Programmatic Environmental Assessment for 80 Acre Infill Oil and Gas Development on *the Southern Ute Indian Reservation*

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APPENDIX G
AIR QUALITY TECHNICAL REPORT

Air Quality Impact Assessment Technical Support Document
Southern Ute Indian Tribe Coal Bed Methane 80-Acre Infill Development
Environmental Assessment

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List of Acronyms

AERMOD	EPA atmospheric dispersion modeling system
AFR	Air Fuel Ratio controller
ANC	acid neutralizing capacity
AQRV	air quality related value(s)
AQS	EPA Air Quality Subsystem database
BACT	Best Available Control Technology
BCs	boundary conditions
BLM	USDI-Bureau of Land Management
C_3	propane
CAA	Clean Air Act
CAMx	Comprehensive Air quality Model
CASTNET	EPA Clean Air Status and Trends Network
CBM	coal bed methane
CDPHE-APCD	Colorado Department of Public Health and Environment – Air Pollution Control Division
CFR	Code of Federal Regulations
CO	carbon monoxide
DEM	digital elevation model
dv	deciview
EGU	electric generating unit
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
EPA-FRM	EPA $PM_{2.5}$ and PM_{10} Mass Networks
FLAG	Federal Land Managers' Air Quality Related Values Workgroup
FR	Federal Register
FRM	federal reference method
ft	foot/feet
g/hp-hour	gram(s) per horsepower - hour
HAP	hazardous air pollutant(s)
HNO_3	nitric acid
hp	horsepower
hr	hour(s)
ICs	initial conditions
IMPROVE	Interagency Monitoring of Protected Visual Environments
IWAQM	Interagency Workgroup on Air Quality Models
ISCST3	Industrial Source Complex – Short Term atmospheric dispersion model
kg/ha-yr	kilogram(s) per hectare - year
km	kilometer(s)
lb/hour	pound(s) per hour
m	meter(s)
MACT	Maximum Achievable Control Technology
MEI	maximally exposed individual
MLE	most likely exposed
MMBtu/hour	million British thermal units per hour
MM5	Mesoscale Model (version 5)
MWhour	megawatt hour
N/A	not applicable

NAAQS	National Ambient Air Quality Standards
NADP	National Acid Deposition Network
NCAR	National Center for Atmospheric Research
NEPA	National Environmental Policy Act
NSCR	non selective catalytic reduction
NSR	New Source Review
NH_3	ammonia
NMED-AQB	New Mexico Environment Department – Air Quality Bureau
NMOGA	New Mexico Oil and Gas Association
NSJB	Northern San Juan Basin
NO_2	nitrogen dioxide
NO_3^-	nitrate ion
NOx	total oxides of nitrogen
NWS	National Weather Service
OC	organic carbon
PBL	planetary boundary layer
PIG	plume in grid
PLC	Programmer Logic Controller
$PM_{2.5}$	fine particulate matter (less than 2.5 microns in effective diameter)
PM_{10}	inhalable particulate matter (less than 10 microns in effective diameter)
ppb	parts per billion
ppm	parts per million
PSD	Prevention of Significant Deterioration
RAWS	Remote Automatic Weather Station
RFS	reasonably foreseeable sources
RICE	Reciprocating Internal Combustion Engines
RMP	Resource Management Plan
ROW	Right Of Way
RPO	Regional Planning Organization
RRF	relative response factor
SCR	selective catalytic reduction
SI	spark ignited
SO_2	sulfur dioxide
$SO_4^=$	sulfate ion
SOA	secondary organic aerosol
STN	EPA Speciation Trends Network
SUIT	Southern Ute Indian Tribe
SUIT PEA	Southern Ute Indian Tribe Programmatic Environmental Assessment
SUIR	Southern Ute Indian Reservation
t/yr	ton(s) per year
USDA	United States Department of Agriculture
USDI	United States Department of the Interior
USGS	United Stated Geological Survey
UTM	Universal Transverse Mercator
VOC	volatile organic compounds
μeq/l	microequivalent(s) per liter
$\mu g/m^3$	microgram(s) per cubic meter

1.0 INTRODUCTION

This document describes the technical approach that was used for evaluating potential air quality impacts associated with proposed infield development of natural gas production within the Southern Ute Indian Tribe (SUIT) Reservation in southwestern Colorado.

This document is organized in the following manner: Section 1 provides an overview of the project. Section 2 presents the regulatory framework for the proposed development. Section 3 provides a detailed description of the emission inventories that were compiled for the proposed infield development as well as the no action case. Section 4 presents information on background air quality levels within the study area. Section 5 presents information on the meteorological data that was used in the analysis. Section 6 presents the modeling methodology for the near field analysis as well as the cumulative far field analysis for air quality related values (AQRVs) in adjacent Class I Areas and ozone throughout the region. The far field analysis also examined regional air quality impacts. Section 7 summarizes the potential impacts for both the near and far field analyses.

1.1 Project Description

The Programmatic Environmental Assessment for Oil and Gas Development on the Southern Ute Indian Reservation (SUIT PEA) proposes the development of 770 coal bed methane (CBM) wells on Tribal and fee surface within the study area. The study area encompasses the SUIR which is 421,000 acres in size (Figure 1-1). Approximately 731, or 95 percent of these wells would be directionally drilled from existing well pad locations and 5 percent of the 770 wells (39 wells) would be drilled on new locations due to environmental or cultural restraints on the existing well pad sites. The total estimated short-term disturbance for 731 co-located wells would be approximately 841 acres. After reclamation, the total amount of well pad disturbance from the co-located well sites would be an estimated 366 acres, assuming 0.5 acres long-term disturbance per well. Co-located wells would not require construction of new access roads or pipeline ROWs. The Fruitland Formation (average depth of 2,600–3,900 feet) is the primary CBM producing horizon and the only horizon considered for the PEA. A typical production life for a CBM well is approximately 25-30 years or longer, depending on economics and reservoir geology; therefore, the life of the project could be as long as 40 years if wells are drilled at slower rates. The wells would be drilled as optional infill wells based on geology and reservoir qualities in areas of low recovery per well.

Approximately 2,404 CBM wells have been constructed throughout the entire study area to date. The proposed alternative was based on 770 infill wells and corresponds to the maximum surface disturbance development. The no action case assumes that no new infill wells would be constructed. It is important to note that this proposal is focused on maintaining current production in the region and will not result in any long-term increase in production. This is because the new wells will replace current production that is declining at a rate of approximately 10 percent per year.

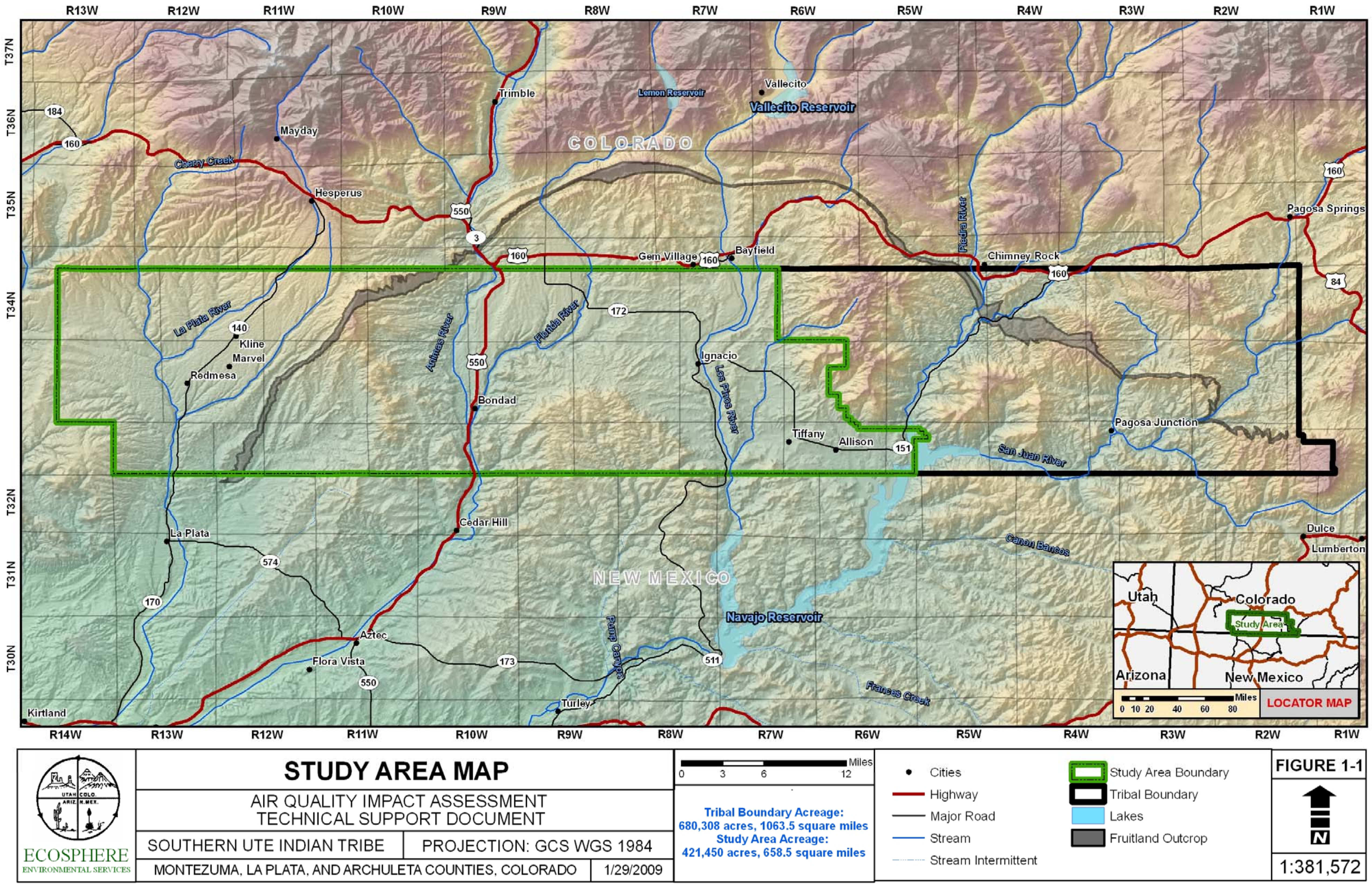

Figure 1-1. Study Area Map

2.0 REGULATORY FRAMEWORK

The U.S. Environmental Protection Agency (EPA) establishes and revises the National Ambient Air Quality Standards (NAAQS) as necessary to protect public health and welfare and sets absolute upper limits for specific air pollutant concentrations at all locations where the public has access. Under the Clean Air Act (CAA), EPA is required to periodically technically review and revise ambient standards based on the most current health effects data. EPA recently revised both the fine particulate matter ($PM_{2.5}$) and ozone NAAQS[1, 2].

States and Indian Tribes have the ability to establish more stringent ambient standards. At the present time, the SUIT has not promulgated any additional ambient air quality standards that are applicable on the SUIR. The State of Colorado has established and implemented a Colorado 3 hour sulfur dioxide (SO_2) ambient air quality standard that is applicable within the State of Colorado but not within the boundaries of the SUIR.

Table 2-1 presents a summary of applicable ambient air quality standards for criteria pollutants as well as Prevention of Significant Deterioration (PSD) increment concentrations for NO_2 SO_2 and PM_{10}.

Given the EIS Study Area's current attainment status, future development projects which have the potential to emit more than 250 tons per year of any criteria pollutant (or certain listed sources that have the potential to emit more than 100 tons per year) would be required to submit a pre-construction PSD permit application (including a regulatory PSD increment consumption analysis) under the federal new source review (NSR) permitting regulations. Development projects subject to PSD regulations must also demonstrate the use of best available control technology (BACT) and show that the combined impacts of all applicable sources would not exceed the PSD increments for nitrogen dioxide (NO_2), particulate matter (PM_{10}) or SO_2. The permit applicant must also demonstrate that cumulative impacts from all existing and proposed sources would comply with the applicable ambient air quality standards throughout the operational lifetime of the permit applicant's project.

CDPHE-APCD, SUIT or EPA may conduct a regulatory PSD increment consumption analysis in order to demonstrate that applicable PSD increments have not been exceeded by all major or minor increment consuming emission sources. The determination of PSD increment consumption is a legal responsibility of the applicable air quality regulatory agencies (with EPA oversight).

In 1999 the CDPHE-APCD conducted a detailed review of NO_2 PSD increment consumption in southwest Colorado and concluded that Class I increment values "are probably not violated" at Mesa Verde National Park or the Weminuche Wilderness Area, but that preliminary results "suggest that there is one isolated hot spot in La Plata County where there is an apparent Class II PSD increment violation." The CDPHE-APCD worked closely with the emission source operator to better understand the specific situation and that action resolved the source-specific PSD Class II increment situation.[3]

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[1] Federal Register Tuesday, October 17, 2006 "National Ambient Air Quality Standards for PM2.5 Final Rule" Pages 61236-61328

[2] Federal Register Thursday, March 27, 2008 "National Ambient Air Quality Standards for Ozone Final Rule" Pages 16436-16514

[3] CDPHE 1999, "Periodic Assessment of Nitrogen Dioxide PSD Increment Consumption in Southwest Colorado"

Table 2-1. Applicable Ambient Air Quality Standards and PSD Increment Values[4]

Pollutant	Averaging Time	National Ambient Air Quality Standards (ppm) (μg/m^3)	Colorado Ambient Air Quality Standards (μg/m^3) [A]	PSD Class I Increment (μg/m^3)	PSD Class II Increment (μg/m^3)
CO	1-hour	9 (40,000) [B]	40,000	N/A	N/A
	8-hour	35 (10,000) [B]	10,000	N/A	N/A
NO_2	Annual	0.053 (100)	100	2.5	25
Ozone	1-hour	0.12 (235) [B]	235	N/A	N/A
	8-hour (1997 std)	.080 [C]	.080	N/A	N/A
	8-hour (2008 std)	0.075 [D]		N/A	N/A
PM_{10}	24-hour	150 [E] (ug/m^3)	150	8	30
	Annual	50 (ug/m^3)	50	4	17
$PM_{2.5}$	24-hour	65 [F] (ug/m^3)	65	N/A	N/A
	24-hour	35 (ug/m^3)	35	N/A	N/A
	Annual	15 (ug/m^3)	15	N/A	N/A
SO_2	3-hour (Secondary)	0.50 (1,300) [B]	700 [B]	25	512
	24-hour	0.14 (365) [B]	365 [B]	5	91
	Annual	0.03 (80)	80	2	20

Source: USEPA 2008
N/A = not applicable
µg/m^3 = micrograms per cubic meter
ppm = parts per million
[A] Not applicable within the Reservation
[B] Not to be exceeded more than once per year.
[C] i)To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 (parts per million (ppm).
ii) The 1997 standard—and the implementation rules for that standard—will remain in place for implementation purposes as USEPA undertakes rule making to address the transition from the 1997 ozone standard to the 2008 ozone standard.
[D] i)The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is $\leq$ 1.
ii) As of June 15, 2005, USEPA revoked the 1-hour ozone standard in all areas except the 8-hour ozone nonattainment Early Action Compact (EAC) Areas.
[E] Not to be exceeded more than once per year on average over 3 years.
[F] To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m^3 (effective December 17, 2006).

[4] http://www.epa.gov/air/criteria.html#4

The U.S. Congress designated mandatory federal Class I Areas on August 7, 1977, including those existing wilderness areas greater than 5,000 acres in size and national parks greater than 6,000 acres in size. All other locations in the country where ambient air quality is within the NAAQS (including attainment and unclassified areas) are designated as PSD Class II Areas with less stringent requirements. In addition, sources subject to PSD permit review procedures for PSD Class I Areas are required to analyze AQRVs including degradation of visibility, deposition of acidic compounds in mountain lakes and effects on sensitive flora and fauna within the PSD Class I Areas.

Most of the EIS Study Area is designated as a PSD Class II Area. The two closest PSD Class I Areas are Mesa Verde National Park and the Weminuche Wilderness Area and are protected by more stringent NO_2, PM_{10}, and SO_2 PSD Class I Area increment threshold as shown in Table 2-1. AQRV impacts were also evaluated at Bandelier National Monument (NM), Canyonlands National Park (UT), La Garita Wilderness Area (CO), Petrified Forest National Park (AZ), and San Pedro Park (NM).

This USDI – Bureau of Land Management (BLM) National Environmental Policy Act (NEPA) analysis compares potential air quality impacts from the proposed action to applicable ambient air quality standards, PSD increments, and AQRVs, but it does not represent a regulatory air quality permit analysis. Comparisons to the PSD Class I and II increments are intended to evaluate a “threshold of concern” for potentially significant adverse impacts, but do not represent a regulatory PSD increment consumption analysis.

2.1 New Source Review and Operating Permits

Under the CAA, emission sources are required to obtain permits. Depending on the attainment status, source type and emission levels, different types of permits are required (e.g. operating and pre-construction). Currently, within the SUIT boundaries new sources in excess of 250 tons per year (or 100 tons per year for specific listed sources) are required to obtain a PSD permit prior to construction. Because the SUIT does not have an approved permitting program, PSD permits are issued by EPA. In addition, sources in excess of 100 tons per year are required to obtain a Title V operating permit. Because neither EPA nor the SUIT has a minor source pre-construction permitting program, sources that do not require PSD pre-construction permits or Title V operating permits do not require air permits. Development of a minor source permitting program is a goal of the long-term plan for the SUIT Reservation Air Program under the CAA programs.

The SUIT/State of Colorado Environmental Commission, along with the Southern Ute Indian Tribal Council will determine whether to adopt EPA’s proposed Minor Source NSR Program (upon promulgation) or develop the Tribe’s own specific minor source permitting program.

In lieu of waiting on a finalization of the EPA minor source program, the Tribe’s Air Quality Program is currently developing a minor source permitting program. The Tribe’s minor source permitting program will mirror certain aspects of the draft Federal Minor Source NSR Program, yet will be tailored towards the specific regulatory needs of the Southern Ute Indian Reservation. Additional provisions currently being examined to be included are 1) institution of a fee-based system and, 2) a source and emissions inventory tracking structure for “existing” minor sources.

2.2 Air Quality Regulations Applicable to the SUIT Infill Project

2.2.1 NSPS for Natural Gas Fired RICE

On January 18, 2008 EPA promulgated a New Source Performance Standard (NSPS) for spark ignited engines[5]. This regulation established minimum emission standards for new, modified and reconstructed stationary natural gas fired (and other fuels) engines. The following subsections present an overview of the new regulation. As a result of the regulation, emissions from applicable engines (especially engines less than 300 horsepower) will be substantially lower than in the past.

Engines Less Than 25 Horsepower

Stationary non-emergency spark ignited (SI) natural gas engines less than 25 horsepower must meet the emission limits indicated in Table 2-2.

Table 2-2. NOx, HC, NMHC and CO Emission Standards for Stationary SI Engines 25 hp Manufactured After July 1, 2008.

Engine Class	Emission Standards in g/hp-hr		
	HC+NOx	NMHC+NOx	CO
I 100 cc< Displacement<225 cc	12.0	11.0	455
I-A Displacement <66 cc	37	-	
I-B 66 cc< Displacement 100 cc	30	27.6	
II Displacement >225 cc	9.0	8.4	

Engines Greater Than 25 Horsepower but Less Than 100 Horsepower

Stationary non-emergency spark ignited (SI) natural gas engines greater than 25 horsepower but less than 100 horsepower manufactured after July 1, 2008 must limit exhaust emissions of NO_x to 2.8 g/hp-hour and CO to 4.8 g/hp-hour.

Engines Greater Than or Equal to 100 Horsepower but Less Than 500 Horsepower

Stationary natural gas engines greater than or equal to 100 horsepower and less than 500 horsepower manufactured after July 1, 2008 must limit exhaust emissions of NO_x to 2.0 g/hp-hour, emissions of CO to 4.0 g/hp-hour and emissions of NMHC to 1.0 g/hp-hour.

More stringent emission standards take effect 3 years later, i.e., for stationary natural gas engines greater than or equal to 100 horsepower and less than 500 horsepower manufactured after January 1, 2011. These engines must comply with a NO_x standard of 1.0 g/hp-hour, a CO standard of 2.0 g/hp-hour, and a NMHC standard of 0.7 g/hp-hour.

Engines Greater Than or Equal to 500 Horsepower

Stationary natural gas engines greater than 500 horsepower manufactured after July 1, 2007 must limit exhaust emissions of NO_x to 2.0 g/hp-hour, emissions of CO to 4.0 g/ hp-hour and emissions

[5] Federal Register January 18, 2008, "Standards of Performance for Stationary Spark Ignition Internal Combustion Engines and National Emission standards for Reciprocating internal Engines; Final Rule".

of NMHC to 1.0 g/ hp-hour.

Stationary natural gas fired engines with a maximum engine power greater than or equal to 500 horsepower that are manufactured after July 1, 2010 must limit exhaust emissions of NO_x to 1.0 g/hp-hour, emissions of CO to 2.0 g/HP-hour and emissions of NMHC to 0.7 g/hp-hour.

2.2.2 Reciprocating Internal Combustion Engines MACT

EPA has promulgated a maximum achievable control technology (MACT) regulation for reciprocating internal combustion engines to address formaldehyde emissions (EPA 2004). This regulation requires emission controls on certain types of engines.

2.3 Other Future Regulatory Actions

The States of Colorado and New Mexico as well as other agencies convened the Four Corners Air Quality Task Force in November 2005 to address air quality issues in the Four Corners Region and consider options for mitigation of air pollution. The Task Force was comprised of more than 100 members and 150 interested parties representing a wide range of perspectives on air quality in the Four Corners Region. Members include private citizens, representatives from public interest groups, universities, industry, and federal, state, Tribal and local governments.

A report developed a compendium of options to address air quality concerns in the Four Corners Region. The Four Corners Report presents an expression of the range of possibilities that could be implemented to improve air quality in the region. It is important to note that no engineering was conducted on the options to evaluate the technical long-term feasibility or the economic costs of the options considered. Currently, air quality modeling (visibility, deposition and ozone) is being conducted to evaluate the air quality benefits of potential mitigation options that were evaluated.

2.4 Additional Mitigation Options Considered for the SUIT Proposed Action

Evaluations of additional mitigation options were considered for new compressor engines and drilling rigs. For the SUIT infill project, compressor engines are the largest NOx emission source.

As discussed in Section 2.2, in January 2008 EPA established a NSPS that is applicable to natural gas fired compressor engines. This standard establishes the minimum level of emission control for compressor engines. This standard is applicable to all new, modified and reconstructed engines.

There is a similar emission standard for diesel engines used on drilling rigs[6] and the NSPS emission standards for these engines are summarized in Table 2-3. Because the life expectancy of a drilling rig engine is 5-10 years[7], there is constant replacement of older engines with new low emission engines.

[6] 40 CFR, Part 60, Subpart IIII
[7] WRAP Oil and Gas 2002/2005 and 2018 Area Source Emission Inventory Improvements 2007

Table 2-3. The Tier 2, 3, and 4 Emission Standards for Large (> 300 hp) Diesel Engines

	300 to 600 hp	600 to 750 hp	> 750 hp	Gen Sets 750 to 1250 hp	Gen sets greater than> 1200 hp
AP-42	14.1[a]	10.9 [b]	10.9 [b]	10.9 [b]	10.9 [b]
Tier 1	6.9	6.9	6.9	6.9	6.9
Tier 2	4.8	4.8	4.8	4.8	4.8
Tier 3	3	3			
Tier 4 Transitional	0.3	0.3	2.6	0.5	0.5
Tier 4 Final	0.3	0.3	2.6	0.5	0.5

[a] Ap-42 Table 3.3-1
[b] Ap-42 Table 3.4-1
Shading = NMHC + NOx

The following presents mitigation options that were evaluated to reduce natural gas fired engine emissions below NSPS requirements.

Existing Engines

BLM does not have any regulatory authority under the Clean Air Act for requiring retrofit mitigation for existing engines as part of the SUIT infill project. The Four Corners Air Quality Task Force is in the process of evaluating emission reductions that could be achieved as well as the overall air quality benefits that could be achieved as a result of implementation of additional controls on sources in the Four Corners Area. However, before any additional mitigation options are implemented through regulation by Colorado, New Mexico or the SUIT, economic and reliability evaluations must be conducted.

As indicated in Table 2-4, the vast number of engines within the reservation boundaries have capacities in excess of 500 horsepower and are controlled with NSCR or are low emitting lean burn engines that currently achieve the 2008 NSPS. For this size engine, the average NOx emission factor is 1.5 g/hp-hour. It is important to note that the inventory identified only one engine in this size class that was not controlled. Consequently, there are few opportunities to retrofit larger existing engines with additional reliable and cost effective controls that will further reduce emissions.

Table 2-4. Distribution of RICE Within the SUIT Boundaries in 2005

Engine Size (hp)	Number of Engines	Number of Engines (percent)	Percentage of Capacity	Average NOx Emission Factor (g/hp-hour)	Total NOx Emissions (t/yr)	Emissions (percent)
Gt. 500	170	53.0	92	1.5	2,982	71
Lt. 500 Gt. 100	76	23.7	6.1	7.7	724	17
Lt. 100 Gt. 25	73	22.7	1.8	12.2	510	12
Lt. 25	2	0.6	0.0	27	11	0.3
Total	**321**		**100**		**4,227**	

New Compressor Engines

The Four Corners Task Force Report provided a detailed analysis of emission reduction options for oil and gas engine mitigation. With respect to the SUIT Infill Project (for the proposed action), mitigation is defined as additional emission controls beyond NSPS (assuming that engines used as part of the infill project will be new and subject to NSPS).

This section examines:

1. Electrification;
2. Lean burn technology;
3. Non selective catalytic reduction (NSCR);
4. Selective catalytic reduction (SCR);
5. Oxidation catalyst

Electrification[8]

In analyzing this option it was assumed that electricity to power electric compressor motors would come from the existing electrical grid. The majority of the base load electricity in the Four Corners Region is produced from coal-fired electrical generation.

The Four Corners Task Force studied using electric motors for operating compressors as opposed to using natural gas fired internal combustion engines. In evaluating the changes in emissions for shifting from natural gas to electric (coal) powered compression, it is necessary to examine the emissions for each power source on an equivalent energy basis. Thus, for the same amount of energy consumption, the change in emissions from natural gas versus electricity must be considered.

The emission data was developed using the EPA program EGRID[9]. In this analysis, it was assumed that for visibility impacts SO_2 and NOx emissions are equivalent in terms of impacts because they cause approximately the same amount of visibility impairment. This is because the dry scattering coefficients for converting SO_4 and NO_3 concentrations into visual range are

[8] Analysis conducted as part of the 2007 Cumulative Effects Section Four Corners Air Quality Task Force Report of Mitigation Options
[9] EPA EGRID Program http://www.epa.gov/cleanenergy/egrid/index.htm

approximately equivalent. NOx emissions do participate in photochemical reactions that produce ozone. Ongoing photochemical analyses, as part of the Four Corners air quality analyses, will address the role of NOx in ozone formation. Both SO_2 and NO_2 ambient concentrations are in compliance with federal and state air quality standards.

As a first order approximation, 1 ton per year of SO_2 emissions will result in the same amount of potential visibility impairment as 1 ton per year of NOx. In reality, because of the more complex and competitive reactions involving both SO_4 and NO_3, SO_2 emissions may result in more visibility impairment than NOx emissions.

From an economic basis, conversion of natural gas-fired engines to electric compression is only practical for large engines and only in areas where electricity is already available within close proximity. This is because most well locations do not currently have electrical power and it would not be cost effective to install power for small engines[10].

In Colorado, most large engines (greater than 500 horsepower) are lean burn or have NSCR installed to reduce emissions (average emission factor for this size engine is 1.5 g/hp-hour). These engines are typically located at remote sites where power is not available.

The energy consumption of a typical lean burn engine was calculated, converted into pounds per mega watt-hour and compared to SO_2 and NOx emissions from existing coal-fired power plants. This was done assuming an emission factor between 1 g/hp-hour and 5 g/hp-hour. It was then assumed that the computed emissions per mega watt of power represented emissions for 1-hour and were converted into tons per year by multiplying 8760 hours per year and dividing by 2000 pounds per ton. As indicated in Table 2-5, a shift from natural gas to electric (coal) for an engine of 1 MWhour capacity (approximately 1,342 horsepower) with an emission factor of 1 g/hp-hour would result in an increase of 14 tons per year of SO_2 + NOx. With engine emissions of approximately 2.0 g/hp-hour there is no net change in overall emissions by shifting from natural gas to electric. For all cases, the shift from natural gas to electricity results in higher greenhouse gas emissions.

[10] The quantification of changes in emissions of this option does not address the cost of implementation or the reliability of the electrical grid. These issues must be considered if this option is deemed beneficial from an environmental perspective.

Table 2-5. Change in SO_2, NO_X and Greenhouse Gas Emissions by Shifting from Natural Gas Compression to Electricity.

Four Corners Grid Average Emissions lbs/MWh		tons/MWh/yr
SO2	2.65	11.6
NOx	3.64	15.9
NOx + SO2	6.29	27.6
CO2	1,989	8711.8

Caterpillar 3608 LE Average Emissions lbs/MWh (equivalent)		Other Emission Rates (gr/hp-hr)				
SO2	0	0	0	0	0	0
Hp/kw-hr	1.342	1.342	1.342	1.342	1.342	1.342
Hp/mw-hr	1,342	1,342	1,342	1,342	1,342	1,342
Cubic feet gas/mw-hr	9,815	9,815	9,815	9,815	9,815	9,815
NOx Emission Rate gr/hp-hr	1	2	3	4	5	16
SO2 lbs/mw-hr	0	0	0	0	0	0
NOx lbs/mw-hr	3.0	5.9	8.9	11.8	14.8	47.3
CO2 lbs/mw-hr	1,138	1,138	1,138	1,138	1,138	1,138
SO2 tons/MWh/yr	0.0	0.0	0.0	0.0	0.0	0.0
NOx tons/MWh/yr	13.0	25.9	38.9	51.8	64.8	207.4
CO2 tons/MWh/yr	4985	4985	4985	4985	4985	4985
Delta SO2 tons/Mwh/yr	11.6	11.6	11.6	11.6	11.6	11.6
Delta NOx tons/Mwh/yr	3.0	-10.0	-22.9	-35.9	-48.9	-191.4
Delta NOx +SO2 tons/MWh/yr	14.6	1.6	-11.3	-24.3	-37.3	-179.8
Delta CO2 tons/Mwh/yr	3727	3727	3727	3727	3727	3727

Cat. 3608 Assumptions:
9815 Btu/kw-hr
"Sweet" Natural Gas
NOx - 1 gr/hp-hr
1 cu ft gas = 1,000 btu

All new engines associated with the SUIT infill project will be required to meet NSPS emission limits. The NOx emission limits are 2 g/hp-hour or less (depending on the year) and shifting to electric motors in place of natural gas engines would result in no changes in NOx emissions. In addition, greenhouse gas emissions would increase by shifting compressors from natural gas to electric.

Lean Burn Technology

Lean burn engines are the main prime mover in gas compression and generator set applications in the Four Corners Area. A lean burn engine has an oxygen level at the exhaust outlet of about 7-8 percent and has corresponding NOx emissions of 2 g/hp-hour or less. This level of NOx emission control is achieved through combustion modification as opposed to end of pipe control and can achieve the emission levels required as part of the NSPS regulation. Some lean burn engines incorporate an air fuel ratio (AFR) control installed at the engine to ensure a proper fuel mixture.

Currently, a large percentage of engines operating in the Four Corners Area with a capacity of greater than 500 horsepower use lean burn technology and achieve, on average, a NOx emission rating of less than 2 g/hp-hour.

Lean burn technology has already been implemented as a mitigation strategy for engines greater than 500 horsepower within the SUIT boundary.

Non Selective Catalytic Reduction

A process which results in a reduction of several pollutants (NOx, CO and THC) is referred to as a non selective catalytic reduction (NSCR) and is applicable only to stoichiometric (rich burn) engines. This technology employs a catalyst that is placed on the engine exhaust. Currently, NSCR is a commonly used control method for rich burn engines. For this control to be effective, engines must operate in a very narrow or regulated air fuel ratio (AFR) operating range in order to maintain the catalyst efficiency. Without an AFR controller, emission reduction efficiencies will vary.

An AFR controller will only maintain an operator-determined set point. For this set point to be at the lowest possible emission setting, an exhaust gas analyzer must be utilized and frequently checked. Some issues associated with current practice NSCR retrofits on existing small engines operating at reduced or variable loads are:

1. There are problems maintaining a sufficient flue gas temperature for correct oxygen sensor operation and the resulting effectiveness of the catalysts.

2. On engines with carburetors, there is difficulty maintaining the AFR at a proper setting.

3. On older engines, the linkage and fuel control may not provide an accurate air fuel mixture.

4. If the AFR drifts low (i.e., richer), ammonia formation will increase in proportion to the NOx reduction but not necessarily in equal amounts.

In a recent paper that examined the reliability of currently available NSCR/AFR solutions for field gas-fired engines, it was found that emissions were not consistent from day to day or even over a few hours[11]. It was found that the raw emissions varied significantly within a short period of time and data indicate a fairly tight operating window for simultaneous control of both NOx and CO to low levels (e.g. < 500 ppm). A major finding was that the NSCR/AFR systems were able to simultaneously control both species to low levels for a small fraction of the time; however, for the majority of the operation one species was much more effectively controlled than the other suggesting that AFR was not able to consistently control the air fuel ratio.

Characterization of NSCR performance control is very effective until the pre-catalyst oxygen concentration surpasses a certain level after which NOx emissions increase rapidly. Concentration of total hydrocarbons follows the same trend as CO as does ammonia. The result is that a tradeoff relationship exists not only between NOx and CO but also between NOx and NH_3 and between NOx and THC. The potentially negative impacts of increased CO, NH_3 and THC must all be considered as NOx is limited to lower levels.

NSCR cannot be used to continuously reduce NOx emissions to levels less than what is specified in the NSPS regulation.

Selective Catalytic Reduction

Selective catalytic reduction is an end of pipe control on lean burn engines and uses excess oxygen in a catalytic reduction system. Reactant injection of industrial grade urea, anhydrous ammonia, or aqueous ammonia is used to facilitate NOx removal. A programmable logic controller (PLC) is used to control the SCR system (for engine mapping/reactant injection requirements). Sampling cells are used to determine the amount of ammonia injected which depends on the amount of NO measured downstream of the catalyst bed.

In the proposed standards for Stationary Spark Ignition Internal Combustion Engines, EPA stated the following with respect to the installation of SCR on natural gas fired engines: "For SI lean burn engines, EPA considered SCR. The technology is effective in reducing NOx emissions as well as other pollutant emissions, if an oxidation catalyst is included. However, the technology has not been widely applied to stationary SI engines and has mostly been used with diesel engines and larger applications in thousands of horsepower in size. This technology requires a significant understanding of its operation and maintenance requirements and is not a simple process to manage. Installation can be complex and requires experienced operators. Costs of SCR are high, and have been rejected by States for this reason. EPA does not believe that SCR is a reasonable option for stationary SI lean burn engines." [12] Consequently, this technology is not readily applicable to unattended oil and gas operations that do not have electricity.

Because there have been very limited installations of this technology for oil and gas compressor engines, there is very little information in the literature regarding the incremental NOx emission reduction of SCR beyond lean burn technology for remote unattended oil and gas operations. Table 2-6 presents a summary of incremental SCR emission reductions and cost effective control estimates for SCR on a lean burn engine.

[11] Sarah Nuss-Warren et.al. 2008, Characterization Of NSCR Performance On Four Stroke Natural Gas-Fueled Rich Burn Engines.
[12] Federal Register Monday, June 12, 2006 40 CFR Parts 69, 63, et al. Standards of Performance for Stationary Spark Ignition Internal Combustion Engines and National Emission Standards for Hazardous Air Pollutants for Reciprocating internal Combustion Engines; Proposed Rule.

There are several concerns regarding this information. First, it is not known if the emission reductions are based on actual performance tests or theoretical emission calculations. It is also not known what the reference basis is for the emission reduction of 6.6 tons per year of NOx. Review of CARB databases regarding NOx engine emissions does not provide any data regarding actual installations of SCR on lean burn engines for oil and gas operations. There is some very limited performance testing on SCR with lean burn engines that operate on pipeline natural gas (as opposed to field gas) for cogeneration facilities. Such emission data for cogeneration facilities is not applicable to oil and gas compressor engines because cogeneration facilities tend to operate at a continuous load and have personnel present to operate the equipment.

Table 2-6. Incremental SCR Emission Reductions and Cost Effective Control Estimates for SCR

Incremental Cost-Effectiveness Estimates for ICE			Control Techniques and Technologies	
			Incremental	Incremental NO_X
Engine Type	Control Comparison	Horsepower	NO_X Reduction	Cost-Effectiveness
			(tons/year)	(\$/ton of NO_X Removed)
Lean Burn				
	From Low-Emission Combustion to SCR (96%)	300-500	**3.3**	8,800
		500-1000	**6.6**	10,300

Because of the limited application data for SCR on natural gas fired engines for oil and gas operations, it is difficult to estimate the amount of potential emission reduction that could be achieved through the implementation of this technology. In addition, it is not clear how well this technology would perform in unattended remote applications. The limited data that does exist suggests that there may only be a small incremental reduction in NOx emissions beyond lean burn technology and this reduction would result at a very high incremental cost. This technology should be considered an emerging technology and merits additional testing for this unique application.

Because of non-linear chemistry involved in photochemical reactions of ozone and secondary aerosols that result in a reduction of visibility, NOx and/or SO_2 emission reductions estimated in this analysis may or may not result in equal improvement in ambient air quality levels. Also, excess ammonia slip within the discharge plume of an engine may accelerate the conversion of NOx emissions into particulate nitrate or sulfate. Table 2-7 presents CARB budgetary costs for the installation of SCR on lean burn engines[13].

Table 2-7. Cost Effective Estimates for ICE Control Techniques and Technologies

Selective Catalytic Reduction for Lean Burn				
Horse Power Range	Capital Cost (S)	Installation Cost(S)	O&M Cost (S/year)	Annualized Cost (S/year)
301-500	43,000	17,000	35,000	36,000
501-1000	116,000	33,000	78,000	78,000
1001-1500	132,000	53,000	117,000	148,000
Average gt 500 hp	**124,000**	**43,000**	**97,500**	**113,000**

[13] California Environmental Protection Agency Air Resources Board, 2001, “Determination of Reasonably Available Control Technology.

In conclusion, the addition of SCR beyond lean burn technology is not a proven or cost effective technology at the present time. With additional development and testing for oil and gas operations, it may become an effective control technology for tertiary control of lean burn engines.

Oxidation Catalyst

Oxidation catalyst can be used to reduce VOC and formaldehyde emissions on lean burn natural gas fired internal combustion engines. This technology converts formaldehyde and VOC emissions to CO_2 through the use of an oxidation catalyst and requires the use of an AFR in conjunction with the catalyst.

This technology can obtain a 90 percent reduction in hydrocarbons and an 80 percent reduction in formaldehyde. As part of the Four Corners Cumulative Effects Analysis, it was found that in Colorado (primarily within the boundary of the SUIT) the installation of oxidation catalyst on new engines greater than 300 horsepower[14] would result in formaldehyde emission reductions of 42 tons per year (a 9 percent reduction in emissions) in 2018. This option would also result in a reduction of 204 tons per year of VOC emissions (a 7 percent reduction in emissions) in 2018.

Facilities that are major sources for HAPS (10 tons per year any one HAP or 25 tons per year for total HAPs) are required to install MACT (oxidation catalyst) on engines to control HAPS.

Drilling Rig Engines

In Wyoming, the addition of SCR controls on drilling rigs has been evaluated (ENSR 2006).The findings of the installation of this technology were significant operational problems and very large capital and operating costs. Recently, second-generation SCR control systems have been developed and implemented in Wyoming, but no information has been published regarding the operability, amount of NOx removal or cost effectiveness. Given the uncertainty in the application of SCR for drilling rigs, the relative contribution of drilling rig emissions to the overall NOx emission inventory and the turnover rate of drilling rig engines associated with the installation of new engines with current federal emission standards, it seems prudent not to require additional mitigation beyond what is currently mandated. If additional mitigation is contemplated, additional analyses are required.

Since the air quality analysis was completed, the SUIT has decided to implement a mitigation strategy requiring all prime mover diesel drilling rig engines to achieve Tier 2 emission standards or better.[15]

2.5 Conclusions

Very little opportunity exists to reduce emissions from natural gas fired engines below NSPS levels. Presently, proven technology does not exist to reduce emissions below the federally mandated limits. For drilling rig engines, technology is emerging that can reduce emissions from drilling engines; however, this technology is very expensive and it seems that current control requirements are appropriate.

[14] The lower size cutoff for current lean burn technology.
[15] Drilling rig engines for new wells, not work overs or recompletion rigs.

3.0 EMISSION INVENTORY DEVELOPMENT

This section presents data regarding emission inventories that were developed as part of the air quality impact analysis. Emission inventories were developed for operations in 2005 and future years. These inventories were used to evaluate air quality effects from production and construction activities for the infill (proposed action) and the no action cases.

The starting point for defining the changes in oil and gas emissions as a result of the proposed 80 acre SUIT infill project was developing an accurate estimate of existing emissions against which changes in emissions as a result of the proposed infill project could be compared. The base case was defined as 2005. Compiling an accurate emission inventory for 2005 was complicated because neither the SUIT nor EPA currently has a minor source construction or operating permit program and thus there is no accurate record of emission sources on the reservation. In order to compile data regarding emissions, the SUIT contacted oil and gas operators within the reservation boundaries and requested data regarding emission sources within the area.

3.1 Existing Production Emissions

3.1.1 Existing Engine Emissions

In February 2007 the SUIT sent a questionnaire to all oil and gas operators regarding air emission sources within the boundaries of the reservation. The survey focused on emissions from natural gas fired engines (compressor, water disposal, etc.), natural gas processing plants and natural gas transmission facilities. The data requested were:

1. Company;
2. Site;
3. Location;
4. Type of equipment;
5. Site rated capacity;
6. Emission factors;
7. Type of air pollution controls;
8. Potential NOx and CO emissions; and
9. Actual NOx and CO emissions.

The survey was sent to 12 operators and all responded to the data request. The data request did not address the basis of the emission factors that were used to calculate emissions nor did it address consistency of data between operators for similar equipment. For example, in some cases the emission factor was based on source testing and in other cases emissions were based on manufacturer data or EPA emission factors. The data was reviewed for accuracy and any identified errors were corrected.

The operator survey provided estimates of emissions of NOx and CO for 2005 but did not provide emissions of hydrocarbons or formaldehyde. Instead, hydrocarbon emissions were calculated using the AP-42 emission factor of 1 g/hp-hour.[16] Formaldehyde emissions were calculated using an emission factor of 0.2 g/hp-hour[17]. In the calculation of hydrocarbon and formaldehyde emissions, the calculated ratio of actual to potential emissions for NOx and CO was used to adjust potential emissions to represent 2005 actual conditions (for NOx the ratio of PTE to actual was 0.71 and for CO the ratio was 0.76 and the average of these was used for VOC and formaldehyde).

Appendix A presents the 2005 base case emission inventory for engines and Table 3-1 presents the distribution of engine size and NOx emissions. The size distribution was selected based on the threshold of the recently promulgated EPA NSPS for Reciprocating Internal Combustion Engines (RICE)[18].

Table 3-1. Distribution of RICE Within the SUIT Boundaries in 2005.

Engine Size (hp)	Number of Engines	Number of Engines (percent)	Percentage of Capacity	Average NOx Emission Factor (g/hp-hour)	Total NOx Emissions (t/yr)	Emissions (percent)
Gt. 500	170	53.0	92	1.5	2,982	71
Lt. 500 Gt. 100	76	23.7	6.1	7.7	724	17
Lt. 100 Gt. 25	73	22.7	1.8	12.2	510	12
Lt. 25	2	0.6	0.0	27	11	0.3
Total	**321**		**100**		**4,227**	

As indicated by this analysis, the vast number of engines within the reservation boundaries have capacities in excess of 500 horsepower and are controlled with NSCR or are low emitting lean burn engines. For this size engine, the average NOx emission factor is 1.5 g/hp-hour. It is important to note that the inventory identified only one engine in this size class that was not controlled. Approximately 24 percent of the engines are in the 100 to 500 horsepower range and have an average emission factor for NOx of 7.7 g/hp-hour. Examination of these data indicate that a portion of the larger engines in this size category have controls while a portion of the smaller engines in this size category do not. The application of controls in this size range is a function that lean burn engines are not manufactured in small horsepower capacities and the reliability of NSCR controls is unproven[19]. Total NOx emissions for engines in the 100 to 500 horsepower size ranges are 724 tons per year (17 percent of total emissions). Engines less than 100 horsepower make up only 1.8 percent of the engines and have an average emission factor of 12.6 g/hp-hour. Emissions for this group of engines are 510 tons per year (12 percent of the emissions).

Figure 3-1 presents source locations for facilities in the region. The hydrocarbon speciation from engines was estimated using the EPA SPECIATE database[20]. Figure 3-2 presents the hydrocarbon composition from engines. This figure indicates that the majority of the hydrocarbons are methane and ethane, which are not regulated VOCs by EPA because of low reactivity.

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[16] EPA, 2000, AP-42 Fifth Edition, Volume I Chapter 3: Stationary Internal Combustion Sources http://www.epa.gov/ttn/chief/ap42/ch03/index.html

[17] EPA, 2000, AP-42 Fifth Edition, Volume I Chapter 3: Stationary Internal Combustion Sources http://www.epa.gov/ttn/chief/ap42/ch03/index.html

[18] Environmental Protection Agency 40 CFR Parts 60, 63, 85 et al. Standards of Performance for Stationary Spark Ignition Internal Combustion Engines and National Emission Standards for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines; Final Rule, January 2008

[19] Four Corners Air Quality Task Force Report of Mitigation Options, 2007

[20] EPA SPECIATE Database, http://www.epa.gov/ttn/chief/software/speciate/index.html

Figure 3-1. SUIT Source Locations

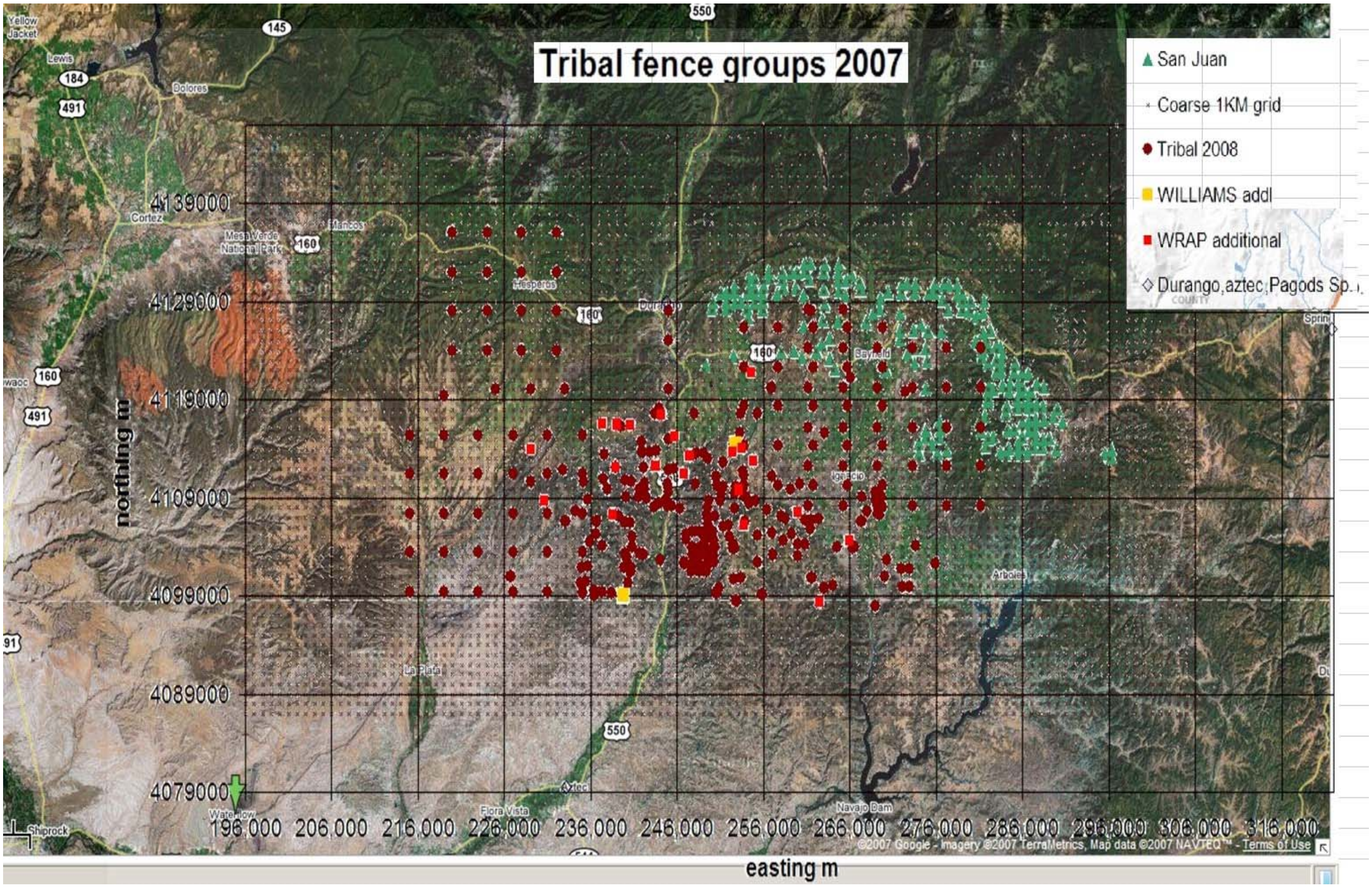
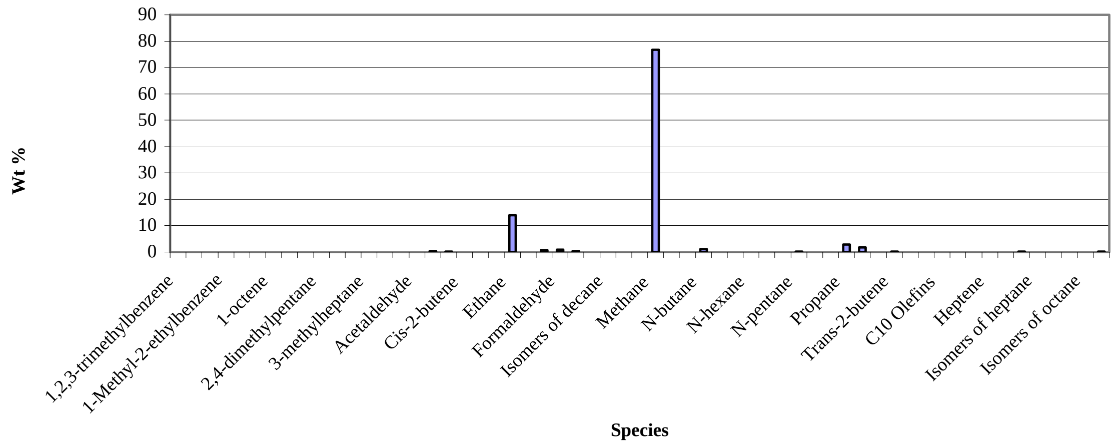


Figure 3-2. Speciation of Hydrocarbons for Natural Gas I/C Engines



3.1.2 Heater Emissions

Table 3-2 provides a summary of the calculation methods for separator heater emissions. Included in this information are the capacity, AP-42 emission factors, load and hours of operation as well as cumulative emissions.

Table 3-2. Heater Emission Calculations

Separator Emissions							
Unit Description							
Design Firing Rate (Million BTU/hour)	0.25						
Number of Separators	1						
Operating Parameters							
Average operating hours per separator:	8760						
Average Load This Year (percent Capacity)	50.0						
Actual Fuel Combustion for the Year for Units							
	Amount	**Unit**	**Content**	**Unit**			
Nat. Gas	1.1	MMSCF	1000.0	Btu/scf			
Potential Natural Gas usage	2.2	MMSCF					
Emissions Data							
	Actual		**Potential**		**Method of**	**Emission**	
Pollutant	**lb/hour**	**Tons**	**lb/hour**	**Tons**	**Determination**	**Factors**	**Units**
Nitrogen oxides	0.01	0.055	0.03	0.11	AP-42	100.0	lb/MMscf
Carbon Monoxide	0.00	0.011	0.01	0.02	AP-42	21.0	lb/MMscf
VOC	0.00	0.004	0.00	0.01	AP-42	8.0	lb/MMscf
2005 Heater Emissions Data							
Number of Heaters 2005	2402						
	Actual		**Potential**		**Method of**	**Emission**	
Pollutant	**lb/hour**	**Tons**	**lb/hour**	**Tons**	**Determination**	**Factors**	**Units**
Nitrogen oxides	30.1	132	60.1	263	AP-42	100.0	lb/MMscf
Carbon Monoxide	6.3	28	12.6	55	AP-42	21.0	lb/MMscf
VOC	2.4	11	4.8	21	AP-42	8.0	lb/MMscf

Note: 2005 well count from Red Willow Production Company

3.1.3 Process Fugitive Emissions

Table 3-3 presents a typical gas composition for coal bed methane produced within the region. As indicated by these data, there are no EPA regulated VOCs (C3 and greater) associated with production of this gas and the majority of the gas is methane.

Table 3-3. Typical Coal Bed Methane Gas Composition[21]

Component	Volume (Percent)	Molecular Weight	Weight (Percent)
Carbon Dioxide	**12.000**	44.010	27.230
Nitrogen	0.032	20.016	0.033
Methane	86.560	16.040	71.550
Ethane	0.580	30.067	0.899
Propane	0.098	44.092	**0.220**
iso-butane	0.012	58.118	0.036
n-Butane	0.012	58.118	0.036
iso-Pentane	0.002	72.144	0.007
n-Pentane	0.001	72.144	0.004
n-Hexane	0.001	86.169	0.009
		Non-reactive VOC	**99.7**

Table 3-4 presents a summary of VOC emissions from wells (non engines) associated with the production of CBM gas in the region.

Table 3-4. VOC Emissions as a Result of Production

Source Type	BP Reported VOC Emissions (t/yr)[22]	Total VOC Emissions (t/yr)
Flares	6	18
Fugitives	8	24
Venting	20	57
Dehydration	11	29
Pneumatic Equipment	5	13
Total	50	141

Note: Scaled based on the number of BP wells to total number of wells

Max number of BP wells in 2005 was 857

Total number of wells in 2005 was 2402

[21] RTP 2004, Northern San Juan Basin Coal Bed Methane Project Air Quality Technical Support Document.
[22] BP 2002 Greenhouse Gas Emission Inventory for Durango, CO Operations.

3.1.4 NOx Emission Summary for 2005

Table 3-5 presents a summary of 2005 emissions within the SUIT boundaries.

Table 3-5. Summary of 2005 Production NO_X Emissions

	Heater Emissions	Engine Total	Drilling	Total Existing CBM
Type of Source	**NOx (t/yr)**	**NOx (t/yr)**	**NOx (t/yr)**	**NOx (t/yr)**
Existing CBM	137	3,318	213	3,668
Conventional	0	495	0	495
Gas Plant	61	676	0	737
Transmission	0	147	0	147
Total	197	4,636	213	5,046

3.2 Future Year Production Inventories

Future year estimates of emissions for the infill and no action cases were calculated on an annual basis starting in 2006 through 2027. Future year emission estimates were developed by estimating the amount of natural gas that would be produced with and without any infill development. The amount of natural gas produced is a function of new production (which declines over time) as well as existing declining production. The amount of compressor capacity needed for infill production is directly correlated to the total as well as the incremental amount of gas produced. Estimating emissions for a declining base case and an incremental increase (with no net increase in production) is a very dynamic process. Thus, as existing production declines, the amount of compressor capacity will decrease from current conditions. The assumption that existing compression and emissions remain constant and that emissions from infill production are added to the base conditions is not an accurate representation of future year emissions. The procedure for estimating future year production is described in the following subsections.

3.2.1 Estimation of Production Volume for Future Years

In order to determine the gas volumes associated with the proposed 80 acre infill CBM development on Tribal lands, a map was used to identify specific well spacing locations that would require federal permitting. A total of 570 wells were identified in areas currently spaced for 80 acre drilling. An additional possible 200 wells were added in areas that might be viable for 80 acre drilling in the future (a total of 770 wells). The SUIT contracted with Cawley, Gillespie, and Associates (CG&A), a well respected CBM reservoir engineering firm of registered professional engineers, to evaluate production with and without infill wells.

CG&A used its extensive San Juan Basin well database to gather information on wells in the study area. These data included coal thickness, gas content, coal isotherm properties, ash content, permeability, initial reservoir pressure, current reservoir pressure, and historical production data from existing 80, 160, and 320 acre infill wells. These data were used to calculate the initial gas-in-place, the gas recovery to date and the remaining gas to be recovered in a section. Type curves were then forecast for the proposed 80 acre wells in the section based on the above referenced variables. The type curves were then crosschecked with historical production of existing similar wells or, in the absence of historical data, reservoir simulation models were used as a reference.

CG&A created a unique 80 acre well decline curve representative of each 80 acre well in a township based upon the reservoir properties and production histories of the wells in that township. Each of the 770 wells was assigned a type curve based upon its location within a specific township. The 770 curves were then combined into a single average curve for the program by volume weighting the curves and combining them. This average curve was used for production scheduling because the specific timing of the drilling of each well cannot be predicted. Production from the new wells was forecast to begin in October 2008, with 80 wells per year being put on production. The forecast was carried out for 20 years until September 2028. Fee infill activity was held flat at the 2006-2007 growth at a rate of 40 wells per year until the Tribal infill production begins in October 2008. The fee infill volumes were projected to decline from October 2008 until September 2028 with no growth in well count.

A volume forecast for existing conventional wells which exist within the exterior boundaries of the reservation was also included in the total volume modeled. The conventional wells were predicted to decline at a rate based on historical trends with no planned development. Figure 3-3 presents estimated production volume for existing and infill production. It is important to note that there is no increase in production as a result of the infill activity. Rather, the infill development simply reduces the overall rate of decline. Figure 3-4 presents the estimated well count with and without infill development.

