APPENDIX A:

AIR QUALITY IMPACT ASSESSMENT PROTOCOL

FINAL
AIR QUALITY IMPACT ASSESSMENT PROTOCOL, ATLANTIC RIM NATURAL GAS PROJECT AND SEMINOE ROAD GAS DEVELOPMENT PROJECT, CARBON COUNTY, WYOMING

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LIST OF ACRONYMS AND ABBREVIATIONS

ANC	Acid neutralizing capacity
AQD	Air Quality Division
AQRV	Air Quality Related Value
ARS	Air Resource Specialists
Atlantic Rim Operators	Anadarko E&P Company LP, Petroleum Development Corporation, Double Eagle Petroleum, Julander Energy, Merit Energy
BACT	Best Available Control Technology
BLM	Bureau of Land Management
C.F.R.	*Code of Federal Regulations*
CAAQS	Colorado Ambient Air Quality Standards
CDPHE/APCD	Colorado Department of Public Health and Environment/Air Pollution Control Division
CD/WII	Continental Divide/Wamsutter II
CO	Carbon monoxide
COGCC	Colorado Oil and Gas Conservation Commission
dv	Deciview
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
FLAG	Federal Land Managers' Air Quality Related Values Workgroup
FLM	Federal Land Managers
GRI	Gas Research Institute
HAP	Hazardous air pollutant
HNO_3	Nitric acid
IAAQS	Idaho Ambient Air Quality Standards
IDEQ	Idaho Division of Environment Quality
IDLH	Immediately Dangerous to Life or Health
IOGCC	Idaho Oil and Gas Conservation Commission
IWAQM	Interagency Workgroup on Air Quality Modeling
kg/ha/yr	Kilograms per hectare per year
LAC	Level of Acceptable Change
LOP	Life of Project
MEI	Maximally Exposed Individual
MLE	Most Likely Exposure
N	Nitrogen
NAAQS	National Ambient Air Quality Standards
NEPA	*National Environmental Policy Act*
NIOSH	National Institute for Occupational Safety and Health
NO_2	Nitrogen dioxide
NO_3	Nitrate
NO_x	Oxides of nitrogen
NPS	National Park Service
NSR	New Source Review
NWS	National Weather Service

LIST OF ACRONYMS AND ABBREVIATIONS (CONTINUED)

O_3	Ozone
Operators	Anadarko E&P Company LP, Dudley & Associates, LLC, and other oil and gas companies
RFO	Rawlins Field Office
PM_{10}	Particulate matter less than or equal to 10 microns in size
$PM_{2.5}$	Particulate matter less than or equal to 2.5 microns in size
ppb	Parts per billion
Protocol	Air Quality Impact Assessment Protocol
PSD	Prevention of Significant Deterioration
QA/QC	Quality Assurance/Quality Control
REL	Reference exposure level
RfC	Reference Concentrations for Chronic Inhalation
RFD	Reasonably foreseeable development
RFFA	Reasonably foreseeable future actions
RMP	Resource Management Plan
ROD	Record of Decision
S	Sulfur
SO_2	Sulfur dioxide
SO_4	Sulfate
SWWYTAF	Southwest Wyoming Technical Air Forum
TRC	TRC Environmental Corporation
UAAQS	Utah Ambient Air Quality Standards
UDEQ-AQD	Utah Department of Environmental Quality-Air Quality Division
UDNR-DOGM	Utah Department of Natural Resources-Division of Oil, Gas, and Mining
URF	Unit risk factor
VOC	Volatile organic compound
WAAQS	Wyoming Ambient Air Quality Standards
WAQSR	Wyoming Air Quality Standards and Regulations
WDEQ	Wyoming Department of Environmental Quality
WOGCC	Wyoming Oil and Gas Conservation Commission
WYDOT	Wyoming Department of Transportation
µeq/l	Microequivalents per liter
$\mu g/m^3$	Micrograms per cubic meter

1.0 INTRODUCTION

TRC Environmental Corporation (TRC) has prepared this Air Quality Impact Assessment Protocol (Protocol) to identify the methodologies for quantifying potential air quality impacts from the proposed Atlantic Rim Natural Gas Project (Atlantic Rim Project) and the proposed Seminoe Road Gas Development Project (Seminoe Road Project). These methodologies are being provided prior to study initiation to ensure that the approach, input data, and computation methods are acceptable to the Bureau of Land Management (BLM) and that other interested parties have the opportunity to review the Protocol and to provide input before the study is initiated. The results of the air quality analysis performed in accordance with this Protocol will be disclosed separately in the Environmental Impact Statement (EIS) for each project.

1.1 ANALYSIS APPROACH

The Atlantic Rim Project and Seminoe Road Project are separate development projects for which all other components of the respective EISs will be performed separately. The locations of these projects are shown in Figure 1.1. Because of the proximity of these projects to one another, and due to nature of air pollutant transport and the potential for long-range cumulative impacts, a single air quality impact assessment is proposed for these projects. Two separate air quality analyses will be conducted to assess localized impacts within each development area (near-field analysis). The far-field analysis for these projects will be a combined effort, utilizing the same model input and regional inventory data. This approach will result in the most representative assessment of cumulative impacts from these projects combined. Far-field impacts will be reported from each project separately (far-field project impacts) and from both projects in combination with other regional data (far-field cumulative impacts). A single Technical Support Document (TSD) will be prepared that includes both projects, describing the air quality analyses performed in technical detail and presenting the results of the analyses.

Due to the projects' locations in south-central Wyoming, cumulative impacts will be assessed from air emissions sources located in portions of Wyoming, northwestern Colorado, northeastern Utah, and southeastern Idaho within the proposed cumulative study area shown on Figure 1.1.

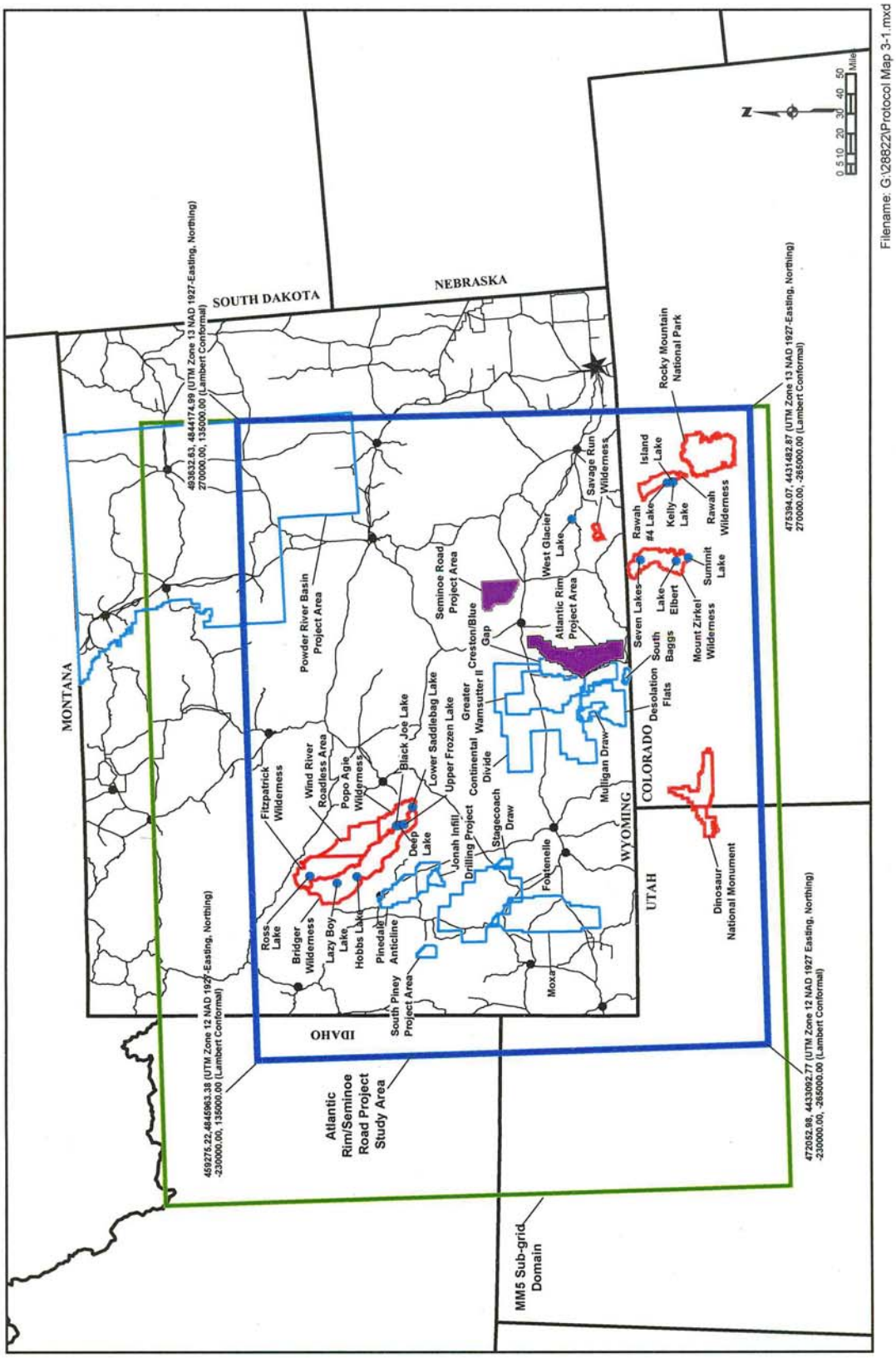

Figure 1.1 Atlantic Rim CBM and Seminoe Road Gas Development Project Areas and Cumulative Impact Area.

cumulative analyses proposed are similar to analyses performed for previous natural gas development projects in Wyoming but are tailored to ensure an accurate assessment of these projects. Specifically, the approach presented in this Protocol differs from previous regional cumulative analyses in two primary aspects. First, the analysis updates visibility and NO_x background data to the most recent data available to more accurately reflect current conditions in the region. This change will advance the emissions inventory period to reflect this more recent background data. Second, the proposed Class I modeling approach will be performed with consideration for recent federal guidance for performing regional Class I analyses (FLAG, 2000; IWAQM, 1998) and will comply with current Wyoming Department of Environmental Quality-Air Quality Division (WDEQ-AQD) recommendations.

1.2 RELATIONSHIPS TO EXISTING PLANS AND DOCUMENTS

The BLM Great Divide Resource Management Plan (RMP)/Record of Decision (ROD) (BLM 1990) directs the management of BLM-administered lands within the project areas. Management of oil and gas resources, as stated in the RMP, provides for leasing, exploration, and development of oil and gas while protecting other resource values. According to the RMP, all public lands in the project areas are suitable for oil and gas leasing and development, subject to certain stipulations. The BLM Rawlins Field Office is currently revising the Great Divide RMP, and this revision is scheduled for completion in 2004. Draft and final RMP documents will be reviewed as they become available to ensure that the analysis proposed in this document remains consistent with the RMP.

