Appendix A

Air Quality Impact Analysis Protocol

Air Quality Impact Analysis Protocol

Draft Supplemental
Pinedale Anticline Oil and Gas Exploration and Development
Environmental Impact Statement

Bureau of Land Management
Wyoming State Office
Cheyenne, Wyoming

Pinedale Field Office
Pinedale, Wyoming

In Cooperation with

State of Wyoming
Sublette County

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List of Acronyms and Abbreviations

ANC	Acid neutralizing capacity
Anschutz	Anschutz Pinedale Corporation
APD	Application for Permit to Drill
AQD	Air Quality Division
AQRV	Air Quality Related Value
AR	Atlantic Rim
ASU	Anschutz, Shell and Ultra
BACT	Best Available Control Technology
BLM	Bureau of Land Management
CASTNET	Clean Air Status and Trends Network
C.F.R.	Code of Federal Regulations
CDPHE/APCD	Colorado Department of Public Health and Environment/Air Pollution Control Division
CO	Carbon monoxide
COGCC	Colorado Oil and Gas Conservation Commission
DEM	Digital Elevation Model
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
Hp	Horsepower
IDEQ	Idaho Division of Environment Quality
IDLH	Immediately Dangerous to Life or Health
IMPROVE	Interagency Modeling of Protected Visual Environment
IOGCC	Idaho Oil and Gas Conservation Commission
IWAQM	Interagency Workgroup on Air Quality Modeling
JIDP	Jonah Infill Drilling Project
kg/ha/yr	Kilograms per hectare per year
km	Kilometer
LAC	Level of Acceptable Change
LOP	Life of Project
LULC	Land Use Land Cover
m	Meter
MEI	Maximally Exposed Individual
MLE	Most Likely Exposure
Mm^{-1}	Inverse Megameters
N	Nitrogen

NAAQS	National Ambient Air Quality Standards
NADP	National Acid Deposition Program
NCDC	National Climate Data Center
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
NTN	National Trends Network
NWS	National Weather Service
O_3	Ozone
Operators	Shell Exploration & Production Company, Ultra Resources, Inc., Questar Exploration & Production Company, Anschutz Pinedale Corporation and other others
PAPA	Pinedale Anticline Project Area
PFO	Pinedale 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
Project	Pinedale Anticline Project
Protocol	Air Quality Impact Assessment Protocol
PSD	Prevention of Significant Deterioration
QA/QC	Quality Assurance/Quality Control
QGM	Questar Gas Management
Questar	Questar Exploration & Production Company
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
RPO	Regional Planning Office
S	Sulfur
SEIS	Supplemental Environmental Impact Statement
Shell	Shell Exploration & Production Company
SO_2	Sulfur dioxide
SO_4	Sulfate
tpy	Tons per year
TRC	TRC Environmental Corporation
UDEQ-AQD	Utah Department of Environmental Quality-Air Quality Division
UDNR-DOGM	Utah Department of Natural Resources-Division of Oil, Gas, and Mining

Ultra	Ultra Resources, Inc.
URF	Unit risk factor
USFS	United States Forest Service
USGS	United States Geological Survey
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
WRAP	Western Regional Air Partnership
μeq/l	Microequivalents per liter
$\mu g/m^3$	Micrograms per cubic meter

1.0 INTRODUCTION

This Air Quality Impact Assessment Protocol (Protocol) identifies the methodologies for quantifying potential air quality impacts from the continued developed in the Pinedale Anticline Project Area (PAPA), herein referred to as the 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 other air quality stakeholders, and that all air quality stakeholders have the opportunity to review the Protocol and provide input before the study is initiated. The location of the Project in west-central Wyoming requires the examination of Project and cumulative source impacts within the study area shown on Map 1.1 from emission sources in Wyoming, northwestern Colorado, northeastern Utah, and southeastern Idaho.

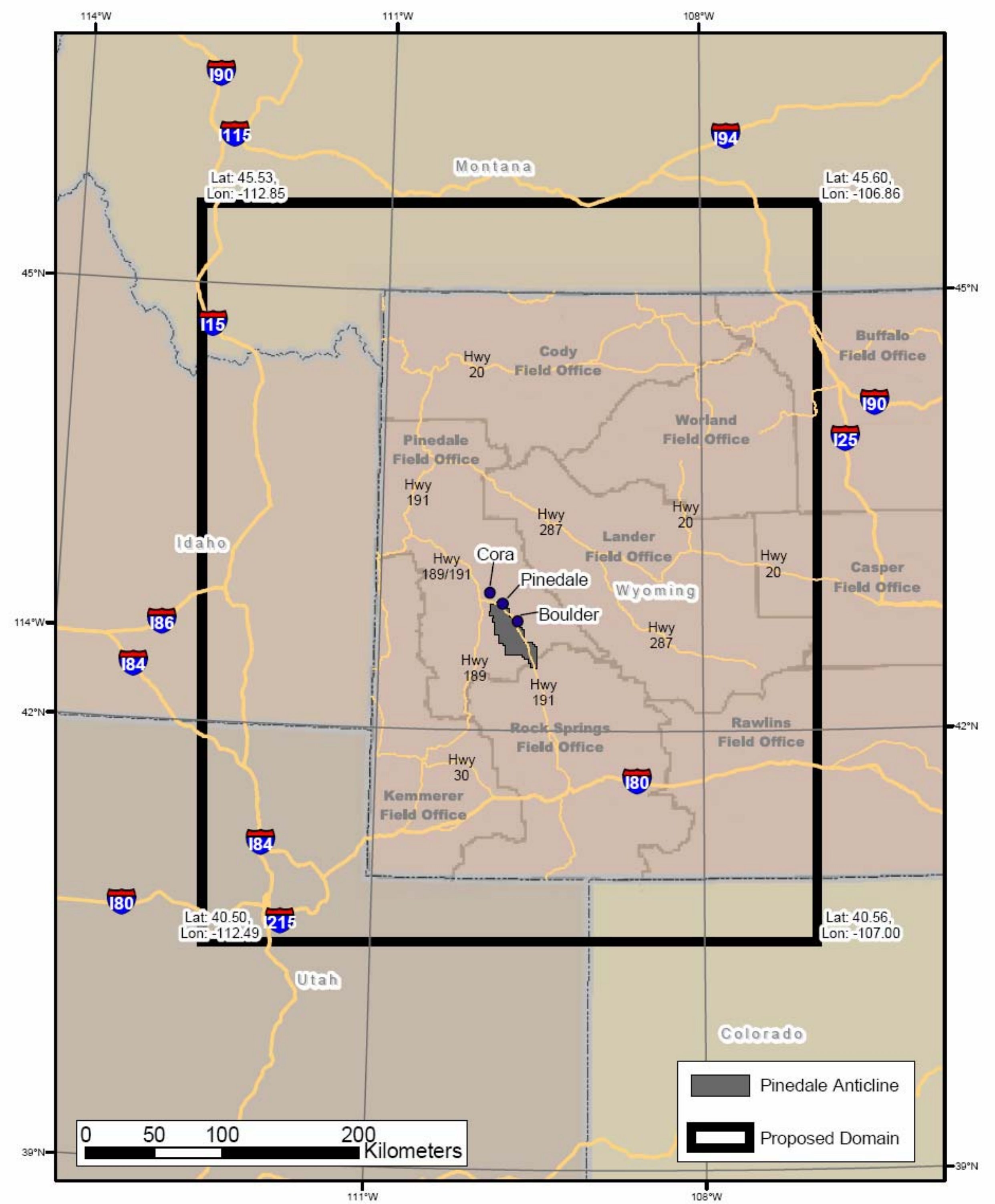
The analysis described in this Protocol differs significantly from previous natural gas development air quality analyses performed in western Wyoming. The study area has been enlarged to the north to include all of Yellowstone National Park and dimensioned in accordance with Interagency Workgroup on Air Quality Modeling (IWAQM) guidance (IWAQM, 1998) to ensure adequate wind flow characterization around each analyzed sensitive area. The analysis will utilize ambient air background data collected in Sublette County since early 2005, and the regional emissions inventory start-date is updated to reflect the use of this recent and representative data. Finally, the far-field modeling analysis utilizes the CALMET/CALPUFF modeling system with 3 years of mesoscale model (MM5 model) meteorological data in accordance with 40 CFR 51 Appendix W, Guideline on Air Quality Models (EPA, 2005a), supplemented with regional NWS meteorological data. The MM5 data are national data sets for years 2001-2003, and are the most current consecutive 3 years that are readily available for CALMET model simulations. These differences from previous analyses will result in an updated analysis that reflects current science and analysis methodologies.

1.1 PROJECT DESCRIPTION

Jointly referred to as the Operators, Ultra Resources, Inc. (Ultra), Shell Exploration & Production Company (Shell), Questar Market Resources including Wexpro Company (Questar), BP America Production Company, Stone Energy Corporation, Yates Petroleum Corporation, and others who agree to participate, have notified the BLM Pinedale Field Office (PFO) that they propose a new long-term development plan that includes limited year-round drilling and completions of natural gas wells within their leaseholdings in the PAPA.

As of December 31, 2005, there were approximately 322 producing well pads and 457 producing wells in the PAPA. An additional 26 pads and 205 producing wells are proposed by the Operators in 2006. The Proposed Action consists of drilling approximately 4,400 new wells (in addition to the 662 wells drilled through 2006) within the PAPA, beginning in 2007. As part of the Proposed Action, there would be up to 48 drilling rigs operating in the PAPA after 2007. The Operators propose to install emissions controls to achieve Tier 2 equivalent emissions on approximately 60 percent of the drilling rig engines by 2009. Questar has previously committed (BLM, 2005a) to install Tier 2 equivalent emission controls on all year-round drilling rigs by 2008. In 2005, a liquids (condensate and produced water) gathering system was installed in the northern leaseholds in the PAPA, reducing overall emissions through reduction in truck traffic.

Map 1.1 Project Location and Study Area.



As part of the Proposed Action, the Operators propose to install a liquids gathering system in the central and southern portions of the PAPA. Operation of the liquids gathering system would require installation of central gathering facilities within the PAPA which would have associated emissions. Condensate would be gathered within the PAPA and the crude petroleum would be transported via pipeline to processing facilities in southwest Wyoming. Produced water would be gathered and trucked from a central location within the PAPA. Operators are currently investigating options for produced water disposal both within and outside of the PAPA. Questar Gas Management (QGM) is proposing to install an additional 7,440 horsepower (hp) of compression at the Pinedale/Gobblers Knob Compressor Station within the PAPA in 2006. QGM also intends to install an additional 31,000 hp in 2009 and 15,500 hp in 2015 at the Pinedale/Gobblers Knob Compressor Station. Jonah Gas Gathering Company (JGGC) is proposing to install an additional 184,000 hp of compression at the Paradise Compressor Station, an additional 37,366 hp at the Falcon Compressor Station and 14,672 hp at the Bird Canyon Compressor Station (outside of the PAPA) all in 2011 as part of the Proposed Action. One 30-inch gas sales pipeline (the Rendezvous Phase 6 – R6) is proposed by Rendezvous Gas Services (RGS) to transport natural gas from the PAPA to the Granger and Blacks Fork processing plants in southwest Wyoming. JGGC is proposing the 36-inch (Paradise to Bird Canyon or PBC Pipeline) and a connecting 45.5-mile long, 30-inch pipeline (Opal Loop III Pipeline) which would transport gas from the PAPA to the Opal and Pioneer gas processing plants. In conjunction with the proposed R6 Pipeline Project, RGS proposes to expand the existing 33.6-acre Granger Gas Processing Plant by 86.4 acres, for a total of 120 acres on BLM-administered federal lands in Section 16, T. 18 N., R. 111 W. The purpose of the proposed expansion is to construct and operate additional natural gas processing facilities to sufficiently increase processing capacity for an anticipated increased input of 600 million standard cubic feet per day (MMSCF/D) of natural gas and crude petroleum. The current Granger Gas Processing Plant capacity is 600 MMSCF/D. The expansion would represent a 100 percent increase in treatment capacity.

BLM will be analyzing the No Action Alternative (Alternative A) in addition to the Proposed Action Alternative (Alternative B) and a third alternative (Alternative C). The No Action Alternative is defined as continued development of the PAPA under current BLM management practices. The Operators have provided estimates of new pads, expansion pads and proposed number of wells that would be drilled under the No Action Alternative with continued management practices under the PAPA ROD. However, at some point, the limits of the PAPA Record of Decision (BLM, 2000b) would be reached for maximum allowed well pads within specific Management Areas and further NEPA (National Environmental Policy Act) analysis will be required for continued development. The liquids gathering systems in the southern and central portions of the PAPA would not be installed under the No Action Alternative. The R6, PBC, and Opal Loop III pipelines would be constructed under the No Action Alternative.

A third alternative will be analyzed (for all resources), as determined by BLM, and would include provisions for concentrating development activities to allow for maintenance of wildlife habitat, seasonal wildlife stipulations, and other environmental impacts. All components included in the Proposed Action Alternative are also a part of Alternative C, and therefore, emissions and associated impacts for the two alternatives would be similar.

1.2 RELATIONSHIP TO EXISTING PLANS AND DOCUMENTS

Potential impacts to air quality resulting from exploration and development of natural gas within the PAPA was previously analyzed in the Pinedale Anticline Oil and Gas Exploration and Development Environmental Impact Statement (PAPA EIS) (BLM, 2000a).

In 2004, Questar submitted a proposal to BLM for limited year-round drilling within their lease holdings in the PAPA. As part of their proposal for mitigation, Questar would install a gathering system to remove condensate and water from the PAPA (reducing truck traffic) and utilize Tier 2 compliant engines or alternate fuels on all drilling rig engines by 2007. In November 2004, BLM issued a Decision Record (BLM, 2004) approving Questar's limited year-round drilling proposal. Although potential emissions from the proposal were disclosed, a complete air quality impact analysis was not conducted because the operator-committed mitigation would cause the impacts to be reduced. In 2005, BLM issued a Decision Record (BLM, 2005a) which allowed for modification of the proposed condensate pipeline route and extended the requirement for the drilling rig engines to become Tier 2 compliant to 2008. Again, potential emissions were disclosed but a complete air quality impact analysis was not conducted.

Also in 2005, Anschutz, Shell and Ultra (ASU) submitted a proposal to BLM for a year-round demonstration project within the PAPA. In September, 2005, BLM issued a Decision Record (BLM, 2005b) that allowed each operator to have two drill rigs on one pad each within crucial winter range during the winter of 2005-2006. For mitigation of the air quality impacts, the operators committed to reduce emissions by testing selective catalytic reduction on two of the drill rigs and testing bi-fuel technology on the other four drilling rigs. Because the proposal represented an overall reduction in emissions (the rigs would have operated in the PAPA outside of crucial winter range if the proposal were not approved), potential emissions were disclosed but a complete air quality impact analysis was not conducted.

In November of 2005, BLM issued a Decision Record (BLM, 2005c) that allowed Questar to have one additional winter drill rig. Four winter completions and one drill rig move were also approved.

Since the PAPA ROD (BLM, 2000b) was issued in July 2000, natural gas development within the PAPA has occurred at a pace greater than was analyzed in the PAPA DEIS as disclosed in the subsequent NEPA documents. The PAPA ROD authorized the development of 700 producing wells and/or well pads, however, the ROD was ambiguous at to whether the limit was wells or well pads. The air quality impact analysis for the PAPA DEIS assumed 700 producing wells and up to eight drilling rigs operating in the PAPA at any one time. As of December 2005, there were approximately 457 producing wells in the PAPA with an additional 205 wells projected for 2006. Twenty-nine of the existing wells were drilled prior to the PAPA ROD, therefore, there would be potentially 633 producing wells by the end of 2006. The PAPA ROD also set an analysis threshold of 376.59 tpy NO_x emissions from compression and 693.5 tpy of NO_x emissions from all sources in the field. The PAPA ROD stated that additional environmental analysis would be conducted if the analysis threshold were exceeded. Even though the limit of 700 producing wells and/or well pads has not been exceeded, the NO_x emissions from all sources in the PAPA currently exceeds the 693.5 tpy analysis limit specified in the PAPA ROD. For this reason, and to analyze the current proposal, BLM has determined that it is necessary to prepare a Supplemental Environmental Impact Statement (SEIS) which includes a complete and accurate air quality impact analysis.

The BLM Pinedale Resource Management Plan (RMP) (BLM, 1988) issued in 1988, amended in 2000, and currently under revision, directs the management of BLM administered lands within the PAPA. 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 PAPA are suitable for oil and gas leasing and development, subject to certain stipulations.

The most recent EIS completed in Sublette County is the Final EIS, Jonah Infill Drilling Project (JIDP), Sublette County, Wyoming (BLM, 2006). This Protocol represents a new and separate analyses from that performed for the JIDP EIS. With the exception of shared methodologies common to many regional modeling analyses, no portions of the JIDP air quality analysis were utilized in this study.

The BLM is currently developing a state-wide cumulative air quality analysis deemed the BLM State of the Atmosphere air quality analysis. That study is in the early development stages, and will utilize a 1-year 2002 Western Regional Air Partnership (WRAP) meteorological dataset and a separate inventory that is not yet available. No portions of the BLM State of the Atmosphere air quality analysis will be utilized in this analysis.

1.3 PROPOSED WORK TASKS

The air quality analysis will address the impacts on ambient air quality and Air Quality Related Values (AQRVs) from: 1) air emissions that have resulted from development and production activities within the PAPA during 2005; 2) potential air emissions from development and production with the PAPA after 2005 that could occur under the Proposed Action and Alternative C; 3) potential air emissions after 2005 resulting from continued development and production activities under the No Action Alternative; and 4) 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], acid deposition, and potential increases in acidification to acid sensitive lakes) will be quantified and compared to applicable thresholds as defined in the Federal Land Managers' (FLMs') Air Quality Related Values Workgroup (FLAG), IWAQM guidance documents (FLAG, 2000 and IWAQM, 1998), and other state and federal agency guidance. Impact assessment criteria are discussed in further detail in Section 5.0 of this Protocol.

The assessment of impacts will include the completion of the following tasks:

- Generate Project development and production emissions inventories (see Section 2.1).
- Compile a regional emissions inventory including specified permitted sources, reasonably foreseeable development (RFD), and reasonably foreseeable future actions (RFFA) (see Section 2.2).
- Assess near-field ambient impacts from Project emissions sources (see Sections 3.0 and 5.1).
- Assess far-field ambient direct project (Project emissions sources) and cumulative impacts (Project plus regional emissions sources), including pollutant concentration, visibility and acid deposition impacts, and potential increases in acidification to acid sensitive lakes, within the modeling domain and at PSD Class I and other sensitive areas (see Sections 4.0 and 5.2).

2.0 EMISSIONS INVENTORY

The Proposed Action for the project includes the development of approximately 4,400 additional natural gas wells within the PAPA beginning in 2007. The No Action Alternative includes continued development under current BLM field authorizations. Under the Proposed Action, drilling would continue for approximately 17 years, with an approximate 60-year life of project (LOP). Production facilities at each well/pad site would include dehydration units, separators, gathering pipelines, and blowdown tanks, with centralized condensate collection facilities (central gathering facilities) at several locations within the PAPA. Ancillary facilities would include new compressor engines at existing compressor stations inside and outside the PAPA.

An emission inventory of 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) (benzene, toluene, ethyl benzene, xylene, n-hexane, and formaldehyde) will be developed for well development activities, production activities, and ancillary facilities planned as part of the Project. Lead emissions will be considered negligible and not calculated in the inventory. The emissions inventory will be developed based on the Proposed Action and field operations data provided by the Operators. The inventory will be developed using field-specific emission test results, manufacturer's emissions data, AP-42 (EPA, 1995), Gas Research Institute (GRI) emission factors, and other accepted engineering methods as described in this section.

2.1 PROJECT EMISSIONS

2.1.1 Field Development Emissions

Emissions-generating activities during field development include: well pad and access road construction; drilling; frac/completion; vehicle travel during the drilling and completion phase; and construction and vehicle travel during installation of the condensate and water gathering system and natural gas pipeline installation. Emission calculations for these and other potential emissions-generating activities will utilize 2005 annual operator emissions reports submitted to the Wyoming Department of Environmental Quality, Air Quality Division (WDEQ-AQD) whenever possible, depending upon availability and applicability by individual emissions source. Drilling engine emissions will be calculated using the following methods, presented in order of preference: field-specific stack test results, EPA Tier emission factors (EPA 2006), or AP-42 emission factors (EPA 1995). AP-42 emission factors will utilize AP-42 Table 3.3-1 for engines less than 600 hp in size and Table 3.4-1 for engines greater than 600 hp in size. Emissions estimates will consider operator-committed emission control devices. An engine usage and operating load factor of 0.42, as used in previous EIS analyses, will be applied for drilling engines. Fugitive particulate emissions from vehicle travel and construction activities and wind erosion emissions from areas disturbed during construction will be calculated using AP-42 emission factors. HAP emissions from combustion sources will be calculated using GRI-HAPCalc® (GRI, 1999) if no manufacturer's or testing data is available. Fugitive dust control efficiencies will be utilized for any watering or dust suppressants applied.

2.1.2 Production Emissions

Sources of pollutant emissions during field production include combustion emissions from wells and compressor engines, and VOC and HAP emissions from gas transmission operations. Fugitive particulate emissions from unpaved road travel and from wind erosion on disturbed areas (such as well pads) will also occur. Emission rates will be developed in accordance with WDEQ-AQD oil and gas permitting guidance (WDEQ, 2001, WDEQ, 2004) where applicable guidance exists.

Combustion equipment emissions will be calculated using EPA Tier emission factors, Best Available Control Technology (BACT) emission rates, manufacturer emission factors, and/or GRI emission factors. Fugitive dust from unpaved roads and wind erosion emissions from disturbed areas will be calculated using AP-42 emission factors. VOC and HAP emissions from production (aside from those arising from combustion sources) will be generated by well-site dehydrators, fugitive leaks, and flashing emissions from liquids stored at Centralized Gathering Facilities. Both fugitive and flashing emissions will be calculated using representative constituent analyses of natural gas and stored liquids. A discussion of BACT applicability and requirements will be included for emissions sources as appropriate, in accordance with WDEQ-AQD oil and gas permitting guidance (WDEQ, 2001 and WDEQ, 2004).

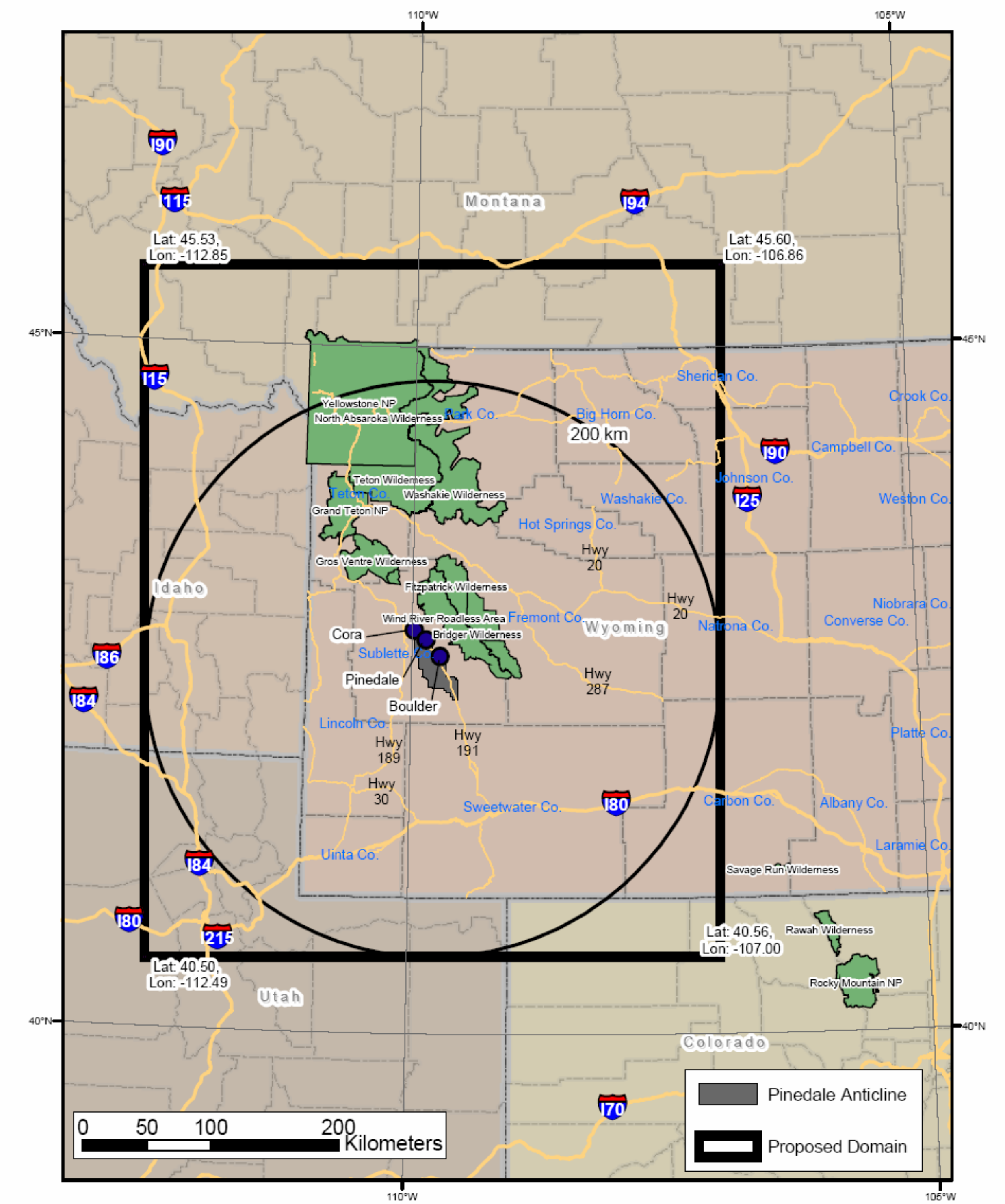
2.2 REGIONAL EMISSIONS INVENTORY

An inventory of existing and proposed emissions sources within a defined area and meeting defined criteria will be conducted and will include the identification of permitted sources, permitted oil and gas wells, RFD, and RFFA. The inventory will be 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 Environmental Quality (IDEQ), Idaho Oil and Gas Conservation Commission (IOGCC), BLM, and other agencies as required.