Figure 3-3. Estimated Production Volume by Year

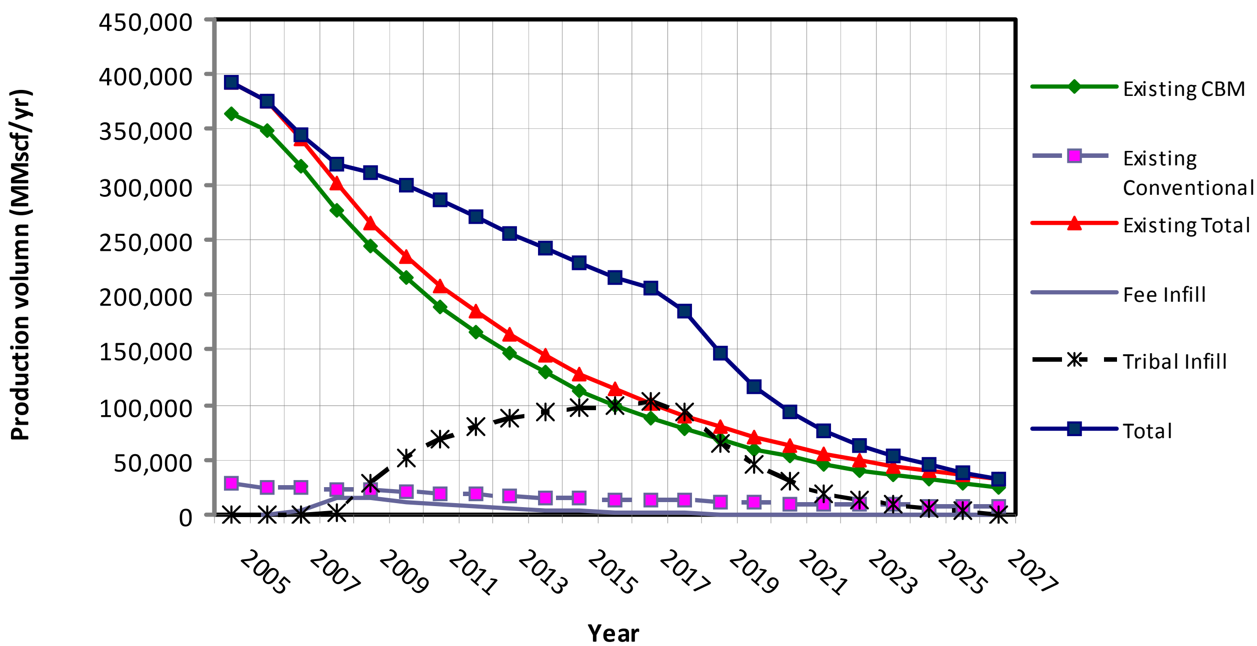
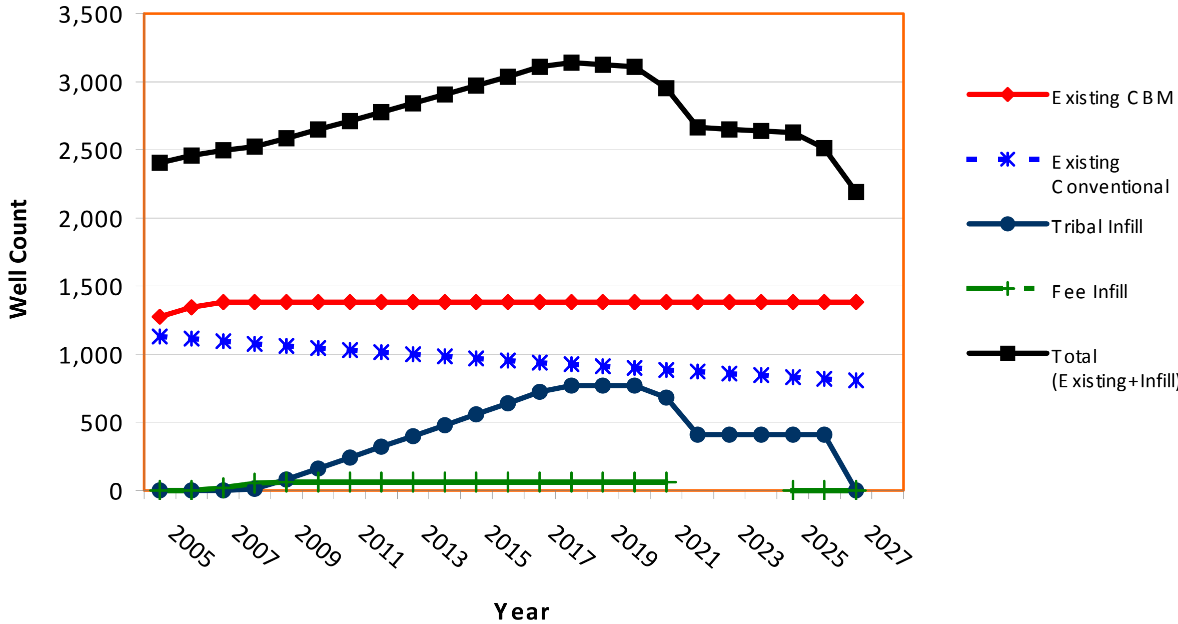


Figure 3-4. Projected Well Count



3.2.2 Future Year Compressor Capacity

To determine compression horsepower requirements over the life of a gas well two inputs are required: the gas volume to be compressed and the pressures at which the gas compressor will operate. The specific pressures needed are the compressor suction pressure and the compressor discharge pressure. The compressor suction pressure is determined by the gathering system operating pressure and the discharge pressure is determined by the gathering pipeline operating pressure.

Coal Bed Methane Pressure Requirements

CBM production characteristics require that the gathering system pipeline pressure that the wells produce against must decline over the life of the well to optimize the rate of gas production as well as the ultimate gas recovered from the coal. CBM wells have a unique production characteristic determined from the fact that the gas molecules are sorbed to the surfaces of the coal rather than simply trapped in the pore space of the coal. The pressure reduction in the coal reservoir allows the CBM gas to desorb into the pore spaces where it can be produced into a completed well bore. The relationship of gas desorbed to reservoir pressure is non-linear such that a much larger amount of gas is released at low pressures than at higher pressures for a fixed amount of reservoir pressure reduction. This is why a small change in abandonment pressure results in a large change in gas desorbed and total amount of gas recovered.

The lower the pressure in the reservoir, the more gas is released from the surfaces of the coal. For the reservoir to be significantly depressured, the connate water in the coal must first be withdrawn by producing water with the gas. These facts combine to create three production cycle phases during the life of the well as shown in Table 3-6.

Table 3-6. CBM Production Phases

Phase	Description	Producing Pressure (psi)
1	Dewatering Phase	50-100
2	Water/Gas Production Phase	30-80
3	Declining Reservoir Pressure Dominated Phase	2-20

Horsepower Factors Based on Observed Gathering System Pressure

Based on the producing pressure requirements for wells, a study of Red Willow Production Company's actual compression and gathering systems was made to ascertain the horsepower consumed per thousand cubic feet of gas produced per day (Mscfd). Each of the three production phases was studied as defined by the gathering system producing pressure. Centralized facilities with three stages of compression as well as systems with wellhead compressors and a central two-stage compression facility were both evaluated. The average horsepower requirements for the three production phases are shown in Table 3-7.

Table 3-7. Compression Requirements as a Function of Pressure.

Phase	Gathering Pressure (psi)	(hp/Mscfd)
1	50-100	0.18
2	30-80	0.24
3	2-20	0.46

Actual installed horsepower will be higher than the figures above which are the amount of horsepower that is required by the system. The horsepower utilization efficiency of an operating system was found to be between 40 percent to 80 percent of installed horsepower. As gas volumes decline and installed compression horsepower remains constant, the system efficiency is reduced. New installations are usually sized to provide approximately 110 percent to 120 percent of the calculated required horsepower to add operating flexibility on actual pressures and volumes.

Horsepower Requirement Calculations

Horsepower requirement calculations were made by multiplying the appropriate horsepower factor for the production cycle phase times the forecasted gas volume. Gathering system pressure reductions were predicted based on the Tribal well infill volume forecast.

Type 1 production cycle phase (0.18 hp/Mscfd) was forecast to continue until after all 770 Tribal infill wells are drilled. Pressures will most likely be held constant in gathering systems as new wells are added and existing wells decline. This occurs from inception in October 2008 until July 2018.

Type 2 production cycle phase (0.24 hp/Mscfd) begins after development of the 770 Tribal wells is completed. At this point with no new wells coming online, the decline in production with a fixed volume of compression is modeled to result in gathering system pressures being pulled down until the compressor efficiencies require reconfiguration. This will occur from August 2018 until January 2020.

Type 3 production cycle phase (0.46 hp/Mscfd) begins as existing compression is reconfigured to

3 stages of compression so that wells are produced at the minimum possible non-vacuum pressure in order to maximize gas recovery and offset decline rates. This will occur from February 2020 until the end of the forecast period.

Confirmation of Calculated Engine Capacity

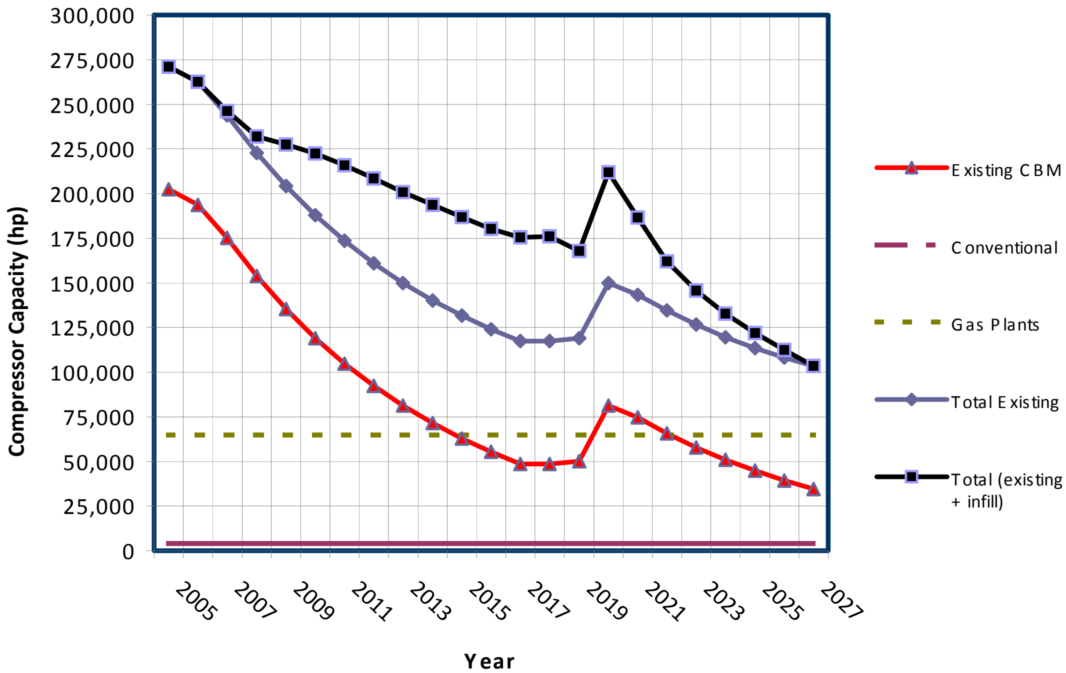
An analysis was conducted to evaluate the accuracy of the production forecasting methodology. The estimated compressor capacity was evaluated starting in 2005 and this was compared to the actual capacity that was operating in 2005. In order to make this comparison, the existing engines were segregated based on usage. Engines that were used for CBM production were included in the comparison and engines associated with conventional gas production, gas plants or transmission were not included in the comparison. Thus, comparison of predicted engine capacity to actual engine capacity in 2005 was done on a consistent basis. Table 3-8 presents the comparison of CBM engine capacity and shows that the methodology used to estimate engine capacity in 2005 underestimated actual usage by 11 percent and represents an accurate method of estimating engine capacity for future cases based on production volume. In order to be conservative, the estimated engine capacity was scaled up by 11 percent to ensure that the estimated engine capacity was not understated.

Table 3-8. Comparison of 2005 Actual Capacity to Model Predicted

	2005 Actual Capacity (hp)	Predicted 2005 Capacity (hp)	Ratio (Pred/Obs)	Percent Under Predicted	Adjusted Capacity (hp)
CBM Existing Capacity	202,308	179,757	0.889	11	202,308

Figure 3-5 presents the estimated changes in engine capacity over the period 2005 through 2027. In estimating compressor capacity it was assumed that gas plant, conventional and transmission compressor capacities would remain constant. In reality, this is a conservative assumption since the amount of gas processed and shipped to sales will decrease as the production volume decreases. The spike that occurs in estimated compression in 2020 is a result of the field entering the declining reservoir pressure dominated phase (Phase 3) when the estimated operating pressure is between 2 and 20 psi. Even with this decrease in pressure and the resulting increase in compressor capacity, the total compression is substantially lower for both the existing production and the infill production than the compression that was operating in 2005. It is also important to note that this spike in compression capacity is a short-term event and then the total amount of compression decreases.

Figure 3-5. Compressor Capacity by Year



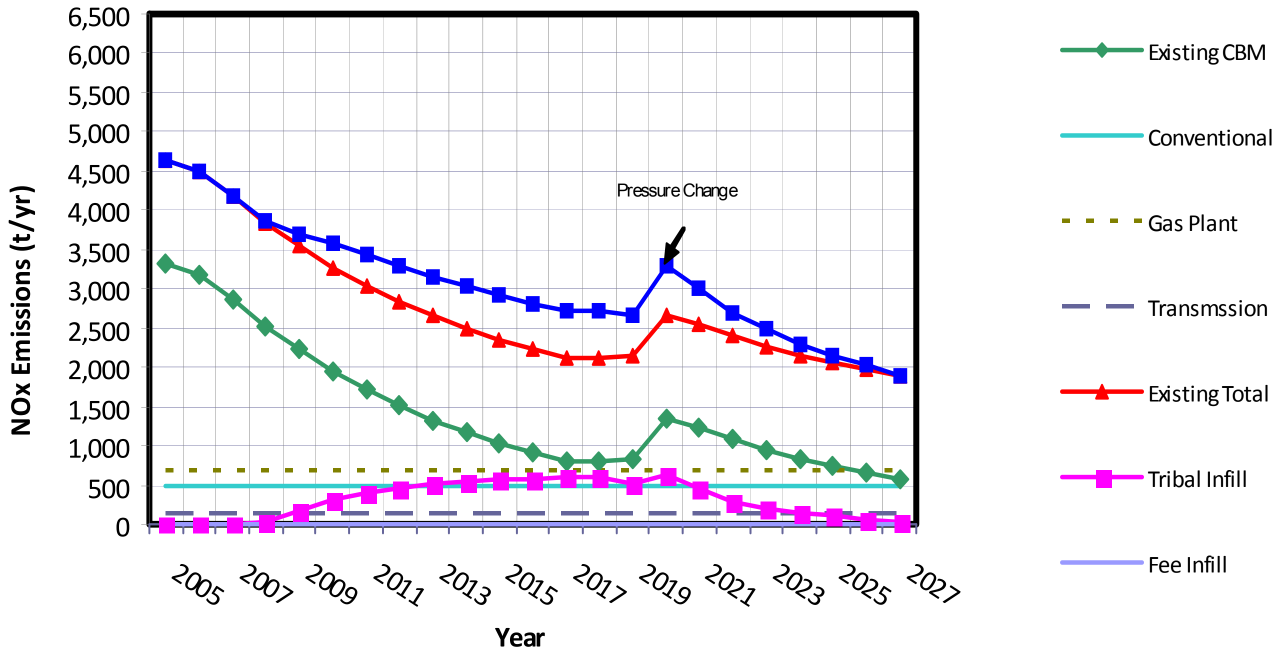
3.2.3 Future Year Compressor Emissions

Emissions from compressor engines associated with the proposed 80 acre infill development and the no action case were estimated using the predicted production volume and the associated engine capacity needed to produce the gas (Figures 3-3 and 3-5). It is important to note that this procedure accounts for both the volume of natural gas produced as well as the system pressure. The next step was to assume that the mix of engines in the future would be the same as the current mix of large and small engines. Table 3-9 presents the distribution of engines that would likely be employed in future years as well as the regulatory driver and associated emission factor. In developing the proposed action it was assumed that the 1 g/hp-hour would be required on new engines with a capacity greater than 500 horsepower for the time period 2008 through 2010. It is anticipated that this action will reduce NOx emissions by 404 tons per year. Figures 3-6 through 3-8 present annual projected emissions for engines within the SUIT boundaries for the proposed infill and the no action cases for NOx, CO and total hydrocarbons. It should be noted that the calculated total emissions are not sensitive to the assumed distribution of engines.

Table 3-9. Annual Engine Growth Projections for SUIT Infill Project

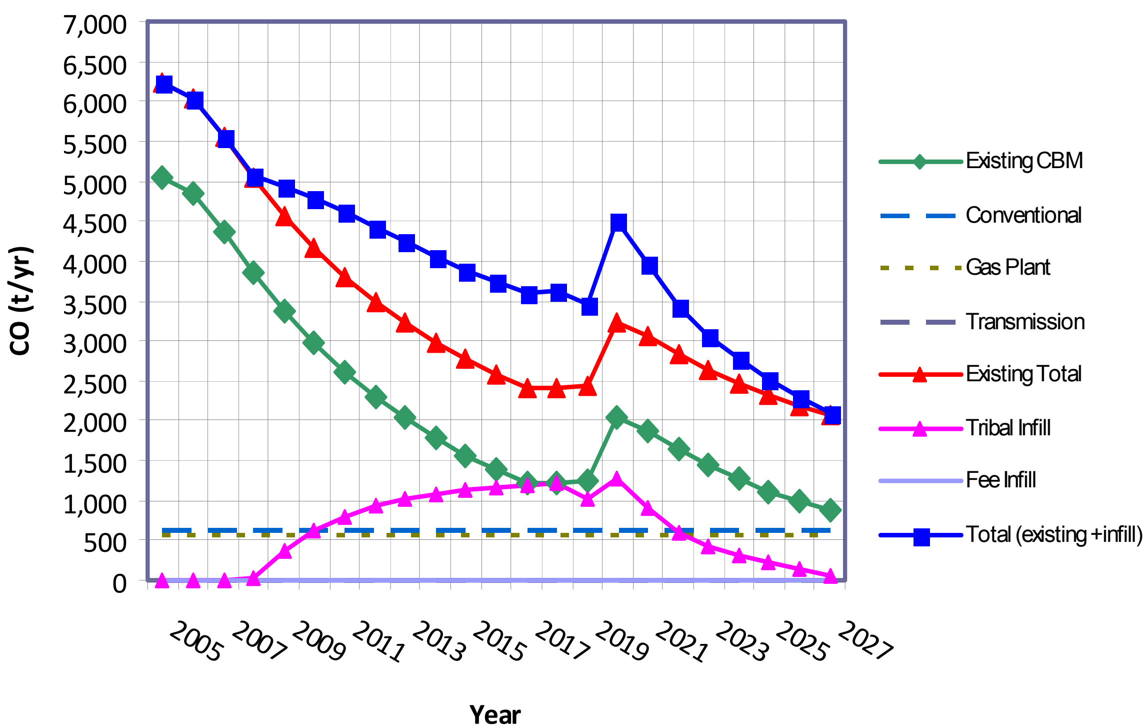
Year	NOx Emissions engines gt 500 hp (t/yr)	NOx Emissions engine capacity gt 500 hp gt 100 hp (t/yr)	NOx Emissions engines capacity lt 100 hp gt 25 hp (t/yr)	NOx Emissions engines capacity lt 25 hp (t/yr)	Infill NOx emissions (t/yr)
2005	0	0	0	0	0
2006	0	0	0	0	0
2007	0	0	0	0	0
2008	13	2	1	0	16
2009	137	18	10	0	166
2010	254	34	19	1	307
2011	334	39	25	1	399
2012	390	43	29	1	463
2013	430	45	32	1	508
2014	457	47	34	1	540
2015	476	49	36	1	562
2016	490	49	37	1	577
2017	507	51	38	1	597
2018	516	51	39	1	607
2019	428	45	32	1	507
2020	542	53	41	1	637
2021	383	42	29	1	455
2022	244	33	18	1	296
2023	171	28	13	0	212
2024	117	25	9	0	151
2025	75	22	6	0	102
2026	37	19	3	0	59
2027	0	17	0	0	17

Figure 3-6. Actual NOx Emissions from Engines



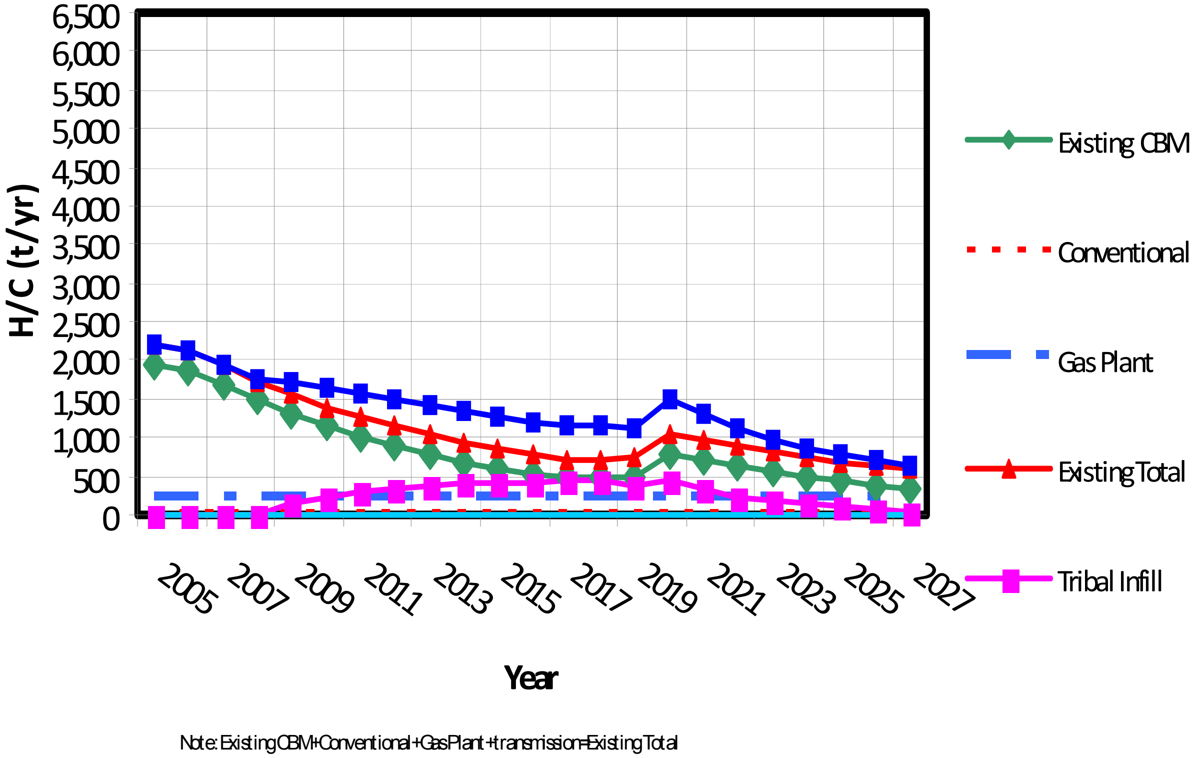
Note: Existing CBM + Conventional + Gas Plant + transmission = Existing Total

Figure 3-7. Actual CO Emissions from Engines



Note: Existing CBM+Conventional+Gas Plant+transmission=Existing Total

Figure 3-8. Actual THC Emissions from Engines



3.2.4 Future Year Heater Emissions

Future year heater emissions were based on the projected well count in Figure 3-4 and emission calculations presented in Table 3-2. Figures 3-9 through 3-10 present annual heater emissions for NOx and CO respectively.

3.2.5 Future Year Drilling Emissions

Table 3-10 presents emission calculations for drilling rigs for Tier 0, Tier 1 and Tier 2 and Table 3-11 presents the level of emission control that was assumed in calculating future year drilling rig emissions. Figure 3-11 presents estimated drilling emissions between 2008 and 2018 for all pollutants. The turnover in engines used to power drilling rigs is based on a 5 to10 year life expectancy[23]. In calculating future year emissions from drilling rig engines, it was conservatively assumed that after 5 years of development the number of Tier 0 and Tier 2 drilling rigs operating on the Reservation would be equal, but in reality the number of Tier 0 drilling rigs is likely to be less than the number of Tier 2 drilling rigs.

[23] WRAP Oil and Gas 2002/2005 and 2018 Area Source Emission Inventory Improvements 2007.

Figure 3-9. Projected NOx Emissions from Heaters

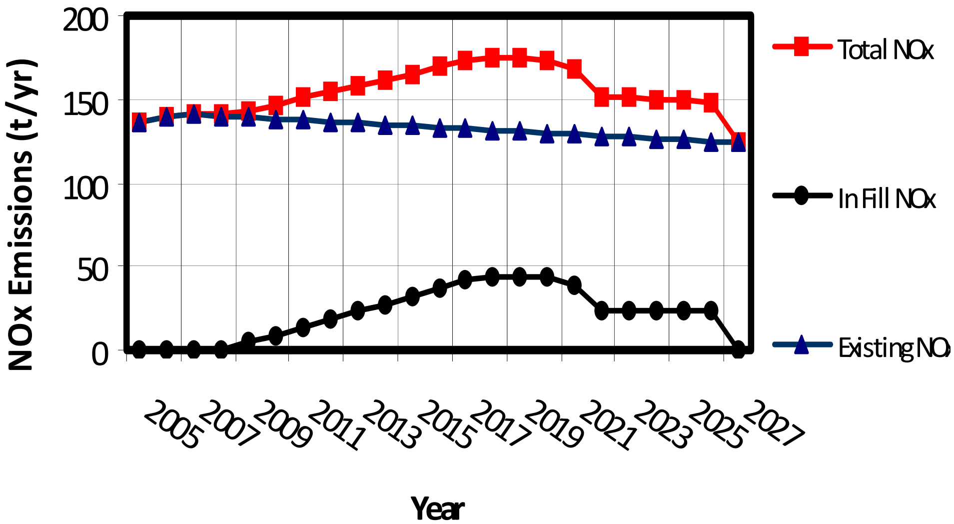


Figure 3-10. Projected CO Emissions from Heaters

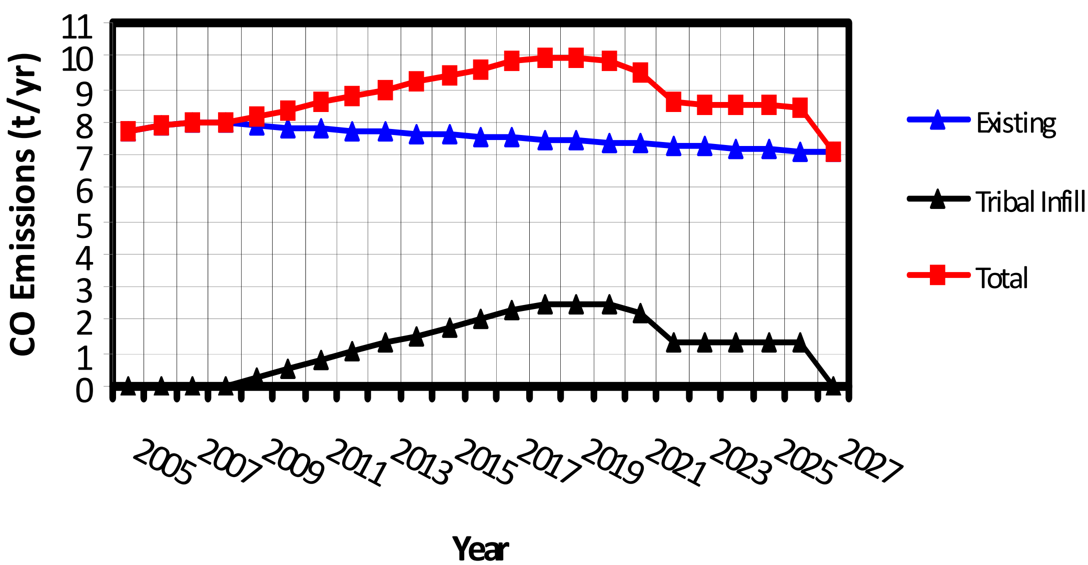


Table 3-10. Drilling Emissions

Control Tier 0

Pollutant	Pollutant Emission Factor (lb/hp-hour)	Total Capacity All Engines (hp)	Overall Load Factor	Drilling Activity Duration (days/well)	Drilling Activity Duration (hours/day)	Emissions (lb/well)	Emissions (t/well)	Emissions (lb/hour/well)
CO	0.00668	2,120	0.42	12	24	1713	0.9	5.9
NOx	0.03100	2,120	0.42	12	24	7949	4.0	27.6
SO_2	0.00205	2,120	0.42	12	24	526	0.3	1.8
H/C	0.00250	2,120	0.42	12	24	641	0.3	2.2
PM_{10}	0.00220	2,120	0.42	12	24	564	0.3	2.0

Control Tier 1

Pollutant	Pollutant Emission Factor (lb/hp-hour)	Total Capacity All Engines (hp)	Overall Load Factor	Drilling Activity Duration (days/well)	Drilling Activity Duration (hours/day)	Emissions (lb/well)	Emissions (t/well)	Emissions (lb/hour/well)
CO	0.01870	2,120	0.42	12	24	4795	2.4	16.7
NOx	0.01500	2,120	0.42	12	24	3847	1.9	13.4
SO_2	0.00035	2,120	0.42	12	24	90	0.0	0.3
H/C	0.00220	2,120	0.42	12	24	564	0.3	2.0
PM_{10}	0.00088	2,120	0.42	12	24	226	0.1	0.8

Control Tier 2

Pollutant	Pollutant Emission Factor (lb/hp-hour)	Total Capacity All Engines (hp)	Overall Load Factor	Drilling Activity Duration (days/well)	Drilling Activity Duration (hours/day)	Emissions (lb/well)	Emissions (t/well)	Emissions (lb/hour/well)
CO	0.00570	2,120	0.42	12	24	1462	0.7	5.1
NOx	0.00900	2,120	0.42	12	24	2308	1.2	8.0
SO_2	0.00035	2,120	0.42	12	24	90	0.0	0.3
H/C	0.00040	2,120	0.42	12	24	103	0.1	0.4
PM_{10}	0.00033	2,120	0.42	12	24	85	0.0	0.3

Notes:

1) The maximum sulfur content in non-road diesel fuels is currently not regulated by the EPA. Nonroad fuels meet an industry specification of 0.5percent (5000 ppm) sulfur, with an average in-use content of about 3000 ppm (for comparison, sulfur level in highway fuels, currently at 500 ppm, will be capped at 15 ppm from June 2006).

2) 500 ppm sulfur level effective June 2007 for fuels used in nonroad, locomotive and marine engines

3) 15 ppm (ultra-low sulfur diesel) effective:

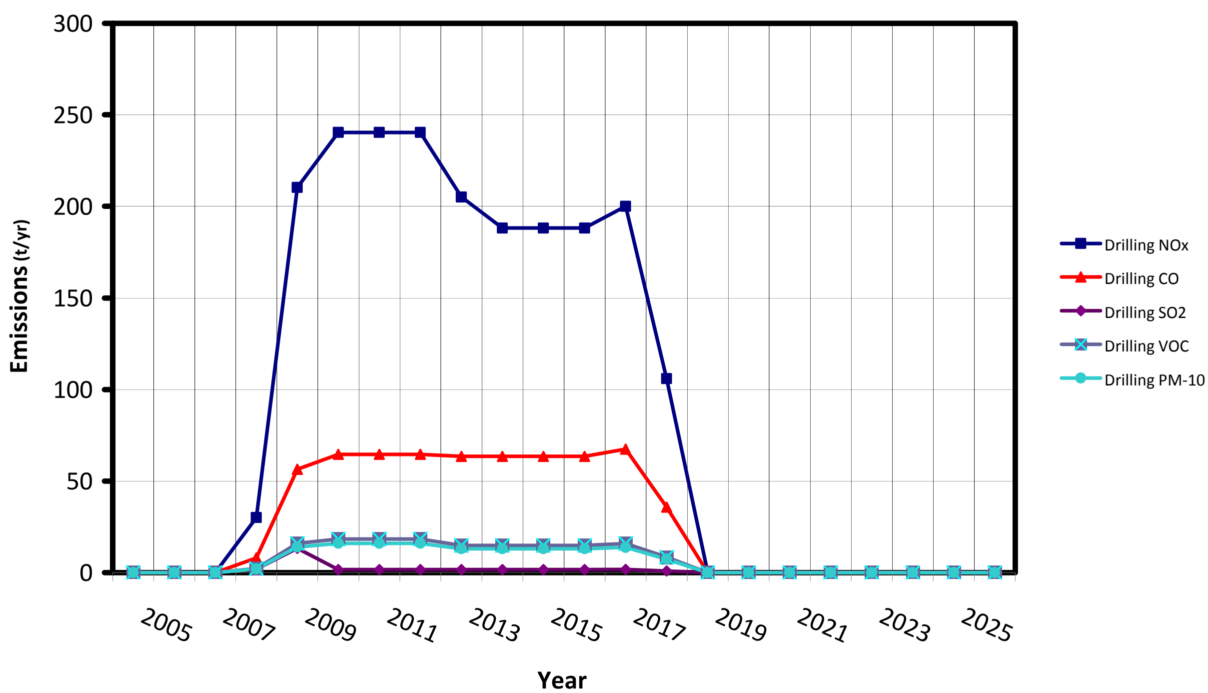
June 2010 for non-road fuel

June 2012 for locomotive and marine fuels

Table 3-11. Assumed Level of Control Used to Calculate Drilling Rig Emissions

Year	Assumed Level of Control
2008	1/3 Tier 2 + 2/3 Tier 0
2009	1/3 Tier 2 + 2/3 Tier 0
2010	1/3 Tier 2 + 2/3 Tier 0 Ultra low sulfur diesel fuel regulation (15 PPM)
2011	1/3 Tier 2 + 2/3 Tier 0
2012	1/3 Tier 2 + 2/3 Tier 0
2013	1/2 tier 2 + 1/2 tier 0
2014	1/2 tier 2 + 1/2 tier 0
2015	1/2 tier 2 + 1/2 tier 0
2016	1/2 tier 2 + 1/2 tier 0
2017	1/2 tier 2 + 1/2 tier 0
2018	1/2 tier 2 + 1/2 tier 0

Figure 3-11. Infill Drilling Emissions



3.3 Total Emissions

At present, detailed site-specific engineering data are not available regarding the exact nature of equipment that would be used or the exact locations where the equipment would be installed. For purposes of this air quality impact assessment, reasonable but conservative assumptions were made regarding cumulative emissions from these potential emission sources.

Figures 3-12 through 3-14 present total annual emissions for the infill project for NOx, CO and THC respectively. It should be noted that for modeling the projected impacts of the proposed infill project in 2018 it was assumed that the peak that is predicted to occur in 2021 as a result of a reduction in pressure was assumed to occur in 2018.

One of the major findings of this analysis is that as a result of declining CBM production on the Reservation, future year emissions without any infill development will be substantially less than 2005 emissions. Also, with infill development, future year emissions will be less than 2005 levels and slightly greater than projected emissions for the no action case.

Figure 3-12. NOx Emissions from All Sources from Existing and Infill Wells

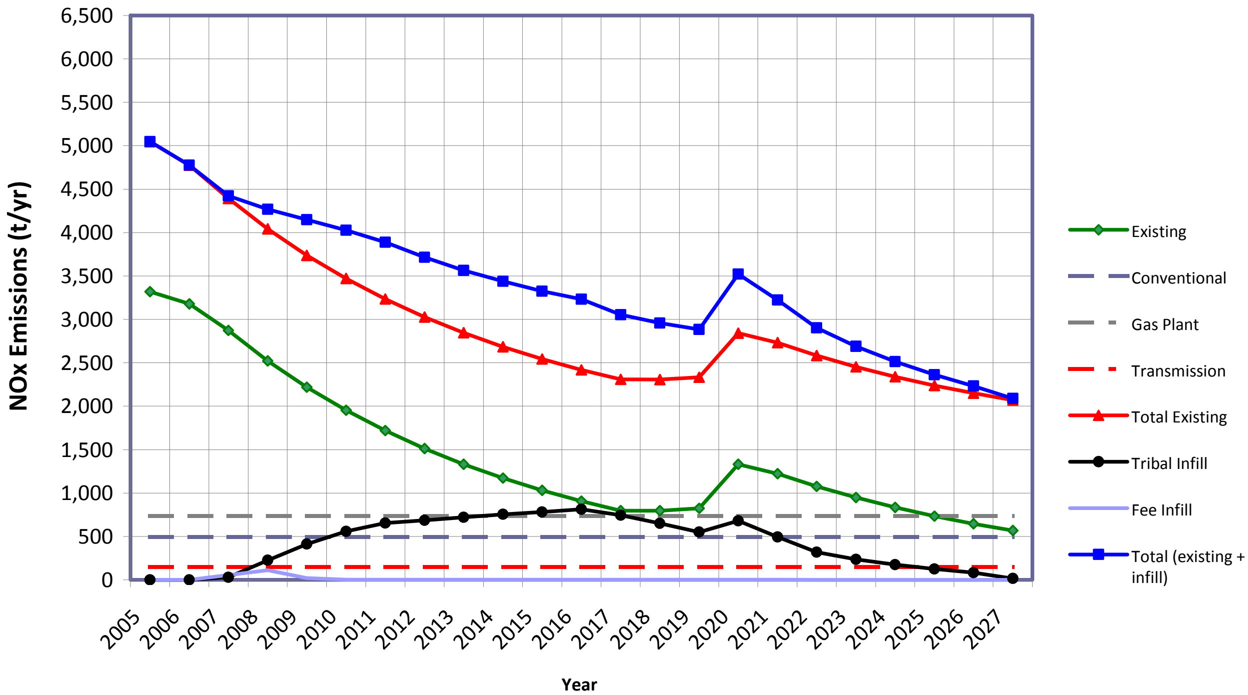


Figure 3-13. CO Emissions from all Sources from Existing and Infill Wells

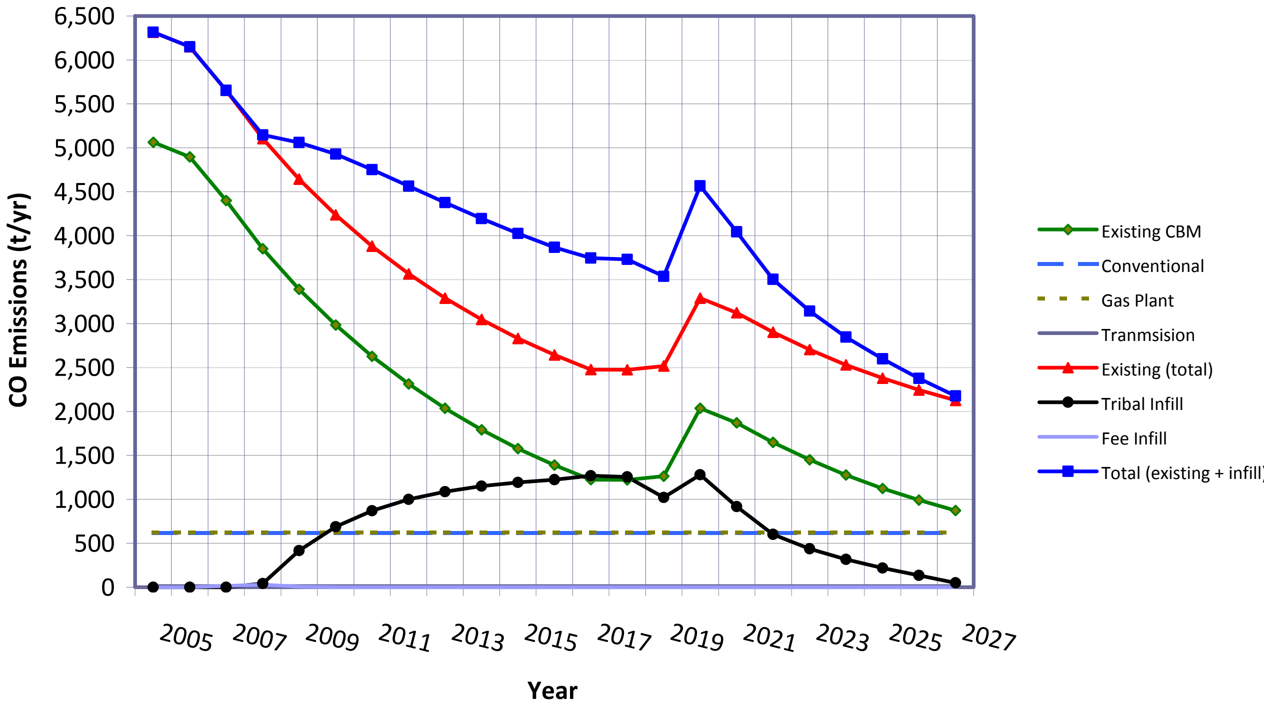
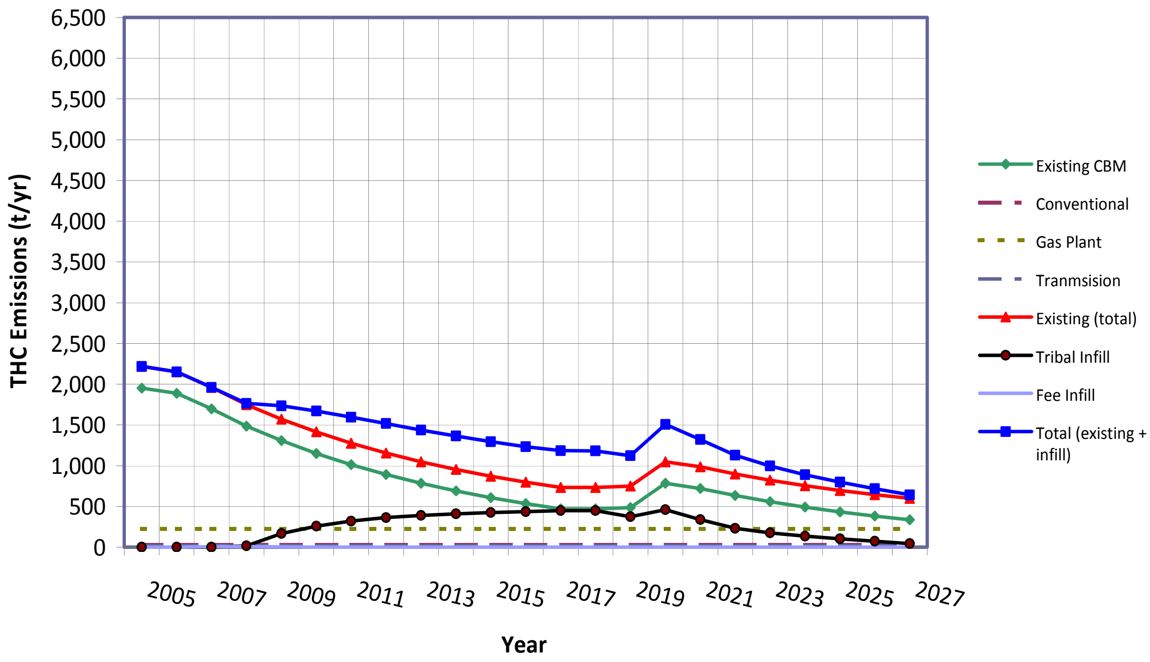


Figure 3-14. THC Emissions from All Sources from Existing and Infill Wells



3.4 Reasonably Foreseeable Sources

Growth estimates and emission inventories for the EIS that have been issued a ROD in the Four Corners Region were developed as part of the Four Corners Modeling Cumulative Effects Analysis and were used in this analysis. In Colorado, there are two applicable projects: 1) The 2002 SUIT EIS and 2) The Northern San Juan EIS. The only applicable ROD in New Mexico is the Farmington Resource Management Plan (RMP).

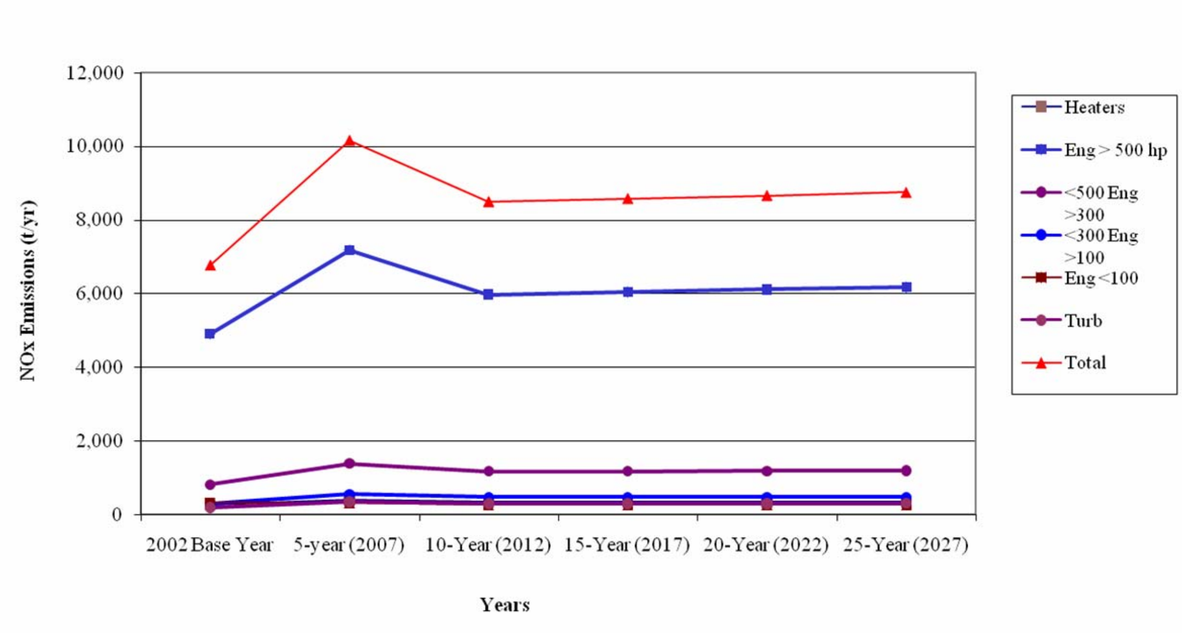
3.4.1 SUIT Oil and Gas Development EIS

The 2002 SUIT ROD was based on a development scenario of 367 wells and 1,763 tons per year of NOx. The estimated emissions were based on an installed compressor capacity of 112,298 horsepower and a NOx emission factor for engines of 1.5 g/hp-hour. The EIS analyzed NOx emission factors for compressor engines of 1, 1.5 and 2 g/hp-hour, however, the ROD did not specify which emission factor was applicable. In the Four Corners Analysis an emission factor of 1.5 g/hp-hour was used because it represents the current level of emission control that has been installed on Tribal land[24]. In developing an emission inventory to be used in modeling for the 2008 SUIT EA and the Four Corners Analysis, a comparison was made between the existing 2005 inventory and the 2002 SUIT EIS proposed action. Sources that were contained in both the 2002 SUIT EIS inventory and the 2005 inventory were eliminated in the future year inventory that was used for future year modeling. Because of the lack of detailed permitting records within the SUIT reservation, there are likely other sources that were included in the 2002 EIS that were constructed and emissions are included in the 2005 inventory.

3.4.2 Northern San Juan EIS Sources

In 2007 BLM issued a ROD for the Northern San Juan EIS. It was assumed that the development period was 25 years Figure 3-15. A condition of the ROD was that all engines in excess of 500 horsepower would achieve an emission limit of 1 g/hp-hour and engines between 499 and 100 horsepower would achieve an emission limit of 2 g/hp-hr.

Figure 3-15. Estimated Growth in Colorado Oil and Gas NOx by Source Type as a Result of the Northern San Juan EIS ROD

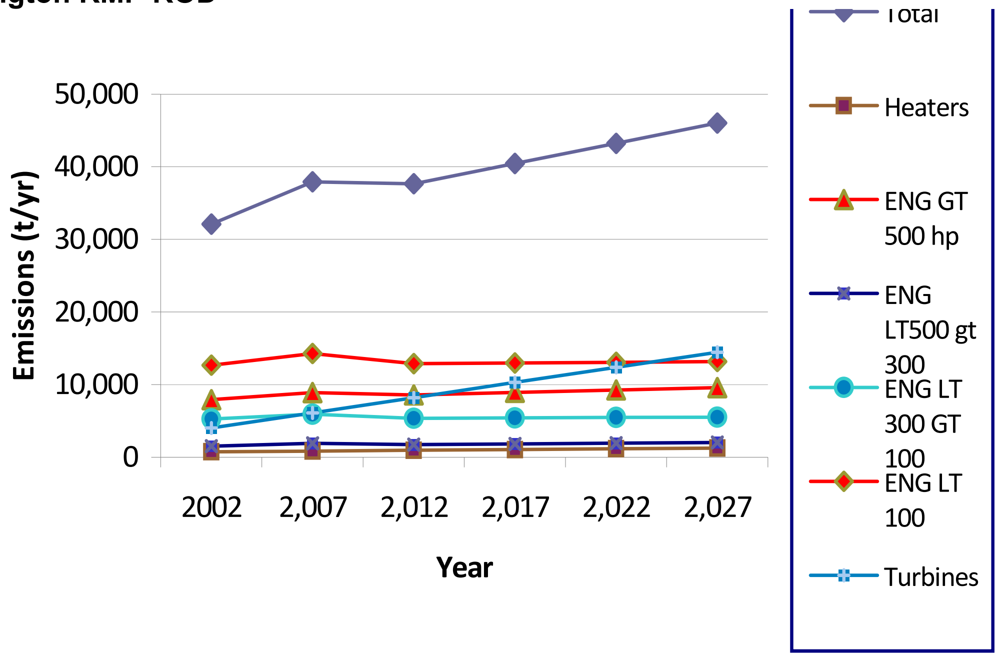


[24] Four Corners Air Quality Task Force 2007, Four Corners Air Quality Task Force Report of Mitigation options

3.4.3 Farmington Resource Management Plan

In 2003 BLM issued a ROD for the Farmington Resource Management Plan with the condition that all engines in excess of 500 horsepower achieve an emission limit of 1 g/hp-hour and engines between 100 and 499 horsepower achieve an emission limit of 2 g/hp-hour. Figure 3-16 presents oil and gas growth in the Four Corners Region of New Mexico as a result of the Farmington RMP. These growth estimates were developed as part of the Four Corners Task Force Report and are being used in the future year modeling analysis without any modification.

Figure 3-16. Projected Changes in NOx Emissions in New Mexico a Result of the Farmington RMP ROD



Small Engine Emission Inventory

The Farmington RMP emission inventory was developed by reviewing the RMP (BLM 2003) and its Technical Support Document (SAIC 2003). It was assumed that small wellhead engines would be installed on 50 percent of the wells and that each small engine would have a capacity of 68.5 horsepower and a NOx emission factor of 9.62 g/hp-hour. Data obtained from the New Mexico Oil and Gas Association (NMOGA) indicated that the weighted average size of small engines installed in the area is 68.5 horsepower with an average NOx emission rate of 6.4 tons per year. Operational data supplied by NMOGA indicated that the utilization rate of the wellhead engines was 54 percent (NMOGA 2003) which was used in development of the 2018 emission inventory. The supplemental ROD required mitigation on small engines, specifically that engines between 25 and 500 horsepower must achieve an emission limit of 2 g/hp-hour. No data was provided regarding how realistic the assumption of 50 percent of the wells having a dedicated small engine would be. It was assumed that an additional 340,911 horsepower would be added. This new engine capacity needs to be contrasted to the current existing small engine (less than 500 horsepower) capacity that was identified as part of the Four Corners Air Quality Task Force Analysis which showed that for engines less than 100 horsepower, the total capacity was 76,241horsepower and for engines greater than 100 horsepower but less than 500 horsepower the total capacity was

59,607 (total capacity of 135,847 horsepower). Thus, the projected capacity is 2.5 times greater than the existing capacity. In addition, it was assumed that the current level of engine capacity would remain constant through 2018 for a production field that is undergoing significant decline. Therefore, the RMP growth scenario has considerable uncertainty associated with it.

Heater Emissions

As part of the Farmington RMP analysis, it also assumed that each well would be equipped with a three-phase separator. Total separator NOx emissions from the development were estimated to be 1,425 tons per year assuming continuous operation throughout the entire year.

Central Compression

The original RMP analysis also provided an estimate of total central compressor capacity of 360,000 horsepower, although no information was provided regarding the number of central compressor stations, the size of individual stations or their locations. It was assumed that 36 central compressor stations would be installed with each having a capacity of 10,000 horsepower. Based on an emission factor of 1.5 g/hp-hour, it was assumed that total NOx emissions from each central compressor station would be 145 tons per year. It was further assumed that each central compressor station would be comprised of four 2,500 horsepower engines.

Comparison of the RMP central compression (assumed at 360,000 horsepower) with the existing New Mexico compression (the total existing engine capacity in excess of 500 horsepower is 378,572 horsepower) indicates that the proposed new capacity is equivalent to the current central compression capacity. In addition, it was assumed that the current level of engine capacity would remain constant through 2018 for a production field that is undergoing significant decline. Therefore, the growth scenario for central compression has considerable uncertainty associated with it.

3.5 Far Field Emissions Inventory

A regional emissions inventory representative of 2005 emissions suitable for use with the CAMx photochemical grid model was developed for this study. This inventory is based on work conducted by ENVIRON and others for the Western Regional Air Partnership (WRAP) and more recently by ENVIRON for the Four Corners Air Quality Task Force along with additional emission inventory development work for sources on the SUIT lands. This 2005 base case inventory is identical to the inventory being used in the Four Corners Air Quality Task Force modeling effort and was used for establishing current air quality conditions and evaluating CAMx model performance.

In addition to the 2005 base case inventory, two future year inventories were developed:

1. A future year base case inventory that reflects both increases and decreases in emissions in the region over the next several years and provides an estimate of air quality conditions for the "no action" alternative. Given the need to model long-term control strategies and the availability of a 2018 inventory developed under the auspices of WRAP, 2018 was chosen as the future year for this analysis.

2. A future year inventory identical to the 2018 no action inventory but with emissions from the proposed 80 acre infill project included (2018 infill scenario).

The 2018 base case ("no action") inventory is identical to the 2018 base case inventory being used by the Four Corners analysis except that projected changes in emissions for oil & gas sources on SUIT lands are included in this inventory whereas the FCAQTF 2018 base case inventory assumes that SUIT emissions in 2018 are identical to 2005 SUIT emissions.

3.5.1 Data Sources and Model-Ready Inventory Development

Emission inventories were prepared for sources within the 4 km, 12 km and 36 km modeling domains shown in Figure 3-17. The inventories contain estimates of anthropogenic PM, SOx, NOx, VOC, CO, NH_3 and windblown dust emissions as well as biogenic VOC and NOx emissions and fire emissions (wildfires and prescribed burns). Primary emissions data sources used in developing the inventories included:

<u>WRAP Regional Inventory Development and Modeling</u>: WRAP funded development of a 2002 emissions inventory processed for use in the CMAQ and CAMx air quality models using the SMOKE emissions processing system. This inventory covers the entire continental U.S. at 36 km resolution. A similar model-ready inventory for 2018 which includes the latest available updates and is known as the PRP18 inventory was also prepared for WRAP.

<u>WRAP Phase II Oil and Gas Emissions Updates</u>: ENVIRON developed a region-wide oil and gas emissions inventory for the western U.S. under contract to WRAP. ENVIRON recently completed updating this inventory for the years 2002, 2005 and 2018. Emissions data for 2002 developed for the Southern Ute Indian Reservation and other areas in connection with the Northern San Juan Coal Bed Methane (CBM) EIS are included in the updated inventory.

<u>Southern Ute 2005 Oil & Gas Emissions</u>: An updated 2005 emissions inventory for 2005 for oil & gas sources on the Southern Ute lands compiled by the Southern Ute Indian Tribe (SUIT, 2005) was used to replace the older SUIT inventory included in the WRAP Phase II inventory.

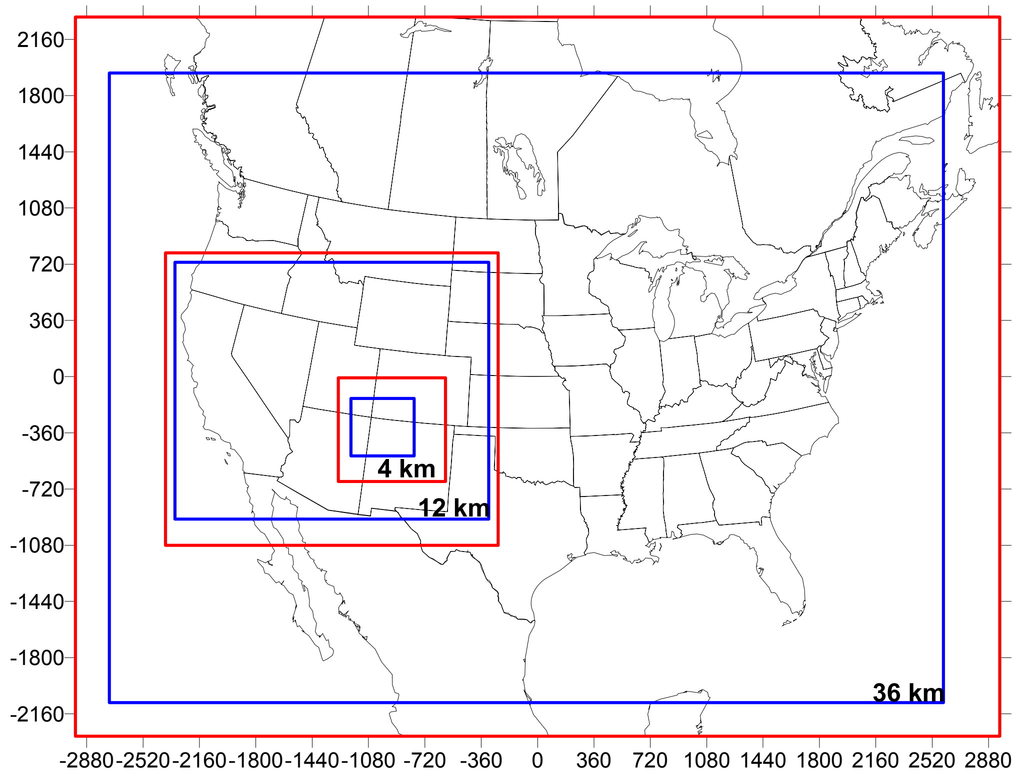
At the time of the PEA analysis, the inventories listed above represent the most accurate estimate of emissions in the region. The largest limitation in the inventories is that the WRAP Phase II Oil and Gas Inventory did not consider VOC emissions associated with production facilities. However, as part of the New Mexico Ozone Early Action Compact, Environ developed a VOC inventory for the region which was used in this analysis. It should also be noted that the 2005 Southern Ute Oil and Gas Inventory is being used in the WRAP Phase III Inventory.