The study area for this impact analysis (CALMET/CALPUFF modeling domain) will be similar to the domain used for the Continental Divide/Greater Wamsutter II EIS (Earth Tech 1999) and the Desolation Flats EIS (BLM 2003). These two study areas included portions of southwest Wyoming, southeast Idaho, northeast Utah, and northwest/north-central Colorado and utilized the CALMET/CALPUFF modeling system to estimate regional air quality impacts. The use of this domain for the current project is appropriate due to the generally central location of the ARPA and SRPA within the domain, and due to the location of the domain with respect to the

Class I and sensitive areas to be analyzed. Furthermore, the MM5 data to be used in this analysis, developed for the Continental Divide/Greater Wamsutter II study and subsequently used in the SWWYTAF study and in several regional EIS analyses, represent the most refined MM5 windfield data currently available for southwest Wyoming.

1.2.1 Atlantic Rim Existing Documents

An interim drilling policy approved in 2001 authorized development in the ARPA concurrent with EIS preparation for the Atlantic Rim Project. A maximum of 200 wells in nine proposed pods and a maximum of 24 wells in each pod were approved within the ARPA in advance of EIS development. Each pod to be developed is required to obtain authorization from the BLM through submittal of an EA following interim drilling policy guidelines. Since approval of the interim drilling plan, four pod Environmental Assessments (EAs) have been submitted for authorization: the Cow Creek Pod EA, Red Rim Pod EA, Blue Sky Pod EA, and Sun Dog Pod EA. The Decision Records (DRs) for these EAs authorize a total of 52 wells within the ARPA, of which 46 have been drilled. Six existing coalbed methane wells originally permitted by North Finn LLC within the ARPA will not count toward the allowed well number as long as they are not included as part of any proposed pod, nor will any injection or monitoring wells required as part of the Atlantic Rim Proposed Action.

1.2.2 Seminoe Road Existing Documents

An EA was completed for a pilot project within the Seminoe Road Project Area, the Seminoe Road Coalbed Methane Pilot Project (WY-030-EA00-288), which proposed drilling, casing, completing and producing 19 gas wells. Eight wells were proposed on federal land and 11 were proposed on private land. Three miles of existing undeveloped road was proposed to be upgraded and approximately 7 miles of new road was proposed to be built. The EA was submitted to the BLM Rawlins Field Office in April, 2001, and a DR for the project was issued in July 2001. The wells are constructed and operating.

A second EA was prepared for a 20.3-mile 16-inch pipeline proposed from the pilot project location to Walcott Junction (WY-030-EA2-229). The EA was released for comment in August 2002, and a DR was issued in September 2002. This pipeline has not yet been constructed.

1.3 PROPOSED WORK TASKS

The air quality analysis will address the impacts on ambient air quality and Air Quality Related Values (AQRVs) resulting from 1) air emissions from construction and production activities at 2,000 new wells proposed within the ARPA, 2) air emissions from construction and production activities at 1,240 new wells proposed in the SRPA, and 3) air emissions from other documented regional emissions sources within the study area. Ambient air quality impacts will be quantified and compared to applicable state and federal standards, and AQRV impacts (impacts on visibility [regional haze] and acid deposition) will be quantified and compared to applicable thresholds as defined in the Federal Land Managers' (FLMs') Air Quality Related Values Workgroup (FLAG), Interagency Workgroup on Air Quality Modeling (IWAQM) guidance documents (FLAG 2000; IWAQM 1998) and other state and federal agency guidance. Impact assessment criteria are discussed in further detail in Section 6.0 of this Protocol.

The assessment of impacts will include the completion of the following five tasks.

- Develop project construction and production emissions inventories for Atlantic Rim and Seminoe Road projects (see Section 3.1).
- Compile cumulative emissions inventory within the study area, including new sources permitted through March 31, 2004, reasonably foreseeable development (RFD), and reasonably foreseeable future actions (RFFA) (see Section 3.2).
- Assess near-field ambient impacts from Atlantic Rim and Seminoe Road project emissions sources (see Sections 4.0 and 6.1).
- Assess far-field ambient impacts (pollutant concentration, visibility, and acid deposition impacts) within the modeling domain and at Class I and other sensitive areas from *project emissions sources* (see Sections 5.0 and 6.2).

- Assess far-field ambient impacts (pollutant concentration, visibility, and acid deposition impacts) within the modeling domain and at Class I and other sensitive areas from all *emissions sources documented in the cumulative emissions inventory* (see Sections 5.0 and 6.2).

2.0 PROJECT DESCRIPTIONS

This section provides an overview of the Atlantic Rim Project and the Seminoe Road Project. These project descriptions are provided here to assist the reader in developing a general understanding the projects to be analyzed and may be subject to revision prior to the Draft or Final EIS document.

2.1 ATLANTIC RIM NATURAL GAS PROJECT

2.1.1 Project Overview

Anadarko E&P Company LP and other oil and gas companies (including Warren E&P, Inc., Double Eagle Petroleum, Julander Energy, and Merit Energy Company), collectively referred to as the Atlantic Rim Operators, propose to continue development of coalbed methane and natural gas resources located within the ARPA (Figure 1.1). The proposed project area is generally located in Townships 13 through 20 North, and Ranges 89 through 92 West, Carbon County, Wyoming. The total project area encompasses approximately 310,335 acres, of which 199,558 acres are federal surface, 16,156 acres are State of Wyoming surface/mineral estate, and 94,621 acres are private surface. The Proposed Action for this project involves the development of 2,000 new wells, including 1,800 coalbed methane wells and 200 natural gas wells, on 1,800 new surface locations. No alternatives besides the No Action Alternative are planned to be proposed at this time.

2.1.2 Well Development

Drilling operations are expected to last from approximately 6 to 10 years, with a life-of-project (LOP) of 20-30 years. Each drill site location would be approximately 200 feet by 200 feet in size, with surface disturbance at each well site approximately 1 acre. Temporary mud pits 15 feet by 35 feet would be constructed and reclaimed following completion operations. Drilling of the natural gas and coalbed methane wells, or water injection wells to be used in support of coalbed methane production operations, would utilize either a conventional or truck-mounted drilling rig. Additional equipment and materials needed for drilling operations would be trucked

to the well site. Each producing coalbed methane well would be drilled to a depth of 2,700 feet to 3,800 feet or deeper, depending upon the depth of the coal seam. Approximately 26 days would be required to develop each gas well (4 days to construct the well pad and access road, 2 days for rig-up, 10 days for drilling, 2-5 days for completion, 2 days for rig-down, and 3 days for pipeline construction). Methane gas may be flared or vented during the testing period at natural gas wells; no gas would be flared or vented at coalbed methane wells.

Drilling water injection wells would utilize gas well drilling equipment and personnel. The injection well depth is expected to range from 3,200 to 4,000 feet, and injection well drilling and completion is expected to require 7-14 days plus an additional 14 days to install surface equipment.

Non-productive gas wells would be reclaimed to the approximate landform existing prior to construction using techniques specified in the Master Surface Use Plan (MSUP). The ARPA is currently accessed by existing developed roads, and access to drill locations from the existing road network would be provided by new and upgraded roads when necessary. If drilling is productive, access roads to the well site would remain in place, and partial reclamation would be completed on segments of the well pad and access road right-of-way (ROW) no longer needed.

Gas-gathering pipeline systems (low pressure, from wellhead to central compressor station), produced water-gathering pipeline systems (low pressure, from wellhead to centralized conditioning facilities or injection facilities), and gas-delivery pipelines (high pressure, from compressor station to existing transmission pipelines) would be constructed in the ARPA. Reclamation of pipeline corridors would occur as soon as practical after pipeline construction was complete.

2.1.3 Well Operation

Coalbed methane wells would utilize electricity to power pumps required during well development and required to initiate and maintain production. Either natural gas- or propane-fired engines would be used to run generators on a temporary basis to power pumps at individual

wells until electric distribution lines were installed. Atlantic Rim Operators may elect to use centrally located generation equipment at area compressor stations and an underground distribution system to provide necessary power to well sites.

Natural gas wells would utilize natural gas-fired equipment at each well site. Several gas-fired heaters would operate intermittently to eliminate the freezing of separated liquids. A burner would also operate with the dehydrator to heat glycol solution. No electricity would be required at natural gas well locations. No well site compression would be utilized at natural gas wells.

2.1.4 Ancillary Facilities

Twelve compressor stations are planned for the ARPA. Each compressor station facility is expected to be constructed within a site area covering approximately 300 feet by 300 feet. About one-half of the compressor station site area will be affected by the construction, maintenance, and operation of the facility. The compressor station facility will be of all-weather construction, having a thick layer of gravel surfacing over the pad site. Topsoil will be removed and conserved for later reclamation activities. The compressor station would consist of an insulated header building containing a separator or a separator and allocation meters for each well. Additional equipment at each compressor station would include a tri-ethylene glycol (TEG) dehydration system, which would dry the gas to meet pipeline-quality specifications of the market pipeline. The water removed in the dehydration system will be pumped from the header building to an approved injection well.

Each compressor station will be sited to allow for the installation of one compressor initially, with the addition of up to two more compressors later in the life of the field. Each compressor would be driven by a natural gas engine that would be designed to meet all specifications established by the WDEQ-AQD.

2.2 SEMINOE ROAD GAS DEVELOPMENT PROJECT

2.2.1 Project Overview

Dudley & Associates, LLC (the project Proponent) notified the BLM in September 2002 of its desire to continue to drill and develop coalbed methane natural gas wells and associated facilities at the Seminoe Road Pilot Plant Project site. The project site is located in Carbon County, Wyoming just north of the Town of Sinclair in Townships 21, 22, 23, and 24 North, Ranges 84, 85, and 86 West, in Carbon County, Wyoming. The site is accessed via County Road 351, also known as the Seminoe Road. The SRPA is approximately 137,000 acres in size and involves a "checkerboard" mixture of mostly federal (49%) and private (49%) land, with some state land (1%). The BLM Rawlins Field Office manages the federal surface lands and the federal mineral estate. Dudley owns or controls oil and gas leasehold interests comprising approximately 80% of the ARPA.

The proposal includes drilling and developing up to 1,240 wells, on up to 785 well pad sites spaced at approximately 1 well pad site every 160 acres. Associated facilities include roads, gas and water collection pipelines, compressor stations, water disposal systems, and a power supply system. The total development, operation, and reclamation of the project is anticipated to occur over a period of between 30 and 40 years. The site will be developed in about 11 phases, with each phase requiring a separate EA.

2.2.2 Well Construction

The three main construction activities on the site that will cause disturbance include the following:

- access roads,
- drill pads, and
- compressor sites.

Access will be needed to all drill sites and compressor sites. An effort will be made to utilize existing roads on site; however, these roads will also require upgrading. Approximately 2,195 acres will be disturbed by access roads. Initially, 2.2 acres will be disturbed for each drill pad. Once wells are completed, about 1.2 acres on each site will be reclaimed. There will be three compressor sites for the project, with each disturbing about 5 acres. Most water, gas, and utility lines will be buried within the access road disturbance corridor.

2.2.3 Well Development

Drilling will be conducted using conventional rotary drill rigs drilling vertical holes. Drilling and spacing unit of 160 acres (i.e., maximum of four well sites per 640-acre section) is anticipated for the project area. The shallower Medicine Bow and Fox Hill coalbed methane extraction zones will be produced from separate wellbores; however, they will share a common well-site with their Mesaverde counterparts. With Medicine Bow and Fox Hill wellbores sharing a common well pad site with their Mesaverde counterparts, no additional land surface is planned to be disturbed in the course of the Medicine Bow and Fox Hill developments. It is estimated that 25% of the original total surface disturbance may be reclaimed as soon as practicable following drilling and well completion operations.