The inventory period proposed in this Protocol has been selected to be consistent with the availability of recent (2005/2006) ambient background data collected in Sublette County, Wyoming. The inventory is proposed to begin on January 1, 2005 and end on February 1, 2006 - 13 months. Due to a typical 30-day lag in availability of permitted source data at state agencies, this end-date will ensure that the data collection can be completed by February 28 to allow timely progression of the dispersion modeling analysis. Some overlap between emission sources which began operating in 2005 and background data monitored during 2005 will exist.

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 Map 2.1.

Map 2.1 CALPUFF/CALMET Modeling Domain and Major/Minor Source Inventory Area.



2.2.1 Existing Inventories

No overlap exists between the inventory timeframe for this Project and the emissions inventories performed for either the JIDP EIS or the Atlantic Rim Natural Gas Development Project EIS (AR EIS), the most recent regional emissions inventories developed in southwest Wyoming. As a result, no portions of the inventories developed for the JIDP EIS or the AR EIS are proposed to be utilized.

A Prevention of Significant Deterioration (PSD) Increment Analysis for NO_2 has been completed by WDEQ-AQD for Sublette County and is currently being performed by WDEQ-AQD for a 300 kilometer radius of the Bridger and Fitzpatrick Wilderness Area. The emissions inventory data compiled by WDEQ-AQD as part of this analysis will not be of use in this inventory effort due to differences in increment inventory requirements and the methodologies set forth in the Protocol.

2.2.2 State Agency Permitted Sources

The regional emissions inventory for the Project will include:

- Major sources located within the inventory area;
- Minor sources located within the inventory area;
- Sources that emit NO_x, SO_2, or $PM_{10}/PM_{2.5}$;
- Sources that began operation on or after January 1, 2005;
- Sources that began operation or were permitted before February 1, 2006; and
- Sources that were permitted within 18 months of January 1, 2005, but are not yet operating (will be inventoried and included as RFFA [see Section 2.2.4]).

The major source inventory area is proposed to be comprised of a 200 kilometer (km) radius from the Project Area, as shown in Map 2.1. The 200 km radius proposed reflects current FLM New Source Review (NSR) regional analysis guidance which requests PSD Class I AQRV analysis for major sources within 200 km of a PSD Class I area. Major sources are defined as those considered major under PSD regulations; i.e., emissions of any one pollutant greater than 250 tpy, or emissions of any pollutant greater than 100 tpy if the source meets certain criteria as outlined in 40 CFR 52.21 or Wyoming Air Quality Standards and Regulations (WAQSR) Chapter 6, Section 4. All increases or decreases in NO_x, SO_2, or $PM_{10}/PM_{2.5}$ at the major sources within this area would be inventoried. In addition, a request would be made to state agencies to indicate any additional major sources outside of the inventory area that may have had large changes in permitted emissions during the inventory period, and these changes would be researched and included in the regional inventory.

The minor source inventory area is proposed to encompass a 200 km radius from the Project Area, as shown in Map 2.1. Minor sources are defined as those sources considered minor under NSR regulations outlined in 40 CFR 52.21. Therefore, the analysis proposed further ensures that regional non-background emissions will be analyzed.

Potential-to-emit (maximum permitted) emission rates will be inventoried. Actual emissions will not be inventoried because work on the regional emissions inventory has indicated that actual emissions are not readily available for most state-permitted sources. In addition, for those sources required to submit them to the permitting agency, actual emissions would not be available immediately following close of the calendar year. Permitted emissions decreases will be included only if the decrease occurs at a PSD major source and if the decrease is verifiable by appropriate state air regulatory authority (WDEQ-AQD, IDEQ, UDEQ-AQD, or CDPHE-

APCD). Sources operating under permit waivers not related to oil and gas production will not be inventoried due to their insignificant nature, and a qualitative discussion of waivers will be presented in the Technical Support Document. Waivers issued to oil and gas wells or production sites will be examined based on emission threshold criteria and will either be included as a production site (>3 tpy total emissions) or assumed to be included in permitted well totals obtained from the oil and gas permitting authority. 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 specifically included in this inventory.

A list of well drilling permits issued between January 1, 2005, and February 1, 2006, will be compiled using permit data obtained from the appropriate oil and gas permitting authority (WOGCC, COGCC, UDNR-DOGM, or IOGCC). Information regarding well type and equipment, and historic and current field production will be used to create a representative emission factor in pounds per well for all emitted pollutants. This average emission factor will be multiplied by the number of wells installed during the study period in each county within the study area to calculate total well emissions by county.

2.2.3 RFD

An inventory of RFD sources will be performed for inclusion in the cumulative dispersion modeling. 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 (if emissions are quantified when modeling commences). RFD information from not-yet-authorized projects will be obtained from contractors working on ongoing air quality analyses for NEPA projects. RFD information for authorized development will be obtained from final NEPA documents that have been submitted to BLM for planned project development, specifically, from the air quality analyses performed for these projects. Undeveloped portions of projects within the PFO will be obtained from BLM PFO project development tracking. For other field offices, total wells or other equipment yet undeveloped will be determined based on plotting state-agency permitted sources spatially and subtracting from authorized totals the number of developed wells and/or total horsepower or emissions from permitted compression that are plotted within each project area. These calculated values will be submitted to BLM for a review of reasonableness prior to use in the modeling analysis.

As an example how RFD would be determined, in an authorized gas field development area for which 2,000 wells were projected and analyzed but only 250 wells have been developed as of the inventory end-date of this study, the 250 developed wells would be included under the permitted source inventory and the remaining 1,750 would be considered RFD. No authorized development would be excluded unless it was permitted and operating outside of the inventory dates outlined in Section 2.1.

Full development of proposed projects inventoried as RFD may or may not coincide with full development of the Project. As a result, the assumption that all RFD are fully developed during the maximum year of Project development may result in some conservatism in the cumulative impact analysis. A preliminary listing of RFD projects which may be examined in this study, as defined in the paragraph above, is presented in Table 2.1. All development areas will be reviewed for inclusion, and those projects generating pollutant emissions during production activities will be included as RFD. The BLM will be consulted to determine the existence of additional NEPA-authorized projects.

More detailed development and operations data will be compiled for all RFD and presented in the Technical Support Document. To ensure a timely, complete modeling analysis, only development authorized through the inventory end-date of February 1, 2006, or for which emissions have been quantified as of the beginning of the modeling analysis, will be included in this analysis. RFD quantified after the inventory end-date will be acknowledged with a qualitative discussion describing the proposed development(s). Similarly, a qualitative discussion and link to the appropriate BLM website will be presented for development currently proposed in the Powder River Basin Coalbed Methane Development Project, located outside of the study domain in northeast Wyoming's Powder River Basin.

2.2.4 RFFA

An inventory of RFFA sources will be performed for inclusion in the cumulative dispersion modeling. For the purposes of this project, RFFA is defined as a source which possesses an unexpired air permit issued on or after July 1, 2003 (18 months prior to January 1, 2005), but the source is not yet operating. The primary source of RFFA information will be state permit records obtained through a file data search.

Table 2.1 Potential RFD in the Study Area.

Atlantic Rim	Jonah II
Big Piney-LaBarge	Jonah Infill
Bird Canyon	Kennedy Oil Pilot
Bird-Opal Loop Pipeline	Merna Pipeline
Black Butte Mine Pit 14	Monnell Oil Recovery
BTA Bravo	Moxa Arch
Burley	Moxa Arch Infill
Castle Creek	Mulligan Draw
Continental Divide/Wamsutter II	Opal Loop Pipeline
Continental Divide/Creston	Pappy Draw
Copper Ridge	Piceance Basin
Creston-Blue Gap	Pinedale Anticline
Desolation Flats	Pioneer Gas Plant
Dripping Rock/Cedar Breaks	Riley Ridge
East LaBarge	Riverton Dome
Essex Mountain	Road Hollow
Fontenelle II	Seminoe Road
Hanna Draw	Sierra Madre
Hanna Draw Pilot	Soda Unit
Hay Reservoir	South Baggs
Hay Reservoir Pilot	South Piney
Hickey-Table Mountain	Stagecoach
Horse Trap	Vermillion Basin
Jack Morrow Hills	Wind River

3.0 NEAR-FIELD ANALYSIS

3.1 MODELING METHODOLOGY

The near-field ambient air quality impact assessment will be performed to quantify maximum pollutant impacts in the vicinity of the Project resulting from development and production emissions. EPA's guideline model, AERMOD (version 04300), will be used to assess these near-field impacts. Regulatory model settings will be utilized with the exception of the non-regulatory setting MSGPRO, which is necessary to handle missing data in the meteorological dataset. Flat terrain will be utilized in the near-field analysis.

One year of meteorological data will be used that includes hourly surface meteorology data (wind speed, wind direction, standard deviation of wind direction [sigma theta], and temperature) collected in the Jonah Field from January 1999 through January 2000, consistent with current WDEQ-AQD permit modeling analysis guidance. A wind rose for these data is presented in Figure 3.1.

The AERMOD preprocessor AERMET will be used to process the Jonah Field meteorological data into a dataset compatible with the AERMOD dispersion model. AERMET will be used to combine the Jonah Field surface measurements with twice daily sounding data from the Riverton, Wyoming NWS site, cloud cover data collected at the Big Piney, Wyoming NWS ASOS site, and solar radiation measurements collected at the Pinedale, Wyoming CASTNET site. Seasonal values for albedo, Bowen ratio and surface roughness length, for land use type “desert shrubland”, selected from tables in the AERMET user’s guide, will be used in processing the meteorological data.

3.2 BACKGROUND DATA

Background pollutant concentrations are used as an indicator of existing conditions in the region, and are assumed to include emissions from industrial emission sources in operation and from mobile, urban, biogenic, and other non-industrial emission sources. These background concentrations are added to modeled near-field Project impacts to calculate total ambient air quality impacts.

Ambient air monitoring is currently being conducted at several locations in Sublette County. Monitoring sites in the Jonah Field and near Boulder and Daniel collect varying ambient concentration, visibility, and meteorological data parameters. Data from one or more of these sites are proposed to replace data collected at the Green River Basin Visibility Study site through 2001 because the Sublette County data are not only more current, but are more representative of conditions in and near the Pinedale Anticline field.

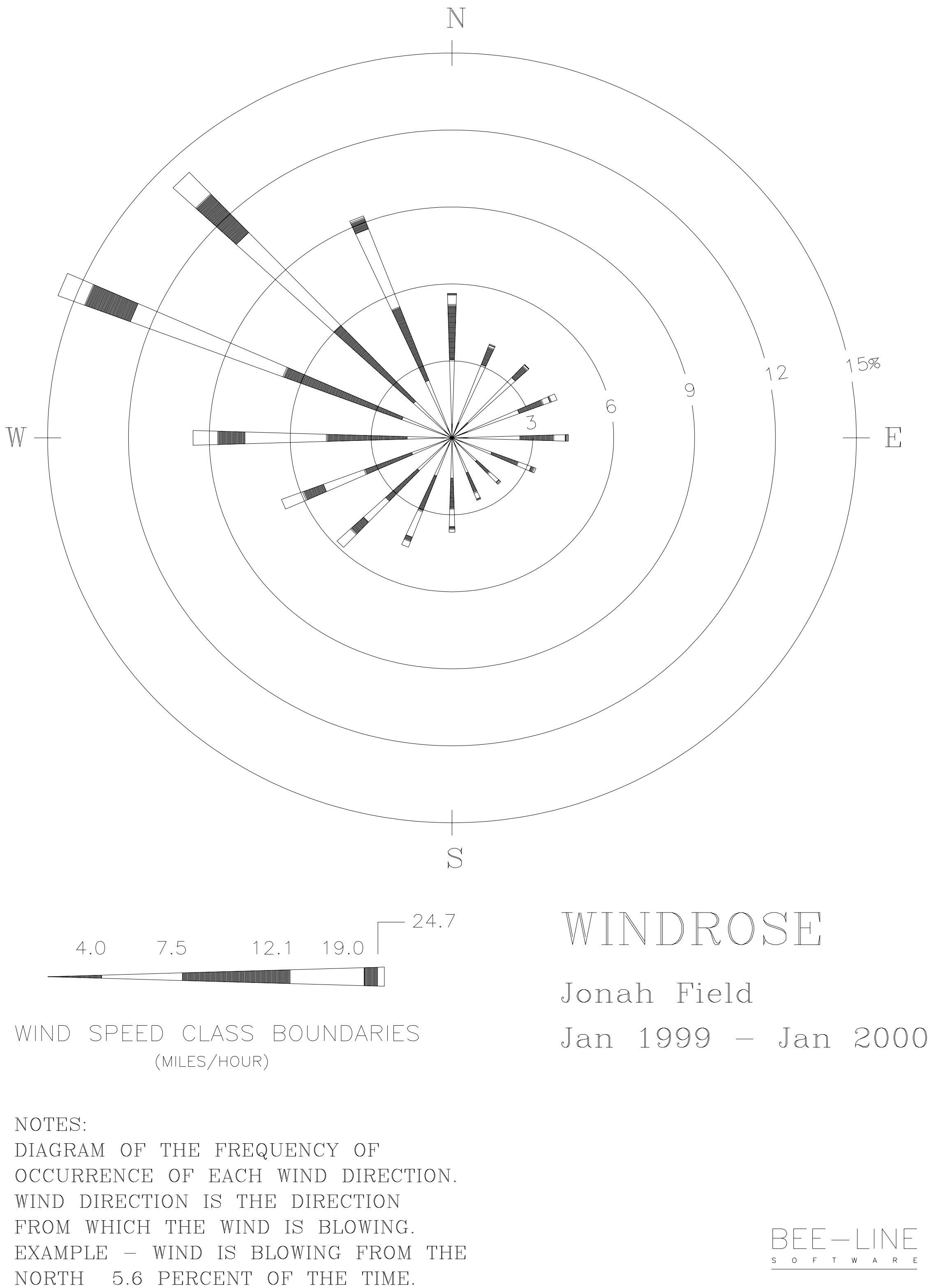


Figure 3.1 Jonah Meteorological Data Windrose

Table 3.1 summarizes the locations, date of start-up, and pollutants monitored for each monitoring site. Monitor locations are shown in relation to the Pinedale Anticline natural gas field in Map 3.1.

Table 3.1 Sublette County Ambient Monitoring Summary.

Monitor	Location	Operator	Start Date	Parameters Monitored
Jonah	Jonah Field	EnCana	1/15/05	PM_{10}, O_3, NO_2, Met, Camera
Boulder	5 mi S and W of Boulder	Shell/WDEQ	2/06/05	PM_{10}, O_3, NO_2, Met, Camera, Nephelometer
Daniel	5 mi S of Daniel	WDEQ	7/01/05	PM_{10}, O_3, NO_2, Met, Camera

As of the date this Protocol was prepared, none of the sites listed in Table 3.1 had available a full year of QA/QC'd data. For review purposes, these limited datasets, representing the data available at this time, are given in this Protocol. Table 3.2 shows ambient concentrations reported for these monitoring sites on the EPA AIRS website on June 8, 2006. WDEQ is developing recommendations for the background site(s) to utilize for this modeling analysis, and the site(s) selected and basis for that selection will be included in the AQTSD. All available monitored data will be reported in Chapter 3 (Affected Environment) of the SEIS.

Map 3.1 Sublette County Monitoring Site Locations.

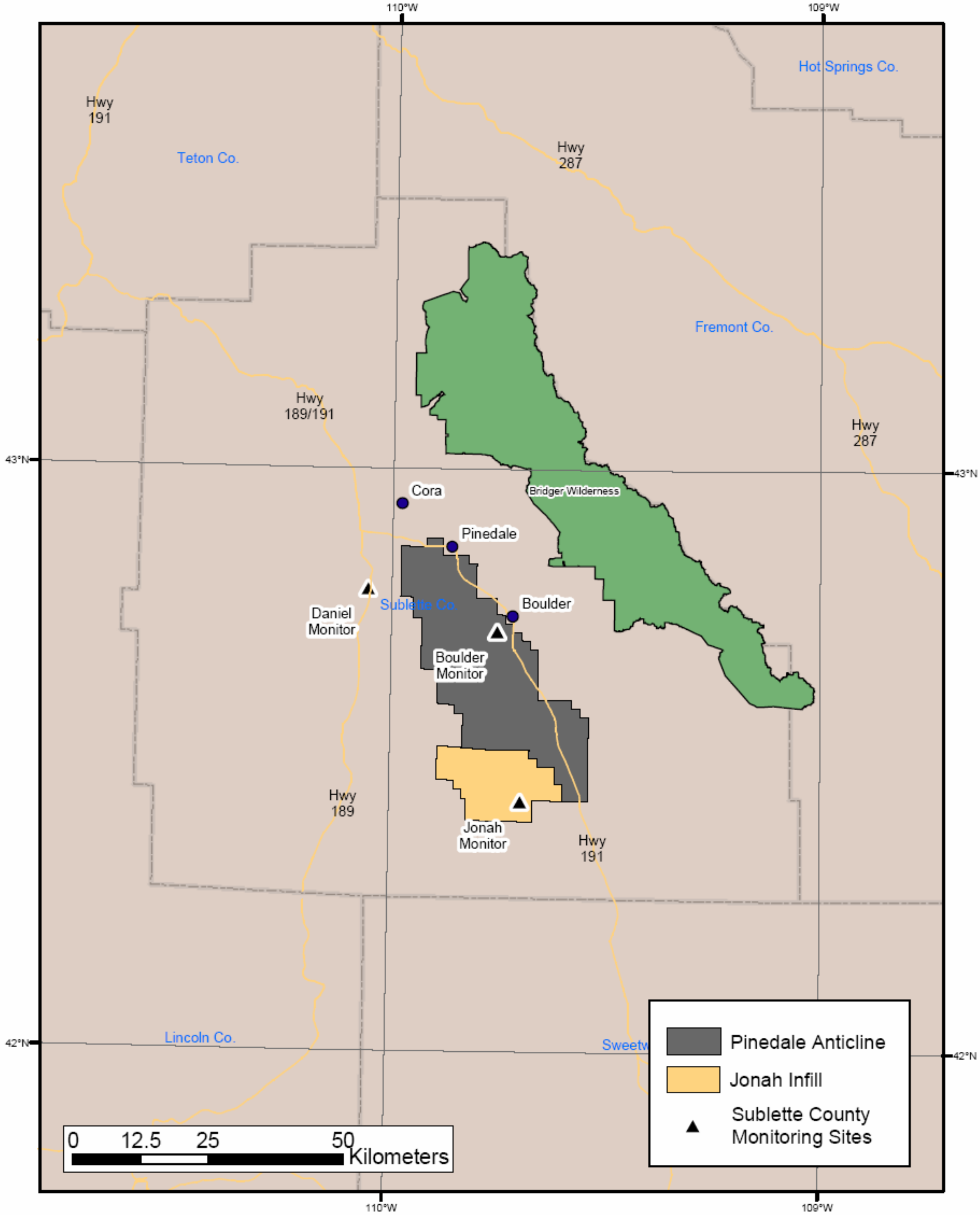


Table 3.2 Ambient Concentrations, Sublette County Monitoring Stations.

Site	Pollutant	Averaging Period	Monitored Concentration ($\mu g/m^3$)
Jonah [1]	NO_2	Annual	19.1
	O_3	1-Hour[2]	214
		8-Hour[2]	152
	PM_{10}	Annual	10
		24-Hour[3]	51
Boulder [4]	NO_2	Annual	7.6
	O_3	1-Hour[2]	186
		8-Hour[2]	158
	PM_{10}	Annual	11
		24-Hour[3]	32
Daniel [5]	NO_2	Annual	5.7
	O_3	1-Hour[2]	138
		8-Hour[2]	132
	PM_{10}	Annual	11
		24-Hour[3]	23
Ryckman Creek [6]	CO	8-Hour[7]	1,381
		1-Hour[3]	3,336
Craven Creek [8]	SO_2	Annual	9
		24-Hour[3]	43
		3-Hour[3]	132

1 Data reflects partial year 2005 (Jan 15-Dec 31). Monitor located in Jonah Field, 40 mi NW of Farson, WY.
2 Highest, fourth highest monitored value.
3 Highest, second highest monitored value.
4 Data reflects quarters 2, 3 and 4, 2005. Monitor 5 mi S and W of Boulder, WY.
5 Data reflects quarters 3 and 4 2005. Monitor 5 mi south of Daniel, WY off Hwy. 18.
6 Data collected by Amoco at Ryckman Creek site for 8-month period 1978-1979, from Riley Ridge EIS (BLM 1983).
7 Second-highest non-overlapping average.
8 Data collected at LaBarge Study Area, Northwest Pipeline Craven Creek Site 1982-1983.

3.3 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 a screening methodology using VOC and NO_x screening tables developed by Scheffe (1988). Ozone models are designed for urban areas, are very expensive and time-consuming to implement, and are not applicable for use in rural areas such as southwest Wyoming. The VOC/NO_x screening tables have been used in other EIS analyses and the BLM supports their use in this application. In recognition of the importance of ozone concentrations, monitoring programs have been implemented by WDEQ-AQD in several areas of Sublette County. The VOC/NO_x screening tables will be used to evaluate potential ozone impacts from various maximum emissions activities that could occur within the PAPA.

Emissions of each pollutant analyzed will be examined to determine 1) the maximum emissions phase during well/field development and 2) the maximum emissions phase during production, and it will be these scenarios that will be modeled to determine near-field project impacts. Based on previous analyses performed for the Jonah Infill Project, Atlantic Rim Project, and Continental Divide Project, it is expected that road construction will generate the greatest PM_{10} and $PM_{2.5}$, and drilling will generate the greatest NO_x, CO, and SO_2 emissions during development. It is anticipated that compressor stations in the field will generate the greatest NO_x, CO, and SO_2 emissions during production. No PM_{10} and $PM_{2.5}$ will be modeled in the near-field analysis for a single pad during production unless it is determined that unpaved road emissions during production are greater than those from a single pad during development.

For development activities, a representative well pad and resource/access road will be developed for modeling. Hourly emission rate adjustment factors will be applied to sources emitting only during specific diurnal 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. Representative sections of drilling engine operations will be modeled at maximum Project Alternative projected pad and drill rig densities. NO_2 concentrations will be calculated for annual averaging periods, CO concentrations for 1-hour and 8-hour averaging periods, and SO_2 concentrations for 3-hour, 24-hour, and annual averaging periods.

