AIR QUALITY ANALYSIS
TECHNICAL SUPPORT DOCUMENT
For San Juan Public Lands Center
Land Management Plan
And Environmental Impact Statement

In Support of Forest Service
Contract AG-3187-C-06-0051
Modifications 009, 015, 021, 022, 023, 027, and 028

Prepared for

Kelly Palmer
USDA FOREST SERVICE
San Juan National Forest
15 Burnett Ct
Durango, Colorado 81301

Prepared by

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, CO 80525
Phone: 970-484-7941
www.air-resource.com

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LIST OF ACRONYMS AND ABBREVIATIONS

AERMOD	Atmospheric Dispersion Modeling System
APCD	State of Colorado Air Pollution Control Division
AQRV	Air Quality Related Values
ARS	Air Resource Specialists, Inc.
b_{ext}	Extinction Coefficient
BART	Best Available Retrofit Technology
BLM	Bureau of Land Management
CALMET	Meteorological Model
CALPUFF	Air Quality Dispersion Model
CDPHE	Colorado Department of Public Health and Environment
CO	Carbon Monoxide
CM	Coarse Mass
EC	Elemental Carbon
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
FLAG	Federal Land Manager's Air Quality Related Values Work Group
FLM	Federal Land Manager
FS	USDA Forest Service
HAPs	Hazardous Air Pollutants
HSH	Highest Second-Highest
IMPROVE	Interagency Monitoring of Protected Visual Environments
IWAQM	Interagency Workgroup on Air Quality Modeling
Mm^{-1}	Inverse Megameter
MM5	Mesoscale Meteorological Model
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NO_2	Nitrogen Dioxide
NO_x	Oxides of Nitrogen; the sum of NO + NO_2
O_3	Ozone
OMC	Organic Mass by Carbon
Pb	Lead
$PM_{2.5}$	Particulate matter less than or equal to 2.5 microns in size
PM_{10}	Particulate matter less than or equal to 10 microns in size
PSD	Prevention of Significant Deterioration
Rayleigh	Scattering by gas molecules, whose size is small compared to the wavelength of radiation
RFD	Reasonably Foreseeable Development
RMP	Resource Management Plan
SJPLC	San Juan Public Lands Center
SO_2	Sulfur Dioxide
TSD	Technical Support Document
VOC	Volatile Organic Compounds
WRAP	Western Regional Air Partnership

EXECUTIVE SUMMARY

This air quality modeling study was conducted to evaluate various land management scenarios being considered under the San Juan Public Lands Center (SJPLC) Land Management Plan and Environmental Impact Statement (EIS).

- Scenario 1 represents leasing of additional public lands for oil and gas development with the maximum development of these lands.
- Scenario 2 represents the No Action Scenario, or no additional leasing of public lands. However, future oil and gas development would occur on already leased public lands along with new development of private land under Scenario 2.
- Scenario 3 represents new leasing of public lands, but with a lower level of new development.

Scenario 3 was not explicitly analyzed in this air quality assessment. The air quality impacts under Scenario 3 would be bounded by the reported impacts for Scenarios 1 and 2. All scenarios included potential emissions from construction and operations.

The air quality modeling analysis used the CALPUFF dispersion modeling system, which is the U.S. Environmental Protection Agency (EPA) approved air quality model for long-range transport (more than 50 kilometers) of pollutants. Many of the Class I Areas of concern for these analyses are located more than 50 kilometers from the leasing areas under consideration.

The modeling considered both the incremental impacts from the proposed development and a comprehensive cumulative analysis. The cumulative emissions inventory included development on lands proposed for leasing, new development on already leased SJPLC lands and private lands in the region, projects identified as reasonable foreseeable development (RFD), and existing emissions from stationary sources in the modeling domain. These existing sources included emissions from the Four Corners Power Plant and San Juan Generating Station, both located in northwestern New Mexico.

Ambient NO_2, SO_2, PM_{10}, and $PM_{2.5}$

The modeling considered impacts of the regulated air pollutants nitrogen dioxide (NO_2), sulfur dioxide (SO_2), particulate matter with diameter less than 10 microns (PM_{10}), and particulate matter with diameter less than 2.5 microns ($PM_{2.5}$). For the modeling, all oxides of nitrogen (NO_X) emissions were conservatively assumed to be in the form of NO_2, which is the regulated Clean Air Act pollutant. The cumulative modeling analysis indicated that concentrations of NO_2, SO_2, PM_{10}, and $PM_{2.5}$ would be at or below the applicable National Ambient Air Quality Standards (NAAQS), with the exception of a small area in northwestern New Mexico where modeled concentrations exceeded the 1-hour, 3-hour, and 24-hour SO_2 NAAQS and 1-hour NO_2 NAAQS.

With respect to the modeled exceedances, the modeling demonstrated that the SJPLC oil and gas development did not cause or contribute to these concentrations. The modeled exceedances were predicted at receptors in close proximity to the Four Corners Power Plant and

San Juan Generating Station, which were the largest NO_X and SO_2 sources modeled in this analysis. Note that the CALPUFF model is designed to best predict concentrations greater than 50 kilometers from a source and that the accuracy of predicted concentrations at receptors less than 50 kilometers is less certain. The modeled exceedances are within 50 kilometers of the Four Corners Power Plant and San Juan Generating Station.

For 1-hour average NO_2, the modeling predicted concentrations above the NAAQS but not at the frequency needed to result in an NAAQS exceedance. The 1-hour NO_2 is based on the 98th percentile for the highest daily concentration, which represents the 8th highest daily 1-hour average concentration. The modeled 1-hour NO_2 concentration based on the 98th percentile is below the NAAQS at all areas except Chaco Culture and the Class II receptors in northwest New Mexico, near the For Corners and San Juan emission sources.

Deposition

The SJPLC modeling also considered the incremental and cumulative impacts of each scenario on nitrogen and sulfur deposition. For the incremental impacts, the Federal Land Managers' threshold of 0.005 kg/ha-yr was used to assess significant impacts. With the exception of Mesa Verde and Canyons of the Ancients, the predicted nitrogen and sulfur deposition was below the FLM threshold. Mesa Verde and Canyons of the Ancients are in close proximity to the proposed development areas. By exceeding the incremental threshold, it becomes more important to consider the cumulative deposition impacts at these locations. The incremental impacts associated with each scenario would add only a few percent to the total deposition predicted by the model at Mesa Verde and Canyons of the Ancients. Also, the cumulative impacts in Mesa Verde and Canyons of the Ancients remain less than the cumulative acid deposition thresholds developed by the Federal Land Managers.

Visibility

Potential impacts to visibility were modeled using CALPUFF. The modeling used two (2) different visibility calculation methods, denoted Method 2 and Method 6. Method 2 is the current procedure documented in the Federal Land Managers Air Quality Workgroup (FLAG) guidance and uses the predicted concentrations of aerosol species from CALPUFF with the daily average relative humidity data to estimate light extinction parameters. Method 6 is the current EPA-approved procedure under the Best Available Retrofit Technology (BART) regulations to assess whether a source contributes to existing visibility impairment. Also, there is a proposed revision to the FLAG guidance which would establish an approved visibility modeling procedure more closely aligned with Method 6, but for these analyses, the draft FLAG guidance had not been adopted in final form yet.

In general, the Method 2 modeling results predicted poorer visibility from the proposed development than Method 6. For the incremental analysis under Scenario 1, predicted impacts exceeded the 5% threshold relatively infrequently (a few days each year). The incremental visibility modeling for Scenario 1 considered only new development on lands being considered for additional leasing. Scenario 2 also had occurrences of degraded visibility as measured by a change in light extinction of greater than 5 percent compared to the FLAG natural background conditions. The magnitude and frequency of these events varied depending of the Class I Area of interest. Mesa Verde appeared to be the Class I Area most impacted by emissions from the project. Other than Mesa Verde, the impacts at the Class I and Class II areas of interest occurred a few days each year. The Scenario 2 emissions evaluated in the incremental analysis are emissions associated with future development on already leased SJPLC lands and nearby private lands.

The combined emissions (Scenario 1 plus Scenario 1) are greater than for the individual scenarios described above. Except for Mesa Verde and Canyons of the Ancients, visibility impacts greater than 5% are infrequent. Using Method 6 versus Method 2, visibility impacts above 5% are noted at Mesa Verde and Canyons of the Ancients, but these impacts are generally less than 10% for the 98th percentile, or 8th highest day.

A cumulative visibility modeling analysis was also conducted, including emissions from each Scenario as well as emissions from future RFD and all existing emission sources on the modeling grid. The cumulative modeling predicted that impacts would result in a substantial degradation in visibility compared to the FLAG recommended natural background condition. This result is not surprising as current visibility monitoring data show degradation of visibility at Class I Areas. However, in comparison to the monitored visibility data, the Method 6 modeled results correlated much better in terms of predicting the magnitude of the visibility impacts, suggesting that Method 6 performed better than Method 2 in this instance. Another finding of the cumulative impact assessment was that the results were virtually identical under Scenarios 1 and 2, suggesting that the project in question (additional oil and gas leasing on SJPLC lands) may not significantly degrade the visibility compared to other already existing or proposed emission sources.

1.0 INTRODUCTION

1.1 BACKGROUND

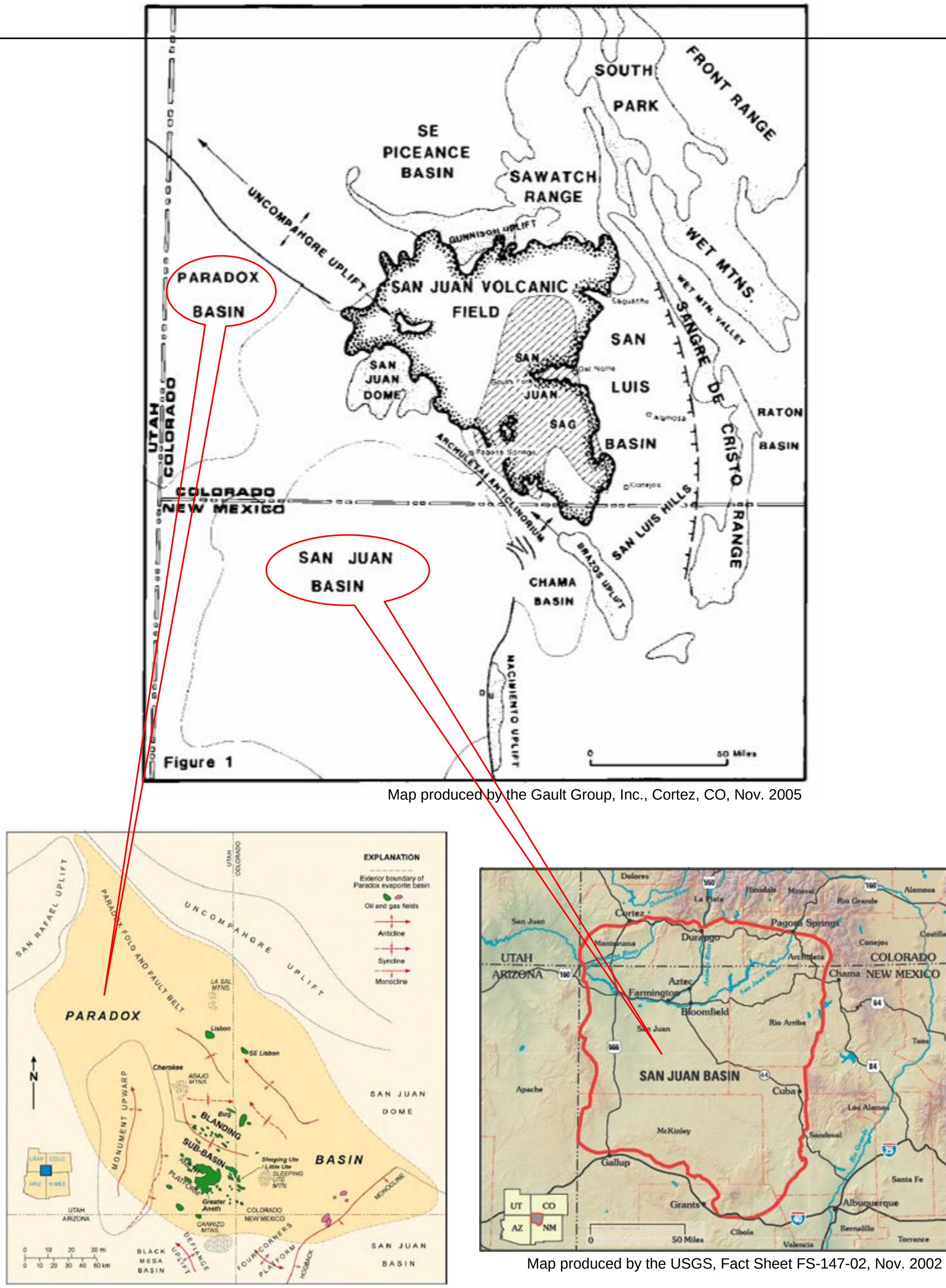
San Juan Public Lands Center (SJPLC) authorized Air Resource Specialists, Inc. (ARS) to conduct a CALPUFF air quality modeling analysis to support the final environmental impact statement (EIS) for its Land Management Plan (Plan). Scenarios under consideration for the Plan include two (2) potential new lease areas for oil and gas development: Paradox Basin Lease Area and the San Juan Sag Lease Area (see Figure 1-1). In addition, infill drilling within active leases in the Northern San Juan Basin was considered, as well as other reasonably foreseeable development (RFD) in the region. A draft Air Quality Modeling Protocol for the SJPLC was prepared in cooperation with appropriate SJPLC stakeholders, listed in Table 1-1, in January 2009.

Modeling of air quality impacts to nearby Class I and Class II areas is required for the SJPLC Land Management Plan as well as for future National Environmental Policy Act (NEPA) analysis as leases are offered for sale and as drilling permits are issued over the next decade. This document assesses potential impacts from air pollutants emitted from the identified development areas, as well as other known or proposed sources and projects in the vicinity (i.e., reasonably foreseeable development). The goal of the modeling is to estimate potential project-specific and cumulative air quality impacts on nearby Class I areas and other Class II areas of concern. Nine (9) Class I and five (5) Class II areas (listed in Table 2-1 of Section 2.0) were identified for assessment for potential project emissions. Predicted SO_2, NO_2, $PM_{2.5}$, and PM_{10} impacts are compared to National Ambient Air Quality Standards (NAAQS) and, where appropriate, Prevention of Significant Deterioration (PSD) increments. Potential impacts on the air quality related values of visibility and acid depositions were also assessed. These comparisons are for disclosure purposes only and do not constitute a regulatory or permitting analysis for hazardous air pollutants (HAPs) and other pollutants.

The exact locations of the emissions sources from leasing operations are not known with sufficient precision for near field modeling to be performed. Therefore, the evaluation of impacts from HAPs or of near field impacts is not included in this analysis. It is expected that a more detailed near field modeling analysis will be conducted in the future as part of the air permitting analysis for new sources under the purview of the Colorado Department of Public Health and Environment (CDPHE). The CDPHE analysis will be completed after the site specific locations and other data are developed.

The evaluation of ozone impacts is not included in this analysis. CALPUFF does not include adequate atmospheric chemistry to simulate the complex atmospheric reactions that lead to the formation of ozone. Current ozone concentrations within the San Juan Basin area are approaching NAAQS limits. The U.S. Environmental Protection Agency (EPA) and CDPHE have agreed with the USDA Forest Service (FS) and Bureau of Land Management (BLM) regarding their approach for modeling air quality impacts using CALPUFF, stipulating that in addition to modeling, phased air monitoring program results could trigger ozone modeling with an appropriate chemical model.

This report is submitted to the SJPLC stakeholders as shown in Table 1-1. Included is an overview of the modeling domain and techniques used (Section 2.0); a description of the regulatory framework that serves as a basis for this project (Section 3.0); an overview of the emissions inventory, existing environment, and background and meteorological data used for model input files (Sections 4.0, 5.0, and 6.0); and a summary of the CALMET and CALPUFF models used (Section 6.0). The products of the modeling analysis follow in Section 7.0. Appendices A and B contain the modeling protocol and emissions inventory documents prepared by ARS for the SJPLC stakeholders' review and approval. Appendix B contains tabular summaries of the CALMET and CALPUFF modeling parameters. Appendix C supports the reasoning that Method 6 visibility CALPUFF results are considered more accurate than Method 2 results.



Map produced by the Gault Group, Inc., Cortez, CO, Nov. 2005

Map modified from Harr, 1996

Map produced by the USGS, Fact Sheet FS-147-02, Nov. 2002

Figure 1-1. Overview Map of San Juan Project Area, Including Paradox Basin and San Juan Basin Inset Maps.

Table 1-1

San Juan Public Lands Center Stakeholders

Stakeholder Represented	Contact Person
USDA Forest Service	Kelly Palmer / Jeff Sorkin / Jeanne Hoadley
Bureau of Land Management	Ed Rumbold
Colorado Department of Public Health and Environment	Chuck Machovec / Gordon Pierce / Jim DiLeo
U.S. Environmental Protection Agency	James Hanley / Kenneth Distler / Joyel Dhieux
National Park Service	Andrea Stacy

2.0 PROJECT DESCRIPTION

As noted in the SJPLC Air Quality Modeling Protocol for San Juan Public Lands (Appendix D), the cumulative CALPUFF modeling analysis summarized in this report was performed including:

- Two of three development scenarios proposed by San Juan Public Lands:
  - Scenario 1 - Maximum Development Scenario
  - Scenario 2 - No Action Scenario (No New Leases)

- Other RFD in the region, including the following seven (7) development projects which SJPLC stakeholders were aware of:
  - Northern San Juan Basin Coalbed Methane EIS
  - Northern San Juan Basin Infill Wells
  - Southern Ute EISs
  - Jicarilla Oil and Gas Leasing EIS (Carson NF)
  - Farmington Field Office Resource Management Plan (RMP)
  - Canyons of the Ancients National Monument RMP
  - Desert Rock Power Plant

- Existing emission sources in the region:
  - Colorado regional sources
  - New Mexico regional sources
  - Utah regional sources
  - Tribal land sources (Arizona, Colorado, New Mexico, and Utah)

The modeling domain is shown in Figure 2-1. The domain is quite large, covering a portion of four (4) western states and includes nine (9) Class I areas and five (5) Class II areas as listed in Table 2-1. The proposed development area within the SJPLC's jurisdiction also includes public lands administered by the USDA Forest Service (FS) and the Bureau of Land Management (BLM). These lands are located east and northeast of Canyons of the Ancients National Monument and north of Mesa Verde National Park.

For purposes of discussion, the development area is presented as two (2) separate projects: Paradox Basin Gothic Shale Well Field (denoted *Gothic Shale Wells*) and Paradox Basin Conventional Wells (denoted *Paradox Conventional*). The Gothic Shale gas field, located within the Paradox and San Juan Basins, is currently considered an economic gas field. Modeling assumptions are based on currently known field characteristics and using spacing information from approximately five (5) wells that have been drilled in the Gothic Shale to date. The Paradox Conventional oil and gas wells were inventoried and analyzed as part of the AERMOD analysis associated with the first draft of the SJPLC Draft Land Management Plan and Draft Environmental Impact Statement (December 2007).

Exact well locations are unknown; therefore, both Gothic Shale and Paradox Conventional well sources were modeled as area sources in CALPUFF. These area sources assume a well density based on the number of wells expected. Although the exact well locations are unknown, the USFS has restrictions on the number of wells per square mile. While it may be possible for actual well density to be higher than what was modeled, the inclusion of a fine grid of receptors in the project area serve to identify areas where local impacts may be a concern. Modeling did not, however, suggest that cumulative impacts on the fine grid would exceed the NAAQS.

The San Juan Sag is another potential lease area on the San Juan Public Lands. For this analysis, wells associated with the San Juan Sag were not modeled. The reasonable foreseeable development assumes only two exploratory wells per year might be drilled and that none of these wells will be productive.

The emissions information used for input to this modeling effort is summarized in Section 4.0. Details and pertinent assumptions relevant to calculating emissions and modeling project impacts can be found in Appendix A (Addendum to Air Quality Modeling Protocol for SJPLC; Emissions Inventory).

Figure 2-1. CALPUFF Modeling Domain (600 km east-west by 450 km north-south) with Class I and Class II Areas Evaluated.

Table 2-1

Class I and Class II Areas
Included in the CALPUFF Analysis for San Juan Public Lands

Class I Areas	State	Federal Land Manager
Arches National Park	Utah	National Park Service
Bandelier National Monument	New Mexico	National Park Service
Black Canyon of the Gunnison National Park	Colorado	National Park Service
Canyonlands National Park	Utah	National Park Service
La Garita Wilderness	Colorado	USDA Forest Service
Mesa Verde National Park	Colorado	National Park Service
San Pedro Parks Wilderness	New Mexico	USDA Forest Service
Weminuche Wilderness	Colorado	USDA Forest Service
West Elk Wilderness	Colorado	USDA Forest Service
Class II Areas	**State**	**Federal Land Manager**
Canyon de Chelly National Monument	Arizona	National Park Service
Canyons of the Ancients National Monument	Colorado	Bureau of Land Management
Chaco Culture National Historic Park	New Mexico	National Park Service
Hovenweep National Monument	Colorado	National Park Service
Natural Bridges National Monument	Utah	National Park Service

3.0 REGULATORY FRAMEWORK

This section describes the air pollution control regulations that are expected to affect future oil and gas development in the SJPLC lease areas. Important regulations include state and federal air quality standards and PSD increments along with emission requirements for new natural gas-fired and diesel-fired equipment.

3.1 STATE AND FEDERAL AIR QUALITY STANDARDS

Federal and state governments have established ambient air quality standards for criteria air pollutants, including carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), 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 ($PM_{2.5}$), ozone (O_3), and lead (Pb). Ozone is typically not emitted directly from emission sources, but at ground level it is created by a chemical reaction among chemical precursors including oxides of nitrogen (NO_X) and volatile organic compounds (VOC).

The EPA classifies all locations in the United States as either "attainment," "non-attainment," or "maintenance" areas with respect to NAAQS. These classifications are determined by comparing actual monitored air pollutant concentrations to their applicable federal standards. As described in the SJPLC Draft Land Management Plan and Draft Environmental Impact Statement (December 2007), most counties in the Four Corners region are classified as attainment for all pollutants; only a small area around the city of Telluride, Colorado, is a PM_{10} Maintenance Area. Unclassified locations are considered "in attainment."

Through the Clean Air Act Amendments of 1977, Congress established a system for the PSD to protect areas that are not classified as non-attainment (i.e., cleaner than the NAAQS). A "PSD increment" classification system was implemented based on the amounts of additional NO_2, PM_{10}, and SO_2 degradation that would be allowed above legally defined baseline levels for specifically designated areas. A Class I area would have the greatest limitations, where little additional degradation would be allowed. A Class II area would permit moderate deterioration associated with controlled growth. Mandatory federal Class I areas were defined in the 1977 Amendments as existing national parks over 6,000 acres and wilderness areas and memorial parks over 5,000 acres, whereas all other areas not classified as non-attainment were defined as Class II. In addition to more stringent ambient air increments, Class I areas are also protected by the regulation of Air Quality Related Values (AQRVs) by the Federal Land Managers (FLMs) responsible for the areas. Typically, FLMs have focused on two specific AQRVs: visibility, and the deposition of acidic species (e.g., nitrogen and sulfur). The mandatory federal Class I areas closest to the SJPLC leased areas and the approximate distances from the locations where development is likely to occur, are:

- Mesa Verde National Park, Colorado (25 km)
- Weminuche Wilderness Area, Colorado (75 km)

The air quality impact analysis described in this technical support document (TSD) has compared the predicted direct and cumulative air impacts of the Project to all state and federal ambient air quality standards, PSD Class I and II increments, and AQRV criteria presented in

Table 3-1, with the exception of CO emissions. Justification for the omission of CO impacts is further discussed in Section 3.1.1 below.

Table 3-1

Air Quality Standards, Increments, and AQRV Criteria

Pollutant/AQRV	Averaging Interval	NAAQS ($\mu g/m^3$)	Class II PSD Increment ($\mu g/m^3$)	Class I PSD Increment ($\mu g/m^3$)	AQRV Thresholds
NO_2	1-Hour	191.2[3]	--	--	--
	Annual	100	25	2.5	--
SO_2	1-Hour	188[3]			
	3-Hour	1300 (700)[1]	512	25	--
	24-Hour	365	91	5	--
	Annual	80	20	2	--
PM_{10}	24-Hour	150	30	10	--
	Annual	50	17	5	--
$PM_{2.5}$	24-Hour	35	--	--	--
	Annual	15	--	--	--
CO	1-Hour	40,000	--	--	--
	8-Hour	10,000	--	--	--
O_3	8-Hour	150	--	--	--
Pb	Quarterly	--	--		--
Visibility (% change)[2]	24-Hour	--	--	--	5% / 10%
Nitrogen Disposition (kg/ha-yr)	Annual	--	--	--	0.005
Sulfur Deposition (kg/ha-yr)	Annual	--	--	--	0.005

Notes:
[1] The State of Colorado has also established a 3-hour SO_2 ambient air quality standard of 700 $\mu g/m^3$, as well as a program similar to the federal PSD increments limiting additional amounts of SO_2 above baseline conditions.
[2] A change in extinction of 10% or greater is believed to be perceptible to most observers. When the change in extinction is 5% or greater, a source is believed to be contributing to any existing visibility impairment. The change in extinction is measured in comparison to a pristine "natural" background that is not impaired by existing emissions.
[3] The actual standard is 100 ppb for NO_2 and 75 ppb for SO_2. The 1-hour NO_2 standard applies to the 98th percentile on the 8th highest day; additional exceedances on a given day do not count. The 1-hour SO_2 standard applies to the 99th percentile or 4th highest day.

3.1.1 CO Emissions and Impacts

Emissions of CO also occur from the various fuel combustion sources associated with the oil and gas development scenarios described in this TSD; however, CO emissions were not estimated and CO impacts were not quantified in this TSD. This approach is justified as follows:

- CO impacts at or near the National Ambient Air Quality Standards (NAAQS) are most often associated with emissions from vehicle traffic (car and truck exhaust) in densely populated urban areas. This TSD evaluates emissions and associated air quality impacts from potential oil and gas development in rural locations where background concentrations of CO are near zero.

- There are no Class I or Class II increments under the Prevention of Significant Deterioration rules for CO.

- CO emissions are not a precursor to visibility degradation or acid deposition impacts.

The NAAQS for CO is approximately 200 times larger than the comparable short-term NAAQS for other pollutants such as NO_2 and SO_2. For comparison, the 1-hour NAAQS for CO is 40,000 $\mu g/m^3$, while the 1-hour NAAQS for SO_2 and NO_2 are both around 200 $\mu g/m^3$. (See Table 3-1 for the exact NAAQS values.) At most common fuel combustion sources, NO_X and CO emissions are generally the same order of magnitude. Since the allowable NO_2 NAAQS is significantly more stringent than the CO NAAQS, if NO_2 impacts from the proposed emissions are determined to be insignificant, the CO impacts will also be insignificant. This conclusion is valid for CO emissions up to 200 times larger than the corresponding NO_X emissions.

3.2 EMISSION STANDARDS

3.2.1 Standards for Non-Road Diesel Engines

In 1997, EPA promulgated a set of emission standards for non-road diesel engines, except for locomotives, engines used in underground mining applications, and large (rated over 37 kw) marine engines. These standards are listed in 40 CFR Part 89.

The non-road engine emission standards apply to engines manufactured after a certain date. The standards allow for a phase-in depending on the engine size. “Tier 2” standards would apply to smaller engines (50 hp or less) along with larger engines sized 750 hp or greater. “Tier 2” standards are effective for engines built in model years 2004-06 or later (depending on engine size).

Engines in the size range of 50-750 hp would be regulated by “Tier 3” standards, which are effective in model years 2006-08 or later (depending on engine size).

These standards would potentially impact all diesel-fired equipment to be used on the SJPLC lease areas, including equipment such as drilling rigs. Given that development of any new leases on these areas will be many years in the future, it is reasonable to expect that most, if not all, of the non-road diesel engines would be newer equipment subject to the applicable Tier 2 or Tier 3 standards.

3.2.2 Stationary Compression Ignition Engines

A new standard applicable to stationary compression ignition engines was adopted by EPA and promulgated as 40 CFR 60 Subpart IIII. Most stationary diesel-powered engines would be covered by these requirements; however, mobile equipment such as drilling rigs would not be covered by Subpart IIII.

Like Tier 2 and Tier 3 standards discussed above, the emission limits vary by engine size and model year. Also, separate standards are set in Subpart IIII for emergency equipment and fire pump engines. Finally, Subpart III sets diesel fuel standards limiting the sulfur content, octane index, and aromatic content.

The Subpart IIII standards generally apply to model year 2007 and later compression ignition engines with a displacement of less than 30 liters per cylinder. Again, by the time that development occurs in the SJPLC lease areas, most (if not all) of the equipment in use would be newer equipment covered by Subpart IIII.

3.2.3 Stationary Spark Ignition Engines

A new standard applicable to stationary spark ignition engines has been adopted by EPA and promulgated as 40 CFR 60 Subpart JJJJ. Most stationary natural gas-powered equipment, such as compressor engines, would be covered by these requirements.

The Subpart JJJJ requirements vary depending on engine size, fuel used, and date of manufacture. Given that development of the oil and gas resources in the SJPLC lease areas is many years off, the engines in use would be expected to be newer equipment subject to Subpart JJJJ. For natural gas-fired engines, more stringent emission standards go into effect for model years 2010 and 2011 and later.

4.0 EMISSIONS INVENTORY DEVELOPMENT

This section discusses the development of the emissions information used for input to the air quality modeling effort. For the SJPLC project, emissions information was developed based on the projected level of development for each scenario analyzed. For RFD projects and other emissions used for the cumulative modeling assessment, data were extracted from associated modeling studies and reports completed by others. Please refer to the Emissions Inventory Addendum (Appendix A) for additional data on the emissions inventory development.

4.1 PROPOSED ACTION AND SCENARIOS

4.1.1 Development Scenarios

Two of three EIS development scenarios proposed by the SJPLC were modeled for this TSD: Scenario 1 - Maximum Development Scenario, and Scenario 2 - No Action Scenario (No New Leases). Each scenario accounts for different levels of potential well development that might occur if currently unleased federal lands are offered for lease. Definitions and specifics of each scenario are presented below.

Scenario 3 studies a lower level of development: 545 new wells versus the 783 new wells modeled in Scenario 1. Scenario 3 was not modeled explicitly since the impacts under Scenario 3 are bracketed by the range of impacts under Scenarios 1 and 2.

For the modeling, the final year of project development was considered. The modeling is based on a year at or near maximum well development plus the final year of construction and drilling. This approach provides for a worst-case assessment as both operational and construction emissions will occur simultaneously.

4.1.1.1 Development Common to All Scenarios

Drilling is expected to continue on state and private lands and on federal lands that are already leased within the Paradox Basin. It is also probable that infill drilling down to 80-acre spacing will occur within the Northern San Juan Basin within the foreseeable future. This new development is expected to occur independent of any new leasing on SJPLC lands. Table 4-1 shows the projected well numbers associated with these currently planned activities. The new wells listed are common to all scenarios, even the No Action Scenario.

Table 4-1

Wells Projected on Current Federal Leases and on Private/State Lands
Common to Scenarios 1 and 2

	State and Private Land	Forest Service Land	BLM Land	Total Additional Wells
Paradox Conventional	50	25 production 10 drilled/reclaimed	125 production 20 drilled/reclaimed	**230**
Gothic Shale Wells	760	105 production 10 drilled/reclaimed	235 production 25 drilled/reclaimed	**1,135**
			GRAND TOTAL	**1,365**

4.1.1.2 Scenario 1: Maximum Development Scenario

This scenario, as depicted in Table 4-2, assumes:

- The maximum number of wells that could be developed in the Paradox Basin Conventional field if the maximum amount of unleased federal lands is leased.
- The maximum number of wells that could be developed in the Gothic Shale gas field if the maximum amount of currently unleased federal lands is leased .

Table 4-2

Well Numbers for Scenario 1 (Maximum Development Scenario)

	Forest Service Land Unleased	BLM Land Unleased	Total Wells
Paradox Conventional	90 production 18 drilled/reclaimed	30 production 10 drilled/reclaimed	**148**
Gothic Shale Wells	425 production 45 drilled/reclaimed	150 production 15 drilled/reclaimed	**635**
		GRAND TOTAL	**783**

4.1.1.3 Scenario 2: No Action Scenario (No New Leases)

This scenario assumes no new leasing of currently unleased federal lands would occur. No new wells are associated with this scenario; however, this scenario still assumes wells projected on currently leased Federal lands or on State/private lands listed in Table 4-1 would be developed.

4.1.2 Operational Field Equipment and Emissions

Once the development scenarios were identified, the next step was to determine the operative equipment needed along with the associated emissions. A summary of operation emissions for each scenario is presented in Table 4-3. These are long-term operational emission estimates only and do not include construction emissions which are estimated separately (see Section 4.3). Due to the differences in developing the more conventional wells in the Paradox Basin versus the Gothic Shale resource, a unique set of assumptions was developed for each area.

The following assumptions were used for the development of conventional wells in the Paradox Basin:

- One (1) 50 hp well head compressor engine per well.
- A NO_X emission factor of 2 g/hp-hr was used for well head compressor engines.

The Paradox Conventional development will utilize already existing compression and gas processing equipment and no additional compression or processing sites are needed.

The following assumptions were developed for the Gothic Shale wells:

- Grouped wellhead compression, eight (8) wells per compressor unit.
- 269 field compression/gathering stations for the well field at 275 hp each.
- Two (2) centralized compressor stations will be built for the field for all scenarios at 30,000 hp each station. Emission rates for each station (tpy) NO_X 180, CO 200, VOC 50, SO_2 6.0, and PM_{10} 13.0.
- One (1) new compressor station, the Pinto Station (Williams Field Services Company), is in the process of CDPHE permitting and site construction. A second compressor station was assumed to have similar equipment, emissions, and total horsepower. The second centralized compressor facility will be built after one-half of the total wells (1,074 wells) are built and producing.
- The compressor facilities were modeled as point sources. The facilities will run 365 days a year and 24 hours a day.
- No new gas processing plants will be constructed. Gas from the Gothic Shale will be transported and processed at the existing Yellow Jacket Facility in Montezuma County, Colorado, owned by Williams Co.

It should be noted that while SO_2 was modeled, operational emissions of SO_2 for the Gothic Shale and Paradox Conventional projects were considered negligible. Therefore, Table

4-3 does not include SO_2, CO, or VOC emissions. Modeling of CO and VOC was not requested by SJPLC and was not included in the modeling analysis. CO impacts would not be a concern for this project. VOCs are a precursor to ozone, which is of concern, but the atmospheric chemistry associated with VOCs and ozone formation is not adequately simulated in CALPUFF, so it would not be appropriate to model VOCs with CALPUFF.

Table 4-3

Emissions Modeled for Scenarios 1 and 2

Project or Source Type	NO_X Emissions (tons per year)	PM_{10} Emissions (tons per year)	$PM_{2.5}$ Emissions (tons per year)
Scenario 2, Emissions Common to all Scenarios			
Paradox Conventional Wells	197	22.1	7.0
Gothic Shale Wells	387	129.7	46.6
Central Compressor Stations	467	(not included)	(not included)
TOTAL	**1051**	**151.8**	**53.7**
Scenario 1, Additional Emissions added to Scenario 2			
Paradox Conventional Wells	118.2	13.3	4.2
Gothic Shale Wells	202.2	67.8	24.4
TOTAL	**320.4**	**81.1**	**28.6**

4.2 CUMULATIVE EMISSIONS INVENTORY

4.2.1 Other Reasonably Foreseeable Development Original Air Quality Analysis

Table 4-4 lists the final RFD projects considered for the San Juan cumulative analysis, the agency responsible for the analysis of each project, and the approximate location of the potential development. The specifics of each project can be found in Appendix A. Where appropriate, some of the original assumptions were modified for a particular RFD project to more accurately reflect the expected emissions. Examples of adjustments include lower levels of currently anticipated development and/or implementation of emission mitigation strategies.

Most of these RFD projects are oil and gas development projects. As such, their air quality modeling typically included only NO_X, SO_2, and PM emissions from gas-fired well head engines. No PM_{10} emissions are included in the SJPLC cumulative analysis for RFD projects that did not originally evaluate PM_{10} impacts; however, PM_{10} and $PM_{2.5}$ emissions have been estimated for all proposed SJPLC proposed scenarios, as well as for those RFD projects in which PM_{10} emissions were included in their original analysis.

Table 4-4

Reasonably Foreseeable Development Projects
Suggested for Inclusion in the Cumulative Analysis for SJPLC

Project	**Agency**	**Approximate Location**
Northern San Juan Basin Coalbed Methane EIS	Colorado BLM	Southwestern Colorado
Northern San Juan Basin Infill Wells	San Juan Public Lands	Southwestern Colorado
Southern Ute EISs	Southern Ute Indian Tribe	Southwestern Colorado
Southern Ute Programmatic EA	Southern Ute Indian Tribe	Southwestern Colorado
Jicarilla Oil and Gas Leasing EIS (Carson NF)	USDA Forest Service	North-central New Mexico
Farmington Field Office RMP	New Mexico BLM	Northwestern New Mexico
Canyons of the Ancients National Monument RMP	Colorado BLM	Southwestern Colorado
Desert Rock Power Plant	STEAG Power, LLC (private industry) & DINE Power Authority (Navajo Nation enterprise)	Northwestern New Mexico
Monticello RMP	Utah BLM	Southeastern Utah
Moab RMP	Utah BLM	Southeastern Utah
Santa Fe NF Oil & Gas EIS	USDA Forest Service	North-central New Mexico
Price RMP	Utah BLM	Eastern Utah

4.2.2 Existing Sources

Emissions information for existing sources located within the modeling domain were obtained from the air quality regulatory agencies in Colorado, New Mexico, and Utah. According to Steven Peplau of the Arizona Department of Environmental Quality (ADEQ), the entire portion of Arizona within the modeling domain was on tribally-controlled land. Emissions information for all Tribal sources (e.g., Southern Ute Indian Tribe) within the modeling domain came from the ongoing Four Corners Air Quality Task Force Study. All emissions information used for the SJPLC modeling analysis are provided on CD with this report.

Although the majority of emissions sources existing within the modeling domain should be included to provide an appropriate estimate of potential cumulative impacts, practical considerations required that the actual number of sources modeled be reduced to a manageable number. As explained in the Addendum to the Air Quality Protocol for San Juan Public Lands

(Appendix A), ARS limited the number of existing sources included in the modeling by doing the following:

- If the sum of a facility's NO_X, SO_2, and PM_{10} emissions was less than 10 tons per year, its impacts were considered insignificant for the purposes of this cumulative analysis and were not included in the modeling.
- Facilities such as gravel pits, mines, or mineral crushing/processing operations with primarily fugitive or ground-based PM_{10} emissions totaling less than 25 tons per year were considered insignificant for the purposes of this cumulative analysis and were not included in the modeling.
- Where possible, facilities reporting multiple units with identical (or nearly identical) stack parameters were modeled by consolidating emissions from the multiple stacks into a single stack.

Justification for the above approaches to reduce the overall number of sources is as follows:

- Impacts from fugitive and ground-based emissions tend to be localized and their contribution of particulate matter to visibility impacts was insignificant compared to those from NO_X and SO_2.
- Many existing particulate matter sources are also small and low enough to the ground that they were dropped from the cumulative analysis without significantly affecting the results.

Existing inventories included major sources of PM_{10} in large quantities and through high enough stacks that their long-range transport and effects on visibility were of concern. For all combustion emissions, PM_{10} emissions were speciated into components constituting elemental carbon, fine particulate ($PM_{2.5}$), coarse particulate, secondary organics, and SO_4, according to their fuel type (coal, gas, diesel, or wood) and emission control equipment, using the tables recommended by the National Park Service (http://www.nature.nps.gov/air/permits/ect). This accounts for the different effects on visibility caused by each particulate species. $PM_{2.5}$ is a subset of PM_{10}; for the purpose of modeling, all PM_{10} emissions were subdivided into coarse particulate and fine particulate matter, where fine particulate is $PM_{2.5}$. Partitioning is necessary because fine and coarse particles scatter light differently.

4.3 CONSTRUCTION EMISSIONS

The impact of emissions from construction activities is often ignored because construction of individual wells is relatively brief and does not continue into the operational phase of the project. However while it is occurring, the impacts from construction can be substantial, particularly in the vicinity of the construction. It is worthwhile to evaluate the magnitude of construction emissions and, where possible, make a quantitative estimate of their impacts on sensitive receptors within the region; however, CALPUFF estimations may be inappropriate because the impacts from construction activities tend to include a lot of ground-based fugitive emissions which do not disperse very far. Therefore, construction emissions were included in the CALPUFF modeling by apportioning emissions on a per well basis to area sources in the same manner as with the operational emissions for the Paradox Conventional and Gothic Shale wells.

For the Gothic Shale and Paradox Conventional wells, construction for each well is expected to take about 30 days from start to finish, and would occur sequentially rather than concurrently (i.e., one at a time), over a period of about fifteen (15) years. Neither the actual timing of the construction activity at any location nor the chronological sequence of such activities within the overall project can be accurately forecast.

Construction emissions for the Gothic Shale and Paradox Conventional wells can be broken down into three (3) phases:

- Well pad and road construction
- Rig up and down
- Completion and testing

The well pad and road construction phase includes several kinds of activities with associated emissions:

- Fugitive emissions from general construction and wind erosion from disturbed land
- Tailpipe emissions from construction equipment and vehicles
- Fugitive emissions from vehicles delivering construction equipment and materials to/from the site
- Tailpipe emissions associated with these delivery vehicles

The rig up and down construction phase includes:

- Fugitive emissions from truck traffic delivering the drilling rig, mud, cement, etc. to/from the site
- Tailpipe emissions associated with these delivery vehicles
- Emissions from the diesel combustion drilling engines

The completion and testing phase includes:

- Fugitive emissions from haul truck traffic
- Tailpipe emissions from haul truck traffic
- Hydraulic fracturing
- Completion flaring

Construction emissions for the new central compressor station would include emissions from:

- Fugitive emissions from general construction and wind erosion
- Tailpipe emissions from construction equipment and vehicles

4.3.1 Gothic Shale Construction Emissions

Estimated construction emissions for the Gothic Shale wells for Scenarios 1 and 2 are presented below in Table 4-5. Scenario 2 is expected to have 1,100 productive wells, but an additional 35 wells are expected to be drilled but found to be unproductive and reclaimed. Scenario 1 is expected to have all the wells from the No Action Scenario (Scenario 2) plus 575 productive wells and another 60 that would be unproductive and reclaimed. Thus, construction emissions include preparing, drilling, and completing the unproductive wells as well as the ones that would eventually be operational.

Wind erosion due to disturbed land during general construction is the most significant contributor of particulate emissions during construction. The majority of NO_X emissions arise from the completion and testing phase, and the highest SO_2 emissions arise from the diesel drilling engines.

4.3.2 Paradox Convention Construction Emissions

Estimated construction emissions for the Paradox Conventional wells for Scenarios 1 and 2 are presented below in Table 4-6. Scenario 2 is expected to have 200 productive wells, but an additional 30 wells are expected to be drilled but found to be unproductive and reclaimed. Scenario 1 is expected to have 120 additional productive wells, plus another 28 that would be unproductive and reclaimed. Thus, construction emissions include preparing, drilling, and completing the unproductive wells as well as the ones that would eventually be operational.

Construction emissions from the Paradox Conventional wells are much lower than those from the Gothic Shale wells, both on a per-well basis, as well as in total. This is because substantially fewer wells Paradox Conventional wells are planned, but also because drilling and fracturing horsepower is much less.

Table 4-5

Construction Emissions for Gothic Shale Wells

Activity	Emissions per well	Total for Scenario 2 (1135 wells)	Additional for Scenario 1 (635 wells)	Total Emissions for Scenario 1 (1770 wells)
Well pad & Road Construction				
Gen const & wind erosion	1217 lbs PM_{10}	691 tons PM_{10}	386 tons PM_{10}	1077 tons PM_{10}
	121.7 lbs $PM_{2.5}$	69.1 tons $PM_{2.5}$	38.6 tons $PM_{2.5}$	108 tons $PM_{2.5}$
Const vehicles - tailpipe	70.2 lbs CO	39.8 tons CO	22.3 tons CO	62.1 tons CO
	222 lbs NO_X	126 tons NO_X	70.4 tons NO_X	196 tons NO_X
	21.8 lbs SO_2	12.4 tons SO_2	6.91 tons SO_2	19.3 tons SO_2
	18.1 lbs PM_{10}	10.3 tons PM_{10}	5.74 tons PM_{10}	16.0 tons PM_{10}
	18.1 lbs $PM_{2.5}$	10.3 tons $PM_{2.5}$	5.74 tons $PM_{2.5}$	16.0 tons $PM_{2.5}$
	8.14 lbs VOCs	4.62 tons VOCs	2.59 tons VOCs	7.21 tons VOCs
Delivery vehicles - fugitives	555 lbs PM_{10}	315 tons PM_{10}	176 tons PM_{10}	492 tons PM_{10}
	85.0 lbs $PM_{2.5}$	48.2 tons $PM_{2.5}$	27.0 tons $PM_{2.5}$	75.2 tons $PM_{2.5}$
Delivery Vehicles - Tailpipe	87.7 lbs CO	49.8 tons CO	27.9 tons CO	77.6 tons CO
	68.1 lbs NO_X	38.6 tons NO_X	21.6 tons NO_X	60.3 tons NO_X
	1.89 lbs SO_2	1.07 tons SO_2	0.600 tons SO_2	1.67 tons SO_2
	33.9 lbs VOCs	19.2 tons VOCs	10.8 tons VOCs	30.0 tons VOCs
Total	158 lbs CO	89.6 tons CO	50.1 tons CO	140 tons CO
Well Pad & Road	290 lbs NO_X	164 tons NO_X	92.0 tons NO_X	256 tons NO_X
Construction	23.7 lbs SO_2	13.4 tons SO_2	7.51 tons SO_2	20.9 tons SO_2
	1772 lbs PM_{10}	1006 tons PM_{10}	563 tons PM_{10}	1569 tons PM_{10}
	140 lbs $PM_{2.5}$	79.3 tons $PM_{2.5}$	44.4 tons $PM_{2.5}$	124 tons $PM_{2.5}$
	42.0 lbs VOCs	23.8 tons VOCs	13.3 tons VOCs	37.2 tons VOCs
Rig Up & Down				
Delivery vehicles - fugitives	192.5 lbs PM_{10}	109 tons PM_{10}	61.1 tons PM_{10}	170 tons PM_{10}
	18.3 lbs $PM_{2.5}$	10.4 tons $PM_{2.5}$	5.80 tons $PM_{2.5}$	16.2 tons $PM_{2.5}$
Delivery Vehicles - Tailpipe	88.7 lbs CO	50.3 tons CO	28.2 tons CO	78.5 tons CO
	68.9 lbs NO_X	39.1 tons NO_X	21.9 tons NO_X	60.9 tons NO_X
	1.91 lbs SO_2	1.08 tons SO_2	0.607 tons SO_2	1.69 tons SO_2
	34.2 lbs VOCs	19.4 tons VOCs	10.9 tons VOCs	30.3 tons VOCs
Diesel drilling engines	1341 lbs CO	761 tons CO	426 tons CO	1187 tons CO
	671 lbs NO_X	381 tons NO_X	213 tons NO_X	594 tons NO_X
	624 lbs SO_2	354 tons SO_2	198 tons SO_2	552 tons SO_2
	669 lbs PM_{10}	380 tons PM_{10}	212 tons PM_{10}	592 tons PM_{10}
	669 lbs $PM_{2.5}$	380 tons $PM_{2.5}$	212 tons $PM_{2.5}$	592 tons $PM_{2.5}$
	469 lbs VOCs	266 tons VOCs	149 tons VOCs	415 tons VOCs
Total	1430 lbs CO	812 tons CO	454 tons CO	1266 tons CO
Rig Up & Down	739 lbs NO_X	420 tons NO_X	235 tons NO_X	654 tons NO_X
	626 lbs SO_2	355 tons SO_2	199 tons SO_2	554 tons SO_2
	862 lbs PM_{10}	489 tons PM_{10}	274 tons PM_{10}	763 tons PM_{10}
	688 lbs $PM_{2.5}$	390 tons $PM_{2.5}$	218 tons $PM_{2.5}$	608 tons $PM_{2.5}$
	504 lbs VOCs	286 tons VOCs	160 tons VOCs	446 tons VOCs

[1] Based on one (1) 1,500 hp drilling engine.

