern boundary of the study area in the Rochelle Hills, and within the Powder River Breaks in the northern portion of the study area. Clinker is commonly found at depth as far as several hundred linear feet away from where it is exposed at the surface. As coal burns, the burn front advances into the hillside until, with increasing depth, fissures in deposits overlying the coal fail to reach the surface. At that point, the supply of air is cut off, extinguishing the fire (Heffern and Coates, 1997).

Recent studies (Kim, 1977 and Kuchta et al., 1980) describe reactions that can raise the temperature of coal to the self-heating point. Self-heating occurs especially when coals are dry and the air is moist. The susceptibility of coals to spontaneous combustion increases with decreasing methane content (Kuchta et al., 1980). Among other compounds, methane reaching the surface can oxidize, producing carbon dioxide and water, and releasing heat in the process. Sarnecki (1991) noted that when water levels drop in unconfined coal aquifers, oxidation increases and the self-heating of coal accelerates until combustion occurs. Goodarzi and Gentzis (1991) described five geologic factors affecting the ignition of coal seams: 1) overburden thickness; 2) water saturation of the coal seam; 3) lithologic composition of the coal-bearing section; 4) morphology of the coal seam; and 5) rank and composition of the coal.

Heffern (1999) compares the characteristics of the San Juan Basin (SJB) of southwest Colorado and northwest New Mexico, with its coal fires, methane seeps, and high temperatures that have killed vegetation, and the PRB to evaluate the potential for coal fires and methane migration or seepage within the PRB. Although some similarities exist between the two basins, there are significant differences.

1. Basin pressurization and regional groundwater flow - The PRB is not an overpressured basin, as is the SJB. Groundwater flow in the PRB coal aquifer is downdip, to the northwest, toward the center of the basin (USGS, 1986b), rather than updip toward the outcrop.

2. Recharge from clinker - Unlike the SJB where there is little groundwater recharge or clinker at the coal outcrop, extensive deposits of porous clinker occurring in the PRB east of the coal mines trap rainfall and snowmelt and recharge the coal aquifer to the west (USGS, 1988; Peacock, 1997).

3. Coal characteristics - The bituminous coal in the SJB, while having less volatile matter, has developed better cleats and fractures than the sub-bituminous coal in the PRB. Due to its cleats, the SJB coal must be completely dewatered to achieve maximum production. The methane in the SJB is largely thermogenic, generated at depth from the high temperatures and pressures associated with burial. In the PRB, the methane is biogenic, and water is retained in the cell structure of the coal. In the PRB, overpumping of water from the coal could shut off methane flow if the cell structure collapses, rather than releasing methane (Selvig and Olde, 1953).

4. Basin structure - In the SJB outcrop area, where methane seepage occurs, it is confined to a much smaller area. Therefore, methane seepage may be more concentrated in the SJB than in the PRB. The SJB also is more highly deformed than the PRB and contains more faults and fractures that could serve as conduits for methane migration. Aubrey, et al. (1998) also notes the lack of substantial caprock in the SJB that would limit the flow of groundwater or methane migration.

5. Experience in existing mines - Mine fires are common in piles of coal fines and along the highwall in PRB mines, and are regularly extinguished. Since CBM development began, mine inspectors have not noted a significant increase or decrease in the number of fires in coal pits located east of the Marquiss and Lighthouse CBM projects where, to date, groundwater drawdown due to CBM development has been greatest. Moreover, the frequency of coal fires in these pits is similar to that for coal pits located some distance from CBM development.

Methane seepage can occur naturally in the vicinity of near-surface coal seams (Glass et al., 1987 and Jones et al., 1987). The potential for methane migration within the PRB is not limited to areas containing near-surface coal seams (areas near the coal outcrops along the eastern margin of the project area) or areas where dewatering has occurred. Methane migration potentially could occur at widespread locations within the PRB, as methane can migrate long distances along naturally-occurring joints or fractures in rocks. Whether methane seepage could accelerate the natural process of coal combustion at the outcrop is an unresolved question.

Most of the coal in the study area is federally-owned. These federal coal lands are within the Wyoming portion of the decertified Powder River Federal Coal Region (USDI BLM, 1998a).
There are sixteen active coal mines or mine complexes adjacent to the study area (**Map 1-2**). In 1998, 293 million tons of coal were produced from mines located in the vicinity of the study area (USDI BLM, 1999c) (**Table 4-10**).

Conventional oil and gas exploration and production also occur within the study area and other portions of the PRB. As of 1996, there were 44 fields and 407 producing conventional oil and gas wells (Dwight's, 1996). Currently producing formations underlying the Wyodak-Anderson seam include several from the upper Cretaceous: Parkman Sandstone, Sussex Sandstone, Teckla Sandstone, Niobrara Shale, and Turner Sandstone. Producing formations from the lower Cretaceous are the Mowry Shale, Muddy Sandstone, and Dakota Sandstone. The Pennsylvanian/Permian Minnelusa Fm is stratigraphically the lowest (oldest) producer.

Drilling for CBM resources within the PRB began in the 1980s. WOGCC production statistics for CBM begin with the year 1987. Drilling accelerated in 1997, and the number of productive CBM wells has doubled since 1997 (WOGCC, 1998a). As of July 1998, 822 CBM wells were producing throughout Wyoming (WOGCC, 1998a).

For the purpose of this analysis, an estimated 890 productive CBM wells are assumed to be in place within the study area as of the end of 1998. Production statistics for 420 productive wells were available for February 1998 (PI/Dwight's, 1998). Production statistics for 638 productive CBM wells were available for November 1998 (PI/Dwight's, 1999).

An estimated 3,000 CBM drilling permits were applied for in the PRB through 1998 (WOGCC, 1999). The large difference between well permitting and productive wells is typical of active hydrocarbon plays such as CBM development within the PRB. The difference between permitted wells and productive wells within the PRB can be attributed to the dynamic plans of operators participating in an active area, and productive wells temporarily shut in awaiting pipeline construction. The estimated ratio of total wells drilled to total productive wells is very high for CBM within the PRB.

The southwestern portion of the study area lies within the Pumpkin Buttes uranium mining district (WGS, 1974). The greatest tonnage of uranium mined within Campbell County was in 1960. Surface deposits in the Pumpkin Buttes area were depleted in the 1960s. Significant subsurface uranium reserves, associated with sandstones within the Wasatch Fm, remain within the district. One in-situ mine within the district, the Christianson Ranch Mine, produced 507,000 pounds of yellow cake in 1997 (WGS, 1999). It is located immediately west of the study area in T45N, R77W. Although there are currently no active mines or plans for new operations within the study area (WGS, 1985 and 1999), in-situ (in place) leaching of subsurface uranium is occurring adjacent to the study area. Three active in-situ operations are located in Converse and Johnson Counties.

WATER RESOURCES

Surface Water

The study area drains into the perennial Little Powder River, Belle Fourche River, Upper Cheyenne River, and Powder River drainages, which are all tributaries of the Missouri River (**Map 1-1**). The major river valleys have wide flat floors and broad floodplains. Tributaries in the study area are incised and drain areas of isolated, flat-topped, clinker covered buttes and mesas, 100 to 500 feet above the valley floors. The drainage density is higher in the northern, southern, and western portions of the study area than in the central portion of the study area. The tributaries are ephemeral with flow occurring in response to storm events and snowmelt.

The Little Powder River flows north, draining the northeastern part of the study area north of Gillette. Its tributaries, from upstream to downstream include Rawhide, Corral, Cow, Cottonwood, Spring, Wildcat, Horse, White Tail, Elk, Dry, and Olmstead Creeks. The Belle Fourche River flows generally to the northeast, through the southern half of the study area. Principal tributaries from upstream to downstream include All Night, Fourmile, Mud Spring, Wild Horse, Threemile, Hay, Rattlesnake, Coal, Dry, Caballo and Donkey Creeks. Upper tributaries of the Cheyenne River generally flow east or southeast. These include Antelope, Little Thunder, and Black Thunder Creeks. The western and northwestern portions of the study area include upper tributaries of the Powder River, which flow southeast to northwest in the study area from Pleasanton north. Tributaries include Beaver Creek, Dead Horse Creek, Barber Creek, Fortification Creek, Bull Creek, Deer Creek, Wild Horse Creek, Ivy Creek, Spotted Horse Creek, L-X Bar Creek, S-A Creek, and Bitter Creek.

The study area is semi-arid with average annual precipitation ranging from 11 to 16 inches. Approximately ten percent of the precipitation falls between December and February and thirty to forty percent occurs between June and August (Martner, 1986). The USGS has collected long-term flow information from some of the larger drainages. This information is summarized in **Table 3-2**. Surface water flow typically is expressed in cubic feet per second (cfs). One cfs is equivalent to 448.83 gallons per minute (gpm). Large flows or volumes of water often are expressed as acre-feet (ac-ft). One ac-ft is equivalent to 43,560 cubic feet or 325,829 gallons.

Contributing watersheds varied in size from 72 to 1,690 square miles in extent. Flows ranged from no flow to 10,300 cfs (approximately 4,623,000 gpm) along the Belle Fourche River, just east of the study area below Moorcroft. At many sites the minimum flow also was the daily median flow, reflecting the semi-arid character of the area. There is very little base flow contribution from groundwater for streams originating in areas underlain by the Fox Hills-Wasatch sequence (USGS, 1986c). Maximum flows occurred in May 1978, when the region experienced a flood of 0.5 percent probability, or a flood which occurs once every 200 years. The mean flows for larger drainages ranged between 0.66 cfs (approximately 300 gpm) for Raven Creek draining a 76-square mile watershed near Moorcroft, and 24.02 cfs (approximately 10,800 gpm) for the Belle Fourche River below Moorcroft.

Table 3-3 summarizes average annual runoff for USGS gaging stations for which data is available for ten years or more. The Little Powder River, Black Thunder and Little Thunder Creek drainages generate between 10 and 19.9 ac-ft of runoff per square mile. Donkey Creek and the drainages tributary to the Powder River yield between 20 and 49.9 ac-ft per square mile. The Belle Fourche drainages exhibit annual runoff volumes between 0 and 9.99 ac-ft per square mile (USGS, 1986c). These ranges of annual yields overestimate runoff within small watersheds, but broadly reflect the larger river basin. Average annual runoff ranges from 667 ac-ft per year on the Dry Fork at the Cheyenne River near Bill, Wyoming to 17,400 ac-ft per year at the Belle Fourche River below Moorcroft, Wyoming.

Storm flows have been calculated by the BLM from data acquired at USGS stations and from other sites for which daily data was available. This information is tabulated on **Table 3-4**. Many stream reaches have very nominal flows during 2- and 5-year, 24-hour storm events.

The water produced from wells typically is expressed in gallons per minute (gpm). One gallon is equivalent to 0.134 cubic feet. One gpm is equivalent to 0.002 cfs (approximately). The flows generated by the discharge of produced water into surface waters typically are expressed in cubic feet per second (cfs). One cfs is equivalent to 448.83 gallons per minute (gpm).

Table 3-2
Flow Statistics from USGS Gaging Stations in Wyodak Study Area

Station Name	**Station Number**	**Drainage Area (sq. mi.)**	**Period of Record**	**Count (n)**	**Mean Flow (cfs)**	**Median Flow (cfs)**	**Minimum Flow (cfs)**	**Maximum Flow (cfs) Date**
Little Powder River Basin								
Little Powder River Below Corral Creek Near Weston	06324890	204	08/31/77 - 09/30/83	2220	5.83	0.23	0	1620 05/18/78
Little Powder River Near Weston	06324925	540	09/01/77 - 10/07/81	1498	22.29	0.58	0	3130 05/18/78
Little Powder River Above Dry Creek Near Weston	06324970	1235	10/01/72 - 01/27/95	8154	19.34	2.30	0	5000 05/19/78
Belle Fourche Basin								

Belle Fourche Below Rattlesnake Creek Near Piney	06425720	495	10/01/75 - 09/30/83	2769	2.43	0.01	0	1060 05/19/78
Coal Creek Near Piney	06425750	71.8	10/01/80 - 09/30/83	1095	1.09	0	0	251 05/27/81
Belle Fourche Above Dry Creek Near Piney	06425780	594	10/01/75 - 09/30/83	2922	4.36	0.07	0	2150 05/18/78
Caballo Creek at Mouth Near Piney	06425900	260	08/31/77 - 09/30/83	2222	2.57	0	0	1500 05/19/78
Raven Creek Near Moorcroft	06425950	76	08/30/77 - 09/30/83	2223	0.66	0	0	213 03/20/78
Donkey Creek Near Moorcroft	06426400	246	08/31/77 - 10/08/81	1500	10.15	0.38	0	2530 05/19/78
Belle Fourche River Below Moorcroft	06426500	1690	10/01/43 - 09/30/96	15711	24.02	11	0	10300 05/19/78
Cheyenne River Basin								
Dry Fork Cheyenne River Near Bill	06365300	128	11/01/76 - 09/30/87	2525	0.83	0.08	0	631 05/18/78
Little Thunder Creek Near Hampshire	06375600	234	09/07/77 - 09/30/96	4773	1.88	0	0	1570 05/18/78
Powder River Basin								
Dead Horse Creek	06313700	151	10/01/71 - 09/30/90	6945	2.07	0.01	0	819 05/18/78

Source:USGS, 1998b

Table 3-3
Average Annual Runoff from Selected USGS Sites

Station Name	USGS Station Number	Average Annual Runoff (ac-ft)	Period of Record
Little Powder River Basin			
Little Powder River above Dry Creek near Weston	06324970	15,920	1973 - 1996
Belle Fourche Basin			
Belle Fourche River	06426500	17,400	1944 -

below Moorcroft			1996
Cheyenne River Basin			
Dry Fork Cheyenne River near Bill	06365300	667	1978 - 1981 1986 - 1987
Little Thunder Creek near Hampshire	06375600	1,370	1977 - 1996
Powder River Basin			
Dead Horse Creek	06313700	1,510	1971 - 1990

Source:USGS, 1986c and 1998b

Produced water from CBM development initiated in 1993 has supplemented stream flow in portions of the study area described in the Marquiss, Lighthouse, and Gillette North CBM Project EAs and the Gillette South CBM Project EIS (BLM 1992a, 1995c, 1996a, and 1997a). Point source discharges ranging from 0.04 to 0.22 cfs (approximately 17 to 100 gpm) per location are supplementing existing flows or wetting otherwise dry channels year-round.

The approximately 890 existing CBM wells in place as of the end of 1998 are expected to produce an estimated 23.8 cfs (an estimated 10,680 gpm) of water above that observed under natural flow conditions. This estimate is based on an average discharge of 12 gpm per well, over the life of the well, except in the Marquiss field where the average discharge per well is 17.5 gpm (Applied Hydrology Associates, 1999 and WDEQ, 1998a). Actual reported data for 420 producing wells averaged 11.44 gpm per well in February 1999 (PI/Dwight's, 1998).

The CBM generated flow from existing wells is confined in the following drainage basins: 1) Wyoming's Belle Fourche River (68 percent of CBM generated flow); 2) Little Powder River, WY and MT (29 percent of CBM generated flow); and 3) Wyoming's Cheyenne River (3 percent of CBM generated flow). None of the CBM generated flows drain west to the Powder River.

Table 3-4 (continued)
Predicted Storm Flows from USGS Gaging Stations1

Station Name	**Station Number**	**Drainage Area (sq. mi.)**	**Flow (cfs)**					
			2-year 24-hour	**5-year 24-hour**	**10-year 24-hour**	**25-year 24-hour**	**50-year 24-hour**	**1[illegible]**
Little Powder River Basin								
Little Powder River Below Corral Creek Near Weston	06324890 T52N, R72W - Section 14	204	0.22	1.4	4.9	16	42	[illegible]
Little Powder River Near Weston	06324925 T54N, R71N - Section 24	540	0.58	4.5	18	90	180	3
Little Powder River Above Dry Creek Near Weston	06324970 T57N, R71W - Section 13	1235	2.3	12	30	81	157.5	2

Belle Fourche Basin								
Wild Horse Creek2	T45N, R73W - Section 12	52	346	819	1,213	1,884	2,662	3,
Threemile Creek2	T46N, R72W - Section 27	41	317	748	1,110	1,724	2,403	3,
West Fork Hay Creek2	T44N, R72W - Section 11	6	131	310	467	725	1,026	1,
Hay Creek2	T46N, R71W - Section 30	96	439	1,037	1,530	2,377	3,294	4,
Rattlesnake Creek2	T46N, R71W - Section 8	10	173	408	612	950	1,338	1,
Belle Fourche Below Rattlesnake Creek Near Piney	06425720 T46N, R71W - Section 9	495	0.01	0.93	3	8.5	18	2
Coal Creek Near Piney	06425750 T46N, R71W - Section 2	71.8	0	0.25	1.1	5.1	11	1
Belle Fourche Above Dry Creek Near Piney	06425780 T47N, R70W - Section 30	594	0.07	1.6	5	15	36.5	7
School Section Draw2	T47N, R72W - Section 16	6	137	324	487	757	1,069	1,
Hoe Creek2	T47N, R72W - Section 2	59	365	864	1,278	1,985	2,670	3,
Caballo Creek at Mouth Near Piney	06425900 T47N, R70W - Section 9	260	0	0.52	2	8.3	18.5	3
Duck Nest Creek3	T48N, R72W - Section 36	8.34	120	350	530	800	1,200	1,
Tisdale Creek3 (above Caballo Mine Permit Boundary)	T47N, R71W - Section 7	13.5	289	773	1,199	1,883	2,462	3,
Raven Creek Near Moorcroft	06425950 T50N, R67W	76	0	0	0	1.1	3	6
Donkey Creek Near Moorcroft	06426400 T50N, R67W	246	0.38	1.6	5.9	20	85	2
Belle Fourche River Below Moorcroft	06426500 T50N, R67W - Section 17	1690	1	11	37	140	364	10
Cheyenne River Basin								
Dry Fork Cheyenne River Near Bill	06365300 T38N, R71W - Section 35	128	0.08	0.34	0.68	1.9	4.6	9
Little Thunder Creek Near Hampshire	06375600 T43N, R67W - Section 33	234	0	0.1	0.61	3.8	12	3
Powder River Basin								
Dead Horse Creek	06313700 T49N, R77W - Section 15	151	0	0.1	0.22	2.7	15	4

1USGS, 1998b
2 USDI BLM, 1997a
3 USDI BLM, 1992a after Carter, 1985 and Amax, 1988 The outflow of surface waters from the study area is reduced by losses due to evapotranspiration and leakage, which are assumed to be one percent of the flow per mile (WSEO, 1998a) with an upper recharge limit of five inches per year. This assumption presumes perennial flow in the drainage and a saturated channel bed. The outflow of surface waters generated from existing CBM wells is expected to yield an estimated 16 cfs (an estimate 7,180 gpm) of water at the study area boundaries above that observed under natural flow conditions. An estimated 19 percent of this outflow (3.1 cfs or 1,395 gpm) drains north toward Montana along the Little Powder River (**Table 4-1**). Approximately 77 percent of the outflow (12.3 cfs or 5,534 gpm) drains east into the Belle Fourche River. Roughly four percent of the outflow (0.6 cfs or 275 gpm) drains east-southeast into the Cheyenne River and its tributaries.

Channels are relatively narrow, with silt and clay bottoms that are grass covered in places (USDI BLM, 1997a). Natural stream flow results primarily from thunderstorms and snowmelt. The groundwater table is intercepted in many reaches; however, very little groundwater is contributed to stream flow. Established floodplains exist along the perennial Little Powder River, Belle Fourche River, Powder River, and along the Cheyenne River and its larger tributaries.

Surface water data (daily discharge, annual peak flow discharge, water quality, sediment, biology) are available from a few USGS stations near the study area. Mines located downstream have collected additional data. The following discussion of water quality was acquired from the Hydrology of Area 50, Northern Great Plains and Rocky Mountain Coal Provinces, Wyoming and Montana (USGS, 1986c). The general type of water found in Campbell County streams is a sodium sulfate. The water is hard due to the concentrations of calcium and magnesium. Surface waters are alkaline within Area 50 and have pHs ranging from 6.1 to 9; most pHs are greater than 8. Alkalinity is high, and exceeds 200 mg/l $CaCO_3$. Pyrite, the precursor of acid mine drainage is present, but high levels of alkalinity buffer the system to prevent acid mine drainage.

Sediment loads are elevated. Sediment concentrations increase in a direct relationship to flow, increasing downstream and during peak flow periods. Clay particles comprise between 38 and 97 percent of the sediment load.

Over 50 percent of the surface water stations had average and median dissolved solids concentrations greater than 2,000 mg/l. There is seasonal variability in an inverse relationship to flows that results in a ten-to-twenty fold difference in TDS concentrations between peak flow periods and low flow periods. TDS concentrations from the Little Powder River area vary between 1,200 mg/l and 3,600 mg/l. Data from stations on the Belle Fourche document TDS concentrations varying between 750 and 4,700 mg/l. Stations on the Cheyenne River record TDS concentrations between 500 and 3,550 mg/l.

Supplemental flows of CBM produced water are typically slightly alkaline, hard sodium bicarbonate waters (USGS, 1984). Total Dissolved Solids (TDS) levels have averaged 764 mg/l TDS for CBM water discharges reported to WDEQ (WDEQ, 1998a).

Manganese concentrations exceed the domestic secondary standard of 0.05 mg/l in 56 percent of samples. Iron concentrations exceed the domestic secondary standard of 0.3 mg/l in 3 percent of the samples. Manganese and iron can cause staining and bitter tastes. Neither metal is present in concentrations that would limit use for stock watering or irrigation.

Selenium concentrations from 381 samples ranged from less than 0.001 to 0.026 mg/l and do not appear to pose a threat to water quality in Campbell and Converse counties. Eight samples, or 2.1 percent of the samples acquired, exceeded the 0.01 mg/l standard for domestic waters.

Surface water quality in the area is generally suitable for livestock. **Table 3-5** shows water quality criteria as it relates to livestock, agricultural, and domestic use. **Table 3-6** contains water quality data from the Belle

Fourche River just downstream of the project area.

The State of Wyoming's Annual 305(b) Report to EPA (WDEQ, 1996) identifies limitations in use attainment from siltation and sediment, nutrients, TDS, flow, and habitat alterations. The rivers of Campbell and Converse Counties mirror that assessment with the primary contaminant in most surface waters being sediment. Sediment concentrations are naturally high in the plains streams within the basin and can be aggravated by human activities. Any surface-disturbing activity or activity which reduces watershed cover (vegetation) can increase erosion, influencing sediment concentrations and loads. The 305(b) report attributes the sources of pollution to overgrazing in rangeland and pasture land, cropland, and the construction of highways, roads, and bridges.

Table 3-5
Water Quality Criteria 1

Use Suitability	Constituent 2			
	Sodium	Chloride	Sulfate (mg/l)	Total Dissolved Solids
Livestock				
Good	---	---	<500	<1,000
Fair	---	---	500 -	1,000 - 3,000
Poor	2,000	---	1,000	>3,000
			>1,000	
Irrigation				
Good	<30% 3	<200	<200	<500
Fair	30 -	200 -	500	500 - 2,000
Poor	75%	550	200 -	>2,000
	>75%	>550	1,000	
Domestic	<115	<250	<250	<500

1Source:McKee and Wolf, 1963; USEPA, 1976; USGS, 1985.
2 All values are in mg/l unless as noted.
3 Exchangeable sodium percentage (ESP) is calculated from meq/l by the following equation as:
$$\frac{Na \times 100}{K + Na + Mg + Ca} \text{ (eq/l)}$$

Table 3-6 (continued)
Chemical Analyses of Waters from the Belle Fourche River below Rattlesnake Creek near Piney, Wyoming

Parameter	Unit	Number of Samples	Mean	Drinking Water Standard	Maximum	Minimum

SITE DESCRIPTION: Belle Fourche River below Rattlesnake Creek. Site located just below the Hilight Road. USGS Site ID 06425720.
LOCATION: North latitude 43-59-04, west longitude 105-23-16.
DRAINAGE AREA: 495 square miles.
PERIOD OF OPERATION: November 6, 1975 through April 13, 1983; and 1994 to 1996.

Water temperature	%C	59	12.31		23.5	0.0
Discharge	cfs	102	13.14		1,060.0	0.0
Specific conductivity	mhos/cm	43	3,962.00		8,000.0	1,100.0
pH	standard units	38	7.91	None	8.1	7.6
Total organic carbon	mg/l	5	9.64		16.0	6.4
Calcium *	mg/l	36	270.00		530.0	95.0
Magnesium *	mg/l	36	171.00		530.0	35.0
Sodium *	mg/l	36	400.00	None	1,200.0	100.0
Potassium *	mg/l	36	16.00		45.0	6.4
Chloride *	mg/l	36	20.00	250 (recommended)	55.0	4.1
Sulfate *	mg/l	36	1,957.00	250 (recommended)	5,400.0	510.0
Fluoride *	mg/l	36	0.45	1.4 - 2.4	0.9	0.2
Silica *	mg/l	36	3.80		9.4	0.2
Silver *	g/l	10	1.10	5	1.0	2.0
Barium *	g/l	4	87.50	1,000	100.0	50.0
Beryllium *	g/l	9	7.90	None	10.0	0.0
Boron *	g/l	36	151.00	None	810.0	50.0
Cadmium *	g/l	10	2.40	10	10.0	0.0
Chromium *	g/l	10	5.00	50	20.0	0.0
Copper *	g/l	10	3.10	None	7.0	1.0
Iron *	g/l	36	77.60	None	410.0	10.0
Lead *	g/l	10	3.90	50	21.0	0.0
Manganese *	g/l	14	234.00	None	800.0	59.0
Molybdenum *	g/l	5	2.20		4.0	0.0
Nickel *	g/l	10	3.40	None	6.0	1.0
Arsenic *	g/l	1	0.00	50	0.0	0.0
Strontium *	g/l	3	2,367.00		3,400.0	1,800.0
Vanadium *	g/l	4	0.325		1.0	0.0
Zinc *	g/l	10	20.40	50	40.0	4.0
Aluminum *	g/l	6	36.70		100.0	10.0
Lithium *	g/l	8	114.00		300.0	34.0
Selenium *	g/l	10	1.00	10	2.0	0.0

Uranium *	g/l	3	9.23		17.0	1.7
Total dissolved solids	mg/l	33	3,046.00	500 (recommended)	7,870.0	809.0
Mercury *	g/l	10	0.15	2	0.5	0.0

* Total dissolved.
Source: USDI BLM, 1997a

The State of Wyoming 1998 Section 303(d) (WDEQ, 1998b) lists identify waterbodies within the state which do not support all of their designed uses. Gillette Fishing Lake, located south of Gillette on Donkey Creek, a tributary of the Belle Fourche, has elevated levels of silt and phosphate which impair or are a threat to the warm water fishery. This was the only site identified within the project area.

Erosion occurs locally in three forms: sheet erosion, gully erosion, and channel/stream bank erosion. Sheet erosion usually can be managed by minimizing surface disturbance and maintaining a good vegetative cover. Gully erosion occurs in steeper terrain underlain by sedimentary rocks common in the plains portions of the area. The Wasatch and Fort Union Fms are particularly susceptible to gully erosion. This type of erosion is difficult to control once initiated. The gully growth is a function of water discharge magnitude and duration which is in turn a function of watershed slope and surface roughness or cover. Gullies can be controlled by controlling discharge and, conversely, sustained or reactivated through increases in discharge over the equilibrium state. Gully erosion follows a threshold pattern. Once gully erosion has occurred, even control of the discharge back to the previous equilibrium level will not stop the growth of the gully. Stream bank and channel erosion are controlled by stream dynamics. Changes in peak flows, sediment load, or base flow all can cause changes in channel morphology. Within most
drainages, sediment concentration increases in a downstream direction; however, sediment yield per unit area decreases. This decrease in yield per unit area is caused by decreasing gradients and wider, better-developed floodplains.

Surface water withdrawals within the study area totaled 36.94 million gallons per day (mgd). **Table 3-7** summarizes water use in 1990 (USGS, 1998a). The 1990 water year in the Powder River Basin saw runoff that was 50 to 70 percent of normal. Almost half of the water was used within the Belle Fourche River basin. Slightly less than half was used in that reach of the Powder River basin between Midwest and Arvada, Wyoming (USGS Hydrologic Unit 10090202). The data from this reach includes contributions from tributaries west of the Powder River, and does not include study area contributions to the Powder River in the far northwest portion of the area. Surface water consumption in the study area is predominantly associated with irrigation use (28.88

Table 3-7 (continued) 1990 Water Uses1 within the WYODAK Study Area

Category	**Little Powder River**	**Belle Fourche River**	**Antelope Creek**	**Upper Cheyenne River**	**Dry Fork Cheyenne River**	**Upper Powder River2**	**Project Area Totals**
Totals							
Withdrawals, groundwater	4.87	12.42	3.35	4.44	0.59	3.17	**28.84**
Surface water withdrawals	4.45	16.68	1.11	1.44	0.24	13.02	**36.94**
Total Withdrawals	9.32	29.10	4.46	5.88	0.83	16.19	**65.78**

Public Supply							
Groundwater withdrawals, fresh	0.12	4.20	0.00	0.00	0.00	0.00	**4.32**
Commercial							
Groundwater withdrawals, fresh	0.00	0.05	0.00	0.00	0.00	0.00	**0.05**
Surface water withdrawals, fresh	0.00	0.04	0.00	0.00	0.00	0.00	**0.04**
Domestic							
Self-supplied groundwater withdrawals, fresh	0.20	0.58	0.01	0.02	0.01	0.09	**0.91**
Self-supplied surface water withdrawals, fresh	0.01	0.03	0.00	0.00	0.00	0.00	**0.04**
Industrial							
Total self-supplied withdrawals, groundwater	0.00	0.26	0.00	0.00	0.00	0.00	**0.26**
Self-supplied surface water withdrawals, fresh	0.00	0.17	0.00	0.00	0.00	0.00	**0.17**
Mining use							
Total withdrawals, groundwater	4.22	6.83	3.30	4.37	0.56	2.99	**22.27**
Total withdrawals, surface water	1.18	1.91	0.93	1.22	0.14	0.84	**6.22**
Consumptive use, total	2.16	3.78	1.55	2.72	0.22	0.65	**11.08**
Livestock (stock) use							
Total withdrawals, groundwater	0.29	0.12	0.04	0.05	0.02	0.09	**0.61**
Total withdrawals, surface water	0.24	0.50	0.18	0.22	0.10	0.35	**1.59**
Irrigation use							
Groundwater withdrawals, fresh	0.04	0.38	0.00	0.00	0.00	0.00	**0.42**
Surface water withdrawals, fresh	3.02	14.03	0.00	0.00	0.00	11.83	**28.88**
Conveyance loss	0.30	4.24	0.00	0.00	0.00	4.73	**9.27**
Consumptive use, total	1.57	2.38	0.00	0.00	0.00	2.50	**6.45**
Reservoir evaporation3							
Reservoir evaporation	0.00	10.44	0.00	0.00	0.00	0.00	**10.44**

1Water use is expressed in millions of gallons per day (mgd).
2 The Upper Powder River Basin is USGS cataloguing unit 10090202 and is located between Midwest and Arvada, WY. This data does include contributions from tributaries west of the Powder River, outside the study

area. This reach of the Powder River does not include study area contributions to the Powder River in the far northwest portion of the area. The values in this column overstate water use of the Powder River within the study area.
3 Reservoir evaporation during 1990 is expressed in thousands of acre-feet.
Source: USGS, 1998a

For Reference:
One gallon = 0.134 cubic feet
One acre-foot = 43,560 cubic feet
There are 325,829 gallons per acre-foot mgd). Mining use totals 6.22 mgd. The public water supply for the 33,400 people living in the drainage basins in 1990 is acquired mainly from groundwater supplies.

Groundwater
Groundwater resources in Campbell County are derived from non-regional, Quaternary alluvial aquifers adjacent to rivers and aquifers within the lower Tertiary Wasatch/Fort Union Fms. Deeper, underlying regional aquifers include the following: the Upper Cretaceous Lance/Fox Hills; the Lower Cretaceous Dakota; and the Paleozoic Madison. These units represent the majority of the significant water-bearing strata; however, there are a few wells completed in formations which are included in "aquitard" groups. These are typically lower yield and poorer quality except near the outcrop. In addition to water supplies that can be developed from these aquifers, there are a few springs typically of the contact type, often at the base of exposed clinker. A generalized description of the Wasatch/Fort Union geology of this area is in **Table 3-1**.

The Wasatch/Fort Union aquifer group includes the Wasatch Fm and the Tongue River (which includes the Wyodak coal), Lebo, and Tullock members of the Fort Union Fm. The Wasatch sand aquifer forms the top of the Fort Union sequence. It is underlain by the Wyodak coal, the source of the coal bed methane for this project. The thickness of the shallowest of the bedrock aquifer systems in the PRB ranges to over 3,000 feet (Feathers et al., 1981).

Alluvial Aquifers
Alluvial aquifers consist of unconsolidated sand, silt, and gravel that underlie floodplains and the adjacent stream terraces. Thicknesses are usually less than 50 feet. Alluvium overlying Tertiary sediments (Fort Union and above) in the central part of the PRB is mostly fine-to medium-grained sand and silt. Coarser deposits occur in the valleys of the Belle Fourche, Cheyenne, Powder, and Little Powder rivers (USGS, 1973). Water yield from the alluvium is a function of grain size and grain-size distribution. Recharge results from surface infiltration and discharge from underlying strata. Local groundwater movement dominates in these systems, movement is along the drainage in a downstream direction.

Water quality in alluvium within the PRB is quite variable, with TDS concentrations varying from 100 to over 4,000 mg/l. Common ranges are from 500 to 1,500 mg/l (USGS, 1973). Analyses from eight wells completed in alluvium within the study area have TDS concentrations averaging 2,232 mg/l, and varying between 467 and 6,610 mg/l. Most waters have calcium or sodium as the dominant metal ion and sulfate on the dominant base ion. An area of sodium bicarbonate alluvial groundwater exists in the northeast portion of the study area (USGS, 1973).

Wasatch Aquifer
The Wasatch aquifer consists primarily of fine- to medium-grained lenticular sandstone beds and sand channels surrounded and interbedded with siltstone, shales, and coals. The thickness increases from east to west from 300 feet at the eastern boundary of the study area to over 1,000 feet at the western limit of the study area. Wasatch shales and siltstones generally do not yield enough water even for intermittent livestock use.

Wells completed in sandstone lenses or sand channels yield 10 to 50 gpm (approximately 0.02 to 0.1 cfs) in the northern portion of the study area. Wells completed near the southern portion of the PRB can yield as much as 500 gpm, which is approximately equivalent to 1 cfs, (USGS, 1988). Artesian conditions are common away from the outcrop particularly from deeper isolated sands. Recharge to the Wasatch Fm is through surface infiltration of precipitation and lateral movement of water from adjacent clinker and alluvium.

Natural discharge occurs at small seeps and springs along surface drainages. Local flow systems are predominant with discharge occurring along creeks and tributaries near recharge areas. Regional groundwater movement is toward the north but is extremely slow due to the fine-grained and discontinuous nature of most of the Wasatch sands.

The prediction of groundwater movement and chemical quality in the PRB can be complex and locally variable. Local leakage between aquifers can occur as a result of faulty well completion techniques and corrosion of casing in old wells where poor quality water initially was cased off (USGS, 1974). Furthermore, the PRB has been drilled extensively in the course of mineral exploration; inconsistent plugging of test holes also is a potential concern. Commingling of aquifers could occur to some degree within the study area.

Water types within the Wasatch Fm are predominantly sodium sulfate and sodium bicarbonate. There are some calcium or magnesium sulfate waters found in the eastern portion of the study area (USGS, 1973). Dissolved solids concentrations in 257 samples acquired from the Wasatch vary between 227 and 8,200 mg/l, have a median concentration of 1,010 mg/l, and have an average concentration of 1,298 mg/l (USGS, 1986c). Analyses from approximately 143 wells completed in the Wasatch, located in and near the study area, vary between 146 to 8,200 mg/l dissolved solids and have an average concentration of 1,415 mg/l (USGS, 1984).

Selenium concentrations can pose water quality risks in Wyoming. Geochemically, the primary source for selenium is volcanic emanations associated with volcanic activity. Sources of selenium in the study area are associated with secondary sources located in biological pools in which selenium has bioaccumulated (NAS, 1974). Shales have the highest concentration of selenium and are the primary source for selenium in the PRB (ASSMR, 1995).

Analysis of trace metals was conducted for approximately 33 wells completed in the Wasatch (USGS, 1984). Selenium concentrations in groundwater range from below the analytical method detection limits in 32 of the samples to 0.02 mg/l (USGS, 1984). The Quality Standards for Wyoming groundwaters identify acceptable concentrations of selenium for domestic, agriculture and livestock use as 0.01 mg/l, 0.02 mg/l and 0.05 mg/l, respectively. The detection limit in a number of the samples (1 mg/l) was greater than the standards. Selenium exceeded the drinking water standard in 4 of 159 samples compiled from the Powder River coal field. Dissolved selenium concentrations, ranging from 0.003 to 0.330 mg/l, reported in Selenium: Reclamation and Environmental Impacts, Special Symposium June 1995, have been recognized in shallow post mining groundwater (spoils) from coal mines in the PRB (USGS, 1988 and Naftz and Rice, 1989). The selenium concentrations in these areas probably result from exposure of crushed Wasatch overburden materials to oxidizing conditions. Oxidizing conditions decrease the stability of selenium-containing oxides and organic matter, resulting in increased selenium concentrations within backfill materials and waters discharging from them (ASSMR, 1995).

Fort Union Formation

The Tongue River Member of the Fort Union Fm contains seven to nine major coal seams (USGS, 1986a), and many discontinuous, lenticular sandstone layers. The Wyodak coal bed has been correlated in many parts of the PRB and has been given different names in different parts of the basin. The coal bed has been called the Wyodak-Anderson or the Wyodak-Canyon coal bed. North of Gillette, the Wyodak coal bed splits into an Upper Wyodak and a Lower Wyodak. In places, the Upper Wyodak separates into the Smith, Swartz, and Anderson coal beds, and the Lower Wyodak separates into the Canyon and Cook coal beds. To the south and west of Gillette, the Wyodak separates into the Anderson and Canyon coal beds. Coal beds equivalent to the Wyodak are tentatively correlated in the vicinity of Sheridan on the western side of the PRB. Recent work by the USGS indicates that the Wyodak combines with other coals to form a 200-ft thick coal seam known as the Big George at a depth of over 1,000 feet in western Campbell County. For ease of reference in this report, the main coal seam that is the target of CBM development will be referred to as the Wyodak, and where it splits into two distinct seams they will be referred to as the Upper and Lower Wyodak.

The Wyodak coal occurs at the top of the Fort Union sequence and is the most continuous hydrogeologic unit in the study area. Water in the Wyodak coal bed away from the outcrop is confined between a basal shale of the overlying Wasatch Fm and a thick shale sequence underlying the coal bed (USGS, 1988). The determination that the coal is a confined aquifer away from the outcrop is further documented by the USGS (1986c) and in various mine permit application packages (PAPs) on file with the WDEQ/LQD. Artesian conditions exist away from the outcrop. The aquifer consists of the Wyodak and associated coals, where the Wyodak splits and separates into multiple seams, interbedded sandstones, and clinker beds. Flow of water in the aquifer is affected in places where the coal seam splits and is interbedded with claystone, shale, and sandstone. Flow in the aquifer also is affected by differences in aquifer properties, caused by varying pattern and degree of fracturing in the coal and by faulting. The permeability of the coal-bearing bed is a function of fracturing. The coal is not isotropic (uniform), and the flow occurs in fractures within the coal. Wells completed within coal generally yield from 10 to 50 gpm (approximately 0.02 to 0.1 cfs) (USGS, 1975). Recharge occurs primarily along the clinker outcrop areas with a small amount of leakage from the overlying Wasatch Fm.

Recharge and discharge also occur locally, where coal underlies valley fill deposits (USGS, 1988). As more operating mines are reclaimed, reclaimed mine areas may become recharge areas for adjacent, undisturbed Wyodak coal. Regional flow is to the northwest and away from the recharge areas, as indicated by the potentiometric surface map prepared by Daddow (USGS, 1986b). In the southern portion of the study area, water flow is to the north, moving toward local discharge areas where Antelope and Porcupine Creeks cross coal outcrops (USGS, 1988). Local flow patterns may differ from regional flow.

Available data suggests that near-surface Fort Union wells do not show a dominant water type but consist primarily of calcium or magnesium sulfate water. As depth increases below 100 feet, calcium and magnesium ions are replaced by sodium and bicarbonates. The predominant water types of existing water wells within the Fort Union Fm consist primarily of sodium bicarbonate and to a lesser extent sodium sulfate (USGS, 1973). Wells penetrating coal seams or other carbonaceous deposits often yield both water and gas (primarily methane).

Solute concentrations within the Fort Union Fm are variable. The average concentration for 73 samples in the study area from the Fort Union Fm is approximately 1,350 mg/l (USGS, 1984). The best quality water typically is obtained from clinker areas. Water from coal beds typically contains 1,000 to 2,000 mg/l TDS (USGS, 1974). The quality of water contained in the coal seam is described in various coal mine PAPs and annual monitoring reports on the file with WDEQ/LQD, and was summarized by the USGS (1988). Based on 379 samples from the Wyodak-Anderson coal aquifer, the median concentration of TDS is 1,310 mg/l. Baseline data from the Rocky Butte Mine lists average TDS concentrations of 1,210 and 2,120 mg/l, reported by Carter and Wyodak, respectively (USDI BLM, 1992f).

Produced water contains an average (mean value) of 764 mg/l Total Dissolved Solids (TDS), based on discharge monitoring report data for 577 CBM effluent (discharge) samples reported to WDEQ between 1/31/93 and 12/31/97 (WDEQ, 1998a) (**Table 3-8**). Specific conductance of water from 32 discharge points in the Marquiss and Lighthouse CBM fields averaged 560 mg/l (ranging from 375 to 710 mg/l for 153 samples, assuming TDS is roughly equivalent to 0.667 times the specific conductance (USDI BLM, 1991). Available monitoring results are not very conclusive as to whether TDS levels within discharged CBM waters vary geographically in any pattern. Preliminary analysis of monitoring results reported to WDEQ suggests that TDS levels may be higher in some northern portions of the study area than levels observed within the Marquiss and Lighthouse areas south of Gillette. These CBM monitoring results also suggest that reported TDS levels in discharged CBM waters are lower than solute concentrations that typically have been documented within the Ft. Union Fm (see above).

Analysis of trace metals was conducted for approximately 31 wells completed in the Fort Union (USGS, 1984). Selenium concentrations in groundwater range from below the analytical method detection limits in 29 of the samples to 0.020 mg/l. However, the detection limit in all of the samples was above the most stringent guidelines within the Quality Standards for Wyoming Groundwaters (0.01 mg/l).

Table 3-8 Statistical Summary of WDEQ Discharge Monitoring Report Data (12/31/93 - 12/31/97)

	Flow		EC	TDS1	pH	Radium 226	TPH
	mgd	gpm	mhos /cm	mg/l	S.U.	pci/l	mg/l
Mean	0.05	34.6	1146	764	7.2	<0.44	<0.529
Standard Error	0.0028		22.70	22.70	0.014	0.0489	0.015
Median	0.03	23.3	992	662	7.2	<0.20	0.500
Minimum	0.00	0.0	110	73	5.7	<0.20	0.000
Maximum	1.14	791.5	6380	4255	8.7	10.60	8.400
Count	569	569	577	577	580	350	576.000
Confidence level (0.95)	0.0055	0.0055	44.49	44.49	0.028	0.0959	0.029

1TDS values derived from multiplying conductivity values by 0.667.
Source: WDEQ, 1998a.

Table 3-9, after Lowry and others (USGS, 1986b), shows trace metal concentrations in groundwater within Coal Area 50, the PRB, which includes all of the study area. This table shows manganese and iron concentrations exceeding secondary domestic standards with some frequency, but also shows a median concentration for all samples acquired that is less than the secondary domestic standard. Water containing manganese and iron concentrations that have been measured in the study area can be used safely for irrigation or stock watering.

Tongue River/Lebo Aquitard

The Tongue River/Lebo consists of sandstone lenses contained in a predominantly shale and siltstone matrix (USGS, 1988). Thick coal beds occur in the upper part of the Lebo Shale member (USGS, 1974). Wells in the Tongue River/Lebo unit typically yield adequate quantities of water for domestic and livestock use if a sufficient thickness of saturated sandstone is penetrated. The shales underlying the Wyodak coal in the vicinity of the existing mines act as a confining layer, providing partial isolation of the coal from underlying strata. Stratigraphically lower aquifers are partially isolated from impacts resulting from dewatering associated with mine activities and CBM production in the Wyodak coal aquifers. As with other Fort Union aquifers, recharge is primarily from inflow at outcrop areas. Groundwater generally flows north. Water quality for the Tongue River/Lebo is as described above for the Wyodak coal aquifer.

Tullock Aquifer

The Tullock aquifer consists of fine- to medium-grained sandstone layers and thin coal seams interbedded with siltstone, shale, and carbonaceous shale (USGS, 1988). The sandstone layers in the Tullock tend to be somewhat coarser and more massive than the overlying Tongue

Table 3-9
Trace Metal Concentrations of Groundwater In Coal Area 50

Dissolved Trace Metal	Number of Analyses	Number of Analyses Exceeding Drinking Water Standards	Percent of Analyses Exceeding Drinking Water Standards	Drinking Water Standards (mg/l)	Median Value (mg/l)	Maximum Analyzed Value (mg/l)
Arsenic	154	1	0.6	0.05a	0.001	0.120
Barium	95	1	1.0	1.0a	0.100	1.100
Cadmium	165	1	0.6	0.01a	0.002	0.017
Chromium	116	0	0.0	0.05a	0.010	0.050
Copper	123	0	0.0	1.0b	0.001	0.104
Iron	366	56	15.3	0.3b	0.100	120.0
Lead	165	6	3.6	0.05a	0.002	0.180
Manganese	257	100	38.9	0.05b	0.040	4.800
Mercury	122	0	0.0	0.002a	0.000	0.0015
Selenium	159	4	2.5	0.01a	4	0.031
Zinc	141	0	0.0	5.0b	0.001	1.800
					0.020	

Source:USGS, 1986.
a National interim primary drinking-water standards (USEPA, 1977).
b National secondary drinking-water regulations (USEPA, 1979).

River/Lebo members of the Fort Union Fm. The Tullock is separated from the overlying members of the Fort Union Fm by a leaky confining layer (Lebo shale). The Tullock is exposed in the west along the Bighorn Uplift and in the east, east of the Little Powder River, in a series of dissected ridges (USGS, 1987). Water yields of 200 to 300 gpm (approximately 0.4 to 0.6 cfs) are available from the Tullock, making this zone attractive for municipal and industrial uses. Most wells for mine facilities are completed in this aquifer. Recharge to the Tullock results from leakage through overlying strata and infiltration along the outcrop areas.

Water Use
Groundwater consumption in the study area averages 28.84 million gallons per day or 32,300 acre- feet per year (**Table 3-7**) (USGS, 1998b). More than 40 percent of this consumption is in the Belle Fourche River watershed. Mining related withdrawals associated with pit dewatering and operational consumption account for 77 percent of the groundwater use in the study area. All water for domestic consumption is derived from groundwater supplies predominately from the Tullock aquifer. Over 90 percent of domestic consumption occurs in the Belle Fourche River Basin, where most of the population resides. Stockwatering and irrigation uses of groundwater accounted for slightly more than one million gallons per day in 1990.

CBM water withdrawals were not significant in 1990, and therefore, are not included in the table. However, approximately 890 productive CBM wells are in place as of the end of 1998. Produced water from the Fort Union aquifer averaged 6.92 million gallons per day based on actual reported production from 420 wells, February 1998 (PI/Dwight's, 1998).

The Wasatch and Fort Union aquifers are the most important local sources of groundwater in the PRB (Feathers et al., 1981). They are developed extensively for shallow domestic and livestock wells. Domestic and livestock wells usually are low yield, (less than 25 gpm or 0.05 cfs), intermittent producers. Water suitable for domestic and livestock uses typically can be found less than 1,000 feet below the surface. Industrial water wells are used primarily to obtain water for use in subsurface injection that promotes secondary recovery of petroleum. At coal mines these wells are used for drinking water and dust abatement. Municipal water supply wells in the project area are predominantly associated with the City of Gillette's use of the Tullock aquifer. Municipal water use in Gillette exceeds two million gallons annually (USGS, 1973).

There are more than 10,000 WSEO-permitted water wells in and around the study area (T40-58 N R70-75W; T45-56N R76W; and T48-52N R77W) of which approximately 3,600 have been canceled or abandoned. Of the remaining approximately 6,900 wells, approximately 4,000 are monitor wells. The list is too lengthy to include in this document but is available at WSEO. The remaining approximately 2,900 wells are used for domestic, industrial, irrigation, municipal, reservoir and stock purposes. The water well location data for all permitted water wells in Wyoming is available from the Wyoming State Engineers Office (WSEO, 1998b and 1999). **Table 3-10** summarizes groundwater use in the Wyodak study area in 1990.

Table 3-10
1998-1999 Data on Type and Number of Wells in the Wyodak Study Area
(T40-58 N R70-75 W; T45-56N R76W; and T48-52N R77W)

Primary Use	**Number of Wells**
Monitor, Miscellaneous, Dewater	3,966
Domestic	510
Industrial	195
Irrigation	25
Municipal	28
Reservoir	22
Stock (not including CBM)	2,163
Unknown	16
TOTAL	6,925

6/10/1998 and 2/1/99 Listings
Source: WSEO, 1998b and WSEO, 1999

CLIMATE
The climate of the eastern PRB is semi-arid with average annual precipitation ranging from 11 to 16 inches. In the study area, 30 percent to 40 percent of the annual precipitation usually occurs in June, July, and August. Only 10 percent of the annual precipitation occurs in December, January, and February (Martner, 1986).

Average annual temperature for the study area is approximately 46%F, with July being the warmest month and January the coldest (USDI BLM, 1997a). Lake and pan evaporation rates are 42 and 60 inches per year, respectively (USDC NOAA, 1979).

The wind data provided by the Air Quality Division of WDEQ for the Hampshire Energy project, shown on **Figure 3-1**, is representative of the study area. Regionally, winds typically come from the northwest and southeast with a secondary maximum from the southwest. Average annual wind speeds range from 9.2 to 13.1 miles per hour, with the highest wind speeds occurring in the winter and spring when gusts frequently reach 30 to 40 miles per hour (USDI BLM, 1979).