One production scenario will be analyzed representing one section of producing wells centered on one compressor station. The compressor station will be modeled equal to the largest station anticipated to operate in the field during the LOP. For the production scenario, annual average nitrogen dioxide (NO_2) concentrations, 1-hour and 8-hour CO concentrations, and SO_2 concentrations for 3-hour, 24-hour, and annual averaging periods will be predicted.

Point sources will be used for modeling emissions from compressors, well-site combustion equipment, and drilling rigs. Volume sources will be used for modeling PM_{10} and $PM_{2.5}$ emissions from road travel and wind erosion during development activities. Model receptors will be located a minimum of 100 meters (m) from development emission sources at 100-m grid spacing. Following WDEQ-AQD compressor modeling guidance, model receptors will be placed at 25-m intervals along anticipated compressor facility fencelines. Compressor stack heights will be set at actual or proposed heights but no greater than 1.5 times compressor building heights. Receptors beyond the compressor facility fenceline will be placed at 100-m intervals or at intervals appropriate to decreased well spacing.

3.4 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. HAPs emissions are expected to include those from well-site fugitives, Central Gathering Facilities and natural gas combustion at compressor stations. Because HAPs will be emitted predominantly during the production phase, only HAP emissions from production 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 3.1. Volume sources will be used for modeling well-site fugitive HAP emissions during production, and point sources will be used to represent compressor engine emissions. A maximum emissions case will be developed for each HAP and that case modeled. A single section of wells under development, or a single section of producing wells centered on a compressor station, whichever produces maximum emissions, is expected to be analyzed. If following emission inventory development another scenario during development or production results in greater total emissions, that scenario will be analyzed.

Receptors will be placed a minimum of 100 m from production wells and at 100-m spacing beyond. Receptors will be placed at 25-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 modeling all other natural gas constituent-based HAPs in the representative area developed for the criteria pollutant modeling as described in Section 3.3. For the long-term assessment, receptors will be placed on a polar grid at 10º intervals equidistant from the emissions source and the nearest residence or expected residence.

Short-term (1-hour) HAP concentrations will be compared to acute Reference Exposure Levels (RELs), shown in Table 3.3. 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 divided by 10 (IDLH/10) 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, 2005b). These values are approximately comparable to mild effects levels for 1-hour exposures.

Long-term exposure to HAPs emitted by the Proposed Action 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, 2005c). Annual modeled HAP concentrations for all HAPs emitted will be compared directly to the non-carcinogenic RfCs shown in Table 3.4.

Table 3.3 Acute RELs.

HAP	REL (mg/m^3)
Benzene	1.3 [1]
Toluene	37 [1]
Ethylbenzene	350 [2]
Xylene	22 [1]
n-Hexane	390 [2]
Formaldehyde	0.094 [1]

1 EPA Air Toxics Database, Table 2 (EPA, 2005b).
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, 2005b).

Table 3.4 Non-Carcinogenic HAP RfCs. [1]

HAP	Non-Carcinogenic RfC [1] (g/m^3)
Benzene	30
Toluene	400
Ethylbenzene	1,000
Xylenes	100
n-Hexane	200
Formaldehyde	9.8

1 EPA Air Toxics Database, Table 1 (EPA, 2005c).

RfCs for suspected carcinogens benzene and formaldehyde are expressed as unit risk factors, shown in Table 3.5. 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 which 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).

Table 3.5 Carcinogenic HAP RfCs and Exposure Adjustment Factors.

Analysis [1]	HAP Constituent	Carcinogenic RfC (Risk Factor) [2] 1/(g/m^3)	Exposure Adjustment Factor
MLE	Benzene	7.8×10^{-6}	0.0949
MLE	Formaldehyde	5.5×10^{-9}	0.0949
MEI	Benzene	7.8×10^{-6}	0.86
MEI	Formaldehyde	5.5×10^{-9}	0.86

1 MLE = most likely exposure; MEI = maximally exposed individual.
2 EPA Air Toxics Database, Table 1 (EPA, 2005c).

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 60 years (i.e., the LOP), corresponding to an adjustment factor of 60/70 = 0.86.

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 (0.86 x 1.0) = 0.86. EPA unit risk factors and adjustment factors are shown in Table 3.5.

4.0 MID-FIELD AND FAR-FIELD ANALYSIS

The purpose of the mid-field and far-field analysis is to quantify potential air quality impacts to both ambient air concentrations and AQRVs from air pollutant emissions of NO_x, SO_2, PM_{10}, and $PM_{2.5}$ expected to result from the development of the project. Ambient air quality impacts beyond the immediate project area and throughout the study area will be analyzed and AQRVs will be analyzed at PSD Class I and sensitive PSD Class II areas. Cumulative impacts also will be quantified by including in the analysis other documented sources of air pollutant emissions within a defined study area. The analyses will be performed using the EPA-approved CALMET/CALPUFF modeling system to predict air quality direct and cumulative impacts at far-field PSD Class I and sensitive PSD Class II areas, and at several mid-field PSD Class II areas including locations within the PAPA. The PSD Class I areas and sensitive PSD Class II areas to be analyzed are shown on Map 2.1 and include the following:

- Bridger Wilderness Area (Class I);
- Fitzpatrick Wilderness Area (Class I);
- Gros Ventre Wilderness Area (Class II);
- Popo Agie Wilderness Area (Class II);
- Wind River Roadless Area (Class II);
- Grand Teton National Park (Class I);
- Teton Wilderness Area (Class I);
- North Absaroka Wilderness Area (Class I);
- Yellowstone National Park (Class I); and
- Washakie Wilderness Area (Class I).

In addition, analyses will be performed for seven lakes designated as acid sensitive located within the sensitive PSD Class I and Class II wilderness areas to assess potential lake acidification from atmospheric deposition impacts. These lakes include the following:

- Deep Lake in the Bridger Wilderness Area;
- Black Joe Lake in the Bridger Wilderness Area;
- Hobbs Lake in the Bridger Wilderness Area;
- Upper Frozen Lake in the Bridger Wilderness Area;
- Lazy Boy Lake in the Bridger Wilderness Area;
- Ross Lake in the Fitzpatrick Wilderness Area; and
- Lower Saddlebag Lake in the Popo Agie Wilderness Area.

The proposed mid-field analysis will assess direct project and cumulative air quality impacts at in-field locations within the PAPA and at other mid-field locations defined as Class II areas (Wyoming regional communities). Mid-field locations to be analyzed were identified by air quality stakeholders group members, and include the Wyoming communities of:

- Boulder;
- Cora; and
- Pinedale.

Air emissions of NO_x, SO_2, PM_{10}, and $PM_{2.5}$ from proposed wells and their associated development activity, as well as from regional emissions as described in Section 2.2, will be modeled. A description of the emissions inventory procedures to be implemented is included in Section 2.0 of this Protocol. The idealization of these emissions sources for input to the CALPUFF model is described in Section 4.3.

CALPUFF results will be post-processed with POSTUTIL and CALPOST to derive air concentrations for comparison to ambient air standards, significance thresholds, and Class I and II Increments; AQRV impacts due to deposition rates for comparison to sulfur (S) and nitrogen (N) deposition thresholds and to calculate acid neutralizing capacity (ANC) for sensitive water bodies; and AQRV impacts due to light extinction change 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 4.5 of this Protocol.

4.1 MODELING METHODOLOGY

The most recent versions of the EPA approved CALMET/CALPUFF modeling system (CALMET Version 5.53b and CALPUFF Version 5.711b dated December 16, 2005) will be used to develop windfields and calculate both ambient concentrations and AQRV impacts. The CALMET meteorological model will be used to develop windfields for 3 years of meteorological data (2001, 2002, and 2003) and the CALPUFF dispersion model will be used to combine these windfields with project-specific and regional emissions inventories of SO_2, NO_x, PM_{10}, and $PM_{2.5}$ to estimate ambient concentrations and AQRV impacts at mid-field and far-field receptor locations. The study area is shown in Map 1.1

The CALMET and CALPUFF models will be used in this analysis following the methods described herein and the following guidance sources:

- *Guideline on Air Quality Models*, 40 *Code of Federal Regulations* (C.F.R.), Part 51, Appendix W (EPA, 2003a);
- *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).

4.2 METEOROLOGICAL MODEL INPUT AND OPTIONS

The CALMET model will be used to develop windfields for the study area shown in Map 1.1. The model domain extent was selected following a 200-km radius criteria (see Map 2.1), centered around the PAPA, for inclusion of PSD Class I and sensitive PSD Class II wilderness areas in the air quality analyses. The proposed modeling domain covers the PAPA and Class I and other sensitive areas within 200-km of the PAPA with a sufficient buffer zone to allow for potential recirculation or flow reversal effects to be evaluated. The selection of a 200-km radius is consistent with other NEPA regional analyses performed for southwest Wyoming and current FLM recommendations for PSD Class I area analyses. The proposed modeling domain follows IWAQM guidance that recommends that the horizontal domain of the model grid extend 50 to 80 km beyond the receptors and sources being modeled, for modeling potential recirculation wind flow effects. All model inputs will be based on a Lambert Conformal Projection given the size of the proposed domain.

Following current EPA modeling guidance and at the request of the BLM, 3 years of windfield data will be developed and used for the modeling analysis. The selected years are 2001, 2002, and 2003, based on the availability of representative MM5 mesoscale model data for the analysis. The 2001, 2002 and 2003 MM5 data were developed for EPA or for a Regional Planning Organization (RPO), have undergone significant QA/QC verification and peer review, and are the most recent available consecutive 3 years of prognostic data that are available. The MM5 data sets that will be used for the analysis include year 2001 data processed at 36-km spacing for EPA (Alpine Geophysics, LLC, 2003), year 2002 data processed at 36-km spacing for WRAP (ENVIRON, 2005) and year 2003 data processed at 36-km spacing for the Midwest RPO (Baker, 2005).

The MM5 data will be used to provide an initial guess field in CALMET. These data will be further processed to 4-km resolution by CALMET to produce a step 1 windfield. Ten vertical layers will be used. Surface meteorology data for observation sites throughout the modeling domain available from National Climatic Data Center (NCDC) integrated surface observation data sets, Clean Air Status and Trends Network (CASTNET) sites, and from onsite data collected by BP America Production Company in the Jonah Field will be incorporated into the windfields. In addition, upper air rawinsonde meteorology data, and precipitation data for applicable observation sites throughout the modeling domain have been obtained from NCDC and will be included in the analysis. USGS 1:250,000-Scale Land Use and Land Cover (LULC) data, and USGS 1º DEM data will be used for land use and terrain data in the development of the CALMET windfields. The CALMET model control switch settings will follow IWAQM guidance. A sample CALMET input control file is included in Attachment A.

Windfields developed for years 2001, 2002 and 2003, at a 4-km grid spacing, will be used to assess impacts from project sources and regional sources at all PSD Class I and sensitive PSD Class II areas and at mid field locations.

4.3 DISPERSION MODEL INPUT AND OPTIONS

CALPUFF will be used to model project-specific and regional emissions of NO_x, SO_2, PM_{10}, and $PM_{2.5}$. The CALPUFF model will be run for each year of CALMET windfields (2001, 2002, and 2003) following IWAQM-recommended default switch settings. A sample CALPUFF input control file is included in Attachment A. Chemical transformations will be modeled based on the MESOPUFF II chemistry mechanism 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 runs. 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. The PM_{10} emissions input to CALPUFF will include only the PM_{10} emissions greater than the $PM_{2.5}$ (i.e., modeled PM_{10} = PM_{10} emission rate – $PM_{2.5}$ emission rate) since $PM_{2.5}$ is modeled as a separate species. Total PM_{10} impacts will be determined in the post-processing of modeled impacts, as discussed in Section 4.5.

4.3.1 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. A review of background ozone monitoring data available for the three years proposed for analysis has indicated that data from the following sites are available for years 2001, 2002, and 2003:

- Pinedale, Wyoming;
- Centennial, Wyoming;
- Yellowstone National Park, Wyoming;
- Craters of the Moon National Park, Idaho; and
- Highland, Utah.

Hourly ozone data sets will be developed from these stations and will be included in the CALPUFF modeling. A representative default value will be determined from data statistics upon review of these data sets and used for missing hours. A background ammonia concentration of 1.0 ppb, as suggested in IWAQM for “arid lands”, will be used.

4.3.2 Receptors

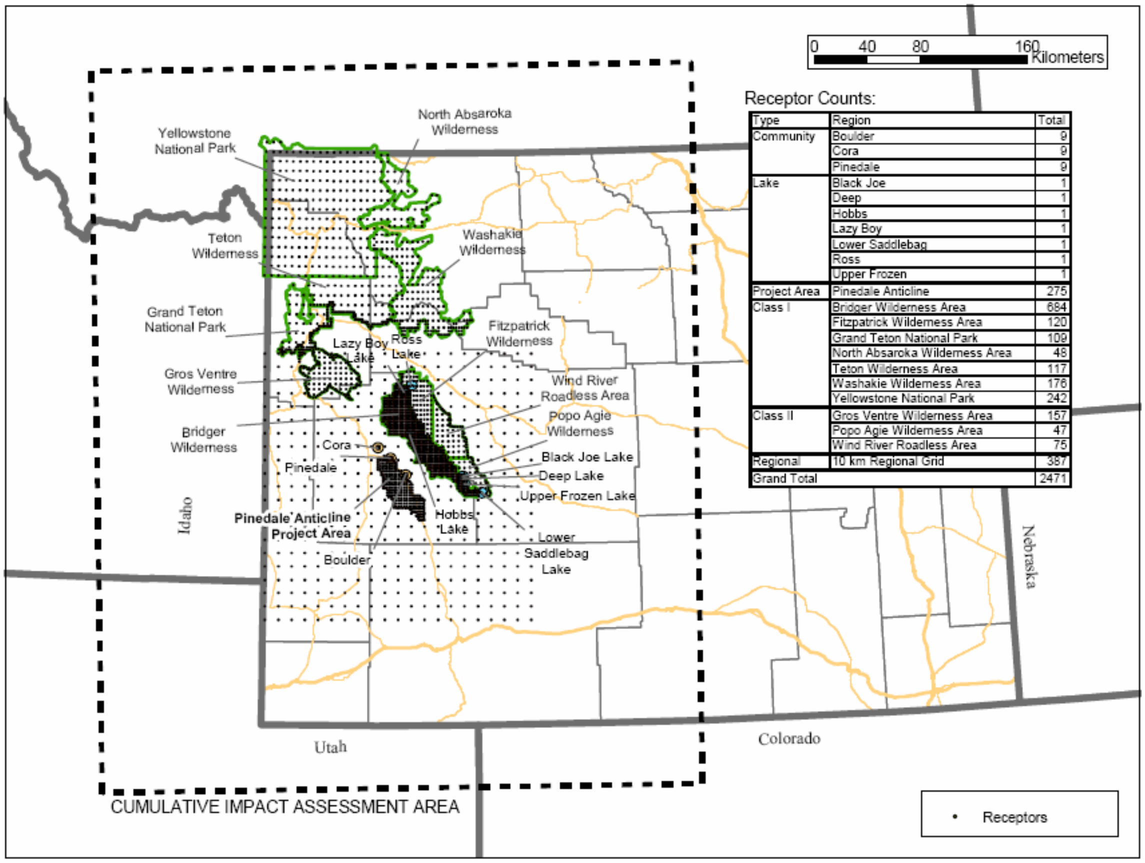
Model receptors will be input to CALPUFF, at which concentration, deposition, and other impacts will be calculated. Receptors at a 2-km grid resolution will be placed throughout the PAPA to calculate in-field cumulative ambient air impacts. Receptors will also be placed at 10-km grid resolution extending out 100 km from the PAPA to calculate cumulative ambient air impacts. At the PSD Class I, and other sensitive PSD Class II areas located within the modeling domain, ambient air and AQRV impacts will be determined. The PSD Class I areas within the modeling domain to be evaluated include:

- Bridger Wilderness Area,
- Fitzpatrick Wilderness Area,
- Teton Wilderness Area,
- Washakie Wilderness Area,
- Grand Teton National Park,
- Yellowstone National Park, and
- North Absaroka Wilderness Area.

Receptor sets available from the National Park Service for PSD Class I areas will be used as a basis for determining modeling receptors for all of these Class I areas. The complete National Park Service receptor set will be used for modeling the nearby Bridger Wilderness Area, however the receptor grid densities will be thinned at the more distance Class I areas, while maintaining adequate area coverage, for consideration of model run times. For the three sensitive PSD Class II areas located within the modeling domain (Gros Ventre and Popo Agie Wilderness Areas, and Wind River Roadless Area), receptor sets will be developed using 2-km spacing along the Wilderness area boundaries and at 4-km spacing within each area. Receptor elevations for the sensitive Class II area receptors and for the receptors within the PAPA and extending outward 100 km will be determined from 1:250,000 scale USGS DEM data.

Discrete receptors will be placed at the seven lakes identified as sensitive to acid deposition. Elevations for the sensitive lake receptors will be derived from 7.5-minute USGS maps. In addition, for the Wyoming regional community locations of Boulder, Pinedale and Cora, receptors will be placed using 3 x 3, 1-km grids for analyses of visibility (AQRV) impacts. At these mid-field Wyoming community locations impacts to visibility (regional haze) will be assessed although these communities are classified as PSD Class II areas where no visibility protection exits under local, state, or federal law. Elevations for the regional community locations will be determined from 1:250:000 scale USGS DEM data. The proposed CALPUFF model receptors are shown in Figure 4.1.

Figure 4.1 CALPUFF Model Receptors



Type	Region	Total
Community	Boulder	9
	Cora	9
	Pinedale	9
Lake	Black Joe	1
	Deep	1
	Hobbs	1
	Lazy Boy	1
	Lower Saddlebag	1
	Ross	1
	Upper Frozen	1
Project Area	Pinedale Anticline	275
Class I	Bridger Wilderness Area	684
	Fitzpatrick Wilderness Area	120
	Grand Teton National Park	109
	North Absaroka Wilderness Area	48
	Teton Wilderness Area	117
	Washakie Wilderness Area	176
	Yellowstone National Park	242
Class II	Gros Ventre Wilderness Area	157
	Popo Agie Wilderness Area	47
	Wind River Roadless Area	75
Regional	10 km Regional Grid	387
Grand Total		2471

4.3.3 Source Parameters

4.3.3.1 Project Emissions

Pollutant emission rates estimated as described in Section 2.0 will be input to CALPUFF to predict air quality impacts from the Project. Emissions scenarios for year 2005 (current conditions), the Proposed Action and No Action Alternatives will be developed and modeled. Emissions for the Proposed Action from both the development phase and well production (field operation) phase will be modeled. For the Proposed Action and No Action alternatives, project emissions after 2005 that could occur from development and production activities over the LOP will be examined to determine an annual period representing a maximum combination of production and development. An additional emissions scenario representing the Proposed Action at maximum production (full field operation) will be modeled. Based upon model results of the modeled maximum emissions scenarios, alternative emissions scenarios considering possible mitigation techniques will be developed and modeled.

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 area of the PAPA 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 PAPA.

The analysis will include future compression requirements projected by the Operators. Compressor engine emissions will be input as point sources with actual expected stack parameters at their anticipated locations.

Due to the close proximity and physical alignment of the PAPA to the Bridger Wilderness sensitivity "zone" modeling will be performed for Project source emissions to determine whether there are any areas within the PAPA that could potentially result in much greater impacts at the Bridger Wilderness. The PAPA will be divided into 3 distinct zones, south, north, and central with emissions spread evenly throughout each area, for these sensitivity runs. Emissions from each zone will be modeled separately and the predicted impacts from each will be compared to determine whether there are any significant differences.

4.3.3.2 Regional Source Emissions

Regional sources, including permitted sources, RFD, and RFFA inventoried according to the methodology described in Section 2.2, will be input to the CALPUFF model as point sources or area sources as appropriate. As part of the emissions inventory, source location and exit parameter data will be obtained.

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, representative stack to reduce model run-time. This procedure was followed in the Pinedale Anticline Oil and Gas Exploration and Development EIS and other EIS regional source inventories. 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 (i.e., well heaters, surface mines, gravel pits, etc.) will be aggregated into area sources in the model, either source location-specific or regional, depending upon the nature of the fugitive emissions sources. The locations of area sources input to the model will be documented in the technical support document. Regional paved and unpaved roadway travel, urban, biogenic, and other non-industrial sources are considered to be included in the ambient air background concentrations described in this Protocol; therefore, those fugitive sources will not be modeled.

4.4 BACKGROUND DATA

4.4.1 Criteria Pollutants

Background values for criteria pollutants will be used as described in Section 3.2.

4.4.2 Visibility

The proposed analysis differs from previous Wyoming NEPA cumulative air quality impact studies in its update of visibility background to include the most current data available at the time of this Protocol. The proposed analysis also uses representative monitoring data collected from the Interagency Modeling of Protected Visual Environment (IMPROVE) network for the time period (2000 to 2004) which coincides with the time period that will be used to establish "baseline conditions" under the EPA Regional Haze Rule (EPA, 2003a). Monitored visibility background data that have undergone QA/QC are currently available through December 31, 2004.

CALPOST will be used to estimate change in light extinction from CALPUFF model concentration results. At the request of the BLM, WDEQ, and USFS three separate methods are proposed for this analysis using FLAG and IMPROVE background visibility data. Two methods which follow recent CALPUFF modeling guidance for Best Available Retrofit Technology (BART) analyses developed for the Visibility Improvement State and Tribal Association of the Southeast (VISTAS) RPO are also proposed (VISTAS, 2006). An additional visibility test using background visibility data determined from nephelometer data measured at Boulder will be performed. The BLM visibility calculation method will utilize CALPOST visibility method 6 (CALPOST model switch setting “MVISBK” set to 6) for computing light extinction change in combination with FLAG background data. The WDEQ visibility calculation method will utilize CALPOST visibility method 6 (MVISBK=6) in combination with IMPROVE background data. The two BART screening calculation procedures will also use CALPOST method 6 combined with background visibility conditions as provided in the *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule* (EPA, 2003b). Method 6 uses monthly averaged humidity factors, and it is not sensitive to synoptic weather events that lead to high extinction events and subsequent explanation as to why certain events should be discounted. The USFS visibility calculation method will use the FLAG background data in combination with hourly relative humidity data from the CALMET windfields (MVISBK=2).

The FLAG method 6 uses seasonal natural background visibility conditions and relative humidity factors at Class I areas. FLAG method 2 uses the seasonal natural background visibility conditions and hourly relative humidity data from surface observations in the CALMET wind field data. For the FLAG methods proposed for this analysis, estimated natural background visibility values as provided in Appendix 2.B of FLAG (2000) will be used. For FLAG method 6, monthly relative humidity factors as provided in the *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule* (EPA, 2003b) will be used. Because natural background data are provided for PSD Class I areas only, data from the nearest PSD Class I area will be used for the sensitive PSD Class II areas. The natural background visibility data, in units of inverse megameters (Mm^{-1}), that will be used with the FLAG visibility analysis for each area analyzed are shown in Table 4.1.

The IMPROVE method as requested by the WDEQ uses reconstructed IMPROVE aerosol total extinction data. The IMPROVE background visibility data are provided as reconstructed aerosol total extinction data, based on the quarterly mean of the 20% cleanest days measured at the Bridger and North Absaroka Wilderness Areas and Yellowstone National Park IMPROVE sites for the 5-year period, years 2000 through 2004, as shown in Table 4.2. These 5 years are defined as “baseline conditions” years for tracking progress under EPA Regional Haze Rule guidance (EPA, 2003a). The IMPROVE method will also utilize monthly relative humidity factors as provided in the *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule*.

Table 4.1 FLAG Report Background Extinction Values.[1]

Site	Season	Hygroscopic (Mm^{-1})	Non-hygroscopic (Mm^{-1})
Bridger Wilderness Area (Will also be used for Popo Agie Wilderness Area and Wind River Roadless Area)	Winter	0.6	4.5
	Spring	0.6	4.5
	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
North Absaroka Wilderness Area	Winter	0.6	4.5
	Spring	0.6	4.5
	Summer	0.6	4.5
	Fall	0.6	4.5
Teton Wilderness Area	Winter	0.6	4.5
	Spring	0.6	4.5
	Summer	0.6	4.5
	Fall	0.6	4.5
Washakie Wilderness Area	Winter	0.6	4.5
	Spring	0.6	4.5
	Summer	0.6	4.5
	Fall	0.6	4.5
Grand Teton National Park (will also be used for Gros Ventre Wilderness Area)	Winter	0.6	4.5
	Spring	0.6	4.5
	Summer	0.6	4.5
	Fall	0.6	4.5
Yellowstone 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).