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Table 4-5 (continued)

Construction Emissions for Gothic Shale Wells

Activity	Emissions per well	Total for Scenario 2 (1135 wells)	Additional for Scenario 1 (635 wells)	Total Emissions for Scenario 1 (1770 wells)
Completion & Testing				
Fracturing Engines	201 lbs CO	114 tons CO	63.9 tons CO	178.1 tons CO
	101 lbs NO_X	57.1 tons NO_X	31.9 tons NO_X	89.0 tons NO_X
	93.5 lbs SO_2	53.1 tons SO_2	29.7 tons SO_2	82.8 tons SO_2
	100 lbs PM_{10}	57.0 tons PM_{10}	31.9 tons PM_{10}	88.8 tons PM_{10}
	100 lbs $PM_{2.5}$	57.0 tons $PM_{2.5}$	31.9 tons $PM_{2.5}$	88.8 tons $PM_{2.5}$
	70.4 lbs VOCs	40.0 tons VOCs	22.4 tons VOCs	62.3 tons VOCs
Haul Truck Traffic - Fugitive	54.6 lbs PM_{10}	31.0 tons PM_{10}	17.3 tons PM_{10}	48.3 tons PM_{10}
	8.12 lbs $PM_{2.5}$	4.61 tons $PM_{2.5}$	2.58 tons $PM_{2.5}$	7.19 tons $PM_{2.5}$
Haul Truck Traffic - Tailpipe	1301 lbs CO	739 tons CO	413 tons CO	1152 tons CO
	1010 lbs NO_X	573 tons NO_X	321 tons NO_X	894 tons NO_X
	28.0 lbs SO_2	15.9 tons SO_2	8.90 tons SO_2	24.8 tons SO_2
	502 lbs VOCs	285 tons VOCs	160 tons VOCs	445 tons VOCs
Total Completion & Testing	1503 lbs CO	853 tons CO	477 tons CO	1330 tons CO
	1111 lbs NO_X	630 tons NO_X	353 tons NO_X	983 tons NO_X
	122 lbs SO2	69.0 tons SO_2	38.6 tons SO_2	108 tons SO_2
	155 lbs PM_{10}	88.0 tons PM_{10}	49.2 tons PM_{10}	137 tons PM_{10}
	109 lbs $PM_{2.5}$	61.6 tons $PM_{2.5}$	34.5 tons $PM_{2.5}$	96.0 tons $PM_{2.5}$
	573 lbs VOCs	325 tons VOCs	182 tons VOCs	507 tons VOCs
TOTAL All Gothic Shale Well Construction Sources	**3091 lbs CO**	**1754 tons CO**	**981 tons CO**	**2735 tons CO**
	2140 lbs NO_X	**1214 tons NO_X**	**679 tons NO_X**	**1894 tons NO_X**
	771 lbs SO_2	**437 tons SO_2**	**245 tons SO_2**	**682 tons SO_2**
	2789 lbs PM_{10}	**1583 tons PM_{10}**	**886 tons PM_{10}**	**2468 tons PM_{10}**
	936 lbs $PM_{2.5}$	**531 tons $PM_{2.5}$**	**297 tons $PM_{2.5}$**	**828 tons $PM_{2.5}$**
	1119 lbs VOCs	**635 tons VOCs**	**355 tons VOCs**	**990 tons VOCs**

Table 4-6

Construction Emissions for Paradox Conventional Wells

Activity	**Emissions per well**	**Total for Scenario 2 (230 wells)**	**Additional for Scenario 1 (148 wells)**	**Total Emissions for Scenario 1 (378 wells)**
Well pad & Road Construction				
Gen const & wind erosion	1217 lbs PM_{10}	140 tons PM_{10}	90.1 tons PM_{10}	230 tons PM_{10}
	122 lbs $PM_{2.5}$	14.0 tons $PM_{2.5}$	9.01 tons $PM_{2.5}$	23.0 tons $PM_{2.5}$
Const vehicles - tailpipe	70.2 lbs CO	8.07 tons CO	5.19 tons CO	13.3 tons CO
	222 lbs NO_X	25.5 tons NO_X	16.4 tons NO_X	41.9 tons NO_X
	21.8 lbs SO_2	2.50 tons SO_2	1.61 tons SO_2	4.12 tons SO_2
	18.1 lbs PM_{10}	2.08 tons PM_{10}	1.34 tons PM_{10}	3.42 tons PM_{10}
	18.1 lbs $PM_{2.5}$	2.08 tons $PM_{2.5}$	1.34 tons $PM_{2.5}$	3.42 tons $PM_{2.5}$
	8.14 lbs VOCs	0.936 tons VOCs	0.603 tons VOCs	1.54 tons VOCs
Delivery vehicles - fugitives	555 lbs PM_{10}	63.9 tons PM_{10}	41.1 tons PM_{10}	105 tons PM_{10}
	85.0 lbs $PM_{2.5}$	9.77 tons $PM_{2.5}$	6.29 tons $PM_{2.5}$	16.1 tons $PM_{2.5}$
Delivery Vehicles - Tailpipe	87.7 lbs CO	10.1 tons CO	6.49 tons CO	16.6 tons CO
	68.1 lbs NO_X	7.83 tons NOx	5.04 tons NOx	12.9 tons NOx
	1.89 lbs SO_2	0.217 tons SO_2	0.140 tons SO_2	0.357 tons SO_2
	33.9 lbs VOCs	3.89 tons VOCs	2.51 tons VOCs	6.40 tons VOCs
Total	158 lbs CO	18.2 tons CO	11.7 tons CO	29.8 tons CO
Well Pad & Road	290 lbs NO_X	33.3 tons NO_X	21.4 tons NO_X	54.8 tons NO_X
Construction	23.7 lbs SO_2	2.72 tons SO_2	1.75 tons SO_2	4 tons SO_2
	1235 lbs PM_{10}	142 tons PM_{10}	91.4 tons PM_{10}	233 tons PM_{10}
	140 lbs PM2.5	16.1 tons $PM_{2.5}$	10.3 tons $PM_{2.5}$	26 tons $PM_{2.5}$
	42.0 lbs VOCs	4.83 ton VOCs	3.11 tons VOCs	8 tons VOCs
Rig Up & Down				
Delivery vehicles - fugitives	373 lbs PM_{10}	43 tons PM_{10}	28 tons PM_{10}	70 tons PM_{10}
	57.2 lbs $PM_{2.5}$	6.58 tons $PM_{2.5}$	4.23 tons $PM_{2.5}$	10.8 tons $PM_{2.5}$
Delivery Vehicles - Tailpipe	93.6 lbs CO	10.8 tons CO	6.93 tons CO	17.7 tons CO
	72.6 lbs NO_X	8.35 tons NOx	5.37 tons NOx	13.7 tons NOx
	2.02 lbs SO_2	0.232 tons SO_2	0.149 tons SO_2	0.381 tons SO_2
	36.1 lbs VOCs	4.15 tons VOCs	2.67 tons VOCs	6.83 tons VOCs
Diesel drilling engines	1341 lbs CO	154 tons CO	99.3 tons CO	254 tons CO
	671 lbs NO_X	77.1 tons NO_X	49.6 tons NO_X	127 tons NO_X
	624 lbs SO_2	71.7 tons SO_2	46.1 tons SO_2	118 tons SO_2
	669 lbs PM_{10}	77.0 tons PM_{10}	49.5 tons PM_{10}	126 tons PM_{10}
	669 lbs $PM_{2.5}$	77.0 tons $PM_{2.5}$	49.5 tons $PM_{2.5}$	126 tons $PM_{2.5}$
	469 lbs VOCs	54.0 tons VOCs	34.7 tons VOCs	88.7 tons VOCs
Total	1435 lbs CO	165 tons CO	106 tons CO	271 tons CO
Rig Up & Down	743 lbs NO_X	85.5 tons NO_X	55.0 tons NO_X	140 tons NO_X
	626 lbs SO_2	71.9 tons SO_2	46.3 tons SO_2	118 tons SO_2
	1042 lbs PM_{10}	120 tons PM_{10}	77 tons PM_{10}	197 tons PM_{10}
	726 lbs $PM_{2.5}$	83.5 tons $PM_{2.5}$	53.8 tons $PM_{2.5}$	137 tons $PM_{2.5}$
	506 lbs VOCs	58.1 tons VOCs	37.4 tons VOCs	95.6 tons VOCs

[1] Based on one (1) 1,500 hp drilling engine.

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Table 4-6 (continued)

Construction Emissions for Paradox Conventional Wells

Activity	Emissions per well	Total for Scenario 2 (230 wells)	Additional for Scenario 1 (148 wells)	Total Emissions for Scenario 1 (378 wells)
Completion & Testing				
Fracturing Engines	41.9 lbs CO	4.82 tons CO	3.10 tons CO	7.92 tons CO
	21.0 lbs NO_X	2.41 tons NO_X	1.55 tons NO_X	3.96 tons NO_X
	19.5 lbs SO_2	2.24 tons SO_2	1.44 tons SO_2	3.68 tons SO_2
	20.9 lbs PM_{10}	2.41 tons PM_{10}	1.55 tons PM_{10}	3.95 tons PM_{10}
	20.9 lbs $PM_{2.5}$	2.41 tons $PM_{2.5}$	1.55 tons $PM_{2.5}$	3.95 tons $PM_{2.5}$
	14.7 lbs VOCs	1.69 tons VOCs	1.09 tons VOCs	2.77 tons VOCs
Haul Truck Traffic - Fugitives	131.3 lbs PM_{10}	15.1 tons PM_{10}	9.71 tons PM_{10}	24.8 tons PM_{10}
	19.88 lbs $PM_{2.5}$	2.29 tons $PM_{2.5}$	1.47 tons $PM_{2.5}$	3.76 tons $PM_{2.5}$
Haul Truck Traffic - Tailpipe	47.8 lbs CO	5.49 tons CO	3.53 tons CO	9.03 tons CO
	37.1 lbs NO_X	4.26 tons NO_X	2.74 tons NO_X	7.01 tons NO_X
	1.03 lbs SO_2	0.118 tons SO_2	0.0762 tons SO_2	0.195 tons SO_2
	18.4 lbs VOCs	2.12 tons VOCs	1.36 tons VOCs	3.49 tons VOCs
Total	89.7 lbs CO	10.3 tons CO	6.64 tons CO	17.0 tons CO
Completion & Testing	58.0 lbs NO_X	6.67 tons NO_X	4.29 tons NO_X	11.0 tons NO_X
	20.5 lbs SO_2	2.36 tons SO_2	1.52 tons SO_2	3.88 tons SO_2
	152 lbs PM_{10}	17.5 tons PM_{10}	11.3 tons PM_{10}	28.8 tons PM_{10}
	40.8 lbs $PM_{2.5}$	4.69 tons $PM_{2.5}$	3.02 tons $PM_{2.5}$	7.71 tons $PM_{2.5}$
	33 lbs VOCs	3.8 tons VOCs	2.5 tons VOCs	6.3 tons VOCs
TOTAL	**1682 lbs CO**	**193 tons CO**	**124 tons CO**	**318 tons CO**
All Gothic Shale Well	**1091 lbs NO_X**	**125 tons NO_X**	**80.7 tons NO_X**	**206 tons NO_X**
Construction Sources	**670 lbs SO_2**	**77.0 tons SO_2**	**49.6 tons SO_2**	**127 tons SO_2**
	2430 lbs PM_{10}	**279 tons PM_{10}**	**180 tons PM_{10}**	**459 tons PM_{10}**
	907 lbs $PM_{2.5}$	**104 tons $PM_{2.5}$**	**67.1 tons $PM_{2.5}$**	**171 tons $PM_{2.5}$**
	581 lbs VOCs	**66.8 tons VOCs**	**43.0 tons VOCs**	**110 tons VOCs**

5.0 EXISTING ENVIRONMENT

The existing environment for air quality is defined by ambient air quality measurements. Because air quality measurements have not been taken from within the proposed leasing areas, nearby representative data from other monitoring locations have been used.

5.1 AIR QUALITY DATA

Table 5-1 summarizes the existing air quality data in southwestern Colorado and northwestern New Mexico for selected air pollutants. Background data were conservatively selected from the monitoring station with the highest concentrations during the "reporting period" (BLM 2007). Data have been taken from air quality measurement stations in La Plata, Colorado; Ignacio, Colorado; Farmington, New Mexico; and Mesa Verde National Park, Colorado.

Table 5-1

Background Air Quality Data

Pollutant (Units of Measurement)	Measured Ambient Concentrations ($\mu g/m^3$)	Monitoring Station
NO_2 – Annual Concentration	17	La Plata, CO
SO_2 – Annual Concentration	5.3	Farmington, NM
SO_2 – 24-hr Highest 2nd High Concentration	21	Farmington, NM
SO_2 – 3-hr Highest 2nd High Concentration	69	Farmington, NM
CO – 8-hr Highest 2nd High Concentration	1864	Ignacio, CO
CO – 1-hr Highest 2nd High Concentration	2330	Ignacio, CO
PM_{10} – Annual Concentration	21	La Plata, CO
PM_{10} – 24-hr Highest 2nd High Concentration	64	La Plata, CO
$PM_{2.5}$ – Annual Concentration	6.9	Farmington, NM
$PM_{2.5}$ – 24-hr Highest 2nd High Concentration	22.5	Mesa Verde NP, CO
O_3 – 8-hr Highest 2nd Concentration	142	Mesa Verde NP, CO
O_3 – 1-hr Highest 2nd Concentration	154	Mesa Verde NP, CO

In general, the ambient air measurements show that existing air quality in the project area is generally good (see Table 3-1 for NAAQS standards). Concentrations for the various air pollutants are well below the applicable state and federal ambient air quality standards. One exception would be for ozone (O_3), where the existing air quality concentrations are approaching the ambient 8-hour air quality standard of 150 $\mu g/m^3$ (75 ppb for an 8-hour average). Ozone is not emitted directly from sources, but instead is formed through photochemical conversions in the atmosphere from other precursor pollutants, primarily VOCs and NO_X.

5.2 AIR QUALITY RELATED VALUES

AQRVs include air quality effects such as acid deposition and visibility. AQRVs are generally important at sensitive airsheds, such as national parks.

Table 5-2 summarizes the background acid deposition estimates for Mesa Verde National Park, which is assumed to be representative of the project area as a whole. This annual average value is a sum of wet and dry deposition estimates based on background data presented in the December 2007 SJPLC Air Quality Assessment (BLM 2007).

Table 5-2

Background Acid Deposition Data

AQRV (Units of Measurement)	Background Deposition	Monitoring Station
Nitrogen Deposition (kg/ha-yr)	2.3	Mesa Verde
Sulfur Deposition (kg/ha-yr)	1.2	Mesa Verde

Existing visibility measurements from the Interagency Monitoring of Protected Visual Environments (IMPROVE) Monitoring Program are shown in Figures 5-1 and 5-2. Data are shown for six (6) Class I areas in the modeling domain where IMPROVE measurements have been collected: Mesa Verde National Park (MEVE1), Bandelier National Monument (BAND1), Canyonlands National Park (CANY1), San Pedro Parks Wilderness (SAPE1), Weminuche Wilderness (WEMI1), and White River National Forest (WHRI1).

The unit of measurement for visibility is extinction in Mm^{-1}. Higher values of extinction infer poorer visibility. The data in Figures 5-1 and 5-2 represent visibility conditions at each area over the period 2000 through 2006 (7 years total). Figure 5-1 depicts the average visibility as measured by extinction for each Class I area over the monitoring period. The extinction values range from about 24 Mm^{-1} at Bandelier to 17 Mm^{-1} at White River. Figure 5-2 depicts the average of the 20% worst visibility days at each Class I area over the monitoring period. The extinction values for the 20% worst days averages about 38 Mm^{-1} at Mesa Verde and Bandelier to about 23 Mm^{-1} at White River.

Visibility impacts are generally assessed in terms of the “natural background” visibility, which represents the expected visibility in the absence of anthropogenic emission sources. Using the “natural background” aerosol concentrations recommended by FLAG, the natural background visibility at Class I areas in the western United States is generally in the range of 16 to 18 Mm^{-1}. Therefore, using the data in Figure 5-2, the worst-case 20% extinction days at the Class I areas of interest have measured change in extinction values that range between 30% at White River to 123% at Mesa Verde and Bandelier.

Also depicted on Figures 5-1 and 5-2 is the extinction separated by the important chemical species. The biggest difference between monitoring sites appears to be the organic mass by carbon (OMC) component of the aerosol mass. Organic carbon on the IMROVE filter is often an indicator of fire emissions. So, those sites with poorest visibility (Mesa Verde and Bandelier) appear to have been impacted by fire emissions compared to other sites in the region.

The background visibility data shown here can also be used to provide a rough check of the modeling results, at least for scenarios that include modeling of already existing emission sources. The CALPUFF model returns a total extinction value (in Mm^{-1}) which can be compared to the IMPROVE measurements to provide a general assessment of model performance.

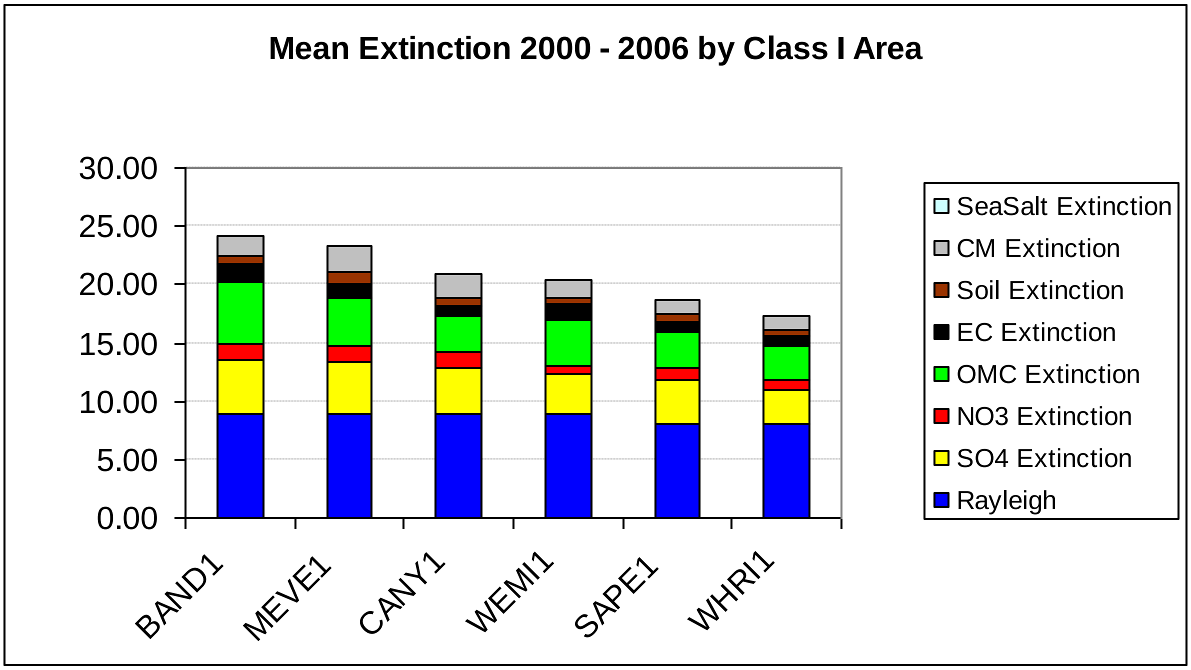


Figure 5-1. Mean Extinction 2000 - 2006 by Class I Area.

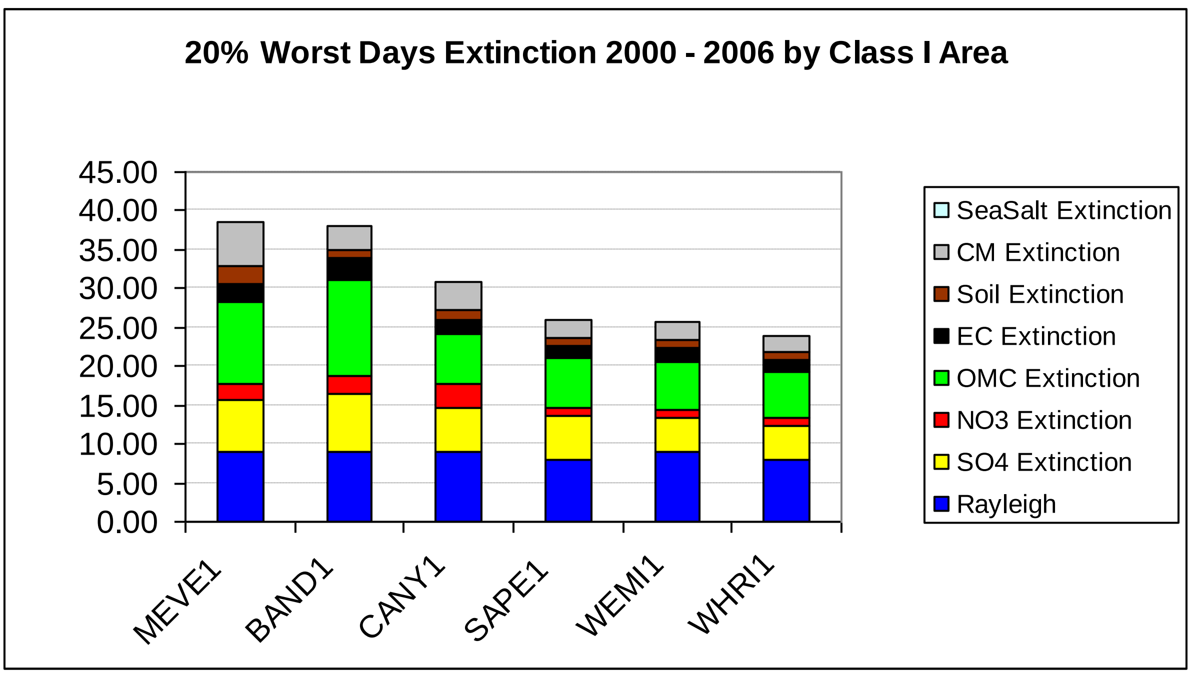


Figure 5-2. 20% Worst Days Extinction 2000 - 2006 by Class I Area.

6.0 AIR QUALITY MODELING

This section provides a brief overview of the technical procedures used to conduct the SJPLC air quality modeling analysis. Additional detail about the modeling procedures can be found in the Air Quality Modeling Protocol (Appendix D).

The air quality modeling for SJPLC used the EPA CALPUFF modeling system, applying gridded meteorological fields that varied both spatially and temporally. Current EPA-approved versions of the CALPUFF modeling system were used:

- CALMET Version 5.8 (level 070623)
- CALPUFF Version 5.8 (level 070623)
- CALPOST Version 5.6394 (level 070622)

CALMET generates the gridded meteorological data fields for later use by CALPUFF. CALPUFF performs the concentration calculations. CALPOST averages and ranks the concentration data and performs the visibility calculations.

6.1 METEOROLOGICAL DATA

The meteorological data input to CALMET included three (3) years of mesoscale meteorological (MM5) data, consisting of 2001-2003 hourly meteorological data obtained from the Western Regional Air Partnership (WRAP) Regional Modeling Center (Riverside, California).

No upper-air stations fell within the modeling domain, therefore upper-air observations were omitted from the CALMET analysis. Surface and precipitation data within the modeling domain for 2001-2003 were the same as those used for the Desert Rock Power Plant's PSD permit application. Surface wind observations were used to adjust the model's meteorological data and terrain-derived winds. Precipitation observations were used to generate gridded hourly precipitation fields for use in the wet/dry deposition calculations.

6.2 MODELING DOMAIN AND RECEPTORS

The CALPUFF modeling grid system extended approximately 50 kilometers between the edge of the domain and any emission source and/or any receptor of interest. The final modeling domain covers a region of over 600 km (east-west) by 450 km (north-south) with a 4 km grid element size and eleven (11) vertical levels. The southwest corner of the grid is located at approximately 35.262° N latitude and 110.835° W longitude.

The receptors used in the CALPUFF analysis included designated Class I, and Class II areas of concern. Figure 6-1 shows the receptor grid pattern within the modeling domain. Receptor grid coordinates for Class I areas modeled were obtained from the NPS Convert Class I Areas utility (NPS Convert Class I Areas MDAC v2.6). Receptors were placed in the Weminuche Wilderness Class I area at selected high mountain lakes (Big Eldorado Lake, Lower Sunlight Lake, Upper Grizzly Lake, and Upper Sunlight Lake) for the evaluation of acid deposition. All other receptors were set for an 8 km fine grid over the SJPLC leasing area and a 24 km coarse grid over the remainder of the modeling domain.

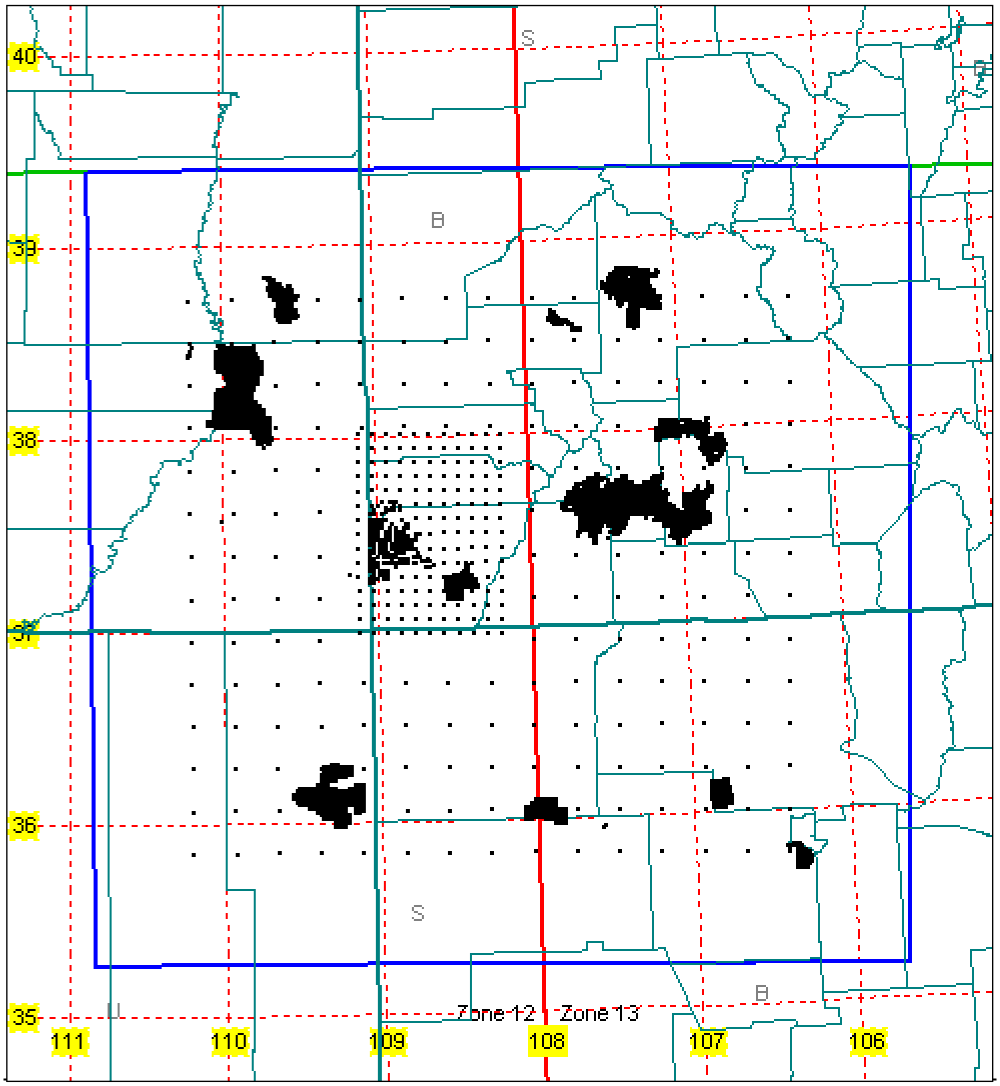


Figure 6-1. SJPLC Modeling Domain and Model Receptor Grids.

6.3 CALPUFF AND CALPOST

CALPUFF model input files were set up for each year of CALMET meteorological data. Inputs to the CALPUFF modeling system included three (3) years of gridded CALMET data (see Section 6.1), project emission rates, source locations, receptor locations, land elevation data, and land use data. Due to the large number of sources, the CALPUFF analysis was split into multiple runs. Outputs from these runs were then combined via CALPOST and other post-processors to evaluate impacts at each of the various receptor sets.

RFD sources were modeled separately from existing sources. Each of the two (2) development scenarios (Scenarios 1 and 2) were also modeled separately. Construction emissions for both scenarios were also modeled separately. The total impact of each scenario was then summed with the existing and RFD sources to yield the potential total impact. Since all known emission sources in the domain were explicitly included in the modeling, an additional background is not necessary (or would be expected to be small). A summary of the model parameters used are detailed in Appendix B.

Technical options for CALPUFF generally followed EPA's Guidelines on Air Quality Models (40 CFR 51, Appendix W) and the Interagency Workshop on Air Quality Modeling (IWAQM) Phase 2 guidance. ARS used FLM-approved "default" parameters where available, such as the "regulatory default" switch (MREG = 1).

Of primary concern were cumulative air quality impacts for concentrations of NO_X, PM_{10}, $PM_{2.5}$, and SO_2 compared to NAAQS. Deposition and visibility impacts were also evaluated. Due to the complexity of the ozone formation at ground-level, ozone impacts were not estimated for the SJPLC modeling analysis.[1]

6.3.1 Concentrations

CALPOST was used to process ambient concentration files for pollutants of interest (NO_X, PM_{10}, $PM_{2.5}$, and SO_2) by performing the appropriate averaging for the air quality standard of interest (1-hour, 3-hour, 24-hour, or annual).

Although this study does not constitute a formal PSD increment analysis, impacts from the proposed sources were compared to PSD increment levels for Class I and Class II areas where appropriate. The modeled emission inventory was not developed for a PSD analysis. For example, many older emission sources that are part of the PSD "baseline" were modeled in order to provide a comprehensive cumulative impact assessment. These older sources which were included in the modeling described here do not consume PSD increment.

6.3.2 Visibility

Visibility calculations were performed in the CALPOST processor using modeled concentrations of the visibility precursor pollutants with appropriate relative humidity data. CALPOST determines the percent change in extinction attributable to the project emissions as compared to a user-specified background extinction. For this modeling study, the standard FLAG "natural background" values for the western United States were used.

The extinction from hygroscopic particles (sulfate and nitrate) is dependent on relative humidity. Two (2) sets of relative humidity data were used in post-processing for SJPLC modeling; Method 2 and Method 6.

[1] Background ozone concentrations were input into CALPUFF, based on ozone observations collected at local ozone monitoring sites. See the SJPLC Modeling Protocol document for more information (Appendix D).

- Method 2 is the currently recommended method from FLAG for a CALPUFF visibility analysis. Method 2 uses the daily relative humidity information calculated by CALMET. For this method the relative humidity in CALPOST is capped (RHMAX = 95%) consistent with current FLM recommendations.

- Method 6 computes extinction from speciated PM measurements, applying monthly relative humidity adjustment factors (provided in EPA's "*Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Program*"). Method 6 has been used in evaluating sources under EPA's Best Available Retrofit Technology (BART) program. Method 6 is also consistent with proposed changes to the FLAG modeling guidance proposed by Federal Land Managers in 2008 (FLAG Phase I Report—REVISED, 2008).

Employing both methods will allow results to be compared to previous studies that used Method 2, as well as to any future studies that use Method 6, should the new FLAG guidance be adopted. Method 6 also counters some of the past criticisms leveled at Method 2 that worst-case impacts associated with high relative humidity values may have occurred at times when natural obscuration of visibility by clouds and/or precipitations may have been present.

CALPOST outputs the predicted change in light extinction for each 24-hour day. These results were reviewed to determine the number of days where the change in light extinction was at or above 5% and 10% (compared to "natural background" conditions) for each Class I or Class II area modeled. Impacts are also discussed in the context of current visibility conditions at the IMPROVE visibility monitoring sites within the modeling domain (Section 7.0).

6.3.3 Background Ammonia

The Interagency Workgroup on Air Quality Modeling[2] (IWAQM, 1998) recommends three ammonia background values for CALPUFF modeling:

- 0.5 ppb for forested lands
- 1.0 ppb for arid lands
- 10 ppb for grasslands

The SJPLC modeling domain is generally a mixture of "arid" and "forested" land use, suggesting that the background ammonia across the modeling domain should be in the range of 0.5 to 1.0 ppb, if the IWAQM Phase II values are to be used. In the CALPUFF model, higher background ammonia levels generally lead to higher ammonium nitrate concentrations in the model predictions. This in turn can result in higher visibility impacts (i.e., greater visibility degradation).

[2] Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report and Recommendations for Modeling Long Range Transport Impacts. IWAQM, 1998. EPA-454/R-98-019, December 1998.

ARS used a reasonable, yet conservative, monthly background ammonia level of 1.0 ppb. This level matches the IWAQM recommendations and generally fits the mean of five (5) ammonia monitoring stations in the modeling domain, 0.76 ppb (Sather et. al. 2008).

6.3.4 Deposition

Total sulfur and nitrogen deposition Class I and Class II areas of concern was also determined using CALPUFF. First, annual wet and dry deposition rates were calculated for all relevant species. CALPOST was then used to calculate the total deposition in kilograms (kg) per hectare (ha) per year (yr) for each modeling year. Impacts from the proposed scenarios were compared to the appropriate deposition threshold.

7.0 AIR QUALITY MODELING RESULTS

This section summarizes the results of air quality modeling analysis. These results are listed for both the *incremental impacts*, which are the changes brought about by the new project(s) alone, and the *cumulative impacts*, which are the summed total of all the impacts from existing sources, other proposed sources and the project(s) in question.

For each scenario, the emissions inventory represents the last year of project development where operational emissions are near their maximum, but well site development is also continuing. As such, the operational and construction emissions described in Section 4.0 would be occurring simultaneously. Both operational and construction emissions were included in the modeling.

For each scenario, air quality impacts for concentrations of NO_X, PM_{10}, $PM_{2.5}$, and SO_2 estimated from CALPUFF modeling are compared to NAAQS, presented below in Table 7-1. Where pertinent, impacts may be compared to the PSD increments, but these comparisons are for disclosure purposes only and do not constitute a regulatory or permitting PSD analysis. When sources go through the air construction permitting process, additional modeling may be required and overseen by the CDPHE, Air Pollution Control Division (APCD), who would advise the applicant on how to evaluate PSD increment, if required.

Table 7-1

National Ambient Air Quality Standards for NO_X, PM_{10}, $PM_{2.5}$, and SO_2[1]

Pollutant	Averaging Time	Concentration (μg/m^3)
Nitrogen Dioxide (NO_2)	Annual	100
	1-Hour	191.2[2]
PM_{10}	Annual	50
	24-Hour	150
$PM_{2.5}$	Annual	15
	24-Hour	35
Sulfur Dioxide (SO_2)	Annual	80
	24-Hour	365
	3-Hour	1300
	1-Hour	188

[1]National standards, other than those based on annual averages, are not to be exceeded more than once a year (except where noted).
[2] The 1-hour standards for NO_2 and SO_2 are approximate. The actual standard is 100 ppb for NO_2 and 75 ppb for SO_2.

Deposition at the Class I and Class II areas of concern is assessed through an analysis of total sulfur (S) and total nitrogen (N) deposition. Annual deposition rates (wet and dry) are first calculated by CALPUFF for all relevant species. Total deposition (i.e., both wet and dry) is summed for each modeling year. Impacts from the proposed scenarios are then compared to the FLM deposition threshold of 0.005 kg/ha-yr. This threshold applies to the incremental impacts, which are from the project only. Although cumulative deposition impacts are presented in the discussions below, an appropriate threshold for cumulative impacts has not been determined. Cumulative deposition impacts are included for informational purposes only, to give land managers a general idea of how much the incremental impacts compare to what is already occurring.

Visibility impacts are presented for each scenario, both in terms of their incremental impacts and their cumulative impacts. Incremental visibility impacts represent impacts from each scenario by itself. The incremental visibility impacts for Scenario 1 include those from the proposed development of 783 wells on currently unleased federal lands. The incremental visibility impacts for Scenario 2 include those from a potential 1,365 wells on currently leased state and private lands. An additional visibility analysis was performed to evaluate the combined incremental impacts from all 2,148 wells. Cumulative visibility impacts represent the degree to which all the modeled sources, existing as well as proposed, degrade visibility as compared to a totally pristine, undeveloped state. Where possible, cumulative visibility impacts are also compared to existing measurements in order to assess whether the model accurately reproduces measured conditions.

7.1 SCENARIO 1: MAXIMUM DEVELOPMENT SCENARIO

7.1.1 Concentrations

This section presents the incremental and cumulative air quality impacts for Scenario 1, which represents the maximum development scenario. The incremental impacts described in this section are those associated with new oil and gas wells on lands being evaluated for leasing under this EIS. Scenario 1 incremental impacts represent the Gothic Shale wells and Paradox Conventional wells on the unleased land only, or the difference between Scenario 1 and Scenario 2.

Unless otherwise noted, modeled concentrations for cumulative impacts represent the contributions from:

- Proposed Gothic Shale and Paradox Conventional wells on currently unleased San Juan Public Lands (including construction-related emissions)
- Gothic Shale and Paradox Conventional wells on already leased land (including construction-related emissions)
- Existing sources in Colorado, Utah, New Mexico, and Arizona
- Other RFD projects (Canyons of the Ancients, Desert Rock, Farmington Field Office RMP, Jicarilla Oil & Gas Leasing EIS, Northern San Juan Coalbed Methane EIS, Northern San Jan Infill Project, and the Southern Ute Indian Tribe EIS)

These cumulative impacts are compared to the NAAQS, presented in Table 7-1, and the PSD Class I and Class II increments and AQRV criteria, presented in Table 3-1. As the modeling already includes all known industrial emission sources in the modeling domain, no "background" concentration is added to the modeled value. Since all known emissions are included, any incremental contribution from non-modeled sources should be insignificant.

7.1.1.1 1-Hour and Annual NO_X Impacts

Class I Areas

Incremental 1-hour and annual NO_X impacts for Scenario 1 are shown in Table 7-2 at Class I areas of interest. Overall, these NO_X concentration impacts are very small, with the highest impacts occurring at Mesa Verde due to the proximity of Mesa Verde to the development area.

Table 7-2

Incremental 1-Hour and Annual NO_X impacts at Class I Areas for Scenario 1 for Each Year of Meteorological Data Modeled

	1-Hour NO_X Impact (µg/m^3)			**Annual NO_X Impact (µg/m^3)**		
Class I Area	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**
Arches	0.1004	0.1552	0.0940	0.002020	0.001613	0.001371
Bandelier	0.0489	0.0865	0.1143	0.000159	0.000159	0.000197
Black Canyon of the Gunnison	0.1871	0.2631	0.5766	0.000890	0.000965	0.001266
Canyonlands	0.2539	0.1260	0.2205	0.002812	0.002080	0.002206
LaGarita	0.0981	0.7006	0.8785	0.000395	0.000681	0.000599
Mesa Verde	2.0703	2.0586	2.8052	0.082366	0.096499	0.093449
San Pedro Parks	0.7764	0.1591	0.1705	0.000458	0.000411	0.000450
Weminuche	0.6034	1.2987	0.4142	0.002114	0.002515	0.002047
West Elk	0.1765	0.5233	0.6225	0.000589	0.000583	0.000997

Cumulative 1-hour and annual NO_X impacts for Scenario 1 are presented below in Table 7-3, and show that these impacts are well below the NAAQS of 100 µg/m^3. The highest NO_X impacts in the Class I areas evaluated would occur at Mesa Verde. Maximum cumulative 1-hour impacts for Scenario 1 range from 47.4 µg/m^3 at Black Canyon of the Gunnison to 771.6 µg/m^3 at Mesa Verde. It should be noted, however, that these are maximum impacts and not impacts for the 98th percentile or 8th highest day, which are what the new 1-hour NO_2 standard is based upon. Unfortunately, the CALPUFF post-processing programs are not set up to directly output the 8th highest day, so some additional examination of the results for sites where the 1-hour maximum exceeded the NO_2 standard was performed, to see if the modeling predicted exceedances of the new standard. Maximum annual NO_X impacts for Scenario 1 range from 0.088 µg/m^3 at West Elk Wilderness to 4.07 µg/m^3 at Mesa Verde National Park. Except for Mesa Verde, the cumulative NO_X impacts are also well below the Class I PSD increment for NO_X of 2.5 µg/m^3. Since this modeling is not a vigorous PSD analysis, the predicted impacts do not suggest that the Class I NO_X increment would be exceeded at Mesa Verde. Overall, these results indicate that NO_X impacts would not be a problem under Scenario 1.

As noted above, additional post-processing of 1-hour NO_2 was performed for sites where the maximum 1-hour NO_2 exceeded the new standard. The actual standard is based on the 98th percentile or 8th highest day, but CALPUFF post-processors are not currently configured to directly output these values. CALPUFF's post-processor can, however, output the top 4 values at each receptor as well as the top 50 of any group. Table 7-4 presents the top four values at each of the sites which had 1-hour maximums above 191.2 $\mu g/m^3$, and shows that while the 1-hour maximum exceeds 191.2 $\mu g/m^3$ for these sites, the 4th highest is below for all sites but Mesa Verde. This additional analysis also showed that the maximum number of exceedances at any receptor was four; therefore, it can be concluded that the 8th highest day is below the standard.

While results in Table 7-3 and Table 7-4 suggest that the 1-hour NO_2 standard is exceeded, it is also assumed that 100% of NO_X is converted to NO_2. These high cumulative impacts occur far from the proposed sources and are unlikely to be due to the project.

Table 7-3

Cumulative 1-Hour and Annual NO_X Impacts at Class I Areas for Scenario 1 for Each Year of Meteorological Data Modeled

Class I Area	**Maximum 1-Hour NO_X Impact ($\mu g/m^3$)**			**Annual NO_X Impact ($\mu g/m^3$)**		
	2001	**2002**	**2003**	**2001**	**2002**	**2003**
Arches	33.7	30.2	95.8	0.257	0.154	0.153
Bandelier	88.3	206.3	102.0	0.898	0.840	0.828
Black Canyon of the Gunnison	27.6	18.7	47.4	0.113	0.110	0.139
Canyonlands	116.9	139.3	95.4	0.611	0.483	0.419
LaGarita	34.6	45.4	82.1	0.182	0.166	0.227
Mesa Verde	518.5	771.6	434.9	4.068	4.285	3.638
San Pedro Parks	44.9	90.8	92.2	1.028	1.199	1.235
Weminuche	248.9	179.4	162.1	0.785	0.846	0.882
West Elk	257.1	17.7	21.7	0.088	0.065	0.086

Table 7-4

Maximum Cumulative 1-Hour NO_X Impacts for Modeled Class I Sites for Scenario 1 that Exceeded the 1-Hour NO_2 Standard of 191.2 μg/m^3

Site	Year	Maximum	2nd	3rd	4th	Max # of exceedances at any receptor
Bandelier	2001	no exceedances				
	2002	206.3	120.9	103.6	94.35	1
	2003	no exceedances				
Mesa Verde	2001	518.53	289.05	207.65	206.54	4
	2002	771.63	287.70	241.86	200.57	4
	2003	434.86	251.28	173.79	171.05	2
Weminuche	2001	248.94	146.05	64.48	56.98	1
	2002	no exceedances				
	2003	no exceedances				
West Elk	2001	257.08	24.83	12.70	11.80	1
	2002	no exceedances				
	2003	no exceedances				

Class II Areas of Interest

Table 7-5 shows the incremental NO_X concentration impacts for Scenario 1 at the Class II areas of concern. These impacts are greatest at Canyons of the Ancients due to the proximity to the project area. Nevertheless, Scenario 1 emissions have only a small incremental impact on NO_X concentrations.

Table 7-5

Incremental 1-Hour and Annual NO_X Impacts at Class II Areas for Scenario 1 for Each Year of Meteorological Data Modeled

Class II Area	1-Hour NO_X Impact (μg/m^3) 2001	2002	2003	Annual NO_X Impact (μg/m^3) 2001	2002	2003
Canyon de Chelly	0.0943	0.1564	0.0345	0.000197	0.000137	0.000086
Canyons of the Ancients	0.6367	0.5507	0.6616	0.026348	0.024953	0.026704
Chaco Culture	0.0557	0.0574	0.0481	0.000172	0.000162	0.000148
Hovenweep	0.2089	0.3497	0.2743	0.002026	0.001919	0.002194
Natural Bridges	0.0899	0.0829	0.0829	0.000764	0.000657	0.000730

Table 7-6 shows the cumulative 1-hour and annual NO_X impacts for the various Class II areas of concern. The Class II area with the highest NO_X impacts was Canyons of the Ancients National Monument. Maximum cumulative 1-hour NO_X impacts at these sites ranged from 165.6 μg/m^3 at Natural Bridges to 707.4 μg/m^3 at Canyons of the Ancients. Because the actual 1-hour NO_2 standard applies to the 98th percentile, additional analyses were performed to determine whether the modeling demonstrated compliance at the sites where the 1-hour maximum exceeds 191.2 $\mu g/m^3$ in order to determine if the 8th highest day exceeds the standard. Maximum annual NO_X impacts at these Class II areas ranged from 0.99 $\mu g/m^3$ at Natural Bridges to 7.29 $\mu g/m^3$ at Canyons of the Ancients. These impacts are all well below the NAAQS of 100 $\mu g/m^3$, and also well below the Class II PSD increment for NO_X of 25 $\mu g/m^3$.

As noted above, additional analyses were performed in order to determine if modeled 1-hour impacts for the 8th highest day exceeded the standard. Table 7-7 shows the 1st, 2nd, 3rd, and 4th highest values for Canyon de Chelly, Canyons of the Ancients, and Chaco Culture. Because the maximum number of 1-hour exceedances at any receptor within Canyon de Chelly and Canyons of the Ancients is below eight, it can be concluded that the standard is not exceeded at these two sites. By examining the top 50 impacts on a receptor-by-receptor basis at Chaco Culture, however, ARS concluded that the 8th highest day exceeded the new 1-hour NO_2 standard for each of the three years modeled (2001 = 275 $\mu g/m^3$, 2002 = 305 $\mu g/m^3$, and 2003 = 326 $\mu g/m^3$). These high impacts occur far from the proposed new sources and are unlikely to be due to the project as evidenced by the low incremental impacts shown in Table 7-5. Local sources around Chaco Culture probably contribute to these modeled exceedances.

Table 7-6

Cumulative 1-Hour and Annual NO_X Impacts at Class II Areas of Interest for Scenario 1 for Each Year of Meteorological Data Modeled

Class II Area	**1-Hour NO_X Impact ($\mu g/m^3$)**			**Annual NO_X Impact ($\mu g/m_3$)**		
	2001	**2002**	**2003**	**2001**	**2002**	**2003**
Canyon de Chelly	265.6	268.8	373.9	1.376	1.031	1.256
Canyons of the Ancients	707.4	522.4	311.1	7.084	7.246	7.291
Chaco Culture	518.4	343.9	373.8	4.021	4.644	4.945
Hovenweep	112.1	94.3	96.7	2.705	2.337	2.138
Natural Bridges	58.1	66.1	165.6	0.990	0.626	0.650

Table 7-7

Maximum Cumulative 1-Hour NO_X Impacts for Modeled Class II Sites that Exceeded the 1-Hour NO_X Standard of 191.2 $\mu g/m^3$

Site	Year	Maximum	2nd	3rd	4th	Max # of exceedances at any receptor
Canyon de Chelly	2001	265.62	202.62	147.51	123.61	2
	2002	268.77	221.75	156.27	144.24	2
	2003	373.89	188.45	156.76	118.80	1
Canyons of the Ancients	2001	707.43	190.46	164.04	149.76	1
	2002	522.36	272.18	253.74	237.91	4
	2003	311.05	214.78	197.94	162.53	3
Chaco Culture	2001	518.39	343.76	331.22	312.84	17
	2002	343.87	334.26	327.20	309.89	30
	2003	373.76	373.12	370.76	364.45	40

Class II Fine Grid within Project Area

Table 7-8 shows the predicted incremental annual NO_X impacts within the fine grid of receptors located in the Gothic Shale and Paradox Conventional development area.[3] The maximum annual NO_X impacts in this area are a bit higher than in the more distant Class I and Class II areas, ranging between 1.3 and 1.5 $\mu g/m^3$.