Model-ready (gridded, hourly) emissions for the 2005 base year for all area sources outside of the 4 km modeling domain were obtained by linearly interpolating between the WRAP 2018 (PRP18) and WRAP 2002 inventories and then applying the temporal allocation surrogates used in the WRAP modeling. Area source emissions on the portion of the 36 km grid that is overlapped by the 12 km modeling domain but outside the 4 km domain were disaggregated to 12 km resolution with emissions evenly divided over the nine 12 x 12 km grid cells within each 36 x 36 km grid cell. Model ready point source emissions for 2005 for sources outside of the Four Corner states were also obtained via linear interpolation between the WRAP 2018 (PRP18) and WRAP 2002 inventories.

Model-ready (gridded, hourly) emissions for 2018 for all point and area sources outside of the 4 km domain were obtained directly from the WRAP 2018 (PRP18) inventory. As the WRAP modeling was done at 36 km resolution, area source emissions on the portion of the 36 km grid that is overlapped by the 12 km modeling domain but outside the 4 km domain were disaggregated to 12 km resolution with emissions evenly divided over the nine 12 x 12 km grid cells within each 36 x 36 km grid cell.

ENVIRON performed additional emissions modeling for 2005 and 2018 inventories at 4 km resolution over the 4 km modeling domain using SMOKE and related tools as described in Appendix A. This provided a more detailed and up to date inventory for the innermost and most important modeling domain. Part of this effort included developing updated emissions estimates for electric generating units (EGUs) and oil & gas activities within the 4 km domain. Revised biogenic emissions estimates were developed for all three modeling domains as described in Appendix B. In addition, emissions from fires (wildfires and prescribed fires) for CO, NOx, VOC, SO_2, and PM were obtained from the National Center for Atmospheric Research (NCAR) 2005 fire database which is derived by NCAR from satellite data. Fire emissions were processed for use in this study over the 12 km western U.S. domain (see Appendix C for details).

Figure 3-17. CAMx 36/12/4 km Modeling Domain to be Used for the Four Corners Air Quality Modeling Study



New Mexico Modeling Domain

CAMx 36 km: 148 x 112 (-2736, -2088) to (2592, 1944)
CAMx 12 km: 167 x 137* (-2316, -912) to (-312, 732)
CAMx 04 km: 101 x 92* (-1192, -508) to (-788, -140)

*** includes buffer cells**

MM5 36 km: 165 x 129 dot points (-2952, -2304) to (2952, 2304)
MM5 12 km: 178 x 157 (-2376, -1080) to (-252, 792)
MM5 04 km: 172 x 167 (-1272, -672) to (-588, -8)

(CAMx domain shown in blue; MM5 meteorological modeling domain shown in red).

3.5.2 Emission Summaries

Annual emissions in the Four Corners-4km domain are summarized by state and major source category for 2005 in Tables 3-12 through 3-15 and for the 2018 no action scenario in Tables 3-16 through 3-19. In these tables, road dust and fugitive dust emissions are included within the area source category whereas windblown dust was included within the biogenic source category. Locomotive, aircraft and other non-road sources are included in the off-road emissions category. In the point source inventory, tribal sources were distinguished from the state sources and hence tribal point source emissions were reported separately from state emissions. For all other source categories, tribal emissions were combined with state emissions. Point sources associated with oil & gas production were separated from other point sources and reported separately in the tables below. Spatial distributions of annual emissions for each major source category in the 2005 inventory are provided in Appendix A.

Comparisons of the 2005 base case and 2018 no action scenarios are provided in Figure 3-18.

Model-ready emissions for the 2018 full infill scenario are identical to those used in the 2018 no action scenario but with emissions from the proposed 80 acre infill added to the appropriate oil & gas source categories. This results in an increase in the domain total oil & gas emissions as shown in Table 3-20. Emissions increases associated with the project are less than 1 percent except for a projected 1.4 percent increase in PM_{10}.

Table 3-12. 2005 NOx Emissions (t/yr) Within the 4 Km Modeling Domain By State and Source Category

STATE/Tribe	Area	On-road	Off-road	Biogenic	Area Oil & Gas	Point Oil & Gas	EGU	Non EGU	Total
Arizona	97	4,661	2,407	211	13				7,389
Colorado	302	3,757	1,910	659	921	2,548		535	10,632
New Mexico	16,036	30,182	11,219	833	37,848	19,834	30,925	3,615	150,492
Utah	42	741	181	130	51	352		78	1,575
Tribes						7,264	41,743	2,770	51,777
Grand Total	16,477	39,340	15,717	1,834	38,832	29,998	72,668	6,997	221,863

Table 3-13. 2005 SO_2 Emissions (t/yr) Within the 4 Km Modeling Domain By State and Source Category

STATE/Tribe	Area	On-road	Off-road	Biogenic	Area Oil & Gas	Point Oil & Gas	EGU	Non EGU	Total
Arizona	20	52	119						191
Colorado	135	62	53		19	14		105	388
New Mexico	5,580	543	625		116	552	17,866	3,020	28,302
Utah	54	12	13		1			1,581	1,661
Tribes						35	12,653	232	12,920
Grand Total	5,789	669	809		136	602	30,518	4,938	43,461

Table 3-14. 2005 VOC Emissions (t/yr) Within the 4 Km Modeling Domain By State and Source Category

STATE/Tribe	Area	On-road	Off-road	Biogenic	Area Oil & Gas	Point Oil & Gas	EGU	Non EGU	Total
Arizona	2,204	3,314	728	29,202	37				35,485
Colorado	3,632	2,616	4,884	84,822	891	1,257		348	98,450
New Mexico	26,675	17,079	5,690	108,515	109,480	7,857	7	1,849	277,152
Utah	479	490	388	15,931	455	77		52	17,872
Tribes						2,219	292	180	2,691
Grand Total	32,989	23,499	11,690	238,471	110,862	11,410	299	2,429	431,649

Table 3-15. 2005 PM Emissions (t/yr) Within the 4 Km Modeling Domain By State and Source Category

STATE/Tribe	Area	On-road	Off-road	Biogenic	Area Oil & Gas	Point Oil & Gas	EGU	Non EGU	Total
Arizona	4282	131	110	21074					25,597
Colorado	2227	119	311	9766	24	34		687	13,168
New Mexico	30,324	925	772	54744		123	25	2,238	89,151
Utah	390	22	31	13057				12	13,512
Tribes						11	965	81	1,057
Grand Total	37,224	1,197	1,224	98,640	24	168	990	3,018	142,485

Table 3-16. 2018 "No Action" Scenario NOx Emissions (t/yr) Within the 4 Km Modeling Domain by State and Source Category

STATE/Tribe	Area	On-road	Off-road	Biogenic	Area Oil & Gas	Point Oil & Gas	EGU	NonEGU	Total
Arizona	117	1,934	1,217	211	13		1,340	0	4,832
Colorado	366	1,456	1,269	659	736	2,939		701	8,126
New Mexico	20,700	9,658	6,142	833	38,630	26,913	21,934	3,777	128,587
Utah	47	337	115	130	50	233		89	1,001
Tribes						6,327	54,306	3,202	63,835
Grand Total	21,231	13,385	8,743	1,834	39,429	36,412	77,580	7,770	206,384

Table 3-17. 2018 "No Action" Scenario SO_2 Emissions (t/yr) Within the 4 Km Modeling Domain by State and Source Category

State	Area	On-road	Off-road	Biogenic	Area Oil & Gas	Point Oil & Gas	EGU	NonEGU	Total
Arizona	24	20	1	0	0		1,452	0	1,497
Colorado	146	16	5	0	6	12		141	326
New Mexico	13,204	140	60	0	122	548	12,607	3,180	29,861
Utah	54	4	0	0	1	0		2122	2,181
Tribes						155	21,253	319	21,727
Grand Total	13,428	180	66	0	129	715	35,312	5,763	55,593

Table 3-18. 2018 "No Action" Scenario VOC Emissions (t/yr) Within the 4 Km Modeling Domain By State and Source Category

State	Area	On-road	Off-road	Biogenic	Area Oil & Gas	Point Oil & Gas	EGU	NonEGU	Total
Arizona	2602	1,848	469	29202	37		41	0	34,199
Colorado	4341	1,217	3,299	84822	876	1,730		413	96,698
New Mexico	34,313	7,753	4,179	108515	131,900	11,150	356	2,153	300,319
Utah	651	277	246	15931	453	103		72	17,733
Tribes						2,001	184	100	2,285
Grand Total	41,906	11,094	8,193	238,471	133,266	14,984	581	2,738	451,233

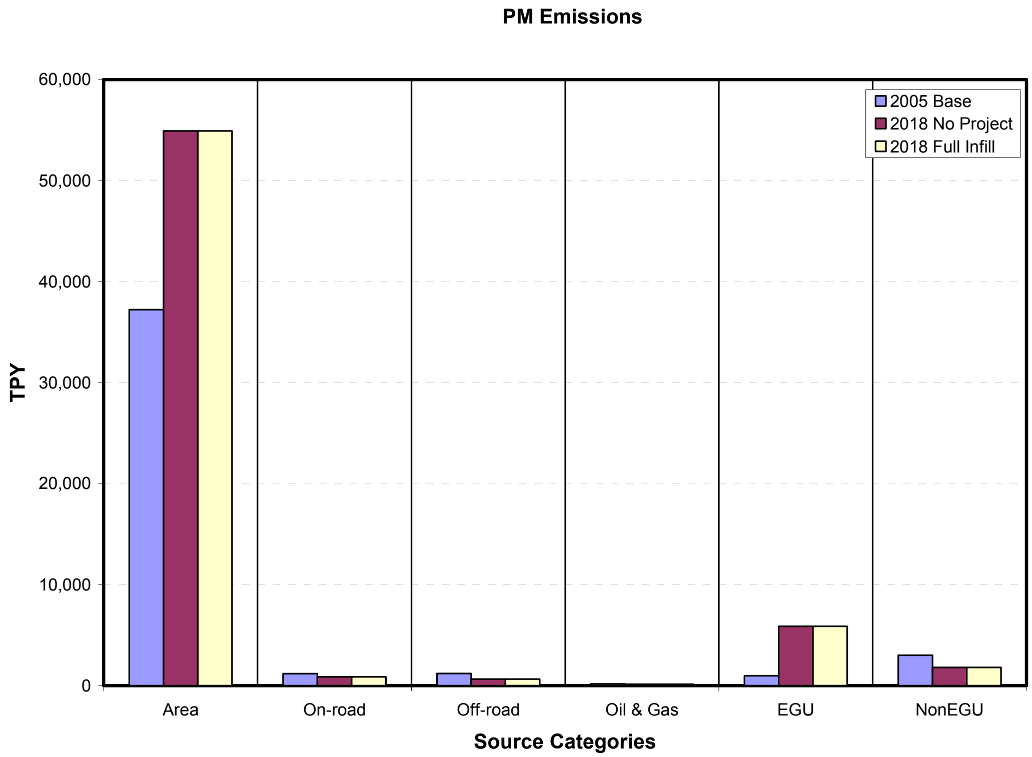
Table 3-19. 2018 "No Action" Scenario PM Emissions (t/yr) Within the 4 Km Modeling Domain by State and Source Category

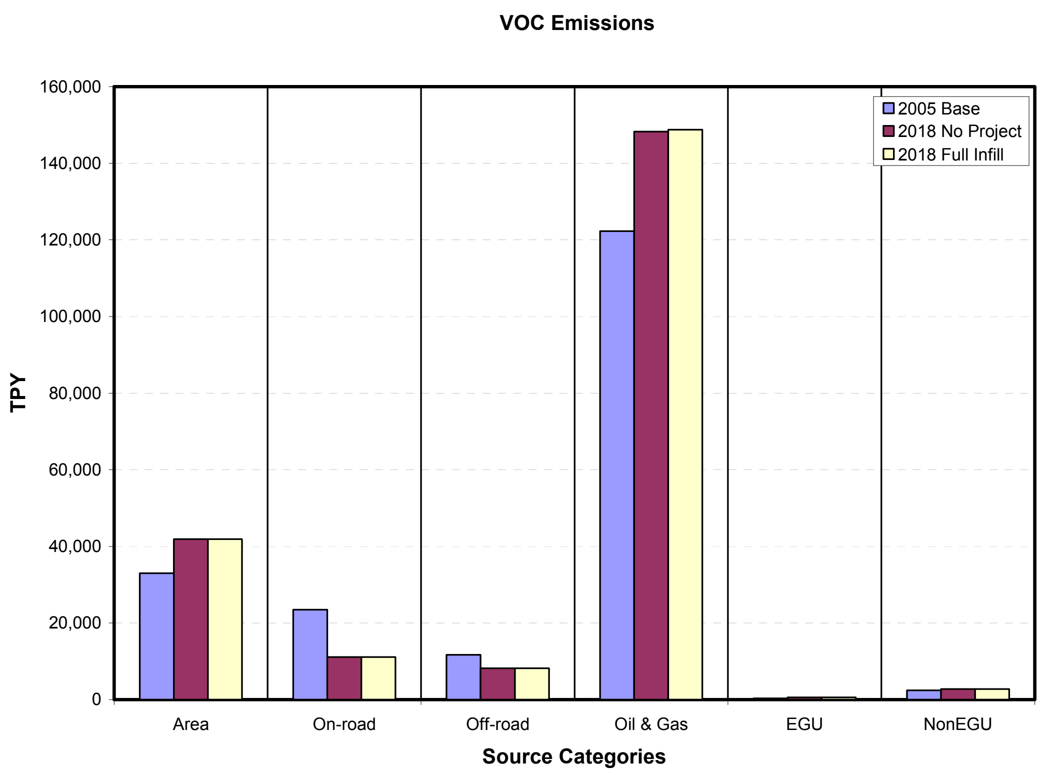
State	Area	On-road	Off-road	Biogenic	Area Oil & Gas	Point Oil & Gas	EGU	NonEGU	Total
Arizona	5393	107	47	21074	0		261	0	26,882
Colorado	2678	88	174	9766	11	26		871	13,614
New Mexico	46,424	670	420	54744	0	106	1,047	833	104,244
Utah	440	18	15	13057	0	0		13	13,543
Tribes						2	4,581	96	4,679
Grand Total	54,934	883	655	98,640	11	134	5,889	1,814	162,960

Table 3-20. Comparison of Total Annual Oil & Gas Emissions (t/yr) Within the 4 Km Domain under The 2018 No Action And 2018 Full Infill Scenarios. Emissions from Other Source Categories Are Identical Between These Two Scenarios

Inventory Scenario	NOx	VOC	SO_2	PM_{10}
No Action	75,841	148,250	844	145
Full Infill	76,520	148,720	844	147
Difference (t/yr)	679	470	0	2
Difference (percent)	0.9	0.3	0.0	1.4

Figure 3-18. Comparative Summaries of Annual Emissions within the 4 Km Domain for the 2005 Base Case and 2018 No Action Scenarios.





3.6 Construction Emissions

Construction emissions associated with the proposed action (and alternatives) would occur mainly due to the installation of new wells involving three sequential phases:

- well pad and resource road construction;
- rig-up, drill and rig-down; and
- well completion and testing.

The SUIT Air Quality analysis performed a detailed emission inventory for the construction phase of development (BLM 2000). No new information was available to revise estimates of those construction emissions. Appendix A presents emission summaries from the previous study, which are directly applicable to this analysis.

3.7 Greenhouse Gas Emissions

Greenhouse gas emissions from natural gas fired engines were calculated based the EPA emission factor of 1.10x 10^2 lbs of CO_2/MMBtu of fuel consumed[25]. Because the amount of engine capacity is predicted to decrease over time as a result of production decline, the emissions of greenhouse gas emissions (CO_2) will also decrease as production decreases. Figure 3-19 presents the estimated changes in CO_2 emissions.

Table 3-21 presents an estimate of greenhouse gas emissions from production activities within the SUIT boundaries based on production from 1,035 wells[26]. From these data, the average methane and CO_2 emissions per well were calculated and found to be 6.9 tons per year of methane and 105.2 tons per year of CO_2. Using these factors, the projected incremental increases in methane and CO_2 emissions were calculated for the 770 well infill project. As a result of the decrease in greenhouse gas emissions from decreases in compressor capacity, it is estimated that there will be a reduction in greenhouse gas emissions of approximately 600,000 tons per year from compressor engines and this decrease will offset the estimated increase of 81,000 tons per year from production related activities and therefore will result in a net reduction of greenhouse gas emissions.

[25] http://www.epa.gov/ttn/chief/ap42/ch03/final/c03s02.pdf
[26] BP 2002 Greenhouse Gas Emission Inventory for Durango, CO Operations

Figure 3-19. Changes in CO_2 Emissions from Natural Gas Fired Engines

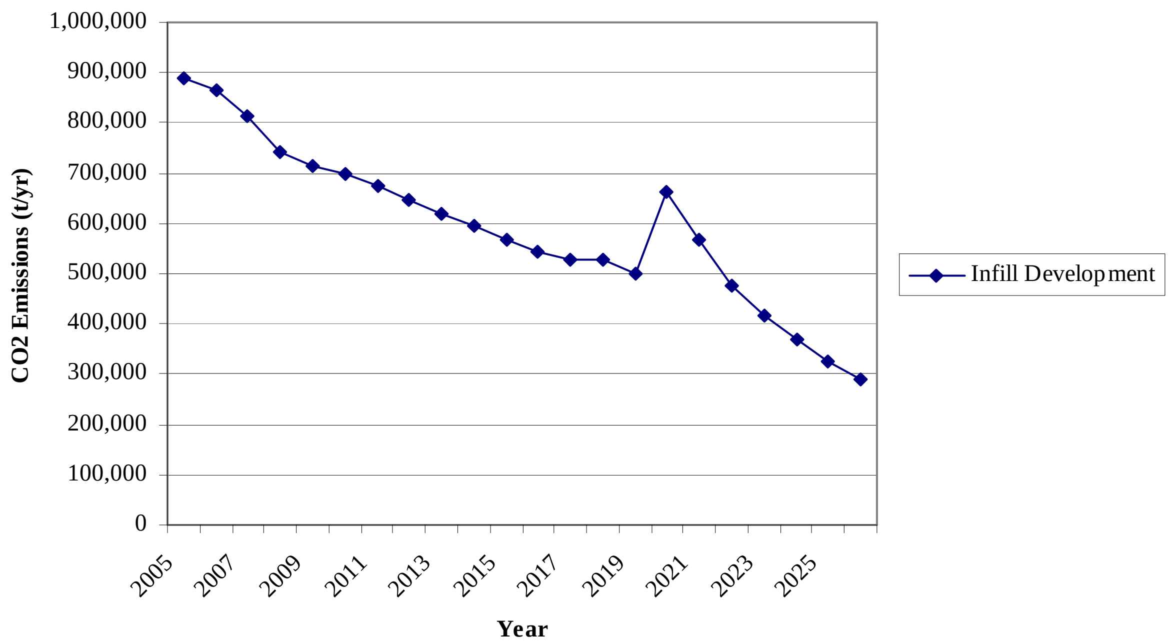


Table 3-21. Changes in Greenhouse Gas Emissions from Production Operations

Pollutant	Equipment (t/yr)	Separator Heater (t/yr)	Process Fugitives (t/yr)	Dehydration Overhead (t/yr)	Dehydrator Burner Emissions (t/yr)	Misc (t/yr)	Venting (t/yr)	Well Completions (t/yr)	Total (t/yr)	Average per Well (t/yr)	Current Emissions (t/yr)	Projected Change in Emissions from 770 Well Infill Project (t/yr)
Methane	844	0	2,544	124	0	0.43	2,585	1,093	7,192	6.9	16,690	5,350
CO2	105	88,700	315	0	9,604	9,856	322	8	108,911	105.2	252,758	81,026

Equipment Emissions = Methanol Pumps, Glycol Heat Medium Pumps, Controllers)

Number of wells 1,035

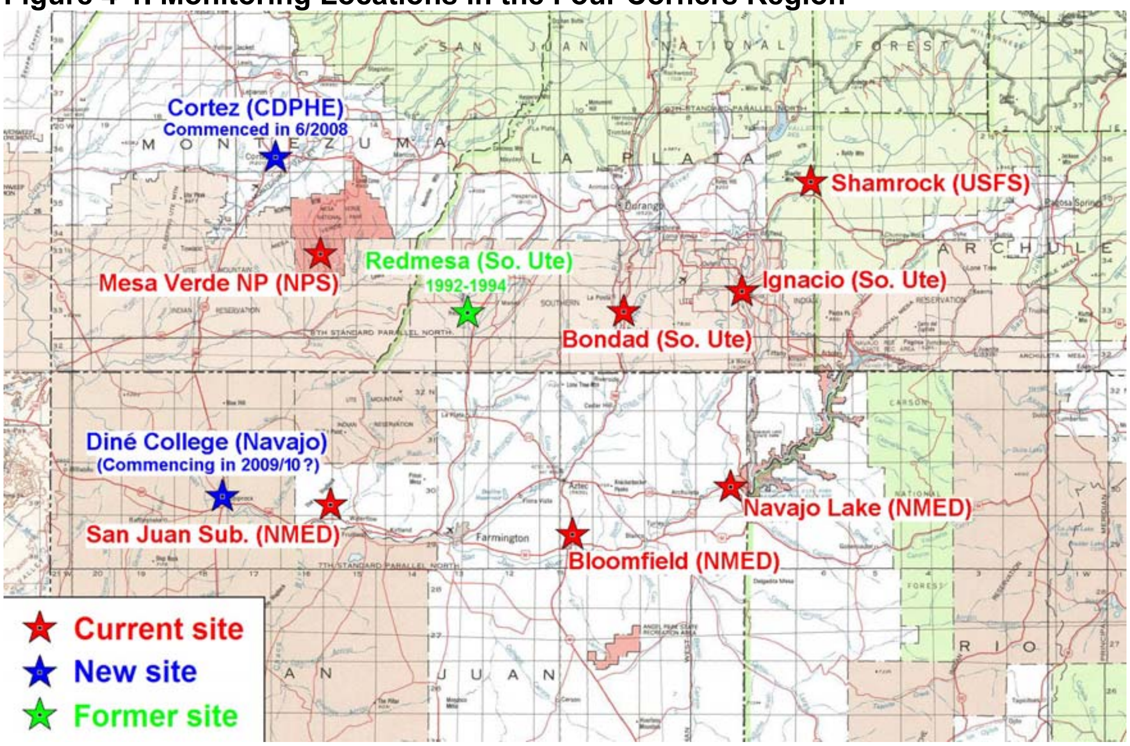
Misc = Diesel + Gasoline + Propane Use and Vehicle Emissions:

4.0 AMBIENT AIR QUALITY DATA

4.1 Criteria Pollutants

Continuous air quality measurements are made at seven locations within the Four Corners Region (Figure 4-1). The SUIT operates two monitoring stations, one located in Ignacio, CO and one in Bondad, CO. The State of New Mexico (NMED) operates one monitoring station near the Four Corners Power Plant (Substation), one near Bloomfield, NM and one near Navajo Lake, NM. The National Park Service operates an ozone monitor at Mesa Verde National Park[27] and the Forest Service (FS) operates a monitoring station Shamrock north of Bayfield, CO.

Figure 4-1. Monitoring Locations in the Four Corners Region



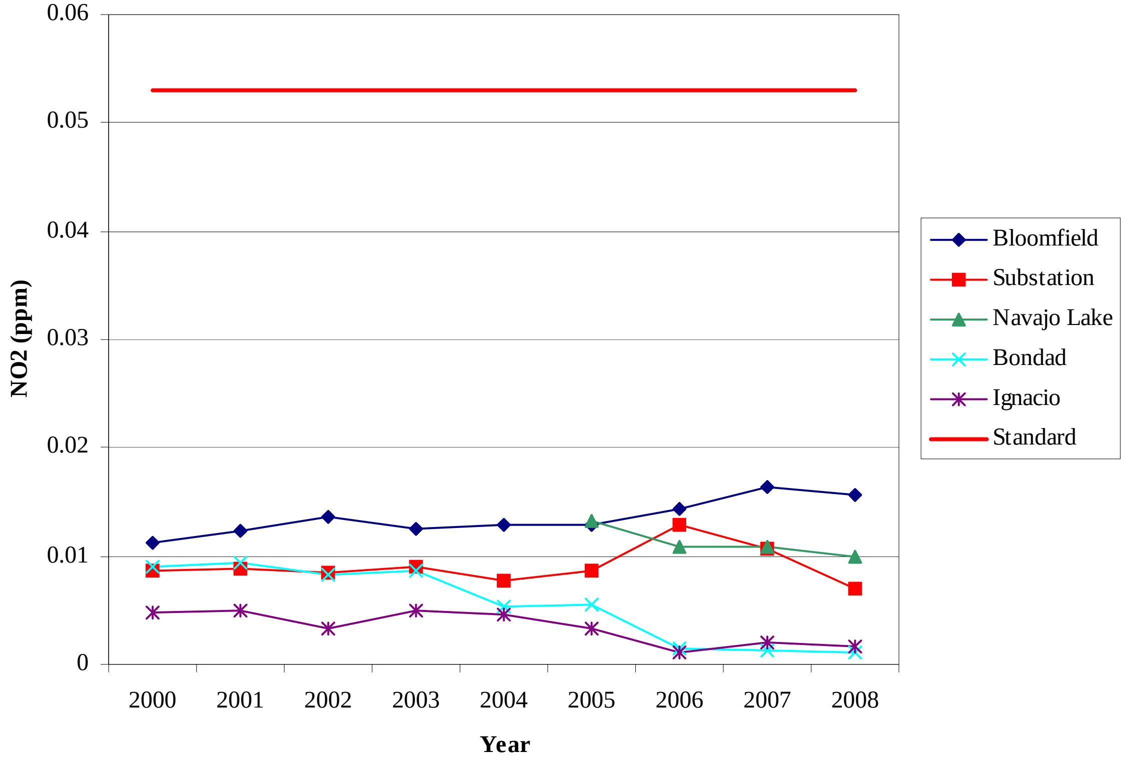
4.1.1 NO_2 Monitoring Data.

Figure 4-2 presents a summary of annual average NO_2 measurements from the Substation, Bloomfield, Navajo Lake, Ignacio and Bondad monitors over the period of 2000 to 2008. The EPA NAAQS for NO_2 is currently an annual average concentration of 0.053 ppm. As indicated by this figure, the monitored concentrations are well below the EPA ambient air quality health standard.

The State of New Mexico has established a short term NO_2 standard, but this standard is not applicable outside the State of New Mexico. The current NO_2 ambient standard is undergoing a mandated scientific review by EPA to determine if the current standard should be revised.

[27] It should be noted that this monitor has not been a reference method monitor in the past but has been recently upgraded to be a reference method monitor

Figure 4-2. Annual Average NO_2 Concentrations

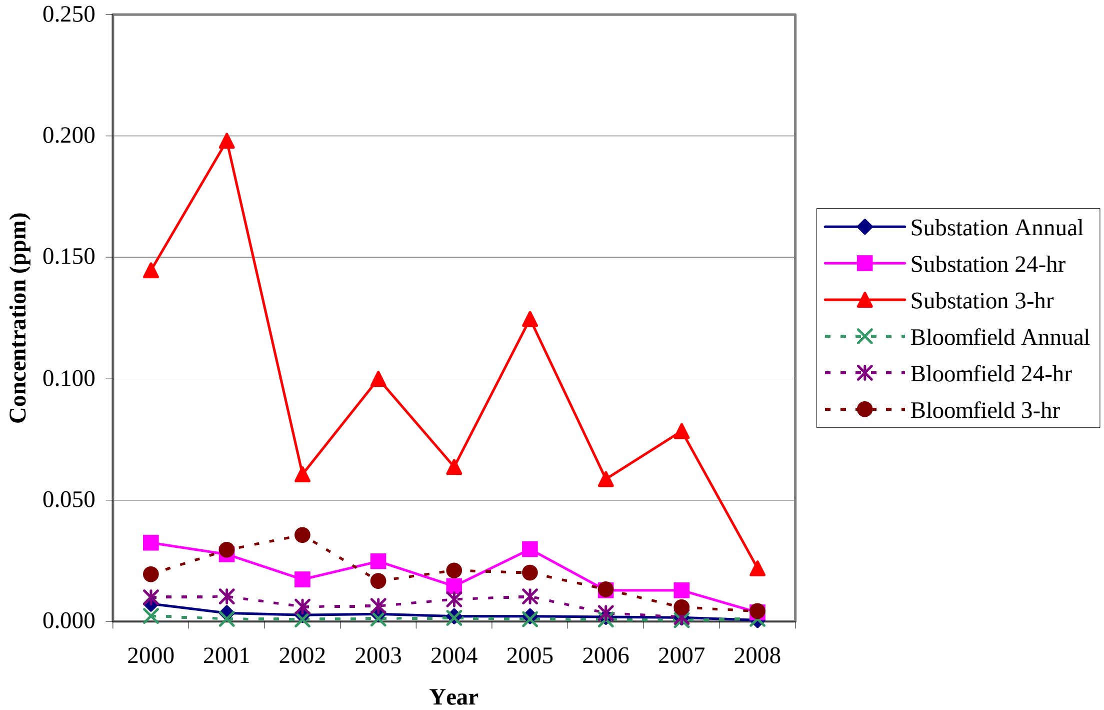


4.1.2 SO_2 Monitoring Data

The only SO_2 monitoring data in the Four Corners Region are the Substation and Bloomfield monitors operated by NMED. Both of these stations are likely influenced by nearby large SO_2 sources and therefore cannot be considered background monitors. Figure 4-3 presents the 2000 through 2008 annual average, maximum 24 hour and maximum 3 hour average concentrations from these two monitors. As indicated by this figure, measured concentrations are well below applicable primary and secondary air quality standards. However, the influence of the Four Corners Power Plant can be observed in Figure 4-3 for a 3 hour averaging time. There is a downward trend in measured concentrations as a result of SO_2 controls installed on this facility.

It is important to note that the 24 hour NAAQS (primary-health) and 3 hour (secondary-welfare) are based on the second highest concentration.

Figure 4-3. Measured SO_2 Concentrations



4.1.3 PM_{10} Monitoring Data

Figure 4-4 present maximum 24 hour PM_{10} measured at the SUIT Bondad and Ignacio monitoring sites and it should be noted that the standard is based on the second highest measured concentration. Figure 4-5 presents the annual average concentration measured at these two monitoring sites. As indicated by these data, measured concentrations are well below the applicable standards.

Figure 4-4. Comparison of Second Highest Measured PM_{10} Concentrations to 150 *u*g/m^3 Second Highest NAAQS

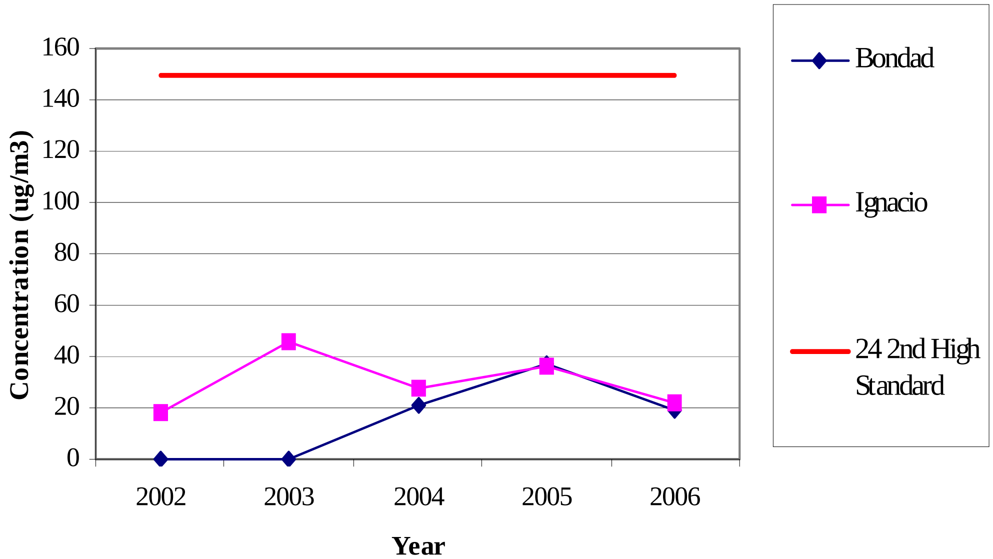
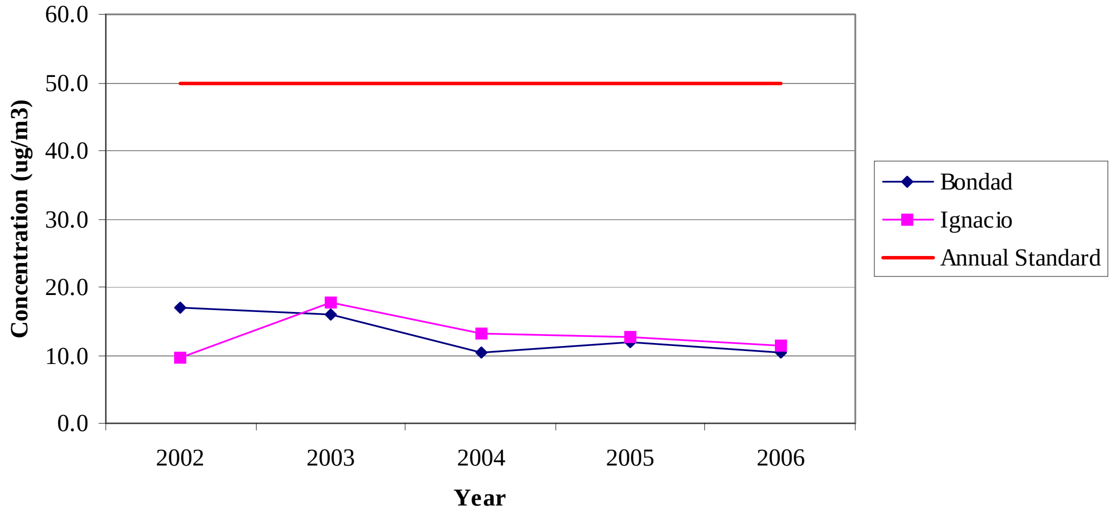


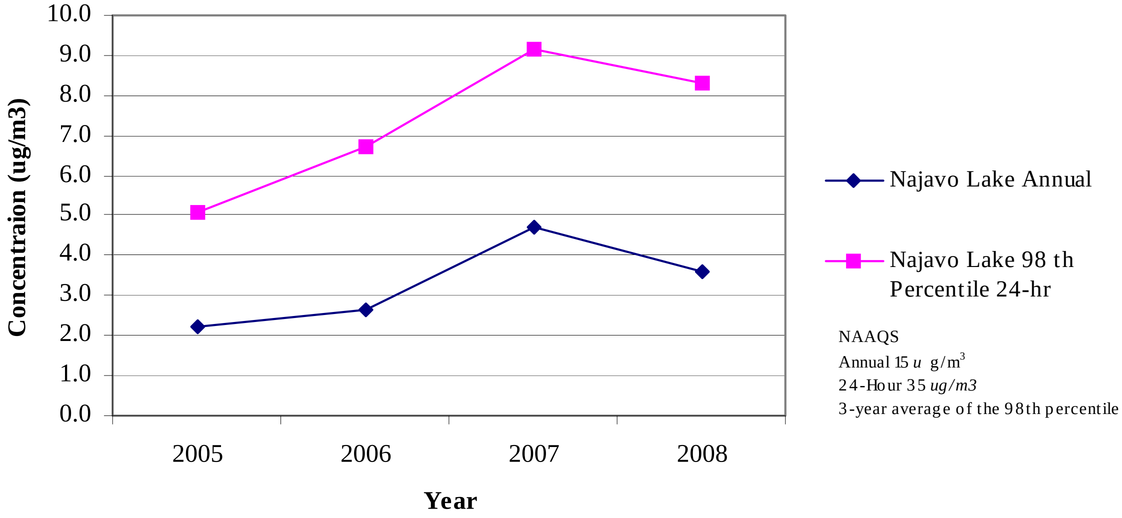
Figure 4-5. Comparison of Annual Average PM_{10} Concentrations to the 50 *u*g/m^3 Annual Average NAAQS



4.1.4 $PM_{2.5}$ Monitoring Data

$PM_{2.5}$ micron particulate sampling is conducted at the Navajo Lake site by NMED. This monitoring has been conducted from July 2005 to the present. Figure 4-6 presents a plot of the annual average and maximum 24 hour concentrations. It should be noted that the short-term standard is expressed as the 3 year average of the 98th percentile (approximately the 7th highest value). As indicated in Figure 4-6, measured concentrations are well below the $PM_{2.5}$ standards.

Figure 4-6. Measured $PM_{2.5}$ Concentrations at the Navajo Lake Monitor

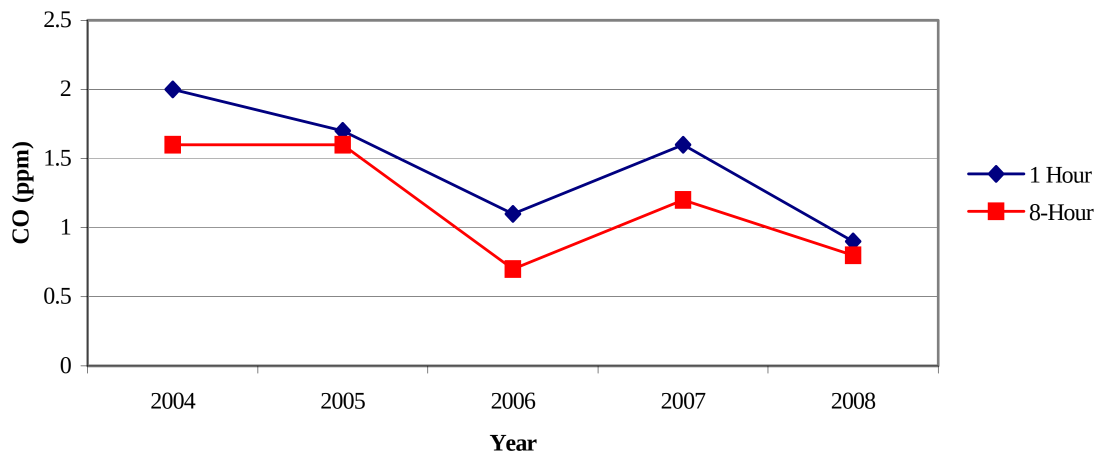


4.1.5 CO Monitoring Data

CO concentrations are measured at the SUIT Ignacio monitoring station and a summary of these data are presented in Figure 4-7.

The State of Colorado (CDPHE) has previously assumed that 1 hour and 8 hour background CO levels are approximately 2,286 *u*g/m^3 compared to 1 hour and 8 hour ambient standards of 40,000 *u*g/m^3 and 10,000 *u*g/m^3 respectively[28].

Figure 4-7. Second High CO Concentrations Measured in the Four Corners Area



4.1.6 Ozone Monitoring Data

Figure 4-8 presents a plot of the 4th highest annual ozone concentration measured at all six monitoring stations over the period 2000 through 2008. Several important trends are apparent in this figure. First, the 4th highest measured ozone concentrations have not

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[28] BLM 2004, Northern San Juan Basin Coalbed Methane EIS

increased over this period. During 2000 through 2004 the concentrations recorded at the Bondad and Ignacio ozone monitors are inconsistent with the other monitors.

Figure 4-8. Maximum Daily 8-hour Ozone Concentrations in the Four Corners Area

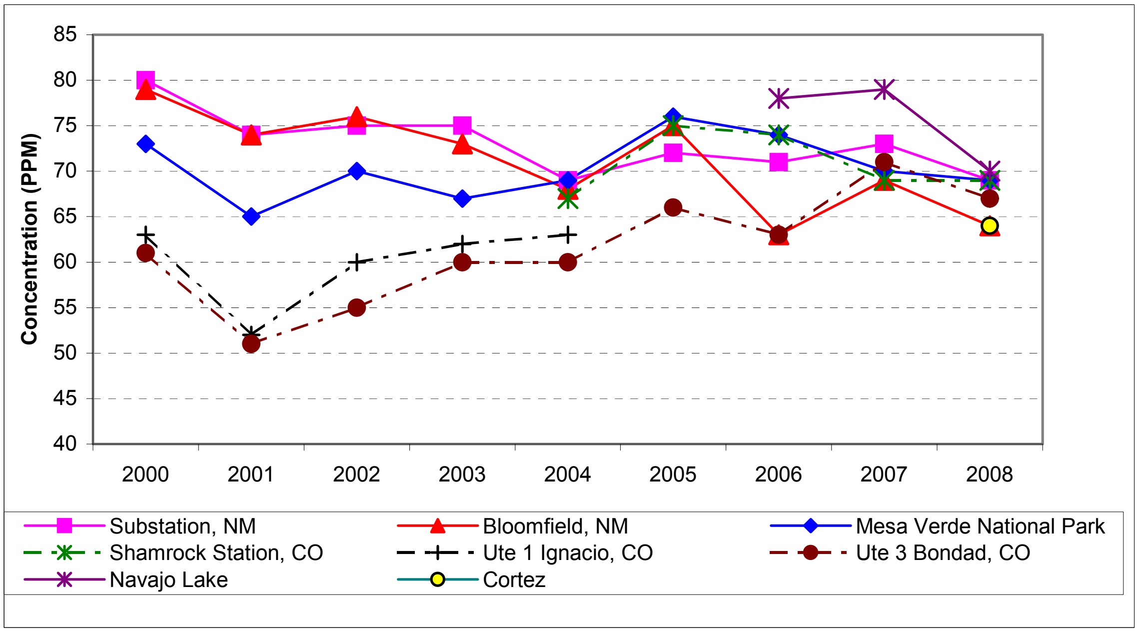


Table 4-1 presents the ozone design value for the period of 2000 through 2008. It should be noted that monitoring data prior to 2006 cannot be used to classify a region as attainment or as non attainment with respect to the revised 75 ppb ozone standard. Thus, design values for the period 2000-2005 are presented for information purposes only.

Table 4-1. Ozone Design Values for the Four Corners Region

Years		Ozone Design Value (ppb)						
		Mesa Verde	Substation	Bloomfield	Navajo Lake	Shamrock	Bondad	Ignacio
2000	2002	74		77				
2001	2003	68		75			56	
2002	2004	70	73	73		72	60	
2003	2005	70	72	73		73	64	65
2004	2006	72	71	69		71	65	66
2005	2007	73	73	70		70	67	67
2006	2008	71	71	66	75	70	67	67

Notes:
1) Only 2006-2008 can be used to define an area non attainment
2) An exceedances of the NAAQS occurs at 76 ppb is an exceedances of the NAAQS

As noted in Table 4-1 indicates that the calculated design values at Mesa Verde, Substation and Shamrock are relatively constant. The Bloomfield design value indicates some variability (66 ppb to 75 ppb) and this change is likely related to increases in NO_2 concentrations.

Table 4-2 presents a summary of measured ozone concentrations when the Navajo Lake ozone monitor values were above 75 ppb. In 2006 at the Navajo Lake monitor there were six days when ozone concentrations were above 75 ppb. It is interesting to note that three of these events occurred on April 20, 21 and 26. April is not typically considered a month when maximum ozone concentrations are measured. During April the Mesa Verde monitor also recorded elevated concentrations. On April 20 Navajo Lake recorded 82 ppb and Mesa Verde recorded 79 ppb. The Substation monitor recorded elevated concentrations but they were slightly lower than Navajo Lake. Bloomfield concentrations were lower than the other monitors probably as a result of NOx emission sources adjacent to the Bloomfield monitor.

The other three days when measured concentrations at the Navajo Lake monitor were above the 75 ppb occurred on June 18, July 14 and July 25. During these events, all other ozone monitors also recorded concentrations in the range of 67 to 88 ppb.

For the 2006 ozone events three things can be concluded. First, the elevated concentrations are regional in nature. Second, background concentrations are a very large percentage of the total concentration. Third, elevated concentrations in April require additional analysis to better understand the mechanisms of rural ozone formation in elevated terrain.

In 2007 there were 16 days when the Navajo Lake monitor measured concentrations in excess of 75 ppb. Five of these days occurred in April 19, 26, 27, 28, and 29. During these events concentrations at Mesa Verde ranged from 58 ppb to 70 ppb. Concentrations at the Substation monitor were very similar and Bloomfield had slightly lower concentrations.

The remaining events occurred in May (3 days), June (3days), July (2 days) and August (3days). During these events the Mesa Verde monitor recorded concentrations in the range of 62 to 71 ppb. The Substation and Bloomfield monitors recorded similar concentrations.

For the 2007 ozone events similar conclusions can be reached as for 2006.

In 2008 magnitude of the monitored concentrations were less than in 2006 and 2007 as well as the frequency of elevated concentrations.

While elevated ozone concentrations have been recorded at the Navajo Lake monitor (although the NAAQS has not been exceeded), several important conclusions can be reached.

1. At the other monitors over the period of 2000 to 2008 ozone concentrations have not increased. There are only 3 years of data at the Navajo Lake monitor, based on the relationship between the peak measured ozone concentrations at the Navajo Lake monitor and the other monitors, there is no evidence that ozone concentrations are increasing at this monitor.

2. A large portion of the elevated concentrations occurred during April and October and such occurrences require additional study to better understand these episodes.

Table 4-2. Comparison of Measured Ozone Concentrations When the Navajo Lake Monitored Values Were Greater than 75 ppb

2006

Navajo Lake			Mesa Verde		Substation		Bloomfield		Shamrock		Bondad		Ignacio	
Rank	Date	8 hour Daily Max (ppb)	Rank	8 hour Daily Max (ppb)	Rank	8 hour Daily Max (ppb)	Rank	8 hour Daily Max (ppb)	Rank	8 hour Daily Max (ppb)	Rank	8 hour Daily Max (ppb)	Rank	8 hour Daily Max (ppb)
2	4/20	82	2	79	2	75	9	62	2	76	2	70	Missing	
5	4/21	78	5	73	14	67	10	61	1	77	4	64	3	48
3	4/26	81	6	72	9	69	2	64	4	74	3	67	4	47
4	6/18	80	15	69	68	59	23	59	8	72	Missing		10	46
1	7/14	87	Missing		1	88	Missing		3	76	1	79	8	46
6	7/25	77	28	67	Missing		4	64	72	62	6	63	157	35

Table 4-2 (continued)

2007

Navajo Lake			Mesa Verde		Substation		Bloomfield		Shamrock		Bondad		Ignacio	
Rank	Date	8 hour Daily Max (ppb)	Rank	8 hour Daily Max (ppb)	Rank	8 hour Daily Max (ppb)	Rank	8 hour Daily Max (ppb)	Rank	8 hour Daily Max (ppb)	Rank	8 hour Daily Max (ppb)	Rank	8 hour Daily Max (ppb)
6	4/19	79	15	67	27	65	21	65	4	69	8	68	70	49
7	4/26	77	70	60	20	66	64	60	33	64	108	55	150	41
5	4/27	79	104	58	44	62	67	60	37	63	93	57	151	41
2	4/28	81	6	70	9	69	30	64	18	67	16	66	82	47
12	4/29	77	79	60	17	67	23	64	122	56	83	58	173	39
11	5/8	77	14	67	109	56	34	63	23	66	21	64	106	45
7	5/11	79	8	69	16	67	4	69	11	68	6	69	102	46
8	5/13	78	9	68	28	65	14	66	3	70	14	67	93	46
10	6/13	78	23	66	31	64	38	62	13	68	7	68	96	46
4	6/23	80	20	66	18	67	5	69	80	60	23	64	128	43
14	6/24	77	51	62	92	57	16	66	34	64	39	62	98	46
15	7/9	77	17	67	32	64	13	67	14	68	20	65	112	45
16	7/18	76	47	62	151	52	39	62	21	66	25	64	114	45
9	8/6	78	46	62	Missing		2	72	9	69	4	71	Missing	
1	8/15	81	22	66	5	73	Missing		2	71	15	66	Missing	
3	8/25	80	4	71	4	74	8	67	8	67	1	83	1	77

Table 4-2 (continued)

2008

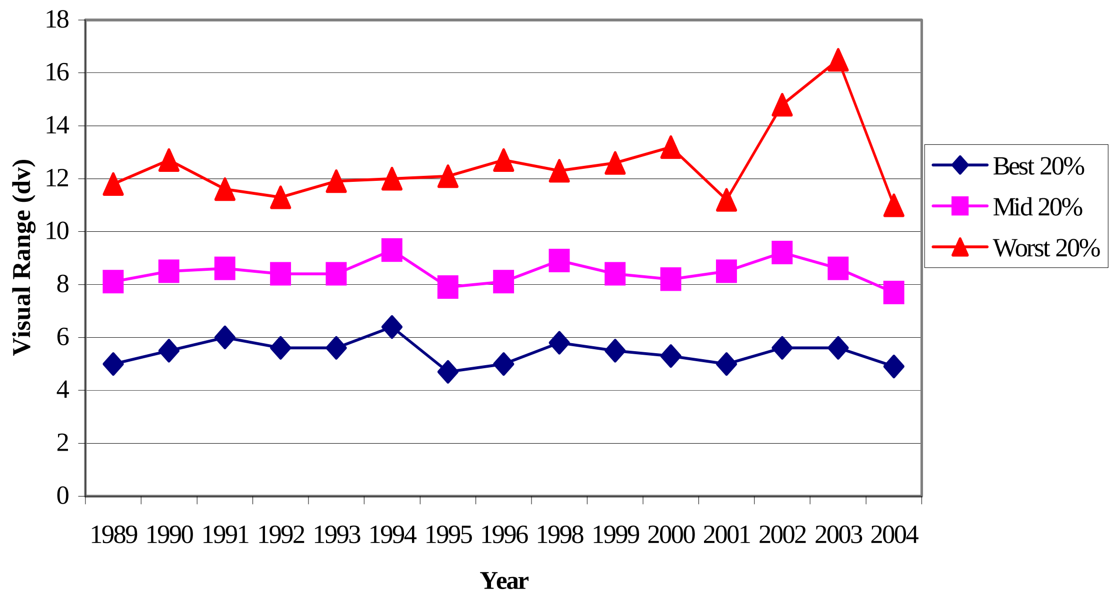
Navajo Lake			Mesa Verde		Substation		Bloomfield		Shamrock		Bondad		Ignacio	
Rank	Date	8 hour Daily Max (ppb)	Rank	8 hour Daily Max (ppb)	Rank	8 hour Daily Max (ppb)	Rank	8 hour Daily Max (ppb)	Rank	8 hour Daily Max (ppb)	Rank	8 hour Daily Max (ppb)	Rank	8 hour Daily Max (ppb)
2	6/4	76	Missing		2	71	2	65	1	75	1	74	Missing	
1	6/13	78	30	61	3	71	Missing		3	71	5	67	1	66

4.2 AQRV Monitoring

4.2.1 Visual Range

Figure 4-9 presents the calculated visual range at Mesa Verde National Park for the 20 percent best, 20 percent middle and 20 percent worst days. These data were obtained from the IMPROVE web site. As indicated in this figure, there has been little change in the best, middle or worst days over the period 1988 through 2004. During 2002 and 2003, visibility on the worst 20 percent of the days increased and then decreased in 2004 to previous levels.

Figure 4-9. Measured Visual Range at Mesa Verde



Figures 4-10 through 4-12 present the contribution of various chemical species for the 20 percent worst days. Figure 4-10 presents the extinction from sulfate and nitrate particulate. What is striking in this figure is that over the period 1989 through 2004 sulfate concentrations show a significant decrease while nitrate particulate indicates an increase. The solid lines in this figure represent least square regressions to the data. What is important to note with respect to these trends is that beginning in 2000 substantial SO_2 reductions were implemented at the Four Corners and San Juan Power Plants. Because sulfate and nitrate formation are likely ammonia limited in this region, the increase in nitrate may be a result of ammonia being shifted from sulfates to nitrates in the power plant plumes.

Figure 4-10. Changes in Sulfate and Nitrate at Mesa Verde for the 20 Percent Worst Days

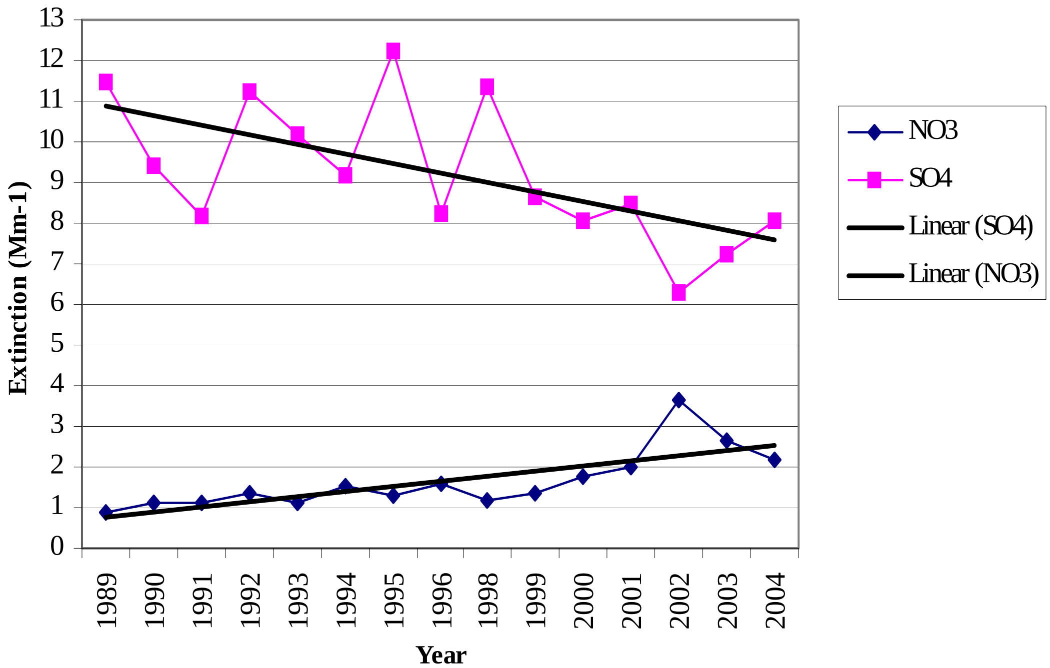


Figure 4-11 presents the extinction from crustal material (wind blown dust) and elemental carbon for the 20 percent worst days at Mesa Verde. This figure indicates that crustal material increased in 2002 and 2003 and is partially responsible for the decrease in visual range for the 20 percent worst days as indicated in Figure 4-6. Figure 4-12 presents the extinction from organic carbon and soil for the 20 percent worst days at Mesa Verde. This figure indicates that organic carbon increased in 2002 and 2003 and is partially responsible for the decrease in visual range for the 20 percent worst days as indicated in Figure 4-9.

Figure 4-11. Changes in Crustal Material and Elemental Carbon at Mesa Verde for the 20 Percent Worst Days

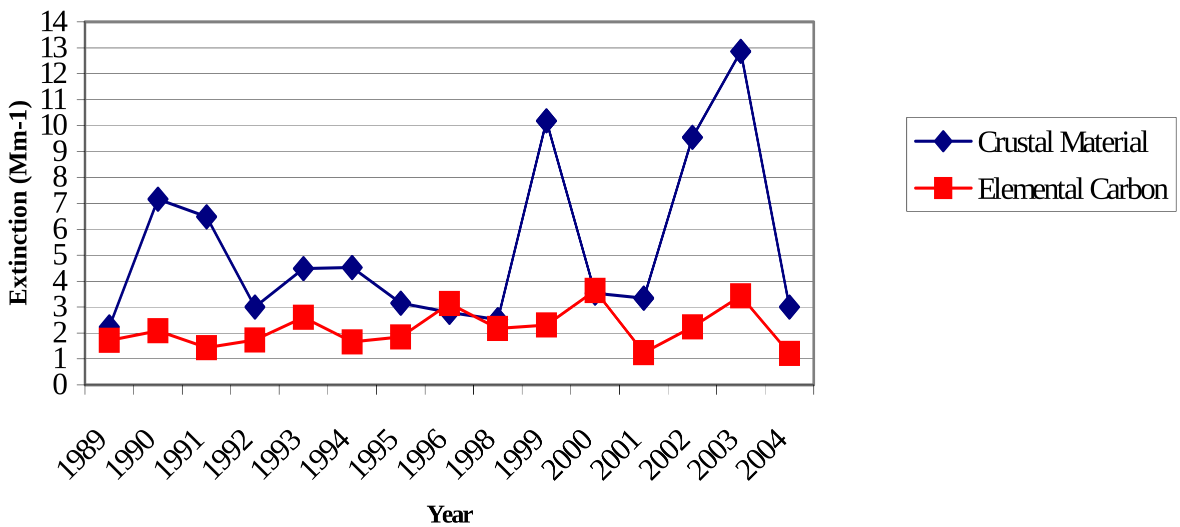


Figure 4-12. Changes in Organic Carbon and Soil at Mesa Verde for the 20 Percent Worst Days

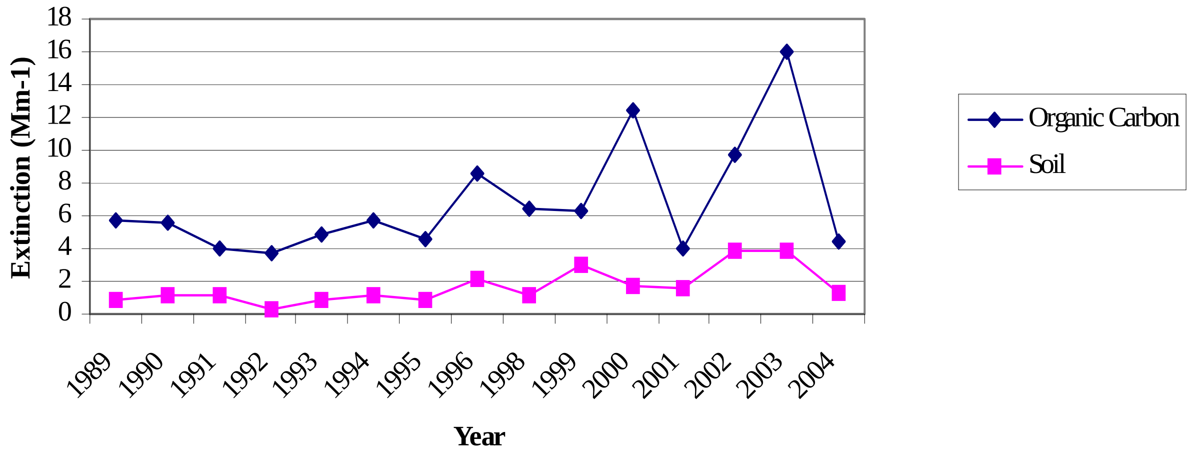


Figure 4-13 presents calculated visual range at Weminuche Wilderness Area for the 20 percent best, 20 percent middle and 20 percent worst days. These data were obtained from the IMPROVE web site. As indicated in this figure, there has been little change in the best, middle or worst days over the period 1988 through 2004.