Table 4.2 IMPROVE Background Aerosol Extinction Values.[1]

IMPROVE Site	Quarter	Hygroscopic (Mm^{-1})	Non-hygroscopic (Mm^{-1})
Bridger	1	0.775	1.233
	2	1.565	3.283
	3	1.791	4.965
	4	0.704	1.192
North Absaroka	1	0.774	1.565
	2	1.326	2.249
	3	1.360	4.931
	4	0.600	1.368
Yellowstone	1	1.104	1.588
	2	1.453	2.983
	3	1.550	5.414
	4	0.738	1.544

[1] Cooperative Institute for Research in the Atmosphere (2006).

Visibility data from the Bridger Wilderness Area IMPROVE site will be used for the Bridger, Fitzpatrick, Gros Ventre, and Popo Agie Wilderness Areas and for the Wind River Roadless Area. Visibility data from the Yellowstone National Park IMPROVE site will be used for the Teton Wilderness Area and for Grand Teton and Yellowstone National Parks. Data from the North Absaroka site will be used for the North Absaroka and Washakie Wilderness Areas. Monthly relative humidity factors are available for the Bridger, Fitzpatrick, Teton, and Washakie Wilderness Areas, and for Grand Teton and Yellowstone National Parks. Relative humidity data for the Bridger Wilderness Area will also be used for the Gros Ventre and Popo Agie Wilderness Areas and for the Wind River Roadless Area analyses.

The two BART screening methods will use the background visibility data provided in Appendix B of the *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule.* These methods use CALPOST visibility method 6. The first test will use the "best days" background visibility condition and the second test will use the annual average background. These background data given in deciview (dv) units are shown in Table 4.3. The BART methods will also utilize monthly relative humidity factors as provided in the *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule*. Because the background visibility and relative humidity data are provided for PSD Class I areas only, data from the nearest PSD Class I area will be used for the sensitive PSD Class II areas.

Table 4.3 Default Natural Conditions.[1]

Site	Annual Average (dv)	Best Days (dv)
Bridger Wilderness	4.52	1.96
Fitzpatrick Wilderness	4.53	1.97
North Absaroka Wilderness	4.53	1.97
Teton Wilderness	4.53	1.97
Washakie Wilderness	4.53	1.97
Grand Teton National Park	4.53	1.97
Yellowstone National Park	4.56	2.00

[1] Default natural conditions from Appendix B (EPA, 2003b).

Background visibility data for the Wyoming regional community locations (Boulder, Cora, and Pinedale) were determined from current nephelometer visibility data collected at Boulder and from transmissometer extinction data and IMPROVE aerosol data collected at the Bridger Wilderness Area (ARS, 2006), since there are no applicable aerosol extinction data collected at these community locations. Quarterly averages of the average days and cleanest 20th percent days were developed from daily averaged extinction measurements for the 1-year period, March 1, 2005 through February 28, 2006. These data are shown in Table 4.4. Relative humidity data factors for the Bridger Wilderness Area will be used for the regional community locations.

Table 4.4 Boulder Background Extinction Data.

Quarter	Annual Average (Mm-1)	20th Cleanest Days (Mm-1)
1	25.6	14.0
2	21.2	14.7
3	24.3	19.0
4	21.4	14.3

4.4.3 Deposition

Background total sulfur (S) and nitrogen (N) deposition data (expressed in kilograms per hectare per year [kg/ha-yr]) collected at National Acid Deposition Program (NADP) National Trends

Network (NTN) and CASTNET station monitoring locations near Pinedale, Wyoming and in Yellowstone National Park are provided in Table 4.5. These background S and N deposition data will be added to modeled cumulative (project alternative and regional sources) deposition impacts to estimate total S and N deposition impacts.

Table 4.5 Background N and S Deposition Values (kg/ha-yr).

Site Location	Nitrogen Deposition	Sulfur Deposition	Year of Monitoring
Pinedale	1.4	0.74	2004
Yellowstone National Park	1.3	0.70	2003

4.4.4 Lake Chemistry

The most recent lake chemistry background ANC data have been obtained from the FLMs for each sensitive lake listed in Section 4.0. The 10th percentile lowest ANC values were calculated for each lake following procedures provided from the USFS. 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 4.6. Of the seven lakes listed in Table 4.6, two lakes (Lazy Boy and Upper Frozen) are considered by the USFS as extremely sensitive to acid deposition since the background ANC values are less than 25 microequivalents per liter (µeq/l).

Table 4.6 Background ANC Values for Acid Sensitive Lakes[1]

Wilderness Area	Lake	Latitude (Deg-Min-Sec)	Longitude (Deg-Min-Sec)	10th Percentile Lowest ANC Value (μeq/l)[2]	Number of Samples	Monitoring Period
Bridger	Black Joe	42º44'22"	109º10'16"	67.1	67	1984-2005
Bridger	Deep	42º43'10"	109º10'15"	59.7	64	1984-2005
Bridger	Hobbs	43º02'08"	109º40'20"	69.9	71	1984-2005
Bridger	Lazy Boy	43º19'57"	109º43'47"	10.8	3	1997-2004
Bridger	Upper Frozen	42º41'13"	109º09'39"	6.0	8	1997-2005
Fitzpatrick	Ross	43º22'41"	109º39'30"	53.7	49	1988-2005
Popo Agie	Lower Saddlebag	42º37'24"	108º59'38"	55.2	48	1989-2005

1 From USFS (2006).
2 10th Percentile Lowest ANC Values reported.

4.5 POST-PROCESSING

For each far-field sensitive area, CALPUFF-modeled concentration impacts will be post-processed with POSTUTIL and CALPOST to derive: 1) concentrations for comparison to ambient air quality standards (WAAQS and NAAQS), and PSD Class I and II Increments; 2) deposition rates for comparison to sulfur (S) and nitrogen (N) deposition levels of concern and to calculate changes to ANC at sensitive lakes; and 3) light extinction changes for comparison to visibility impact thresholds. For the mid-field analyses, CALPOST concentrations will be post-processed to estimate light extinction changes at regional communities for comparison to the visibility impact thresholds. For in-field locations, CALPUFF concentrations will be post-processed to compute applicable concentration impacts for comparison to WAAQS and NAAQS.

In post-processing the PM_{10} impacts at all far-field receptor locations, project alternative traffic emissions of PM_{10} (production and development) will not be included in the total estimated impacts, only the $PM_{2.5}$ impacts will be considered. This is based on supporting documentation from the WRAP analyses of mechanically generated fugitive dust emissions that suggest that particles larger than $PM_{2.5}$ tend to deposit out rapidly near the emissions source and do not transport over long distances (Countess et al., 2001). The WRAP findings suggest that nearly 90 percent of PM_{10} particles from unpaved road emissions are depleted within approximately 50 meters. In addition, even if the PM_{10} particles were in a well mixed 10 meter layer, with an average wind speed of 5 meters per second, only 10 percent of the PM_{10} particles could travel up to 36 kilometers. Since this phenomenon is not modeled adequately in CALPUFF; therefore, to avoid overestimates of PM_{10} impacts at far-field locations, these sources will not be considered in the total modeled impacts. However, the total PM_{10} impacts from traffic emissions will be included in all in-field concentration estimates.

4.5.1 Concentration

CALPOST will be used to process the CALPUFF concentration output file to compute appropriate 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).

4.5.2 Visibility

As discussed in Section 4.4.2, visibility impacts (measured as change in light extinction) will be calculated using five separate methods, which differ primarily by the background data used to derive the percent change in visibility. Changes in light extinction will be estimated for both Project emissions and regional source emissions at receptor locations outlined in Section 4.3.2 of this Protocol.

CALPOST will be run using the FLAG data 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 either monthly relative humidity factors (BLM test) or hourly relative humidity data from the CALMET wind fields (USFS test), due to CALPUFF-predicted particle species concentrations. Seasonal background extinction values used for the FLAG method are shown in Table 4.1. 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 at each receptor, with the results reported as change in deciview (dv). The CALPOST switch 'MVISBK' is set to 6 for the BLM test and is set to 2 for the USFS method. The relative humidity data cutoff in CALPOST will be set to 98 for the USFS test. The FLAG method conservatively assumes that the seasonal natural visibility conditions occur on every day during the entire season.

CALPOST will also be run using the IMPROVE data (WDEQ test) to calculate the change in daily (24-hour) 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 North Absaroka wilderness areas and Yellowstone 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 also set to 6 for this method. Similar to the FLAG method, the IMPROVE method also conservatively assumes that the cleanest visibility conditions occur on every day during each day of the year.

For the BART screening methods CALPOST will also be run using the annual background visibility data from Appendix B of (EPA, 200b) provided in Table 4.3. The first test will use the "best days" background visibility condition and the second test will use the annual average background. The background extinction data given in dv units will be converted to values in Mm^{-1} using the haze index equation ($HI=10\ln(b_{ext}/10)$) given in EPA, 2003b. These methods use the annual background extinction values and monthly averaged relative humidity factors to estimate the change in light extinction. The CALPOST switch 'MVISBK' is set to 6 for these methods. The extinction values will be input to CALPOST as BKSOIL (non-hygroscopic). Using these parameters, CALPOST will be used to compute the change in daily (24-hour) visibility for each method.

For the Wyoming regional community locations (Boulder, Cora, and Pinedale) adjusted nephelometer data collected at Boulder will be used to calculate the change in daily (24-hour) light extinction. The CALPOST switch ‘MVISBK' will be set to 6 for this method. This method uses quarterly averaged background visibility data and monthly averaged relative humidity factors to estimate the change in light extinction. The quarterly averaged extinction data for the cleanest 20^{th} percent days (Table 4.4) will be used for this visibility test. Relative humidity data factors for the Bridger Wilderness Area (EPA, 2003b) will be used for the regional community locations.

4.5.3 Deposition

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

5.0 AIR QUALITY IMPACTS

5.1 NEAR-FIELD

Maximum predicted concentrations in the vicinity of project emissions sources will be compared with the Wyoming Ambient Air Quality Standards (WAAQS), National Ambient Air Quality Standards (NAAQS), and applicable Prevention of Significant Deterioration (PSD) Class II increments shown in Table 5.1. Maximum modeled concentrations will be added to the existing ambient air quality background concentrations shown in Table 3.2, and the total concentrations will be compared to corresponding NAAQS and WAAQS as shown in Table 5.1. Direct project impacts will be compared to Class II PSD Increments. This PSD 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. Near-field HAP impacts from short-term (acute) exposure and for calculation of long-term risk are assessed as described in Section 3.4.

5.2 FAR-FIELD

5.2.1 Ambient Concentration Impacts

Modeled concentrations predicted in PSD Class I and sensitive Class II areas from direct project and regional sources will be compared to ambient air quality standards and PSD increments, shown in Table 5.2. Modeled impacts including applicable background concentrations will be compared with ambient air quality standards. Direct project and cumulative impacts will be compared to applicable PSD increments. The PSD demonstrations are for information only and are not regulatory PSD Increment consumption analyses, which would be completed as necessary by the WDEQ-AQD.

Table 5.1 Ambient Air Quality Standards and PSD Class II Increments for Comparison to Near-Field Analysis Results (μg/m^3).

Pollutant/Averaging Time	NAAQS	WAAQS	PSD Class II Increment[1]
CO			
1-hour[2]	40,000	40,000	--[3]
8-hour[2]	10,000	10,000	--
NO_2			
Annual[4]	100	100	25
O_3			
1-hour [2]	235	235	--
8-hour[5]	157	157	--
PM_{10}			
24-hour[2]	150	150	30
Annual[4]	50	50	17
$PM_{2.5}$			
24-hour[2]	65	65	--
Annual[4]	15	15	--
SO_2			
3-hour[2]	1,300	1,300	512
24-hour[2]	365	260	91
Annual[4]	80	60	20

1 The PSD demonstrations serve information purposes only and do not constitute a regulatory PSD increment consumption analysis.
2 No more than one exceedance per year.
3 -- = No PSD Class II increment has been established for this pollutant.
4 Annual arithmetic mean.
5 Average of annual fourth-highest daily maximum 8-hour average.

Table 5.2 NAAQS, WAAQS, and PSD Class I and Class II Increments for Comparison to Far-field Analysis Results (μg/m³).

Pollutant/Averaging Time	NAAQS	WAAQS	PSD Class I Increment [1]	PSD Class II Increment [1]
NO_2				
Annual[2]	100	100	2.5	25
SO_2				
3-hour[3]	1,300	1,300	25	512
24-hour[3]	365	260	5	91
Annual[2]	80	60	2	20
PM_{10}				
24-hour[3]	150	150	8	30
Annual[2]	50	50	4	17
$PM_{2.5}$				
24-hour	65	65	--	--
Annual	15	15	--	--

[1] The PSD demonstrations serve information purposes only and do not constitute a regulatory PSD increment consumption analysis.
[2] Annual arithmetic mean.
[3] No more than one exceedance per year is allowed.

5.2.2 Visibility

Change in 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), with the results reported in percent change in light extinction and change in deciview (dv). The thresholds are defined as 5% and 10% of the reference background visibility or 0.5 and 1.0 dv for project sources alone and cumulative source impacts, respectively. FLAG (2000) also identifies a goal that any specific project combined with cumulative new source growth will have no days of visibility impairment at or above 1.0 dv in any Class I area. These thresholds and the FLAG guidelines were developed for NSR applications where an AQRV analysis is required, as part of a PSD permit application. The BLM considers a 1.0 dv change as a significant adverse impact; however, there are no applicable local, state, tribal, or federal regulatory visibility standards. The USFS considers a 0.5-dv change as a threshold in order to protect visibility in sensitive areas. It is the responsibility of the jurisdictional Federal Land Manager or Tribal government responsible for that land to determine when adverse impacts are significant or not, and these may differ from BLM levels for significant adverse impacts.

Visibility impact assessments following FLAG guidance are typically based on the maximum predicted daily (24-hour) visibility impacts on an annual basis. The maximum number of days above threshold values and the maximum predicted impacts are reported. Visibility impact assessments following EPA's regional haze rule guidance (EPA, 2005d) use the annual 98th percentile maximum predicted daily values (8th highest daily value) for assessing visibility impacts.

For each PSD Class I and sensitive Class II area, comparisons of direct project and cumulative change in light extinction impacts to 1.0 and 0.5-dv change thresholds will be provided in the technical support document. Maximum annual predicted visibility impacts will be reported for the BLM, WDEQ, USFS, and regional community location visibility tests along with the corresponding 98th percentile values. For the two BART screening tests only the annual 98th percentile values will be reported.

5.2.3 Deposition

Maximum predicted S and N deposition impacts will be estimated for each analyzed direct project and cumulative source scenario. Predicted direct project impacts will be compared to the National Park Service (NPS) deposition analysis thresholds (DATs) for total N and S deposition in the western U.S., which are defined as 0.005 kilograms per hectare per year (kg/ha-year) for both N and S (NPS, 2001). Total deposition impacts, including background deposition values, from direct project and regional sources will be compared to USFS levels of concern, defined as 5 kg/ha-yr for S and 3 kg/ha-yr for N (Fox et al., 1989). It is understood that the USFS no longer considers these levels of concern to be protective; however, in the absence of alternative FLM-approved values, comparisons with these values will be made.

5.2.4 ANC

The CALPUFF-predicted annual deposition fluxes of S and N at sensitive lake receptors listed in Section 4.4.4 will be used to estimate the change in ANC. The change in ANC will be calculated following the January 2000, USFS Rocky Mountain Region's *Screening Methodology for Calculating ANC Change to High Elevation Lakes, User's Guide* (USFS, 2000). The predicted changes in ANC will be compared with the USFS's Level of Acceptable Change (LAC) thresholds of 10% for lakes with ANC values greater than 25 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 several analyzed lakes. ANC calculations will be performed for both Project emissions and for cumulative source emissions.

5.3 MID-FIELD

5.3.1 Ambient Concentration Impacts

Modeled concentrations predicted within PAPA in-field locations from direct project and regional sources will be compared to ambient air quality standards and applicable PSD Class II increments, shown in Table 5.2. Modeled impacts including applicable background concentrations will be compared with ambient air quality standards. Direct project and cumulative impacts will be compared to applicable PSD Class II increments. The PSD demonstrations are for information only and are not regulatory PSD Increment consumption analyses, which would be completed as necessary by the WDEQ-AQD.

5.3.2 Visibility

For each Wyoming regional community location included in the modeling analyses (Boulder, Cora, and Pinedale), comparisons of direct project and cumulative change in light extinction impacts to 1.0-dv change thresholds will be provided. At these mid-field Wyoming community locations impacts to visibility will be assessed, at the request of the Stakeholders group, although these communities are classified as PSD Class II areas where no visibility protection exits under local, state, or federal law.

6.0 REFERENCES

Air Resource Specialists, Inc. 2006. Estimation of Boulder b_{ext} Using the Boulder Nephelometer and Measurements from the Bridger Wilderness Area. Air Resource Specialists, Inc., Fort Collins CO, June 2006.

Alpine Geophysics, LLC. 2005. Annual Application for MM5 for Calendar Year 2001 Meteorological Modeling Performance Summary for Application to PM2.5/Haze/Ozone Modeling Projects. Lake Michigan Air Directors Consortium, Midwest Regional Planning Organization, Des Plaines, Illinois.

Baker. 2005. Meteorological Modeling Performance Summary for Application to PM2.5/Haze/Ozone Modeling Projects. Lake Michigan Air Directors Consortium, Midwest Regional Planning Organization, Des Plaines, Illinois.

Bureau of Land Management. 1983. Riley Ridge Natural Gas Project Air Resources Technical Report. U.S. Department of Interior, Bureau of Land Management, Kemmerer Field Office, Kemmerer, Wyoming, in cooperation with Environmental Research and Technology Inc.

______. 1988. Pinedale Resource Management Plan Record of Decision. U.S. Department of Interior, Bureau of Land Management, Pinedale Resource Area, Rock Springs District, Rock Springs, Wyoming.

______. 2000a. Pinedale Anticline Oil and Gas Exploration and Development Project Final Environmental Impact Statement. U.S. Department of Interior, Bureau of Land Management, Pinedale Field Office, Pinedale, Wyoming, in cooperation with U.S. Forest Service, U.S. Army Corps of Engineers, and State of Wyoming.

______. 2000b. Pinedale Anticline Oil and Gas Exploration and Development Project Record of Decision. U.S. Department of Interior, Bureau of Land Management, Pinedale Field Office, Pinedale, Wyoming, in cooperation with U.S. Forest Service, U.S. Army Corps of Engineers, and State of Wyoming.

______. 2004. Questar Year-Round Drilling Proposal, Finding of No Significant Impact, Decision Record and Environmental Assessment. U.S. Department of Interior, Bureau of Land Management, Pinedale Field Office, Pinedale, Wyoming, in cooperation with the State of Wyoming.

______. 2005a. Questar Year-Round Drilling Proposal Condensate Pipeline Modification, Finding of No Significant Impact, Decision Record and Environmental Assessment. U.S. Department of Interior, Bureau of Land Management, Pinedale Field Office, Pinedale, Wyoming.

______. 2005b. ASU Year-Round Drilling Demonstration Project, Finding of No Significant Impact, Decision Record and Environmental Assessment. U.S. Department of Interior, Bureau of Land Management, Pinedale Field Office, Pinedale, Wyoming, in cooperation with the State of Wyoming and Sublette County.

______. 2005c. Questar Year-Round Drilling Proposal Addendum, Finding of No Significant Impact, Decision Record and Environmental Assessment. U.S. Department of Interior, Bureau of Land Management, Pinedale Field Office, Pinedale, Wyoming.

______. 2006. Jonah Infill Drilling Project, Final Environmental Impact Statement. U.S. Department of Interior, Bureau of Land Management, Pinedale Field Office, Pinedale, Wyoming and Rock Springs Field Office, Rock Springs, Wyoming in cooperation with the State of Wyoming.

Cooperative Institute for Research in the Atmosphere. 2003. Interagency Monitoring of Protected Visual Environments (IMPROVE) summary data provided by Scott Copeland, Cooperative Institute for Research in the Atmosphere, Colorado State University, February 2006.

Countess, R.J., W.R. Barnard, C.S. Claiborn, D.A. Gillette, D.A. Latimer, T.G. Pace, J.G. Watson. 2001. Methodology for Estimating Fugitive Windblown and Mechanically Resuspended Road Dust Emissions Applicable for Regional Scale Air Quality Modeling. Report No. 30203-9. Western Regional Air Partnership, Denver, Colorado.

Environmental Protection Agency. 1990. Draft New Source Review Workshop Manual – Prevention of Significant Deterioration and Nonattainment Area Permitting. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. October 1990.

______. 1993. Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure. Preliminary Review Draft.

______. 1995. Compilation of Air Pollutant Emission Factors (AP-42), Vol. 1, Stationary Point and Area Sources, Fifth Edition. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

______. 2003a. Guidance for Tracking Progress Under the Regional Haze Rule. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

______. 2003b. Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

______. 2005a. Guideline on Air Quality Models. Updated 2005. Environmental Protection Agency Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. Published in Federal Register, Vol. 70, No. 216, November 9, 2005.

______. 2005b. Air Toxics Database, Table 2, Acute Dose-Response Values for Screening Risk Assessments (6/02/2005). Office of Air Quality Planning and Standards (OAQPS). Technology Transfer Network Air Toxics Website. <http://www.epa.gov/ttn/atw/toxsource/Table2.pdf>. Data accessed February 2, 2006.

______. 2005c. Air Toxics Database, Table 1, Prioritized Chronic Dose-Response Values (2/28/2005). Office of Air Quality Planning and Standards (OAQPS). Technology Transfer Network Air Toxics Website. <http://www.epa.gov/ttn/atw/toxsource/Table1.pdf>. Data accessed February 2, 2006.

______. 2005d. Regional Haze Regulations and Guidelines for Best Available Retrofit Technology (BART) Determinations; Final Rule, Federal Register Volume 70, No. 128, July 6, 2005.

______. 2006. 40 CFR Chapter 1. Section 89.112 Oxides of nitrogen, carbon monoxide, hydrocarbon, and particulate matter exhaust emission standards. Environmental Protection Agency. Accessed March 2006.

ENVIRON. 2005. Annual 2002 MM5 Meteorological Modeling to Support Regional Haze Modeling of the Western United States, Draft Final Report, Prepared for The Western Regional Air Partnership, Denver, Colorado. ENVIRON International Corporation and University of California at Riverside. March 2005.

Federal Land Managers' Air Quality Related Values Workgroup. 2000. Federal Land Managers' Air Quality Related Values Workgroup (FLAG) Phase I Report. U.S. Forest Service-Air Quality Program, National Park Service-Air Resources Division, U.S. Fish and Wildlife Service-Air Quality Branch. December 2000.

Fox, Douglas, Ann M. Bartuska, James G. Byrne, Ellis Cowling, Rich Fisher, Gene E. Likens, Steven E. Lindberg, Rick A. Linthurst, Jay Messer, and Dale S. Nichols. 1989. A Screening Procedure to Evaluate Air Pollution Effects on Class I Wilderness Areas. General Technical Report RM-168. U.S.D.A. Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 36 pp.

Gas Research Institute. 1999. GRI-HAPCalc® Version 3.01. Gas Research Institute. Des Plaines, Illinois.

Interagency Workgroup on Air Quality Modeling. 1998. Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report and Recommendations for Modeling Long Range Transport Impacts. EPA-454/R-98-019. Office of Quality Planning and Standards. U.S. EPA, Research Triangle Park, North Carolina. December 1998.

McNally, D.E. and T.W. Tesch. 2002. Annual Meteorological Modeling Protocol: Annual Application of the MM5 Model to the Continental United States. Prepared for United States Environmental Protection Agency, Office of Quality Planning and Standards. U.S. EPA, Research Triangle Park, North Carolina.

National Park Service. 2001. Guidance on Nitrogen and Sulfur Deposition Analysis Thresholds. National Park Service and U.S. Fish and Wildlife Service. National Park Service Air Resources Division. <http://www.aqd.nps.gov/ard/flagfree/2001>, Data accessed July 2003.

Scheffe, Richard D. 1988. VOC/NO_x Point Source Screening Tables. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. August 1988.