AIR QUALITY
In the vicinity of the study area, the main sources of air pollution are natural sources of dust, vehicle traffic, surface coal mines, power plants, and various sources associated with oil and gas production facilities and

pipelines. Vehicle traffic is responsible for tailpipe emissions, which consist mainly of nitrogen oxides (NOx) and carbon monoxide (CO), and for the emission of fugitive dust from paved and unpaved surfaces. The main pollutants of concern associated with surface coal mining are fugitive dust from vehicle traffic and earth moving activity and NOX from mining vehicles, blasting, and coal transport trains. Fossil fuel-fired power plants, compressor stations, and large generators produce emissions of NOX, sulfur dioxide (SO2), CO, particulates (TSP, and PM10), volatile organic compounds (VOCs), and smaller amounts of other pollutants.

National and State of Wyoming Ambient Air Quality Standards have been developed to determine the maximum concentrations of a pollutant in the air to protect the public health and welfare with an adequate degree of safety. The pollutants of concern for the Wyodak CBM project are nitrogen dioxides (NO2), carbon monoxide (CO), and inhalable particulates with an aerodynamic diameter of less than 10 microns (PM10). The standard established for nitrogen dioxide (NO2), shown in **Table 3-11**, is 100 g/m3 as an annual average. The standards established for CO are 40,000 g/m3 as a one-hour maximum and 10,000 g/m3 as an eight-hour maximum. PM10 has an annual average standard of 50 g/m3 and a maximum 24-hour value of 150 g/m3.

The air quality of the study area is generally good, especially considering the level of mining development and oil and gas operations within and near the area. PM10 has been monitored continuously at the School Administration Building in Gillette, Wyoming since 1991. The Gillette data is representative of the study area because it is very close to the geographical center of the study area and is close to many of the existing sources of pollutants. PM10 was also monitored at the same location from 1985 through 1987. Figure 3-1 Representative Windrose Wyodak CBM Project - Hampshire Energy

Table 3-11
National and Wyoming Air Quality Standards

Air Pollutant	**Averaging Period**	**Wyoming AAQS (g/m3)b**	**NAAQSa (g/m3)b**
(PM10)c	24-hourd	150	150
	annuale	50	50
Nitrogen dioxide	annuald	100	100
Sulfur dioxide	3-hourd	1,300	---
	24-hourd	260	365
	annuale	60	80
Carbon monoxide	1-hourd	40,000	40,0 00
	8-hourd	10,000	10,0 00

aNational ambient air quality standard.
b (g/m3) = micrograms per cubic meter.
c Respirable particulate matter (less than 10 microns in diameter) which can penetrate deep into the lungs and cause health problems.
d May not be exceeded more than once per year.
e Arithmetic mean may not be exceeded

The terrain in the study area has low topographic relief. There are few physical constraints to pollutant dispersal. Pollutants are likely to disperse freely in all directions. Though there are few topographical obstructions that hamper pollution dispersion, the area frequently experiences temperature inversions caused by low mixing heights and low wind speeds that hinder pollutant dispersion below mixing heights (PEDCo, 1983).

Visibility of more than 60 miles is common in the project area and has been documented (USDI BLM, 1995b). Significant reductions in visibility are related to weather conditions associated with high relative humidity, such as fog, haze, rain, and snow.

As shown on **Table 3-12**, the PM10 annual average ambient concentration ranged from 16.1 micrograms per cubic meter (g/m3) to 17.7 g/m3 during 1991-1997. These values are 34 percent and less of the applicable annual average standard of 50 g/m3 (**Table 3-11**). Generally, the maximum 24-hour values have been less than 50 percent of the applicable standards. The highest 24-hour value during 1997 was 120 g/m3 associated with a period of high dust generated on unpaved roads. The second highest value during 1997 was only 27 g/m3.

Table 3-12 Wyodak Study Area Gillette Ambient Pollutant Concentration Data

Year	PM10 Annual Mean (g/m3)	PM10 24-hour Maximum (g/m3)	Year	NO2 Arithmetic Average (g/m3)	Black Thunder Mine	Belle Ayr Mine
1986	18.2	36	1975	6		
1987[1]	28.0	42	1976	4		
1991	17.7	27	1977	4		
1992	16.1	34	1978	11		
1993	17.2	36	1979	11		
1994	16.4	34	1980	12		
1995	16.1	75	1981	14		
1996	16.5	46	1982	11		
1997	16.8	120[2]	1983[3]	17		
			1996[4]	13	13	16
			1997[5]	28	23	33

1Monitoring discontinued July 1987. Reactivated September 1991.
2 Road dust impact. Second highest value in 1997 was 27 (g/m3).
3 Monitoring discontinued December 1983. Reactivated March 1996 to April 1997.
4 1996 arithmetic average March to December.
5 1997 Arithmetic average January to April.
Source: WDEQ, 1997

The NO2 monitoring was discontinued after 1983 at Gillette. The WDEQ re-activated the monitoring program at Gillette in March 1996. The average for the entire period was 16.5 g/m3. The WDEQ discontinued the monitoring in May 1997. During this same period, NO2 data were also collected at the Belle Ayr Mine and the Black Thunder Mine (**Figure 3-2**). The period averages for these mines were consistent with the Gillette data. The average for the entire period at the Black Thunder Mine was 15.6 g/m3, while the Belle Ayr data showed an average of 19.4 g/m3.

SOILS

A general soil association map for Wyoming has been published in a digital format by the U. S. Department of Agriculture's (USDA) Natural Resources Conservation Service (NRCS). The State Soil Geographic Database (STATSGO) (USDA NRCS, 1995) was designed primarily for regional, multistate, river basin, state, and multi-county resource planning, management and monitoring.

Figure 3-2 NO2 Monitoring at Gillette, Wyoming - March 1996 to April 1997 STATSGO is intended to give a general overview of soils distribution and occurrence in the planning area, and is not suitable for site specific evaluations. More detailed information is available from the NRCS office in Gillette.

The distribution and occurrence of soils can be highly variable and is dependent on a number of factors including slope, geology, vegetation, climate and age. The general soils information presented in the STATSGO database is summarized below in **Table 3-13** and soil unit mapping for the study area is presented on **Map 3-1**. Twenty-four general map units (associations) comprised of 38 soil series are present in the area. The percentage of the study area occupied by each map unit also is included in the table.

The predominant soil mapping units based on acreage within the proposed study area are:

€ WY130 Renohill-Bidman-Ulm (21.0 percent)
€ WY050 Shingle-Taluce-Kishona (22.2 percent)
€ WY126 Hiland-Vonalee-Maysdorf (10.0 percent)
€ WY128 Renohill-Cushman-Cambria (10.5 percent)
€ WY125 Shingle-Theedle-Wibaux (8.1 percent)
€ WY129 Bidman-Parmleed-Renohill (7.6 percent)
€ WY124 Platsher-Kishona-Parmleed (6.7 percent)

The area occupied by these seven soil map units comprises 86 percent of the study area. The remaining 17 map units occupy 14 percent of the study area.

Key soil characteristics related to erosion and salinity, and the soil's rating of suitability for use in reclamation are presented by soil series for each of the seven dominant soil mapping units shown in **Table 3-14**.

Slope and K-factor are factors that are used in the estimation of soil erosion potential.

Hydrologic soil groups are used in watershed planning to estimate runoff from rainfall. The hydrologic group is based on the infiltration rate of a soil after prolonged wetting. There are four hydrologic groups (A, B, C, D). Group A soils have the lowest runoff potential, and group D soils have the greatest.

Wind erosion groups are based on soil texture, and relate how susceptible a soil is to wind erosion. Nine groupings have been developed (1, 2, 3, 4, 4L, 5, 6, 7, 8), the lower the number, the greater the risk of wind erosion. Group 1 contains sand, which is highly susceptible to wind erosion, and group 8 contains very wet or stony soils which are not subject to wind erosion.

Table 3-13
General Soils Information - Areal Extent of Soil Units

STATSGO Map Unit	Map Unit Name	Percent of Area
WY004	Haverson - Glenberg - Bone	0.4
WY044	Harve - Hanly - Glendive	<0.1
WY045	Cabbart - Yawdim - Thurlow	0.5
WY046	Cabba - Ringling - Yawdim	1.9
WY047	Draknab - Arvada - Bidman	0.1
WY048	Riverwash - Haverdad - Clarkelen	1.5
WY049	Shingle - Renohill - Forkwood	0.1

WY050	Shingle - Taluce - Kishona	22.2
WY051	Wyarno-Hargreave-Moskee	1.1
WY082	Renohill - Shingle - Parmleed	0.3
WY124	Platsher - Kishona - Hiland	6.7
WY125	Shingle - Theedle - Wibaux	8.1
WY126	Hiland - Vonalee - Maysdorf	10.0
WY127	Kishona - Shingle - Theedle	2.0
WY128	Renohill - Cushman - Cambria	10.5
WY129	Bidman - Parmleed - Renohill	7.6
WY130	Renohill - Bidman - Ulm	21.0
WY203	Clarkelen - Draknab - Haverdad	<0.1
WY206	Wibaux - Rock Outcrop - Shingle	0.3
WY207	Hiland - Bowbac - Tassel	1.6
WY208	Shingle - Samday - Hiland	1.4
WY209	Hiland - Shingle - Tassel	1.6
WY210	Ulm - Renohill - Shingle	0.2
WY211	Shingle - Tassel - Rock Outcrop	0.8

Map 3-1 Soils This page intentionally left blank

Table 3-14 Study Area Soil Series Characteristics

Map Unit	Major Soil Series	Surface Texture	Slope Range (%)	K-factor 1	Hydrologic Group2	Wind Erosion Group3	Salinity4 (mmhos /cm)	Reclamation Suitability 5
WY050	Kishona	loam	3-6	.37	B	4L	0-8	fair
	Shingle	loam	10-40	.36	D	4L	0-2	fair
	Taluce	sandy loam	15-40	.20	D	3	0-2	fair

WY124	Platsher	loam	0-9	.29	C	5	0-4	fair
	Kishona	loam	0-15	.37	B	4L	0-8	fair
	Hiland	sandy loam	3-15	.21	B	3	0-4	fair
WY125	Shingle	clay loam	0-75	.36	D	4L	0-2	fair
	Theedle	loam	3-40	.37	B	4L	0-8	fair
	Wibaux	rocky loam	0-75	.15	C	8	0-2	unsuitable
WY126	Hiland	sandy loam	0-15	.21	B	3	0-4	fair
	Maysdorf	sandy loam	0-15	.30	B	3	2-6	fair
	Vonalee	sandy loam	0-15	.27	B	3	0-2	fair
WY128	Renohill	clay loam	3-15	.37	C	6	0-4	fair
	Cushman	loam	0-15	.36	B	5	0-2	good
	Cambria	loam	0-9	.37	B	5	0-2	fair
WY129	Bidman	fine sandy loam	0-9	.39	C	6	0-2	fair
	Parmleed	loam	3-15	.36	C	3	0-2	fair
	Renohill	clay loam	3-15	.37	C	6	0-4	fair
WY130	Renohill	clay loam	3-15	.37	C	6	0-4	fair
	Bidman	loam	0-6	.39	C	6	0-2	fair
	Ulm	clay loam	0-6	.37	C	6	0-6	fair

1Soil erodibility factor. It is the rate of soil loss per rainfall erosion index unit. Values range from 0.02 to 0.69.
2 A group of soils having the same runoff potential under similar storm and cover conditions.
3 A grouping of soils that have similar properties affecting their resistance to soil blowing in cultivated areas.
4 A measurement of the amount of soluble salts in a soil expressed millimhos per centimeter.
5 Ratings, ranging from good to unsuitable, characterize the ability of soil material to support the re-establishment of vegetation. The ratings are based on the soil's texture, coarse fragment percentage by volume, percent organic matter, pH, salinity, available water retention capacity, and permeability (USDA FS, 1979).

Salinity levels for the predominant soils in the study area (**Table 3-14**) are low to moderate (less than 2 mmhos/cm to 8 mmhos/cm). Soil Conversation Service (SCS) mapping provides supporting evidence of the mostly low soil salinity levels in the study area. Salinity levels in soils occupying the bottoms of playas within closed drainage basins of northern Converse County are predominately low (USDA SCS, 1986). Additional supporting evidence of mostly low soil salinity levels in the study area is that about 75 percent of playa bottoms in the Campbell County soil survey area are non-saline, less than 2 mmhos/cm (NRCS, 1999).

Assuming consistency among playa soil salinity levels among Converse, Campbell, Johnson, and Sheridan Counties, the majority of playa bottoms in the study area should not have elevated levels of soil salinity. Although salts may not have accumulated in the area's playa bottoms, higher salinity levels (greater than 8 mmhos/cm) are present in some clayey alluvial soils (USDA SCS, 1986). These saline soils will likely occupy areas of minor extent on toe slopes, alluvial fans, and stream terraces throughout the study area.

The suitability for use in reclamation of most of the dominant soils in the study area ranges from "good" to "fair" (USDA FS, 1979) (**Table 3-14**). Only the Wibaux soil series of the Shingle- Theedle-Wibaux map unit poses any limitations to reclamation. High coarse fragment content combined with limited volume of soil material, due the soil being shallow, are the main factors leading to the classification as "unsuitable."

VEGETATION RESOURCES

The vegetation within the study area consists of species common to eastern Wyoming. Mixed grass prairie and Wyoming Big Sagebrush are co-dominant vegetation types, although portions of each have been replaced by either irrigated or dry crop agriculture. Several other less common vegetation types also occur within the study area. Intact ponderosa pine communities are present in the northern portions of the study area and riparian areas are found along several of the perennial streams within the area. This latter vegetation type represents a small but diverse community. The composition of these relatively lush areas varies widely, ranging from wooded areas dominated by cottonwood, to shrubby areas dominated by willow, to areas which are purely graminoid in nature (Clark, 1987). Wetlands also are present, and are discussed in separately in this chapter.

WETLANDS

Wetlands are landscape features that are delineated on the basis of specific soil, vegetation, and hydrologic conditions. Wetlands are defined as areas typically flooded or saturated frequently enough, and long enough, with surface water or groundwater, that these areas support mostly vegetation adapted for growth in soils that are saturated under normal circumstances (40 CFR 230 and USDI BLM, 1998g). Wetlands typically include swamps, marshes, bogs and similar areas. Waters of the U.S. is a collective term for all areas subject to regulation by the U.S. Army Corps of Engineers (COE) under Section 404 of the Clean Water Act. Wetlands occurring within waters of the U.S., including intermittent and ephemeral draws, creeks and rivers, playa lakes, and wetlands within the study area, are jurisdictional areas where the discharge of dredge and fill material is regulated by the COE. Adding produced water in and of itself, or subsequently reducing or eliminating the flow of produced water, to a wetland or other waters of the U.S. is not an activity regulated by the COE (US Army COE, 1998).

Several types of wetland systems are present within the study area. Like the riparian areas, the areal extent of these wetland systems is not indicative of their significance. While limited in size, the vegetation in these environments is highly productive and diverse, and provides habitat for many wildlife species. Further, the systems as a whole play important roles in controlling flood waters, recharging groundwater, and filtering pollutants (Niering, 1985).

Riverine wetlands, defined by their close proximity to perennial streams, occur sporadically along several of the drainages within the study area. These areas are supported not only by the groundwater associated with the stream, but by periodic flooding events, and by splash-back from stream flow. Willow (*Salix exigua, S. amygdaloides*), scouring rush (*Equisetum* spp.), sedges (*Carex* spp), and rushes (*Juncus* spp.) are common species within these environments (USDI BLM, 1998g and USDA FS, 1987).

Depressional areas which are naturally subirrigated support palustrine wetlands. These wetlands are commonly referred to as wet meadows and support a variety of lush plant life. Common species are sedges, rushes, cordgrass (*Spartina* spp.), mint (*Mentha* spp.) and buttercup (*Ranunculus* spp.). Depressional areas which hold water may support lacustrine wetlands. When natural, these wetland areas are called playa lakes, however, man made structures such as stock ponds also may support these systems. Cattails (*Typha* spp.) and bulrush (*Scirpus* spp.) often are the most common species in these systems, although lady's thumb (*Polygonum* spp.), verbena (*Verbena* spp.) and milkweed (*Asclepias* spp.) also may occur (USDI BLM, 1998g and USDA FS, 1987).

WILDLIFE AND FISHERIES

Wildlife species that inhabit the study area include big game, predators, small mammals, raptors, songbirds, and upland gamebirds. Aquatic resources in the area are limited and are restricted to the Belle Fourche, Powder, Little Powder, and Cheyenne rivers.

Big game species include antelope (*Antilocapra americana*), white-tailed deer (*Odocoileus virginanus*), mule deer (*Odocoileus hemionus*), and elk (*Cervus canadensis*). Both antelope and mule deer are expected to occur throughout the study area. White-tailed deer typically are restricted to wooded drainages within the area.

The WGFD has identified antelope winter, winter/yearlong, and yearlong ranges throughout the area. Winter range is that area where a population or portion of a population uses the documented suitable habitat sites within this range annually, in substantial numbers during the winter period. The winter period is generally from December 1 through April 30. Winter/yearlong range is that area where a population or portion of a population makes general use of the documented suitable habitat within this range on a year-round basis. But during the winter (December 1 through April 30), there is a significant influx of additional animals into the area from other seasonal ranges. Yearlong range is that area where a population or portion of a population makes general use of the suitable documented habitat within the range on a year-round basis, with the exception of severe conditions which may force animals to leave the area (USDI BLM, undated).

Both yearlong and winter white-tailed deer range has been identified in the study area. The definition of each of these range types is the same as was described for antelope.

Mule deer yearlong and winter/yearlong range occurs throughout the study area. The description of these ranges is the same as was described for antelope and white-tailed deer.

Elk occur in the northwest portion of the study area on yearlong and crucial winter/yearlong range and calving areas. This herd is the Fortification elk herd, and consists of approximately 200 to 300 animals. Elk within the herd generally are restricted to the Fortification Creek Wilderness Study Area (WSA) and surrounding areas in the western portion of the study area (USDI BLM,, 1999a).

Predators expected to occur in the area include coyotes (*Canis latrans*), badgers (*Taxidea taxus*), raccoons (*Procyon lotor*), bobcats (*Felis rufus*), and red fox (*Vulpes vulpes*). These species are anticipated to occur within all habitat types in the study area. Swift fox (*Vulpes velox*) is a rare species which may occur within the study area. A scent box survey of the general study area, found the presence of swift fox within the study area. However, no direct observations of swift fox have been made (USDI BLM, 1999a).

The most commonly occurring small mammals within the study area may include prairie voles (*Microtus ochrogaster*), white-footed deer mouse (*Peromyscus maniculatus*), bushy-tailed woodrat (*Neotoma cinerea*), black-tailed prairie dogs (*Cynomys ludvicianus*), and desert cottontails (*Sylvilagus audubonii*). A total of six black-tailed prairie dog colonies have been identified within the study area. However, additional colonies are expected to occur within the study area.

Raptor species occurring seasonally in the study area include red-tailed hawks *(Buteo jamaicensis*), golden eagles (*Aquila chrysaetos*), Swainson's hawks (*Buteo swainsoni*), ferruginous hawks (*Buteo regalis*), prairie falcons (*Falco mexicanus*), great horned owls *(Bubo virginianus*), burrowing owls (*Athene cunicularia*), American Kestrels (*Falco sparverius*), and Northern harriers (*Circus cyaneus*). Both bald eagles (*Haliaectus leucocephalus*) and rough-legged hawks (*Buteo lagopus*) occur in the area during the winter. However, no rough-legged hawk or bald eagle nests have been documented to occur within the area. Raptor surveys have been conducted within the area during previous seasons and in 1998 aerial surveys of about 90 percent of the study area were conducted in cooperation with WGFD. **Tables 3-15a, 3-15b,** and **3-15c** indicate the species and status of nests located during these surveys. Previous reports indicated that the number of active ferruginous hawk and golden eagle nests had decreased within the study area (USDI BLM, 1995b). Typical nesting periods for raptor species are March-July. During the 1998 study, ferruginous hawk production within the area was 2.29 young/successful nest (7 of the 14 active nests that were checked for productivity failed). A total of 20 additional active ferruginous hawk nests with a total of 37 young were located during the final week of the nest survey for a production of 1.85 young/active nest. Golden eagle production in the study area was 1.47 young/active nest.

Numerous songbirds occur within the study area. The diversity and density of these species vary by season. Typical species include horned lark (*Eremophila alpestris*), loggerhead shrike (*Lanius ludovicianus*), sage thrasher (*Oreoscoptes montanus*), mountain bluebird (*Sialia currucoides*), western meadowlark (*Sturnella neglecta*), and vesper sparrow *(Pooecetes gramineus*).

Table 3-15a
1998 Nest Status

Species	Active1	Nonactive2	No. of Young3
Ferruginous Hawk	48	240	73
Swainson's hawk	15		10
Red-tailed hawk	54	43	22
Golden eagle	19	10	17
Great Horned Owl	6		9

Source:USDI BLM, 1999a

Table 3-15b
1997 Nest Status

Species	Active1	Nonactive2	No. of Young3
Ferruginous hawk	5	14	16
Swainson's hawk	3	1	0
Red-tailed hawk	9	4	2
Golden eagle	2	1	0

Source:USDI BLM, 1998e

Table 3-15c
1996 Nest Status

Species	Active1	Nonactive2	No. of Young3
Ferruginous hawk	9	16	4
Swainson's hawk	0	0	0
Red-tailed hawk	0	0	0
Golden eagle	2	13	1

1ACTIVE means a nest where a breeding attempt was made or did not fledge young.
2 NONACTIVE means any nest that was inactive, dilapidated, destroyed or previously located and now gone.
3 NO. OF YOUNG means young in the nest or eggs observed.
Source: USDI BLM, 1998e

Gamebirds within the study area include sage grouse (*Centrocercus urophasianus*), sharp-tailed grouse (*Tympanuchus phasianellus*), mourning doves (*Zenaida macroura*), ducks, and geese. Numerous grouse leks have been identified within the study area. In addition, a two-mile buffer zone around each lek site has been identified. This two-mile buffer represents an area where disturbance is restricted from March 1 through June 15. A comparison was made of the number of sage grouse strutting/breeding grounds (leks) to the total number of grounds identified in the study area since 1980. This was done in an attempt to identify cumulative impacts that may be occurring in the area as a result of human activity and habitat disturbance or loss. There were 64 historic sage grouse leks identified in the area since 1980, only 23 leks have been active in the last 5 years. Thus we may assume that sage grouse only occupy 36 percent of their former range.

Aquatic species are generally restricted to the Belle Fourche, Cheyenne, and Powder rivers. Species within the Powder River include goldeye (*Hiodon alosoides*), common carp *(Cyprinus carpio*), creek chub (*Semotilus atromaculatus*), flathead chub (*Platygobio gracilis*), longnose dace (*Rhinichthys cataractae*), sand shiner (*Notropsis stramineus missouriensis*), plains minnow (*Hybognathus placitus*), fathead minnow (*Pimephales promelas*), shorthead redhorse *(Moxostoma macrolepidotum*), white sucker (*Catostomus commersoni*), black bullhead (*Ameturus melas*), channel catfish (*Ictalurus punctatus*), sturgeon chub (*Macrhybopsis gelida*), stonecat (*Noturus flavus*), longnose sucker (*Catostomus catostomus*), plains killifish (*Fundulus zebrinus*), quillback (*Carpiodes cyprinus*), river carpsucker (*Carpiodes carpio*), rock bass (*Amblophtes rupestris*), sauger (*Stizostedion canadense*), shovelnose sturgeon (*Scaphirhynchus platorynchos*), red shiner (*Cyprinella lutrensis*), and western silvery minnow (*Hybognathus argyritis*). Species within the Little Powder River are similar to the Powder River and also include green sunfish (*Lepomis cyanellus*). Within the Belle Fourche River the following species are known to occur: common carp, creek chub, shorthead redhorse, black bullhead, channel catfish, (*Ictalurus punctatus*) flathead chub, fathead minnow, longnose dace, plains minnow, river carpsucker, sand shiner, white sucker, red shiner, and green sunfish. Species within the Cheyenne River are similar to the other rivers and also may include plains topminnow (*Fundulus sciadicus*), and plains killifish.

SPECIAL STATUS SPECIES

Contact between the BLM and the U.S. Fish and Wildlife Service (USFWS) has identified the following four federally listed threatened or endangered species as potentially occurring within the study area: the endangered black-footed ferret (*Mustela nigripes*); threatened bald eagle; endangered peregrine falcon (*Falco peregrinus*); and the endangered Ute Ladies'-Tresses (*Spiranthes diluvialis*). In addition to the threatened and endangered species, three candidate species have been identified as potentially occurring within the area: the swift fox; mountain plover (*Charadrius montanus*); and sturgeon chub. The status of the black-tailed prairie dog currently is under review by the USFWS. In addition to the federally listed species, 27 species have been designated by the FS as sensitive species that occur or potentially may occur in the study area (USDA FS, 1998b). The following is a brief description of each species as well as the potential habitat each species utilizes.

Black-footed ferret

Black-footed ferrets are primarily nocturnal animals that are nearly always associated with prairie dogs. Prairie dogs are the ferret's source of prey and prairie dog burrows provide dens and rearing areas for ferret young. A single black-tailed prairie dog colony of 32 ha (80 acres) or a complex of smaller colonies occurring within a circle with a 7-km (4.3-mi) radius that totals 32 ha is considered to be the minimal size necessary to constitute potential habitat for the black-footed ferret (USFWS, 1989a). At least six prairie dog colonies have been identified within the study area. However, additional colonies are anticipated to occur within the study area.

Bald eagle

Feeding areas, diurnal perches, and night roosts are fundamental elements of bald eagle winter range. Although eagles can fly as far as 24 km (15 mi) to and from these elements, they primarily inhabit areas where all three elements are available in comparatively close proximity (Swisher, 1964).

Although eagle presence in winter is not directly correlated with open water (Swisher, 1964), eagles usually occur near large rivers and lakes (Sprunt and Ligas, 1963). Because the eagle's use of water areas generally decreases as ice cover increases (USDI BLM, 1980b), open water is considered an important feature of their winter habitat (USDI BLM, 1973). Eagles are particularly attracted to large bodies of water downstream from hydroelectric dams where dead or dying fish or waterfowl are readily accessible (Cooksey, 1962 and Ingram, 1965).

Food availability is probably the single most important factor affecting winter eagle distribution and abundance (Steenhof, 1976). Fish and waterfowl are the primary food sources where eagles occur along rivers, lakes, streams, and dams. In some regions, carrion can also be an important food source.

Perches are an essential element in the bald eagle's selection of foraging areas, because they are necessary for hunting and resting. Ice, driftwood, fence posts, cliffs and rock outcrops, gravel bars in rivers, shorelines, telephone poles, open hillsides, and trees are used as perches. However, dead deciduous trees are preferred (Stalmaster and Newman, 1979).

Roosts are areas used for sleeping and providing protection from winter storms. Usually, eagles leave the roost for feeding areas in early morning and return in the evening. However, during severe weather they may remain at the roost all day.

Roosts may be used by individual birds or small to large groups of birds. Also, roosts can be used in successive years. Large, live trees of dominant or co-dominant species that occur in sheltered areas (e.g., in the protected slopes of a valley or ravine or behind a bluff) are preferred (Lish, 1975).

Three bald eagle winter roosts have been identified in the study area. One is located in the northern edge of the study area, one is located along the southwestern edge of the study area, and the other is along the southern edge of the study area (USDI BLM, 1998e).

Peregrine falcon

Peregrine falcons occupy a wide variety of habitats. They typically are associated with open country near rivers, marshes, and coasts. Cliffs are the preferred nesting substrate, however, tall man-made structures (i.e. high rise buildings and towers) also may be used (USDA FS, 1991).

Breeding begins in March when males establish territories. Three to four eggs are laid in mid-April. Incubation lasts from 33 to 34 days. The young hatch in mid-May. Young generally fledge in six weeks and remain dependent on the adults for several weeks (USDA FS, 1991).

Peregrines typically prey on birds such a waterfowl, shorebirds, grouse, and pigeons. Prey is taken by striking from above after a high speed dive. Foraging occurs within 10 miles of the nest, however, 80 percent occurs within a one mile radius of the nest (USDA FS, 1991).

No peregrine falcon nests are known to occur within the study area.

Ute Ladies'-Tresses

The Ute Ladies'-Tresses orchid occurs primarily in wetland areas where vegetation is relatively open, not overly dense or overgrown (USFWS, 1989b and 1990; Jennings, 1989 and 1990). A few populations in eastern Utah and Colorado are found in riparian woodlands, but the orchid seems generally intolerant of shade, preferring open, grass and forb-dominated sites instead. Most occurrences are along riparian edges, gravel bars, old oxbows, and moist to wet areas near freshwater lakes or springs (USFWS, 1991). Plants usually occur in small scattered groups occupying relatively small areas with the riparian system (Stone, 1993).

Ute Ladies'-Tresses are endemic to moist soils in mesic or wet meadows near springs, lakes, or perennial streams. The elevational range of the species is 4,300 to 7,000 feet (Stone, 1993). This orchid may require "permanent sub-irrigation", indicating a close affinity with floodplain areas where the water table is near the surface throughout the growing season, continuing into late summer or early autumn.

Swift fox

Swift fox typically inhabit short- and mid-grass prairies. In northwestern Colorado swift fox appear to prefer relatively flat to gently rolling topography. They rarely are found in gullies, washes, or canyons.

Swift fox feed on small rodents, rabbits, and birds. Jackrabbits comprise the majority of their diet, however, ground squirrels, ground-nesting birds, and prairie dogs also are included.

Mating occurs from late December through February. Pups are born in late March, April, or early May. Four to five pups are produced and they do not emerge until they are four to five weeks old. Dens are generally located on flat areas, or along slopes or ridges that offer good views of the surrounding area (Fitzgerald, Meaney and

Armstrong, 1994).

One swift fox occurrence has been identified within the southeastern portion of the study area. A swift fox den survey is currently being conducted in the study area. The results of this survey will be included when available.

Mountain plover

Mountain plover is a small migratory bird that utilizes high, dry, shortgrass prairies seasonally. Within these habitats, areas of blue gramma (*Bouteloua gracilis*) and buffalograss (*Buchloe dactyloides*) are most often utilized. In addition, areas of mixed grass associations dominated by needle-and-thread (*Stipa comata*) and blue gramma also are utilized (USFWS, 1983).

Nests consist of a small scrape on flat ground in open areas. Most nests are placed on slopes of less than 5 degrees, and occur in areas of buffalo grass, blue gramma, scattered cacti, and western wheatgrass (*Agropyron smithii*). These areas typically support vegetation that is less than 3 inches tall in April. Within Colorado more than half of identified nests occurred within 12 inches of old cow manure piles and almost 20 percent were found against old manure piles. In addition, nests in Montana were nearly always associated with the grazed shortgrass of prairie dog colonies (USFWS, 1983).

In southwestern Wyoming, observations suggest plovers arrive on their breeding grounds as early as March 25; however, the average arrival date is April 13. Egg laying typically begins in late April with the last clutch laid in mid-June. Most clutches hatch from late March through late June, with the chicks fledging in early to late June. Once the broods hatch, plovers tend to move large distances from the nest. The birds typically beginning migrating out of the area by mid-August. However, some birds may stay until late September (USFWS, 1983).

The study area is anticipated to contain large areas of potential habitat for the mountain plover.

Sturgeon chub

Sturgeon chub occur almost exclusively in the Missouri River drainage system. The range of this fish species encompasses the river's headwaters in Montana and Wyoming to its mouth at the Gulf of Mexico. In Wyoming chub are restricted to the Lower Bighorn and Powder Rivers.

Preferred habitat is above gravel bottoms within large, turbid, fast-moving rivers. Chub are most abundant in gravel riffles, but sometimes are found in sandy bottom pools containing some gravel. Sturgeon chub usually occur in less than 3 feet of water, and eat primarily bottom-dwelling invertebrates. Chub spawn in late spring to midsummer (until late July) when water temperatures are between 65 and 72%F. Spawning occurs within shallow rapids over gravel and rock. The Powder River in Wyoming supports the largest known reproducing population of sturgeon chub.

Other Species, Including FS Sensitive Species

In addition to the federally listed species, 27 species have been designated by the FS as sensitive species that occur or potentially may occur in the part of the TBNG that is within the southern part of the study area (USDA FS, 1998b). FS sensitive species are those species identified by the Regional Forester for which population viability is a concern, as evidenced by either a significant current or predicted downward trend in population numbers or density, or significant current or predicted downward trend in habitat capability that would reduce a species' existing distribution. **Table 3-16** lists these species and their potential for occurrence within the study area. These species potentially occur within the TBNG.

The black-tailed prairie dog is a small mammal commonly occurring within the study area. A total of six black-tailed prairie dog colonies have been identified within the study area. However, additional colonies are expected to occur within the study area.

CULTURAL RESOURCES

The study area supported extensive herds of bison in the prehistoric and early historic periods. The seasonal to irregular availability of water and general lack of sheltered areas discouraged large, permanent settlements. The principal local raw materials for prehistoric stone tool manufacture are porcellanite and non-volcanic glass. The latter lithic materials are byproducts of the metamorphosis of claystones by burning coal seams.

Overview of Known Cultural Resources

Cultural sites are generally defined as discrete locations of past human activity which can include artifacts, structures, works of art, landscape modifications, and natural features or resources important to tradition or history. Sites can also include extensive linear features such as trails, roads or railroads, broad areas considered as "cultural landscapes," and traditional use areas. Significant sites are defined as those sites that are listed on or eligible for the National Register of Historic Places under the criteria for eligibility (36 CFR §60.4), including Traditional Cultural Properties.

Table 3-16 (continued) U.S. Forest Service Sensitive Species

Species Common name (*Scientific name*)	**Suitable Habitat**	**Potential for Occurrence Based on Suitable Habitat**
Fish		
Flathead chub (*Hybopsis gracilis*)	Common in large, silty rivers east of the Continental Divide; found within the project area in Antelope creek, the Cheyenne River, and the Little Powder River.	High1
Plains topminnow (*Fundulus sciadicus*)	Inhabits clear streams with sand and gravel bottoms; found in the headwaters of the Cheyenne River within the project area.	Medium2
Reptiles and Amphibians		
Northern leopard frog (*Rana pipiens*)	Found in or near permanent water.	High
Tiger salamander (*Ambystoma tigrinum*)	Inhabits moist environments below 10,000 feet out of sun and wind; larvae may be found in streams, lakes, and ponds.	High
Milk snake (*Lampropeltis triangulum*)	Found under stones, logs, and other debris, in prairie, river bottoms, rocky hillsides, and forests.	High
Black Hills red-bellied snake (*Storeria occipitomeoculae pahasapae*)	Found under debris in cottonwood-willow and ponderosa pine habitat, especially in hilly areas.	High
Mammals		
Townsend's big-eared bat (*Plecotus*	Roosts in caves; forages over desert shrublands, pinyon-	High

townsendii)	juniper woodlands, and dry coniferous forests.	
Fringed-tailed myotis (*Myotis thysanodes pahasapensis*)	Occurs in isolated populations from the Black Hills south to Laramie; forages over grasslands, deserts, and woodlands; roosts in caves, mines, and crevices.	High
Swift fox (*Vulpes velox*)	Inhabits rolling short-grass prairie; observed within the project area.	High
Birds		
American bittern (*Botaurus lentiginosus*)	Summer resident, occurring in marshes, swamps, reedy lakes, rivers, moist meadows, and riparian thickets.	Medium
Western yellow-billed cuckoo (*Coccyzus americanus*)	Found in cottonwood or willow riparian areas.	High
Greater Sandhill crane (*Grus canadensis*)	Summer resident, occurring in open areas having shallow water with some areas of dense vegetation.	Medium
Long-billed curlew (*Numenius americanus*)	Summer resident that prefers sagebrush-grassland in open areas with few shrubs.	High
Ferruginous hawk (*Buteo regalis*)	Summer resident that nests in rock outcrops, in trees, and on the ground; known to occur within the project area.	High
White-faced ibis (*Plegadis chihi*)	Summer resident which exclusively inhabits ponds, marshes, muddy pools, stream margins and river banks.	Medium
Common loon (*Gavia immer*)	Inhabits high elevation rivers, lakes, and ponds having deep water and vegetation up to waters edge.	None3
Merlin (*Falco columbarius*)	Year-round resident living in open areas, coniferous forests, and deciduous woodlands along rivers.	High
Western burrowing owl (*Athene cunicularia*)	Summer resident which inhabits vacant prairie dog burrows in short-grass prairie areas.	High
Loggerhead shrike (*Lanius ludovicianus*)	Summer resident of upland sagebrush shrubland/grassland and pine-juniper woodlands; shrubs and lookout perches are	High

	important habitats.	
Fox sparrow (*Passerella iliaca*)	Inhabits native riparian shrubs with adjacent coniferous forest or woodland-chaparral, aspen woodlands, and willow thickets.	Medium
Black-backed woodpecker (*Picoides arcticus*)	Lives in coniferous forests, especially ones that have burned.	None
Mountain plover (*Charadrius montanus*)	Summer resident, found in shortgrass and midgrass grasslands; prefers vegetative height under 4 inches.	High
Upland sandpiper (*Bartramia longicauda*)	Summer resident of upland grasslands with few shrubs; ground nester.	High
Baird's sparrow (*Ammodramus bairdii*)	Summer resident of upland grasslands; ground nester in open prairie.	High
Black tern (*Chlidonias niger*)	Summer resident of freshwater marshes, wet meadows, and marshy lakes; nests on floating mats of dead vegetation.	None
Lewis' woodpecker (*Melanerpes lewis)*	Summer resident of cottonwood riparian areas, ponderosa-pine, and pine-juniper coniferous forests.	Medium
Invertebrates		
Tawny-crescent butterfly (*Phyciodes batesi*)	Inhabits moist forest borders; usually found in riparian areas or around moist soil.	None

1High= Suitable habitat occurs within project area and species has been documented within the project area
2 Medium= Limited amount of habitat occurs within project area, but species does occur within the project area.
3 None= Suitable habitat does not occur within the project area

The study area encompasses several previous environmental assessments, overviews, and Class II sample inventories, including the South Gillette Coal Bed Methane Environmental Assessment (USDI BLM, 1996b), the North Gillette Coal Bed Methane Environmental Assessment (USDI BLM, 1996b), the Campbell and Johnson Counties Coal Bed Methane Environmental Assessment (USDI BLM, 1990a), the Eastern Powder River Basin Class II Inventory (Peebles et al., 1981). There also have been numerous small to moderate investigations completed for highway improvements and for producing coal mines scattered along the eastern edge of the study area.

Although the Paleoindian and Early Plains Archaic periods are comparatively weakly represented in this region, all of the prehistoric periods, from Clovis to Protohistoric are known from this region. Prehistoric site densities can be high in some areas, particularly along ridgetops and near larger and more reliable drainages. In the Protohistoric and early historic periods this was the territory of the Arikara, Crow, Lakota, Northern Arapaho, Northern Cheyenne, and Shoshone. Numerous confrontations between Euroamerican settlers and the latter tribal groups occurred in this area.

Fur trade presence in the Powder River Basin was transient in comparison with other parts of the regions, because the fur resources of these drainages were rapidly depleted. The major emigrant trails of the 1840s and

1850s had passed south of the study area along the North Platte. With the emergence of the Montana gold fields during the 1860s, trails were developed through the study area. The Sawyer expeditions of 1864 and 1865 attempted to establish a wagon road through the Powder River Basin south of Gillette. The more southerly route of the Bozeman Trail, extending from Fort Laramie through the southwest portion of the study area, and along the eastern edge of the Bighorn Mountains, became a major route through the region for several years. Other important historic corridors within or near the study area were the Black and Yellow Trail, the Texas Cattle Trail, and the Cheyenne-Deadwood Stage Road.

Permanent settlement of any magnitude within the study area began in the 1880s. The earliest settlement was focused on livestock, but by the turn of the century coal mining had become an important element of the regional economy. Until recent decades, sheep and cattle production remained as mainstays of the regional economy, but mineral and energy development clearly has become dominant.

Results of File Search

Files searches were conducted through the Wyoming Cultural Records Office on June 4, 1998 and February 7, 1999, for the study area. These files searches indicated that 1,253 previous investigations are on record for the Proposed Action project area, and 1,572 are on record for the Alternative 1 expanded project area. Of those reports 663 in the Proposed Action project area and 760 in the Alternative 1 expanded project area were completed prior to 1983 when state wide standards were implemented for cultural resource investigations and reporting. Those earlier reports might not be considered adequate by present standards and must be reviewed individually to evaluate their adequacy. Approximately two percent of the study area has been inventoried adequately for cultural resources by current standards, and much of that inventory area has been along the eastern edge of the study area within and around producing coal mines and well fields.

Table 3-17 lists the numbers of cultural resource sites, and the numbers of significant cultural resource sites that have been formally recorded in the Proposed Action project area and the Alternative 1 expanded project area. A total of 1,307 sites have been documented in the Proposed Action area, and 1,642 in the Alternative 1 area.

Approximately 70 percent of the recorded prehistoric sites are recorded as lithic scatters in both the Proposed Action and the Alternative 1 areas. The next most abundant prehistoric site types are open camps and artifact scatters with features (17 percent). The presence of both artifacts and features, especially hearths, was often the key criterion used to identify sites as open camps in pre-1980s site recording. In contrast the open camps and artifact scatters with features dominate the significant sites (53 percent), and lithic scatters, although still strongly represented, are only 34 percent of the significant sites.

Native American Consultation

Recent legislation requires consultation with interested Native American tribal groups. Within the study area, these tribal and cultural groups are considered to include the Crow, Northern Cheyenne, Arapaho, Shoshone, Arikara, and western Sioux Lakota tribes. As part of the consultation process, copies of the EIS will be sent to the designated cultural officer of each tribe for review and comment. No Native American special interest sites are known to occur at this time. Should previously unknown but significant sites be identified as part of this consultation or

in the course of project development, BLM is required to notify and consider the concerns of those Native American tribes most likely to be associated with the find.

LAND USE AND TRANSPORTATION

Land ownership, shown on **Map 1-2** consists primarily of private lands intermingled with federal and state lands. Isolated tracts of BLM-administered lands, state-owned lands, and the TBNG are located within the study area.

Within the study area, approximately 11.7 percent of surface ownership is federal (USDI BLM, 1999b), and consists primarily of lands administered by the BLM and FS. Federal lands administered by the BLM and FS in the study area consist of numerous isolated islands and tracts of land surrounded by private lands. In Campbell, Johnson, and Sheridan counties, BLM lands within the study area are administered by Buffalo Field Office (BFO). BLM lands in Converse County are administered by the Casper Field Office.

Table 3-17
Site Types Known for Wyodak Study Area

Site Type Encoded in Database:	**Proposed Action**		**Alternative 1**	
	Total	**Eligible/ Listed**	**Total**	**Eligible/ Listed**
Prehistoric - Total	953	104	1157	115
Lithic Scatter	670	36	808	39
Mixed Artifact Scatter	3	2	3	2
Other Material Scatter	1	0	2	0
Open Camp	62	23	71	23
Artifacts and Features	102	30	125	36
Features Only	57	5	70	6
Multiple Component/Stratified	1	1	1	1
Stone Circles	35	4	44	4
Lithic Source	7	1	14	1
Rock Alignment	1	0	1	0
Structure/lodge	0	0	1	0
Cairns	5	0	5	0
Bison Kill/Bone Bed	4	1	6	2
Bone Scatter	2	1	2	1
Rock Art	1	0	1	0
Human Bone	1	0	1	0
Unknown/Uncoded	1	0	2	0
Paleontology	1	0	1	0
Historic - Total	379	28	527	35
Conservation	1	0	1	0
Exploration	1	1	2	1
Farming	14	5	16	6
Mining	7	0	7	0
Ranching	171	11	263	14
Transportation	24	6	31	8
Urban	2	1	4	1
Unknown/Uncoded	159	4	203	5
Total	1333/1307a	132	1685 /1642a	150

aThe total number of recorded site types is 1,333 for the Proposed Action project area and 1,685 for Alternative 1 expanded project area. However, 26 of the sites in the Proposed Action and 43 in Alternative 1 are recorded as both historic and prehistoric site types. Consequently only 1,307 sites in the Proposed Action and 1,642 sites in Alternative 1 with unique site numbers are represented in this sample. The BLM is responsible for the balanced management of public lands and resources so that their various values are considered in a combination that will best serve the needs of the American people. The TBNG is administered by the Medicine Bow - Routt National Forest. The FS is responsible for the balanced management of national forests and grasslands and resources so that their various values are considered in a combination that will best serve the needs of the American people. Management by the BLM and FS is based upon the principles of multiple use and sustained yield.

The 12,419 acre Fortification Creek Wilderness Study Area (WSA) situated northwest of Gillette is included within the study area. This portion of the northern Powder River Breaks is managed to maintain the area without impairment of its wilderness values, in accordance with interim BLM management policy, pending congressional action that determines its management policies and standards (USDI BLM, 1985). Only a small portion of the WSA, just west of Wild Horse Creek and the main railroad line connecting Gillette and Sheridan, is within the Proposed Action project area. Fortification Creek, within the central portion of the WSA, is located west of the Proposed Action project area.

The mineral estate (mineral ownership) of lands within the study area is federally owned, at least in part, throughout most of the area. Many privately owned lands have a mineral estate that is, at least in part, federally owned. Federal ownership of oil and gas totals about 1,293,000 acres (56 percent) of the study area. Federal ownership of coal totals about 2,053,000 acres (89 percent) (**Maps 1-3 and 1-4**). All of the federal mineral estate within the study area is open to locatable mineral exploration and development.

The State of Wyoming owns an estimated 6.2 percent of the land surface and mineral estate within the study area. All of the state-owned lands in the study area are State Trust lands that are available for mineral and agricultural leasing, timber leasing and sales, and public recreation. State Trust lands generate revenues that are reserved for the benefit of designated beneficiaries. These beneficiaries are the common (public) schools, universities, and other public institutions in Wyoming.

The remaining 82.1 percent of land ownership in the study area (Alternative 1 expanded project area) is private, as shown on **Map 1-2**.

The primary land cover type in the study area is rangeland (mixed grass cover type and Wyoming Big Sagebrush type). Other land cover types in the study area include cropland (irrigated and dryland), human settlements (Gillette and Wright), and mining operations. Livestock grazing, oil and gas production, clinker quarrying, and coal mining are the primary uses of the rangeland cover type in the study area. Most livestock grazing is cattle, although some sheep are also grazed. The Durham Meat Company, a ranch located south of Gillette, raises buffalo (bison) for meat production. The primary use of BLM lands within the study area is grazing.

Recreational land use in the study area includes hunting for mule deer, pronghorn antelope, and elk. Upland game birds and waterfowl also are hunted in limited numbers.
Existing oil and gas fields are scattered throughout the study area. The Marquiss, Lighthouse, and Gillette South CBM projects are located in the southern portion of the study area (**Map 1-1**). The Gillette North CBM assessment area is located just north of Gillette.

Coal mining occurs primarily in the eastern portion of the study area, as shown in **Map 1-2**. There are sixteen active coal mine lease areas within and adjacent to the study area. Active coal mines located south of Gillette include Caballo, Belle Ayr, Cordero-Rojo Complex, Coal Creek, Jacobs Ranch, Black Thunder, North Rochelle, Rochelle, North Antelope and Antelope. North of Gillette, active coal mines include Buckskin, Rawhide, Eagle Butte, Dry Fork, Fort Union/Kfx, and Wyodak.

Gillette is the hub of the existing transportation network in the study area. The major transportation corridors include State Route 59, the principal north-south highway through Campbell County and Gillette, and Interstate

90, the principal east-west highway. Other highways crossing through the study area are U.S. Route 14, and State Routes 50 and 387. Numerous county roads provide local access to public and private lands.

The study area has one major railroad and numerous oil and gas pipelines. The Burlington-Northern/Santa Fe and Union Pacific Railroad passes through Campbell County to the east, west and south of Gillette. Several spur lines connect the railroad with area coal mines for transporting the coal that originates in the PRB. Alternative routes are still under consideration for the proposed DM&E Railroad expansion into Wyoming. The track would terminate at the coal mines located east of State Highway 59 and south of Gillette, in Campbell County, just east of the study area.

There is one public airport in the study area. The Gillette-Campbell County Airport is located three miles northwest of Gillette. The VOR (radio aid used for navigation) is located at the airport.

RECREATION

Recreational use of the study area by the public is limited, as most of the land is privately owned. Opportunities for dispersed recreation exist on federal and state lands. No developed recreational sites are located in the study area. The nearest developed recreation sites are located in Gillette.

The TBNG provides opportunities for hiking, sight-seeing, hunting and fishing. There are no developed campgrounds in the TBNG, however, camping is allowed.

Dispersed recreational opportunities in the project area include hunting, fishing, sightseeing, all-terrain vehicle (ATV) use, and camping. Hunting is the principal recreation activity on public lands in the study area. Hunting also occurs on some private lands. Pronghorn antelope, mule deer, elk, cottontail rabbit, and sharp-tailed and sage grouse are hunted in the study area (Gillette Convention and Visitors Bureau, 1998). The Marquiss and Lighthouse EAs also identified mourning dove, sage grouse, waterfowl, and cotton-tailed rabbit as resident game species (USDI BLM, 1992a and 1995c).

VISUAL RESOURCES

The landscape of the study area is characterized by open grasslands, low rolling hills, and unobstructed views of many miles. Most of the area is covered with dryland vegetation consisting of grasses and shrubs. Ponderosa pine covers large portions of the north quarter of the study area. Outside the urban areas of Gillette and Wright, the study area is characterized by a rural landscape that has been modified by oil and gas field developments, coal mines and grazing. Grazing activities are evident in most of the study area. Highways, county roads, private roads and utility lines also are evident throughout the study area.

Visual resource management guidelines for BLM lands are to manage public lands for current visual resource management (VRM) classifications and guidelines. The VRM system is the basic tool used by BLM to inventory and manage visual resources on public lands. The VRM classes constitute a spectrum ranging from Class I through Class IV that provides for an increasing level of change within the characteristic landscape. Each VRM class combines an evaluation of visual quality, visual sensitivity of the area, and viewing distances.

Visual resources of BLM-administered lands in the study area are managed in accordance with VRM Classes II, III, IV and V (USDI BLM, 1980c), as shown in **Table 3-18** (USDI BLM, 1984). The inventory includes state and private lands as well as BLM lands, however the BLM manages visual resources only on BLM lands. The objectives of the BLM VRM classes in the Buffalo Resource Area are defined below.

Table 3-18
Visual Resource Management in the Wyodak Study Area

Visual Class	**Percent of Project Area**	**Percent of Expanded Project Area (2,317,000**

	(1,538,000 acres)	**acres)**
BLM (includes BLM and private lands)		
VRM Class II	0	0.1
VRM Class III	0.7	0.9
VRM Class IV	95.5	96.4
VRM Class V	0.2	0.2
FS (Thunder Basin National Grassland)		
Modification (VQO)	3.6	2.4
Total Project Area	100.0	100.0

€ Class II - Class II provides for activities that would not be evident in the characteristic landscape. Contrasts are seen, but must not attract attention.