Figure 4-13. Measured Visual Range at Weminuche

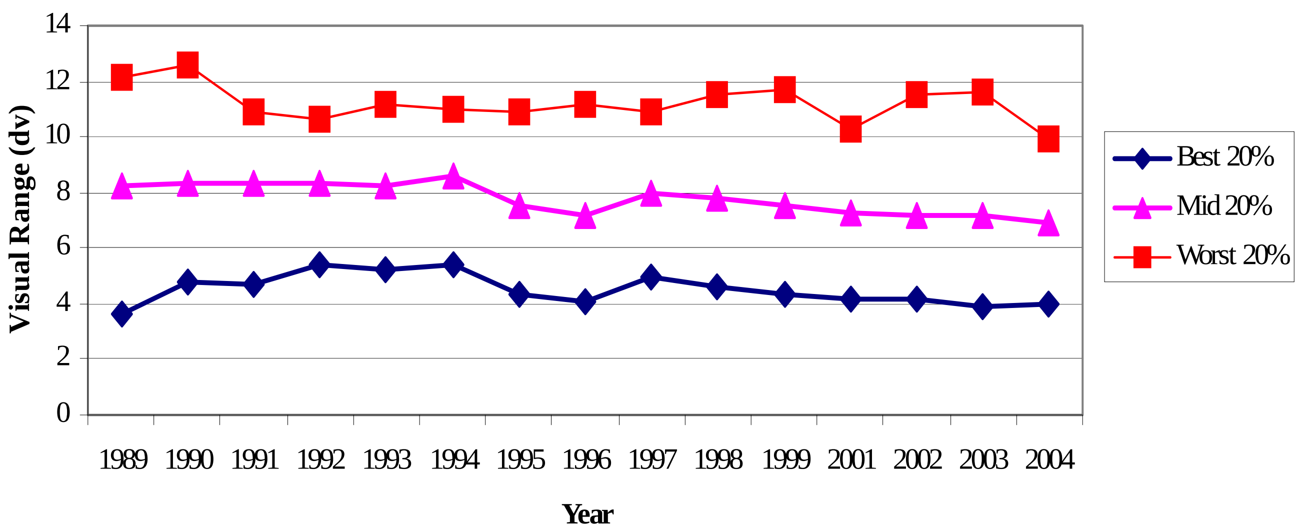
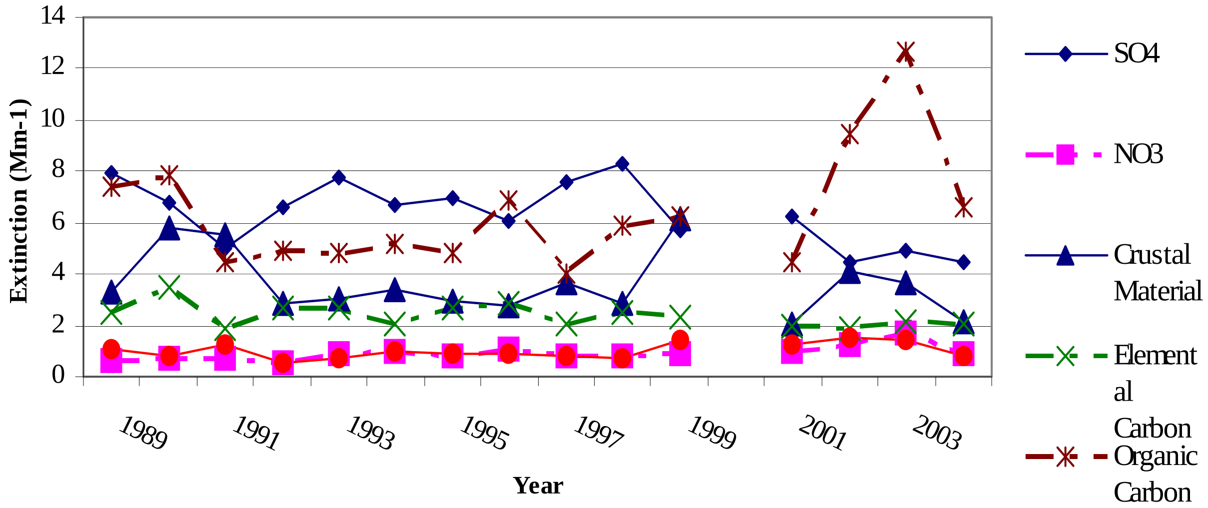


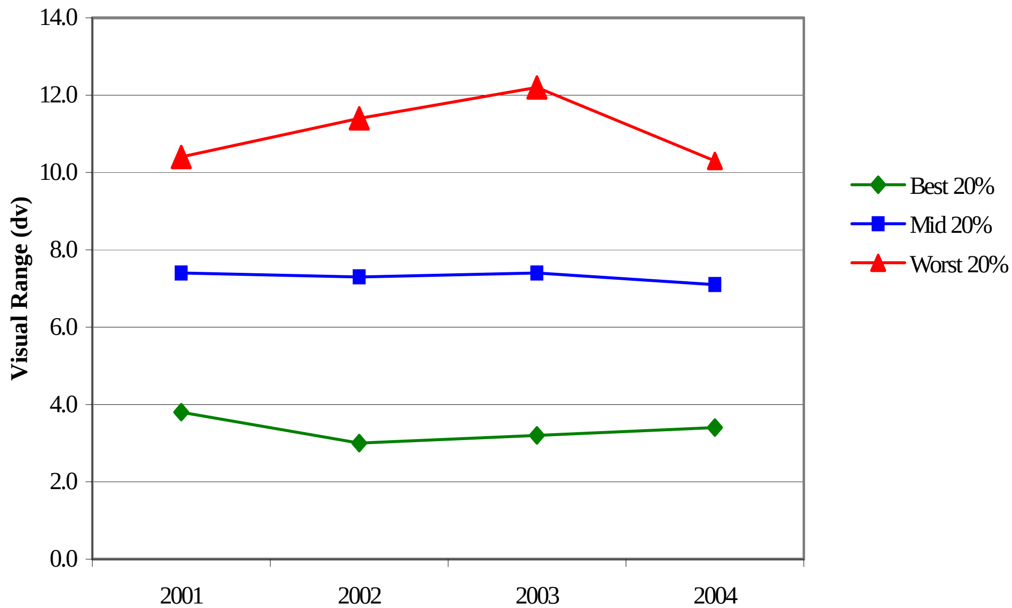
Figure 4-14 presents the composition of the fine particulate on the 20 percent worst visibility days. As indicated in this figure, in general, sulfate extinction is the largest fraction of the overall extinction budget. Nitrate extinction remained constant over this period and is a very small fraction of the extinction budget during the days with the worst visibility.

Figure 4-14. Chemical Composition of Fine Particulates at Weminuche Wilderness Area



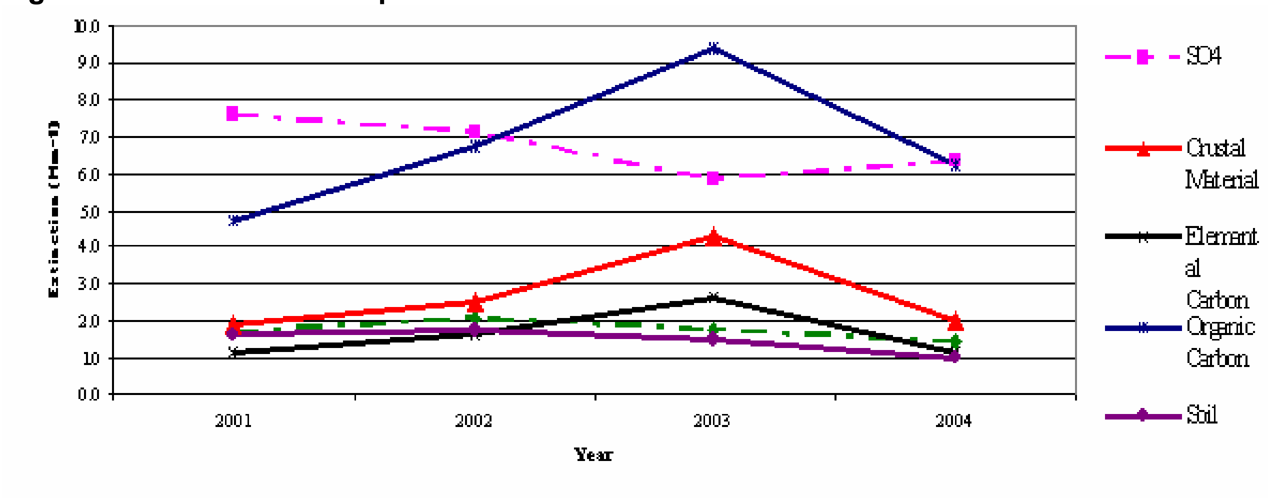
Figures 4-15 and 4-16 present visual range and fine particulate composition for the San Pedro Class I Area. The period of record is 2001 to present and data are available through 2004. As indicated in Figure 4-15, there has been relatively little change in visibility over this period. The exception is that in 2003 there was a reduction in visibility for the 20 percent worst days.

Figure 4-15. Measured Visual Range at the San Pedro Class I Area



Over the period 2001 through 2004, a reduction in the extinction budget for sulfate particulate was observed at San Pedro for the days with the worst visibility. In general, sulfate is the component with the highest extinction budget. In 2003 a peak in crustal material and organics was observed for the worst visibility days and this increase corresponds to the reduction in overall visibility noted in Figure 4-16. Nitrate particulates are a relatively small component in the overall extinction budget and there has been a slight reduction in the nitrate extinction budget.

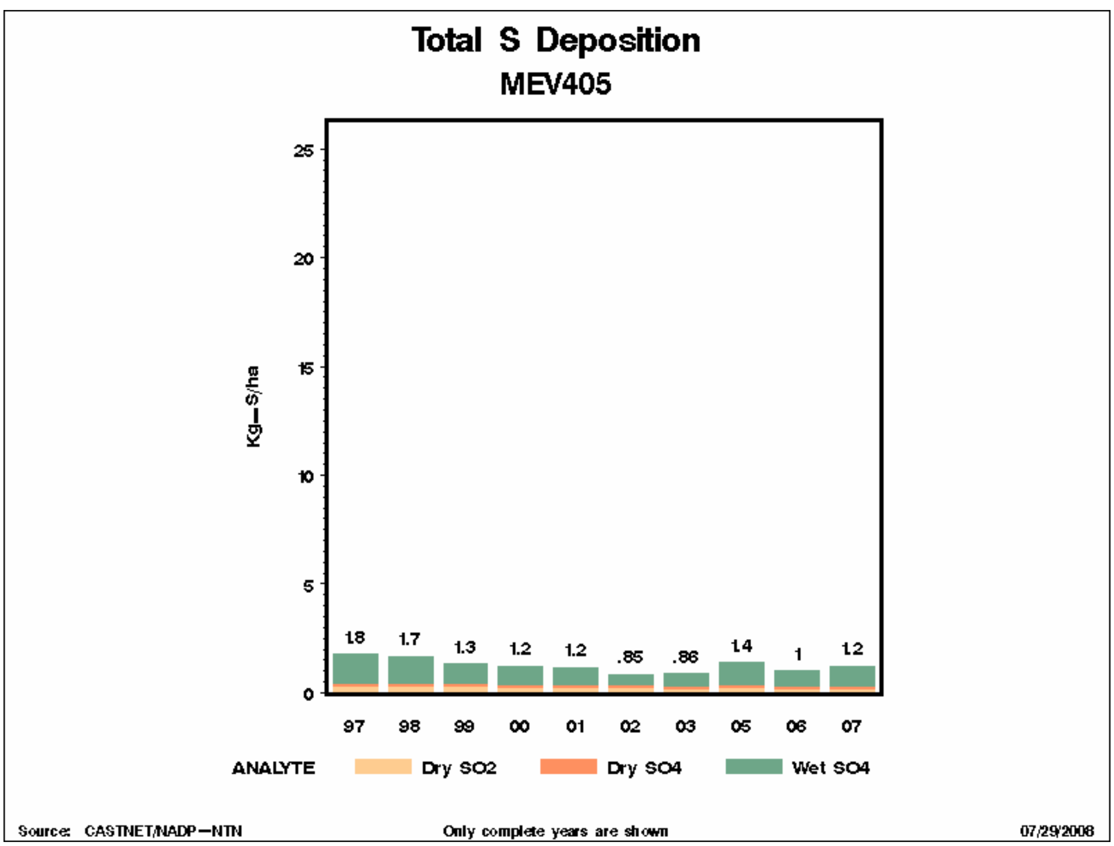
Figure 4-16. Chemical Composition of Fine Particulates at the San Pedro Class I Area



4.2.2 Deposition

Figure 4-17 presents total sulfur deposition at Mesa Verde over the period 1997 through 2007.[29] Figure 4-18 presents total nitrogen deposition over this same period at Mesa Verde.

Figure 4-17. Sulfur Deposition at Mesa Verde



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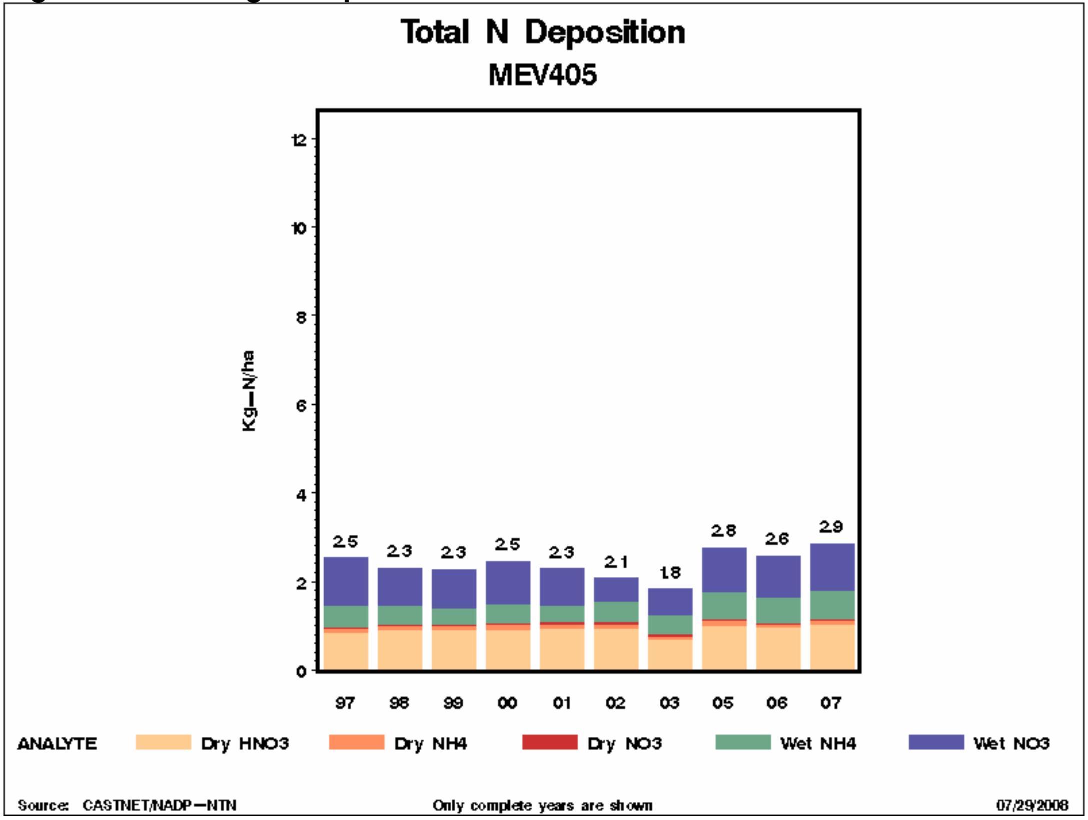
[29] CASTNET website http://www.epa.gov/castnet/

Figure 4-18. Nitrogen Deposition at Mesa Verde



Lake Chemistry

Eleven lakes of concern were identified within the Weminuche Wilderness Area, while the USDI-National Park Service has not identified any sensitive lakes within Mesa Verde National Park. The Weminuche sensitive lakes and their background acid neutralizing capacity (ANC; reported in microequivalents per liter, or µeq/l) values are presented in Table 4-3.

Table 4-3. Weminuche Wilderness Area Sensitive Lakes

Sensitive Lake	Background Acid Neutralizing Capacity (µeq/l)
Big Eldorado	0.9
Four Mile Pothole	124.8
Lake Due South of Ute Lake	14.3
Little Eldorado Lake	0.1
Little Granite Lake	76.2
Lower Sunlight	4.6
Middle Ute Lake	42.5
Small Pond Above Trout Lake	24.6
Upper Grizzly	1.7
Upper Sunlight	1.7
White Dome Lake	0.1

5.0 METEOROLOGICAL DATA

5.1 Near Field Meteorological Data

Preprocessed AERMOD meteorological data used for the near field modeling analysis were obtained from the State of New Mexico web site.[30] These data were processed by the State of New Mexico using the AERMET preprocessor to produce a dataset compatible with the AERMOD dispersion model. The AERMET model was used to combine the surface measurements from Bloomfield, New Mexico and twice daily sounding data from Albuquerque, New Mexico. Seasonal values for albedo, Bowen ratio and surface roughness length were used. Land use type was based on "desert shrub land" and was selected from tables in the AERMET user's guide.

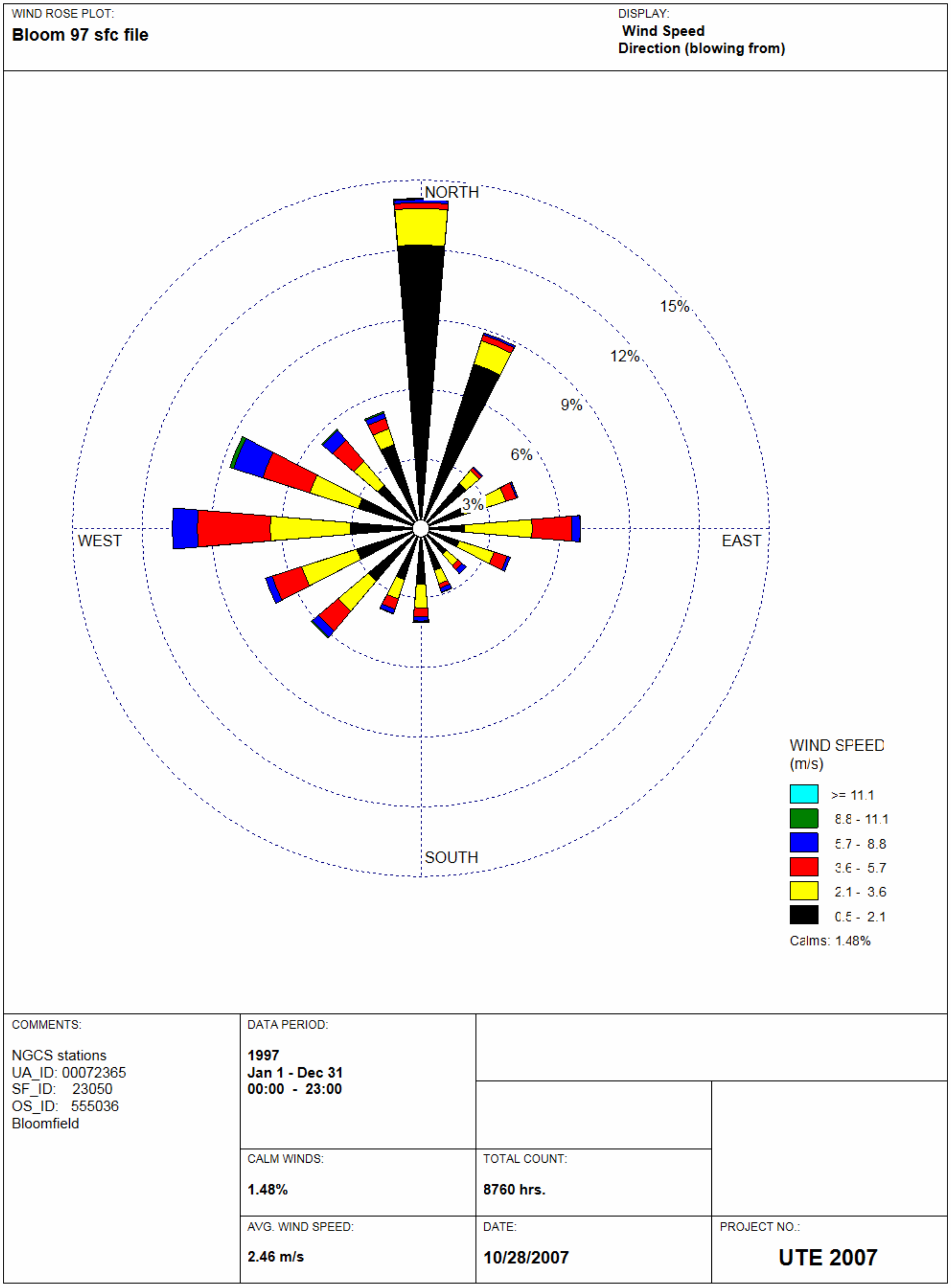
Figure 5-1 presents a wind rose from this meteorological data.

5.2 Meteorological Modeling for the Far-Field Analysis

Based on the need to model the air quality impacts of the proposed 80 acre in-fill project and other existing and reasonably foreseeable sources over the entire Four Corners Region, a complete annual simulation of gridded high resolution 3-dimensional meteorological fields was needed for the 2005 base year. An existing application of the Pennsylvania State University/National Center for Atmospheric Research (PSU/NCAR) Mesoscale Model (MM5) was selected for this purpose. MM5 (Dudhia, 1993; Grell et al., 1994: www.mmm.ucar.edu/mm5) is a limited-area, non-hydrostatic, terrain-following model designed to simulate mesoscale atmospheric circulation. The model is supported by several pre- and post-processing programs which are referred to collectively as the MM5 modeling system. MM5 was applied for the calendar year 2005 over a set of nested modeling domains that cover the continental United States at a 36km grid spacing, the southwestern United States at a 12km spacing, and the Four Corners Region (New Mexico, Utah, Arizona, and Colorado) at a 4km spacing. Additional details of the MM5 modeling procedure and input data sources are provided in Appendix D. This appendix also includes results of an evaluation of the MM5 model performance with respect to the model's ability to reproduce observed wind, temperature, water vapor mixing ratio and precipitation patterns. Also included is a comparison of the 2005 MM5 model performance with MM5 performance in other recent meteorological modeling studies.

[30] NMED web site http://www.nmenv.state.nm.us/aqb/modeling/index.html

Figure 5-1. Wind Rose for Bloomfield, New Mexico



6.0 AIR QUALITY MODELING METHODOLOGY

6.1 Near Field Production

The EPA's proposed guideline dispersion model, AERMOD (version 07026), was used to assess near field impacts of criteria pollutants CO, NO_2 as well as to estimate long-term formaldehyde (HAP) impacts. This version of AERMOD utilizes the PRIME building downwash algorithms, which are the most recent "state of science" algorithms for modeling applications where aerodynamic building downwash is a concern. One year of Bloomfield meteorology data (1997) was used with the AERMOD dispersion model to estimate these pollutant impacts (Section 5.1). Impacts from construction were previously determined using the EPA ISC model as part of the 2002 SUIT EIS. Since estimated construction emissions remained unchanged, the 2002 modeling was not revised and is reported in this document for completeness. $PM_{2.5}$ construction impacts were determined by ratioing the PM_{10} results.

Ozone impacts were estimated using the CAMx photochemical grid model (see Section 6.2).

6.1.1 Receptor Grid

Nested fine and coarse receptor grids were used in this analysis. The fine receptor grid was designed to identify maximum impacts from sources associated with the existing sources and the proposed action. This grid was constructed around each existing facility that had NOx emissions in excess of 70 tons per year (Table 6-1). A fine nested grid extending to 500 meters was placed around each of the 16 sources listed in Table 6-1 with a resolution of 25 meters.

Table 6-1. Facilities that Incorporated a Fine Receptor Grid

Facility Name	Modeling ID	NOx Emissions (t/yr)
Florida River	GBP246	245.7
Bondad	GRE96	169.2
Arkansas Loop	GrE81	164.5
Coyote Gulch	GRE64	147.7
EP Bondad	GEI3	115.4
Treating Site 6 B	GRE68	108.5
Jacques	GSAL133	101.2
Outlaw	GRE60	97.5
4 Queens	GBP249	91.8
Treating Site 7B	GUN8	91.7
Dry Creek	GBP238	89.3
Treating Site 8	GBP350	83.9
Capote	GRE101	83.2
Elk Point	GRE48	76.4
Spring Creek	GRE53	74.6
Treating Site 6	GRE107	72.9

Since stack heights of the compressors are similar to the building heights, it was important to consider aerodynamic plume downwash when estimating potential maximum impacts. Under downwash conditions, the largest impacts would likely occur close to the facility's fence line. Thus, the receptor grid was designed to ensure that the concentrations resulting from such effects were quantified. A computer program was used to calculate receptor locations around each assumed new emission source and to generate the fine receptor grid when sources of the proposed development would be less than 1 kilometer apart. A plot showing many of the fine receptor grids is shown in Figure 6-1. The fine receptor grid developed for NO_2 impacts was also used for CO and formaldehyde impacts.

Figure 6-1. Examples of Near Field Fine Receptor Grid

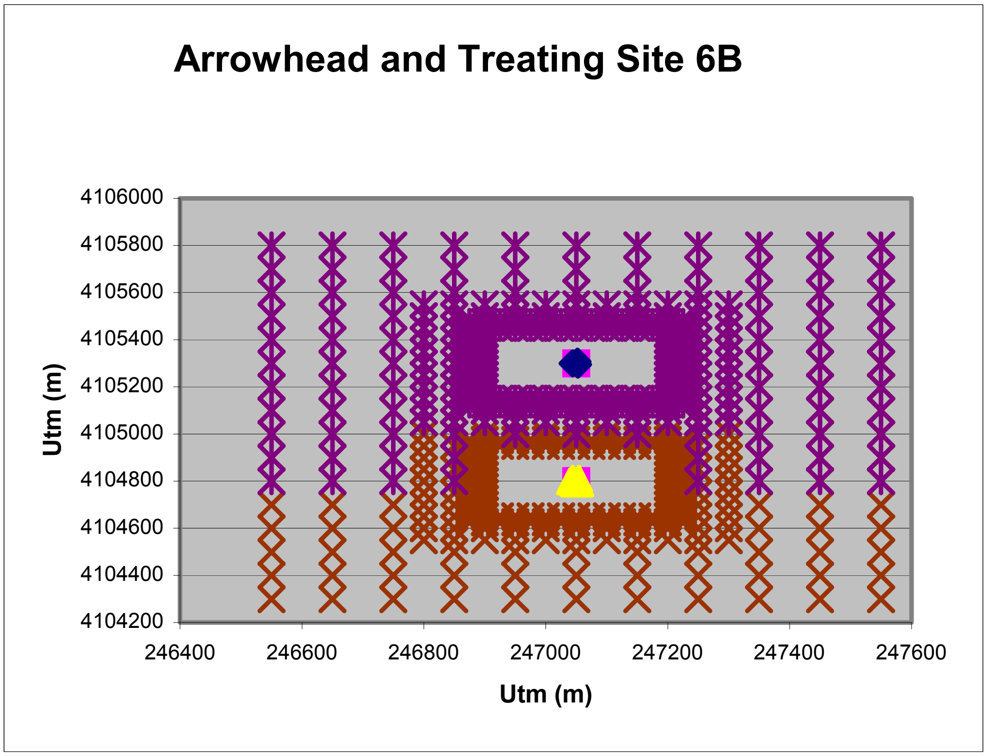
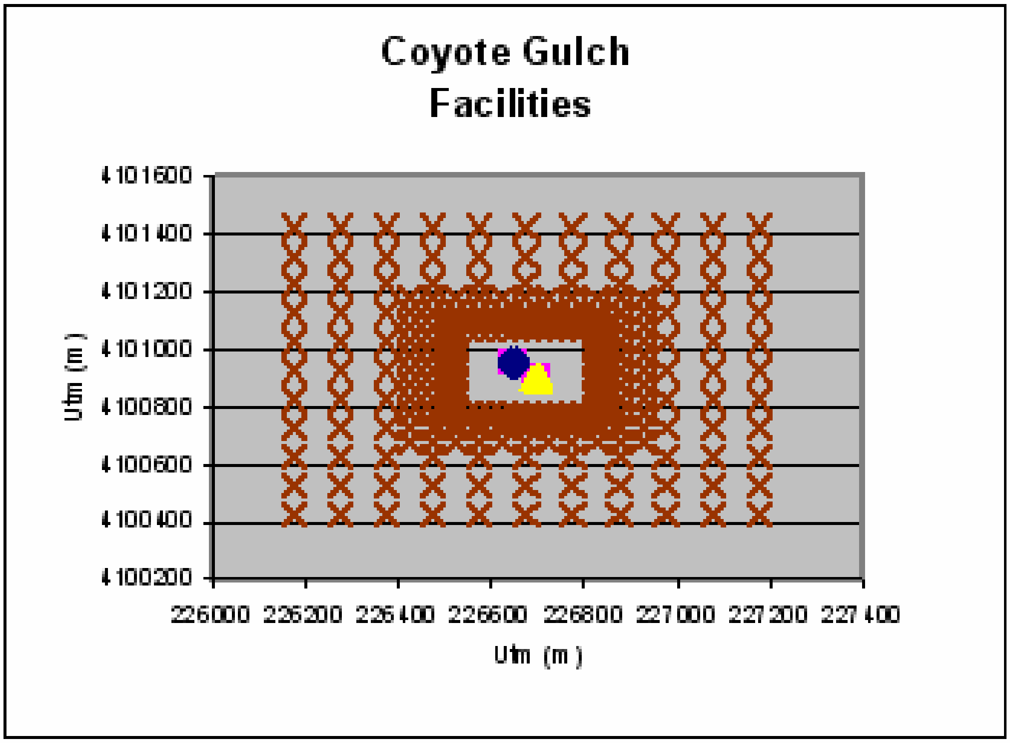


Figure 6-1 cont.



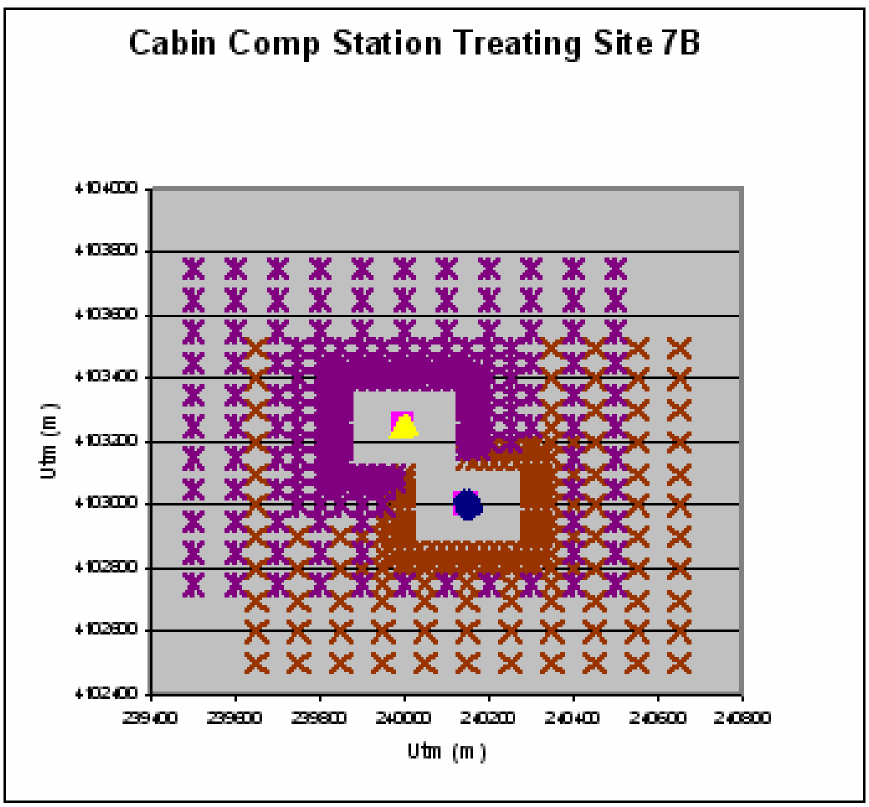
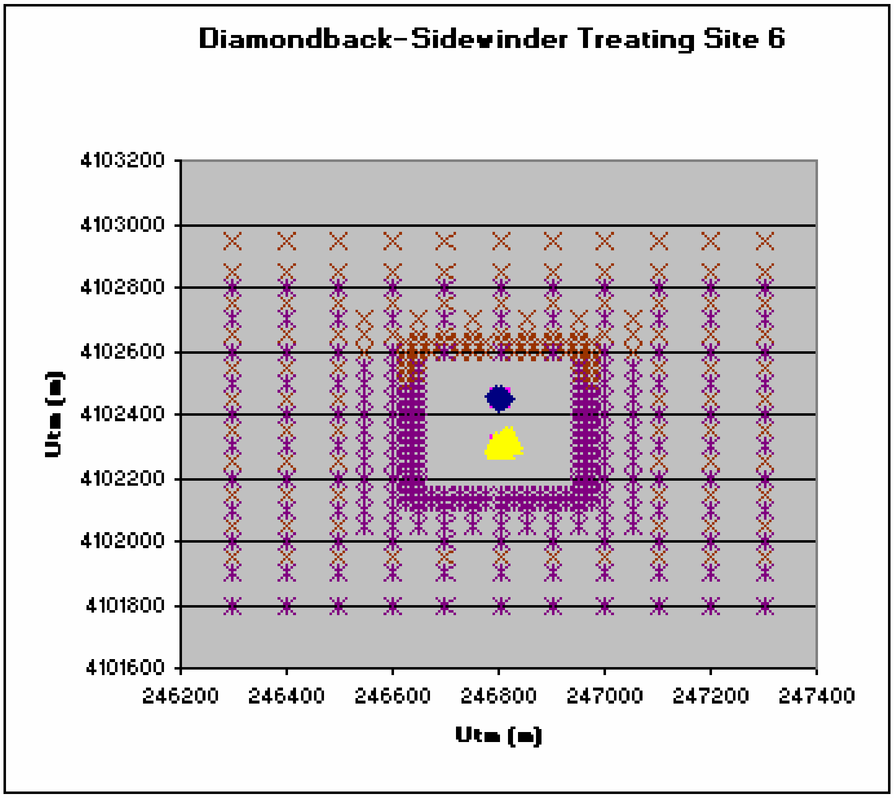


Figure 6-1 cont.



The coarse receptor grid was created to cover the entire EIS Study Area so that impacts throughout the region could be evaluated. The grid was laid out using a rectangular grid with 1,000 m resolution. As shown in Figure 6-2, the fine grids around individual compressor stations are embedded within the coarse grid. Terrain elevations were determined using the AERMAP program.

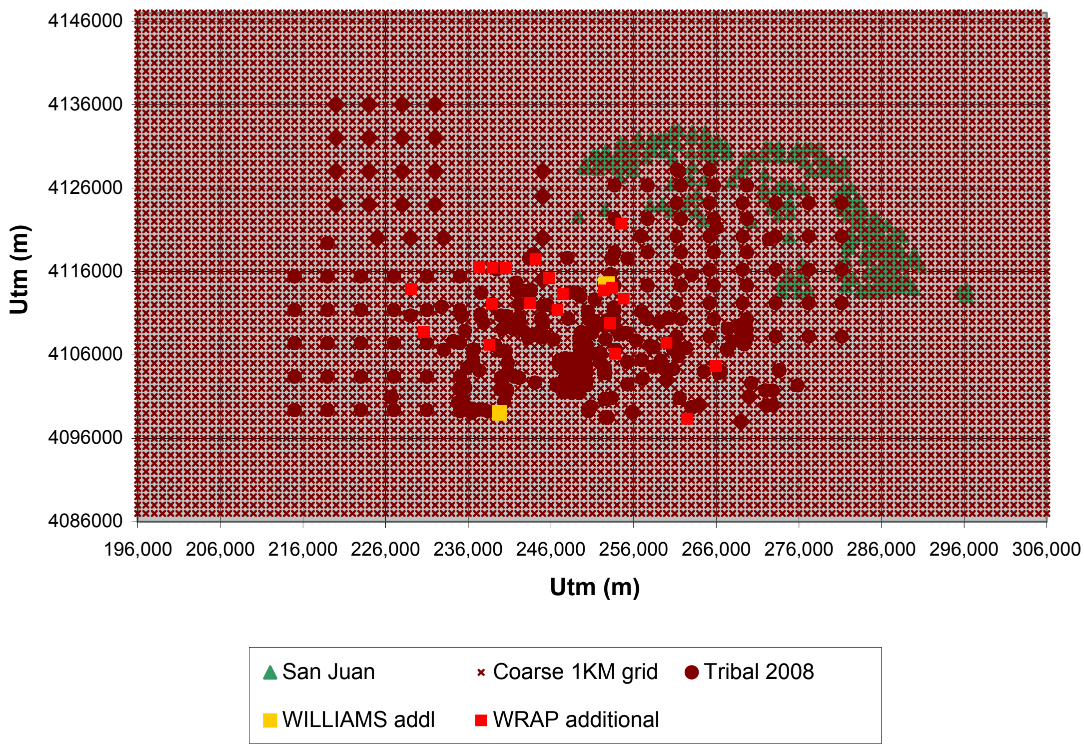
Modeling results were reviewed to ensure that the receptor grids identified the location and magnitude of the maximum impacts.

6.1.2 Model Options

The EPA's proposed guideline dispersion model, AERMOD, was used to compute estimated near field concentrations from operations for NO_2, CO, and formaldehyde. AERMOD was run using one year of AERMET preprocessed Bloomfield meteorology data following all regulatory default switch settings.

For NO_2 and formaldehyde, annual average concentrations were computed. For CO, 1 hour and 8 hour average concentrations were computed. The averaging periods are consistent with the averaging times of the NAAQS.

Figure 6-2. Coarse Receptor Grid and Source Locations



6.1.3 Emission Inventory

NO_2

Modeling for NO_2 was conducted for the base case using the 2005 SUIT base case inventory and the RFD emission inventory from the Northern San Juan EIS under full development. Emissions from the Farmington RMP were not included in the near field analysis. This is consistent with other near field analyses that have been conducted in the area[31]. Thus, modeling impacts reflect a very conservative upper bound of impacts (2005 base case SUIT plus maximum development of RFD sources).

The operator data did not provide data on exact source location or stack parameters. Source locations for modeling were estimated by distributing emissions in AERMOD in the proximity of the facility location. Stack exit velocity was based on combustion calculations and physical stack and building dimensions were based on engineering judgment.

In order to examine 2018 impacts (proposed action and no action), the base case Tribal modeling impacts were ratioed as indicated in the following equations:

2018 Tribal Impacts = Base Tribal Impacts x (2018 Tribal Emissions/2005Tribal Emissions)

2018 Total Impacts = 2018 Tribal Impacts + RFD impacts

[31] RTP, 2005, Northern San Juan EIS Technical Support Document

Note: 2018 Tribal Impacts refer to both 2018 proposed action and 2018 no action.

The AERMOD source group was turned on so that impacts from Tribal sources and other sources could be identified. The analysis assumed that when decreases in compressor capacity occur as a result of decline in production, the capacity will be reduced across the existing compressors and that new compression as a result of infill production would be added at these same facilities. Detailed engineering is not available to address the reduction and addition of infill compressor capacity in any other manner.

CO

Only SUIT sources were used in the CO modeling.

Formaldehyde

Only SUIT sources were used in the formaldehyde modeling.

6.1.4 Building Downwash

The AERMOD model provides the option to simulate aerodynamic plume downwash on the lee side of buildings (and other obstacles) that may be adjacent to the source. Downwash can produce elevated ground level concentrations close to structures. The occurrence of downwash depends on the interaction between the stack height, the distance between the stack and nearby buildings, the dimensions of the buildings as well as meteorological conditions.

Estimates of assumed building dimensions for the proposed compressor stations were developed as part of the emission inventory. Because of the lack of detailed engineering data, building dimensions have been assumed to apply uniformly regardless of wind direction.

6.1.5 Conversion of NOx into NO_2

Emissions of NOx as a result of burning natural gas would be primarily in the form of nitrogen oxide which can be photochemically converted into NO_2 in the presence of ambient ozone. EPA's regulatory default NO_2/NOx conversion ratio of 0.75 (EPA 2003a) was used to estimate NO_2 concentrations for comparison with the NAAQS. Potential NO_2 impacts were therefore calculated by multiplying the NOx emission rate by 0.75 prior to inclusion in the AERMOD model. Given the rural nature of the EIS Study Area, this procedure can be viewed as a reasonable but conservative application.

6.2 Far Field Air Quality Modeling

A regional scale air quality photochemical modeling study has been undertaken by the Four Corners Air Quality Task Force which is comprised of the states of New Mexico and Colorado, the Southern Ute and Navajo Indian tribes, Federal Land Managers as well as other stakeholders and members of the public. The Four Corners Air Quality Task Force was formed to evaluate the benefits of mitigation options that could be implemented to improve ambient air quality in the Four Corners Region. An integral part of this evaluation is the use of air quality modeling to quantify the potential air quality improvements resulting from alternative mitigation options. Extensive development of air quality modeling methods and data bases has been conducted by ENVIRON for the Four Corners Air Quality Task Force for this purpose, resulting in a regional air quality planning tool which can be used to evaluate impacts of both future development projects and alternative emission reduction strategies.[32] Regional modeling for the Four Corners Air Quality Task Force consisted of the following tasks:

1. Development of a modeling protocol;

2. Development of a base case and 2018 future year emission inventory;

3. Performance of base case model evaluation for 2005 to assess model accuracy;

4. Application of the model to a 2018 base case emissions inventory (with no mitigation options)

5. Use of the model to evaluate changes in ambient air quality estimated to result from implementation of five alternative mitigation options.

The Four Corners Air Quality Task Force regional modeling was used to evaluate potential air quality changes associated with the SUIT proposed infill project. The SUIT analysis used results from tasks 1 – 3 above together with a new 2018 base case “no action” model run that incorporates the same emission inventory as in Task 4 above but with growth estimates applied to sources on SUIT lands and a 2018 proposed (full infill) project scenario model run that incorporates the proposed infill project emissions into the 2018 base case inventory. Apart from these limited exceptions, all of the analyses performed for this study are consistent with the Four Corners study.

The Four Corners Air Quality Task Force regional modeling employs the Comprehensive Air quality Model with extensions (CAMx, v4.51). CAMx is a publicly available (www.camx.com) three-dimensional multi-scale photochemical/aerosol grid model that is developed and maintained by ENVIRON International Corporation (ENVIRON, 2008). CAMx is an ideal platform to treat a variety of air quality issues including ozone, particulate matter (PM), visibility, acid deposition, and air toxics. CAMx has been widely used in recent years by a variety regulatory agencies for 1-hr and 8 hour ozone and PM SIP modeling studies, as well as by several Regional Planning Organizations (RPOs) for regional haze modeling. It is currently being used to evaluate air quality impacts of several oil and gas development projects in the western U.S.

Base Case Modeling: A modeling domain comprised of a series of nested grids with 36, 12, and 4 km grid spacing (resolution) was defined for the Four Corners Air Quality Task Force modeling as previously shown in Figure 3-16. The 4 km domain includes the Southern Ute tribal lands and is sufficient for evaluating the impacts of the proposed 80-acre infill project on nearby protected (Class I) and surrounding areas. The rationale for the modeling domain configuration and vertical layer structure is described in the Four Corners Modeling Protocol (ENVIRON, 2007). The 2005 MM5 meteorological data fields, developed as described in Section 5.2, were processed into CAMx inputs for this domain configuration and quality-assured. Emission inputs for the CAMx 2005 base case were developed as described in Section 3.2. CAMx was run first on the single 36 km grid for the entire year; each quarter was run separately, which included a 15-day model spin-up period before the first day of each quarter. Gridded hourly concentrations of all chemical species from the 36-km run were used to generate initial conditions (ICs) and boundary conditions (BCs) for the 12 km grid. Then CAMx was exercised on the combined 12/4-km grid system in a fully two-way interactive manner for each quarter of 2005, each with a 5-day model spin-up period.

[32] http://www.nmenv.state.nm.us/aqb/4C/Modeling.html

Model Performance Evaluation: A comprehensive model performance evaluation was conducted on the 2005 base case simulation. Available measurements for ozone, speciated PM and total PM mass were compared with model output over a large geographic region. Well-established model evaluation software and techniques were employed, which have been developed from regional modeling conducted for the Western Regional Air Partnership (WRAP) and other urban and regional-scale modeling programs. Statistical performance metrics were compared to acceptance goals and criteria established over the past several years by the EPA and RPOs. Graphical displays of model performance were generated, including scatter plots, time series plots, spatial maps of model predictions, "bugle" plots and other displays.

Future-Year Modeling: After completing the 2005 base case analysis, a 2018 base case ("no action") scenario was run using the 2018 emission inventory described in Section 3.2. In addition, a second 2018 scenario was run using the "full infill" emissions scenario also described in Section 3.2. Like the 2005 base case, these future year modeling scenarios were run on the 12/4-km nested grid system. Boundary conditions for these runs were kept the same as in the 2005 base case run. Model results were used to evaluate future year air quality impacts for ozone and PM concentrations, visibility, and acid deposition as described in Section 7.2.

Each of the above steps in the modeling analysis is described in more detail in the following subsections.

6.2.1 2005 Base Case Modeling

Databases required to configure and operate CAMx for the Four Corners Air Quality Modeling Study are as follows:

- Three-dimensional hourly meteorological fields generated by MM5 and prepared using the MM5CAMx interface processor (see Section 5.2);
- Two-dimensional land use/land cover and topography, as prepared for MM5, and generated using the MM5CAMx interface processor;
- Two-dimensional low-level (surface layer) emissions and elevated point source emissions generated the SMOKE emissions processor (see Section 3.5.1);
- Initial/boundary (IC/BC) inputs for the coarsest (master) 36 km grid as prepared by WRAP from GEOSCHEM global model output;
- Two-dimensional albedo/haze/ozone column fields developed using the CAMx AHOMAP pre-processor;
- Photolysis rates look up table developed using the albedo/haze/ozone column fields and the TUV radiative transfer model.

Meteorological Inputs

Meteorological data for this analysis were derived from MM5 modeling of the calendar year 2005 on a similar 36/12/4 km nested grid structure (as described in Section 5.2). It is necessary to convert raw output from the MM5 meteorological model to formats and variables used by CAMx specifically. The MM5CAMx translation processor was used to complete this task. MM5CAMx includes the ability to interpolate data from the native map projections used by the meteorological model to any projection to be specified for the air quality model (CAMx may be applied on Lambert Conformal, Polar Stereographic, or UTM Cartesian projections, or in geodetic latitude/longitude).

CAMx requires meteorological input data for the parameters described in Table 6-2. All of these input data are derived from the MM5 results. MM5CAMx performs several functions:

1. Extracts data from the MM5 grids to the corresponding CAMx grids; in this study, the extraction includes a simple one-to-one mapping from the MM5 Lambert Conformal grid to the CAMx Lambert Conformal grid, with appropriate windowing to remove the extra row/columns in the MM5 grids.

2. Performs mass-weighted vertical aggregation of data for CAMx layers that span multiple MM5 layers – in this project 34 MM5 layers were aggregated to 19 CAMx layers spanning the depth between the surface and ~15 km MSL.

3. Applies diagnostic analysis techniques to derive key variables required by CAMx that are not directly output by MM5 (e.g., vertical diffusion coefficients and some cloud information).

Table 6-2. CAMx meteorological input data requirements.

CAMx Input Parameter	Description
Layer interface height (m)	3-D gridded hourly time-varying layer heights
Winds (m/s)	3-D gridded hourly wind vectors (u,v)
Temperature (K)	3-D gridded hourly temperature and 2-D gridded surface temperature
Pressure (mb)	3-D gridded hourly pressure
Vertical Diffusivity (m^2/s)	3-D gridded hourly vertical exchange coefficients
Water Vapor (ppm)	3-D gridded hourly water vapor mixing ratio
Cloud Cover	3-D gridded hourly cloud and precip water contents
Land use Distribution	2-D gridded static landuse/landcover distribution

The MM5CAMx program has been written to carefully preserve the consistency of the predicted wind, temperature and pressure fields output by MM5. This is the key to preparing mass-consistent inputs for CAMx, and therefore for obtaining high quality performance from CAMx.

The MM5CAMx processor was used to process the 2005 MM5 output data fields from each modeling grid to the CAMx grids, variables and formats. Layer collapsing was employed to reduce the number of vertical layers from the 34 used in the MM5 modeling (as shown in Appendix F Table 1).

Vertical diffusivities (Kv) are an important input to the CAMx simulation since they determine the rate and depth of mixing in the planetary boundary layer (PBL) and above. The MM5CAMx program offers up to three options to determine Kv fields from MM5 meteorological parameters, depending on the physics options set in MM5. Given the configuration of MM5 used for the Four Corners modeling, two Kv options were available in MM5CAMx for this project: the CMAQ method and the O'Brien (1970) profile method. The O'Brien approach was used throughout all developmental and final modeling simulations. The O'Brien method yields generally lower mixing rates and slightly lower mixing depths than the more vigorous CMAQ method.

Developmental CAMx runs indicated a bias toward under predictions for most PM species; this was attributed to many issues, including lack of natural emissions (dust, fires) and poor meteorological performance for precipitation and boundary layer mixing. Early sequential tests investigated sensitivity to precipitation and boundary layer depths, in which wet deposition was turned off and the mixing depth as diagnosed using the O'Brien method in MM5CAMx was reduced artificially. Results of both tests showed that PM species concentrations were not sensitive to either change. Therefore the under prediction biases were attributed to emission uncertainties.

Emission Inputs

Model-ready emission files for CAMx simulations were prepared as described in Section 3.2.

Initial and Boundary Conditions

For the WRAP modeling of the 2002 year, boundary conditions for the continental U.S. 36 km RPO domain were based on a 2002 simulation of the Harvard GEOS-CHEM global transport and chemistry model. The GEOS-CHEM 2002 output was processed as 3 hourly spatially varying boundary conditions along the edges of the 36 km RPO grid. For modeling years other than 2002, ENVIRON processed the 2002 GEOS-CHEM data into 12 sets of monthly-averaged diurnally varying boundary conditions. This approach has been successfully used for several recent SIP modeling efforts in the Southwest U.S. (e.g., Phoenix, Las Vegas), and was similarly used to provide 36-km grid boundary conditions for this study. Boundary conditions for the 12/4-km nested grid run were extracted from the 36-km CAMx results.

Developmental CAMx runs indicated very high ozone concentrations over the Rocky Mountains of Colorado during the mid-spring period, often reaching as high as 90 ppb for daily maximum 8 hour averages. Peak observed concentrations during this period rarely exceeded 65 ppb. This problem was apparent on all three CAMx domains (36, 12, and 4-km grids), and in fact mirrored a similar result from 2002 36-km WRAP CMAQ modeling. After significant effort to identify the cause, it was found that the lateral boundary conditions extracted from GEOS-CHEM in the top-most layers (layers 17-19, 8-15 km MSL) were reflecting stratospheric ozone levels in excess of 200 ppb during the springtime, and these high concentrations were being vertically transported downward over the highest terrain. This further indicated that vigorous vertical circulation systems were being generated over complex terrain in both CAMx and CMAQ. To overcome this problem, the 36-km ozone boundary conditions in the uppermost layer were artificially reduced to tropospheric levels by assigning each grid cell in layer 19 to the average ozone in layers 18 and 19. Ozone performance was dramatically improved during the springtime, with only a minor impact on summertime ozone levels.

Default initial concentrations developed for the 2002 WRAP CMAQ simulations were also used to specify CAMx initial conditions for each quarter of the 2005 CAMx simulation. A 15-day spin-up period was run before each quarter to eliminate any significant influence of these arbitrary initial conditions. Initial conditions for the 12/4-km nested grid simulations were extracted from the 36-km grid results 5 days prior to the beginning of each quarter.

Ancillary Inputs

Additional CAMx model inputs were prepared using standard data sources and processors. For example, total integrated ozone column data for 2005 were obtained from the TOMS satellite database[33] and processed as input into CAMx using the AHOMAP preprocessor. Ozone column data were processed for each month of 2005, according to the monthly average files obtained from that web site. Surface characteristics, including UV albedo and daily snowcover, were defined based on data output by the MM5 simulation (as processed by MM5CAMx). The photolysis rates lookup table was prepared using the NCAR TUV radiative transfer pre-processor according to the range of ozone column and surface characteristics data described above. TUV outputs a monthly clear-sky photolysis look up table that is directly input to CAMx; the table defines photolysis rates for six photolytic reactions over a range of solar zenith angles, altitudes, ozone column, surface UV albedo, and haze turbidity. CAMx internally adjusts the photolysis rates for cloud cover according to the cloud inputs provided to CAMx (from MM5 via MM5CAMx).

CAMx Model Options

The latest public-released version of CAMx (v4.51) was employed for this study. The CAMx configuration options included the following:

- CAMx was run separately on the 36-km grid (resulting in "one-way" grid nesting between the 36 km grid and the 12/4 km nests);
- CAMx was run on the 12/4-km nested grid systems (resulting in interactive "two-way" grid nesting between the 12 and 4 km grids);
- The CB05 gas-phase chemistry was employed, and solved using the fast CMC hybrid solver;
- The Coarse/Fine (CF) static two-mode aerosol chemistry mechanism was employed, which uses RADM aqueous-phase chemistry, ISORROPIA inorganic aerosol thermodynamics (sulfate/nitrate/ammonium equilibrium), and the latest updates to the SOAP secondary organic aerosol chemistry module;
- The Plume-in-Grid (PiG) subgrid-scale plume module was not used given that the regional scales in this study were addressed with a high-resolution 4-km grid;
- The PPM advection solver was employed;
- Dry and wet deposition were both active;
- Probing Tools were not employed (these include source apportionment, decoupled direct method of sensitivity analysis, process analysis, and reactive tracers).

Modeling Strategy

An initial CAMx simulation was performed for the entirety of 2005 on the 36 km continental RPO domain. Hourly gridded output from this run was then processed to generate initial and boundary conditions for the interactive two-way 12/4 km model simulations. The strategy for performing the annual 36 and 12/4 km grid simulations was to run CAMx separately for each of four quarters of the year (January-March, April-June, July-September, and October-December). The CAMx simulation for each quarter was comprised of a series of single-day simulations, in which the model is restarted at midnight UTC (1700 local standard time). This facilitated the use of various day-of-week specific emissions and other inputs that needed to be provided to the model on a

[33] http://jwocky.gsfc.nasa.gov/

daily basis.

A 15 day “spinup” period was added prior to the start of each quarter for the 36 km grid run as a way to remove the influence of initial conditions. A single set of WRAP initial conditions were used to cold-start the model at beginning of all four 15-day spinup periods. Prior tests of CAMx on the RPO grid suggest that at least two weeks are needed to remove a significant fraction of the initial conditions from such large domains. Alternatively, a 5 day spinup period was used to initialize the 12/4-km grid quarterly simulations. The initial conditions used for each of the four 5-day spinups were extracted from the 36-km grid output to remain consistent with the manner in which 12-km boundary conditions were generated.

As was done in several recent annual modeling studies, we initially selected two representative monthly periods to perform diagnostic and sensitivity testing with CAMx on the 12/4-km nested grid system: a summer month characterized by high ozone and anthropogenic PM (e.g., SO_4) and a winter month characterized by high NO_3 (note that EC and OC occur year round and are heavily associated with natural emissions). Using the 12/4-km emissions and meteorology, and boundary conditions generated from the 36 km 2005 annual run, initial 2005 base case simulations were run for the chosen summer and winter months of 2005, and a preliminary model performance evaluation was conducted. Results of this performance evaluation were used to guide a series of diagnostic and sensitivity tests designed to identify the optimal model configuration for simulating ozone and PM air quality in the Four Corners region.

6.2.2 CAMx Performance Evaluation

A critical component of every air quality modeling study is the model performance evaluation, where the modeled estimates for the base year are compared against observed values to assess the model’s accuracy and provide an indication of its reliability as a tool to guide effective air quality management. The Four Corners modeling protocol,[34] which is used as the basis for the SUIT analysis, discusses a general evaluation approach based upon the methods, data, and analyses recommended in the EPA modeling guidance (EPA, 2008). The protocol also delineates the specific analyses and products that were to be generated under the Four Corners modeling program according to schedule and available resources. These analyses and products generated as part of the Four Corners work were used in the SUIT analysis.

All mathematical models possess inherent limitations owing to the necessary simplifications and approximations made in formulating the governing equations, implementing them for numerical solution on fast computers, and in supplying them with input data sets and parameters that are themselves approximations of the full state of the atmosphere and emissions processes. Like all air quality models, a major limitation of CAMx rests with the input fields that characterize emissions, meteorology, and initial/boundary conditions. Key science limitations in the model itself include the nitrate formation chemistry and the secondary organic aerosol (SOA) module. Preliminary modeling by the RPOs (e.g., WRAP, VISTAS and CENRAP) found both CAMx and CMAQ nitrate performance suspect with winter overestimations and summer underestimations (Morris et al., 2004, 2005). While not as poor as CMAQ, the VISTAS and CENRAP modeling also found CAMx performance for Organic Carbon (OC) to be less than ideal; much of the OC performance problems have been due to deficiencies in the SOA module that in the past has failed to account for several known processes important to SOA (e.g., polymerization). Much of these limitations have been addressed in an improved SOA module now available in the version of CAMx used in this analysis (version 4.51); additional research in this area is ongoing.

[34] http://www.nmenv.state.nm.us/aqb/4C/Modeling.html

Overview and Context

The Four Corners modeling protocol laid out the "roadmap" for achieving an adequately tested modeling system for regulatory use. This does not mean that every analysis identified was carried out or even possible according to available resources, the existing aerometric databases, and present technology constraints. Hence, the protocol describes a range of model testing methodologies *potentially* available to adequately evaluate the performance of the CAMx air quality modeling system for the 2005 annual period. Procedures for evaluating PM models are much less established than for ozone, and research is ongoing.