U.S.D.A. Forest Service. 2000. Screening Methodology for Calculating ANC Change to High Elevation Lakes, User's Guide. U.S. Department of Agriculture (USDA) Forest Service, Rocky Mountain Region. January 2000.

______. 2006. Unpublished lake water chemistry data provided by Terry Svalberg, USDA Forest Service, February 2006.

Visbility Improvement State and Tribal Association of the Southeast. 2006. Protocol for the Application of the CALPUFF Model for Analyses of Best Available Retrofit Technology (BART), Revision 2. Visibility Improvement State and Tribal Association of the Southeast (VISTAS), March 2006.

Wyoming Department of Environmental Quality. 2001. Oil and Gas Production Facilities Chapter 6, Section 2 Permitting Guidance, Wyoming Department of Environmental Quality-Air Quality Division. June 1997 with revisions through August 2001.

______. 2004. Jonah & Pinedale Anticline Gas Fields Additions to Oil and Gas Production Facility Emission Control and Permitting Requirements. State of Wyoming Department of Environmental Quality, Air Quality Division. July 28, 2004.

Attachment A

Sample CALMET and CALPUFF Input Control Files

CALMET Input Control File

```
Pinedale Anticline Project Sample CALMET Input File, April
Meteorological Data - 2001 MM5 Data, 34 sfc, 61 precip, & 2 ua stations
116 x 138 Modeling Domain w/ 4 km spacing - Lambert Conformal Coordinates
---------------- Run title (3 lines) ------------------------------------------

                    CALMET MODEL CONTROL FILE
                    --------------------------

-------------------------------------------------------------------------------

INPUT GROUP: 0 -- Input and Output File Names


Subgroup (a)
------------
Default Name  Type          File Name
------------  ----          ---------
GEO.DAT       input    ! GEODAT= GEO4KMC.DAT       !
SURF.DAT      input    ! SRFDAT= SURF01_final.DAT  !
CLOUD.DAT     input    * CLDDAT=                   *
PRECIP.DAT    input    ! PRCDAT= PRECIP01.DAT      !
MM4.DAT       input    ! MM4DAT= pinedale_2001-04.mm5 !
WT.DAT        input    * WTDAT=                  *
CALMET.LST    output   ! METLST= apr01.LST     !
CALMET.DAT    output   ! METDAT= apr01.DAT     !
PACOUT.DAT    output   * PACDAT=               *

All file names will be converted to lower case if LCFILES = T
Otherwise, if LCFILES = F, file names will be converted to UPPER CASE
         T = lower case      ! LCFILES = T !
         F = UPPER CASE

NUMBER OF UPPER AIR & OVERWATER STATIONS:

    Number of upper air stations (NUSTA)  No default     ! NUSTA =  2   !
    Number of overwater met stations
                                 (NOWSTA) No default     ! NOWSTA =  0  !

                       !END!
--------------------------------------------------------------------------------
Subgroup (b)
---------------------------------
Upper air files (one per station)
---------------------------------
Default Name  Type       File Name
------------  ----       ---------
UP1.DAT       input     1  ! UPDAT=upriw01_rev.dat! !END!
UP2.DAT       input     2  ! UPDAT=upslc01_rev.dat! !END!
--------------------------------------------------------------------------------
Subgroup (c)
-----------------------------------------
Overwater station files (one per station)
-----------------------------------------
Default Name  Type       File Name
------------  ----       ---------
--------------------------------------------------------------------------------
Subgroup (d)
----------------
Other file names
----------------

Default Name  Type       File Name
------------  ----       ---------
DIAG.DAT      input      * DIADAT=                  *
PROG.DAT      input      * PRGDAT=                  *
TEST.PRT      output     * TSTPRT=                  *
TEST.OUT      output     * TSTOUT=                  *
TEST.KIN      output     * TSTKIN=                  *
TEST.FRD      output     * TSTFRD=                  *
TEST.SLP      output     * TSTSLP=                  *
```

```
-------------------------------------------------------------------------------
NOTES: (1) File/path names can be up to 70 characters in length
       (2) Subgroups (a) and (d) must have ONE 'END' (surround by
           delimiters) at the end of the group
       (3) Subgroups (b) and (c) must have an 'END' (surround by
           delimiters) at the end of EACH LINE

                         !END!


-------------------------------------------------------------------------------

INPUT GROUP: 1 -- General run control parameters
--------------

     Starting date:   Year (IBYR) -- No default       ! IBYR=  2001  !
                     Month (IBMO) -- No default       ! IBMO=  4  !
                       Day (IBDY) -- No default       ! IBDY=  1  !
                      Hour (IBHR) -- No default       ! IBHR=  0  !

     Base time zone        (IBTZ) -- No default       ! IBTZ=  7  !
        PST = 08, MST = 07
        CST = 06, EST = 05

     Length of run (hours) (IRLG) -- No default       ! IRLG=  720  !

     Run type            (IRTYPE) -- Default: 1       ! IRTYPE=  1  !

        0 = Computes wind fields only
        1 = Computes wind fields and micrometeorological variables
            (u*, w*, L, zi, etc.)
        (IRTYPE must be 1 to run CALPUFF or CALGRID)

     Compute special data fields required
     by CALGRID (i.e., 3-D fields of W wind
     components and temperature)
     in additional to regular            Default: T    ! LCALGRD = T !
     fields ? (LCALGRD)
     (LCALGRD must be T to run CALGRID)

      Flag to stop run after
      SETUP phase (ITEST)             Default: 2       ! ITEST=  2   !
      (Used to allow checking
      of the model inputs, files, etc.)
      ITEST = 1 - STOPS program after SETUP phase
      ITEST = 2 - Continues with execution of
                  COMPUTATIONAL phase after SETUP

!END!

-------------------------------------------------------------------------------

INPUT GROUP: 2 -- Map Projection and Grid control parameters
--------------

     Projection for all (X,Y):
     -------------------------

     Map projection
     (PMAP)                     Default: UTM    ! PMAP = LCC  !

         UTM :  Universal Transverse Mercator
         TTM :  Tangential Transverse Mercator
         LCC :  Lambert Conformal Conic
          PS :  Polar Stereographic
          EM :  Equatorial Mercator
        LAZA :  Lambert Azimuthal Equal Area

     False Easting and Northing (km) at the projection origin
     (Used only if PMAP= TTM, LCC, or LAZA)
     (FEAST)                    Default=0.0     ! FEAST  = 0.000  !
```

```
(FNORTH)                   Default=0.0     ! FNORTH = 0.000  !

UTM zone (1 to 60)
(Used only if PMAP=UTM)
(IUTMZN)                   No Default      ! IUTMZN =  12   !

Hemisphere for UTM projection?
(Used only if PMAP=UTM)
(UTMHEM)                   Default: N      ! UTMHEM = N  !
    N   :  Northern hemisphere projection
    S   :  Southern hemisphere projection

Latitude and Longitude (decimal degrees) of projection origin
(Used only if PMAP= TTM, LCC, PS, EM, or LAZA)
(RLAT0)                    No Default      ! RLAT0 = 43.05N  !
(RLON0)                    No Default      ! RLON0 = 109.80W  !

    TTM :  RLON0 identifies central (true N/S) meridian of projection
           RLAT0 selected for convenience
    LCC :  RLON0 identifies central (true N/S) meridian of projection
           RLAT0 selected for convenience
    PS  :  RLON0 identifies central (grid N/S) meridian of projection
           RLAT0 selected for convenience
    EM  :  RLON0 identifies central meridian of projection
           RLAT0 is REPLACED by 0.0N (Equator)
    LAZA:  RLON0 identifies longitude of tangent-point of mapping plane
           RLAT0 identifies latitude of tangent-point of mapping plane

Matching parallel(s) of latitude (decimal degrees) for projection
(Used only if PMAP= LCC or PS)
(XLAT1)                    No Default      ! XLAT1 = 30.000N  !
(XLAT2)                    No Default      ! XLAT2 = 60.000N  !

    LCC :  Projection cone slices through Earth's surface at XLAT1 and XLAT2
    PS  :  Projection plane slices through Earth at XLAT1
           (XLAT2 is not used)

----------
Note:  Latitudes and longitudes should be positive, and include a
       letter N,S,E, or W indicating north or south latitude, and
       east or west longitude.  For example,
       35.9  N Latitude  =  35.9N
       118.7 E Longitude = 118.7E


Datum-region
------------

The Datum-Region for the coordinates is identified by a character
string.  Many mapping products currently available use the model of the
Earth known as the World Geodetic System 1984 (WGS-G ).  Other local
models may be in use, and their selection in CALMET will make its output
consistent with local mapping products.  The list of Datum-Regions with
official transformation parameters provided by the National Imagery and
Mapping Agency (NIMA).

NIMA Datum - Regions(Examples)
------------------------------------------------------------------------------
WGS-G     WGS-84 GRS 80, Global coverage
NAS-C     NORTH AMERICAN 1927 Clarke 1866, MEAN FOR (CONUS)
NWS-27    NWS 6370KM Radius, Global Sphere (NAD27)
NWS-84    NWS 6370KM Radius, Global Sphere (WGS84)
ESR-S     ESRI REFERENCE Normal Sphere (6371KM Radius), Global Reference Sphere

Datum-region for output coordinates
(DATUM)                    Default: WGS-G     ! DATUM = WGS-G   !


Horizontal grid definition:
---------------------------
```

```
     Rectangular grid defined for projection PMAP,
     with X the Easting and Y the Northing coordinate

            No. X grid cells (NX)      No default     ! NX =   116  !
            No. Y grid cells (NY)      No default     ! NY =   138  !

     Grid spacing (DGRIDKM)            No default     ! DGRIDKM = 4. !
                                       Units: km

     Reference grid coordinate of
     SOUTHWEST corner of grid cell (1,1)

        X coordinate (XORIGKM)         No default     ! XORIGKM = -232.000 !
        Y coordinate (YORIGKM)         No default     ! YORIGKM = -272.000 !
                                       Units: km


     Vertical grid definition:
     -------------------------

        No. of vertical layers (NZ)    No default     ! NZ =  10  !

        Cell face heights in arbitrary
        vertical grid (ZFACE(NZ+1))    No defaults
                                       Units: m
        ! ZFACE = 0.,20.,40.,100.,160.,320.,560.,1000.,1500.,2250.,3200. !

!END!


-------------------------------------------------------------------------------

INPUT GROUP: 3 -- Output Options
--------------


    DISK OUTPUT OPTION

       Save met. fields in an unformatted
       output file ?             (LSAVE)  Default: T     ! LSAVE = T !
       (F = Do not save, T = Save)

       Type of unformatted output file:
       (IFORMO)                           Default: 1    ! IFORMO =  1  !

            1 = CALPUFF/CALGRID type file (CALMET.DAT)
            2 = MESOPUFF-II type file     (PACOUT.DAT)


    LINE PRINTER OUTPUT OPTIONS:

       Print met. fields ?  (LPRINT)      Default: F     ! LPRINT = F !
       (F = Do not print, T = Print)
       (NOTE: parameters below control which
              met. variables are printed)

       Print interval
       (IPRINF) in hours                  Default: 1     ! IPRINF =  1  !
       (Meteorological fields are printed
        every  1  hours)


       Specify which layers of U, V wind component
       to print (IUVOUT(NZ)) -- NOTE: NZ values must be entered
       (0=Do not print, 1=Print)
       (used only if LPRINT=T)        Defaults: NZ*0
       ! IUVOUT =  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0  !
       -----------------------


       Specify which levels of the W wind component to print
```

```
(NOTE: W defined at TOP cell face --  10  values)
(IWOUT(NZ)) -- NOTE: NZ values must be entered
(0=Do not print, 1=Print)
(used only if LPRINT=T & LCALGRD=T)
-----------------------------------
                                     Defaults: NZ*0
 ! IWOUT =  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0  !


Specify which levels of the 3-D temperature field to print
(ITOUT(NZ)) -- NOTE: NZ values must be entered
(0=Do not print, 1=Print)
(used only if LPRINT=T & LCALGRD=T)
-----------------------------------
                                     Defaults: NZ*0
 ! ITOUT =  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0  !

Specify which meteorological fields
to print
(used only if LPRINT=T)             Defaults: 0 (all variables)
-----------------------


  Variable            Print ?
                  (0 = do not print,
                   1 = print)
  --------        ------------------

!  STABILITY  =           0           ! - PGT stability class
!  USTAR      =           0           ! - Friction velocity
!  MONIN      =           0           ! - Monin-Obukhov length
!  MIXHT      =           0           ! - Mixing height
!  WSTAR      =           0           ! - Convective velocity scale
!  PRECIP     =           0           ! - Precipitation rate
!  SENSHEAT   =           0           ! - Sensible heat flux
!  CONVZI     =           0           ! - Convective mixing ht.


Testing and debug print options for micrometeorological module

   Print input meteorological data and
   internal variables (LDB)         Default: F       ! LDB = F !
   (F = Do not print, T = print)
   (NOTE: this option produces large amounts of output)

   First time step for which debug data
   are printed (NN1)                Default: 1       ! NN1 =  1  !

   Last time step for which debug data
   are printed (NN2)                Default: 1       ! NN2 =  2  !


Testing and debug print options for wind field module
(all of the following print options control output to
 wind field module's output files: TEST.PRT, TEST.OUT,
 TEST.KIN, TEST.FRD, and TEST.SLP)

   Control variable for writing the test/debug
   wind fields to disk files (IOUTD)
   (0=Do not write, 1=write)        Default: 0       ! IOUTD =  0  !

   Number of levels, starting at the surface,
   to print (NZPRN2)                Default: 1       ! NZPRN2 =  1  !

   Print the INTERPOLATED wind components ?
   (IPR0) (0=no, 1=yes)             Default: 0       !  IPR0 =  0  !

   Print the TERRAIN ADJUSTED surface wind
   components ?
   (IPR1) (0=no, 1=yes)             Default: 0       !  IPR1 =  0  !
```

```
          Print the SMOOTHED wind components and
          the INITIAL DIVERGENCE fields ?
          (IPR2) (0=no, 1=yes)             Default: 0       !  IPR2 =  0  !

          Print the FINAL wind speed and direction
          fields ?
          (IPR3) (0=no, 1=yes)             Default: 0       !  IPR3 =  0  !

          Print the FINAL DIVERGENCE fields ?
          (IPR4) (0=no, 1=yes)             Default: 0       !  IPR4 =  0  !

          Print the winds after KINEMATIC effects
          are added ?
          (IPR5) (0=no, 1=yes)             Default: 0       !  IPR5 =  0  !

          Print the winds after the FROUDE NUMBER
          adjustment is made ?
          (IPR6) (0=no, 1=yes)             Default: 0       !  IPR6 =  0  !

          Print the winds after SLOPE FLOWS
          are added ?
          (IPR7) (0=no, 1=yes)             Default: 0       !  IPR7 =  0  !

          Print the FINAL wind field components ?
          (IPR8) (0=no, 1=yes)             Default: 0       !  IPR8 =  0  !

!END!


-------------------------------------------------------------------------------

INPUT GROUP: 4 -- Meteorological data options
--------------

    NO OBSERVATION MODE             (NOOBS)  Default: 0     ! NOOBS =  0   !
          0 = Use surface, overwater, and upper air stations
          1 = Use surface and overwater stations (no upper air observations)
              Use MM5 for upper air data
          2 = No surface, overwater, or upper air observations
              Use MM5 for surface, overwater, and upper air data

    NUMBER OF SURFACE & PRECIP. METEOROLOGICAL STATIONS

       Number of surface stations   (NSSTA)  No default     ! NSSTA =  34  !

       Number of precipitation stations
       (NPSTA=-1: flag for use of MM5 precip data)
                                    (NPSTA)  No default     ! NPSTA =  61  !

    CLOUD DATA OPTIONS
       Gridded cloud fields:
                                   (ICLOUD)  Default: 0     ! ICLOUD =  0  !
       ICLOUD = 0 - Gridded clouds not used
       ICLOUD = 1 - Gridded CLOUD.DAT generated as OUTPUT
       ICLOUD = 2 - Gridded CLOUD.DAT read as INPUT
       ICLOUD = 3 - Gridded cloud cover from Prognostic Rel. Humidity

    FILE FORMATS

       Surface meteorological data file format
                                   (IFORMS)  Default: 2     ! IFORMS =  2  !
       (1 = unformatted (e.g., SMERGE output))
       (2 = formatted   (free-formatted user input))

       Precipitation data file format
                                   (IFORMP)  Default: 2     ! IFORMP =  2  !
       (1 = unformatted (e.g., PMERGE output))
       (2 = formatted   (free-formatted user input))

       Cloud data file format
                                   (IFORMC)  Default: 2     ! IFORMC =  2  !
```

```
      (1 = unformatted - CALMET unformatted output)
      (2 = formatted   - free-formatted CALMET output or user input)

!END!


-------------------------------------------------------------------------------

INPUT GROUP: 5 -- Wind Field Options and Parameters
--------------


    WIND FIELD MODEL OPTIONS
      Model selection variable (IWFCOD)     Default: 1      ! IWFCOD =  1  !
         0 = Objective analysis only
         1 = Diagnostic wind module

      Compute Froude number adjustment
      effects ? (IFRADJ)                    Default: 1      ! IFRADJ =  1  !
      (0 = NO, 1 = YES)

      Compute kinematic effects ? (IKINE)   Default: 0      ! IKINE  =  0  !
      (0 = NO, 1 = YES)

      Use O'Brien procedure for adjustment
      of the vertical velocity ? (IOBR)     Default: 0      ! IOBR =  0  !
      (0 = NO, 1 = YES)

      Compute slope flow effects ? (ISLOPE) Default: 1      ! ISLOPE  =  1  !
      (0 = NO, 1 = YES)

      Extrapolate surface wind observations
      to upper layers ? (IEXTRP)            Default: -4     ! IEXTRP = -4  !
      (1 = no extrapolation is done,
       2 = power law extrapolation used,
       3 = user input multiplicative factors
           for layers 2 - NZ used (see FEXTRP array)
       4 = similarity theory used
       -1, -2, -3, -4 = same as above except layer 1 data
           at upper air stations are ignored

      Extrapolate surface winds even
      if calm? (ICALM)                      Default: 0      ! ICALM  =  0  !
      (0 = NO, 1 = YES)

      Layer-dependent biases modifying the weights of
      surface and upper air stations (BIAS(NZ))
        -1<=BIAS<=1
      Negative BIAS reduces the weight of upper air stations
        (e.g. BIAS=-0.1 reduces the weight of upper air stations
      by 10%; BIAS= -1, reduces their weight by 100 %)
      Positive BIAS reduces the weight of surface stations
        (e.g. BIAS= 0.2 reduces the weight of surface stations
      by 20%; BIAS=1 reduces their weight by 100%)
      Zero BIAS leaves weights unchanged (1/R**2 interpolation)
      Default: NZ*0
                             ! BIAS =  -1 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0  !

      Minimum distance from nearest upper air station
      to surface station for which extrapolation
      of surface winds at surface station will be allowed
      (RMIN2: Set to -1 for IEXTRP = 4 or other situations
       where all surface stations should be extrapolated)
                                             Default: 4.    ! RMIN2 = -1.0 !

      Use gridded prognostic wind field model
      output fields as input to the diagnostic
      wind field model (IPROG)              Default: 0      ! IPROG =  14  !
      (0 = No, [IWFCOD = 0 or 1]
       1 = Yes, use CSUMM prog. winds as Step 1 field, [IWFCOD = 0]
       2 = Yes, use CSUMM prog. winds as initial guess field [IWFCOD = 1]
```

```
        3 = Yes, use winds from MM4.DAT file as Step 1 field [IWFCOD = 0]
        4 = Yes, use winds from MM4.DAT file as initial guess field [IWFCOD = 1]
        5 = Yes, use winds from MM4.DAT file as observations [IWFCOD = 1]
        13 = Yes, use winds from MM5.DAT file as Step 1 field [IWFCOD = 0]