€ Class III - The objective is to provide for management activities that may contrast with the basic landscape elements, but remain subordinate to the existing landscape character.

€ Class IV - The objective is to provide for management activities that may require major modifications to the existing landscape. The level of change to the landscape can be high and may be visually dominant, but should repeat the form, line, color and texture of the landscape.

€ Class V - The classification is applied to areas where the natural character of the landscape has been disturbed to a point where rehabilitation is needed to bring it up to one of the four other classifications.

Most of the study area (96.4 percent) is designated as VRM Class IV. Under Class IV, activities may be dominant, but should repeat the form, line, color, and texture of the landscape. Class II areas consist of the scenic landscape corridor along portions of Interstate 90 and State Route 14 on the west side of the study area. Class III areas are visible primarily from Interstate 90 east of Gillette, and from approximately 2.5 miles of State Route 50 located south of Gillette. The Fortification Creek Wilderness Study Area (west-central part of study area) and Indian Butte cultural resource area (southwest portion of the study area) also are managed as VRM Class III areas. Management activities in VRM Class III areas may be evident, but should remain subordinate to the existing landscape. Existing coal mines along the east boundary of the study area are managed as VRM Class V areas. Class V applies to areas where the natural character has been drastically altered, and the area requires rehabilitation to upgrade it to VRM Classes I through IV. In the study area, coal mines consist of extensive surface mining activities that dominate the landscape within the Class V areas.

The Medicine Bow National Forest has inventoried Visual Quality Objectives (VQOs) for the portion of the federally owned surface within the TBNG and the study area. The FS management objectives for visual resources within the TBNG are to provide for characteristic landscapes that satisfy the adopted VQO. The federally owned TBNG lands in the study area are managed in accordance with the VQO of modification (USDA FS, 1992).

FS management direction for visual resource management requires that facility and structure design, color of materials, location and orientation meet the adopted VQOs for the management area affected by the project. Monitoring is required for oil and gas exploration and development on leased grasslands upon completion of the project in order to establish compliance with the adopted VQOs. Visual resource management objectives for the modification and maximum modification VQOs should be met within three full growing seasons after completion of a project.

NOISE

The study area has land uses that vary from sparsely populated rural regions to more densely populated urbanized areas, such as towns. Background noise measurements have not been conducted in the study area. Existing or background noise levels in sparsely populated areas are likely to be similar to the analysis of background noise levels completed for the Enron Burley Area (USDI BLM, 1994c). Background noise levels for the EPA category "farm in valley" are: daytime, 29 dBA; evening, 39 dBA; and nighttime, 32 dBA. Local conditions, such as topography and frequent high winds, can alter background noise conditions. The unit of measure used to represent sound pressure levels (decibels) using the A-weighted scale is (dBA). It is a measure designed to simulate human hearing by placing less emphasis on lower frequency noise because the human ear does not perceive sounds at low frequency in the same manner as sounds at higher frequencies.

SOCIOECONOMICS

The study area is located within Campbell County and small portions of Converse, Johnson, and Sheridan counties. There are two incorporated municipalities affected by the proposed project; Gillette and Wright. Gillette is the county seat and the largest incorporated city in Campbell County. Wright is located in southern Campbell County. There are no incorporated communities in Converse, Johnson, or Sheridan Counties that are located within the study area.

The 1997 population of Campbell County is estimated at 32,087. The populations of Gillette and Wright are estimated at 19,289 and 1,347, respectively. In 1997, the population of Converse County was estimated to be 12,295. **Table 3-19** summarizes population growth in Campbell, Converse, Johnson, and Sheridan Counties between 1980 and 1997.

Table 3-19
Population in Campbell, Converse, Johnson, and Sheridan Counties

Year	**1980**	**1990**	**1995**	**1996**	**1997**	**2000 (projected)**
Campbell County	24,367	29,370	31,456	31,951	32,087	32,970
Gillette	14,545	17,545	21,023	21,585	19,289	19,744
Wright	na	1,117	1,357	1,385	1,347	1,378
Converse County	14,069	11,128	11,929	12,112	12,295	12,350
Johnson County	6,700	6,145	6,627	6,717	6,796	6,920
Sheridan County	25,048	23,562	24,997	25,203	25,199	25,900

Source:Wyoming Division of Economic Analysis, 1997; and CCEDC, 1997

Mineral production of coal, oil, and gas is the dominant economic activity in Campbell County. It is also an important economic sector in Converse County. Wyoming is the top coal producing state in the United States. More than 90 percent of the coal produced in Wyoming comes from Campbell County (Campbell County Chamber of Commerce, 1998). Campbell County also produces approximately 25 percent of the oil produced in Wyoming each year. **Table 3-20** shows the state assessed mineral production valuations for the affected counties and the State of Wyoming for its 1997 fiscal year, which are based on 1996 production.

Agriculture, consisting of livestock production and dryland farming, also is an important sector of the economic base within the affected counties. According to the Campbell County Economic Development Corporation (CCEDC, 1997), the livestock population in the county consists primarily of cattle and sheep. Most cropland in Campbell County produces wheat, barley, oats and hay for feed. Agriculture in Converse, Johnson, and

Sheridan Counties consists of ranching, row crops such as wheat, barley and oats, and irrigated forage crops.

Wyoming Department of Employment (WDOE) records describe the employment sectors in the affected counties. The largest employment sectors in Campbell County are mining, retail trade, government and services (WDOE, 1998a). In 1996, the average total employment for Campbell County was 15,988. The mining sector accounted for 4,087 workers, or 25.6 percent of total employment in the county. Retail trade accounted for 17.5 percent of the total employment. State, local and federal government employed 18.9 of the total workforce. Service industries accounted for approximately 14.8 percent of employment. Agriculture, which is part of the economic base of the county, accounted for 0.5 percent of employment. The 1996 annual average unemployment rate was 4.7 percent. The average unemployment rate for the state was 5.0 percent in 1996 (WDOE, 1998b).

In Converse County, the largest employment sectors are government, retail, mining and services (WDOE, 1998a). In 1996, the average total employment for Converse County was 4,124. Government accounted for 27.7 percent of total employment. The retail sector accounted for 19.9 percent. Mining employed 15.9 percent of the total workforce. Service industries accounted for about 12.8 percent of employment. Agriculture, which consists primarily of ranching, accounted for 1.7 percent of employment. The 1996 annual average unemployment rate was 5.4 percent.

The largest employment sectors in Johnson and Sheridan Counties are government, retail, and services (WDOE, 1998a) and is documented in records maintained by the Bureau of Economic Analysis (BEA) within the U.S. Department of Commerce. In 1996, the total labor force in Johnson County was 3,747 workers. In Sheridan County the labor force was 13,608 workers. The 1996 annual average unemployment rate was 3.8 percent in Johnson County and 4.8 percent in Sheridan County.

Per capita income indicates the economic well-being of the residents of an area and is documented in records maintained by the Bureau of Economic Analysis (BEA) within the U.S. Department of Commerce (USDC). The per capita income in Campbell County averaged $21,908 in 1996, which ranked sixth in the State of Wyoming, and was 101 percent of the average 1996 per capita income of $21,587 for the State of Wyoming (USDC BEA, 1998). Total personal income for the county in 1996 was approximately $700 million, which accounted for 6.8 percent of the 1996 total personal income for the State of Wyoming, approximately $10.4 billion (USDC BEA, 1998).

Table 3-20 Taxable Valuation of Mineral Production for Fiscal Year 1997, Based on 1996 Production Campbell, Converse, Johnson, and Sheridan Counties

	Mineral Valuation							
	Coal	**Oil**	**Natural Gas**	**Sand & Gravel**	**Uranium**	**Other Minerals 1**	**All Minerals2**	**Total Assessed Valuation2**
Wyoming Valuation	1.22 billion	1.26 billion	1.08 billion	7.87 million	15.4 million	293 billion	3.88 billion	7.15 billion

Campbell County Valuation	933 million	322 million	29.1 million	1.98 million	6.90 million	0	1.29 billion	1.59 billion
Percent of State's Valuation	76.5	25.6	2.7	25.2	44.8	0	33.2	22.2
Converse County Valuation	49.5 million	81.8 million	32.2 million	0.47 million	8.32 million	0.26 million	172.6 million	0.28 billion
Percent of State's Valuation	4.1	6.5	3.0	6.0	54.0	0.09	4.4	3.9
Johnson County Valuation	0	28.0 million	1.1 million	0.24 million	0.18 million	1.28 million	30.8 million	0.08 billion
Percent of State's Valuation	0	2.2	0.1	3.0	1.2	0.4	0.8	1.1
Sheridan County Valuation	0.18 million	1.08 million	0	0.21 million	0	0	1.5 million	0.12 billion
Percent of State's Valuation	0.01	0.09	0	2.7	0	0	0.04	1.7

Source:Wyoming Department of Revenue (WDR) records, for the State of Wyoming; fiscal year 1997 was July 1, 1996 through June 30, 1997 (WDR, 1999a).
1 Includes bentonite produced in Johnson County and leonardite produced in Converse County.
2 Mineral production valuation is 54.2 percent of Wyoming's 1997 statewide valuation (WDR, 1999b). Total 1996 county personal income earned from the mining sector, including oil and gas extraction, was nearly $250 million, representing 42.2 percent of the total personal 1996 income for the county (USDC BEA, 1998).

The per capita income in Converse County averaged $18,094 in 1996, which ranked 18th in the State of Wyoming, and was 84 percent of the state average. Total personal income for the county in 1996 was approximately $219 million, which accounted for 2.1 percent of the 1996 state total. Total 1996 county personal income earned from the mining sector, including oil and gas extraction, was approximately $56 million, representing 25.6 percent of the total personal 1996 income for the county (USDC BEA, 1998). Earnings from the mining sector increased 15.8 percent from 1995 earnings in Converse County.

The per capita income in Johnson County averaged $20,571 in 1996, which ranked 12th in the State of Wyoming, and was 95 percent of the state average. Total personal income for the county in 1996 was approximately $138 million, which accounted for 1.3 percent of the 1996 state total. The mining sector accounted for 11.3 percent of earnings in 1996, and was one of the fastest growing industries in the county (USDC BEA, 1998).

The per capita income in Sheridan County averaged $23,332 in 1996, which ranked 3rd in the State of Wyoming, and was 108 percent of the state average. Total personal income for the county in 1996 was approximately $588 million, which accounted for 5.7 percent of the 1996 state total. The mining industry was not a significant sector of the economy in 1996.

The majority of available housing units in the study area are located in the communities of Gillette and Wright. In 1996, there were approximately 7,474 housing units in Gillette and 492 housing units in Wright (as of December 1995). In Gillette, the average cost of a new three-bedroom home in 1996 was $109,900. The average 1996 cost for a new home in Wright was $88,000. Approximately 30 percent of the existing housing stock in Gillette were rental units. The average rent for an apartment was $350 in 1996. As of October 1994, the overall vacancy rate in Gillette for all types of housing was approximately 2 percent (Gillette Department of Community Development, 1997).

Government and community services available in the Counties include county government, law enforcement, fire protection, roads and bridges, infrastructure and maintenance, solid waste disposal, medical and emergency services, public school systems, a community college, and county libraries.

CHAPTER 4

ENVIRONMENTAL CONSEQUENCES

INTRODUCTION

This chapter analyzes the impacts of implementing the No Action Alternative, the Proposed Action, and Alternative 1 for the Wyodak CBM Project. CBM development on BLM-administered lands will be subject to land use decisions described in the "Planning Decisions" section of the RMP Record of Decision. CBM development on FS-administered lands will be conducted in accordance with applicable land use decisions, goals and objectives, and management standards and guidelines described in the LRMP and Record of Decision. Other assumptions utilized in preparing this analysis of environmental consequences are described below.

Environmental consequences associated with CBM projects located in western Campbell County and eastern Johnson County have been analyzed previously by BLM. Completed environmental analyses consist of the Marquiss, Pistol Point, Rawhide Butte, Lighthouse, and Gillette North EAs, and the Gillette South EIS (USDI BLM, 1990a 1992a, 1992b, 1992c, 1995c, 1996a, and 1997a).

GEOLOGY AND MINERAL RESOURCES

Proposed Action

Methane is produced from CBM wells drilled into underlying coal seams in the PRB. Peak gas production for the 3,000 proposed CBM wells could average 375 million cubic feet per day (mmcf/day) based on an estimated average production rate over the life of a well of 125 thousand cubic feet per day (mcf/day) per well. Initial production rates are expected to exceed this average during the first few years of production, then steadily decline during the well's economic life. Production records from the WOGCC (WOGCC, 1998a) indicate that CBM wells in Wyoming were producing at an average rate of approximately 200 mcf/day per well in 1998. For purposes of this analysis, if all 3,000 proposed wells were producing gas at the estimated average rate at the same time, then annual CBM production under the Proposed Action could approach 137 billion cubic feet per year (bcf/year). Annual CBM production in the U.S. in 1994 was 858 bcf (Stevens et al., 1996). However, CBM accounted for only five percent of the total U.S. natural gas production (Petzet, 1996). Total natural gas production in Wyoming in 1996 was 782 bcf (Energy Information Administration, 1997). In FY96 (year ending June 30, 1996) CBM production in Wyoming was 5.6 bcf or less than one percent of Wyoming's natural gas production for that year. CBM production almost tripled, to an estimated 15.9 bcf in FY98 (year ending June 30, 1998), according to the Wyoming Annual Report for 1998, Wyoming Department of Administration and Information (WDAI, 1999a).

CBM development occurring upstream from nearby surface coal mines could affect coal mining operations. CBM generated water discharged upstream from coal mines could increase surface flows in the vicinity of coal operations or decrease the rate of groundwater withdrawals that currently accompany ongoing coal mining operations. There likely will be impacts to sediment structures in the coal mine permit areas. These structures have been designed to accommodate historical flow rates that do not include contributions from CBM generated flows. Some design aspects of mining operations may need to be changed. Any required revisions to approved mine plans would impact operators and agencies involved in reviewing proposed changes. Timeframes needed to change design aspects of mining operations may affect the timeframes for initiation of CBM discharges. CBM generated flows are not likely to be lower quality (i.e., have elevated TDS over existing flows). The effects on the availability of groundwater for mining operations and the effects of increased surface flows on mine facilities could be mitigated site-specifically through cooperative agreements among CBM and mine operators, as potential effects are identified. Additional discussion of water impacts occurs later in this chapter.

Underground coal mine workings, surface excavations, and the partial removal of groundwater from coal seams (during mining operations or CBM development) can make more oxygen available in the coal seam, which contributes to conditions necessary for spontaneous coal combustion. Exposures of clinker in the eastern PRB occur primarily along the eastern boundary of the project area in the Rochelle Hills and in the Powder River Breaks of the northwest portion of the project area (Heffern and Coats, 1997). The oxidation of methane at or near the surface produces heat, and also can contribute to conditions necessary for spontaneous combustion.

However, CBM wells in the PRB are projected to be a minimum of 350 feet deep, and CBM development is expected to occur west of the line of coal outcrops where coal is produced from surface mines. At depth, the groundwater contained in the coal seam is under pressure. The water levels in wells completed in the coal typically rise up above the coal layer, creating what is called hydraulic head in the well. The partial removal of water from the coal seam during CBM development depressurizes the coal seam, and reduces this hydraulic head, but is not likely to leave the coal seam in a condition where oxygen would replace water in the coal seam and result in spontaneous combustion.

Partial dewatering of the Wyodak coal seam already has occurred in the PRB during mining and will continue as mining and CBM development proceed, possibly enhancing the potential for methane migration to occur within the PRB. Experience from coal mining has shown that methane seeps involving potentially explosive concentrations of methane can occur in the vicinity of near-surface coal seams (Glass et al, 1987 and Jones et al, 1987). Methane migration within the PRB potentially would not be limited to areas containing near-surface coal seams (areas near the coal outcrops along the eastern margin of the project area) or areas where dewatering has occurred.

Methane migration potentially could occur over short or long distances within the PRB, along naturally-occurring joints and fractures. Methane could emerge from water wells near CBM production areas, affecting water wells, residences or coal mine facilities. The escape of methane also can result from inadequate well control procedures or faulty well casing or plugging. Methane would be controlled through APD conditions of approval that address well control, casing, ventilation, and plugging procedures appropriate to site-specific CBM development plans. If methane seeps occurred, vegetation surrounding a seep likely would be killed or stressed, unless resistant to the local conditions near the seep. Soil productivity likely would be decreased.

Conflicts between CBM drilling and existing or potential surface coal mining may occur. Development of CBM wells would be precluded in areas of active or impending coal mining. Locating wells in areas where future mining may take place would preclude mining during the life of wells located in the proposed mining area. Coal in these areas could be mined after CBM extraction is completed or terminated, or after an agreement is negotiated between the CBM operators and the coal mine operators.

Developing the project would not be likely to impact the recovery of other mineral resources in the area. In the project area, oil and gas have been produced from geologic formations occurring several thousand feet below the coal seam. Salable minerals, primarily clinker, sand, and gravel, are produced from surface deposits. Subsurface uranium deposits located near the southwestern portion of the project area are associated with Wasatch Fm sandstones. Although currently there are no active uranium operations in the study area, in-situ (in place) leaching of subsurface uranium is occurring adjacent to the study area. Withdrawal of CBM and water from the stratigraphically lower Ft. Union Fm would not be likely to impact the potential recovery of uranium resources within or near the project area. No other locatable mineral deposits are known to exist in the project area. Development of existing mineral rights in the project area would be based on existing claims, lease terms and agreements; future conflicts would be dealt with on a case-by-case basis.

Other potential impacts, such as creating geologic hazards or disturbing paleontological resources are not likely to occur.

Alternative 1

Under Alternative 1, there would be 5,000 new productive CBM wells. Therefore, production under this alternative is projected to be 67 percent greater than under the Proposed Action. There would be less dewatering required at the coal mines under Alternative 1 than under the Proposed Action. Alternative 1 may generate more conflicts over the logical development of the coal resource than the Proposed Action in areas of intensive development near the coal outcrops along the eastern boundary of the expanded project area. However, Alternative 1 development is widespread across a greater portion of the PRB than the Proposed Action, and the additional CBM infrastructure located farther west, within the expanded project area under Alternative 1, actually may diminish the competition between gas and coal producers.

No Action

Under the No Action Alternative, there would be 2,000 new productive wells (located on private and state mineral ownership lands). Therefore, production under this alternative is projected to be 33 percent less than under the Proposed Action. The No Action Alternative will have less impact on mine dewatering activities than the other two alternatives, but will yield a reduction of volume from existing conditions. The No Action Alternative may result in fewer conflicts between gas and coal producers than the other two alternatives. However, the probable development of the No Action Alternative likely would occur closer to the coal outcrop, in places where state and private ownerships of oil and gas rights are concentrated and coal and gas conflicts are most likely to occur.

SURFACE WATER

The goal of BLM's water management program is to comply with relevant laws and policies for protecting and enhancing the quality, quantity, and use of waters on public lands.

For the purpose of this analysis, surface water flow is expressed in cubic feet per second (cfs). The water produced from wells is expressed in gallons per minute (gpm). One cfs is equivalent to 448.83 gpm. Large flows or volumes of water are expressed as acre-feet (ac-ft). One ac-ft is equivalent to 43,560 cubic feet or 325,829 gallons.

Proposed Action

Each productive well within the project area will generate methane and water throughout the production period. The production period for some wells may be interrupted by temporary and unpredictable shut-ins resulting from changing economic conditions, workovers, scheduled maintenance or monitoring, mechanical problems, or unavailable pipeline capacity. The productive life of a CBM well within the project area has been estimated to be 12 years (USDI BLM, 1997a), and may possibly be 15 years.

The rate of water production may decline with time, however, flows are expected to average 12 gpm throughout the life of each productive well. This estimated pumping and discharge rate is based on actual pump rates for 420 CBM wells drilled over the last four years and located in Campbell County, Wyoming (PI/Dwight's, 1998). The Proposed Action would establish an estimated 3,000 CBM wells that would be drilled in the project area over a five to ten year period, with approximately 400 productive wells being added each year. Existing CBM wells, and the earliest wells drilled as this project is implemented would stop generating water when their productive life ends, before the 10 to 20 year project life concludes.

CBM generated flows would be distributed to an estimated 500 to 1,000 points where they would be discharged under terms of NPDES discharge permits issued by WDEQ. There is likely to be an average of one water discharge point per three to six CBM wells. The discharge at each of these points would average 36 to 72 gpm over the life of the wells producing the water. Maximum discharge anticipated at a single discharge point, on average, over the life of the wells, would be approximately 100 gpm or 0.22 cfs if produced water from 8 wells were discharged at one location. A CBM generated flow of 0.22 cfs represents the average annual runoff from approximately 18 square miles, using a composite of the flow statistics presented in **Table 3-2**. A CBM generated flow of 0.22 cfs would substantially exceed the typical 2-year, 24-hour storm flow from one square mile, due to the aridity of the region.

Design and siting of discharge facilities must be carefully controlled or limited where channels are not stable, armored, or large enough to accommodate the flows that would be anticipated. If the maximum flow (0.22 cfs) were discharged continuously into a channel three feet wide, water depth in the channel resulting from the discharge would be only 0.6 inch, and the velocity would be less than 1.9 feet per second. Velocity would decrease as slopes drop.

The increased daily flows would be available for subsequent beneficial uses such as livestock watering and wildlife use, development of fisheries, and crop irrigation in places where water and soil quality permit. Landowners currently are utilizing discharged waters from CBM wells already drilled within the project area for beneficial uses. As drainages become perennial, these CBM flows will be further diminished by one percent of the flow per mile downstream, through recharge to alluvium and the Wasatch sands and through losses from evapotranspiration (conveyance loss) (WSEO, 1998a).

The quality of the water is good for livestock, poor for irrigation use, and is generally better than the naturally occurring water in the Belle Fourche River just downstream of the project area, which contains 809 to 7,870 mg/l TDS (**Table 3-4**). The TDS of CBM produced water from the Wyodak-Anderson coal within the project area has averaged 764 mg/l based on WDEQ discharge monitoring report data (WDEQ, 1998a).

Water Flow

CBM generated surface water likely will be available for only 10 to 20 years. Twenty years after this project is initiated, CBM generated flows are expected to return to levels seen prior to 1993, when flows from CBM development were not present, if no additional CBM development or groundwater development follows this project.

CBM generated flows within the project area are expected to increase from 15.1 million gallons per day to a maximum of 66.1 million gallons per day (occurring in years 2006-2007). Water would be discharged from an estimated 500 to 1,000 locations. Total conveyance losses at project boundaries are expected to be 23 to 58 percent of projected CBM discharges. Infiltration losses are generally assumed to be about 20 percent of total conveyance losses (Babb, 1998). The equivalent outflow at the project boundary would be much less than one cfs for the Powder River, nine cfs for the Little Powder River, thirty-three cfs for the Belle Fourche River, and seven cfs for the Upper Cheyenne River following loss of approximately one percent of the flow per mile to infiltration and to evapotranspiration along the channels (**Table 4-1**). These conveyance losses are based on site-specific data (USGS, 1998b) and general State of Wyoming Board of Control calculation procedures (WSEO, 1998a).

The maximum water volume produced annually from the flow rates discussed above is expected to increase from an estimated 8,624 ac-ft per year in 1998 to 75,000 ac-ft per year (occurring in years 2006-2007). The groundwater modeling study predicted that annual yield at the project boundary would be 20 ac-ft for the Powder River, 3,105 ac-ft for the Little Powder River, 21,478 ac-ft for the Belle Fourche River and 7,399 ac-ft for the Upper Cheyenne River (**Table 4-1**). The Proposed Action would double the annual yield from the Belle Fourche and Upper Cheyenne drainages (**Table 4-2**).

In contrast to naturally occurring flows, which fluctuate with changing seasons, CBM generated flows occur year-round, at a relatively constant rate. Average daily flows would be increased, likely resulting in draws and drainages, previously ephemeral, becoming perennial downstream from the discharge points. Average and median flows are expected to increase. Unless design and location of discharge points are carefully controlled or limited, localized flooding may occur with increased frequency and magnitude where channel or basin capacity is insufficient to handle increased flows.

Spring flows are expected to increase with the addition of CBM-generated flows. Channels may be more likely to overbank during snowmelt, flooding nearby fields. Localized erosion and gully formation, water damaged structures, inundated vegetation (if flooding occurs too late in the growing season), and siltation or breaching of irrigation ditches or reservoirs may result from large, late, or prolonged flood events. Overbank deposits can produce nutrient-rich and arable soils, which may enhance agricultural uses of the affected lands. Alternatively, overbank deposits may add saline or fine grained sediments to a floodplain, decreasing productivity and lowering infiltration rates. The latter could occur in watersheds downgradient from saline soils or soils developed from shales.

Flows resulting from year-round discharge of produced waters may become frozen during winter, filling channels and associated culverts with ice, and causing localized flooding, with effects similar to those described above. Topographic basins and playas (old lakebeds) may become inundated if water is discharged into them. Inundation may be greater during the winter when playas are frozen, and less evaporation occurs. Water yields of affected basins are expected to increase.

Increases in average daily flows in the smaller, less well-developed drainages could result in degradation of these systems caused by increased stream erosion and sedimentation. These increased flows are likely to cause sustained downcutting in fluvial environments where discharge of produced waters occurs. Sustained downcutting will increase channel capacity within the upper and middle reaches of watersheds over time, decreasing the likelihood that overbank flooding will occur in these areas in the future, after flows return to present levels. In lower reaches of the watershed, however, flow in uplands through incised channels will result in higher velocities and a greater percentage of a given flood peak being transported downstream, creating an increased hazard of future flooding in a channel reach distant from the CBM activities.

Table 4-1 Projected Outflow at Project Boundary for Existing and Proposed CBM Well Scenarios

Drainage Basin	Length of Channels for Drainage1 (miles)	Expected CBM Well Discharge: Number of Wells in Basin	Expected CBM Well Discharge: Total Discharge 2 (gpm)	Conveyance Loss3 (1% per mile) (gpm)	Equivalent Recharge Rate4 (in/yr)	Outflow at Project Boundary: (gpm)	(cfs)	(ac-ft/yr)
Existing Well Scenario - 890 Wells								
Upper Reach of Powder River	86	0	0	8	0.00	0	0	0
Middle Reach of Powder River	28	0	0	0	0.00	0	0	0
Little Powder River	87	280	3,360	1,965	0.13	1,395	3	2,250
Belle Fourche River	35	580	7,895	2,361	0.74	5,534	12	8,927
Upper Cheyenne River	27	30	360	85	0.27	275	1	444
No Action Scenario - 2,890 Wells								
Upper Reach of Powder River	86	70	840	486	0.01	354	1	571
Middle Reach of Powder River	28	0	0	0	0.00	0	0	0
Little Powder River	87	780	9,360	5,474	0.36	3,886	9	6,269
Belle Fourche River	35	1,690	21,215	6,346	2.00	14,869	33	23,989
Upper Cheyenne River	27	350	4,200	988	3.13	3,212	7	5,182
Proposed Action - 3,890 Wells								
Upper Reach of Powder River	86	210	2,520	1,458	0.04	1,062	2	1,713

Middle Reach of Powder River	28	0	0	0	0.00	0	0	0
Little Powder River	87	1,000	12,000	7,018	0.47	4,982	11	8,037
Belle Fourche River	35	2,210	27,455	8,212	2.58	19,243	43	31,045
Upper Cheyenne River	38	470	5,640	1,808	5.73	3,832	9	6,182
Alternative 1 - 5,890 Wells								
Upper Reach of Powder River	86	1,040	12,480	7,222	0.18	5,258	12	8.483
Middle Reach of Power River	28	250	3,000	731	0.41	2,269	5	3,660
Little Powder River	87	1,070	12,840	7,509	0.50	5,331	12	8,600
Belle Fourche River	58	2,670	32,975	14,503	4.56	18,472	41	29,800
Upper Cheyenne River	38	860	10,320	3,294	10.43	7,026	16	11,336

1Only included drainage channels adjacent to or downgradient of CBM well fields and within the project area.
2 Based on average discharge of 12 gpm, except in the Marquiss field, where average discharge is 17.5 gpm.
3 Loss due to infiltration + evapotranspiration along the channels.
4 Infiltration (recharge assumed to be 20% of conveyance loss.

Table 4-2
CBM Annual Runoff Compared with Average Annual Runoff by Drainage Basin

	Projected Outflow from CBM Discharges at Project Boundary (ac-ft/yr)	Average Runoff Annual1 (ac-ft/yr)	CBM Discharges as a Percent of Average Annual Discharges
Existing Well Scenario - 890 Wells			
Upper Reach of Powder River at Arvada, WY	0	200,700	0
Middle Reach of Powder River at Moorhead, MT	0	327,500	0
Little Powder River at Weston, WY	2,250	15,920	14
Belle Fourche River below Moorcroft, WY	8,927	17,400	51
Upper Cheyenne River at Edgemont, SD	444	58,790	0.8
Proposed Action - 3,890 Wells			
Upper Reach of Powder River at Arvada, WY	1,713	200,700	0.8
Middle Reach of Powder River at Moorhead, MT	0	327,500	0
Little Powder River at Weston, WY	8,037	15,920	50
Belle Fourche River below	31,045	17,400	178

Moorcroft, WY			
Upper Cheyenne River at Edgemont, SD	6,182	58,790	11
Alternative 1 - 5,890 Wells			
Upper Reach of Powder River at Arvada, WY	8,483	200,700	4.2
Middle Reach of Powder River at Moorhead, MT	3,660	327,500	0
Little Powder River at Weston, WY	8,600	15,920	54
Belle Fourche River below Moorcroft, WY	29,800	17,400	171
Upper Cheyenne River at Edgemont, SD	11,336	58,790	19
No Action Scenario - 2,890 Wells			
Upper Reach of Powder River at Arvada, WY	571	200,700	0.3
Middle Reach of Powder River at Moorhead, MT	0	327,500	0
Little Powder River at Weston, WY	6,269	15,920	39
Belle Fourche River below Moorcroft, WY	23,989	17,400	138
Upper Cheyenne River at Edgemont, SD	5,182	58,790	9

1USGS, 1998b The type of sediments incised by a channel is a co-dominant factor with discharge in controlling channel cross sectional form. Narrow and deep channels are typical for streams traversing areas where sediments have high silt/clay content, as are found within the project area. Where this downcutting occurs in highly erodible soils, ravines or gullies are likely to develop unless discharge points are carefully located and designed.

The increased volume of sediment transported downstream from discharge points may cause sustained aggradation in fluvial environments downvalley, within lower reaches, as the stream gradient decreases. Wherever this sediment deposition occurs downstream from CBM discharge points, channel capacity may decrease over time, possibly increasing the likelihood that localized flooding will occur. When surface flows return to present levels at the end of the project's life, the risk of localized flooding would be elevated until the channel has re-established a balance between channel capacity and floodplain morphology.

Downcutting (or stream erosion) within the upper reaches of a drainage system and sediment deposition (or aggradation) within its lower reaches, are natural processes that occur as a stream ages through time. As the stream channel becomes incised through erosion, the slope of the stream and its velocity are reduced, and further erosion is limited. While drainages are not expected to flow under completely natural conditions within this very small segment of geologic time, the relatively constant CBM generated flows are not expected to alter regionally characteristic landforms during the life of the project.

Stream meander wavelengths vary with discharge rates. Large streams tend to have large meanders and small streams tend to have small meanders. During the project's life, some streams may begin to re-establish meander patterns on a longer wavelength, in response to increased flows, or especially, as a consequence of a major flood event. When surface flows return to present levels at the end of the project's life, the possibility of stream meanders being re-established on longer wavelengths will no longer exist.

New springs may develop in areas that are recharged by newly saturated alluvial aquifers or Wasatch sands. If compaction occurs during construction or production activities, spring flow may be inhibited locally. Natural discharge of springs potentially can be impacted by reduction in hydraulic head in the source aquifer unit. Potential impacts to spring flow, especially those related to scoria aquifers like the one feeding Moyer Springs (4-32), can be analyzed site-specifically, as needed, during review of APDs or Sundry Notices, and impacts mitigated through the application of special conditions of approval for drilling or production operations.

Water Quality

Existing water quality has curtailed beneficial uses within some segments of the Belle Fourche drainage downstream from any discharge points that would be established under the Proposed Action. CBM generated flows within the project area are expected to be of higher quality than existing flows within some downstream segments of the drainage. The feasibility of designing surface water discharge facilities that could prevent higher quality CBM generated flows or increased sediment loads from reaching the affected segments of the Belle Fourche drainage can be analyzed site-specifically, as needed, during review of APDs or Sundry Notices. The quality of discharged waters can be protected through the application of special conditions of approval for drilling or production operations that provide for the careful location and design of discharge facilities in the vicinity of impaired water bodies. During the APD approval process the current WDEQ 303(d) map and listing of impaired water bodies will be consulted.

Surface water salinity within the project area currently exceeds 2,000 mg/l TDS for over half of all samples analyzed. Produced water will have a greater bicarbonate character than naturally occurring surface waters. During fifteen of the twenty years of the project's life, CBM generated water having TDS concentrations averaging 764 mg/l (WDEQ, 1998a) will comprise approximately one-half of the total surface water volume produced annually in the project area. TDS concentrations in drainages within the project area typically experience substantial fluctuations occurring in inverse relationship to flow, which are expected to be buffered by the constant CBM generated flows. Locally, TDS concentrations within surface waters may rise slightly in the short-term due to increased stream erosion or runoff over disturbed lands during operations.

Table 3-6 summarizes the mean and maximum concentrations of metals from 95 to 366 samples of the Fort Union Fm (USDI BLM, 1997a) Fifteen percent of 366 samples exceeded drinking water standards for iron of 0.3 mg/l. Thirty-nine percent of 257 samples exceeded drinking water standards for manganese of 0.05 mg/l. Iron and manganese drinking water standards are based on aesthetics rather than toxicity; these metals can tint water and stain clothes but typically will not cause health effects. Radioactive radium-226 is analyzed in the NPDES discharge monitoring reports of CBM generated waters, but is rarely present. Neither metal concentrations nor radioactive materials are expected to cause detrimental impacts to water quality.

Sediment concentrations in surface waters will increase on a daily basis if discharges of produced waters are not directed into stable or armored channels. Increased stream erosion may cause sediment concentrations in surface waters to rise over present levels. Runoff from disturbed areas may cause sediment concentrations in surface waters to rise over present levels unless timely recontouring and revegetation of disturbed areas occur. A discussion of disturbance-based sediment loss for this project may be found in the soils section of this chapter.

The total estimated area that may be affected by disturbance related to drilling and construction or installation of production facilities or pipelines under the Proposed Action is 16,751 acres, or about 1.1 percent of the total project area of 1.54 million acres. The long-term disturbance area required for production facilities and pipelines is estimated to be 6,514 acres. After surface flows return to present levels, very little additional sediment (over present levels) is likely to be introduced into surface waters, as stream erosion returns to rates similar to those presently occurring.

The State of Wyoming's 1998 Section 303(d) lists identify water bodies within the state which do not support all of their designated uses (WDEQ, 1998b). There is one site within the project area, the Gillette Fishing Lake, which has elevated silt and phosphate levels which impair or are a threat to the warm water fishery. These water qualities may be aggravated by the Proposed Action. Two sites downstream of the project area on the Belle Fourche River (USGS sites 6428050 and 6426500) have fecal coliform concentrations which impair secondary and contact recreation, respectively. Additional water in the drainage may improve the water quality at these sites. Table B of Wyoming's 1998 Section 303(d) list identifies water bodies which will have waste load allocations imposed within the next two years as part of the NPDES renewal process. The Belle Fourche River below the Hulett Wastewater Treatment Plant downstream of the project area will have Total Maximum Daily Loads (TMDLs) imposed for ammonia, fecal coliform and total residual chlorine, to support a warm water fishery and secondary recreation within this reach.

Water Use

Produced water from CBM wells is most likely to be used for stock watering, fisheries, and irrigation. Surface water withdrawals were estimated to be 36.94 million gallons per day in 1990 (USGS, 1998a). In 1998, water available for withdrawal increased by an estimated 41 percent to 52.1 million gallons per day with the addition of discharges of CBM generated flows. The maximum water volume expected to be produced during the life of the project is estimated to be 66.1 million gallons per day. The average volume of water to be produced during the life of the project is 33 million gallons per day, increasing, on average, the volume of water available for use by 189 percent. Conveyance loss of one percent per mile (WSEO, 1998a) from evapotranspiration and recharge would result in some CBM produced waters not being available for surface water diversion (Babb, 1998).

Discharge of CBM produced waters also may be used to create small ponds or reservoirs. These impoundments may be stocked as fisheries, developed for recreational use, or utilized to provide water storage capacity for agricultural or livestock purposes. Water impoundments, playas and small depressions situated in the vicinity of discharge from productive wells or in the vicinity of areas where groundwater recharge occurs, can be expected to have a constant source of water. Slow-moving water or shallow perimeter areas are expected to support the growth of wetland species.

Indirect impacts from the Proposed Action that are related to surface water resources are described in the following categories: ecosystems; wildlife and fisheries; land use; and socioeconomics.

Ecosystems

Increased surface waters, surface flows, and availability of water year-round are likely to improve the health of the biological components of ecosystems within the project area during the life of the project. Plants and animals inhabiting arid areas live under difficult conditions. Water is available only irregularly and in sparing amounts, or as an erosive deluge, within arid environments. Water transports nutrients to soils and is necessary for life. Landscapes with greater amounts of available surface water typically support enhanced vegetative land cover for soil conservation, increased diversity of vegetative species, and increased populations of amphibians, wildfowl and other wildlife species. These are discussed in more detail in the biological sections.

Hydric soils characteristic of wetlands would be likely to develop during the life of the project, where abundant surface water is concentrated in specific locations throughout most of the year. Depressions which are subject to sustained flow would serve as sediment filters and support more abundant plant and animal life than surrounding arid areas. The availability of water year-round and the nutrient-rich sediments deposited in wet areas combine to increase site productivity. Vegetation growth rates and mass typically are much higher within wet areas than in surrounding drier sites. Soils high in salts, such as could occur in playas or closed basins, will not produce as much vegetation with increased water and the plants will be less palatable and nutritious.

Riverine environments, where fluvial (stream processes) are at work on the landscape year-round, are expected to have minor increases in areal extent during the life of the project (20 years). The acreage that will undergo riverine habitat improvement, caused by increased surface flows, is likely to be much less than one acre per discharge point. Approximately 2,500 discharge points will be utilized to implement the Proposed Action. After twenty years, and unless groundwater development continues at the conclusion of the CBM project, riverine environments including riparian zones and other areas improved by CBM produced waters will revert to present conditions, reducing infiltration rates and vegetative cover, and lowering species diversity in the immediate vicinity.

Evaporation from shallow impounded CBM waters may produce highly saline reservoirs or ponds, resulting in aquatic ecosystems within playas that have high salinity requirements. After 20 years, at the conclusion of the project, these ecosystems will lose their source of water and die if landowners do not elect to continue pumping water from wells drilled to produce CBM. These former reservoirs and ponds may be difficult to revegetate unless adequate site preparation occurs. Soil may be lost from unvegetated areas due to wind erosion unless reclamation efforts are timely.

CBM generated flows, alone, are unlikely to cause significant flooding within the project area. In combination with a large storm event or snowmelt, CBM generated flows may contribute to the formation of overbank deposits, which would accumulate during any flood events. Overbank deposits can provide additional nutrients to fields that become flooded. A flood event may effectively shorten the growing season by inhibiting plant growth until fields dry out.

Wildlife and Fisheries

An increase in available water or forage may result in increased wildlife populations. Increased or new wildlife populations are likely to depend on water bodies and vegetation supported by CBM produced waters. After 20 years, (and unless groundwater development continues at the conclusion of the project), wildlife habitats improved by CBM produced waters will revert to present conditions, reducing some wildlife populations.

Increased CBM generated flows may permit the development of fisheries within reservoirs created to receive discharges. However, sediment concentrations could increase, diminishing some river-based fisheries, unless adequate erosion control or mitigation measures are included in water management plans. After 20 years, (and unless groundwater development continues at the conclusion of the project), fisheries and aquatic habitats improved or created by CBM produced waters will revert to present conditions, reducing some populations and species diversity.

Land Use

Use of irrigation for agricultural production is likely to increase. This development is most likely to occur on lands where flood irrigation is feasible. Flood irrigation is likely to support an increase in acreage used as cropland or an improvement in range productivity. Land covers are likely to change from open range to irrigated land in areas where CBM produced water is available and contains TDS concentrations which are reliably less than 850 mg/l.

Some open livestock range may be replaced by wet areas or streamside vegetation, which would be utilized differently by livestock. Diversion of water to stock tanks and new or old reservoirs will change livestock distribution and range utilization. Additional fencing may be required in some areas to limit overuse by livestock. These and other improvements might be useful only during the life of the project.

Sub-irrigated fields may not dry out as quickly with the addition of CBM produced water, which could reduce production of forage or crops. For example, ranchers accustomed to producing two cuttings of hay from a sub-irrigated field could see this production reduced to one cutting.

An increase in available stock water or range productivity is likely to permit an increase in the number of cattle. At the end of this project life, unless groundwater development continues, or unless stocking rates of rangeland decrease to pre-1990 levels, accelerated erosion resulting from overgrazing would likely occur.

Recreational hunting and fishing opportunities, which are controlled by landowners on private lands, may increase locally, if populations of game animals and game fish rise, in response to increased availability of surface water and forage.

Stream erosion and resulting sediment accumulation may cause increased deposition in instream reservoirs located downvalley. These reservoirs may need to have accumulated sediments removed in order to retain adequate storage capacity.

Socioeconomics

After 20 years, (and unless groundwater development continues at the conclusion of the project), fisheries and wildlife habitats improved or created by CBM produced waters will revert to present conditions, reducing or eliminating enhanced opportunities for hunting, fishing, and recreational activities. Ranchers and stockmen who had counted on CBM waters to support increased livestock herds or other endeavors would be unable to continue reliance upon these additional sources of revenue. The value of improvements, such as fencing, or other expenditures in developing surface water withdrawals may be reduced at the end of the project life.

Mitigating Measures

Mitigation measures in the form of water management plans will be developed and applied as a cooperative effort at the APD level of analysis, on a site-specific basis or under a Plan of Development (POD) on a project-level basis (**Appendix B**). This effort will include the agencies with jurisdiction (the BLM, FS, COE, WSEO, WOGCC and/or WDEQ) in consultation with the involved land managers and conservation districts, operators, landowners, and nearby downstream interests, including users of waters and landowners affected by impacts of increased flows on access, ranching, or mining operations. The cooperative efforts of all stakeholders will be necessary in developing water management plans that identify mitigating measures for areas or drainages where high CBM generated flows are or could be impacting existing uses. Some of the measures that could be applied at each site include:

€ Produced water may be dispersed in the upper reaches of drainages through the installation of stock tanks.

€ Produced water may be transported to distant discharge points, which could require the use of water disposal pipelines that are more than one-half mile long.

€ Produced water will be discharged into existing stream channels, reservoirs, stock ponds, and stock tanks in a manner that will not cause increased or accelerated erosion. This has been done effectively in past CBM projects by using energy dissipators at discharge points and by discharging into channels that are well developed and large enough to handle the increased flows. Energy dissipation can be achieved through the use of rock, placement of concrete control structures and/or the establishment of hydrophytic vegetation.

€ Alternative discharge points will be utilized, as appropriate, to minimize spring flooding of fields or to provide for other seasonal use.

€ Discharge outfalls may use alternative outfalls for use with irrigation, as agreed upon by operator and landowner or lessee.

€ Existing downstream culverts may need to be replaced with larger sizes to handle new flows. New culverts will need to be sized considering total flows.

€ Discharges will be limited to a volume less than or equal to the naturally occurring mean annual peak flow that can be handled by the channel cross-section under anticipated conditions, including flood events such as the 2-year 24-hour storm.

€ Local springs will be identified, and construction will be avoided in these areas.
€ Discharge into playas will be avoided unless issues related to potential wetland creation, maintenance of discharge facilities, reclamation, and accountability are agreed upon by the operator and landowner or lessee.

€ Discharge points will be selected in stable channels or reservoirs away from any significant downstream headcuts or other major erosional features. Outfall design may include discharge aprons and downstream stabilization of channel side slopes to prevent erosion and provide energy dissipation.

€ Discharge facilities will be designed site-specifically using best management practices, to accommodate livestock access to water, to control erosion, and to limit sedimentation.

€ Irrigation diversions to increase channel length and in-stream impoundments will be established, as appropriate, and as agreed upon by the operator and landowner or lessee.

€ Downstream impoundments may need new or redesigned outlet works in order to handle the steady inflow provided by CBM discharge water.

€ Wetland zones adjacent to impoundments will be utilized to promote deposition, as appropriate, and as agreed upon by the operator, landowner, or lessee, and appropriate state and federal agencies.

€ As per State of Wyoming monitoring requirements contained in approved permits, and BLM or FS monitoring requirements contained in approved monitoring plans, volume and water quality parameters [pH, EC, radium-226 and total petroleum hydrocarbons (TPH)] will be monitored at discharge sites by CBM producers as part of WDEQ NPDES permits. Monitoring at selected stations on the Little Powder, Powder, Belle Fourche and Cheyenne Rivers and/or their tributaries will consist of a full suite analysis, including TDS. River monitoring plans will be developed in consultation with the USGS and the BLM.

€ The areal extent of surface disturbance and the length of time that the area will remain disturbed before interim or final reclamation activities commence will be minimized.

€ Interim and final reclamation of all disturbed areas will proceed in a timely manner. Reclamation activities will be conducted during time frames established by federal land management agencies, landowners and affected interests.

€ Reclamation must produce a natural appearance and must be consistent with site conditions, area management standards, and projected uses, as agreed upon by the operator, landowner or lessee, and appropriate state and federal agencies.

€ Reclamation will include, as appropriate, recontouring, establishment of desirable, perennial vegetation, stabilization and erosion control of all disturbed areas. Additional measures, such as topsoil conservation, temporary fencing, mulching, or weed control will be utilized, as appropriate, to ensure long-term vegetative stabilization of all disturbed areas. Reclamation standards will be agreed upon by the operator, landowner or lessee, and appropriate state and federal agencies.

Alternative 1
Except for those changes noted below, the environmental consequences to water resources are not expected to vary between the Proposed Action and Alternative 1.

Production would be established from 5,000 productive CBM wells to be drilled in an expanded (enlarged) project area over a 3 to 5 year period, with 800 to 1,000 wells being drilled each year. The average well density for new wells (estimated to be 1.4 wells per square mile) would be about the same for the Proposed Action and Alternative 1.

CBM generated flows within the expanded project area are expected to increase from 15.1 mgd to 100.1 mgd (occurring in years 2003 to 2007). An estimated 833 to 1,667 discharge points would be utilized to implement Alternative 1. Estimated outflow at the project boundary would be less than 12 cfs for the upper reach of the Powder River, 5 cfs for tributaries to the middle reach of the Powder River, 12 cfs for the Little Powder River, 41 cfs for the Belle Fourche River and 16 cfs for the Upper Cheyenne River (**Table 4-1**). This reflects the anticipated discharges coupled with infiltration and evapotranspiration along the channels.

The maximum volume of water produced annually based on the above flow rates is expected to increase from an estimated 8,624 ac-ft per year in 1998 to 113,559 ac-ft per year (occurring in years 2003 to 2007). The groundwater modeling study predicted that annual CBM yields at the project boundary would be 8,483 ac-ft for the upper reach of the Powder River, 3,660 ac-ft for the middle reach of the Powder River, 8,600 ac-ft for the Little Powder River, 29,800 ac-ft for the Belle Fourche River, and 11,336 ac-ft for the Upper Cheyenne River. This would increase the annual runoff from the upper reaches of the Powder River by 4.2 percent, middle reaches of the Powder River by 1.1 percent, Little Powder River by 54 percent. Annual yields from the Belle Fourche and Upper Cheyenne Rivers would increase by 171 and 19 percent, respectively (**Table 4-2**).

The average amount of water to be produced during the life of the project is expected to be 58 mgd, increasing on average, the amount of surface water available for use by an estimated 257 percent.

The total estimated area that may be affected by disturbance related to drilling and construction or installation of production facilities or pipelines under Alternative 1 is 26,491 acres, or about 1.2 percent of the expanded project area of 2.3 million acres. The long-term disturbance area that would be needed for production facilities and pipelines is estimated to be 10,788 acres. After surface flows return to present levels, very little additional sediment (over present levels) is likely to be introduced into surface waters, as stream erosion returns to rates similar to those presently occurring.

No Action

Except for those changes noted below, the environmental consequences are not expected to vary between the Proposed Action and the No Action Alternative.

Production will be established from 2,000 coal bed methane wells to be drilled over a five year period, with an estimated 400 wells being drilled each year. The average well density for new wells is estimated to be 0.8 wells per square mile.

CBM generated flows within the project area are expected to increase from an estimated 15.1 mgd to 49.1 mgd (occurring in years 2003 to 2007). An estimated 333 to 667 water discharge points are anticipated under the No Action Alternative. The estimated outflow at the project boundary would be much less than one cfs for the Powder River, 9 cfs for the Little Powder River, 33 cfs for the Belle Fourche River and 7.0 cfs for the Upper Cheyenne River (**Table 4-1**). This reflects the anticipated discharges coupled with infiltration and evapotranspiration loss along the channels.

The maximum volume of water produced annually based on the flow rates above is expected to increase from an estimated 8,624 ac-ft per year to 55,719 ac-ft per year (occurring in years 2003 to 2007). The groundwater modeling study projected that average annual yields for the Powder, Little Powder, Belle Fourche and Upper Cheyenne Rivers at the study area boundaries would be 571, 6, 269, 23, 989, and 5,182 ac-ft respectively, which would represent runoff increases of 0.3, 39, 138, and 9 percent, respectively (**Table 4-2**).

The average amount of water to be produced during the life of the project is expected to be 27 mgd, increasing on average, the amount of surface water available for use by an estimated 173 percent.

GROUNDWATER

The effects of CBM development on groundwater resources are described in terms of a loss in hydraulic pressure head in the coal aquifer. Effects of coal mining activities and other existing or reasonably foreseeable conditions are analyzed within this chapter for the Proposed Action, Alternative 1, and No Action development scenarios. The effects are seen as a drop in the water level (drawdown) in nearby wells that are completed in the coal aquifer. As groundwater leaves the aquifer and enters the well bore, the water level in a well completed in the coal aquifer rises above the level of the aquifer, and a hydraulic pressure head is generated. Partial removal of groundwater from the coal aquifer (through coal mining operations or CBM development) can reduce the hydraulic pressure head and lower the water level in nearby wells completed in the coal seam. After CBM development (and water removal) ends, water levels in nearby wells are expected to recover somewhat as coal aquifer recharge occurs.