Table 7-8

Incremental Annual NO_X Impacts within the Fine Grid of Class II Receptors within the Project Area for Scenario 1

Modeling Year	NO_X Impact ($\mu g/m^3$)	Receptor Location: Lambert-Conformal Coordinates		Receptor Location: Longitude/Latitude Coordinates	
2001	1.295	124	180	108.5549	37.6472
2002	1.450	124	180	108.5549	37.6472
2003	1.436	124	180	108.5549	37.6472

[3] The new 1-hour NO_2 standard was implemented after all the modeling had been performed. SJPL requested that 1-hour impacts be calculated at Class I areas and selected Class II areas but did not require this additional analysis for the fine and coarse grid receptor sets.

Table 7-9 shows the predicted NO_X impacts within the fine grid of receptors located in the Gothic Shale and Paradox Conventional development area. Cumulative impacts are low.

Table 7-9

Cumulative Annual NO_X Impacts at the Fine Grid of Class II Receptors within the Project Area for Scenario 1

Modeling Year	NO_X Impact ($\mu g/m^3$)	Receptor Location			
		Lambert-Conformal Coordinates		Longitude/Latitude Coordinates	
2001	10.3	132	108	108.4776	36.9821
2002	10.7	132	108	108.4776	36.9821
2003	10.2	148	108	108.2932	36.9791

Class II Coarse Grid within Modeling Domain

Incremental NO_X impacts within the coarse grid of Class II receptors located outside the development area are presented below in Table 7-10. The incremental NO_X impacts are lower in the coarse Class II grid as these receptors are more distant from the project area.

Table 7-10

Incremental Annual NO_X Impacts within the Coarse Grid of Other Class II Receptors within the Modeling Domain for Scenario 1

Modeling Year	NO_X Impact ($\mu g/m^3$)	Receptor Location			
		Lambert-Conformal Coordinates		Longitude/Latitude Coordinates	
2001	0.0258	78	248	109.0818	38.2813
2002	0.0258	78	248	109.0818	38.2813
2003	0.0280	78	248	109.0818	38.2813

Cumulative NO_X impacts within the coarse grid of Class II receptors located outside the development area are presented below in Table 7-11. The maximum annual NO_X impact is 62.6 $\mu g/m^3$, which is below the NAAQS of 100 $\mu g/m^3$. The coarse grid receptor with the highest annual NO_X impacts is less than 7.5 km (~ 4.7 miles) from the Four Corners Power Plant, which emits over 49,000 tons per year of NO_X, and less than 13.7 km from the San Juan Generating Station, which emits over 40,000 tons per year of NO_X. These are likely the significant contributing sources to the NO_X impacts. In addition, numerous existing oil and gas wells are in this part of New Mexico, and additional NO_X sources are anticipated in this area in conjunction with the Farmington RMP RFD.

Table 7-11

Cumulative Annual NO_X Impacts
within the Coarse Grid of Other Class II Receptors
within the Modeling Domain for Scenario 1

Modeling Year	**NO_X Impact ($\mu g/m^3$)**	**Receptor Location**			
		Lambert-Conformal Coordinates		**Longitude/Latitude Coordinates**	
2001	52.5	126	80	108.5527	36.7253
2002	62.6	126	80	108.5527	36.7253
2003	52.3	126	80	108.5527	36.7253

Figures 7-1 and 7-2 present contour plots, depicting Lambert-Conformal coordinates, of composited maximum 1-hour and annual NO_X impacts for the three years modeled. These plots show that the maximum modeled cumulative NO_X impacts under Scenario 1 would occur in New Mexico, relatively close to the Four Corners Power Plant and the San Juan Generating Station.

Conclusion

For all receptors modeled, cumulative annual NO_X impacts for Scenario 1 do not exceed the NAAQS standard of 100 $\mu g/m^3$. Cumulative 1-hour NO_X impacts are below the new standard at all sites and receptors modeled, except for Chaco Culture, where impacts from local sources, not the proposed project, dominate.

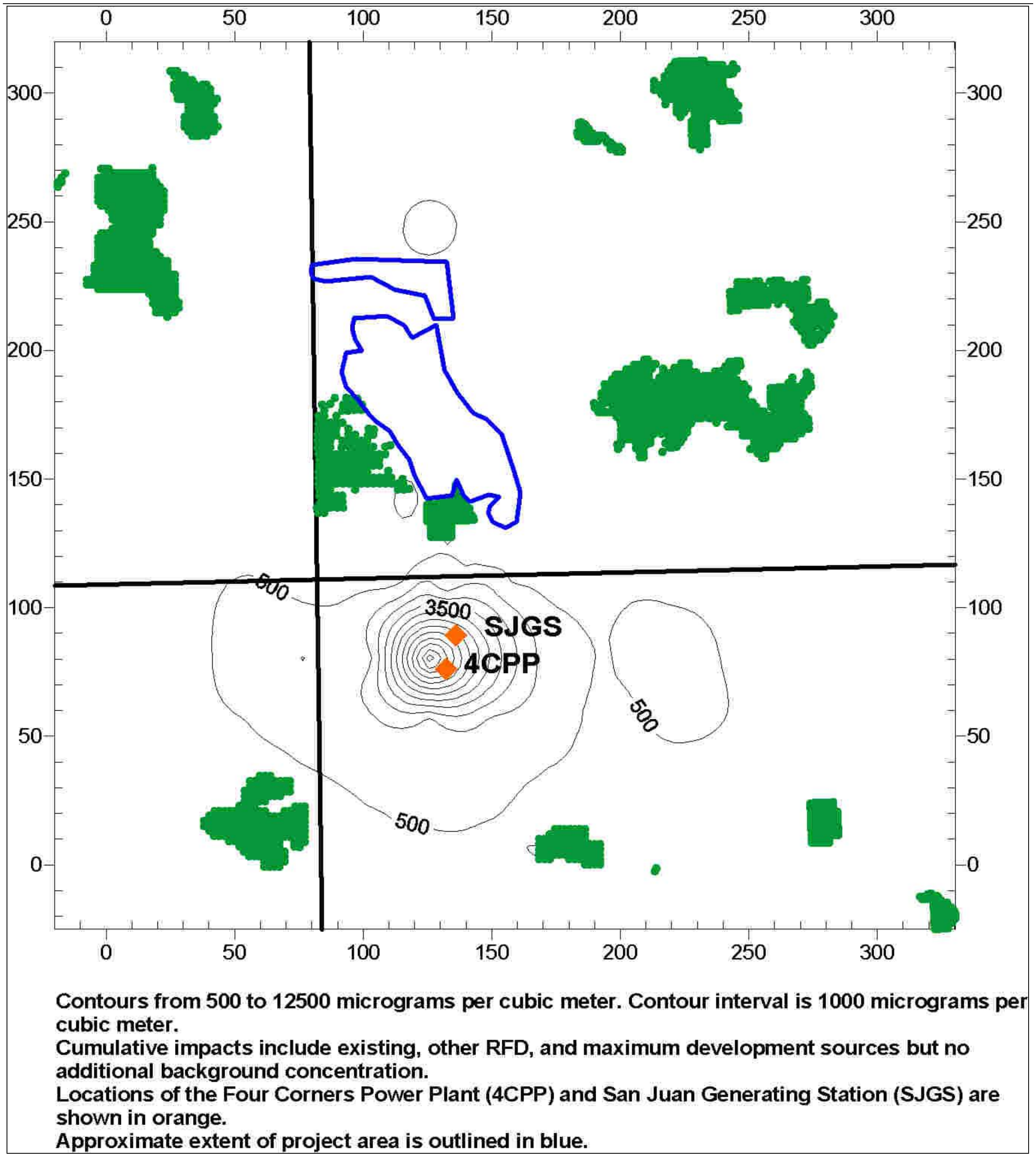


Figure 7-1. Composite of Cumulative 1-Hour Maximum NO_X Modeled Impacts for 2001-2003 for Scenario 1.

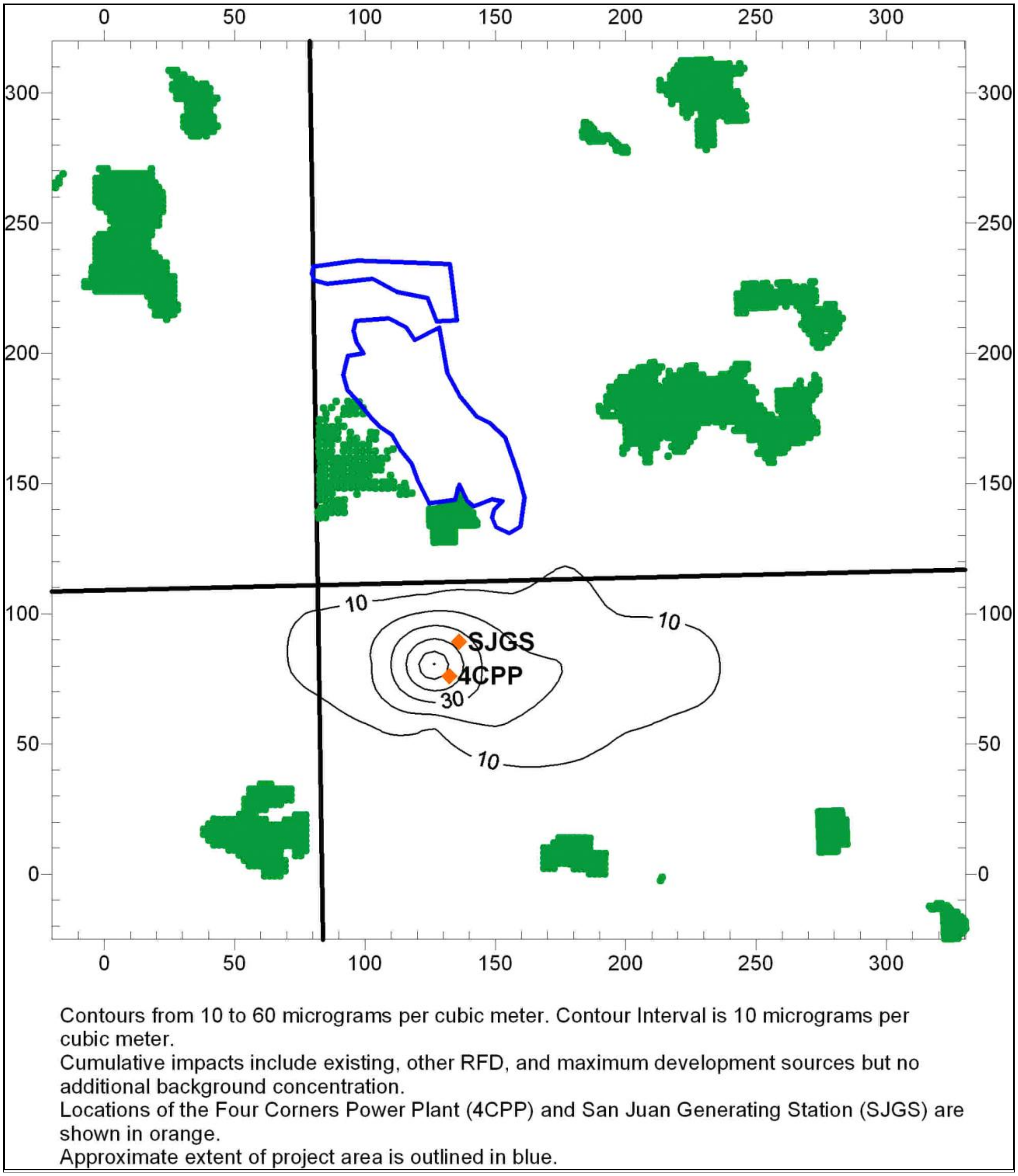


Figure 7-2. Composite of Cumulative Annual NO_X Modeled Impacts for 2001-2003 for Scenario 1.

7.1.1.2 24-Hour and Annual PM_{10} Impacts

Class I Areas

Incremental 24-hour and annual PM_{10} impacts at the Class I areas for Scenario 1 are presented below in Table 7-12. These results show that the highest incremental PM_{10} impacts within a Class I area would occur at Mesa Verde. However, the PM_{10} incremental impacts are relatively small at each Class I area modeled.

Table 7-12

Incremental 24-Hour and Annual PM_{10} Impacts at Class I Areas for Scenario 1 for Each Year of Meteorological Data Modeled

	Highest Second-Highest 24-Hour PM_{10} Impacts (µg/m3)			Maximum Annual PM_{10} Impacts (µg/m3)		
Class I Area	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**
Arches	0.0281	0.0266	0.0294	0.00454	0.00422	0.00325
Bandelier	0.0142	0.0119	0.0192	0.00084	0.00089	0.00080
Black Canyon of the Gunnison	0.0561	0.0276	0.0520	0.00287	0.00276	0.00296
Canyonlands	0.0468	0.0407	0.0365	0.00515	0.00450	0.00440
LaGarita	0.0153	0.0301	0.0240	0.00160	0.00250	0.00214
Mesa Verde	0.2150	0.2916	0.3023	0.06320	0.07441	0.07221
San Pedro Parks	0.0225	0.0214	0.0222	0.00144	0.00155	0.00151
Weminuche	0.0693	0.0650	0.0444	0.00435	0.00648	0.00521
West Elk	0.0319	0.0256	0.0444	0.00208	0.00197	0.00232

Cumulative 24-hour and annual PM_{10} impacts at the Class I areas for Scenario 1 are presented in Table 7-13. These results show that the highest cumulative PM_{10} impacts within a Class I area would occur at Mesa Verde. Maximum annual PM_{10} impacts for Scenario 1 ranged from 0.209 $\mu g/m^3$ at Arches National Park to 10.1 $\mu g/m^3$ at Mesa Verde. These impacts are well below the NAAQS for annual PM_{10} of 50 $\mu g/m^3$. Except for Mesa Verde, these cumulative impacts are also well below the annual Class I PSD increment for PM_{10} of 5 $\mu g/m^3$. As with NO_X, the modeled inventory does not represent a vigorous PSD increment analysis. As such, these results do not suggest that Class I increments are being exceeded at Mesa Verde.

Highest second-highest (HSH) cumulative 24-hour PM_{10} impacts for Scenario 1 ranged from 2.07 $\mu g/m^3$ at Arches to 66.98 $\mu g/m^3$ at Mesa Verde. These cumulative impacts are well below the 24-hour NAAQS for PM_{10} of 150 $\mu g/m^3$. The HSH concentration is used for 24-hour compliance as the 24-hour PM_{10} NAAQS allows an average of one (1) exceedance per year before a violation is declared.

Table 7-13

Cumulative 24-Hour and Annual PM_{10} Impacts at Class I areas for Scenario 1 for Each Year of Meteorological Data Modeled

Class I Area	Highest Second-Highest 24-Hour Impacts ($\mu g/m^3$)			Maximum Annual Impacts ($\mu g/m^3$)		
	2001	**2002**	**2003**	**2001**	**2002**	**2003**
Arches	2.073	2.004	2.006	0.209	0.171	0.173
Bandelier	3.648	7.658	3.949	0.503	0.452	0.451
Black Canyon of the Gunnison	2.215	1.697	4.270	0.225	0.263	0.281
Canyonlands	2.204	2.514	1.879	0.241	0.201	0.198
LaGarita	1.622	1.863	6.272	0.130	0.167	0.239
Mesa Verde	24.267	36.952	66.977	4.171	5.990	10.121
San Pedro Parks	2.343	2.925	3.095	0.244	0.283	0.307
Weminuche	8.690	7.969	13.097	0.374	0.520	0.802
West Elk	3.703	6.297	8.296	0.344	0.410	0.710

The higher impacts at Mesa Verde suggest the presence of a large PM_{10} emission source in the cumulative inventory close to or upwind of Mesa Verde.

Class II Areas of Interest

Table 7-14 shows the incremental 24-hour and annual PM_{10} impacts for Scenario 1 at the various Class II areas of interest. The Class II area with the highest incremental annual PM_{10} impact was Canyons of the Ancients National Monument. The incremental effect of the project on PM_{10} concentrations is small.

Table 7-14

Incremental 24-Hour and Annual PM_{10} Impacts at Class II Areas of Interest for Scenario 1

Class II Area	Highest Second-Highest 24-Hour PM_{10} Impacts (µg/m3)			Maximum Annual PM_{10} Impacts (µg/m3)		
	2001	**2002**	**2003**	**2001**	**2002**	**2003**
Canyon de Chelly	0.0231	0.0184	0.0094	0.00076	0.00061	0.00067
Canyons of the Ancients	0.1227	0.1121	0.1144	0.02830	0.02851	0.03000
Chaco Culture	0.0135	0.0130	0.0118	0.00088	0.00088	0.00089
Hovenweep	0.0363	0.0390	0.0399	0.00509	0.00509	0.00544
Natural Bridges	0.0252	0.0215	0.0210	0.00208	0.00198	0.00220

Table 7-15 shows the cumulative 24-hour and annual PM_{10} impacts for Scenario 1 at the various Class II areas of interest. The Class II area with the highest cumulative annual PM_{10} impact was Canyons of the Ancients National Monument. Maximum annual PM_{10} impacts at these Class II areas ranged from 0.281 $\mu g/m^3$ at Natural Bridges to 1.54 $\mu g/m^3$ at Canyons of the Ancients. These impacts are all well below the annual NAAQS for PM_{10} of 50 $\mu g/m^3$.

HSH cumulative 24-hour PM_{10} impacts for Scenario 1 ranged from 3.04 $\mu g/m^3$ at Natural Bridges to 9.11 $\mu g/m^3$ at Canyon de Chelly National Monument. These cumulative impacts are well below the 24-hour NAAQS for PM_{10} of 150 $\mu g/m^3$.

Table 7-15

Cumulative 24-Hour and Annual PM_{10} Impacts at Class II Areas of Interest for Scenario 1 for Each Year of Meteorological Data Modeled

	Highest Second-Highest 24-Hour Impacts ($\mu g/m^3$)			**Maximum Annual Impacts ($\mu g/m^3$)**		
Class II Area	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**
Canyon de Chelly	5.49	5.96	6.27	0.307	0.278	0.334
Canyons of the Ancients	4.70	5.25	9.11	1.193	1.227	1.544
Chaco Culture	4.25	2.82	3.98	0.374	0.357	0.369
Hovenweep	3.16	2.97	4.38	0.701	0.697	0.886
Natural Bridges	2.34	2.53	3.04	0.281	0.222	0.233

<u>Class II Fine Grid within Project Area</u>

Table 7-16 shows the incremental PM_{10} impacts for the fine grid of receptors within the immediate project area. The maximum incremental 24-hour PM_{10} impact ranged between 2.47 and 2.78 $\mu g/m^3$ and the maximum incremental annual PM_{10} impact ranged between 0.93 to 1.05 $\mu g/m^3$.

Table 7-17 shows the cumulative PM_{10} impacts for the fine grid of receptors within the immediate project area. The maximum cumulative 24-hour PM_{10} impact was 130.7 $\mu g/m^3$ and the maximum cumulative annual PM_{10} impact was 27.7 $\mu g/m^3$. These impacts occurred at the eastern edge of the fine grid, suggesting that the dominant source of PM_{10} within the domain is outside the immediate project area to the east.

Table 7-16

Incremental 24-Hour and Annual PM_{10} Impacts within the Fine Grid of other Class II Receptors within the Project Area for Scenario 1 for Each Year of Meteorological Data Modeled

Averaging Period	Year	PM_{10} Impact ($\mu g/m^3$)	Receptor Location: Lambert-Conformal Coordinates		Receptor Location: Longitude/Latitude Coordinates	
HSH 24-Hour	2001	2.63	108	196	108.7384	37.7973
	2002	2.78	124	180	108.5549	37.6472
	2003	2.47	124	180	108.5549	37.6472
Maximum Annual	2001	0.930	124	180	108.5549	37.6472
	2002	1.046	124	180	108.5549	37.6472
	2003	1.034	124	180	108.5549	37.6472

Table 7-17

Cumulative 24-Hour and Annual PM_{10} Impacts within the Fine Grid of Class II Receptors within the Project Area for Scenario 1 for Each Year of Meteorological Data Modeled

Averaging Period	Year	PM_{10} Impact ($\mu g/m^3$)	Receptor Location: Lambert-Conformal Coordinates		Receptor Location: Longitude/Latitude Coordinates	
HSH 24-Hour	2001	55.8	156	140	108.1926	37.2724
	2002	72.2	156	140	108.1926	37.2724
	2003	130.7	156	132	108.1947	37.1986
Maximum Annual	2001	13.4	156	132	108.1947	37.1986
	2002	14.9	156	132	108.1947	37.1986
	2003	27.7	156	132	108.1947	37.1986

<u>Class II Coarse Grid within Modeling Domain</u>

Incremental 24-hour and annual PM_{10} impacts within the coarse grid of Class II receptors outside the immediate development area are presented below in Table 7-18. In the coarse grid, incremental impacts are less compared to the fine grid due to the greater distance to the coarse grid receptors. PM_{10} incremental impacts are small at the coarse grid receptors.

Table 7-18

Incremental 24-Hour and Annual Incremental PM_{10} Impacts within the Coarse Grid of Other Class II Receptors within the Modeling Domain for Scenario 1 for Each Year of Meteorological Data Modeled

Averaging Period	Year	PM_{10} Impact ($\mu g/m^3$)	Receptor Location			
			Lambert-Conformal Coordinates		Longitude/Latitude Coordinates	
HSH 24-Hour	2001	0.1386	78	272	109.0786	38.5031
	2002	0.1402	78	272	109.0786	38.5031
	2003	0.1575	78	272	109.0786	38.5031
Maximum Annual	2001	0.0231	78	248	109.0818	38.2813
	2002	0.0280	78	248	109.0818	38.2813
	2003	0.0237	78	248	109.0818	38.2813

Cumulative 24-hour and annual PM_{10} impacts within the coarse grid of Class II receptors outside the immediate development area are presented below in Table 7-19. The HSH 24-hour cumulative PM_{10} impact for Scenario 1 is 94.9 $\mu g/m^3$ and the maximum annual PM_{10} impact is 11.9 $\mu g/m^3$. The location of these impacts is due south of Mesa Verde, in the same spot as the maximum annual NO_X impacts. The location is near the Four Corners Power Plant (which emits over 3,500 tons per year of PM_{10}), and the San Juan Generating Station (which emits over 4,100 tons per year of PM_{10}). These sources appear to be the significant contributors to PM_{10} concentration in the modeling year and could also be the primary cause of the predicted impacts at Mesa Verde.

Table 7-19

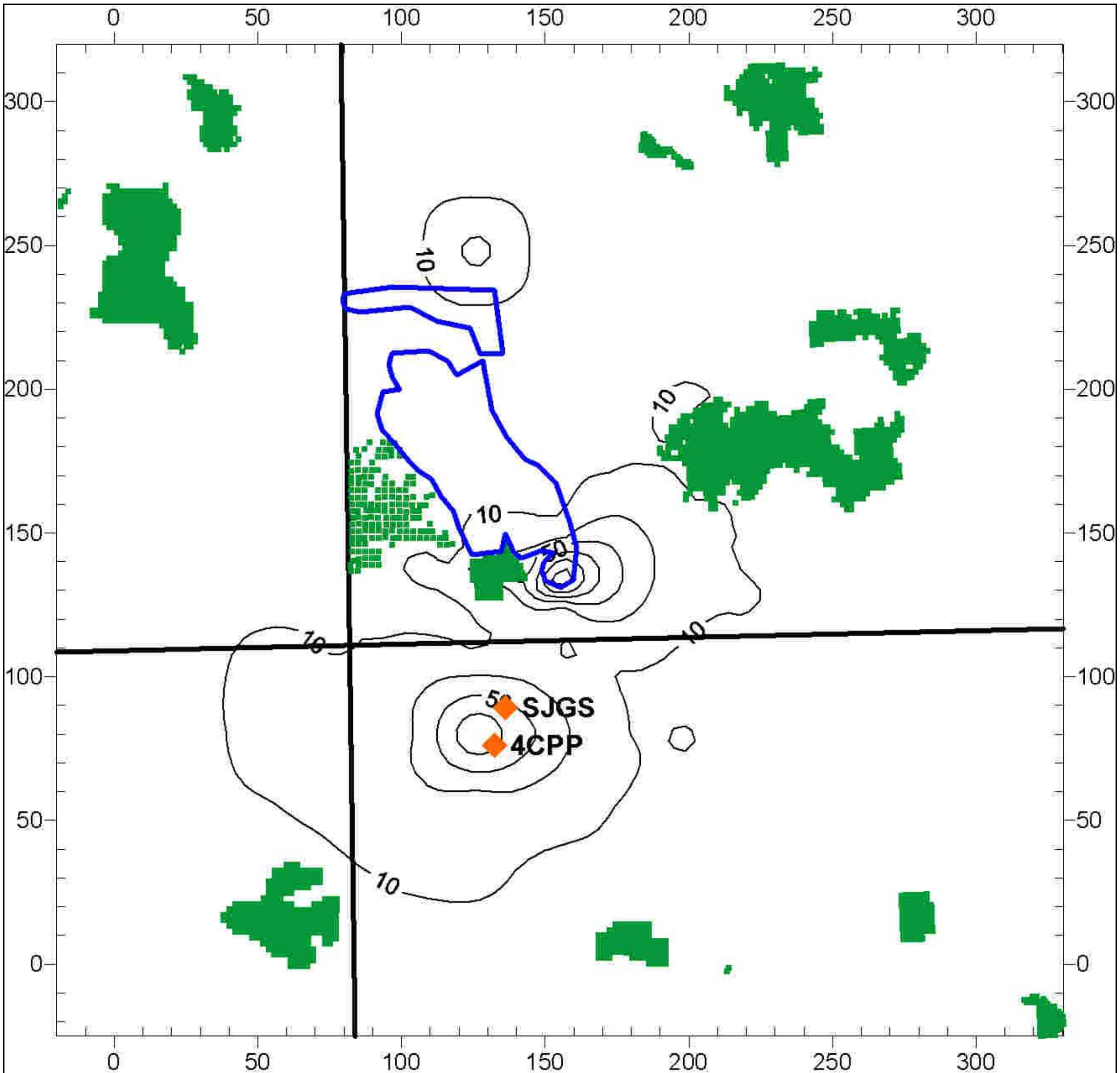
Cumulative 24-Hour and Annual PM_{10} Impacts within the Coarse Grid of Other Class II Receptors within the Modeling Domain for Scenario 1 for Each Year of Meteorological Data Modeled

Averaging Period	Year	PM_{10} Impact ($\mu g/m^3$)	Receptor Location			
			Lambert-Conformal Coordinates		Longitude/Latitude Coordinates	
HSH 24-Hour	2001	74.0	126	80	108.5527	36.7253
	2002	94.9	126	80	108.5527	36.7253
	2003	63.1	126	80	108.5527	36.7253
Maximum Annual	2001	9.46	126	80	108.5527	36.7253
	2002	11.88	126	80	108.5527	36.7253
	2003	9.74	126	80	108.5527	36.7253

Figures 7-3 and 7-4, depicting Lambert-Conformal coordinates, are composites of the 24-hour and annual PM_{10} impacts, respectively. These plots show that the highest PM_{10} impacts are outside the project area in northwestern New Mexico, near the San Juan Generating Station and the Four Corners Power Plant.

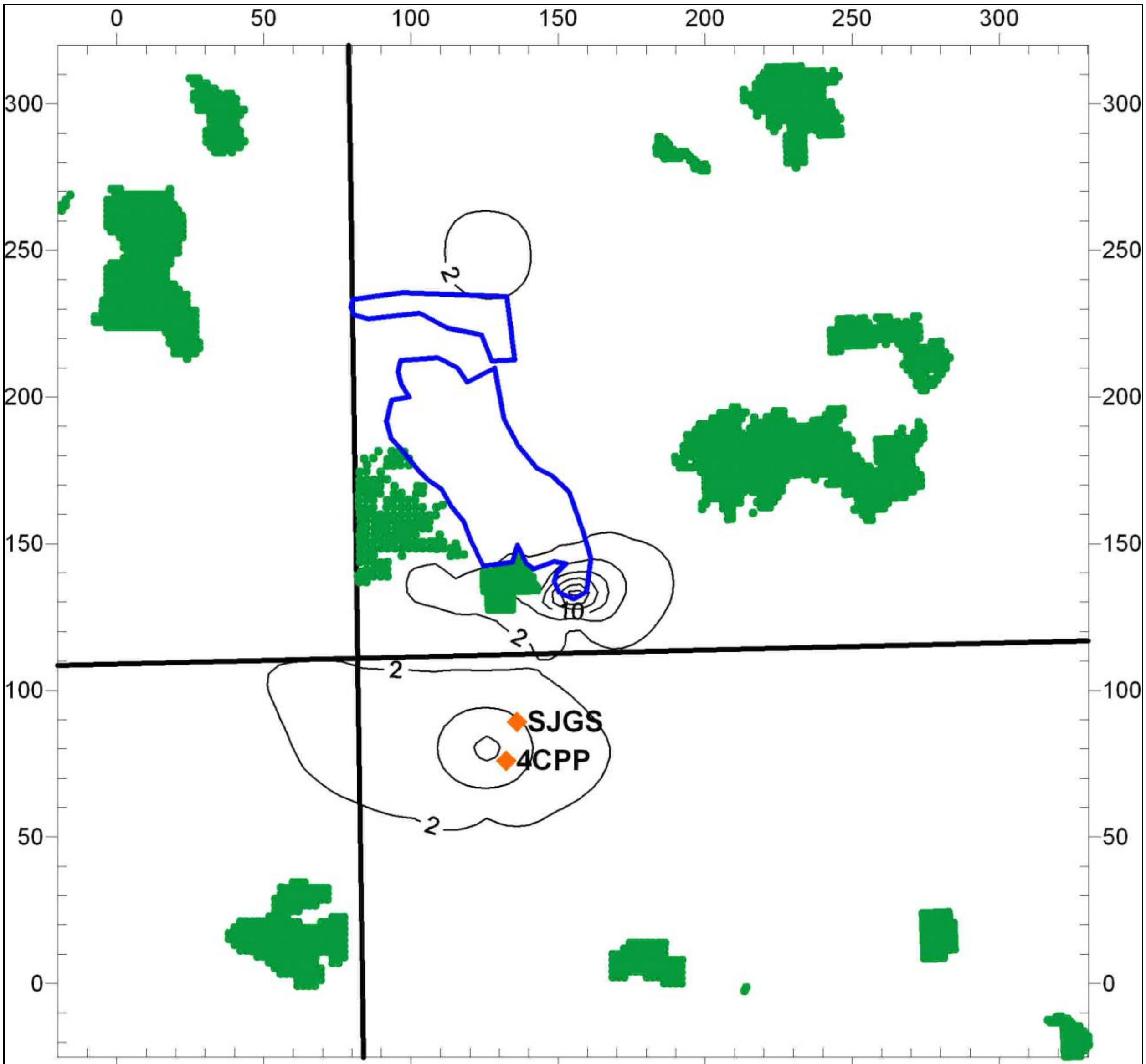
Conclusion

Cumulative PM_{10} impacts for Scenario 1 do not exceed their respective 24-hour or annual NAAQS for all receptors evaluated.



Contours from 10 to 120 micrograms per cubic meter. Contour interval is 20 micrograms per cubic meter.
Cumulative impacts include existing, other RFD, and maximum development sources but no additional background concentration.
Locations of the Four Corners Power Plant (4CPP) and San Juan Generating Station (SJGS) are shown in orange.
Approximate extent of project area is outlined in blue.

Figure 7-3. Composite of Cumulative Highest Second-Highest 24-Hour PM_{10} Modeled Impacts for 2001-2003 for Scenario 1.



Contours from 2 to 22 micrograms per cubic meter, contour interval of 4 micrograms per cubic meter.
Cumulative impacts include existing, other RFD, and maximum development sources but no additional background concentration.
Locations of the Four Corners Power Plant (4CPP) and San Juan Generating Station (SJGS) are shown in orange.
Approximate extent of project area is outlined in blue.

Figure 7-4. Composite of Cumulative Annual PM_{10} Modeled Impacts for 2001-2003 for Scenario 1.

7.1.1.3 24-Hour and Annual $PM_{2.5}$ Impacts

Class I Areas

Incremental 24-hour and annual average $PM_{2.5}$ impacts at the Class I areas for Scenario 1 are presented below in Table 7-20. These results show that the highest incremental $PM_{2.5}$ impacts within a Class I area would occur at Mesa Verde. However, the $PM_{2.5}$ incremental impacts are relatively small at each Class I area modeled.

Table 7-20

Incremental 24-Hour and Annual $PM_{2.5}$ Impacts at Class I Areas for Scenario 1 for Each Year of Meteorological Data Modeled

Class I Area	Highest Second-Highest 24-Hour $PM_{2.5}$ Impacts (µg/m3)			Maximum Annual $PM_{2.5}$ Impacts (µg/m3)		
	2001	**2002**	**2003**	**2001**	**2002**	**2003**
Arches	0.01014	0.00945	0.01057	0.001616	0.001494	0.001151
Bandelier	0.00519	0.00430	0.00695	0.000302	0.000322	0.000291
Black Canyon of the Gunnison	0.02004	0.00981	0.01855	0.001026	0.000986	0.001060
Canyonlands	0.01684	0.01462	0.01313	0.001845	0.001618	0.001575
LaGarita	0.00547	0.01081	0.00880	0.000577	0.000898	0.000770
Mesa Verde	0.07913	0.10579	0.11089	0.022911	0.026979	0.026182
San Pedro Parks	0.00826	0.00780	0.00802	0.000519	0.000559	0.000544
Weminuche	0.02504	0.02348	0.01603	0.001569	0.002337	0.001880
West Elk	0.01132	0.00917	0.01572	0.000744	0.000708	0.000830

Cumulative 24-hour and annual average $PM_{2.5}$ impacts at the Class I areas for Scenario 1 are presented in Table 7-21. These results also show that the highest cumulative $PM_{2.5}$ impacts within a Class I area would occur at Mesa Verde with a maximum $PM_{2.5}$ concentration of 1.09 $\mu g/m^3$. All other Class I areas had lower $PM_{2.5}$ impacts than Mesa Verde. All impacts are well below the NAAQS for annual $PM_{2.5}$ of 15 $\mu g/m^3$.

Table 7-21

Cumulative 24-Hour and Annual $PM_{2.5}$ Impacts at Class I areas for Scenario 1 for Each Year of Meteorological Data Modeled

Class I Area	Highest Second-Highest 24-Hour Impacts ($\mu g/m^3$)			Maximum Annual Impacts ($\mu g/m^3$)		
	2001	2002	2003	2001	2002	2003
Arches	0.782	0.801	0.541	0.0506	0.0456	0.0360
Bandelier	0.228	0.374	0.361	0.0421	0.0432	0.0468
Black Canyon of the Gunnison	0.609	0.717	0.588	0.0488	0.0613	0.0532
Canyonlands	0.494	0.468	0.407	0.0586	0.0490	0.0453
LaGarita	0.306	0.491	0.642	0.0241	0.0312	0.0368
Mesa Verde	2.501	3.887	7.070	0.4958	0.6858	1.0921
San Pedro Parks	0.360	0.432	0.515	0.0461	0.0561	0.0588
Weminuche	1.124	0.809	1.509	0.0587	0.0775	0.1042
West Elk	0.615	0.699	0.859	0.0517	0.0610	0.0879

Highest second-highest (HSH) cumulative 24-hour $PM_{2.5}$ impacts for Scenario 1 ranged from 0.361 $\mu g/m^3$ at Bandelier to 7.070 $\mu g/m^3$ at Mesa Verde. These cumulative impacts are well below the 24-hour NAAQS for $PM_{2.5}$ of 65 $\mu g/m^3$. The HSH concentration is used for 24-hour compliance as the 24-hour $PM_{2.5}$ NAAQS allows an average of one (1) exceedance per year before a violation is declared.

Class II Areas of Interest

Table 7-22 shows the incremental 24-hour and annual $PM_{2.5}$ impacts for Scenario 1 at the various Class II areas of interest. The Class II area with the highest incremental annual $PM_{2.5}$ impact was Canyons of the Ancients National Monument. The incremental effect of the project on $PM_{2.5}$ concentrations is small.

Table 7-22

Incremental 24-Hour and Annual $PM_{2.5}$ Impacts at Class II Areas of Interest for Scenario 1

Class II Area	Highest Second-Highest 24-Hour $PM_{2.5}$ Impacts ($\mu g/m^3$)			Maximum Annual $PM_{2.5}$ Impacts ($\mu g/m^3$)		
	2001	2002	2003	2001	2002	2003
Canyon de Chelly	0.00844	0.00662	0.00339	0.000274	0.000222	0.000244
Canyons of the Ancients	0.04410	0.04060	0.04234	0.010228	0.010314	0.010850
Chaco Culture	0.00488	0.00472	0.00429	0.000320	0.000321	0.000322
Hovenweep	0.01316	0.01400	0.01462	0.001840	0.001841	0.001969
Natural Bridges	0.00902	0.00777	0.00757	0.000750	0.000715	0.000793

Table 7-23 shows the cumulative 24-hour and annual $PM_{2.5}$ impacts for Scenario 1 at the various Class II areas of interest. The Class II area with the highest cumulative annual $PM_{2.5}$ impact was Canyons of the Ancients. Maximum annual $PM_{2.5}$ impacts at these Class II areas ranged from 0.063 $\mu g/m^3$ at Canyon de Chelly to 0.250 $\mu g/m^3$ at Canyons of the Ancients. These impacts are all well below the annual NAAQS of 15 $\mu g/m^3$ for $PM_{2.5}$.

HSH cumulative 24-hour $PM_{2.5}$ impacts for Scenario 1 ranged from 0.676 $\mu g/m^3$ at Natural Bridges to 1.026 $\mu g/m^3$ at Canyon de Chelly National Monument. These cumulative impacts are well below the 24-hour NAAQS for $PM_{2.5}$ of 65 $\mu g/m^3$.

Table 7-23

Cumulative 24-Hour and Annual $PM_{2.5}$ Impacts at Class II Areas of Interest for Scenario 1 for Each Year of Meteorological Data Modeled

	Highest Second-Highest 24-Hour Impacts ($\mu g/m^3$)			**Maximum Annual Impacts ($\mu g/m^3$)**		
Class II Area	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**
Canyon de Chelly	1.026	0.955	0.973	0.061	0.052	0.063
Canyons of the Ancients	0.941	0.823	1.242	0.226	0.222	0.250
Chaco Culture	0.924	0.993	1.091	0.101	0.107	0.104
Hovenweep	0.663	0.592	0.694	0.140	0.137	0.145
Natural Bridges	0.672	0.520	0.676	0.066	0.050	0.049

Class II Fine Grid within Project Area

Table 7-24 shows the incremental $PM_{2.5}$ impacts for the fine grid of receptors within the immediate project area. The maximum incremental 24-hour $PM_{2.5}$ impact was about 1.0 $\mu g/m^3$ and the maximum incremental annual $PM_{2.5}$ impact was about 0.37 $\mu g/m^3$.

Table 7-25 shows the cumulative $PM_{2.5}$ impacts for the fine grid of receptors within the immediate project area. The maximum cumulative 24-hour $PM_{2.5}$ impact was 13.15 $\mu g/m^3$ and the maximum cumulative annual $PM_{2.5}$ impact was 2.84 $\mu g/m^3$. All impacts are below the NAAQS for $PM_{2.5}$. These impacts occurred at the eastern edge of the fine grid, suggesting that the dominant source of $PM_{2.5}$ within the domain is outside the immediate project area to the east.

Table 7-24

Incremental 24-Hour and Annual $PM_{2.5}$ Impacts within the Fine Grid of other Class II Receptors within the Project Area for Scenario 1 for Each Year of Meteorological Data Modeled

Averaging Period	Year	$PM_{2.5}$ Impact ($\mu g/m^3$)	Receptor Location			
			Lambert-Conformal Coordinates		Longitude/Latitude Coordinates	
HSH 24-Hour	2001	0.954	108	196	108.7384	37.7973
	2002	0.998	124	180	108.5549	37.6472
	2003	0.893	124	180	108.5549	37.6472
Maximum Annual	2001	0.332	124	180	108.5549	37.6472
	2002	0.374	124	180	108.5549	37.6472
	2003	0.370	124	180	108.5549	37.6472

Table 7-25

Cumulative 24-Hour and Annual $PM_{2.5}$ Impacts within the Fine Grid of Class II Receptors within the Project Area for Scenario 1 for Each Year of Meteorological Data Modeled

Averaging Period	Year	$PM_{2.5}$ Impact ($\mu g/m^3$)	Receptor Location			
			Lambert-Conformal Coordinates		Longitude/Latitude Coordinates	
HSH 24-Hour	2001	6.29	156	140	108.1926	37.2724
	2002	7.51	156	140	108.1926	37.2724
	2003	13.15	156	132	108.1947	37.1986
Maximum Annual	2001	1.40	156	132	108.1947	37.1986
	2002	1.56	156	132	108.1947	37.1986
	2003	2.84	156	132	108.1947	37.1986

Class II Coarse Grid within Modeling Domain

Incremental 24-hour and annual $PM_{2.5}$ impacts within the coarse grid of Class II receptors outside the immediate development area are presented below in Table 7-26. In the coarse grid, incremental impacts are less compared to the fine grid, due to the greater distance from the project area.

Table 7-26

Incremental 24-Hour and Annual Incremental $PM_{2.5}$ Impacts
within the Coarse Grid of other Class II Receptors
within the Modeling Domain for Scenario 1
for Each Year of Meteorological Data Modeled

Averaging Period	Year	$PM_{2.5}$ Impact ($\mu g/m^3$)	Receptor Location			
			Lambert-Conformal Coordinates		Longitude/Latitude Coordinates	
HSH 24-Hour	2001	0.0497	78	272	109.0786	38.5031
	2002	0.0488	78	272	109.0786	38.5031
	2003	0.0561	78	272	109.0786	38.5031
Maximum Annual	2001	0.00806	78	248	109.0818	38.2813
	2002	0.00966	78	248	109.0818	38.2813
	2003	0.00815	78	248	109.0818	38.2813

Cumulative 24-hour and annual $PM_{2.5}$ impacts within the coarse grid of Class II receptors outside the immediate development area are presented below in Table 7-27. The HSH 24-hour cumulative $PM_{2.5}$ impact for Scenario 1 is 15.2 $\mu g/m^3$ and the maximum annual $PM_{2.5}$ impact is 2.12 $\mu g/m^3$. The location of these impacts is due south of Mesa Verde, in the same spot as the maximum annual NO_X impacts. All impacts are below the respective NAAQS.

Table 7-27

Cumulative 24-Hour and Annual $PM_{2.5}$ Impacts
within the Coarse Grid of Other Class II Receptors
within the Modeling Domain for Scenario 1
for Each Year of Meteorological Data Modeled

Averaging Period	Year	$PM_{2.5}$ Impact ($\mu g/m^3$)	Receptor Location			
			Lambert-Conformal Coordinates		Longitude/Latitude Coordinates	
HSH 24-Hour	2001	11.9	126	80	108.5527	36.7253
	2002	15.2	126	80	108.5527	36.7253
	2003	10.5	126	80	108.5527	36.7253
Maximum Annual	2001	1.75	126	80	108.5527	36.7253
	2002	2.12	126	80	108.5527	36.7253
	2003	1.75	126	80	108.5527	36.7253

Figures 7-5 and 7-6, depicting Lambert-Conformal coordinates, are composites of the 24-hour and annual $PM_{2.5}$ impacts, respectively. These plots show that the highest $PM_{2.5}$ impacts are outside the project area in northwestern New Mexico, near the San Juan Generating Station and the Four Corners Power Plant.

Conclusion

Cumulative $PM_{2.5}$ impacts for Scenario 1 do not exceed their respective 24-hour or annual NAAQS for all receptors evaluated.

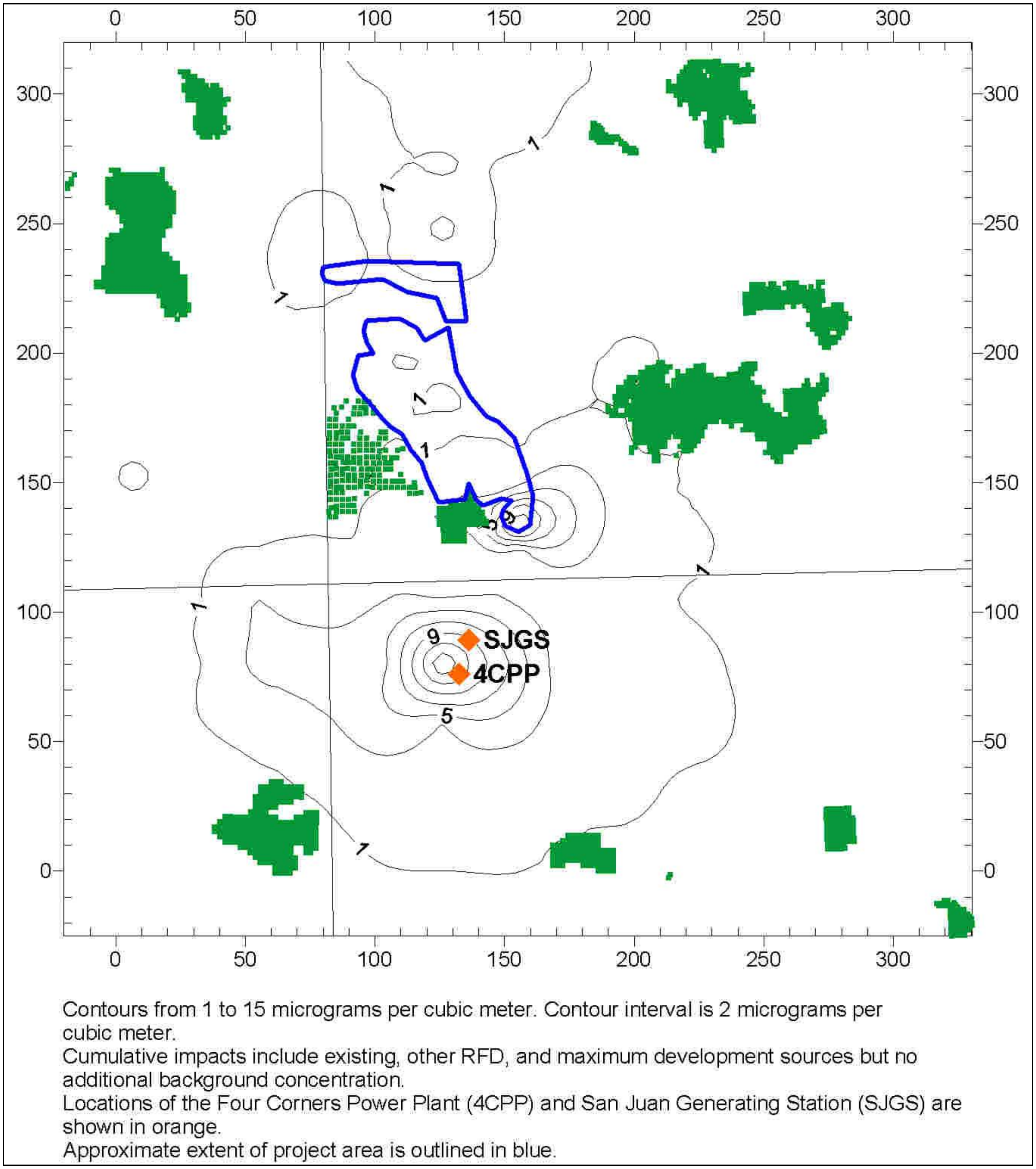
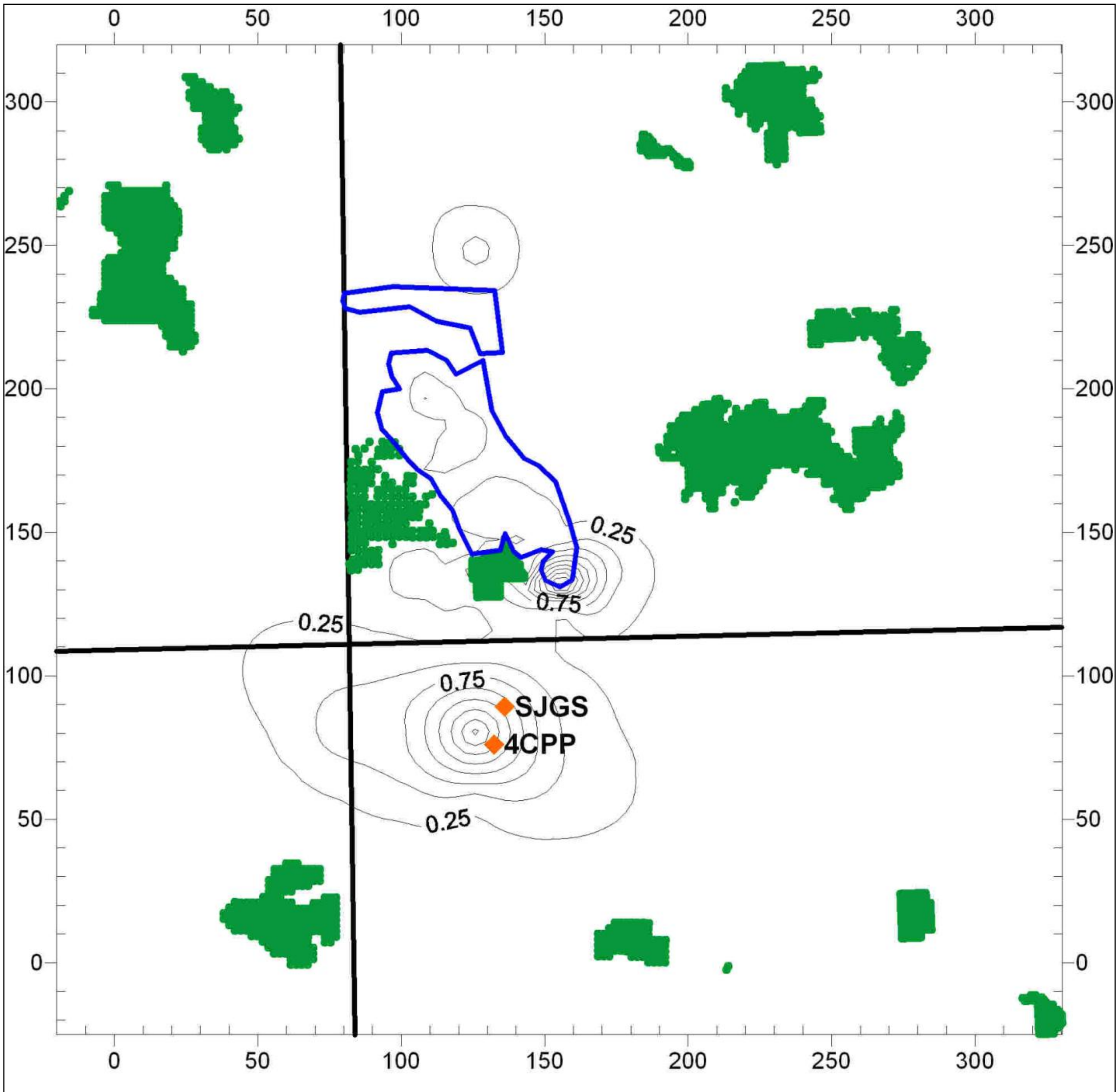


Figure 7-5. Composite of Cumulative Highest Second-Highest 24-Hour $PM_{2.5}$ Modeled Impacts for 2001-2003, for Scenario 1.