        14 = Yes, use winds from MM5.DAT file as initial guess field [IWFCOD = 1]
        15 = Yes, use winds from MM5.DAT file as observations [IWFCOD = 1]

      Timestep (hours) of the prognostic
      model input data   (ISTEPPG)          Default: 1      ! ISTEPPG =  1   !

   RADIUS OF INFLUENCE PARAMETERS

      Use varying radius of influence       Default: F      ! LVARY =  F!
      (if no stations are found within RMAX1,RMAX2,
       or RMAX3, then the closest station will be used)

      Maximum radius of influence over land
      in the surface layer (RMAX1)          No default      ! RMAX1 = 20. !
                                            Units: km
      Maximum radius of influence over land
      aloft (RMAX2)                         No default      ! RMAX2 = 40. !
                                            Units: km
      Maximum radius of influence over water
      (RMAX3)                               No default      ! RMAX3 = 40. !
                                            Units: km


   OTHER WIND FIELD INPUT PARAMETERS

      Minimum radius of influence used in
      the wind field interpolation (RMIN)   Default: 0.1    ! RMIN = 0.1 !
                                            Units: km
      Radius of influence of terrain
      features (TERRAD)                     No default      ! TERRAD = 15. !

                                            Units: km
      Relative weighting of the first
      guess field and observations in the
      SURFACE layer (R1)                    No default      ! R1 = 5. !
      (R1 is the distance from an           Units: km
      observational station at which the
      observation and first guess field are
      equally weighted)

      Relative weighting of the first
      guess field and observations in the
      layers ALOFT (R2)                     No default      ! R2 = 15. !
      (R2 is applied in the upper layers    Units: km
      in the same manner as R1 is used in
      the surface layer).

      Relative weighting parameter of the
      prognostic wind field data (RPROG)    No default      ! RPROG = 0. !
      (Used only if IPROG = 1)              Units: km
      ------------------------

      Maximum acceptable divergence in the
      divergence minimization procedure
      (DIVLIM)                              Default: 5.E-6  ! DIVLIM= 5.0E-06 !

      Maximum number of iterations in the
      divergence min. procedure (NITER)     Default: 50     ! NITER =  50  !

      Number of passes in the smoothing
      procedure (NSMTH(NZ))
      NOTE: NZ values must be entered
           Default: 2,(mxnz-1)*4 ! NSMTH =
 2 ,  4 ,  4 ,  4 ,  4 ,  4 ,  4 ,  4 ,  4 ,  4  !

      Maximum number of stations used in
      each layer for the interpolation of
```

```
   data to a grid point (NINTR2(NZ))
   NOTE: NZ values must be entered      Default: 99.    ! NINTR2 =
   99 ,  99 ,  99 ,  99 ,  99 ,  99 ,  99 ,  99 ,  99 ,  99  !

   Critical Froude number (CRITFN)      Default: 1.0    ! CRITFN = 1. !

   Empirical factor controlling the
   influence of kinematic effects
   (ALPHA)                              Default: 0.1    ! ALPHA = 0.1 !

   Multiplicative scaling factor for
   extrapolation of surface observations
   to upper layers (FEXTR2(NZ))         Default: NZ*0.0
   ! FEXTR2 = 0., 0., 0., 0., 0., 0., 0., 0., 0., 0. !
   (Used only if IEXTRP = 3 or -3)


BARRIER INFORMATION

   Number of barriers to interpolation
   of the wind fields (NBAR)            Default: 0      ! NBAR =  0  !

   THE FOLLOWING 4 VARIABLES ARE INCLUDED
   ONLY IF NBAR > 0
   NOTE: NBAR values must be entered    No defaults
         for each variable              Units: km

      X coordinate of BEGINNING
      of each barrier (XBBAR(NBAR))     ! XBBAR = 0. !
      Y coordinate of BEGINNING
      of each barrier (YBBAR(NBAR))     ! YBBAR = 0. !

      X coordinate of ENDING
      of each barrier (XEBAR(NBAR))     ! XEBAR = 0. !
      Y coordinate of ENDING
      of each barrier (YEBAR(NBAR))     ! YEBAR = 0. !


DIAGNOSTIC MODULE DATA INPUT OPTIONS

   Surface temperature (IDIOPT1)        Default: 0      ! IDIOPT1 =  0  !
      0 = Compute internally from
          hourly surface observations
      1 = Read preprocessed values from
          a data file (DIAG.DAT)

      Surface met. station to use for
      the surface temperature (ISURFT)  No default     ! ISURFT =  18  !
      (Must be a value from 1 to NSSTA)
      (Used only if IDIOPT1 = 0)
      --------------------------

   Domain-averaged temperature lapse
   rate (IDIOPT2)                       Default: 0     ! IDIOPT2 =  0  !
      0 = Compute internally from
          twice-daily upper air observations
      1 = Read hourly preprocessed values
          from a data file (DIAG.DAT)

      Upper air station to use for
      the domain-scale lapse rate (IUPT) No default     ! IUPT   =  1 !
      (Must be a value from 1 to NUSTA)
      (Used only if IDIOPT2 = 0)
      --------------------------

      Depth through which the domain-scale
      lapse rate is computed (ZUPT)     Default: 200.  ! ZUPT = 200. !
      (Used only if IDIOPT2 = 0)        Units: meters
      --------------------------

   Domain-averaged wind components
```

```
       (IDIOPT3)                            Default: 0     ! IDIOPT3 =  0  !
          0 = Compute internally from
              twice-daily upper air observations
          1 = Read hourly preprocessed values
              a data file (DIAG.DAT)

          Upper air station to use for
          the domain-scale winds (IUPWND)    Default: -1    ! IUPWND = -1  !
          (Must be a value from -1 to NUSTA)
          (Used only if IDIOPT3 = 0)
          --------------------------

          Bottom and top of layer through
          which the domain-scale winds
          are computed
          (ZUPWND(1), ZUPWND(2))        Defaults: 1., 1000. ! ZUPWND= 1., 1000. !
          (Used only if IDIOPT3 = 0)    Units: meters
          --------------------------

       Observed surface wind components
       for wind field module (IDIOPT4)  Default: 0     ! IDIOPT4 =  0  !
          0 = Read WS, WD from a surface
              data file (SURF.DAT)
          1 = Read hourly preprocessed U, V from
              a data file (DIAG.DAT)

       Observed upper air wind components
       for wind field module (IDIOPT5)  Default: 0     ! IDIOPT5 =  0  !
          0 = Read WS, WD from an upper
              air data file (UP1.DAT, UP2.DAT, etc.)
          1 = Read hourly preprocessed U, V from
              a data file (DIAG.DAT)

       LAKE BREEZE INFORMATION

          Use Lake Breeze Module  (LLBREZE)
                                          Default: F      ! LLBREZE = F !

           Number of lake breeze regions (NBOX)           ! NBOX =  0  !

        X Grid line 1 defining the region of interest
                                                       ! XG1 = 0. !
        X Grid line 2 defining the region of interest
                                                       ! XG2 = 0. !
        Y Grid line 1 defining the region of interest
                                                       ! YG1 = 0. !
        Y Grid line 2 defining the region of interest
                                                       ! YG2 = 0. !

         X Point defining the coastline (Straight line)
                   (XBCST)  (KM)   Default: none    ! XBCST = 0. !

         Y Point defining the coastline (Straight line)
                   (YBCST)  (KM)   Default: none    ! YBCST = 0. !

         X Point defining the coastline (Straight line)
                   (XECST)  (KM)   Default: none    ! XECST = 0. !

         Y Point defining the coastline (Straight line)
                   (YECST)  (KM)   Default: none    ! YECST = 0. !


       Number of stations in the region     Default: none ! NLB =  0 !
       (Surface stations + upper air stations)

       Station ID's  in the region   (METBXID(NLB))
       (Surface stations first, then upper air stations)
         ! METBXID =  0 !

!END!
```

```
-------------------------------------------------------------------------------

INPUT GROUP: 6 -- Mixing Height, Temperature and Precipitation Parameters
--------------

    EMPIRICAL MIXING HEIGHT CONSTANTS

       Neutral, mechanical equation
       (CONSTB)                              Default: 1.41   ! CONSTB = 1.41 !
       Convective mixing ht. equation
       (CONSTE)                              Default: 0.15   ! CONSTE = 0.15 !
       Stable mixing ht. equation
       (CONSTN)                              Default: 2400.  ! CONSTN = 2400.!
       Overwater mixing ht. equation
       (CONSTW)                              Default: 0.16   ! CONSTW = 0.16 !
       Absolute value of Coriolis
       parameter (FCORIOL)                   Default: 1.E-4  ! FCORIOL = 1.0E-04!
                                             Units: (1/s)

    SPATIAL AVERAGING OF MIXING HEIGHTS

       Conduct spatial averaging
       (IAVEZI)  (0=no, 1=yes)               Default: 1      ! IAVEZI =  1  !

       Max. search radius in averaging
       process (MNMDAV)                      Default: 1      ! MNMDAV =  1  !
                                             Units: Grid
                                                    cells
       Half-angle of upwind looking cone
       for averaging (HAFANG)                Default: 30.    ! HAFANG = 30. !
                                             Units: deg.
       Layer of winds used in upwind
       averaging (ILEVZI)                    Default: 1      ! ILEVZI =  1  !
       (must be between 1 and NZ)

    OTHER MIXING HEIGHT VARIABLES

       Minimum potential temperature lapse
       rate in the stable layer above the
       current convective mixing ht.         Default: 0.001  ! DPTMIN = 0.001 !
       (DPTMIN)                              Units: deg. K/m
       Depth of layer above current conv.
       mixing height through which lapse     Default: 200.   ! DZZI = 200. !
       rate is computed (DZZI)               Units: meters

       Minimum overland mixing height        Default:  50.   ! ZIMIN = 50. !
       (ZIMIN)                               Units: meters
       Maximum overland mixing height        Default: 3000.  ! ZIMAX = 3000. !
       (ZIMAX)                               Units: meters
       Minimum overwater mixing height       Default:   50.  ! ZIMINW = 50. !
       (ZIMINW) -- (Not used if observed     Units: meters
       overwater mixing hts. are used)
       Maximum overwater mixing height       Default: 3000.  ! ZIMAXW = 3000. !
       (ZIMAXW) -- (Not used if observed     Units: meters
       overwater mixing hts. are used)


    TEMPERATURE PARAMETERS

       3D temperature from observations or
       from prognostic data? (ITPROG)        Default:0         !ITPROG =  0   !

          0 = Use Surface and upper air stations
              (only if NOOBS = 0)
          1 = Use Surface stations (no upper air observations)
              Use MM5 for upper air data
              (only if NOOBS = 0,1)
          2 = No surface or upper air observations
              Use MM5 for surface and upper air data
              (only if NOOBS = 0,1,2)
```

```
       Interpolation type
       (1 = 1/R ; 2 = 1/R**2)              Default:1         ! IRAD =  1  !

       Radius of influence for temperature
       interpolation (TRADKM)              Default: 500.     ! TRADKM = 500. !
                                           Units: km

       Maximum Number of stations to include
       in temperature interpolation (NUMTS)  Default: 5        ! NUMTS = 5  !

       Conduct spatial averaging of temp-
       eratures (IAVET)  (0=no, 1=yes)        Default: 1     ! IAVET =  1  !
       (will use mixing ht MNMDAV,HAFANG
        so make sure they are correct)

       Default temperature gradient        Default: -.0098 ! TGDEFB = -0.0098 !
       below the mixing height over
       water (K/m) (TGDEFB)

       Default temperature gradient        Default: -.0045 ! TGDEFA = -0.0045 !
       above the mixing height over
       water (K/m) (TGDEFA)

       Beginning (JWAT1) and ending (JWAT2)
       land use categories for temperature                  ! JWAT1 =  999  !
       interpolation over water -- Make                     ! JWAT2 =  999  !
       bigger than largest land use to disable

   PRECIP INTERPOLATION PARAMETERS

       Method of interpolation (NFLAGP)      Default = 2    ! NFLAGP =  2  !
        (1=1/R,2=1/R**2,3=EXP/R**2)
       Radius of Influence (km) (SIGMAP)     Default = 100.0  ! SIGMAP = 100. !
        (0.0 => use half dist. btwn
         nearest stns w & w/out
         precip when NFLAGP = 3)
       Minimum Precip. Rate Cutoff (mm/hr)   Default = 0.01  ! CUTP = 0.01 !
        (values < CUTP = 0.0 mm/hr)
!END!


-------------------------------------------------------------------------------

INPUT GROUP: 7 -- Surface meteorological station parameters
--------------

     SURFACE STATION VARIABLES
     (One record per station --  34  records in all)


             1     2
         Name   ID            X coord.   Y coord.   Time   Anem.
                               (km)       (km)      zone   Ht.(m)
       ----------------------------------------------------------
! SS1  ='KPIH' 25780      -218.40091   -10.51052  7     10.0 !
! SS2  ='KIDA' 25785      -177.12294    52.6585   7      7.9 !
! SS3  ='KMLD' 25786      -198.54764   -93.61361  7      7.9 !
! SS4  ='KU78' 25868      -141.38824   -41.39212  7      9.1 !
! SS5  ='KRXE' 26818      -155.41907    86.02029  7     10.0 !
! SS6  ='KRKS' 25744        59.16297  -155.54793  7     10.0 !
! SS7  ='KRWL' 25745       209.12218  -130.91878  7     10.1 !
! SS8  ='KLND' 25760        84.37669   -24.46433  7     10.0 !
! SS9  ='KRIW' 25765       104.96267     2.69977  7     10.1 !
! SS10 ='KEVW' 25775      -100.06805  -190.8622   7     10.1 !
! SS11 ='KJAC' 25776       -72.8003     59.48678  7     10.1 !
! SS12 ='KBYG' 26654       237.27166   147.69128  7     10.0 !
! SS13 ='KSHR' 26660       216.58147   188.17299  7     10.0 !
! SS14 =' P60' 26664       -47.35795   161.23067  7     10.1 !
! SS15 ='KWRL' 26665       143.43285   100.12221  7      6.1 !
! SS16 ='KGEY' 26667       131.85671   158.91996  7     10.0 !
```

```
! SS17 ='KCOD' 26700        60.13412   157.80002  7     10.0 !
! SS18 ='KBPI' 26710       -23.81807   -50.12008  7     10.1 !
! SS19 ='KWEY' 26763       -99.60432   172.59078  7      9.8 !
! SS20 ='KWYS' 26764      -100.84845   176.15375  7     10.0 !
! SS21 ='KBIL' 26770        93.84694   295.95191  7     10.0 !
! SS22 ='KDLN' 26796      -208.45779   239.76404  7     10.1 !
! SS23 ='KBZN' 26797      -102.66088   294.27092  7     10.1 !
! SS24 ='KLVM' 26798       -47.61005   284.67335  7     10.1 !
! SS25 ='KCAG' 25700       187.62061  -271.50088  7     10.1 !
! SS26 ='KHDN' 25715       209.55603  -270.83858  7     10.1 !
! SS27 ='KLGU' 24796      -164.94212  -134.03061  7     10.1 !
! SS28 ='KVEL' 25705        20.5709   -281.35837  7     10.1 !
! SS29 ='KSLC' 25720      -177.26493  -241.31181  7     10.0 !
! SS30 ='KOGD' 25750      -180.11159  -196.34621  7     10.1 !
! SS31 ='KHIF' 25755      -176.2922   -205.38351  7      4.0 !
! SS32 ='YEL ' 40800       -46.12183   162.29469  7     10.0 !
! SS33 ='PND ' 16500         0.9474    -12.99608  7     10.0 !
! SS34 ='BP  ' 88888        17.81917   -62.49556  7     10.0 !
-------------------
      1
        Four character string for station name
        (MUST START IN COLUMN 9)

      2
        Five digit integer for station ID

!END!


-------------------------------------------------------------------------------

INPUT GROUP: 8 -- Upper air meteorological station parameters
--------------

     UPPER AIR STATION VARIABLES
     (One record per station --  2  records in all)

            1     2
         Name    ID      X coord.   Y coord.  Time zone
                           (km)       (km)
        -----------------------------------------------
! US1  ='KRIW'   24061   104.96267    2.69977   7  !
! US2  ='KSLC'   24127  -177.26493 -241.31181   7  !
-------------------
      1
        Four character string for station name
        (MUST START IN COLUMN 9)

      2
        Five digit integer for station ID

!END!


-------------------------------------------------------------------------------

INPUT GROUP: 9 -- Precipitation station parameters
--------------

     PRECIPITATION STATION VARIABLES
     (One record per station -- 61  records in all)
     (NOT INCLUDED IF NPSTA = 0)

           1          2
         Name   Station    X coord.  Y coord.
                  Code       (km)      (km)
         ------------------------------------
! PS1  ='wy01'   480697    -25.18903     -55.48678   !
! PS2  ='wy02'   481000    127.85275      38.89125   !
! PS3  ='wy03'   482715     11.71824      51.87955   !
! PS4  ='wy04'   483100    -93.33238    -190.96246   !
```

```
! PS5  ='wy05'   484910    -75.60488      46.95638   !
! PS6  ='wy06'   485345    -46.03946     163.04547   !
! PS7  ='wy07'   485390     84.37669     -24.46433   !
! PS8  ='wy08'   486440    -60.83393      86.2015    !
! PS9  ='wy09'   486555    -43.25857    -191.4888    !
! PS10 ='wy10'   486597     71.60517    -185.85961   !
! PS11 ='wy11'   486875    128.4441      -52.41299   !
! PS12 ='wy12'   487375    221.908         2.07873   !
! PS13 ='wy13'   487388     78.96463     186.56739   !
! PS14 ='wy14'   487533    209.12218    -130.91878   !
! PS15 ='wy15'   487760    112.90137      -0.81532   !
! PS16 ='wy16'   487845     59.16297    -155.54793   !
! PS17 ='wy17'   488155    216.58147     188.17299   !
! PS18 ='wy18'   488626    222.41663     168.61917   !
! PS19 ='wy19'   488852    187.05716     112.02419   !
! PS20 ='wy20'   488858    189.11058      85.23487   !
! PS21 ='wy21'   488875    124.73298      65.67754   !
! PS22 ='wy22'   488888     85.65817      72.21319   !
! PS23 ='wy23'   489770    141.99217     105.45823   !
! PS24 ='mt01'   238880     31.4484      268.46619   !
! PS25 ='mt02'   241102     66.84776     245.46093   !
! PS26 ='mt03'   241995    -12.7135      211.18771   !
! PS27 ='mt04'   242414   -214.10091     223.85037   !
! PS28 ='mt05'   244038   -117.00852     196.19446   !
! PS29 ='mt06'   244820   -154.6657      168.36357   !
! PS30 ='mt07'   245030   -213.25997     173.66436   !
! PS31 ='mt08'   245106    184.21809     246.17434   !
! PS32 ='mt09'   248866    -99.57469     174.41529   !
! PS33 ='mt10'   249240    141.37159     245.0234    !
! PS34 ='id01'   102707   -185.15259     131.62072   !
! PS35 ='id02'   103732   -154.80382     -48.27933   !
! PS36 ='id03'   104230   -132.85674     -12.88857   !
! PS37 ='id04'   104456   -155.3827       34.14257   !
! PS38 ='id05'   104598   -120.54867     147.9516    !
! PS39 ='id06'   107211   -218.40091     -10.51052   !
! PS40 ='id07'   109065   -115.21477      86.97115   !
! PS41 ='id08'   109158   -181.07979     -42.21091   !
! PS42 ='ut01'   420342   -154.37442    -256.21165   !
! PS43 ='ut02'   420820   -170.20753    -234.28564   !
! PS44 ='ut03'   421590   -110.16865    -226.63895   !
! PS45 ='ut04'   421759   -162.65911    -259.56512   !
! PS46 ='ut05'   422385   -133.18577    -222.55076   !
! PS47 ='ut06'   422726   -173.81347    -216.21337   !
! PS48 ='ut07'   423348   -221.51477    -259.67418   !
! PS49 ='ut08'   424538   -173.81347    -216.21337   !
! PS50 ='ut09'   425186   -161.0086     -137.67918   !
! PS51 ='ut10'   425194   -167.92116    -146.42983   !
! PS52 ='ut11'   425815    -57.47079    -266.71134   !
! PS53 ='ut12'   425892   -156.9036     -245.38432   !
! PS54 ='ut13'   426374   -117.32655    -248.04269   !
! PS55 ='ut14'   426404   -174.52533    -191.1179    !
! PS56 ='ut15'   426414   -181.31211    -192.76148   !
! PS57 ='ut16'   426648   -140.72813    -254.68803   !
! PS58 ='ut17'   426757   -180.66118    -169.42997   !
! PS59 ='ut18'   426938   -188.80849    -124.34066   !
! PS60 ='ut19'   427598   -177.26493    -241.31181   !
! PS61 ='ut20'   427846   -146.29735    -261.78067   !

-------------------
      1
        Four character string for station name
        (MUST START IN COLUMN 9)

      2
        Six digit station code composed of state
        code (first 2 digits) and station ID (last
        4 digits)

!END!
```