In developing CBM, a portion of the water contained in the coal aquifer is removed at specific locations, releasing methane for collection. The primary groundwater impact associated with development of the Wyodak CBM Project involves loss in available hydraulic head in the target formation (the Wyodak-Anderson coal seam). This head loss could impact water wells completed in the coal seam, in the form of reduced well yields and potential methane production. Surface discharge of extracted groundwater from CBM operations potentially can enhance recharge of shallow aquifers below creek areas.

Specific groundwater issues associated with the proposed Wyodak CBM development include:

Local and regional coal aquifer drawdown resulting from CBM development and surface coal mining.
Maximum areal extent of coal aquifer drawdown.
The magnitude of projected coal aquifer drawdown under various CBM development scenarios.
The extent of coal aquifer utilization and the effect of predicted drawdown on this use.
Wasatch sand aquifer drawdown resulting from CBM development and surface coal mining.
The rate of coal aquifer recharge after CBM operations cease.
The contribution of surface discharge of extracted coal groundwater to the recharge of shallow Wasatch sand aquifers.
The differentiation of coal aquifer drawdown effects resulting from coal mining and CBM development.

Hydrogeologic Framework
A detailed description of the geology and hydrology of the area is given in Chapter 3. The focus of the impact assessment is the Wyodak-Anderson coal seam (top of the Fort Union Fm) and the overlying Wasatch Fm. The dip of the Fort Union coals in the eastern PRB is generally 1-2 degrees to the west-northwest, although the Wyodak-Anderson coal has numerous "rolls" so that, locally, dips may be quite variable. The Wasatch Fm has several discontinuous sand units that are utilized for water supply. The base of the Wasatch Fm, directly above the Wyodak-Anderson seam, typically is a low permeability claystone that forms a hydraulic confining unit for the coal.

The coal and overburden are eroded where the Wasatch Fm and Wyodak-Anderson coal contact intercepts the land surface to the east. Range fires and spontaneous combustion have ignited the areas of exposed coal at the land surface. The burning of these coal deposits has created a land form composed of permeable material (clinker), formed from the baking and subsequent collapse of the sediments originally above the coal.

Recharge to groundwater aquifers occurs from infiltration of direct precipitation (rain and snowmelt), runoff in creek valleys and standing water in playas. Precipitation provides a minimal source of recharge over most of the area because the climate and surface features prohibit significant infiltration. Infiltration is significant in areas of more permeable surface geologic units such as the clinker that occurs at the eastern outcrop area of the Wyodak coal. The clinker areas are generally considered to form significant recharge areas for the coal. Infiltration of surface water in creek valleys is also generally considered to be an important source of recharge to shallow aquifers. The Wyoming Board of Control currently considers surface water losses in river flows due to evapotranspiration and leakage (termed conveyance loss) to be about one percent of the flow per mile. Evapotranspiration probably accounts for most of the conveyance losses, particularly during the summer months. Recharge of shallow aquifers due to leakage from rivers is likely to be approximately 20 percent of the conveyance loss.

Hydraulic connection between the shallow Wasatch sands and the Wyodak-Anderson coal is limited due to the low permeability claystones that separate the two units. However, if the hydraulic head (water level) in the coal is naturally lower than in the overlying sands, then there is the potential for leakage from the sands into the coal. The natural leakage rate will typically be extremely small, but taken over a large area can amount to a significant portion of the total recharge into the coal. Locally, hydraulic connection between the coal and Wasatch sands may be enhanced should the integrity of the confining layer be compromised by water supply wells screened through both the coal and the overlying sands, by deteriorating well casings, or by poorly plugged oil and gas wells or exploratory drill holes. Leakage from the Wasatch sands into the coal may be enhanced if water levels in the coal are lowered as a result of coal dewatering activities. Due to the limited hydraulic communication between the coal and the overlying Wasatch sands, a significant period of time (typically several years) will likely pass before significant drawdown (drop in water level) effects in the sands are apparent.

Through time, many clinker deposits have become saturated as a result of the infiltration of precipitation and snowmelt. "Ponding" of water may occur along this interface where the clinker meets the less permeable coal and sediments of the Wasatch Fm. Springs may form at the base of the clinker deposits. The Moyer Spring north of Gillette is a good example of this situation.

Regional groundwater flow is generally to the northwest (downdip) towards potential discharge areas in the north central part of the PRB (USGS, 1986b). Coal wells in the vicinity of the Powder River exhibit flowing artesian conditions that indicate upward flow gradients. This supports the potential for groundwater discharge along the northern part of the Powder River, although physical evidence for this, in the form of springs and sustained river baseflow are not readily apparent. It is assumed that most of the discharge is diffuse and may be consumed by evapotranspiration so that it does not appear as a surface flow.

Groundwater Modeling Methodology

Numerical groundwater flow modeling was used to predict the impacts of the Wyodak CBM Project. Modeling was necessary because of the large extent, variability, and cumulative stresses imposed by mining and CBM development on the Fort Union and Wasatch aquifer units. Assessment of CBM development impacts has been performed for earlier environmental assessments for the Marquiss, Lighthouse, North Gillette, and South Gillette areas (USDI BLM, 1992a, 1995c, 1996a and 1997a). A detailed modeling study was completed for the Little Thunder drainage basin in the southeastern part of the PRB (WWRC, 1997). A modeling study of the Lighthouse CBM development also has been recently completed (WWRC, in press). The information from earlier studies has been incorporated wherever practical into the modeling work for the Wyodak CBM EIS.

The main features and assumptions of the model used for the Wyodak CBM EIS are briefly described here. The complete technical description of this groundwater analysis is found in the *Technical Report for the Wyodak CBM Project*, *Groundwater Modeling of Impacts Associated with Mining and Coal Bed Methane Development in the Eastern Powder River Basin*, on file at the BLM Casper Field Office in Casper, WY and at the BLM Buffalo Field Office in Buffalo, WY. This report describes the specific hydrogeologic data on which the model was based. It also describes the numerical model and model assumptions in more detail.

The hydrogeologic model code selected was the latest version of the USGS Three Dimensional Finite Difference Modular Groundwater Flow Model MODFLOW96. This model code is widely accepted by regulatory agencies and currently is used by the BLM.

The model consists of eight geologic layers. The lowermost two layers (layers 7 and 8) represent the Lebo Member and the shale aquitard separating the Lebo from the overlying Wyodak coal bed. The Wyodak coal bed is represented by layers 4, 5 and 6 in the model. The Wyodak consists of several coal beds that split and merge in the PRB. The model consolidates these splits into two coal beds (layers 4 and 6), separated by an intervening shale parting (layer 5). The Wyodak coal transitions into more highly permeable clinker at the eastern outcrop area. Data on the coal seams and structure were weakest in the northern portion of the modeled area. Overlying the coal is a layer (layer 3) representing shales within the Wasatch Fm that acts as a confining unit between the coal and the discontinuous sandstones within the Wasatch Fm. The second layer represents the Wasatch Fm discontinuous sandstone units. The uppermost layer (layer 1) represents the surface geologic units that include shales, sandstones, and alluvial sands within creek valleys.

Other geologic boundaries that were incorporated into the model include faults and lineaments that are suspected of having a significant influence on groundwater flow regimes. Faults may act as impermeable (no-flow) boundaries and lineaments as zones of augmented hydraulic conductivity in the model.

Stresses imposed from surface mining were simulated as drains. Stresses imposed from CBM development were simulated as pumping wells at a static 12 gpm for an estimated 15-year life. Due to the large number of proposed CBM wells, the uncertain location of the wells, and the large area involved, the model wells actually simulated "pods" of CBM wells, consisting of 8 to 12 wells in relatively small areas.

Model calibration was done to pre-mining, or in a few cases, earliest available static water levels. This was assumed to represent steady state conditions. The model was calibrated in transient state by matching against available historic water level monitoring data.

The mining sequence was simulated, for geographic locations projected to be mined, as incremental impacts in one year stress periods from approximately 1975 (the earliest mining along the Wyodak outcrop with the exception of the Wyodak mine east of Gillette) to the present. Predictive simulations of impacts were modeled to year 2225, about 200 years beyond the presently anticipated end-of-mining, in year 2021. Mine plan maps of record on file with the Office of Surface Mining in Denver, Colorado were used to project the mining sequence. These life of mine maps show coal removal sequences and mine progression. Annual progress of the mine plans was superimposed on the grid as drains within the model, with the pits left open for two years and then closed. Current CBM production was simulated in the area using the historic operational data from the existing fields. Future CBM development was simulated using the best estimate of future development rate that is described in Chapter 2. Mining impacts were modeled with, and without CBM development in order to differentiate the impacts of the two imposed stresses.

The groundwater flow model was used to predict the areal extent of aquifer drawdowns due to the superimposed stresses of the proposed CBM development and mining operations on a year-by-year basis. CBM development of the PRB started in 1989. Rawhide Butte field represented the first commercial CBM production in the PRB. Most of the CBM development to date has been in the Marquiss and Lighthouse areas south of Gillette, and in the vicinity of the Buckskin and Eagle Butte mines north of Gillette. As of March 1998, there were approximately 420 operating CBM wells in the project area (PI/Dwight's, 1998). By November 1998 production data was available for 638 operating CBM wells in the PRB (PI/Dwight's, 1999). Based on drilling permit applications approved by the BLM, it is estimated that, as of the end of 1998, there are 890 productive CBM wells; 250 wells in the Gillette North assessment area and 640 wells in the Gillette South assessment area. The approximate locations and timing of CBM development through 1998 were input into the model based on actual well records. The location and timing for future CBM development were based on engineering judgement considering the distance from existing and proposed pipelines and known favorable areas for CBM development. Mining development was based on mining plans, as described above. For the model, the No Action Alternative assumed 2,890 wells would be operating in the project area (2,000 new wells plus the 890 wells existing at the end of 1998). The Proposed Action has 3,890 wells operating in the project area (3,000 new wells and 890 wells existing at the end of 1998) and Alternative 1 has 5,890 wells operating in the expanded project area (5,000 new wells and 890 wells existing at the end of 1998).

The following discussion outlines the projected impacts to groundwater quantity and quality under the Proposed Action, Alternative 1, and the No Action Alternative. The differences in projected impacts under the three alternatives are only significant with respect to the extent of drawdown in the coal and Wasatch aquifers. There is very little difference in the impacts to water quality under the three alternatives.

Proposed Action
Water Quantity
Prediction of Local and Regional Coal Aquifer Drawdown Resulting from the Development
Figures 4-1 and 4-2 show the interpreted cumulative water level changes measured in the coal aquifer between the years 1980 and 1995 in the two areas where there has been significant CBM development. The maps are based on data collected by the Gillette Area Groundwater Monitoring Organization (GAGMO). Most of the mining in the PRB was initiated after 1977 (with the exception of the Wyodak and Belle Ayr mines) so that the use of 1980 as the baseline year (i.e. pre-mining) is reasonable. For comparison, the model predicted drawdowns for year 1995 are shown in **Figures 4-3 and 4-4**. It can be seen that the model predicted drawdowns

for the year 1995 compare favorably with actual measured drawdowns.

The model predicted maximum in the coal aquifer for the Proposed Action CBM development is in the year 2015, and is shown in **Figures 4-5 and 4-6** for the Upper Wyodak and Lower Wyodak coals, respectively. Because the mining and CBM operations are dynamic, the maximum areal extent of drawdown changes over time and may increase in some areas of the PRB while recovering in others. The CBM water production in the project area is expected to reach a maximum in the next 7 to 10 years, between 2006 and 2007, resulting in maximum drawdown in about the year 2015.

The maximum extent of drawdown, defined as a drawdown of at least five feet, extends ten to twenty-two miles from the edge of potential dense CBM development such as in the central part of the project area. Predictions of maximum drawdown and extent of drawdown are based on the projected pod locations, Actual drilling locations and density of drilling may result in shifts of drawdown contours from the results illustrated in the figures. In addition, simplification of the elevation and thickness of the coal seam in the northern portion of the PRB may result in a slight underestimation of the maximum depth and extent of drawdown.

Maximum drawdowns occur in the vicinity of active mining operations and in the centers of CBM development. Within the northern portion of the project area, CBM production is primarily from the Upper Wyodak with projected drawdowns generally as much as 450 feet in the center of the well field. In the southern portion of the project area, the Upper and Lower Wyodak seams are both tapped for CBM development. Maximum drawdowns are projected to be greater than 300 feet within active well fields, and up to 550 feet in the center of the well field. Depths of drawdown are approximately 50 feet more in the Lower Wyodak coal than in the Upper Wyodak coal. Figure 4-1 GAGMO Coal Drawdown, 1995, Area 1 This page intentionally left blank Figure 4-2 GAGMO Coal Drawdown, 1995, Area 2 This page intentionally left blank Figure 4-3 Modeled Existing Drawdown, 1975 - 1995, Proposed Action, Upper Wyodak Coal This page intentionally left blank Figure 4-4 Modeled Existing Drawdown, 1975 - 1995, Proposed Action, Lower Wyodak Coal This page intentionally left blank Figure 4-5 Maximum Modeled Drawdown 1975 - 2015, Proposed Action, Upper Wyodak Coal This page intentionally left blank Figure 4-6 Maximum Modeled Drawdown 1975 - 2015, Proposed Action, Lower Wyodak Coal This page intentionally left blank Hydraulic head in the coal, as measured by the water level in a well completed in the coal, may be several hundred feet above the top of the coal. This is particularly true in the western part of the project area where the depth to the coal may be over 1200 feet while the depth to water in a well tapping the coal may be only 400 feet, resulting in a hydraulic head of 800 feet. Dewatering of the coal in these areas by CBM development can result in drawdown of the hydraulic head to the top of the coal (up to 800 feet), even though the thickness of the coal itself may only be 100 feet.

Recovery of water levels in the coal is apparent after CBM production starts to decline. Production is expected to end by around the year 2024. Recharge to the coal comes primarily from the redistribution of stored water in the surrounding coal and continued slow leakage from overlying Wasatch sand aquifers. In 2050, drawdowns of between 25 and 100 feet are anticipated in the northern portion of the project area and drawdowns of between 125 and 250 feet are anticipated in the southern portion of the project area. The maximum extent of the 5-foot drawdown extends 12 to18 miles from the edges of former CBM development.

Prediction of Coal Aquifer Drawdown Rate

The rate of coal aquifer drawdown is presented by graphs of modeled drawdown versus time at selected locations in the model. These graphs also illustrate the recovery of water levels following the cessation of CBM operations and mining operations. The locations of the monitoring points are shown on **Figure 4-7**. Water level drawdown graphs for selected monitoring wells in the northern and southern portions of the project area are shown in **Figures 4-8 and 4-9**. The graphs show that the water level changes in the coal aquifer induced by CBM operations tend to be fairly rapid. Initial recovery of coal water levels following cessation of CBM operations also is rapid, although complete recovery to pre-operation conditions may take hundreds of years.

Extent of Aquifer Utilization and the Effect of Predicted Drawdown on this Use

The extent of aquifer utilization has been largely documented in previous assessments. This work was updated and supplemented by examination of WSEO records (**Table 3-8**). Impacts to individual water wells completed within the coal, and in sands above the coal, would depend on proximity to dewatering wells, depth and completion interval of the water well, and the water well yield required to maintain it as a usable source. Drawdown of water levels in coal aquifers caused by CBM development potentially may impact individual well users by reducing well yield. Withdrawal of water from the coal aquifer during CBM development can depressurize the aquifer and induce methane release into nearby water wells. Water level changes are not expected to be as significant in the aquifers above or below the coal because the coal is partially confined both above and below by a low permeability claystone layer. Drawdown of water levels in the overlying Wasatch sand aquifers also can impact individual well yields but is not likely to induce methane production in these wells. The underlying Lebo Fm is a shale sequence 800 to 1,000 feet thick (USDI BLM, 1994a), and therefore, the underlying Tullock aquifer should exhibit minimal changes as a consequence of CBM development. For individually impacted water wells, see the "Mitigation Measures" section. A standard agreement has been developed by CBM operators to monitor and mitigate impacts to individual well owners that are caused by CBM operations. A copy of this agreement format is contained in **Appendix D**.

Wells fully penetrating the coal with pumps set low within the coal are likely to be less impacted than those only partially penetrating the coal and with relatively shallow set pumps. Water still will be available from the coal at a deeper depth and from shallower or deeper aquifers.

The model predicts over 500 feet of coal aquifer drawdown near the centers of active CBM development, with drawdown in excess of five feet extending some ten to twenty miles from these areas (**Figures 4-5 and 4-6**). The maximum available drawdown (the hydraulic pressure head) in the coal aquifer in the affected areas ranges from 300 to 1,000 feet. Most individual water supply wells in the coal seam do not exceed 600 feet and have up to 300 feet of available drawdown. Well pumps typically are set between 50 to 200 feet below the static water level in the well. Significant impact in terms of well yield or availability is likely to be an issue only if the drawdown exceeds about 20 to 30 percent of available drawdown at any given location. This area would tend to coincide with the area of drawdown in excess of about 100 feet. The decreased head against which the well pump has to operate may cause the pump discharge to decrease.

However, if sufficient available drawdown remains in the well, yield may be restored by installing a larger pump. In cases where the drawdown causes the water level in a well to drop below the intake of the pump, the pump may have to be lowered in the well.

Individual coal aquifer well users may experience increased methane emissions if their wells fall within an area of significant aquifer depressurization. Records of first indications of methane production in monitoring wells that have experienced water level drops due to mining indicate that methane emission from the coal can occur with as little as 50 feet of head drop (AMAX Coal West groundwater monitoring data). Consequently, coal wells within the predicted 50- foot drawdown area may be susceptible to this impact. Methane emissions by a well pose a potential explosive safety hazard, particularly if gases can build up in an enclosed space. Well houses need to be well ventilated.

Over most of the eastern PRB, the Wyodak-Anderson coal is separated from sands in the overlying Wasatch Fm by continuous, low-permeability clay and silt units of variable thickness. Examination of drilling and geophysical logs from coal mine permits and from twelve state-owned sections south of Gillette and west of the coal mine permit areas shows that the thickness of this confining unit ranges from 11 to 363 feet. In most cases, the clay confining unit was at least 30 feet thick. The large variation in thickness is mostly a function of whether any significant sands exist in the lower part of the Wasatch Fm at a given location. This clay unit has the effect of partially isolating the coal from the overlying Wasatch sands. This low permeability zone allows limited hydraulic communication between the coal and the overlying Wasatch sands. A significant period of time (typically several years) will likely pass before drawdown effects in the overlying Wasatch sands are apparent as a result of pumping groundwater from the coal. In addition, as noted in Chapter 3, the integrity of the confining layer may be compromised locally by water supply wells screened through both the coal and the overlying sands, by deteriorating well casings, or by poorly plugged oil and gas wells or exploratory drill holes.

Figure 4-7 Locations of Monitoring Wells, Wyodak Coal This page intentionally left blank Figure 4-8 Comparison of Alternatives for Maximum Drawdown Over Time, Upper Wyodak Coal Figure 4-9 Drawdown vs. Time Graphs for Selected BLM Monitoring Wells Partial isolation of aquifers overlying the coal has been supported by the results of the BLM water monitoring efforts at the Marquiss CBM project, which has had the longest history of operation (since 1993). In this instance, the BLM has operated two paired wells (a well completed in the coal and a well completed in the next overlying sand zone) since the beginning of the project. Communication has been seen between the deeper (coal) wells and the shallow (sand) wells. Water level decline in the coal well is up to 200 feet during the five years of monitoring while the water level decline in the overlying aquifer has been documented, but at a relatively mild rate (ten to twenty feet over five years in one well).

CBM production relies on the integrity of the confining layer above the coal. Without the confining layer, the gas would be free to escape to the atmosphere and water leaking downward from shallower layers would make it more difficult or impossible to lower the pressure in the coal seam by pumping water from it.

Information from coal mines located east of the project area indicates that the significant sands within the Fort Union Fm usually are located well below the coal. These sands are not likely to be affected by pumping (USDI BLM, 1992a).

Drawdown impacts in the overlying Wasatch sand aquifers are predicted to be much less than in the coal aquifer, but may be significant. Model predictions in the Wasatch sands are less reliable than in the coal because of the discontinuous nature of the sands. Predictions are for a sand unit ranging from 200 to 500 feet above the coal. **Figure 4-9** shows the drawdown vs. time predicted in the Wasatch sands. Maximum drawdowns occur in the vicinity of active mining operations and in the centers of CBM development. The predicted drawdown in the Wasatch Fm associated with CBM development is about 60 feet in 2015. However, drawdown is predicted to continue after the cessation of the project, averaging 125 feet long-term (**Figure 4-9**). There are likely to be local areas in the Wasatch sands which see greater drawdown than predicted by the model due to conducive faults, poorly grouted well bores, and exploration borings. This amount of drawdown may cause impacts to users of Wasatch aquifer water. In addition, the water well agreement would provide sufficient protection to landowners if impacts occur.

Projected drawdown graphs for the Wasatch sands at one location within the southern portion of the project area are shown in **Figure 4-9**. Drawdown in the Wasatch sands tends to increase slowly as leakage is induced by partial dewatering of the underlying coal. The drawdown continues after CBM operations cease, and coal water levels start to recover, because the Wasatch Fm is a source of recharge to the coal.

Projected Impacts to Springs
Springs issuing from the Wasatch sands into surface drainages are unlikely to be affected by CBM development. This is due to the projected limited effect of CBM development on Wasatch Fm water levels described in the previous section.

The public expressed concern regarding the potential impact of CBM development on springs issuing from the clinker outcrops, such as the Moyer Springs north of Gillette. Moyer Springs is located in Sec. 30 T51N R71W, outside the proposed project area but its recharge area is close to the CBM development area.

Moyer Springs is located at the base of an exposed clinker deposit that is in the outcrop area of the target coal seam (known as the Roland-Smith in this area of the PRB). Recharge of the springs is through surface infiltration and lateral movement of water from adjacent clinker and alluvium. Large areas of clinker are exposed northeast and southeast of Moyer Springs (USGS, 1978).

This exposure allows a large amount of recharge to the clinker by infiltration of rainfall and snowmelt. USGS (1973) reported a flow of 200 gallons per minute from Moyer Springs. The contact between the clinker and the associated coal seam in this area appears to have a low permeability. Although the natural discharge of springs potentially can be impacted by a reduction in the hydraulic head in the source aquifer unit, the presence of a low permeability zone between the clinker and the target coal results in water in the clinker being channeled to the spring rather than recharging the coal. The presence of the low permeability zone between the clinker and the target coal inhibits flow between these units. This fact and the high flow rate observed at Moyer Springs imply that production of Wyodak groundwater during CBM operations should not adversely affect the hydrology of Moyer Springs. The potential impact to Moyer Springs flows by proposed surface mining has been recognized, as removal of the Wasatch Fm and alluvial overburden during mining operations may decrease recharge to the spring. Accordingly, the Dry Fork Mine Permit requires Dry Fork Coal Company to protect the clinker aquifer that feeds Moyer Springs.

CBM operations are not expected to have any impact on Moyer Spring water quality because discharge water is not likely to encroach on the recharge area of the spring. Water from Moyer Springs is of calcium sulfate chemical type, with total dissolved solids concentrations in the 1000 mg/l to 2000 mg/l range (USGS, 1973). CBM production water from the Wyodak coal will be of equal or better quality. Therefore, even if some CBM discharge water did recharge the Moyer Springs, CBM operations should not adversely affect its water quality.

The description of potential impacts to Moyer Springs is applicable to other springs issuing from clinker outcrops. Therefore, no impacts to these springs are projected.

Rate of Coal Aquifer Recharge after CBM Operations Cease

Recovery of groundwater levels in the coal aquifer after CBM operations cease is best illustrated in the drawdown graphs of selected monitoring locations in **Figure 4-8 and 4-9**. Initially recovery is primarily due to redistribution of groundwater stored in the aquifer. When the stresses of pumping are removed, the groundwater in storage to the west, north and south of the CBM development area will resaturate and repressurize the areas that were partially depressurized during operations. The amount of groundwater storage within the coal to the west of the development is enormous, and redistribution is predicted to result in a fairly rapid initial recovery of water levels in the coal. The model predicts that this initial rapid recovery period will occur over three to four years, but water levels only will recover to within 30 to 100 feet of pre-operational conditions.

Complete water level recovery will be a very long-term process because actual recharge to the coal aquifer needs to replace groundwater removed from storage during CBM operations. Actual recharge to the coal through surface infiltration at the eastern outcrop area is a relatively slow process. Coal mining along the eastern subcrop results in minimal recharge to the coal while mines are active, due to the groundwater sink caused by pit dewatering. As mines are reclaimed and eventually shut down, the backfilled areas would become long-term recharge zones for the coal aquifer. Infiltration through backfill areas may be very significant because permeability of the backfill materials tends to be much higher than in the original unmined materials. In addition, most of the creeks would be diverted over these backfilled areas, providing a significant source of recharge water.

Contribution of Extracted Coal Groundwater to the Recharge of Shallow Wasatch Sand Aquifers

Extracted groundwater from CBM operations currently is released to surface waters. A portion of the released water recharges the alluvium along the creek valleys that in turn recharges the underlying Wasatch units. AMAX Coal West's Belle Ayr Mine monitoring data noted slight "mounding" of groundwater levels within the Wasatch sand in the vicinity of Caballo Creek, indicating that this recharge is occurring. The extent of recharge has not been quantified and is primarily a function of the permeability of the surficial Wasatch geologic units underlying the creeks in any given area.

The recharge effect was evaluated in this analysis by examining the area of affected alluvial drainages and the probable range of vertical infiltration rates into the Wasatch Fm below the creeks. The total discharge from CBM operations was calculated for each of the major surface drainages under the three alternatives (**Tables 2-1 and 2-2**). This discharge was assumed to flow toward the major creeks within each drainage. Surface water losses in river flows due to conveyance losses (evapotranspiration and leakage) were assumed to be one percent of the flow per mile (WSEO, 1998a). Recharge of shallow aquifers due to leakage from rivers was assumed to be 20 percent of the conveyance loss (Babb, 1998). The area of alluvium was estimated for all major creeks downgradient from proposed CBM operations and the river leakage then expressed as an equivalent recharge. An upper recharge limit of five inches per year was assumed, based on the expected ability of the underlying Wasatch to accept this recharge. This recharge along the major drainages was then input into the model for the time period when CBM operations are expected to be active.

The Wasatch sand maximum drawdown for the year 2182 (**Figure 4-10, 4-11, and 4-12**) shows much less drawdown than the Fort Union coals since the Wasatch sands are recharged by water infiltrating into the alluvium. Maximum Wasatch sand drawdowns range from 100 feet in the north to 175 feet in the central portion of the project area, south of Gillette. Maximum drawdowns border the eastern boundary of the project area near the coal outcrop. The areal extent of drawdown to the five-foot drawdown contour ranges to the west from 16 to 30 miles. There is significantly less drawdown of the Wasatch sands in the vicinity of major creeks as a result of the recharge. In some areas, a build-up of water levels is predicted.

Effect of Variable Pumping Rates on Predicted Impacts
The projected pumping rates for the proposed CBM development scenarios are estimated based on experience from current operations. As stated earlier, the model used a uniform well extraction rate of 12 gallons per minute for the entire duration of an assumed 15-year life for each well. This rate is considered to be conservative in terms of drawdown prediction because the more extensive dewatering effect of the denser well spacing in the proposed development may result in lesser pumping rates for individual wells or a more rapid decline in these rates.

Water Quality
Groundwater produced from the Wyodak coal during CBM operations will be discharged to local drainages. This water has the potential to recharge shallow aquifers, primarily local alluvial aquifers and Wasatch Fm sands, as discussed in the section of water quantity impacts. Drilling is not expected to modify water quality in the formations drilled in the development of CBM well. Thus, there should be no impact to the quality of alluvial aquifers, the Wasatch sands nor the Wyodak coal. Similarly, groundwater quality in the major bedrock aquifers below the Wyodak coal will not be affected by CBM operations. Alluvial water quality may become less saline with active constant recharge from surface waters.

Recharge by coal aquifer water will result in localized mixing with the waters of the alluvial and Wasatch aquifers. Comparison of total dissolved solids (TDS) and specific chemical constituent concentrations in the Wyodak coal groundwater with Wasatch and alluvial aquifer groundwater will show the impact this mixing will have on water quality in these upper aquifers.
Figure 4-10 Maximum Modeled Drawdown 1975 - 2182, Proposed Action, Wasatch Sand This page intentionally left blank Figure 4-11 Maximum Modeled Drawdown 1975 - 2182, Alternative 1, Wasatch Sand This page intentionally left blank Figure 4-12 Maximum Modeled Drawdown 1975 - 2182, No Action, Wasatch Sand This page intentionally left blank Potential Water Quality Impacts Due to Recharge of Coal Aquifer Water As discussed in Chapter 3, groundwater quality in the Wyodak coal (average TDS = 764 mg/l, WDEQ, 1998a) is typically equal to or better in quality than that in the Wasatch Fm (average TDS = 1,415 mg/l) and alluvial aquifers (average TDS = 2,232 mg/l). Chemical groundwater type in the Wyodak coal is predominantly sodium bicarbonate as compared with the Wasatch Fm and alluvium (calcium and sodium sulfate). Coal aquifer water typically does not have elevated concentrations of selenium. Therefore, discharge of Wyodak production water from the CBM program to local alluvial and Wasatch aquifers is not projected to adversely affect groundwater quality in these aquifers. There may be a slight shift from a calcium/sodium sulfate dominated water chemistry towards a more sodium bicarbonate type. However, this shift is only likely to be noticeable in localized areas of alluvial recharge. The water chemistry shift is not anticipated to be very significant or detrimental. Sodium bicarbonate water generally is considered to be better than calcium/sodium sulfate water for domestic and stock uses. Sulfate has a secondary drinking water quality standard of 250 mg/l while bicarbonate has no water quality standard.

Potential Impacts to Groundwater Quality due to Drilling Operations

During drilling of CBM production wells, various chemical additives are added to the drilling fluids to enhance drill cutting removal and hole stability. Typically, the Wasatch Fm is drilled using mud rotary drilling techniques. Drilling mud is usually native mud and bentonite. As hole conditions dictate, small amounts of polymer additives and/or potassium chloride salts may be added for hole cleaning and clay stabilization. The potassium chloride and the chemicals within the polymers do not pose toxicity problems it used in accordance with manufactures' specifications. Well casing extending to the top of the target coal seam is cemented into place. The coal is then drilled out using air rotary drilling techniques. A drilling foam is usually added to the air to enhance cuttings removal. The chemicals within the foam are also non-toxic, when used in accordance with manufacturers' specifications.

Most of the drilling fluids are removed from the borehole during well completion and are collected in surface drilling pits during both the mud-rotary and air-rotary drilling operations. After drilling is complete, the drilling pits are allowed to dry out and then are backfilled and revegetated. Post drilling fracturing of the coal seam for permeability enhancement involves the injection of clean water only. This water is removed during subsequent water production from the well. Based on the use of non-toxic chemicals during well-drilling operations and the removal of most drilling fluids, there is an extremely low potential for degradation of groundwater in either the coal or Wasatch sand aquifers due to CBM exploration and development.

Alternative 1

Compared with the Proposed Action, drawdowns in the coal aquifer are more extensive for Alternative 1. This is illustrated in **Figures 4-13 and 4-14** for year 2014 as the time of greatest drawdown impact in the expanded project area. The more extensive drawdown area results from more widespread CBM development and the extraction of groundwater from a larger number of wells. As noted previously, modeled results reflect educated projections of the locations and densities of well pods within the expanded project area. Actual drilling sites may modify the locations of maximum drawdown and the extent of drawdown. Furthermore, the representation of projected drawdowns is weak in the northern portion of the expanded project area due to insufficient data. A comparison of the extent and depth of drawdown for the three Alternatives is summarized on **Table 4-3**.

The maximum extent of drawdown in both the Upper and Lower Wyodak coals, defined as a drawdown of at least five feet, extends about 30 to 34 miles from the centers of potential dense CBM development such as in the northern part of the Gillette South assessment area. In areas of potentially less dense development, such as west of Highway 50 and south of the town of Wright, the extent of drawdown is about 18 miles. Maximum drawdowns in the areas of most extensive development are slightly more than for the Proposed Action development scenario. The maximum predicted extent of drawdown in the northern portion of the expanded project area is over 450 feet, and is over 575 feet in the area south of Gillette, and exceeds 350 feet in the southern portion of the expanded project area for the Upper Wyodak coal seam.

Maximum Wasatch Fm drawdowns range from 100 to 175 feet (**Figure 4-11**). Maximum drawdowns border the eastern boundary of the expanded project area near the coal outcrop. The areal extent of drawdown to the 5-foot contour level ranges to the west from 27 miles to 39 miles.

No Action

Compared with the Proposed Action, drawdowns in the coal aquifer are less extensive under the No Action Alternative. This is illustrated in **Figures 4-15 and 4-16** for year 2012 as the time of greatest drawdown impact in the project area. The less extensive drawdown results from lower and less dense CBM development. The maximum extent of drawdown extends about nine to twenty-one miles from the point of maximum drawdown. Maximum drawdowns in the areas of most extensive development are similar or slightly less than expected drawdowns for the Proposed Action. The maximum predicted drawdown in the Upper Wyodak coal for the northern portion of the project area is over 400 feet, for the central portion of the project area south of Gillette is over 525 feet, and for the southern portion of the project area is 275 feet. The extent of drawdown and maximum drawdown is slightly greater for the Lower Wyodak coal (**Table 4-3**).

The maximum drawdown projected for the Wasatch Fm will occur along the eastern boundary of the project area and will range from 100 to 150 feet (**Figure 4-12**). The areal extent of drawdown to the five-foot contour level ranges to the west from 16 miles to 28 miles. Figure 4-13 Maximum Modeled Drawdown 1975 - 2014, Alternative 1, Upper Wyodak Coal This page intentionally left blank Figure 4-14 Maximum Modeled Drawdown 1975 - 2014, Alternative 1, Lower Wyodak Coal This page intentionally left blank Figure 4-15 Maximum Modeled Drawdown 1975 - 2012, No Action, Upper Wyodak Coal This page intentionally left blank Figure 4-16 Maximum Modeled Drawdown 1975 - 2012, No Action, Lower Wyodak Coal This page intentionally left blank

Table 4-3
Comparison of Extent and Depth of Maximum Drawdown by Alternatives

	Proposed Action	Alternative 1	No Action
Upper Coal			
5' Drawdown Extension (miles)			
North	12	18-21	9
Central	22	30	21
South	18	34	18
Maximum Drawdown (feet)			
North	450	425	400
Central	550	575	525
South	300	350	275
Lower Coal			
5' Drawdown Extension (miles)			
North	14	10-18	12
Central	18	28	18
South	20	34	22
Maximum Drawdown (feet)			
North	375	375	450
Central	600	675	600
South	325	375	375
Wasatch			
5' Drawdown Extension (miles)			
North	16	27	16
Central	30	34	28
South	26	39	28
Maximum Drawdown (feet)			
North	100	100	100
Central	175	175	150
South	150	175	125

AIR QUALITY

The air quality in and near the eastern PRB would be affected by dust generated by vehicles and earth-moving equipment during construction activities; emissions of nitrogen oxides (NOx), carbon monoxide, and Hazardous Air Pollutants (HAPs), in the form of formaldehyde, from the operation of natural gas-powered compressor engines; dust generated by vehicles traveling to and from facilities during the operational phase; and tailpipe gaseous emissions from these vehicles. This section quantifies the projected pollutant emissions and compares the environmental effects produced by these emissions to National Ambient Air Quality Standards (NAAQS) and Wyoming Ambient Air Quality Standards (WAAQS). The impacts on regional visibility and Air Quality

Related Values (AQRVs), related to acid deposition of nitrates and sulfates, at Class I areas and sensitive Class II areas resulting from the Proposed Action, Alternative 1, and the No Action Alternative also are described.

Comparable quantities of compression facilities would be anticipated under the Proposed Action Alternative 1, and the No Action Alternative, as the Companies' field-wide plans for orderly development of CBM resources in the PRB are initiated. The Companies' field-wide compression plans, currently under development, are not constrained by the scope of this EIS analysis and the number of productive wells under consideration here. The Companies and the BLM have developed a conceptual CBM gas field development scenario that includes prospective gas compression facilities. Although this is a conceptual plan and subsequent locations may change, the proposed type and locations of compressors were analyzed in this air quality impact analysis.

Air pollution impacts are limited by federal and state regulations and are administered by the Air Quality Division of WDEQ. Section 21 of the Wyoming Air Quality Standards and Regulations requires that all proposed pollutant emission sources apply for a Section 21 permit and undergo a permit application review. Prior to construction and/or operation of any pollutant sources analyzed in this EIS, the Air Quality Division of WDEQ has the regulatory authority to review permit applications and to require permits, fees, and pollution control equipment. Additional site specific air quality analyses would be performed, and additional emission control measures, including Best Available Control Technology (BACT), may be required to ensure protection of regional air quality and AQRVs.

Potential air quality impacts were analyzed based on an assessment protocol developed specifically for this project in consultation with and after review by the Companies, BLM, U.S. Department of Interior - National Park Service (NPS), FS, EPA, and WDEQ. As a result of this coordinated effort, air quality modeling was conducted to determine the potential air quality impacts resulting from the proposed CBM development. The complete technical description of this air quality analysis is found in the technical reference document, *Air Quality Impact Analysis for the Wyodak CBM Project*, on file at the BLM State Office in Cheyenne, Wyoming and at the BLM's Buffalo Field Office in Buffalo, Wyoming.

Near-Range Dispersion Modeling

Project-only and cumulative near-range air quality impacts from the operation of natural gas- powered compressor engines were predicted using the EPA-approved Industrial Source Complex Short Term (ISCST3) Dispersion Model, version 98356, as specified by the User's Guide for the Industrial Source Complex Dispersion Model (USEPA, 1995b). The ISCST3 model has the capability to handle the very large number of pollutant sources and receptors that were used in this analysis. The ISCST3 model was approved by air quality specialists from the BLM, EPA, NPS, FS, and the WDEQ for the simulation of multiple point sources in the near-range analysis. The ISCST3 model requires input variables that describe the source (emission rates and exhaust characteristics), the meteorological conditions (weather) that govern transport and dispersion of pollutants, and the receptor points (location and elevation of points where ambient pollutant concentrations are predicted). The model has several options that affect the simulation. The regulatory default options recommended by the EPA and WDEQ were used to model the air quality impacts under Alternative 1.

A large grid of receptors was used in the model to ensure an adequate spatial coverage for the expanded project area. The receptor grid had a 1,000-meter spacing centered approximately at Gillette, Wyoming and extended 50 kilometers in all directions from the boundary of the expanded project area. The grid had a horizontal extent of 254 kilometers from north to south and 155 kilometers from east to west consisting of over 39,000 receptor locations. The elevation of each receptor was determined from Digital Elevation Models developed by the USGS.

A year of meteorological data collected in 1981 for the Hampshire Energy Project was provided by the WDEQ. This data set has been fully scrutinized and evaluated by the WDEQ and has been used for many permit activities in the past. The most recent use of this data set was for the Prevention of Significant Deterioration (PSD) permit for the Two Elks coal-fired power plant near Gillette, Wyoming. The proposed compressors (**Table 2-1**) were modeled as point sources. Emission rates were those listed in **Table 4-4**. All the compressors were placed at locations projected by the proponents to ensure the delivery of CBM gas to sales pipelines.

The WDEQ monitoring data represent the ambient air concentration of NO2 that exists within the study area prior to the implementation of the Wyodak CBM Project. The near-range analysis considered all air pollutant sources that began operation after April 1997 (the date of the latest WDEQ monitoring data available for use in this analysis) or that were reasonably expected to begin operation after April 1997.

Table 4-4 (continued) Wyodak Compressor Emissions

1500-hp PIPELINE COMPRESSORS WAUKESHA 7042 GSI

Pollutant	100% Load Per Engine	90% Load Per Engine			Annual Project Total 5 stations 18 engines (27,000 hp)
	lb/hr	lb/hr	gm/sec	tons/yr	tons/yr
NOx	4.960	4.460	0.562	19.5	351.6
CO	9.920	8.930	1.126	39.1	704.0
VOC1	3.310	2.980	0.376	13.1	234.9
PM10	negligible	negligible	negligible	negligible	negligible
SO2	negligible	negligible	negligible	negligible	negligible

1500-hp FIELD COMPRESSORS

Pollutant	100% Load Per Engine	90% Load Per Engine			Annual Project Total 43 Engines at 24 Locations (64,500 hp)
	lb/hr	lb/hr	gm/sec	tons/yr	tons/yr
NOx	4.960	4.460	0.562	19.5	840.0
CO	9.920	8.930	1.126	39.1	1,681.9
VOC1	3.310	2.980	0.376	13.1	561.3
PM10	negligible	negligible	negligible	negligible	negligible
SO2	negligible	negligible	negligible	negligible	negligible

1000-hp FIELD COMPRESSORS

Pollutant	100% Load Per Engine	90% Load Per Engine			Annual Project Total 13 Engines (13,000 hp)
	lb/hr	lb/hr	gm/sec	tons/yr	tons/yr
NOx	3.310	2.980	0.376	13.1	169.7
CO	6.610	5.950	0.750	26.1	338.8

VOC1	2.210	1.990	0.251	8.7	113.3
PM10	negligible	negligible	negligible	negligible	negligible
SO2	negligible	negligible	negligible	negligible	negligible

380-hp BOOSTER COMPRESSORS

Pollutant	**100% Load Per Engine**	**90% Load Per Engine**			**Annual Project Total 220 Engines at 147 Locations (83,600 hp)**
	lb/hr	**lb/hr**	**gm/sec**	**tons/yr**	**tons/yr**
NOx	1.670	1.500	0.189	6.6	1,445.4
CO	2.510	2.260	0.285	9.9	2,177.7
VOC1	0.840	0.760	0.096	3.3	732.3
PM10	negligible	negligible	negligible	negligible	negligible
SO2	negligible	negligible	negligible	negligible	negligible

PROJECT TOTAL

Pollutant	**Annual Project tons/yr**
NOx	2,806.7
CO	4,902.4
VOC1	1,641.8
PM10	negligible
SO2	negligible

1The VOC emission factor is total hydrocarbon.

Far-Range Modeling

Long-range ambient air quality impacts on visibility and other air quality related values (AQRVs) in regional Class I areas and sensitive Class II areas were assessed using the CALMET/CALPUFF (version 5.0) transport and dispersion modeling system (Scire et al., 1990a and 1990b; USEPA, 1995a; and Earth Tech, Inc., 1998). For this analysis, far-range impacts were defined as impacts to areas that are at least 50 kilometers beyond the expanded project area. The far-range AQRV analysis was performed within a modeling domain that encompassed an estimated 80,240 square miles in northeastern Wyoming, southeastern Montana, western South Dakota, and northwestern Nebraska. Far-range impacts in distant Class I areas, as well as Class II areas deemed sensitive by the NPS and FS, were evaluated. Potential impacts to nine different areas in Wyoming, South Dakota and Montana were modeled with the CALPUFF model. A summary of the nine areas included in the modeling evaluation is listed in **Table 4-5**.

Table 4-5
Class I and Sensitive Class II Areas

Name of Area	**State**	**Classification of Area**	**Managed by**	**Approximate Distance to Proposed Wyodak Project (km)**

Northern Cheyenne Reservation	MT	Class I	Tribe	150
Badlands National Park	SD	Class I	NPS	230
Wind Cave National Park	SD	Class I	NPS	185
Black Elk Wilderness	SD	Class II	FS	170
Jewel Cave National Monument	SD	Class II	NPS	155
Mt. Rushmore National Monument	SD	Class II	NPS	180
Cloud Peak Wilderness	WY	Class II	FS	105
Devils Tower National Monument	WY	Class II	NPS	90
Florence Lake*	WY	Class II	FS	120

*Florence Lake is situated within the Cloud Peak Wilderness

Potential impacts Class I and sensitive Class II areas were analyzed using a slightly different emissions inventory, since 1995 monitoring data from Class I areas were determined by the Wyodak Air Quality Advisory Committee (WAQAC) to be the most representative year at Class I areas. Therefore, the far-range analysis considered all pollutant sources that began operating after 1995, or were reasonably expected to begin operation after 1995.

The methods recommended by the Interagency Workgroup on Air Quality Modeling (IWAQM) in their Phase 2 Summary Report (USEPA, 1998) for a refined modeling analysis (as opposed to a screening-type analysis) were followed to best approximate impacts from the modeled sources. This included use of a fully-developed time and space varying characterization of the meteorology using CALMET, and placement of receptors within the Class I and sensitive Class II areas.

Potential air quality impacts and effects on AQRVs in the Class I areas and sensitive Class II areas were evaluated for emissions from the proposed project and non-project sources. The cumulative effects from a combination of both the project and non-project sources also were evaluated. Due to the distance from the expanded project area to the Class I and sensitive Class II areas, the primary effect on visibility is due to potential increases in regional haze. Therefore, a regional haze analysis, using the IWAQM-recommended procedures, was conducted for each of these areas. In addition to the regional haze analysis, the increased potential for deposition (wet and dry) of acidic compounds was evaluated for each area and Florence Lake, (a sensitive lake located within Cloud Peak Wilderness, Wyoming).

Alternative 1

Construction Impacts

Under Alternative 1, 5,000 CBM wells would be drilled. Surface disturbance associated with Wyodak CBM development is much smaller than the disturbance for conventional natural gas development and the drilling and completion-process time is much shorter. Fugitive dust would be generated by earth-moving activities such as vegetation clearing, stockpiling of top soil, and grading. A portion of fugitive dust is made up of PM10, a regulated pollutant defined as inhalable particulates less than 10 microns in diameter. As a result, fugitive dust levels would be temporarily elevated near construction activities. However, the overall impact from fugitive dust would be insignificant during construction activities for the following reasons.

€ Access to drilling locations would be provided by existing roads and two-track roads traversing over natural terrain. In most cases, no new surface disturbance would be required for access roads to be constructed. Short roads may be constructed in difficult terrain for an estimated ten percent of the wells. Access to these drilling locations would result in a potential disturbance of 1.8 acres per well.

€ Drilling operations would be confined to a 100 feet by 100 feet (0.22 acres) drill site. Vegetation would not be removed except in limited areas where cuts and fills would be necessary. Drilling would take one to three days and completion would last another one to three days.

€ Once the well has been successfully tested, it would be shut-in awaiting construction of the pipelines from the well to the central pods. Pipeline construction for each pipeline segment likely would last for about five days. Reclamation of the pipeline right-of-way would begin as soon as possible after construction and testing of the pipeline would be complete.

€ Construction activities and construction-related dust from one well and its associated pipeline likely would not overlap in time and space with the construction of another nearby well and its pipelines. Activities planned concurrently in close proximity could be scheduled through the cooperative efforts of CBM operators, landowners, and the BLM (and FS) to reduce overlapping fugitive dust emissions.

Operational Impacts

Natural Gas Compressors

The air quality analysis focuses on the emissions from the natural-gas fired compressors required to move the CBM gas from the wellhead to pipelines for transport to markets outside the expanded project area. The project will be designed to use Best Available Control Technology (BACT) to minimize emissions from compressor engines. The precise systems will be determined through a BACT analysis conducted as part of the Wyoming Section 21 permitting process. Based on preliminary information, the emission control systems may include the use of lean-burn natural gas reciprocating engines and/or catalytic controlled rich lean engines to limit emissions of NOx.

For the operational phase of the project, emission inventories for nitrogen oxides (NOx), carbon monoxide (CO), and volatile organic compounds (VOC), a precursor of ozone, were calculated for compressors. NOx and CO are the only pollutants anticipated to be significant in a rural area where ozone levels are unclassified and are not monitored. According to the Wyoming Air Quality Standards and Regulations (WAQSR), Section 9(b), "VOC emissions shall be limited through the application of BACT in accordance with Section 21 of the WAQSR. Therefore, NOx and CO were the only pollutants from compressor engines analyzed for ambient air impacts.

Within the expanded project area, as of the end of April 1997, 15 compressor stations were operating with a total of 39 Waukesha 1500-hp engines and 5 Waukesha 1000-hp engines. These engines are already operating and are considered part of the monitored background and were not included in the air quality analysis.

As part of the project, the Companies would install and operate pipeline compressors, field gathering line compressors, and booster compressors. The booster compressors would receive CBM gas from the wellheads at a pressure of about 3 psi. Each booster compressor would service 20 wells. After increasing the gas pressure to about 70 or 100 psi, five booster compressors would then transport the gas to a 1000-hp or 1500-hp field compressor where the gas pressure would be increased to 700 to 1,400 psi for transport to transmission pipelines. Transmission pipeline compressors would increase the pipeline pressure to about 1,300 psi to transport gas along the sales pipeline.

The Companies would construct and operate new field compressor stations with one or two Waukesha 7042 GSI or Waukesha 7042 GL lean-burn engines at each location. Additional 1500-hp engines would be installed at some of the existing compressor stations. A total of 43 new 1500-hp engines would be distributed among 3 existing and 21 proposed compressor station locations. Another 13 field compressor stations would be installed with one 1000-hp Waukesha engine. Additionally, 220 380-hp Caterpillar CAT 3408 TA booster engines would be distributed at 147 locations throughout the expanded project area. It is currently unknown whether one or two booster engines would be required at each location. For the purpose of this analysis, it is assumed that 1.5 engines would be at each location. Finally, five pipeline compressor stations (one 12,000-hp station with 8 engines, one 6,000-hp station with 4 engines, and three 3,000-hp stations with 2 engines) would be installed. The total rating of all the new proposed compressors would be 161,100 hp for field gathering and 27,000 hp for transmission pipeline transport.

Emission rates that were analyzed for the 1500-hp and 1000-hp Waukesha engines in this analysis were 1.5 grams per horsepower hour (gm/hp-hr) for NOx, 2.0 gm/hp-hr for CO, and 1.0 gm/hp-hr for VOCs. The 1.5 gm/hp-hr NOx emission rate for compressor engines was used as an average and conservative estimate. The BACT analysis in the permitting process may demonstrate that some of the compressor stations, especially the multi-unit facilities, may be required to operate with a lower NOx emission rate. The emission rates analyzed for the CAT 3408 380-hp engines were 2.0 gm/hp-hr for NOx, 3.0 gm/hp-hr for CO, and 1.0 gm/hp-hr for VOCs. A 90 percent load factor was applied to each compressor engine because it is assumed that not all engines in the expanded project area would operate simultaneously throughout the year. Hourly and annual emissions from the Alternative 1 compressor engines that are based upon the proposed emission rates are shown in **Table 4-4**.

Air Quality Impacts

The NAAQS and WAAQS have been developed to represent the maximum concentrations of a pollutant allowed in the air in order to protect public health and welfare with an adequate degree of safety. The standard for NO2, shown in Chapter 3, Air Quality, is 100 g/m3 as an annual average. The standard for CO, also shown in Chapter 3, is 40,000 g/m3 as a one-hour maximum and 10,000 g/m3 as an eight-hour maximum. The average NO2 background concentration throughout the vicinity of the expanded project area is assumed to be 16.5 g/m3 based on measured data at Gillette. An adequate margin for public health and welfare could still be maintained if the NO2 concentration increased by 83.5 g/m3.