2.2.4 Ancillary Facilities

The initial analysis of gas produced from the pilot project wells in the Mesaverde coals indicates no need for nitrogen or CO_2 extraction facilities. Plans for construction of a compressor facility and a 20-mile long high-pressure pipeline were recently approved by the BLM (WY-030-EA2-229) to connect the pilot project wells to a sales transmission pipeline near Walcott, Wyoming. It is anticipated that two more compressor facilities/sites will be needed over the life of the project. In the event of field electrification, ROWs for utility lines will also be required.

2.2.5 Power Requirements

It is anticipated that the lighting, pumps, and compressors will utilize electricity from the existing power line that runs through the project site. However, Dudley is currently evaluating other power sources for the project.

2.2.6 Reclamation

At the time of final reclamation, the following steps will occur as approved by the APDs for the project:

- decommissioning of facilities,
- removal of structures, facilities and roads,
- well abandonment and sealing,
- recontouring and regrading,
- soil replacement,
- mulching,
- permanent revegetation, and
- reclamation management and monitoring.

3.0 EMISSIONS INVENTORY

3.1 PROJECT EMISSIONS

The Atlantic Rim and Seminoe Road projects will generate air emissions during well, pipeline, and ancillary facility construction during well production, and during operation of ancillary facilities in the project areas. Emissions inventories for oxides of nitrogen (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO), particulate matter less than or equal to 10 microns in size (PM_{10}), particulate matter less than or equal to 2.5 microns in size ($PM_{2.5}$), volatile organic compounds (VOC), and hazardous air pollutants (HAPs) (formaldehyde from natural gas combustion; benzene, toluene, ethyl benzene, xylene, and n-hexane from natural gas well operation) will be developed for both construction and production activities and for ancillary facilities. Lead emissions will be considered negligible and will not be calculated in the inventory. The emissions inventory will be developed based on the Proposed Actions with assistance from the Operators, using the most likely operating scenarios identified for each activity. The inventory will be developed using manufacturer's emissions data, the Environmental Protection Agency's (EPA's) AP-42 (EPA 1995), Gas Research Institute (GRI) emission factors, and other accepted engineering methods as described in greater detail below.

3.1.1 Construction Emissions

Emissions-generating construction activities may include wellpad and access road construction, drilling engine operation, completion flaring, vehicle travel during the drilling and completion phase, and construction activities and vehicle travel during pipeline installation. Drilling engine and flaring emissions will be calculated using AP-42 or other acceptable engineering methods. Flaring emissions would occur only at natural gas wells within the ARPA, and flaring emissions calculations and assumptions will be provided to WDEQ-AQD for review during development of the inventory, as requested. Fugitive particulate emissions from vehicle travel and construction activities, wind erosion emissions from areas disturbed during construction, and combustion source emissions will be calculated using AP-42 emission factors or other accepted

engineering methods. Fugitive dust may be controlled using water or dust suppressants as defined by each proponent.

3.1.2 Production Emissions

Coal bed methane wells in both the ARPA and SRPA would emit the criteria pollutants NO_x, CO, VOC, PM_{10}, and $PM_{2.5}$. Sources of criteria pollutant emissions at coalbed methane wellsites during the production phase would include combustion emissions from generators powering well-site pumps (NO_x, CO, VOC, and formaldehyde) and fugitive particulate emissions from unpaved road travel and from wind erosion of disturbed areas such as the unreclaimed portions of well pads (PM_{10} and $PM_{2.5}$). Combustion emissions from well site pumps would not occur in either field if/when electricity becomes available.

Traditional natural gas production within the ARPA would emit the criteria pollutants NO_x, CO, VOC, PM_{10}, and $PM_{2.5}$ and the HAPs benzene, toluene, ethylbenzene, xylene, and n-hexane. Sources of criteria pollutant emissions at natural gas wellsites during the production phase would include combustion emissions from natural gas-fired burners operating in the well-site separators (NO_x, CO, and VOC). Primary sources of well site VOC and HAPs would be well-site liquids storage tanks and fugitive leaks. Smokeless flare controls on certain liquids storage tanks are required to reduce VOC and total HAPs by 98% by weight. Fugitive particulate emissions from unpaved road travel and from wind erosion of disturbed areas such as the unreclaimed portions of well pads would also occur (PM_{10} and $PM_{2.5}$).

Compressor and generator engines centrally located within the ARPA and SRPA fields would also be sources of criteria pollutant and HAPs emissions (NO_x, CO, VOC, and the HAP formaldehyde). Centralized compressor stations within the ARPA would also include gas dehydration facilities, with VOC and HAPs (benzene, toluene, ethylbenzene, xylene, and n-hexane) emissions occurring from flashing from the dehydrator reboiler.

Pollutant emission rates for all emission sources will be calculated using AP-42, manufacturer's, GRI emission factors, or other engineering methods in accordance with WDEQ-AQD oil and gas

permitting guidance (WDEQ 2001) where applicable guidance exists. Fugitive VOC and HAPs emissions from natural gas wells will be calculated using representative constituent analyses of natural gas and stored liquids. Fugitive dust from unpaved roads and wind erosion emissions from disturbed areas will be calculated using AP-42 emission factors. Compressor engine emissions will be based on emission factors from existing WDEQ-AQD construction permits issued for facilities in each Project Area, which include recent WDEQ-AQD Best Achievable Control Technology (BACT) determinations for similar engines. A discussion of BACT applicability and requirements will be included for applicable emissions sources, following WDEQ-AQD oil and gas permitting guidance (WDEQ 2001).

3.2 REGIONAL EMISSIONS INVENTORY

A regional emissions inventory of existing and proposed emissions sources within the study area has been developed for use in the BLM's Rawlins and Pinedale RMP revision air quality analyses, the Jonah Infill Drilling Project air quality analysis, and this analysis. The inventory includes the identification of permitted sources, oil and gas wells, RFD, and RFFA as described later in this section, and was developed using data obtained from WDEQ-AQD, Wyoming Oil and Gas Conservation Commission (WOGCC), Colorado Department of Public Health and Environment/Air Pollution Control Division (CDPHE/APCD), Colorado Oil and Gas Conservation Commission (COGCC), Utah Department of Environmental Quality-Air Quality Division (UDEQ-AQD), Utah Department of Natural Resources-Division of Oil, Gas, and Mining (UDNR-DOGM), Idaho Division of Environment Quality (IDEQ), Idaho Oil and Gas Conservation Commission (IOGCC), BLM, and other agencies as required.

The time period of emissions data included in this regional inventory differs from that of previous regional studies in its use of more current visibility and NO_x background data in the cumulative analysis. Furthermore, the updated background values more accurately reflect current background conditions, and the reduction in years of emission sources modeled helps to simplify the analysis. These data are described in greater detail in Section 5.2.4 of this Protocol. The original inventory period selected was January 1, 2001 through June 30, 2003. That period

has been updated through March 31, 2004, to better characterize current permitted emissions. The inventory start-date remains January 1, 2001. Some overlap between emission sources that began operating in 2001 and background data monitored during 2001 will exist; however, this overlap does provide additional conservatism to the analysis.

Sources of PM_{10}, $PM_{2.5}$, NO_X, and SO_2 emissions within the study area (the CALPUFF/ CALMET modeling domain) will be inventoried. The study area is shown in Figure 3.1.

3.2.1 Existing Inventories

Three cumulative inventories have been completed as part of NEPA projects in southwest Wyoming, and each included a portion of the study area proposed for this analysis. The first was completed as part of the Continental Divide/Wamsutter II (CD/WII) EIS (BLM 1999b) and the second was performed for the Pinedale Anticline EIS (BLM 1999a). A third cumulative inventory in the region has been prepared for the Desolation Flats EIS (BLM 2003). The Desolation Flats EIS study utilized the CD/WII EIS study area and built upon the previous studies listed above, and it included emissions sources permitted through December 31, 2000. The data contained in these inventories precede the start-date of the regional inventory proposed for this analysis.

3.2.2 Permitted Sources

The regional emissions inventory will include emission sources that:

- are located within the study area;
- emit NO_x, SO_2, or PM_{10}/$PM_{2.5}$;
- began operation on or after January 1, 2001;
- began operation or were permitted before March 31, 2004; and
- were permitted within 18 months of January 1, 2001, but are not yet operating (will be inventoried and included as RFFA [see Section 3.2.4]).

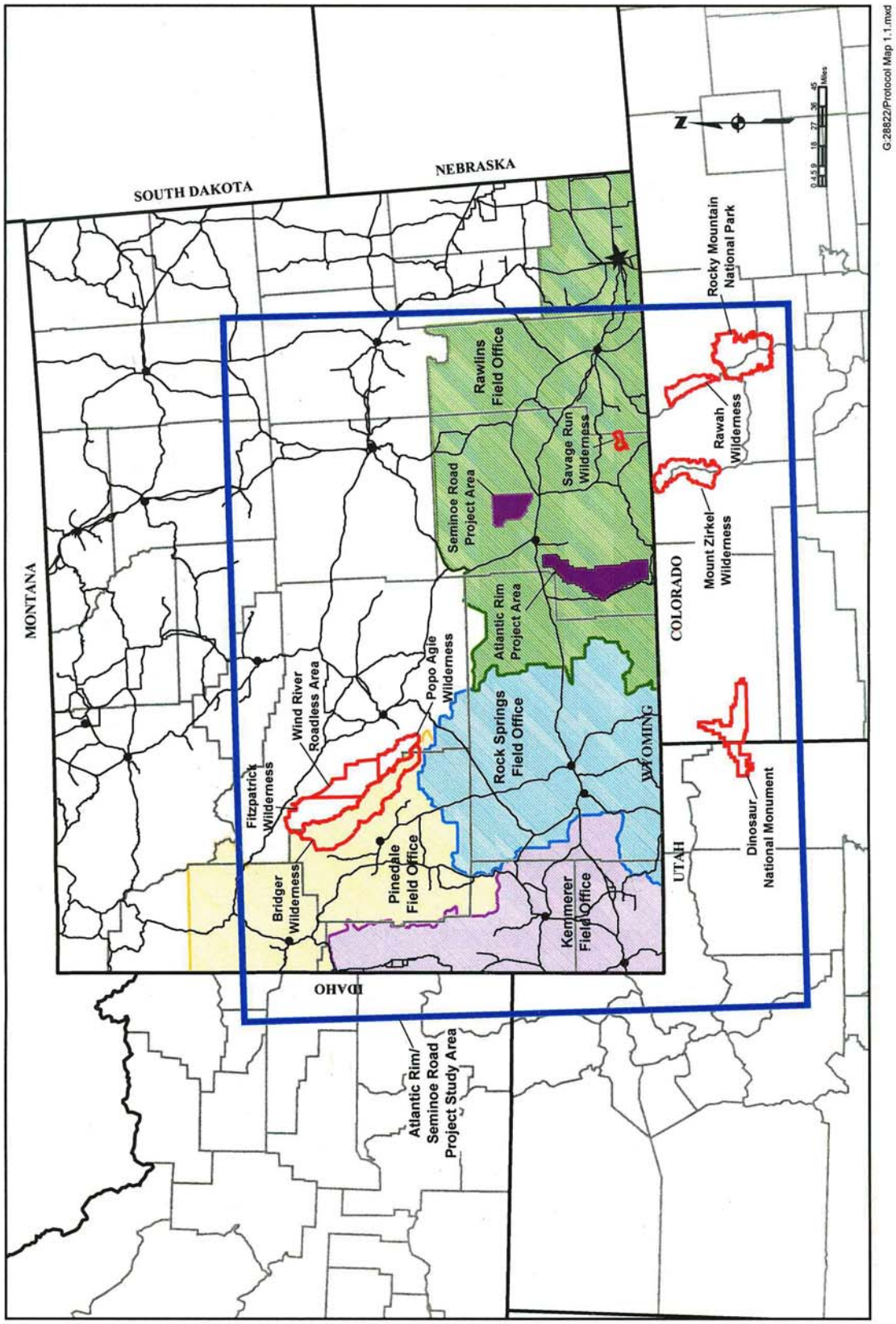

Figure 3.1 Cumulative Study Area/Modeling Domain and Sensitive Areas.