CALPUFF Input Control File

Pinedale Anticline – Sample CALPUFF Input File

```
---------------- Run title (3 lines) -----------------------------------------

                    CALPUFF MODEL CONTROL FILE
                    --------------------------

-------------------------------------------------------------------------------

INPUT GROUP: 0 -- Input and Output File Names

--------------
Default Name  Type          File Name
------------  ----          ---------
CALMET.DAT    input    * METDAT =             *
    or
ISCMET.DAT    input    * ISCDAT =             *
    or
PLMMET.DAT    input    * PLMDAT =             *
    or
PROFILE.DAT   input    * PRFDAT =             *
SURFACE.DAT   input    * SFCDAT =             *
RESTARTB.DAT  input    * RSTARTB=             *
--------------------------------------------------------------------------------
CALPUFF.LST   output   ! PUFLST =CALPUFF.LST   !
CONC.DAT      output   ! CONDAT =CONC.DAT      !
DFLX.DAT      output   ! DFDAT  =DFLX.DAT      !
WFLX.DAT      output   ! WFDAT  =WFLX.DAT      !

VISB.DAT      output   * VISDAT =  *
RESTARTE.DAT  output   * RSTARTE=             *
--------------------------------------------------------------------------------
Emission Files
--------------
PTEMARB.DAT   input    * PTDAT  =             *
VOLEMARB.DAT  input    * VOLDAT =             *
BAEMARB.DAT   input    * ARDAT  =             *
LNEMARB.DAT   input    * LNDAT  =             *
--------------------------------------------------------------------------------
Other Files
-----------
OZONE.DAT     input    ! OZDAT  =2001ozone.dat    !
VD.DAT        input    * VDDAT  =             *
CHEM.DAT      input    * CHEMDAT=             *
H2O2.DAT      input    * H2O2DAT=             *
HILL.DAT      input    * HILDAT=             *
HILLRCT.DAT   input    * RCTDAT=             *
COASTLN.DAT   input    * CSTDAT=             *
FLUXBDY.DAT   input    * BDYDAT=             *
BCON.DAT      input    * BCNDAT=             *
DEBUG.DAT     output   * DEBUG =             *
MASSFLX.DAT   output   * FLXDAT=             *
MASSBAL.DAT   output   * BALDAT=             *
FOG.DAT       output   * FOGDAT=             *
--------------------------------------------------------------------------------
All file names will be converted to lower case if LCFILES = T
Otherwise, if LCFILES = F, file names will be converted to UPPER CASE
         T = lower case      ! LCFILES = T !
         F = UPPER CASE
NOTE: (1) file/path names can be up to 70 characters in length


Provision for multiple input files
----------------------------------

     Number of CALMET.DAT files for run (NMETDAT)
                                     Default: 1       ! NMETDAT =   12 !

     Number of PTEMARB.DAT files for run (NPTDAT)
                                     Default: 0       ! NPTDAT =  0  !

     Number of BAEMARB.DAT files for run (NARDAT)
                                     Default: 0       ! NARDAT =  0  !

     Number of VOLEMARB.DAT files for run (NVOLDAT)
                                     Default: 0       ! NVOLDAT =  0  !

!END!
```

```
-------------
Subgroup (0a)
-------------

  The following CALMET.DAT filenames are processed in sequence if NMETDAT>1

Default Name  Type          File Name
------------  ----          ---------
 none         input    ! METDAT=jan01.dat     !  !END!
 none         input    ! METDAT=feb01.dat     !  !END!
 none         input    ! METDAT=mar01.dat     !  !END!
 none         input    ! METDAT=apr01.dat     !  !END!
 none         input    ! METDAT=may01.dat     !  !END!
 none         input    ! METDAT=jun01.dat     !  !END!
 none         input    ! METDAT=jul01.dat     !  !END!
 none         input    ! METDAT=aug01.dat     !  !END!
 none         input    ! METDAT=sep01.dat     !  !END!
 none         input    ! METDAT=oct01.dat     !  !END!
 none         input    ! METDAT=nov01.dat     !  !END!
 none         input    ! METDAT=dec01.dat     !  !END!

--------------------------------------------------------------------------------

INPUT GROUP: 1 -- General run control parameters
--------------

    Option to run all periods found
    in the met. file     (METRUN)   Default: 0       ! METRUN =   0  !

         METRUN = 0 - Run period explicitly defined below
         METRUN = 1 - Run all periods in met. file

     Starting date:   Year (IBYR) -- No default       ! IBYR =  2001  !
     (used only if   Month (IBMO) -- No default       ! IBMO =  1  !
      METRUN = 0)      Day (IBDY) -- No default       ! IBDY =  1  !
                      Hour (IBHR) -- No default       ! IBHR =  1  !

     Base time zone        (XBTZ) -- No default       ! XBTZ = 7.0  !
        PST = 8., MST = 7.
        CST = 6., EST = 5.

     Length of run (hours) (IRLG) -- No default       ! IRLG =  8760 !

     Number of chemical species (NSPEC)
                                     Default: 5       ! NSPEC =  7   !

     Number of chemical species
     to be emitted  (NSE)            Default: 3       ! NSE =  4     !

     Flag to stop run after
     SETUP phase (ITEST)             Default: 2       ! ITEST =  2   !
     (Used to allow checking
     of the model inputs, files, etc.)
           ITEST = 1 - STOPS program after SETUP phase
           ITEST = 2 - Continues with execution of program
                       after SETUP

     Restart Configuration:

        Control flag (MRESTART)      Default: 0       ! MRESTART =  0   !

           0 = Do not read or write a restart file
           1 = Read a restart file at the beginning of
               the run
           2 = Write a restart file during run
           3 = Read a restart file at beginning of run
               and write a restart file during run

        Number of periods in Restart
        output cycle (NRESPD)        Default: 0       ! NRESPD =  0   !

           0 = File written only at last period
          >0 = File updated every NRESPD periods

     Meteorological Data Format (METFM)
                                     Default: 1       ! METFM =  1   !

           METFM = 1 - CALMET binary file (CALMET.MET)
           METFM = 2 - ISC ASCII file (ISCMET.MET)
           METFM = 3 - AUSPLUME ASCII file (PLMMET.MET)
```

```
          METFM = 4 - CTDM plus tower file (PROFILE.DAT) and
                      surface parameters file (SURFACE.DAT)

     PG sigma-y is adjusted by the factor (AVET/PGTIME)**0.2
     Averaging Time (minutes) (AVET)
                                Default: 60.0    ! AVET = 60. !
     PG Averaging Time (minutes) (PGTIME)
                                Default: 60.0    ! PGTIME = 60. !


!END!


-------------------------------------------------------------------------------

INPUT GROUP: 2 -- Technical options
--------------


     Vertical distribution used in the
     near field (MGAUSS)                  Default: 1     ! MGAUSS =  1   !
        0 = uniform
        1 = Gaussian

     Terrain adjustment method
     (MCTADJ)                             Default: 3     ! MCTADJ =  3   !
        0 = no adjustment
        1 = ISC-type of terrain adjustment
        2 = simple, CALPUFF-type of terrain
            adjustment
        3 = partial plume path adjustment

     Subgrid-scale complex terrain
     flag (MCTSG)                         Default: 0     ! MCTSG =  0   !
        0 = not modeled
        1 = modeled

     Near-field puffs modeled as
     elongated 0 (MSLUG)                  Default: 0     ! MSLUG =  0   !
        0 = no
        1 = yes (slug model used)

     Transitional plume rise modeled ?
     (MTRANS)                             Default: 1     ! MTRANS =  1   !
        0 = no  (i.e., final rise only)
        1 = yes (i.e., transitional rise computed)

     Stack tip downwash? (MTIP)           Default: 1     ! MTIP =  1  !
        0 = no  (i.e., no stack tip downwash)
        1 = yes (i.e., use stack tip downwash)

     Vertical wind shear modeled above
     stack top? (MSHEAR)                  Default: 0     ! MSHEAR =  0  !
        0 = no  (i.e., vertical wind shear not modeled)
        1 = yes (i.e., vertical wind shear modeled)

     Puff splitting allowed? (MSPLIT)     Default: 0     ! MSPLIT =  0  !
        0 = no (i.e., puffs not split)
        1 = yes (i.e., puffs are split)

     Chemical mechanism flag (MCHEM)      Default: 1     ! MCHEM =  1   !
        0 = chemical transformation not
            modeled
        1 = transformation rates computed
            internally (MESOPUFF II scheme)
        2 = user-specified transformation
            rates used
        3 = transformation rates computed
            internally (RIVAD/ARM3 scheme)
        4 = secondary organic aerosol formation
            computed (MESOPUFF II scheme for OH)

     Aqueous phase transformation flag (MAQCHEM)
     (Used only if MCHEM = 1, or 3)       Default: 0     ! MAQCHEM =  0   !
        0 = aqueous phase transformation
            not modeled
        1 = transformation rates adjusted
            for aqueous phase reactions

     Wet removal modeled ? (MWET)         Default: 1     ! MWET =  1   !
        0 = no
```

```
   1 = yes

Dry deposition modeled ? (MDRY)       Default: 1     ! MDRY =  1   !
   0 = no
   1 = yes
   (dry deposition method specified
    for each species in Input Group 3)

Method used to compute dispersion
coefficients (MDISP)                  Default: 3     ! MDISP =  3   !

   1 = dispersion coefficients computed from measured values
       of turbulence, sigma v, sigma w
   2 = dispersion coefficients from internally calculated
       sigma v, sigma w using micrometeorological variables
       (u*, w*, L, etc.)
   3 = PG dispersion coefficients for RURAL areas (computed using
       the ISCST multi-segment approximation) and MP coefficients in
       urban areas
   4 = same as 3 except PG coefficients computed using
       the MESOPUFF II eqns.
   5 = CTDM sigmas used for stable and neutral conditions.
       For unstable conditions, sigmas are computed as in
       MDISP = 3, described above.  MDISP = 5 assumes that
       measured values are read

Sigma-v/sigma-theta, sigma-w measurements used? (MTURBVW)
(Used only if MDISP = 1 or 5)         Default: 3     ! MTURBVW =  3  !
   1 = use sigma-v or sigma-theta measurements
       from PROFILE.DAT to compute sigma-y
       (valid for METFM = 1, 2, 3, 4)
   2 = use sigma-w measurements
       from PROFILE.DAT to compute sigma-z
       (valid for METFM = 1, 2, 3, 4)
   3 = use both sigma-(v/theta) and sigma-w
       from PROFILE.DAT to compute sigma-y and sigma-z
       (valid for METFM = 1, 2, 3, 4)
   4 = use sigma-theta measurements
       from PLMMET.DAT to compute sigma-y
       (valid only if METFM = 3)

Back-up method used to compute dispersion
when measured turbulence data are
missing (MDISP2)                      Default: 3     ! MDISP2 =  3  !
(used only if MDISP = 1 or 5)
   2 = dispersion coefficients from internally calculated
       sigma v, sigma w using micrometeorological variables
       (u*, w*, L, etc.)
   3 = PG dispersion coefficients for RURAL areas (computed using
       the ISCST multi-segment approximation) and MP coefficients in
       urban areas
   4 = same as 3 except PG coefficients computed using
       the MESOPUFF II eqns.

PG sigma-y,z adj. for roughness?      Default: 0     ! MROUGH =  0  !
(MROUGH)
   0 = no
   1 = yes

Partial plume penetration of          Default: 1     ! MPARTL =  1  !
elevated inversion?
(MPARTL)
   0 = no
   1 = yes

Strength of temperature inversion     Default: 0     ! MTINV =  0  !
provided in PROFILE.DAT extended records?
(MTINV)
   0 = no (computed from measured/default gradients)
   1 = yes

PDF used for dispersion under convective conditions?
                                      Default: 0     ! MPDF =  0  !
(MPDF)
   0 = no
   1 = yes

Sub-Grid TIBL module used for shore line?
                                      Default: 0     ! MSGTIBL = 0  !
(MSGTIBL)
   0 = no
```

```
        1 = yes

     Boundary conditions (concentration) modeled?
                                          Default: 0     ! MBCON = 0  !
     (MBCON)
        0 = no
        1 = yes


     Analyses of fogging and icing impacts due to emissions from
     arrays of mechanically-forced cooling towers can be performed
     using CALPUFF in conjunction with a cooling tower emissions
     processor (CTEMISS) and its associated postprocessors.  Hourly
     emissions of water vapor and temperature from each cooling tower
     cell are computed for the current cell configuration and ambient
     conditions by CTEMISS. CALPUFF models the dispersion of these
     emissions and provides cloud information in a specialized format
     for further analysis. Output to FOG.DAT is provided in either
     'plume mode' or 'receptor mode' format.

     Configure for FOG Model output?
                                          Default: 0     ! MFOG =  0   !
     (MFOG)
        0 = no
        1 = yes  - report results in PLUME Mode format
        2 = yes  - report results in RECEPTOR Mode format


     Test options specified to see if
     they conform to regulatory
     values? (MREG)                       Default: 1     ! MREG =  0   !

        0 = NO checks are made
        1 = Technical options must conform to USEPA
            Long Range Transport (LRT) guidance
                       METFM    1 or 2
                       AVET     60. (min)
                       PGTIME   60. (min)
                       MGAUSS   1
                       MCTADJ   3
                       MTRANS   1
                       MTIP     1
                       MCHEM    1 or 3 (if modeling SOx, NOx)
                       MWET     1
                       MDRY     1
                       MDISP    2 or 3
                       MPDF     0 if MDISP=3
                                1 if MDISP=2
                       MROUGH   0
                       MPARTL   1
                       SYTDEP   550. (m)
                       MHFTSZ   0


!END!


-------------------------------------------------------------------------------

INPUT GROUP: 3a, 3b -- Species list
-------------------

------------
Subgroup (3a)
------------

  The following species are modeled:

! CSPEC =          SO2 !         !END!
! CSPEC =          SO4 !         !END!
! CSPEC =          NOX !         !END!
! CSPEC =         HNO3 !         !END!
! CSPEC =          NO3 !         !END!
! CSPEC =          PMF !         !END!
! CSPEC =          PMC !         !END!


                                                       Dry                 OUTPUT GROUP
    SPECIES          MODELED          EMITTED       DEPOSITED                 NUMBER
     NAME         (0=NO, 1=YES)    (0=NO, 1=YES)    (0=NO,                  (0=NONE,
   (Limit: 12                                        1=COMPUTED-GAS         1=1st CGRUP,
```

```
    Characters                                     2=COMPUTED-PARTICLE   2=2nd CGRUP,
    in length)                                     3=USER-SPECIFIED)     3= etc.)

!          SO2  =         1,              1,           1,                0   !
!          SO4  =         1,              0,           2,                0   !
!          NOX  =         1,              1,           1,                0   !
!         HNO3  =         1,              0,           1,                0   !
!          NO3  =         1,              0,           2,                0   !
!          PMF  =         1,              1,           2,                0   !
!          PMC  =         1,              1,           2,                0   !

!END!

-------------
Subgroup (3b)
-------------
  The following names are used for Species-Groups in which results
  for certain species are combined (added) prior to output.  The
  CGRUP name will be used as the species name in output files.
  Use this feature to model specific particle-size distributions
  by treating each size-range as a separate species.
  Order must be consistent with 3(a) above.



-------------------------------------------------------------------------------


INPUT GROUP: 4 -- Map Projection and Grid control parameters
--------------

     Projection for all (X,Y):
     -------------------------

     Map projection
     (PMAP)                     Default: UTM    ! PMAP = LCC  !

         UTM :  Universal Transverse Mercator
         TTM :  Tangential Transverse Mercator
         LCC :  Lambert Conformal Conic
          PS :  Polar Stereographic
          EM :  Equatorial Mercator
        LAZA :  Lambert Azimuthal Equal Area

     False Easting and Northing (km) at the projection origin
     (Used only if PMAP= TTM, LCC, or LAZA)
     (FEAST)                    Default=0.0     ! FEAST  = 0.000  !
     (FNORTH)                   Default=0.0     ! FNORTH = 0.000  !

     UTM zone (1 to 60)
     (Used only if PMAP=UTM)
     (IUTMZN)                   No Default      ! IUTMZN =  12   !

     Hemisphere for UTM projection?
     (Used only if PMAP=UTM)
     (UTMHEM)                   Default: N      ! UTMHEM = N  !
         N   :  Northern hemisphere projection
         S   :  Southern hemisphere projection

     Latitude and Longitude (decimal degrees) of projection origin
     (Used only if PMAP= TTM, LCC, PS, EM, or LAZA)
     (RLAT0)                    No Default      ! RLAT0 =  43.05N  !
     (RLON0)                    No Default      ! RLON0 =  109.80W  !

         TTM :  RLON0 identifies central (true N/S) meridian of projection
                RLAT0 selected for convenience
         LCC :  RLON0 identifies central (true N/S) meridian of projection
                RLAT0 selected for convenience
         PS  :  RLON0 identifies central (grid N/S) meridian of projection
                RLAT0 selected for convenience
         EM  :  RLON0 identifies central meridian of projection
                RLAT0 is REPLACED by 0.0N (Equator)
         LAZA:  RLON0 identifies longitude of tangent-point of mapping plane
                RLAT0 identifies latitude of tangent-point of mapping plane

     Matching parallel(s) of latitude (decimal degrees) for projection
     (Used only if PMAP= LCC or PS)
     (XLAT1)                    No Default      ! XLAT1 =  30N  !
     (XLAT2)                    No Default      ! XLAT2 =  60N  !

         LCC :  Projection cone slices through Earth's surface at XLAT1 and XLAT2
```

```
        PS  :  Projection plane slices through Earth at XLAT1
               (XLAT2 is not used)

    ----------
    Note:  Latitudes and longitudes should be positive, and include a
           letter N,S,E, or W indicating north or south latitude, and
           east or west longitude.  For example,
           35.9  N Latitude  =  35.9N
           118.7 E Longitude = 118.7E


    Datum-region
    ------------

    The Datum-Region for the coordinates is identified by a character
    string.  Many mapping products currently available use the model of the
    Earth known as the World Geodetic System 1984 (WGS-G ).  Other local
    models may be in use, and their selection in CALMET will make its output
    consistent with local mapping products.  The list of Datum-Regions with
    official transformation parameters provided by the National Imagery and
    Mapping Agency (NIMA).

    NIMA Datum - Regions(Examples)
    ------------------------------------------------------------------------------
    WGS-G     WGS-84 GRS 80, Global coverage
    NAS-C     NORTH AMERICAN 1927 Clarke 1866, MEAN FOR (CONUS)
    NWS-27    NWS 6370KM Radius, Global Sphere (NAD27)
    NWS-84    NWS 6370KM Radius, Global Sphere (WGS84)
    ESR-S     ESRI REFERENCE Normal Sphere (6371KM Radius), Global Reference Sphere

    Datum-region for output coordinates
    (DATUM)                    Default: WGS-G     ! DATUM = WGS-G  !


METEOROLOGICAL Grid:

    Rectangular grid defined for projection PMAP,
    with X the Easting and Y the Northing coordinate

           No. X grid cells (NX)      No default     ! NX =  116   !
           No. Y grid cells (NY)      No default     ! NY =  138  !
        No. vertical layers (NZ)      No default     ! NZ =  10   !

          Grid spacing (DGRIDKM)      No default     ! DGRIDKM = 4. !
                                      Units: km

               Cell face heights
                   (ZFACE(nz+1))      No defaults
                                      Units: m
       ! ZFACE = 0.,20.,40.,100.,160.,320.,560.,1000.,1500.,2250.,3200. !


           Reference Coordinates
          of SOUTHWEST corner of
                grid cell(1, 1):

       X coordinate (XORIGKM)         No default     ! XORIGKM = -232.000 !
       Y coordinate (YORIGKM)         No default     ! YORIGKM = -272.000 !
                                     Units: km


COMPUTATIONAL Grid:

    The computational grid is identical to or a subset of the MET. grid.
    The lower left (LL) corner of the computational grid is at grid point
    (IBCOMP, JBCOMP) of the MET. grid.  The upper right (UR) corner of the
    computational grid is at grid point (IECOMP, JECOMP) of the MET. grid.
    The grid spacing of the computational grid is the same as the MET. grid.

       X index of LL corner (IBCOMP)      No default     ! IBCOMP =  1   !
                 (1 <= IBCOMP <= NX)

       Y index of LL corner (JBCOMP)      No default     ! JBCOMP =  1   !
                 (1 <= JBCOMP <= NY)


       X index of UR corner (IECOMP)      No default     ! IECOMP =  116   !
                 (1 <= IECOMP <= NX)

       Y index of UR corner (JECOMP)      No default     ! JECOMP =  138   !
                 (1 <= JECOMP <= NY)
```

```
SAMPLING Grid (GRIDDED RECEPTORS):

     The lower left (LL) corner of the sampling grid is at grid point
     (IBSAMP, JBSAMP) of the MET. grid.  The upper right (UR) corner of the
     sampling grid is at grid point (IESAMP, JESAMP) of the MET. grid.
     The sampling grid must be identical to or a subset of the computational
     grid.  It may be a nested grid inside the computational grid.
     The grid spacing of the sampling grid is DGRIDKM/MESHDN.

        Logical flag indicating if gridded
        receptors are used (LSAMP)         Default: T     ! LSAMP = F !
        (T=yes, F=no)

        X index of LL corner (IBSAMP)      No default     ! IBSAMP =   1  !
         (IBCOMP <= IBSAMP <= IECOMP)

        Y index of LL corner (JBSAMP)      No default     ! JBSAMP =   1  !
         (JBCOMP <= JBSAMP <= JECOMP)


        X index of UR corner (IESAMP)      No default     ! IESAMP =   1  !
         (IBCOMP <= IESAMP <= IECOMP)

        Y index of UR corner (JESAMP)      No default     ! JESAMP =   1  !
         (JBCOMP <= JESAMP <= JECOMP)


       Nesting factor of the sampling
        grid (MESHDN)                      Default: 1     ! MESHDN =  2  !
        (MESHDN is an integer >= 1)

!END!

-------------------------------------------------------------------------------


INPUT GROUP: 5 -- Output Options
--------------
                                             *                           *
     FILE                       DEFAULT VALUE             VALUE THIS RUN
     ----                       -------------             --------------

   Concentrations (ICON)              1                   !  ICON =  1   !
   Dry Fluxes (IDRY)                  1                   !  IDRY =  1   !
   Wet Fluxes (IWET)                  1                   !  IWET =  1   !
   Relative Humidity (IVIS)           1                   !  IVIS =  1   !
    (relative humidity file is
     required for visibility
     analysis)
   Use data compression option in output file?
   (LCOMPRS)                           Default: T         ! LCOMPRS = T !

   *
    0 = Do not create file, 1 = create file


    DIAGNOSTIC MASS FLUX OUTPUT OPTIONS:

       Mass flux across specified boundaries
       for selected species reported hourly?
       (IMFLX)                         Default: 0         ! IMFLX =  0  !
         0 = no
         1 = yes (FLUXBDY.DAT and MASSFLX.DAT filenames
                  are specified in Input Group 0)

       Mass balance for each species
       reported hourly?
       (IMBAL)                         Default: 0         ! IMBAL =  0  !
         0 = no
         1 = yes (MASSBAL.DAT filename is
              specified in Input Group 0)


    LINE PRINTER OUTPUT OPTIONS:

       Print concentrations (ICPRT)    Default: 0         ! ICPRT =  0   !
       Print dry fluxes (IDPRT)        Default: 0         ! IDPRT =  0   !
```

```
      Print wet fluxes (IWPRT)        Default: 0         ! IWPRT =  0   !
      (0 = Do not print, 1 = Print)

      Concentration print interval
      (ICFRQ) in hours                Default: 1         ! ICFRQ =  1   !
      Dry flux print interval
      (IDFRQ) in hours                Default: 1         ! IDFRQ =  1   !
      Wet flux print interval
      (IWFRQ) in hours                Default: 1         ! IWFRQ =  1   !

      Units for Line Printer Output
      (IPRTU)                         Default: 1         ! IPRTU =  3   !
                      for            for
                 Concentration    Deposition
          1 =       g/m**3         g/m**2/s
          2 =      mg/m**3        mg/m**2/s
          3 =      ug/m**3        ug/m**2/s
          4 =      ng/m**3        ng/m**2/s
          5 =     Odour Units

      Messages tracking progress of run
      written to the screen ?
      (IMESG)                         Default: 2         ! IMESG =  2   !
        0 = no
        1 = yes (advection step, puff ID)
        2 = yes (YYYYJJJHH, # old puffs, # emitted puffs)


    SPECIES (or GROUP for combined species) LIST FOR OUTPUT OPTIONS

                ---- CONCENTRATIONS ----   ------ DRY FLUXES ------   ------ WET FLUXES ------   -- MASS FLUX
--
   SPECIES
   /GROUP         PRINTED?  SAVED ON DISK?   PRINTED?  SAVED ON DISK?   PRINTED?  SAVED ON DISK?   SAVED ON
DISK?
   -------       ------------------------   ------------------------   ------------------------   -------------
--
!          SO2 =     0,          1,          0,          1,          0,          1,          0  !
!          SO4 =     0,          1,          0,          1,          0,          1,          0  !
!          NOX =     0,          1,          0,          1,          0,          1,          0  !
!         HNO3 =     0,          1,          0,          1,          0,          1,          0  !
!          NO3 =     0,          1,          0,          1,          0,          1,          0  !
!          PMF =     0,          1,          0,          1,          0,          1,          0
!
!          PMC =     0,          1,          0,          1,          0,          1,          0  !

    OPTIONS FOR PRINTING "DEBUG" QUANTITIES (much output)

      Logical for debug output
      (LDEBUG)                                 Default: F     ! LDEBUG = F !

      First puff to track
      (IPFDEB)                                 Default: 1     ! IPFDEB =  1  !

      Number of puffs to track
      (NPFDEB)                                 Default: 1     ! NPFDEB =  1  !

      Met. period to start output
      (NN1)                                    Default: 1     ! NN1 =  1   !

      Met. period to end output
      (NN2)                                    Default: 10    ! NN2 =  10  !

!END!


-------------------------------------------------------------------------------


INPUT GROUP: 6a, 6b, & 6c -- Subgrid scale complex terrain inputs
-------------------------

---------------
Subgroup (6a)
---------------
      Number of terrain features (NHILL)       Default: 0     ! NHILL =  0   !

      Number of special complex terrain
      receptors  (NCTREC)                      Default: 0     ! NCTREC =  0   !

      Terrain and CTSG Receptor data for
```

```
       CTSG hills input in CTDM format ?
       (MHILL)                                No Default     ! MHILL =  0   !
       1 = Hill and Receptor data created
           by CTDM processors & read from
           HILL.DAT and HILLRCT.DAT files
       2 = Hill data created by OPTHILL &
           input below in Subgroup (6b);
           Receptor data in Subgroup (6c)

       Factor to convert horizontal dimensions  Default: 1.0   ! XHILL2M = 1. !
       to meters (MHILL=1)

       Factor to convert vertical dimensions    Default: 1.0   ! ZHILL2M = 1. !
       to meters (MHILL=1)

       X-origin of CTDM system relative to      No Default     ! XCTDMKM = 0.0E00 !
       CALPUFF coordinate system, in Kilometers (MHILL=1)

       Y-origin of CTDM system relative to      No Default     ! YCTDMKM = 0.0E00 !
       CALPUFF coordinate system, in Kilometers (MHILL=1)

! END !

---------------
Subgroup (6b)
---------------

                      1 **
     HILL information


HILL            XC         YC        THETAH  ZGRID  RELIEF    EXPO 1    EXPO 2   SCALE 1    SCALE 2    AMAX1
AMAX2
 NO.           (km)       (km)       (deg.)   (m)     (m)       (m)       (m)       (m)        (m)        (m)
(m)
----          ----      ----      ------  -----  ------    ------    ------   -------    -------    -----     -
----

---------------
Subgroup (6c)
---------------

    COMPLEX TERRAIN RECEPTOR INFORMATION

                      XRCT         YRCT        ZRCT          XHH
                      (km)         (km)         (m)
                     ------        -----      ------         ----


-------------------
1
     Description of Complex Terrain Variables:
          XC, YC  = Coordinates of center of hill
          THETAH  = Orientation of major axis of hill (clockwise from
                    North)
          ZGRID   = Height of the  0  of the grid above mean sea
                    level
          RELIEF  = Height of the crest of the hill above the grid elevation
          EXPO 1  = Hill-shape exponent for the major axis
          EXPO 2  = Hill-shape exponent for the major axis
          SCALE 1 = Horizontal length scale along the major axis
          SCALE 2 = Horizontal length scale along the minor axis
          AMAX    = Maximum allowed axis length for the major axis
          BMAX    = Maximum allowed axis length for the major axis

          XRCT, YRCT = Coordinates of the complex terrain receptors
          ZRCT    = Height of the ground (MSL) at the complex terrain
                    Receptor
          XHH     = Hill number associated with each complex terrain receptor
                    (NOTE: MUST BE ENTERED AS A REAL NUMBER)

   **
     NOTE: DATA for each hill and CTSG receptor are treated as a separate
           input subgroup and therefore must end with an input group terminator.

-------------------------------------------------------------------------------


INPUT GROUP: 7 -- Chemical parameters for dry deposition of gases
--------------
```

```
      SPECIES       DIFFUSIVITY        ALPHA STAR        REACTIVITY     MESOPHYLL RESISTANCE       HENRY'S LAW
COEFFICIENT
       NAME       (cm**2/s)                                                (s/cm)           (dimensionless)
      -------     -----------      ----------      ----------    --------------------     ----------

!         SO2 =     0.1509,         1000.,           8.,               0.,                   0.04 !
!         NOX =     0.1656,            1.,           8.,               5.,                    3.5 !