The maximum modeled near-range ambient air concentrations of pollutants are summarized in **Table 4-6**. The maximum NO2 concentration, 9 g/m3, is only nine percent of the NAAQS. When the average NO2 background of 16.5 g/m3 is added, the maximum ambient air concentration would be 25.5 g/m3, a level contains only 25 percent of the NO2 allowable under the NAAQS. The result of the near-range NO2 analysis for the entire area encompassing and surrounding the expanded project area is shown on **Figure 4-17**. Most of the analysis area would have concentrations less than 1.0 g/m3, a value considered to have insignificant effects on air quality in a region. The CO increases would be approximately one to two percent of the allowable standard and also would not be a significant impact. Since the CO ambient levels would be small compared to the NAAQS, CO effects were not analyzed further.

Table 4-6 Wyodak CBM Project Near-Range Air Quality Impacts

Pollutant	**Averaging**	**Ambient Air Quality**	**Modeled Concentration**	**Modeled Concentration with**	**Percent of**

	Time	Standard (g/m3)	(g/m3)	Background (g/m3)	NAAQS
NO2	Annual	100	9.0	25.5	25.5
CO	1 hour	40,000	373	NA	0.9
CO	8 hours	10,000	179	NA	1.8

g/m3 = micrograms of pollutant per cubic meter of air

Figure 4-17 NO2 Annual Air Quality Impacts - Proposed Action and Alternative 1 Hazardous Air Pollutant Impacts

Hazardous Air Pollutants (HAP) would occur as formaldehyde, recognized as a carcinogen, from the incomplete combustion of natural gas. The Gas Research Institute (GRI) has conducted testing on pipeline compressor engines of the type proposed for this project. GRI conducted 49 tests on 20 engines and the highest emission rate was 0.45 gm/hp-hr. Although the engine specifications and resultant formaldehyde emissions for this project may vary, the recent rate of 0.45 gm/hp-hr is proposed as a maximum emission rate for this conservative analysis. There is a wide range of potential emissions. Testing may be required to establish potential formaldehyde emission rates.

The ambient concentration near one compressor site with eight 1,500-hp engines was calculated using the ISCST3 dispersion model, the Hampshire Energy meteorological data, and a 250-meter spacing grid from a fence line encompassing a three-acre site, extending ten kilometers (km) from the compressor station. Since WDEQ has not established an ambient air concentration level (AACL) for formaldehyde, the annual modeled ambient air concentration was compared to the State of Idaho's AACL of 0.077 g/m3, recognized as a level that could cause cancer in less than one in a million people. To further validate this value, the State of Arizona uses 0.08 g/m3 as the annual criteria. Based on the results of the model, the annual formaldehyde ambient air concentration would exceed the AACL within ten kilometers of an eight-engine (12,000-hp) compressor station.

Therefore, to minimize the predicted risk, the largest compressor station (12,000-hp) should not be constructed and operated within ten kilometers of an established residence. Other compressor stations would have less formaldehyde emissions, and therefore, the radius of concern around those stations would be less than 10 km if the facility configuration, terrain, stack parameters, and pollution control equipment were identical to the analyzed case. Therefore, the radius of concern around these facilities would be less than ten kilometers.

Since the analysis indicates a potential impact on public safety, the WDEQ permitting process, especially for the largest compressor engine complex, would address mitigation to lessen the formaldehyde risk. Possible mitigation to lessen the formaldehyde risk could include raising the stack to reduce ground level impacts or adding a CO catalytic oxidizer that would result in more complete combustion of natural gas, and thus reduce the formation of formaldehyde.

Vehicle Operational Impacts

Fugitive dust emissions, in the form of PM10, would occur from road dust generated by project vehicles, and wind-blown erosion on disturbed acreage such as well sites, compressor stations, and roads.

Fugitive dust emissions from vehicles on unpaved roads are calculated from the following formula (USEPA, 1995):

E[lb/VMT] = 5.9 x k x (s/12) x (S/30) x (W/3)0.7 x (w/4)0.5 x ((365-p)/365)

Where:

VMT = vehicle mile traveled

k = particle size multiplier; 0.36 for PM10

s = road silt content; 12 percent for a rural dirt road

S = average vehicle speed; 40 mph

W = vehicle weight; 3 tons for project vehicles
w = number of wheels; 4 wheels for project vehicles
p = number of days with more than 0.01 inches of precipitation; 100 for the expanded project area

Therefore, the average emission factor would be 2.05 lbs/VMT. The average daily traffic on potentially dusty roads to operate and maintain wells and facilities under Alternative 1 would be 30,000 miles per day. Therefore, average daily PM10 emissions from vehicles would be 61,500 lbs or 30.75 tons. It must be noted that these emissions would occur throughout the 2.3 million acre expanded project area. Putting these dust emissions into a localized perspective, an average of 0.0192 pounds (or 0.3 ounces) of dust per day would be generated in any given acre of the expanded project area. Any dust generated by vehicles at a given location would be localized and short-term in the vicinity of the road. Generally, the impacts would be negligible except for residences close to a well-traveled road or a vehicle traveling directly behind another vehicle.

Fugitive dust emissions would also occur from wind blown erosion and are calculated as follows. The emission factor for these exposed areas is 0.38 ton/acre/year (USEPA, 1995b). Fugitive dust emissions in the form of PM10 from wind blown erosion would be associated with the disturbed acreage from project facilities, and would be 3,123 lbs/day or 955.7 tons/year. However, these impacts would be negligible for the following reason. The long-term disturbed area from project facilities and constructed roads susceptible to wind-blown erosion would be 2,514 acres (see Chapter 2). This disturbance would only constitute 0.1 percent of the expanded project area. Fugitive dust generated from project facilities would be negligible compared to the dust naturally generated from the semi-arid climatic conditions, sparse vegetation, and strong winds on the 2.3 million acres within the expanded project area.

NOx emissions also would result from tailpipe emissions of project vehicles. A NOx emission factor of 1.5 gm NOx per vehicle mile was used for project vehicles (USEPA, 1991). Accordingly, 99.1 lbs ((1.5 gm/mile x 30,000 miles)/454 gm/lb) would be produced per day, or 18.09 tons/year. Distributing these emissions over the expanded project area, the NOx tailpipe emissions over the entire expanded project area would amount to 0.015 pound per acre per year.

Far-Range Impacts

Far-range potential air quality and AQRV impacts including visibility and acid deposition were analyzed for regional Class I and sensitive Class II areas (**Table 4-7**) for the Wyodak CBM Project. Because the ISCST3 model is recognized as yielding overly conservative results for modeling application beyond 50 kilometers, cumulative impacts were assessed using the CALMET/CALPUFF transport and dispersion modeling system. Due to the distance of the proposed project from the Class I and sensitive Class II areas, the primary impact on visibility is due to potential increases in regional haze that would lead to a reduction in visibility. Therefore, a regional haze analysis, using IWAQM recommended procedures with the CALMET/CALPUFF model, was conducted for each of the areas. In addition to the regional haze analysis, the increased potential for acid deposition at each Class I and II area was evaluated.

Far-Range Air Quality Impacts

Based on emission source inventories for the proposed Wyodak CBM Project the annual NO2 impacts were modeled and compared with the Prevention of Significant Deterioration Class I increments at the Class I areas and the National Ambient Air Quality Standards at each sensitive Class II area. Air quality standards are the most stringent at Class I areas (National Parks and large designated wildernesses) to afford the most protection for these pristine areas. The results of the ambient air quality analysis for each area of concern are provided in **Table 4-7**. **Table 4-7** demonstrates that no air quality standards would be exceeded by the project emissions.

Table 4-7
Wyodak CBM Project Far-Range Air Quality Impacts (g/m3)

	Type of	Annual	24-hr	Annual

Area	Area	NO2	PM10	PM10
Northern Cheyenne Reservation, MT	Class I	0.01	0.19	0.02
Badlands National Park, SD	Class I	0.005	0.08	0.01
Wind Cave National Park, SD	Class I	0.01	0.47	0.03
Class I PSD Increment		**2.5**	**4**	**8**
Black Elk Wilderness, SD	Class II	0.01	0.42	0.03
Jewel Cave National Monument, SD	Class II	0.01	2.35	0.04
Mt. Rushmore National Monument, SD	Class II	0.01	1.90	0.02
Cloud Peak Wilderness, WY	Class II	0.001	0.72	0.03
Devils Tower National Monument, WY	Class II	0.02	0.54	0.11
National Ambient Air Quality Standard		**100**	**150**	**50**

Regional Haze Impacts

Regional haze, caused by increased atmospheric concentrations of primary particulate emissions and secondary aerosols, such as nitrates and sulfates, is characterized by decreases in visual range and contrast of observed landscape features. Visual range is defined as the farthest distance that a dark object, such as a ridgeline, can be clearly viewed against a light background, a bright sky. The plume from an emissions source at sufficiently large distances from the source may not be visible because it is dispersed; however, the chemical species in the plume may still contribute to regional haze.

For the purposes of assessing regional visibility degradation due to specific sources of air pollution, the primary focus of this analysis was on the contribution to light extinction of fine particles of nitrate and sulfate compounds and particulate matter, and how visibility is affected by changes to the extinction coefficient. The extinction coefficient is proportional to the attenuation of light per unit distance due to scattering and absorption by gases and particles. Apportioning the extinction coefficient among various atmospheric constituents provides a method to estimate the change in visibility caused by a change in pollutant concentration.

Another method for evaluating effects on regional haze relies on calculating the deciview change. A deciview is defined as a visibility index which appears to be linear with humanly perceived changes under assumed commonly occurring conditions. Deciview increases with increasing visibility impairment. The deciview is a simple logarithmic transformation of the extinction coefficient, and therefore is easily determined from measured or modeled concentrations. A one to two deciview increment change in visibility may be just noticeable. A computed deciview change of 0.5 or less is considered to be the limit of acceptable change to both the NPS and the FS. Conversely, more than one day with a computed deciview change exceeding 0.5 deciview is considered an adverse impact. Limits of Acceptable Change (LAC) for AQRVs, including visibility and acid deposition, are policies that federal land managers adhere to in their decision-making processes.

Based on modeled concentrations from the proposed Wyodak CBM Project, emissions were computed and their impact on visibility was assessed. Procedures for assessing regional haze impacts are outlined in the IWAQM Phase 2 Report (USEPA 1998). These procedures involve computing the ambient concentrations of nitrates, sulfates, and coarse particulates in the atmosphere from emitted NOx, SO2, and PM10. From these particulate species concentrations, extinction coefficients were computed and the resulting change in deciview was calculated. The ratio of the existing extinction coefficient (background conditions) to the calculated extinction coefficient provides the change in extinction.

Estimates of background visibility conditions at Class I areas are available from the IMPROVE (Interagency

Monitoring of Protected Visual Environments) network. For this analysis, IMPROVE baseline seasonal visibility data (background extinction values) from Badlands National Park were used for each Class I and sensitive Class II area except for the Cloud Peak Wilderness, which relied on seasonal IMPROVE visibility data from the Bridger Wilderness. These data are shown in **Table 4-8**. The changes in extinction due to project emission sources were estimated by summing the contribution to extinction from nitrates, sulfates, and coarse particulates. For ammonium nitrate the maximum daily concentrations were adjusted using average relative humidity correction factors associated with the data from IMPROVE for seasonal average cleanest 20 percent conditions in Badlands National Park and the Bridger Wilderness (**Table 4-8**).

Table 4-8
IMPROVE3 Baseline Visibility Data
For 20 Percent Cleanest Conditions

	Spring	Summer	Fall	Winter
Badlands National Park, SD1				
Standard Visual Range (km)	147.8	143.0	169.1	169.8
Relative Humidity Factor	3.01	2.73	2.69	3.24
Bridger Wilderness, WY2				
Standard Visual Range (km)	222.8	205.4	239.0	271.5
Relative Humidity Factor	2.29	1.66	2.30	2.34

1Data from Badlands National Park were used to assess regional haze impacts at the following areas: Badlands National Park, Wind Cave National Park, Northern Cheyenne Reservation, Black Elk Wilderness, Devils Tower National Monument, Mt. Rushmore National Monument, and Jewel Cave National Monument.
2 Data from Bridger Wilderness were used to assess regional haze impacts at Cloud Peak Wilderness.
3 IMPROVE data from Winter 1987 to Summer 1997.
Source: John Vimont, NPS, 1999.

Based on modeled concentrations of NOx and PM10 from the proposed Wyodak CBM Project emissions, extinction coefficients were computed and their impact on visibility was assessed. The impacts to regional haze at most of the locations evaluated in this analysis would slightly exceed the NPS and FS policies regarding limits of acceptable change that state that more than one day per year with a deciview change of greater than 0.5 would be an adverse impact. Impacts at Class I areas are predicted to exceed the NPS and FS criteria on two to four days. The impacts at sensitive Class II areas are predicted to exceed the criteria on one to five days. The results are summarized in **Table 4-9**.

Table 4-9
Predicted Annual Days of Regional Haze Visibility Reductions At Class I and Sensitive Class II Areas from Wyodak CBM Project

Area	Type of Area	Number of Days deciview change >0.5	Number of Days deciview change >1.0
Northern Cheyenne Reservation	Class I	2	1
Badlands National Park	Class I	4	0
Wind Cave National Park	Class I	3	0
Black Elk Wilderness	Class II	1	0

Jewel Cave, National Monument	Class II	1	0
Mt. Rushmore, National Monument	Class II	1	0
Cloud Peak Wilderness	Class II	1	0
Devils Tower National Monument	Class II	5	0

Note:Florence Lake is situated within the Cloud Peak Wilderness and is not listed separately here.

AQRV Impact (Acid Deposition)
In addition to evaluating potential impacts to visibility in Class I and sensitive Class II areas, an assessment of potential impacts to other AQRVs in these areas was performed. The AQRVs of concern for the Class I and sensitive Class II areas include soil, water, flora, and fauna. For impacts to AQRVs, other than visibility, acid deposition of nitrates and sulfates is of primary interest due to its effects on lake acidification, as well as possibly affecting flora and fauna.

The AQRV impact analysis for the Wyodak CBM project evaluated potential impacts to AQRVs by computing the deposition loading (lb/acre/year) of nitrogen, in addition to evaluating potential effects of acid deposition on Florence Lake (a sensitive lake located within Cloud Peak Wilderness, Wyoming). Nitrogen would originate from wet and dry deposition of nitrates and nitric acid, as well as dry deposition of NOX. Sulfur would originate from wet and dry deposition of sulfates and SO2. Sulfur was calculated for cumulative sources only, due to low values, and is shown in **Table 4-17** and discussed under Air Quality in the Cumulative Impacts section of this chapter.

To evaluate potential impacts to AQRVs, the wet and dry deposition of the nitrogen and sulfur- containing chemicals listed above were computed using the CALPUFF model. Annual fluxes (mass per unit area) calculated for the Class I and sensitive Class II areas were compared to the acceptable incremental impact levels of 2.7 to 4.5 lb/acre/year for evaluating effects on soil, flora, and fauna. The acid deposition calculations used in this analysis followed the procedures outlined in the IWAQM Phase 2 Report (USEPA, 1998) and FS guidance (USDA FS, 1999).

To evaluate the impacts to aquatic systems (namely Florence Lake) from acid deposition, the loss of Acidification Neutralization Capacity (ANC), in micro-equivalents per liter (eq/l), and change in pH were computed using FS methods (USDA FS, 1987). Since the baseline ANC at Florence Lake is 37.6 eq/l (USDA FS, 1999), the limit of acceptable change in the ANC is 10 percent.

The results of the AQRV analysis for effects from acid deposition are summarized in **Table 4-10**. Included in each table, for each area, are the maximum annual deposition fluxes of nitrogen due to proposed project emissions. The analysis shows that the highest acid deposition would be 0.33 percent of the lower value (a 2.7 lb/acre/year limit of acceptable change) considered to be an adverse effect. Therefore, the Wyodak CBM Project would not have an adverse effect on acid deposition at any of the Class I or sensitive Class II areas.

Table 4-10
Predicted Levels of Acid Deposition from Wyodak CBM Project (lb/acre/year)

Area	**Total Nitrogen Deposition**	**Significance Level**
Northern Cheyenne Reservation	0.003	2.7 - 4.5
Badlands National Park	0.002	2.7 - 4.5

Wind Cave National Park	0.004	2.7 - 4.5
Black Elk Wilderness	0.004	2.7 - 4.5
Jewel Cave National Monument	0.01	2.7 - 4.5
Mt. Rushmore National Monument	0.008	2.7 - 4.5
Cloud Peak Wilderness	0.0006	2.7 - 4.5
Devils Tower National Monument	0.01	2.7 - 4.5

Table 4-11 shows the results of the ANC calculations for Florence Lake. The expected changes in ANC due to proposed project impacts are considerably lower than the limit of acceptable change of 10 percent.

Table 4-11
Predicted Acidification Neutralization Capacity (ANC)
Analysis for Florence Lake, WY

	Change in ANC from Baseline (%)
Cumulative Sources	0.26
Non-project Sources	0.24
Project Sources	0.02
USFS LAC	10

Note:Florence Lake baseline ANC = 37.6 eq/l.

Proposed Action
Construction Impacts
The magnitude of construction impacts under the Proposed Action would be expected to be less than impacts described under Alternative 1, based on 40 percent fewer wells and associated construction activities occurring under the Proposed Action. However, the nature of the construction impacts under the Proposed Action would be similar to Alternative 1.

Operational Impacts
The impacts associated with natural gas compressors and hazardous air pollutants would be expected to be the same under the Proposed Action as those described under Alternative 1.

Vehicle operational impacts under the Proposed Action would be expected to be 15 percent lower than Alternative 1 as 15 percent fewer project vehicles likely would be used for production operations under the Proposed Action.

Visibility Impacts
The impacts under the Proposed Action would be expected to be similar to those described under Alternative 1.

AQRV Impacts
The impacts under the Proposed Action would be expected to be similar to those described under Alternative 1.

No Action
Construction Impacts
The magnitude of construction impacts under the No Action Alternative would be expected to be 60 percent less than impacts described under Alternative 1, based on 60 percent fewer wells and associated construction activities occurring under the No Action Alternative. However, the nature of the construction impacts under the No Action Alternative would be similar to Alternative 1.

Operational Impacts
The impacts associated with natural gas compressors and air pollutants would be expected to be the same under the No Action Alternative as those described under Alternative 1.

The vehicle operational impacts under the No Action Alternative would be expected to be less than those anticipated under Alternative 1, based on 60 percent fewer wells (and production pods) visited regularly by project vehicles under the No Action Alternative.

Visibility Impacts
The impacts under the No Action Alternative would be expected to be similar to those described under Alternative 1.

AQRV Impacts
The impacts would be expected to be similar under the No Action Alternative to those described under Alternative 1.

SOILS
Proposed Action
Impacts to soils from the construction of CBM production facilities, access roads and pipelines would include:

€ Removal of protective vegetative cover and loss of soil/vegetative productivity;
€ Increased exposure of surface soil materials to accelerated erosion from blading and/or compaction of soil materials; and
€ Loss of soil profile development, soil structure, and nutrients from soil excavation and mixing of soil horizons.

Soils on an estimated 16,751 acres of land may be affected by CBM development activities. Only portions of most operations areas would be likely to have soils disturbed during drilling or installation of facilities. An estimated 6,514 acres of land would have soils affected by long-term disturbances related to construction of production facilities, roads, and pipelines under the Proposed Action.

During site preparation prior to construction of facilities, vegetation is removed and soil is disturbed and compacted. These acts of breaking up and exposing the soil to erosive forces can accelerate soil loss from wind and water erosion until vegetative cover is reestablished. Accelerated soil loss would be minimized by limiting the following: the removal of vegetation; the leveling of work areas; and the location of wells on slopes that would require cuts-and-fills for well pad construction. Because the Proposed Action calls for well placement in less steep areas which will not require drill pad leveling and cuts-and-fills, soil loss due to water erosion will likely be effectively controlled during construction through best management practices for the control of runoff and sediment transport. Timely initiation of reclamation and revegetation efforts should effectively and immediately control accelerated soil loss due to either wind or water erosion. Effective reclamation efforts would minimize both short- and long-term impacts.

The largest single impact on the soil resource resulting from CBM development would be the disturbance of 14,848 acres from use of linear unsurfaced, two-track roads and construction of buried pipelines (pod gathering, trunklines, and water discharge). Runoff, particularly channelized flows in road tracks and pipeline rights-of-way, which have been compacted and/or cleared of vegetation, can be high and can result in accelerated erosion where slopes are steep or long. However, the Proposed Action calls for minimizing road construction which would require cuts-and-fills. Pipeline construction also will avoid steeper slopes where possible. Where necessary, erosion control features, such as water bars or other means of diverting flows off sloping pipeline rights-of-way, would be constructed to control increased runoff and erosion.

Estimates of annual soil loss for the 15 most common soil series in the project area (**Table 3-14**) were computed using the Revised Universal Soil Loss Equation (USDA, 1997). For each soil, the estimates were calculated using three scenarios: undisturbed (existing rangeland condition), disturbed (vegetative cover removed and loose, uncompacted surface soil conditions), and reclaimed (one year following recontouring, soil preparation, and seeding). For the undisturbed scenario, estimates among the soils ranged from lows of 0.4 to highs of 3.8 tons/acre/year. For disturbed conditions, estimates ranged from 2.1 to 14 tons/acre/year. For conditions following one year of reclamation, estimates ranged from 0.8 to 6.6 tons/acre/year.

With the implementation of effective reclamation practices, vegetative cover would likely return to a mostly natural appearance in the project area within two to three years (USDI BLM, 1998g. However, soil loss would likely increase substantially in the short-term following disturbance until reclamation measures become effective in controlling runoff. Soil loss under the short-term, "disturbed" scenario would exceed acceptable levels for 9 of the 15 dominant soil series. These potential soil losses point to a need for adoption of Best Management Practices (BMPs) during construction. Following construction, erosion control measures and/or features will need to be continued and maintained until adequate vegetative cover is re-established, channelized flows (rill and gully features) are eliminated, and the re-establishment of protective vegetative cover is achieved. Reclamation practices used on previous CBM projects in the project area have resulted in limited accelerated soil erosion and a high level of reclamation success (USDI BLM, 1996a).

The amount of soil loss also can be reduced substantially by avoiding areas of highly erosive soils when drill sites, two-track access routes, and pipeline routes are surveyed and staked. These areas of highly erosive soils include badlands, steep-walled drainages, sand blowout areas, and other areas subject to active headward erosion.

Soil materials typically are mixed during underground pipeline construction. When less productive subsoil becomes mixed with the topsoil (surface soil horizon or layer), overall reclamation potential and effectiveness in re-establishing vegetation in the disturbed area can be reduced. Compaction from pipeline construction vehicles also can reduce the effectiveness of a revegetation program as compacted soils can inhibit moisture and air infiltration and limit vegetative success.

The suitability for reclamation of most of the dominant soils in the study area is "fair" on a scale ranging from "good" to "unsuitable" (**Table 3-14**). Only the shallow, rocky Wibaux soil is classified as potentially "unsuitable" for use in reclamation. Most steep areas occupied by this soil will be avoided, minimizing disturbance and the need for subsequent reclamation efforts.

The use of produced water for irrigation may diminish the long-term productivity of soils when the produced water and soils are either saline or sodic. Sustained irrigation using waters that have TDS concentrations greater than 750 mg/l and sodium adsorption ratios (SAR) greater than six could decrease long-term productivity. The application of fast flowing waters on erosive soils or steep slopes likely would result in increased erosion and sedimentation and reduced long-term range productivity.

A specific impact to topsoil and potentially, reclamation suitability, may occur should produced water from CBM wells be discharged at points within closed basins. Water discharged within a closed basin will drain to the low point in the basin or playa. Although the accumulation of salts in the playa bottoms within the project area has not occurred in most cases under natural precipitation and runoff conditions, the sustained release of produced water from CBM wells may add additional salts to the playa soils, resulting in an elevation of salinity levels over time. Salts accumulate in closed basins as water is evaporated, leaving its dissolved minerals behind as solids. Both long-term ponding of water and the periodic ponding of water followed by evaporation and drying of the playa bottoms could change soil conditions by increasing salinity, which may alter the composition of vegetation supported by the playa bottom.

Also, regardless of the salinity levels in the inflows and playa soils, the long-term ponding of playa bottoms would alter soil/playa bottom conditions and would result in changed soil conditions. Continuous wet soils would "kill off" the existing vegetative cover as most of the species are dryland species and are not "water loving." The absence of a living cover would likely allow for an invasion of weedy species, potentially noxious weeds, which may take hold and be difficult to replace, even with desirable adapted species.

The development of saline and wet soil conditions will be minimized by locating most discharge points in open watersheds where water will not accumulate in playa situations.

Alternative 1

Acres of soil disturbance for the 5,000 productive wells, roads, and ancillary facilities proposed under Alternative 1 could be expected to be 67 percent greater than under the Proposed Action. Otherwise impacts to soils under this alternative would be similar to the Proposed Action.

Soils on an estimated 26,491 acres of land may be affected by CBM development activities. Only portions of operations areas would be likely to have soils disturbed during drilling or installation of facilities. An estimated 10,788 acres of land would have soils affected by long-term disturbances related to construction of production facilities, roads, and pipelines under Alternative 1.

No Action

Acres of soil disturbance for the 2,000 productive wells, roads, and ancillary facilities proposed under this alternative could be expected to be 33 percent less than under the Proposed Action. Otherwise impacts to soils under this alternative would be similar to the Proposed Action.

Soils on an estimated 11,881 acres of land may be affected by CBM development activities. Only portions of most operations areas would be likely to have soils disturbed during drilling or installation of facilities. An estimated 4,377 acres of land would have soils affected by long-term disturbances related to construction of production facilities, roads, and pipelines under the No Action Alternative.

VEGETATION RESOURCES

Proposed Action

Most CBM drilling operations are likely to occur over natural terrain. An estimated 16,751 acres (or about 1.1 percent of the project area) may be affected by operations, which would include the drilling of 3,000 productive wells. Only portions of most operations areas would be likely to have vegetation disturbed or removed, even temporarily, during drilling or installation of production facilities. The sites affected would be dispersed throughout the project area. The mosaic versus concentrated pattern of areas potentially affected by the Proposed Action will be likely to limit the magnitude of drilling or construction impacts to any vegetation type.

Short-term disturbance during drilling and construction of production facilities and pipelines is likely to vary in duration from a few days to a few months in any area. Drill sites, gas gathering lines, trunklines, and water discharge lines, which may affect 10,273 acres, are considered to be short-term impacts to vegetation resources since these areas would be reclaimed soon after construction, during the next spring or fall season. Most areas would be revegetated within one to three years. Two-track access roads to unproductive wells also would be considered to be short-term impacts, since these areas would be reclaimed, if disturbance occurred, soon after use.

Short-term impacts to vegetation resources are likely to consist of the partial or complete removal of existing vegetation and soil compaction. Most of the acreage affected by short-term disturbances will be returned to forage production within one to three years, as disturbed areas are revegetated. Reclamation bonds, which are held by agencies as a guarantee that successful reclamation will occur, would not be returned to the Companies until sufficient monitoring documents successful reclamation efforts.

Long-term disturbance will occur over the life of the project, and is expected to be reclaimed at the conclusion of the project. Long-term impacts to vegetation resources would be associated with access roads to productive wells, wellhead facilities, compressor stations, pod facilities, improved roads to production pods, and booster compressors, and would affect an estimated 6,514 acres. Vegetation is likely to be disturbed, damaged, or removed during installation or use of these proposed CBM facilities and soil likely will be compacted.

Reclamation and final closure of the proposed operations will re-establish vegetation suitable for forage and wildlife habitat in the disturbance areas.

This disturbance may be repeated a number of times during the life of the project as additional operators conduct operations within the same areas. Maintenance of each well and other facilities will occur over the life of the facility, or approximately 12 to 20 years.

During CBM development, the abundance, species composition, and diversity of vegetative species found near discharge points or water bodies formed to hold discharged water likely will change noticeably. First, as discharge occurs and more surface water becomes available, species with higher water requirements will appear and gradually will increase in abundance. Streamside (riparian) vegetation will increase along drainages where discharge is occurring. Then, as discharge declines and less surface water is available to support plant growth, species adapted to growing under wet, oxygen-starved conditions will become stressed and eventually will decrease in numbers in areas where discharge ends. Water-loving vegetation will be replaced by plant species which are adapted to dryland growing conditions within former discharge areas. Also, undesirable weedy species, including noxious weeds, may invade these former discharge areas as they dry out, or other areas disturbed by CBM development, unless timely site reclamation occurs.

Sites influenced by the continued evaporation of discharge waters could develop concentrations of salts within soils. Closed basins, playas (old lakebeds) and reservoirs may be difficult to reclaim unless these sites are analyzed carefully to evaluate their chemical and physical characteristics and to identify any soil amendments or site-specific reclamation techniques that should be incorporated within reclamation plans.

Construction and operational activities associated with the Proposed Action would be likely to indirectly impact vegetation within the project area by increasing the potential for the establishment of noxious weed populations. This increase would be driven by two factors. First, the creation of disturbed areas would increase the number of areas hospitable to weedy invasions and second, the project related traffic in and out of the area would act as a transportation mechanism to bring weed seeds into the project area.

The long-term vegetation productivity of disturbed areas and areas adjacent, could be reduced under the Proposed Action. Vegetation productivity in the areas of disturbance could experience an unrecoverable loss unless disturbed areas are revegetated promptly using methods and species designed site-specifically to restore productivity. Actions that will enhance restoration of vegetation productivity from desirable species include the following site preparation and reclamation techniques: mechanical loosening or roughening of the soil where compacted (discing or ripping); fertilization or soil amendment; seeding to proper depth with desirable species; mulching to retain soil moisture; transplanting containerized plants to speed the establishment of slow-growing species; control of noxious weeds; or temporary fencing to exclude livestock until vegetation is re-established successfully.

The potential for the occurrence of reduced productivity also would be heavily dependent upon the level of mitigation activities conducted during the project and after it ends. Mitigation activities most effective in reducing the potential for decreased vegetation production include timely and well planned reclamation and effective noxious weed management, avoidance of disturbance within playas (old lakebeds), and avoidance of discharge within closed basins, playas, and areas with soils that would be difficult to revegetate.

Residual impacts from CBM development include reduced plant species diversity, particularly Wyoming Big Sagebrush, on some reclaimed lands. Reclaimed areas would be dominated initially by grassland vegetation that is less diverse than undisturbed areas. Within about ten years following reclamation, a diverse, productive, and permanent vegetative cover would be re-established on disturbed areas. It may take from 20 to 100 years to restore shrubs to existing density levels observed in some undisturbed portions of the project area (USDI BLM, 1998c).

Alternative 1

Under Alternative 1, surface disturbance impacts related to CBM development would be similar in nature to those described for the Proposed Action but would occur throughout the expanded project area. An estimated 26,491 acres (or about 1.2 percent of the project area) would be affected by the drilling and operation of 5,000 new productive wells. Access roads to unproductive wells, gathering lines, trunklines, and water discharge lines would disturb an estimated 15,763 acres. These impacts are considered to be short-term to vegetation resources, since these areas would be reclaimed soon after construction. Long-term impacts to vegetation resources would be associated with wellhead facilities, compressor stations, pod facilities, improved roads, and booster stations covering approximately 10,788 acres.

No Action

Under the No Action Alternative, approximately 2,000 new productive wells would be drilled on private and state-owned mineral lands. This would result in direct and indirect losses to vegetation productivity similar to those described for the Proposed Action. An estimated 11,881 acres (or about 0.8 percent of the project area) would be affected by CBM operations. Of these, short-term impacts to vegetation resources would cover 7,528 acres and long-term disturbance to vegetation resources would affect 4,377 acres.

While potentially similar in nature to the Proposed Action, these impacts could be more enduring. Federal permits would not be required to drill on these lands, and environmental protection measures such as reclamation and noxious weed control may not be mandated by land owners or possibly would not be monitored as closely. As a consequence, the impacts to vegetation resources could occur with less mitigation planned in advance and short-term impacts could persist.

WETLANDS

Proposed Action

Federal agencies are directed to take action to minimize the destruction, loss, or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands. The operating procedures used by BLM to implement this federal policy are summarized in **Appendix A**. Generally, surface disturbance is prohibited within 500 feet of surface water, including all types of wetlands, or riparian areas, unless an acceptable plan for mitigation is agreed upon. Disturbance of all wetlands is mitigated acre for acre. Reclamation of private surface lands considers the landowner's goals for reclaimed lands.

Facility placement would be designed for wetland avoidance whenever feasible under the Proposed Action. Wetlands within the project area would not likely be filled or dredged during CBM development. Therefore, wetlands would not likely be directly impacted, but could be indirectly affected.

As water discharge occurs under the Proposed Action, existing wetlands may increase in areal extent, and new wetlands may develop. As discharge declines when wells complete their productive life and less surface water is available to support plant growth, species adapted to growing in the expanded or new wetlands would become stressed and eventually would disappear. Wetland vegetation within wetlands created or enlarged by CBM generated flows would be replaced by plant species adapted to dryland growing conditions when these flows cease. When discharge eventually ends, the areal extent of wetlands would revert to pre-CBM development conditions.

The State of Wyoming Department of Environmental Quality, Water Quality Division administers a State Wetland Bank. Landowners have the opportunity to "bank" newly created or expanded wetland areas. "Banked" provisional wetlands from CBM discharges serve as a record of prior non-wetland status, and maybe be used for temporary mitigation in the event a landowner requires a wetland credit.

A detailed study to identify jurisdictional wetlands is required by the COE prior to permitting activities involving dredge or fill. Adding produced water in and of itself, or subsequently reducing or eliminating the flow of produced water, to a wetland or other waters of the U.S. is not an activity regulated by the COE (**Appendix A**). For any jurisdictional wetlands identified that may be impacted, a detailed mitigation plan would be developed during the APD or Sundry Notice approval process. Federal requirements to replace all impacted wetlands would mitigate this loss, so environmental impacts would occur only during the life of the project (including reclamation). Replacement plans for wetlands would be addressed in the APD surface use plan.

The potential for the elimination of existing wetlands or impairment of the function of existing wetlands would be dependent on the level of mitigation activities conducted during and after the life of the project. Mitigation activities most effective in reducing the potential for adversely impacting existing wetlands include the following: avoidance of discharge within playas and closed basins; avoidance of discharge within or near existing wetlands (if increased discharge volumes or subsequent recharge of shallow aquifers would inundate and kill woody species, especially willows or cottonwoods); and avoidance of disturbance within all delineated or recognized wetlands.

If impacts to wetlands occur, these impacts would not be expected to be permanent. Any loss of existing wetlands would be mitigated through replacement, and indirect effects from added water would last only as long as the productive life of the well(s) contributing flow to each discharge point. During the period of time after CBM development begins and before wetland replacement is complete, wetland functions would be lost. In addition, reclaimed wetlands may not function in the same way as the affected wetlands did before CBM development. Residual impacts to wetlands function, species composition and diversity, and landscape features may occur following reclamation.

Surface disturbance associated with construction and operational activities would increase the potential for noxious weed invasion of wetland communities. Undesirable weedy species also may invade wetlands as they dry out at or near the end of the project life, unless timely reclamation occurs. Any invasion of wetlands by noxious weeds or undesirable weedy species could decrease wetland values (wetland function, species diversity, wildlife habitat).

Sites influenced by the continued evaporation of CBM produced waters during the extended time discharge is occurring could develop concentrations salts concentrated within soils. Closed basins, playas (old lakebeds) and reservoirs may be difficult to reclaim unless these sites are analyzed carefully to evaluate their chemical and physical characteristics, and to identify any soil amendments or site-specific reclamation techniques that should be incorporated within reclamation plans.

Alternative 1

Although similar in nature to the Proposed Action, a total of 5,000 productive wells would be drilled under Alternative 1. Therefore, impacts to wetlands could be as much as 67 percent higher than expected under the Proposed Action.

Under Alternative 1, wetland impacts resulting from the construction and operation of CBM development projects would be similar to those described under the Proposed Action, except that they would result in increased surface water discharge, which would result in an increase in wetland extent. The potential for noxious weed invasion would be higher, which could cause wetland values (wetland function, species diversity, wildlife habitat) to decline.

No Action

Under the No Action Alternative, approximately 2,000 productive wells would be drilled on private and state-owned mineral estate lands. This would result in impacts to wetlands that are similar to those described under the Proposed Action, but could affect 33 percent fewer wetlands. The same wetland mitigation required by the COE would apply on all lands regardless of ownership. While similar in nature to the Proposed Action, these impacts could be more enduring. Noxious weed control might not be mandated by land owners or monitored as closely. As a consequence, impacts to wetlands caused by noxious weed invasion and establishment could be more likely to occur.

WILDLIFE AND FISHERIES

Proposed Action

The Proposed Action could affect up to 16,751 acres of terrestrial wildlife habitat during the life of the project. This represents 1.1 percent of the project area. Up to 6,514 acres (or 0.4 percent of the project area) of this potential habitat loss is likely to be long-term, approximately 15 years. The remaining affected areas, an estimated 10,273 acres, would be associated with short-term effects lasting one to three years or less until the affected habitat is reclaimed.

Long-term habitat losses would be associated with well access roads, wellhead facilities, compressor stations, pod facilities, improved roads to production pods, and booster compressors. Access roads to unproductive wells, gathering lines, trunklines, and water discharge lines are considered to be short-term impacts, since these would be reclaimed soon after construction during the next fall or spring season. Not all of the land potentially affected by CBM operations will be disturbed and lost as habitat, even temporarily. Most CBM operations will occur over natural terrain. Only minimal portions of most operations areas actually will be disturbed during installation of production facilities.

The habitat areas potentially affected would be scattered throughout the project area. The dispersed versus concentrated pattern of areas potentially affected by the Proposed Action will likely limit the magnitude of impacts to any one habitat type. However, the effects of CBM operations and increased human presence also will occur over a large area.

Direct loss of habitat could reduce or eliminate forage, hiding cover, breeding sites, nesting cover, and thermal cover contained within areas affected by CBM operations. Reductions that would adversely affect available forage or carrying capacity, areas of seasonal importance, or special habitats such as nesting sites, can be analyzed site-specifically, and impacts minimized through the application of special conditions of approval for drilling or production operations.

Terrestrial wildlife species dependent on areas affected by CBM operations are likely to be displaced. Displaced animals may be incorporated into adjacent populations. Displaced animals that do not become habituated to CBM operations may experience prolonged stress reactions, resulting in increased disease rates, decreased reproductive rates, or increased mortality. Some species may become less likely to inhabit or frequent the project area. Populations of species dependent upon and drawn to areas with more abundant surface water may increasingly inhabit or frequent the project area during the life of the project.

Depending upon variables such as species behavior, density, and habitat, displaced or adjacent populations may experience increased mortality, decreased reproductive rates, or other compensatory or additive responses. The species most impacted would be those that rely primarily on mixed prairie and Wyoming Big Sagebrush habitats, including small mammals such as prairie voles, and desert cottontails; birds such as sage thrasher, vesper sparrow, and western meadowlark; and associated predators such as coyotes, badgers, swift fox, burrowing owls, ferruginous hawks, golden eagles, and northern harriers.

Wildlife disturbances due to drilling within the project area would be less than that which is normally associated with conventional oil and gas drilling operations. Drilling at each of the CBM drill sites is expected to take only one to three days as compared to a range between two weeks and two months for conventional oil and gas wells. Drilling at conventional oil and gas wells normally continues 24 hours/day, however, CBM wells will not drill continuously. Truck-mounted water well drill rigs would be used to drill CBM wells instead of the multi-component rigs used to drill conventional wells. In addition, the drill site size and road construction standards are less than those required for conventional rigs. Operators would use existing trails and two-track roads whenever possible.

Noise associated with the compressor stations and booster compressors is expected to increase above existing levels. However, the location of noise sources may have a short-term effect on animals near those areas. Some animals may be displaced an unknown distance from the noise source; however, others would be become habituated to the noise.

The managed discharge of CBM produced waters within the project area likely would benefit wildlife and fisheries habitats and populations. Potential benefits likely would include the following: habitat creation or enhancement; increased availability of water to meet species' needs; increased forage productivity or carrying capacity; increased surface flows; and creation or enlargement of water storage (in reservoirs or ponds).

The groundwater appropriated as CBM produced water likely will have groundwater appropriation rights filed with the WSEO on behalf of the CBM operator and surface landowner. Once discharged onto the surface, downstream landowners can file for the appropriation of surface water below discharge points. Federal and state authority to control the nature of subsequent beneficial uses of CBM produced water likely will be limited. Many CBM discharges would be controlled by surface landowners. The management of CBM discharges specifically to benefit wildlife and fisheries likely would not occur without close collaboration and cooperation among all affected interests.

Big Game

Implementation of the Proposed Action potentially may remove (either temporarily or permanently) up to 16,751 acres of antelope winter, winter/yearlong, and year long range as well as mule deer yearlong and winter/yearlong range. In addition, both yearlong and winter white-tailed deer range may be impacted within the project area.

CBM development operations located near the Fortification Creek WSA may cause short-term disturbances to elk populations within it and surrounding areas. Elk may be displaced temporarily by nearby operations, but disturbance and habitat losses within the WSA will be minimized and limited to short-term disturbances because surface occupancy is prohibited within the WSA to protect wilderness values. Activities, including short- and long-term disturbances, may occur in the area immediately outside the northeastern boundary of the WSA, where surface occupancy is allowed. This area near Wild Horse Creek also contains a portion of the main railroad transportation corridor connecting Gillette and Sheridan. Elk occurring in this area already are likely to be habituated to increased activity levels, and may become habituated to CBM development.

Although drilling and construction activities would displace antelope, deer, or elk away from the area, the animals are likely to become accustomed to these activities. Observations of antelope in existing CBM fields suggest that they become somewhat tolerant of human activity during most of the year, with the exception of hunting season. New roads and increased access to the project area may increase the potential for poaching. If big game ranges are affected by the Proposed Action, timing restrictions that limit or prohibit activity during seasonal periods of use by wildlife populations can be incorporated within APD or Sundry Notice conditions of approval to reduce or eliminate the potential for these impacts.

Upland Birds

Numerous grouse leks have been identified within the project area. These areas may be impacted by the Proposed Action. Drilling and human activities within two miles of leks during the breeding and nesting season may cause a decline or disruption of breeding activities. Permanent activity, or disturbance within _ mile of a lek may cause grouse to abandon the lek or move away from the area, so occupancy within this _ mile area around a known lek is prohibited by BLM. BLM previously has also identified a two-mile buffer around each of the leks within which surface disturbance has been restricted between March 1 through June 15. Special habitats will be analyzed site-specifically, as needed, during review of APDs or Sundry Notices, and impacts minimized through the application of special conditions of approval for drilling or production operations.

Raptors

Raptors may be affected by the loss of prey base resulting from the potential disturbance of up to 16,751 acres of habitat. Some raptors would be able to take advantage of prey availability in reclaimed habitats. Most raptors are intolerant of human activity during the breeding season. Raptor nesting within the project area could decline as a response to increased human activity and development within the PRB. Activity levels under the Proposed Action may result in reductions in nesting success within the project area. Special habitats will be analyzed site-specifically, as needed, during review of APDs or Sundry Notices, and impacts minimized through the application of special conditions of approval for drilling or production operations.

Powerline facilities placed above ground may increase the potential mortality resulting from collisions and electrocutions. If electric lines are placed underground whenever feasible, the potential for increased mortality would be reduced. Any powerline facilities constructed above ground will be constructed in a manner that will minimize the potential for collisions and electrocutions.

Waterfowl, Shorebirds, and Other Species

Waterfowl populations could increase if the water produced by CBM operations is stored in reservoirs or ponds. The majority of waterfowl are found in the area during their seasonal migrations. However, if suitable nesting habitat is created within the area, some birds may stay and produce broods. Previous studies have indicated that one brood of ducks or geese would be likely to be produced on each water body created that is at least one acre in size.

In addition to waterfowl, populations of other species such as amphibians and shorebirds may increase as surface water resources become more abundant within the project area. Bird species that may occur within the project area during the summer include songbirds. These species are attracted to areas with surface water that supports riparian areas and to wetlands, which may become more abundant. As former discharge areas dry out when water production ends, vegetation with higher water requirements will become less abundant. After water production ends, the project area is likely to revert to being less attractive to waterfowl, shorebirds, amphibians, songbirds, and other species that prefer diverse vegetation having higher water requirements.

Under the Proposed Action, 3,000 productive wells would produce water distributed among 2,500 discharge points within the project area. Unless produced water from a number of wells is gathered together for discharge, it is not anticipated that any single discharge point would supply sufficient water to increase the amount of waterfowl habitat within the project area. The combination of discharge points may provide additional habitat at the mid and lower reaches of various drainages, and may increase wet areas and riverine environments. These areas will cease to exist after water production related to CBM development stops, unless landowners wish to maintain them by continuing to pump water from the wells.

Fish

Some produced waters are likely to be ponded or held in reservoirs prior to discharge. This would increase the amount of aquatic habitat within the project area. Some previous impoundments within the project area have been stocked with game fish. It is anticipated that this could also occur under the Proposed Action.

Surface disturbance under the Proposed Action will be spread out over a large area, and most operations will occur over natural terrain without utilizing cut and fill construction techniques. As discussed in the previous water quality section, CBM development is not likely to degrade water quality in local streams by increasing sediment loads. This would also be true in the headwaters of the Cheyenne River, where the plains topminnow may occur. Site-specific conditions of approval for APDs, which provide for erosion control and timely and effective reclamation of short-term disturbances, would minimize the potential for impacts to species that live in clear streams.

Alternative 1

Impacts to the wildlife and fisheries resources that would occur under Alternative 1 would be similar to those described in the Proposed Action. The major difference is that 5,000 productive wells would be drilled under Alternative 1. This would result in an estimated 26,491 acres of potential disturbance, of which 10,788 acres would be affected long-term (during the life of the project). The remaining 15,763 acres would be likely to be affected only by short-term disturbances (estimated to be one year or less in duration). This would result in nearly the same percentage (0.5 percent versus 0.4 percent) of potential long-term habitat loss for wildlife within the expanded project area as was projected under the Proposed Action.

No Action

Initially, impacts to wildlife and fisheries resources under the No Action alternative would be similar to those already occurring within the project area. However, approximately 2,000 productive wells would be drilled on private and state-owned lands. An estimated 11,881 acres (or about 0.8 percent of the project area) potentially would be affected by this additional CBM development. Of these acres, short-term impacts could affect 7,528 acres and long-term disturbance could affect 4,377 acres.

While potentially similar in nature to the Proposed Action, wildlife impacts on private and state lands could be greater. Federal permits would not be required to drill on these lands, and environmental protection measures, such as reclamation, wildlife buffer zones or nesting season restrictions, and noxious weed control, might not be mandated by landowners or monitored as closely. As a consequence, the impacts to wildlife habitats could occur with less avoidance or mitigation. Habitats may not be as well restored to existing conditions.

SPECIAL STATUS SPECIES

Proposed Action

Seven federally listed special status species have been identified as potentially occurring within the project area. In addition to the federally listed species, the FS has identified 27 sensitive species that potentially occur within the project area, and the status of the black-tailed prairie dog currently is undergoing review by the USFWS for possible designation as a threatened species. The following is a brief discussion of the direct and indirect impacts that may occur under the Proposed Action, and how these species may be affected. Potential impacts to these species will be analyzed site-specifically, as needed, during review of APDs or Sundry Notices, and impacts eliminated or minimized through the application of special conditions of approval for drilling or production operations.

Bald Eagle

Bald eagles foraging or roosting within the project area are not likely to be affected by the Proposed Action. Only three bald eagle winter roost sites are known to occur within the project area. Access to these areas can be carefully controlled or avoided during the winter, to eliminate or minimize impacts to wintering birds. Minor amounts of foraging habitat are likely to be lost under the Proposed Action, however, based on the large amount of remaining habitat, an impact to eagles frequenting the project area is not anticipated.

Black-Footed Ferret

Although black-footed ferrets are not known to occur within the project area, potentially suitable habitat does occur (i.e., prairie dog colonies). If a facility is proposed to occur within a prairie dog colony of sufficient size and density to support ferrets, a survey would be required prior to ground disturbing activities.

Peregrine Falcon

Peregrine falcons are not likely to be affected by the Proposed Action. No peregrines are known to nest within the project area. The Proposed Action may be beneficial to peregrines by creating habitat for waterfowl, which may increase foraging habitat for peregrines.

Swift Fox

If swift fox occur within the project area, impacts to this species may occur as a result of the Proposed Action. The nature of anticipated impacts will depend on the location of facilities in relation to den locations. Potential impacts to this species will be analyzed site-specifically, as needed, during review of APDs or Sundry Notices, and impacts eliminated or minimized through the application of special conditions of approval for drilling or production operations.

Mountain Plover

Mountain plovers are likely to be found throughout the project area. Therefore, potential impacts to this species could occur. Impacts could occur during the nesting season, which typically occurs from mid-March through late-June. Stipulations to mitigate impacts, which may include preconstruction surveys or timing limitations, could reduce or eliminate impacts.

Sturgeon Chub

Impacts to the sturgeon chub are not anticipated. No habitat for the chub occurs within the project area. Although large amounts of water would be produced as a result of the Proposed Action, these waters are not anticipated to significantly increase flows within the Powder River.

Ute-Ladies Tresses

Impacts to Ute-ladies tresses found within the project area may occur as a result of the Proposed Action. Potential effects are highly dependent upon the location of proposed facilities. If ground disturbing activities occur within potentially suitable habitat (i.e.: wetlands), surveys would be required prior to any ground-disturbing activities.

Other Species, Including FS Sensitive Species

In addition to the seven federally listed species, 27 FS sensitive species potentially occur within the project area. Of these, the common loon, black-backed woodpecker, and tawny-crescent butterfly are not expected to be affected by any of the action alternatives due to the lack of suitable habitats for these species within the project area.

Six sensitive species, the plains topminnow, American bittern, greater sandhill crane, white-faced ibis, fox sparrow, and Lewis' woodpecker potentially may occur within the project area and could be affected by the action alternatives.

The remaining seventeen FS sensitive species (**Table 3-16**) and the black-tailed prairie dog have a high likelihood of occurring or are known to occur within the project area. These species also could be affected under the Proposed Action. Habitats for these species that may be impacted can be analyzed site-specifically and impacts eliminated or minimized through the application of special conditions of approval for drilling or production operations. The BLM's standard operating procedures are to avoid impacts to prairie dog colonies.