The evaluation of the CAMx modeling system for the annual 2005 simulation was consistent with EPA's modeling guidance, which essentially calls for an operational evaluation of the model focusing on a specific set of gas phase and aerosol chemical species and a suite of statistical metrics for quantifying model response over the annual cycle. Emphasis was placed on assessing: (a) how accurately the model predicts observed concentrations; and (b) how accurately the model predicts responses of predicted air quality to changes in inputs. Over the past 20 years, a substantial body of information and analytical techniques has been developed to address the first aspect. Unfortunately, even today there are little rigorous methods available for quantifying the accuracy and precision of a model's predicted concentration changes as the result of emissions changes.

When designing a model performance evaluation, it is important to understand how the modeling results will ultimately be used. EPA modeling guidance not only provides a framework for the Four Corners model performance evaluation approach, but just as importantly describes the methodology by which to project base-year pollutant levels to target years. A key concept in EPA's guidance is that the modeling projections are used in a relative sense to scale or roll back the observed individual PM species concentrations. The model-derived ratios of future-year to current-year concentrations are called relative response factors (RRFs). Since the model is used to project future year $PM_{2.5}$ species components rather than total $PM_{2.5}$ mass, then the model performance for each of the components is actually more important than for total $PM_{2.5}$ mass for which the standard was written. These $PM_{2.5}$ species components are:

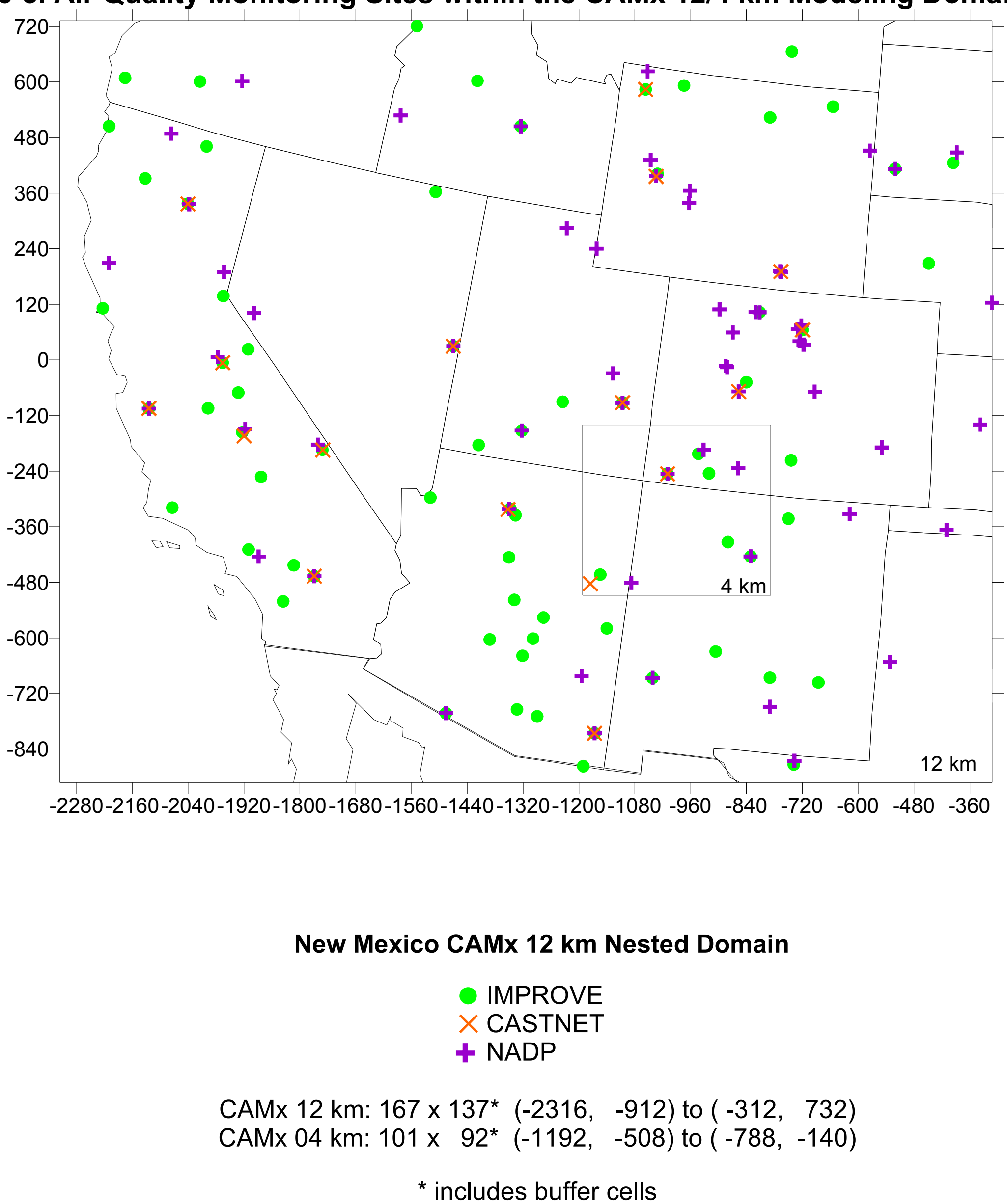
- Sulfate (PSO_4);
- Nitrate (PNO_3);
- Ammonium (PNH_4);
- Organic Carbon (OC);
- Elemental Carbon (EC); and
- Other Inorganic fine Particulate (FPRM and FCRS).

Therefore, the model testing concentrated on an operational evaluation of the model predictions for those PM components listed above. We also evaluated the modeling system for its ability to accurately estimate ozone. The correct simulation of gas-phase oxidants is needed for PM since correct, unbiased simulation of gas-phase photochemistry is a necessary element of reliable secondary PM predictions. This evaluation was carried out across the 4-km grid for the entire year and also on a month-by-month to daily basis to help build confidence that the modeling system operated correctly.

Evaluation Datasets

The CAMx model performance evaluation for the 2005 base year included analyses of predictions against available measurements at ground-level monitors throughout the 4-km modeling domain. Unfortunately, there were no aloft data for the 2005 period in the Four Corners Area. Concentration measurements from a number of monitoring networks were used to the fullest extent possible in the CAMx model performance evaluation. Drawn from available state and federal monitoring networks in New Mexico, Colorado, Arizona, and Utah as well as in surrounding states, these surface measurements included ozone, NOx, SO_2, total PM mass and PM species components. Routine gas-phase concentration measurements for ozone, NOx and CO are archived in EPA's Air Quality Subsystem (AQS) database. Other sources of information were the various PM monitoring networks including the: (a) Interagency Monitoring of Protected Visual Environments (IMPROVE), (b) Clean Air Status and Trends Network (CASTNET), (c) EPA $PM_{2.5}$ and PM_{10} Mass Networks (EPA-FRM), (d) EPA Speciation Trends Network (STN); and (e) National Acid Deposition Network (NADP). Typically, these networks provide ozone, other gas phase precursors and product species, PM, and visibility measurements. Additional ozone measurements were obtained from a FS monitoring site at Shamrock, Colorado. Figure 6-3 shows locations of the standard monitoring network sites within the 12 km modeling domain.

Figure 6-3. Air Quality Monitoring Sites within the CAMx 12/4 km Modeling Domain



Statistical Performance Metrics

Table 6-3 lists a standard set of EPA recommended statistical performance measures that were used during this study to evaluate CAMx performance (EPA, 1991, 2001). Typically, the statistical metrics are calculated for all monitoring sites across the full computational domain for all simulation days. In this evaluation, we stratified the performance statistics across relevant space and time scales. As part of the operational evaluation, the gas-phase and aerosol statistical measures shown in Table 6-3 were computed for the full 4-km domain and for specific sites. Temporally, we computed the statistical measures for the appropriate averaging times: 8 hourly for ozone, and 24 hour for total $PM_{2.5}$, sulfate, nitrate, EC, OC, and other aerosol species. Statistics are reported at daily, monthly, and annual time scales.

Table 6-3. Core Statistical Measures Used in the Four Corners Air Quality Model Evaluation with Ground-Level Data

Statistical Measure	Mathematical Expression	Notes
Coefficient of determination (***r***[2])	$$\frac{\left[\sum_{i=1}^{N}(P_i-\overline{P})(O_i-\overline{O})\right]^2}{\sum_{i=1}^{N}(P_i-\overline{P})^2\sum_{i=1}^{N}(O_i-\overline{O})^2}$$	P_i = prediction at time/location *i*; O_i = observation at time/location *i*; $\overline{P}$ = arithmetic average of P_i; $\overline{O}$ = arithmetic average of O_i
Normalized Gross Error (***NGE***)	$$\frac{1}{N}\sum_{i=1}^{N}\frac{\lvert P_i-O_i\rvert}{O_i}$$	Reported as %
Normalized Bias (***NB***)	$$\frac{1}{N}\sum_{i=1}^{N}\frac{(P_i-O_i)}{O_i}$$	Reported as %
Fractional Gross Error (***FGE***)	$$\frac{2}{N}\sum_{i=1}^{N}\left\lvert\frac{P_i-O_i}{P_i+O_i}\right\rvert$$	Reported as %
Fractional Bias (***FB***)	$$\frac{2}{N}\sum_{i=1}^{N}\left(\frac{P_i-O_i}{P_i+O_i}\right)$$	Reported as %

Establishment of performance goals and criteria for modeling is a necessary but difficult activity, and has been an area of ongoing research and debate (Morris et al., 2005). Here, performance *goals* refer to targets that we believe a good performing PM model should achieve, whereas less stringent performance *criteria* represent a minimal level of model performance that a PM model should achieve for use in regulatory modeling. Performance goals are necessary in order to provide consistency in model applications and expectations across the country, while criteria provide standardization in how much weight may be accorded modeling study results in the decision-making process. It is a problematic activity, though, because many areas present unique challenges and no one set of performance goals is likely to fit all needs. Equally concerning is the very real danger that modeling studies will be truncated when the "statistics look right" before full assessment of the model's reliability is made. This has the potential for breeding built-in compensating errors as modelers strive to achieve good statistics as opposed to searching for the explanations for poor performance and then rectifying them.

Decades ago EPA (1991) established performance goals for 1-hour ozone centered on the use of normalized bias (<15 percent) and error (<35 percent). However, when these evaluation metrics were later adapted to PM and its components, difficulties arose because performance statistics that divide by low concentration observations (such as nitrate, which is often zero) become practically meaningless. In time, this has led to the introduction of the fractional bias and error metrics. EPA modeling guidance notes that PM models may not be able to achieve goals similar to those of ozone, and that better performance should be achieved for those PM components that make up the major fraction of total PM mass than those that are minor contributors. In fact, differences in measurement techniques for some PM species likely exceed the more stringent ozone performance goals. For example, recent comparisons of PM measurements using the IMPROVE and STN technologies found differences of ~20 percent for sulfate and ~50 percent for elemental carbon (Morris et al., 2005).

As with ozone in the 1980s, actual experience with PM models has led to the development of the current performance expectations for these models. For example, PM_{10} SIP model performance goals of 30 percent and 50 percent for normalized gross error have been used for southern California (SCAQMD, 1997; 2003) and Phoenix (ENVIRON, 1998), respectively. Boyland and Russell (2006) have proposed fractional bias and error goals of 30 percent and 50 percent, and fractional bias and error criteria of 60 percent and 75 percent, respectively. Furthermore, they proposed that these goals and criteria values vary as a function of concentration, such that below 2 $\mu g/m^3$, they expand exponentially to 200 percent (the maximum of fractional bias and error) at zero observed concentrations. The following levels of model performance criteria (Table 6-4) have been adopted for RPO regional visibility modeling using CMAQ, and we carry these forth into the Four Corners modeling assessment. We regard the above goals and criteria not as a pass/fail test, but rather as a basis of inter-comparing model performance across studies, sensitivity tests and models.

Table 6-4. Model Performance Criteria

Fractional Bias	Fractional Error	Qualitative Performance
≤ ±15%	≤ 35%	Excellent
≤ ±30%	≤ 50%	Good
≤ ±60%	≤ 75%	Average, each PM component should meet for regulatory modeling
> ±60%	> 75%	Poor, indicating fundamental problems with the modeling system

Model Performance Evaluation Results: Ozone

Model performance for ozone was evaluated primarily using monitoring sites located within the 4 km modeling domain as listed in Appendix F, Figure 1 (note that the USFS Shamrock site in the Colorado San Juan Mountains is not shown in this figure). Additional evaluation of ozone prediction performance was conducted using data from CASTNET sites located throughout the intermountain western U.S. within the 12 km domain as shown in Appendix F, Figure 1. Monthly mean fractional error statistics for hourly ozone at sites in the 4 km and 12 km domains, respectively, are summarized in Appendix F, Figure 1.

Fractional metrics were chosen to evaluate performance for all hours of each month of the year since many observations reach zero concentrations, especially in winter months. Results from two model runs are shown: “original” refers to an initial CAMx simulation that used unmodified 36-km grid boundary conditions taken directly from the 2002 WRAP modeling (derived from GEOS-CHEM global model results as explained earlier); “final” refer to the final CAMx configuration in which the 36-km grid boundary conditions were modified to ensure tropospheric ozone levels in the topmost layers (as explained earlier). The performance sensitivity from this change is substantial, especially in winter months and within the 4-km grid. The winter months were most impacted because stratospheric ozone levels (reaching well above 100 ppb) exist much lower in the atmosphere and in combination with vigorous wintertime weather systems, this ozone is easily transported to the surface in the grid models. The 4-km grid was more impacted than the 12-km grid because the highest and most complex terrain exists in the 4-km grid area where both CAMx and CMAQ showed the most impact from the GEOS-CHEM boundary conditions.

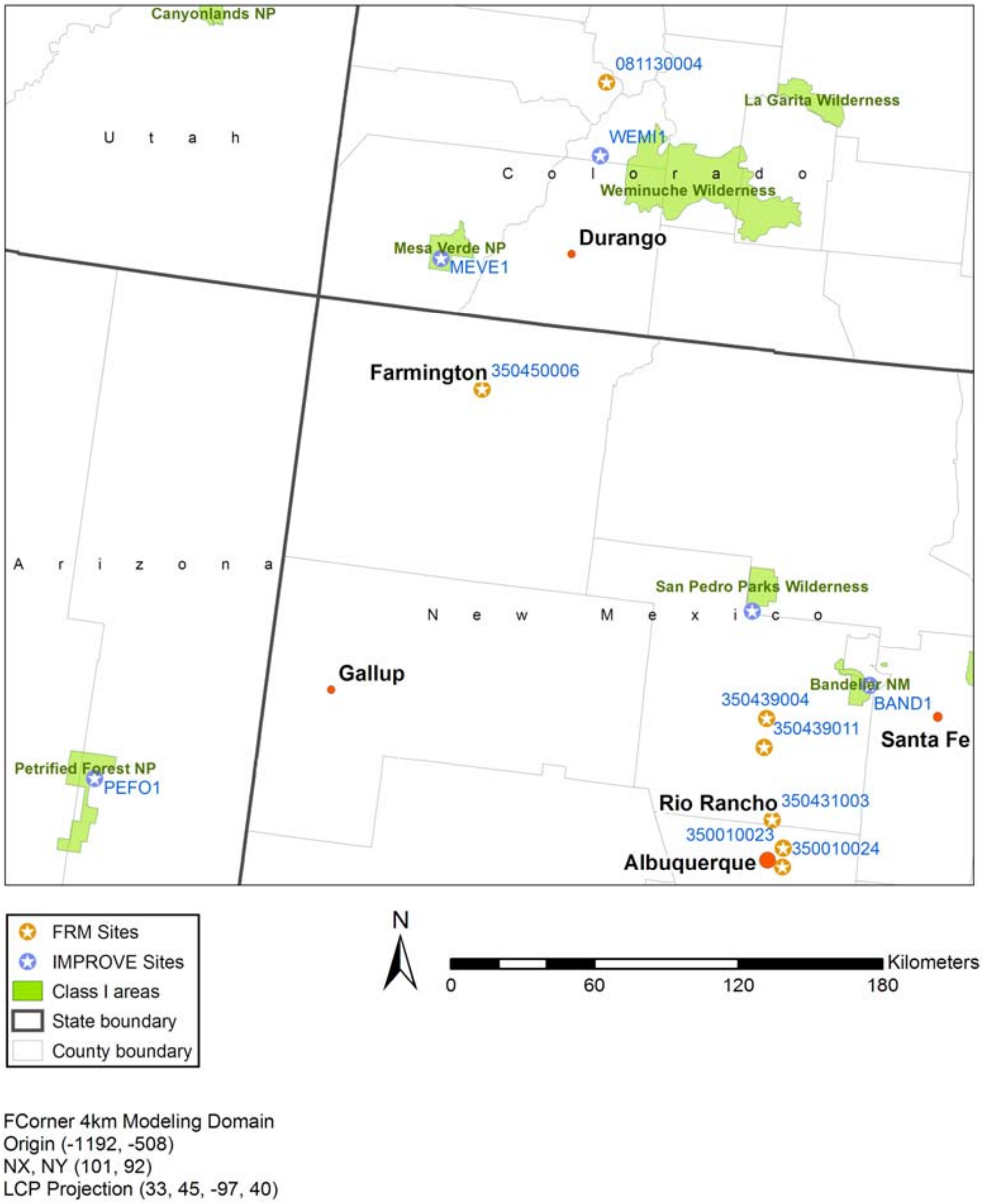
A more informative approach is to determine gross bias and error for observation-prediction pairings above a minimum ozone concentration, as recommended by EPA guidance (EPA, 2008). In Appendix F, Figures 9 and 10, monthly gross bias and error are shown respectively for observed hourly ozone above 40 ppb. Relative to long-established EPA acceptance criteria, most months are within the 15 percent bias envelope and all months are within the 35 percent error envelope. The bias pattern fall into the summertime months; ozone hours above 40 ppb tend to be under predicted while all ozone hours are near a zero bias relative to the rest of the year. This indicates that CAMx exhibits the largest under predictions for the highest ozone concentrations.

Appendix F, Figure 11 shows time series of hourly observed ozone and co-located CAMx predictions at sites within the 4-km grid for April and July, 2005. CAMx results were taken from the final 2005 base case simulation. The more rural sites show little diurnal variation, while the more urban-influenced sites (such as around Farmington, NM) show strong diurnal variations associated with local NOx emissions that remove ozone to near zero concentrations at night. CAMx cannot be expected to match the strong local NOx influences on ozone since much of that occur at scales below the resolution of the CAMx grid. CAMx does not capture the rather large diurnal ozone variations at the Shamrock and Gothic rural sites. In the latter case, Gothic is located in the 12-km grid, so model resolution has an even greater impact on performance at that site. Even so, it is difficult to say what the causes of the observed diurnal ozone patterns would be at these sites; apparently local emissions and meteorological influences have some effect there that the model cannot replicate according to the procedures used to process emissions and to simulate the meteorology.

Model Performance Evaluation Results: PM

Monitoring sites used in the model performance evaluation for PM are shown in Figure 6-4. This includes speciated particulate matter monitoring at IMPROVE and CASTNET sites, and federal reference method (FRM) monitoring of total $PM_{2.5}$ and PM_{10} mass at FRM sites. One of the best ways to summarize monthly/annual speciated PM performance is through the use of “bugle” plots, an approach first developed by the VISTAS RPO and now widely used in many regional PM modeling studies throughout the U.S. In these plots, monthly fractional bias and error statistics by site and month are plotted in relation to the respective monthly-averaged observed concentrations (i.e., each plotted point represents bias or error for one site and one month). Sites are color-coded by network to facilitate comparison among networks. The PM performance goals and criteria values are also plotted to show how the field of bias/error points fall within these ranges. As noted earlier, VISTAS proposed that these goals/criteria vary as a function of observed concentration, such that below 2 $\mu g/m^3$, they expand exponentially to 200 percent (the maximum of fractional bias and error) at zero observed concentrations. Hence these goal/criteria lines take on a “bugle” appearance at low concentrations, giving more leeway for a wider range of acceptable model performance.

Figure 6-4. PM Monitoring Sites within the 4 Km Modeling Domain



Appendix F, Figure 2 presents monthly fractional error/bias performance for total and speciated $PM_{2.5}$ concentrations in the form of bugle plots. Only sites within the 4-km grid are evaluated. In terms of total $PM_{2.5}$, the model performs well except for a few months at IMPROVE sites, which show an under prediction tendency. Typical of the cleaner western U.S., observed total $PM_{2.5}$ concentrations do not exceed 10 $\mu g/m^3$ on a monthly basis.

The best performing PM species is sulfate, which is well within acceptance goals for the entire year and for both networks. Nitrate is observed at very low concentrations, and CAMx shows a wide range of over and under predictions for this relatively unimportant PM component. Ammonium is driven primarily by the sulfate concentrations, and is replicated rather well with perhaps a tendency for under prediction. Elemental carbon shows an under prediction bias, but at very low concentrations and is not important for the overall PM mass budget, Since there is no chemistry involved with elemental carbon, its performance is entirely related to inaccuracies in emissions characterization and dispersion. Our largest concern is the under prediction of organic carbon, a component that dominates the $PM_{2.5}$ mass budget. Several months are outside the performance goals, primarily in late spring and early summer. Developmental CAMx simulations were undertaken to evaluate the impact of adding wildfires as a potentially large source of this component. While the additional fire emissions improved performance some, the statistical gains were marginal at best. As stated earlier, the science of organic aerosol chemistry is complex and currently not well characterized in models. The remaining component “soil”, which is a catch-all for all remaining fine PM dominated by crustal components, is rooted mostly in wind-blown dust emissions in the western U.S. It too comprises a large fraction of the mass budget (on par with sulfate), and although it exhibits an under prediction tendency, soil is generally well replicated given the obvious uncertainties in emission estimates.

6.2.3 Conclusions Regarding the CAMx Model Performance Evaluation

As part of the modeling analysis, a compressive evaluation of the CAMx model was conducted which compared model predictions to ambient air measurements. With the exception of organic carbon, the CAMx model exceeded EPA model performance guidelines.

7.0 ASSESSMENT OF AIR QUALITY IMPACTS

7.1 Near Field Impacts

7.1.1 NAAQS

A modeling analysis of total cumulative air quality impacts was performed to demonstrate that the combined effects of the proposed action (and alternatives), existing (including permitted but not operating sources), and other RFS would not violate NAAQS. Total pollutant concentrations were represented by adding the maximum measured background pollutant concentrations for a given averaging period to the maximum predicted concentrations for determining compliance with the NAAQS. Compliance with the 1 hour and 8 hour CO standards as well as annual NO_2 standards was demonstrated.

Carbon Monoxide

Modeling was conducted to demonstrate compliance with the CO 1 hour NAAQS of 40,000 μg/m^3 and the 8 hour NAAQS of 10,000 μg/m^3 (Table 7-1). Modeling was performed for the base case and 2018 year proposed action and no action. As indicated in Table 7-1, the maximum predicted CO impacts were 2,135 *u*g/m^3 (approximately 6 percent of the 40,000 *u*g/m^3 1-hour standard). Comparison of the 2005 base case and the no action cases indicated that there is a 1,034 *u*g/m^3 reduction in peak 1 hour CO impacts. For the proposed action the reduction compared to base case is 598 *u*g/m^3.

For 8 hour CO the maximum predicted concentrations for the 2005 base case are 2,755 *u*g/m^3 (approximately 28 percent of the 40,000 *u*g/m^3 1-hour standard). Comparison of the 2005 base case to the no action case indicates a 227 *u*g/m^3 reduction in predicted impacts. Comparison of the 2005 base case and the proposed action indicates a reduction in maximum predicted CO concentrations of 131 *u*g/m^3.

Nitrogen Dioxide

Table 7-2 presents the maximum predicted direct and cumulative (including other existing sources, RFS and background) concentrations where the proposed action sources would have their maximum impacts. As indicated in this table, the cumulative impacts are well below the applicable NO_2 annual NAAQS of 100 *u*g/m^3. There is a 1ug/m^3 reduction in annual NO_2 impacts between the 2018 cases and the 2005 baseline. In addition, predicted concentrations are below the PSD II NO_2 increment. This finding is consistent with the NO_2 increment analysis preformed by CDPHE (1999).

Table 7-1. Maximum Predicted CO Near Field Impacts

	2005 ($\mu g/m^3$)	No Action ($\mu g/m^3$)	Proposed Action ($\mu g/m^3$)
Maximum Direct 1-hour Impact	2,136	1,101	1,537
EPA Cumulative Significance Threshold	2,000	2,000	2,000
Maximum 1-hour Background	2,286	2,286	2,286
Total 1-hour Impact	4,422	3,387	3,823
1-hour NAAQS	40,000	40,000	40,000
Location of Maximum 1-hour Impact UTM Easting (m) UTM Northing (m)	 243,350 4,108,600	 250,000 4,124,900	 250,000 4,124,900
Date	97-10-22-01	97-10-22-01	97-10-22-01
Maximum Direct 8 hour Impact	469	242	338
EPA Cumulative Significance Threshold	500	500	500
Maximum 8 hour Background	2,286	2,286	2,286
Total 8 hour Impact	2,755	2,528	2,624
8 hour NAAQS	10,000	10,000	10,000
Location of Maximum 8 hour Impact UTM Easting (m) UTM Northing (m)	 246,700 4,101,900	 246,700 4,101,900	 246,700 4,101,900
Date	97-01-19-08	97-01-19-08	97-01-19-08

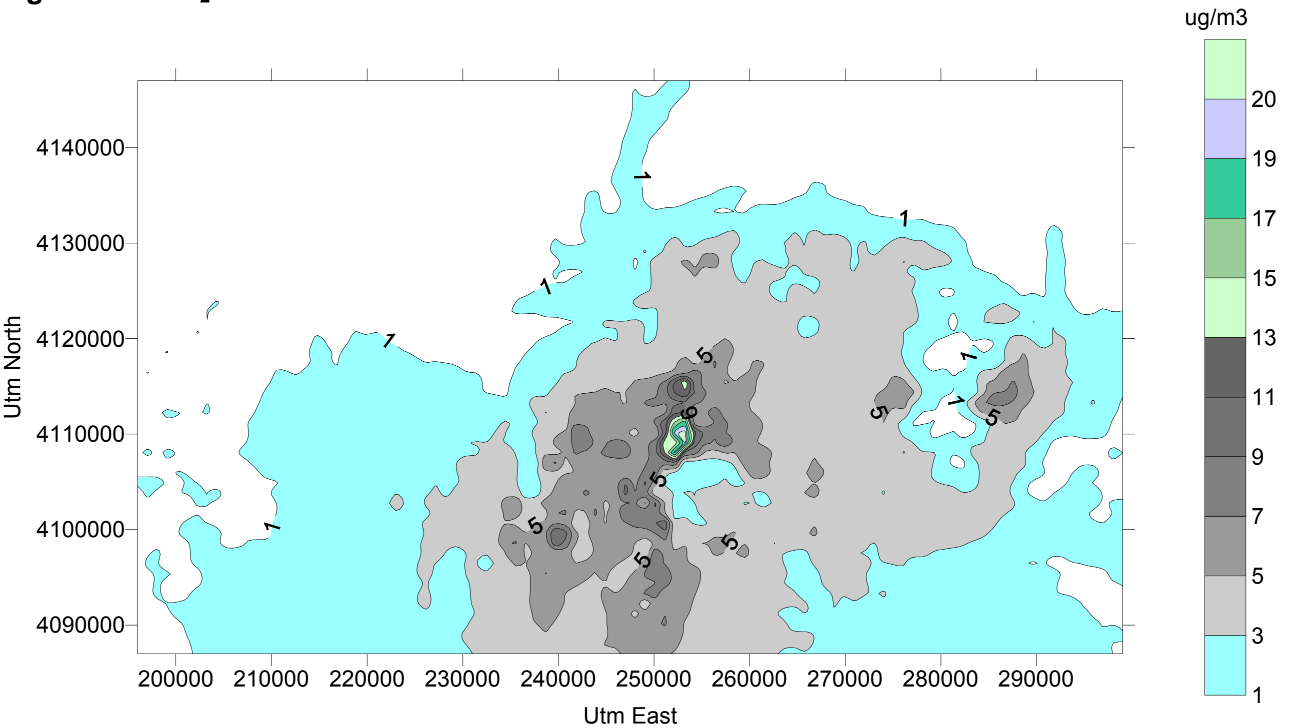
UTM - Universal Transverse Mercator

Table 7-2. Maximum Predicted NO_2 Near Field Impacts (µg/m3)

	2005 Baseline ($\mu g/m^3$)	No Action ($\mu g/m^3$)	Proposed Action ($\mu g/m^3$)
Maximum Direct Annual Impact (2)	23.5	22.8	22.8
SUIT Source impacts	9.4	5.4	6.7
PSD Class II Increment	25	25	25
Maximum Annual Background	**9.4**	9.4	9.4
Total Annual Impact	32.9	32.2	32.2
Annual NAAQS	100	100	100
Location of Maximum Annual Impact UTM Easting (m) UTM Northing (m)	 253,000 4,112,000	 288,400 4,112,800	 288,400 4,112,800

Figure 7-1 presents NO_2 concentrations for the 2005 Base Case and as indicated by this plot, maximum predicted concentrations are very localized.

Figure 7-1. NO_2 Contour Plot of 2005 Baseline Concentrations



7.1.2 PSD Increment Values (Proposed Action and Alternatives)

Near field modeling was also conducted to compare predicted impacts from the proposed action directly to PSD Class II increments. Given the lack of detailed engineering data available for this PEA analysis, as well as information regarding which existing sources actually consume the increments, a rigorous PSD analysis is not possible. Further, BLM does not have the regulatory authority to conduct such an analysis. This comparison was made to indicate potential significance only and is not intended to be a regulatory PSD increment consumption analysis.

The regulatory authority responsible for administrating the PSD program is also responsible for performing a detailed increment analysis and such an analysis would be based on established baseline conditions, permit application data and existing increment consuming sources, but not sources that are simply undergoing NEPA review. Because this is not a regulatory PSD increment analysis, these results are presented for disclosure purposes only.

As indicated in Table 7-2, predicted concentrations for the 2005 Base Case, the No Action and Proposed Action are less than the PSD Class II Increment.

7.1.3 Incremental Risk from HAPs

As previously stated because the gas produced is CBM, the only HAP that would be emitted from the sources associated with the proposed action is formaldehyde. Maximum cumulative concentrations of formaldehyde associated with the proposed action were used to evaluate incremental health risks. This analysis focused on the potential incremental cancer risk to the most likely exposed (MLE) and the maximum exposed individual (MEI). Long-term (annual average) formaldehyde concentrations were adjusted for the expected project lifetime and were the multiplied by EPA's formaldehyde unit risk factor to obtain an estimate of incremental cancer risk which reflects the maximum potential incremental risk, but does not represent the total risk to any particular individual.

The incremental cancer risk was based on the maximum predicted annual average formaldehyde concentration and EPA's unit risk factor of 1.3×10^{-5} (EPA 2003c). The resulting estimated MLE and MEI incremental cancer risks were compared against the cancer risk threshold range of 1 to 100×10^{-6}, (e.g.; 10^{-4} to 10^{-6}). The cancer risk values were also adjusted to account for duration of exposure and time spent at home as detailed below. The EPA MLE criterion assumes that a person would be exposed to the maximum concentration continuously for a period of 70 yr. The criterion allows for an adjustment to reflect the normal years of occupancy at a specific residence.

For the MLE scenario, the exposure duration is assumed to be 9 years which corresponds to the mean duration that a family remains at a single residence (EPA 1992). The resulting MLE residency adjustment factor for 9 yr ÷ 70 yr is 0.129. A second daily exposure factor accounts for the percentage of time during any given day that a potentially exposed person is at home. The analysis assumed a maximum "at home" exposure fraction of 0.64. During the remainder of the day, it was conservatively assumed the same individual would be exposed to 25 percent of the maximum concentration. Therefore, the MLE daily exposure adjustment factor was [(0.64 x (1.0)] + [(0.36) x (0.25)], or 0.73. Combining the two adjustment factors for the MLE scenario results in an overall adjustment value of 0.0939 (0.129 x 0.73).

For the MEI scenario, the exposure duration was assumed to be the life of a typical natural gas well, or 20 yr. Thus, the MEI residency adjustment factor was 20 yr ÷ 70 yr, or 0.286. For the MEI scenario, it was conservatively assumed that a person would remain at home 24 hours per day for the entire 20 yr production period; therefore the daily adjustment factor was 1.0. Combining the two adjustment factors for the MEI scenario results in an overall adjustment value of 0.286 (0.286 x 1.0).

To calculate the incremental cancer risk for the MLE and MEI scenarios, the maximum annual predicted formaldehyde concentration was first multiplied by EPA's unit risk factor and then by the appropriate overall adjustment values. The maximum annual formaldehyde concentration was predicted to be 5.1 $\mu g/m^3$ for the 2005 base case. Therefore, the calculated MLE and MEI values became 6.2×10^{-6} and 19×10^{-6}, respectively, which are both within the acceptable 1 to 100×10^{-6} range of risk impacts. For the No Action Case the maximum predicted concentration was 2.9 ug/m^3, the MLE was 3.6×10^{-6} and the MEI was 11×10^{-6}. For the proposed action the maximum predicted concentration was 3.6 ug/m^3, the MLE was 4.4×10^{-6} and the MEI was 13×10^{-6}.

Estimated incremental risks for the 2005, 2018 Alternative 1, and 2018 Alternative 2 are presented in Table 7-3 and are at the lower end of the EPA risk criteria. It should be noted that the maximum predicted concentrations and incremental risk estimates are very localized at facility boundaries. In addition, the calculated incremental risk shows a reduction over the 2005 baseline conditions.

Table 7-3. Maximum Predicted Incremental Cancer Risks by Alternative

Alternative	Maximum conc. ($\mu g/m^3$)	UTM Easting (m)	UTM Northing (m)	Unit Risk Factor	MLE Exposure factor	MEI Exposure Factor	Total MEI Risk	Total MLE Risk
2005 Base Case	5.1	246,700	4,101,900	1.30×10^{-5}	0.0939	0.286	1.9×10^{-5}	6.2×10^{-6}
No Action	2.9	246,700	4,101,900	1.30×10^{-5}	0.0939	0.286	1.1×10^{-5}	3.6×10^{-6}
Proposed Action	3.6	246,700	4,101,900	1.30×10^{-5}	0.0939	0.286	1.3×10^{-6}	4.4×10^{-6}

7.2 Air Quality Impacts: Far Field Analysis

In this section we summarize results of the CAMx modeling of air quality impacts over the "4 km" modeling domain depicted in Figure 3-17. CAMx results for the 2005 base case scenario, the 2018 "no action" scenario, and the 2018 "full infill" or "proposed action" scenario as described in Section 3 were used in this analysis. The 2005 base case scenario modeling used for this analysis is identical (same emission inventory and same modeling methodology) to the Four Corners modeling analysis being conducted for the Four Corners Air Quality Task Force. For the future year scenarios, the same modeling methodologies and emission inventories were used as in the Four Corners future year modeling except that the inventories included forecasted changes in SUIT emissions sources for the no action and proposed action scenarios.

Atmospheric chemistry resulting in ozone and secondary PM formation from directly emitted precursor species is complex and non-linear and as a result it is necessary to perform modeling that accounts for the cumulative changes in emissions at all sources within the region. Increases in emissions of ozone and PM precursors can result in disproportionate changes in ozone and secondary PM. Under certain conditions, precursor emission increases can even result in decreases in ozone and some secondary PM species. For this analysis it is important to note that oil and gas emissions within the SUIT boundaries for the no action scenario are less than SUIT emissions under the 2005 base case scenario. There is an increase in SUIT emissions under the proposed action scenario relative to the 2018 no action scenario but emissions under the proposed action scenario are still lower than the 2005 base case. By contrast, it was estimated that total regional emissions would increase based on economic growth and other forecast indicators (i.e., EIS RODs). While emission increases expected in future years under the 80 acre infill project would by themselves produce one set of changes in ozone and PM, emission changes in other sources in the Four Corners region occurring during the same time period will alter the impact of the 80 acre infill project. Thus, we consider here air quality impacts (i.e., changes in pollutant concentrations and their impacts on air quality related values including visibility and acid deposition) for three scenarios:

1. The "no action impact" which is based on the difference between air quality conditions estimated under the 2018 no action scenario and the 2005 base case scenario,

2. The "cumulative project impact" which is based on the difference between air quality conditions predicted under the 2018 full infill scenario and the 2005 base case, and

3. The "incremental project impact" which is based on the difference between air quality conditions predicted under the 2018 full infill scenario and the 2018 no action scenario.

For reasons noted above, these air quality changes are not additive: the difference between the cumulative project impact and the no action impact is in general *not* equal to the incremental project impact. The incremental project impact reflects air quality changes resulting solely from emission increases estimated to be associated with the full infill scenario *and these changes are expressed within the context of emissions from all other sources projected for 2018*. On the other hand, the cumulative project impact reflects air quality changes resulting not only from the 80 acre infill project emissions but also from changes in emissions from all other sources which are projected to occur between 2005 and 2018 within the 4, 12, and 36 km modeling domains.

7.2.1 National Ambient Air Quality Standards

Incremental and cumulative project impacts were analyzed in reference to the National Ambient

Air Quality Standards (NAAQS) for ozone and $PM_{2.5}$. In keeping with EPA guidance (EPA, 2007), model results were used in a relative manner to evaluate NAAQS attainment in areas where ambient ozone monitoring is conducted. This involved calculating relative reduction factors (RRFs) which are defined as the ratio of concentrations predicted under, for example, the 2018 full infill scenario to concentrations predicted under the 2005 base case. RRFs are then multiplied by *observed* design values (e.g., annual 4^{th} highest 8 hour average ozone concentration) taken from data collected at ambient monitoring sites to derive the predicted 2018 design value. The resulting estimated future year design value is then compared with the level of the NAAQS. EPA's Modeled Attainment Test Software (MATS, see Abt, 2008) was used to make these calculations. Detailed MATS procedures used in this analysis are described in Appendix E. Results for each pollutant are described below.

Ozone

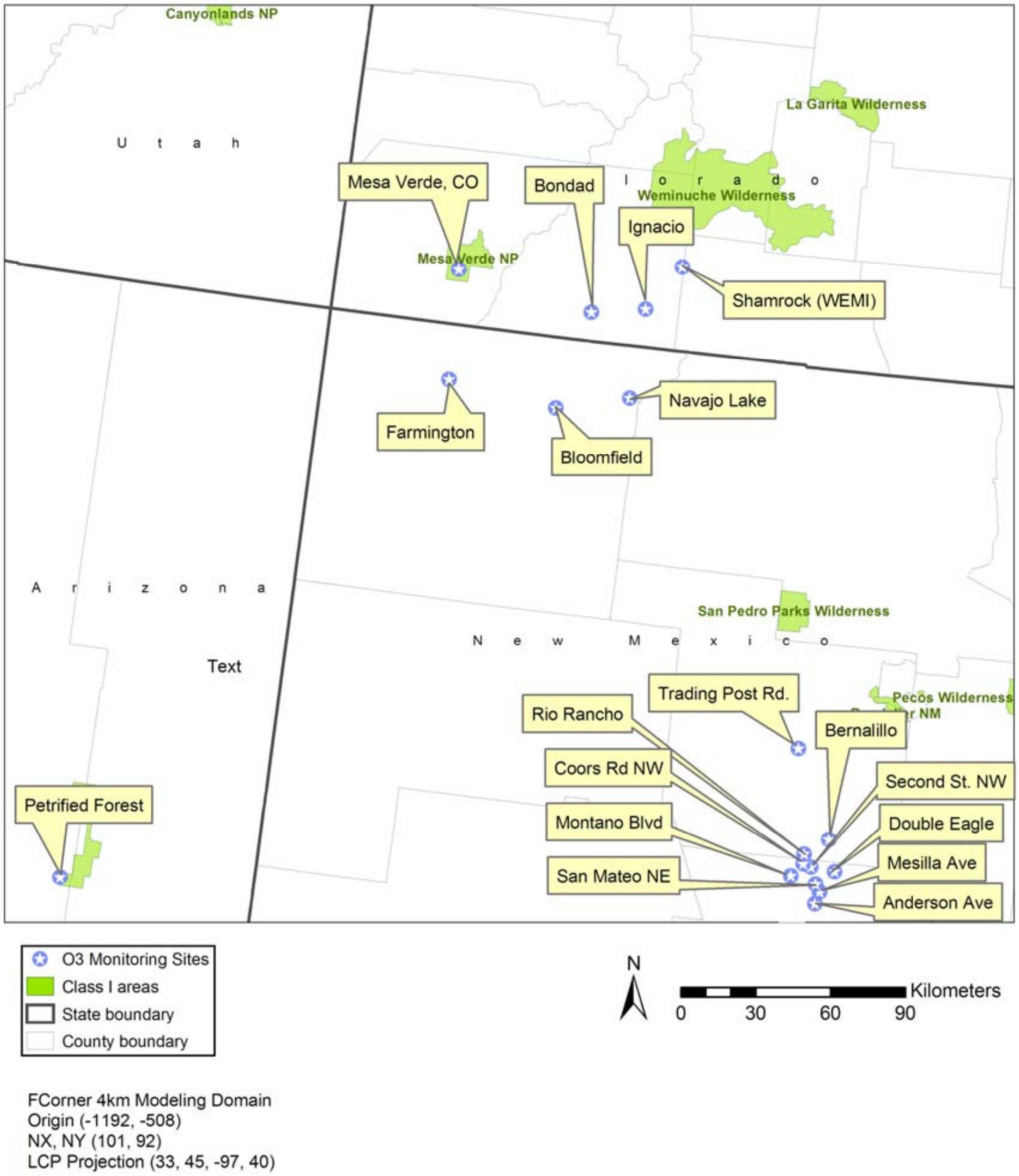
MATS was used to calculate ozone design values under both the 2018 full infill scenario and the 2018 no action scenario at ozone monitoring sites within the 4 km modeling domain. Ozone monitoring data used in this analysis are listed in Table 7-4; a map of the monitoring site locations is provided in Figure 7-2. Monitoring sites in highlighted rows in Table 7- 4 are those which are located in relatively close proximity to the proposed action emission sources. The majority of the remaining sites are located near Albuquerque are most likely influenced more by local emission sources than by sources from the proposed action. These other sites are located over 200 km away from the proposed action sources. Although the Navajo Lake monitor is listed in Table 7-4, this site was not operating prior to 2006 and therefore does not meet the EPA data completeness criterion for calculation of a predicted 2018 design value based on 2005 model results (EPA, 2007). In addition, the validity of data from this site has recently been called into question (Jones, 2009).

Table 7-4. Ozone Monitoring Sites within the 4 Km Domain Used in the Calculation of Predicted 2018 Ozone Design Values

Site ID	Site Name	County	State
04-017-0119	Petrified Forest	Navajo	CO
08-067-SHAM	Shamrock	La Plata	CO
08-067-7001	Ignacio	La Plata	CO
08-067-7003	Bondad	La Plata	CO
08-083-0101	Mesa Verde	Montezuma	CO
35-001-1012	Double Eagle School	Bernalillo	NM
35-001-1013	Second St. NW	Bernalillo	NM
35-001-1014	Coors Rd NW	Bernalillo	NM
35-001-0019	Mesilla Ave	Bernalillo	NM
35-001-0023	San Mateo NE	Bernalillo	NM
35-001-0024	Anderson Ave	Bernalillo	NM
35-001-0027	Montano Blvd	Bernalillo	NM
35-043-1001	Bernalillo	Sandoval	NM
35-043-1003	Rio Rancho	Sandoval	NM
35-043-9004	Trading Post Rd.	Sandoval	NM
35-045-0009	Bloomfield	San Juan	NM
35-045-0018	Navajo Lake	San Juan	NM
35-045-1005	Farmington	San Juan	NM

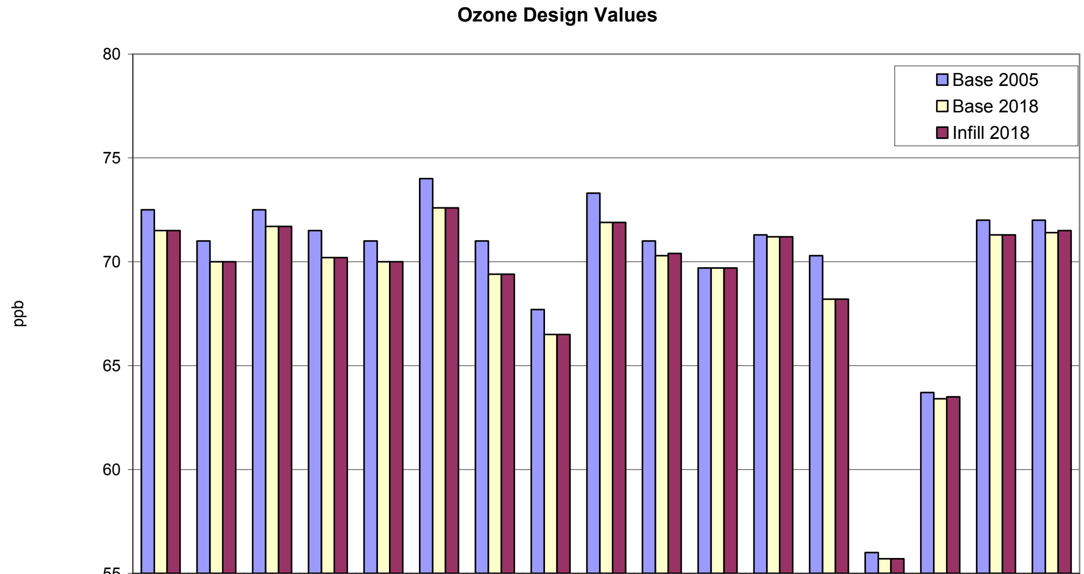
Note: Highlighted rows indicate monitors located in relatively close proximity to the proposed action emission sources.

Figure 7-2. Ozone Monitoring Sites in the 4 Km Domain



Design values predicted under the 2018 no action scenario and the 2018 full infill scenario using MATS are shown together with the *observed* base case design values in Figure 7-3. Design values are predicted to be lower under both the 2018 no action and the 2018 full infill scenario as compared to 2005 at all locations except at the Bloomfield (site 35-045-0009) where it is unchanged. In addition, there is almost no difference in predicted design values between the 2018 no action and full infill scenarios. Thus, model results show no significant impact on ozone design values from the 80 acre infill project and no new violations of the ozone NAAQS are expected under the full infill scenario.

Figure 7-3. Ozone 8 Hour Design Values as of 2005 (Observed) and as Predicted Using the MATS Methodology Under the 2018 No Action and 2018 Full Infill Scenarios



Site ID	35001 0019	35001 0023	35001 0024	35001 0027	35001 1012	35001 1013	35001 1014	35043 1001	35043 1003	35043 9004	35045 0009	35045 1005	40170 119	80677 001	80677 003	8067S HAM	80830 101
Base 2005	73	71	73	72	71	74	71	68	73	71	70	71	70	56	64	72	72
Base 2018	72	70	72	70	70	73	69	67	72	70	70	71	68	56	63	71	71
Infill 2018	72	70	72	70	70	73	69	67	72	70	70	71	68	56	64	71	72

Site ID

Note: Values in table are rounded to nearest ppb; see Table 7- 4 for a key to the Site IDs.

Ozone Increments at Unmonitored Locations

EPA[35] provides guidance on estimating future year ozone design values at potential "hot spots" within the modeling domain where monitoring data are not available. This procedure, which is also implemented via MATS, is based on the spatial interpolation of monitored design values using spatial gradients in the predicted field of ozone concentrations. While this procedure may be appropriate in an urban area with a dense network of ozone monitors, spatial interpolation of data over the complex terrain within the large, sparsely monitored Four Corners region can lead to highly questionable results. For this reason the MATS unmonitored attainment test was not used to estimate 2018 design values at unmonitored locations within the 4 km modeling domain. Instead, summaries of model results interpreted in an absolute sense (i.e., without use of RRFs) were generated to highlight the impact of the 80 acre infill project and the impact of emissions changes projected between 2005 and 2018 on ozone levels throughout the 4 km domain.

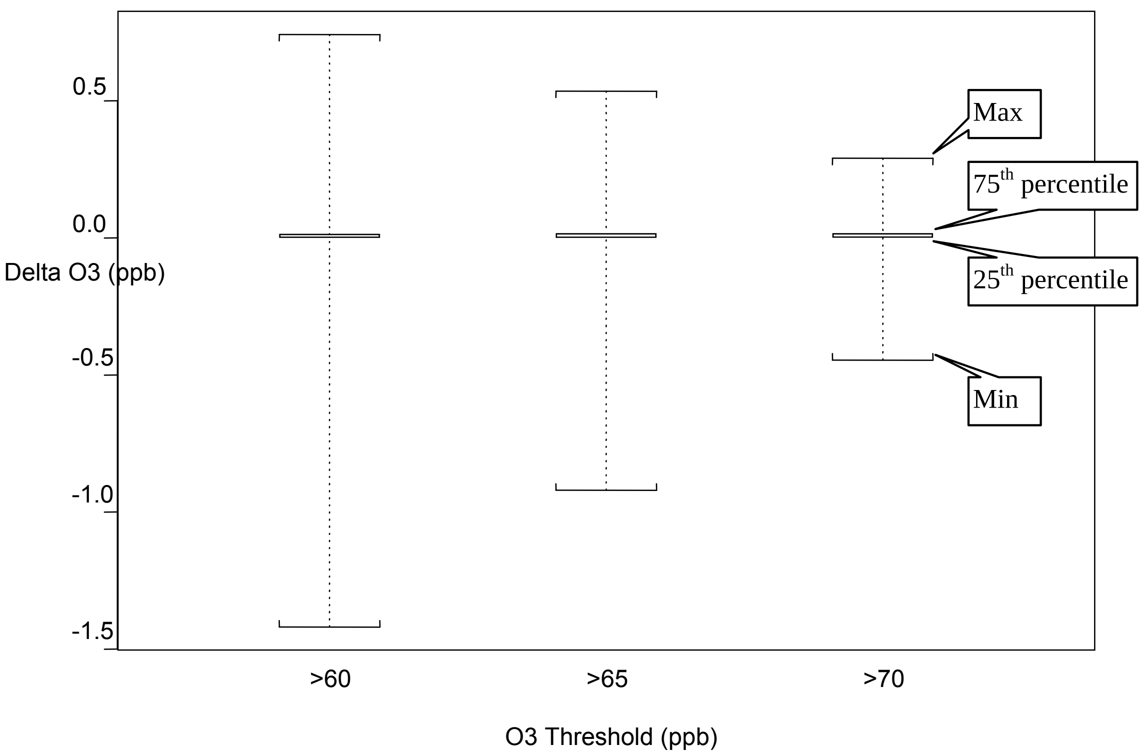
Predicted increments in daily maximum 8 hour ozone concentrations between the 2018 full infill scenario and the 2018 no action scenario are summarized in Figures 7-4 and 7-5. These figures are based on the predicted ozone change for all grid-cell-days in the 4 km domain for which ozone exceeds 60 ppb under the 2018 no action scenario. Side-by-side box plots in Figure 7-4 show the distribution of ozone increments for all grid-cell-days with ozone greater than 60 ppb, 65 ppb and 70 ppb. The maximum ozone increase over all grid-cell-days > 60 ppb is 0.7 ppb whereas the

[35] EPA, 2007, "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze" EPA454/B-07-002, April 2007.

maximum over all grid-cell-days > 70 ppb is 0.3 ppb. In other words, the maximum predicted ozone increment on high ozone days associated with the proposed project is particularly small (less than 1 percent of the NAAQS). This is further illustrated in Figure 7-5 which presents the same results in the form of a scatter plot and shows that the maximum increments are nearly all less than 0.5 ppb. Negative ozone increments represent situations in which NO emissions from the proposed project retard ozone formation under VOC limited conditions.

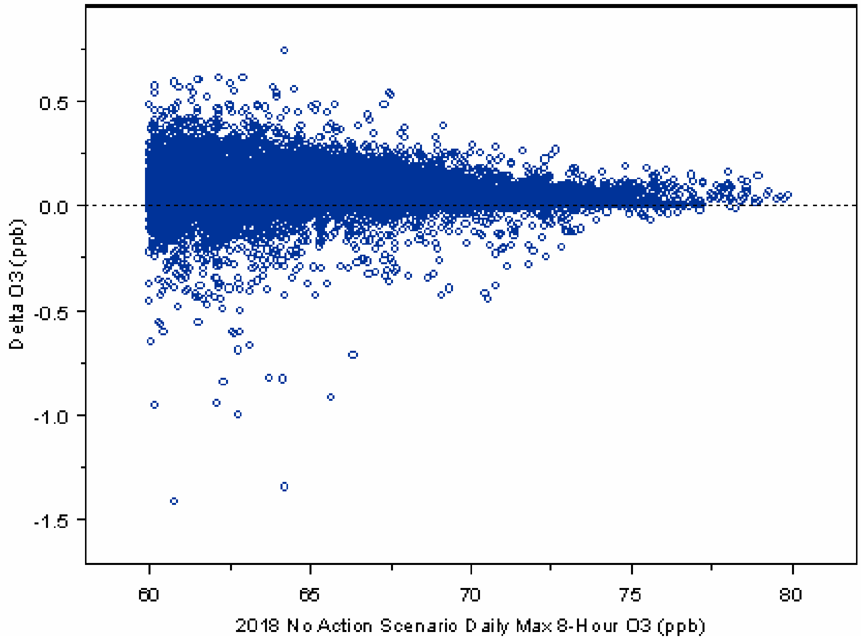
A similar analysis of predicted ozone increments between the 2005 base case and the 2018 no action scenario is presented in Figures 7-6 and 7-7. These results show that ozone increments associated with emission changes between 2005 and the 2018 no action scenario, while at most a few ppb, are nevertheless significantly larger than the project ozone incremental impacts (i.e., difference between the 2018 infill and 2018 no action scenarios) shown in Figures 7-4 and 7-6. In other words, while ozone concentrations may increase by a few ppb on some days at some locations between 2005 and the 2018 no action scenario due to changes in emissions from various source categories, ozone increases associated with the proposed 80 acre infill project are extremely small. It is important to note that changes in emissions between the 2005 base case and the 2018 no action scenario include decreases in emissions from SUIT sources as well as increases in emissions from some other sources (see Section 3.2).

Figure 7-4. Box Plots Showing Distribution of Differences in Predicted Daily Maximum 8 Hour Ozone Concentrations



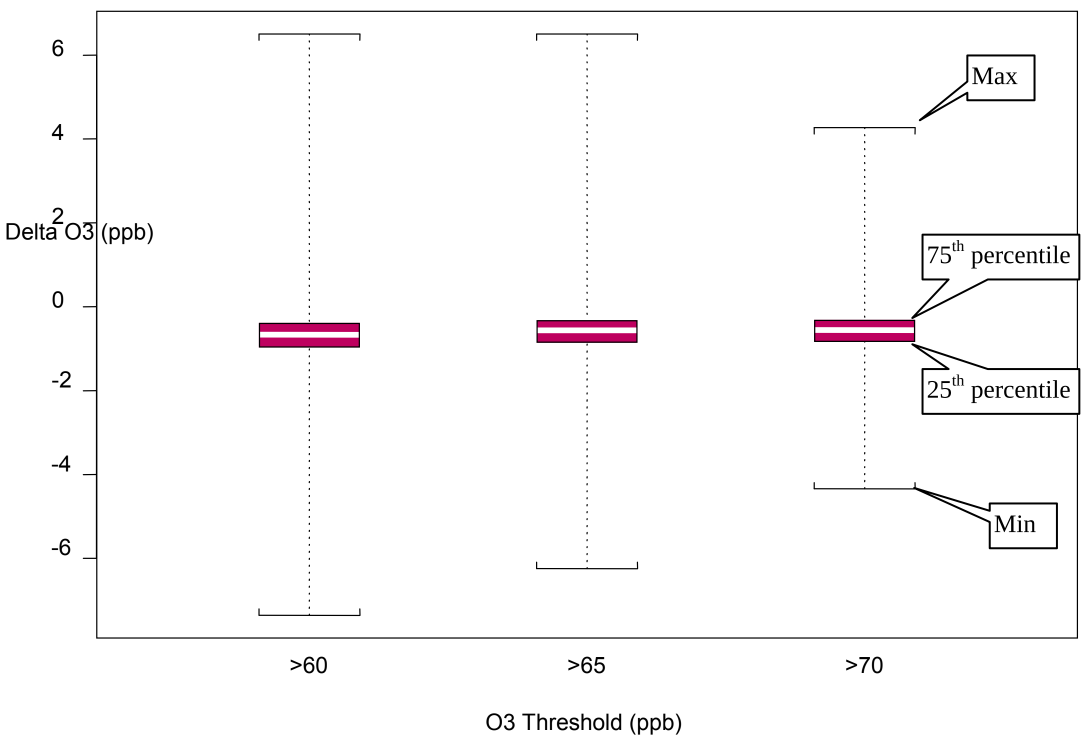
Note: Differences are paired in time and space: 2018 full infill scenario – 2018 no action scenario over the 4 Km domain for grid all grid-cell–hours with predicted 2018 ozone exceeding 60, 65 and 70 ppb.

Figure 7-5. Relationship of Predicted Increment in Daily Maximum 8 Hour Average Ozone



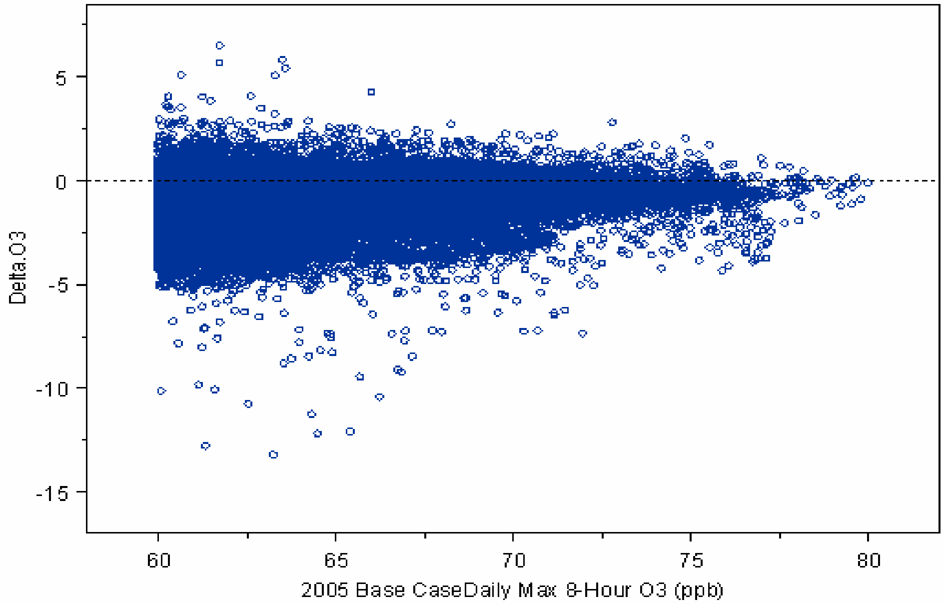
Note: Shown are differences (2018 full infill – 2018 no action) matched in time and space as a function of predicted ozone under the 2018 no action scenario.