Contours from 0.25 to 2.5 micrograms per cubic meter, contour interval of 0.25 micrograms per cubic meter.
Cumulative impacts include existing, other RFD, and maximum development sources but no additional background concentration.
Locations of the Four Corners Power Plant (4CPP) and San Juan Generating Station (SJGS) are shown in orange.
Approximate extent of project area is outlined in blue.

Figure 7-6. Composite of Cumulative Annual $PM_{2.5}$ Modeled Impacts for 2001-2003, for Scenario 1.

7.1.1.4 1-Hour, 3-Hour, 24-Hour, and Annual SO_2 Impacts

Class I Areas

Incremental 1-hour, 3-hour, 24-hour, and annual SO_2 impacts for Scenario 1 are presented below in Table 7-28 at the end of this subsection. Incremental impacts at Class I areas are very small due to the magnitude of project-related SO_2 emissions.

Cumulative 1-hour, 3-hour, 24-hour and annual SO_2 impacts for Scenario 1 are presented in Table 7-29. This table shows that the maximum 1-hour SO_2 impact is below the standard at Class I areas with the exception of Bandelier, Canyonlands, Mesa Verde, and Weminuche. While the actual 1-hour standard is based on the value of the 99th percentile day, CALPUFF's post-processors are not currently set up to compute that value. Therefore, several additional analyses were performed to evaluate whether modeled 1-hour SO_2 impacts comply with the standard. Table 7-30 presents the results of the additional analyses performed to determine whether modeled 1-hour SO_2 impacts comply with the new standard. This table shows that while the maximum 1-hour impact is high, the 2nd, 3rd, and 4th highest impacts at all Class I receptors decrease such that the 99th percentile, or 4th highest day, is below the standard. The Class I area with the highest cumulative SO_2 impacts was Mesa Verde. Highest second-highest cumulative 3-hour SO_2 impacts ranged from 7.97 $\mu g/m^3$ at West Elk Wilderness to 132 $\mu g/m^3$ at Mesa Verde.

Highest second-highest cumulative 24-hour SO_2 impacts ranged from 2.40 mg/m^3 at West Elk to 25.3 $\mu g/m^3$ at Mesa Verde. These cumulative impacts are well below the 24-hour NAAQS for SO_2 of 365 $\mu g/m^3$.

Maximum annual cumulative SO_2 impacts ranged from 0.182 $\mu g/m^3$ at West Elk to 2.53 $\mu g/m^3$ at Mesa Verde. These impacts are well below the annual NAAQS for SO_2 of 80 $\mu g/m^3$, and except for Mesa Verde, these cumulative impacts are also well below the annual Class I PSD increment for SO_2 of 2 $\mu g/m^3$.

Again, as the modeled SO_2 inventory does not represent a vigorous PSD increment analysis, these results do not indicate that Class I PSD increments are exceeded at any particular Class I area.

Class II Areas of Interest

Table 7-31 shows the incremental SO_2 impacts for Scenario 1 at the Class II areas of interest. Because the project-specific SO_2 emissions are small under Scenario 1, the incremental SO_2 impacts are also small at the Class II areas of interest.

Table 7-32 shows the cumulative SO_2 impacts for Scenario 1 at the Class II areas of interest. This table shows that the maximum 1-hour SO_2 impact is above the standard at Canyon de Chelly, Canyons of the Ancients, Chaco Culture, and Natural Bridges. However, because the 1-hour standard is based on the 99th percentile value, or the 4th highest day, additional analyses were performed to deduce whether modeled impacts at these sites exceed the standard. These additional analyses, presented in Table 7-33, show that the 4th highest day is below the 1-hour SO_2 standard for these sites. HSH 3-hour SO_2 impacts ranged from 67.2 $\mu g/m^3$ at Hovenweep to

103.5 μg/m^3 at Canyon de Chelly. Predicted SO_2 impacts are below the Class II PSD Increment for 3-hour SO_2 of 512 μg/m^3.

HSH cumulative 24-hour SO_2 impacts for Scenario 1 ranged from 11.8 μg/m^3 at Natural Bridges to 21.9 μg/m^3 at Canyon de Chelly. These cumulative impacts are also below the 24-hour NAAQS for SO_2 of 365 μg/m^3, as well as below the Class II PSD Increment for 24-hour SO_2 of 91 μg/m^3.

Maximum annual SO_2 impacts at these Class II areas under Scenario 1 ranged from 1.01 μg/m^3 at Natural Bridges to 2.66 μg/m^3 at Hovenweep. These impacts are below the NAAQS of 80 μg/m^3, and also well below the Class II PSD increment for annual SO_2 of 20 μg/m^3.

Table 7-28

Incremental 1-Hour, 3-Hour, 24-Hour, and Annual SO_2 Impacts at Class I Areas for Scenario 1 for Each Year of Meteorological Data Modeled

Class I Area	Maximum 1-Hour SO_2 Impacts (μg/m^3)			Highest Second-Highest 3-Hour SO_2 Impacts (μg/m^3)		
	2001	**2002**	**2003**	**2001**	**2002**	**2003**
Arches	0.01728	0.02484	0.01785	0.01200	0.01245	0.00980
Bandelier	0.03615	0.04258	0.03439	0.00923	0.00483	0.01017
Black Canyon of the Gunnison	0.11850	0.05396	0.07683	0.02600	0.01553	0.02534
Canyonlands	0.04119	0.02339	0.03192	0.01570	0.01437	0.01427
LaGarita	0.01829	0.10533	0.22496	0.00711	0.01685	0.01531
Mesa Verde	0.28535	0.24732	0.33921	0.09322	0.14685	0.12086
San Pedro Parks	0.08142	0.03621	0.03660	0.01644	0.01650	0.01413
Weminuche	0.09538	0.20003	0.07099	0.02044	0.03863	0.01835
West Elk	0.04728	0.08439	0.11044	0.01578	0.01745	0.03186

Class I Area	Highest Second-Highest 24-Hour SO_2 Impacts (μg/m^3)			Maximum Annual SO_2 Impacts (μg/m^3)		
	2001	**2002**	**2003**	**2001**	**2002**	**2003**
Arches	0.00372	0.00216	0.00311	0.000488	0.000416	0.000327
Bandelier	0.00147	0.00107	0.00240	0.000079	0.000081	0.000077
Black Canyon of the Gunnison	0.00552	0.00290	0.00567	0.000288	0.000271	0.000301
Canyonlands	0.00520	0.00360	0.00429	0.000568	0.000473	0.000471
LaGarita	0.00146	0.00360	0.00305	0.000162	0.000251	0.000216
Mesa Verde	0.03226	0.04779	0.03732	0.010595	0.012440	0.012042
San Pedro Parks	0.00283	0.00340	0.00216	0.000147	0.000152	0.000152
Weminuche	0.00697	0.01023	0.00478	0.000501	0.000718	0.000571
West Elk	0.00347	0.00317	0.00477	0.000207	0.000193	0.000236

Table 7-29

Cumulative 1-Hour, 3-Hour, 24-Hour, and Annual SO_2 Impacts at Class I Areas for Scenario 1 for Each Year of Meteorological Data Modeled

	Maximum 1-Hour SO_2 Impacts ($\mu g/m^3$)			Highest Second-Highest 3-Hour SO_2 Impacts ($\mu g/m^3$)		
Class I Area	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**
Arches	52.07	45.71	134.88	19.95	14.68	49.61
Bandelier	88.99	208.12	103.91	33.44	70.14	33.53
Black Canyon of the Gunnison	40.86	36.08	69.93	8.48	8.84	16.73
Canyonlands	154.14	257.06	112.41	42.04	67.50	32.19
LaGarita	65.49	64.45	102.45	20.82	22.57	28.29
Mesa Verde	549.84	808.74	443.66	131.83	98.58	115.37
San Pedro Parks	49.76	101.12	79.81	18.18	37.06	28.05
Weminuche	394.66	208.54	181.25	33.05	44.46	46.29
West Elk	605.75	33.32	28.13	7.97	5.46	7.21

	Highest Second-Highest 24-Hour SO_2 Impacts ($\mu g/m^3$)			Maximum Annual SO_2 Impacts ($\mu g/m^3$)		
Class I Area	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**
Arches	4.25	2.99	7.64	0.288	0.196	0.202
Bandelier	5.68	8.84	4.82	0.655	0.659	0.588
Black Canyon of the Gunnison	2.79	1.45	3.24	0.200	0.199	0.201
Canyonlands	8.10	9.03	6.99	0.628	0.576	0.443
LaGarita	3.41	3.86	5.55	0.206	0.235	0.232
Mesa Verde	25.00	25.27	21.24	2.526	2.443	2.056
San Pedro Parks	4.49	7.30	7.88	0.602	0.764	0.751
Weminuche	8.40	10.13	9.15	0.457	0.549	0.542
West Elk	1.74	1.36	2.40	0.182	0.137	0.137

Table 7-30

Maximum Cumulative 1-Hour SO_2 Impacts for Modeled Class I Sites for Scenario 1 that Exceeded the 1-Hour SO_2 Standard of 188 $\mu g/m^3$

Site	**Year**	**Maximum**	**2nd**	**3rd**	**4th**	**Max # of exceedances at any receptor**
Bandelier	2001			no exceedances		
	2002	208.12	122.74	105.16	98.81	1
	2003			no exceedances		
Canyonlands	2001			no exceedances		
	2002	257.06	143.93	125.02	94.27	1
	2003			no exceedances		
Mesa Verde	2001	549.84	309.22	223.80	187.09	3
	2002	808.74	177.89	153.60	135.87	1
	2003	443.66	200.93	166.23	158.28	2
Weminuche	2001	394.66	97.92	75.59	50.87	1
	2002			no exceedances		
	2003			no exceedances		
West Elk	2001	605.75	31.49	21.66	12.43	1
	2002			no exceedances		
	2003			no exceedances		

Table 7-31

Incremental 1-Hour, 3-Hour, 24-Hour, and Annual SO_2 Impacts at Class II Areas of Interest for Scenario 1 for Each Year of Meteorological Data Modeled

	Maximum 1-Hour SO_2 Impacts (µg/m^3)			**Highest Second-Highest 3-Hour SO_2 Impacts (µg/m^3)**		
Class II Area	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**
Canyon de Chelly	0.02612	0.02276	0.00648	0.01207	0.00500	0.00313
Canyons of the Ancients	0.08631	0.06967	0.07188	0.03987	0.03674	0.04180
Chaco Culture	0.01014	0.00745	0.00680	0.00377	0.00389	0.00446
Hovenweep	0.03598	0.05104	0.04495	0.01856	0.02690	0.02465
Natural Bridges	0.01358	0.01296	0.01330	0.00976	0.00873	0.00901

	Highest Second-Highest 24-Hour SO_2 Impacts (µg/m^3)			**Maximum Annual SO_2 Impacts (µg/m^3)**		
Class II Area	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**
Canyon de Chelly	0.00261	0.00170	0.00102	0.000071	0.000055	0.000058
Canyons of the Ancients	0.01748	0.01155	0.01059	0.003786	0.003698	0.003905
Chaco Culture	0.00123	0.00115	0.00103	0.000079	0.000076	0.000076
Hovenweep	0.00387	0.00467	0.00398	0.000600	0.000593	0.000646
Natural Bridges	0.00277	0.00251	0.00225	0.000230	0.000212	0.000240

Table 7-32

Cumulative 1-Hour, 3-Hour, 24-Hour, and Annual SO_2 Impacts at Class II Areas of Interest for Scenario 1 for Each Year of Meteorological Data Modeled

	Maximum 1-Hour SO_2 Impacts ($\mu g/m^3$)			**Highest Second-Highest 3-Hour SO_2 Impacts ($\mu g/m^3$)**		
Class II Area	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**
Canyon de Chelly	351.9	336.0	454.1	97.8	103.5	99.0
Canyons of the Ancients	790.9	554.1	366.3	100.3	70.2	75.1
Chaco Culture	594.2	184.4	294.6	89.0	67.6	68.6
Hovenweep	107.1	99.3	93.0	59.0	58.6	67.2
Natural Bridges	97.0	161.3	238.5	37.0	67.3	42.5

	Highest Second-Highest 24-Hour SO_2 Impacts ($\mu g/m^3$)			**Maximum Annual SO_2 Impacts ($\mu g/m^3$)**		
Class II Area	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**
Canyon de Chelly	21.9	19.0	18.9	1.078	0.923	1.087
Canyons of the Ancients	8.1	13.1	15.9	2.225	1.958	1.831
Chaco Culture	18.3	14.9	17.1	1.769	1.819	1.740
Hovenweep	15.4	12.3	17.4	2.660	2.399	2.213
Natural Bridges	11.8	9.7	9.8	1.015	0.777	0.710

Table 7-33

Maximum Cumulative 1-Hour SO_2 Impacts for Modeled Class II Sites for Scenario 1 that Exceeded the 1-Hour SO_2 Standard of 188 $\mu g/m^3$

Site	Year	Maximum	2nd	3rd	4th	Max # of exceedances at any receptor
Canyon de Chelly	2001	351.85	215.60	161.94	147.99	2
	2002	336.00	295.02	234.09	209.45*	4
	2003	454.07	222.54	176.70	119.33	2
Canyons of the Ancients	2001	790.91	235.33	180.18	119.98	2
	2002	554.11	139.95	93.63	85.24	1
	2003	366.33	156.55	121.01	119.29	1
Chaco Culture	2001	594.21	215.41	127.16	100.94	2
	2002	no exceedances				
	2003	294.57	137.04	102.15	98.17	1
Natural Bridges	2002	no exceedances				
	2003	no exceedances				
	2003	238.46	223.48	141.85	95.21	2

* Canyon de Chelly's highest and 2nd highest exceedances occur on the same day. The 5th highest was deduced to be below 200 by examining top 50 impacts.

Class II Fine Grid within Project Area

Table 7-34 shows the incremental SO_2 impacts for the fine grid receptors within the immediate project area.[4] The incremental SO_2 impacts are small because the project-related SO_2 emissions are also small.

[4] The new 1-hour SO_2 standard was implemented after all the modeling had been performed. SJPL requested that 1-hour impacts be calculated at Class I areas and selected Class II areas but did not require ARS to evaluate 1-hour impacts at the fine and coarse grid receptors.

Table 7-34

Incremental 3-Hour, 24-Hour, and Annual SO_2 Impacts
within the Fine Grid of Other Class II Receptors
within the Project Area for Scenario 1

Rank and Averaging Period	Year	SO_2 Impact ($\mu g/m^3$)	Receptor Location			
			Lambert-Conformal Coordinates		Longitude/Latitude Coordinates	
HSH 3-Hour	2001	0.870	124	180	108.5549	37.6472
	2002	0.910	148	156	108.5649	37.2046
	2003	0.970	124	180	108.5549	37.6472
HSH 24-Hour	2001	0.328	124	180	108.5549	37.6472
	2002	0.365	124	180	108.5549	37.6472
	2003	0.368	148	156	108.5649	37.2046
Maximum Annual	2001	0.139	124	180	108.5549	37.6472
	2002	0.157	124	180	108.5549	37.6472
	2003	0.156	124	180	108.5549	37.6472

Table 7-35 shows the cumulative SO_2 impacts for the fine grid receptors within the immediate project area. The highest second-highest cumulative 3-hour SO_2 impact was 473 $\mu g/m^3$, the highest second-highest 24-hour SO_2 impact was 78.1 μ/m^3, and the maximum annual SO_2 impact on the fine grid was 8.74 $\mu g/m^3$. These impacts are all well below their respective NAAQS.[5] For each averaging period, maximum SO_2 impacts on the fine grid all occurred along the southernmost row of receptors, suggesting that the dominant source of SO_2 within the domain may be outside the immediate project area to the south.

[5] The 3-hour ambient air quality standard has been replaced by the new 1-hour SO_2 standard. However, there is no new PSD increment for 1-hour SO_2, so the 3-hour impacts are retained here for purposes of comparison to the 3-hour PSD increment.

Table 7-35

Cumulative 3-Hour, 24-Hour, and Annual SO_2 Impacts within the Fine Grid of Other Class II Receptors within the Project Area for Scenario 1

Rank and Averaging Period	Year	SO_2 Impact ($\mu g/m^3$)	Receptor Location			
			Lambert-Conformal Coordinates		Longitude/Latitude Coordinates	
HSH 3-Hour	2001	295	116	108	108.6621	36.9848
	2002	450	148	108	108.2932	36.9791
	2003	473	140	108	108.3854	36.9807
HSH 24-Hour	2001	56.9	116	108	108.6621	36.9848
	2002	75.2	148	108	108.2932	36.9791
	2003	78.1	140	108	108.3854	36.9807
Maximum Annual	2001	8.74	76	108	109.1234	36.9898
	2002	7.91	76	108	109.1234	36.9898
	2003	7.79	76	108	109.1234	36.9898

Class II Coarse Grid within Modeling Domain

Incremental 3-hour, 24-hour, and annual SO_2 impacts within the coarse grid of Class II receptors outside the immediate development area are presented below in Table 7-36. Compared to the fine grid, incremental SO_2 impacts for the coarse grid are less as these receptors are more distant from the project area. These impacts are also minimal due to the small magnitude of project-specific emissions.

Cumulative 3-hour, 24-hour, and annual SO_2 impacts within the coarse grid of Class II receptors outside the immediate development area are presented in Table 7-37. The highest second-highest 3-hour SO_2 impact was 2,745 $\mu g/m^3$, the HSH 24-hour SO_2 impact was 469 $\mu g/m^3$, and the maximum annual SO_2 impact was 48.0 $\mu g/m^3$. The modeled 24-hour impacts exceed the NAAQS, but the annual impact is below its NAAQS. The location of these coarse grid impacts is due south of Mesa Verde, in the same spot as the maximum coarse grid NO_X and PM_{10} impacts, which is near the Four Corners Power Plant (which emits over 27,000 tons per year of SO_2), and near the San Juan Generating Station (which emits over 32,000 tons per year of SO_2). It is important to note that the Gothic Shale and Paradox Conventional projects will not emit appreciable SO_2; therefore, these modeled NAAQS exceedances for SO_2 are wholly due to existing and/or other RFD and not due to the projects under review for this EIS. These cumulative impacts do not signify a violation. Rather they show that cumulative impacts from existing sources and the other RFD may pose a problem and need to be carefully examined by the regulatory agencies prior to issuing permits for new construction in the area.

Table 7-36

Incremental 3-Hour, 24-Hour, and Annual SO_2 Impacts
within the Coarse Grid of Other Class II Receptors
within the Modeling Domain for Scenario 1

Rank and Averaging Period	Year	SO_2 Impact ($\mu g/m^3$)	Receptor Location			
			Lambert-Conformal Coordinates		Longitude/Latitude Coordinates	
HSH 3-Hour	2001	0.0598	78	272	109.0786	38.5031
	2002	0.0626	78	272	109.0786	38.5031
	2003	0.1003	78	272	109.0786	38.5031
HSH 24-Hour	2001	0.0155	78	272	109.0786	38.5031
	2002	0.0146	78	272	109.0786	38.5031
	2003	0.0186	78	272	109.0786	38.5031
Maximum Annual	2001	0.00282	78	248	109.0818	38.2813
	2002	0.00323	78	248	109.0818	38.2813
	2003	0.00272	78	248	109.0818	38.2813

Table 7-37

Cumulative 3-Hour, 24-Hour, and Annual SO_2 Impacts
within the Coarse Grid of Other Class II Receptors
within the Modeling Domain for Scenario 1

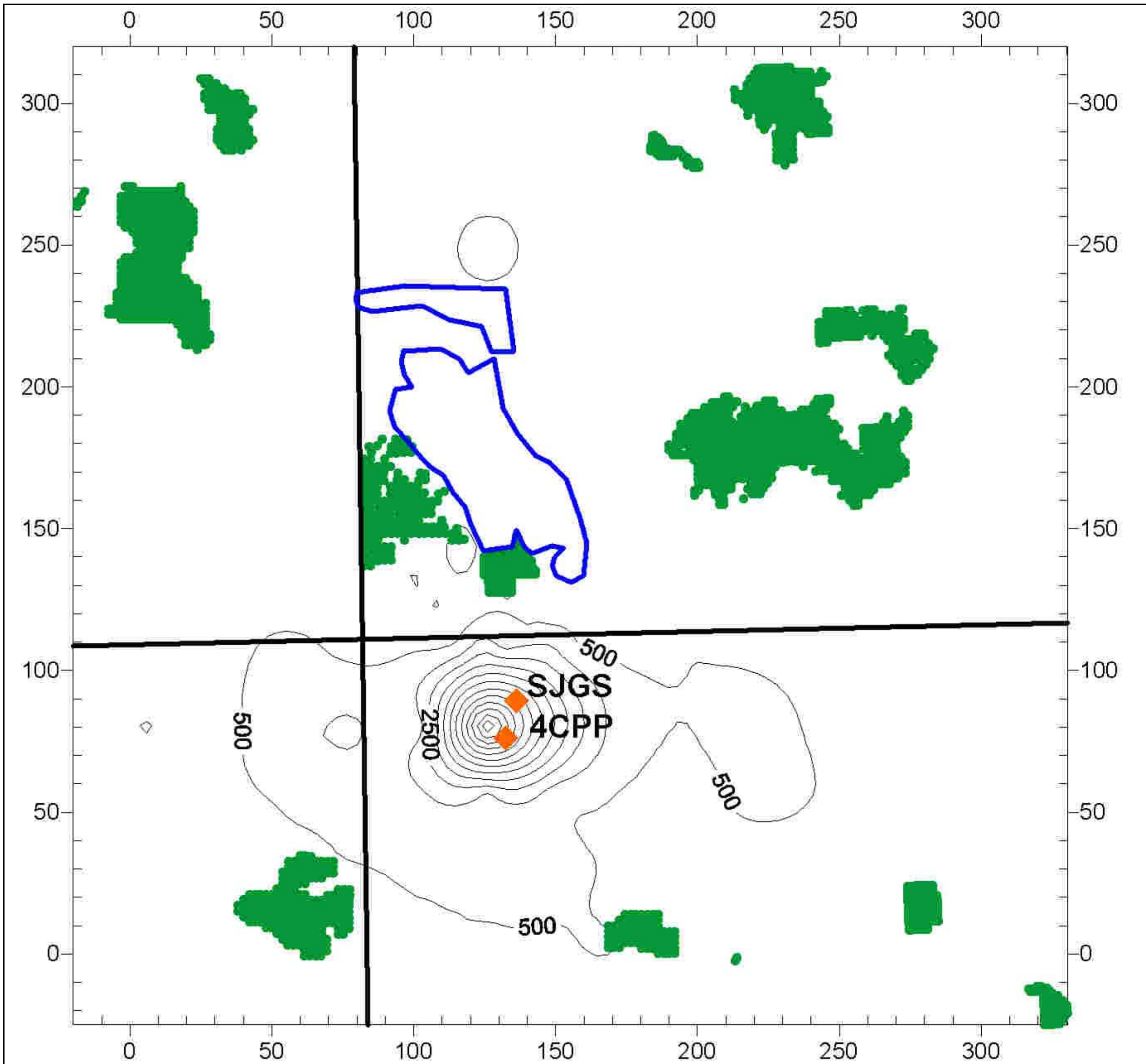
Rank and Averaging Period	Year	SO_2 Impact ($\mu g/m^3$)	Receptor Location			
			Lambert-Conformal Coordinates		Longitude/Latitude Coordinates	
HSH 3-Hour	2001	2745	126	80	108.5527	36.7253
	2002	2646	126	80	108.5527	36.7253
	2003	1995	126	80	108.5527	36.7253
HSH 24-Hour	2001	383	126	80	108.5527	36.7253
	2002	469	126	80	108.5527	36.7253
	2003	318	126	80	108.5527	36.7253
Maximum Annual	2001	47.2	126	80	108.5527	36.7253
	2002	58.3	126	80	108.5527	36.7253
	2003	48.0	126	80	108.5527	36.7253

Despite the prediction of SO_2 concentrations in excess of the NAAQS, these results should be viewed with caution. First, CALPUFF is not the preferred air quality model for receptors in the near-field (within 50 km of the source). For near-field impacts, AERMOD is the preferred air quality model according to the EPA Guidance on Air Quality Models. Also, in this study, emission sources with similar stack parameters were combined in order to keep the number of sources modeled manageable. Therefore, the Four Corners and San Juan Power Plants were each modeled as a single stack. This modeling methodology results in conservative impact estimates, especially in the near-field. So, although elevated SO_2 concentrations would be expected in the vicinity of the Four Corners and San Juan Power Plants, the accuracy of CALPUFF predictions that show possible NAAQS violations is less certain.

Figures 7-7 through 7-10 are composites, depicting Lambert-Conformal coordinates of cumulative 1-hour, 3-hour, 24-hour, and annual SO_2 impacts, respectively, and show that the highest impacts are outside the project area in northwestern New Mexico, near the San Juan and Four Corners Plants.

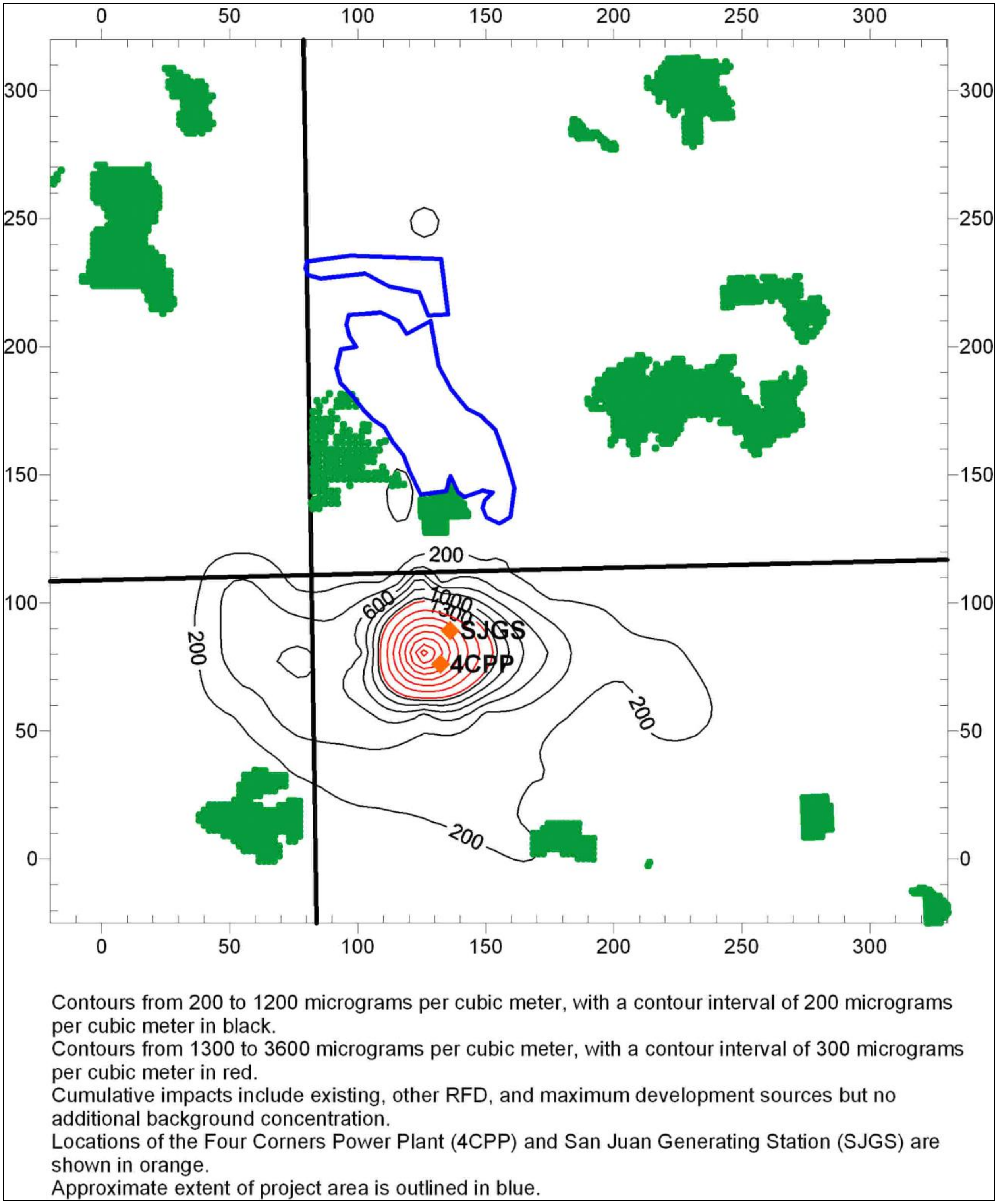
Conclusion

Modeled cumulative SO_2 impacts are predicted to exceed the 24-hour NAAQS in northwestern New Mexico, near the San Juan and Four Corners Power Plants, but the SJPLC development projects under review for this EIS do not contribute to these predicted exceedances. However, as this modeling study was not designed to address near-field impacts from San Juan and Four Corners, these results should not be used to specifically address SO_2 attainment in northwest New Mexico.

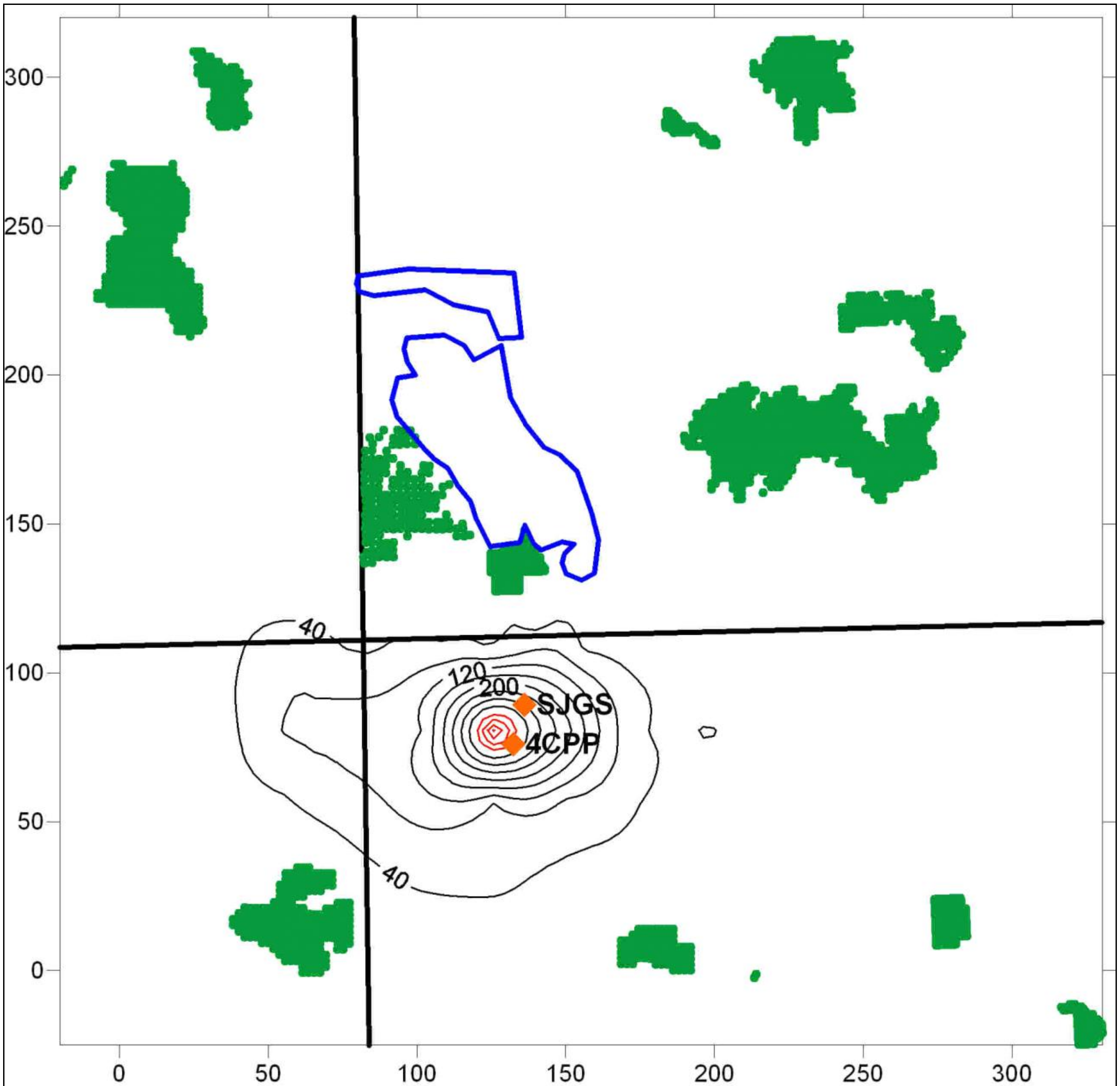


Contours from 500 to 12500 micrograms per cubic meter. Contour interval is 1000 micrograms per cubic meter.
Cumulative impacts include existing, other RFD, and maximum development sources but no additional background concentration.
Locations of the Four Corners Power Plant (4CPP) and San Juan Generating Station (SJGS) are shown in orange.
Approximate extent of project area is outlined in blue.

Figure 7-7. Composite of Cumulative Maximum 1-Hour SO_2 Modeled Impacts for 2001-2003, for Scenario 1.

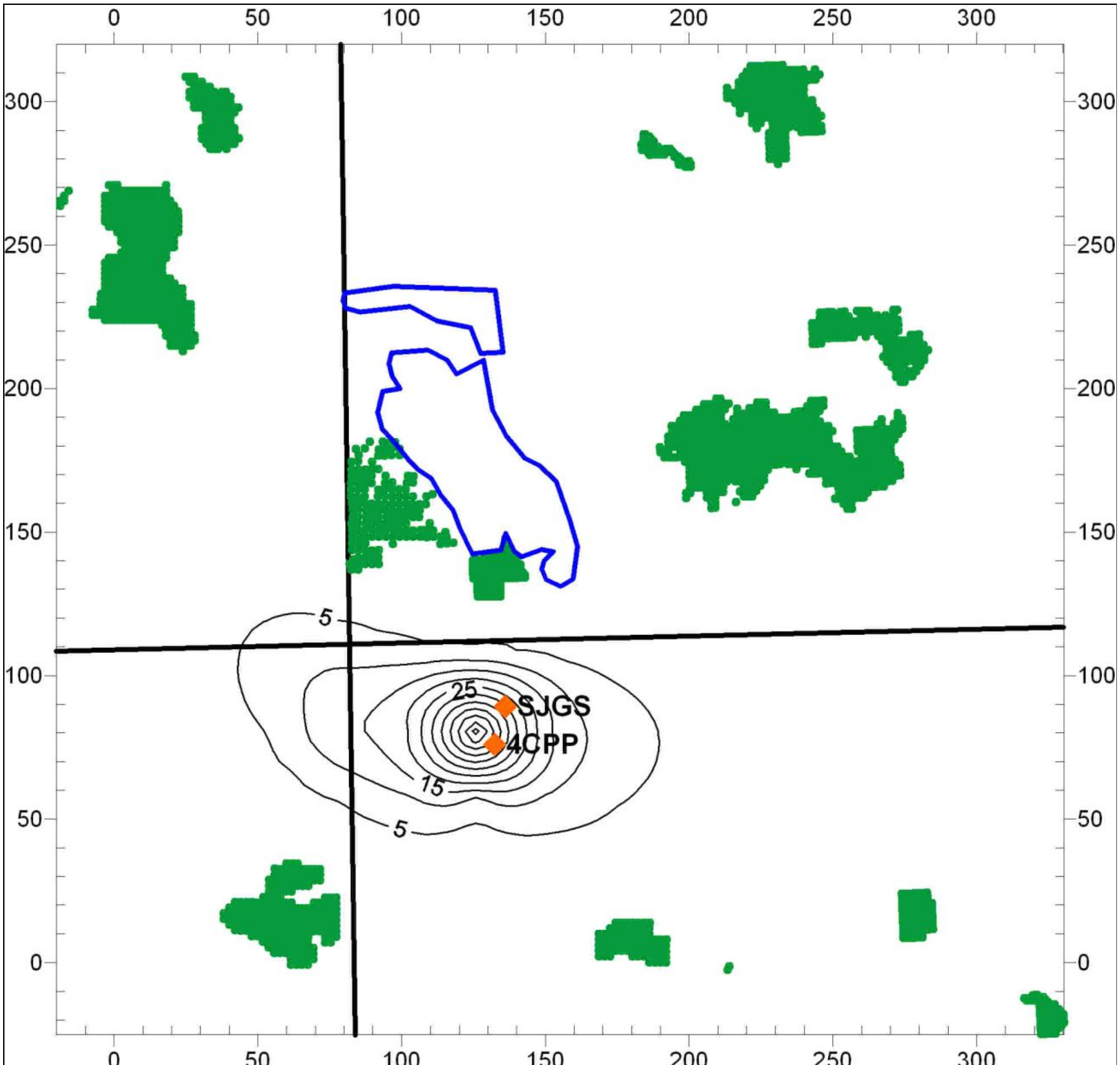


7-8. Composite of Cumulative Highest Second-Highest 3-Hour SO_2 Modeled Impacts for 2001-2003, for Scenario 1.



Contours from 40 to 320 micrograms per cubic meter in black, with a contour interval of 40 micrograms per cubic meter.
Contours from 365 to 255 micrograms per cubic meter (above the 24-hour NAAQS for SO2) in red with a contour interval of 30 micrograms per cubic meter.
Cumulative impacts include existing, other RFD, and maximum development sources but no additional background concentration.
Locations of the Four Corners Power Plant (4CPP) and San Juan Generating Station (SJGS) are shown in orange.
Approximate extent of project area is outlined in blue.

Figure 7-9. Composite of Cumulative Highest Second-Highest 24-Hour SO_2 Modeled Impacts for 2001-2003 for Scenario 1.



Contours from 5 to 55 micrograms per cubic meter, contour interval of 5 micrograms per cubic meter.
Cumulative impacts include existing, other RFD, and maximum development sources but no additional background concentration.
Locations of the Four Corners Power Plant (4CPP) and San Juan Generating Station (SJGS) are shown in orange.
Approximate extent of project area is outlined in blue.

Figure 7-10. Composite of Cumulative Annual SO_2 Modeled Impacts for 2001-2003, for Scenario 1.

7.1.2 Deposition

This section provides a summary of deposition impacts and includes both incremental and cumulative impacts. For Scenario 1, incremental impacts represent the Gothic Shale wells and Paradox Conventional wells on the unleased land only, or the difference between Scenario 1 and Scenario 2. Incremental deposition impacts are compared to the FLM threshold of 0.005 kilograms per hectare per year (kg/ha-yr). This threshold is used as a trigger for further FLM analysis, rather than an adverse impact threshold. Project-specific impacts below this threshold are considered insignificant. An impact above the 0.005 kg/ha-yr threshold does not necessarily indicate a problem, only that it could require further study, taking the sensitivity of local soils, vegetation, and wildlife into account.

Cumulative deposition impacts are defined as the total deposition arising from all sources, which include development included under Scenario 1, existing sources, and the proposed other RFD projects.

In addition to the Class I and II receptors described in Section 6.0, deposition was evaluated at four (4) high mountain lakes within the Weminuche Wilderness: Big Eldorado Lake, Lower Sunlight Lake, Upper Sunlight Lake, and Upper Grizzly Lake.

7.1.2.1 Nitrogen Deposition Impacts

Class I Areas

Table 7-38 presents incremental nitrogen deposition impacts from Scenario 1 at the Class I areas of interest. Incremental impacts ranged from 0.000213 kg./ha-yr at Bandelier to 0.02285 kg/ha-yr at Mesa Verde. Impacts exceed the “West DAT” 0.005 kg/ha-yr FLM significance threshold (FLAG, 2009) only at Mesa Verde, which is within a few kilometers of some of the proposed well locations. The 0.005 kg/ha-yr significance threshold is typically used for individual sources and is a valid threshold for assessing incremental project effects. Exceedances serve as a trigger for further FLM analysis, rather than an adverse impact threshold.

Cumulative nitrogen deposition impacts under Scenario 1 for the Class I areas are shown below in Table 7-39. Cumulative impacts ranged from 0.100 kg/ha-yr at West Elk to 1.60 kg/ha-yr at Mesa Verde. These figures estimate the total deposition from all existing and proposed development. Even at Mesa Verde, the project-specific nitrogen deposition would increase the total deposition by only one percent.

Table 7-38

Incremental Nitrogen Deposition at Class I Areas for Scenario 1
for Each Year of Meteorological Data Modeled

Class I Area	Incremental Nitrogen Deposition (kg/ha-yr)		
	2001	**2002**	**2003**
Arches	0.000751	0.000627	0.000568
Bandelier	0.000118	0.000108	0.000213
Black Canyon of the Gunnison	0.000464	0.000383	0.000437
Canyonlands	0.000937	0.000756	0.000895
LaGarita	0.000330	0.000473	0.000427
Mesa Verde	0.013993	0.022852	0.022831
San Pedro Parks	0.000241	0.000196	0.000303
Weminuche	0.001455	0.001403	0.001345
West Elk	0.000342	0.000310	0.000359

Table 7-39

Cumulative Nitrogen Deposition at Class I Areas for Scenario 1
for Each Year of Meteorological Data Modeled

Class I Area	Nitrogen Deposition (kg/ha-yr)		
	2001	**2002**	**2003**
Arches	0.128	0.090	0.080
Bandelier	0.429	0.372	0.371
Black Canyon of the Gunnison	0.123	0.096	0.098
Canyonlands	0.310	0.245	0.239
LaGarita	0.166	0.141	0.133
Mesa Verde	1.604	1.517	1.462
San Pedro Parks	0.526	0.523	0.514
Weminuche	0.404	0.471	0.440
West Elk	0.100	0.093	0.076

Class II Areas of Interest

The incremental nitrogen deposition impacts presented in Table 7-40. These impacts ranged from 0.000114 kg/ha-yr at Canyon de Chelly to 0.006911 kg/ha-yr at Canyons of the Ancients. Nitrogen deposition impacts do not exceed the 0.005 kg/ha-yr threshold at the Class II areas of interest.

Table 7-40

Incremental Nitrogen Deposition at Class II Areas of Interest for Scenario 1
for Each Year of Meteorological Data Modeled

	Incremental Nitrogen Deposition (kg/ha-yr)		
Class II Area	**2001**	**2002**	**2003**
Canyon de Chelly	0.000072	0.000058	0.000114
Canyons of the Ancients	0.006743	0.006135	0.006911
Chaco Culture	0.000155	0.000119	0.000122
Hovenweep	0.000602	0.000612	0.000852
Natural Bridges	0.000331	0.000312	0.000439

Cumulative nitrogen deposition impacts for the Class II areas of interest are shown below in Table 7-41. Impacts ranged from 0.382 kg/ha-yr at Natural Bridges to 2.17 kg/ha-yr at Canyons of the Ancients.

Table 7-41

Cumulative Nitrogen Deposition at Class II Areas of Interest for Scenario 1
for Each Year of Meteorological Data Modeled

	Nitrogen Deposition (kg/ha-yr)		
Class II Area	**2001**	**2002**	**2003**
Canyon de Chelly	0.413	0.307	0.414
Canyons of the Ancients	2.173	2.062	2.160
Chaco Culture	0.905	0.948	1.063
Hovenweep	0.585	0.490	0.567
Natural Bridges	0.382	0.286	0.307

Sensitive Mountain Lakes within Weminuche

Incremental nitrogen deposition for four (4) sensitive mountain lakes within the Weminuche Wilderness are presented in Table 7-42. Maximum incremental impacts range from 0.000691 kg/ha-yr at Big Eldorado Lake to 0.000955 kg/ha-yr at Upper Grizzly Lake. These impacts are all well below the 0.005 kg/ha-yr FLM deposition threshold.

Table 7-42

Incremental Nitrogen Deposition Impacts
at High Mountain Lakes in Weminuche for Scenario 1
for Each Year of Meteorological Data Modeled

Mountain Lake	Nitrogen Deposition (kg/ha-yr)		
	2001	**2002**	**2003**
Big Eldorado Lake	0.000691	0.000694	0.000823
Lower Sunlight Lake	0.000815	0.000830	0.000943
Upper Sunlight Lake	0.000800	0.000818	0.000933
Upper Grizzly Lake	0.000828	0.000843	0.000955

Cumulative nitrogen deposition impacts for Scenario 1 are presented in Table 7-43. Modeled impacts ranged from 0.176 kg/ha-yr at Big Eldorado Lake to 0.221 kg/ha-yr at Upper Grizzly Lake.

Table 7-43

Cumulative Deposition Impacts
at High Mountain Lakes in Weminuche for Scenario 1
for Each Year of Meteorological Data Modeled

Mountain Lake	Nitrogen Deposition (kg/ha-yr)		
	2001	**2002**	**2003**
Big Eldorado Lake	0.176	0.172	0.174
Lower Sunlight Lake	0.204	0.216	0.217
Upper Sunlight Lake	0.198	0.209	0.211
Upper Grizzly Lake	0.207	0.220	0.221

Conclusion

Incremental nitrogen deposition impacts at all modeled receptors were below the 0.005 kg/ha-yr FLM threshold, except at Mesa Verde. Here, the incremental deposition would increase the total nitrogen deposition by only one percent.