Alternative 1

Impacts to special status species that would likely occur under Alternative 1 would be similar to those described in the Proposed Action. The major difference from the Proposed Action is that 5,000 new productive wells would be drilled under Alternative 1. This would result in 26,491 acres of potential disturbance, of which 10,788 acres would be affected long-term (during the life of the project). The remaining 15,763 acres would be likely to be affected only by short-term disturbances (estimated to be one year or less in duration). This would result in nearly the same percentage (0.5 percent versus 0.4 percent) of potential long-term habitat loss for special status species within the expanded project area as was projected under the Proposed Action. Potential impacts to these species would be analyzed site-specifically, as needed, during review of APDs or Sundry Notices, and impacts eliminated or minimized through the application of special conditions of approval for drilling or production operations.

No Action

Initially, impacts to special status species under the No Action alternative would be similar to those already occurring within the project area. However, under the No Action Alternative approximately 2,000 productive wells may be drilled on private and state-owned lands. Because no federal permits are required to drill on these lands, protection measures for special status species might not be mandated by the landowners or monitored as closely.

CULTURAL RESOURCES

Cultural sites are nonrenewable resources and once disturbed lose much of their preserved information, integrity, and heritage value. Significant cultural resource sites are defined as those sites evaluated as eligible for or listed on the National Register of Historic Places (NRHP). Avoidance of significant sites is the preferred alternative to mitigate adverse impact because well pad construction, access roads, collection pipelines, and limited vehicle use have the potential to disturb such sites. BLM, and FS when involved, require archaeological study of access, site, and right-of-way areas on an individual well or area basis, encompassing the area of potential effect, as part of the APD approval process.

BLM encourages preservation of cultural properties whenever possible. Data recovery is undertaken when a direct impact to a significant property cannot be avoided. Inadvertent or unintentional impacts to a significant site may be found to be the developer's responsibility and may require data recovery. Such problems are less likely when sound project planning occurs. When adverse effect is eliminated by avoidance of the property, the effect is considered "no effect." When mitigation is by avoidance of contributing elements or through an approved data recovery plan, the effect to the cultural property is considered "no adverse effect."

Impacts to traditional cultural properties, sacred sites and localities of traditional concern, such as medicinal plant collecting areas, also must be considered. Although the proponent may notify Native American tribal governments of their intent, the lead federal agency is responsible for consultation with tribal representatives. Consultation allows the authorized tribal representatives to express their concerns on how the proposed project might directly affect traditional cultural properties and sacred sites, or might affect access to sites, or their ability to use or protect them.

Proposed Action

Only about three percent of the project area for the Proposed Action has been inventoried for the presence of cultural resources and 121 of the 1,307 known cultural resources have been recommended eligible or listed on the NRHP (**Table 4-12**). The largest numbers of identified sites have been prehistoric lithic scatters and historic ranching sites. If it is assumed that the areas that have been inventoried for cultural resources are representative of the range of settings in the project area and that cultural sites are randomly distributed across the landscape, there are likely to be as many as 4,000 eligible cultural resources in the project area for the Proposed Action. This indicates that there is a high potential for additional significant cultural properties being discovered when cultural resource inventories are undertaken during the APD approval process.

Because the distribution of wells and facilities is not established and cannot be compared directly to the distribution of known sites and previous cultural resource inventories, no accurate estimates can be made of how many significant historic properties may be affected by the Proposed Action. Based on the limited results of previous investigations, and assuming that sites are evenly distributed throughout the project area, approximately 8.5 sites are estimated per square mile. Within the project area for the Proposed Action approximately 9 percent of the known sites are recommended eligible for or listed on the NRHP. Given the assumption used in the impact analysis presented earlier in this chapter, and the estimate that the area of potential direct surface disturbance for the Proposed Action would be 16,751 acres, it can be estimated approximately 230 cultural resource sites may be impacted by the Proposed Action, and that 21 of those sites will be significant and will require avoidance or mitigation measures.

All areas of proposed ground disturbing activity will be inventoried for cultural resources at the APD phase of each action. Any discovered cultural resources will be evaluated for eligibility to the NRHP. It should be possible to avoid direct impact to many significant properties, but construction and operation of the proposed wells and facilities may have indirect effects. Indirect effects may result from traffic or other activities outside the identified areas of disturbance, or from changes to soil stability or drainage patterns. Indirect effects can be minimized by soil stabilization measures and protective barriers to restrict traffic in sensitive areas.

Where direct effects cannot be avoided, an approved data recovery plan will be developed in consultation with SHPO to mitigate the adverse impacts of the Proposed Action. Specific plans for avoidance or data recovery will be recommended for any significant sites within the area of potential effect of the proposed activities. Data recovery will collect a statistically valid sample of those data elements that make the site significant and will be unavoidably disturbed or destroyed by the proposed undertaking. Certain historic sites, such as significant historic trails, may be significant for their setting and context, and may be sensitive to visual intrusions, that must be mitigated by modifications to location and design of the proposed project. In addition, specific procedures will be established for the treatment of unanticipated discoveries and unmarked human remains that are not identified by surface cultural resource inventory.

A large number of cultural properties within the project area remain unevaluated. When the literature search for a proposed project indicates that an unevaluated site occurs, the operator has the option of relocating the project or assessing the site to determine significance. If portions of a site do not contribute to significance, the project could be located on that portion.

Table 4-12 (continued) Eligible and National Register Sites in the Proposed Action Area

EL*	Site No.	Site Name	Site Type
E	48CA0061	Bison Kill	prehistoric bison bone bed
K	48CA0089	Wagensen	prehistoric stone circles, camp, bone bed
C	48CA0131	MAC Key	prehistoric stone circles
E	48CA0258	SP 1	prehistoric lithic scatter, possible camp
E	48CA0270	Bonepile Rifle Pits	historic fight (Sawyer Expedition)
C	48CA0271	Sawyer Wagon Fight	prehistoric lithic scatter
C	48CA0271	Sawyer Wagon Fight	historic fight, exploration
E	48CA0289	CM-5 Homestead	historic homestead
E	48CA0331		prehistoric lithic scatter, possible camp
E	48CA0439	CB 1	prehistoric lithic scatter, possible camp
E	48CA0472	CM 7 (SHPHRDR)	prehistoric artifact scatter, historic camp
E	48CA0477	CM 13(CRRL)	historic corral
E	48CA0503	Meadowlark Farm	historic farm
E	48CA0505	Czapla Ranch	historic ranch
E	48CA0522	1980P-5	prehistoric lithic scatter, possible camp
E	48CA0541	Locality 2	prehistoric lithic scatter, possible camp

E	48CA0553	80P-6	prehistoric lithic scatter, possible camp
C	48CA0557		prehistoric artifacts and features
C	48CA0564	80P-52,53,55	prehistoric lithic scatter, possible camp
C	48CA0582	80P-24	prehistoric artifacts and features
E	48CA0858	SH-16-2	prehistoric lithic scatter, possible camp
E	48CA0860	SH-16-4	prehistoric stone circles
E	48CA0868	SH-16-12	prehistoric lithic scatter, possible camp
E	48CA0874	SH-16-18	historic
E	48CA1166	81P1	prehistoric stone circles
E	48CA1272	Moyer Homestead	historic homestead
E	48CA1297	RR-12	prehistoric lithic scatter, possible camp
E	48CA1312	5041-2	prehistoric open camp, habitation
C	48CA1329	MZ 503	prehistoric stone circles
C	48CA1342	MZ 516	prehistoric lithic scatter, possible camp
C	48CA1366	MZ 540	prehistoric lithic scatter, possible camp
E	48CA1431	6018-3	prehistoric lithic scatter, possible camp
C	48CA1439	MZ 96	prehistoric open camp, habitation
C	48CA1582	6084-1(DGT,RTCL,PRVY)	historic dugout
C	48CA1617	ETSI-OWSA-7-CERAMI CS	prehistoric artifacts and features

C	48CA1840	6220-19	prehistoric artifacts and features
C	48CA1842	6220-21	prehistoric artifacts and features
C	48CA1845	6220-24	historic ranch
C	48CA1848	6220-27	prehistoric artifacts and features
C	48CA1855	6220-34	prehistoric artifacts and features
E	48CA1860	6220-38	prehistoric artifacts and features
E	48CA1861	6220-40	prehistoric mixed artifact scatter
E	48CA1868	Bill Schmidt Place	historic ranch
C	48CA1881	Hung Antelope	historic homestead
C	48CA1882	Oscar Dunlap Ranch	historic ranch
C	48CA1903	Morgan Homestead	historic homestead
C	48CA1906		prehistoric lithic scatter
E	48CA1925	577-B	prehistoric lithic scatter
E	48CA1949	L/T 11-83-3	prehistoric mixed artifact scatter
E	48CA1951	L/T 11-83-5	prehistoric artifacts and features
E	48CA1959	L/T 11-83-13	prehistoric artifacts and features
C	48CA1987		prehistoric artifacts and features
E	48CA2081	1154	prehistoric artifacts and features
C	48CA2104	84-101-2	prehistoric lithic scatter
E	48CA2118	NB-4	prehistoric lithic scatter

E	48CA2119	NB-5	prehistoric lithic scatter
E	48CA2121	NB-7	prehistoric artifacts and features
E	48CA2122	NB-8	prehistoric lithic scatter
C	48CA2135	PAA 282-ARCHAIC	prehistoric artifacts and features
C	48CA2173	1557-OFF SURV-BURIED	prehistoric features
C	48CA2196	LTA9-85-A-5	prehistoric lithic scatter
E	48CA2257	Bridge WYO 387	historic bridge
E	48CA2258	Bridge Hay Crk	historic bridge
E	48CA2259	Bridge Hay Crk	historic bridge
C	48CA2289	2016-193	prehistoric artifacts and features
C	48CA2340	2111-3 OS	prehistoric artifacts and features
E	48CA2477	Bridge DWK Porcupine Crk	historic bridge
C	48CA2479	2565-1	prehistoric features
C	48CA2506	2676-4	prehistoric lithic scatter
C	48CA2507	2676-5	prehistoric artifacts and features
C	48CA2514	2676-18	prehistoric lithic scatter
C	48CA2515	2676-19	prehistoric lithic scatter
C	48CA2518	2676-22	historic ranch
C	48CA2518	2676-22	prehistoric lithic scatter
C	48CA2519	2676-23	historic ranch
C	48CA2519	2676-23	prehistoric artifacts and features
C	48CA252	2676-30	historic urban

	0	Turnercrest	lodging
E	48CA2694	MA611-2	historic bridge
C	48CA2760	WY-7-93 #1	historic ranch
C	48CA2762	WY-7-93 #3	prehistoric artifacts and features
E	48CA2892	G1-95/J3	prehistoric artifacts and features
E	48CA2902	FA94-194-1	prehistoric artifacts and features
E	48CA2907	FA94-194-6	prehistoric artifacts and features
E	48CA2987	FA95-74-15	prehistoric lithic scatter
E	48CA2987	FA95-74-15	historic
E	48CA3030	G2	prehistoric artifacts and features
E	48CA3067	D2	prehistoric artifacts and features
E	48CA3092	PAS-98-109-1	prehistoric artifacts and features
R	48CO0165	Bozeman Trail Spring D	historic trail
K	48CO0412	AP 1	prehistoric open camp, habitation
K	48CO0413	AP 2	prehistoric lithic scatter, possible camp
K	48CO0418	AP 7	prehistoric lithic scatter, possible camp
E	48CO0419	AP 8	prehistoric open camp, habitation
K	48CO0423	AP 12	prehistoric open camp, habitation
K	48CO0425	AP 14	prehistoric open camp, habitation
K	48CO0426	AP 15 (HMSTD)	prehistoric open camp, habitation
K	48CO042	AP 17	prehistoric open

	8		camp, habitation
K	48CO0431	AP 20	prehistoric lithic scatter, possible camp
K	48CO0433	AP 22	prehistoric lithic scatter, possible camp
K	48CO0440	AP 31	prehistoric lithic scatter, possible camp
K	48CO0441	AP 33	prehistoric open camp, habitation
K	48CO0442	AP 28	prehistoric lithic source
K	48CO0445	AP 34	prehistoric lithic scatter, possible camp
K	48CO0446	AP 35	prehistoric open camp, habitation
K	48CO0449	AP 38	prehistoric open camp, habitation
K	48CO0450	AP 39	prehistoric open camp, habitation
K	48CO0452	AP 41	prehistoric open camp, habitation
K	48CO0455	AP 45	prehistoric lithic scatter, possible camp
K	48CO0457	AP 47	prehistoric open camp, habitation
K	48CO0480	AP 50	prehistoric open camp, habitation
K	48CO0481	AP 52	prehistoric open camp, habitation
K	48CO0482	AP 54	prehistoric open camp, habitation
K	48CO0486	AP 69	prehistoric open camp, habitation
K	48CO0493	AP 83	prehistoric open camp, habitation
K	48CO0494	AP 85	prehistoric lithic scatter, possible camp
K	48CO0495	AP 87	prehistoric lithic scatter, possible camp
K	48CO0500	AP 97 (HMSTD)	historic homestead
K	48CO051	AP 68	prehistoric

	3		hearths
K	48CO0514	AP 70	prehistoric hearths
K	48CO0515	AP 111	prehistoric open camp, habitation
K	48CO0516	AP 113	prehistoric open camp, habitation
E	48CO0517	AP 115	prehistoric open camp, habitation
E	48CO0711	81-10-1	prehistoric open camp, habitation
E	48CO0730	2477-1	prehistoric multi-component site
E	48CO0762	2631-2	prehistoric lithic scatter, possible camp
E	48CO0929	PAA-70	prehistoric artifacts and features
C	48CO1043	Off survey	prehistoric artifacts and features
C	48CO1172	1392-1	prehistoric artifacts and features
C	48CO1174	1392-3	prehistoric features
C	48CO1176	1392-5 shed, graves	historic ranching, graves
C	48CO1176	1392-5	prehistoric artifacts and features

* EL abbreviations:
C - Concurrence of SHPO and a lead federal agency that the site is eligible for the NRHP.
E - Recommended eligible for the NRHP by a qualified professional.
K - Officially Determined Eligible by the Keeper of the NRHP.
R - Listed on the NRHP. Alternative 1

Alternative 1 is an expanded area encompassing the project area under the Proposed Action and an additional 1,200 square miles. Most of the additional area is north and west of the Proposed Action project area. (Alternative 1 will involve the drilling and operation of 2,000 more productive wells and related facilities than the Proposed Action.) An additional 335 cultural resource sites, 13 of which are recommended eligible or listed on the NRHP (**Table 4-13**), have been identified in the expanded project area under Alternative 1. The proportion of previously inventoried area in the entire Alternative 1 project area is roughly the same as for the Proposed Action. Similarly, final well locations have not been identified. Each location will be assessed and reviewed during the APD approval process.

Table 4-13 Additional Eligible and National Register Sites in

the Alternate 1 Area

EL*	Site No.	Site Name	Site Type
E	48CA0302	Ruby Site	prehistoric bison kill
E	48CA0964	MR-4 Shed	prehistoric lithic scatter, possible camp
E	48CA1165	2545-1 Homestead	historic homestead
C	48CA2157	Off survey - inscriptions-grave	historic inscription and grave
E	48CA2405	LOC 1 OS2229	prehistoric artifacts and features
E	48CA1871		prehistoric artifacts and features; hearths/FCR
C	48CA2082	288-718-52 Christensen	historic homestead - ranching
C	48CA2154	1413-117	prehistoric features; hearths/FCR
E	48CA2156	288-11 Barn & Pens	historic - ranching
C	48CA2192	288-133	prehistoric lithic scatter
C	48CA2195	LTA9-85-3998	prehistoric artifacts and features; hearths/FCR
E	48CA2284	1996-165	prehistoric artifacts and features; hearths/FCR
E	48CA2318	2014-189	prehistoric lithic scatter; chipping/knapping station
C	48JO0923	Jim Cole Homestead	historic homestead - ranching
K	48JO1129	Bridge EEN Schoonover	historic bridge - transportation
C	48JO1431	AEC90-42	prehistoric artifacts and features; ceramics
E	48JO1480	AEC93-30	prehistoric artifacts and features; hearths/FCR
E	48SH0258	Chicago-Burlington-Quincy Railroad	historic railroad - transportation

*EL abbreviations:

C - Concurrence of SHPO and a lead federal agency that the site is eligible for the NRHP.
E - Recommended eligible for the NRHP by a qualified professional.
K - Officially Determined Eligible by the Keeper of the NRHP.
R - Listed on the NRHP.

Based on current information direct impact to significant cultural properties cannot be precisely identified. Like the Proposed Action, the likelihood that additional significant cultural properties will be found in the area of potential effect of the proposed wells and related facilities is high. Given the assumption of 8.5 sites per square mile and the estimate earlier in this chapter of 26,491 acres of potential direct disturbance, approximately 352 cultural resource sites may be impacted by Alternative 1, and 42 of those are likely to be significant and require avoidance or mitigation measures. All areas of proposed ground disturbance and traffic will be inventoried for the presence of cultural resources at the APD phase, and all discovered cultural resources will be evaluated for eligibility to the NRHP. Specific plans for avoidance or data recovery will be recommended for any significant sites within the area of potential effect of the proposed activities. In addition, specific procedures will be established for the treatment of unanticipated discoveries and unmarked human remains that are not identified by surface cultural resource inventory.

No Action

Development, consisting of the drilling, completion, and operation of as many as 2,000 additional wells and associated facilities, would proceed on private and state mineral leases. The majority of currently known and documented cultural sites have been recorded by federally mandated investigations on federal surface. Using the same assumptions as those used above for the potential density of sites under the Proposed Action and Alternative 1, and the projection that the area of disturbance under the No Action Alternative would be approximately 11,881 acres, about 155 cultural sites would be impacted by the No Action Alternative. It is likely that about 18 significant cultural properties will be impacted by the individual well developments under the No Action Alternative, but these will not be federal undertakings under the jurisdiction of the Department of the Interior and would not require mitigation. Some proportion of the linear facilities (access roads, pipelines, and power lines) associated with these wells are likely to cross federal surface and would be considered federal undertakings subject to federal guidelines and regulations protecting cultural resources. These actions would be subject to the same requirements for cultural resource inventory, evaluation, and treatment as the federal wells and associated facilities that would be developed under Proposed Action and Alternative 1.

LAND USE AND TRANSPORTATION

Potential impacts to land uses and transportation from CBM field development would result from curtailed or constrained activities or productivity within the project area, from limited or prohibited access that removes land from existing uses, or from surface disturbance necessary for proposed CBM facilities. The Proposed Action and Alternative 1 would be consistent with the BLM RMP and the FS LRMP, which provide for multiple land uses. These alternatives also would be consistent with county planning efforts.

Proposed Action

Land Use

Surface ownership in the project area consists of BLM and FS-administered federal lands (8.5 percent), private lands, and state lands. Land ownership is not expected to change due to implementation of any alternative. Easements will be negotiated with land owners, or secured through the permitting processes of appropriate federal, state and local agencies. Of the proposed 3,000 productive wells, an estimated half or 1,500 wells and ancillary facilities would be located on lands where CBM is owned by the federal government, even though only 8.5 percent of the surface is managed by the federal government, as stated above.

Grazing and crop production are the dominant land uses that likely could be affected under the Proposed Action. Excess unmanaged CBM produced waters discharged upstream could result in localized flooding or permanent subirrigation that could cause access or culvert problems, impacts to hay and other crop yields or number of cuttings, siltation or breaching of existing stock reservoirs, ponds, irrigation ditches or other agricultural structures, erosion or productivity loss of fragile soils, or a decrease in available forage or carrying capacity for livestock, if mitigation of these downstream impacts is not adequately addressed in water management plans (**Appendix B**).

Coal mining could be affected in some areas. Impacts on coal mining are described earlier in this chapter under geology and mineral resources. Other land uses, including oil and gas production and clinker quarrying, are not likely to be affected. An increased demand for clinker used as surfacing material is likely to exist during the initial CBM development period.

Impacts to water wells in the vicinity of CBM development may occur. These wells may experience lowered yields, a loss in productivity, or seepage of methane, creating potentially explosive conditions. Adequate ventilation of well coverings would reduce the risk of methane becoming concentrated in these enclosed areas. Methane migration and seepage are described earlier in this chapter under geology and mineral resources. A water well agreement (**Appendix D**) has been developed to address mitigation of impacts to nearby, properly permitted water wells.

Scattered subdivisions near Gillette are located within the project area. If CBM development activities are proposed in the vicinity of these residences, site-specific mitigating measures will be developed to minimize the impacts of CBM development and resolve conflicts with existing uses.

Short-term disturbance during drilling and construction of production and pipeline facilities will vary in duration from a few days to a few months in any area. This disturbance may be repeated a number of times during the life of the project as additional operators conduct operations within the same sections. An estimated 16,751 acres or about 1.1 percent of the project area may be affected by operations. Not all of this area will undergo surface disturbance. Subsequent to drilling and construction of production facilities and pipelines, areas not needed for production will be reclaimed and revegetated, facilitating a return to existing uses. Over the project life, uneconomic and depleted wells will be plugged and abandoned, and the disturbance reclaimed and revegetated to approximate pre-project conditions. Only portions of the long-term disturbance area required for production and maintenance (6,514 acres, estimated) will be removed from existing uses during the life of the project.

During the construction phase of the project, under any alternative, existing land uses will be temporarily disrupted as properties are entered by construction crews in order to assemble and install facilities. Residents of the area will be impacted by the sights and sounds of construction. Public access to many parts of the project area is very limited by private landownership. Local access will be disrupted temporarily at some locations during development activities. Short-term disruption of existing uses during construction will consist of the physical intrusion of the crew and equipment, the generation of dust and noise, and the obstruction of traffic.

Long-term to permanent effects on land use in the project area will result from the installation and operation of the proposed facilities over the estimated 20 year life of the project. Existing land uses may be displaced by some project facilities over the lifetime of the project under the Proposed Action. The acreage removed from existing land uses by project facilities will be very small in relation to the area available for these uses in adjacent areas of public lands (up to 6,514 acres of disturbance, or 0.4 percent of the project area, estimated).

Land use within the proposed disturbance areas will shift to CBM extraction for the life of the project, but is not likely to exclude existing uses anywhere except at production pods and compression facilities. These locations would be the only areas where other uses would be fenced out. Areas surrounding active operations will continue to serve existing land uses during project operations. Reclamation and final closure of the proposed operations will re-establish the land uses of grazing and wildlife habitat in the disturbance areas.

Maintenance of each well and other facilities will occur over the life of the facility, or approximately 12 to 20 years. Maintenance activities will consist of periodic disturbances of noise, dust, and traffic, and possibly restricted access to properties located adjacent to wells and other facilities. The frequency of well service visits may range between weekly and monthly. Production pods likely will be visited daily. Access to properties adjacent to production pods or compression facilities may be restricted by fencing around these CBM facilities. Access to adjacent properties can be re-routed to minimize any impacts or inconvenience to landowners or the public.

Grazing and wildlife habitat in rangelands are the primary existing land uses in the project area that could be disturbed by the proposed facilities. During the life of the project, up to an estimated 6,514 acres are expected to be removed from existing rangeland in the project area by proposed CBM facilities. No facilities will be located within urban land uses in Gillette or Wright, however facilities may be located adjacent to or within the unincorporated multi-acre housing developments within the county. Croplands and recreational uses (mostly hunting) are minor uses of the project area, and will experience minor impacts from the project.

Short-term impacts to grazing will consist of the disturbance of livestock and wildlife during the construction phase. Long-term impacts to grazing as a result of project development will be the removal of a small amount of available forage from the following areas: each productive well location; improved roads to production pods; production pods; and compression facilities. Long-term disturbance will occur only over the life of the project, and is expected to be reclaimed at the conclusion of the project. Most of the acreage affected by short-term disturbances will be returned to forage production within one to three years, as disturbed areas are revegetated.

CBM produced waters would be available to landowners for subsequent beneficial uses (**Appendix B**). These waters may not be suitable for irrigation, but likely would provide some beneficial impacts to grazing. Produced water from CBM operations will aid in distributing livestock and wildlife, providing more temperate water in both winter and summer, and enhancing vegetation diversity and productivity near discharge points and along drainages. The enhanced water and livestock distribution may allow more even use of available forage. Irrigation use of the produced waters may be limited due to erosive and alkaline soils that occur in the region.

At the conclusion of the project, wells beneficial for livestock or wildlife use, and roads or other facilities useful to land owners could be developed permanently as private or public facilities. Roads and facilities no longer needed will be removed and the affected area will be rehabilitated.

This project is expected to last 12 to 20 years. After that time, the facilities, (including wells) will either be turned over to the surface owner or removed and the area rehabilitated. The only facilities remaining will be those beneficial to surface owners or the public.

Transportation

The development of CBM within the project area will require two-track roads over natural terrain to access well sites and facilities, and the construction of additional roads to access some facilities. The roads will supplement state, county, BLM and private road systems already in place. Existing roads and two-track access routes will be improved only as necessary. Wherever feasible, each access road will be constructed in a transportation corridor that will also include gas and water pipelines, and electrical cables.

There will be traffic associated with moving equipment and personnel over public highways and local roads during CBM development under the Proposed Action. Impacts on the existing transportation system and traffic levels in the affected counties would vary between initial development (5 to 10 years) and long-term operations (10 to 20 years). Project-related personnel requirements decrease from 477 during initial development to 286 during long-term operations (**Table 4-14**). Project-related traffic would be expected to decrease correspondingly, by an estimated 40 percent, after the initial development period.

Project-related traffic levels would be attributed to drilling (30 percent), construction (25 percent), and operations (45 percent) during the initial development period. During long-term operations, drilling and construction combined would require 20 percent of the project-related personnel, and operations would require 80 percent of the project-related personnel.

Traffic levels and impacts resulting from construction-related activities are expected to be short-term, lasting from a few days to a few months in any area. Traffic on roads crossed by any of the proposed pipelines or power lines will experience relatively minor delays during construction,

Table 4-14
Proposed Project Employees

Job Description	Proposed Action Estimate Number of Employees		Alternative 1 Estimate Number of Employees	
	Initial Development	Long Term	Initial Development	Long Term
Drilling Rig (3 employees per rig)	75	12	150	24
Geological supervision	8	4	16	8
Production (1 per 100 wells)	30	30	50	50
Foreman	12	8	24	16
Superintendents	6	4	12	8
Pipeline/ Compressors				
2 operators per station	108	108	108	108
1 operator per 4 booster compressors	58	58	58	58
Meter Technicians	6	12	10	20
Maintenance	2	8	4	14
Construction/Maintenance				
Heavy equipment operators	60	12	120	24
Laborers	40	8	80	16
Supervisor	10	2	20	4
Cementing Services (3 employees per truck)	18	6	30	9
Wireline/Logging (1 employee per truck)	12	4	20	7
Archaeological (2 employees per truck)	12	2	20	4
Surveyor (2 employees per crew)	8	2	14	4
Clerical	12	6	20	10
Total	477	286	756	384

caused by lane closures. The remaining lanes will be capable of handling the expected traffic levels. The addition of an estimated 110 vehicles for construction and maintenance operations during the initial development period, dispersed throughout the 2,400 square miles contained in the project area, would not result in a large increase in traffic on state and local roads.

Trucks will be used to transport drilling rigs, water, earthmoving equipment and personnel to each drill site during the life of the project. After the initial development period, drilling activities will continue at a greatly reduced rate. Drill sites would be dispersed throughout the 2,400 square miles contained in the project area. The addition of an estimated 130 vehicles for drilling operations during the initial development period, dispersed throughout the project area, would not result in a large increase in traffic on state and local roads.

Traffic levels and impacts resulting from CBM production operations will consist of the daily travel of employees involved in the operations, metering, and maintenance of production pods, pipelines, and compression facilities. The addition of an estimated 220 vehicles for production operations during the life of the project, dispersed throughout the 2,400 square miles contained in the project area, would not result in a large increase in traffic on state and local roads.

Project-related traffic would not conflict with existing traffic or existing uses of roads. There will be an increase in the traffic levels on primary access routes. The increase in traffic levels occurring at any one time is expected to fall within the capacity of the roads. Project-related traffic over the life of the project may be noticeable, at times, on local highways during limited periods when drilling, construction, and production operations are occurring concurrently within the same general area.

The impacts to the transportation networks in the project area are expected to be minor due to the low levels of employment needed for the project. This applies to the construction, operation, and abandonment phases of the project.

For the purposes of this analysis, the following assumptions were made for all alternatives regarding future coal train traffic from the project area in the eastern PRB, recognizing that current coal contracts are likely to change between 1996 and 2015. Existing railroad lines to the west, east, and south would each carry approximately one-third of the reasonably foreseeable increase in coal train traffic.

Alternative 1
Alternative 1 includes all of the environmental effects as described for the Proposed Action, but differs from the Proposed Action in the number of wells to be developed, the number of proposed project employees, the size of the expanded project area, and the acreage of land to be disturbed short-term and long-term, or removed from existing uses.

An estimated 26,491 acres or about 1.2 percent of the expanded project area may be affected by operations. Not all of this area that may be affected will undergo surface disturbance. Subsequent to drilling and construction of production facilities and pipelines, areas not needed for production will be reclaimed and revegetated, facilitating a return to existing uses. Only portions of the long-term, disturbance area required for production and maintenance (10,788 acres, estimated) will be removed from existing uses during the life of the project (**Table 2-2**).

Long-term to permanent effects on land use in the expanded project area will result from the installation and operation of the proposed facilities over the 20 year life of the project. Existing land uses will be displaced by project facilities over the lifetime of the project under any action alternative. The acreage removed from existing land uses by project facilities will be very small in relation to the area available for these uses in adjacent areas of public lands (10,788 acres, or 0.5 percent of the expanded project area, estimated).

The estimated area that may be affected by disturbance related to drilling and construction or installation of production facilities or pipelines under Alternative 1 is 26,491 acres, or about 1.2 percent of the expanded project area of 2.3 million acres. The surface disturbance areas for each type of facility are described in Chapter 2. Over the project life, uneconomic and depleted wells will be plugged and abandoned, and the disturbance reclaimed and revegetated to approximate pre-project conditions.

During the life of the project, up to an estimated 10,788 acres are expected to be removed from existing rangeland in the expanded project area by proposed CBM facilities. Other impacts to existing land uses are expected to be the same as those described for the Proposed Action.

Under Alternative 1, impacts on the existing transportation system and traffic levels in the affected counties would vary between initial development (3 to 5 years) and long-term operations (10 to 20 years). Project-related personnel requirements decrease from 756 during initial development to 384 during long-term operations (**Table 4-14**). Project related traffic would be expected to decrease correspondingly, by an estimated 50 percent, after the initial development period.

An estimated 220 vehicles would be added to the expanded project area for construction and maintenance operations during an initial development period of 3 to 5 years. An estimated 260 vehicles would be added to the expanded project area for drilling operations during the same period. An estimated 260 vehicles would be added for production operations and would continue to be used during the life of the project. The project related traffic associated with these additional vehicles would be dispersed throughout the 3,600 square miles contained in the expanded project area, and would not result in a large increase in traffic on state and local roads.

No Action
Under the No Action Alternative, approximately 2,000 productive wells would be drilled on private and state-owned mineral lands. This would result in impacts to land use and transportation similar to those described for the Proposed Action. An estimated 11,881 acres (or about 0.8 percent of the project area) may be affected by CBM operations. Short-term disturbances to land use and transportation may affect 4,377 acres. Long-term disturbance to land use and transportation may affect 7,528 acres.

RECREATION
Direct impacts to recreation occur when recreation opportunities are enhanced, limited or curtailed within an area, or when recreation uses are created, displaced, or eliminated by proposed CBM facilities or if federal, state or county objectives for recreation cannot be met. Impacts to recreation resources occur if recreation facilities undergo substantial change or degradation.

Proposed Action
Recreational access to most of the project area is limited, as most of the surface in the project area is privately owned. Opportunities for dispersed recreation exist on federal and state lands, but little use is known to occur. No developed recreational sites are located within the project area. The nearest developed recreation sites are located in Gillette. Recreation activities displaced by project facilities are likely to add increased use on adjacent public lands.

Dispersed recreational opportunities in the affected counties include hunting, fishing, sightseeing, and camping. Dispersed recreation is not a primary use of public or private lands within the project area. There is expected to be little change in existing levels of dispersed recreation activities on public lands surrounding the project area as a result of CBM development under the Proposed Action. Existing levels of recreation activity are expected to continue on these lands.

Hunting is the principal recreation activity on public and private lands in the project area. According to observations supporting the conclusions drawn from the environmental analysis of the Marquiss and Lighthouse Field EAs (USDI BLM, 1992a and 1995c), no significant negative impacts to hunting in the project area were anticipated, since wildlife populations were not likely to be reduced.

The acreage removed from wildlife habitat by project facilities under the Proposed Action (an estimated 6,514 acres or 0.4 percent of the project area) is not likely to adversely affect hunting and fishing opportunities within the project area. Recreational hunting and fishing opportunities, which are controlled by landowners on private lands, may increase locally within the project area, as populations of game animals and game fish rise locally during the life of the project, in response to increased availability of surface water and forage. However, increased access and human activity associated with CBM development may adversely affect wildlife populations which support various recreational activities. This can be seen in the decline of raptor and grouse populations.

The development of roads and well facilities will result in greater physical access to the project area. However, a majority of this access will be not be available to the public, since much of the surface within the project area is privately owned.

Pipeline installation along existing road rights-of-way is likely to inconvenience recreational visitors to the project area who may use affected roads to gain access to recreational opportunities. Construction activities also may limit recreational use of roads and trails temporarily, as well as degrade the visual quality of the recreation experience. Road and trail access is likely to be restored to existing uses within a few days to a few months, once construction or installation activities have been completed.

Construction-related noise could reduce the overall quality of the recreational experience. However, construction-related increases will be short-term and, generally restricted to the immediate vicinity of the work. Audible noise from the operation of proposed facilities is discussed in the noise impact section of this chapter.

The operators have stated they will work with landowners in the project area to enhance the use of the good quality, discharged water. This practice may promote the impoundment of discharged water and use for wetlands and/or fisheries development. Given the potential quality of discharged water associated with the project, it is reasonable to conclude that enhanced vegetation and increased water availability probably will have beneficial effects on fish and wildlife and their habitats, and may enhance recreational opportunities in the immediate vicinity of any reservoirs created. This will continue until water production ceases.

Indirect impacts to recreation would occur if the proposed project resulted in a change in the level of visitation to the area, or if the project will affect growth in the affected counties, thereby changing the utilization of existing recreation facilities and uses. The proposed project is not expected to affect the level of visitation or growth in the counties.

Alternative 1

Alternative 1 includes all of the environmental effects as described for the Proposed Action, but differs from the Proposed Action in the number of wells to be developed, the acres of land to be disturbed temporarily or removed from existing uses during the life of the project, and the volume of water to be produced from CBM wells. The impacts to existing recreational uses are expected to be the same for this expanded project area as those described for the Proposed Action.

No Action

The No Action Alternative includes all of the environmental effects as described for the Proposed Action, but differs from the Proposed Action in the number of wells to be developed, the acres of land to be disturbed temporarily or removed from existing uses during the life of the project, and the volume of water to be produced from CBM wells. Although fewer wells, the impacts to existing recreational uses are expected to be the same as those described for the Proposed Action.

VISUAL RESOURCES

Impacts to visual resources occur from disturbance of the landscape by project activities and the addition to the landscape of proposed facilities including the wellhead facilities, production pods, and gas compression facilities and associated pipelines and access roads. Impacts to visual resources are measured by the amount of change or degradation to the character of the landscape as seen from sensitive viewpoints, or by whether the management objectives of applicable VRM classifications cannot be met.

Short-term impacts to the visual character of the landscape can result from construction of small temporary pits on drill sites, well drilling, and associated construction of ancillary facilities such as access roads, pipelines, production pods, and gas compression facilities. Each two-track well access road would connect with local roads that provide access into the project area. All gathering lines, water lines, high pressure gas lines and underground electrical cables would be located along road rights-of-way wherever feasible, and would likely result in visual impacts that exceed the impacts of the access roads alone.

In the event that the installation of underground electrical distribution lines is not practical, aboveground distribution lines most likely will be installed adjacent to transportation corridors. The pole structures would introduce straight, vertical lines and color contrasts. The impacts from the introduction of these elements into the landscape can be noticeable when viewed from sensitive viewpoints, when structures are visible in scenic landscapes, and when structures are skylined.

Proposed Action

Drill site preparation, drilling, and well completion activities would be accomplished using drilling rigs, water trucks, backhoes, graders, or dozers and well servicing equipment. During a period of several days to a week, these activities would detract from the visual quality of the landscape at each drill location. The visual intrusion of these activities would be site specific and would not be likely to affect visitors outside the viewshed of each drill site within the project area.

Construction activities would be evident to people using roads within the project area. Users of the area would be impacted by the sight and the dust of construction activities. In addition, the transport of equipment and materials to the project area would be evident to other travelers on local highways which will be used to access the site.

Long-term impacts over the life of the project would result from the addition of the wells to the landscape, and the disturbance of lands utilized for associated facilities such as gathering lines, well service roads, and access roads. The most visible components of the proposed facilities are expected to be wellhead facilities at each productive well, production pod facilities, improved roads to production pods, and gas compression facilities located at centralized sites within the project area. CBM development is not expected to change the visual character of the existing rural landscape within the project area, which currently includes considerable modification from other oil and gas activities, and from coal mining.

Visual Resource Management
Most of the wells on BLM lands within the project area would likely be located on BLM VRM Class IV lands. The construction and operation of each well and the ancillary facilities will be consistent with VRM Class IV objectives, provided that every attempt is made to minimize the adverse visual impacts through careful location of facilities, minimal disturbance of the site, and design of facilities so that they harmonize with the surrounding landscape. Consequently, none of the disturbed acreage would be displaced from the existing BLM inventory of lands managed with VRM Class IV. The proposed facility developments would be consistent with management objectives.

VRM Class II and III areas have been mapped along Interstate 90, State Route 14, and State Route 50, however any proposed facilities along the highways would be located on private lands and would not be managed in accordance with BLM's visual resource directives. BLM lands in the Fortification Creek Wilderness Study Area (west-central part of project area) and Indian Butte (southwest project area) are mapped as VRM Class III areas. The proposed facilities contrast with the basic landscape elements, but remain subordinate to the existing landscape character, which includes existing oil and gas developments. Consequently, none of the disturbed acreage would be displaced from the existing BLM inventory of lands managed as VRM Class III. Proposed facility developments would be consistent with management objectives.

All proposed facilities would be consistent with BLM management objectives for VRM Class V areas, which provide for areas where the natural character has been drastically altered.

All proposed wells and facilities under the Proposed Action would be consistent with FS visual quality objectives for the Thunder Basin National Grassland. Adverse visual impacts would be minimized through careful location of facilities, minimal disturbance of affected sites, and design of facilities so that they harmonize with the surrounding landscape.

Changes in the visual character of the landscape due to the proposed activities are likely to be similar to impacts from existing oil and gas field developments in the project area. The impacts from some facilities will be lessened by using procedures different from conventional oil or gas field development. Use of two-track and existing roads and centralization of gas compression facilities along existing roads will minimize the visual impact of the road network. The use of buried power lines to each well, where feasible, will reduce the linear element in the landscape.

The proposed CBM development in the project area, including associated facilities such as roads and pipelines, will not result in a noticeable change to the existing scenic integrity of the area. This development is part of the ongoing CBM development of the region.

Long term visual impacts will be minimized by designing permanent structures to harmonize with the surrounding landscape to the extent feasible, recontouring and revegetating disturbed areas no longer needed for operations as soon as practicable, and by reshaping straight edges of clearings resulting from roads, pipelines, well pads, and compression facilities to create irregular or indistinct edges. Construction debris will be removed immediately, as it creates undesirable textural contrasts with the landscape. In addition, resource protection measures proposed for erosion control, road construction, rehabilitation and revegetation, and wildlife protection will be implemented during the approval of APDs and Sundry Notices. These measures also would mitigate impacts to visual quality.

Alternative 1

Alternative 1 includes all of the environmental effects as described for the Proposed Action, but differs from the Proposed Action in the number of wells to be developed, the acres of land to be disturbed temporarily or removed from existing uses during the life of the project, and the volume of water to be produced from CBM wells. The impacts to the characteristic landscape within this expanded project area are expected to be the same as those described for the Proposed Action.

No Action

The No Action Alternative includes all of the environmental effects described for the Proposed Action, but differs from the Proposed Action in the number of wells to be developed, the acres of land to be disturbed temporarily or removed from existing uses during the life of the project, and the volume of water to be produced from CBM wells. The impacts to the characteristic landscape within the project area are expected to be the same as those described for the Proposed Action.

NOISE

Proposed Action and Alternative 1

The USEPA (USEPA, 1974) has established an average 24-hour noise level of 55 dBA as the maximum noise level that does not adversely affect public health and welfare. No definitive data has been established concerning noise levels that affect animals. No laws concerning quantitative noise levels have been established by the State of Wyoming or the BLM. Therefore, lacking any quantitative statutory guidelines, noise levels above 55 dBA are considered a noise impact for this analysis.

Noise levels would be temporarily elevated above the general rural background noise of 35 to 40 dBA during construction of facilities. Construction-related noise would result from vehicle traffic and drilling rigs. However, activities at each drill site would occur for only one to five days during the short drilling period. Therefore, well pad construction activities would not cause any significant noise impacts. Construction related noise would last longer for the 30 to 60 days required to construct a compressor site or less for pipeline construction. However, the noise from each site would be relatively short-term and the individual sites would be sufficiently widespread so that the elevated noise levels from each site would not overlap in time or space with another site.

The highest operational noise levels would occur around compressor stations. Noise has been measured at typical pipeline compressor units (USGS, 1981). A noise level of 77 dBA at 50 feet from a compressor station can be expected, since all compressors would be installed in enclosed buildings due to Wyoming weather conditions.

To calculate the noise impact of a compressor, the measured noise level was mathematically propagated using the Inverse Square Law of Noise Propagation (Harris, 1991). Briefly, this formulation states that noise decreases by approximately 6 dBA with every doubling of the distance from the source. This methodology is an accurate assessment of noise propagation and is represented as:

$$L2 = L1 - 20 \log (R2/R1)$$

where:

L2 = noise level at a selected distance R2 from the source

L1 = noise level measured at a distance R1 from the source.

Based upon the calculations, the noise levels around a compressor would be below 55 dBA at an estimated 600 feet from the compressor site. Therefore, compressors should be located at least 600 feet from sensitive receptors (residences, schools, medical facilities, and recreation areas).

No Action

The effects of noise from construction activities and each individual site would be the same as under the Proposed Action. However, less construction activity would occur so construction noise would be less frequent and more widespread.

SOCIOECONOMICS

Proposed Action

Impacts to the socioeconomic structure of Campbell, Converse, Johnson, and Sheridan counties, including population, housing, and employment, resulting from drilling and construction of ancillary facilities such as roads and pipelines are expected to occur over a five to ten year period under the Proposed Action. The socioeconomic impacts resulting from CBM production activities are expected to occur over the proposed life of the project, 12 to 20 years. Most of the production is expected to occur in Campbell County, and most employees are likely to reside in Gillette or Wright. Campbell County is likely to be affected by fiscal and social impacts to a greater extent than Converse, Johnson, and Sheridan counties.

Socioeconomic impacts resulting from CBM development are a major concern because considerable energy-related development has occurred in and around Campbell County during the past 30 years. Wyoming's economy has been structured around the basic industries of extractive minerals, agriculture, tourism, timber, and manufacturing. Many Wyoming communities depend on the mineral industry for much of their economic well being. The 1997 assessed valuation on all minerals produced in Wyoming during 1996 accounted for 54.2 percent of the state's total assessed valuation (WDR, 1999b). The mineral industry is a significant revenue base for both local and state government in Wyoming (WDR, 1997).

There have been several forecasts developed for future coal supply and demand in the PRB. The State of Wyoming's Consensus Revenue Estimating Group (CREG) develops mineral price and production forecasts for major mineral commodities twice each year to estimate the state's anticipated revenues. For 1999, coal production increases by six percent 321.5 million tons. For the year 2000 and beyond, coal production continues to increase, but at a smaller rate of increase. Coal production is expected to total 363.1 million tons in 2004 (WDAI, 1999c). In 2015 the coal supply from Wyoming's PRB mines is expected to be 386.7 million tons, or approximately 32 percent of the total future domestic demand, according to the 1998 Future Total Supply Forecast for the Southern PRB (WY) by Resource Data International (USDI BLM, 1998c).

Between 1998 and 2020, coal prices (from 1998 Data Resources Incorporated prices for the PRB, 8,400 Btu) are forecast to decline to a low of $2.98, and then are expected to climb to $3.23, in constant 1998 dollars (USDI BLM, 1998c). By 2005, annual coal production is projected to generate about $2.6 billion of total economic activity, including $351 million of personal income. Coal production in 2005 is expected to support the equivalent of nearly 15,885 full-time positions (USDI BLM, 1996c).

CBM production under the Proposed Action would be generated by 3,000 productive wells. Each well is expected to produce 125 thousand cubic feet (mcf) per day on average, during the life of the well. Most recently, in January 1999 CREG estimated a natural gas price of $1.75 per mcf during the period 1999 to 2004 (WDAI, 1999c). For the purposes of this analysis, a potential price of $1.75 per mcf over the life of the project is assumed. For the purposes of this analysis CBM wells are expected to produce on the average 0.3 billion cubic feet (bcf) over their 12 to 15 year economic life (Barrett Resources, 1998). Using these estimates, over its productive life, each well would generate an estimated sales value of $525,000 (constant 1998 dollars). Using this estimated sales value per well, under the Proposed Action, CBM production is expected to contribute sales valued at nearly $1.6 billion (constant 1998 dollars) over the life of the project to the local, state, regional, and national economies.

Employment and Personal Income

Oil and gas operations play an important direct and indirect role in the local economy through the wages paid to employees. Wages and salaries paid to CBM project employees contribute to the total personal income of every county where employees reside. Additional personal income would be generated for residents of the counties and the state by circulation and recirculation of dollars paid out as business expenditures, and as state and local taxes.

The impacts of CBM development on local employment are not expected to be large in comparison with the total local workforce. The long-term workforce requirement of 286 employees and the initial development workforce requirement of 477 employees are expected to be met primarily from local or nearby communities. The existing community infrastructure provides the necessary housing and support services for oil and gas developments, which are a primary economic sector in Campbell and Converse Counties.

The proposed project is expected to employ an estimated long-term workforce of 286 people over the 12 to 15 year minimum life of the project. Employment for the five to ten year construction and installation period (initial development period) is estimated at 477 employees. Contract labor, service and support personnel would be used where practical. The workforce estimate assumes drilling with 25 drilling rigs, on average, during the initial development period and with 4 drilling rigs throughout the project life. After the initial development period, rigs would drill replacement wells for those depleted, plugged and abandoned, or for isolated field development.

The primary activities in the initial development phase will be well drilling and completion, and construction of associated facilities. Once the initial development phase is completed, the workforce will be reduced to the long-term workforce of 286 employees for the remainder of the project. Long-term employees would be involved in ongoing production and compression operations, maintenance, well plugging and abandonment, reclamation, and replacement well drilling activities. The projected work categories and estimated number of employees are shown in **Table 4-14.**

The total number of employees represents a direct addition of jobs to the economies of Campbell, Converse, Johnson, and Sheridan counties. However, it is expected that the majority of workers would be hired from the local labor force. In 1996, there were approximately 876 unemployed people in Campbell County 1,147 unemployed people in the other three counties, or 2,023 unemployed people in all (USDC, 1998). In addition, workers with the required skills would enter the labor market as other projects in the mining and energy development sectors of the counties are completed. There likely would be sufficient workers in the local labor force to meet projected employment requirements. The number of long-term project employees required under Proposed Action represents nearly one-third of Campbell County's unemployed workforce and about 14 percent of the total 1996 unemployment in the affected counties.

The addition of 286 long-term jobs to the local economy during the life of the project would result in purchases and expenditures made by project employees within and outside of the affected counties, which would in turn stimulate the creation of 400 additional jobs (as determined by an employment multiplier of 2.4) (Barrett Resources, 1998). Of the 400 additional, indirect jobs (jobs which become available in support industries as a result of project activities), approximately 50 percent or 200 jobs would be created in the affected counties (USDI BLM, 1995b). Long-term jobs would be created for 486 people through direct and indirect employment associated with CBM development in the affected counties (Campbell, Converse, Johnson, and Sheridan). The 286 project jobs and the additional 200 jobs also would contribute personal income to the local economy. Since the vast majority of service and retail trade activity occurs in the Gillette area, it is assumed that most of these support industry jobs would be created in Gillette.

The initial development workforce of 477 employees is inclusive of the 286 long-term employees. Workers employed only for the duration of the initial development period would total 191 employees. These short-term workers would stimulate the creation of an additional 267 support industry jobs. An estimated 134 of the jobs would be created in the affected counties, resulting in a total of 401 short-term workers added to the economies of the counties during the initial development period.

The wages and salaries paid to long-term project employees would contribute an estimated total annual personal income to the local economy of $11,600,000 (in constant, 1998 dollars) using an average annual income of $40,700 (Barrett Resources, 1998). The additional 200 local jobs created by the stimulation of the economy would contribute an additional $8,100,000 per year, totaling $19,700,000 of annual personal income contributed to the affected counties. Over the minimum 12-year life of the project, there would be approximately $236,000,000 (in constant 1998 dollars) contributed to the local economy through long-term employment (Barrett Resources, 1998).

The wages and salaries paid to short-term workers (direct and indirect employees) during the initial development period would contribute an estimated total annual personal income to the local economy of $13,200,000 (in constant, 1998 dollars using an average annual income of $40,700). Over the initial development period there would be an estimated $99,000,000 (constant 1998 dollars) contributed to the local economy through short-term employment.

In 1996 the total annual personal income for Campbell County was approximately $700 million (USDC, 1998). The annual personal income resulting from long-term employment under the Proposed Action ($19,700,000) would be less than three percent of the total annual personal income for Campbell County. During the initial development period the personal income gains under the Proposed Action ($32,900,000) would be less than five percent of the total annual personal income for Campbell County.

Federal Royalty and Production Taxes

Federal royalties would be paid for each well producing from federally owned oil and gas mineral estate. After administrative costs are deducted, half of the royalties would be retained by the federal government, and used for the General Fund and various other funds. The remaining half would be distributed to the State of Wyoming, and used for schools, roads and other public works. For the purpose of this analysis, royalties are estimated as a percentage of the total projected yield from each well multiplied by the market price for the product.

For the purpose of this analysis, federal royalties have been estimated as $65,625 per federal well (using 12.5 percent of the estimated sales value of $525,000 for each well). Of the 3,000 proposed CBM wells, up to 1,500 are expected to be federal wells. The proposed project is expected to generate estimated federal royalties of $98,000,000 (in constant 1998 dollars) over the life of the project. One-half of this total ($49,000,000) would be distributed to the federal government. The remaining half would go to the State of Wyoming based on equivalent royalty rate.