To illustrate the inventory cut-off date, an emissions source that was permitted *and* began operation in late 2000 would not be included in the inventory. However, an emissions source that was permitted in late 2000 but began operation in early 2001 would be included in the inventory. An emissions source permitted in late 2000 (and therefore within 18 months prior to January 1, 2001) but not yet operating would be included as RFFA. An emission source that begins operation in April 2004, after the inventory cut-off date, would be included only if it was permitted on or before March 31, 2004.

The time frame proposed for this inventory was developed based on several criteria. First, the inventory time period begins on January 1 of the same year for which updated NO_x background data are available. This ensures that impacts from cumulative sources will be conservative, since sources permitted throughout 2001 and beyond are combined with background data that includes measurements taken through 2001. Second, the inclusion of emissions sources permitted 18 months prior to the inventory start-date, but not yet operating, is based on the minimum amount of time, of all states inventoried, that a permit could remain in effect if construction had not yet commenced. This assumes that facilities permitted prior to 18 months before the inventory start-date are operational and allows a review of start-up dates for those within the 18-month window, ensuring a more accurate depiction of permitted sources vs. RFFA.

Potential-to-emit (maximum permitted) emission rates will be used because work on the regional emissions inventory has indicated that actual emissions are not readily available for most state-permitted sources. Emissions decreases will be included only if the decrease occurs at a major source and if the decrease is verifiable by WDEQ-AQD. Sources operating under Wyoming permit waivers will not be inventoried, an approach consistent with previous EIS air quality studies in southwest Wyoming. However, a discussion of total Wyoming waivers during the inventory time period will be presented in the TSD. WDEQ-AQD issues waivers on a case-by-case basis using no specific emissions thresholds and does not electronically track emissions from sources issued waivers; therefore, data on average emissions per waiver are unavailable. Mobile source emissions not directly resulting from the Proposed Action, biogenic sources,

urban sources, and other non-industrial emission sources are assumed to be included in monitored background concentrations and are not included in this analysis.

3.2.3 WOGCC/COGCC/UDNR-DOGM/IOGCC Sources

A list of well drilling permits issued between January 1, 2001, and March 31, 2004, have been compiled using permit data obtained from WOGCC, COGCC, UDNR-DOGM, and IOGCC. Information regarding well type and equipment, and historic and current field production will be compiled, and representative emission factors will be developed to calculate emissions by county for both gas wells and crude oil wells.

3.2.4 RFD and RFFA

An inventory of RFD and RFFA sources will be performed for inclusion in the cumulative dispersion modeling. For the purposes of this analysis, RFFA is defined as a source which possesses an unexpired air permit issued on or after July 1, 1999 (18 months prior to January 1, 2001) but the source is not yet operating. The primary source of RFFA information is state permit records obtained through a file data search.

RFD is defined as 1) air emissions from the undeveloped portions of authorized NEPA projects, and 2) air emissions from not-yet-authorized NEPA projects that have been quantified and that are available at the time modeling for this analysis commences. RFD information has been obtained from final NEPA documents that have been submitted to BLM for planned project development and from BLM's ongoing list of projects under development. Undeveloped portions of authorized projects will be obtained by tracking state-permitted project development to determine total wells or other equipment yet undeveloped. For instance, for an authorized gas field development area for which 2,000 wells and 10,000 hp compression were projected and analyzed but only 250 wells have been permitted through WOGCC and 3,000 hp compression have been permitted through WDEQ-AQD as of the inventory end-date of this study, 250 wells and 3,000 hp compression would be RFFA (if permitted within the inventory timeframe), and the remaining 1,750 wells and 7,000 compression would be considered RFD. RFD information from

not-yet-authorized projects currently under development will be obtained from contractors working air quality analyses for those NEPA projects.

Full development of proposed projects inventoried as RFD may or may not coincide with full Atlantic Rim or Seminoe Road project development. As a result, the inclusion of RFD in the cumulative analysis may result in overly conservative impact estimates. To ensure reasonable but conservative analysis results for all stages of project development, the cumulative modeling analysis discussed later in this Protocol will be performed both with and without RFD sources. A preliminary listing of potential RFD projects to be examined in this study, as defined in the paragraph above, is presented in Table 3.1. All development areas will be reviewed for inclusion, and those projects with significant pollutant emissions during production activities will

Table 3.1 Potential RFD in the Study Area.

Big Piney-LaBarge	Lower Brush Creek (Kennedy Oil)
BTA Bravo	Moxa Arch
Burley	Mulligan Draw
Burlington Little Monument	Pacific Rim Shallow Gas
Cave Gulch	Pinedale Anticline
Continental Divide/Wamsutter II	Pioneer Gas Plant
Cooper Reservoir	Powder River Basin (portion within study area)
Copper Ridge Shallow Gas	Riley Ridge
Creston-Blue Gap	Road Hollow
Cutthroat Gas Processing	Sierra Madre
Desolation Flats	Soda Unit
Eighth Granger Gas Plant	South Baggs
Fontenelle Natural Gas Infill	South Piney
Hams Fork Pipeline	Stagecoach
Hickey-Table Mountain	Vermillion Basin
Horse Trap	Wind River
Jack Morrow Hills	9 Lease Management Areas (Bridger-Teton NF)
Jonah Infill Project	

be included as RFD. During completion of this analysis, more detailed development and operations data will be compiled for all RFD and presented in the TSD. To ensure a timely and complete modeling analysis, only development authorized through the inventory end-date of March 31, 2004, or not yet authorized but quantified as of the beginning of the modeling analysis will be included in this analysis. For RFD quantified after the inventory end-date, a qualitative discussion will be presented describing the proposed development(s). Similarly, a qualitative discussion will be presented for development currently proposed in the Powder River Basin Coalbed Methane Development Project, located predominantly outside of the Atlantic Rim/Seminoe Road study domain in northeast Wyoming's Powder River Basin.

4.0 CRITERIA POLLUTANT NEAR-FIELD MODELING

4.1 MODELING METHODOLOGY

The near-field ambient air quality impact assessment will be performed to quantify maximum pollutant impacts in the vicinity of the project area resulting from construction and production emissions. EPA's proposed guideline model, AERMOD (version 02222), will be used to assess these near-field impacts, and EPA's BPIP PRIME will be used to calculate building downwash parameters for input to AERMOD.

The most recent one year of complete meteorological data collected at the Rawlins, Wyoming airport, 2003, will be used in this analysis. Continuous meteorological measurements have been collected at the Rawlins airport since October 2000, and a windrose for the period of record (through December, 2003) is provided in Figure 4.1. These data reflect the most current and representative data measurements in the area.

The AERMOD preprocessor AERMET will be used to process Rawlins meteorological data into formats compatible with AERMOD. In addition to the data collected at the Rawlins surface station, AERMET requires upper air, twice daily sounding, meteorological data. Twice daily sounding data collected at Riverton, Wyoming will be used for this analysis. The AERMAP terrain processor will be used to develop terrain data for receptors used in the analyses.

4.2 BACKGROUND DATA

Background concentration data collected for criteria pollutants at regional monitoring sites will be added to concentrations modeled in the near-field analysis to establish total pollutant concentrations for comparison to ambient air quality standards. The most representative monitored regional background concentrations available for criteria pollutants are shown in

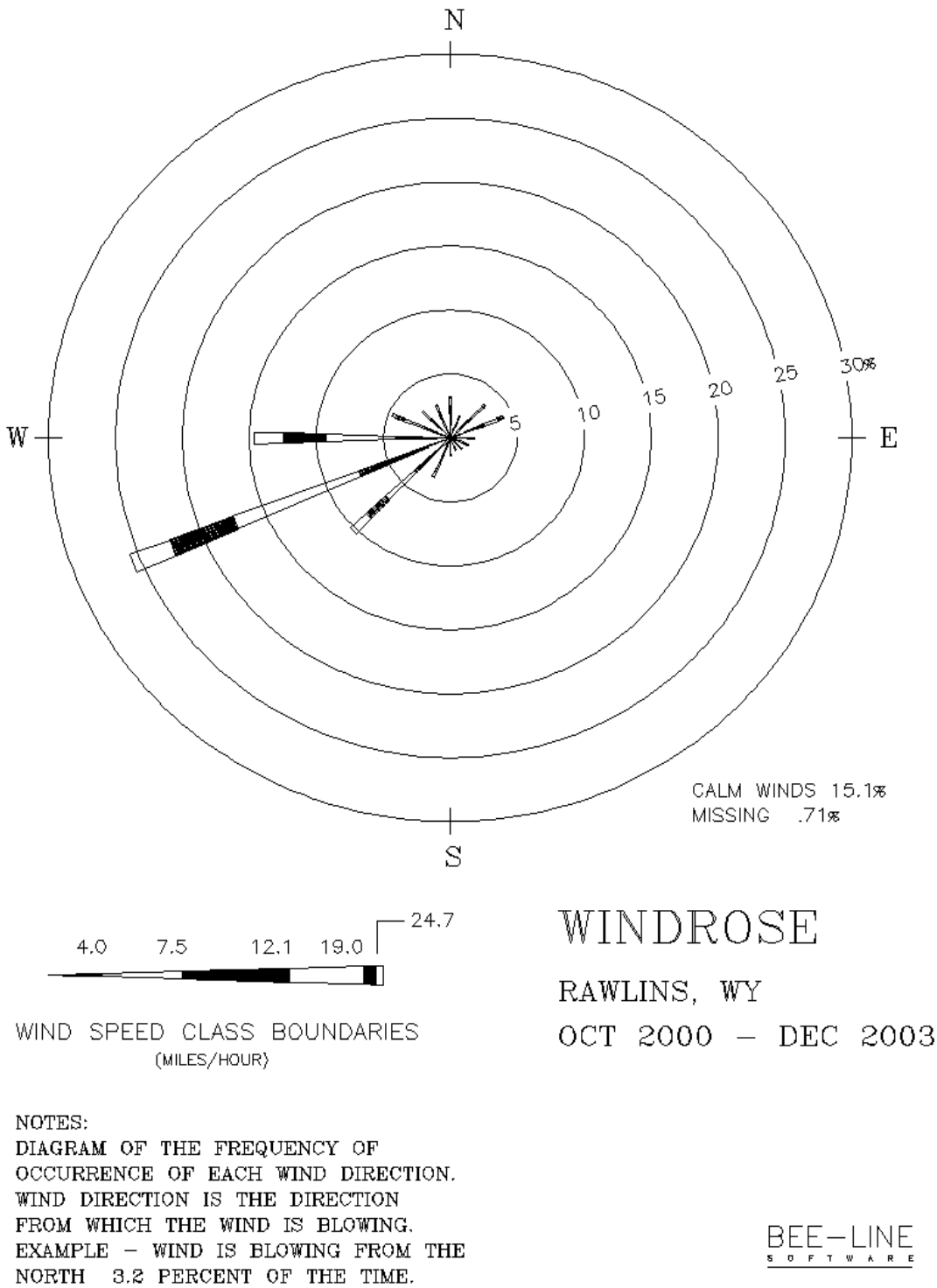

Figure 4.1 Wind Rose, Rawlins, WY 2001-2002.