7.1.2.2 Sulfur Deposition Impacts

As was noted earlier, emissions of sulfur containing compounds for the projects studied were very low. Operational SO_2 emissions would be nearly negligible because the well head engines do not emit appreciable SO_2. However, construction emissions include some SO_2, so the incremental sulfur deposition impacts are not zero.

Class I Areas

Incremental sulfur deposition impacts for the Class I areas under Scenario 1 are shown in Table 7-44. Incremental impacts ranged from 0.000068 kg/ha-yr at Bandelier to 0.006196 at Mesa Verde. Mesa Verde was the only site with impacts exceeding the 0.005 kg/ha-yr FLM deposition threshold.

Table 7-44

Incremental Sulfur Deposition at Class I Areas for Scenario 1
for Each Year of Meteorological Data Modeled

	Sulfur Deposition (kg/ha-yr)		
Class I Area	**2001**	**2002**	**2003**
Arches	0.000238	0.000191	0.000173
Bandelier	0.000058	0.000056	0.000068
Black Canyon of the Gunnison	0.000163	0.000138	0.000156
Canyonlands	0.000291	0.000244	0.000294
LaGarita	0.000123	0.000171	0.000147
Mesa Verde	0.005634	0.005985	0.006196
San Pedro Parks	0.000099	0.000088	0.000106
Weminuche	0.000514	0.000552	0.000515
West Elk	0.000127	0.000112	0.000131

Cumulative sulfur deposition impacts for the Class I areas under Scenario 1 are shown in Table 7-45. Impacts ranged from 0.128 kilograms per hectare per year (kg/ha-yr) at West Elk to 1.65 kg/ha-yr at Mesa Verde.

Table 7-45

Cumulative Sulfur Deposition at Class I Areas for Scenario 1
for Each Year of Meteorological Data Modeled

Class I Area	Sulfur Deposition (kg/ha-yr)		
	2001	**2002**	**2003**
Arches	0.150	0.116	0.098
Bandelier	0.496	0.454	0.416
Black Canyon of the Gunnison	0.157	0.130	0.145
Canyonlands	0.401	0.370	0.314
LaGarita	0.184	0.186	0.175
Mesa Verde	1.653	1.463	1.435
San Pedro Parks	0.499	0.531	0.511
Weminuche	0.332	0.502	0.405
West Elk	0.128	0.112	0.105

Class II Areas of Interest

Incremental sulfur deposition impacts for the Class II areas of interest are shown below in Table 7-46. Impacts ranged from 0.000043 kg/ha-yr at Canyon de Chelly to 0.001967 kg/ha-yr at Canyons of the Ancients.

Table 7-46

Incremental Sulfur Deposition at Class II Areas for Scenario 1
for Each Year of Meteorological Data Modeled

Class II Area	Sulfur Deposition (kg/ha-yr)		
	2001	**2002**	**2003**
Canyon de Chelly	0.000029	0.000023	0.000043
Canyons of the Ancients	0.001779	0.001667	0.001967
Chaco Culture	0.000052	0.000043	0.000048
Hovenweep	0.000220	0.000217	0.000317
Natural Bridges	0.000127	0.000115	0.000166

Cumulative sulfur deposition impacts for the Class II areas of interest are shown below in Table 7-47. Impacts ranged from 0.501 kg/ha-yr at Canyon de Chelly to 1.16 kg/ha-yr at Canyons of the Ancients.

Table 7-47

Cumulative Sulfur Deposition at Class II Areas of Interest for Scenario 1
for Each Year of Meteorological Data Modeled

Class II Area	Sulfur Deposition (kg/ha-yr)		
	2001	**2002**	**2003**
Canyon de Chelly	0.481	0.429	0.501
Canyons of the Ancients	1.157	1.095	1.154
Chaco Culture	0.609	0.624	0.579
Hovenweep	0.761	0.665	0.758
Natural Bridges	0.549	0.458	0.450

Sensitive Mountain Lakes within Weminuche

Incremental sulfur deposition for four (4) sensitive mountain lakes within the Weminuche Wilderness are presented in Table 7-48. Incremental sulfur deposition impacts are very small.

Table 7-48

Incremental Sulfur Deposition
at High Mountain Lakes at Weminuche for Scenario 1
for Each Year of Meteorological Data Modeled

Mountain Lake	Sulfur Deposition (kg/ha-yr)		
	2001	**2002**	**2003**
Big Eldorado Lake	0.000223	0.000252	0.000397
Lower Sunlight Lake	0.000273	0.000313	0.000480
Upper Sunlight Lake	0.000266	0.000306	0.000470
Upper Grizzly Lake	0.000278	0.000319	0.000487

Cumulative sulfur deposition for four (4) sensitive mountain lakes within the Weminuche Wilderness are presented below in Table 7-49. Impacts range from 0.229 kg/ha-yr at Big Eldorado Lake to 0.290 kg/ha-yr at Upper Grizzly Lake.

Table 7-49

Cumulative Sulfur Deposition
at High Mountain Lakes at Weminuche for Scenario 1
for Each Year of Meteorological Data Modeled

	Sulfur Deposition (kg/ha-yr)		
Mountain Lake	**2001**	**2002**	**2003**
Big Eldorado Lake	0.197	0.229	0.209
Lower Sunlight Lake	0.220	0.285	0.253
Upper Sunlight Lake	0.215	0.276	0.248
Upper Grizzly Lake	0.222	0.290	0.257

7.1.3 Visibility Impacts

Visibility impacts have been calculated using two different methods. “Method 2” is currently the preferred means of estimating visibility impacts under FLAG guidance. In Method 2, visibility calculations use ambient concentrations of the visibility precursor pollutants along with hourly relative humidity data, and the calculated percent change in extinction is compared to the standard FLAG “natural background” values for the western United States. Consistent with current FLM recommendations, Method 2 uses the average daily relative humidity, capped at 95%.

Proposed changes to FLAG guidance include switching to visibility “Method 6” (or a variation of “Method 6”), which computes extinction from speciated particulate measurements but applies monthly RH adjustment factors to sulfate and nitrate specific for each location. Extinction changes on the 8th highest day per year, which represents the 98th percentile, are compared to the 5% and 10% thresholds to address the significance of visibility impacts.

The following discussions of visibility impacts include the customary consideration of incremental impacts, where “Incremental Impacts” for Scenario 1 are only those from the development on currently unleased land. “Combined Incremental Impacts” refer to the changes from both Scenario 1 (development on currently unleased land) and Scenario 2 (development on lands in the project area that are already approved for leasing). In addition to the Class I and II receptors described in Section 6.0, visibility was evaluated at three (3) selected vistas in Colorado, Lizard Head Pass, Chalk Mountain, and Dolores Canyon Overlook.

It is important to realize that in the Four Corners region, a vast amount of existing sources already degrade visibility, and that the incremental impacts from individual projects, albeit small in many cases, are adding to existing degradation. Even though the visibility analysis for individual projects may show only a small, or even relatively insignificant, amount of visibility degradation when considered alone, when the impacts from all the existing and proposed sources are added together, the effects on visibility can be substantial. Therefore, SJPLC requested that the cumulative impacts from existing and other RFD be addressed in this study to provide FLMs, stakeholders and other interested parties a more complete picture of what could happen to visibility in these public areas.

This section also presents modeled cumulative visibility impacts from all future sources (i.e., currently existing, RFD, and the proposed Scenarios), and compares these results to existing visibility measurements at five IMPROVE sites within the modeling domain.

7.1.3.1 Method 2

Class I Areas

Table 7-50, presented at the end of this subsection, lists the estimated maximum change in extinction coefficient (b_{ext}) for Scenario 1, calculated using Method 2 for each Class I area. Maximum incremental visibility changes for Class I areas calculated using Method 2 ranged from 0.64% at Bandelier, to 8.34% at Mesa Verde. Mesa Verde was the only Class I site exhibiting an incremental extinction change greater than 5%.

Class II Areas of Interest

The estimated maximum change in b_{ext} for incremental Scenario 1 emissions at the Class II areas of interest, calculated using Method 2, is shown in Table 7-51. The only Class II area with an extinction change greater than 5% was Canyons of the Ancients. Maximum incremental visibility changes for these Class II areas ranged from a 1.12% at Natural Bridges National Monument, to 7.46% at Canyons of the Ancients.

Selected Vistas

The estimated maximum change in b_{ext} from incremental Scenario 1 emissions at the three (3) selected vistas in Colorado is shown below in Table 7-52. Applying visibility Method 2, Lizard Head Pass and Dolores Canyon Overlook had a predicted extinction change greater than 5%. At Lizard Head, impacts above 5% occurred on only one (1) day for the three (3) years modeled, and at Dolores Canyon Overlook, the incremental visibility impacts occurred on two (2) days during the three (3) years modeled.

Conclusion

For Scenario 1 incremental impacts, maximum extinction changes calculated using visibility Method 2 exceeded the 5% threshold at Mesa Verde, Canyons of the Ancients, Lizard Head Pass, and Dolores Canyon Overlook, but only for one (1) to three (3) days in three (3) years. No days with visibility changes over 5% were modeled at other receptors.

Table 7-50

Estimated Maximum Change in Extinction Coefficient (b_{ext}), Number of Days with Extinction Changes Greater than 5% and Greater than 10% Estimated Using Visibility Method 2 for Scenario 1, Incremental Impacts at Class I Areas

Class I Area	**2001**			**2002**			**2003**		
	% Change High Day 24-Hour b_{ext} (1/Mega-m)	**Days > 5%**	**Days > 10%**	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**
Arches	1.96%	0	0	0.95%	0	0	2.17%	0	0
Bandelier	0.64%	0	0	0.47%	0	0	0.53%	0	0
Black Canyon of the Gunnison	1.41%	0	0	0.98%	0	0	1.76%	0	0
Canyonlands	2.91%	0	0	1.36%	0	0	2.02%	0	0
LaGarita	0.67%	0	0	0.85%	0	0	1.97%	0	0
Mesa Verde	5.90%	2	0	7.01%	2	0	8.34%	3	0
San Pedro Parks	1.24%	0	0	0.95%	0	0	0.94%	0	0
Weminuche	3.79%	0	0	2.39%	0	0	3.17%	0	0
West Elk	1.35%	0	0	0.72%	0	0	1.24%	0	0

Table 7-51

Estimated Maximum Change in Extinction Coefficient (b_{ext}), Number of Days with Extinction Changes Greater than 5% and Greater than 10% Estimated Using Visibility Method 2 for Scenario 1, Incremental Impacts at Class II Areas of Interest

	2001			2002			2003		
Class II Area	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**
Canyon de Chelly	2.68%	0	0	1.17%	0	0	0.41%	0	0
Canyons of the Ancients	6.64%	1	0	5.81%	1	0	7.46%	1	0
Chaco Culture	0.85%	0	0	1.38%	0	0	0.77%	0	0
Hovenweep	1.77%	0	0	2.54%	0	0	1.31%	0	0
Natural Bridges	0.90%	0	0	0.73%	0	0	1.12%	0	0

Table 7-52

Estimated Maximum Change in Extinction Coefficient (b_{ext}), Number of Days with Extinction Changes Greater than 5% and Greater than 10% Estimated Using Visibility Method 2 for Scenario 1, Incremental Impacts at Selected Vistas

	2001			2002			2003		
Visibility Sites	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**
Lizard Head Pass	7.64%	1	0	2.11%	0	0	4.81%	0	0
Chalk Mountain	0.94%	0	0	0.80%	0	0	0.80%	0	0
Dolores Canyon Overlook	3.55%	0	0	5.07%	1	0	8.43%	1	0

7.1.3.2 Method 6

Class I Areas

Table 7-53 presents the estimated change in b_{ext} at Class I areas for incremental impacts under Scenario 1, calculated with Method 6. Incremental extinction changes on the 8th highest day in each year, which represents the 98th percentile, are compared to the 5% and 10% thresholds. According to this visibility estimation method, none of the Class I areas will experience incremental extinction changes greater than 5% under Scenario 1. The Class I area with the lowest incremental changes in visibility was Bandelier with an 8th high extinction change of 0.21%; Mesa Verde had the highest incremental visibility changes with a highest 8th high extinction change of 1.85%.

Class II Areas of Interest

Table 7-54 presents the modeled incremental change in extinction coefficient (b_{ext}) for the Class II areas under Scenario 1, calculated with Method 6. These results show that none of the Class II areas of interest had an extinction change greater than 5%. Incremental extinction changes on the 8th highest day ranged from 0.27% at both Canyon de Chelly and Chaco Culture National Historic Park, to 1.60% at Canyons of the Ancients.

Selected Vistas

Table 7-55 presents the modeled incremental change in extinction coefficient (b_{ext}) under Scenario 1 for the selected vistas, calculated with Method 6. With this visibility calculation method, none of these vistas are expected to experience extinction changes greater than 5%. Similar to Method 2, the vista with the lowest incremental change in visibility was Chalk Mountain with an 8th high extinction change of 0.28%. Dolores Canyon Overlook had the highest incremental visibility changes with an 8th high extinction change of 1.20%.

Conclusion

Applying visibility Method 6, none of the receptors modeled would have an 8th highest extinction change greater than 5%.

Table 7-53

Estimated Maximum Change in Extinction Coefficient (b_{ext}), Number of Days with Extinction Changes Greater than 5% and Greater than 10% Estimated Using Visibility Method 6 for Scenario 1, Incremental Impacts at Class I Areas

	2001				**2002**				**2003**			
Class I Area	**% Change Highest Day 24-Hour b_{ext} (1/Mega-m)**	**% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change Highest Day 24-Hour b_{ext} (1/Mega-m)**	**% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change Highest Day 24-Hour b_{ext} (1/Mega-m)**	**% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**
Arches	1.31%	0.74%	0	0	0.82%	0.56%	0	0	1.10%	0.46%	0	0
Bandelier	0.36%	0.21%	0	0	0.30%	0.21%	0	0	0.76%	0.17%	0	0
Black Canyon of the Gunnison	1.65%	0.44%	0	0	0.72%	0.39%	0	0	1.06%	0.49%	0	0
Canyonlands	1.42%	0.82%	0	0	1.23%	0.68%	0	0	1.25%	0.62%	0	0
LaGarita	0.53%	0.20%	0	0	1.08%	0.36%	0	0	2.22%	0.33%	0	0
Mesa Verde	2.40%	1.47%	0	0	4.05%	1.73%	0	0	4.92%	1.85%	0	0
San Pedro Parks	1.14%	0.30%	0	0	0.68%	0.36%	0	0	1.16%	0.31%	0	0
Weminuche	1.54%	0.48%	0	0	1.90%	0.64%	0	0	2.15%	0.58%	0	0
West Elk	0.97%	0.38%	0	0	0.56%	0.33%	0	0	1.36%	0.41%	0	0

Table 7-54

Estimated Maximum Change in Extinction Coefficient (b_{ext}), Number of Days with Extinction Changes Greater than 5% and Greater than 10% Estimated Using Visibility Method 6 for Scenario 1, Incremental Impacts at Class II Areas of Interest

	2001				2002				2003			
Class II Area	**% Change Highest Day 24-Hour b_{ext} (1/Mega-m)**	**% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change Highest Day 24-Hour b_{ext} (1/Mega-m)**	**% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change Highest Day 24-Hour b_{ext} (1/Mega-m)**	**% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**
Canyon de Chelly	1.22%	0.27%	0	0	0.59%	0.21%	0	0	0.51%	0.15%	0	0
Canyons of the Ancients	3.14%	1.60%	0	0	2.03%	1.39%	0	0	2.80%	1.39%	0	0
Chaco Culture	0.46%	0.21%	0	0	0.65%	0.27%	0	0	0.43%	0.22%	0	0
Hovenweep	1.21%	0.73%	0	0	1.91%	0.62%	0	0	1.64%	0.72%	0	0
Natural Bridges	1.08%	0.45%	0	0	0.75%	0.38%	0	0	0.74%	0.46%	0	0

Table 7-55

Estimated Maximum Change in Extinction Coefficient (b_{ext}), Number of Days with Extinction Changes Greater than 5% and Greater than 10% Estimated Using Visibility Method 6 for Scenario 1, Incremental Impacts at Selected Vistas

Visibility Sites	2001				2002				2003			
	% Change Highest Day 24-Hour b_{ext} (1/Mega-m)	% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)	Days > 5%	Days > 10%	% Change Highest Day 24-Hour b_{ext} (1/Mega-m)	% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)	Days > 5%	Days > 10%	% Change Highest Day 24-Hour b_{ext} (1/Mega-m)	% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)	Days > 5%	Days > 10%
Lizard Head Pass	2.59%	0.40%	0	0	1.22%	0.56%	0	0	2.99%	0.60%	0	0
Chalk Mountain	0.56%	0.19%	0	0	1.14%	0.26%	0	0	0.56%	0.28%	0	0
Dolores Canyon Overlook	1.83%	1.15%	0	0	2.55%	1.16%	0	0	3.36%	1.20%	0	0

7.1.3.3 Combined Incremental Visibility Impacts for the Maximum Development Scenario (Scenario 1) and the No New Leases Scenario (Scenario 2)

This section presents the “Combined Incremental Visibility” impacts for the Class I and Class II receptors, and represents the changes from both the development on currently unleased land (Scenario 1) and the development on lands in the project area that are already approved for leasing (Scenario 2). “Combined Incremental Visibility” does not including impacts from existing sources or other projects, only the changes expected from the Gothic Shale and Paradox Conventional development including the construction of 783 wells described in Scenario 1 and 1,365 wells in Scenario 2, added together. The three (3) scenic vistas, Lizard Head Pass, Chalk Mountain, and Dolores Canyon Overlook, were not evaluated for combined incremental visibility impacts.

Method 2

Table 7-56, presented at the end of this subsection, lists the estimated maximum change in extinction coefficient (b_{ext}) from the combined incremental emission increases calculated using Method 2 for each Class I area. Maximum incremental visibility changes for Class I areas calculated using Method 2 ranged from 2.42% at Bandelier, to 39.1% at Mesa Verde. Three (3) Class I areas had combined incremental impacts below 5%: Bandelier, San Pedro Parks, and West Elk. Sites with combined incremental impacts above 10% were Arches, Canyonlands, Mesa Verde, and Weminuche.

The estimated maximum change in b_{ext} for the combined incremental emissions increase at the Class II areas of interest, calculated using Method 2, is shown in Table 7-57. The only Class II area with an extinction change less than 5% was Natural Bridges. Sites with combined incremental visibility impacts above 10% are Canyon de Chelly, Canyons of the Ancients, and Hovenweep.

Maximum extinction changes calculated using visibility Method 2 exceeded the 10% threshold at several Class I and Class II receptor sites.

Method 6

Table 7-58 presents the estimated change in b_{ext} at Class I areas from combined incremental emissions increases, calculated with Method 6. Combined incremental extinction changes on the 8th highest day in each year, which represents the 98th percentile, are compared to the 5% and 10% thresholds. According to this visibility estimation method, none of the Class I areas will experience incremental extinction changes greater than 10% based on the 8th highest day. However, Arches, Canyonlands, Mesa Verde, and Weminuche would have incremental extinction changes above 5% on some days. The Class I area with the lowest combined incremental changes in visibility was Bandelier with an 8th high extinction change of 0.79%; Mesa Verde had the highest incremental visibility changes with an 8th high extinction change of 17.38%.

Table 7-59 presents the modeled combined incremental change in extinction coefficient (b_{ext}) for the Class II areas calculated with Method 6. All sites had some days with combined incremental extinction changes above 5%. However, Canyons of the Ancients was the only site with combined incremental extinction changes on its 8th highest day above 5%. Incremental extinction changes on the 8th highest day ranged from 1.12% at Canyon de Chelly to 8.77% at Canyons of the Ancients.

Conclusion

Applying visibility Method 6, only Mesa Verde and Canyons of the Ancients would have an 8th highest extinction change greater than 5%, but none of the receptors modeled would have a modeled 8th highest extinction change greater than 10%.

Table 7-56

Estimated Maximum Change in Extinction Coefficient (b_{ext}), Number of Days with Extinction Changes Greater than 5% and Greater than 10% Estimated Using Visibility Method 2 for Scenario 1, Combined Incremental Impacts at Class I Areas of Interest

	2001			2002			2003		
Class I Area	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**
Arches	12.94%	2	1	2.92%	0	0	9.78%	2	0
Bandelier	2.42%	0	0	2.11%	0	0	1.99%	0	0
Black Canyon of the Gunnison	4.98%	0	0	3.91%	0	0	6.00%	2	0
Canyonlands	10.14%	9	1	6.40%	2	0	9.38%	2	0
LaGarita	2.45%	0	0	2.60%	0	0	7.19%	1	0
Mesa Verde	28.19%	55	13	39.11%	63	16	37.28%	71	20
San Pedro Parks	4.57%	0	0	4.31%	0	0	3.76%	0	0
Weminuche	15.09%	2	1	7.87%	3	0	11.44%	4	1
West Elk	4.41%	0	0	2.13%	0	0	4.14%	0	0

Table 7-57

Estimated Maximum Change in Extinction Coefficient (b_{ext}), Number of Days with Extinction Changes Greater than 5% and Greater than 10% Estimated Using Visibility Method 2 for Scenario 1, Combined Incremental Impacts at Class II Areas of Interest

	2001			2002			2003		
Class II Area	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**
Canyon de Chelly	12.33%	2	1	5.77%	1	0	1.75%	0	0
Canyons of the Ancients	56.45%	73	22	33.97%	74	23	52.72%	78	24
Chaco Culture	3.90%	0	0	6.12%	1	0	3.37%	0	0
Hovenweep	12.14%	3	1	10.69%	4	1	6.44%	2	0
Natural Bridges	3.71%	0	0	3.31%	0	0	4.95%	0	0

Table 7-58

Estimated Maximum Change in Extinction Coefficient (b_{ext}), Number of Days with Extinction Changes Greater than 5% and Greater than 10% Estimated Using Visibility Method 6, Combined Incremental Impacts at Class I Areas

	2001				2002				2003			
Class I Area	**% Change Highest Day 24-Hour b_{ext} (1/Mega-m)**	**% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change Highest Day 24-Hour b_{ext} (1/Mega-m)**	**% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change Highest Day 24-Hour b_{ext} (1/Mega-m)**	**% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**
Arches	5.05%	3.01%	1	0	3.18%	2.29%	0	0	4.02%	1.96%	0	0
Bandelier	1.45%	0.79%	0	0	1.21%	0.74%	0	0	2.67%	0.67%	0	0
Black Canyon of the Gunnison	4.63%	1.60%	0	0	2.09%	1.55%	0	0	3.57%	2.35%	0	0
Canyonlands	5.87%	4.31%	3	0	4.26%	2.92%	0	0	4.70%	2.82%	0	0
LaGarita	1.95%	0.63%	0	0	3.19%	1.13%	0	0	5.79%	1.12%	1	0
Mesa Verde	9.76%	7.14%	29	0	19.97%	8.59%	52	6	18.31%	17.38%	51	4
San Pedro Parks	3.89%	1.15%	0	0	2.17%	1.27%	0	0	3.71%	1.09%	0	0
Weminuche	5.86%	1.48%	1	0	4.12%	2.32%	0	0	7.34%	1.74%	1	0
West Elk	2.86%	1.21%	0	0	1.88%	1.04%	0	0	3.47%	1.32%	0	0

Table 7-59

Estimated Maximum Change in Extinction Coefficient (b_{ext}), Number of Days with Extinction Changes Greater than 5% and Greater than 10% Estimated Using Visibility Method 6, Combined Incremental Impacts at Class II Areas of Interest

	2001				**2002**				**2003**			
Class II Area	**% Change Highest Day 24-Hour b_{ext} (1/Mega-m)**	**% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change Highest Day 24-Hour b_{ext} (1/Mega-m)**	**% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change Highest Day 24-Hour b_{ext} (1/Mega-m)**	**% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**
Canyon de Chelly	5.49%	1.12%	1	0	2.79%	0.84%	0	0	2.23%	0.71%	0	0
Canyons of the Ancients	22.92%	8.77%	40	3	14.40%	8.62%	50	5	18.48%	8.67%	45	4
Chaco Culture	1.99%	1.06%	0	0	2.77%	1.08%	0	0	1.85%	1.04%	0	0
Hovenweep	5.74%	3.46%	2	0	7.88%	3.11%	1	0	6.86%	3.32%	3	0
Natural Bridges	5.27%	2.04%	1	0	3.41%	1.90%	0	0	3.25%	2.24%	0	0

7.1.3.4 Cumulative Visibility Impacts for the Maximum Development Scenario, Scenario 1

Method 2

Tables 7-60, 7-61, and 7-62, presented at the end of this subsection, show the modeled cumulative visibility impact using Method 2 for Scenario 1, which is the maximum development scenario. Table 7-60 depicts the cumulative visibility impacts at the Class I areas of interest, Table 7-61 depicts impacts at the Class II areas of interest, and Table 7-62 depicts the impacts at other specific points of interest. The sources modeled for the cumulative visibility analysis include new development on currently unleased lands under the maximum development scenario, future development of already leased lands in the immediate project area, other RFD projects in the region, and existing air emission sources.

The cumulative visibility modeling analysis validates what was already known from review of existing visibility monitoring data (See Section 5.0), i.e., visibility in the region is already impaired from existing sources. All of the receptors modeled show that visibility would be impaired by emissions from the cumulative sources, based on a definition of impairment being a change in extinction of 10% or more compared to natural visibility conditions.

The CALPUFF modeling results reported here can be evaluated by comparison to the existing IMPROVE visibility measurements (See Section 5.0). Since the existing sources are also part of the cumulative modeling assessment, the visibility impacts from the IMPROVE measurements should be represented in the modeling results. For example, based on the IMPROVE measurements described in Section 5.0, current visibility impairment is greatest at Mesa Verde and Bandelier, and least at White River (which is the monitoring site representative of Black Canyon of the Gunnison, West Elk, and LaGarita). Similar to the visibility measurements, the CALPUFF modeling also shows that cumulative impacts are greatest at Mesa Verde and generally lowest at LaGarita, West Elk, and Black Canyon of the Gunnison. Weminuche also shows relatively high impacts in the CALPUFF modeling, but these impacts are not currently evident in the IMPROVE data. The elevated impacts are not picked up by the model at Bandelier, but this may be because Bandelier is located near the edge of the CALPUFF modeling domain and all of the emission sources that impact visibility at Bandelier are probably not included in this modeling assessment.

The Method 2 cumulative visibility impacts are quite large and suggest significantly worse visibility than documented by the IMPROVE measurements described in Section 5.0. This difference may be in part due to the fact that Method 2 results show the absolute worst-case day, while the IMPROVE data are the average of the worst-case 20% days, which would be approximately the 90th percentile or the 36th highest day in any year. However, these higher results may also indicate that the CALPUFF model under Method 2 overpredicts the true visibility impacts, perhaps significantly.

Despite the conclusion of the cumulative modeling analysis that visibility is already degraded by existing sources, it should be noted that current EPA regulations require that each state develop a State Implementation Plan (SIP) to improve visibility and make reasonable further progress toward the national visibility goal of remedying any existing anthropogenic visibility impairment. Since the specifics of planned emission reductions from Regional Haze SIPs have yet to be developed, any such reductions are not incorporated into the cumulative modeling analysis. However, some of these emission reductions are expected to occur concurrently with the additional oil and gas development being evaluated in this modeling study.

Table 7-60

Estimated Maximum Change in Extinction Coefficient (b_{ext}), Number of Days with Extinction Changes Greater than 5% and Greater than 10% Estimated Using Visibility Method 2 for Scenario 1, Cumulative Impacts (Existing Sources, Other RFD Projects, and Scenario 1) at Class I Areas of Interest

	2001			**2002**			**2003**		
Class I Area	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**
Arches	362.56%	159	97	111.70%	138	85	319.76%	106	61
Bandelier	228.00%	232	156	247.77%	215	132	228.39%	213	138
Black Canyon of the Gunnison	163.81%	177	110	115.11%	191	124	198.76%	162	94
Canyonlands	513.88%	163	132	220.86%	163	119	401.55%	137	104
LaGarita	147.77%	157	106	122.35%	212	130	181.04%	160	101
Mesa Verde	489.92%	347	322	402.77%	339	318	495.22%	342	327
San Pedro Parks	260.10%	215	158	265.36%	225	165	262.57%	234	178
Weminuche	629.66%	258	196	258.96%	300	243	268.72%	266	203
West Elk	458.37%	178	115	106.94%	185	106	170.74%	189	105

Table 7-61

Estimated Maximum Change in Extinction Coefficient (b_{ext}), Number of Days with Extinction Changes Greater than 5% and Greater than 10% Estimated Using Visibility Method 2 for Scenario 1, Cumulative Impacts (Existing Sources, Other RFD Projects, and Scenario 1) at Class II Areas of Interest

Class II Area	2001			2002			2003		
	% Change High Day 24-Hour b_{ext} (1/Mega-m)	**Days > 5%**	**Days > 10%**	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**
Canyon de Chelly	425.46%	237	204	498.27%	226	177	276.34%	212	169
Canyons of the Ancients	852.32%	363	357	443.21%	364	358	467.43%	363	358
Chaco Culture	299.41%	266	223	485.17%	265	208	519.10%	259	224
Hovenweep	630.12%	316	269	304.07%	301	257	370.82%	303	251
Natural Bridges	333.01%	149	125	231.20%	145	116	229.61%	136	94

Table 7-62

Estimated Maximum Change in Extinction Coefficient (b_{ext}), Number of Days with Extinction Changes Greater than 5% and Greater than 10% Estimated Using Visibility Method 2 for Scenario 1, Cumulative Impacts (Existing Sources, Other RFD Projects, and Scenario 1) at Selected Vistas

Visibility Sites	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**
Lizard Head Pass	317.00%	193	135	146.39%	231	155	199.16%	189	108
Chalk Mountain	164.30%	209	144	190.14%	248	176	192.56%	226	156
Dolores Canyon Overlook	258.72%	221	170	242.41%	226	175	234.59%	211	151

Method 6

Tables 7-63, 7-64, and 7-65, presented at the end of this subsection, show the modeled cumulative visibility impact using Method 6 for Scenario 1, which is the maximum development scenario. Table 7-63 depicts the cumulative visibility impacts at the Class I areas of interest, Table 7-64 depicts impacts at the Class II areas of interest, and Table 7-65 depicts the impacts at other specific points of interest. The sources modeled for the cumulative analysis include new development on currently unleased lands under the maximum development scenario, future development of already leased lands in the immediate project area, other RFD projects in the region, and existing air emission sources.

Similar to the Method 2 results, the cumulative analysis under Method 6 validates what was already known from review of existing visibility monitoring data, i.e., visibility in the region, is already impaired from existing sources. All of the receptors modeled show that visibility would be impaired by the emissions from the cumulative sources, based on a definition of impairment being represented by a change in extinction of 10% or more compared to natural visibility conditions.

However, compared to Method 2, the magnitude of the predicted visibility impacts under Method 6 are significantly lower. In fact, the Method 6 cumulative results much more closely align with the IMPROVE measurements described in the Existing Environment (Section 5.0). Using the 8th highest day (98th percentile), the cumulative visibility impacts under Method 6 generally show that the change in extinction compared to natural visibility at most Class I areas evaluated is less than 100%. As indicated in Section 5, the current visibility conditions at the Class I areas of interest compared to natural background were equivalent to a change in extinction of up to 123%. The exception is Mesa Verde, where the predicted change in extinction based on the 8th highest day under Method 6 is closer to 277%.

Because the Method 6 results for the cumulative modeling more closely align with the current visibility under the IMPROVE measurements, these results suggest that the Method 6 CALPUFF results may be more accurate than Method 2 in this case. This conclusion is further clarified in Appendix C (Comparison of CALPUFF Results with IMPROVE Measurements).

Table 7-63

Estimated Maximum Change in Extinction Coefficient (b_{ext}), Number of Days with Extinction Changes Greater than 5% and Greater than 10% Estimated Using Visibility Method 6 for Scenario 1, Cumulative Impacts (Existing Sources, Other RFD Projects, and Scenario 1) at Class I Areas of Interest

	2001				2002				2003			
Class I Area	**% Change Highest Day 24-Hour b_{ext} (1/Mega-m)**	**% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change Highest Day 24-Hour b_{ext} (1/Mega-m)**	**% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change Highest Day 24-Hour b_{ext} (1/Mega-m)**	**% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**
Arches	154.97%	91.45%	163	104	94.99%	65.81%	144	94	120.66%	80.60%	119	71
Bandelier	92.92%	57.85%	231	150	114.23%	64.32%	233	148	90.56%	62.33%	231	149
Black Canyon of the Gunnison	96.92%	63.37%	186	113	91.25%	64.25%	213	151	107.92%	76.28%	191	109
Canyonlands	217.40%	116.51%	138	137	199.82%	93.09%	172	129	150.08%	86.25%	148	111
LaGarita	115.16%	45.37%	168	117	78.54%	60.63%	225	165	174.35%	70.56%	177	122
Mesa Verde	373.36%	173.87%	344	316	474.58%	208.73%	345	318	451.72%	277.64%	340	323
San Pedro Parks	124.94%	89.31%	216	170	130.56%	98.84%	240	191	154.16%	95.51%	246	197
Weminuche	460.41%	76.04%	260	194	148.32%	98.71%	304	252	174.48%	117.59%	269	211
West Elk	310.88%	53.05%	179	111	80.95%	45.37%	221	125	110.65%	63.90%	211	118

Table 7-64

Estimated Maximum Change in Extinction Coefficient (b_{ext}), Number of Days with Extinction Changes Greater than 5% and Greater than 10% Estimated Using Visibility Method 6 for Scenario 1, Cumulative Impacts (Existing Sources, Other RFD Projects, and Scenario 1) at Class II Areas of Interest

	2001				2002				2003			
Class II Area	**% Change Highest Day 24-Hour b_{ext} (1/Mega-m)**	**% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change Highest Day 24-Hour b_{ext} (1/Mega-m)**	**% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change Highest Day 24-Hour b_{ext} (1/Mega-m)**	**% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**
Canyon de Chelly	414.05%	126.27%	230	182	355.69%	185.21%	226	171	295.86%	139.53%	213	159
Canyons of the Ancients	464.95%	164.18%	363	360	219.19%	157.58%	364	361	218.11%	157.60%	363	360
Chaco Culture	420.95%	135.55%	274	210	233.83%	126.76%	272	220	188.72%	134.55%	264	226
Hovenweep	285.17%	133.39%	316	272	161.78%	135.69%	314	272	251.95%	159.48%	310	266
Natural Bridges	152.57%	116.45%	144	122	184.54%	97.28%	144	114	231.78%	87.90%	134	95

Table 7-65

Estimated Maximum Change in Extinction Coefficient (b_{ext}), Number of Days with Extinction Changes Greater than 5% and Greater than 10% Estimated Using Visibility Method 6 for Scenario 1, Cumulative Impacts (Existing Sources, Other RFD Projects, and Scenario 1) at Selected Vistas

	2001				2002				2003			
Visibility Sites	**% Change Highest Day 24-Hour b_{ext} (1/Mega-m)**	**% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change Highest Day 24-Hour b_{ext} (1/Mega-m)**	**% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change Highest Day 24-Hour b_{ext} (1/Mega-m)**	**% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**
Lizard Head Pass	150.00%	59.93%	203	132	122.14%	89.11%	254	188	140.05%	73.28%	205	122
Chalk Mountain	84.97%	45.73%	201	135	97.98%	80.55%	250	190	106.55%	60.94%	230	171
Dolores Canyon Overlook	112.64%	90.72%	231	167	146.74%	107.64%	230	186	132.06%	71.43%	215	159

7.2 SCENARIO 2: NO ACTION SCENARIO (NO NEW LEASES)

7.2.1 Concentrations

This section presents the incremental and cumulative air quality impacts for Scenario 2, which represents the No Action Scenario. The incremental impacts described in this section are from emissions associated with additional oil and gas development on lands in the project area that are already approved for leasing. This new development is expected to occur even under the No Action Scenario. Unless otherwise noted, modeled concentrations for cumulative impacts represent the contributions from:

- Gothic Shale and Paradox Conventional wells to be constructed on already leased San Juan Public Land (including construction-related emissions)
- Existing sources in Colorado, Utah, New Mexico, and Arizona
- Other RFD Projects (Canyons of the Ancients, Desert Rock, Farmington Field Office RMP, Jicarilla Oil & Gas Leasing EIS, Northern San Juan Coalbed Methane EIS, Northern San Jan Infill Project, and the Southern Ute Indian Tribe EIS)

These cumulative impacts are compared to the applicable NAAQS, presented in Table 7-1, and the PSD Class I and Class II increments and AQRV criteria, presented in Table 3-1. As the modeling includes all known industrial emission sources in the modeling domain, no background concentration is added to the modeled value. Since all known emissions are included, any incremental contributions from non-modeled sources should be insignificant.

Contour plots of the cumulative NO_X, particulate, and SO_2 impacts for Scenario 2 are not included. The differences between the cumulative impacts for both scenarios are essentially negligible.

7.2.1.1 1-Hour and Annual NO_X Impacts

Class I Areas

Incremental 1-hour and annual NO_X impacts for Scenario 2 are presented below in Table 7-66 for the Class I areas of interest. These impacts show that the highest incremental NO_X impacts in the Class I areas evaluated would occur at Mesa Verde. Overall NO_X concentration impacts are relatively small, with annual average NO_X impacts generally at or below 0.5 $\mu g/m^3$.

Cumulative 1-hour and annual NO_X impacts for Scenario 2 are presented below in Table 7-67. Maximum cumulative 1-hour NO_X impacts for Scenario 2 range from 47.4 $\mu g/m^3$ at Black Canyon of the Gunnison to 771.6 $\mu g/m^3$ at Mesa Verde. It should be noted that these are maximum impacts and not the 98th percentile or the 8th highest day due to the limitations of CALPUFF's post-processors. Additional analyses, including outputting the top 4 values at each receptor, the top 50 values of any group, and the number of exceedances at each receptor, were performed in order to evaluate whether the modeling predicted exceedances of the new standard. These impacts show that the highest NO_X impacts in the Class I areas evaluated would occur at Mesa Verde. Maximum annual NO_X impacts for Scenario 2 range from 0.087 $\mu g/m^3$ at West Elk Wilderness to 4.282 $\mu g/m^3$ at Mesa Verde. These impacts are well below the annual NAAQS of

100 μg/m^3. Except for Mesa Verde, the cumulative NO_X impacts are also well below the Class I PSD increment for NO_X of 2.5 μg/m^3. However, as the modeled inventory does not represent a rigorous PSD analysis, these results do not suggest that a Class I increment problem exists at Mesa Verde.

As noted above, additional post-processing of 1-hour NO_2 was performed for sites where the maximum 1-hour NO_2 exceeds the new standard. The actual standard applies to the 98th percentile or 8th highest day; however, CALPUFF post-processors are not currently configured to output these values directly. By examining the top 4 values at each receptor, the top 50 values of each receptor set, and the number of individual exceedances, ARS was able to determine that the new 1-hour standard will be met at all Class I receptors. Results of these additional analyses are presented in Table 7-68.

Table 7-66

Incremental 1-Hour and Annual NO_X Impacts at Class I Areas for Scenario 2 for Each Year of Meteorological Data Modeled

	Maximum 1-Hour NO_X Impact (μg/m^3)			Annual NO_X Impact (μg/m^3)		
Class I Area	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**
Arches	0.3935	0.2828	0.3029	0.00857	0.00607	0.00548
Bandelier	0.0946	0.2902	0.2512	0.00050	0.00051	0.00065
Black Canyon of the Gunnison	0.2755	0.5353	0.6364	0.00234	0.00249	0.00334
Canyonlands	1.5982	0.6107	0.8561	0.01587	0.01215	0.01262
LaGarita	0.1859	0.8469	1.3224	0.00104	0.00177	0.00168
Mesa Verde	12.8800	16.4380	19.4690	0.44393	0.53131	0.53077
San Pedro Parks	1.4572	0.2239	0.3100	0.00129	0.00129	0.00153
Weminuche	1.0361	1.8229	0.6120	0.00564	0.00687	0.00533
West Elk	0.2916	1.0098	0.9301	0.00144	0.00155	0.00232

Table 7-67

Cumulative 1-Hour and Annual NO_X Impacts at Class I Areas for Scenario 2 for Each Year of Meteorological Data Modeled

Class I Area	Maximum 1-Hour NO_X Impact ($\mu g/m^3$) 2001	2002	2003	Annual NO_X Impact ($\mu g/m^3$) 2001	2002	2003
Arches	33.7	30.2	95.8	0.255	0.152	0.152
Bandelier	88.3	206.3	102.0	0.828	0.840	0.828
Black Canyon of the Gunnison	27.6	18.7	47.4	0.113	0.109	0.138
Canyonlands	116.9	139.3	95.4	0.609	0.482	0.417
LaGarita	34.6	45.4	82.1	0.181	0.166	0.227
Mesa Verde	518.5	771.6	434.9	4.064	4.282	3.634
San Pedro Parks	44.9	90.8	92.2	1.028	1.199	1.235
Weminuche	248.9	179.4	162.1	0.783	0.844	0.880
West Elk	257.1	17.7	21.7	0.087	0.065	0.086

Table 7-68

Maximum Cumulative 1-Hour NO_X Impacts for Modeled Class I Sites for Scenario 2 that Exceeded the 1-Hour NO_X Standard of 191.2 $\mu g/m^3$

Site	Year	Maximum	2nd	3rd	4th	Max # of exceedances at any receptor
Bandelier	2001	no exceedances				
	2002	206.32	120.90	103.61	94.35	1
	2003	no exceedances				
Mesa Verde	2001	518.53	289.05	207.65	206.54	4
	2002	771.63	287.70	241.86	200.57	4
	2003	434.86	251.28	173.79	171.05	2
Weminuche	2001	248.93	146.05	64.48	56.98	1
	2002	no exceedances				
	2003	no exceedances				
West Elk	2001	257.06	24.82	12.70	11.80	1
	2002	no exceedances				
	2003	no exceedances				

Class II Areas of Interest

Table 7-69 shows the maximum 1-hour incremental and annual incremental NO_X concentration impacts for Scenario 2 at the Class II areas of interest. Maximum 1-hour incremental NO_X impacts ranged from 0.320 $\mu g/m^3$ at Natural Bridges to 18.45 $\mu g/m^3$ at Canyons of the Ancients. The Class II area with the highest annual NO_X impact was Canyons of the Ancients. The Scenario 2 incremental NO_X impacts are generally small, with annual concentrations at about 0.6 μg/m^3 at Canyons of the Ancients and much less at the other Class II areas of interest.

Table 7-69

Incremental 1-Hour and Annual NO_X Impacts
at Class II Areas of Interest for Scenario 2

Class II Area	Maximum 1-Hour NO_X Impact (μg/m^3) 2001	2002	2003	Annual NO_X Impact (μg/m^3) 2001	2002	2003
Canyon de Chelly	0.465	0.806	0.297	0.000980	0.000810	0.000553
Canyons of the Ancients	17.891	16.745	18.450	0.579100	0.589760	0.620060
Chaco Culture	0.275	0.389	0.227	0.000981	0.000845	0.000802
Hovenweep	0.917	1.478	1.016	0.011480	0.010628	0.011743
Natural Bridges	0.320	0.317	0.285	0.004312	0.004382	0.004191

Tables 7-70 and 7-71 show the cumulative 1-hour and annual NO_X impacts for the Class II areas of concern. Maximum cumulative 1-hour NO_X impacts for Class II areas ranged from 112.1 μg/m^3 at Hovenweep to 707.4 μg/m^3 at Canyons of the Ancients. While these results suggest that the 1-hour standard would be exceeded, the standard actually applies to the 98th percentile, or 8th highest day. Therefore, additional analyses were performed in order to determine whether the modeled impacts predicted an exceedance on the 8th highest day. The Class II area with the highest annual NO_X impact was Canyons of the Ancients. Maximum annual NO_X impacts at these Class II areas ranged from 0.989 μg/m^3 at Natural Bridges to 7.285 μg/m^3 at Canyons of the Ancients. These impacts are all well below the NAAQS of 100 μg/m^3, and also well below the Class II PSD increment for NO_X of 25 μg/m^3.

While results in Table 7-70 suggest that the 1-hour NO_2 standard is exceeded, it is also assumed that 100% of NO_X is converted to NO_2. This is a conservative assumption that presupposes adequate ozone and the time available for emitted NO to be converted to NO_2. As noted above, additional analyses were performed because CALPUFF post-processors are not capable of outputting the 98th percentile, or 8th highest day, directly. Results of these additional analyses are presented in Table 7-71 and show that the standard is met at Canyon de Chelly and Canyons of the Ancients. At Chaco Culture, it was necessary to examine the top 50 impacts on a receptor by receptor basis to determine the impacts on the 8th highest day, which was 275 μg/m^3 for 2001, 305 μg/m^3 for 2002, and 326 μg/m^3 for 2003. These high impacts occur far from the proposed new sources and are unlikely to be due to the project, as evidenced by the low incremental impacts show in Table 7-69. Local sources around Chaco Culture probably contribute to these modeled exceedances.

Table 7-70

Cumulative 1-Hour and Annual NO_X Impacts
at Class II Areas of Interest for Scenario 2

Class II Area	Maximum 1-Hour NO_X Impact ($\mu g/m^3$)			Annual NO_X Impact ($\mu g/m^3$)		
	2001	2002	2003	2001	2002	2003
Canyon de Chelly	265.6	268.8	373.9	1.376	1.031	1.256
Canyons of the Ancients	707.4	522.4	311.1	7.078	7.241	7.285
Chaco Culture	518.4	343.9	373.8	4.021	4.644	4.945
Hovenweep	112.1	94.3	96.7	2.703	2.335	2.136
Natural Bridges	58.1	66.1	165.6	0.989	0.625	0.650

Table 7-71

Maximum Cumulative 1-Hour NO_X Impacts for Modeled Class II Sites for Scenario 2
that Exceeded the 1-Hour NO_X Standard of 191.2 $\mu g/m^3$

Site	Year	Maximum	2nd	3rd	4th	Max # of exceedances at any receptor
Canyon de Chelly	2001	265.61	202.62	147.50	123.61	2
	2002	268.77	221.75	156.26	144.24	2
	2003	373.89	188.45	156.75	118.80	1
Canyons of the Ancients	2001	707.42	190.46	164.03	149.76	1
	2002	522.36	272.18	253.74	237.91	4
	2003	311.05	214.78	197.94	162.53	3
Chaco Culture	2001	518.39	343.76	331.22	312.84	17
	2002	343.87	334.26	327.20	309.89	30
	2003	373.76	373.12	370.76	364.45	40

Class II Fine Grid within Project Area

Table 7-72 shows the predicted incremental NO_X impacts within the fine grid of receptors covering the planned development area.[6] The incremental NO_X impacts are somewhat higher in these areas, due to the proximity of the fine grid receptors to the development area. The maximum incremental NO_X impact under Scenario 2 is slightly above 2.0 $\mu g/m^3$.

[6] The new 1-hour NO_2 standard was implemented after all the modeling had been performed. SJPL requested that 1-hour impacts be calculated at Class I and sensitive Class II areas but did not require this additional analysis for the fine grid and coarse grid receptor sets.

Table 7-72

Incremental Annual NO_X Impacts
within the Fine Grid of Class II Receptors
within the Project Area for Scenario 2

Modeling Year	NO_X Impact ($\mu g/m^3$)	Receptor Location			
		Lambert-Conformal Coordinates		Longitude/Latitude Coordinates	
2001	2.03	124	156	108.8426	37.2082
2002	2.15	124	156	108.8426	37.2082
2003	2.18	124	156	108.8426	37.2082

Table 7-73 shows the predicted cumulative NO_X impacts within the fine grid of receptors covering the planned development area. The highest cumulative NO_X impact was 10.7 $\mu g/m^3$ occurring along the southern most row of fine grid receptors, directly south of Mesa Verde. This impact location suggests that the dominant source of NO_X within the modeling domain is south of the fine grid, and outside the immediate SJPLC project area.