State royalties would be paid for each well producing from state-owned oil and gas mineral estate (an estimated 6.3 percent of 3,000 wells or 190 wells). For the purpose of this analysis, State of Wyoming royalties have been estimated as $65,625 per state well (using 12.5 percent of the estimated sales volume of $525,000 for each well). The proposed project is expected to generate approximately $12,000,000 (in constant 1998 dollars) in state royalties over the life of the project. State royalties are placed in the permanent fund and used for schools and public institutions.

Fee royalties would be paid to the royalty owner(s) of each well producing from the privately- owned mineral estate. The amounts paid as fee royalties are not available to BLM for the purpose of this analysis. State and county governments do not receive royalties generated from private mineral lands, but do collect severance and advalorem taxes, and sales and use taxes (USDI BLM, 1995b).

Sales and Use Taxes

The Proposed Action would contribute to revenues of the State of Wyoming and its counties through sales and use taxes from the purchase and use of tangible goods. The State of Wyoming collects a four percent sales and use tax for each well, and the counties each collect one percent per well, for a total sales and use tax of five percent (Barrett Resources, 1998). State taxes are retained by the state, and are partially distributed to county and municipal governments. County sales and use taxes are distributed primarily to the counties imposing the tax.

Sales and use taxes for oil and gas operations are applied to the following categories of tangible goods and services that are purchased or used during CBM development: 1) coring or sampling; 2) well logging; 3) formation testing; 4) plugging and abandonment; 5) production casing; and 6) well completion. Generally, those services directly related to drilling are not taxable. Well maintenance and repair services are taxable. Purchases of separate lines, tanks, and other units used in the collection, processing, or transportation of oil or gas are taxable.

The taxable value per well is estimated to be $30,000. This figure was calculated by applying an estimated factor of 60 percent (taxable goods and services) to a total well cost of $50,000 (Barrett Resources, 1998). The total well cost consists of drilling, completion and facilities costs. The five percent sales and use tax is estimated to be $1,500 per well (0.05 x $30,000). There are a total of 3,000 wells proposed for the project, which would result in total sales and use taxes of $4,500,000 (constant 1998 dollars, which removes the effect of inflation) paid to the state and the counties over the period of time that taxable goods and services are purchased (life of the project).

Severance taxes on fee wells are calculated at a six percent rate for the State of Wyoming (Barrett Resources, 1998). Based on a sales value of $525,000 per well, the severance tax per fee well over the life of the project is expected to be $31,500. Of the proposed 3,000 CBM wells, an estimated 1,310 wells would be fee wells. The Proposed Action is expected to generate $41,000,000 (constant 1998 dollars) in severance taxes over the life of the project.

County advalorem tax rates (mil levy) for Campbell, Converse, Johnson, and Sheridan Counties vary slightly, but, for the purpose of this analysis are estimated as six percent of the sales value ($525,000) for fee wells (Obernolte, 1999). The total advalorem over the life of the project for the estimated 1,310 fee wells under the Proposed Action is expected to be $41,000,000 (constant 1998 dollars).

The Proposed Action is expected to generate estimated state and county taxes totaling $86,500,000 over the life of the project.

Housing and Community Resources

Minor employment or population changes are anticipated as a direct result of implementation of the Proposed Action. The increase in population will be small relative to the total population. Because most employees are expected to be hired locally, the demand for additional temporary or permanent housing within or near the project area likely can be met with the existing housing supply, depending on the vacancy rates during the period of operations. The majority of available housing units in the project area are located in the communities of Gillette and Wright. Construction-phase workers who migrate into the area may reside in rental units within these communities. The rental vacancy rate for 1994 in the county was two percent, or approximately 45 rental housing units (Gillette Department of Community Development, 1997). There likely will be sufficient existing rental units to house the in-migrant portion of the proposed workforce. Additional rental units may be constructed if the existing supply of vacant rental units becomes exhausted.

There is expected to be no discernible impact on local government or community services from increased population under the Proposed Action. Increased tax revenues collected as a result of CBM development could be utilized to benefit or improve local government or community services.

According to the *Gillette News Record* (USDI BLM, 1995b), proposals by Encoal to build a coal treatment plant and North American Power Group to build the Two Elk power plant could bring about 2,900 construction workers and their families into the Gillette area during construction. This impact would be two to three years long. Gillette, Wright, and the surrounding area likely would have enough resources to handle this influx of people.

Local Economic Impact

Substantial mineral development has been occurring in the local counties (Campbell, Converse, Johnson, and Sheridan) over an extended period of time. The local counties are accustomed to absorbing fluctuations in mineral development activities, which cause cycles of increasing and decreasing demands for workers, housing, and community services. CBM development is not as labor-intensive as coal mining or conventional oil and gas development.

The following discussion summarizes statements and estimates that are documented earlier in this socioeconomics section. During the initial development period (in 2005), CBM development in the PRB would support the equivalent of 811 full-time positions (191 short-term project employees, 134 short-term support industry jobs, 286 long-term project employees, and 200 long-term support industry positions). In contrast, PRB coal production in 2005 will support the equivalent of nearly 15,885 full-time positions. CBM-related employment would total approximately five percent of the employment level represented by coal production.

The demands for qualified local workers and housing may be met by the counties. An influx of new residents (qualified workers, people seeking opportunities) into the local counties could exhaust the available supply of temporary or permanent housing resulting in some construction of new housing units. The number of workers required under the Proposed Action is expected to be too small to affect the employment, population, and personal income trends in the counties, or in the communities of Gillette or Wright.

The estimated economic impact to the local counties over the life of the project from personal income and sales/use taxes would include the following: 1) $236 million (long-term employment); 2) $99 million (short-term employment); and 3) $86.5 million (sales and use taxes). This economic impact would total over $420 million over the life of the project (constant 1998 dollars).

In addition, the State of Wyoming would receive an estimated $49 million in federal royalties and $12 million in state royalties (in constant 1998 dollars) over the life of the project. Some of these monies also would be used to benefit the local counties.

Environmental Justice

This socioeconomic analysis provided a consideration of impacts with regard to disproportionately adverse impacts on minority and/or low-income groups, including Native Americans. No potentially adverse impacts that disproportionately affect Native American tribes or minority and/or low-income groups have been identified. Issues relating to the social, cultural, and economic well-being, and health of minorities and low income groups (environmental justice issues) were evaluated during the analysis of the Proposed Action on socioeconomic resources, surface water and groundwater quality, air quality, hazardous materials, and other elements of the human environment. No environmental justice issues were identified.

Implementing the Proposed Action would have no affects on the social, cultural, and economic well-being, and health of minorities and low income groups. With regard to environmental justice issues affecting Native American tribes or groups, the Wyodak coalbed methane project area contains no tribal lands or Indian communities, and no treaty rights or Indian trust resources are known to exist for this area. There are no communities within the project area that would be likely to be physically impacted by the reasonably foreseeable development of coalbed methane. Gillette and Wright are the communities nearest the proposed CBM development activities.

Alternative 1

Alternative 1 includes all of the socioeconomic analysis of effects described under the Proposed Action, and only differs from that analysis as described here in this section. CBM production under Alternative 1 would be generated by 5,000 productive wells. Each well is expected to produce 125 mcf per day, on average, during the life of the well. For the purposes of this analysis a potential price of $1.75 per mcf over the life of the project is assumed. For the purposes of this analysis CBM wells are expected to produce on the average 0.3 billion cubic feet (bcf) over their 12 to 15 year economic life. Each well would generate an estimated sales value of $525,000 per well (constant 1998 dollars). Under Alternative 1, CBM production is expected to contribute sales valued at $2.6 billion (constant 1998 dollars) over the life of the project to the local, state, regional, and national economies.

Impacts to the socioeconomic structure of Campbell, Converse, Johnson, and Sheridan counties, including population, housing, and employment are similar for the Proposed Action and Alternative 1. Larger revenues can be expected from a larger number of wells and a larger number of employees. Therefore, there will be a larger fiscal impact as a result of the implementation of Alternative 1.

Employment and Personal Income

There would be an additional 2,000 productive wells drilled under Alternative 1, compared to the Proposed Action, for a total of 5,000 productive wells. The number of employees required during initial development and long-term operations under Alternative 1 are shown in **Table 4-14**.

The impacts of CBM development on local employment are not expected to be large in comparison with the total local workforce. The long-term and short-term workforce requirements are expected to be met primarily from local or nearby communities. There are sufficient workers in the local labor force to meet projected employment requirements. The number of workers required for the project is expected to be too small to affect the employment, population and personal income trends in the counties, or in the communities of Gillette and Wright. In addition to direct project employment (e.g. workers or contractors hired for all phases of the project), indirect or secondary employment (jobs which become available in support industries as a result of project activities) would be created as a result of project activities.

The proposed project is expected to employ an estimated long-term workforce of 384 people over the 12 to 15 year minimum life of the project. Employment for the five year construction and installation period (initial development period) is estimated at 756 employees. The workforce estimate assumes drilling 50 drilling rigs, on average, during the initial development period and with eight drilling rigs throughout the project life.

The addition of 384 long-term jobs to the local economy during the life of the project would result in purchases and expenditures made by project employees within and outside of the affected counties, which would in turn stimulate the creation of 538 additional jobs (as determined by an employment multiplier of 2.4) (Barrett Resources, 1998). Of the 538 additional, indirect jobs, approximately 50 percent or 269 jobs would be created in the affected counties. Jobs would be created for 653 people through direct and indirect employment associated with CBM development in the affected counties (Campbell, Converse, Johnson, and Sheridan). The 384 project jobs and the additional 269 jobs also would contribute personal income to the local economy. Since the vast majority of service and retail trade activity occurs in the Gillette area, it is assumed that most of these support industry jobs would be created in Gillette.

The initial development workforce of 756 employees is inclusive of the 384 long-term employees. Workers employed only for the duration of the five-year initial development period would total 372 employees. These short-term workers would stimulate the creation of an additional 521 support industry jobs. An estimated 260 of the jobs would be created in the affected counties, resulting in a total of 632 short-term workers added to the economies of the counties during the initial development period.

The wages and salaries paid to long-term project employees would contribute an estimated total annual personal income to the local economy of $15,600,000 (in constant, 1998 dollars with an average annual income of $40,700). The additional 269 local jobs created by the stimulation of the economy would contribute an additional $10,900,000 per year, totaling $26,500,000 of annual personal income contributed to the affected counties. Over the minimum 12-year life of the project, there would be approximately $318,000,000 (in constant 1998 dollars) contributed to the local economy through long-term employment (Barrett Resources, 1998).

The wages and salaries paid to short-term workers (direct and indirect employees) during the initial development period would contribute an estimated total annual personal income to the local economy of $25,700,000 (in constant, 1998 dollars with an average annual income of $40,700). Over the initial development period there would be an estimated $128,500,000 (in constant 1998 dollars) contributed to the local economy through short-term employment.

The annual personal income resulting from long-term employment under Alternative 1 ($26,500,000) would be less than four percent of the total annual personal income for Campbell County. During the initial development period the personal income gains under Alternative 1 ($52,200,000) would be about 7.5 percent of the total annual personal income for Campbell County.

Federal Royalty and Production Taxes

For the purpose of this analysis, federal royalties have been estimated as $65,625 per federal well. Of the 5,000 proposed wells, approximately 2,500 may be federal wells. The proposed project would generate estimated federal royalties of $164,000,000 (constant 1998 dollars) over the life of the project.

For the purpose of this analysis, State of Wyoming royalties have been estimated as $65,625 per state well over the life of the well. Of the 5,000 proposed CBM wells, an estimated 6.2 percent or 310 wells would be state wells. Alternative 1 is expected to generate approximately $20,000,000 (constant 1998 dollars) in state royalties over the life of the project.

Fee royalties would be paid to the royalty owner(s) of each well producing from the privately-owned mineral estate. The amounts paid as fee royalties are not available to BLM for the purpose of this analysis. State and county governments do not receive royalties generated from private lands but do collect severance and advalorem taxes, and sales and use taxes (USDI BLM, 1995b).

Sales and Use Taxes

The five percent sales and use tax is estimated to be $1,500 per well (0.05 x $30,000). There are a total of 5,000 wells proposed for the project under Alternative 1, which would result in total sales and use taxes of $7,500,000 (constant 1998 dollars) paid to the state and the counties over the period of time that taxable goods and services are purchased (life of the project).

Severance taxes on fee wells are calculated at a six percent rate for the State of Wyoming. Based on the individual well sales value of $525,000 (constant 1998 dollars), the severance tax per fee well over the life of the project is expected to be $31,500. Of the 5,000 proposed CBM wells, an estimated 2,190 wells would be fee wells. Alternative 1 is expected to generate $69,000,0000 (constant 1998 dollars) in severance taxes over the life of the project.

County advalorem taxes are estimated as six percent of the sales value ($525,000) for fee wells. The total advalorem over the life of the project for the estimated 2,190 fee wells is expected to be $69,000,000 (constant 1998 dollars).

Alternative 1 is expected to generate estimated state and county taxes totaling $145,500,000 (in constant 1998 dollars) over the life of the project.

Housing and Community Resources

There would be 756 workers required for the initial development and 384 workers required for long-term operational phases. The additional employees would result in an increase in impacts on housing and community resources additional to those described for the Proposed Action. Increased impacts on housing and community resources may be noticeable during the initial development period, but would not be substantial.

Local Economic Impact

During the initial development period (in 2005), CBM development under Alternative 1 would support the equivalent of 1,285 full-time positions (372 short-term project employees, 260 short-term support industry jobs, 384 long-term project employees, and 269 long-term support industry positions). CBM-related employment under Alternative 1 would total approximately eight percent of the employment level represented by coal production (the equivalent of nearly 15,885 full-time positions).

The estimated economic impact to the local counties over the life of the project from personal income and sales/use taxes would include the following: 1) $318 million (long-term employment); 2) $128.5 million (short-term employment); and 3) $145.5 million (sales and use taxes). This economic impact would total nearly $600 million over the life of the project (constant 1998 dollars).

In addition, the State of Wyoming would receive an estimated $82 million in federal royalties and $20 million in state royalties (in constant 1998 dollars) over the life of the project. Some of these monies also would be used to benefit the local counties.

No Action

The No Action Alternative includes all of the socioeconomic analysis of effects described under the Proposed Action, and only differs from that analysis as described here in this section. CBM production under the No Action Alternative would be generated by approximately 2,000 new productive wells drilled on private and state-owned mineral lands. Using an estimated total sales volume of $525,000 per well (in constant 1998 dollars) over the life of the well, production under the No Action Alternative is expected to contribute CBM sales valued at just over $1 billion (in constant 1998 dollars) over the life of the project to local, state, regional, and national economies. Impacts to the socioeconomic structure of the affected counties would be similar to the Proposed Action, but of a lesser extent. Lesser revenues from fewer wells, and no federal wells, will produce a smaller fiscal impact under the No Action Alternative.

Approximately one-third fewer wells would be drilled under the No Action Alternative compared to the Proposed Action. The personal income gains generated by the No Action Alternative would be approximately one-third less than the Proposed Action.

Employment and Personal Income

The wages and salaries paid to long-term project employees would contribute an estimated total annual personal income to the local economy of $7,700,000 (in constant, 1998 dollars with an average annual income of $40,700). The additional local support industry jobs created by the stimulation of the economy would contribute an additional $5,400,000 per year, totaling $13,000,000 of annual personal income contributed to the affected counties. Over the minimum 12-year life of the project, there would be approximately $157,000,000 (in constant 1998 dollars) contributed to the local economy through long-term employment.

The wages and salaries paid to short-term workers (direct and indirect employees) during the initial development period would contribute an estimated total annual personal income to the local economy of $8,800,000 (in constant, 1998 dollars with an average annual income of $40,700). Over the initial development period there would be an estimated $66,000,000 (in constant 1998 dollars) contributed to the local economy through short-term employment.

The annual personal income resulting from long-term employment under the No Action Alternative ($13,100,000) would be less than two percent of the total annual personal income for Campbell County. During the initial development period the personal income gains under the No Action Alternative ($21,900,000) would be about three percent of the total annual personal income for Campbell County.

Federal Royalty and Production Taxes

The federal royalty is estimated to be $65,625 per federal well over the productive life of the well. Of the 2,000 proposed wells, none are projected to be federal wells unless drainage of federal CBM resources is identified by the BLM. The No Action Alternative is not anticipated to generate federal royalties over the life of the project.

For the purpose of this analysis, State of Wyoming royalties have been estimated as $65,625 per state well over the life of the well. Of the 2,000 proposed CBM wells, approximately ten percent or 200 wells would be state wells. The No Action Alternative is expected to generate approximately $13,000,000 in state royalties over the life of the project.

Fee royalties would be paid to the royalty owner(s) of each well producing from the privately-owned mineral estate. The amounts paid as fee royalties are not available to BLM for the purposed of this analysis. The amounts paid as fee royalties are not available to BLM for the purpose of this analysis. Of the 2,000 proposed CBM wells, approximately 90 percent or 1,800 wells would be fee wells. State and county governments do not receive royalties generated from wells on private mineral lands but do collect severance and advalorem taxes, and sales and use taxes (USDI BLM, 1995b).

Sales and Use Taxes

The five percent sales and use tax is estimated to be $1,500 per well (0.05 x $30,000). A total of 2,000 wells are likely to be drilled on private and state-owned mineral lands under the No Action Alternative, which would result in total sales and use taxes of $3,000,000 paid to the state and the counties over the period of time that taxable goods and services are purchased (life of the project).

Severance taxes are calculated at a six percent rate for the State of Wyoming. Based on the sales value of $525,000 (constant 1998 dollars) per fee well over the life of the project, the severance tax per fee well over the life of the project is expected to be $31,500. Of the proposed 2,000 CBM wells, approximately 90 percent or 1,800 wells would be fee wells. The No Action Alternative is expected to generate approximately $57,000,000 in severance taxes on fee wells over the life of the project.

County advalorem taxes are estimated as six percent of the sales value ($525,000) for fee wells. The total advalorem over the life of the project for the estimated 1,800 fee wells under the No Action Alternative is expected to be approximately $57,000,000 (constant 1998 dollars).

The No Action Alternative is expected to generate state and county taxes totaling $117,000,000 over the life of the project.

Local Economic Impact

The estimated economic impact to the local counties over the life of the project from personal income and sales/use taxes would include the following: 1) $157 million (long-term employment); 2) $66 million (short-term employment); and 3) $117 million (sales and use taxes). This economic impact would total $340 million over the life of the project (constant 1998 dollars).

In addition the State of Wyoming would receive an estimated $13 million (constant 1998 dollars) in state royalties and no federal royalties associated with this project. Some of these monies also would be used to benefit the local counties.

CUMULATIVE IMPACTS

Cumulative impacts result from the incremental impacts of an action added to other past, present, and reasonably foreseeable future actions, regardless of who is responsible for such actions. Cumulative impacts can result from individually minor, but collectively significant, actions occurring over time.

The PRB contains very large reserves of fossil fuels (oil, gas, and coal) and reserves of the mineral uranium. Oil and gas are produced from conventional reservoirs or fields, coal is produced from large surface mines, and gas also is produced from coal beds through groupings of CBM development wells. Uranium has been produced in the past from surface mines and currently is being produced by in-situ leaching at three localities in the PRB.

The BLM analyzed activity levels, production statistics, and surface disturbance in 1995 from all mineral and energy development in the PRB to check previous forecasts and to ensure that the reasonably foreseeable development of coal, conventional oil and gas, and CBM remains within the development scenarios used previously to analyze and predict the environmental effects of these activities. BLM's most recent compilation of statistics is summarized in the following two paragraphs (USDI BLM, 1996c, 1997b, and 1998d).

The cumulative surface disturbance from coal development and production from mines located in Campbell and Converse counties, that are partially within and adjacent to the study area, was reported to WDEQ in 1997 as 46,849 acres (**Table 4-15**). Of this total acreage disturbed by coal mining, 12,805 acres were reported to WDEQ as permanently reseeded. Coal mining disturbs about 2,000 acres annually.

Table 4-15
Coal Production and Disturbance for Mines in the Wyodak Study Area

Mine	1998 Production (million tons)	Currently Permitted Coal Production (million tons)	Reasonably Forseeable Coal Production Rates (2015) (million tons)	Cumulative Disturbance (1997 - 1998) (acres)	Cumulative Permanent Reclamation (1997 - 1998) (acres)
Antelope	19.4	30	25	2,749.50	336.60
Belle Ayr	22.5	25	37	4,496.00	1,285.10
Black Thunder	42.7	55	45	6,684.00	2,584.00
Buckskin	17.3	24	20	1,830.70	431.60
Caballo1	25.9	51	42	4,029.00	987.50
Clovis Point2	0	0	0	694.32	156.70
Coal Creek	7.1	18	15	1,461.00	192.00
Cordero-Rojo3	37.0	60	49	6,884.1	1,627.0
Dry Fork	1.0	15	0	967.68	108.82
Eagle Butte	18.1	35	29	2,395.00	560.50
Fort Union/KFx4	0	9.4	0	367.50	70.19
Jacobs Ranch	29.1	35	29	5,355.40	3,251.80
North Antelope/Rochelle	64.6	65	54	4,860.6	510.6
North Rochelle	<<.01	20	16	446.29	5.70
Rawhide	5.4	24	20	2,539.50	547.40
Wyodak	3.3	10	8	943.05	149.60
TOTAL	**293.45**	**476.4**	**389**	**46,848.94**	**12,805.11**

1The Caballo Mine includes the Caballo and former Rocky Butte leases. The Caballo Mine Operator (Peabody) bought the Rocky Butte leases.
2 Kennecott owns the Caballo Rojo and Cordero Mines, which they refer to as the Cordero-Rojo Complex. There are separate mine permits on each of these mines.
3 Clovis Point Mine has been shut down, the leases are sold to adjacent mines or relinquished, and the facilities are sold.
4 KFx bought part of the Fort Union Mine and facilities to test a coal enhancement process.
5 The 293 million tons of coal produced by mines in the Wyodak study area during 1998 represents an estimated 93 percent of Wyoming's coal production for 1998.
Sources: WDEQ, 1998c; WDOE, 1998c; WGS, 1996b; USDI BLM, 1998d, 1999a, and 1999d; and Greystone, 1999. Coal reclamation bonds are held for a minimum of ten years following permanent seeding of disturbed areas. About 1,850 acres are reclaimed annually (USDI BLM, 1996c). Mining and reclamation rates are expected to increase through the year 2015; the balance between reclamation and mining should remain about

the same. Uranium mining activity has disturbed approximately 4,400 acres. Sand, gravel, and scoria extraction operations have disturbed an estimated 1,200 acres (Barrett Resources, 1998).

In 1994 there were about 3,212 producing oil and gas wells (including CBM wells) located in the vicinity of the project area (Campbell and Converse Counties). An estimated 129 of these producing wells were CBM wells. The cumulative surface disturbance resulting from producing conventional oil and gas wells and facilities is expected to remain relatively constant over the next twenty years, as the acreage from new producing wells remains approximately equal to the acreage reclaimed when wells are plugged and abandoned. In 1994 an estimate of 3 acres per well was used to project existing long-term disturbance for all facilities related to producing conventional oil and gas wells. At that time, an estimate of 2 acres per well was used to project long-term disturbance for all facilities related to productive CBM wells. For this analysis, a per well estimate of long-term disturbance (2.2 acres per CBM well) can be calculated from **Table 2-2**.

Cumulative, long-term disturbance from producing conventional oil and gas wells continues to affect about 1,200 acres, or about one-quarter to one-half acre per producing well (USDI BLM, 1998h). This realistic expression of disturbed areas that remain to be reclaimed includes only production pads and facilities that will be reclaimed when production ends. The road system developed for oil and gas exploration within the study area (which represents a large portion of the 1994 estimate of disturbed areas) has been in place for up to 20 or 30 years in many areas. It will remain to serve the area's transportation needs after oil and gas production ends. None of the disturbed acreage when this transportation network was constructed, is included within the cumulative disturbed acreage for conventional oil and gas operations used in this analysis.

Using the same development assumptions applied in this analysis (**Table 2-2**), CBM development occurring through the end of 1998 may affect up to 5,200 acres by the time all facilities required to support the 890 CBM wells already analyzed by BLM are in place. Long-term disturbance, until production from these 890 wells ends, would affect about 2,000 acres.

CBM development under the Proposed Action (3,000 new wells) may affect 16,751 acres during the life of the project. Long-term disturbance under the Proposed Action, until production ends, would affect an estimated 6,514 acres. Cumulatively, an estimated 22,000 acres may be disturbed by CBM development within the project area (from 890 wells in place as of the end of 1998 and from 3,000 new wells that would be drilled under the Proposed Action). About 8,500 acres would be affected by long-term disturbance (from 890 wells in place as of the end of 1998 and from 3,000 new wells that would be drilled under the Proposed Action), until CBM production ends, (expected to be within 20 years).

Projected CBM development under Alternative 1 (5,000 new wells) would affect 26,491 acres during the life of the project. Long-term disturbance under Alternative 1, until production ends, would affect an estimated 10,788 acres. Cumulatively, an estimated 31,700 acres would be disturbed by CBM development within the expanded project area (from 890 wells in place as of the end of 1998 and from 5,000 new wells that would be drilled under Alternative 1). About 12,800 acres would be affected by long-term disturbance (from 890 wells in place as of the end of 1998 and from 5,000 new wells that would be drilled under Alternative 1), until CBM production ends (expected to be within 20 years).

Projected CBM development under the No Action Alternative (2,000 new wells) would affect 11,881 acres during the life of the project. Long-term disturbance under the No Action Alternative would affect an estimated 4,377 acres. Cumulatively, an estimated 17,100 acres may be disturbed by CBM development within the project area (from 890 wells in place as of the end of 1998 and from 2,000 new wells that would be drilled under the No Action Alternative). About 6,400 acres would be affected by long-term disturbance (from 890 wells in place as of the end of 1998 and from 2,000 new wells that would be drilled under the No Action Alternative), until CBM production ends (expected to be within 20 years).

Conventional oil and gas production generally has decreased in Wyoming's PRB since 1981 (USDI BLM, 1998h). In recent years, more wells have been plugged annually than have been drilled, although acres disturbed vs. acres reclaimed have remained relatively constant. The exception to this trend is the current interest in developing shallow CBM resources just west of the coal mines. Since 1992, the BLM has prepared five EAs and one EIS analyzing CBM development projects in this area. This EIS is being prepared because companies are proposing new CBM projects outside of previously approved areas or additional drilling in existing fields. The proximity of the CBM development to the coal mines creates the potential for overlapping impacts to groundwater and local communities. Only about 50 percent of the CBM rights are federally owned in the area of interest for current development. The remainder of CBM rights are privately- and state-owned. CBM wells are being drilled on privately- and state-owned oil and gas leases after approvals by the WOGCC, WDEQ, and the WSEO. Approval of drilling on federal leases within the project area currently is awaiting completion of this EIS to evaluate the individual and cumulative impacts of proposed CBM development.

In the PRB, the coal reserves currently leased represent a small percentage of the total coal reserves, but a large percentage of those most shallow reserves that are the most economical to recover. Removal of this coal is an irreversible and irretrievable impact. PRB coal was used to generate electricity for the public in 19 states and Canada in 1995. The members of the public in those states benefit from the low utility rates related to the price of coal, from the clean air due to the low sulfur content of the coal, and from the royalties and bonus payments that the federal government receives from the coal. Locally, continued sale of PRB coal helps support and maintain stabile municipal, county, and state economies.

Proposed Action

Geology and Mineral Resources

Mineral and energy resources are non-renewable resources. Although supplies of low-sulfur coal and CBM within the project area are vast, these resources can be exhausted within the eastern PRB as a cumulative effect of continuing production. CBM production under the Proposed Action would represent an irreversible commitment of resources as the methane produced no longer would be available for future use. Natural gas is a non-renewable resource that forms as organic matter decays and undergoes chemical changes over geologic time. Although methane continues to collect very slowly underground, during CBM production it is extracted much more rapidly than it collects. Available supplies of methane within the project area may be depleted at a future date, but will not be depleted by the Proposed Action.

Each level of decision-making by agencies ensures the orderly development of federally owned energy resources. This development results in actions that are incrementally more irreversible as more site-specific analysis occurs. Leasing already has occurred within the project area, and has conveyed to the lessees, assignees, and designated operators the right to explore for, develop, and produce oil and gas resources contained in leaseholdings, during the primary terms and any extensions granted. Leases within the project area have been issued with surface occupancy rights, meaning that drilling and production can be authorized within the leaseholding.

The Proposed Action would allow CBM development within the project area during the next 10 to 20 years. The Proposed Action also would provide a framework for future site-specific environmental analyses needed to authorize specific CBM drilling and production activities. When drilling permits for specific CBM development and production activities are issued at a later date by the BLM or the FS, these authorizations will represent irreversible actions. CBM development and production would be approved and would be likely to occur.

Oil production has been mostly declining in Campbell and Converse Counties, as well as the rest of the state. Gas production has remained relatively stable in the two counties. Actual 1994 oil production for Campbell and Converse Counties was 24,160,000 barrels; conventional gas production for the same period was 46,080,000 mcf; and coal bed methane production for the same period was 2,380,000 mcf (USDI BLM, 1995b).

If all 3,000 new CBM wells proposed under the Proposed Action and all 890 wells in place as of the end of 1998 were producing gas at the average production rate estimated over the life of each well (125 mcf per day per well), at the same time, then cumulative annual CBM production from the PRB could approach 177 bcf (estimated) in 2004. This gas volume would be equivalent to 13 percent of Wyoming's projected 2004 natural gas production of 1.34 trillion cubic feet (WDAI, 1996b).

Wyoming coal production increased from 94.0 million tons in 1980 to an estimated 314.5 million tons in 1998, Wyoming State Inspection of Mines and Gillette News Record 1/10/99, (USDI BLM, 1996c and 1999c). Campbell and Converse counties produce 85 percent to 95 percent of Wyoming coal each year. The increasing state production is primarily due to increasing sales of inexpensive low-sulfur PRB coal to electric utilities who must comply with requirements of the 1990 Clean Air Act Amendments. These electric utilities account for most of Wyoming's coal sales. Increases in demand for electricity probably will result in a continuing demand for federal coal from Wyoming's PRB (USDI BLM, 1996c). **Table 4-15** shows recent coal production from mines within and adjacent to the study area.

The BLM's status check report on coal development in the PRB, (USDI BLM, 1996c), documented actual cumulative mineral development impacts in the PRB from 1980 to 1995 and compared them with the cumulative mineral development impacts predicted in previous regional EISs. In Wyoming, the status check compares actual development in Campbell and Converse Counties with the predictions in the Eastern Powder River Coal Final EIS (USDI BLM, 1979) and the Powder River Coal Final EIS (USDI BLM, 1981). A primary conclusion reached in the status check was that regional coal production levels are within predicted coal production levels, except for the southern group of mines, where production has exceeded predictions. The Wyoming status check also considers predictions that were made in *Cumulative Potential Hydrologic Impacts of Surface Coal Mining in the Eastern Powder River Structural Basin* (USGS, 1988). The status check and recent updates (USDI BLM, 1998d) are incorporated by reference into this analysis.

CBM development would have little effect on topography. However, following surface coal mining and reclamation, topography would be modified in an elongated corridor east of and paralleling Wyoming Highway 59 from just north of Gillette, Wyoming, south for about 75 miles. The topography in the PRB is characterized by relatively flat or rolling topography.

After reclamation, these characteristics would be emphasized in the reclaimed area. Pre-mining features that were more topographically unique (for example, steeper hills and gullies, rock outcrops) typically would be smoothed out. The reduction in topographic diversity may lower the carrying capacity for big game in the reclaimed areas; however, big game ranges typically are very large and mining activities usually are not located in habitats defined as crucial. The overall flattening and lowering of the topography would be likely to result in increased infiltration of surface water and reduced peak flows from drainages within mined areas. These impact of these changes would be minimized by the orientation of drainage systems within the project area. Streams typically flow from west to east across the area rather than from north to south along the entire corridor. Therefore, only a very small part of each stream_s drainage area would be disturbed. **Table 4-15** displays cumulative acres disturbed and acres reclaimed by the mines located within and adjacent to the project area.

Other mineral development levels in Wyoming's PRB currently are less than predicted in the regional EISs. In the 1970s, significant uranium development was anticipated in southwestern Campbell County and northwestern Converse County, but extensive development never occurred because of the reduced price of uranium since the early 1980s. However, there are three active in-situ uranium operations in Converse and Johnson counties, but there are no active uranium mines or mills.

Scoria is quarried by coal mines, the counties, and a few construction firms for use as road surfacing material. Bentonite is mined in parts of Wyoming's PRB, in Johnson County.

Surface Water

Surface water within the project area and watersheds downstream is derived from precipitation, groundwater pumping, discharge at downgradient outcrops, and from waters released from storage reservoirs.

Existing junior water rights holders are expected to have a more reliable source of water. The permitting workload of the WSEO is expected to increase, as beneficial uses of water are filed with the WSEO. Additional filings for the impoundment and beneficial use of CBM generated waters also may occur. These junior rights may be used during the life of the project, as long as there is adequate water for allocation.

The water produced from CBM wells may decrease the amount of dewatering that coal mining companies need to do. This dewatering associated with coal mining was estimated by the USGS in 1990 to be 22.27 million gallons per day (USGS, 1998a). If dewatering associated with mining decreases enough that water consumption needs for mine operations are no longer met by the dewatering, mining companies probably will increase their withdrawals of surface water from present levels (estimated to be 6.22 million gallons per day).

A USGS study published in 1988 predicted that major streams in the PRB would exhibit increased runoff ranging from 0.4 percent in the Cheyenne River to 4.3 percent in Coal Creek due to cumulative disturbance as a result of existing and proposed surface coal mining (USGS, 1988). CBM development was not considered in that analysis, but depending on the level of development, runoff could increase substantially in some of the area's streams. To date, water produced by CBM wells typically has been used for stock or other purposes by the surface landowners in the area of development.

The surface coal mines would have additional surface water to manage through their mines. Culverts carrying water from upstream reaches of overlying watersheds may have to be re-sized. Diversion channels for natural flows may have to be re-sized to handle additional base flows. Mining operations which partially treat water in their siltation reservoirs would have additional water to treat. In these situations, the water quality at the mines' NPDES discharge points may be diminished by commingling CBM discharge waters with those from the surface mines.

In 1990, surface water withdrawals of approximately 29.3 million gallons per day provided for the irrigation of 6,830 acres in the Little Powder River, Belle Fourche, and Powder River drainages during a below average water year (USGS, 1998a). Flood irrigation occurred on 72 percent of the acreage. Not all withdrawals were consumed, and return flows were approximately 68 percent of irrigation withdrawal rates.

Less than two percent of irrigation waters in the project area were obtained by groundwater withdrawals (USGS, 1998a). Groundwater withdrawals for irrigation waters may decrease with greater availability of surface water produced from CBM wells. Groundwater withdrawals of 0.61 million gallons per day for stock watering also may decrease with greater availability of CBM generated surface waters.

The Proposed Action is likely to have the cumulative effect and appearance of providing portions of the project area with limited irrigation over an extended period of time, as soil conditions and discharge water quality permit, with natural drainages used as "irrigation canals" and some shallow impoundments constructed to receive and provide limited storage of CBM generated flows. Some prairie used as open range is likely to change to irrigated pasture or cropland, and then change back to prairie after water production ends. As CBM generated flows are introduced, the transition between prairie and irrigated pasture is likely to be relatively smooth unless high flows affect existing uses, requiring water management plans and site-specific mitigating measures. However, as available surface water diminishes and vegetation with higher water requirements becomes stressed or overgrazed, invader species, including noxious weeds, may be introduced or may increase within the project area.

Stock watering currently accounts for water use totaling 2.2 million gallons per day and is concentrated within the Little Powder River, Belle Fourche River and upper reach of the Powder River (**Table 3-5**). Increases in stock watering would occur with the judicious impoundment of CBM produced waters that are discharged in the headwaters of these drainages. Landowners may choose to start running cattle or increase the size of their herds resulting in greater increases in stock watering within those drainages which currently have little or no livestock use.

Water produced from conventional oil and gas drilling is not discharged directly to surface waters. These waters are treated to meet effluent limitations and must be discharged under permit from WDEQ.

By the end of the project's life, some drainage draws within the project area may be one to several feet deeper than they are today due to stream erosion. Careful selection of discharge points and appropriate armoring of splash pads will prevent or mitigate this impact. However, downvalley, a careful observer may feel that there may be a few more bar or beach deposits within perennial streams or rivers than there are today. Springs that had been flowing more regularly for over a decade, and perhaps have been developed, may develop reduced or irregular flows which approximate present conditions.

Reservoirs downstream of the project area likely will receive more water and could receive more sediment as a consequence of CBM development. Additional water would better support adjudicated water uses downstream of Lake Sakakawea on the Missouri River, Keyhole State Reservoir on the Belle Fourche and Angostura Reservoir on the Cheyenne. CBM produced water would not be significant to Lake Sakakawea (27,920,000 acre-feet), for which the projected discharge at the boundary under the Proposed Action would be an estimated 9,750 acre-feet (ac-ft), but may influence the other two. During the 1996 water year, water storage in Keyhole Reservoir ranged from 106,000 to 153,800 ac-ft, and the historic average volume is 87,000 ac-ft (USDI BOR, 1998). The reservoir has the capability to store 193,800 ac-ft per year. The Proposed Action would add an estimated 31,045 ac-ft per year or 2,587 ac-ft per month maximum. This would not significantly change the approximate 4,000 acre-foot print of the reservoir nor its depth, if managed in a manner which did not result in long-term storage of this water. Angostura Reservoir has a maximum volume of 130,700 ac-ft and averages 112,000 ac-ft. The Proposed Action would add a maximum of 6,182 ac-ft (estimated) per year, or 515 ac-ft per month. This reservoir is managed close to its capacity, and while monthly inflows would not significantly change its surface area and depth, produced waters probably would be passed through the reservoir. Current water management protocols may be revised as discharges from CBM development rise.

Over the life of the project, CBM produced water would amount to an estimated 1,226,916 ac-ft of water, assuming that the wells produce an average of 12 gpm of water throughout a fifteen-year life.

Groundwater

The common, and potentially cumulative impacts to groundwater resources by activities associated with CBM development and those impacts associated with coal mining include withdrawal of water from the coal seam resulting in a loss of head in the coal, and the surface discharge of this produced water. These cumulative impacts are addressed earlier in this chapter, as existing and reasonably foreseeable groundwater conditions were included in the impact assessment for proposed CBM development. Differentiation of impacts between CBM development activities and coal development activities is presented below.

There are some similarities and also significant differences in the impacts associated with mining and CBM development. These include:

<u>Impacts to the Coal Aquifer:</u> Both mining and CBM development result in partial removal of water from the coal seam. Mining actually removes the coal while CBM development leaves the coal essentially undisturbed.

<u>Impacts to Aquifers Stratigraphically above the Coal:</u> The Fort Union and Wasatch Fms are hydrologically separated by low permeability claystones. In mining, the shallower aquifers (the overburden) must be removed to access the coal; therefore, the impacts to these aquifers are significant. In CBM development, these aquifers are essentially undisturbed and impacts are limited. Leakage from the Wasatch sands into the coal may be enhanced by CBM development because water levels in the coal are lowered as a result of partial coal dewatering. Due to the limited hydraulic communication between the coal and the overlying Wasatch sands, a significant period of time (typically several years), will likely pass before significant drawdown effects in the sands are apparent.

<u>Changes in Infiltration Rates and Recharge:</u> In mining, the overburden and coal aquifers are removed and replaced with backfill material. The recharge through the spoils is likely to be higher than the original undisturbed materials. In CBM development, the aquifer remains essentially undisturbed and the recharge mechanism is unchanged.

Changes in Groundwater Quality: After mining, the aquifer (Wyodak coal) is replaced with mine spoils which have the potential to change the quality of the aquifer. In CBM development, water is simply being removed; there are no foreign materials introduced to the system.

Discharge of Produced Waters: Both mining and CBM development result in water collection and discharge to surface streams. Mine inflow water is first stored in sediment ponds to reduce sediment that is picked up in the pit and much of the water is used for dust suppression. The discharge water from sediment ponds is potentially higher in TDS and of lower quality due to sediment mixing and concentration by evaporation. CBM discharge is essentially sediment free, although discharge to creeks can increase sediment loading. Infiltration of discharged water can recharge the alluvial and shallow Wasatch sand aquifers, and potentially influence their water quality.

Subcoal Fort Union Aquifers: Mining may impact subcoal aquifers by influencing recharge water quality. Groundwater withdrawals from lower aquifers for mine use also may impact subcoal aquifers. It is unlikely that CBM development will impact the subcoal aquifers; therefore, there will be no cumulative impact.

The cumulative impact of surface coal mining and other activities (including CBM development) on groundwater emerged as an area of concern during the scoping process and in comments received on coal leasing proposals and the CBM projects. Decreasing the hydraulic head on the coal aquifer would not adversely impact coal production. The decrease in the water level may reduce the availability of pit water for mining operations. CBM development may change the timing of coal extraction but would not affect sustainable development of the resource.

The Land Quality Division (LQD) of the WDEQ is required by the Surface Mining Control and Reclamation Act (SMCRA) and LQD rules and regulations (WDEQ, 1998d) to assess the potential for cumulative hydrologic impacts of current and anticipated mining on the ground and surface water systems each time a mine permit application or a mine permit revision is made.

In 1987, the USGS, in cooperation with the LQD and the Office of Surface Mining, Reclamation and Enforcement (OSM), conducted a study of the hydrology of the eastern PRB. The purpose of the study was to provide the hydrologic information needed to perform these assessments. The resulting document, "Cumulative Potential Hydrologic Impacts of Surface Coal Mining in the Eastern Powder River Structural Basin, Northeastern Wyoming," (CHIA) describes the cumulative effects of all current and anticipated mining (as of 1987) on the hydrologic system (USGS, 1988). At the time, the 1988 CHIA was the most comprehensive basin-wide assessment of the potential hydrologic impacts of surface coal mining in the Wyoming PRB. However, the CHIA did not address the impacts of CBM development, as this was not anticipated at the time.

As a result of a cooperative agreement signed in 1993, BLM, OSM, the University of Wyoming, and the WSEO provided assistance to LQD in updating the CHIA process. A pilot CHIA study was performed in the Little Thunder Drainage Basin (WWRC, 1997). An assessment of groundwater impacts for Lighthouse CBM development in the eastern PRB was performed under an extension of the 1993 agreement, but the results have not yet been published. Information from this work was used in the compilation of this EIS where appropriate. This EIS describes anticipated impacts using the latest available information.

Existing Monitoring Programs

Monitoring programs required by LQD and administered by the mining companies have been established in the eastern PRB. Each mine is required to monitor groundwater levels in the coal itself as well as in shallower aquifers in the area surrounding their operations. There are also requirements for drilling monitoring wells in the backfill areas of the mines in order to record the water level recovery in these areas. In addition to the mine monitoring required by LQD, the WDEQ, WSEO, WOGCC, and the BLM have required water monitoring to be done for different aspects of CBM projects.

The Gillette Area Groundwater Monitoring Organization (GAGMO) is a voluntary group formed in 1980. The purpose of GAGMO is to assemble and report the hydrologic monitoring data being collected by the coal mining companies operating in the eastern PRB of Wyoming, from the Buckskin Mine north of Gillette to the Antelope Mine in northern Converse County. Members of GAGMO include most of the companies with operating or proposed mines in that area, the WDEQ, the WSEO, the BLM, the USGS, and the OSM, which joined in 1991. The Dave Johnston Mine near Glenrock is not a member of GAGMO.

Each year GAGMO contracts with an independent firm to publish the results of the monitoring for that year. In 1996 GAGMO published two reports--an annual report for 1995 and a 15-year report. The 15-year report, prepared by Hydro-Engineering of Casper, summarized the data accumulated during the last 15 years of monitoring in the PRB. According to that report, approximately 600 monitoring wells were operated at 20 operating or proposed coal mines in 1995 (Hydro-Engineering, 1996).

A major groundwater issue is the extent of the loss in hydraulic head in the coal and shallower aquifers in the area surrounding the mines. Most of the monitoring wells included in the GAGMO 15-year report are completed in the coal beds, in the overlying sediments, or in sand channels or interburden between the coal beds. **Figures 4-1 and 4-2**, taken from the GAGMO 15-year report, shows the changes in water levels in the coal seams after 15 years of monitoring (Hydro-Engineering, 1996). **Figure 4-18** shows the area where actual decline in hydraulic head in the coal seam has been greater than 5 feet in 15 years, in comparison with the predicted worst-case five-foot decline derived from groundwater modeling done by the mines. LQD policy, which is required by state law, is to have the mining companies determine the maximum probable extent of the five-foot drawdown line through modeling.

In general, drawdown in the coal does not extend east of the coal mines because the mines are located on or near the coal outcrop line. The actual 15-year, five-foot groundwater drawdown contours have not exceeded worst-case development drawdown predictions for the mines north and east of Gillette or for the mines east and southeast of Reno Junction (which includes the North Rochelle Mine). Drawdowns are reaching the predicted worst-case drawdown levels in the central group of mines, located between Gillette and Wright (**Figure 4-18**). This is because there is an overlap of drawdown impacts from coal mining and CBM development. The projected worst-case drawdown lines shown in **Figure 4-18** are based on projected coal mining only.
Figure 4-18 Comparison Between the 1995 Cumulative Drawdowns and the Mines' Worst-Case Drawdown and the USGS Predicted Cumulative Drawdowns in the Coal Aquifer This page intentionally left blank
Similarly, the actual five-foot drawdown levels are well within the cumulative drawdown levels predicted by the CHIA for the mines north and south of Gillette (USGS, 1988). However, actual drawdown levels have reached the CHIA's predicted cumulative drawdown level in the group of mines between Gillette and Wright because of overlapping CBM and coal mining impacts. The 1988 CHIA predicted the approximate area of five feet or more water level decline in the Wyodak coal aquifer that would result from "all anticipated coal mining." "All anticipated coal mining", as referred to in the 1988 CHIA, includes 16 surface coal mines operating at the time the report was prepared and six additional mines proposed at that time. All of the currently producing mines were considered in the CHIA analysis (USGS, 1988). CBM development was not anticipated at the time that analysis was prepared. The 1988 CHIA concluded that water supply wells completed in the coal may be affected as far away as eight miles from mine pits as a result of the anticipated coal mining, but the effects at that distance were assumed to be minimal.

The additional groundwater impacts that would be expected as a result of the Wyodak CBM development would be additive in nature and would extend the area experiencing a loss in hydraulic head to the west of the coal mining area. The area between the CBM fields and the mines would be subjected to the cumulative impacts of these two distinct activities. The overlapping drawdown impacts of the two activities is additive. The 15-year GAGMO report points out that there already appears to be an area of overlapping impacts between the Marquiss and Lighthouse CBM projects and the Caballo, Belle Ayr, Caballo Rojo, and Cordero mines (**Figure 4-18**). The groundwater flow model developed for the Wyodak CBM Project EIS, and previously described, accounts for impacts due to both mining and CBM development.

The differentiation of drawdown effects from coal mining and CBM operations also was simulated using the computer model. This was done by performing a simulation of mining effects alone, and then performing a separate simulation with the superimposed stresses of the CBM operations. The difference in projected drawdown in the coal may be attributed to the CBM operations.

The result of this differentiation is presented in the form of drawdown difference maps and hydrographs from selected locations showing the results of the two simulations. The drawdown attributed to CBM operations is shown for the year 2015, the anticipated maximum drawdown year for CBM operations (**Figures 4-19 and 4-20**).

The maximum areal extent of drawdown, defined as a drawdown of at least five feet, ranges to the west about 12 to 22 miles from the centers of CBM development. Comparison of drawdown extent due to CBM operations alone with that of combined CBM development and mining for the same year, (**Figures 4-5 and 4-6**), shows that CBM withdrawals are primarily responsible for drawdowns to the west of the major CBM developments. For the Upper Wyodak coal, the maximum predicted drawdown due to CBM operations only is about 375 feet in the northern portion of the project area; it is about 550 feet in the central portion of the project area; and it is about 300 feet in the southern portion of the project area.

Proposed Monitoring Program
A proposed groundwater monitoring program has been outlined in Chapter 2 "Proposed Action and Alternatives". Specific locations for new monitoring wells are suggested. The modeling results confirm that most of the drawdown associated with CBM development will be concentrated in the area of dense CBM development. Drawdown in excess of 50 feet, which has the potential to impact water well yields and methane generation, extends up to 15 miles from areas of concentrated development. Monitoring wells should be located on the periphery of these development areas. Initially monitoring wells should be located within the area where drawdown in excess of 50 feet is projected. Actual monitoring data will confirm the projections and will allow refinement of the model as development proceeds. Additional monitoring wells may be required farther from the development areas if drawdown exceeds projections.

Air Quality
A cumulative impact analysis was performed to determine the impacts on air quality from the Wyodak CBM Project and other reasonably foreseeable actions. The results of the following analyses are described in this section: near-range analysis using the ISCST3 dispersion model; far-range analysis using the CALMET/CALPUFF model; and cumulative impact analyses for air quality and Air Quality Related Values (AQRVs).

The cumulative impact analysis for air quality assumed that background data measured at Gillette are representative of pollutant sources that are occurring presently. Sources not listed in the emissions inventory are assumed to be part of the monitored background. Reasonably foreseeable incremental increases for background sources are represented in the emissions inventory.

Near-Range Cumulative Emission Inventory
The near-range cumulative impact emissions inventory included the following:

1) All Wyodak proposed compressor engines (**Table 2-1**);

2) All stationary point sources* that began operation after April 1997;

3) All stationary point sources* permitted and reasonably expected to begin operation after April 1997;
Figure 4-19 Maximum Modeled Drawdown 1975 - 2015, Proposed Action-CBM Only, Upper Wyodak Coal This page intentionally left blank Figure 4-20 Maximum Modeled Drawdown 1975 - 2015, Proposed Action, CBM Only, Lower Wyodak Coal This page intentionally left blank 4) Potential incremental increase in surface coal mining emissions based upon a comparison between NOx emissions estimated from 1997 coal production and the level of NOx emissions to be expected if the mines attain their reasonably foreseeable coal production

in 2015; and

5) Potential incremental increase in train locomotive NOx emissions based upon the difference between train traffic levels to transport coal produced in 1997 and the projected train traffic to transport the reasonably foreseeable coal production in 2015.

* All stationary sources in northeast Wyoming, southeast Montana, western South Dakota, and northwestern Nebraska.

Table 4-16 shows the relative amount of annual NOx emissions that would occur from each group of sources considered in the near-range cumulative analysis.