Figure 7-6. Box Plots Showing Distribution of Differences in Predicted Daily Maximum 8 Hour Ozone Concentrations



Note: Paired in time and space: 2018 no action scenario – 2005 base case over the 4 km domain for grid all grid-cell-hours with predicted 2005 ozone exceeding 60, 65 and 70 ppb.

Figure 7-7. Relationship of Predicted Increment in Daily Maximum 8 Hour Average Ozone



Note: 2018 no action – 2005 base case to magnitude of predicted ozone under the 2005 base case (values matched in space and time).

The following figures present predicted ozone design values (annual fourth highest daily maximum 8-hour average concentration) in each 4 x 4 km model surface grid cell over the 4 km modeling domain (NM, CO, AZ, UT state and county boundaries are shown in each map). Figure 7-8 presents design values for the 2005 base case, the 2018 base case (no action) and the 2018 full infill scenario (proposed action).

Figure 7-9 presents the difference in design values between the 2018 base case (no action) and the 2005 base case, the 2018 full infill scenario and the 2005 base case and the difference between no action and full infill scenario. The difference plots are not paired in time.36 Several important conclusions can be reached from the difference plots. First, for the 2018 minus 2005 base case there is a general reduction in predicted ozone design values over the region. The same trend is observed for the difference between the 2018 infill development and the 2005 base case. The maximum predicted increase in design value for the 2018 infill case minus the 2018 no action is 0.03 ppb as indicted by the dark brown shaded cells just north of the AZ – CO border. In addition, over the majority of the modeling domain differences in predicted ozone design values between these two scenarios are negligible (less than ± 0.08 ppb).

[36] Day on which design values shown in top two figures occurs varies from one grid cell to the next, thus these maps represent a composite of many days. As a result, design values from which the differences shown in Figure 2 are computed are not matched in time. For example, the 2018 full infill scenario design value may occur on a different date than the 2018 base case design value in any given grid cell and the two dates can differ from one grid cell to the next.

Figure 7-8. Ozone Design Values in the Four Corners Area for Different Emission Scenarios as Part of the SUIT PEA

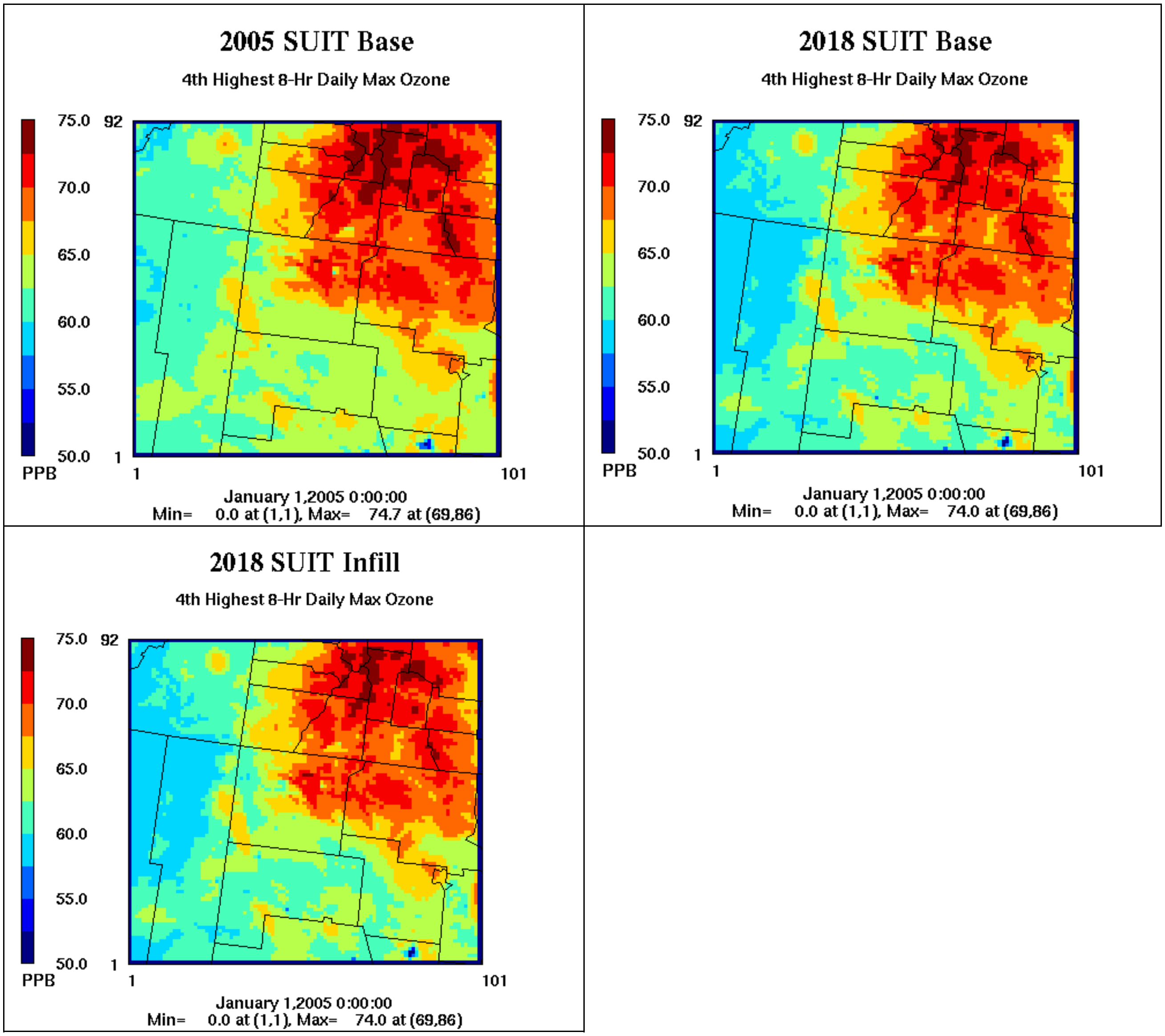
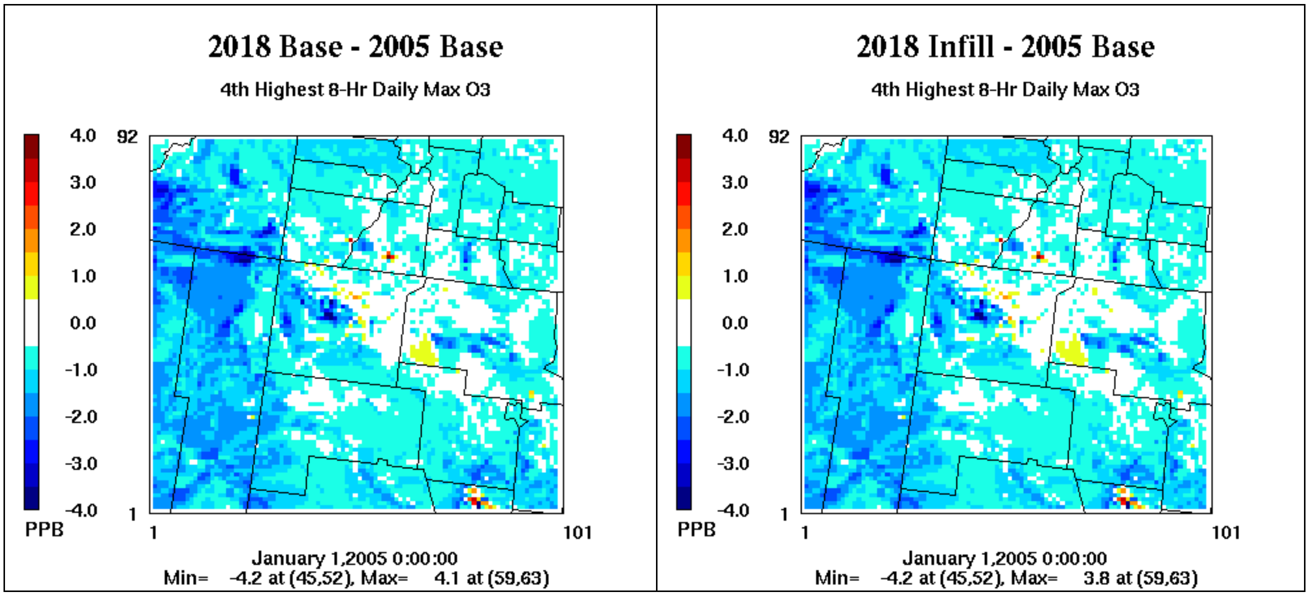


Figure 7-9. Difference in Ozone Design Values in the Four Corners Area for Different Emission Scenarios as Part of the SUIT PEA



$PM_{2.5}$

Future year (2018) $PM_{2.5}$ design values for both the no action and infill scenarios were estimated by applying RRFs to observed $PM_{2.5}$ design values using EPA's MATS methodology in a manner similar to the ozone analysis described above. PM monitoring sites used in this analysis are listed in Table 7-5; monitoring site locations are shown in Figure 7-10. Monitors located closest to the proposed project sources are highlighted in Table 7-5. Details of the MATS application are provided in Appendix E.

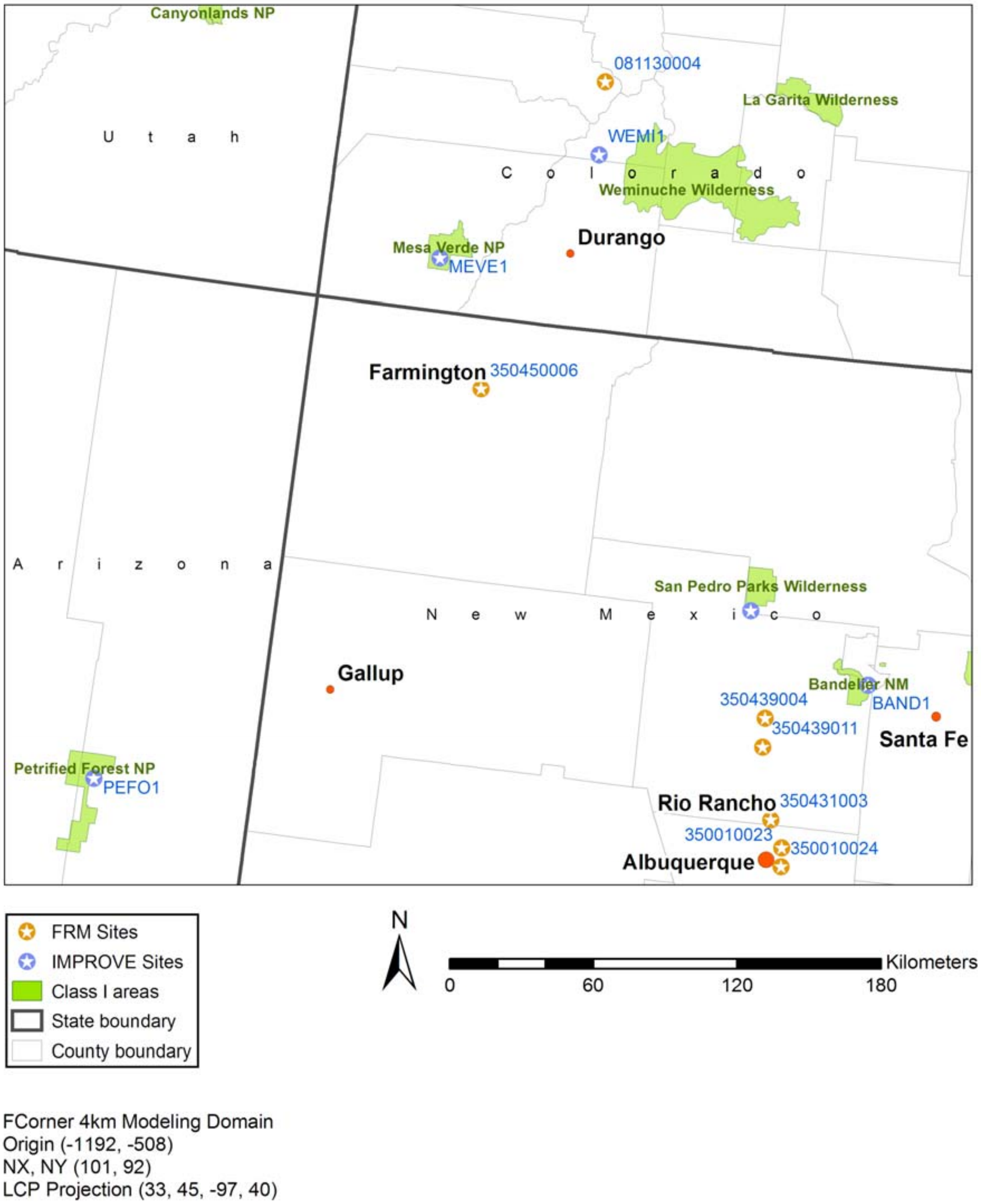
Table 7-5. PM Monitoring Sites within the 4 Km Domain Used in the Calculation of Predicted 2018 $PM_{2.5}$ Design Values

Site ID	Site Name	County	State	Type
08-111-WEMI1[a]	Weminuche	San Juan	CO	IMPROVE
08-113-0004	Telluride	San Miguel	CO	FRM
08-083-0101[a]	Mesa Verde	Montezuma	CO	IMPROVE
35-039-9000[a]	San Pedro Parks	Rio Arriba	NM	IMPROVE
35-BAND1[a]	Bandelier	Los Alamos	NM	IMPROVE
35-001-0023	San Mateo NE	Bernalillo	NM	FRM
35-001-0024	Anderson Ave	Bernalillo	NM	FRM
35-043-9011	Zia Pueblo	Sandoval	NM	FRM
35-043-1003	Rio Rancho	Sandoval	NM	FRM
35-045-0006	Animas (Farmington)	San Juan	NM	FRM
35-49-0020	Santa Fe	Santa Fe	NM	FRM
04-017-PEFO1[a]	Petrified Forest	Navajo	AZ	IMPROVE

[a]Used for speciation only.

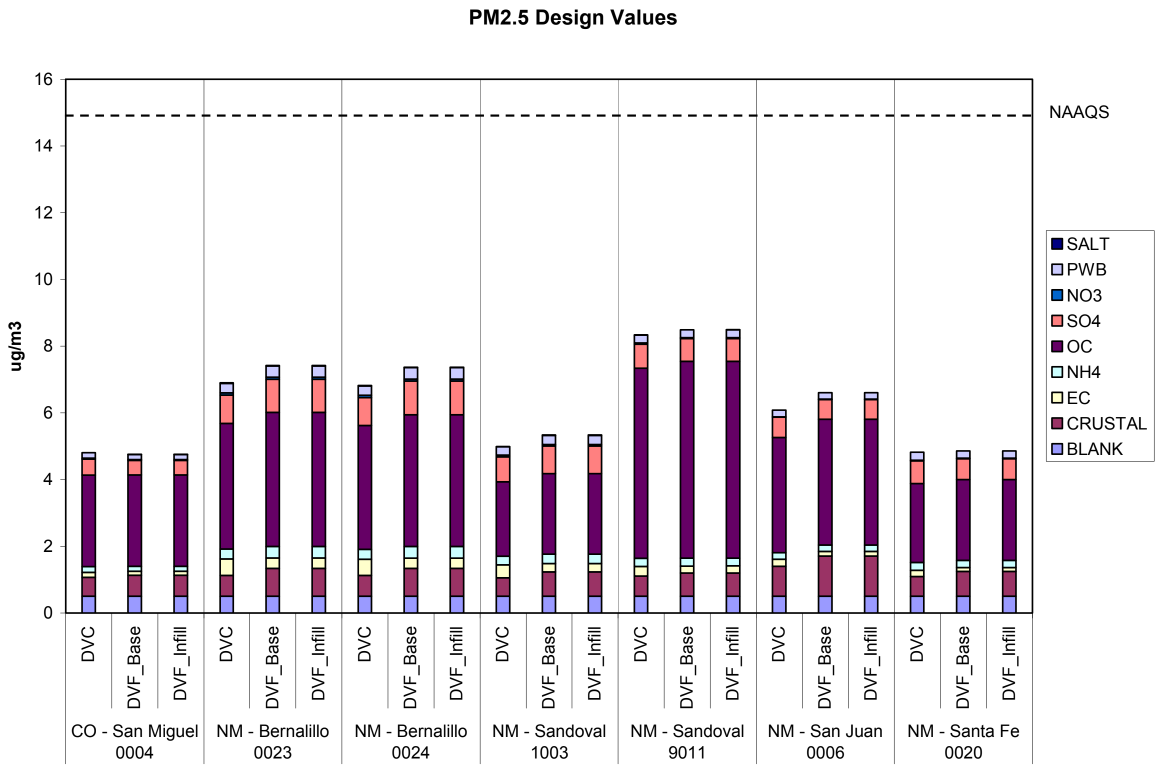
Note: Highlighted rows indicate monitors located closest to the proposed project sources – see Figure 7-10.

Figure 7-10. PM Monitoring Sites in the 4 Km Domain



Current (2005 base case) $PM_{2.5}$ annual design values (DVC) and projected future design values under the 2018 no action (DVF_Base) and full infill scenario (DVF_Infill) as computed by MATS are compared in Figure 7-11. All values are well below the 15 µg/m^3 NAAQS with relatively small changes between the 2005 base case and the 2018 full infill scenario.

Figure 7-11. $PM_{2.5}$ Annual Design Values at monitoring Sites in the 4 km Domain as Calculated by MATS for the 2005 Base Case



Note: Values denoted as DVC, the 2018 no action scenario (values denoted as DVF_Base) and the 2018 full infill scenario (values denoted as DVF_infill). Monitoring sites are listed in Table 7-5.

Note that MATS only computes PM design values at the FRM monitoring sites (see Figure 7-11) since only data from these sites are used to determine attainment of the PM NAAQS. Total $PM_{2.5}$ mass data collected at the IMPROVE sites is not comparable to the level of the NAAQS.

7.2.2 Incremental Concentration Impacts

In this section we present both the *cumulative incremental impacts* (concentrations predicted under the 2018 full infill scenario minus concentrations predicted under the 2005 base case) and *project incremental impacts* (concentrations predicted under the 2018 full infill scenario minus concentrations predicted under the 2005 base case) for PSD pollutants (SO_2, PM_{10}, NO_2) at locations within Class I areas located in the 4 km domain. Results for $PM_{2.5}$ are included here for the sake of completeness. Incremental impacts were computed for annual averages on a grid cell by grid cell basis for all grid cells within or partially covering each Class I area. Increments for 24 hour and 3 hour averages are also shown.

It should be noted that this comparison is not intended to be a complete regulatory PSD increment consumption analysis, but rather an assessment indicating that the PSD increments are not likely to be exceeded by the proposed 80 acre infill project. For any project requiring a PSD permit, the regulatory authority responsible for administrating the PSD program is responsible for performing a detailed increment analysis; such an analysis would be based on established baseline conditions, permit application data, and existing increment consuming sources, but not sources that are simply undergoing NEPA review. Because this is not a regulatory PSD increment analysis, these results are presented here for disclosure purposes only.

Because of the regional nature of the emission inventories used in the modeling and the fact that these inventories do not indicate if emissions are increment consuming sources (i.e., built after the baseline was set) it is not possible to compare model predictions to PSD increments. However, what can be concluded is because the incremental changes in predicted levels are small (2018 proposed action – 2018 no action as well as 2018 –2005 baseline), the likelihood of the proposed action exceeding the PSD increments is unlikely. Further a NO_2 increment consumption analysis conducted by CDPHE-APCD (1999) concluded that PSD increments were not exceeded.

Cumulative Increments

Maximum predicted *cumulative* increments over all Class I Areas within the 4 km domain are presented along with the maximum allowed PSD increments for purposes of comparison in Tables 7-6 through 7-10. These impacts represent predictions for the 2018 full infill scenario minus predictions for the 2005 base case. Predicted cumulative increment consumptions are all well below the allowable PSD limits with the exception of the maximum 24 hour PM_{10} increment (10 μg/m^3) which exceeds the maximum PSD limit (8 μg/m^3). However, the second highest predicted 24 hour PM_{10} increment (7.6 μg/m^3 – see footnote to table) is below the PSD limit.[37] In all cases, the maximum predicted cumulative increments occurred at Bandelier National Monument located near the southeastern corner of the 4 km domain approximately 200 km from the SUIT project sources; predicted increments at the other Class I Areas, including those areas closest to the SUIT lands, are much smaller. As shown below, the proposed 80 acre infill project itself is not projected to significantly impact PM_{10} concentrations in Bandelier (maximum 24 hour PM_{10} impact less than 0.1 μg/m^3 as shown in Table 7-8). It appears that the relatively large PM_{10} increment calculated at Bandelier is due to an increase in PM emissions from a source or sources within the local vicinity of this Class I Area and is not related to emissions on the Reservation.

A complete listing of maximum predicted cumulative increments by Class I Area is provided in Table 7-7 (annual averages), Tables 7-8 and 7-9 (24-hour averages) and Table 7-10 (3-hour averages). Note that negative increments represent increment expansion resulting from emission reductions projected to occur for some source categories between 2005 and 2018 (see Section 3.2).

Table 7-6. Maximum Predicted Cumulative Incremental impacts (μg/m^3) Over All Class I Areas within the 4 km Modeling Domain

	SO_2		PM_{10}		NO_2	
	Max Predicted	Max Allowed	Max Predicted	Max Allowed	Max Predicted	Max Allowed
Annual Avg	0.2	2	2.0	4	0.0	2.5
Max 24 Hour Avg	2.6[a]	5	10.0[c]	8	N/A	N/A
Max 3 hr Avg	7.7[b]	25	N/A	N/A	N/A	N/A

[a]Second highest value is 1.9 μg/m^3
[b]Second highest value is 6.1 μg/m^3
[c]Second highest value is 7.6 μg/m^3
Note: From all new sources and emission changes at existing sources under the 2018 full infill scenario relative to the 2005 base case as compared to maximum allowable Class I Area PSD increments.

[37] Second highest calculated as the spatial maximum of the second highest increments in each Class I area grid cell, i.e., the "high second high".

Table 7-7. Maximum Annual Average Cumulative Incremental Impacts in Class I Areas within the 4 km Modeling Domain

Class I Area	SO_2 (µg/m^3)	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	NO_2 (µg/m^3)
Bandelier	0.23	2.00	0.19	-0.11
Canyonlands	-0.07	-0.05	-0.07	-0.06
La Garita	-0.02	-0.05	-0.06	-0.02
Mesa Verde	-0.07	0.05	-0.05	-0.31
Petrified Forest	-0.49	-0.01	-0.10	-0.28
San Pedro Parks	-0.00	0.04	-0.04	-0.00
Weminuche	-0.02	-0.04	-0.05	-0.01

Note: From all new sources and emission changes at existing sources under the 2018 full infill scenario relative to the 2005 base case.

Table 7-8. Maximum 24 Hour Average Cumulative Incremental Impacts in Class I Areas within the 4 km Modeling Domain

Class I Area	SO_2 (µg/m^3)	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)
Bandelier	2.59	10.05	1.34
Canyonlands	0.28	0.40	0.32
La Garita	0.09	0.15	0.13
Mesa Verde	0.58	0.88	0.80
Petrified Forest	1.41	0.53	0.25
San Pedro Parks	0.47	0.52	0.49
Weminuche	0.26	0.29	0.27

Note: From all new sources and emission changes at existing sources under the 2018 full infill scenario relative to the 2005 base case.

Table 7-9. Second Highest 24 hour Average Cumulative Incremental Impacts in Class I Areas within the 4 km Modeling Domain

Class I Area	SO_2 (µg/m^3)	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)
Bandelier	1.89	7.58	1.28
Canyonlands	0.28	0.34	0.26
La Garita	0.08	0.11	0.10
Mesa Verde	0.55	0.70	0.27
Petrified Forest	1.20	0.51	0.21
San Pedro Parks	0.46	0.43	0.29
Weminuche	0.24	0.27	0.23

Note: From all new sources and emission changes at existing sources under the 2018 full infill scenario relative to the 2005 base case.

Table 7-10. Maximum and Second Highest 3 Hour Average Cumulative Incremental SO_2 Impacts in Class I Areas within the 4 km Modeling Domain

Class I Area	Highest SO_2 ($\mu g/m^3$)	Second highest ($\mu g/m^3$)
Bandelier	7.68	6.07
Canyonlands	1.59	0.96
La Garita	0.68	0.54
Mesa Verde	3.03	2.51
Petrified Forest	3.42	3.14
San Pedro Parks	2.84	1.65
Weminuche	1.24	1.16

Note: From all new sources and emission changes at existing sources under the 2018 full infill scenario relative to the 2005 base case.

Project Increments

Maximum *project* incremental impacts over all Class I Areas within the 4 km domain are presented along with the maximum allowed PSD increments for purposes of comparison in Table 7-11. These impacts represent predictions for the 2018 full infill scenario minus predictions for the 2018 no action scenario. These results show that the predicted Class I Area increment consumptions associated with the 80 acre infill project are extremely small, indicating that nearly all of the cumulative increment consumption shown in the preceding tables is due to emission increases not associated with the proposed action. A complete listing of maximum predicted project increments by Class I Area is provided in Table 7-12 (annual averages), Tables 7-13 and 7-14 (24 hour averages) and Table 7-15 (3 hour averages).

Table 7-11. Maximum Predicted *Project* Incremental Impacts (μg/m3) over all Class I Areas within the 4 km Modeling Domain.

	SO_2		PM_{10}		NO_2	
	Max Predicted	Max Allowed	Max Predicted	Max Allowed	Max Predicted	Max Allowed
Annual Avg	0.00	2	0.00	4	0.02	2.5
Max 24 Hour Avg	0.00	5	0.09	8	N/A	N/A
Max 3 hr Avg	0.00	25	N/A	N/A	N/A	N/A

Note: From all new sources and emission changes at existing sources under the 2018 full infill scenario relative to the 2018 no action scenario as compared to maximum allowable Class I Area PSD increments

Table 7-12. Maximum Annual Average Project Incremental Impacts

Class I Area	SO_2 ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)
Bandelier	0.000	0.000	0.000	0.001
Canyonlands	0.000	0.000	0.000	0.002
La Garita	0.000	0.000	0.000	0.001
Mesa Verde	0.000	0.001	0.001	0.023
Petrified Forest	0.000	0.001	0.000	0.000
San Pedro Parks	0.000	0.000	0.000	0.002
Weminuche	0.000	0.001	0.001	0.011

Note: 2018 full infill scenario – 2018 no project scenario in Class I Areas within the 4 km modeling domain.

Table 7-13. Maximum 24 Hour Average Project Incremental Impacts

Class I Area	SO_2 (μg/m^3)	PM_{10} (μg/m^3)	$PM_{2.5}$ (μg/m^3)
Bandelier	0.000	0.064	0.064
Canyonlands	0.000	0.050	0.050
La Garita	0.000	0.023	0.024
Mesa Verde	0.001	0.091	0.091
Petrified Forest	0.000	0.093	0.093
San Pedro Parks	0.000	0.055	0.055
Weminuche	0.000	0.054	0.054

Note: 2018 full infill scenario – 2018 no project scenario) in Class I Areas within the 4 km modeling domain.

Table 7-14. Second Highest 24 Hour Average Project Incremental Impacts

Class I Area	SO_2 (μg/m^3)	PM_{10} (μg/m^3)	$PM_{2.5}$ (μg/m^3)
Bandelier	0.000	0.061	0.061
Canyonlands	0.000	0.024	0.024
La Garita	0.000	0.017	0.017
Mesa Verde	0.000	0.082	0.082
Petrified Forest	0.000	0.062	0.062
San Pedro Parks	0.000	0.048	0.048
Weminuche	0.000	0.054	0.054

Note: 2018 full infill scenario – 2018 no project scenario in Class I Areas within the 4 km modeling domain.

Table 7-15. Highest and Second Highest 3 Hour Average Project Incremental Impacts

Class I Area	Highest SO_2 (μg/m^3)	Second highest SO_2 (μg/m^3)
Bandelier	0.000	0.000
Canyonlands	0.001	0.001
La Garita	0.000	0.000
Mesa Verde	0.002	0.001
Petrified Forest	0.001	0.000
San Pedro Parks	0.002	0.000
Weminuche	0.001	0.001

Note: 2018 full infill scenario – 2018 no project scenario in Class I Areas within the 4 km modeling domain.

7.2.3 Visibility Impacts

In this section we present both the cumulative incremental impacts and project incremental impacts on visibility levels in Class I Areas located within the 4 km modeling domain. Cumulative incremental impacts are based on the differences in concentrations of visibility reducing pollutants between the 2018 full infill scenario and the 2005 base case. Project incremental impacts are based on the differences in concentrations between the 2018 full infill scenario and the 2018 no action scenario. Incremental visibility changes were calculated using the revised IMPROVE extinction equation:

$b_{project}$ = 2.2 × fS(RH) × [Small Sulfate] + 4.8 × fL(RH) × [Large Sulfate]
+ 2.4 × fS(RH) × [Small Nitrate] + 5.1 × fL(RH) × [Large Nitrate]
+ 2.8 × [Small Organic Mass] + 6.1 × [Large Organic Mass]
+ 10 × [Elemental Carbon]
+ 1 × [Fine Soil]
+ 0.6 × [Coarse Mass]
+ 1.7 × fSS(RH) × [Sea Salt]
+ Rayleigh Scattering (Site Specific)
+ 0.33 × [NO2 (ppb)] {or as: 0.1755 × [NO2 (μg/m3)]}

Where:

[ ] indicates concentrations in $\mu g/m^3$
fS(RH) = Relative humidity adjustment factor for small sulfate and nitrate
fL(RH) = Relative humidity adjustment factor for large sulfate and nitrate
fSS(RH) = Relative humidity adjustment factor for sea salt
For Total Sulfate < 20 $\mu g/m^3$:
[Large Sulfate] = ([Total Sulfate] / 20 $\mu g/m^3$) × [Total Sulfate]
For Total Sulfate ≥ 20 $\mu g/m^3$:
[Large Sulfate] = [Total Sulfate]

And:

[Small Sulfate] = [Total Sulfate] – [Large Sulfate]
To calculate large and small nitrate and organic mass, substitute ({Large, Small, Total} {Nitrate, Organic Mass}) for Sulfate

The resulting light extinction coefficient, $B_{project}$, is then converted to the Deciveiw Haze Index scale measured in deciviews (dV):

$$DHI = 10 \ln(b_{project}/10)$$

Where:

ln = natural logarithm

Differences between different scenarios are then calculated as:

$$DHI\_{full\ infill} – DHI\_{noaction} =$$
$$10 \ln (B_{full\_infill}/10) – 10 \ln(B_{noaction}/10) =$$
$$10 \ln(B_{full\_infill}/ B_{noaction})$$

Monthly default values of f_s(RH),f_L(RH) and f_{SS}(RH) and annual Rayleigh extinctions for each Class I Area were obtained from FLAG Phase I Report—Revised (FLAG, 2008).

Maximum daily average visibility changes resulting from the cumulative incremental impact are summarized in Table 7-16 for the eight highest days during the year (the eighth highest day corresponds to the annual 98th percentile deciview change). Also listed in Table 7-16 are the project visibility increments on days corresponding to these eight highest cumulative increment days. In most cases, the project impact is a small fraction of the maximum cumulative impact, especially at Bandelier where the maximum cumulative impacts are predicted: the maximum cumulative impact days at Bandelier are not associated with any significant project impacts. Bandelier is the only Class I Area where the 98th percentile cumulative visibility impact exceeds 1 dV. Examination of model results shows that visibility reductions predicted at Bandelier appear to be associated with projected increases between 2005 and 2018 in PM or PM precursor emissions from local sources in the vicinity of Bandelier and not from the proposed project.

Maximum daily visibility impacts from the project increments (which in general occur on different days than the maximum cumulative impacts) are listed in Table 7-17. Project impacts are well below 1 dV at all Class I Areas. The maximum project impact (0.3 dV) is predicted to occur at Mesa Verde.

Table 7-16. Predicted cumulative visibility impacts (2018 full infill scenario visibility minus 2005 base case visibility) on eight highest days in each Class I Area and predicted project visibility impacts (2018 full infill scenario visibility minus 2018 no action scenario visibility) on the same days.

Class I Area	Date (month/day)	dV Change	
		Cumulative Increment	Project Increment
Bandelier	2/10	1.7	<0.05
	11/08	1.6	<0.05
	1/10	1.3	<0.05
	2/09	1.2	<0.05
	1/17	1.2	<0.05
	1/03	1.2	<0.05
	11/10	1.1	<0.05
	2/22	1.1	<0.05
Canyonlands	5/15	0.7	<0.05
	11/10	0.6	<0.05
	11/09	0.5	<0.05
	5/29	0.5	<0.05
	4/15	0.4	<0.05
	11/02	0.3	<0.05
	5/17	0.3	<0.05
	8/18	0.2	<0.05
La Garita	11/10	0.3	<0.05
	9/18	0.3	<0.05
	6/15	0.2	<0.05
	5/20	0.2	<0.05
	11/09	0.2	<0.05
	1/04	0.2	<0.05
	6/21	0.2	<0.05
	11/11	0.2	<0.05
Mesa Verde	5/05	0.2	<0.05
	11/10	0.1	<0.05
	6/21	0.1	<0.05
	7/22	0.0	<0.05
	9/03	0.0	<0.05
	10/02	0.0	<0.05
	11/11	0.0	<0.05
	2/23	0.0	<0.05
Petrified Forest	2/18	0.2	<0.05
	9/10	0.2	<0.05
	1/04	0.2	<0.05
	2/07	0.1	<0.05
	1/27	0.1	<0.05
	11/08	0.0	<0.05
	11/09	0.0	<0.05
	4/24	0.0	<0.05
San Pedro Park	5/01	1.7	<0.05
	2/11	1.0	<0.05
	5/25	0.8	<0.05
	7/20	0.7	<0.05

Class I Area	Date (month/day)	dV Change	
		Cumulative Increment	Project Increment
	11/10	0.5	<0.05
	11/09	0.5	<0.05
	7/07	0.5	<0.05
	5/27	0.4	<0.05
Weminuche	1/04	0.7	<0.05
	6/17	0.7	<0.05
	6/16	0.4	<0.05
	11/10	0.4	<0.05
	1/11	0.2	<0.05
	6/21	0.1	<0.05
	11/09	0.1	<0.05
	2/22	0.1	<0.05

Table 7-17. Maximum Predicted Daily Project Visibility Impacts (2018 Full Infill Scenario Visibility Minus 2018 No Action Scenario Visibility) on the Same Days

Class I Area	Date (Month/Day)	Project Impact (dV)
Bandelier NM	7/20	0.1
Canyonlands NP	1/21	0.1
La Garita Wild	9/27	0.1
Mesa Verde NP	12/25	0.3
Petrified Forest NP	8/26	0.1
San Pedro Park	5/13	0.1
Weminuche Wild	10/24	0.1

Note: Highlighted rows indicate areas located closest to the proposed project sources.

7.2.4 Deposition

Releases of certain nitrogen and sulfur pollutant species into the air can result in the deposition of acidic species to the earth's surface at downwind locations. This acid deposition can produce undesirable changes to water chemistry in certain water bodies that lack sufficient acid neutralizing capacity (ANC). Eleven lakes in Class I Areas within the 4 km modeling domain have been identified as being sensitive to acid deposition (BLM, 2002); all of these lakes are located within the Weminuche Wilderness. The potential for increased acidification of these sensitive lakes was evaluated by computing changes in total annual deposition of nitrogen (N) and sulfur (S) for a) cumulative impacts (2018 infill – 2005 base case) and b) project incremental impacts (2018 infill – 2018 no action). ANC changes were calculated using FS procedures (USDAFS, 2000). Since deposition is calculated by CAMx for a full set of nitrogen and sulfur species, all applicable acidic species were included in the deposition calculation rather than the more limited set of species included in acid deposition calculations based on CALPUFF model results. This results in a somewhat more conservative estimate of acid deposition as compared to a standard CALPUFF analysis.

Predicted changes in ANC were compared to acceptable limits established by the FS (Blett, 1999) for the Weminuche Wilderness Area (no more than a 10 percent change in ANC for those water bodies where the existing ANC is at or above 25 microequivalents per liter (µeq/l) and no more than a 1 µeq/l change for those extremely sensitive water bodies where the existing ANC is below 25 µeq/l. Results are shown for the cumulative impacts in Table 7-18 and for the project incremental impacts in Table 7-19. Cumulative changes (Table 7-18) are all negative (i.e., less than zero) indicating that emission reductions between the 2005 base case and the 2018 infill scenario are predicted to result in a *decrease* in the deposition of acidic species to the sensitive lakes. For the project incremental impacts (Table 7-19), the small emission increases associated with the proposed action are predicted to result in only minor decreases in ANC, all of which are well below the applicable significance thresholds.

Table 7-18. Predicted Change in Acid Neutralizing Capacity (ANC) of Sensitive Lakes due to Cumulative Impacts (2018 Infill – 2005 Base Case)

Sensitive Lake	Minimum Background ANC (μeq/l)	Predicted Change[b] (%)	Applicable Threshold (%)
Big Eldorado	0.885	-442.25	113.0%[a]
Four Mile Pothole	124.76	-3.15	10.0%
Lake Due South of Ute Lake	14.26	-27.73	7.0%[a]
Little Eldorado Lake	0.05	-7827.78	2000.0%[a]
Little Granite Lake	76.2	-6.29	10.0%
Lower Sunlight	4.55	-84.81	22.0%[a]
Middle Ute Lake	42.45	-8.11	10.0%
Small Pond Above Trout Lake	24.56	-15.37	4.1%[a]
Upper Grizzly	1.7	-229.47	58.8%[a]
Upper Sunlight	1.661	-235.87	60.2%[a]
White Dome Lake	0.144	-2684.06	694.4%[a]

[a] For sensitive lakes with minimum background AN C values less than 25 μeq/l, the threshold of concern is less than a 1 μeq/l reduction below the minimum background AN C value (e.g.; for Big Eldorado Lake, 1.13 x 0.885 μeq/l equals 1 μeq/l).
[b] A negative change indicates a net decrease in deposition of acidic nitrogen and sulfur species.

Table 7-19. Predicted change in acid neutralizing capacity (ANC) of sensitive lakes due to project incremental impacts (2018 infill – 2018 no action)

Sensitive Lake	Minimum Background ANC (μeq/l)	Predicted Change (%)	Applicable Threshold (%)
Big Eldorado	0.885	4.01	113.0%[a]
Four Mile Pothole	124.76	0.05	10.0%
Lake Due South of Ute Lake	14.26	0.44	7.0%[a]
Little Eldorado Lake	0.05	71.04	2000.0%[a]
Little Granite Lake	76.2	0.10	10.0%
Lower Sunlight	4.55	0.90	22.0%[a]
Middle Ute Lake	42.45	0.11	10.0%
Small Pond Above Trout Lake	24.56	0.27	4.1%[a]
Upper Grizzly	1.7	2.57	58.8%[a]
Upper Sunlight	1.661	2.64	60.2%[a]
White Dome Lake	0.144	24.36	694.4%[a]

[a] For sensitive lakes with minimum background AN C values less than 25 μeq/l, the threshold of concern is less than a 1 μeq/l reduction below the minimum background AN C value (e.g.; for Big Eldorado Lake, 1.13 x 0.885 μeq/l equals 1 μeq/l).

7.3 Construction Impacts

Estimated construction impacts are presented in Table 7-20. These model results were performed as part of the 2002 EIS and because no estimated changes in emissions were projected, these results are included in this analysis. $PM_{2.5}$ construction impacts were developed from the previous PM_{10} modeling results by ratioing the PM_{10} model predictions to the ratio of $PM_{2.5}/PM_{10}$ emissions. This maximum model estimate was added to an assumed background concentration of the average of the seventh highest measured $PM_{2.5}$ concentration over the period of 2005 through 2008. As indicated by this conservative screening calculation, construction impacts will not result in an exceedance of the $PM_{2.5}$ 24 hour NAAQS.

A direct comparison of the $PM_{2..5}$ impacts with the 24 hour standard is difficult because of the temporary nature of the construction emissions (3 days) and the fact that compliance with the short term standard references the 98th percentile concentration averaged over a 3-year period. Also, comparison with the annual standard is not meaningful.

Table 7-20. Summary of Predicted Maximum Pollutant Concentrations During Construction and Comparison with NAAQS

Pollutant	Averaging Period	SUIT Source (ug/m^3)	Background (ug/m^3)	Total Concen. (ug/m^3)	NAAQS (ug/m^3)	% of Standard	Location of Maximum		Time (MM/DAY/HR)
							X (m)	Y(m)	
$PM_{2.5}$	24-hour	7.9	8.75	16.6	35	48	804.44	674.82	1/25/2024
PM_{10}	24-hour	51.38	50.2	101.58	150	67.72	804.44	674.82	1/25/2024
SO_2	3-hour	130.6	58.57	189.17	1300	14.55	0	250	12/11/2006
SO_2	24-hour	30.14	23.96	54.1	365	14.82	170.84	115.39	12/14/2024

Note: The projected SO_2 impacts do not reflect the use of low sulfur diesel

7.4 Conclusions Regarding Air Quality Impact Analysis

The following conclusions can be drawn regarding potential air quality impacts of the proposed infill development

1. For NO_2, the proposed infill development results in a slight increase in ambient concentrations over the no action case, however, both the no action and the infill case result in a net reduction in ambient NO_2 concentrations compared to the 2005 base case.

2. While BLM has no regulatory authority regarding NO_2 PSD increments, the analysis indicates that for 2005 PSD increments are not exceeded and because of the decrease in emissions, future year PSD increment consumption will be less than in 2005

3. For ozone, photochemical grid modeling was conducted and it was concluded that the proposed action does not result in any new predicted exceedances of the 0.075 ppm daily maximum 8 hour ozone standard and does not significantly contribute to any predicted concentrations above the standard.

4. For Class I Area visibility, the proposed infill development does not result in predicted visibility impacts greater than 0.5 dV.

5. Predicted changes in Class I Area deposition as a result of infill development were less than FS established thresholds.

6. Predicted construction impacts of infill development are temporary and do not result in predicted exceedances of ambient air quality standards.

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Appendix A

Emission Inventory

1.0 SUIT 2005 Inventory

An inventory of oil and gas emissions was compiled by the Southern Ute Indian Tribe (SUIT, 2005) for the calendar year 2005. Oil and gas source categories in the Southern Ute inventory include drill rigs, compressors, heaters, other engines, venting, flaring, and process fugitives. ENVIRON reviewed that inventory and incorporated the emissions into the inventory used for this modeling project.

The starting point for defining the changes in oil and gas emissions as a result of the proposed 80 acre SUIT infill project was developing an accurate estimate of existing emissions against which changes in emissions as a result of the proposed infill project could be compared. The base case was defined as 2005. Compiling an accurate emission inventory for 2005 was complicated because neither the SUIT nor EPA currently has a minor source construction or operating permit program and thus there is no accurate record of emission sources on the reservation. In order to compile data regarding emissions, the SUIT contacted oil and gas operators within the reservation boundaries and requested data regarding emission sources within the area.

Existing Engine Emissions

In February 2007 the SUIT sent a questionnaire to all oil and gas operators regarding air emission sources within the boundaries of the reservation. The survey focused on emissions from natural gas fired engines (compressor, water disposal, etc.), natural gas processing plants and natural gas transmission facilities. The data requested were:

1. Company;
2. Site;
3. Location;
4. Type of equipment;
5. Site rated capacity;
6. Emission factors;
7. Type of air pollution controls;
8. Potential NOx and CO emissions; and
9. Actual NOx and CO emissions.

The survey was sent to 12 operators and all responded to the data request. The data request did not address the basis of the emission factors that were used to calculate emissions nor did it address consistency of data between operators for similar equipment. For example, in some cases the emission factor was based on source testing and in other cases emissions were based on manufacturer data or EPA emission factors. The data was reviewed for accuracy and any identified errors were corrected.

The operator survey provided estimates of emissions of NOx and CO for 2005 but did not provide emissions of hydrocarbons or formaldehyde. Instead, hydrocarbon emissions were calculated using the AP-42 emission factor of 1 g/hp-hour.[1] Formaldehyde

[1] EPA, 2000, AP-42 Fifth Edition, Volume I Chapter 3: Stationary Internal Combustion Sources http://www.epa.gov/ttn/chief/ap42/ch03/index.html

emissions were calculated using an emission factor of 0.2 g/hp-hour[2]. In the calculation of hydrocarbon and formaldehyde emissions, the calculated ratio of actual to potential emissions for NOx and CO was used to adjust potential emissions to represent 2005 actual conditions (for NOx the ratio of PTE to actual was 0.71 and for CO the ratio was 0.76 and the average of these was used for VOC and formaldehyde).

In February 2007 the SUIT sent a questionnaire to all oil and gas operators regarding air emission sources within the boundaries of the reservation. The survey focused on emissions from natural gas fired engines (compressor, water disposal, etc.), natural gas processing plants and natural gas transmission facilities. The data requested were:

10. Company;
11. Site;
12. Location;
13. Type of equipment;
14. Site rated capacity;
15. Emission factors;
16. Type of air pollution controls;
17. Potential NOx and CO emissions; and
18. Actual NOx and CO emissions.

The survey was sent to 12 operators and all responded to the data request. The data request did not address the basis of the emission factors that were used to calculate emissions nor did it address consistency of data between operators for similar equipment. For example, in some cases the emission factor was based on source testing and in other cases emissions were based on manufacturer data or EPA emission factors. The data was reviewed for accuracy and any identified errors were corrected.

Tables A-1 through A-3 present the SUIT 2005 emission inventory.

[2] EPA, 2000, AP-42 Fifth Edition, Volume I Chapter 3: Stationary Internal Combustion Sources http://www.epa.gov/ttn/chief/ap42/ch03/index.html

Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp-hr)	VOC Emission Factor (g/hp-hr)	HAP Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Potential HAP VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)	Actual HAP Emissions (t/yr)
El Paso Natural Gas Company	Bondad Compressor Station	37°05'52"	107°46'09"	Solar Centaur 50-6200L	6130	5,238					N/A (turbine)	92	23			49	1.6		
El Paso Natural Gas Company	Bondad Compressor Station	37°05'52"	107°46'09"	Solar Centaur 50-6200L	6130	5,238					N/A (turbine)	92	23			57	1.9		
El Paso Natural Gas Company	Bondad Compressor Station	37°05'52"	107°46'09"	Solar Centaur 50-6200LS	6130	5,238					N/A (turbine)	19	23			9	0.9		
						15,714					**Facility total**	**203**	**68**	**0**	**0**	**115**	**4**	**0**	**0**
XTO	Alamo CDP	37.06032	107.78859	Waukesha 5790GL	1272	1,158	1.5	2.3	1	0.22	lean burn	17	25.7	11.2	2.5	4	25.6	7.1	1.6
						1,158					**Facility total**	**17**	**26**	**11**	**2**	**4**	**26**	**7**	**2**
XTO	M.Smith U 1	37.04343	107.5835	3304 Cat n/a	95	73	16.72	2.3	1	0.22	rich burn	12	1.6	0.7	0.2	2	1.56	0.4	0.1
						73					**Facility total**	**12**	**2**	**1**	**0**	**2**	**2**	**0**	**0**
Universal	BOX CANYON BOOSTER	37.0132222	-107.7999722	Wauk VRG 330 (Arrow)	68	50	11	45	1	0.22	None	5	21.7	0.5	0.1	5	21.8	0.5	0.1
Universal	SUTE 33-10 #23-1 Mv	37.0939700	-107.9081600	Wauk VRG 330 (Arrow)	68	50	11	45	1	0.22	None	5	21.7	0.5	0.1	5	21.8	0.5	0.1
Universal	SUTE 33-10 #22-2 Mv	37.0940400	-107.9239100	Wauk VRG 330 (Arrow)	68	50	11	45	1	0.22	None	5	21.7	0.5	0.1	5	21.8	0.5	0.1
Universal	SUTE 33-10 #23-2 Mv	37.0935870	-107.8969230	Wauk VRG 330 (Arrow)	68	50	11	45	1	0.22	None	5	21.7	0.5	0.1	5	21.8	0.5	0.1
Universal	SUTE 33-10 #24-2 Mv	37.0851950	-107.8883990	Wauk VRG 330 (Arrow)	68	50	11	45	1	0.22	None	5	21.7	0.5	0.1	5	21.8	0.5	0.1
Universal	SUTE 32-7 #12-2 Mv	37.0359700	-107.5537200	Wauk VRG 330 (Arrow)	68	50	11	45	1	0.22	None	5	21.7	0.5	0.1	5	21.8	0.5	0.1
Universal	SUTE United 34-10 #35-1 Mv	37.1444800	-107.9065400	Wauk VRG 330 (Arrow)	68	50	11	45	1	0.22	None	5	21.7	0.5	0.1	5	21.8	0.5	0.1
Universal	CABIN COMP STATION #1	37.0414166	-107.9238055	G3512 LE CAT	810	766	2	1.6	1	0.22	LB	15	11.8	7.4	1.6	15	11.9	7.4	1.6
Universal	CABIN COMP STATION #2	37.0414166	-107.9238055	G3512 LE CAT	810	766	2	1.6	1	0.22	LB	15	11.8	7.4	1.6	15	11.9	7.4	1.6
Universal	DEER CANYON STATION	37.0514722	-107.8946388	G3412C LE	637	527	1	2	1	0.22	LB/AFRC	5	10.2	5.1	1.1	5	10.2	5.1	1.1
Universal	S UTE 32-10 #5-5 FC	37.0485300	-107.9533900	Waukesha F-18GL	433	350	2	1.7	1	0.22	LB	7	5.7	3.4	0.7	7	5.8	3.4	0.7

Table A-1. 2005 SUIT Inventory page 2 of 22

Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp-hr)	VOC Emission Factor (g/hp-hr)	HAP Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Potential HAP VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)	Actual HAP Emissions (t/yr)
Universal	SUTE 32-10 #6-4 FC	37.0510000	-107.9699700	Waukesha F-18GL	433	350	2	1.7	1	0.22	LB	7	5.7	3.4	0.7	7	5.8	3.4	0.7
Universal	SUTE 32-10 #10-6 FC	37.0286590	-107.9149080	Wauk H24GL HCR	530	420	2	1.7	1	0.22	LB	8	6.9	4.1	0.9	8	6.9	4.1	0.9
Universal	SUTE 32-10 #3-7 FC	37.0479710	-107.9144030	Waukesha F-18GL	433	350	2	1.7	1	0.22	LB	7	5.7	3.4	0.7	7	5.8	3.4	0.7
Universal	SUTE 33-10 #27-6 FC	37.0699830	-107.9183990	AJAX DPC-360	360	266	6.3	1.4	1	0.22	None	16	3.6	2.6	0.6	16	3.6	2.6	0.6
Universal	SUTE 33-10 #2-9 FC	37.0430350	-107.9051440	AJAX DPC-360LE	360	266	2	1.6	1	0.22	LB	5	4.1	2.6	0.6	5	4.1	2.6	0.6
Universal	SUTE 33-10 #34-5 FC	37.0574450	-107.9151170	AJAX DPC-600LE (540LE)	600	450	2	1.6	1	0.22	LB	9	6.9	4.3	1.0	9	7.0	4.4	1.0
Universal	TIFFANY (32-7 #12-3 Mv)	37.0359400	-107.5639500	CAT G3304 NA LCR	83	68	14.8	1.5	1	0.22	None	10	1.0	0.7	0.1	10	1.0	0.7	0.1
Universal	SUTE 32-10 #10-1 Mv	37.0288240	-107.9239780	Wauk VRG 330 (Arrow)	68	50	11	45	1	0.22	None	5	21.7	0.5	0.1	5	21.8	0.5	0.1
Universal	Soute 32-10 #2-2 Mv	37.0419100	-107.8989700	Wauk VRG 330 (Arrow)	68	50	11	45	1	0.22	None	5	21.7	0.5	0.1	5	21.8	0.5	0.1
Universal	McElvain	37.0794760	-107.6729450	G3516 TALE CAT	1265	1,127	2	1.9	1	0.22	LB	22	20.7	10.9	2.4	22	20.8	10.9	2.4
Universal	SUTE 33-9 #22-8 FC	37.0932620	-107.8160980	G3508	476	430	2	1.68	1	0.22	LB/AFRC	8	7.0	4.1	0.9	8	7.0	4.2	0.9
Universal	SUTE 33-9 #22-9 FC	37.0865980	-107.8183670	G3509	476	430	2	1.68	1	0.22	LB/AFRC	8	7.0	4.1	0.9	8	7.0	4.2	0.9
Universal	RW SAWMILL	37.1581300	-107.9340800	G3516 TALE CAT	1265	1,127	2	1.9	1	0.22	LB	22	20.7	10.9	2.4	22	20.8	10.9	2.4
Universal	Oxford #1 Main	37.1587000	-107.6684400	Wauk L7042GL	1478	1,280	1.5	2.65	1	0.22	LB	19	32.7	12.3	2.7	19	32.9	12.4	2.7
Universal	N BLACKRIDGE #2 Main	37.1069166	-107.9798611	G3516 TALE CAT	1265	1,127	2	1.9	1	0.22	LB	22	20.7	10.9	2.4	22	20.8	10.9	2.4
Universal	N BLACKRIDGE #4 Booster	37.1069166	-107.9798611	G3412C LE CAT	637	527	1	2	1	0.22	LB/AFRC	5	10.2	5.1	1.1	5	10.2	5.1	1.1
Universal	N BLACKRIDGE #5 Booster	37.1069166	-107.9798611	G3412C LE CAT	637	527	1	2	1	0.22	LB/AFRC	5	10.2	5.1	1.1	5	10.2	5.1	1.1
Universal	ROUND TOP Main	37.1159840	-108.0072620	G3516 TALE CAT	1265	1,127	2	1.9	1	0.22	LB	22	20.7	10.9	2.4	22	20.8	10.9	2.4
Universal	ROUND TOP Booster	37.1159840	-108.0072620	Wauk L5794LT	1445	1,153	2.6	2	1	0.22	LB	29	22.2	11.1	2.4	29	22.4	11.2	2.5
						13,884					Facility total	312	441	134	29	313	443	135	30

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Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp-hr)	VOC Emission Factor (g/hp-hr)	HAP Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Potential HAP VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)	Actual HAP Emissions (t/yr)
Universal	COYOTE GULCH STATION #1 Main (114013)	37.0168888	-108.0726111	Wauk L7042GL	1478	1,200	1.5	2.6	1	0.22	LB	17	30.1	11.6	2.5	17	30.3	11.6	2.6
Universal	COYOTE GULCH STATION #2 Booster (114054)	37.0168888	-108.0726111	Wauk L7042GL	1478	1,200	1.5	2.6	1	0.22	LB	17	30.1	11.6	2.5	17	30.3	11.6	2.6
Universal	COYOTE GULCH STATION #6 Main (114034)	37.0168888	-108.0726111	Wauk L7042GL	1478	1,200	1.5	2.6	1	0.22	LB	17	30.1	11.6	2.5	17	30.3	11.6	2.6
Universal	COYOTE GULCH STATION #7 Booster (114014)	37.0168888	-108.0726111	Wauk L7042GL	1478	1,200	1.5	2.6	1	0.22	LB	17	30.1	11.6	2.5	17	30.3	11.6	2.6
						4,800					Facility total	69	120	46	10	70	121	47	10
Red Willow	FMOA #2	37.1072777	-107.8063888	G342TAW CAT	265	250	1.5	1.5	1	0.22	LB	4	3.6	2.4	0.5	4	3.6	2.4	0.5
Red Willow	SUTE 33-10 #15-1	37.1084700	-107.9261900	G3306 CAT	95	95	19.5	1.7	1	0.22	None	18	1.6	0.9	0.2	18	1.6	0.9	0.2
Red Willow	SUTE 33-10 #27-2 Mv	37.0704700	-107.9255200	Wauk 155 (Arrow)	26	22	45	11	1	0.22	None	10	2.3	0.2	0.0	10	2.3	0.2	0.0
						367					Facility total	31	8	4	1	31	8	4	1
Transwestern Pipeline Company	LaPlata A Compressor Station	37° 08.26'	107° 47.07'	Solar Centaur 50-H	5,478	4,006	0.41	0.28	1	0.22	Water Injection	32	55	38.6	8.5	14	11.25	12.1	2.7
Transwestern Pipeline Company	LaPlata A Compressor Station	37° 08.26'	107° 47.07'	Solar Taurus 60 T7002	6,937	5,548	0.31	0.29	1	0.22	Solonox or Lean Premix	19	24	53.5	11.8	18	13.01	39.4	8.7
						9,554					Facility total	51	79	92	20	31	24	52	11
Red Cedar	Animas	37° 08' 13.7"	107° 53' 13.8"	Waukesha - L7042GL	1478	1,342	1.5	2.7	1	0.22	Lean Burn Techno	19	35.0	12.9	2.8	19	34.4	12.7	2.8
Red Cedar	Animas	37° 08' 13.7"	107° 53' 13.8"	Waukesha - L7042GL	1478	1,342	1.5	2.7	1	0.22	Lean Burn Techno	19	35.0	12.9	2.8	19	34.3	12.7	2.8
Red Cedar	Animas	37° 08' 13.7"	107° 53' 13.8"	Waukesha - L7042GL	1478	1,342	1.5	2.7	1	0.22	Lean Burn Techno	19	35.0	12.9	2.8	19	34.4	12.7	2.8
Red Cedar	Animas	37° 08' 13.7"	107° 53' 13.8"	Waukesha - L7042GL	1478	1,342	1.5	2.7	1	0.22	Lean Burn Techno	19	35.0	12.9	2.8	19	34.4	12.7	2.8