Table 7-73

Cumulative Annual NO_X Impacts
within the Fine Grid of Class II Receptors
within the Project Area for Scenario 2

Modeling Year	NO_X Impact ($\mu g/m^3$)	Receptor Location			
		Lambert-Conformal Coordinates		Longitude/Latitude Coordinates	
2001	10.3	132	108	108.4776	36.9821
2002	10.7	132	108	108.4776	36.9821
2003	10.2	148	108	108.2932	36.9791

Class II Coarse Grid within Modeling Domain

Incremental maximum annual NO_X impacts within the coarse grid of Class II receptors are presented below in Table 7-74. Compared to the fine grid, impacts in the coarse Class II grid are lower as the coarse grid receptors are more distant from the project area. The maximum incremental NO_X impact in the coarse grid is about 0.2 μg/m^3 annual mean.

Table 7-74

Incremental Annual NO_X Impacts
within the Coarse Grid of Other Class II Receptors
within the Modeling Domain for Scenario 2

Modeling Year	NO_X Impact (μg/m^3)	Receptor Location			
		Lambert-Conformal Coordinates		Longitude/Latitude Coordinates	
2001	0.146	78	248	109.0818	38.2813
2002	0.196	78	248	109.0818	38.2813
2003	0.162	78	248	109.0818	38.2813

Cumulative maximum annual NO_X impacts within the coarse grid of Class II receptors are presented below in Table 7-75. The maximum annual NO_X impact is 62.6 μg/m^3, which is below the NAAQS of 100 μg/m^3. The coarse grid receptor with the highest annual NO_X impacts is the same as Scenario 1. This location is near the Four Corners Power Plant, which emits over 49,000 tons per year of NO_X, and the San Juan Generating Station, which emits over 40,000 tons per year of NO_X. In addition, numerous existing oil and gas wells are in this part of New Mexico, and NO_X sources are anticipated in this region in conjunction with the Farmington RMP RFD.

Table 7-75

Cumulative Annual NO_X Impacts
on the Coarse Grid of Other Class II Receptors
within the Modeling Domain for Scenario 2

Modeling Year	NO_X Impact (μg/m^3)	Location		Receptor Location	
		Lambert-Conformal Coordinates		Longitude/Latitude Coordinates	
2001	52.5	126	80	108.5527	36.7253
2002	62.6	126	80	108.5527	36.7253
2003	52.3	126	80	108.5527	36.7253

Conclusion

All cumulative annual NO_X impacts for Scenario 2 are below the NAAQS of 100 μg/m^3.

7.2.1.2 24-Hour and Annual PM_{10} Impacts

Class I Areas

Incremental 24-hour and annual PM_{10} impacts for Scenario 2 are presented below in Table 7-76. These results show that the highest incremental PM_{10} impacts within a Class I area would occur at Mesa Verde. However, the PM_{10} incremental impacts under Scenario 2 are relatively small at each Class I area modeled.

Table 7-76

Incremental 24-Hour and Annual PM_{10} Impacts at Class I Areas for Scenario 2 for Each Year of Meteorological Data Modeled

Class I Area	Highest Second-Highest 24-Hour PM_{10} Impacts ($\mu g/m^3$)			Maximum Annual PM_{10} Impacts ($\mu g/m^3$)		
	2001	**2002**	**2003**	**2001**	**2002**	**2003**
Arches	0.0649	0.0543	0.0625	0.01002	0.90951	0.00731
Bandelier	0.0263	0.0206	0.0335	0.00153	0.00168	0.00154
Black Canyon of the Gunnison	0.0921	0.0464	0.1067	0.00479	0.00476	0.00531
Canyonlands	0.0880	0.0674	0.0913	0.01379	0.01156	0.01143
LaGarita	0.0239	0.0457	0.0491	0.00263	0.00401	0.00345
Mesa Verde	0.6824	0.9295	0.9775	0.29308	0.35468	0.35010
San Pedro Parks	0.0367	0.0295	0.0392	0.00257	0.00271	0.00277
Weminuche	0.1071	0.1102	0.0664	0.00672	0.00964	0.00784
West Elk	0.0426	0.0424	0.0731	0.00338	0.00334	0.00384

Cumulative 24-hour and annual PM_{10} impacts for Scenario 2 are presented below in Table 7-77. These results show that the highest cumulative PM_{10} impacts within a Class I area would occur at Mesa Verde. Maximum annual PM_{10} impacts for Scenario 1 ranged from 0.205 $\mu g/m^3$ at Arches to 10.10 $\mu g/m^3$ at Mesa Verde. These impacts are well below the NAAQS for annual PM_{10} of 50 $\mu g/m^3$, and except for Mesa Verde, these cumulative impacts are also well below the annual Class I PSD increment for PM_{10} of 5 $\mu g/m^3$. As with NO_X, the modeled inventory does not represent a vigorous PSD analysis, so these results should not be used to suggest that the PSD increment is being exceeded at Mesa Verde.

HSH cumulative 24-hour PM_{10} impacts for Scenario 2 ranged from 2.05 $\mu g/m^3$ at Arches to 66.97 $\mu g/m^3$ at Mesa Verde. These cumulative impacts are well below the 24-hour NAAQS for PM_{10} of 150 $\mu g/m^3$. The higher impacts at Mesa Verde suggest the presence of a large PM_{10} emissions source in the cumulative inventory close to or upwind of Mesa Verde.

Table 7-77

Cumulative 24-Hour and Annual PM_{10} Impacts at Class I Areas for Scenario 2 for Each Year of Meteorological Data Modeled

	Highest Second-Highest 24-Hour Impacts (μg/m³)			**Maximum Annual Impacts (μg/m³)**		
Class I Area	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**
Arches	2.05	2.00	2.00	0.205	0.167	0.171
Bandelier	3.65	7.66	3.95	0.502	0.452	0.450
Black Canyon of the Gunnison	2.21	1.69	4.24	0.223	0.260	0.278
Canyonlands	2.20	2.51	1.86	0.236	0.197	0.193
LaGarita	1.62	1.84	6.27	0.128	0.164	0.237
Mesa Verde	24.26	36.94	66.97	4.156	5.974	10.106
San Pedro Parks	2.34	2.92	3.08	0.242	0.282	0.306
Weminuche	8.61	7.96	13.09	0.369	0.514	0.797
West Elk	3.70	6.29	8.30	0.342	0.408	0.708

<u>Class II Areas of Interest</u>

Table 7-78 shows the incremental 24-hour and annual PM_{10} impacts for Scenario 2 at the various Class II areas of interest. The Class II area with the highest incremental annual PM_{10} impact was Canyons of the Ancients. The incremental effect of Scenario 2 emissions on PM_{10} concentrations is small.

Table 7-78

Incremental 24-Hour and Annual PM_{10} Impacts at Class II Areas of Interest for Scenario 2 for Each Year of Meteorological Data Modeled

	Highest Second-Highest 24-Hour PM_{10} Impacts (μg/m³)			**Maximum Annual PM_{10} Impacts (μg/m³)**		
Class II Area	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**
Canyon de Chelly	0.0543	0.0457	0.0277	0.00169	0.00141	0.00143
Canyons of the Ancients	0.5174	0.5501	0.6024	0.16197	0.18219	0.18121
Chaco Culture	0.0282	0.0299	0.0221	0.00176	0.00175	0.00172
Hovenweep	0.0846	0.0769	0.1198	0.01296	0.01321	0.01457
Natural Bridges	0.0427	0.0426	0.0414	0.00499	0.00511	0.00512

Table 7-79 shows the cumulative 24-hour and annual PM_{10} impacts for Scenario 2 at the various Class II areas of interest. The Class II area with the highest cumulative annual PM_{10} impact was Canyons of the Ancients. Maximum annual PM_{10} impacts at these Class II areas ranged from 0.279 $\mu g/m^3$ at Natural Bridges to 1.217 $\mu g/m^3$ at Canyons of the Ancients. These impacts are all well below the NAAQS for annual PM_{10} of 50 $\mu g/m^3$.

HSH cumulative 24-hour PM_{10} impacts for Scenario 1 ranged from 3.04 $\mu g/m^3$ at Natural Bridges to 9.09 $\mu g/m^3$ at Canyons of the Ancients. These cumulative impacts are well below the 24-hour NAAQS for PM_{10} of 150 $\mu g/m^3$.

Table 7-79

Cumulative 24-Hour and Annual PM_{10} Impacts at Class II Areas of Interest for Scenario 2 for Each Year of Meteorological Data Modeled

	Highest Second-Highest 24-Hour Impacts ($\mu g/m^3$)			**Maximum Annual Impacts ($\mu g/m^3$)**		
Class II Area	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**
Canyon de Chelly	5.48	5.96	6.26	0.307	0.278	0.333
Canyons of the Ancients	4.69	5.24	9.09	1.176	1.217	0.193
Chaco Culture	4.24	2.82	3.97	0.373	0.357	0.368
Hovenweep	3.16	2.97	4.38	0.696	0.692	0.881
Natural Bridges	2.34	2.52	3.04	0.279	0.220	0.231

Class II Fine Grid within Project Area

Table 7-80 shows the incremental PM_{10} impacts for the fine grid receptors within the immediate project area. The maximum incremental 24-hour PM_{10} impact ranged between 1.65 and 2.53 $\mu g/m^3$ and the maximum incremental annual PM_{10} impact on the fine grid ranged between 0.82 and 0.92 $\mu g/m^3$.

Table 7-81 shows the cumulative PM_{10} impacts for the fine grid receptors within the immediate project area. The maximum cumulative 24-hour PM_{10} impact was 131 $\mu g/m^3$ (over 87% of the NAAQS) and the maximum cumulative annual PM_{10} impact on the fine grid was 27.7 $\mu g/m^3$. These impacts occurred at the eastern edge of the fine grid, suggesting that the dominant source of PM_{10} within the domain is outside the immediate project area to the east.

Table 7-80

Incremental 24-Hour and Annual PM_{10} Impacts within the Fine Grid of Other Class II Receptors within the Project Area for Scenario 2for Each Year of Meteorological Data Modeled

Averaging Period	Year	PM_{10} Impact ($\mu g/m^3$)	Receptor Location			
			Lambert-Conformal Coordinates		Longitude/Latitude Coordinates	
HSH 24-Hour	2001	1.65	140	164	108.3723	37.4968
	2002	2.21	132	156	108.7501	37.2071
	2003	2.53	140	164	108.3723	37.4968
Maximum Annual	2001	0.821	132	156	108.7501	37.2071
	2002	0.910	132	156	108.7501	37.2071
	2003	0.921	132	156	108.7501	37.2071

Table 7-81

Cumulative 24-Hour and Annual PM_{10} Impacts at Fine Grid of Class II Receptors within the Project Area for Scenario 2for Each Year of Meteorological Data Modeled

Averaging Period	Year	PM_{10} Impact ($\mu g/m^3$)	Receptor Location			
			Lambert-Conformal Coordinates		Longitude/Latitude Coordinates	
HSH 24-Hour	2001	55.4	156	140	108.1926	37.2724
	2002	71.9	156	140	108.1926	37.2724
	2003	130.7	156	132	108.1947	37.1986
Maximum Annual	2001	13.4	156	132	108.1947	37.1986
	2002	14.9	156	132	108.1947	37.1986
	2003	27.7	156	132	108.1947	37.1986

Class II Coarse Grid within Modeling Domain

Incremental 24-hour and annual PM_{10} impacts within the coarse grid of Class II receptors outside the immediate development area are presented below in Table 7-82. In the coarse grid, incremental impacts are less compared to the fine grid due to the increasing distance from the project emissions sources. PM_{10} incremental impacts are small under Scenario 2 at the coarse grid receptors.

Table 7-82

Incremental 24-Hour and Annual Incremental PM_{10} Impacts within the Coarse Grid of Other Class II Receptors within the Modeling Domain for Scenario 2

Averaging Period	Year	PM_{10} Impact ($\mu g/m^3$)	Receptor Location			
			Lambert-Conformal Coordinates		Longitude/Latitude Coordinates	
HSH 24-Hour	2001	0.376	78	224	109.0851	38.0596
	2002	0.000	102	224	108.8036	38.0567
	2003	0.412	78	248	109.0818	38.2813
Maximum Annual	2001	0.0811	78	248	109.0818	38.2813
	2002	0.0000	78	248	109.0818	38.2813
	2003	0.0913	78	248	109.0818	38.2813

Cumulative 24-hour and annual PM_{10} impacts within the coarse grid of Class II receptors outside the immediate development area are presented below in Table 7-83. The HSH 24-hour cumulative PM_{10} impact for Scenario 2 is 94.9 $\mu g/m^3$, and the maximum annual PM_{10} impact is 11.9 $\mu g/m^3$. The location of these impacts is due south of Mesa Verde, in the same spot as the maximum annual NO_X impacts, less than 7.5 km from the Four Corners Power Plant (which emits over 3,500 tons per year of PM_{10}), which is near the San Juan Generating Station (which emits over 4,100 tons per year of PM_{10}).

Table 7-83

Cumulative 24-Hour and Annual PM_{10} Impacts within the Coarse Grid of Other Class II Receptors within the Modeling Domain for Scenario 2

Averaging Period	Year	PM_{10} Impact ($\mu g/m^3$)	Receptor Location			
			Lambert-Conformal Coordinates		Longitude/Latitude Coordinates	
HSH 24-Hour	2001	74.0	126	80	108.5527	36.7253
	2002	94.9	126	80	108.5527	36.7253
	2003	63.1	126	80	108.5527	36.7253
Maximum Annual	2001	9.46	126	80	108.5527	36.7253
	2002	11.9	126	80	108.5527	36.7253
	2003	9.74	126	80	108.5527	36.7253

Conclusion

Cumulative PM_{10} impacts for Scenario 2 do not exceed their respective 24-hour or annual NAAQS for all receptors evaluated.

7.2.1.3 24-Hour and Annual $PM_{2.5}$ Impacts

Class I Areas

Incremental 24-hour and annual average $PM_{2.5}$ impacts for Scenario 2 are presented below in Table 7-84. These results show that the highest incremental $PM_{2.5}$ impacts within a Class I area would occur at Mesa Verde. However, the $PM_{2.5}$ incremental impacts under Scenario 2 are relatively small at each Class I area modeled.

Cumulative 24-hour and annual $PM_{2.5}$ impacts for Scenario 2 are presented below in Table 7-85. These results show that the highest cumulative $PM_{2.5}$ impacts within a Class I area would occur at Mesa Verde. Maximum annual $PM_{2.5}$ impacts for Scenario 2 ranged from 0.036 $\mu g/m^3$ at La Garita to 1.086 $\mu g/m^3$ at Mesa Verde. These impacts are well below the NAAQS for annual $PM_{2.5}$ of 15 $\mu g/m^3$.

HSH cumulative 24-hour $PM_{2.5}$ impacts for Scenario 2 ranged from 0.372 $\mu g/m^3$ at Bandelier to 7.067 $\mu g/m^3$ at Mesa Verde. These cumulative impacts are well below the 24-hour NAAQS for $PM_{2.5}$ of 65 $\mu g/m^3$.

Table 7-84

Incremental 24-Hour and Annual $PM_{2.5}$ Impacts at Class I Areas for Scenario 2
for Each Year of Meteorological Data Modeled

Class I Area	Highest Second-Highest 24-Hour $PM_{2.5}$ Impacts ($\mu g/m^3$)			Maximum Annual $PM_{2.5}$ Impacts ($\mu g/m^3$)		
	2001	2002	2003	2001	2002	2003
Arches	0.0235	0.0190	0.0221	0.00352	0.01899	0.00255
Bandelier	0.0094	0.0075	0.0122	0.00055	0.00061	0.00056
Black Canyon of the Gunnison	0.0326	0.0166	0.0385	0.00171	0.00170	0.00189
Canyonlands	0.0291	0.0246	0.0333	0.00491	0.00416	0.00408
LaGarita	0.0086	0.0165	0.0179	0.00095	0.00144	0.00124
Mesa Verde	0.2472	0.3368	0.3542	0.10621	0.12854	0.12688
San Pedro Parks	0.0131	0.0107	0.0143	0.00093	0.00098	0.00101
Weminuche	0.0388	0.0400	0.0241	0.00243	0.00349	0.00284
West Elk	0.0154	0.0153	0.0264	0.00121	0.00120	0.00137

Table 7-85

Cumulative 24-Hour and Annual $PM_{2.5}$ Impacts at Class I Areas for Scenario 2 for Each Year of Meteorological Data Modeled

	Highest Second-Highest 24-Hour Impacts (µg/m³)			**Maximum Annual Impacts (µg/m³)**		
Class I Area	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**
Arches	0.782	0.801	0.541	0.0492	0.0442	0.0351
Bandelier	0.228	0.372	0.361	0.0419	0.0430	0.0466
Black Canyon of the Gunnison	0.607	0.717	0.586	0.0478	0.0604	0.0522
Canyonlands	0.493	0.468	0.403	0.0567	0.0474	0.0437
LaGarita	0.300	0.491	0.640	0.0236	0.0303	0.0360
Mesa Verde	2.500	3.887	7.067	0.4906	0.6795	1.0864
San Pedro Parks	0.357	0.428	0.515	0.0456	0.0555	0.0583
Weminuche	1.099	0.807	1.507	0.0572	0.0753	0.1024
West Elk	0.615	0.696	0.859	0.0511	0.0604	0.0872

Class II Areas of Interest

Table 7-86 shows the incremental 24-hour and annual $PM_{2.5}$ impacts for Scenario 2 at the various Class II areas of interest. The Class II area with the highest incremental $PM_{2.5}$ impact was Canyons of the Ancients. The incremental effect of Scenario 2 emissions on $PM_{2.5}$ concentrations is small.

Table 7-86

Incremental 24-Hour and Annual $PM_{2.5}$ Impacts at Class II Areas of Interest for Scenario 2 for Each Year of Meteorological Data Modeled

	Highest Second-Highest 24-Hour $PM_{2.5}$ Impacts (µg/m³)			**Maximum Annual $PM_{2.5}$ Impacts (µg/m³)**		
Class II Area	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**
Canyon de Chelly	0.0195	0.0165	0.0100	0.00061	0.00051	0.00052
Canyons of the Ancients	0.1896	0.1997	0.2207	0.05871	0.06607	0.06569
Chaco Culture	0.0102	0.0108	0.0081	0.00064	0.00063	0.00062
Hovenweep	0.0308	0.0279	0.0438	0.00471	0.00480	0.00530
Natural Bridges	0.0155	0.0155	0.0149	0.00181	0.00185	0.00185

Table 7-87 shows the cumulative 24-hour and annual $PM_{2.5}$ impacts for Scenario 2 at the various Class II areas of interest. The Class II area with the highest cumulative annual $PM_{2.5}$ impact was Canyons of the Ancients, with a predicted maximum annual $PM_{2.5}$ impact of 0.2435 μg/m^3.

HSH cumulative 24-hour $PM_{2.5}$ impacts for Scenario 2 ranged from 0.673 μg/m^3 at Natural Bridges to 1.236 μg/m^3 at Canyons of the Ancients.

Table 7-87

Cumulative 24-Hour and Annual $PM_{2.5}$ Impacts
at Class II Areas of Interest for Scenario 2
for Each Year of Meteorological Data Modeled

	Highest Second-Highest 24-Hour Impacts (μg/m^3)			Maximum Annual Impacts (μg/m^3)		
Class II Area	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**
Canyon de Chelly	1.026	0.955	0.970	0.0610	0.0517	0.0626
Canyons of the Ancients	0.936	0.817	1.236	0.2191	0.2159	0.2435
Chaco Culture	0.923	0.992	1.090	0.1009	0.1071	0.1041
Hovenweep	0.663	0.591	0.693	0.1386	0.1351	0.1434
Natural Bridges	0.672	0.515	0.673	0.0648	0.0495	0.0479

<u>Class II Fine Grid within Project Area</u>

Table 7-88 shows the incremental $PM_{2.5}$ impacts for the fine grid receptors within the immediate project area. The maximum incremental 24-hour $PM_{2.5}$ impact was less than 1.0 μg/m^3. The maximum incremental annual $PM_{2.5}$ impact on the fine grid was about 0.33 μg/m^3.

Table 7-88

Incremental 24-Hour and Annual $PM_{2.5}$ Impacts within the Fine Grid of Other Class II Receptors within the Project Area for Scenario 2 for Each Year of Meteorological Data Modeled

			Receptor Location			
Averaging Period	**Year**	**$PM_{2.5}$ Impact (μg/m^3)**	**Lambert-Conformal Coordinates**		**Longitude/Latitude Coordinates**	
HSH 24-Hour	2001	0.600	140	164	108.3723	37.4968
	2002	0.800	132	156	108.7501	37.2071
	2003	0.922	140	164	108.3723	37.4968
Maximum Annual	2001	0.298	132	156	108.7501	37.2071
	2002	0.330	132	156	108.7501	37.2071
	2003	0.334	132	156	108.7501	37.2071

Table 7-89 shows the cumulative $PM_{2.5}$ impacts for the fine grid receptors within the immediate project area. The maximum cumulative 24-hour $PM_{2.5}$ impact was 13.15 μg/m^3 and the maximum cumulative annual $PM_{2.5}$ impact on the fine grid was 2.84 μg/m^3. These impacts occurred at the eastern edge of the fine grid.

Table 7-89

Cumulative 24-Hour and Annual $PM_{2.5}$ Impacts at Fine Grid of Class II Receptors within the Project Area for Scenario 2 for Each Year of Meteorological Data Modeled

Averaging Period	Year	$PM_{2.5}$ Impact (μg/m^3)	Receptor Location			
			Lambert-Conformal Coordinates		Longitude/Latitude Coordinates	
HSH 24-Hour	2001	6.13	156	140	108.1926	37.2724
	2002	7.41	156	140	108.1926	37.2724
	2003	13.15	156	132	108.1947	37.1986
Maximum Annual	2001	1.40	156	132	108.1947	37.1986
	2002	1.56	156	132	108.1947	37.1986
	2003	2.84	156	132	108.1947	37.1986

<u>Class II Coarse Grid within Modeling Domain</u>

Incremental 24-hour and annual $PM_{2.5}$ impacts within the coarse grid of Class II receptors outside the immediate development area are presented below in Table 7-90. In the coarse grid, incremental impacts are less compared to the fine grid, due to the increasing distance from the project emissions sources. $PM_{2.5}$ incremental impacts are small under Scenario 2 at the coarse grid receptors.

Table 7-90

Incremental 24-Hour and Annual Incremental $PM_{2.5}$ Impacts within the Coarse Grid of Other Class II Receptors within the Modeling Domain for Scenario 2

Averaging Period	Year	$PM_{2.5}$ Impact (μg/m^3)	Receptor Location			
			Lambert-Conformal Coordinates		Longitude/Latitude Coordinates	
HSH 24-Hour	2001	0.121	78	224	109.0851	38.0596
	2002	0.163	102	224	108.8036	38.0567
	2003	0.134	78	248	109.0818	38.2813
Maximum Annual	2001	0.0273	78	248	109.0818	38.2813
	2002	0.0361	78	248	109.0818	38.2813
	2003	0.0305	78	248	109.0818	38.2813

Cumulative 24-hour and annual $PM_{2.5}$ impacts within the coarse grid of Class II receptors outside the immediate development area are presented below in Table 7-91. The maximum HSH 24-hour cumulative $PM_{2.5}$ impact for Scenario 2 is 15.2 μg/m^3, and the maximum annual $PM_{2.5}$ impact is 2.12 μg/m^3.

Table 7-91

Cumulative 24-Hour and Annual $PM_{2.5}$ Impacts within the Coarse Grid of Other Class II Receptors within the Modeling Domain for Scenario 2

Averaging Period	Year	$PM_{2.5}$ Impact (μg/m^3)	Receptor Location			
			Lambert-Conformal Coordinates		Longitude/Latitude Coordinates	
HSH 24-Hour	2001	11.9	126	80	108.5527	36.7253
	2002	15.2	126	80	108.5527	36.7253
	2003	10.5	126	80	108.5527	36.7253
Maximum Annual	2001	1.75	126	80	108.5527	36.7253
	2002	2.12	126	80	108.5527	36.7253
	2003	1.75	126	80	108.5527	36.7253

Conclusion

Cumulative $PM_{2.5}$ impacts for Scenario 2 do not exceed their respective 24-hour or annual NAAQS for all receptors evaluated.

7.2.1.4 1-Hour, 3-Hour, 24-Hour, and Annual SO_2 Impacts

Class I Areas

Incremental 1-hour, 3-hour, 24-hour and annual SO_2 impacts for Scenario 2 are presented at the end of this subsection in Table 7-92. The incremental SO_2 impacts from Scenario 2 are very small due to the minimal SO_2 emissions from project sources.

Cumulative 1-hour, 3-hour, 24-hour and annual SO_2 impacts for Scenario 2 are presented in Table 7-93. This table shows that the maximum 1-hour SO_2 impact is below the standard at Class I areas, except for Bandelier, Canyonlands, Mesa Verde, and Weminuche. While the actual 1-hour standard is based on the 99th percentile day, CALPUFF's post-processors are not presently set up to compute that value. Therefore, several additional analyses were performed to evaluate whether modeled 1-hour SO2 impacts comply with the standard. The Class I area with the highest cumulative SO_2 impacts was Mesa Verde. Highest second-highest cumulative 3-hour SO_2 impacts ranged from 7.97 μg/m^3 at West Elk Wilderness to 131.83 μg/m^3 at Mesa Verde.

Table 7-94 presents the results of the additional analyses performed to determine whether modeled 1-hour SO_2 impacts comply with the new standard. This table shows that while the maximum 1-hour impact is high, the 2nd, 3rd, and 4th highest impacts at all Class I receptors decrease such that the 99th percentile, or 4th highest day, is below the standard.

Highest second-highest cumulative 24-hour SO_2 impacts ranged from 2.40 μg/m^3 at West Elk to 25.3 μg/m^3 at Mesa Verde. These cumulative impacts are well below the 24-hour NAAQS for SO_2 of 365 μg/m^3.

Maximum annual cumulative SO_2 impacts ranged from 0.182 μg/m^3 at West Elk to 2.53 μg/m^3 at Mesa Verde. These impacts are well below the annual NAAQS for SO_2 of 80 μg/m^3, and except for Mesa Verde, these cumulative impacts are also well below the annual Class I PSD increment for SO_2 of 2 μg/m^3.

Again, as the modeled SO_2 inventory does not represent a rigorous PSD increment analysis, these results do not necessarily indicate that Class I PSD increments are exceeded at any particular Class I area.

Class II Areas of Interest

Table 7-95, presented at the end of this subsection, shows the incremental SO_2 impacts for Scenario 2 at the Class II areas of interest. Because the project-specific SO_2 emissions are small under Scenario 2, the incremental SO_2 impacts are also small at the Class II areas of interest.

Table 7-96 shows the cumulative SO_2 impacts for Scenario 2 at the Class II areas of interest. This table shows that the maximum 1-hour SO_2 impact is above the standard at Canyon de Chelly, Canyons of the Ancients, and Chaco Culture. However, because the 1-hour standard is based on the 99th percentile, or 4th highest day, additional analyses were performed to deduce whether modeled impacts at these sites exceeded the standard. These additional analyses, presented in Table 7-97, show that the 4th highest day is below the 1-hour standard for these sites. HSH 3-hour SO_2 impacts ranged from 67.2 μg/m^3 at Hovenweep to 104 μg/m^3 at Canyon de Chelly. All predicted SO_2 impacts are below the Class II PSD Increment for 3-hour SO_2 of 512 μg/m^3.

HSH cumulative 24-hour SO_2 impacts for Scenario 2 ranged from 11.8 μg/m^3 at Natural Bridges to 21.9 μg/m^3 at Canyon de Chelly. These cumulative impacts are below the 24-hour NAAQS for SO_2 of 365 μg/m^3, as well as below the Class II PSD Increment for 24-hour SO_2 of 91 μg/m^3.

Maximum annual SO_2 impacts at these Class II areas under Scenario 2 ranged from 1.02 μg/m^3 at Natural Bridges to 2.66 μg/m^3 at Hovenweep. These impacts are all well below the NAAQS of 80 μg/m^3, and also well below the Class II PSD increment for annual SO_2 of 20 μg/m^3.

Table 7-92

Incremental 1-Hour, 3-Hour, 24-Hour, and Annual SO_2 Impacts at Class I Areas for Scenario 2 for Each Year of Meteorological Data Modeled

Class I Area	Maximum 1-Hour SO_2 Impacts (µg/m^3)			Highest Second-Highest 3-Hour SO_2 Impacts (µg/m^3)		
	2001	**2002**	**2003**	**2001**	**2002**	**2003**
Arches	0.0255	0.0398	0.0265	0.0219	0.0199	0.0151
Bandelier	0.0463	0.1366	0.0577	0.0181	0.0093	0.0206
Black Canyon of the Gunnison	0.1650	0.0748	0.1701	0.0426	0.0227	0.0538
Canyonlands	0.1005	0.0982	0.0583	0.0436	0.0296	0.0389
LaGarita	0.0356	0.1601	0.3245	0.0136	0.0284	0.0312
Mesa Verde	1.0967	0.8298	0.8384	0.4229	0.4053	0.4538
San Pedro Parks	0.1398	0.0548	0.0591	0.0249	0.0210	0.0195
Weminuche	0.1683	0.2675	0.0933	0.0335	0.0531	0.0292
West Elk	0.0636	0.1416	0.1409	0.0199	0.0267	0.0435

Class I Area	Highest Second-Highest 24-Hour SO_2 Impacts (µg/m^3)			Maximum Annual SO_2 Impacts (µg/m^3)		
	2001	**2002**	**2003**	**2001**	**2002**	**2003**
Arches	0.00886	0.00434	0.00573	0.001118	0.000910	0.000763
Bandelier	0.00286	0.00193	0.00431	0.000153	0.000164	0.000159
Black Canyon of the Gunnison	0.00970	0.00502	0.01252	0.000499	0.000484	0.000564
Canyonlands	0.00873	0.00708	0.01012	0.001579	0.001279	0.001278
LaGarita	0.00236	0.00557	0.00563	0.000281	0.000418	0.000362
Mesa Verde	0.12012	0.16132	0.16847	0.049812	0.060289	0.059605
San Pedro Parks	0.00508	0.00410	0.00441	0.000277	0.000273	0.000296
Weminuche	0.01073	0.01403	0.00759	0.000789	0.001104	0.000893
West Elk	0.00428	0.00501	0.00722	0.000349	0.000336	0.000403

Table 7-93

Cumulative 1-Hour, 3-Hour, 24-Hour, and Annual SO_2 Impacts at Class I Areas for Scenario 2 for Each Year of Meteorological Data Modeled

Class I Area	Maximum 1-Hour SO_2 Impacts ($\mu g/m^3$)			Highest Second-Highest 3-Hour SO_2 Impacts ($\mu g/m^3$)		
	2001	**2002**	**2003**	**2001**	**2002**	**2003**
Arches	52.1	45.7	134.9	19.94	14.67	49.61
Bandelier	89.0	208.1	103.9	33.44	70.14	33.53
Black Canyon of the Gunnison	40.9	36.1	69.9	8.48	8.84	16.73
Canyonlands	154.1	257.1	112.4	42.04	67.50	32.19
LaGarita	65.5	64.4	102.4	20.82	22.57	28.28
Mesa Verde	549.8	808.7	443.7	131.83	98.58	115.37
San Pedro Parks	49.8	101.1	79.8	18.18	37.06	28.04
Weminuche	394.7	208.5	181.3	33.05	44.46	46.29
West Elk	605.7	33.3	28.1	7.97	5.46	7.21

Class I Area	Highest Second-Highest 24-Hour SO_2 Impacts ($\mu g/m^3$)			Maximum Annual SO_2 Impacts ($\mu g/m^3$)		
	2001	**2002**	**2003**	**2001**	**2002**	**2003**
Arches	4.25	2.99	7.64	0.288	0.195	0.202
Bandelier	5.68	8.84	4.82	0.655	0.659	0.588
Black Canyon of the Gunnison	2.79	1.45	3.24	0.200	0.199	0.200
Canyonlands	8.10	9.03	6.99	0.628	0.576	0.442
LaGarita	3.41	3.86	5.54	0.206	0.235	0.232
Mesa Verde	25.00	25.27	21.24	2.525	2.443	2.055
San Pedro Parks	4.49	7.30	7.88	0.602	0.764	0.751
Weminuche	8.40	10.13	9.15	0.457	0.548	0.542
West Elk	1.74	1.36	2.40	0.182	0.137	0.136

Table 7-94

Maximum Cumulative 1-Hour SO_2 Impacts for Modeled Class I Sites for Scenario 2 that Exceeded the 1-Hour SO_2 Standard of 188 μg/m^3

Site	Year	Maximum	2nd	3rd	4th	Max # of exceedances at any receptor
Bandelier	2001	no exceedances				
	2002	208.12	122.74	105.16	98.81	1
	2003	no exceedances				
Mesa Verde	2001	549.83	309.22	223.80	187.09	3
	2002	808.74	177.89	153.60	135.87	1
	2003	443.66	200.93	166.23	158.28	2
Weminuche	2001	394.65	97.92	75.59	50.86	1
	2002	no exceedances				
	2003	no exceedances				
West Elk	2001	605.74	31.49	21.66	12.43	1
	2002	no exceedances				
	2003	no exceedances				

Table 7-95

Incremental 1-Hour, 3-Hour, 24-Hour, and Annual SO_2 Impacts at Class II Areas of Interest for Scenario 2 for Each Year Modeled

Class II Area	Maximum 1-Hour SO_2 Impacts (μg/m^3)			Highest Second-Highest 3-Hour SO_2 Impacts (μg/m^3)		
	2001	2002	2003	2001	2002	2003
Canyon de Chelly	0.0973	0.0782	0.0341	0.0395	0.0207	0.0081
Canyons of the Ancients	0.5785	0.5990	0.5181	0.2177	0.1690	0.2084
Chaco Culture	0.0175	0.0471	0.0296	0.0082	0.0093	0.0096
Hovenweep	0.0666	0.0873	0.0834	0.0407	0.0473	0.0394
Natural Bridges	0.0216	0.0226	0.0241	0.0170	0.0168	0.0151

Class II Area	Highest Second-Highest 24-Hour SO_2 Impacts (μg/m^3)			Maximum Annual SO_2 Impacts (μg/m^3)		
	2001	2002	2003	2001	2002	2003
Canyon de Chelly	0.00656	0.00459	0.00214	0.000173	0.000141	0.000140
Canyons of the Ancients	0.06834	0.07117	0.07130	0.025948	0.028978	0.028975
Chaco Culture	0.00225	0.00248	0.00219	0.000173	0.000171	0.000167
Hovenweep	0.00846	0.00941	0.01046	0.001643	0.001655	0.001829
Natural Bridges	0.00559	0.00485	0.00488	0.000598	0.000603	0.000608

Table 7-96

Cumulative 1-Hour, 3-Hour, 24-Hour, and Annual SO_2 Impacts at Class II Areas of Interest for Scenario 2 for Each Modeled Year

Class II Area	Maximum 1-Hour SO_2 Impacts (µg/m^3)			Highest Second-Highest 3-Hour SO_2 Impacts (µg/m^3)		
	2001	**2002**	**2003**	**2001**	**2002**	**2003**
Canyon de Chelly	351.9	336.0	454.1	97.8	103.5	99.0
Canyons of the Ancients	790.9	554.1	366.3	100.3	70.2	75.1
Chaco Culture	594.2	184.4	294.6	89.0	67.6	68.6
Hovenweep	107.1	99.3	93.0	59.0	58.6	67.2
Natural Bridges	97.0	161.3	238.5	37.0	67.3	42.5

Class II Area	Highest Second-Highest 24-Hour SO_2 Impacts (µg/m^3)			Maximum Annual SO_2 Impacts (µg/m^3)		
	2001	**2002**	**2003**	**2001**	**2002**	**2003**
Canyon de Chelly	21.92	18.97	18.87	1.078	0.923	1.087
Canyons of the Ancients	15.56	13.05	15.92	2.225	1.957	1.831
Chaco Culture	18.28	14.85	17.08	1.769	1.818	1.740
Hovenweep	15.44	12.32	17.40	2.659	2.398	2.212
Natural Bridges	11.82	9.67	9.82	1.015	0.777	0.710

Table 7-97

Maximum Cumulative 1-Hour SO_2 Impacts for Modeled Class II Sites for Scenario 2 that Exceeded the 1-Hour SO_2 Standard of 188 µg/m^3

Site	Year	Maximum	2nd	3rd	4th	Max # of exceedances at any receptor
Canyon de Chelly	2001	351.85	215.60	161.94	147.99	2
	2002	336.00	295.02	234.09	209.45*	4
	2003	454.07	222.54	176.70	119.33	2
Canyons of the Ancients	2001	790.91	235.33	180.18	119.97	2
	2002	554.11	139.95	93.63	85.24	1
	2003	366.33	156.55	121.01	119.29	1
Chaco Culture	2001	594.21	215.41	127.16	100.94	2
	2002			no exceedances		
	2003	294.57	137.04	102.15	98.17	1

* Canyon de Chelly's highest and 2nd highest exceedances occur on the same day. The 5th highest was deduced to be below 200 by examining top 50 impacts.

Class II Fine Grid within Project Area

Table 7-98 shows the incremental SO_2 impacts for the fine grid receptors within the immediate project area.[7] The incremental SO_2 impacts are small in the fine grid receptors because the project-specific SO_2 emissions are also small under Scenario 2.

Table 7-98

Incremental 3-Hour, 24-Hour, and Annual SO_2 Impacts within the Fine Grid of Other Class II Receptors within the Project Area for Scenario 2

Rank and Averaging Period	Year	SO_2 Impact ($\mu g/m^3$)	Receptor Location			
			Lambert-Conformal Coordinates		Longitude/Latitude Coordinates	
HSH 3-Hour	2001	1.07	132	156	108.7501	37.2071
	2002	1.09	156	140	108.1926	37.2724
	2003	1.12	132	156	108.7501	37.2071
HSH 24-Hour	2001	0.255	132	156	108.7501	37.2071
	2002	0.367	132	156	108.7501	37.2071
	2003	0.380	132	156	108.7501	37.2071
Maximum Annual	2001	0.140	132	156	108.7501	37.2071
	2002	0.155	132	156	108.7501	37.2071
	2003	0.157	132	156	108.7501	37.2071

Table 7-99 shows the cumulative SO_2 impacts for the fine grid receptors within the immediate project area. The HSH cumulative 3-hour SO_2 impact was 473 $\mu g/m^3$, the highest second-highest 24-hour SO_2 impact was 78.1 μ/m^3, and the maximum annual SO_2 impact on the fine grid was 8.74 $\mu g/m^3$. These impacts are all below their respective NAAQS. For each averaging period, maximum SO_2 impacts on the fine grid all occurred along the southernmost row of receptors, suggesting that the dominant source of SO_2 within the domain may be outside the immediate project area to the south.

[7] The new 1-hour SO_2 standard was implemented after all the modeling had been performed. SJPL requested that 1-hour impacts be calculated at Class I and sensitive Class 2 areas, but did not require ARS to evaluate 1-hour impacts at the fine and coarse grid receptors.

Table 7-99

Cumulative 3-Hour, 24-Hour, and Annual SO_2 Impacts within the Fine Grid of Other Class II Receptors within the Project Area for Scenario 2

Rank and Averaging Period	Year	SO_2 Impact ($\mu g/m^3$)	Receptor Location			
			Lambert-Conformal Coordinates		Longitude/Latitude Coordinates	
HSH 3-Hour	2001	295	116	108	108.6621	36.9848
	2002	450	148	108	108.2932	36.9791
	2003	473	140	108	108.3854	36.9807
HSH 24-Hour	2001	56.9	116	108	108.6621	36.9848
	2002	75.2	148	108	108.2932	36.9791
	2003	78.1	140	108	108.3854	36.9807
Maximum Annual	2001	8.74	76	108	109.1234	36.9898
	2002	7.91	76	108	109.1234	36.9898
	2003	7.79	76	108	109.1234	36.9898

Class II Coarse Grid within Modeling Domain

Incremental 3-hour, 24-hour, and annual SO_2 impacts within the coarse grid of Class II receptors outside the immediate development area are presented below in Table 7-100. Compared to the fine grid, the incremental SO_2 impacts are less as the coarse grid receptors are more distant from the project area. These impacts are near zero due to the small magnitude of project-specific SO_2 emissions.

Table 7-100

Incremental 3-Hour, 24-Hour, and Annual SO_2 Impacts within the Coarse Grid of Other Class II Receptors within the Modeling Domain for Scenario 2

Rank and Averaging Period	Year	SO_2 Impact ($\mu g/m^3$)	Receptor Location			
			Lambert-Conformal Coordinates		Longitude/Latitude Coordinates	
HSH 3-Hour	2001	0.152	78	224	109.0850706	38.0596
	2002	0.208	78	224	109.0850706	38.0596
	2003	0.187	78	224	109.0850706	38.0596
HSH 24-Hour	2001	0.0426	78	248	109.0818426	38.2813
	2002	0.0606	78	248	109.0818426	38.2813
	2003	0.0489	78	248	109.0818426	38.2813
Maximum Annual	2001	0.0105	78	248	109.0818426	38.2813
	2002	0.0134	78	248	109.0818426	38.2813
	2003	0.0113	78	248	109.0818426	38.2813

Cumulative 3-hour, 24-hour, and annual SO_2 impacts within the coarse grid of Class II receptors outside the immediate development area are presented below in Table 7-101. The highest second-highest 3-hour SO_2 impact was 2,745 μg/m^3, the HSH 24-hour SO_2 impact was 469 μg/m^3, and the maximum annual SO_2 impact was 58.3 μg/m^3. The modeled 24-hour impacts exceed the 24-hour NAAQS, but the annual impact is below its NAAQS. The location of these coarse grid impacts is due south of Mesa Verde, in the same spot as the maximum coarse grid NO_X and PM_{10} impacts, which is near the Four Corners Power Plant (which emits over 27,000 tons per year of SO_2), and less than 13.7 km from the San Juan Generating Station (which emits over 32,000 tons per year of SO_2). It is important to note that the Gothic Shale and Paradox Conventional projects will not emit appreciable SO_2; therefore, these modeled NAAQS exceedances for SO_2 are wholly due to existing and/or other RFD and not due to the projects under review for this EIS.

Table 7-101

Cumulative 3-Hour, 24-Hour, and Annual SO_2 Impacts within the Coarse Grid of Other Class II Receptors within the Modeling Domain for Scenario 2

Rank and Averaging Period	Year	SO_2 Impact (μg/m^3)	Receptor Location			
			Lambert-Conformal Coordinates		Longitude/Latitude Coordinates	
HSH 3-Hour	2001	2745	126	80	108.5527	36.7253
	2002	2646	126	80	108.5527	36.7253
	2003	1995	126	80	108.5527	36.7253
HSH 24-Hour	2001	383	126	80	108.5527	36.7253
	2002	469	126	80	108.5527	36.7253
	2003	318	126	80	108.5527	36.7253
Maximum Annual	2001	47.2	126	80	108.5527	36.7253
	2002	58.3	126	80	108.5527	36.7253
	2003	48.0	126	80	108.5527	36.7253

Despite the prediction of SO_2 concentrations in excess of the NAAQS, these results should be viewed with caution. First, CALPUFF is not the preferred air quality model for receptors in the near-field (within 50 km of the source). For near-field impacts, AERMOD is the preferred air quality model according to the EPA Guidance on Air Quality Models. Also, in this study, emission sources with similar stack parameters were combined in order to keep the number of sources modeled manageable. Therefore, the Four Corners and San Juan Power Plants were each modeled as a single stack. This modeling methodology results in conservative impact estimates, especially in the near-field. So, although elevated SO_2 concentrations would be expected in the vicinity of the Four Corners and San Juan Power Plants, the accuracy of CALPUFF predictions that show possible NAAQS violations is less certain.

Conclusion

Modeled cumulative SO_2 impacts are predicted to exceed the 24-hour NAAQS in northwestern New Mexico, near the San Juan and Four Corners Power Plants, but the SJPLC development projects under review for this EIS do not contribute to these predicted exceedances. However, as this modeling study was not designed to address near-field impacts from San Juan and Four Corners, these results should not be used to specifically address SO_2 attainment in northwest New Mexico.

7.2.2 Deposition

This section provides a summary of deposition impacts and includes both incremental and cumulative impacts. For Scenario 2, incremental impacts represent contributions from the expected development of Gothic Shale and Paradox Conventional wells on land that is already leased. Incremental impacts are compared to the FLM threshold of 0.005 kilograms per hectare per year (kg/ha-yr). This threshold is used as a trigger for further FLM analysis, rather than an adverse impact threshold. Project specific impacts below this threshold are considered insignificant. An impact above the 0.005 kg/ha-yr threshold does not necessarily indicate a problem, only that it could require further study, taking the sensitivity of local soils, vegetation, and wildlife into account.

Cumulative deposition impacts are defined as the total deposition arising from all sources, which include Scenario 2 plus existing sources and the proposed RFD.

In addition to the Class I and II receptors described in Section 6.0, deposition was evaluated at four high mountain lakes within Weminuche: Big Eldorado Lake, Lower Sunlight Lake, Upper Sunlight Lake, and Upper Grizzly Lake.

7.2.2.1 Nitrogen Deposition Impacts

Class I Areas

Table 7-102 presents incremental nitrogen deposition impacts from Scenario 2 at the Class I areas. Incremental impacts ranged from 0.000702 kg./ha-yr at Bandelier to 0.092807 kg/ha-yr at Mesa Verde. Impacts exceed the 0.005 kg/ha-yr FLM threshold only at Mesa Verde, which is within a few kilometers of some of the proposed well locations. The 0.005 kg/ha-yr threshold is used as a trigger for further FLM analysis, rather than an adverse impact threshold.

Table 7-102

Incremental Nitrogen Deposition at Class I Areas for Scenario 2
for Each Year of Meteorological Data Modeled

Class I Area	Incremental Nitrogen Deposition (kg/ha-yr)		
	2001	**2002**	**2003**
Arches	0.002654	0.002079	0.001898
Bandelier	0.000401	0.000356	0.000702
Black Canyon of the Gunnison	0.001359	0.001061	0.001213
Canyonlands	0.004867	0.003901	0.004254
LaGarita	0.000989	0.001341	0.001246
Mesa Verde	0.086869	0.089988	0.092807
San Pedro Parks	0.000773	0.000678	0.000969
Weminuche	0.004042	0.003869	0.003510
West Elk	0.000952	0.000938	0.000974

Cumulative nitrogen deposition impacts under Scenario 2 for the Class I areas are shown below in Table 7-103. Cumulative impacts ranged from 0.100 kg/ha-yr at West Elk to 1.60 kg/ha-yr at Mesa Verde. These figures estimate the total deposition from all existing and proposed development.

Table 7-103

Cumulative Nitrogen Deposition at Class I Areas for Scenario 2
for Each Year of Meteorological Data Modeled

Class I Area	Nitrogen Deposition (kg/ha-yr)		
	2001	**2002**	**2003**
Arches	0.127	0.089	0.079
Bandelier	0.429	0.372	0.370
Black Canyon of the Gunnison	0.123	0.096	0.098
Canyonlands	0.310	0.244	0.238
LaGarita	0.165	0.141	0.132
Mesa Verde	1.603	1.515	1.461
San Pedro Parks	0.526	0.523	0.514
Weminuche	0.403	0.469	0.438
West Elk	0.100	0.093	0.075

Class II Areas of Interest

The incremental nitrogen deposition impacts are presented in Table 7-104. These impacts ranged from 0.000479 kg/ha-yr at Canyon de Chelly to 0.144479 kg/ha-yr at Canyons of the Ancients. Nitrogen deposition impacts exceed the 0.005 kg/ha-yr threshold only at Canyons of the Ancients, which is within a few kilometers of some of the proposed Scenario 2 development.

Table 7-104

Incremental Nitrogen Deposition at Class II Areas of Interest for Scenario 2 for Each Year of Meteorological Data Modeled

Class II Area	Incremental Nitrogen Deposition (kg/ha-yr)		
	2001	**2002**	**2003**
Canyon de Chelly	0.000310	0.000270	0.000479
Canyons of the Ancients	0.137815	0.133574	0.144479
Chaco Culture	0.000667	0.000528	0.000485
Hovenweep	0.002832	0.002905	0.003687
Natural Bridges	0.001595	0.001650	0.001982

Cumulative nitrogen deposition impacts for the Class II areas of interest are shown below in Table 7-105. Impacts ranged from 0.381 kg/ha-yr at Natural Bridges to 2.170 kg/ha-yr at Canyons of the Ancients.