Table 4.1. Background concentrations of HAPs are not available and are assumed to be minimal; furthermore, comparison thresholds are based on incremental exposure rather than total exposure, as discussed in Section 6.0 of this Protocol.

4.3 CRITERIA POLLUTANT IMPACT ASSESSMENT

Criteria pollutants PM_{10}, $PM_{2.5}$, NO_x, SO_2, and CO will be modeled with AERMOD. Ozone (O_3) formation and impacts will not be modeled using AERMOD; rather, ozone impacts will be estimated from NO_x and VOC emissions using a screening methodology developed by Scheffe (1988). For all other pollutants, emissions of each pollutant will be examined to determine the development phase (i.e., construction or production) during which emissions will be greatest, and it will be this development-phase/emission-rate combination that will be modeled to determine near-field project impacts. Based on previous analyses, it is expected that construction activities will generate the greatest PM_{10}, $PM_{2.5}$, and SO_2 emissions and that production activities will generate the greatest NO_x and CO emissions.

For construction activities, a representative well pad and resource/access road will be developed for each development project that represents a reasonable well pad/road layout. Hourly emission rate adjustment factors will be applied to sources emitting only during specific diurnal/seasonal periods. For PM_{10} and $PM_{2.5}$, this layout will be modeled using the meteorological data described above 36 times, once at each of 36 10º rotations, to ensure that impacts from all directional layout configurations and meteorological conditions are assessed. In accordance with averaging periods for which ambient standards exist, PM_{10} and $PM_{2.5}$ concentrations will be calculated for 24-hour and annual averaging periods, and SO_2 concentrations will be calculated for 3-hour, 24-hour, and annual averaging periods.

NO_x and CO impacts from production activities will be analyzed for each development project. Because the approximate layout is known for the proposed wells and because production emission release characteristics are likely to result in combined impacts of these pollutants, the entire field will be modeled for each project.

Table 4.1 Near-Field Analysis Background Ambient Air Quality Concentrations ($\mu g/m^3$).

Pollutant	Averaging Period	Measured Background Concentration
Carbon monoxide (CO)[1]	1-hour	3,336
	8-hour	1,381
Nitrogen dioxide (NO_2)[2]	Annual	3.4
Ozone (O_3)[3]	1-hour	169
	8-hour	147
PM_{10}[4]	24-hour	33
	Annual	16
$PM_{2.5}$[4]	24-hour	13
	Annual	5
Sulfur dioxide (SO_2)[5]	3-hour	132
	24-hour	43
	Annual	9

1 Data collected by Amoco at Ryckman Creek for an 8-month period during 1978-1979, summarized in the Riley Ridge EIS (BLM 1983).

2 Data collected at Green River Basin Visibility Study site, Green River, Wyoming, during period January-December 2001 (Air Resource Specialists [ARS] 2002).

3 Data collected at Green River Basin Visibility Study site, Green River, Wyoming, during period June 10, 1998, through December 31, 2001 (ARS 2002).

4 Data collected by WDEQ-AQD at Emerson Building, Cheyenne, Wyoming, Year 2001.

5 Data collected at LaBarge Study Area, Northwest Pipeline Craven Creek Site, 1982-1983.

Point sources will be used for modeling NO_x and CO emissions from compressors and well-site combustion equipment and for modeling SO_2 emissions from drilling rigs during construction activities. Volume sources will be used for modeling PM_{10} and $PM_{2.5}$ emissions from road travel and wind erosion during construction activities.

Model receptors will be located a minimum of 200 m from construction emission sources at 100-m grid spacing. Following WDEQ-AQD compressor modeling guidance, model receptors will be placed at 50-m intervals along anticipated compressor facility fencelines. Receptors beyond the compressor facility fenceline will be placed at 100-m intervals. Compressor stack heights will be set at actual or proposed heights but no greater than 1.5 times compressor building heights. Compressor stations will be based on currently permitted compressor stations

within each project area and building downwash data will be input to the model as developed for existing permitting efforts.

4.4 HAP IMPACT ASSESSMENT

Near-field HAP concentrations will be calculated for assessing impacts both in the immediate vicinity of project area emission sources for short-term (acute) exposure assessment and at greater distances for calculation of long-term risk. Because HAPs will be emitted predominantly during the production phase, only HAP emissions from production will be analyzed.

Negligible HAPs would be emitted from coal bed methane wells aside from formaldehyde emitted from combustion equipment. Formaldehyde emissions would occur from any combustion equipment located at coalbed methane wells and at compressor stations located within the ARPA and SRPA. Formaldehyde, benzene, toluene, ethylbenzene, xylene, and n-hexane would occur from well combustion, gas dehydration, fugitive leaks, and condensate liquids storage at traditional natural gas wells within the ARPA. All of these HAPs will be analyzed.

The modeling methodology for the short-term and long-term HAP impact assessments is nearly identical to the methodology outlined in Section 4.1. Volume or area sources will be used for modeling any well-site fugitive HAP emissions or field-wide generation, and point sources will be used to represent compressor station engine emissions.

Field-wide emissions sources will be modeled. Receptors will be placed a minimum of 100 m from production wells and at 100-m spacing beyond. Receptors will be placed at 50-m intervals along compressor fence lines and at 100-m spacing beyond. The short-term HAP assessment will consist of modeling formaldehyde emissions from a representative natural gas-fired compressor station and downhole pump generators at each well in the field-wide configuration developed for the NOx and CO modeling as described in Section 4.3. For the long-term assessment, field-wide emissions will be modeled with receptors placed at the location of the nearest residence to any production operation.

Short-term (1-hour) HAP concentrations will be compared to acute Reference Exposure Levels (RELs), shown in Table 4.2. RELs are defined as concentrations at or below which no adverse health effects are expected. No RELs are available for ethylbenzene and n-hexane; instead, the available Immediately Dangerous to Life or Health (IDLH) values are used. These IDLH values are determined by the National Institute for Occupational Safety and Health (NIOSH) and were obtained from EPA's Air Toxics Database (EPA 2002).

Long-term exposure to HAPs emitted by the Proposed Actions will be compared to Reference Concentrations for Chronic Inhalation (RfCs). An RfC is defined by EPA as the daily inhalation concentration at which no long-term adverse health effects are expected. RfCs exist for both non-carcinogenic and carcinogenic effects on human health (EPA 2002). Annual modeled HAP concentrations for all HAPs emitted will be compared directly to the non-carcinogenic RfCs shown in Table 4.3.

RfCs for suspected carcinogens benzene and formaldehyde are expressed as risk factors, shown in Table 4.4. Accepted methods for risk assessment will be used to evaluate the incremental cancer risk for these pollutants.

Annual modeled concentrations will be multiplied by EPA's unit risk factors (URF) (based on 70-year exposure) for those pollutants, and then the product will be multiplied by an adjustment factor that represents the ratio of projected exposure time to 70 years. The adjustment factors represent two scenarios: a most likely exposure (MLE) scenario and one reflective of the maximally exposed individual (MEI).

The MLE duration will be assumed to be 9 years, which corresponds to the mean duration that a family remains at a residence (EPA 1993). This duration corresponds to an adjustment factor of 9/70 = 0.13. The duration of exposure for the MEI is assumed to be 50 years (i.e., the LOP), corresponding to an adjustment factor of 50/70 = 0.71.

Table 4.2 Acute RELs.

HAP	REL (mg/m^3)
Benzene	1.3 [1]
Toluene	37 [1]
Ethylbenzene	35 [2]
Xylene	22 [1]
n-Hexane	39 [2]
Formaldehyde	0.094 [1]

[1] EPA Air Toxics Database, Table 2 (EPA 2002).
[2] No REL available for these HAPs. Values shown are from Immediately Dangerous to Life or Health (IDLH/10), EPA Air Toxics Database, Table 2 (EPA 2002).

Table 4.3 Non-Carcinogenic HAP RfCs.

HAP	Non-Carcinogenic RfC [1] ($\mu g/m^3$)
Benzene	30
Toluene	400
Ethylbenzene	1,000
Xylenes	430
n-Hexane	200
Formaldehyde	9.8

[1] EPA Air Toxics Database, Table 1 (EPA 2002).

Table 4.4 Carcinogenic HAP URFs and Exposure Adjustment Factors.

Analysis[1]	HAP Constituent	Carcinogenic URF (Unit Risk Factor) [2] $1/(\mu g/m^3)$	Exposure Adjustment Factor
MLE	Benzene	7.8×10^{-6}	0.0949
MLE	Formaldehyde	1.3×10^{-5}	0.0949
MEI	Benzene	7.8×10^{-6}	0.71
MEI	Formaldehyde	1.3×10^{-5}	0.71

[1] MLE = most likely exposure; MEI = maximally exposed individual.
[2] EPA Air Toxics Database, Table 1 (EPA 2002).

A second adjustment will be made for time spent at home versus time spent elsewhere. For the MLE scenario, the at-home time fraction is 0.64 (EPA 1993), and it will be assumed that during the rest of the day the individual would remain in an area where annual HAP concentrations would be one quarter as large as the maximum annual average concentration. Therefore, the MLE adjustment factor will be (0.13) x [(0.64 x 1.0) + (0.36 x 0.25)] = 0.0949. The MEI scenario assumes that the individual is at home 100% of the time, for a final adjustment factor of (0.71 x 1.0) = 0.71. EPA unit risk factors and adjustment factors are shown in Table 4.4.

5.0 FAR-FIELD ANALYSIS

5.1 METHODOLOGY

The purpose of the far-field analysis is to quantify the impacts on Class I and other sensitive areas from air pollutant emissions expected to result from the development of the two projects. Ambient air quality impacts beyond the immediate project areas and throughout the study area will be analyzed. Cumulative impacts also will be quantified by including in the analysis other documented sources of air pollutant emissions within the study area. To achieve these goals, the most current long-range modeling analysis tools will be used in conjunction with the most recent guidance for their utilization.

As requested by BLM and generally accepted for long-range modeling analyses, the CALMET/CALPUFF modeling system (Earth Tech 2003) will be used in this analysis. The study will be performed in accordance with the following recent and major guidance sources:

- guidance provided by representatives of the BLM, the National Park Service, and the USDA Forest Service;
- *Guideline on Air Quality Models*, 40 *Code of Federal Regulations* (C.F.R.), Part 51, Appendix W;
- *Interagency Work Group on Air Quality Modeling (IWAQM) Phase 2 Summary Report and Recommendations for Modeling Long Range Transport Impacts*, EPA-454/R-98-019, Office of Air Quality Planning and Standards, December 1998 (IWAQM 1998); and
- *Federal Land Managers - Air Quality Related Values Workgroup (FLAG), Phase I Report*, December 2000 (FLAG 2000).