Table 4-16
Cumulative NOx Emissions for Near-Range Air Quality Analysis

Source	Emissions after April 1997 (tons/year)	Percent of Total
Wyodak Proposed Compressors	2,806	13.2
Other Point Sources	7,400	34.8
Coal Mines Increase	6,449	30.2
Coal Trains Increase	4,637	21.8
Total	**21,292**	**100.0**

Far-Range Cumulative Emissions Inventory
The Wyodak proposed project emissions, along with the WDEQ-approved non-project emissions inventory used for the Class I and sensitive Class II air quality, regional haze, and acid deposition (AQRV) analyses, included the following sources of NOx, SO2, and PM10. Although NOx would be the significant pollutant from the proposed Wyodak compressor engines, the PM10 and SO2 emissions also were included in the analysis because of the contribution these pollutants make to potential visual degradation and acidic deposition. The far-range cumulative impact emissions inventory included the following:

1. All Wyodak proposed compressor engines (NOx);

2. Vehicle exhaust from proposed Wyodak project vehicles (NOx);

3. Road dust generated by proposed Wyodak project vehicles (PM10);

4. Fugitive dust emissions from Wyodak project disturbed areas not yet revegetated and not covered by facilities (PM10);

5. All stationary sources that began operation after 1995 or later (NOx, PM10, and SO2);

6. All stationary point sources permitted and reasonably expected to be operating after 1995 (NOx, PM10, and SO2);

7. Potential incremental increase in surface coal mining NOx emissions from blasting, vehicles, and train traffic at the mine areas, based upon a comparison between NOx emissions resulting from 1995 coal production and the level of NOx emissions that would be expected in 2015 if the mines attain their reasonably foreseeable coal production (NOx);

8. Potential incremental increase in surface coal mining PM10 emissions, based upon a comparison between PM10 fugitive emissions resulting from 1995 coal production and the level of PM10 fugitive emissions that would be expected in 2015 if the mines attain their reasonably foreseeable coal production (PM10);

9. Potential incremental increase in mining vehicle exhaust emissions, based upon a ratio of NOx vehicular emissions to SO2 vehicular emissions and a comparison between NOx emissions based on 1995 coal production and the level of NOx emissions that would be expected in 2015 if the mines attain their reasonably foreseeable coal production; and

10. Potential incremental increase in train locomotive NOx emissions, based upon the difference between train traffic levels that transported coal produced in 1995 and the projected train traffic levels needed to transport reasonably foreseeable coal production in 2015.

Table 4-17 shows the relative amount of annual NOx, SO2, and PM10 emissions that would occur from each group of sources considered in the far-range cumulative analysis.

Near-Range Cumulative Air Quality Impacts
The maximum NO2 concentration from all near-range cumulative sources would be 49 g/m3, when added to the NO2 background concentration in the region. As shown on **Figure 4-21**, the largest impacts in the analysis area are emissions from the coal mines, proposed coal-fired power plants to the east of the expanded project area, and along railroads. The majority of the impacts in the areas just east of the Wyodak CBM Project boundary result from tailpipe emissions from large diesel-fueled trucks hauling coal. High concentrations of NOx also would occur along the railroad lines. However, the EPA has mandated a 46 percent (approximately) reduction in locomotive NOx emissions by the year 2007. Therefore, this analysis represents the maximum impacts from locomotive emissions that are predicted to occur without the EPA-mandated NOx emission reductions in order to disclose potential impacts. The results are summarized in **Table 4-18**.

Table 4-17
Cumulative Pollutant Emissions for Far-Range Air Quality/AQRV Analysis

Source	**Emissions after 1995 (tons/year)**			**Percent of Total**		
	NOx	**SO2**	**PM10**	**NOx**	**SO2**	**PM10**
Wyodak Sources						
Proposed Compressors	2,806			5.8	0.0	0.0
Road Dust from Vehicle Traffic			11,22 4	0.0	0.0	65.0
Fugitive Dust from Disturbed Areas			956	0.0	0.0	5.5
Project Vehicle Exhaust	18			0.0	0.0	0.0
Non-Project Sources						
Other Point Sources	7,662	5,03 2	917	15.8	90.1	5.3
Coal Mines Incremental Increase (blasting, vehicle exhaust, trains on site)	6,940			14.3	0.0	0.0
Coal Mines Incremental Increase of Fugitive Dust			4184	0.0	0.0	24.2

Coal Mines Incremental Increase from Mining Vehicles		551		0.0	9.9	0.0
Coal Trains Incremental Increase	31,003			64.0	0.0	0.0
Total	48,429	5,583	17,281	100	100	100

Table 4-18 Wyodak NO2 Cumulative Near-Range Air Quality Impacts

	NAAQS (g /m3)	**Maximum Modeled Concentration (g/m3)**	**Percent of Standard**	**Maximum Modeled Concentration (g/m3 with Background (16.5 g/m3)**	**Percent of Standard with Background**
All Sources	100	32.5	32.5	49	49
Proposed Action Sources	100	9	9	25.5	25.5

Far-Range Air Quality Impacts

Figure 4-21 NO2 Air Quality Impacts - Cumulative Effects Based on emission source inventories for both the proposed Wyodak CBM Project and other regional non-project sources, maximum 3-hour, 24-hour, and annual SO2 impacts, the 24-hour and annual PM10 and annual NO2 impacts were modeled and compared with the Prevention of Significant Deterioration Class I increments at the Class I areas and the National Ambient Air Quality Standards at each sensitive Class II area. It is important to note that this is not a complete PSD increment analysis and the references to PSD increments and NAAQS are only to determine potential impacts and are not intended as an air quality regulatory determination. Air quality standards are the most stringent at Class I areas (National Parks and large designated wildernesses) to afford the most protection for these pristine areas. The results of the air quality analysis for each area are provided in **Table 4-19**. The table includes the modeled concentrations due to cumulative impacts (proposed project plus other non-project sources). For comparison, the impacts from the Wyodak CBM Project alone are also shown. **Table 4-19** demonstrates that no air quality standards would be exceeded by the total cumulative emissions.

Regional Haze Impacts

Regional haze impacts were based on the proposed Wyodak CBM Project emissions (modeled concentrations of NOx and PM10) and non-project related sources within the CALPUFF modeling domain (including projected NOx emission increases from coal trains, and NOx, SO2, and PM10 from coal mines). Extinction coefficients were computed and their effect on visibility assessed.

The impacts to regional haze at all the locations evaluated in this analysis would be significant when evaluating all the cumulative pollutant sources. However, the contribution of sources from the Wyodak CBM Project only would be minor when compared to the other cumulative sources. Regional haze at Class I and sensitive Class II areas would be predicted to adversely affect visibility at all areas. Visibility at Class I areas would be reduced by more than five percent (greater than 0.5 deciview), ranging from 136 days per year at Wind Cave National Park to 116 days per year at Badlands National Park. Visibility at the sensitive Class II areas would be reduced by more than five percent (greater than 0.5 deciview), ranging from 121 days per year at Devils Tower National Monument to 53 days per year at Cloud Peak Wilderness. For comparison, the Wyodak CBM Project would contribute two to four days to the regional haze impairment at Class I areas and one to five days at sensitive Class II areas. **Table 4-20** summarizes the results.

AQRV Impact (Acid Deposition)
In addition to evaluating potential impacts to visibility in Class I and sensitive Class II areas, an assessment of potential impacts to other AQRVs in these areas was performed. The AQRVs of concern for the Class I and sensitive Class II areas include soil, water, flora, and fauna. For impacts to AQRVs, other than visibility, acid deposition of nitrates and sulfates is of primary interest due to its effects on lake acidification, as well as possibly affecting flora and fauna.

The AQRV impact analysis for the Wyodak CBM Project evaluated potential impacts to AQRVs by computing the amount of nitrogen and sulfur that would be deposited on land masses within the Class I and II areas. Additionally, the potential effects of acid deposition on Florence Lake (a sensitive lake located within Cloud Peak Wilderness, Wyoming) were also evaluated at the request of the FS. Nitrogen would originate from wet and dry deposition of nitrates and nitric acid, as well as dry deposition of NOx. Sulfur would originate from wet and dry deposition of sulfates and SO2.

Table 4-19 Results of Air Quality Impact Analysis (g/m3)

Area	**Annual NO2**	**24-h r PM1 0**	**Annual PM10**	**3-hr SO2**	**24-h r SO2**	**Annual SO2**
	CUMULATIVE IMPACTS					
Northern Cheyenne Reservation, MT	0.59	0.32	0.02	1.12	0.27	0.01
Badlands National Park, SD	0.16	0.21	0.02	1.94	0.46	0.04
Wind Cave National Park, SD	0.40	0.52	0.05	2.03	0.74	0.06
Class I PSD Increment	**2.5**	**4**	**8**	**25**	**5**	**2**
Black Elk Wilderness, SD	0.17	0.97	0.04	2.46	0.71	0.06
Jewel Cave National Monument, SD	0.30	4.09	0.07	3.88	0.84	0.08
Mt. Rushmore National Monument, SD	0.15	3.13	0.04	1.89	0.53	0.05
Cloud Peak Wilderness, WY	0.07	0.85	0.04	1.04	0.30	0.01
Devils Tower National Monument, WY	0.35	0.77	0.15	2.79	0.49	0.06
National Ambient	**100**	**150**	**50**	**1300**	**365**	**80**

Air Quality Standard						
	PROJECT ONLY IMPACTS					
Northern Cheyenne Reservation, MT	0.01	0.19	0.02	NA	NA	NA
Badlands National Park, SD	0.005	0.08	0.01	NA	NA	NA
Wind Cave National Park, SD	0.01	0.47	0.03	NA	NA	NA
Class I PSD Increment	**2.5**	**4**	**8**	NA	NA	NA
Black Elk Wilderness, SD	0.01	0.42	0.03	NA	NA	NA
Jewel Cave National Monument, SD	0.01	2.35	0.04	NA	NA	NA
Mt. Rushmore National Monument, SD	0.01	1.90	0.02	NA	NA	NA
Cloud Peak Wilderness, WY	0.001	0.72	0.03	NA	NA	NA
Devils Tower National Monument, WY	0.02	0.54	0.11	NA	NA	NA
National Ambient Air Quality Standard	**100**	**150**	**50**	NA	NA	NA

Notes:Project-related sulfur dioxide concentrations were not calculated since these sources only emit NOx and PM10. Florence Lake is situated within the Cloud Peak Wilderness and is not listed separately here.

Table 4-20
Predicted Annual Days of Visibility Reductions At Class I and Class II Sensitive Areas from Wyodak CBM Project and Cumulative Sources

		All Cumulative Sources		**Wyodak Project**	
Location	**Type of Airshed**	**Number of Days deciview change >0.5**	**Number of Days deciview change >1.0**	**Number of Days deciview change >0.5**	**Number of Days deciview change >1.0**
Northern Cheyenne Reservation	Class I	134	74	2	1
Badlands National Park	Class I	116	78	4	0
Wind Cave National Park	Class I	136	89	3	0
Black Elk Wilderness	Class II	98	52	2	0
Jewel Cave, NM	Class II	112	64	1	0
Mt. Rushmore, NM	Class II	92	47	1	0

Cloud Peak Wilderness	Class II	53	26	1	0
Devils Tower National Monument	Class II	121	70	5	0

Note:Florence Lake is situated within the Cloud Peak Wilderness and is not listed separately here.

Table 4-21
Predicted Levels of Acid Deposition from Cumulative Sources and Wyodak CBM Project
(lb/acre/year)

Area	Significance Level	Total Nitrogen Deposition	Total Sulfur Deposition
Northern Cheyenne Reservation	2.7 - 4.5	0.13	0.009
Badlands National Park	2.7 - 4.5	0.04	0.02
Wind Cave National Park	2.7 - 4.5	0.13	0.04
Black Elk Wilderness	2.7 - 4.5	0.09	0.04
Jewel Cave National Monument	2.7 - 4.5	0.14	0.06
Mt. Rushmore National Monument	2.7 - 4.5	0.08	0.04
Cloud Peak Wilderness	2.7 - 4.5	0.03	0.008
Devils Tower National Monument	2.7 - 4.5	0.13	0.04

To evaluate potential impacts to AQRVs, the wet and dry deposition of the nitrogen and sulfur- containing chemicals listed above were computed using the CALPUFF model. Annual fluxes (mass per unit area) calculated for the Class I and sensitive Class II areas were compared to the limits of acceptable change (2.7 to 4.5 lb/acre/year) for evaluating effects on soil, flora, and fauna. The acid deposition calculations used in this analysis followed the procedures outlined in the IWAQM Phase 2 Report (USEPA, 1998) and FS guidance (USDA FS, 1999).

To evaluate the impacts to aquatic systems (Florence Lake) from acid deposition, the loss of Acidification Neutralization Capacity (ANC), in micro-equivalents per liter (eq/l), and change in pH were computed using FS methods (USFS, 1987). Since the baseline ANC at Florence Lake is 37.6 eq/l (USDA FS, 1999), the limit of acceptable change in the ANC is 10 percent.

The results of the AQRV analysis for effects from acid deposition are summarized in **Table 4-21**. The maximum annual deposition fluxes of nitrogen and sulfur due to cumulative, non-project, and proposed project emissions are shown for each Class I and II area. As the data shows, the highest nitrogen deposition would be 0.14 lb/acre/year, a value that is only five percent of the lower limit of acceptable change.

Table 4-22 shows the results of the ANC calculations for Florence Lake. The results show that the expected changes in ANC due to cumulative impacts, non-project impacts, and proposed project impacts are considerably lower than the limit of acceptable change of 10 percent.

Table 4-22
Acidification Neutralization Capacity (ANC)

Analysis for Florence Lake, WY

	Change in ANC from Baseline (%)
Cumulative Sources	0.26
Non-project Sources	0.24
Project Sources	0.02
USFS LAC	10

Note:Florence Lake baseline ANC = 37.6 eq/l.

Soils

The existing 890 CBM wells, access roads, and ancillary facilities within the project area as of the end of 1998 have disturbed up to an estimated 5,200 acres of soils. The long-term soil disturbance associated with these 890 wells is approximately 2,000 acres. The cumulative impact of this existing long-term disturbance associated with CBM development added to potential long-term disturbance of 6,514 acres under the Proposed Action amounts to approximately 8,500 acres of long-term soil disturbance anticipated due to CBM development.

Disturbed soil conditions resulting from mineral development projects occurring within and adjacent to the project area contribute to the cumulative impacts to soils in the PRB. Cumulative existing surface disturbance (not yet permanently reseeded) consists of the following (USDI BLM, 1997a and 1998d): 1) coal mining, approximately 34,000 acres (**Table 4-15**); 2) uranium mining activity, approximately 4,400 acres; 3) sand, gravel, and scoria mining operations, approximately 1,200 acres (Barrett Resources, 1998); and 4) CBM wells, approximately 2,000 acres (890 wells x 2.2 acres per well, this analysis, **Table 2-2**). Disturbed soil conditions presently total nearly 42,000 acres within and adjacent to the project area.

This existing cumulative impact to soils would be increased under the Proposed Action by the additional disturbances related to CBM development and additional disturbances related to other mineral resource projects. In 20 years, when CBM development ends, there may be 50,000 acres within the study area that would have been affected by long-term disturbances related to coal mining, conventional oil and gas development, uranium mining activity, sand, gravel and scoria operations, and CBM development. Reclamation of this acreage may be just underway or may not yet have begun. These disturbed areas could increase runoff and accelerate erosion until reclamation is completed, unless best management practices are used to control erosion and limit soil loss from disturbed areas during construction and initial reclamation activities.

Vegetation Resources

Most of the land that is being disturbed by ongoing CBM development or would be disturbed under the Proposed Action is grassland, sagebrush shrubland, or rough breaks used for grazing and wildlife habitat. Rangeland is, by far, the predominant land use in the PRB, comprising 92 percent of the land in Campbell and Converse counties.

Portions of the project area have been and continue to be disturbed by past and ongoing CBM development, coal mining and other mining activities, and conventional oil and gas development. In 20 years, when CBM development ends there may be 50,000 acres within the project area that have been affected by long-term disturbances to revegetation resources related to coal mining and other mining activities, cumulative oil and gas development, and CBM development. Reclamation of this acreage may be just underway or may not yet have begun. These 50,000 acres (estimated by this analysis) would have little or no vegetative productivity until reclamation occurred.

Areas disturbed by coal mining would not be likely to be recovered sufficiently for reclamation bond release until about ten years after reclamation is begun. Short-term disturbances during CBM or conventional oil and gas development, associated with drilling or installation of facilities, followed by reclamation, likely would last three years or less. Long-term disturbances during CBM development, continuing during the life of the project and followed by reclamation, likely would last ten to twenty years in all. Long-term disturbances associated with conventional oil and gas development or other mineral development activities, followed by reclamation, may last 15 to 25 years.

During the life of the project, the abundance, species composition, and diversity of vegetative species found near discharge points or water bodies formed to hold discharged water would change noticeably. First, as discharge occurs and more surface water becomes available, species with higher water requirements would appear and gradually would increase in abundance. Streamside (riparian) vegetation would increase along drainages where discharge is occurring. Existing wetlands may increase in areal extent, and new wetlands may develop. Then, as discharge declines and less surface water is available to support plant growth, species adapted to growing in riparian areas, or in wetlands under wet, oxygen-starved conditions, would become stressed and eventually would disappear. Water-loving vegetation within wetlands created or enlarged by CBM generated flows would be replaced by plant species adapted to dryland growing conditions when these flows cease. The areal extent of wetlands would revert to pre-CBM development conditions.

Undesirable species, including noxious weeds, may invade these former discharge areas as they dry out or may invade other areas disturbed by CBM development, unless timely site reclamation occurs. Sites influenced by the continued evaporation of somewhat saline discharge waters may be difficult to revegetate unless analyzed carefully to evaluate their chemical and physical characteristics, and to identify any soil amendments or site-specific reclamation techniques that should be incorporated within reclamation plans. Actions that may be necessary to achieve or enhance growth of desirable plant species include the following reclamation techniques: mechanical loosening or roughening of the soil where compacted; fertilization or soil amendment; seeding to proper depths with desirable species; mulching to retain soil moisture; transplanting containerized plants to speed the establishment of slow-growing species; control of noxious weeds; or temporary fencing to exclude livestock until vegetation is successfully re-established.

Vegetative manipulations within the project area associated with ranching operations have included the removal or reduction of grassland-shrubland plant communities, and replacement with cultivated crops or a general reduction of shrubs (mainly big sagebrush) in favor of grass species. Reclamation of surface disturbance related to coal mining, oil and gas development, and CBM development also has reduced shrub density. Shrubs are relatively unproductive for livestock, but are very important for wildlife and are an important component of big game winter range.

Potential long-term cumulative impacts from coal and other mining activities, oil and gas development, and CBM development include reduced plant species diversity, particularly big sagebrush, on some reclaimed lands. Reclaimed areas would be dominated initially by grassland vegetation that is less diverse than undisturbed areas. Within about ten years following reclamation, a diverse, productive, and permanent vegetative cover would likely be re-established on disturbed areas. Reclaimed vegetative communities may never completely match the surrounding native plant community in species composition or diversity. Site productivity for grasses and forbs would return to presently existing levels with timely and well planned reclamation, but productivity for shrub and tree (woody) species would likely be lower for many years following reclamation. The ecosystem functions presently served by the existing vegetative community may not be served as well, or at all, by the reclaimed vegetative community, especially initially, when the density of woody species would be most reduced.

Wetlands

The decrease in areal extent of wetlands that would occur when discharge ends would affect wildlife species that had been attracted to these areas during the life of the project. As the affected areas dry out, wildlife populations likely would no longer frequent them.

The cumulative impacts of CBM development on wetlands, under the Proposed Action, would be dependent upon the extent to which discharge waters are gathered in reservoirs or ponds during the life of the project. The discharge of water from single wells into dry drainages would not produce as noticeable an impact on the overall extent of wetlands. Discharge from multiple wells could expand the overall extent of wetlands due to the increased release of water to area drainages from a single point.

Flat-lying areas near reservoirs or ponds may develop wetland communities during the time period that water is produced. These wetlands would attract wildlife, provide water for livestock, and provide opportunities for recreational fishing (if stocked). The loss of these wetlands when discharge ends would have an impact upon wildlife (especially waterfowl and other species that live in or near water), livestock operations, and recreation. Small wetland areas that would develop along previously dry drainages also would be lost when water discharge ends, but the loss of these areas would likely have a smaller impact on recreation and livestock operations.

Wildlife and Fisheries

The cumulative effects analysis area for wildlife and fisheries resources includes approximately 3,600 square miles or 2,309,000 acres. This area represents the expanded project area analyzed under Alternative 1. The project area analyzed under the Proposed Action, approximately 2,400 square miles or 1,538,000 acres, is wholly contained within the cumulative effects analysis area for wildlife and fisheries resources. The Proposed Action potentially could affect an estimated 6,751 acres in addition to the areas already disturbed by ongoing CBM development. Up to an estimated 6,514 acres of this potential habitat loss is likely to be long-term, approximately 15 years.

Effects of the Proposed Action would be cumulative on many species of wildlife. Successful reclamation would result in a habitat mosaic in the area that would differ from pre-development conditions. This mosaic would include undisturbed pre-development habitats, as well as a variety of reclaimed habitats. Depending upon the site, reclaimed habitats would provide variable (somewhat flattened) topography, combinations of native and introduced plants, younger age classes of shrubs, and patches of vegetation that were not present prior to development. While some wildlife species might not regain their pre-development distribution and density, others not present before development (or present in limited numbers and distribution) may benefit from reclaimed habitats.

Species dependent upon relatively scarce riparian and wetland habitats may benefit as a result of the Proposed Action, but only as long as water is produced. With the increase in water within various drainages, riparian and wetland habitats should improve and increase in size. Therefore, species populations dependent on streamside habitat types should increase during the life of the project, and for as long as water production continues. Populations would be expected to return to present levels after twenty years, when water production is expected to end.

Cumulative impacts to most wildlife species would increase as additional habitat is disturbed, but would moderate as more land is reclaimed. Big game would be subject to the greatest cumulative effects. Until reclamation replaces disturbed acreage, the Proposed Action may remove portions of winter, winter/yearlong, severe winter, and yearlong range for antelope, mule deer, white-tailed deer, and elk. In addition, CBM development in both the Gillette South and Gillette North areas, coal mining, other mining activities, and conventional oil and gas development already have impacted some of this range. Additional disturbance from construction and maintenance of roads, pipelines, pods, compressor stations, and reservoirs, as well as increased human use of the area could cause additional stress to big game populations. In many cases, big game populations can habituate to human activity, so the duration of this effect may be short-term. Upon cessation of development and/or reclamation, most disturbed areas would be available for big game. If big game ranges are affected by the Proposed Action, timing restrictions can be incorporated within APD or Sundry Notice conditions of approval to reduce or eliminate these impacts.

Following reclamation of surface disturbance related to coal mining, other mining activities, oil and gas development, and CBM development, shrub density on reclaimed areas would be reduced. The cumulative reduction in the important shrub component that is critical for winter range, may reduce the overwinter survival of big game and sage grouse. The spring and summer habitat for grazing species dependent upon grassland plant communities would benefit from increased grass cover.

The ecosystem functions presently served by the existing vegetative community may not be served as well, or at all, by the reclaimed vegetative community, especially initially, when the density of woody species would be most reduced. Reclaimed wetland communities having fewer woody species would not continue to function as bird sanctuaries and would attract fewer raptors or songbirds. Reclaimed grasslands with a reduced shrub component would not continue to function well as nesting sites for some bird species, and would not provide the nutritious forage for big game species that is needed for well functioning winter range.

Raptor and grouse breeding areas have been diminishing statewide for at least the last 30 years due, in part, to surface-disturbing activities. Coal mining and gas exploration and development have been identified as potential contributors to this observed decline in breeding habitats. The reduction in sagebrush habitat has been inferred to be the cause of the observed downward trend in sage grouse populations. As a result, yearlong prohibitions on surface occupancy, restrictions on disturbance or use, and seasonal restrictions on activities have been applied to operations occurring within or near crucial areas. These restrictions have helped to protect important raptor and grouse habitat, and would be continued under the Proposed Action.

Potential cumulative effects on raptors include the loss of foraging habitat for some species. Other species may benefit from habitat alterations that result in higher densities of preferred prey. Some raptors may experience increased mortality from collisions with electric lines while flying during times of poor visibility or while pursuing prey, engaging in courtship flights, or defending territory. Other effects could include mortality from electrocution or indiscriminate shooting in areas with increased accessibility. Prohibiting or limiting surface occupancy during all or portions of the year can protect important raptor habitat. The addition of transmission poles during reclamation may replace raptor perching sites that are lost.

Cumulative surface disturbance of habitat from mining, CBM production, and oil and gas development is not expected to directly affect sage grouse populations if prohibitions on surface occupancy and restriction on activities continue to be applied within and near crucial habitat areas. Few vital sage grouse wintering areas or leks have been disturbed or are likely to be disturbed.

Indirect impacts may occur. Noise related to CBM drilling and production activities could indirectly affect sage grouse reproductive success. Sage grouse leks close to active development could be abandoned if noise associated with activities elevates existing ambient noise levels. Surface coal mining activity is known to contribute to a drop in male sage grouse attendance at leks close to active mining. Over time, this can alter the distribution of breeding grouse (Remington and Braun, 1991).

Because sage grouse populations throughout Wyoming have been declining over the past several years, indirect noise impacts could be significant to local populations, when evaluated with the cumulative impacts of all mineral and energy-related development occurring in the area. The BLM previously has identified a two-mile buffer around each of the leks to address the impacts on sage grouse populations. Within these buffer zones surface disturbance has been restricted between March 1 through June 15 and permanent surface facilities have been prohibited within _ mile of a known lek. Special habitats can be analyzed site-specifically, as needed, during review of APDs or Sundry Notices, and impacts minimized through the application of special conditions of approval for drilling or production operations.

Numerous grazing management projects (fencing, reservoir development, spring development, well construction, vegetative treatments) also have impacted wildlife habitats in the area. The consequences of these developments have proven beneficial to some species and detrimental to others. Fencing has aided in segregation and distribution of livestock grazing, but sheep-tight woven-wire fence has severely restricted antelope movement. Water developments are used by wildlife; however, without proper livestock management, many of these areas can become over grazed. Developed reservoirs provide waterfowl, fish, and amphibian habitat, and CBM development has further enhanced this habitat.

Cumulative impacts of CBM development are expected to include the creation of significant waterfowl habitat during the life of the project and for as long as water production continues. The habitat created during CBM development and water discharge would be lost when discharge ends. No contributing impacts to waterfowl from already-approved mining have been identified. Most of these birds are transient and most of the existing ponds are ephemeral.

Habitat disturbance and reclamation, the creation of barriers to movement, increased human presence, and mortality due to increased poaching and vehicle collisions involving pronghorn, would produce cumulative impacts to pronghorn populations occurring within the area. These impacts result from the combined effects of coal mining and other mining activities, conventional oil and gas development, and CBM development. Approved concentrated coal mining and related disturbances already are affecting pronghorn. Habitat has been disturbed and barriers to seasonal and daily movements have been created. CBM development would increase the acres of habitat disturbed, but is not likely to create additional barriers to movement. Human populations associated with CBM development may become involved in poaching, vehicle/pronghorn collisions, and disturbance of animals.

The cumulative disturbance related to existing and proposed mineral development in the PRB could cause a reduction in habitat for small mammal and bird species. Many of these species are highly mobile, have access to adjacent habitats, and possess a high reproductive potential. As a result, these species are expected to adapt quickly to changing conditions and invade suitable reclaimed lands.

Cumulative impacts on fish habitat and populations are expected to be minimal. Local drainages presently have limited value due to intermittent or ephemeral flows. Some of the permanent pools along drainages support minnows and other nongame fish. Larger impoundments and streams in the area have fish populations. CBM development could result in the establishment or enhancement of fisheries habitat for a period of twenty years and for as long as water production continues. As CBM production and the discharge of produced waters decline and eventually end, fish habitat and populations also will decline and return to present levels.

Special Status Species

A biological assessment prepared for the eastern PRB concluded that coal mining operations might affect bald eagles. Following requirements of the Endangered Species Act, a biological opinion from the USFWS was expanded to include a commentary on black-footed ferrets and peregrine falcons (USFWS, 1982). The opinion stated that cumulative impacts would not be adverse for bald eagles or peregrines but might be adverse for ferrets. As a result, BLM requires ferret surveys within one year of surface disturbance, either as a commitment in the mine plan or as an oil and gas permit stipulation. Ferret surveys also are required by the BLM if wells are to be located in or directly adjacent to prairie dog towns. USFWS requirements also mandate surveys for Ute-ladies_ tresses and mountain plovers in potential habitat before surface-disturbing activities commence. Any potential impacts to special status species, including threatened and endangered species and FS sensitive species, are expected to be mitigated if these environmental protection measures are followed. No significant cumulative impacts to special status species, including threatened and endangered species and FS sensitive species, are anticipated.

Cultural Resources

In most cases, treatment of significant sites is confined to those that would be directly impacted, while those that may be indirectly impacted receive little or no consideration unless a direct energy development effect can be established. Increased population levels associated with energy development coupled with increased access to remote areas are known to result in increased inadvertent damage to cultural resources and an increase in vandalism.

A majority of the known cultural resource sites in the PRB have been recorded as a result of studies at existing and proposed energy development sites where the oil and gas estate is federally owned. An average density estimate of 8.5 sites per square mile (640 acres) can be made based on existing inventories, and typically about 10 percent of these sites are eligible for the NRHP. Unlike strip mining activities, many of the sites identified during surveys for oil and gas and CBM activities can be avoided. Clearly, a number of significant sites, or sites eligible for nomination to the National Register, have been or will be impacted by energy development, including the proposed CBM project in the PRB. Ground disturbance, the major impact, can affect the integrity of a site or destroy it. Changes in setting or context also may greatly impact historical properties. Mitigation measures such as stabilizing, restoring, or moving buildings may cause adverse impacts to context, in-place values, and overall integrity. Additionally, loss of sites through mitigation can constitute an adverse impact by eliminating the site from the regional database and affecting its future research potential.

Beneficial results also can be expected from energy development. Valuable data that would otherwise be lost are collected during cultural resource surveys. Mitigation also results in the collection and preservation of data that would otherwise be lost.

No cumulative impacts to Native American traditional values or religious sites are expected to occur.

Land Use and Transportation

The character of lands reclaimed following coal mining, conventional oil and gas development, and CBM development may be altered permanently. Effects on coal-mined lands would include flattened topography, increased surface drainage, increased infiltration rates, reduced diversity of vegetative cover, and reduced sagebrush density. The reclaimed area for one mine may affect several thousand acres concentrated in a few sites within several square miles. The character of lands reclaimed following conventional oil and gas development also may be permanently altered as described above, to a lesser degree than coal-mined lands, with little topographic flattening. The reclaimed areas for one producing field may affect a number of small sites concentrated within five to twenty square miles. The character of lands reclaimed following CBM development also may be altered slightly as described above. The changes typically would be less noticeable than those related to conventional oil and gas development, but would affect a large number of very small sites dispersed over a very large area. The affected area for CBM development under the Proposed Action would affect nearly seventeen thousand acres spread over more than two thousand square miles.

Most sites disturbed during coal mining or conventional oil and gas development undergo significant surface disturbance using cut and fill construction techniques, and require recontouring and revegetation at the conclusion of operations. About ten percent of the sites disturbed during CBM development would undergo significant surface disturbance using cut and fill construction techniques.

The decreased plant diversity (Chapter 4, Vegetation Resources) would not have a serious effect on productivity of the reclaimed areas. Post-CBM development land uses (rangeland, cropland, wildlife habitat, and mining/oil and gas development) would be achieved even with the changes in land character, vegetative species composition and diversity that are anticipated under the Proposed Action.

No cumulative effects on land use within the project area are anticipated. Land use within the proposed disturbance areas would shift to CBM extraction for the life of the project, but is not likely to exclude existing uses anywhere except at production pods and compression facilities. These locations would be the only areas where other uses would be fenced out. Areas surrounding active operations will continue to serve existing land uses during project operations. Reclamation and final closure of the proposed operations would re-establish the land uses of grazing and wildlife habitat in the disturbance areas under the Proposed Action.

New or enhanced transportation facilities (roads, railroads, and pipelines) are expected to occur as a result of the energy development in the assessment area. The extent of these changes cannot be described site-specifically at this time; these changes are dependent upon the extent of increased production of oil, gas, water and coal.

Recreation

The cumulative effect of the development of roads and well facilities would be improved vehicular access to the area. However, a majority of this access would be not be available to the public since much of the surface is privately owned, and there are no recreation facilities.

The cumulative acreage likely to be affected long-term by production facilities under the Proposed Action (approximately 6,514 acres) is not likely to have a cumulative effect on hunting and fishing opportunities. Recreational hunting and fishing opportunities, which are controlled by landowners on private lands, may increase locally within portions of the area, as populations of game animals and game fish rise locally during the life of the project, in response to increased availability of surface water and forage. This small cumulative enhancement of recreational opportunities in the immediate vicinity of any reservoirs created would be temporary, and would last only as long as water production continues. Although the proposed project is not expected to affect the level of visitation or growth in the counties, recreation visitors may become accustomed to recreational experiences in the vicinity of ponds or flowing water over the life of the project. Visitors will have to accept anticipated reductions in surface water when water discharge ends.

Cumulative impacts from the increased human presence associated with the cumulative energy development in the PRB, are likely to cause increased levels of legal and illegal hunting. Conversely, the mines in the area have become refuges for big game animals during hunting seasons since most are closed to hunting. Energy development-related secondary impacts to wildlife have and would continue to result from human population growth. Energy development has been the primary cause of human influx into the eastern PRB. The demand for outdoor recreational activities, including hunting and fishing, have increased proportionately. However, at the same time these demands are increasing, wildlife habitat and populations are being affected by increased surface disturbance.

Demand for hunting licenses may increase to the point that a lower success in drawing particular licenses would occur; hunting and fishing may become less enjoyable due to more limited success and overcrowding; poaching may increase; the increase in people and traffic has and may continue to result in shooting of nongame species and road kills; and increased off-road activities have and would continue to result in disturbance of wildlife during sensitive wintering or reproductive periods. Travel management during hunting season, including seasonal road closures to the public, could disperse hunters throughout the area, reduce hunting pressure in popular areas, and facilitate a more enjoyable experience for hunters.

Visual Resources
The cumulative effects of CBM development on the landscape are not expected to change the visual character of the existing rural landscape within the area, which currently includes considerable modification from other oil and gas activities, and from coal mining.

A principal visual impact in this area is the visibility of coal mine pits and facility areas. However, anyone likely to see these facilities would either be passing through the area or visiting on related business. After mining, the reclaimed slopes might appear somewhat smoother than pre-mining slopes, and there would be fewer gullies than at present. Even so, the landscape of the reclaimed mines would look very much like undisturbed landscape in the area. Except from the air, energy development activities, including CBM development, are not visible from more than a few miles away.

Noise
The cumulative effects of noise levels resulting from CBM development are not expected to be noticeable to residents or visitors within the area except during construction activities or around compressor facilities. Noise levels would be temporarily elevated above the general rural background noise of 35 to 40 dBA during construction of facilities. However, the noise from each site would be relatively short-term at the individual sites and would be sufficiently widespread so that the elevated noise levels from each site would not overlap in time or space with another site.

The highest operational noise levels would occur around compressor stations. Noise has been measured at typical pipeline compressor units (USDI BLM, 1981). A noise level of 87 dBA at 50 feet from a compressor station can be expected. Noise levels around a compressor would decrease to 61 dBA at 1,000 feet from a compressor and 55 dBA at 2,000 feet away. The noise would decrease further by about 10 to 20 dBA if the compressor would be in an enclosure.

Socioeconomics

When available supplies of CBM within the project area are depleted through production, this natural gas no longer will be available for local use, to sell as a marketable product to regional markets, or to generate jobs and wealth for local communities, Counties, or the State of Wyoming. Although the Proposed Action will not deplete the project area's CBM resources, at whatever time in the future the mineral and energy resources within the project area are depleted, substantial socioeconomic impacts to communities within and near the project area are likely to occur.

Cumulative socioeconomic impacts are a major concern because considerable energy-related development has occurred in and around Campbell County during the past 30 years. Wyoming's economy has been structured around the basic industries of extractive minerals, agriculture, tourism, timber, and manufacturing. Many Wyoming communities depend on the mineral industry for much of their economic well being. The assessed valuation on total minerals produced in 1996, just over $4 billion (WDAF, 1999a), accounted for more than 50 percent of the state's total assessed valuation (WDR, 1999b). The mineral industry is a significant revenue base for both local and state government in Wyoming (WDR, 1997).

Coal production in the PRB is projected to total 363.1 million tons in the year 2004 (WDAI, 1999c). By 2005, annual coal production is projected to generate about $2.6 billion of total economic activity, including $351 million of personal income, and will support the equivalent of nearly 15,885 full-time positions (USDI BLM, 1996c). CBM production is expected to contribute sales valued at nearly $1.6 billion (constant 1998 dollars) over the life of the project to the local, state, regional, and national economies (refer to socioeconomics section of this chapter).

While the cumulative economic value of CBM development under the Proposed Action is very large, the cumulative workforce required for this project is expected to be much smaller than the workforce associated with coal production in the affected counties. CBM-related employment would total approximately five percent of the employment level represented by coal production. The number of workers required under the Proposed Action is expected to be too small to affect the employment, population, and personal income trends in Campbell, Converse, Johnson, and Sheridan Counties, or in the communities of Gillette or Wright. The local counties are accustomed to absorbing fluctuations in mineral development activities, which cause cycles of increasing and decreasing demands for workers, housing, and community services.

The demands for qualified local workers and housing may be met by the counties. An influx of new residents (qualified workers or people seeking opportunities) into the local counties to meet the combined workforce requirements for energy development, coal mining, and power plant construction (proposed Two Elk power plant), could exhaust the available supply of temporary or permanent housing in the counties, resulting in some construction of new housing units.

The estimated economic impact to the local counties over the life of the project from personal income and sales/use taxes would total over $420 million (constant 1998 dollars) under the Proposed Action (refer to page 4-92) In addition, the State of Wyoming would receive an estimated $49 million in federal royalties and $12 million in state royalties (constant 1998 dollars) over the life of the project. Some of these monies also would be used to benefit the local counties.

The remaining federal royalties, an estimated $49 million (constant 1998 dollars) over the life of the project, would be distributed to the federal government.

Implementing the Proposed Action would have no cumulative effects on the social, cultural, and economic well-being, and health of minorities and low income groups. With regard to environmental justice issues affecting Native American tribes or groups, the Wyodak coalbed methane project area contains no tribal lands or Indian communities, and no treaty rights or Indian trust resources are known to exist for this area.

Alternative 1

Alternative 1 includes all of the cumulative effects as described for the Proposed Action, but differs from the Proposed Action in the number of wells that would be drilled, the cumulative acreage that might be disturbed during the life of the project, the cumulative CBM produced water that would be discharged, the cumulative effects on groundwater resources, the cumulative effects on air quality, and the anticipated cumulative socioeconomic impacts.

Except for the changes noted below, the cumulative impacts of Alternative 1 are not expected to vary from those described for the Proposed Action.

The cumulative acreage within the expanded project area that may be affected by drilling and production operations for approximately 5,000 productive CBM wells under Alternative 1 is described in the Introduction to the Cumulative Impacts section.

If all 5,000 new CBM wells proposed under Alternative 1 and all 890 wells in place as of the end of 1998 were producing gas in 2004 at the average production rate over the life of each well (125 mcf per day per well) at the same time, then cumulative annual CBM production from the PRB could approach 268 bcf (estimated). This gas volume would be equivalent to 20 percent of Wyoming's projected 2004 natural gas production of 1.34 trillion cubic feet (WDAI, 1999b).

The cumulative impacts for surface water would basically be the same as those described for the Proposed Action. However, quantitatively, over the life of the project, water produced from the CBM wells will be greater than under the Proposed Action. It is anticipated that 1,703,388 acre feet of produced water will be discharged into the surface water drainages of the area over an estimated 19-year period. Alternative 1 would add a maximum of 29,800 acre-feet per year to Keyhole Reservoir, 11,336 acre feet per year to Angostura Reservoir, and 12,260 acre-feet per year to Sakakawea Reservoir.

The cumulative impacts for groundwater resources will be similar to those described under the Proposed Action. However, additional CBM development, coupled with coal mining dewatering would expand the area of drawdown to 15 to 30 miles from the centers of intense CBM development. Coal bed dewatering from coal mining would be a smaller component of the predicted dewatering than noted for the Proposed Action.

The cumulative impact of the existing long-term soil, vegetation, and wildlife habitat disturbances associated with CBM development, added to potential long-term disturbance of 10,788 acres (estimated) under Alternative 1 amounts to approximately 12,800 acres of long-term soil, vegetation, and wildlife habitat disturbances anticipated due to CBM development. In 20 years, when CBM development under Alternative 1 ends, there may be 54,000 acres within the study area that have been affected by long-term soil, vegetation, and wildlife habitat disturbances associated with mineral and energy resource projects.

CBM production is expected to contribute sales valued at $2.6 billion (constant 1998 dollars) over the life of the project to the local, state, regional, and national economies.

The estimated economic impact to the local counties over the life of the project from personal income and sales/use taxes would total nearly $600 million (constant 1998 dollars) under Alternative 1. In addition, the State of Wyoming would receive an estimated $82 million in federal royalties and $20 million in state royalties (constant 1998 dollars) over the life of the project. Some of these monies also would be used to benefit the local counties.

The remaining federal royalties, an estimated $82 million (constant 1998 dollars) over the life of the project, would be distributed to the federal government.

No Action

The No Action Alternative includes all of the cumulative effects as described for the Proposed Action, but differs from the Proposed Action in the number of wells that would be drilled, the cumulative acreage that might be disturbed during the life of the project, the cumulative CBM generated flows that would be discharged, the cumulative impacts on groundwater resources, the cumulative impacts on air quality, and the anticipated cumulative socioeconomic impacts.

Except for the changes noted below, the cumulative impacts of the No Action Alternative are not expected to vary from those described for the Proposed Action.

The cumulative acreage within the project area that may be affected by drilling and production operations for approximately 2,000 productive CBM wells under the No Action Alternative is described in the introduction to the cumulative impacts section.

If all 2,000 new CBM wells proposed under the No Action Alternative and all 890 wells in place as of the end of 1998 were producing gas in 2004 at the average production rate over the life of each well (125 mcf per day per well) at the same time, then cumulative annual CBM production from the PRB could approach 131 bcf (estimated). This gas volume would be equivalent to 10 percent of Wyoming's projected 2004 natural gas production of 1.34 trillion cubic feet (WDAI, 1999b).

The cumulative impacts for surface water would be slightly less than those described under the Proposed Action. However, quantitatively, discharge of water from CBM wells developed prior to the approval of this EIS, and from CBM development on private or state lands will amount to 835,788 acre feet over a 20-year period. Discharge would add a maximum of 23,989 acre-feet per year to Keyhole Reservoir, 5,182 acre-feet per year to Angostura Reservoir and 571 acre-feet per year to Lake Sakakawea.

The general cumulative effects discussion on groundwater resources from the Proposed Action is similar for the No Action Alternative. However, the maximum drawdown would be fifty feet less than the Proposed Action, at more than 200 feet for the northern project area, and more than 250 feet in the southern area. The relative importance of coal mine dewatering to total dewatering would be greater under this alternative than under the two action alternatives.

The cumulative impact of the existing long-term soil, vegetation, and wildlife habitat disturbances associated with CBM development, added to potential long-term disturbance of 4,377 acres (estimated) under the No Action Alternative, amounts to approximately 6,400 acres of long-term soil, vegetation, and wildlife habitat disturbances anticipated due to CBM development. In 20 years, when CBM development under the No Action Alternative ends, there may be 48,000 acres within the study area that have been affected by long-term soil, vegetation, and wildlife habitat disturbances associated with mineral and energy resource projects.

CBM production is expected to contribute sales valued at just over $1 billion (constant 1998 dollars) over the life of the project to the local, state, regional, and national economies.

The estimated economic impact to the local counties over the life of the project from personal income and sales/use taxes would total just over $300 million (constant 1998 dollars) under the No Action Alternative. In addition, the State of Wyoming would receive an estimated $13 million in state royalties (constant 1998 dollars) and no federal royalties over the life of the project. Some of these monies also would be used to benefit the local counties.

CHAPTER 5

CONSULTATION AND COORDINATION

SCOPING PROCESS

The scoping process and public participation are addressed in the "Public Participation" section of Chapter 1 of this EIS.

CONSULTATION AND COORDINATION

The following agencies, groups, and companies have provided input to this EIS.

Federal Agencies
U.S. Forest Service
U.S. Geological Survey
U.S. Fish and Wildlife Service
National Park Service
U.S. Environmental Protection Agency
Department of the Army, Corps of Engineers
Bureau of Reclamation
Office of Surface Mining
Natural Resources Conservation Service

Tribes/Native American Representatives
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Crow Creek Sioux Tribal Council, Chairman
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Northern Cheyenne Cultural Committee, Ms. Adeline Whitewolf
Sant'Angelo & Trope, Mr. Jack F. Trope

State of Wyoming
Wyoming Department of Administration and Information
Wyoming Department of Agriculture
Wyoming Department of Environmental Quality
Wyoming Game and Fish Department
Wyoming Geological Survey
Wyoming Office of Federal Land Policy
Wyoming Office of State Lands and Investments
Wyoming Oil and Gas Conservation Commission
Wyoming Public Service Commission
Wyoming State Engineer's Office
Wyoming State Historic Preservation Office
Wyoming Water Development Commission

Citizens' Groups and Regional Societies
Powder River Basin Resource Council
Inyan Kara Grazing Association
Wyoming Independent Producers Association
National Mining Association

Companies
Torch Operating Company
Devon Energy Corporation
M. John Kennedy
Barrett Resources Corporation
Redstone Resources, Inc.
Western Gas Resources, Inc.
Lance Oil & Gas Company, Inc.
Yates Petroleum
Rim Operating
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CHAPTER 6
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CHAPTER 7

ACRONYMS

ac-ft Acre-feet (1 acre-foot = 329,829 gallons)

ac-ft/yr Acre-feet per year

APD Application for permit to drill

AQD Air Quality Division, Wyoming Department of Environmental Quality

ASSMR American Society of Surface Mining and Reclamation

AUM Animal unit month

BACT Best Available Control Technology

bbl Barrel (42 gallons)

bpd Barrels per day

bcf Billion cubic feet

BEA Bureau of Economic Analysis

BFO Buffalo Field Office, Bureau of Land Management

BLM Bureau of Land Management, U.S. Department of the Interior

CBM Coal bed methane

CEQ Council on Environmental Quality

CFR Code of Federal Regulations. Numbers refer to title and part; that is, 40 CFR 1500 refers to title 40, part 1500.

cfs Cubic feet per second (equivalent to 448.83 gallons per minute)

CO Carbon Monoxide

COE U.S. Army Corps of Engineers

COI Circle of influence of a CBM production well

CHIA "Cumulative Potential Hydrologic Impacts of Surface Coal Mining in the Eastern Powder River Structural Basin, Northeastern Wyoming"

CCEDC Campbell County Economic Development Corporation

dBA A-weighted scale, decibels

DOE U.S. Department of Energy

EA Environmental assessment

EC Electrical conductivity, measured in mhos/cm

EIS Environmental impact statement

EPA U.S. Environmental Protection Agency

ESP Exchangeable sodium percentage

Fm Formation (geologic)

FS U.S. Forest Service, U.S. Department of Agriculture

gm/hp-hr Grams per horsepower-hour

gpm Gallons per minute (equivalent to 0.002 cfs, approximately)

GAGMO Gillette Area Groundwater Monitoring Organization (coal operators)

HAP Hazardous Air Pollutants

HP Horsepower

km Kilometer

LBA Lease by application

LQD Land Quality Division, Wyoming Department of Environmental Quality

LRMP Land and Resource Management Plan

mcf Thousand cubic feet

MCFD One thousand cubic feet per day

mg/l Milligrams per liter (1 mg = 1 ppm [part per million]; 1 liter = 0.264 gallons)

mgd Million gallons per day

g/l Micrograms per liter (1 g = one thousandth of a milligram or 0.001 mg or 1ppb [part per billion])

g/m3 Micrograms per cubic meter (1 cubic meter = 1.308 cubic yards)

mmcf Million cubic feet

mmhos/cm Soluble salts (salinity) in a soil expressed in millimhos per centimeter

MMCFD One million cubic feet per day

MT Montana

NAAQS National Ambient Air Quality standards

NAS National Academy of Sciences

NEPA National Environmental Policy Act of 1969

NOX Nitrogen Oxides

NO2 Nitrogen Dioxide

NOAA National Oceanic and Atmospheric Administration

NOI Notice of Intent (to prepare an EIS)

NPDES National Pollution Discharge Elimination System

NPS National Park Service, U.S. Department of Interior

NRHP National Register of Historic Places

NRCS Natural Resources Conservation Service

OSM Office of Surface Mining, Reclamation and Enforcement

PAP Permit application packages

pci/l Picocurie per liter, used to measure Radium 226

pH Acidity, measured in standard units

PM10 Particulate matter less than 10 micrometers (respirable)

PRAGMO Powder River Area Groundwater Monitoring Organization

PRB Powder River Basin

psi Pounds per square inch

PVC Plastic (polyvinyl chloride-type, used in plastic pipes and well casings)

R__W Range number West, an east-west rectangular land survey area coordinate

RMP Resource Management Plan

ROD Record of Decision

S__ Section number, a rectangular land survey area

SAR Sodium Absorption Ratio

SCS Soil Conservation Service, U.S. Department of Agriculture

SHPO State Historic Preservation Officer

SMCRA Surface Mining Control and Reclamation Act of 1977

SO2 Sulfur dioxide

Sq mi Square miles

STATSGO State Soil Geographic Database

T__N Township number North, a north-south rectangular land survey area coordinate

TBNG Thunder Basin National Grassland

TDS Total dissolved solids

TPH Total petroleum hydrocarbons

TSP Total suspended particulates

TSS Total suspended sediments

mhos/cm Micromhos per centimeter {thousandths of unit of specific conductance) (a measure of electrical conductivity)

USDA U.S. Department of Agriculture

USDC U.S. Department of Commerce

USDI U.S. Department of the Interior

USFWS U.S. Fish and Wildlife Service, U.S. Department of the Interior

USGS Geological Survey, United States Department of the Interior

VOCs Volatile Organic Compounds

VOR VHF (very high frequency) Omnidirectional Range (radio aid used for navigation)

VQO Visual Quality Objective

VRM Visual resource management

WDEQ Wyoming Department of Environmental Quality

WDR Wyoming Department of Revenue

WGA Wyoming Geological Association

WGFD Wyoming Game and Fish Department

WGS Wyoming Geological Survey

WOGCC Wyoming Oil and Gas Conservation Commission

WQD Water Quality Division, Wyoming Department of Environmental Quality

WSA Wilderness Study Area

WSEO Wyoming State Engineer's Office

WWRC Wyoming Water Resources Center

WY Wyoming