Table 7-105

Cumulative Nitrogen Deposition at Class II Areas of Interest for Scenario 2 for Each Year of Meteorological Data Modeled

Class II Area	Nitrogen Deposition (kg/ha-yr)		
	2001	**2002**	**2003**
Canyon de Chelly	0.413	0.307	0.413
Canyons of the Ancients	2.170	2.060	2.158
Chaco Culture	0.904	0.948	1.063
Hovenweep	0.584	0.490	0.566
Natural Bridges	0.381	0.286	0.307

Sensitive Mountain Lakes within Weminuche

Incremental nitrogen deposition results under Scenario 2 at four (4) sensitive mountain lakes within the Weminuche Wilderness are presented in Table 7-106. Maximum impacts range from 0.00216 kg/ha-yr at Big Eldorado Lake to 0.00262 kg/ha-yr at Upper Grizzly Lake. These impacts are all well below the 0.005 kg/ha-yr FLM threshold.

Table 7-106

Incremental Nitrogen Deposition Impacts
at High Mountain Lakes in Weminuche for Scenario 2
for Each Year of Meteorological Data Modeled

Deposition Sites	Nitrogen Deposition (kg/ha-yr)		
	2001	**2002**	**2003**
Big Eldorado Lake	0.00188	0.00216	0.00192
Lower Sunlight Lake	0.00229	0.00258	0.00220
Upper Sunlight Lake	0.00224	0.00254	0.00218
Upper Grizzly Lake	0.00233	0.00262	0.00223

Cumulative nitrogen deposition impacts for Scenario 2 at these high mountain lakes are presented below in Table 7-107. Modeled impacts ranged from 0.175 kg/ha-yr at Big Eldorado Lake to 0.221 kg/ha-yr at Upper Grizzly Lake.

Table 7-107

Cumulative Deposition Impacts
at High Mountain Lakes in Weminuche for Scenario 2
for Each Year of Meteorological Data Modeled

Deposition Sites	Sulfur Deposition (kg/ha-yr)		
	2001	**2002**	**2003**
Big Eldorado Lake	0.175	0.172	0.174
Lower Sunlight Lake	0.203	0.215	0.217
Upper Sunlight Lake	0.198	0.208	0.211
Upper Grizzly Lake	0.206	0.219	0.221

Conclusion

Under Scenario 2, incremental nitrogen deposition would exceed the 0.005 kg/ha-yr FLM threshold at Mesa Verde and at Canyons of the Ancients. Both sites are very close to the proposed SJPLC development area. While impacts above this threshold do not necessarily pose a problem, they do warrant further study, taking into account the sensitivity of local soils, vegetation, and wildlife. Compared to the cumulative nitrogen deposition, the incremental increases associated with Scenario 2 are small.

7.2.2.2 Sulfur Deposition Impacts

As was noted earlier, expected emissions of sulfur containing compounds for the oil and gas development projects studied here were very low. Operational SO_2 emissions would be nearly negligible because the well head engines do not emit appreciable SO_2. However, construction emissions include SO_2 from drilling and tailpipe emissions, so incremental sulfur deposition impacts are not zero.

Class I Areas

Incremental sulfur deposition impacts for the Class I areas under Scenario 2 are shown below in Table 7-108. Incremental sulfur deposition impacts ranged from 0.000137 kg/ha-yr at Bandelier to 0.020250 at Mesa Verde. Mesa Verde was the only site with impacts exceeding the 0.005 kg/ha-yr FLM deposition threshold.

Table 7-108

Incremental Sulfur Deposition at Class I Areas for Scenario 2

	Sulfur Deposition (kg/ha-yr)		
Class I Area	**2001**	**2002**	**2003**
Arches	0.000484	0.000454	0.000359
Bandelier	0.000113	0.000130	0.000137
Black Canyon of the Gunnison	0.000296	0.000291	0.000290
Canyonlands	0.000761	0.000702	0.000703
LaGarita	0.000219	0.000352	0.000260
Mesa Verde	0.018771	0.020119	0.020250
San Pedro Parks	0.000190	0.000208	0.000205
Weminuche	0.000814	0.001167	0.000785
West Elk	0.000228	0.000240	0.000230

Cumulative sulfur deposition impacts for the Class I areas under Scenario 2 are shown below in Table 7-109. Impacts ranged from 0.128 kilograms per hectare per year (kg/ha-yr) at West Elk to 1.652 kg/ha-yr at Mesa Verde.

Table 7-109

Cumulative Sulfur Deposition at Class I Areas for Scenario 2

	Sulfur Deposition (kg/ha-yr)		
Class I Area	**2001**	**2002**	**2003**
Arches	0.150	0.115	0.098
Bandelier	0.496	0.454	0.416
Black Canyon of the Gunnison	0.157	0.130	0.145
Canyonlands	0.401	0.370	0.314
LaGarita	0.184	0.185	0.175
Mesa Verde	1.652	1.463	1.434
San Pedro Parks	0.499	0.531	0.511
Weminuche	0.332	0.501	0.405
West Elk	0.128	0.112	0.104

Incremental sulfur deposition impacts for the Class II areas of interest are shown below in Table 7-110. Impacts ranged from 0.000094 kg/ha-yr at Canyon de Chelly to 0.011401 kg/ha-yr at Canyons of the Ancients.

Table 7-110

Incremental Sulfur Deposition at Class II Areas for Scenario 2

	Sulfur Deposition (kg/ha-yr)		
Class II Area	**2001**	**2002**	**2003**
Canyon de Chelly	0.000071	0.000065	0.000094
Canyons of the Ancients	0.010362	0.011135	0.011401
Chaco Culture	0.000114	0.000145	0.000101
Hovenweep	0.000543	0.000725	0.000766
Natural Bridges	0.000310	0.000346	0.000374

Cumulative sulfur deposition impacts for the Class II areas of interest are shown below in Table 7-111. Impacts ranged from 0.500 kg/ha-yr at Canyon de Chelly to 1.156 kg/ha-yr at Canyons of the Ancients.

Table 7-111

Cumulative Sulfur Deposition at Class II Areas of Interest for Scenario 2

	Sulfur Deposition (kg/ha-yr)		
Class II Area	**2001**	**2002**	**2003**
Canyon de Chelly	0.481	0.429	0.500
Canyons of the Ancients	1.156	1.094	1.153
Chaco Culture	0.609	0.624	0.579
Hovenweep	0.761	0.665	0.758
Natural Bridges	0.549	0.457	0.450

Sensitive Mountain Lakes within Weminuche

Incremental sulfur deposition for four (4) sensitive mountain lakes within the Weminuche Wilderness are presented below in Table 7-112. The incremental sulfur deposition impacts are small under Scenario 2.

Table 7-112

Incremental Sulfur Deposition
at High Mountain Lakes at Weminuche for Scenario 2

	Sulfur Deposition (kg/ha-yr)		
Deposition Sites	**2001**	**2002**	**2003**
Big Eldorado Lake	0.000371	0.000597	0.000397
Lower Sunlight Lake	0.000449	0.000758	0.000480
Upper Sunlight Lake	0.000439	0.000741	0.000470
Upper Grizzly Lake	0.000457	0.000772	0.000487

Cumulative sulfur deposition for four (4) sensitive mountain lakes within the Weminuche Wilderness are presented below in Table 7-113. Impacts range from 0.229 kg/ha-yr at Big Eldorado Lake to 0.290 kg/ha-yr at Upper Grizzly Lake.

Table 7-113

Cumulative Sulfur Deposition
at High Mountain Lakes at Weminuche for Scenario 2

Deposition Sites	Sulfur Deposition (kg/ha-yr)		
	2001	**2002**	**2003**
Big Eldorado Lake	0.197	0.229	0.209
Lower Sunlight Lake	0.220	0.285	0.253
Upper Sunlight Lake	0.215	0.275	0.248
Upper Grizzly Lake	0.222	0.290	0.257

Conclusion

Under Scenario 2, incremental sulfur deposition would exceed the 0.005 kg/ha-hr FLM threshold at Mesa Verde and Canyons of the Ancients. Both sites are vary close to the proposed SJPLC development area. While impacts above this threshold do not necessarily pose a problem, they do warrant further study, taking into account the sensitivity of local soils, vegetation, and wildfire. Compared to the cumulative sulfur deposition, the incremental increases associated with Scenario 2 are small.

7.2.3 Visibility

As noted in Section 7.1.3, visibility impacts have been calculated using both Method 2, the currently preferred method under the FLAG guidance, and Method 6, which is the method used for BART modeling reviews and mimics proposed changes to FLAG guidance. In Method 2, visibility calculations use ambient concentrations of the visibility precursor pollutants along with hourly relative humidity data, and the calculated percent change in extinction is compared to the standard FLAG "natural background" values for the western United States. Consistent with current FLM recommendations, Method 2 uses the average daily relative humidity, capped at 95%.

Visibility Method 6 computes extinction from speciated particulate measurements but applies monthly relative humidity adjustment factors for sulfate and nitrate, specific for each location. Extinction changes on the 8th highest day, which represents the 98th percentile, are compared to the 5% and 10% thresholds to address the significance of visibility impacts.

The following discussions of visibility impacts include the customary consideration of incremental impacts – where "Incremental Impacts" for Scenario 2 are those from the Gothic Shale and Paradox Conventional development on already leased land. In addition to the Class I and II receptors described in Section 6.0, visibility was evaluated at three (3) selected vistas in Colorado, Lizard Head Pass, Chalk Mountain, and Dolores Canyon Overlook, as requested by SJPLC.

In addition to the incremental impacts on visibility from the sources to be built under Scenario 2, a cumulative visibility impact analysis was also prepared. Modeled cumulative visibility impacts included all existing and future sources under Scenario 2 (i.e., RFD, existing, and the Scenario 2 Gothic Shale and Paradox Conventional development). The cumulative visibility modeling results are compared to existing visibility measurements at five (5) IMPROVE sites within the modeling domain.

7.2.3.1 Method 2

Class I Areas

The estimated maximum change in extinction coefficient (b_{ext}) for incremental emissions under Scenario 2, calculated using Method 2, is shown in Table 7-114, presented at the end of this subsection. Maximum incremental visibility changes ranged from a 1.83% at Bandelier, to 32.16% at Mesa Verde. Mesa Verde was the site exhibiting the largest extinction change of greater than 10%, but two (2) other sites, Arches and Weminuche, had one (1) day with an extinction change greater than 10%. At Mesa Verde, the modeled frequency of impact was up to 57 days per year over 5% change and up to 15 days per year over 10% change. At the other areas, impacts above 5% were 6 days or less. All changes are relative to the "natural background" visibility.

Although Scenario 2 is the No Action Scenario, the modeled emissions reported here represent the emissions associated with future development on land already leased for oil and gas development. The impacts reported in this section are from these emissions.

Class II Areas of Interest

The estimated maximum incremental change in b_{ext} for the Class II areas of interest under Scenario 2, calculated using Method 2, is shown below in Table 7-115, presented at the end of this subsection. Canyons of the Ancients and Hovenweep were the only Class II areas of interest that had an extinction change greater than 10%. Maximum incremental visibility changes for these Class II areas ranged from a 3.83% at Natural Bridges National Monument, to 51.28% at Canyons of the Ancients, which is within a few kilometers of some of the proposed development for this Scenario. Canyons of the Ancients had a predicted impact frequency of up to 68 days per year over 5% and up to 21 days per year over 10%. Impact frequency was no more than 2 days per year at the other Class II receptors. All changes are relative to the "natural background" visibility.

Selected Vistas

The estimated maximum incremental change in b_{ext} from Scenario 2 for the three (3) selected vistas in Colorado is shown in Table 7-116. Applying visibility Method 2, two (2) out of the three (3) sites, Lizard Head Pass (21.16%) and Dolores Canyon Overlook (19.93%), had an extinction change greater than 10%, although these impacts occurred only a few days in each year. Maximum incremental visibility changes calculated using Method 2 ranged from 2.55% at Chalk Mountain, to 21.16% at Lizard Head Pass.

Conclusion

Using visibility Method 2, extinction changes under Scenario 2 would exceed the 10% threshold at three (3) Class I areas (Arches, Mesa Verde, and Weminuche), as well as at two (2) Class II areas of interest (Canyons of the Ancients and Hovenweep). Except at Mesa Verde (15 days) and Canyons of the Ancients (21 days), these impacts are relatively infrequent, occurring only a few days per year. These impacts come from the expected future emissions from lands already leased for oil and gas development.

Table 7-114

Estimated Maximum Change in Extinction Coefficient (b_{ext}), Number of Days with Extinction Changes Greater than 5% and Greater than 10% Estimated Using Visibility Method 2 for Scenario 2, Incremental Impacts for Class I Areas

	2001			2002			2003		
Class I Area	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**
Arches	10.98%	2	1	2.03%	0	0	7.62%	2	0
Bandelier	1.83%	0	0	1.64%	0	0	1.48%	0	0
Black Canyon of the Gunnison	3.87%	0	0	2.93%	0	0	4.28%	0	0
Canyonlands	7.82%	6	0	5.04%	2	0	7.59%	1	0
LaGarita	1.78%	0	0	1.94%	0	0	5.23%	1	0
Mesa Verde	22.32%	40	9	32.16%	53	14	31.89%	57	15
San Pedro Parks	3.33%	0	0	3.36%	0	0	2.83%	0	0
Weminuche	11.31%	2	1	5.62%	2	0	8.27%	2	0
West Elk	3.07%	0	0	1.61%	0	0	3.00%	0	0

Table 7-115

Estimated Maximum Change in Extinction Coefficient (b_{ext}), Number of Days with Extinction Changes Greater than 5%, and Greater than 10% Estimated Using Visibility Method 2 for Scenario 2, Incremental Impacts for Class II Areas of Interest

	2001			2002			2003		
Class II Area	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**
Canyon de Chelly	9.76%	2	0	4.60%	0	0	1.34%	0	0
Canyons of the Ancients	51.28%	63	14	29.23%	67	21	46.47%	68	18
Chaco Culture	3.06%	0	0	4.74%	0	0	2.60%	0	0
Hovenweep	10.37%	2	1	8.16%	1	0	5.19%	1	0
Natural Bridges	2.95%	0	0	2.58%	0	0	3.83%	0	0

Table 7-116

Estimated Maximum Change in Extinction Coefficient (b_{ext}), Number of Days with Extinction Changes Greater than 5%, and Greater than 10% Estimated Using Visibility Method 2 for Scenario 2, Incremental Impacts at Selected Vistas

	2001			2002			2003		
Visibility Sites	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**
Lizard Head Pass	21.16%	1	1	2.74%	0	0	9.19%	2	0
Chalk Mountain	2.55%	0	0	2.26%	0	0	1.77%	0	0
Dolores Canyon Overlook	9.96%	5	0	14.95%	6	2	19.93%	6	1

7.2.3.2 Method 6

Class I Areas

Table 7-117, presented at the end of this subsection, shows the estimated incremental change in b_{ext} for Class I areas under Scenario 2, calculated with Method 6. Incremental extinction changes on the 8th highest day, which represents the 98th percentile, are compared to the 5% and 10% thresholds. According to this visibility estimation method, Mesa Verde is the only Class I area that is expected to experience extinction changes greater than 10% under Scenario 2. The Class I area with the lowest incremental changes in visibility calculated with Method 6 was Bandelier with an 8th high extinction change of 0.57%; Mesa Verde's highest 8th highest extinction change was 16.13%.

Class II Areas of Interest

Table 7-118 presents the estimated incremental change in extinction coefficient (b_{ext}) for the Class II areas under Scenario 2, calculated with Method 6. Canyons of the Ancients and Hovenweep had predicted extinction changes greater than 5%, although Hovenweep impacts were no more than one (1) day per year. Incremental extinction changes on the 8th highest day ranged from 0.85% at both Canyon de Chelly and Chaco Culture, to 7.58% at Canyons of the Ancients.

Selected Vistas

Table 7-119 presents the estimated incremental change in extinction coefficient (b_{ext}) for the selected vistas, calculated with Method 6. With this visibility calculation method, two (2) of the three (3) vistas had modeled extinction changes greater than 5% under Scenario 2. As was the case with Method 2, the vista with the lowest incremental change in visibility was Chalk Mountain with an 8th high extinction change of 0.92%, and Dolores Canyon Overlook had the highest 8th high extinction change of 4.07%. While Method 6 predicted several instances of extinction changes greater than 5% at these three (3) vistas, the 8th high values were all lower than the 5% threshold.

Conclusion

Using visibility Method 6, the only locations with extinction changes greater than 10% were Mesa Verde and Canyons of the Ancients. Several locations (Weminuche, Hovenweep, Lizard Head Pass, and Dolores Canyon Overlook) had visibility impacts greater than 5% under Method 6, but these impacts were relatively infrequent.

Table 7-117

Estimated Maximum Change in Extinction Coefficient (b_{ext}), Number of Days with Extinction Changes Greater than 5%, and Greater than 10% Estimated Using Visibility Method 6 for Scenario 2, Incremental Impacts at Class I Areas

	2001				2002				2003			
Class I Area	**% Change Highest Day 24-Hour b_{ext} (1/Mega-m)**	**% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change Highest Day 24-Hour b_{ext} (1/Mega-m)**	**% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change Highest Day 24-Hour b_{ext} (1/Mega-m)**	**% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**
Arches	4.02%	2.34%	0	0	2.37%	1.67%	0	0	2.93%	1.46%	0	0
Bandelier	1.09%	0.57%	0	0	0.96%	0.55%	0	0	1.93%	0.49%	0	0
Black Canyon of the Gunnison	3.08%	1.15%	0	0	1.47%	1.09%	0	0	2.56%	1.27%	0	0
Canyonlands	4.48%	3.48%	0	0	3.57%	2.28%	0	0	3.87%	2.20%	0	0
LaGarita	1.42%	0.47%	0	0	2.21%	0.78%	0	0	3.88%	0.90%	0	0
Mesa Verde	7.80%	5.88%	16	0	16.13%	7.71%	35	3	14.27%	7.63%	35	4
San Pedro Parks	2.76%	0.86%	0	0	1.67%	0.98%	0	0	2.56%	0.83%	0	0
Weminuche	4.42%	1.12%	0	0	2.32%	1.71%	0	0	5.19%	1.15%	1	0
West Elk	1.99%	0.81%	0	0	1.39%	0.76%	0	0	2.15%	0.94%	0	0

Table 7-118

Estimated Maximum Change in Extinction Coefficient (b_{ext}), Number of Days with Extinction Changes Greater than 5%, and Greater than 10% Estimated Using Visibility Method 6 for Scenario 2, Incremental Impacts at Class II Areas of Interest

	2001				2002				2003			
Class II Area	**% Change Highest Day 24-Hour b_{ext} (1/Mega-m)**	**% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change Highest Day 24-Hour b_{ext} (1/Mega-m)**	**% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**	**% Change Highest Day 24-Hour b_{ext} (1/Mega-m)**	**% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)**	**Days > 5%**	**Days > 10%**
Canyon de Chelly	4.32%	0.85%	0	0	2.22%	0.64%	0	0	1.72%	0.56%	0	0
Canyons of the Ancients	20.39%	7.43%	26	1	12.46%	7.47%	36	2	16.15%	7.58%	33	3
Chaco Culture	1.53%	0.85%	0	0	2.12%	0.81%	0	0	1.48%	0.85%	0	0
Hovenweep	4.54%	2.81%	0	0	5.99%	2.51%	1	0	5.24%	2.61%	1	0
Natural Bridges	4.20%	1.60%	0	0	2.66%	1.57%	0	0	2.54%	1.80%	0	0

Table 7-119

Estimated Maximum Change in Extinction Coefficient (b_{ext}), Number of Days with Extinction Changes Greater than 5%, and Greater than 10% Estimated Using Visibility Method 6 for Scenario 2, Incremental Impacts at Selected Vistas

Visibility Sites	2001				2002				2003			
	% Change Highest Day 24-Hour b_{ext} (1/Mega-m)	% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)	Days > 5%	Days > 10%	% Change Highest Day 24-Hour b_{ext} (1/Mega-m)	% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)	Days > 5%	Days > 10%	% Change Highest Day 24-Hour b_{ext} (1/Mega-m)	% Change 8th High Day 24-Hour b_{ext} (1/Mega-m)	Days > 5%	Days > 10%
Lizard Head Pass	7.01%	0.82%	1	0	2.56%	1.41%	0	0	5.25%	1.27%	0	0
Chalk Mountain	1.47%	0.53%	0	0	2.65%	0.92%	0	0	1.18%	0.62%	0	0
Dolores Canyon Overlook	4.86%	3.08%	0	0	7.02%	4.07%	4	0	7.33%	2.40%	1	0

7.2.3.3 Cumulative Visibility Impacts from Scenario 2 (No Action Scenario)

A cumulative visibility modeling assessment was also conducted for Scenario 2, which is the No Action Scenario. The No Action Scenario considers all of the same emission sources as Scenario 1, except for the emissions associated with development on land being considered for leasing under this RMP revision. Emission sources in Scenario 2 (No Action) include future development of already leased lands, future RFD projects, and existing sources.

The cumulative impacts under Scenario 2 are very similar to Scenario 1, and in many cases, the impacts are identical. This is true for results under both Method 2 and Method 6. Therefore, the reader should refer to Section 7.1.3.4 (Cumulative Visibility Impacts for Scenario 1) for a discussion of the cumulative impacts for Scenario 2.

While it is recognized that the cumulative modeling assessment and regional monitoring data both document that existing visibility is already impaired compared to natural conditions; the similarity of cumulative impacts modeled by Scenarios 1 and 2 suggest that the development of the additional lands being considered for leasing under this RMP revision does not significantly aggravate the level of existing visibility impairment. This finding is consistent with the incremental visibility modeling analysis for Scenario 1.

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APPENDIX A

Draft Addendum to Air Quality Modeling Protocol
for San Juan Public Lands
Emissions Inventory for CALPUFF Modeling

Prepared August 6, 2009

ADDENDUM TO AIR QUALITY MODELING PROTOCOL FOR SAN JUAN PUBLIC LANDS: EMISSIONS INVENTORY FOR CALPUFF MODELING

Prepared for:

Kelly Palmer
SAN JUAN NATIONAL FOREST
15 Burnette Court
Durango, CO 81301

Prepared by:

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, CO 80525
Phone: 970-484-7941
www.air-resource.com

May 18, 2009

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1.0 INTRODUCTION

As noted in the Air Quality Modeling Protocol for San Juan Public Lands (ARS, 2009), a cumulative CALPUFF modeling analysis will be performed that includes:

- The three development alternatives proposed by San Juan Public Lands (SJPL).
- Other Reasonably Foreseeable Development (RFD) in the region, including development addressed in Resource Management Plans (RMPs), Environmental Impact Statements (EISs), and any private projects stakeholders may be aware of.
- Existing sources in the region.

At the “Kickoff” meeting to discuss the modeling protocol January 9, 2009, stakeholders expressed an interest in seeing the emissions inventory for the cumulative modeling; however, much of these data had not yet been obtained. Furthermore, some of the emissions inventories used for other RFD analyses may need to be modified, to apply changes in legally allowable emission rates enacted after the analysis was performed, or to account for differences between the proposed action and what was approved in the Record of Decision (ROD).

This document delineates the emissions inventories to be used in the cumulative analysis for the SJPL CALPUFF modeling, and presents the strategies Air Resource Specialists, Inc. (ARS) proposes to employ to modify these inventories, if necessary. SJPL will distribute this Emissions Inventory Addendum to the modeling protocol to interested stakeholders. If further modifications to these emissions are requested by stakeholders and approved by SJPL, they will be addressed in the technical support document as well as a notice sent to the interested stakeholders.

2.0 ADDITIONAL RECEPTOR LOCATIONS

As noted in the modeling protocol, the modeling domain (**Figure 1**) is quite large and includes nine (9) Class I areas and parts of four (4) western states. Along with the Class I and sensitive Class II areas shown in **Figure 1,** an additional nested grid of receptors has been added at the suggestion of the stakeholders, with a fine grid of receptors at 8 km resolution around the project area, and a coarse grid of receptors at 24 km resolution that extends over the rest of the domain. These two (2) receptor grids do not extend into the 50 km buffer zone around the edges of the modeling domain. **Figure 2** shows the nested fine and coarse receptor grids along with the receptors for the Class I and Class II areas to be included in the study.

The model will also include the following Class II receptors for sensitive Scenic Vistas located on the San Juan Public Lands:

- View 107 Lizard Head Pass Overlook
- View 119 Chalk Mountain, South San Juan Wilderness
- View 122 Dolores Canyon Overlook

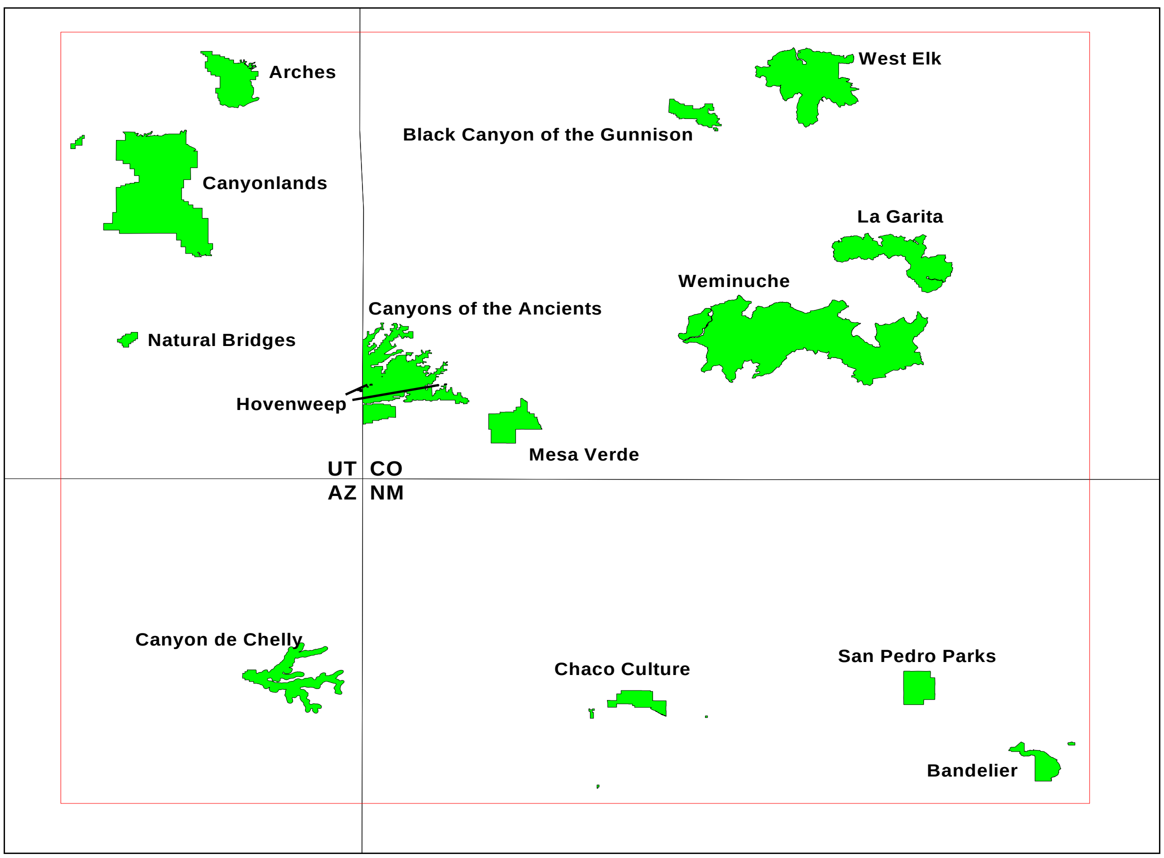

FIGURE 1. CALPUFF MODELING DOMAIN, WITH CLASS I AND CLASS II AREAS TO BE EVALUATED.

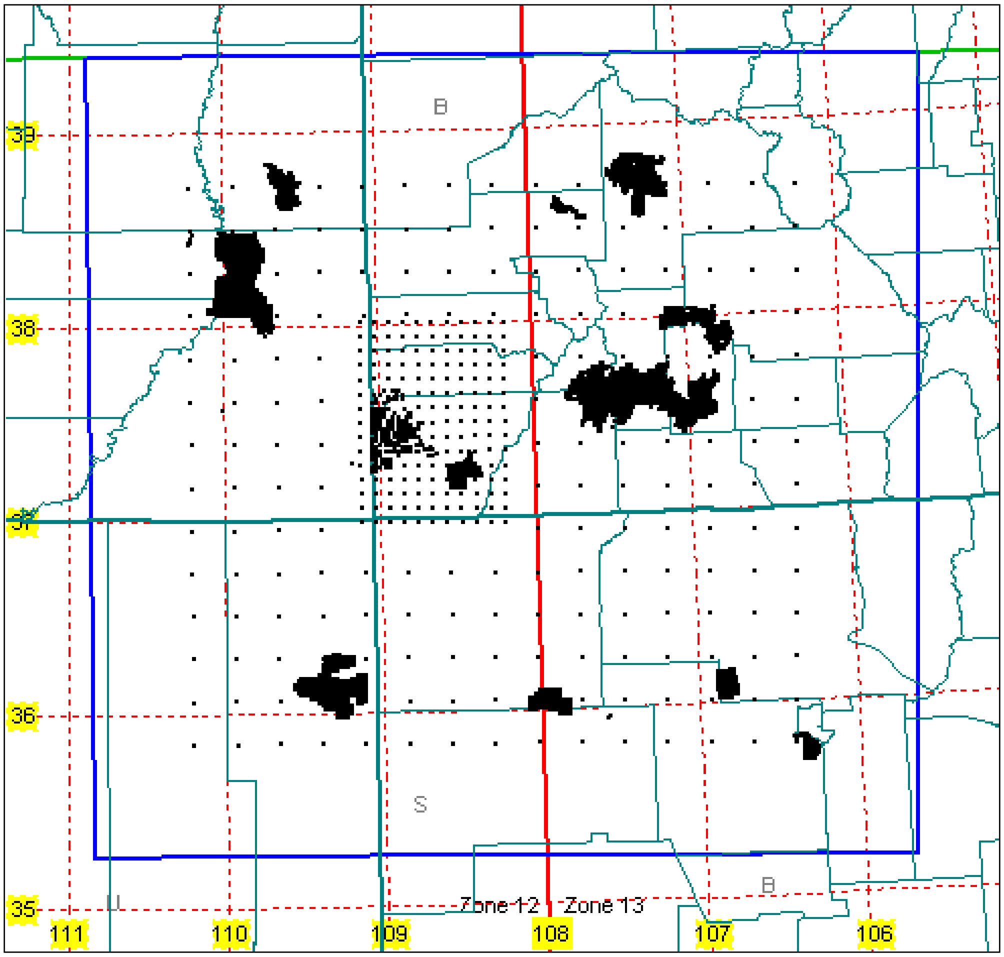

Figure 2. Fine Grid (8 km) Receptors in the San Juan Public Lands Region, and Coarse Grid (24 km) Receptors Over the Rest of the Domain.

3.0 DEVELOPMENT ALTERNATIVES PROPOSED BY SJPL

The proposed development area within San Juan Public Lands' jurisdiction includes public lands administered by the USDA-Forest Service and the Bureau of Land Management, located east and northeast of Canyons of the Ancients National Monument and north of Mesa Verde National Park. For purposes of discussion the development is presented here as two (2) separate projects: Paradox Basin Gothic Shale Well Field, and Paradox Basin Conventional Wells. These development projects are discussed below, including appropriate details and pertinent assumptions relevant to calculating emissions and modeling project impacts.

Details regarding the three development alternatives to be modeled follow the discussion of the two (2) projects.

3.1 GOTHIC SHALE WELLS

3.1.1 General Assumptions for the Gothic Shale Well Field

The Gothic Shale gas field has recently been considered a viable economic gas field. Assumptions are based on currently known field characteristics and using information from approximately five (5) wells that have been drilled in the Gothic Shale to date. The following assumptions will be applied when modeling potential emissions for the Gothic Shale well field.

3.1.2 Wells

Exact well locations are unknown at this point; therefore, all well sources within the Gothic Shale development area will be modeled as area sources in CALPUFF. The hypothetical locations of wells in the Gothic field are attached as a spreadsheet in **Exhibit 1**. A PDF map of hypothetical Gothic Shale well locations is provided as **Exhibit 2**.

Because of the uncertainty associated with this gas field, a certain number of wells are expected to be unsuccessful as producing wells. It is assumed these wells will be drilled and immediately reclaimed. Only emissions associated with construction will be used for these wells.

3.1.3 Gas and Fluids Produced

The following assumptions apply to gas and fluids produced at the wellhead:

- The average daily gas produced per well is 322 M standard cubic feet per day (scfd).
- Estimated Ultimate Recovery (EUR) for a typical well is 2.75 billion cubic feet (bcf).
- Condensate production is 5 bbl/1 million standard cubic feet (MMscf) gas.
- American Petroleum Institute (API) gravity of condensate is 60.
- Separators/Condensate tank flash emissions at wellhead will be controlled to 95% control efficiency.
- 20% of dehydration requirements will occur at the wellhead.
- Dehydrators on private mineral estate will have 10-20% control efficiency at the wellhead.
- Dehydrators on Federal estate will have 80% or better control efficiency at the wellhead.

- The remaining 80% of dehydration will be centralized and controlled at a minimum 95% control efficiency.

3.1.4 Compression

The following assumptions will be applied in calculating emissions from compressors:

- No wellhead compression.
- Six (6) compressor stations will be built for the field for all alternatives.
- Two stage centralized compression will be used. Assume 200 pounds per square inch (psi) at the wellhead and 800 psi line pressure.
- One new compressor station, the Pinto Station (Williams Field Services Company), is in the process of CDPHE permitting and site construction. The other five compressor stations will have similar equipment, emissions, and total horse power.
- The specifications, engine make and model, and stack parameters for the Pinto Station are attached as **Exhibit 3**. Potential locations, and stack information for the Pinto and other future compressor stations are in **Exhibit 1**.
- The compressor stations will be modeled as point sources. The stations will run 365 days a year and 24 hours a day.
- Colorado Control Requirements, Statewide Regulation 7 will be applied to all compressor stations.
- Total well field horsepower (hp) will be 44,000 – 50,000 or an average of 112 hp/MMscfd.

3.1.5 Gas Processing

No new gas processing plants will be constructed. Gas from the Gothic Shale will be transported and processed at the existing Yellow Jacket Facility in Montezuma County, Colorado owned by Williams Company.

3.1.6 Well Fracturing

3.1.6.1 Water

A typical Gothic Shale gas well uses 2.835 million gallons of water or 8.7 acre-feet of water to drill, fracture and complete the well. No water will be obtained from public lands; all water will be purchased by the gas companies from private sources. It is unknown at this time how used/waste drilling fluids will be disposed of after hydraulic fracturing is completed, but it will be assumed that no disposal will occur on public lands. Therefore, in addition to emissions from compressors at the well head and the six new central compressor facilities, emissions from the transport and use of water for well fracturing will be estimated, according to the following assumptions:

- One frac tank is 21,000 gallons (2807 cubic feet) and weighs 175,000 lbs full, which is too heavy to haul on a highway. Tanks will be brought in empty and filled by water trucks.
- 137 large frac tanks will be required to store 2.8 million gallons of water per well.
- Tanker trucks with an average capacity of 5,000 gallon will haul water to fill tanks.

- Each well will require an average of 567 round trips for water tankers to fill all 137 frac tanks.
- An additional 567 round trips per well will be required to haul away frac fluids.
- The average one-way distance for these water-hauling trips is 35 miles one-way (70 miles round trip).

3.1.6.2 Sand

In addition to needing water, fracturing operations will need sand delivered to each well site. The following assumptions will be applied in calculating emissions from sand transport and delivery:

- Each well will use 379,040 cubic feet (14,039 cubic yards) of dry sand, which weighs 236,900 tons.
- One large bottom dump trailer can haul 24 yards of sand; therefore sand hauling will require 585 round trips per well.
- An average one-way distance for these sand-hauling trips of 35 miles (70 mile round trip) will be assumed

3.1.6.3 Other Materials

Besides water and sand, additives such as biocide, acid, potassium chloride, gelling and breaker agents, scale inhibitors, pH chemicals, friction reducers, scale and corrosion inhibitors, surfactants, etc. also must be transported to each well site. These materials will comprise less than 1% of the drilling water volume, but will amount to approximately 12,000 gallons or 1604 cubic feet (59 cubic yards), and require semi truck 10 round trips haul these materials to each site.

3.1.6.4 Engines

Large horsepower engines will be required to pump and pressurize frac fluids into the Gothic formation to produce the well. Emissions, which will arise both from the operation of these engines as well as from their transport to and from the site will be estimated, applying the following assumptions:

- Each frac operations will require a 2,500 hp diesel engine at 2,500 hp; specifications for a Caterpillar 3512C engine will be assumed as typical engine for emissions purposes, as shown in **Exhibit 4**.
- Nine (9) engines will be hauled per truck/trailer.
- Nine (9) trucks will haul in nine (9) engines each.
- Frac operations will run engines/pumps 15 hours of continuous operation.
- An average one-way distance of 20 miles (40 miles round trip) will be assumed for transporting these diesel engines. Most transport will involve equipment being moved from well to well within the field with intermittent long distance transport.
- Additionally 5 round trips of large diesel passenger trucks for monitoring, mixing, and other vehicles will be assumed.

3.1.7 Construction, Drilling, and Other Activities

Assumptions regarding the amount of disturbance, pad and road construction, drilling, vehicles etc. are summarized in a spreadsheet as **Exhibit 5**.

3.2 CONVENTIONAL WELLS – PARADOX BASIN

3.2.1 General Assumptions for the Paradox Well Field

The Paradox Basin conventional oil and gas wells were inventoried and analyzed as part of the AERMOD analysis associated with the first draft of the San Juan Plan Revision. The same emissions inventory and assumptions will be used for this CALPUFF modeling effort, and are summarized below.

3.2.2 Wells

Exact well locations are unknown at this point; therefore, all well sources within the Paradox Basin development area will be modeled as area sources in CALPUFF. Also, because of the uncertainty associated with this gas field, a certain number of wells are expected to be unsuccessful as producing wells. It is assumed these wells will be drilled and immediately reclaimed. Only emissions associated with construction will be used for these wells.

3.2.3 Compression

The following assumptions will be applied in calculating emissions from compressors:

- One (1) 50 hp well head compressor engine per well
- A NO_X emission factor of 2 g/hp-hr will be used for well head compressor engines
- One (1) 350 hp compressor station will be built for the field for all alternatives.
- A NO_X emission factor of 1 g/hp-hr will be used for central compressor engines
- The compressor station will be modeled as a point source. The station will run 365 days a year, 24 hours a day.

3.3 ALTERNATIVES TO BE MODELED

Three alternatives will be modeled in the following order:

1. Maximum Potential Development
2. No Lease Alternative
3. Alternative C

Each of these alternatives accounts for different levels of potential well development that might occur if currently un-leased Federal lands are offered for lease. Definitions and specifics of each alternative are presented below.

3.3.1 Actions Common to All Alternatives

Drilling is expected to continue on state and private lands and on federal lands that are already leased within the Paradox Basin (both Paradox Conventional wells and Gothic Gas Shale wells.) It is also a reasonably foreseeable future action that infill drilling down to 80-acre spacing will occur within the Northern San Juan Basin. The projected well numbers associated with these activities are common to all alternatives, even the No Action alternative.

Table 1

Additional Wells Common to All Alternatives

	State and Private Land	Forest Service Land	BLM Land	Total
Paradox Conventional	50	25 production 10 drilled/reclaimed	128 production 20 drilled/reclaimed	233
Paradox - Gothic Shale Gas	760	94 production 7 drilled/reclaimed	231 production 21 drilled/reclaimed	1113
Grand Total				1346

3.3.2 Alternative #1: Maximum Potential Development

San Juan Public Lands requests this alternative/scenario be modeled first. If the maximum potential development scenario shows no air quality problems (e.g. significant visibility degradation, NAAQS, deposition) the other alternatives may need no further modeling. This scenario assumes:

- The maximum number of wells that could be developed in the Gothic Shale gas field if the maximum amount of currently un-leased Federal lands are leased
- The maximum number of wells that could be developed in the Paradox Basin Conventional field if the maximum amount of un-leased Federal lands are leased

Table 2

Well Numbers for Maximum Potential Development

	Forest Service Land Un-leased	BLM Land Un-leased	Total
Paradox Conventional	90 production 18 drilled/reclaimed	32 production 12 drilled/reclaimed	152
Paradox - Gothic Shale Gas	408 production 40 drilled/reclaimed	146 production 12 drilled/reclaimed	606
Grand Total (Paradox Conventional + Gothic Shale Gas)			758

3.3.3 Alternative #2: No Lease Alternative

This scenario assumes no new leasing of currently un-leased Federal lands would occur. San Juan Public Lands requests this alternative/scenario be modeled second. No new wells are associated with this alternative. Note, however, that this alternative would still include the wells listed in **Table 1**.

Table 3

Well Numbers for No New Leasing Scenario

	Forest Service Land	BLM Land	Total
Paradox Conventional	0	0	0
Paradox - Gothic Shale Gas	0	0	0
Grand Total (Paradox Conventional + Gothic Shale Gas)			0

3.3.4 Alternative C

This scenario assumes a slightly lower amount of well field development compared to the maximum development scenario.

Table 4

Well Numbers for Alternative C

	Forest Service Land	BLM Land	Total
Paradox Conventional	82 production 17 drilled/reclaimed	29 production 11 drilled/reclaimed	139
Paradox - Gothic Shale Gas	378 production 36 drilled/reclaimed	136 production 11 drilled/reclaimed	561
Grand Total (Paradox Conventional + Gothic Shale Gas)			700

4.0 REASONABLY FORESEEABLE DEVELOPMENT PROJECTS

Numerous projects have been identified as potential candidates for inclusion in the cumulative analysis. **Table 5** lists the RFD projects considered for the San Juan cumulative analysis, the agency responsible for the analysis, and the approximate location of the potential development. The specifics of each project, including the assumptions made in its RMP, EIS, Air Quality Technical Support Document (TSD) or permit application, estimated emissions, and how ARS proposes to include it in the cumulative CALPUFF modeling analysis for SJPL are discussed below. A summary table of the various RFD projects, and the assumptions applied in developing their emissions inventories, is shown in **Exhibit 6**.

Table 5

Reasonably Foreseeable Development Projects Suggested for Inclusion in the Cumulative Analysis for SJPL

Project	**Agency**	**Approximate Location**
Northern San Juan Basin Coalbed Methane EIS	Colorado BLM	Southwestern Colorado
Northern San Juan Basin Infill Wells	Southern Ute Indian Tribe	Southwestern Colorado
Southern Ute EISs	Southern Ute Indian Tribe	Southwestern Colorado
Jicarilla Oil and Gas Leasing EIS (Carson NF)	USDA-Forest Service	North-central New Mexico
Farmington Field Office RMP	New Mexico BLM	Northwestern New Mexico
Canyons of the Ancients National Monument RMP	Colorado BLM	Southwestern Colorado
Desert Rock Power Plant	STEAG Power, LLC (private industry) & DINE Power Authority (Navajo Nation enterprise)	Northwestern New Mexico
Monticello RMP	Utah BLM	Southeastern Utah
Moab RMP	Utah BLM	Southeastern Utah
SantaFe NF Oil & Gas EIS	USDA Forest Service	North-central New Mexico
Price RMP	Utah BLM	Eastern Utah

Most of the RFD projects are oil and gas development projects. As such, their air quality modeling usually only included NO_X; SO_2 and PM_{10} emissions from gas-fired well head engines and central compressors were considered negligible. If PM_{10} emissions for an RFD project, such as those from construction, disturbed land, or traffic on unpaved service roads were estimated and included in the project's air quality analysis, these PM_{10} emissions will be included in the cumulative modeling for SJPL. If such emissions were not included, it would be out of scope for SJPL to estimate PM_{10} emissions for other projects. Therefore SJPL will not include PM_{10} in the cumulative analysis for projects that did not evaluate PM_{10} impacts. SJPL will include PM_{10}

emissions for its proposed alternatives, and will include PM_{10} emissions in the cumulative analysis for any RFD that included PM_{10} in their analysis.

4.1 NORTHERN SAN JUAN BASIN COALBED METHANE EIS

RTP Environmental prepared the air quality analysis for the Northern San Juan Basin Coalbed Methane (NSJCBM) EIS in June 2004. Three out of five proposed development alternatives were modeled including the preferred alternative which would have:

- 296 wells
- 14,382 total hp of well head compression
- 41,000 total hp of central compression
- 1440 tons per year (tpy) NO_X emitted (616 tpy from central compressors, 61 tpy from dehydrators, and 731 tpy from well head compressors)

NSJCBM assumed NO_X emissions of 10 g/hp-hr for well head compressors and 1.5 g/hp-hr for central compressors. However, *all* NO_X emissions were modeled at 75% of these figures. The discussion of NSJCBM's near field modeling (done with ISCST3, the appropriate EPA guideline model at the time) acknowledged that NO_X emissions were modeled at 75%, which is the default "ambient ratio" used to account for incomplete conversion of NO to NO_2 when insufficient ozone is present. Such an approach is inappropriate for CALPUFF modeling, as CALPUFF includes atmospheric chemistry and takes ambient ozone into account (either via a specified background value or a separate data file of hourly ozone values; modeling for SJPL will include the latter). The NSJCBM technical support document made no mention of an ozone data file for their "far field" CALPUFF modeling, nor of the "MNITRATE" switch; presumably this feature was not used.

Scott Archer of the BLM provided ARS with the CALPUFF input files for the three scenarios modeled for NSJCBM, as well as those for the other RFD projects that were included in the NSJCBM cumulative analysis. ARS plans to update NSJCBM's modeling input parameters for Alternative 1, NSJCBM's preferred alternative, as follows:

- The full and appropriate NO_X emission rate will be used for all sources and not 75% of this value.
- Total central compression will be reduced by a conservative estimate of 30%, to a final total of 28,700 hp. The San Juan Public Lands and industry acknowledge that centralized well field compression was overestimated in the original NSJB EIS analysis.
- Emission rates for the small well head compressors will be adjusted to correspond to an emission factor for compressor engines lower than the 10 g/hp-hr used in the NSJCBM modeling (48 hp engines). A value of 2.0 g/hp-hr NOx emissions will be used for all engines between 40 and 300 hp located on federal lands regardless of the construction date, as recommended by SJPL.
- Emission rates for central compressors will be adjusted to reflect 1.0 g/hp-hr, the maximum value allowed after July 1, 2010, for engines greater than 500 hp. Per direction from SJPL, 1.0 g/hp-hr NOx emissions will be applied for all compressors 300 hp or greater located on federal lands regardless of the construction date.

- Emissions from dehydrators, which were modeled by adding their emissions to those from compressor emissions, will be adjusted to reflect true emission rates at allowable emission factors.

4.2 NORTHERN SAN JUAN BASIN INFILL WELLS IN COLORADO
(Wells North of the Ute Line)

4.2.1 General Assumptions for the Northern San Juan Basin Infill Well Field in Colorado

The Northern San Juan Basin Infill Well Project is not part of the San Juan Plan Revision, but rather is a separate project to be modeled for cumulative effects similar to the Southern Ute PEA and other projects. Although there are several emission inventories associated with the Northern San Juan Basin EIS (NSJB EIS), there are no emission inventories available for the new infill drilling project. The emission inventory for this project was compiled by the San Juan Public Lands with some input from industry. This project accounts for an increase in well numbers as well spacing changes from 160-acre spacing (NSJB EIS) to 80-acre spacing (Northern San Juan Basin Infill).

Please note that infill drilling on the Southern Ute Indian Reservation located south of the Ute Line within the Northern San Juan Basin in Colorado is not included in this inventory. The SUIT PEA emission inventory provided by ENVIRON to ARS accounts for well development south of the Ute Line. See discussion below (in Section 4.3) for additional inventory information about the SUIT PEA.

4.2.2 Wells

A total of 489 new infill wells would be associated with 80-acre spacing infill drilling north of the Ute Line on all land ownerships. Construction of infill wells in general would start in 2011 and continue for 6 years at an average of 82 wells drilled per year. A spreadsheet of well locations across the Northern San Juan Basin infill area has been developed by the San Juan Public Lands (**Exhibit 7**). These locations were generated assuming all planned and existing wells analyzed in the NSJB EIS would have one additional well drilled on the same pad. It was assumed that zero infill wells at 80 acre spacing would be drilled on the Fruitland Outcrop.

4.2.3 Electric Well Head Engines Vs. Gas Fired Well Head Engines

Regardless of the power source, each infill well would have one 48 hp engine (either a pump jack, a progressive cavity pump, or a small compressor engine) plus one separator heater. The separator heaters on average only run six (6) months per year.