Air emissions of NO_x, SO_2, PM_{10}, and $PM_{2.5}$ from 1) the Atlantic Rim Proposed Action, 2) the Seminoe Road Proposed Action, and 3) cumulative emissions, including all currently permitted and operating, permitted but not yet operating, and RFD emissions sources within the modeling

domain as described in Section 3.0 will be modeled. The idealization of these emissions sources for input to the CALPUFF model is described in Section 5.2.

The proposed modeling domain for this analysis, along with other regional features, is shown in Figure 3.1. This modeling domain was developed following IWAQM guidance, which suggests that the domain should extend at least 50 km beyond sources and receptor areas. This guidance was followed to the extent possible based on the MM5 data available. The CALPUFF dispersion model will be run with CALMET wind field data, developed for year 1995, to predict the transport and dispersion of pollutants. The CALMET year was selected because of the availability of 20 km mesoscale model (MM5) data which was developed for use in other EIS projects in this region and the SWWYTAF study.

CALPUFF output will be post-processed with POSTUTIL and CALPOST to derive concentrations for comparison to ambient standards, significance thresholds, and Class I and II Increments; deposition rates for comparison to sulfur (S) and nitrogen (N) deposition thresholds and to calculate acid neutralizing capacity (ANC) for sensitive water bodies; and light extinction for comparison to visibility impact thresholds in Class I and other sensitive areas. A discussion of the post-processing methodology to be used is provided in Section 5.3 of this Protocol.

5.2 MODEL INPUT

5.2.1 Model Selection and Settings

5.2.1.1 CALMET

The most recently released version of the CALMET modeling system (July 11, 2003) will be used. The SWWYTAF CALMET methodology is proposed for use in combination with meteorological data updated for use in the Pinedale Anticline EIS. This approach ensures consistency with the well-accepted SWWYTAF study while incorporating improved data quality resulting from extensive quality assurance/quality control (QA/QC) procedures performed on data used in the Pinedale Anticline EIS (BLM 1999a). This analysis utilizes the regional

mesoscale meteorological (MM5) data subgrid processed to 20-km spacing, and surface and precipitation data updated for use in the Pinedale Anticline EIS as discussed below.

The CALMET wind fields utilized in the Pinedale Anticline EIS study were based upon wind fields developed by Earth Tech for the SWWYTAF study (Earth Tech 2001). As part of the Pinedale Anticline EIS, Air Sciences performed extensive review and QA/QC of surface station and precipitation data used in SWWYTAF, and corrections were made. These QA/QC'd surface data will be used in this analysis, along with additional surface stations not included in the Pinedale Anticline study.

A total of 51 surface meteorological stations will be used. Of these stations, an additional six stations that were originally included in SWWYTAF but not used in the Pinedale Anticline analysis and two Wyoming Department of Transportation surface stations were added to the dataset. Appendix A lists all surface meteorological data sites proposed for use in this CALMET analysis.

A total of 134 precipitation stations used in the SWWYTAF study will be used for this analysis. The Pinedale Anticline modeling analysis identified problems with the subset of the original SWWYTAF precipitation data files that were used in the Pinedale Anticline study – specifically, that the data for the month of December were missing. The SWWYTAF precipitation data proposed for use in this analysis have been corrected.

Four upper air meteorological stations will be used to supplement the MM5 upper air estimates in accordance with National Park Service (NPS) recommendations. Denver and Grand Junction, Colorado, Salt Lake City, Utah, and Riverton, Wyoming upper air data will be used in this analysis

Differences between the SWWYTAF study and the Pinedale Anticline EIS study include 1) upper air observations were not used in the Pinedale Anticline EIS and 2) changes were made to CALMET input settings in the Pinedale Anticline EIS from those originally used in

SWWYTAF. A detailed description of the modeling methodology used in the Pinedale Anticline EIS can be found in the supporting air quality technical document (BLM 1999b).

The uniform horizontal grid is processed to 4-km resolution, based on a Lambert Conformal Projection defined with a central longitude/latitude at (-108.55°, 42.55°) and first and second latitude parallels at 30° and 60°. The modeling domain consists of 125 x 100 4-km grid cells, and covers the project area and Class I and other sensitive areas with a sufficient buffer zone to allow for potential recirculation or flow reversal effects to be evaluated. The total area of the modeling domain is 500 x 400 km. Ten vertical layers exist at heights of 20, 40, 100, 140, 320, 580, 1,020, 1,480, 2,220, and 2,980 m. The extents of the horizontal grid, which form the extents of the cumulative study area, are shown in Figure 3.1.

5.2.1.2 CALPUFF

The most recently released version of the CALPUFF modeling system (July 11, 2003) will be used. The CALPUFF model will be run using the IWAQM-recommended default switch settings for all parameters. Chemical transformation will be based on the MESOPUFF II chemistry for conversion of SO_2 to sulfate (SO_4) and NO_x to nitric acid (HNO_3) and nitrate (NO_3). Each of these pollutant species will be included in the CALPUFF model run. NO_x, HNO_3, and SO_2 will be modeled with gaseous deposition and SO_4, NO_3, PM_{10}, and $PM_{2.5}$ will be modeled using particle deposition. Electronic copies of CALMET, CALPUFF, and CALPOST input files will be included with the TSD.

5.2.2 Emissions

5.2.2.1 Project Emissions

Pollutant emission rates estimated as described in Section 3.0 will be input to CALPUFF to predict air quality impacts from the projects. Emissions from both the construction phase and well production (field operation) phase will be modeled for each project. Emissions from construction activities and production activities over each project's LOP may be examined to

determine an annual period representing a maximum combination of production and construction.

Particulate emissions generated from production traffic and construction traffic will be included in the field-wide modeling scenarios to estimate maximum in-field PM_{10} and $PM_{2.5}$ impacts. However, for far-field modeling scenarios, only $PM_{2.5}$ traffic emissions will be included. It is assumed that most of the particles larger than $PM_{2.5}$ would deposit out near the emissions source and would not transport to the distant sensitive receptor areas.

Hourly emission-rate adjustment factors will be applied to emissions that occur only during specific diurnal periods, such as travel on unpaved roads. Seasonal adjustment factors will be applied to compensate for increased gas well-heater use in the winter months. Well locations will be modeled as area sources within the specific project area they are projected to be located in, on a rectangular grid not exceeding 4 x 4 km spacing and possessing a total area not exceeding the total area of the respective project area. Compressor-engine emissions will be input as point sources with actual expected stack parameters at their permitted locations. It is anticipated that compression emissions will be modeled at 90% load in the far-field analysis only.

Although the Seminoe Road Proposed Action includes electrification of the field and thus the elimination of natural gas-fired generators at pumps within the field, a second scenario is proposed to be analyzed which assumes no electricity would be available in the field throughout the LOP. The Atlantic Rim Proposed Action does not yet include a definitive plan for electrification; therefore, only a non-electrified scenario is proposed to be analyzed for the ARPA at this time.

5.2.2.2 Cumulative Source Emissions

Cumulative sources, including permitted sources, RFD, and RFFA inventoried following the methodology described in Section 3.2, will be input to the CALPUFF model as point sources or area sources. As part of the emissions inventory, source location and exit parameter data will be

obtained. Permitted and proposed sources will be modeled both alone and with RFD and RFFA sources to provide a clear analysis of the impacts attributable to each.

Pollutant emissions from stacks will be modeled as point sources in the CALPUFF model. Multiple stacks within single facilities will be combined into a single, worst-case stack to reduce model run-time. Worst-case stack parameters will be selected based on the potential for the greatest long-range impacts (i.e., greater stack height, greater exhaust flow rate).

Fugitive emissions will be aggregated into area sources in the model, and area sources will be placed either specific to individual source locations or specific to the region in which the sources are location, depending upon the nature of the fugitive emissions sources. The locations of area sources input to the model will be disclosed in the TSD. Because regional paved and unpaved roadway travel not associated with any specific regional well development field and biogenic sources are considered to be included in the ambient air background concentrations described in this Protocol, those fugitive sources will not be modeled.

5.2.3 Receptors

Model receptors will be input to CALPUFF, at which concentration, deposition, and other impacts will be calculated. A gridded Cartesian receptor grid will be placed in and around the project area to identify maximum cumulative concentrations. Receptors will be placed along the boundaries of all Class I and sensitive areas at 2-km spacing and within the boundaries of those areas at 4-km resolution.

Prevention of Significant Deterioration (PSD) Class I and other sensitive areas located within the modeling domain and the distance of each from the ARPA and SRPA are shown in Figure 3.1. Federal Class I areas to be evaluated are as follows:

- Bridger Wilderness Area,
- Fitzpatrick Wilderness Area,
- Mount Zirkel Wilderness Area,
- Rawah Wilderness Area,
- Rocky Mountain National Park,

- Savage Run Wilderness Area (Federal Class II, Wyoming Class I), and
- Dinosaur National Monument (Federal Class II, Colorado Class I SO_2 only).

Several PSD Class II areas are located within the modeling domain for which ambient air and AQRV impacts assessments are not mandatory but have been requested. These Class II sensitive areas are as follows:

- Popo Agie Wilderness Area (Federal Class II) and
- Wind River Roadless Area (Federal Class II).

In addition, discrete receptors will be placed at the following sensitive lakes identified as the most sensitive to acid deposition:

- Black Joe Lake, Bridger Wilderness Area,
- Deep Lake, Bridger Wilderness Area,
- Hobbs Lake, Bridger Wilderness Area,
- Lazy Boy Lake, Bridger Wilderness Area,
- Upper Frozen Lake, Bridger Wilderness Area,
- Ross Lake, Fitzpatrick Wilderness Area,
- West Glacier Lake, Glacier Lakes Ecosystem Experiments Site (GLEES),
- Lake Elbert, Mount Zirkel Wilderness Area,
- Seven Lakes, Mount Zirkel Wilderness Area,
- Summit Lake, Mount Zirkel Wilderness Area,
- Lower Saddlebag Lake, Popo Agie Wilderness Area,
- Island Lake, Rawah Wilderness Area,
- Kelly Lake, Rawah Wilderness Area, and
- Rawah Lake #4, Rawah Wilderness Area.

5.2.4 Background Data

5.2.4.1 Criteria Pollutants

Ambient air concentration data collected at monitoring sites in the region provide a measure of background conditions in existence during the most recent available time period. Regional monitoring-based background values for criteria pollutants (PM_{10}, $PM_{2.5}$, NO_x, and SO_2) were collected at monitoring sites in Wyoming and are summarized in Table 5.1. These ambient air background concentrations will be added to modeled pollutant concentrations (expressed in micrograms per cubic meter [$\mu g/m^3$]) to arrive at total ambient air quality impacts for comparison to National Ambient Air Quality Standards (NAAQS) and Wyoming Ambient Air Quality Standards (WAAQS), as discussed in Section 6.0.

Table 5.1 Far-Field Analysis Background Ambient Air Quality Concentrations ($\mu g/m^3$).