!        HNO3 =     0.1628,            1.,          18.,               0.,             0.00000008 !

!END!


-------------------------------------------------------------------------------


INPUT GROUP: 8 -- Size parameters for dry deposition of particles
--------------

     For SINGLE SPECIES, the mean and standard deviation are used to
     compute a deposition velocity for NINT (see group 9) size-ranges,
     and these are then averaged to obtain a mean deposition velocity.

     For GROUPED SPECIES, the size distribution should be explicitly
     specified (by the 'species' in the group), and the standard deviation
     for each should be entered as 0.  The model will then use the
     deposition velocity for the stated mean diameter.

      SPECIES      GEOMETRIC MASS MEAN        GEOMETRIC STANDARD
       NAME             DIAMETER                   DEVIATION
                        (microns)                  (microns)
      -------      -------------------        ------------------
!         SO4 =          0.48,                      2.   !
!         NO3 =          0.48,                      2.   !
!         PMF =          0.48,                      2.   !
!         PMC =          3.00,                      2.   !

!END!


-------------------------------------------------------------------------------


INPUT GROUP: 9 -- Miscellaneous dry deposition parameters
--------------

     Reference cuticle resistance (s/cm)
     (RCUTR)                           Default: 30    !  RCUTR = 30.0 !
     Reference ground resistance  (s/cm)
     (RGR)                             Default: 10    !    RGR = 10.0 !
     Reference pollutant reactivity
     (REACTR)                          Default: 8     ! REACTR = 8.0 !

     Number of particle-size intervals used to
     evaluate effective particle deposition velocity
     (NINT)                            Default: 9     !   NINT =  9  !

     Vegetation state in unirrigated areas
     (IVEG)                            Default: 1     !   IVEG =  1   !
        IVEG=1 for active and unstressed vegetation
        IVEG=2 for active and stressed vegetation
        IVEG=3 for inactive vegetation

!END!


-------------------------------------------------------------------------------


INPUT GROUP: 10 -- Wet Deposition Parameters
---------------


                      Scavenging Coefficient -- Units: (sec)**(-1)

       Pollutant      Liquid Precip.       Frozen Precip.
       ---------      --------------       --------------
!         SO2 =         3.0E-05,             0.0E00 !
!         SO4 =         1.0E-04,            3.0E-05 !
!        HNO3 =         6.0E-05,             0.0E00 !
!         NO3 =         1.0E-04,            3.0E-05 !
!        PM10 =         1.0E-04,            3.0E-05 !
```

```
!END!

-------------------------------------------------------------------------------

INPUT GROUP: 11 -- Chemistry Parameters
---------------

     Ozone data input option (MOZ)     Default: 1            ! MOZ =  1   !
     (Used only if MCHEM = 1, 3, or 4)
        0 = use a monthly background ozone value
        1 = read hourly ozone concentrations from
            the OZONE.DAT data file

     Monthly ozone concentrations
     (Used only if MCHEM = 1, 3, or 4 and
      MOZ = 0 or MOZ = 1 and all hourly O3 data missing)
     (BCKO3) in ppb                    Default: 12*80.
     !  BCKO3 = 44.70, 44.70, 44.70, 44.70, 44.70, 44.70, 44.70, 44.70, 44.70, 44.70, 44.70, 44.70 !

     Monthly ammonia concentrations
     (Used only if MCHEM = 1, or 3)
     (BCKNH3) in ppb                   Default: 12*10.
     !  BCKNH3 = 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00 !

     Nighttime SO2 loss rate (RNITE1)
     in percent/hour                   Default: 0.2          ! RNITE1 = .2 !

     Nighttime NOx loss rate (RNITE2)
     in percent/hour                   Default: 2.0          ! RNITE2 = 2.0 !

     Nighttime HNO3 formation rate (RNITE3)
     in percent/hour                   Default: 2.0          ! RNITE3 = 2.0 !

     H2O2 data input option (MH2O2)    Default: 1            ! MH2O2 =  1   !
     (Used only if MAQCHEM = 1)
        0 = use a monthly background H2O2 value
        1 = read hourly H2O2 concentrations from
            the H2O2.DAT data file

     Monthly H2O2 concentrations
     (Used only if MQACHEM = 1 and
      MH2O2 = 0 or MH2O2 = 1 and all hourly H2O2 data missing)
     (BCKH2O2) in ppb                  Default: 12*1.
     !  BCKH2O2 = 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00 !


 --- Data for SECONDARY ORGANIC AEROSOL (SOA) Option
     (used only if MCHEM = 4)

     The SOA module uses monthly values of:
          Fine particulate concentration in ug/m^3 (BCKPMF)
          Organic fraction of fine particulate     (OFRAC)
          VOC / NOX ratio (after reaction)         (VCNX)
     to characterize the air mass when computing
     the formation of SOA from VOC emissions.
     Typical values for several distinct air mass types are:

        Month    1    2    3    4    5    6    7    8    9   10   11   12
                Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov  Dec

     Clean Continental
        BCKPMF   1.   1.   1.   1.   1.   1.   1.   1.   1.   1.   1.   1.
        OFRAC  .15  .15  .20  .20  .20  .20  .20  .20  .20  .20  .20  .15
        VCNX    50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.

     Clean Marine (surface)
        BCKPMF  .5   .5   .5   .5   .5   .5   .5   .5   .5   .5   .5   .5
        OFRAC  .25  .25  .30  .30  .30  .30  .30  .30  .30  .30  .30  .25
        VCNX    50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.

     Urban - low biogenic (controls present)
        BCKPMF  30.  30.  30.  30.  30.  30.  30.  30.  30.  30.  30.  30.
        OFRAC  .20  .20  .25  .25  .25  .25  .25  .25  .20  .20  .20  .20
        VCNX     4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.

     Urban - high biogenic (controls present)
        BCKPMF  60.  60.  60.  60.  60.  60.  60.  60.  60.  60.  60.  60.
        OFRAC  .25  .25  .30  .30  .30  .55  .55  .55  .35  .35  .35  .25
```

```
        VCNX    15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.

     Regional Plume
        BCKPMF  20.  20.  20.  20.  20.  20.  20.  20.  20.  20.  20.  20.
        OFRAC  .20  .20  .25  .35  .25  .40  .40  .40  .30  .30  .30  .20
        VCNX    15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.

     Urban - no controls present
        BCKPMF 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100.
        OFRAC  .30  .30  .35  .35  .35  .55  .55  .55  .35  .35  .35  .30
        VCNX     2.   2.   2.   2.   2.   2.   2.   2.   2.   2.   2.   2.

     Default: Clean Continental
     !  BCKPMF = 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00 !
     !  OFRAC  = 0.15, 0.15, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.15 !
     !  VCNX   = 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00 !


!END!


-------------------------------------------------------------------------------


INPUT GROUP: 12 -- Misc. Dispersion and Computational Parameters
---------------

     Horizontal size of puff (m) beyond which
     time-dependent dispersion equations (Heffter)
     are used to determine sigma-y and
     sigma-z (SYTDEP)                           Default: 550.   ! SYTDEP = 5.5E02 !

     Switch for using Heffter equation for sigma z
     as above (0 = Not use Heffter; 1 = use Heffter
     (MHFTSZ)                                   Default: 0      ! MHFTSZ =  0   !

     Stability class used to determine plume
     growth rates for puffs above the boundary
     layer (JSUP)                               Default: 5      ! JSUP =  5   !

     Vertical dispersion constant for stable
     conditions (k1 in Eqn. 2.7-3)  (CONK1)     Default: 0.01   ! CONK1 = .01 !

     Vertical dispersion constant for neutral/
     unstable conditions (k2 in Eqn. 2.7-4)
     (CONK2)                                    Default: 0.1    ! CONK2 = .1 !

     Factor for determining Transition-point from
     Schulman-Scire to Huber-Snyder Building Downwash
     scheme (SS used for Hs < Hb + TBD * HL)
     (TBD)                                      Default: 0.5    ! TBD = .5 !
        TBD < 0   ==> always use Huber-Snyder
        TBD = 1.5 ==> always use Schulman-Scire
        TBD = 0.5 ==> ISC Transition-point

     Range of land use categories for which
     urban dispersion is assumed
     (IURB1, IURB2)                             Default: 10     ! IURB1 =  10  !
                                                         19     ! IURB2 =  19  !

     Site characterization parameters for single-point Met data files ---------
     (needed for METFM = 2,3,4)

        Land use category for modeling domain
        (ILANDUIN)                              Default: 20     ! ILANDUIN =  20  !

        Roughness length (m) for modeling domain
        (Z0IN)                                  Default: 0.25   ! Z0IN = .25 !

        Leaf area index for modeling domain
        (XLAIIN)                                Default: 3.0    ! XLAIIN = 3.0 !

        Elevation above sea level (m)
        (ELEVIN)                                Default: 0.0    ! ELEVIN = .0 !

        Latitude (degrees) for met location
        (XLATIN)                                Default: -999.  ! XLATIN = -999.0 !

        Longitude (degrees) for met location
        (XLONIN)                                Default: -999.  ! XLONIN = -999.0 !
```

```
Specialized information for interpreting single-point Met data files -----

   Anemometer height (m) (Used only if METFM = 2,3)
   (ANEMHT)                            Default: 10.    ! ANEMHT = 10.0 !

   Form of lateral turbulance data in PROFILE.DAT file
   (Used only if METFM = 4 or MTURBVW = 1 or 3)
   (ISIGMAV)                           Default: 1      ! ISIGMAV =  0  !
       0 = read sigma-theta
       1 = read sigma-v

   Choice of mixing heights (Used only if METFM = 4)
   (IMIXCTDM)                          Default: 0      ! IMIXCTDM =  0  !
       0 = read PREDICTED mixing heights
       1 = read OBSERVED mixing heights

Maximum length of a slug (met. grid units)
(XMXLEN)                               Default: 1.0    ! XMXLEN = 1.0 !

Maximum travel distance of a puff/slug (in
grid units) during one sampling step
(XSAMLEN)                              Default: 1.0    ! XSAMLEN = 1.0 !

Maximum Number of slugs/puffs release from
one source during one time step
(MXNEW)                                Default: 99     ! MXNEW =  99   !

Maximum Number of sampling steps for
one puff/slug during one time step
(MXSAM)                                Default: 99     ! MXSAM =  99   !

Number of iterations used when computing
the transport wind for a sampling step
that includes gradual rise (for CALMET
and PROFILE winds)
(NCOUNT)                               Default: 2      ! NCOUNT =  2   !

Minimum sigma y for a new puff/slug (m)
(SYMIN)                                Default: 1.0    ! SYMIN = 1.0  !

Minimum sigma z for a new puff/slug (m)
(SZMIN)                                Default: 1.0    ! SZMIN = 1.0  !

Default minimum turbulence velocities
sigma-v and sigma-w for each
stability class (m/s)
(SVMIN(6) and SWMIN(6))     Default SVMIN : .50,  .50,  .50,  .50,  .50,  .50
                            Default SWMIN : .20,  .12,  .08,  .06,  .03,  .016

                          Stability Class :  A     B     C     D     E     F
                                            ---   ---   ---   ---   ---   ---
                                  ! SVMIN = 0.500, 0.500, 0.500, 0.500, 0.500, 0.500!
                                  ! SWMIN = 0.200, 0.120, 0.080, 0.060, 0.030, 0.016!

Divergence criterion for dw/dz across puff
used to initiate adjustment for horizontal
convergence (1/s)
Partial adjustment starts at CDIV(1), and
full adjustment is reached at CDIV(2)
(CDIV(2))                              Default: 0.0,0.0  ! CDIV = .0, .0 !

Minimum wind speed (m/s) allowed for
non-calm conditions. Also used as minimum
speed returned when using power-law
extrapolation toward surface
(WSCALM)                               Default: 0.5    ! WSCALM = .5 !

Maximum mixing height (m)
(XMAXZI)                               Default: 3000.  ! XMAXZI = 3000.0 !

Minimum mixing height (m)
(XMINZI)                               Default: 50.    ! XMINZI = 50.0 !

Default wind speed classes --
5 upper bounds (m/s) are entered;
the 6th class has no upper limit
(WSCAT(5))                        Default   :
                                  ISC RURAL : 1.54, 3.09, 5.14, 8.23, 10.8 (10.8+)

                         Wind Speed Class :  1     2     3     4     5
                                            ---   ---   ---   ---   ---
```

```
                                 ! WSCAT = 1.54, 3.09, 5.14, 8.23, 10.80 !

Default wind speed profile power-law
exponents for stabilities 1-6
(PLX0(6))                       Default   : ISC RURAL values
                                ISC RURAL : .07, .07, .10, .15, .35, .55
                                ISC URBAN : .15, .15, .20, .25, .30, .30

                          Stability Class :  A     B     C     D     E     F
                                            ---   ---   ---   ---   ---   ---
                                  ! PLX0 = 0.07, 0.07, 0.10, 0.15, 0.35, 0.55 !

Default potential temperature gradient
for stable classes E, F (degK/m)
(PTG0(2))                       Default: 0.020, 0.035
                                  ! PTG0 = 0.020,   0.035 !

Default plume path coefficients for
each stability class (used when option
for partial plume height terrain adjustment
is selected -- MCTADJ=3)
(PPC(6))                  Stability Class :  A     B     C     D     E     F
                             Default  PPC : .50,  .50,  .50,  .50,  .35,  .35
                                            ---   ---   ---   ---   ---   ---
                                  !  PPC = 0.50, 0.50, 0.50, 0.50, 0.35, 0.35 !

Slug-to-puff transition criterion factor
equal to sigma-y/length of slug
(SL2PF)                               Default: 10.       ! SL2PF = 10.0 !

Puff-splitting control variables ------------------------

  VERTICAL SPLIT
  --------------

  Number of puffs that result every time a puff
  is split - nsplit=2 means that 1 puff splits
  into 2
  (NSPLIT)                            Default:   3       ! NSPLIT =  3  !

  Time(s) of a day when split puffs are eligible to
  be split once again; this is typically set once
  per day, around sunset before nocturnal shear develops.
  24 values: 0 is midnight (00:00) and 23 is 11 PM (23:00)
  0=do not re-split    1=eligible for re-split
  (IRESPLIT(24))                      Default:  Hour 17 = 1
  !  IRESPLIT = 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0 !

  Split is allowed only if last hour's mixing
  height (m) exceeds a minimum value
  (ZISPLIT)                           Default: 100.      ! ZISPLIT = 100.0 !

  Split is allowed only if ratio of last hour's
  mixing ht to the maximum mixing ht experienced
  by the puff is less than a maximum value (this
  postpones a split until a nocturnal layer develops)
  (ROLDMAX)                           Default: 0.25      ! ROLDMAX = 0.25 !


  HORIZONTAL SPLIT
  ----------------

  Number of puffs that result every time a puff
  is split - nsplith=5 means that 1 puff splits
  into 5
  (NSPLITH)                           Default:   5       ! NSPLITH =  5  !

  Minimum sigma-y (Grid Cells Units) of puff
  before it may be split
  (SYSPLITH)                          Default:  1.0      ! SYSPLITH = 1.0 !

  Minimum puff elongation rate (SYSPLITH/hr) due to
  wind shear, before it may be split
  (SHSPLITH)                          Default:  2.       ! SHSPLITH = 2.0 !

  Minimum concentration (g/m^3) of each
  species in puff before it may be split
  Enter array of NSPEC values; if a single value is
  entered, it will be used for ALL species
  (CNSPLITH)                          Default:  1.0E-07   ! CNSPLITH = 1.0E-07 !
```

```
     Integration control variables ------------------------

       Fractional convergence criterion for numerical SLUG
       sampling integration
       (EPSSLUG)                          Default:   1.0e-04  ! EPSSLUG = 1.0E-04 !

       Fractional convergence criterion for numerical AREA
       source integration
       (EPSAREA)                          Default:   1.0e-06  ! EPSAREA = 1.0E-06 !

       Trajectory step-length (m) used for numerical rise
       integration
       (DSRISE)                           Default:   1.0      ! DSRISE = 1.0 !

!END!


-------------------------------------------------------------------------------


INPUT GROUPS: 13a, 13b, 13c, 13d -- Point source parameters
--------------------------------

---------------
Subgroup (13a)
---------------

     Number of point sources with
     parameters provided below      (NPT1)  No default  !  NPT1 =  0 !

     Units used for point source
     emissions below                (IPTU)  Default: 1  !  IPTU =   1  !
           1 =        g/s
           2 =       kg/hr
           3 =       lb/hr
           4 =     tons/yr
           5 =     Odour Unit * m**3/s  (vol. flux of odour compound)
           6 =     Odour Unit * m**3/min
           7 =     metric tons/yr

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (13d)        (NSPT1) Default: 0  !  NSPT1 =  0  !

     Number of point sources with
     variable emission parameters
     provided in external file      (NPT2)  No default  !  NPT2 =  0  !

     (If NPT2 > 0, these point
     source emissions are read from
     the file: PTEMARB.DAT)

!END!

---------------
Subgroup (13b)
---------------
                                      a
          POINT SOURCE: CONSTANT DATA
          -----------------------------
                                                                                b           c
  Source      X UTM     Y UTM     Stack   Base     Stack    Exit  Exit    Bldg.  Emission
   No.     Coordinate Coordinate Height Elevation Diameter  Vel.  Temp.   Dwash   Rates
              (km)      (km)       (m)      (m)       (m)  (m/s) (deg. K)
  ------   ---------- ---------- ------  ------   -------- ----- -------- ----- --------



--------

    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.

     SRCNAM  is a 12-character name for a source
             (No default)
     X       is an array holding the source data listed by the column headings
             (No default)
     SIGYZI  is an array holding the initial sigma-y and sigma-z (m)
             (Default: 0.,0.)
```

```
     FMFAC   is a vertical momentum flux factor (0. or 1.0) used to represent
             the effect of rain-caps or other physical configurations that
             reduce momentum rise associated with the actual exit velocity.
             (Default: 1.0  -- full momentum used)

    b
     0. = No building downwash modeled, 1. = downwash modeled
     NOTE: must be entered as a REAL number (i.e., with decimal point)

    c
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by IPTU
     (e.g. 1 for g/s).

---------------
Subgroup (13c)
---------------

           BUILDING DIMENSION DATA FOR SOURCES SUBJECT TO DOWNWASH
           -------------------------------------------------------
Source                                                                     a
 No.       Effective building width and height (in meters) every 10 degrees
------     --------------------------------------------------------------------

--------

    a
     Each pair of width and height values is treated as a separate input
     subgroup and therefore must end with an input group terminator.

---------------
Subgroup (13d)
---------------
                                                a
          POINT SOURCE: VARIABLE EMISSIONS DATA
          ---------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 13b.  Factors entered multiply the rates in 13b.
     Skip sources here that have constant emissions.  For more elaborate
     variation in source parameters, use PTEMARB.DAT and NPT2 > 0.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                                Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
           5 =       Temperature   (12 scaling factors, where temperature
                                    classes have upper bounds (C) of:
                                    0, 5, 10, 15, 20, 25, 30, 35, 40,
                                    45, 50, 50+)



--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.


-------------------------------------------------------------------------------


INPUT GROUPS: 14a, 14b, 14c, 14d -- Area source parameters
--------------------------------

---------------
Subgroup (14a)
---------------

     Number of polygon area sources with
     parameters specified below (NAR1)       No default  !  NAR1 =  0   !

     Units used for area source
```

```
     emissions below            (IARU)       Default: 1  !  IARU =   1  !
           1 =        g/m**2/s
           2 =       kg/m**2/hr
           3 =       lb/m**2/hr
           4 =     tons/m**2/yr
           5 =     Odour Unit * m/s  (vol. flux/m**2 of odour compound)
           6 =     Odour Unit * m/min
           7 =     metric tons/m**2/yr

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (14d)        (NSAR1) Default: 0  !  NSAR1 =  0  !

     Number of buoyant polygon area sources
     with variable location and emission
     parameters (NAR2)                      No default  !  NAR2 =  0   !
     (If NAR2 > 0, ALL parameter data for
     these sources are read from the file: BAEMARB.DAT)

!END!

---------------
Subgroup (14b)
---------------
                                     a
          AREA SOURCE: CONSTANT DATA
          ----------------------------
                                                         b
Source           Effect.    Base      Initial    Emission
 No.             Height   Elevation   Sigma z     Rates
                   (m)       (m)       (m)
-------          ------    ------     --------   ---------
Subgroup (14b)


--------
    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.
    b
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
     modeled,  but not emitted.  Units are specified by IARU
     (e.g. 1 for g/m**2/s).

---------------
Subgroup (14c)
---------------

           COORDINATES (UTM-km) FOR EACH VERTEX(4) OF EACH POLYGON
           --------------------------------------------------------
Source                                                              a
 No.       Ordered list of X followed by list of Y,  grouped by source
------     ------------------------------------------------------------


--------
    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.


---------------
Subgroup (14d)
---------------
                                               a
          AREA SOURCE: VARIABLE EMISSIONS DATA
          --------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 14b.  Factors entered multiply the rates in 14b.
     Skip sources here that have constant emissions.  For more elaborate
     variation in source parameters, use BAEMARB.DAT and NAR2 > 0.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                                Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
```

```
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
           5 =       Temperature   (12 scaling factors, where temperature
                                    classes have upper bounds (C) of:
                                    0, 5, 10, 15, 20, 25, 30, 35, 40,
                                    45, 50, 50+)



--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.


-------------------------------------------------------------------------------

INPUT GROUPS: 15a, 15b, 15c -- Line source parameters
---------------------------

---------------
Subgroup (15a)
---------------

     Number of buoyant line sources
     with variable location and emission
     parameters (NLN2)                             No default  !  NLN2 =  0   !

     (If NLN2 > 0, ALL parameter data for
      these sources are read from the file: LNEMARB.DAT)

     Number of buoyant line sources (NLINES)       No default   ! NLINES =  0  !

     Units used for line source
     emissions below               (ILNU)          Default: 1  !  ILNU =   1  !
           1 =        g/s
           2 =       kg/hr
           3 =       lb/hr
           4 =     tons/yr
           5 =     Odour Unit * m**3/s  (vol. flux of odour compound)
           6 =     Odour Unit * m**3/min
           7 =     metric tons/yr

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (15c)       (NSLN1) Default: 0  !  NSLN1 =  0  !

     Maximum number of segments used to model
     each line (MXNSEG)                            Default: 7   ! MXNSEG =  7  !

     The following variables are required only if NLINES > 0.  They are
     used in the buoyant line source plume rise calculations.

        Number of distances at which               Default: 6   ! NLRISE =  6  !
        transitional rise is computed

        Average building length (XL)               No default   ! XL = .0 !
                                                   (in meters)

        Average building height (HBL)              No default   ! HBL = .0 !
                                                   (in meters)

        Average building width (WBL)               No default   ! WBL = .0 !
                                                   (in meters)

        Average line source width (WML)            No default   ! WML = .0 !
                                                   (in meters)

        Average separation between buildings (DXL)  No default   ! DXL = .0 !
                                                   (in meters)

        Average buoyancy parameter (FPRIMEL)       No default   ! FPRIMEL = .0 !
                                                   (in m**4/s**3)

!END!

---------------
```

```
Subgroup (15b)
---------------

          BUOYANT LINE SOURCE: CONSTANT DATA
          ----------------------------------
                                                                                               a
Source     Beg. X      Beg. Y      End. X    End. Y     Release    Base        Emission
 No.     Coordinate  Coordinate  Coordinate Coordinate  Height    Elevation      Rates
            (km)        (km)        (km)       (km)       (m)       (m)
------   ----------  ----------  ---------  ----------  -------   ---------    ---------

    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.

    b
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by ILNTU
     (e.g. 1 for g/s).

---------------
Subgroup (15c)
---------------
                                                        a
          BUOYANT LINE SOURCE: VARIABLE EMISSIONS DATA
          ----------------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 15b.  Factors entered multiply the rates in 15b.
     Skip sources here that have constant emissions.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                             Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
           5 =       Temperature   (12 scaling factors, where temperature
                                    classes have upper bounds (C) of:
                                    0, 5, 10, 15, 20, 25, 30, 35, 40,
                                    45, 50, 50+)



--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.


-------------------------------------------------------------------------------


INPUT GROUPS: 16a, 16b, 16c -- Volume source parameters
---------------------------

---------------
Subgroup (16a)
---------------

     Number of volume sources with
     parameters provided in 16b,c (NVL1)     No default  !  NVL1 =  0   !

     Units used for volume source
     emissions below in 16b       (IVLU)     Default: 1  !  IVLU =   4  !
           1 =        g/s
           2 =       kg/hr
           3 =       lb/hr
           4 =     tons/yr
           5 =     Odour Unit * m**3/s  (vol. flux of odour compound)
           6 =     Odour Unit * m**3/min
           7 =     metric tons/yr

     Number of source-species
     combinations with variable
```

```
     emissions scaling factors
     provided below in (16c)      (NSVL1)    Default: 0  !  NSVL1 =  0  !

     Number of volume sources with
     variable location and emission
     parameters                   (NVL2)     No default  !  NVL2 =   0   !

     (If NVL2 > 0, ALL parameter data for
      these sources are read from the VOLEMARB.DAT file(s) )

!END!

---------------
Subgroup (16b)
---------------
                                        a
           VOLUME SOURCE: CONSTANT DATA
           ------------------------------
                                                                              b
        X UTM      Y UTM      Effect.    Base     Initial    Initial    Emission
     Coordinate  Coordinate   Height   Elevation  Sigma y    Sigma z     Rates
        (km)       (km)        (m)       (m)        (m)        (m)
     ----------  ----------   ------    ------    --------   --------   --------


--------
    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.

    b
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by IVLU
     (e.g. 1 for g/s).

---------------
Subgroup (16c)
---------------
                                                 a
          VOLUME SOURCE: VARIABLE EMISSIONS DATA
          ---------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 16b.  Factors entered multiply the rates in 16b.
     Skip sources here that have constant emissions.  For more elaborate
     variation in source parameters, use VOLEMARB.DAT and NVL2 > 0.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                             Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
           5 =       Temperature   (12 scaling factors, where temperature
                                    classes have upper bounds (C) of:
                                    0, 5, 10, 15, 20, 25, 30, 35, 40,
                                    45, 50, 50+)



--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.


-------------------------------------------------------------------------------

INPUT GROUPS: 17a & 17b -- Non-gridded (discrete) receptor information
----------------------

---------------
Subgroup (17a)
---------------
```

```
     Number of non-gridded receptors (NREC)  No default  !  NREC =  0   !

!END!

---------------
Subgroup (17b)
---------------
                                               a
           NON-GRIDDED (DISCRETE) RECEPTOR DATA
           ------------------------------------

                  X UTM       Y UTM        Ground       Height   b
Receptor       Coordinate   Coordinate    Elevation   Above Ground
  No.            (km)         (km)           (m)          (m)
--------       ----------   ----------    ---------   ------------
-------------
    a
     Data for each receptor are treated as a separate input subgroup
     and therefore must end with an input group terminator.

    b
     Receptor height above ground is optional.  If no value is entered,
     the receptor is placed on the ground.
```