The NSJB Infill Well spreadsheet (**Exhibit 7**) identifies conservatively which wells might be electrified as well development progresses. It is assumed that 70% of infill wells will be electrified in La Plata County north of the Ute Line, excluding the Saul’s Creek area on Federal lands and the Rabbit Mountain Area on Federal lands. None of the wells in Archuleta County would be electrified. These estimates are for modeling purposes only and are not meant to serve as absolute commitments to electrification on a well by well basis.

For wells identified as electric powered, generator sets will be used until electricity is brought to the site. On average, the generator sets would be used for 6 months per site. The generator sets are 160 hp engines rated at 2.0 g/hp-hr for NO_X, 4.0 g/hp-hr for CO, and 0.23 g/hp-hr for HAPs. Approximately 22 generator sets would be in use north of the Ute line for six (6) years until the drilling is completed (calculated by 258 electrified wells built over six (6) years, average 43 electrified wells/year, each generator set services 2 wells per year). Once the site is electrified, the generator sets would be removed and taken to a new well site. All projected well head compression, if needed, would be electrified on these sites. All separator heaters would be electrified on these sites.

Wells powered by natural gas will be assumed to have one 48 hp engine with 2.0 g/hp-hr NO_X emissions. Separator heater emission factors will be calculated using the following emission factors from AP-42 Section 1.4: NO_X 100 lb/MMscf, CO 84 lb/MMscf, and HAPs 11.3 lb/MMscf with the heat capacity of a single well 0.25 MMBtu/hr. Emission factors per well of 0.025 lbs/hr NO_X, 0.021 lbs/hr CO, and 0.002825 lbs/hr HAPs will be assumed for separator heaters.

4.2.4 Condensate and Produced Water

Produced water is typical of wells in the Northern San Juan Basin. Any new underground injection control wells for the disposal of produced water north of the Ute line would be completely electrified. However, no new produced water injection wells are planned for the new Northern Basin Infill wells.

The Gothic Shale wells will have no wellhead dehydration, only centralized dehydration. Centralized dehydration will have no VOC emissions. It is also assumed that the project will have no produced condensate, no flash tank emissions, no condensate tanks and no tank batteries. No new gas processing plants will be constructed.

4.2.5 Centralized Compression

There are no plans to construct new centralized compression sites north of the Ute Line. It is conservatively assumed that one more natural gas fired compressor unit will be added to the Pinon Compressor Site on BLM land north of the Ute line. This site and this additional unit have been accounted for in the Northern San Juan Basin EIS inventory for air quality analysis. A recent emissions test for the units at the Pinon Compressor Station is included as **Exhibit 8**. The results of this test are assumed to be the emissions rates that should be modeled for this station and the future additional compressor unit.

No new centralized compression stations would be built for infill drilling. Centralized compressor stations to be used for the infill drilling wells are included in the emission inventories for the NSJB EIS and the Southern Ute Indian Tribe Programmatic EA.

4.2.6 Construction, Drilling, and Other Activities

Assumptions regarding the amount of disturbance, pad and road construction, drilling, vehicles etc. are summarized in a spreadsheet as **Exhibit 5**.

4.3 SOUTHERN UTE INDIAN TRIBE EIS

The NSJCBM EIS Technical Support Document (TSD) included RFD emissions for the Southern Ute Indian Tribe (SUIT) EIS in its cumulative analysis. The tribe did not do air quality modeling for its RFD; however, the BLM had a proposed action inventory to work from, and presented a list of sources and model input parameters in Appendix E of its Air Quality TSD (RTP Environmental, 2004). NSJCBM employed a NO_X emission factor of 1.5 g/hp-hr for central compressors. If SJPL elects to use the SUIT RFD emissions inventory NSJCBM developed, ARS proposes making the following adjustments to model input parameters:

- Employ the full and appropriate NO_X emission rate (not 75% of this value).
- Depending on feedback from SJPL and the stakeholders, a lower NO_X emission factor may be applied for central compressor engines greater than 500 hp. However, facilities on SUIT-controlled land are not subject to the same regulations as those administered by the states, so higher emission levels may be allowed.

Because the emissions inventory NSJCBM used was based on a proposed inventory developed in 2000, ARS also obtained more recent emissions inventories for the SUIT from Environ. These inventories had been used in the modeling performed for the Four Corners Air Quality Task Force (not yet published). These inventories included both a file representing current emissions (as of 2005) for existing sources on Southern Ute-controlled tribal lands, as well as one representing expected future emissions for sources on Southern Ute land in 2018. Documentation accompanying the emissions inventory files indicates that the 2018 SUIT emissions included "proposed 80 acre infill project emissions." However, Environ's documentation indicated that rather than listing additional sources, "Infill project emissions were distributed among the existing sources." Both files have the same number of sources, same source names, and identical stack parameters, but different emission rates. Some sources have higher emission rates projected for 2018, others have lower emissions. Although the 2018 SUIT emissions inventory is supposed to include additional RFD, total NO_X, CO, and VOC emissions are 25% – 29% lower than those in the 2005 inventory.

According to Four Corners Modeling 2005 & 2008 Emissions Inventory (August 2008) prepared by Allison Pollack of Environ[8], emissions for 2018 were left constant at 2005 emissions, and no more drilling is allowed per SUIT 1999 EIS.

There does not appear to be much (if any) duplication of the sources listed in NSJCBM's projected emission inventory for future development on SUIT lands and those listed in Environ's files. For reference, total NO_X emissions for SUIT RFD in NJSCBM's analysis were 18,496 tpy; the emissions inventories from Environ indicated 4694 tpy in 2005 and 3350 tpy in 2018.

4.4 JICARILLA OIL AND GAS LEASING EIS (CARSON NF)

The Jicarilla Ranger District is in the Carson National Forest, in northwestern New Mexico, about 80 km east of Farmington. In 2005 ARS performed the CALPUFF modeling for the Jicarilla Oil and Gas Leasing EIS, which would include:

[8] http://www.nmenv.state.nm.us/aqb/4C/Documents/FourCornersModelingProject_2005_2018Emissions_Inventory_080708.pdf.

- A maximum of 694 oil and gas wells
- central compressor stations
- An estimated 3828 tpy of additional NO_X emissions (3558 tpy from well head compressors and 273 tpy from central compressors)

The well heads would also have separator units equipped with small combustion burners. The emissions from the separators would be small compared to those from the well head compressors, and were omitted from the analysis.

In preparing the emissions inventory for Jicarilla, it was assumed that:

- Well head engines would be 95 hp, but would operate at 85% load
- 50% of wells would require a well head compressor
- Well head compressor engines would emit NO_X at 13.15 g/hp-hr
- 18,000 hp of central compression (~3000 hp per station) would be needed
- Central compressors would emit NO_X at 1.64 g/hp-hr

Due to the number of wells (almost 700), ARS modeled the well head compressors as 20 area sources, with differing emission rates depending on the number of wells per section.[9] The same approach will be used when including the Jicarilla RFD in cumulative modeling for SJPL; however, emission rates for Jicarilla's well head and central compressor engines will be adjusted as follows:

- A value of 2.0 g/hp-hr NOx emissions will be used for all engines between 40 and 300 hp located on federal lands regardless of the construction date, as recommended by SJPL.
- Per direction from SJPL, a 1.0 g/hp-hr NOx emission factor will be applied for all compressors 300 hp or greater located on federal lands regardless of the construction date.

4.5 FARMINGTON FIELD OFFICE RMP

The BLM Farmington Field Office RMP RFD was included in the cumulative modeling for both NSJCBM and Jicarilla. This project would have as many as 4421 new wells, with well head engines installed on 50% of the wells, and a central compressor capacity of 360,000 hp. NSJCBM reviewed the original Farmington RMP emission inventory and modified it as follows:

- Emissions from well head engines were aggregated into 190 point sources, with each point representing emissions from 26.2 engines.
- Well head engines were assumed to be 68.5 hp, consistent with data on the weighted average size of small well head engines in the region from the New Mexico Oil and Gas Association (NMOGA).

[9] ARS intends to use a similar approach in modeling the SJPL development alternatives, aggregating multiple wells into area sources.

- Well head engines were modeled with a NO_X emission factor of both 9.62 g/hp-hr (per NMOGA data for existing units) and 2.0 g/hp-hr (for lean-burn engines).
- Utilization rates of well head engines were assumed to be 54%, consistent with NMOGA data.
- Each well was assumed to have a separator; 70 separators (with total NO_X emissions of 7.5 tpy) were added to each of the 190 small well head engine modeling point sources (where each point source represents 26.2 actual well head engines).
- NSJCBM assumed there would be 36 central compressor stations, each with a capacity of 10,000 hp; stack parameters were based on the assumption that each central compressor station would have four 2,500 hp engines.
- A NO_X emission factor of 1.5 g/hp-hr was assumed for the central compressor engines.
- Central compressor engine locations were estimated by placing a compressor station in each of the 36 townships with the highest number of existing wells.

As with their own project, NSJCBM modeled Farmington RFD well head NO_X emissions at 75 % of their calculated values, in addition to assuming utilization would be only 54%. Therefore while the potential emissions from 4971 well head engines at 68.5 hp and 9.62 g/hp-hr would total 31,639 tpy, NSJCBM actually only modeled 13,903 tpy of NO_X emissions from compressor engines.

According to NSJCBM's CALPUFF modeling files for Farmington's central compressors, 36 point sources were modeled at 3.13 g/s, which amounts to 3917 tons per year. This value is 75% of NSJCBM's calculated value of 5210 tpy.

While modeling NO_X at 75% of its expected emission rate to account for incomplete conversion of NO to NO_2 in the absence of sufficient ozone is acceptable for ISC and AERMOD applications, it is not appropriate for CALPUFF applications because CALPUFF simulates atmospheric chemistry processes that ISC and AERMOD do not. Using a lower emission rate for CALPUFF would lower results not only for NO_X impacts but also for other results affected by NO_X or nitrogen compounds such as visibility and nitrogen deposition.

To use NSJCBM's CALPUFF modeling files for the Farmington RFD in SJPL's cumulative modeling analysis, the following adjustments are proposed:

- Recalculate well head engine emissions using 2.0 g/hp-h for all wells on Federal lands if engines are less than 300 hp but greater than 40 hp regardless of construction date).
- Drop the 54% utilization assumption for well head engines. Assume 100% utilization unless SJPL or stakeholders recommend a lower value.
- Recalculate central compressor emissions to reflect the new limit (effective July 1, 2010) of 1.0 g/hp-hr, rather than the 1.5 g/hp-hr employed by NSJCBM.
- Model at the full, appropriate emission rate for NO_X and not 75% of that value, allowing CALPUFF's atmospheric chemistry algorithms to account for available ozone with an "ozone.dat" file of hourly observations at sites throughout the modeling domain.

The Farmington RMP was also included in the cumulative analysis for Jicarilla, using emissions and source locations based on information in the NSJCBM TSD, Appendix F (ARS did not have the NSJCBM CALPUFF modeling files at that time). Because exact locations of the wells and compressors were not known (NSJCBM used approximate locations), groups of sources that NSJCBM had modeled as point sources were aggregated and modeled as area sources.[10] This resulted in 18 area sources representing central compressors and 23 area sources representing well heads. Emissions used in the Jicarilla cumulative modeling were based on the calculations presented in the NSJCBM TSD, Appendix F; therefore the emission rates for Farmington RFD used in Jicarilla's cumulative modeling did not have the 75% reduction factor found in NSJCBM's CALPUFF modeling files. They did, however, include the 54% utilization factor.

If ARS were to use Jicarilla's CALPUFF modeling files for Farmington in SJPL's cumulative modeling analysis, the same adjustments would need to be applied as were listed above for NSJCBM's CALPUFF input files. These include:

- Recalculating emission rates to reflect the new allowable emission factors effective July 1, 2010 for engines greater than 500 hp of 1.0 g/hp-hr NO_X
- Recalculating well head engine emissions using 2.0 g/hp-h for all wells on Federal lands if engines are less than 300 hp but greater than 40 hp regardless of construction date)
- Dropping the 54% utilization factor applied to well head engines

4.6 CANYONS OF THE ANCIENTS NATIONAL MONUMENT RMP

The air quality analysis for the Canyons of the Ancients National Monument (CANM) RMP was conducted by RTP Environmental in July 2006. This project would include:

- 81 oil and gas wells
- 69 CO_2 wells
- Eight (8) central compressor stations (4 for CO_2 and 4 for natural gas)

Estimated project emissions included 360 tpy of NO_X (215.3 tpy from construction/144.7 tpy from production), 232.6 tpy of CO (38.7 tpy from construction/183.9 tpy from production), and 14.7 tpy of SO_2 (14.5 tpy from construction/0.2 tpy from production).

Assumptions used in estimating project emissions for CANM include:

- The four (4) CO_2 compressor stations will be electrically driven and produce no air emissions.
- The four (4) natural gas central compressor stations will require 350 hp engines.

[10] Sources were also grouped into area sources to minimize computational time. However, recent benchmarking suggests that CALPUFF's algorithms for area sources are more computationally intensive than those for point sources, by a ratio of over 10 to 1, based on execution times. While the use of area sources to represent a group of point sources is not inappropriate, particularly when exact locations of these sources are not known, a run-time savings would only be achieved if an area source represents at least 11 point sources.

- The 81 natural gas well head compressors will require 50 hp engines.
- Central compressors would emit NO_X at approximately 12.2 g/hp-hr[11].
- Well head compressors would emit NO_X at approximately 10.0 g/hp-hr[12].

Impacts were evaluated for only one Class I area, Mesa Verde National Park, approximately 40 km east of CANM. The next closest Class I area is Weminuche Wilderness, about 112 km to the east. Impacts at Mesa Verde would presumably be higher than those at any of the Class I areas further away. Since Mesa Verde is within 50 km of CANM, the analysis was performed with AERMOD.

Construction emissions and production emissions were modeled separately. Production was modeled by placing two central 350 hp compressors in each of two sections (total compression of 1400 hp), at two separate sections in the monument where development is likely to occur (Island Butte unit for oil and gas wells/Cutthroat area for CO_2 wells). Each of these two sections also included four well head heaters; however, total emissions for the 81 new oil and gas wells were apportioned to these eight engines, resulting in a modeling analysis with fewer sources.

While the approach CANM employed may be adequate for assessing long-range impacts to a Class I area 40 km away, it concentrates the emissions from about ten wells into one, thereby concentrating the impacts at locations nearby.[13] As shown in Figure 2, the SJPL modeling will have receptors much closer than 40 km, including receptors in the monument itself, as well as a fine grid of receptors in and around the SJPL development immediately to the east and northeast of the monument. Therefore a different source configuration to represent CANMs' RFD may be advisable, to avoid "bull's eyes" resulting from concentrating the potential emissions from the project.

ARS proposes that the emissions from the proposed development at CANM be modeled as a small number of area sources, centered over the approximate locations RTP used in the ISC modeling, to minimize the potentially exaggerated localized impact in the vicinity. As with the RFD for other projects, the following adjustments would be applied to emissions estimates for CANM:

- Central compressors would be limited to 1 g/hp-hr, per the limit (effective July 1, 2010) for engines between 100 and 500 hp.
- Well head engine emissions would be recalculated to reflect 2.0 g/hp-hr NOx emissions for all engines between 40 and 300 hp located on federal lands after the ROD is signed (assume from 2010 on)

[11] Emission calculations presented in Table A-21 of CANM's Draft RMP/DEIS are based on expected natural gas usage; the emission rate of 9.4263 lb/hr back-calculates to 12.2164 g/hp-hr.
[12] Emission calculations presented in Table A-24 of CANM's Draft RMP/DEIS.
[13] It should be noted that RTP Environmental also performed near-field analyses using a generic layout to demonstrate that near-field impacts would not exceed applicable standards.

4.7 DESERT ROCK ENERGY FACILITY

The Desert Rock Energy Facility (Desert Rock) is a proposed coal-fired power plant to be located on Navajo land in northwest New Mexico, about 25 miles southwest of Farmington. The PSD permit application was prepared by ENSR International (now AECOM Environmental), and submitted to the USEPA in May 2004. ARS has the PSD permit application, as well as all the CALMET and CALPUFF modeling files for Desert Rock. According to the permit application, Desert Rock's potential emissions would be 3525 tpy of NO_X, 5529 tpy of CO, 3319 tpy of SO_2, and 1220 tpy of PM_{10}.[14]

Emissions from Desert Rock will be included in the SJPL cumulative modeling as they appear in the CALPUFF input files that accompanied its PSD permit application, unless SJPL or stakeholders have some reason to modify these values. One exception is that PM_{10} emissions will be speciated; i.e., the components of the particulate matter – such as elemental carbon, fine PM, coarse PM, secondary organics, and SO_4 – will be estimated, based on tables prepared by the National Parks Service (http://www.nature.nps/gov/air/permits/ect) for coal-fired combustion turbines with the emission control equipment planned for Desert Rock. This facility will have high stacks with a high potential for long-range transport. therefore including these different PM_{10} components, which each affect visibility differently will allow for better estimates of cumulative visibility impacts.

4.8 MONTICELLO RMP

The Utah BLM's Monticello Field Office's RMP did not include modeling for the proposed 72 oil and gas wells included in their project because the air quality impacts from this RFD were not a concern. CANM included emissions from the Monticello RMP in their cumulative analysis by roughly estimating the emissions and consolidating the Monticello emissions into a single 10 km x 10 km volume source, about 40 km west of CANM.

Without more specific knowledge about emissions sources within the Monticello RMP, SJPL decided not to include this project in the cumulative modeling analysis. Cumulative impacts in the vicinity of Monticello may be under-estimated due to the inability to adequately model this project.

4.9 MOAB RMP

The Utah BLM's Moab Field Office's RMP did not include modeling for the proposed development project because the air quality impacts were not a concern. It is difficult to tell from the RMP and ROD exactly how many oil and gas wells or other types of development might occur within this region. CANM did not include Moab in its cumulative analysis because at 80 km away, it was beyond the valid distance for ISC applications.

Without more specific knowledge about emissions sources within the Moab RMP, SJPL decided not to include this project in the cumulative modeling analysis. Cumulative impacts in

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[14] Modeled emissions are somewhat higher, perhaps due to round-off error, but possibly also due to the need to model "worst case" 24-hour emission rates in order to evaluate visibility impacts. Emissions during start-up and shut-down periods tend to be higher; thus the reason for higher 24-hour emission rates.

the vicinity of Moab may be under-estimated due to the inability to adequately model this project.

4.10 SANTA FE NF OIL AND GAS EIS

The Santa Fe National Forest Oil and Gas RFD would include about 20 wells. Although some stakeholders initially recommended including this small project in the cumulative analysis, SJPL was unable to obtain the EIS or TSD in a timely manner. Without more specific knowledge about the emissions expected from this RFD, SJPL decided not to include this project in the modeling analysis. Cumulative impacts in the vicinity of SantaFe National Forest may be underestimated without the inclusion of SantaFe NF RFD. However, emissions from this relatively small 20-well project would likely be negligible compared to those from the proposed SJPL alternatives.

4.11 PRICE RMP

The Utah BLM's Price Field Office's RMP did not include modeling for the proposed development project because the air quality impacts in the Price vicinity were not a concern. It is difficult to tell from the RMP and ROD exactly how many oil and gas wells or other types of development might occur within this region.

Without more specific knowledge about emissions sources within the Price RMP, SJPL decided not to include this project in the cumulative modeling analysis. Cumulative impacts in the Price vicinity may be underestimated due to the inability to adequately model this project; however, since air quality in that region is very good, exceedances of ambient air quality standards are unlikely. The Price Field Office's jurisdiction is in the far northwestern portion of the modeling domain; thus, excluding its RFD would have very little effect on cumulative impacts in the vicinity of SJPL.

5.0 EXISTING SOURCES IN COLORADO, NEW MEXICO, UTAH, AND ARIZONA

A large number of emissions sources exist within the modeling domain and should be included in the cumulative analysis in order to provide an appropriate estimate of potential cumulative impacts. However, practical considerations require that the actual number of sources modeled be reduced to a manageable number. ARS proposes limiting the number of existing sources included in the modeling by doing the following:

- If the sum of a facility's NO_X, SO_2, and PM_{10} emissions is less than 10 tons per year, its impacts are to be considered insignificant for the purposes of this cumulative analysis and will not be included in the modeling.
- Facilities such as gravel pits, mines, or mineral crushing/processing operations with primarily fugitive or ground-based PM_{10} emissions totaling less than 25 tons per year will also be considered insignificant for the purposes of this cumulative analysis and will not be included in the modeling.
- Where possible, facilities that have multiple units with identical (or nearly identical) stack parameters will be modeled by consolidating emissions from multiple stacks into a single stack.

The proposed oil and gas development will not include a substantial amount of PM_{10} emissions. Therefore, the PM_{10} impacts from the proposed development scenarios are not expected to be a concern; the same would hold true for cumulative PM_{10} impacts. Impacts from fugitive and ground-based emissions tend to be localized, and the contribution of PM_{10} to visibility impacts is not as significant as that from NO_X and SO_2. Dropping PM_{10} emissions from existing sources that emit less than 25 tons per year can reduce the number of sources to be modeled without significantly affecting the results of this analysis.

While many existing PM_{10} sources are sufficiently small and low to the ground that they can be dropped from the cumulative analysis without significantly affecting the results, the existing source inventories also include some major sources that emit PM_{10} in large quantities and through high enough stacks that their long-range transport and effects on visibility would be of concern in the cumulative analysis. As with the Desert Rock project, PM_{10} emissions from combustion sources will be speciated into components constituting elemental carbon, fine particulate, coarse particulate, secondary organics, and SO_4, according to their fuel type (coal, gas, diesel or wood) and emission control equipment, using the tables recommended by the National Parks Service (http://www.hature.nps.gov.air/permits/ect).

5.1 COLORADO SOURCES

Emissions information for existing Colorado sources within the domain was obtained from the Colorado Department of Public Health and Environment, and is included as **Exhibit 9**. To minimize the number of sources, emissions from sources at a facility that have identical stack parameters will be consolidated into a single source.[15]

[15] In cases where most of the emissions are from a dominant stack, emissions from other sources may be assigned to the dominant stack, despite having different stack parameters. These assignments are noted in a "comments" column.

Like most tribal organizations in the U.S., the Southern Ute Indian Tribe (SUIT) operates and permits emissions sources independently from the state where it is located (in this case, Colorado). Therefore, Colorado's emissions inventory does not include emissions sources on SUIT lands. These sources are included in the SUIT inventory provided by Environ.[16]

5.2 NEW MEXICO SOURCES

Emissions information for existing New Mexico sources within the domain was obtained from the New Mexico Environmental Department Air Quality Bureau, and is included on CD as **Exhibit 10**. Where possible, emissions from sources at a facility that have identical stack parameters have been consolidated into a single source. Tribal sources within New Mexico are included in the "tribal" inventories obtained from Environ.

5.3 UTAH SOURCES

Emissions information for existing Utah sources within the domain was obtained from Deborah McMurtrie of the Utah Division of Air Quality, and is included as **Exhibit 11**. Where possible, emissions from sources at a facility that have identical stack parameters will be consolidated into a single source.

5.4 ARIZONA SOURCES AND TRIBAL SOURCES

The portion of the modeling domain that is in Arizona is all tribal land. Environ provided emissions inventories for Tribal sources that were not SUIT sources in separate files, one for oil and gas sources (OG), one for electric generating units (EGU), and one for non-OG/nonEGU sources. These files will be evaluated to ensure that sources outside the modeling domain are excluded from the cumulative analysis, as well as to ensure that there is no duplication between these tribal sources and the other states' emissions inventories. Currently the emissions inventories obtained from Environ are in an *.ida format and require some pre-processing before they can be interpreted using readily available programs like notepad or Excel. Therefore these "tribal" emissions inventories are not included in this document. They will, however be included in the final technical support document, and can be distributed in advance to any interested stakeholder prior to modeling, if desired.

[16] The SUIT emissions inventory is considered confidential and is not supplied with this document.

6.0 REFERENCES

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EXHIBIT 1 through EXHIBIT 11

Not included here, but as a separate Acrobat PDF File
Emissions Inventory Addendum-Exhibits 1-11.pdf

APPENDIX B

CALMET and CALPUFF Modeling Parameters

Table B-1

CALMET Parameters for SJPLC Modeling

Parameter	Description	Default Value	SJPLC Analysis Value	Notes
Group 0				
GEODAT	Name of geophysical data file	GEO.DAT	TBD	
SRFDAT	Name of surface data file	SURF.DAT	TBD	
CLDDAT	Name of cloud cover data file	User Defined	n/a	Gridded cloud cover data not used
PRCDAT	Name of precipitation data file	PRECIP.DAT	TBD	
MM4DAT	MM4/MM5 data file name	MM4.DAT	TBD	
WTDAT	Gridded weighting obs. Vs. MM4 data	WT.DAT	n/a	
METLST	CALMET output list file	CALMET.LST	TBD	Files will be logically named with month and year
MEETDAT	Output met data file (CALMET format)	CALMET.DAT	TBD	Files will be logically named with month and year
PACDAT		User Defined	TBD	
LCFILES	Convert file names to lower case?	T	T	
NUSTA	Number of upper-air data sites	User Defined	***	May vary from year to year
NOWSTA	Number of over-water met stations	User Defined	0	Modeling domain is completely over land
UPDAT	Names of upper-air data files	UPn.DAT	***	
SEADAT	Over-water station files	SEAn.dat	0	Modeling domain is completely over land
DIADAT	Processed input met data	DIAG.DAT	n/a	
PRGDAT	Gridded prognostic wind field	PROG.DAT	n/a	
TSTPRT	Test file containing debug variables	TEST.PRT	TBD	
TSTOUT	Test file containing final wind fields	TEST.OUT	TBD	
TSTKIN	Test file containing winds after kinematic effects	TEST.KIN	TBD	
TSTFRD	Test file containing winds after Froude number effects	TEST.FRD	TBD	
TSTLSP	Test file containing winds after slope flow effects	TEST.SLP	TBD	
Group 1				
IBYR	Beginning year	User Defined	TBD	Will model 1996, 2001, and 2002 calendar years
IBMO	Beginning month	User Defined	TBD	Will model all 12 months
IBDY	Beginning day	User Defined	TBD	Will model all days of each month, where possible
IBHR	Beginning hour	User Defined	TBD	Will model all times of day, where possible
IBTZ	Beginning time zone	User Defined	7	

Table B-1 (Continued)

CALMET Parameters for SJPLC Modeling

Parameter	Description	Default Value	SJPLC Analysis Value	Notes
IBLG	Length of run (hours)	User Defined	TBD	Will run an entire year (8760 hours), where possible
IRTYPE	Run type (must be 1 for CALPUFF or CALGRID)	1	1	
LCALGRD	Are w-components and temperature needed? Must be T for CALGRID or to use subgrid scale complex terrain option in CALPUFF.	T	T	
ITEST	Flag to stop run after setup	2	2	
Group 2				
PMAP	Map projection	UTM	LCC	Modeling domain is 715 km by 550 km, so use Lambert Conformal Coordinates
FEAST	False Easting (used only if PMAP=TTM, LCC, or LAZA)	0.0	0.0	
FNORTH	False Northing (used only if PMAP=TTM, LCC, or LAZA)	0.0	0.0	
IUTMZN	UTM Zone (used only if PMAP=UTM)	User Defined	(12, 13)	Not applicable; using Lambert Conformal Coordinates
UTMHEM	Hemisphere of UTM projection (used only if PMAP=UTM)	N	N	
RLAT0	Latitude of projection origin (used only if PMAP=TTM, LCC, PS, EM, or LAZA)	User Defined	43.0	
RLON0	Longitude of projection origin (used only if PMAP=TTM, LCC, PS, EM, or LAZA)	User Defined	107.5	
XLAT1	Matching parallel of latitude (used only if PMAP=LCC or PS)	User Defined	30	
XLAT2	Matching parallel of latitude (used only if PMAP=LCC or PS)	User Defined	60	
DATUM	Coordinate datum for output coordinates	WGS-G	NWS-27	
NX	Number of east-west grid cells	User Defined	152	
NY	Number of north-south grid cells	User Defined	110	
DGRIDKM	Grid spacing	User Defined	5 km	
XORIGKM	Southwest grid cell X coordinate	User Defined	-380 km	
YORIGKM	Southwest grid cell Y coordinate	User Defined	-275 km	
NZ	Number of vertical layers	User Defined	9	
ZFACE	Vertical face heights (m) (NZ+1 values)	User Defined	0, 20, 40, 80, 120, 360, 600, 1320, 1960,	

Table B-1 (Continued)

CALMET Parameters for SJPLC Modeling

Parameter	Description	Default Value	SJPLC Analysis Value	Notes
			3040	
Group 3				
LSAVE	Save met data fields in an unformatted file?	T	T	
INFORMO	Format of unformatted file (1 for CALPUFF)	1	1	
LPRINT	Print met fields	F	F	
IPRINTF	Print interval (hours)	1	1	
LDB	Print input met data and internal variables?	F	F	
NN1	First time step for which debug data are printed	1	1	
NN2	Last time step for which debug data are printed	1	1	
IOUTD	Control writing test/debug wind fields	0	0	
NZPRN2	Number of levels to print	0	1	
IPR0	Print interpolated wind components?	0	0	
IPR1	Print terrain-adjusted surface components?	0	0	
IPR2	Print smoothed wind components and initial divergence fields?	0	0	
IPR3	Print final wind speed and direction fields?	0	0	
IPR4	Print final divergence fields?	0	0	
IPR5	Print wind fields after kinematic effects are added?	0	0	
IPR6	Print winds after Froude number adjustment?	0	0	
IPR7	Print winds after slope flows are added?	0	0	
IPR8	Print final wind field components?	0	0	
Group 4				
NOOBS	No observation mode	0	0	Use surface stations, upper air observations, AND MM5 for upper air data.
NSSTA	Number of stations in SURF.DAT file	User Defined	***	May vary depending on what is available for each year. All DATSAV3 data within at least 10 km of domain boundary
NPSTA	Number of stations in PRECIP.DAT	User Defined	***	May vary depending on what is available fore each year. All TD3240 data within at least 10 km of domain boundary
ICLOUD	Is cloud data to be input as gridded fields? (0 = No)	0	0	
IFORMS	Format of surface data (2 – formatted)	2	2	

Table B-1 (Continued)

CALMET Parameters for SJPLC Modeling

Parameter	Description	Default Value	SJPLC Analysis Value	Notes
IFORMP	Format of precipitation (2 – formatted)	2	2	
IFORMC	Format of cloud data (2 – formatted)	2	1	1 = unformatted Not used
Group 5				
IWFCOD	Generate winds by diagnostic wind module? (1 = Yes)	1	1	
IFRADJ	Adjust winds using Froude number effects? (1 = Yes)	1	1	
IKINE	Adjust winds using kinematic effects? (1 = Yes)	0	0	
IOBR	Use O'Brian procedure for vertical winds? (0 = No; 1 = Yes)	0	1	
ISLOPE	Compute slope flows? (1 = Yes)	1	1	
IEXTRP	Extrapolate surface winds to upper layers? (-4 = use similarity theory and ignore layer 1 of upper air station data)	-4	-4	
ICALM	Extrapolate surface calms to upper layers? (0 = No)	0	0	
BIAS	Surface/upper-air weighting factors (NZ values)	NZ*0	(-1, 0, 0, 0, 0, 0, 0, 0)	
RMIN2	Distance (km) around an upper air site where vertical extrapolation is excluded (Set to -1 if IEXTRP = 4)	4	-4	
IPROG	Use gridded MM4/5 output fields as input to diagnostic wind field model?	0	0	
ISTEPPG	Time step (hours) of MM4/5 data	1	1	
LVARY	Use varying radius to develop surface winds?	F	T	
RMAX1	Max surface over-land extrapolation radius (km)	User Defined	25	Reasonable estimate of half the distance between surface stations.
RMAX2	Max aloft over-land extrapolation radius (km)	User Defined	100	Reasonable estimate of half the distance between MM5 data points.
RMAX3	Maximum over-water extrapolation radius (km)	User Defined	100	Not applicable, but must be declared.
RMIN	Minimum extrapolation radius (km)	0.1	0.1	
TERRAD	Radius of influence of terrain features (km)	User Defined	15	Guidance is that a value between 5-10 times grid spacing should be reasonable. However, highly

Table B-1 (Continued)

CALMET Parameters for SJPLC Modeling

Parameter	Description	Default Value	SJPLC Analysis Value	Notes
				complex terrain in some regions warrants a smaller radius
R1	Relative weight at surface of Step 1 field and obs	User Defined	25	Equal to about 3 grid lengths; localizes effects of surface observations, which is appropriate in complex terrain.
R2	Relative weight aloft of Step 1 field and obs	User Defined	100	Equal to about 3 grid lengths; localizes effects of surface observations, which is appropriate in complex terrain.
RPROG	Relative weight of MM4/5 wind field (used only if IPROG=1)	User Defined	0	n/a
DIVLIM	Maximum acceptable divergence	5.E-6	5.E-6	
NITER	Max number of passes in divergence minimization	50	50	
NSMTH	Number of passes in smoothing (NZ values)	2, 4*(NZ-1)	2, 4, 4, 4, 4, 4, 4, 4, 4, 4	
NINTR2	Max number of stations for interpolations (NZ values)	99	99, 99, 99, 99, 99, 99, 99, 99, 99, 99	
CRITFN	Critical Froude number 1.0	1.0	1	
ALOPHA	Empirical factor triggering kinematic effects	0.1	0.1	
FEXTR2	Multiplicative scaling factor for extrapolation of surface obs to upper layers.	NZ*0.0	NZ*0.0	
NBAR	Number of barriers to interpolation of the wind fields.	User Defined	n/a	n/a
XBBAR	X coord of the beginning of each barrier	User Defined	n/a	n/a
YBBAR	Y coord of the beginning of each barrier	User Defined	n/a	n/a
XEBAR	X coord of the end of each barrier	User Defined	n/a	n/a
YEBAR	Y coord of the end of each barrier	User Defined	n/a	n/a
IDIOPT1	Compute temperatures from observations (0 = True)	0	0	
ISURFT	Surface station to use for surface temperature (between 1 and NSSTA)	User Defined	***	
IDIOPT2	Domain averaged temperature lapse rate	0	0	
IUPT	Station for lapse rates (between 1 and NUSTA)	User Defined	1	
ZUPT	Depth of domain-average lapse rate (m)	200	200	

Table B-1 (Continued)

CALMET Parameters for SJPLC Modeling

Parameter	Description	Default Value	SJPLC Analysis Value	Notes
IDIOPT3	Domain averaged wind components	0	0	
IUPWND	Upper air station for domain winds (-1 – 1/r**2 interpolation of all stations)	-1	-1	
ZUPWND	Bottom and top of layer for 1st guess winds (m)	1, 1000	1, 1	
IDIOPT4	Read surface winds from SURF.DAT? (0 = True)	0	0	
IDIOPT5	Read aloft winds from UPn.DAT? (0 = True)	0	0	
LLBREZE	Use lake breeze model?	F	F	
Group 6				
CONSTB	Neutral mixing height B constant	1.41	1.41	
CONSTE	Convective mixing height E constant	0.15	0.15	
CONSTN	Stable mixing height N constant	2400	2400	
CONSTW	Over-water mixing height W constant	0.16	0.16	
FCORIOL	Absolute value of Coriolis parameter	1E-4	1E-4	
IAVEXZI	Spatial averaging of mixing heights? (1 = True)	1	1	
MNMDAV	Max averaging radius (number of grid cells)	1	1	
HAFANG	Half-angle for looking upwind (degrees)	30	30	
ILEVZI	Layer to use in upwind averaging (between 1 and NZ)	1	1	
DPTMIN	Minimum capping potential temperature lapse rate	0.001	0.001	
DZZI	Depth for computing capping lapse rate (m)	200	200	
ZIMIN	Minimum over-land mixing height (m)	50	50	
ZIMAX	Maximum over-land mixing height (m)	3000	3000	
ZIMINW	Minimum over-water mixing height (m)	50	50	
ZIMAXW	Maximum over-water mixing height (m)	3000	3000	
ITPROG	3D temperature from observations or MM4/5 data?	0	2	
IRAD	Form of temperature interpolation (1 = 1/r)	1	1	
TRADKM	Radius of temperature interpolation (km)	500	500	
NUMTS	Mac number of stations in temperature interpolations	5	5	
IAVET	Conduct spatial averaging of temperature?	1	1	

Table B-1 (Continued)

CALMET Parameters for SJPLC Modeling

Parameter	Description	Default Value	SJPLC Analysis Value	Notes
TGDEFB	Default over-water mixed layer lapse rate (K/m)	-0.0098	-0.0098	
TGDEFA	Default over-water mixed lapse rate (K/m)	-0.0045	-0.0045	
JWAT1	Beginning land use type defining water	User defined	1000	
JWAT2	Ending land use type defining water	User defined	1000	
NFLAGP	Method for precipitation interpolation (2 = 1/r**2)	2	2	
SIGMAP	Precip radius for interpolations (km)	100	100	
CUTP	Minimum cut off precip rate (mm/hr)	0.01	0.01	
Group 7				
SSn	NSSTA input records for surface stations	User Defined	(10)	Can vary, depending on what is available each year
Group 8				
USn	NUSTA input records for upper-air stations	User Defined	(3)	Can vary, depending on what is available each year
Group 7				
PSn	NPSTA input records for precipitation stations	User Defined	(151)	Can vary, depending on what is available each year

Table B-2

Critical CALPUFF Parameters

Parameter	Description	Default Value	SJPLC Analysis Value	Notes
Group 1				
METRUN	Run all periods (1) or a subset (0)?	0	0	
IBYR	Beginning year	User Defined	***	Will model 2001, 2002, and 2003 calendar years
IBMO	Beginning month	User Defined	***	Will model all 12 months
IBDY	Beginning day	User Defined	***	Will model all days of each month, where possible
IBHR	Beginning hour	User Defined	***	Will model all times of day, where possible
XBTZ	Beginning time zone	User Defined	7	
IRLG	Length of run (hours)	User Defined		Will run an entire year (8760 hours), where possible
NSPEC	Number of species modeled (for MESOPUFF II chemistry)	5	10	
NSE	Number of species emitted	3	8	
MRESTART	Restart options (0 = no restart), allows splitting runs into smaller segments	0	2 or 3	2 = Write a restart file during run 3 = Read a restart file at beginning of run and write a restart file during run
NRESPD	Restart configuration	0	24	
METFM	Format of input meteorology (1 = CALMET)	1	1	
AVET	Average time lateral dispersion parameters (minutes)	60	60	
PGTIME	PV averaging time	60	60	
Group 2				
MGAUSS	Near-field vertical distribution (1 = Gaussian)	1	1	
MCTADJ	Terrain adjustments to plume path (3 = Plume path)	3	3	
MCTSG	Do we have subgrid hills? (0 = No), allows CTDM-like treatment for subgrid scale hills	0	0	
MSLUG	Near-field puff treatment (0 = No slugs)	0	0	
MTRANS	Model transitional plume rise? (1 = Yes)	1	1	
MTIP	Treat stack tip downwash? (1 = Yes)	1	1	
MBDW	Building downwash method	1	1	

Table B-2 (Continued)

Critical CALPUFF Parameters

Parameter	Description	Default Value	SJPLC Analysis Value	Notes
MSHEAR	Treat vertical wind shear? (0 = No)	0	0	
MSPLIT	Allow puffs to split? (0 = No)	0	0	
MCHEM	MESOPUFF-II Chemistry? (1 = Yes)	1	1	
MAQCHEM	Aqueous phase transform flag	0	0	
MWET	Model wet deposition? (1 = Yes)	1	1	
MDRY	Model dry deposition? (1 = Yes)	1	1	
MDISP	Method for dispersion coefficients (3 = PG & MP)	3	3	
MTURBVW	Turbulence characterization? (Only if MDISP = 1 or 5)	3	3	
MDISP2	Backup coefficients (Only if MDISP = 1 or 5)	3	3	
MROUGH	Adjust PG for surface roughness? (0 = No)	0	0	
MPARTL	Model partial plume penetration? (0 = No)	1	1	
MTINV	Elevated inversion strength (0 = compute from data)	0	0	
MPDF	Use PDF for convective dispersion? (0 = No)	0	0	
MSGTIBL	Use TIBL module? 0 = No) allows treatment of subgrid scale coastal areas	0	0	
MBCON	Boundary conditions modeled?	0	0	
MFOG	Configure for FOG model output?	0	0	
MREG	Regulatory default checks? (1 = Yes)	1	1	
Group 3				
CSPECn	Names of species modeled (for MESOPUFF II, must be SO2, SO4, NOX, HNO3, NO3)	User Defined	SO2, SO4, NOX, HNO3, NO3, SOA, PM10, FPM, PMC, EC	

Table B-2 (Continued)

Critical CALPUFF Parameters

Parameter	Description	Default Value	SJPLC Analysis Value	Notes
Group 4				
	Map projection and grid control parameters			Same as used for CALMET
Group 5				
ICON	Output concentrations? (1 = Yes)	1	1	
IDRY	Output dry deposition flux? (1 = Yes)	1	1	
IWET	Output wet deposition flux? (1 = Yes)	1	1	
IVIS	Output RH for visibility calculations (1 = Yes)	1	1	
LCOMPRS	Use compression option in output? (T = Yes)	T	T	
ICPRT	Print concentrations? (0 = No)	0	0	
IDPRT	Print dry deposition fluxes (0 = No)	0	0	
IWPRT	Print wet deposition fluxes (0 = No)	0	0	
ICFRQ	Concentration print interval (1 = hourly)	1	1	
IDFRQ	Dry deposition flux print interval (1 = hourly)	1	1	
IWFRQ	West deposition flux print interval (1 = hourly)	1	1	
IPRTU	Print output units (1 – g/m**3; g/m**2/s)	1	1	
IMESG	Status messages to screen? (1 = Yes)	2	2	
Output Species	Where to output various species	User Defined	SO2, SO4, NOX, HNO3, NO3, SOA, PM10, FPM, PMC, EC	
LDEBUG	Turn on debug tracking? (F = No)	F	F	

Table B-2 (Continued)

Critical CALPUFF Parameters

Parameter	Description	Default Value	SJPLC Analysis Value	Notes
Group 7				
Dry Gas Deposition	Chemical parameters of gaseous deposition species	User Defined	SO2=0.1509, 1000, 8, 0, 0.04 NO2=0.1656, 1, 8, 5, 3.5 HNO3=0.1628, 1, 18.0, 8E-8	Default values provided in CALPUFF user's guide
Group 8				
Dry Particulate Deposition	Chemical parameters of particulate deposition species	User Defined	SO4: 0.48, 2 NO3: 0.48, 2 PM10: 0.48, 2 SO4: 0.48, 2 NO3: 0.48, 2 SOA: 0.48, 2 EC: 0.48, 2 FPM: 0.48, 2 PMC: 3.75, 2	
Group 9				
RCUTR	Reference cuticle resistance (s/cm)	30.	30.	
RGR	Reference ground resistance (s/cm)	10.	10.	
REACTR	Reference gravity	8	8	
NINT	Number of particle-size intervals	9	9	
IVEG	Vegetative state (1 = active and unstressed)	1	1	

Table B-2 (Continued)

Critical CALPUFF Parameters

Parameter	Description	Default Value	SJPLC Analysis Value	Notes
Group 10				
Wet Dep	Wet deposition parameters	User Defined	SO2: 0.00003, 0 SO4: 0.0001, 0.00003 NOX: 0., 0., HNO3: 0.00006, 0. NO3: 0.0001, 0.00003 SOA: 0.0002, 0.00003 PM10: 0.0001, 0.00003 FPM: 0.0001, 0.00003 PMC: 0.0001, 0.00003 EC: 0.0001, 0.00003	
Group 11				
MOZ	Ozone background? (1 = read from ozone.dat)	1	1	
BCKO3	Ozone default (ppb) (Use only for missing data)	80	80	
BCKNH3	Ammonia background (ppb)	10	1.0	
RNITE1	Nighttime SO2 loss rate (%/hr)	0.2	0.2	
RNITE2	Nighttime NOx loss rate (%/hr)	2	2	
RNITE3	Nighttime HNO3 loss rate (%/hr)	2	2	
MH202	H202 data option	1	1	n/a
Group 12				
SYTDEP	Horizontal size (m) to switch to time dependence	550.	550.	

Table B-2 (Continued)

Critical CALPUFF Parameters

Parameter	Description	Default Value	SJPLC Analysis Value	Notes
MHFTSE	Use Heffter for vertical dispersion? (0 = No)	0	0	
JSUP	PG Stability class above mixed layer	5	5	
CONK1	Stable dispersion constant (Eq 2.7-3)	0.01	0.01	
CONK2	Neutral dispersion constant (Eq 2.7-4)	0.1	0.1	
TBD	Transition for downwash algorithms (0.5 = ISC)	0.5	0.5	
IURB1	Beginning urban land use type	10	10	
IURB2	Ending urban land use type	19	19	
XMXLEN	Maximum slug length in units of DGRIDKM	1	1	
XSAMLEN	Maximum puff travel distance per sampling step (units of DGRIDKM)	1	1	
MXNEW	Maximum number of puffs per hour	99	99	
MXSAM	Maximum sampling steps per hour	99	99	
SL2PF	Maximum Sy/puff length	10	10	

APPENDIX C

Comparison of CALPUFF Results with IMPROVE Measurements

Comparison of CALPUFF Results with IMPROVE Measurements

One method of verifying the CALPUFF modeling results for visibility reported in this document is to compare the model output with measurements of existing visibility conditions derived from the Interagency Monitoring of Protected Visual Environments (IMPROVE) program. The IMPROVE data for various Class I areas in the modeling domain were summarized in Figures 5-1 and 5-2 of the TSD. The measured IMPROVE data summarized in the TSD reflect monitored visibility conditions over the period 2000-06.

The comparison of CALPUFF modeling results against the IMPROVE visibility measurements was based on the "existing sources" subset from the model calculations as emissions from projected future activity would not be reflected in the measured visibility data. Also, since the model user is generally interested in the "worst-case" impacts determined by the model for a given emissions scenario, the model vs. measurements comparisons are limited to the "average of the 20% worst-case days" as determined from the IMPROVE data, which generally correlates to the 90th percentile measurement. The CALPUFF modeling results are summarized below for those Class I areas in the modeling domain that also have IMPROVE monitors.

Class I Area	IMPROVE Measurement (Average of 20% Worst Case Days, 2000-06)	CALPUFF Method 2 (Mean Highest Extinction, 2001-03)	CALPUFF Method 6 (Mean 8th Highest Extinction, 2001-03)
Bandelier	37	49.9	25.0
Canyonlands	31	65.5	31.1
Mesa Verde	38	77.0	50.3
San Pedro Parks	26	64.4	30.6
Weminuche	26	73.1	30.7

All values listed above are in units of total extinction (Inverse Megameters, 1/Mm)

In general, Method 2 tends to produce consistently higher visibility impacts compared to Method 6 at the Class I areas modeled for this comparison. Some of this difference is due to the form of the extinction value returned by CALPUFF in that Method 2 returns the highest daily value for a given year while Method 6 returns the 8th highest daily value for any given year, which represents the 98th percentile.

However, the Method 6 results tend to more closely match the measured IMPROVE data at each of the Class I areas. At Bandelier, the Method 6 model predictions actually underpredict the worst-case visibility conditions (based on the 90th percentile measurement). However, Bandelier is toward the eastern edge of the modeling domain, so not all of the sources that contribute to visibility impacts at Bandelier may have been included in this modeling study. Also, Bandelier shows a relatively high extinction contribution from organic aerosols, which may be an indicator of impacts from local and/or regional wildfires. Wildfire emissions were not modeled in this CALPUFF study.

Otherwise, the CALPUFF model predictions for Method 6 tend to be near or slightly higher than the measured extinction from the IMPROVE program. However, even if CALPUFF reproduces the total extinction measured in the IMPROVE data, the correlation between the modeled and measured data degrades significantly for individual chemical species that contribute to extinction (i.e., sulfate, nitrate, etc.).

Overall, since the CALPUFF results for Method 6 in this study correlate better with the IMPROVE measurements compared to the CALPUFF results for Method 2, the conclusion is that Method 6 appears to perform better than Method 2 for the situation modeled in this particular TSD. Based on that finding, the user should probably rely more heavily on the Method 6 results reported in the TSD compared to Method 2.