Pollutant	Averaging Period	Measured Background Concentration
Nitrogen dioxide (NO_2)[1]	Annual	3.4
Ozone (O_3)[2]	1-hour	169
	8-hour	147
PM_{10}[3]	24-hour	33
	Annual	16
$PM_{2.5}$[3]	24-hour	13
	Annual	5
Sulfur dioxide (SO_2)[4]	3-hour	132
	24-hour	43
	Annual	9

1 Data collected at Green River Basin Visibility Study site, Green River, Wyoming during period January-December 2001 (ARS 2002).
2 Data collected at Green River Basin Visibility Study site, Green River, Wyoming during period June 10, 1998, through December 31, 2001 (ARS 2002).
3 Data collected by WDEQ-AQD at Emerson Building, Cheyenne, Wyoming, Year 2001.
4 Data collected at LaBarge Study Area at the Northwest Pipeline Craven Creek Site 1982-1983.

5.2.4.2 Chemical Species

The CALPUFF chemistry algorithms require hourly estimates of background ammonia and ozone concentrations for the conversion of SO_2 and NO/NO_2 to sulfates and nitrates, respectively. While ammonia concentrations are thought to be fairly uniform spatially, ozone concentrations vary greatly over time and space. A review of background ozone data indicates that six ozone stations are available in the region for year 1995. 1995 ozone data are used because they are concurrent with the CALMET windfields, which were created using 1995 surface and MM5 datasets. Ozone stations proposed for use are as follows:

- Pinedale, Wyoming,
- Centennial, Wyoming,
- Yellowstone National Park, Wyoming,
- Craters of the Moon National Park, Idaho,
- Highland, Utah, and
- Mount Zirkel Visibility Study, Hayden, Colorado.

Hourly ozone data from these stations will be included in the CALPUFF modeling, with a default value of 44.7 parts per billion (ppb) (7 a.m.-7 p.m. mean, used for SWWYTAF) used for missing hours. A background ammonia concentration of 1.0 ppb as suggested in the IWAQM Phase 2 guidance (for arid lands) will be used.

5.2.4.3 Visibility

The proposed analysis differs from previous Wyoming NEPA cumulative air quality analyses in its update of visibility background to include the most current data available at the time of this Protocol. Monitored visibility background data that have undergone QA/QC are currently available through December 31, 2002. This analysis proposes to utilize IMPROVE visibility data for the period of record 1988 through 2002 and 2001 NO_x background data collected in the final year of the Green River Basin Visibility Study and to revise the period of regional emissions inventory to reflect industrial activity occurring during and since that updated

background to represent the most appropriate combination of measured background and modeled impacts.

WDEQ-AQD has prepared an annual report on Wyoming's long-term strategy for visibility protection in Class I areas (WDEQ 2003). An assessment of visibility monitoring data is presented as Appendix F of that report, including an analysis of trends in visibility monitored at Wyoming IMPROVE, Wyoming Visibility Monitoring Network sites, and Regional IMPROVE sites. Bridger Wilderness, Mount Zirkel Wilderness, and Rocky Mountain National Park IMPROVE sites are the closest monitoring sites to the project area, and data reported from these sites extend from January 1989 through December 2001. As a result, visibility trends at these sites are of particular interest. These visibility trends are well-illustrated by graphs in WDEQ-AQD's report, Graphs 3 and 6, which are presented in Appendix B of this Protocol. A detailed description of the data and assumptions behind these graphs are not presented here; rather, the reader is referred to the WDEQ-AQD report (WDEQ 2003).

As this graph indicates, visibility conditions at the Bridger Wilderness and Rocky Mountain National Park have not decreased since 1989 (Bridger WA), 1995 (Mount Zirkel WA), and 1991 (Rocky Mountain NP) (Appendix B). It is important to note the significant fluctuations in monitored visibility during the period from 1995 through 1997 and that previous Wyoming NEPA cumulative air quality analyses utilized visibility background data monitored through 1997. Updating background visibility will improve the quality of the analysis by providing a longer period of record and allowing a better estimate of long-term visibility conditions in the region.

CALPOST will be used to estimate change in light extinction from CALPUFF model concentration results. At the request of the BLM and following the most current agency recommendations, two separate methods are proposed for this analysis: FLAG and IMPROVE.

The FLAG method uses seasonal natural background visibility conditions and relative humidity factors at Class I areas. This method is highly conservative since values of estimated natural

background are generally less than measured background, and a calculated light extinction value will therefore comprise a greater percentage of the total light extinction (background plus calculated). For the FLAG method proposed for this analysis, estimated natural background visibility values as provided in Appendix 2.B of FLAG (2000), and monthly relative humidity factors as provided in the *Draft Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule* (EPA 2001) will be used. Because natural background data are provided for Federal Class I areas only, data from the nearest Federal Class I area will be used for other areas analyzed but not classified as Federal Class I areas. The natural background visibility data that will be used with the FLAG visibility analysis for each area analyzed are shown in Table 5.2.

Table 5.2 FLAG Report Background Extinction Values.[1]

Site	Season	Hygroscopic (Mm^{-1})	Non-hygroscopic (Mm^{-1})
Bridger Wilderness Area	Winter	0.6	4.5
(will also be used for Popo Agie Wilderness Area and	Spring	0.6	4.5
Wind River Roadless Area)	Summer	0.6	4.5
	Fall	0.6	4.5
Fitzpatrick Wilderness Area	Winter	0.6	4.5
	Spring	0.6	4.5
	Summer	0.6	4.5
	Fall	0.6	4.5
Mount Zirkel Wilderness Area	Winter	0.6	4.5
(will also be used for Savage Run Wilderness Area	Spring	0.6	4.5
and Dinosaur National Park)	Summer	0.6	4.5
	Fall	0.6	4.5
Rawah Wilderness Area	Winter	0.6	4.5
	Spring	0.6	4.5
	Summer	0.6	4.5
	Fall	0.6	4.5
Rocky Mountain National Park	Winter	0.6	4.5
	Spring	0.6	4.5
	Summer	0.6	4.5
	Fall	0.6	4.5

[1] FLAG (2000).

The IMPROVE method uses reconstructed IMPROVE aerosol extinction data. Background visibility data will be based on the quarterly mean of the 20% cleanest days measured at the Bridger Wilderness Area, Mount Zirkel Wilderness Area, and Rocky Mountain National Park IMPROVE sites. The IMPROVE method will also utilize monthly relative humidity factors as provided in the *Draft Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule*. The seasonal mean of the 20% cleanest days visibility data will be determined using data from the historical record through December 2002.

Visibility data from the Bridger Wilderness Area IMPROVE site will be used for the Bridger, Fitzpatrick, and Popo Agie Wilderness Areas and for the Wind River Roadless Area. Visibility data from the Rocky Mountain National Park IMPROVE site will be used for Rawah Wilderness Area and for Rocky Mountain National Park, and data from the Mount Zirkel IMPROVE site will be used for the Mount Zirkel and Savage Run Wilderness Areas and for Dinosaur National Park. Monthly relative humidity data are available for the Bridger, Fitzpatrick, Mount Zirkel, and Rawah Wilderness Areas and for Rocky Mountain National Park. Relative humidity data for the Bridger Wilderness Area will also be used for the Popo Agie Wilderness Area and for the Wind River Roadless Area analyses, and relative humidity data for the Mount Zirkel Wilderness Area will be also be used for the Savage Run Wilderness Area and for Dinosaur National Park.

5.2.4.4 Lake Chemistry

The most recent lake chemistry background ANC data have been obtained from the FLMs for each sensitive lake listed in Section 5.2.4. The 10th percentile lowest ANC values were calculated for each lake following procedures provided from the USDA Forest Service. The ANC values proposed for use in this analysis and the number of samples used in the calculation of the 10th percentile lowest ANC values are provided in Table 5.3.

Table 5.3 Background ANC Values for Acid Sensitive Lakes.

Wilderness Area	Lake	Latitude (Deg-Min-Sec)	Longitude (Deg-Min-Sec)	10th Percentile Lowest ANC Value (µeq/l)	Number of Samples
Bridger	Black Joe	42º44’22”	109º10’16”	67.0	61
Bridger	Deep	42º43’10”	109º10’15”	59.9	58
Bridger	Hobbs	43º02’08”	109º40’20”	69.9	65
Bridger	Lazy Boy	43º19’57”	109º43’47”	18.8	1
Bridger	Upper Frozen	42º41’08”	109º09’38”	5.0	6
Fitzpatrick	Ross	43º22’41”	109º39’30”	53.5	44
GLEES [1]	West Glacier Lake	41º22’38”	106º15’31”	35.2	14
Mount Zirkel	Lake Elbert	40º38’3”	106º42’25”	51.9	55
Mount Zirkel	Seven Lakes (LG East)	40º53’45”	106º40’55”	36.2	55
Mount Zirkel	Summit Lake	40º32’43”	106º40’55”	47.3	95
Popo Agie	Lower Saddlebag	42º37’24”	108º59’38”	55.5	43
Rawah	Island Lake	40º37’38”	105º56’26”	68.7	15
Rawah	Kelly Lake	40º37’32”	105º57’34”	181.1	13
Rawah	Rawah Lake #4	4040’16”	105º57’28”	41.2	13

[1] GLEES (Glacier Lakes Ecosystem Experiments Site), Medicine Bow National Forest, Snowy Range, Wyoming.

5.3 POST-PROCESSING

5.3.1 Concentration

CALPOST will be used to process the CALPUFF concentration output file to compute maximum concentration values for SO_2 (3-hour, 24-hour, and annual average), $PM_{2.5}$ (24-hour and annual average), PM_{10} (24-hour and annual average), and NO_2 (annual average).

5.3.2 Visibility

As discussed in Section 5.2.4.3, visibility impacts (measured as change in light extinction) will be calculated using two separate methods, which differ by the background data used to derive the percent change in visibility. Changes in light extinction will be estimated for both project emissions and cumulative source emissions at receptor locations outlined in Section 5.2.3 of this Protocol.

CALPOST will first be run using the FLAG method recommended screening mode (MVISBK = 6) to calculate the change in light extinction from natural background conditions. This procedure computes light extinction changes from seasonal estimates of natural background aerosol concentrations and monthly relative humidity factors from the Regional Haze Rule and CALPUFF-predicted particle species concentrations. Seasonal background extinction values used for the FLAG method are shown in Table 5.2. Those values will be input to CALPOST as variables $BKSO_4$ (dry hygroscopic) and BKSOIL (non-hygroscopic). Using these parameters, CALPOST will compute the change in daily (24-hour) visibility, with the results reported in percent change in light extinction and change in deciview (dv). The FLAG method conservatively assumes that the seasonal natural visibility conditions occur on every day during the entire season.

CALPOST will then be run using the IMPROVE method to calculate the change in light extinction using the quarterly mean of the 20% cleanest days particle mass data as background conditions. Quarterly speciated aerosol data for the 20% cleanest days, measured at the Bridger

and Mount Zirkel Wilderness Areas and Rocky Mountain National Park IMPROVE sites will be used. This method uses the quarterly background aerosol concentrations and monthly averaged relative humidity factors to estimate the change in light extinction. The CALPOST switch 'MVISBK' is set to 6 for this method. Similar to the FLAG method, the WDEQ method also conservatively assumes that the cleanest seasonal visibility conditions occur on every day during the entire season.

5.3.3 Deposition

The POSTUTIL utility provided with the CALPUFF modeling system will be used to estimate total S and N fluxes from CALPUFF-predicted wet and dry fluxes of SO_2, SO_4, NO_x, NO_3, HNO_3, PM_{10}, and $PM_{2.5}$. CALPOST will be used to summarize the annual S and N deposition values from the POSTUTIL program.

6.0 ASSESSMENT OF AIR QUALITY IMPACTS

6.1 NEAR-FIELD

Pollutant significance levels are set forth in Wyoming Air Quality Standards and Regulations (WAQSR). Under the New Source Review (NSR) process, an emission source that models pollutant concentrations (from its operations alone) that are below these significance levels is typically exempt from additional modeling analyses for the insignificant pollutant. In this near-field modeling analysis, significance levels will be compared to project concentrations predicted by AERMOD as an indicator of the magnitude of impact from each project alone. Another demonstration of project-only impacts will be made by comparison of project concentrations to Class II PSD Increments. This demonstration is for information only and is not a regulatory PSD Increment consumption analysis, which would be completed as necessary during the WDEQ-AQD permitting process.

In addition, the WDEQ-AQD has been authorized by EPA to enforce ambient air quality standards set forth in the *Clean Air Act* through approval of the Wyoming State Implementation Plan. The NAAQS and ambient standards adopted by state regulatory agencies set absolute upper limits for specific air pollutant concentrations (expressed in $\mu g/m^3$) at all locations where the public has access. Modeled concentrations occurring from construction and production operations will be added to the existing ambient air quality background concentrations shown in Table 4.1, and the total concentrations will be compared to corresponding NAAQS and WAAQS shown in Table 6.1.

Ambient air quality standards, significance levels, and PSD Class II Increments are shown in Table 6.1.

Table 6.1 Ambient Standards, Class II PSD Increments, and Significance Levels for Comparison to Near-Field Analysis Results ($\mu g/m^3$).

Pollutant/Averaging Time	Ambient Air Quality Standards		PSD Class II Increment	Class II Significance Level
	National	Wyoming		
Carbon monoxide (CO)				
1-hour[1]	40,000	40,000	--	2,000
8-hour[1]	10,000	10,000	--	500
Nitrogen dioxide (NO_2)				
Annual[2]	100	100	25	1
Ozone (O_3)				
1-hour	235	235	--	--
8-hour[3]	157	157	--	--
PM_{10}				
24-hour[1]	150	150	30	5
Annual[2]	50	50	17	1
$PM_{2.5}$				
24-hour[4]	65	65	NA	--
Annual [4]	15	15	NA	--
Sulfur dioxide (SO_2)				
3-hour[1]	1,300	1,300	512	25
24-hour[1]	365	260	91	5
Annual[2]	80	60	20	1

1 No more than one exceedance per year.
2 Annual arithmetic mean.
3 Average of annual fourth-highest daily maximum 8-hour average.
4 Proposed.

6.2 FAR-FIELD

6.2.1 NAAQS and WAAQS

Modeled concentrations of NO_x, SO_2, PM_{10}, and $PM_{2.5}$ from each project alone, predicted at regular grid spacing throughout the modeling domain, will be compared to corresponding NAAQS and WAAQS shown in Table 6.1. Cumulative impacts (i.e., projects plus permitted state inventories, RFD, and RFFA) predicted at these receptors will also be compared to the NAAQS and WAAQS.

6.2.2 Class I and Class II Increments

Under federal and state PSD regulations, increases in ambient air concentrations in Class I areas are limited by PSD Class I Increments. Specifically, emissions associated with a particular development may increase ambient concentrations above baseline levels only within those specific increments developed for SO_2, PM_{10}, and NO_2. PSD Class I Increments are set forth in federal and state PSD regulations and are shown in Table 6.2. EPA has also proposed modeled significance levels for Class I areas, which would eliminate further analysis under the NSR program if ambient concentrations were shown to be below significance levels (also shown in Table 6.2). PSD Class II Increments are applicable in Class II areas and are shown in Table 6.1.

Table 6.2 PSD Class I Increments and Significance Level Concentrations ($\mu g/m^3$).

Pollutant	Averaging Period	Class I Increment	Significance Level[1]
SO_2	Annual	2	0.1
	24-hour	5	0.2
	3-hour	25	1.0
PM_{10}	Annual	4	0.2
	24-hour	8	0.3
NO_2	Annual	2.5	0.1

[1] Proposed Class I significance levels, *Federal Register*/Vol. 61, No. 142, pg. 38292, July 23, 1996.

Modeled concentrations predicted in Federal PSD Class I areas from each project alone will be compared to Class I significance levels and Class I Increments, and cumulative modeling results
predicted within Federal PSD Class I areas will be compared to Class I Increments. Project and cumulative impacts predicted at sensitive areas designated as PSD Class II areas will be compared to Class II Increments.

These demonstrations are for information only and are not regulatory PSD Increment consumption analyses, which would be completed during WDEQ-AQD permitting processes if required. Emissions sources of the size associated with this natural gas development are typically too small to require a PSD Increment analysis.

6.2.3 Visibility

Atmospheric light extinction relative to background conditions is used to measure regional haze. Analysis thresholds for atmospheric light extinction are set forth in FLAG (2000). The thresholds are defined as 5% and 10% of the reference background visibility (or 0.5 and 1.0 dv) for projects sources alone and cumulative source impacts, respectively. In general, if impacts are greater than these thresholds, FLMs may consider conditions (magnitude, frequency, duration, etc.) of the impact on a case by case basis. These thresholds and the FLAG guidelines were developed for NSR applications where an AQRV analysis is required as part of a PSD permit application.

6.2.4 Deposition

CALPUFF will be used to predict the total wet and dry fluxes of SO_2, SO_4, NO_x, NO_3, and HNO_3 at the sensitive receptor areas. The modeled deposition flux of each oxide of S or N will then be adjusted for the difference of the molecular weight of their oxide and then summed to yield a total deposition flux of S or N. The total S deposition and N deposition from project emissions will be calculated and presented in kilograms/hectare/year (kg/ha/yr). These values will be compared to the 0.005 kg/ha/yr deposition analysis thresholds defined by NPS for total N and total S in the western U.S. (NPS 2001). Estimated total deposition fluxes of S and N from cumulative source impacts at sensitive areas will be compared with threshold values for

terrestrial ecosystems presented by the USDA Forest Service in its screening procedure to evaluate effects of air pollution in eastern region wildernesses cited as Class I air quality areas (Fox et al. 1989). These threshold values are 5 and 3 kg/ha/yr for total S and N deposition fluxes, respectively.

6.2.5 ANC

The CALPUFF-predicted annual deposition fluxes of S and N at sensitive lake receptors listed in Section 5.2.3 will be used to estimate the change in ANC. The change in ANC will be calculated following the January 2000, USDA Forest Service Rocky Mountain Region's *Screening Methodology for Calculating ANC Change to High Elevation Lakes, User's Guide* (USDA Forest Service 2000). The predicted changes in ANC will be compared with the USDA Forest Service's Level of Acceptable Change (LAC) thresholds of 10% for lakes with ANC values greater than 25 microequivalents per liter (μeq/l) and 1 μeq/l for lakes with background ANC values of 25 μeq/l and less. Lake impacts will be assessed with consideration of limited data points available for Upper Frozen Lake and Lazy Boy Lake. ANC calculations will be performed for both project emissions and for cumulative source emissions.

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APPENDIX A:
CALMET SURFACE STATIONS

Table A.1 CALMET Surface Stations.

		Location		Location Lambert Conformal[1]	
Station ID	Station Type	Latitude	Longitude	X(km)	Y(km)
Amoco	Industrial	41.429993	-110.890007	-188.837	-117.730
Exxon	Industrial	41.840019	-110.150002	-128.247	-75.080
General Chemical	Industrial	41.590008	-109.759995	-97.396	-102.530
Naughton	Industrial	41.759960	-110.589989	-163.727	-82.890
OCI	Industrial	41.730015	-109.669991	-89.941	-87.569
TG Soda	Industrial	41.690029	-109.889999	-107.679	-91.600
Pinedale	NDDN	42.437225	-108.940804	-97.579	41.610
Centennial	NDDN	43.839733	-110.370804	181.131	-130.873
Lander	NWS	42.345829	-107.552803	-14.192	29.040
Rock Spings	NWS	41.270840	-107.581902	-41.850	-102.050
Casper	NWS	43.679401	-109.611107	163.698	41.900
Salt Lake	NWS	42.300037	-111.237808	-247.589	-219.230
Evanston	NWS	42.537231	-111.854698	-200.631	-133.529
Hayden	NWS	43.723564	-110.710297	115.118	-241.221
Ogden	NWS	42.894428	-111.840599	-245.962	-154.600
Jackson	NWS	43.472195	-110.016701	-169.576	115.150
Riverton	NWS	42.483307	-110.472801	3.930	48.370
Rawlins	NWS	42.490799	-110.526703	108.284	-79.759
Soda Springs	NWS	42.978313	-109.116707	-222.333	-13.320
Vernal	NWS	42.586975	-108.287003	-62.525	-245.160
Worland	NWS	41.645992	-108.583008	46.380	152.760
Cody	NWS	41.715012	-107.699997	-35.756	211.436
Idaho Falls	NWS	41.295990	-110.773003	-273.915	109.943
Denver	NWS	43.091991	-107.320999	335.813	-324.404
Denver	NWS	42.560005	-106.852989	335.813	-324.404
Grand Junction	NWS	41.000008	-107.629997	18.459	-376.037
Cheyenne	NWS	40.450012	-107.589996	302.347	-143.592
Anderson Ridge	RAWS	40.449955	-108.030006	-31.013	-12.050
Burro Hill	RAWS	42.930042	-109.790001	-141.055	140.200
Camp Creek	RAWS	42.819977	-108.730003	79.256	-21.460
Cow Creek	RAWS	41.600040	-109.069992	78.342	-137.150
Elkhorn	RAWS	42.919987	-106.469994	-82.435	121.920
Getch Hollow	RAWS	40.469982	-111.570000	-213.753	-23.290
Grace	RAWS	41.280006	-111.029999	-261.735	4.029
Grand Teton	RAWS	40.299980	-107.150002	-167.686	128.380
Pole Canyon	RAWS	41.069969	-111.579994	-259.041	42.350
Raspberry	RAWS	43.599983	-110.729996	-114.350	100.161
Riley Ridge	RAWS	42.999962	-108.500008	-152.455	-5.340
Snider Basin	RAWS	41.799953	-107.199997	-156.708	-4.430
Wind River	RAWS	42.389965	-111.349991	-44.560	46.200
Beaver Rim	WYDOT	40.270027	-109.309998	20.818	4.010

Table A.1 (Continued)

		Location		Location Lambert Conformal[1]	
Station ID	Station Type	Latitude	Longitude	X(km)	Y(km)
Bitter Creek	WYDOT	43.969982	-107.950005	-2.654	-97.240
Continental Divide	WYDOT	41.310000	-106.310000	68.278	-89.450
First Divide	WYDOT	44.517000	-109.017000	-179.798	-132.419
Hiland	WYDOT	43.517000	-112.067000	96.447	59.000
Pathfinder Hi.	WYDOT	43.940000	-106.640000	134.381	2.500
I-25 Divide	WYDOT	44.270000	-108.870000	147.707	151.128
Meeteetsee	WYDOT	39.460000	-104.520000	-24.607	184.857
Baggs	Zirkel	39.460000	-104.520000	74.785	-166.360
Craig Mtn	Zirkel	39.060000	-108.330000	78.747	-225.580
Juniper Mtn.	Zirkel	41.150000	-104.820000	42.655	-225.920

[1] Reference latitude 42.55, reference longitude -108.55.