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Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp-hr)	VOC Emission Factor (g/hp-hr)	HAP Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Potential HAP VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)	Actual HAP Emissions (t/yr)
						5,368					**Facility total**	**78**	**140**	**52**	**11**	**76**	**138**	**51**	**11**
Red Cedar	Arrowhead	37° 03' 42.5"	107° 50' 42.3"	Cat. 3516LE (SITA)	1050	1,047	1.5	1.96	1	0.22	n/a	15	19.8	10.1	2.2	15	19.51	10.0	2.2
Red Cedar	Arrowhead	37° 03' 42.5"	107° 50' 42.3"	Cat. 3516LE (SITA)	1050	1,047	1.5	1.96	1	0.22	n/a	15	19.8	10.1	2.2	15	19.62	10.0	2.2
Red Cedar	Arrowhead	37° 03' 42.5"	107° 50' 42.3"	Cat. 3516LE (SITA)	1050	1,047	1.5	1.96	1	0.22	n/a	15	19.8	10.1	2.2	15	19.61	10.0	2.2
						3,141					**Facility total**	**45**	**59**	**30**	**7**	**45**	**59**	**30**	**7**
Red Cedar	Arkansas Loop	37° 03' 08.8"	107° 47' 01.2"	Superior 8 SGTB	1350	1,283	1.5	3	1	0.22	Lean Burn Techno	19	37.1	12.4	2.7	16	32.8	10.9	2.4
Red Cedar	Arkansas Loop	37° 03' 08.8"	107° 47' 01.2"	Superior 8 SGTB	1350	1,283	1.5	3	1	0.22	Lean Burn Techno	19	37.1	12.4	2.7	13	26.4	8.8	1.9
Red Cedar	Arkansas Loop	37° 03' 08.8"	107° 47' 01.2"	Superior 16 SGTB	2650	2,518	1.5	1.6	1	0.22	Lean Burn Techno	36	38.9	24.3	5.3	34	35.9	22.4	4.9
Red Cedar	Arkansas Loop	37° 03' 08.8"	107° 47' 01.2"	Superior 16 SGTB	2650	2,518	1.5	1.6	1	0.22	Lean Burn Techno	36	38.9	24.3	5.3	35	37.2	23.2	5.1
Red Cedar	Arkansas Loop	37° 03' 08.8"	107° 47' 01.2"	Superior 16 SGTB	2650	2,518	1.5	1.6	1	0.22	Lean Burn Techno	36	38.9	24.3	5.3	35	37.5	23.5	5.2
Red Cedar	Arkansas Loop	37° 03' 08.8"	107° 47' 01.2"	Superior 16 SGTB	2650	2,518	1.5	1.6	1	0.22	Lean Burn Techno	36	38.9	24.3	5.3	35	37.3	23.3	5.1
Red Cedar	Arkansas Loop	37° 03' 08.8"	107° 47' 01.2"	Waukesha 5790 GL	1215	1,074	1.5	2.65	1	0.22	Lean Burn Techno	16	27.5	10.4	2.3	15	26.9	10.1	2.2
Red Cedar	Arkansas Loop	37° 03' 08.8"	107° 47' 01.2"	Waukesha 5790 GL	1215	1,074	1.5	2.65	1	0.22	Lean Burn Techno	16	27.5	10.4	2.3	15	27.3	10.3	2.3
Red Cedar	Arkansas Loop	37° 03' 08.8"	107° 47' 01.2"	Waukesha 5790 GL	1215	1,074	1.5	2.65	1	0.22	Lean Burn Techno	16	27.5	10.4	2.3	16	27.4	10.3	2.3
						15,860					**Facility total**	**230**	**312**	**153**	**34**	**214**	**289**	**143**	**31**
Red Cedar	Blackridge	37° 3' 31.3"	107° 57' 43.1"	Waukesha - L7042GL	1478	1,306	1.5	2.65	1	0.22	Lean Burn Techno	19	33.4	12.6	2.8	19	32.69	12.3	2.7
						1,306					**Facility total**	**19**	**33**	**13**	**3**	**19**	**33**	**12**	**3**
Red Cedar	Bondad	37° 05' 19.9"	107° 52' 55.3"	Waukesha - L7042GL	1478	1,342	1.5	4.56(lb/hr)	1	0.22	Lean Burn w/Oxida	19	20.0	12.9	2.8	19	19.14	12.4	2.7
Red Cedar	Bondad	37° 05' 19.9"	107° 52' 55.3"	Waukesha - L7042GL	1478	1,342	1.5	4.56(lb/hr)	1	0.22	Lean Burn w/Oxida	19	20.0	12.9	2.8	18	18.18	11.8	2.6
Red Cedar	Bondad	37° 05' 19.9"	107° 52' 55.3"	Waukesha - L7042GL	1478	1,342	1.5	4.56(lb/hr)	1	0.22	Lean Burn w/Oxida	19	20.0	12.9	2.8	19	19.32	12.5	2.8
Red Cedar	Bondad [6]	37° 05' 19.9"	107° 52' 55.3"	Waukesha - L7042GL	1478	1,342	1.5	4.56(lb/hr)	1	0.22	Lean Burn w/Oxida	19	20.0	12.9	2.8	18	18.78	12.2	2.7
Red Cedar	Bondad	37° 05' 19.9"	107° 52' 55.3"	Waukesha - L7042GL	1478	1,342	1.5	4.56(lb/hr)	1	0.22	Lean Burn w/Oxida	19	20.0	12.9	2.8	17	17.01	11.0	2.4

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Red Cedar	Bondad	37° 05' 19.9"	107° 52' 55.3"	Waukesha - L7042GL	1478	1,342	1.5	4.56(lb/hr)	1	0.22	Lean Burn w/Oxida	19	20.0	12.9	2.8	19	19.76	12.8	2.8
Red Cedar	Bondad	37° 05' 19.9"	107° 52' 55.3"	Waukesha - L7042GL	1478	1,342	1.5	4.56(lb/hr)	1	0.22	Lean Burn w/Oxida	19	20.0	12.9	2.8	18	18.86	12.2	2.7
Red Cedar	Bondad	37° 05' 19.9"	107° 52' 55.3"	Waukesha - L7042GL	1478	1,342	1.5	4.56(lb/hr)	1	0.22	Lean Burn w/Oxida	19	20.0	12.9	2.8	19	19.11	12.4	2.7
Red Cedar	Bondad	37° 05' 19.9"	107° 52' 55.3"	Waukesha - L7042GL	1478	1,342	1.5	2.65	1	0.22	Lean Burn Techno	19	34.3	12.9	2.8	3	2.69	1.4	0.3
Red Cedar	Bondad [6]	37° 05' 19.9"	107° 52' 55.3"	Waukesha - L7042GL	1478	1,342	1.5	2.65	1	0.22	Lean Burn Techno	19	34.3	12.9	2.8	17	17.28	8.9	1.9
						13,420					Facility total	194	228	129	28	166	170	108	24
Red Cedar	Capote	37° 3' 39.7"	107° 49' 21.1"	Waukesha - L7042GL	1478	1,324	1.5	2.65	1	0.22	Lean Burn Techno	19	33.8	12.8	2.8	19	33	12.5	2.7
Red Cedar	Capote	37° 3' 39.7"	107° 49' 21.1"	Waukesha - L7042GL	1478	1,324	1.5	2.65	1	0.22	Lean Burn Techno	19	33.8	12.8	2.8	19	33.4	12.6	2.8
Red Cedar	Capote	37° 3' 39.7"	107° 49' 21.1"	Waukesha - L7042GL	1478	1,324	1.5	2.65	1	0.22	Lean Burn Techno	19	33.8	12.8	2.8	19	33.4	12.6	2.8
Red Cedar	Capote	37° 3' 39.7"	107° 49' 21.1"	Waukesha - L7042GL	1478	1,324	1.5	2.65	1	0.22	Lean Burn Techno	19	33.8	12.8	2.8	19	33.4	12.6	2.8
Red Cedar	Capote	37° 3' 39.7"	107° 49' 21.1"	Waukesha - L7042GL	1478	1,324	1.5	2.65	1	0.22	Lean Burn Techno	19	33.8	12.8	2.8	19	32.9	12.4	2.7
Red Cedar	Capote	37° 3' 39.7"	107° 49' 21.1"	Waukesha - L7042GL	1478	1,324	1.5	2.65	1	0.22	Lean Burn Techno	19	33.8	12.8	2.8	19	33.3	12.6	2.8
						7,944					Facility total	115	203	77	17	113	199	75	17
Red Cedar	Cox Canyon	37° 0' 55"	107° 55' 6.3"	Waukesha - L7042GL	1478	1,333	1.5	2.65	1	0.22	Lean Burn Techno	19	34.1	12.9	2.8	19	32.91	12.4	2.7
						1,333					Facility total	19	34	13	3	19	33	12	3
Red Cedar	Coyote Gulch TP	37° 01' 07.0"	107° 04' 40.0"	Cat. - 3616LE	4445	4,334	0.7	1.9	1	0.22	Lean Burn Techno	29	79.4	41.8	9.2	21	58.1	30.6	6.7
Red Cedar	Coyote Gulch TP	37° 01' 07.0"	107° 04' 40.0"	Cat. - 3616LE	4445	4,334	0.7	1.9	1	0.22	Lean Burn Techno	29	79.4	41.8	9.2	19	52.5	27.6	6.1
Red Cedar	Coyote Gulch TP	37° 01' 07.0"	107° 04' 40.0"	Cat. - 3612LE	3550	3,252	0.7	1.9	1	0.22	Lean Burn Techno	22	59.6	31.4	6.9	8	22.5	11.8	2.6
						11,920					Facility total	80	218	115	25	49	133	70	15
Red Cedar	Diamondback-Sidewinder	37° 2' 9.7"	107° 50' 48.3"	Waukesha - L7042GL	1478	1,330	1.5	2.65	1	0.22	Lean Burn Techno	19	34.0	12.8	2.8	19	33.4	12.6	2.8
Red Cedar	Diamondback-Sidewinder	37° 2' 9.7"	107° 50' 48.3"	Waukesha - L7042GL	1478	1,330	1.5	2.65	1	0.22	Lean Burn Techno	19	34.0	12.8	2.8	13	23.3	8.8	1.9
Red Cedar	Diamondback-Sidewinder	37° 2' 9.7"	107° 50' 48.3"	Waukesha - L7042GL	1478	1,330	1.5	2.65	1	0.22	Lean Burn Techno	19	34.0	12.8	2.8	8	14.8	5.6	1.2

Table A-1. 2005 SUIT Inventory

Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp-hr)	VOC Emission Factor (g/hp-hr)	HAP Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Potential HAP VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)	Actual HAP Emissions (t/yr)
Red Cedar	Diamondback-Sidewinder	37° 2' 9.7"	107° 50' 48.3"	Waukesha - L7042GL	1478	1,330	1.5	2.65	1	0.22	Lean Burn Techno	19	34.0	12.8	2.8	19	33.4	12.6	2.8
Red Cedar	Diamondback-Sidewinder	37° 2' 9.7"	107° 50' 48.3"	Cummins GTA8.3-LC-GI	185	168	14.9	2.19	1	0.22	n/a	24	3.6	1.6	0.4	14	2.02	0.9	0.2
						5,488					**Facility total**	**101**	**140**	**53**	**12**	**73**	**107**	**41**	**9**
Red Cedar	East Alamo	37° 3' 44.5"	107° 45' 9.9"	Cat. 3516-SITA	1050	1,047	1.5	1.96	1	0.22	n/a	15	19.8	10.1	2.2	15	19.67	10.0	2.2
Red Cedar	East Alamo	37° 3' 44.5"	107° 45' 9.9"	Cat. 3516-SITA	1050	1,047	1.5	1.96	1	0.22	n/a	15	19.8	10.1	2.2	15	19.64	10.0	2.2
						2,094					**Facility total**	**30**	**40**	**20**	**4**	**30**	**39**	**20**	**4**
Red Cedar	Elk Point	37° 04' 30.7"	107° 46' 8.6"	Cat 3516LE	1322	1,322	1.5	1.89	1	0.22	n/a	19	24.1	12.8	2.8	19	24.13	12.8	2.8
Red Cedar	Elk Point	37° 04' 30.7"	107° 46' 8.6"	Cat 3516LE	1322	1,322	1.5	1.89	1	0.22	n/a	19	24.1	12.8	2.8	19	24.13	12.8	2.8
Red Cedar	Elk Point	37° 04' 30.7"	107° 46' 8.6"	Cat 3516LE	1322	1,322	1.5	1.89	1	0.22	n/a	19	24.1	12.8	2.8	19	24.13	12.8	2.8
Red Cedar	Elk Point	37° 04' 30.7"	107° 46' 8.6"	Cat 3516LE	1322	1,322	1.5	1.89	1	0.22	n/a	19	24.1	12.8	2.8	19	24.13	12.8	2.8
						5,288					**Facility total**	**77**	**96**	**51**	**11**	**77**	**97**	**51**	**11**
Red Cedar	Homestead [7]	37° 2' 41.8	107° 43' 52"	Waukesha - L7042GL	1478	1,318	1.7	3.1	1	0.22	Lean Burn Techno	22	39.4	12.7	2.8	21	39	12.6	2.8
Red Cedar	Homestead [7]	37° 2' 41.8"	107° 43' 52"	Waukesha - L7042GL	1478	1,318	1.7	3.1	1	0.22	Lean Burn Techno	22	39.4	12.7	2.8	22	39.7	12.8	2.8
Red Cedar	Homestead [7]	37° 2' 41.8"	107° 43' 52"	Waukesha - L7042GL	1478	1,318	1.7	3.1	1	0.22	Lean Burn Techno	22	38.8	12.7	2.8	21	38.8	12.6	2.8
						3,954					**Facility total**	**65**	**118**	**38**	**8**	**65**	**118**	**38**	**8**
Red Cedar	La Boca	37° 03' 12.87	107° 37' 39.94"	Waukesha - L7042GL	1478	1,318	1.5	2.65	1	0.22	Lean Burn Techno	19	33.7	12.7	2.8	2	3.6	1.4	0.3
						1,318													
Red Cedar	La Posta [6]	37° 8' 7.4"	107° 54' 19.6"	Waukesha - L7042GL	1478	1,333	1.5	2.7	1	0.22	Lean Burn Techno	19	34.7	12.9	2.8	19	34.2	12.7	2.8
Red Cedar	La Posta	37° 8' 7.4"	107° 54' 19.6"	Waukesha - L7042GL	1478	1,333	1.5	2.7	1	0.22	Lean Burn Techno	19	34.7	12.9	2.8	19	34.5	12.8	2.8
Red Cedar	La Posta	37° 8' 7.4"	107° 54' 19.6"	Waukesha - L7042GL	1478	1,333	1.5	2.7	1	0.22	Lean Burn Techno	19	34.7	12.9	2.8	19	34.5	12.8	2.8
Red Cedar	La Posta	37° 8' 7.4"	107° 54' 19.6"	Waukesha - L7042GL	1478	1,333	1.5	2.7	1	0.22	Lean Burn Techno	19	34.7	12.9	2.8	19	34.4	12.7	2.8
						5,332					**Facility total**	**77**	**139**	**51**	**11**	**77**	**138**	**51**	**11**
Red Cedar	North Blackridge	37° 5' 25.8"	107° 58' 28.9"	Waukesha - L7042GL	1478	1,306	1.5	2.65	1	0.22	Lean Burn Techno	19	33.4	12.6	2.8	19	32.82	12.4	2.7
						1,306					**Facility total**	**19**	**33**	**13**	**3**	**19**	**33**		

Table A-1. 2005 SUIT Inventory page 7 of 22

Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp-hr)	VOC Emission Factor (g/hp-hr)	HAP Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Potential HAP VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)	Actual HAP Emissions (t/yr)
Red Cedar	Outlaw	37° 10' 25"	107° 46' 42"	Cat G3606	1775	1,775	0.7	2.5	1	0.22	Lean Burn Techno	12	42.8	17.1	3.8	10	35.8	14.3	3.1
Red Cedar	Outlaw	37° 10' 25"	107° 46' 42"	Cat G3606	1775	1,775	0.7	2.5	1	0.22	Lean Burn Techno	12	42.8	17.1	3.8	10	35.6	14.3	3.1
Red Cedar	Outlaw	37° 10' 25"	107° 46' 42"	Cat G3606	1775	1,775	0.7	2.5	1	0.22	Lean Burn Techno	12	42.8	17.1	3.8	10	33.9	13.6	3.0
Red Cedar	Outlaw	37° 10' 25"	107° 46' 42"	Cat G3606	1775	1,775	0.7	2.5	1	0.22	Lean Burn Techno	12	42.8	17.1	3.8	9	32.8	13.1	2.9
Red Cedar	Outlaw	37° 10' 25"	107° 46' 42"	Cat G3606	1775	1,775	0.7	2.5	1	0.22	Lean Burn Techno	12	42.8	17.1	3.8	10	34.8	13.9	3.1
Red Cedar	Outlaw	37° 10' 25"	107° 46' 42"	Onan Gen. - 125GGKB	185	178	14.8	2.13	1	0.22	n/a	25	3.7	1.7	0.4	25	3.7	1.7	0.4
						9,053					Facility total	85	218	87	19	74	177		
Red Cedar	Pump Canyon	37° 01' 31"	107° 40' 49"	Waukesha - L7042GL	1478	1,330	1.5	2.65	1	0.22	n/a	19	34.0	12.8	2.8	19	33.8	12.8	2.8
Red Cedar	Pump Canyon	37° 01' 31"	107° 40' 49"	Waukesha - L7042GL	1478	1,330	1.5	2.65	1	0.22	n/a	19	34.0	12.8	2.8	19	33.8	12.8	2.8
Red Cedar	Pump Canyon	37° 01' 31"	107° 40' 49"	Waukesha - L7042GL	1478	1,330	1.5	2.65	1	0.22	n/a	19	34.0	12.8	2.8	19	33.7	12.7	2.8
Red Cedar	Pump Canyon	37° 01' 31"	107° 40' 49"	Cat G3612LE	3227	2,927	0.7	2.5	1	0.22	Oxidation Catalyst	20	70.6	28.2	6.2	19	2.1	14.3	3.1
						6,917					Facility total	78	173	67	15	77	103		
Red Cedar	Sawmill	37° 10' 16.3"	107° 53' 25.1"	Waukesha - L7042GL	1478	1,306	1.5	2.65	1	0.22	Lean Burn Techno	19	33.4	12.6	2.8	19	32.99	12.5	2.7
Red Cedar	Sawmill	37° 10' 16.3"	107° 53' 25.1"	Waukesha - L7042GL	1478	1,306	1.5	2.65	1	0.22	Lean Burn Techno	19	33.4	12.6	2.8	18	32.54	12.3	2.7
						2,612					Facility total	38	67	25	6	37	66	25	5
Red Cedar	Six Shooter	37° 3' 55.4"	107° 44' 0.2"	Waukesha - L7042GL	1478	1,324	1.5	2.65	1	0.22	Lean Burn Techno	19	33.8	12.8	2.8	19	33.53	12.7	2.8
Red Cedar	Six Shooter	37° 3' 55.4"	107° 44' 0.2"	Waukesha - L7042GL	1478	1,324	1.5	2.65	1	0.22	Lean Burn Techno	19	33.8	12.8	2.8	19	33.38	12.6	2.8
						2,648					Facility total	38	68	26	6	38	67		
Not Part 71 facility																			
Red Cedar	Spring Creek	37°03'29"	107°32'46"	Cat 3516LE	1340	1,340	1.5	0.132	1	0.22	AFRC & Oxidation	19	1.7	12.9	2.8	17	1.54	11.7	2.6
Red Cedar	Spring Creek	37°03'29"	107°32'46"	Cat 3516LE	1340	1,340	1.5	0.132	1	0.22	AFRC & Oxidation	19	1.7	12.9	2.8	17	1.54	11.7	2.6
Red Cedar	Spring Creek	37°03'29"	107°32'46"	Cat 3516LE	1340	1,340	1.5	0.132	1	0.22	AFRC & Oxidation	19	1.7	12.9	2.8	17	1.54	11.7	2.6
Red Cedar	Spring Creek	37°03'29"	107°32'46"	Cat 3516LE	1340	1,340	1.5	1.89	1	0.22	n/a	19	24.4	12.9	2.8	2	2.08	1.1	0.2
Red Cedar	Spring Creek	37°03'29"	107°32'46"	Cat 3516LE	1340	1,340	1.5	1.89	1	0.22	n/a	19	24.4	12.9	2.8	2	2.08	1.1	0.2
						6,700					Facility total	97	54	65	14	56	9	37	8
Red Cedar	Trail Canyon	37° 2' 59.1"	107° 46' 55.7"	Cat 3516LE	1000	980	2	1.5	1	0.22	n/a	19	14.2	9.5	2.1	18	13.68	9.1	2.0
Red Cedar	Trail Canyon	37° 2' 59.1"	107° 46' 55.7"	Cat 3516LE	1000	980	2	1.5	1	0.22	n/a	19	14.2	9.5	2.1	18	13.68	9.1	2.0
						1,960					Facility total	38	28	19	4	37	27	18	4

Table A-1. 2005 SUIT Inventory

Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp-hr)	VOC Emission Factor (g/hp-hr)	HAP Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Potential HAP VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)	Actual HAP Emissions (t/yr)
Red Cedar	Trunk T	37° 3' 1.1"	107° 47' 3.3"	Waukesha L7042GL	1478	1,324	1.5	2.65	1	0.22	Lean Burn Techno	19	33.8	12.8	2.8	19	32.81	12.4	2.7
						1,324					Facility total	19	34	13	3	19	33	12	3
Red Cedar	West La Posta	37° 7' 56.6"	107° 57' 13.7"	Cat. 3516 - SITA	1050	1,047	1.5	1.96	1	0.22	n/a	15	19.8	10.1	2.2	15	19.61	10.0	2.2
						1,047					Facility total	15	20	10	2	15	20	10	2
Samson	S Ignacio CDP	37.05451	-107.62555	Waukesha 7044 GSI	1680	1,680	1.3	13.8	1	0.22	AFRC/NSCR Cata	21	223.7	16.2	3.6	11	7.6	4.4	1.0
Samson	S Ignacio CDP	37.05451	-107.62555	Waukesha 7042 GL	1232	1,113	0.9	2.65	1	0.22	Lean Burn/OC	10	28.5	10.7	2.4	10	4.3	6.2	1.4
Samson	S Ignacio CDP	37.05451	-107.62555	Waukesha 7042 GL	1232	1,113	0.9	2.65	1	0.22	Lean Burn/OC	10	28.5	10.7	2.4	10	4.3	6.2	1.4
Samson	S Ignacio CDP	37.05451	-107.62555	Waukesha 7042 GL	1478	1,359	0.9	2.65	1	0.22	Lean Burn/OC	12	34.8	13.1	2.9	12	5.2	7.5	1.7
Samson	S Ignacio CDP	37.05451	-107.62555	Waukesha 5794 LT	1445	1,399	2.5	0.45	1	0.22	Lean Burn/OC	34	6.1	13.5	3.0	34	6.1	13.5	3.0
						6,665					Facility total	86	321	64	14	76	28	38	8
not a Part 71 permits																			
Samson	Jaques CDP	37.07896	-107.99005	Waukesha 5794 LT	1445	1,399	2.5	1.8	1	0.22	Lean Burn	34	24.3	13.5	3.0	34	24.3	13.5	3.0
Samson	Jaques CDP	37.07896	-107.99005	Waukesha 5794 LT	1445	1,399	2.5	1.8	1	0.22	Lean Burn	34	24.3	13.5	3.0	34	24.3	13.5	3.0
Samson	Jaques CDP	37.07896	-107.99005	Waukesha 5794 LT	1445	1,399	2.5	0.45	1	0.22	Lean Burn/OC	34	6.1	13.5	3.0	34	6.1	13.5	3.0
						4,198					Facility total	101	55	40	9	101	55	40	9
Samson	Deadhorse CDP	37.19932	-107.56442	Waukesha 5794 LT	1445	1,399	2.5	1.8	1	0.22	Lean Burn	34	24.3	13.5	3.0	34	24.3	13.5	3.0
						1,399					Facility total	34	24	13	3	34	24	13	3
Samson	Wolfe 33-7-22 #4	37.086181	-107.596214	Cat 3306 NA	145	110	1.09	1.97	1	0.22	AFRC/NSCR Cata	1	2.1	1.1	0.2	1	2.1	1.1	0.2
Samson	Wolfe 33-7-22 #2	37.08512	-107.59407	Cat 3306 NA	145	110	10.9	13.1	1	0.22	None	12	13.9	1.1	0.2	12	13.9	1.1	0.2
						220					Facility total	13	16	2	0	13	16	2	0
Samson	Ute 33-7-22 #5	37.09239	-107.59097	Cat 3306 NA	145	110	10.9	13.1	1	0.22	None	12	13.9	1.1	0.2	12	13.9	1.1	0.2
Samson	Ute 33-7-22 #3	37.092369	-107.590729	Cat 3306 NA	145	110	1.09	1.97	1	0.22	AFRC/NSCR Cata	1	2.1	1.1	0.2	1	2.1	1.1	0.2
						220					Facility total	13	16	2	0	13	16	2	0

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Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp-hr)	VOC Emission Factor (g/hp-hr)	HAP Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Potential HAP VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)	Actual HAP Emissions (t/yr)
Samson	Underwood 33-7-15 #5	37.105546	-107.600479	Cat 3306 TA	203	160	21.2	1.5	1	0.22	None	33	2.3	1.5	0.3	33	2.3	1.5	0.3
Samson	Underwood 33-7-15 #3	37.099394	-107.599374	Cat 3306 NA	145	110	1.09	1.97	1	0.22	AFRC/NSCR Cata	1	2.1	1.1	0.2	1	2.1	1.1	0.2
						270					**Facility total**	**34**	**4**	**3**	**1**	**34**	**4**	**3**	**1**
Samson	Mcelvain 33-8-19 #1	37.09214	-107.76439	Cat 3306 TA	220	175	20.5	1.6	1	0.22	None	35	2.7	1.7	0.4	35	2.7	1.7	0.4
						175					**Facility total**	**35**	**3**	**2**	**0**	**35**	**3**	**2**	**0**
Samson	Mcelvain #4	37.02017	-107.55336	Waukesha VRG 220	45	38	9	9	1	0.22	None	3	3.3	0.4	0.1	3	3.3	0.4	0.1
						38					**Facility total**	**3**	**3**	**0**	**0**	**3**	**3**	**0**	**0**
Samson	Mcelvain #3	37.01946	-107.5618	Waukesha VRG 330	68	58	9	9	1	0.22	None	5	5.0	0.6	0.1	5	5	0.6	0.1
						58					**Facility total**	**5**	**5**	**1**	**0**	**5**	**5**	**1**	**0**
Samson	Ignacio 33-8 20	37.07911	-107.71693	Waukesha VRG 330	68	58	9	9	1	0.22	None	5	5.0	0.6	0.1	5	5	0.6	0.1
Samson	Ignacio 33-8 #19A	37.0562	-107.68983	Waukesha VRG 330	68	58	9	9	1	0.22	None	5	5.0	0.6	0.1	5	5	0.6	0.1
						116					**Facility total**	**10**	**10**	**1**	**0**	**10**	**10**	**1**	**0**
Samson	Hill 33-9-12 #1	37.1176	-107.77213	Cat 3306 NA	145	110	10.9	13.1	1	0.22	None	12	13.9	1.1	0.2	12	13.9	1.1	0.2
Samson	Hill 33-9-12 #3	37.12117	-107.77314	Waukesha F1197	186	149	8.5	35	1	0.22	None	12	50.3	1.4	0.3	12	50.3	1.4	0.3
Samson	Behrmann 33-7-15 CP	37.10112	-107.59143	Cat 3306 NA	145	110	1.09	1.97	1	0.22	AFRC/NSCR Cata	1	2.1	1.1	0.2	1	2.1	1.1	0.2
Samson	Mcelvain 33-8-19 #3	37.09383	-107.75558	Waukesha F1197	186	149	8.5	35	1	0.22	None	12	50.3	1.4	0.3	12	50.3	1.4	0.3
						518					**Facility total**	**37**	**117**	**5**	**1**	**37**	**117**	**5**	**1**
Chevron	Southern Ute 22-2	37.072129	-107.817066	Caterpillar G3512TALE	697	697	2.00	2.28	1	0.22	N/A	13.44	15.32	6.7	1.5	2.51	2.86	1.3	0.3
Chevron	Southern Ute 10	37.064499	-107.836797	Caterpillar 3306TA	175	175	2.00	1.50	1	0.22	AFRC/NSCR	3.37	2.53	1.7	0.4	0.04	0.03	0.0	0.0
Chevron	Sam Burch 23 & 4	37.05006	-107.826186	Caterpillar 3306TA	175	175	2.00	1.50	1	0.22	AFRC/NSCR	3.37	2.53	1.7	0.4	1.54	1.15	0.8	0.2
Chevron	Southern Ute 18	37.065489	-107.817806	Caterpillar 3306TA	175	175	2.00	1.50	1	0.22	AFRC/NSCR	3.37	2.53	1.7	0.4	1.20	0.90	0.6	0.1

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Chevron	Sam Burch 20 & 3	37.02756	-107.817456	Caterpillar 3306TA	175	175	2.00	1.50	1	0.22	AFRC/NSCR	3.37	2.53	1.7	0.4	1.39	1.04	0.7	0.2
Chevron	Sam Burch 13	37.04228	-107.808236	Caterpillar 3306TA	175	104	2.00	1.50	1	0.22	AFRC/NSCR	3.37	2.53	1.0	0.2	2.01	1.51	0.6	0.1
Chevron	Sam Burch 14	37.050329	-107.836137	Caterpillar 3306TA	175	79	2.00	1.50	1	0.22	AFRC/NSCR	3.37	2.53	0.8	0.2	1.53	1.15	0.3	0.1
Chevron	Sam Burch 28 & 12	37.03447	-107.816726	Caterpillar 3306TA	175	54	2.00	1.50	1	0.22	AFRC/NSCR	3.37	2.53	0.5	0.1	1.05	0.78	0.2	0.0
Chevron	Sam Burch 27	37.02764	-107.826926	Caterpillar 3306TA	175	71	2.00	1.50	1	0.22	AFRC/NSCR	3.37	2.53	0.7	0.2	1.38	1.04	0.3	0.1
Chevron	Sam Burch 22 & 2	37.04236	-107.836776	Caterpillar 3306TA	175	84	2.00	1.50	1	0.22	AFRC/NSCR	3.37	2.53	0.8	0.2	1.63	1.22	0.4	0.1
Chevron	Sam Burch 19 & 5	37.03558	-107.828186	Caterpillar 3306TA	175	133	2.00	1.50	1	0.22	AFRC/NSCR	3.37	2.53	1.3	0.3	2.56	1.92	1.0	0.2
Chevron	Sam Burch 24	37.04198	-107.817916	Caterpillar 3306TA	175	26	2.00	1.50	1	0.22	AFRC/NSCR	3.37	2.53	0.3	0.1	0.51	0.38	0.0	0.0
Chevron	Sam Burch 29 & 10	37.04302	-107.827506	Caterpillar 3306TA	175	0	2.00	1.50	1	0.22	AFRC/NSCR	3.37	2.53	0.0	0.0	0.00	0.00	0.0	0.0
Chevron	Sam Burch 11	37.04845	-107.815886	Caterpillar 3306TA	175	95	2.00	1.50	1	0.22	AFRC/NSCR	3.37	2.53	0.9	0.2	1.84	1.38	0.5	0.1
Chevron	Southern Ute 11& 5	37.056059	-107.808306	Caterpillar 3306TA	175	72	2.00	1.50	1	0.22	AFRC/NSCR	3.37	2.53	0.7	0.2	1.40	1.05	0.3	0.1
Chevron	Sam Burch 25 & 8	37.05049	-107.806926	Caterpillar 3306TA	175	18	2.00	1.50	1	0.22	AFRC/NSCR	3.37	2.53	0.2	0.0	0.35	0.26	0.0	0.0
Chevron	Sam Burch 30 &15	37.03487	-107.836416	Caterpillar 3306TA	175	65	2.00	1.50	1	0.22	AFRC/NSCR	3.37	2.53	0.6	0.1	1.25	0.94	0.2	0.1
Chevron	Southern Ute 26-4	37.070339	-107.797016	Caterpillar 3306TA	175	134	2.00	1.50	1	0.22	AFRC/NSCR	3.37	2.53	1.3	0.3	2.59	1.95	1.0	0.2
Chevron	Sam Burch 18 & 1	37.02789	-107.837006	Caterpillar 3306TA	175	96	2.00	1.50	1	0.22	AFRC/NSCR	3.37	2.53	0.9	0.2	1.85	1.38	0.5	0.1
Chevron	Southern Ute 15	37.079379	-107.818306	Caterpillar 3508 LE	542	152	2.00	1.60	1	0.22	N/A	10.45	8.36	1.5	0.3	2.94	2.35	0.4	0.1
Chevron	Southern Ute 27-1	37.099918	-107.94959	Waukesha F18GL	241	5			1	0.22	Unknown	18.65	31.39	0.1	0.0	0.42	0.71	0.0	0.0
Chevron	Black Ridge 17-1	37.079429	-107.808096	Caterpillar G3408TA	344	43			1	0.22	Unknown	26.64	44.84	0.4	0.1	3.31	5.57	0.1	0.0
Chevron	Southern Ute 16-5	37.064879	-107.810066	Caterpillar 3412LELCR	548	7	1.00	2.00	1	0.22	N/A	5.29	10.57	0.1	0.0	0.06	0.13	0.0	0.0
Chevron	Southern Ute 20	37.064009	-107.827386	Ajax 2202 LE	254	128	1.90	1.00	1	0.22	N/A	4.65	2.45	1.2	0.3	2.34	1.23	0.6	0.1
Chevron	Southern Ute 26 & 21	37.057609	-107.818786	Ajax 2202 LE	258	156	1.90	1.00	1	0.22	N/A	4.73	2.49	1.5	0.3	2.86	1.50	0.9	0.2
Chevron	Southern Ute 9	37.03602	-107.807906	Ajax 2202 LE	254	81	1.90	1.00	1	0.22	N/A	4.65	2.45	0.8	0.2	1.49	0.78	0.3	0.1

Table A-1. 2005 SUIT Inventory

Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp-hr)	VOC Emission Factor (g/hp-hr)	HAP Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Potential HAP VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)	Actual HAP Emissions (t/yr)
Chevron	Southern Ute 19	37.175607	-107.884739	Ajax 2202 LE	254	91	1.90	1.00	1	0.22	N/A	4.65	2.45	0.9	0.2	1.67	0.88	0.3	0.1
Chevron	Sam Burch 21	37.175607	-107.884739	Ajax 2202 LE	254	88	1.90	1.00	1	0.22	N/A	4.65	2.45	0.8	0.2	1.61	0.85	0.3	0.1
Chevron	Indian Creek #4	37.175607	-107.884739	Caterpillar 3516	1152	635	1.50	1.89	1	0.22	N/A	16.68	21.01	6.1	1.3	9.19	11.58	3.4	0.7
Chevron	Indian Creek #2	37.175607	-107.884739	Caterpillar 3516	1152	633	1.50	1.89	1	0.22	N/A	16.68	21.01	6.1	1.3	9.17	11.56	3.4	0.7
Chevron	Indian Creek #3	37.056998	-108.064913	Caterpillar 3516	1152	635	1.50	1.89	1	0.22	N/A	16.68	21.01	6.1	1.3	9.19	11.58	3.4	0.7
Chevron	Indian Creek #1	37.056998	-108.064913	Caterpillar 3516	1152	623	1.50	1.89	1	0.22	N/A	16.68	21.01	6.0	1.3	9.03	11.38	3.3	0.7
Chevron	Valencia Canyon 32-1 S	37.109098	-107.95422	Caterpillar 3516	863	246	1.50	1.90	1	0.22	N/A	12.50	15.83	2.4	0.5	3.56	4.51	0.7	0.1
Chevron	Valencia Canyon 32-1 N	37.109098	-107.95422	Caterpillar 3516	863	237	1.50	1.90	1	0.22	N/A	12.50	15.83	2.3	0.5	3.43	4.35	0.6	0.1
Chevron	Black Ridge 17-2 (N)	37.064049	107.827296	Caterpillar 3516	1152	206	2.00	1.89	1	0.22	N/A	22.24	21.01	2.0	0.4	3.98	3.76	0.4	0.1
Chevron	Black Ridge 17-2 (S)	37.071429	-107.789855	Caterpillar 3516	1152	208	2.00	1.89	1	0.22	N/A	22.24	21.01	2.0	0.4	4.01	3.79	0.4	0.1
Chevron	Southern Ute 21-2	37.064049	107.827296	Ford 460	21	21	8.02		1	0.22	Unknown	1.33	2.24	0.2	0.0	1.61	2.70	0.2	0.1
Chevron	Southern Ute 26-5	37.071429	-107.789855	Caterpillar 3306 TA	175	0	22.80	1.50	1	0.22	Unknown	38.44	2.53	0.0	0.0	0.00	0.00	0.0	0.0
						6,622					Facility total	334	331	64	14	97	100	27	6
Williams Four Corners LLC	Trunk J	37° 6' 39.876"	-107° 41' 55.313"	Waukesha 7042GL	1478	943	1.5	2.65	1	0.22	leanburn	14	24.1	9.1	2.0	14	24.1	9.1	2.0
						943					Facility total	14	24	9	2	14	24	9	2
Williams Four Corners LLC	Ute E	37° 7' 14.466"	-107° 56' 19.405"	Waukesha 7042G	1173	994	2	3	1	0.22	NSCR	19	28.8	9.6	2.1	19	28.8	9.6	2.1
						994					Facility total	19	29	10	2	19	29	10	2
Williams Four Corners LLC	PLA-9	37° 0' 10.798"	-107° 55' 26.661"	Waukesha 7042GL	1478	1,115	1.5	2.65	1	0.22	leanburn	16	28.5	10.8	2.4	16	28.5	10.8	2.4
						1,115					Facility total	16	29	11	2	16	29	11	2
Williams Four Corners LLC	Ignacio	37° 8; 43.000"	-107° 47' 4.000"	Clark TLA-6		2,000	11.28	2.4	1	0.22	none	218	46.3	19.3	4.2	218	46.3	19.3	4.2
						2,000					Facility total	218	46	19	4	218	46	19	4

Table A-1. 2005 SUIT Inventory page 12 of 22

Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp-hr)	VOC Emission Factor (g/hp-hr)	HAP Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Potential HAP VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)	Actual HAP Emissions (t/yr)
Maralex Resources	Shelhammer CDP	location is NW 1/4 of the SW 1/4 of section 10, T33N, R7W		Caterpillar 945, model G3512 TALE	800	632	2	1.8	1	0.22	lean burn	12	11.0	6.1	1.3	12	11.0	6.1	1.3
						632					Facility total	12	11	6	1	12	11	6	1
Williams Production	NWCH 32-10 #021 PC	37.0046	-107.9394	Cat G3304 NA HCR	95	81	14.8	12	1	0.22		12	9.3	0.8	0.2	12	9.3	0.8	0.2
Williams Production	NWCH 32-10 #018 MV	37.00707	-107.96218	Cat G3304 NA HCR	95	80	14.8	12	1	0.22		11	9.3	0.8	0.2	11	9.3	0.8	0.2
Williams Production	NWCH 32-10 #015A	37.02938	-107.97169	Arrow VRG 330 B	80	68	12.05	33.58	1	0.22		8	21.9	0.7	0.1	8	21.9	0.7	0.1
Williams Production	NWCH 32-10 #017A	37.01523	-107.97404	Cat G3304 NA HCR	95	80	14.8	12	1	0.22		11	9.3	0.8	0.2	11	9.3	0.8	0.2
Williams Production	NWCH 32-10 #013	37.02768	-107.98014	Cat G3304 NA HCR	95	81	14.8	12	1	0.22		12	9.4	0.8	0.2	12	9.4	0.8	0.2
Williams Production	NWCH 32-10 #009	37.00388	-107.9776	Arrow VRG 330	68	58	11.9	28.7	1	0.22		7	16.0	0.6	0.1	7	16.0	0.6	0.1
Williams Production	NWCH 32-10 #007	37.03721	-107.8773	Arrow VRG 330	68	59	11.9	28.7	1	0.22		7	16.3	0.6	0.1	7	16.3	0.6	0.1
Williams Production	NWCH 32-10 #003	37.00637	-107.95151	Cat G3306 NA HCR	150	127	15.1	12.5	1	0.22		18	15.3	1.2	0.3	18	15.3	1.2	0.3
Williams Production	NWCH 32-10 #002	37.00218	-107.96221	Arrow VRG 330	68	58	11.9	28.7	1	0.22		7	16.0	0.6	0.1	7	16.0	0.6	0.1
Williams Production	NWCH 32-10 #001	37.01302	-107.98119	Waukesha VRG 330	68	58	10.8	1.96	1	0.22		6	1.1	0.6	0.1	6	1.1	0.6	0.1
						749					Facility total	98	124	7	2	98	124	7	2
Williams Production	McCarville #1	37.09275	-107.80135	Cat G3304 NA HCR	95	80	14.8	12	1	0.22		11	9.3	0.8	0.2	11	9.3	0.8	0.2
						80					Facility total	11	9	1	0	11	9	1	0
Williams Production	Ignacio 33-8 #014	37.10626	-107.7106	Arrow VRG 330	68	57	11.9	28.7	1	0.22		7	15.9	0.6	0.1	7	15.9	0.6	0.1
						57					Facility total	7	16	1	0	7	16	1	0
Williams Production	Ignacio 33-7 #018DK	37.10145	-107.61744	Cat G3304 NA HCR	95	81	14.8	12	1	0.22		12	9.4	0.8	0.2	12	9.4	0.8	0.2
						81					Facility total	12	9	1	0	12	9		
Williams Production	Docar #002A	37.07796	-107.6821	Arrow VRG 330	68	58	11.9	28.7	1	0.22		7	16.0	0.6	0.1	7	16.0	0.6	0.1
Williams Production	Docar #002	37.07772	-107.69094	Ariel E-97	50	42	4.2	3.6	1	0.22		2	1.5	0.4	0.1	2	1.5	0.4	0.1

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Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp-hr)	VOC Emission Factor (g/hp-hr)	HAP Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Potential HAP VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)	Actual HAP Emissions (t/yr)
Williams Production	Docar #001	37.07026	-107.68365	Waukesha VRG 330	68	58	10.8	1.96	1	0.22		6	1.1	0.6	0.1	6	1.1	0.6	0.1
						158					**Facility total**	**14**	**19**	**2**	**0**	**14**	**19**	**2**	**0**
Williams Production	Carr #001M	37.08443	-107.85345	Cat G3304 NA HCR	95	82	14.7	2	1	0.22		12	1.6	0.8	0.2	12	1.6	0.8	0.2
						82					**Facility total**	**12**	**2**	**1**	**0**	**12**	**2**	**1**	**0**
Williams Production	Bondad 33-9 #051	37.12035	-107.8703	Cat G3304 NA HCR	95	81	14.7	2	1	0.22		11	1.6	0.8	0.2	11	1.6	0.8	0.2
Williams Production	Bondad 33-9 #032	37.0859	-107.74144	Arrow VRG 330	68	58	11.9	28.7	1	0.22		7	16.2	0.6	0.1	7	16.2	0.6	0.1
Williams Production	Bondad 33-9 #031A	37.08629	-107.87056	Waukesha VRG 330	68	58	10.8	1.96	1	0.22		6	1.1	0.6	0.1	6	1.1	0.6	0.1
Williams Production	Bondad 33-9 #031	37.09247	-107.87233	Cat G3304 NA HCR	95	82	14.7	2	1	0.22		12	1.6	0.8	0.2	12	1.6	0.8	0.2
Williams Production	Bondad 33-9 #026A	37.09966	-107.80107	Cat G3304 NA HCR	95	80	14.8	12	1	0.22		11	9.3	0.8	0.2	11	9.3	0.8	0.2
Williams Production	Bondad 33-9 #026	37.10567	-107.7986	Arrow VRG 220	45	38	12.95	1.104	1	0.22		5	0.4	0.4	0.1	5	0.4	0.4	0.1
Williams Production	Bondad 33-9 #023A	37.09963	-107.86906	Cat G3304 NA HCR	95	81	14.7	2	1	0.22		11	1.6	0.8	0.2	11	1.6	0.8	0.2
Williams Production	Bondad 33-9 #022A	37.12901	-107.79947	Arrow VRG 330	68	58	11.9	28.7	1	0.22		7	16.1	0.6	0.1	7	16.1	0.6	0.1
Williams Production	Bondad 33-9 #018A	37.0423	-107.5204	Cummins G5.9C	84	72	9	15.2	1	0.22		6	10.5	0.7	0.2	6	10.5	0.7	0.2
Williams Production	Bondad 33-9 #015A	37.08638	-107.78309	Arrow VRG 330	68	57	11.9	28.7	1	0.22		7	15.9	0.6	0.1	7	15.9	0.6	0.1
Williams Production	Bondad 33-9 #014	37.10697	-107.87111	Arrow VRG 330	68	58	11.9	28.7	1	0.22		7	16.1	0.6	0.1	7	16.1	0.6	0.1
Williams Production	Bondad 33-9 #011	37.11532	-107.80811	Cat G3304 NA HCR	95	80	14.8	12	1	0.22		11	9.3	0.8	0.2	11	9.3	0.8	0.2
Williams Production	Bondad 33-9 #010A	37.13575	-107.82483	Cat G3304 NA HCR	95	81	14.7	2	1	0.22		11	1.6	0.8	0.2	11	1.6	0.8	0.2
Williams Production	Bondad 33-9 #010	37.13581	-107.83386	Cat G3304 NA HCR	95	81	14.8	12	1	0.22		12	9.4	0.8	0.2	12	9.4	0.8	0.2
Williams Production	Bondad 33-9 #008	37.0872	-107.86452	Cat G3304 NA HCR	95	81	14.8	12	1	0.22		12	9.4	0.8	0.2	12	9.4	0.8	0.2
Williams Production	Bondad 33-9 #007A	37.10082	-107.78327	Arrow VRG 330	68	57	11.9	28.7	1	0.22		7	15.9	0.6	0.1	7	15.9	0.6	0.1
Williams Production	Bondad 33-9 #007	37.10676	-107.78203	Cat G3304 NA HCR	95	80	14.8	12	1	0.22		11	9.3	0.8	0.2	11	9.3	0.8	0.2
Williams Production	Bondad 33-9 #006	37.12154	-107.86372	Cat G3306TA	220	187	20.5	1.6	1	0.22		37	2.9	1.8	0.4	37	2.9	1.8	0.4

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Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp-hr)	VOC Emission Factor (g/hp-hr)	HAP Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Potential HAP VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)	Actual HAP Emissions (t/yr)
Williams Production	Bondad 33-9 #005	37.1318	-107.81898	Cat G3304 NA HCR	95	81	14.7	2	1	0.22		12	1.6	0.8	0.2	12	1.6	0.8	0.2
						1,453					Facility total	202	149	14	3	202	149	14	3
Williams Production	Bondad 33-10 #026	37.10806	-107.91766	Arrow VRG 330	68	58	11.9	28.7	1	0.22		7	16.1	0.6	0.1	7	16.1	0.6	0.1
Williams Production	Bondad 33-10 #020A	37.10114	-107.90666	Arrow VRG 330	68	58	11.9	28.7	1	0.22		7	16.2	0.6	0.1	7	16.2	0.6	0.1
Williams Production	Bondad 33-10 #017A	37.10733	-107.90131	Arrow VRG 330	68	58	11.9	28.7	1	0.22		7	16.1	0.6	0.1	7	16.1	0.6	0.1
Williams Production	Bondad 33-10 #017	37.10141	-107.9008	Arrow VRG 330	68	58	11.9	28.7	1	0.22		7	16.2	0.6	0.1	7	16.2	0.6	0.1
Williams Production	Bondad 33-10 #016A	37.13595	-107.89459	Cat G3304 NA HCR	95	81	14.8	12	1	0.22		12	9.4	0.8	0.2	12	9.4	0.8	0.2
Williams Production	Bondad 33-10 #005A	37.12168	-107.90205	Cat G3304 NA HCR	95	81	14.8	12	1	0.22		12	9.4	0.8	0.2	12	9.4	0.8	0.2
						396					Facility total	50	83	4	1	50	83		
BHEP	Ute 34-3	37.065	-107.70718	Ajax DPC-2803 LE	600	452	2	1.2	1	0.22	lean burn	9	5.2	4.4	1.0	9	5	4.4	1.0
BHEP	Ute 34-16	37.05613	-107.69915	Cat. G342TAW	265	200	20.5	0.8	1	0.22	none	40	1.5	1.9	0.4	40	2	1.9	0.4
BHEP	Ute 33-10	37.05831	-107.71817	Ajax DPC-180	180	139	6.3	1.4	1	0.22	none	8	1.9	1.3	0.3	8	2	1.3	0.3
						791					Facility total	57	9	8	2	57	9	8	2
BP	Wellhead Compression (Various Locations)	See BP source tab		Ajax 2801: 25 Units	192	162	1.5	9.5	1	0.22	LB	59	371.2	1.6	0.3	19	52	0.4	0.1
BP	Wellhead Compression (Various Locations)	See BP source tab		Ajax 2802: 32 Units	384	323	2.0	9.5	1	0.22	LB	199	947.3	3.1	0.7	79	131	0.8	0.2
BP	Wellhead Compression (Various Locations)	See BP source tab		Ajax 2803: 31 Units	600	510	2.0	8.0	1	0.22	LB	305	1220.2	4.9	1.1	266	659	3.5	0.8
BP	Wellhead Compression (Various Locations)	See BP source tab		Ajax 2202: 14 Units	296	249	3.0	11.0	1	0.22	LB	101	369.9	2.4	0.5	33	232	1.2	0.3

Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp-hr)	VOC Emission Factor (g/hp-hr)	HAP Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Potential HAP VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)	Actual HAP Emissions (t/yr)
BP	Wellhead Compression (Various Locations)	See BP source tab		Cummins GTA: 1 unit	116	116	16.5	3.3	1	0.22	LB	18	3.7	1.1	0.2	7	1	0.4	0.1
BP	Wellhead Compression (Various Locations)	See BP source tab		Waukesha Arrow 330: 1 unit	68	61	11.6	14.6	1	0.22	LB	7	8.6	0.6	0.1	0	1	0.0	0.0
BP	Wellhead Compression (Various Locations)	See BP source tab		Waukesha F1197-G: 1 unit	162	110	20.0	35.0	1	0.22	LB	21	37.1	1.1	0.2	21	36	1.0	0.2
BP	Wellhead Compression (Various Locations)	See BP source tab		Waukesha F11-GSI: 3 units	225	196	24.0	30.5	1	0.22	LB	136	57.7	1.9	0.4	0	0	0.0	0.0
BP	Wellhead Compression (Various Locations)	See BP source tab		Waukesha F18-GL: 4	375	300	2.6	1.8	1	0.22	LB	30	20.8	2.9	0.6	29	20	2.8	0.6
BP	Wellhead Compression (Various Locations)	See BP source tab		Waukesha H24 GL: 2	530	424	2.6	3.2	1	0.22	LB	21	13.1	4.1	0.9	20	13	4.0	0.9
BP	Wellhead Compression (Various Locations)	See BP source tab		Waukesha L36 GL: 2	800	640	1.0	2.5	1	0.22	LB	12	15.4	6.2	1.4	12	15	5.9	1.3
BP	Wellhead Compression (Various Locations)	See BP source tab		Caterpillar G3304-NA	95	95	19.0	1.0	1	0.22		17	0.9	0.9	0.2	0	0	0.0	0.0
BP	Wellhead Compression (Various Locations)	See BP source tab		Compressco	50	50	9.4	6.8	1	0.22		5	3.3	0.5	0.1	0	0	0.0	0.0
						3,236					Facility total	932	3,069	31	7	487	1,163	20	4
BP	Dry Creek	37.13538889	-107.9054444	Waukesha L7042GL	1478	1,285	1.5	2.6	1	0.22	LB	19	32.2	12.4	2.7	18.38	32.47	12.4	2.7
BP	Dry Creek			Waukesha L7042GL	1478	1,285	1.5	2.6	1	0.22	LB	19	32.2	12.4	2.7	18.38	32.47	12.4	2.7
BP	Dry Creek			Waukesha L7042GL	1478	1,285	1.5	2.6	1	0.22	LB	19	32.2	12.4	2.7	18.38	32.47	12.4	2.7

Table A-1. 2005 SUIT Inventory

Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp-hr)	VOC Emission Factor (g/hp-hr)	HAP Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Potential HAP VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)	Actual HAP Emissions (t/yr)
BP	Dry Creek			Waukesha L5794GL	1379	1,379	2.6	2.6	1	0.22	LB	35	34.6	13.3	2.9	34.20	26.31	11.6	2.6
						5,234					**Facility total**	**90**	**131**	**50**	**11**	**89**	**124**	**49**	**11**
BP	Florida River	37.09777778	-107.7691667	Solar Centaur H	45 mmBtu/h	--	--	--			--	n/a	n/a			91.2	35.0	0.0	0.0
BP	Florida River			Solar Centaur H	45 mmBtu/h	--	--	--			--	n/a	n/a			100.4	55.6	0.0	0.0
BP	Florida River			Amine Heater	4.5 mmBtu/h	--	--	--			--	n/a	n/a			24.3	20.2	0.0	0.0
BP	Florida River			Amine Heater	44 mmBtu/h	--	--	--			--	n/a	n/a			24.0	20.2	0.0	0.0
BP	Florida River			Glycol Dehy	.5 mmBtu/h	--	--	--			--	n/a	n/a			1.4	1.1	0.0	0.0
BP	Florida River			Glycol Dehy	.5 mmBtu/h	--	--	--			--	n/a	n/a			1.0	0.8	0.0	0.0
BP	Florida River			Glycol Dehy	.5 mmBtu/h	--	--	--			--	n/a	n/a			1.0	0.9	0.0	0.0
BP	Florida River			Flare Pilot	.0 mmBtu/h	--	--	--			--	n/a	n/a			2.4	12.9	0.0	0.0
BP	Florida River			Cummins QSK-60	2922	2,922	0.7	0.7			SCR and Oxicat	n/a	n/a			0.3	0.4	0.0	0.0
BP	Florida River			Cummins QSK-60	2922	2,922	0.7	0.7			SCR and Oxicat	n/a	n/a			0.3	0.4	0.0	0.0
BP	Florida River			Cummins QSK-60	2922	2,922	0.7	0.7			SCR and Oxicat	n/a	n/a			0.3	0.4	0.0	0.0
BP	Florida River			Cummins QSK-60	2922	2,922	0.7	0.7			SCR and Oxicat	n/a	n/a			0.3	0.4	0.0	0.0
BP	Florida River			Cummins QSK-60	2922	2,922	0.7	0.7			SCR and Oxicat	n/a	n/a			0.3	0.4	0.0	0.0
BP	Florida River			Cummins QSK-60	2922	2,922	0.7	0.7			SCR and Oxicat	n/a	n/a			0.3	0.4	0.0	0.0
BP	Florida River			Cummins QSK-60	2922	2,922	0.7	0.7			SCR and Oxicat	n/a	n/a			0.3	0.4	0.0	0.0
BP	Florida River			Cummins QSK-60	2922	2,922	0.7	0.7			SCR and Oxicat	n/a	n/a			0.3	0.4	0.0	0.0
BP	Florida River			Cummins QSK-60	2922	2,922	0.7	0.7			SCR and Oxicat	n/a	n/a			0.3	0.4	0.0	0.0
BP	Florida River			Cummins QSK-60	2922	2,922	0.7	0.7			SCR and Oxicat	n/a	n/a			0.3	0.4	0.0	0.0
BP	Florida River			Cummins QSK-60	2922	2,922	0.7	0.7			SCR and Oxicat	n/a	n/a			0.3	0.4	0.0	0.0
BP	Florida River			Cummins QSK-60	2922	2,922	0.7	0.7			SCR and Oxicat	n/a	n/a			0.3	0.4	0.0	0.0
						35,064					**Facility total**					**249**	**151**	**0**	**0**
BP	4 Queens	37.17361111	-107.7783333	Caterpillar 3608TALE	2025	2,025	2.0	2.0	1	0.22	LB	39	39.1	19.5	4.3	38.5	38.5	19.3	4.2

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Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp-hr)	VOC Emission Factor (g/hp-hr)	HAP Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Potential HAP VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)	Actual HAP Emissions (t/yr)
BP	4 Queens			Caterpillar 3608TALE	2025	2,025	2.0	2.0	1	0.22	LB	39	39.1	19.5	4.3	38.5	38.5	19.3	4.2
BP	4 Queens			Caterpillar G3306-NA	109	109	14.0	14.0	1	0.22	--	15	14.7	1.1	0.2	14.7	1.2	0.6	0.1
						4,159					Facility total	93	93	40	9	92	78	39	9
		UTM coordinates																	
BP	Helen Montgomery	245.000	4125.000	Caterpillar 3516	1085	973	2.4	2.4	1	0.22	--	23	22.5	9.4	2.1	0.0	0.0	0.0	0.0
						973					Facility total	23	23	9	2	0	0	0	0
BP	Miera	37.17361111	-107.7783333	Caterpillar G3606TALE	1895	1,850	0.7	0.7	1	0.22	LB w/Oxicat	12	12.5	17.8	3.9	12.3	3.5	11.3	2.5
BP	Miera			Caterpillar G3606TALE	1895	1,850	0.7	0.7	1	0.22	LB w/Oxicat	12	12.5	17.8	3.9	12.3	3.5	11.3	2.5
BP	Miera			Caterpillar G3606TALE	1895	1,850	0.7	0.7	1	0.22	LB w/Oxicat	12	12.5	17.8	3.9	12.3	3.5	11.3	2.5
BP	Miera			Caterpillar G3606TALE	1895	1,850	0.7	2.5	1	0.22	LB	12	43.7	17.8	3.9	12.3	44.0	17.8	3.9
						7,400					Facility total	50	81	71	16	49	55	52	11
BP	Pinion	245.000	4110.000	Caterpillar G3608TA	2200	2,200	2.0	2.0	1	0.22	LB	42	42.4	21.2	4.7	11.7	17.5	7.3	1.6
BP	Pinion	UTM coordinates		Caterpillar G3608TA	2200	2,200	2.0	2.0	1	0.22	LB	42	42.4	21.2	4.7	0.0	0.0	0.0	0.0
						4,400					Facility total	85	85	42	9	12	18	7	2
BP	Salvador	37.13766667	-107.7845	Waukesha L7042GL	1478	1,285	1.5	3.0	1	0.22	LB w/Oxicat	19	37.2	12.4	2.7	18.4	36.7	12.2	2.7
BP	Salvador			Waukesha F3521GL	738	708	1.5	2.9	1	0.22	LB	10	19.8	6.8	1.5	10.0	20.0	6.8	1.5
BP	Salvador			Waukesha L7042GSI	1478	1,285	1.5	2.9	1	0.22	RB w/NSCR W/AF	19	36.0	12.4	2.7	18.1	36.2	12.3	2.7
BP	Salvador			Waukesha L7042GL	1478	1,285	1.5	2.9	1	0.22	LB	19	36.0	12.4	2.7	18.1	36.2	12.3	2.7
BP	Salvador			Waukesha L7042GL	1478	1,285	1.5	1.5	1	0.22	LB	19	18.6	12.4	2.7	0.0	0.0	0.0	0.0
BP	Salvador			Arrow VRG330	68	61	11.6	11.6	1	0.22	--	7	6.8	0.6	0.1	0.4	0.6	0.0	0.0
						5,909					Facility total	91	154	57	13	65	130	44	10
		UTM coordinates																	
BP	Southern Ute 2-2	245.000	4115.000	Caterpillar 3306	109	109	16.8	16.8	1	0.22	--	18	17.7	1.1	0.2	0.1	0.0	0.0	0.0
						109					Facility total	18	18	1	0	0	0		

Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp-hr)	VOC Emission Factor (g/hp-hr)	HAP Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Potential HAP VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)	Actual HAP Emissions (t/yr)
BP	Tiffany	37.08886111	-107.8820278	Waukesha L7042GL	1478	1,285	1.5	2.6	1	0.22	LB	19	32.2	12.4	2.7	18.1	32.1	12.2	2.7
						1,285					Facility total	19	32	12	3	18	32		
BP	Treating Site 1	263139	4099660	Waukesha L5790GSI	1215	1,166	1.0	1.8	1	0.22	RB w/NSCR w/AFR	11	20.2	11.2	2.5	10.1	20.2	10.6	2.3
BP	Treating Site 1	UTM coordinates		Waukesha L5790GSI	1215	1,166	1.0	1.8	1	0.22	RB w/NSCR w/AFR	11	20.2	11.2	2.5	10.0	20.0	10.6	2.3
BP	Treating Site 1			Waukesha VRG330	68	61	11.0	20.0	1	0.22	--	6	11.8	0.6	0.1	2.0	12.1	0.4	0.1
BP	Treating Site 1			Waukesha F11-G	105	91	20.7	20.7	1	0.22	--	18	18.2	0.9	0.2	10.9	17.9	0.7	0.2
BP	Treating Site 1			Waukesha F18-GL	375	300	2.6	2.6	1	0.22	LB	8	7.5	2.9	0.6	0.0	0.0	0.0	0.0
BP	Treating Site 1			Tank Heater	500 mbtu/hr	--	--	--	1	0.22	--					0.0	0.0		
BP	Treating Site 1			Tank Heater	500 mbtu/hr	--	--	--	1	0.22	--					0.0	0.0		
BP	Treating Site 1			Reboiler	500 mbtu/hr	--	--	--	1	0.22	--					0.1	0.1		
BP	Treating Site 1			Reboiler	500 mbtu/hr	--	--	--	1	0.22	--					0.1	0.1		
BP	Treating Site 1			Tank Heater	250 mbtu/hr	--	--	--	1	0.22	--					0.0	0.0		
						2,784					Facility total	55	78	27	6	33	70	22	5
BP	Treating Site 2	37.03602778	-107.84675	Waukesha L5790GSI	1215	1,166	1.0	1.8	1	0.22	RB w/NSCR w/AFR	11	20.2	11.2	2.5	10.0	20.1	10.6	2.3
BP	Treating Site 2			Waukesha L5790GSI	1215	1,166	1.0	1.8	1	0.22	RB w/NSCR w/AFR	11	20.2	11.2	2.5	10.3	20.6	10.9	2.4
BP	Treating Site 2			Waukesha VRG330	68	61	11.0	40.0	1	0.22	--	6	23.5	0.6	0.1	4.0	23.9	0.5	0.1
BP	Treating Site 2			Waukesha L7042GL	1478	1,285	1.5	2.4	1	0.22	--	19	29.1	12.4	2.7	16.5	29.1	11.7	2.6
BP	Treating Site 2			Tank Heater	500 mbtu/hr	--	--	--	1	0.22	--					0.0	0.0		
BP	Treating Site 2			Tank Heater	500 mbtu/hr	--	--	--	1	0.22	--					0.0	0.0		
BP	Treating Site 2			Reboiler	750 mbtu/hr	--	--	--	1	0.22	--					0.2	0.1		
BP	Treating Site 2			Reboiler	850 mbtu/hr	--	--	--	1	0.22	--					0.2	0.2		
BP	Treating Site 2			Tank Heater	250 mbtu/hr	--	--	--	1	0.22	--					0.0	0.0		
						3,678					Facility total	48	93	35	8	41	94	34	7
BP	Treating Site 4	37.05805556	-107.5461111	Waukesha F3521GSI	738	708	1.0	1.8	1	0.22	LB	7	12.3	6.8	1.5	6.3	12.6	6.6	1.5
BP	Treating Site 4			Waukesha F3521GSI	738	708	1.0	1.8	1	0.22	LB	7	12.3	6.8	1.5	6.1	12.3	6.5	1.4
BP	Treating Site 4			Waukesha L5790GSI	1215	1,166	1.0	1.8	1	0.22	RB w/NSCR	11	20.2	11.2	2.5	10.0	20.0	10.5	2.3
BP	Treating Site 4			Waukesha F11-GSI	225	196	24.0	24.0	1	0.22	--	45	45.4	1.9	0.4	0.0	0.0	0.0	0.0

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Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp-hr)	VOC Emission Factor (g/hp-hr)	HAP Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Potential HAP VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)	Actual HAP Emissions (t/yr)
BP	Treating Site 4			Waukesha F1197-G	162	110	20.0	32.0	1	0.22	--	21	34.0	1.1	0.2	19.2	33.6	1.0	0.2
BP	Treating Site 4			Waukesha F18 GL	375	300	2.6	2.6	1	0.22	LB	8	7.5	2.9	0.6	6.5	4.4	2.1	0.5
BP	Treating Site 4			Tank Heater	500 mbtu/hr	--	--	--			--					0.0	0.0		
BP	Treating Site 4			Tank Heater	500 mbtu/hr	--	--	--			--					0.0	0.0		
BP	Treating Site 4			Tank Heater	500 mbtu/hr	--	--	--			--					0.0	0.0		
BP	Treating Site 4			Tank Heater	500 mbtu/hr	--	--	--			--					0.0	0.0		
BP	Treating Site 4			Reboiler	750 mbtu/hr	--	--	--			--					0.2	0.1		
BP	Treating Site 4			Reboiler	850 mbtu/hr	--	--	--			--					0.2	0.2		
BP	Treating Site 4			Tank Heater	250 mbtu/hr	--	--	--			--					0.0	0.0		
						3,188					Facility total	99	132	31	7	48	83	27	6
BP	Treating Site 4A	37.11107667	-107.6986981	Waukesha L7042GL	1478	1,285	1.5	2.8	1	0.22	LB	19	34.7	12.4	2.7	17.2	34.3	11.9	2.6
BP	Treating Site 4A			Caterpillar G3606LE	1775	1,714	0.7	2.4	1	0.22	LB	12	38.9	16.5	3.6	10.8	38.7	16.0	3.5
BP	Treating Site 4A			Waukesha VRG330	68	61	11.0	40.0	1	0.22	--	6	23.5	0.6	0.1	5.8	23.9	0.6	0.1
BP	Treating Site 4A			Reboiler	750 mbtu/hr	--	--	--			--					0.2	0.1		
BP	Treating Site 4A			Reboiler	850 mbtu/hr	--	--	--			--					0.2	0.2		
BP	Treating Site 4A			Tank Heater	500 mbtu/hr	--	--	--			--					0.0	0.0		
						3,060					Facility total	37	97	30	6	34	97	28	6
BP	Treating Site 5A	37.05805556	-107.5461111	Caterpillar G3606LE	1895	1,864	0.7	0.7	1	0.22	LB	13	42.3	18.0	4.0	11.8	42.3	17.4	3.8
BP	Treating Site 5A			Caterpillar G3606LE	1895	1,864	0.7	0.7	1	0.22	LB	13	41.8	18.0	4.0	11.7	41.8	17.4	3.8
BP	Treating Site 5A			Waukesha F817-G	108	92	18.0	25.5	1	0.22	--	16	22.6	0.9	0.2	10.8	22.8	0.7	0.2
BP	Treating Site 5A			Reboiler	750 mbtu/hr	--	--	--			--					0.2	0.1		
BP	Treating Site 5A			Reboiler	750 mbtu/hr	--	--	--			--					0.2	0.1		
BP	Treating Site 5A			Separator	275 mbtu/hr	--	--	--			--					0.0	0.0		
BP	Treating Site 5A			Tank Heater	375 mbtu/hr	--	--	--			--					0.0	0.0		
						3,820					Facility total	41	107	37	8	35	107	36	8
BP	Treating Site 6	37.05805556	-107.5461111	Waukesha L5790GSI	1215	1,166	1.0	1.4	1	0.22	RB w/NSCR	11	15.7	11.2	2.5	8.0	16.0	9.7	2.1

Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp-hr)	VOC Emission Factor (g/hp-hr)	HAP Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Potential HAP VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)	Actual HAP Emissions (t/yr)
BP	Treating Site 6			Waukesha L5790GSI	1215	1,166	1.0	1.4	1	0.22	RB w/NSCR	11	15.7	11.2	2.5	8.1	16.2	9.8	2.2
BP	Treating Site 6			Waukesha F18-GL	375	300	2.6	2.6	1	0.22	LB	8	7.5	2.9	0.6	0.0	0.0	0.0	0.0
BP	Treating Site 6			Waukesha F11-GSI	225	196	24.0	24.0	1	0.22	--	45	45.4	1.9	0.4	7.2	9.1	0.3	0.1
BP	Treating Site 6			Waukesha VRG330	68	61	11.0	40.0	1	0.22	--	6	23.5	0.6	0.1	4.0	23.9	0.5	0.1
BP	Treating Site 6			Tank Heater	500 mbtu/hr	--	--	--			--					0.0	0.0		
BP	Treating Site 6			Tank Heater	500 mbtu/hr	--	--	--			--					0.0	0.0		
BP	Treating Site 6			Tank Heater	500 mbtu/hr	--	--	--			--					0.0	0.0		
BP	Treating Site 6			Tank Heater	500 mbtu/hr	--	--	--			--					0.0	0.0		
BP	Treating Site 6			Reboiler	500 mbtu/hr	--	--	--			--					0.1	0.1		
						2,889					Facility total	82	108	28	6	27	65	20	4
BP	Treating Site 6B	37.02527778	-107.6802778	Waukesha P9390-GSI	1970	1,891	2.0	2.8	1	0.22	RB w/NSCR	36	51.1	18.2	4.0	33.9	50.9	17.6	3.9
BP	Treating Site 6B			Waukesha F11-G	135	117	28.0	34.0	1	0.22	--	32	38.4	1.1	0.2	28.5	38.7	1.1	0.2
BP	Treating Site 6B			Reboiler	875 mbtu/hr	--	--	--			--					0.2	0.2		
BP	Treating Site 6B			Reboiler	750 mbtu/hr	--	--	--			--					0.2	0.1		
BP	Treating Site 6B			Tank Heater	375 mbtu/hr	--	--	--			--					0.2	0.1		
BP	Treating Site 6B			Tank Heater	150 mbtu/hr	--	--	--			--						0.1		
						2,008					Facility total	68	89	19	4	63	90	19	4
BP	Treating Site 7	37.17361111	-107.7783333	Waukesha F817-G	108	108	16.0	34.0	1	0.22	--	17	35.4	1.0	0.2	15.0	31.8	0.9	0.2
BP	Treating Site 7			Waukesha F2895-G	421	404	18.0	18.0	1	0.22	--	70	70.2	3.9	0.9	16.4	25.6	1.2	0.3
BP	Treating Site 7			Waukesha F2895-G	421	404	18.0	18.0	1	0.22	RB w/NSCR	70	70.2	3.9	0.9	0.0	0.0	0.0	0.0
BP	Treating Site 7			Waukesha F11-G	225	196	24.0	24.0	1	0.22	--	45	45.4	1.9	0.4	1.2	1.5	0.1	0.0
BP	Treating Site 7			Waukesha L5790GSI	1215	1,166	1.0	1.0	1	0.22	RB w/NSCR	11	11.2	11.2	2.5	2.6	5.3	4.0	0.9
BP	Treating Site 7			Tank Heater	500 mbtu/hr	--	--	--			--					0.0	0.0		
BP	Treating Site 7			Tank Heater	500 mbtu/hr	--	--	--			--					0.0	0.0		
BP	Treating Site 7			Tank Heater	500 mbtu/hr	--	--	--			--					0.0	0.0		
BP	Treating Site 7			Tank Heater	500 mbtu/hr	--	--	--			--					0.0	0.0		
BP	Treating Site 7			Tank Heater	500 mbtu/hr	--	--	--			--					0.0	0.0		
BP	Treating Site 7			Reboiler	600 mbtu/hr	--	--	--			--					0.1	0.1		

Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp-hr)	VOC Emission Factor (g/hp-hr)	HAP Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Potential HAP VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)	Actual HAP Emissions (t/yr)
						2,278					Facility total	214	232	22	5	35	64	6	1
BP	Treating Site 7B	37.13538889	-107.9054444	Waukesha P9390-GSI	1970	1,891	2.0	2.8	1	0.22	RB w/NSCR	36	51.1	18.2	4.0	34.0	51.0	17.6	3.9
BP	Treating Site 7B			Waukesha L7042GL	1478	1,285	1.5	1.5	1	0.22	LB	19	18.6	12.4	2.7	4.4	8.8	4.4	1.0
BP	Treating Site 7B			Waukesha VRG330	68	61	11.0	40.0	1	0.22	--	6	23.5	0.6	0.1	5.8	23.9	0.6	0.1
BP	Treating Site 7B			Reboiler	875 mbtu/hr	--	--	--			--					0.2	0.2		
BP	Treating Site 7B			Tank Heater	375 mbtu/hr	--	--	--			--					0.0	0.0		
						3,237					Facility total	62	93	31	7	44	84	23	5
BP	Treating Site 8	37.08886111	-107.8820278	Waukesha 5790GL	1215	1,166	2.3	2.3	1	0.22	LB w/Oxicat	26	25.9	11.2	2.5	23.7	3.1	5.8	1.3
BP	Treating Site 8			Waukesha 5790GL	1215	1,166	2.3	2.3	1	0.22	LB	26	25.9	11.2	2.5	19.4	25.7	9.8	2.2
BP	Treating Site 8			Waukesha P9390-GSI	1970	1,891	2.0	2.9	1	0.22	RB w/NSCR	36	52.9	18.2	4.0	34.4	51.7	17.5	3.9
BP	Treating Site 8			Caterpillar G3608LE	2520	2,419	0.7	0.7	1	0.22	LB	16	16.3	23.3	5.1	0.0	0.0	0.0	0.0
BP	Treating Site 8			Waukesha F18 GL	400	320	2.6	2.6	1	0.22	LB	8	8.0	3.1	0.7	0.3	0.2	0.1	0.0
BP	Treating Site 8			Waukesha VRG330	68	61	11.0	40.0	1	0.22	--	6	23.5	0.6	0.1	5.8	23.9	0.6	0.1
BP	Treating Site 8			Reboiler	600 mbtu/hr	--	--	--			--					0.1	0.1		
BP	Treating Site 8			Reboiler	500 mbtu/hr	--	--	--			--					0.1	0.1		
BP	Treating Site 8			Tank Heater	375 mbtu/hr	--	--	--			--					0.0	0.0		
						7,023					Facility total	119	153	68	15	84	105	34	7
BP	Treating Site 9	236735	4106828	Waukesha F3521GSI	738	708	1.0	1.0	1	0.22	RB w/NSCR w/AFR	7	6.8	6.8	1.5	3.2	6.4	4.8	1.1
BP	Treating Site 9			Waukesha F3521GSI	738	708	1.0	1.0	1	0.22	RB w/NSCR w/AFR	7	6.8	6.8	1.5	1.6	3.2	2.4	0.5
BP	Treating Site 9			Waukesha VRG330	68	61	11.0	40.0	1	0.22	--	6	23.5	0.6	0.1	4.0	23.9	0.5	0.1
BP	Treating Site 9			Tank Heater	500 mbtu/hr	--	--	--			--					0.0	0.0		
BP	Treating Site 9			Tank Heater	500 mbtu/hr	--	--	--			--					0.0	0.0		
BP	Treating Site 9			Tank Heater	375 mbtu/hr	--	--	--			--					0.0	0.0		
BP	Treating Site 9			Tank Heater	375 mbtu/hr	--	--	--			--					0.0	0.0		
BP	Treating Site 9			Reboiler	341 mbtu/hr	--	--	--			--					0.1	0.0		
						1,477					Facility total	20	37	14	3	9	34	8	2

Table A-1. 2005 SUIT Inventory

Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp-hr)	VOC Emission Factor (g/hp-hr)	HAP Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Potential HAP VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)	Actual HAP Emissions (t/yr)
BP	Wolf Point	37.053575	-107.6277611	Waukesha L7042GL	1478	1,285	1.5	2.0	1	0.22	LB	19	24.8	12.4	2.7	18.6	24.8	12.4	2.7
						1,285					Facility total	19	25	12	3	19	25	12.4	2.7
					Total	296,468						5,961	9,576	2,358	519	4,691	6,303	1,740	383

Engine Type	Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp hr)	VOC Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)
CBM	XTO	Alamo CDP	37.06032	107.78859	Waukesha 5790GL	1272	1,158	1.5	0.65	1	lean burn	17	7.3	11.2	4	7.3	8.2
CBM	XTO	M.Smith U 1	37.04343	107.5835	3304 Cat n/a	95	73	16.72	0.77	1	rich burn	12	2.3	0.7	2	1.56	0.5
CBM	Universal	CABIN COMP STATION #1	37.0414166	-107.9238055	G3512 LE CAT	810	766	2	1.6	1	LB	15	11.8	7.4	15	11.9	5.4
CBM	Universal	CABIN COMP STATION #2	37.0414166	-107.9238055	G3512 LE CAT	810	766	2	1.6	1	LB	15	11.8	7.4	15	11.9	5.4
CBM	Universal	DEER CANYON STATION	37.0514722	-107.8946388	G3412C LE	637	527	1	2	1	LB/AFRC	5	10.2	5.1	5	10.2	3.7
CBM	Universal	S UTE 32-10 #5-5 FC	37.0485300	-107.9533900	Waukesha F-18GL	433	350	2	1.7	1	LB	7	5.7	3.4	7	5.8	2.5
CBM	Universal	SUTE 32-10 #6-4 FC	37.0510000	-107.9699700	Waukesha F-18GL	433	350	2	1.7	1	LB	7	5.7	3.4	7	5.8	2.5
CBM	Universal	SUTE 32-10 #10-6 FC	37.0286590	-107.9149080	Wauk H24GL HCR	530	420	2	1.7	1	LB	8	6.9	4.1	8	6.9	3.0
CBM	Universal	SUTE 32-10 #3-7 FC	37.0479710	-107.9144030	Waukesha F-18GL	433	350	2	1.7	1	LB	7	5.7	3.4	7	5.8	2.5
CBM	Universal	SUTE 33-10 #27-6 FC	37.0699830	-107.9183990	AJAX DPC-360	360	266	6.3	1.4	1	None	16	3.6	2.6	16	3.6	1.9
CBM	Universal	SUTE 33-10 #2-9 FC	37.0430350	-107.9051440	AJAX DPC-360LE	360	266	2	1.6	1	LB	5	4.1	2.6	5	4.1	1.9
CBM	Universal	SUTE 33-10 #34-5 FC	37.0574450	-107.9151170	AJAX DPC-600LE (540LE)	600	450	2	1.6	1	LB	9	6.9	4.3	9	7.0	3.2
CBM	Universal	McElvain	37.0794760	-107.6729450	G3516 TALE CAT	1265	1,127	2	1.9	1	LB	22	20.7	10.9	22	20.8	8.0
CBM	Universal	SUTE 33-9 #22-8 FC	37.0932620	-107.8160980	G3508	476	430	2	1.68	1	LB/AFRC	8	7.0	4.1	8	7.0	3.0
CBM	Universal	SUTE 33-9 #22-9 FC	37.0865980	-107.8183670	G3509	476	430	2	1.68	1	LB/AFRC	8	7.0	4.1	8	7.0	3.0
CBM	Universal	RW SAWMILL	37.1581300	-107.9340800	G3516 TALE CAT	1265	1,127	2	1.9	1	LB	22	20.7	10.9	22	20.8	8.0
CBM	Universal	Oxford #1 Main	37.1587000	-107.6684400	Wauk L7042GL	1478	1,280	1.5	2.65	1	LB	19	32.7	12.3	19	32.9	9.1
CBM	Universal	N BLACKRIDGE #2 Main	37.1069166	-107.9798611	G3516 TALE CAT	1265	1,127	2	1.9	1	LB	22	20.7	10.9	22	20.8	8.0
CBM	Universal	N BLACKRIDGE #4 Booster	37.1069166	-107.9798611	G3412C LE CAT	637	527	1	2	1	LB/AFRC	5	10.2	5.1	5	10.2	3.7
CBM	Universal	N BLACKRIDGE #5 Booster	37.1069166	-107.9798611	G3412C LE CAT	637	527	1	2	1	LB/AFRC	5	10.2	5.1	5	10.2	3.7
CBM	Universal	ROUND TOP Main	37.1159840	-108.0072620	G3516 TALE CAT	1265	1,127	2	1.9	1	LB	22	20.7	10.9	22	20.8	8.0
CBM	Universal	ROUND TOP Booster	37.1159840	-108.0072620	Wauk L5794LT	1445	1,153	2.6	2	1	LB	29	22.2	11.1	29	22.4	8.2
CBM	Universal	COYOTE GULCH STATION #1 Main (114013)	37.0168888	-108.0726111	Wauk L7042GL	1478	1,200	1.5	2.6	1	LB	17	30.1	11.6	17	30.3	8.5
CBM	Universal	COYOTE GULCH STATION #2 Booster (114054)	37.0168888	-108.0726111	Wauk L7042GL	1478	1,200	1.5	2.6	1	LB	17	30.1	11.6	17	30.3	8.5
CBM	Universal	COYOTE GULCH STATION #6 Main (114034)	37.0168888	-108.0726111	Wauk L7042GL	1478	1,200	1.5	2.6	1	LB	17	30.1	11.6	17	30.3	8.5
CBM	Universal	COYOTE GULCH STATION #7 Booster (114014)	37.0168888	-108.0726111	Wauk L7042GL	1478	1,200	1.5	2.6	1	LB	17	30.1	11.6	17	30.3	8.5
CBM	Red Cedar	Animas	37° 08' 13.7"	107° 53' 13.8"	Waukesha - L7042GL	1478	1,342	1.5	2.7	1	Lean Burn Technology	19	35.0	12.9	19	34.4	9.5
CBM	Red Cedar	Animas	37° 08' 13.7"	107° 53' 13.8"	Waukesha - L7042GL	1478	1,342	1.5	2.7	1	Lean Burn Technology	19	35.0	12.9	19	34.3	9.5
CBM	Red Cedar	Animas	37° 08' 13.7"	107° 53' 13.8"	Waukesha - L7042GL	1478	1,342	1.5	2.7	1	Lean Burn Technology	19	35.0	12.9	19	34.4	9.5
CBM	Red Cedar	Animas	37° 08' 13.7"	107° 53' 13.8"	Waukesha - L7042GL	1478	1,342	1.5	2.7	1	Lean Burn Technology	19	35.0	12.9	19	34.4	9.5
CBM	Red Cedar	Arrowhead	37° 03' 42.5"	107° 50' 42.3"	Cat. 3516LE (SITA)	1050	1,047	1.5	1.96	1	n/a	15	19.8	10.1	15	19.51	7.4
CBM	Red Cedar	Arrowhead	37° 03' 42.5"	107° 50' 42.3"	Cat. 3516LE (SITA)	1050	1,047	1.5	1.96	1	n/a	15	19.8	10.1	15	19.62	7.4
CBM	Red Cedar	Arrowhead	37° 03' 42.5"	107° 50' 42.3"	Cat. 3516LE (SITA)	1050	1,047	1.5	1.96	1	n/a	15	19.8	10.1	15	19.61	7.4
CBM	Red Cedar	Blackridge	37° 3' 31.3"	107° 57' 43.1"	Waukesha - L7042GL	1478	1,306	1.5	2.65	1	Lean Burn Technology	19	33.4	12.6	19	32.69	9.2
CBM	Red Cedar	Bondad	37° 05' 19.9"	107° 52' 55.3"	Waukesha - L7042GL	1478	1,342	1.5	4.56(lb/hr)	1	Lean Burn w/Oxidation Catalyst	19	20.0	12.9	19	19.14	9.5

Table A-2. 2005 SUIT Engine Inventory Sorted by Usage page 2 of 11

Engine Type	Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp hr)	VOC Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)
CBM	Red Cedar	Bondad	37° 05' 19.9"	107° 52' 55.3"	Waukesha - L7042GL	1478	1,342	1.5	4.56(lb/hr)	1	Lean Burn w/Oxidation Catalyst	19	20.0	12.9	18	18.18	9.5
CBM	Red Cedar	Bondad	37° 05' 19.9"	107° 52' 55.3"	Waukesha - L7042GL	1478	1,342	1.5	4.56(lb/hr)	1	Lean Burn w/Oxidation Catalyst	19	20.0	12.9	19	19.32	9.5
CBM	Red Cedar	Bondad (6)	37° 05' 19.9"	107° 52' 55.3"	Waukesha - L7042GL	1478	1,342	1.5	4.56(lb/hr)	1	Lean Burn w/Oxidation Catalyst	19	20.0	12.9	18	18.78	9.5
CBM	Red Cedar	Bondad	37° 05' 19.9"	107° 52' 55.3"	Waukesha - L7042GL	1478	1,342	1.5	4.56(lb/hr)	1	Lean Burn w/Oxidation Catalyst	19	20.0	12.9	17	17.01	9.5
CBM	Red Cedar	Bondad	37° 05' 19.9"	107° 52' 55.3"	Waukesha - L7042GL	1478	1,342	1.5	4.56(lb/hr)	1	Lean Burn w/Oxidation Catalyst	19	20.0	12.9	19	19.76	9.5
CBM	Red Cedar	Bondad	37° 05' 19.9"	107° 52' 55.3"	Waukesha - L7042GL	1478	1,342	1.5	4.56(lb/hr)	1	Lean Burn w/Oxidation Catalyst	19	20.0	12.9	18	18.86	9.5
CBM	Red Cedar	Bondad	37° 05' 19.9"	107° 52' 55.3"	Waukesha - L7042GL	1478	1,342	1.5	4.56(lb/hr)	1	Lean Burn w/Oxidation Catalyst	19	20.0	12.9	19	19.11	9.5
CBM	Red Cedar	Bondad	37° 05' 19.9"	107° 52' 55.3"	Waukesha - L7042GL	1478	1,342	1.5	2.65	1	Lean Burn Technology	19	34.3	12.9	3	2.69	9.5
CBM	Red Cedar	Bondad (6)	37° 05' 19.9"	107° 52' 55.3"	Waukesha - L7042GL	1478	1,342	1.5	2.65	1	Lean Burn Technology	19	34.3	12.9	17	17.28	9.5
CBM	Red Cedar	Capote	37° 3' 39.7"	107° 49' 21.1"	Waukesha - L7042GL	1478	1,324	1.5	2.65	1	Lean Burn Technology	19	33.8	12.8	19	33	9.4
CBM	Red Cedar	Capote	37° 3' 39.7"	107° 49' 21.1"	Waukesha - L7042GL	1478	1,324	1.5	2.65	1	Lean Burn Technology	19	33.8	12.8	19	33.4	9.4
CBM	Red Cedar	Capote	37° 3' 39.7"	107° 49' 21.1"	Waukesha - L7042GL	1478	1,324	1.5	2.65	1	Lean Burn Technology	19	33.8	12.8	19	33.4	9.4
CBM	Red Cedar	Capote	37° 3' 39.7"	107° 49' 21.1"	Waukesha - L7042GL	1478	1,324	1.5	2.65	1	Lean Burn Technology	19	33.8	12.8	19	33.4	9.4
CBM	Red Cedar	Capote	37° 3' 39.7"	107° 49' 21.1"	Waukesha - L7042GL	1478	1,324	1.5	2.65	1	Lean Burn Technology	19	33.8	12.8	19	32.9	9.4
CBM	Red Cedar	Capote	37° 3' 39.7"	107° 49' 21.1"	Waukesha - L7042GL	1478	1,324	1.5	2.65	1	Lean Burn Technology	19	33.8	12.8	19	33.3	9.4
CBM	Red Cedar	Cox Canyon	37° 0' 55"	107° 55' 6.3"	Waukesha - L7042GL	1478	1,333	1.5	2.65	1	Lean Burn Technology	19	34.1	12.9	19	32.91	9.4
CBM	Red Cedar	Diamondback-Sidewinder	37° 2' 9.7"	107° 50' 48.3"	Waukesha - L7042GL	1478	1,330	1.5	2.65	1	Lean Burn Technology	19	34.0	12.8	19	33.4	9.4
CBM	Red Cedar	Diamondback-Sidewinder	37° 2' 9.7"	107° 50' 48.3"	Waukesha - L7042GL	1478	1,330	1.5	2.65	1	Lean Burn Technology	19	34.0	12.8	13	23.3	9.4
CBM	Red Cedar	Diamondback-Sidewinder	37° 2' 9.7"	107° 50' 48.3"	Waukesha - L7042GL	1478	1,330	1.5	2.65	1	Lean Burn Technology	19	34.0	12.8	8	14.8	9.4

Table A-2. 2005 SUIT Engine Inventory Sorted by Usage page 3 of 11

Engine Type	Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp hr)	VOC Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)
CBM	Red Cedar	Diamondback-Sidewinder	37° 2' 9.7"	107° 50' 48.3"	Waukesha - L7042GL	1478	1,330	1.5	2.65	1	Lean Burn Technology	19	34.0	12.8	19	33.4	9.4
CBM	Red Cedar	Diamondback-Sidewinder	37° 2' 9.7"	107° 50' 48.3"	Cummins GTA8.3-LC-GI	185	168	14.9	2.19	1	n/a	24	3.6	1.6	14	2.02	1.2
CBM	Red Cedar	East Alamo	37° 3' 44.5"	107° 45' 9.9"	Cat. 3516-SITA	1050	1,047	1.5	1.96	1	n/a	15	19.8	10.1	15	19.67	7.4
CBM	Red Cedar	East Alamo	37° 3' 44.5"	107° 45' 9.9"	Cat. 3516-SITA	1050	1,047	1.5	1.96	1	n/a	15	19.8	10.1	15	19.64	7.4
CBM	Red Cedar	Elk Point	37° 04' 30.7"	107° 46' 8.6"	Cat 3516LE	1322	1,322	1.5	1.89	1	n/a	19	24.1	12.8	19	24.13	9.3
CBM	Red Cedar	Elk Point	37° 04' 30.7"	107° 46' 8.6"	Cat 3516LE	1322	1,322	1.5	1.89	1	n/a	19	24.1	12.8	19	24.13	9.3
CBM	Red Cedar	Elk Point	37° 04' 30.7"	107° 46' 8.6"	Cat 3516LE	1322	1,322	1.5	1.89	1	n/a	19	24.1	12.8	19	24.13	9.3
CBM	Red Cedar	Elk Point	37° 04' 30.7"	107° 46' 8.6"	Cat 3516LE	1322	1,322	1.5	1.89	1	n/a	19	24.1	12.8	19	24.13	9.3
CBM	Red Cedar	Homestead (7)	37° 2' 41.8	107° 43' 52"	Waukesha - L7042GL	1478	1,318	1.7	3.1	1	Lean Burn Technology	22	39.4	12.7	21	39	9.3
CBM	Red Cedar	Homestead (7)	37° 2' 41.8"	107° 43' 52"	Waukesha - L7042GL	1478	1,318	1.7	3.1	1	Lean Burn Technology	22	39.4	12.7	22	39.7	9.3
CBM	Red Cedar	Homestead (7)	37° 2' 41.8"	107° 43' 52"	Waukesha - L7042GL	1478	1,318	1.7	3.1	1	Lean Burn Technology	22	39.4	12.7	21	38.8	9.3
CBM	Red Cedar	La Boca	37° 03' 12.87	107° 37' 39.94"	Waukesha - L7042GL	1478	1,318	1.5	2.65	1	Lean Burn Technology	19	33.7	12.7	2	3.6	9.3
CBM	Red Cedar	La Posta (6)	37° 8' 7.4"	107° 54' 19.6"	Waukesha - L7042GL	1478	1,333	1.5	2.7	1	Lean Burn Technology	19	34.7	12.9	19	34.2	9.4
CBM	Red Cedar	La Posta	37° 8' 7.4"	107° 54' 19.6"	Waukesha - L7042GL	1478	1,333	1.5	2.7	1	Lean Burn Technology	19	34.7	12.9	19	34.5	9.4
CBM	Red Cedar	La Posta	37° 8' 7.4"	107° 54' 19.6"	Waukesha - L7042GL	1478	1,333	1.5	2.7	1	Lean Burn Technology	19	34.7	12.9	19	34.5	9.4
CBM	Red Cedar	La Posta	37° 8' 7.4"	107° 54' 19.6"	Waukesha - L7042GL	1478	1,333	1.5	2.7	1	Lean Burn Technology	19	34.7	12.9	19	34.4	9.4
CBM	Red Cedar	North Blackridge	37° 5' 25.8"	107° 58' 28.9"	Waukesha - L7042GL	1478	1,306	1.5	2.65	1	Lean Burn Technology	19	33.4	12.6	19	32.82	9.2
CBM	Red Cedar	Outlaw	37° 10' 25"	107° 46' 42"	Cat G3606	1775	1,775	0.7	2.5	1	Lean Burn Technology	12	42.8	17.1	10	35.8	12.6
CBM	Red Cedar	Outlaw	37° 10' 25"	107° 46' 42"	Cat G3606	1775	1,775	0.7	2.5	1	Lean Burn Technology	12	42.8	17.1	10	35.6	12.6
CBM	Red Cedar	Outlaw	37° 10' 25"	107° 46' 42"	Cat G3606	1775	1,775	0.7	2.5	1	Lean Burn Technology	12	42.8	17.1	10	33.9	12.6
CBM	Red Cedar	Outlaw	37° 10' 25"	107° 46' 42"	Cat G3606	1775	1,775	0.7	2.5	1	Lean Burn Technology	12	42.8	17.1	9	32.8	12.6
CBM	Red Cedar	Outlaw	37° 10' 25"	107° 46' 42"	Cat G3606	1775	1,775	0.7	2.5	1	Lean Burn Technology	12	42.8	17.1	10	34.8	12.6
CBM	Red Cedar	Outlaw	37° 10' 25"	107° 46' 42"	Onan Gen. - 125GGKB	185	178	14.8	2.13	1	n/a	25	3.7	1.7	25	3.7	1.3
CBM	Red Cedar	Pump Canyon	37° 01' 31"	107° 40' 49"	Waukesha - L7042GL	1478	1,330	1.5	2.65	1	n/a	19	34.0	12.8	19	33.8	9.4
CBM	Red Cedar	Pump Canyon	37° 01' 31"	107° 40' 49"	Waukesha - L7042GL	1478	1,330	1.5	2.65	1	n/a	19	34.0	12.8	19	33.8	9.4
CBM	Red Cedar	Pump Canyon	37° 01' 31"	107° 40' 49"	Waukesha - L7042GL	1478	1,330	1.5	2.65	1	n/a	19	34.0	12.8	19	33.7	9.4
CBM	Red Cedar	Pump Canyon	37° 01' 31"	107° 40' 49"	Cat G3612LE	3227	2,927	0.7	2.5	1	Oxidation Catalyst	20	70.6	28.2	19	2.1	20.7
CBM	Red Cedar	Sawmill	37° 10' 16.3"	107° 53' 25.1"	Waukesha - L7042GL	1478	1,306	1.5	2.65	1	Lean Burn Technology	19	33.4	12.6	19	32.99	9.2

Table A-2. 2005 SUIT Engine Inventory Sorted by Usage

Engine Type	Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp hr)	VOC Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)
CBM	Red Cedar	Sawmill	37° 10' 16.3"	107° 53' 25.1"	Waukesha - L7042GL	1478	1,306	1.5	2.65	1	Lean Burn Technology	19	33.4	12.6	18	32.54	9.2
CBM	Red Cedar	Six Shooter	37° 3' 55.4"	107° 44' 0.2"	Waukesha - L7042GL	1478	1,324	1.5	2.65	1	Lean Burn Technology	19	33.8	12.8	19	33.53	9.4
CBM	Red Cedar	Six Shooter	37° 3' 55.4"	107° 44' 0.2"	Waukesha - L7042GL	1478	1,324	1.5	2.65	1	Lean Burn Technology	19	33.8	12.8	19	33.38	9.4
CBM	Red Cedar	Spring Creek	37°03'29"	107°32'46"	Cat 3516LE	1340	1,340	1.5	0.132	1	AFRC & Oxidation Catalyst	19	1.7	12.9	17	1.54	9.5
CBM	Red Cedar	Spring Creek	37°03'29"	107°32'46"	Cat 3516LE	1340	1,340	1.5	0.132	1	AFRC & Oxidation Catalyst	19	1.7	12.9	17	1.54	9.5
CBM	Red Cedar	Spring Creek	37°03'29"	107°32'46"	Cat 3516LE	1340	1,340	1.5	0.132	1	AFRC & Oxidation Catalyst	19	1.7	12.9	17	1.54	9.5
CBM	Red Cedar	Spring Creek	37°03'29"	107°32'46"	Cat 3516LE	1340	1,340	1.5	1.89	1	n/a	19	24.4	12.9	2	2.08	9.5
CBM	Red Cedar	Spring Creek	37°03'29"	107°32'46"	Cat 3516LE	1340	1,340	1.5	1.89	1	n/a	19	24.4	12.9	2	2.08	9.5
CBM	Red Cedar	Trail Canyon	37° 2' 59.1"	107° 46' 55.7"	Cat 3516LE	1000	980	2	1.5	1	n/a	19	14.2	9.5	18	13.68	6.9
CBM	Red Cedar	Trail Canyon	37° 2' 59.1"	107° 46' 55.7"	Cat 3516LE	1000	980	2	1.5	1	n/a	19	14.2	9.5	18	13.68	6.9
CBM	Red Cedar	Trunk T	37° 3' 1.1"	107° 47' 3.3"	Waukesha L7042GL	1478	1,324	1.5	2.65	1	Lean Burn Technology	19	33.8	12.8	19	32.81	9.4
CBM	Red Cedar	West La Posta	37° 7' 56.6"	107° 57' 13.7"	Cat. 3516 - SITA	1050	1,047	1.5	1.96	1	n/a	15	19.8	10.1	15	19.61	7.4
CBM	Samson	S Ignacio CDP	37.05451	-107.62555	Waukesha 7044 GSI	1680	1,680	1.3	13.8	1	AFRC/NSCR Catalyst	21	223.7	16.2	11	7.6	11.9
CBM	Samson	S Ignacio CDP	37.05451	-107.62555	Waukesha 7042 GL	1232	1,113	0.9	2.65	1	Lean Burn/OC	10	28.5	10.7	10	4.3	7.9
CBM	Samson	S Ignacio CDP	37.05451	-107.62555	Waukesha 7042 GL	1232	1,113	0.9	2.65	1	Lean Burn/OC	10	28.5	10.7	10	4.3	7.9
CBM	Samson	S Ignacio CDP	37.05451	-107.62555	Waukesha 7042 GL	1478	1,359	0.9	2.65	1	Lean Burn/OC	12	34.8	13.1	12	5.2	9.6
CBM	Samson	S Ignacio CDP	37.05451	-107.62555	Waukesha 5794 LT	1445	1,399	2.5	0.45	1	Lean Burn/OC	34	6.1	13.5	34	6.1	9.9
CBM	Samson	Jaques CDP	37.07896	-107.99005	Waukesha 5794 LT	1445	1,399	2.5	1.8	1	Lean Burn	34	24.3	13.5	34	24.3	9.9
CBM	Samson	Jaques CDP	37.07896	-107.99005	Waukesha 5794 LT	1445	1,399	2.5	1.8	1	Lean Burn	34	24.3	13.5	34	24.3	9.9
CBM	Samson	Jaques CDP	37.07896	-107.99005	Waukesha 5794 LT	1445	1,399	2.5	0.45	1	Lean Burn/OC	34	6.1	13.5	34	6.1	9.9
CBM	Samson	Deadhorse CDP	37.19932	-107.56442	Waukesha 5794 LT	1445	1,399	2.5	1.8	1	Lean Burn	34	24.3	13.5	34	24.3	9.9
CBM	Samson	Wolfe 33-7-22 #4	37.086181	-107.596214	Cat 3306 NA	145	110	1.09	1.97	1	AFRC/NSCR Catalyst	1	2.1	1.1	1	2.1	0.8
CBM	Samson	Wolfe 33-7-22 #2	37.08512	-107.59407	Cat 3306 NA	145	110	10.9	13.1	1	None	12	13.9	1.1	12	13.9	0.8
CBM	Samson	Ute 33-7-22 #5	37.09239	-107.59097	Cat 3306 NA	145	110	10.9	13.1	1	None	12	13.9	1.1	12	13.9	0.8
CBM	Samson	Ute 33-7-22 #3	37.092369	-107.590729	Cat 3306 NA	145	110	1.09	1.97	1	AFRC/NSCR Catalyst	1	2.1	1.1	1	2.1	0.8
CBM	Samson	Underwood 33-7-15 #5	37.105546	-107.600479	Cat 3306 TA	203	160	21.2	1.5	1	None	33	2.3	1.5	33	2.3	1.1
CBM	Samson	Underwood 33-7-15 #3	37.099394	-107.599374	Cat 3306 NA	145	110	1.09	1.97	1	AFRC/NSCR Catalyst	1	2.1	1.1	1	2.1	0.8
CBM	Samson	Mcelvain 33-8-19 #1	37.09214	-107.76439	Cat 3306 TA	220	175	20.5	1.6	1	None	35	2.7	1.7	35	2.7	1.2
CBM	Samson	Mcelvain #4	37.02017	-107.55336	Waukesha VRG 220	45	38	9	9	1	None	3	3.3	0.4	3	3.3	0.3
CBM	Samson	Mcelvain #3	37.01946	-107.5618	Waukesha VRG 330	68	58	9	9	1	None	5	5.0	0.6	5	5	0.4
CBM	Samson	Ignacio 33-8 20	37.07911	-107.71693	Waukesha VRG 330	68	58	9	9	1	None	5	5.0	0.6	5	5	0.4
CBM	Samson	Ignacio 33-8 #19A	37.0562	-107.68983	Waukesha VRG 330	68	58	9	9	1	None	5	5.0	0.6	5	5	0.4

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Engine Type	Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp hr)	VOC Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)
CBM	Samson	Hill 33-9-12 #1	37.1176	-107.77213	Cat 3306 NA	145	110	10.9	13.1	1	None	12	13.9	1.1	12	13.9	0.8
CBM	Samson	Hill 33-9-12 #3	37.12117	-107.77314	Waukesha F1197	186	149	8.5	35	1	None	12	50.3	1.4	12	50.3	1.1
CBM	Samson	Behrmann 33-7-15 CP	37.10112	-107.59143	Cat 3306 NA	145	110	1.09	1.97	1	AFRC/NSCR Catalyst	1	2.1	1.1	1	2.1	0.8
CBM	Samson	Mcelvain 33-8-19 #3	37.09383	-107.75558	Waukesha F1197	186	149	8.5	35	1	None	12	50.3	1.4	12	50.3	1.1
CBM	Chevron	Southern Ute 22-2	37.072129	-107.817066	Caterpillar G3512TALE	697	130	2.00	2.28	1	N/A	13.44	2.9	1.3	2.51	2.86	0.9
CBM	Chevron	Southern Ute 10	37.064499	-107.836797	Caterpillar 3306TA	175	2	2.00	1.50	1	AFRC/NSCR	3.37	0.0	0.0	0.04	0.03	0.0
CBM	Chevron	Sam Burch 23 & 4	37.05006	-107.826186	Caterpillar 3306TA	175	80	2.00	1.50	1	AFRC/NSCR	3.37	1.2	0.8	1.54	1.15	0.6
CBM	Chevron	Southern Ute 18	37.065489	-107.817806	Caterpillar 3306TA	175	62	2.00	1.50	1	AFRC/NSCR	3.37	0.9	0.6	1.20	0.90	0.4
CBM	Chevron	Sam Burch 20 & 3	37.02756	-107.817456	Caterpillar 3306TA	175	72	2.00	1.50	1	AFRC/NSCR	3.37	1.0	0.7	1.39	1.04	0.5
CBM	Chevron	Sam Burch 13	37.04228	-107.808236	Caterpillar 3306TA	175	104	2.00	1.50	1	AFRC/NSCR	3.37	1.5	1.0	2.01	1.51	0.7
CBM	Chevron	Sam Burch 14	37.050329	-107.836137	Caterpillar 3306TA	175	79	2.00	1.50	1	AFRC/NSCR	3.37	1.1	0.8	1.53	1.15	0.6
CBM	Chevron	Sam Burch 28 & 12	37.03447	-107.816726	Caterpillar 3306TA	175	54	2.00	1.50	1	AFRC/NSCR	3.37	0.8	0.5	1.05	0.78	0.4
CBM	Chevron	Sam Burch 27	37.02764	-107.826926	Caterpillar 3306TA	175	71	2.00	1.50	1	AFRC/NSCR	3.37	1.0	0.7	1.38	1.04	0.5
CBM	Chevron	Sam Burch 22 & 2	37.04236	-107.836776	Caterpillar 3306TA	175	84	2.00	1.50	1	AFRC/NSCR	3.37	1.2	0.8	1.63	1.22	0.6
CBM	Chevron	Sam Burch 19 & 5	37.03558	-107.828186	Caterpillar 3306TA	175	133	2.00	1.50	1	AFRC/NSCR	3.37	1.9	1.3	2.56	1.92	0.9
CBM	Chevron	Sam Burch 24	37.04198	-107.817916	Caterpillar 3306TA	175	26	2.00	1.50	1	AFRC/NSCR	3.37	0.4	0.3	0.51	0.38	0.2
CBM	Chevron	Sam Burch 29 & 10	37.04302	-107.827506	Caterpillar 3306TA	175	0	2.00	1.50	1	AFRC/NSCR	3.37	0.0	0.0	0.00	0.00	0.0
CBM	Chevron	Sam Burch 11	37.04845	-107.815886	Caterpillar 3306TA	175	95	2.00	1.50	1	AFRC/NSCR	3.37	1.4	0.9	1.84	1.38	0.7
CBM	Chevron	Southern Ute 11& 5	37.056059	-107.808306	Caterpillar 3306TA	175	72	2.00	1.50	1	AFRC/NSCR	3.37	1.0	0.7	1.40	1.05	0.5
CBM	Chevron	Sam Burch 25 & 8	37.05049	-107.806926	Caterpillar 3306TA	175	18	2.00	1.50	1	AFRC/NSCR	3.37	0.3	0.2	0.35	0.26	0.1
CBM	Chevron	Sam Burch 30 &15	37.03487	-107.836416	Caterpillar 3306TA	175	65	2.00	1.50	1	AFRC/NSCR	3.37	0.9	0.6	1.25	0.94	0.5
CBM	Chevron	Southern Ute 26-4	37.070339	-107.797016	Caterpillar 3306TA	175	134	2.00	1.50	1	AFRC/NSCR	3.37	1.9	1.3	2.59	1.95	0.9
CBM	Chevron	Sam Burch 18 & 1	37.02789	-107.837006	Caterpillar 3306TA	175	96	2.00	1.50	1	AFRC/NSCR	3.37	1.4	0.9	1.85	1.38	0.7
CBM	Chevron	Southern Ute 15	37.079379	-107.818306	Caterpillar 3508 LE	542	152	2.00	1.60	1	N/A	10.45	2.3	1.5	2.94	2.35	1.1
CBM	Chevron	Southern Ute 27-1	37.099918	-107.94959	Waukesha F18GL	241	5		2.00	1	Unknown	18.65	0.7	0.7	0.42	0.71	0.5
CBM	Chevron	Black Ridge 17-1	37.079429	-107.808096	Caterpillar G3408TA	344	43		2.00	1	Unknown	26.64	0.8	0.4	3.31	0.8	0.3
CBM	Chevron	Southern Ute 16-5	37.064879	-107.810066	Caterpillar 3412LELCR	548	7	1.00	2.00	1	N/A	5.29	0.1	0.1	0.06	0.13	0.0
CBM	Chevron	Southern Ute 20	37.064009	-107.827386	Ajax 2202 LE	254	128	1.90	1.00	1	N/A	4.65	1.2	1.2	2.34	1.23	0.9
CBM	Chevron	Southern Ute 26 & 21	37.057609	-107.818786	Ajax 2202 LE	258	156	1.90	1.00	1	N/A	4.73	1.5	1.5	2.86	1.50	1.1
CBM	Chevron	Southern Ute 9	37.03602	-107.807906	Ajax 2202 LE	254	81	1.90	1.00	1	N/A	4.65	0.8	0.8	1.49	0.78	0.6
CBM	Chevron	Southern Ute 19	37.175607	-107.884739	Ajax 2202 LE	254	91	1.90	1.00	1	N/A	4.65	0.9	0.9	1.67	0.88	0.6
CBM	Chevron	Sam Burch 21	37.175607	-107.884739	Ajax 2202 LE	254	88	1.90	1.00	1	N/A	4.65	0.8	0.8	1.61	0.85	0.6
CBM	Chevron	Indian Creek #4	37.175607	-107.884739	Caterpillar 3516	1152	635	1.50	1.89	1	N/A	16.68	11.6	6.1	9.19	11.58	4.5
CBM	Chevron	Indian Creek #2	37.175607	-107.884739	Caterpillar 3516	1152	633	1.50	1.89	1	N/A	16.68	11.5	6.1	9.17	11.56	4.5
CBM	Chevron	Indian Creek #3	37.056998	-108.064913	Caterpillar 3516	1152	635	1.50	1.89	1	N/A	16.68	11.6	6.1	9.19	11.58	4.5
CBM	Chevron	Indian Creek #1	37.056998	-108.064913	Caterpillar 3516	1152	623	1.50	1.89	1	N/A	16.68	11.4	6.0	9.03	11.38	4.4
CBM	Chevron	Valencia Canyon 32-1 S	37.109098	-107.95422	Caterpillar 3516	863	246	1.50	1.90	1	N/A	12.50	4.5	2.4	3.56	4.51	1.7
CBM	Chevron	Valencia Canyon 32-1 N	37.109098	-107.95422	Caterpillar 3516	863	237	1.50	1.90	1	N/A	12.50	4.3	2.3	3.43	4.35	1.7
CBM	Chevron	Black Ridge 17-2 (N)	37.064049	107.827296	Caterpillar 3516	1152	206	2.00	1.89	1	N/A	22.24	3.8	2.0	3.98	3.76	1.5
CBM	Chevron	Black Ridge 17-2 (S)	37.071429	-107.789855	Caterpillar 3516	1152	208	2.00	1.89	1	N/A	22.24	3.8	2.0	4.01	3.79	1.5
CBM	Chevron	Southern Ute 21-2			Ford 460	17	21	8.02	2.00	1	Unknown	1.33	0.4	0.2	1.61	0.4	0.1
CBM	Chevron	Southern Ute 26-5			Caterpillar 3306 TA	175	0	22.80	1.50	1	Unknown	38.44	0.0	0.0	0.00	0.00	0.0
CBM	Williams Four Corners LLC	Trunk J	37° 6' 39.876"	-107° 41' 55.313"	Waukesha 7042GL	1478	943	1.5	2.65	1	leanburn	14	24.1	9.1	14	24	6.7

Table A-2. 2005 SUIT Engine Inventory Sorted by Usage

Engine Type	Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp hr)	VOC Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)
CBM	Williams Four Corners LLC	Ute E	37° 7' 14.466"	-107° 56' 19.405"	Waukesha 7042G	1173	994	2	3	1	NSCR	19	28.8	9.6	19	29	7.0
CBM	Williams Four Corners LLC	PLA-9	37° 0' 10.798"	-107° 55' 26.661"	Waukesha 7042GL	1478	1,115	1.5	2.65	1	leanburn	16	28.5	10.8	16	29	7.9
CBM	Maralex Resources	Shelhammer CDP	location is NW 1/4 of the SW 1/4 of section 10, T33N, R7W		Caterpillar 945, model G3512 TALE	800	632	2	1.8	1	lean burn	12	11.0	6.1	12	11	4.5
CBM	BHEP	Ute 34-3	37.065	-107.70718	Ajax DPC-2803-LE	600	452	2	1.2	1	lean burn	9	5.2	4.4	9	5	3.2
CBM	BHEP	Ute 34-16	37.05613	-107.69915	Cat. G342TAW	265	200	20.5	0.8	1	none	40	1.5	1.9	40	2	1.4
CBM	BHEP	Ute 33-10	37.05831	-107.71817	Ajax DPC-180	180	139	6.3	1.4	1	none	8	1.9	1.3	8	2	1.0
CBM	BP	Wellhead Compression (Various Locations)	Distribute among other BP Sources		Ajax 2801: 25 Units	192	162	1.5	2.7	1	LB	59	105.5	1.6	19	52	1.1
CBM	BP	Wellhead Compression (Various Locations)	Distribute among other BP Sources		Ajax 2802: 32 Units	384	323	2.0	1.6	1	LB	199	159.5	3.1	79	131	2.3
CBM	BP	Wellhead Compression (Various Locations)	Distribute among other BP Sources		Ajax 2803: 31 Units	600	510	2.0	1.6	1	LB	305	244.0	4.9	266	244.0	3.6
CBM	BP	Wellhead Compression (Various Locations)	Distribute among other BP Sources		Ajax 2202: 14 Units	296	249	3.0	11.0	1	LB	101	369.9	2.4	33	232	1.8
CBM	BP	Wellhead Compression (Various Locations)	Distribute among other BP Sources		Cummins GTA: 1 unit	116	116	16.5	3.3	1	LB	18	3.7	1.1	7	1	0.8
CBM	BP	Wellhead Compression (Various Locations)	Distribute among other BP Sources		Waukesha Arrow 330: 1 unit	68	61	11.6	14.6	1	LB	7	8.6	0.6	0	1	0.4
CBM	BP	Wellhead Compression (Various Locations)	Distribute among other BP Sources		Waukesha F1197-G: 1 unit	162	110	20.0	35.0	1	LB	21	37.1	1.1	21	36	0.8
CBM	BP	Wellhead Compression (Various Locations)	Distribute among other BP Sources		Waukesha F11-GSI: 3 units	225	196	24.0	30.5	1	LB	136	57.7	1.9	0	0	1.4
CBM	BP	Wellhead Compression (Various Locations)	Distribute among other BP Sources		Waukesha F18-GL: 4	375	300	2.6	1.8	1	LB	30	20.8	2.9	29	20	2.1
CBM	BP	Wellhead Compression (Various Locations)	Distribute among other BP Sources		Waukesha H24 GL: 2	530	424	2.6	1.8	1	LB	21	14.3	4.1	20	13	3.0
CBM	BP	Wellhead Compression (Various Locations)	Distribute among other BP Sources		Waukesha L36 GL: 2	800	640	1.0	1.3	1	LB	12	16.1	6.2	12	15	4.5
CBM	BP	Wellhead Compression (Various Locations)	Distribute among other BP Sources		Caterpillar G3304-NA	95	95	19.0	1.0	1		17	0.9	0.9	0	0	0.7
CBM	BP	Wellhead Compression (Various Locations)	Distribute among other BP Sources		Compressco	50	50	9.4	6.8	1		5	3.3	0.5	0	0	0.4
CBM	BP	Dry Creek	37.13538889	-107.9054444	Waukesha L7042GL	1478	1285	1.5	1.5	1	LB	19	18.6	12.4	18.38	18.6	9.1
CBM	BP	Dry Creek			Waukesha L7042GL	1478	1285	1.5	1.5	1	LB	19	18.6	12.4	18.38	18.6	9.1
CBM	BP	Dry Creek			Waukesha L7042GL	1478	1285	1.5	1.5	1	LB	19	18.6	12.4	18.38	18.6	9.1
CBM	BP	Dry Creek			Waukesha L5794GL	1379	1379	2.6	2.6	1	LB	35	34.6	13.3	34.20	26.31	9.8
CBM	BP	4 Queens	37.17361111	-107.7783333	Caterpillar 3608TALE	2025	2025	2.0	2.0	1	LB	39	39.1	19.5	38.5	38.5	14.3
CBM	BP	4 Queens			Caterpillar 3608TALE	2025	2025	2.0	2.0	1	LB	39	39.1	19.5	38.5	38.5	14.3
CBM	BP	4 Queens			Caterpillar G3306-NA	109	109	14.0	14.0	1	--	15	14.7	1.1	14.7	1.2	0.8

Table A-2. 2005 SUIT Engine Inventory Sorted by Usage

Engine Type	Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp hr)	VOC Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)
CBM	BP	Helen Montgomery	?	?	Caterpillar 3516	1085	973	2.4	2.4	1	--	23	22.5	9.4	0.0	0.0	6.9
CBM	BP	Miera	37.17361111	-107.7783333	Caterpillar G3606TALE	1895	1850	0.7	0.7	1	LB w/Oxicat	12	12.5	17.8	12.3	3.5	13.1
CBM	BP	Miera			Caterpillar G3606TALE	1895	1850	0.7	0.7	1	LB w/Oxicat	12	12.5	17.8	12.3	3.5	13.1
CBM	BP	Miera			Caterpillar G3606TALE	1895	1850	0.7	0.7	1	LB w/Oxicat	12	12.5	17.8	12.3	3.5	13.1
CBM	BP	Miera			Caterpillar G3606TALE	1895	1850	0.7	0.7	1	LB	12	12.5	17.8	12.3	12.5	13.1
CBM	BP	Pinon	?	?	Caterpillar G3608TA	2200	2200	2.0	2.0	1	LB	42	42.4	21.2	11.7	17.5	15.6
CBM	BP	Pinon			Caterpillar G3608TA	2200	2200	2.0	2.0	1	LB	42	42.4	21.2	0.0	0.0	15.6
CBM	BP	Salvador	37.13766667	-107.7845	Waukesha L7042GL	1478	1285	1.5	1.5	1	LB w/Oxicat	19	18.6	12.4	18.4	18.6	9.1
CBM	BP	Salvador			Waukesha F3521GL	738	708	1.5	2.9	1	LB	10	19.8	6.8	10.0	20.0	5.0
CBM	BP	Salvador			Waukesha L7042GSI	1478	1285	1.5	2.9	1	RB w/NSCR W/AFR	19	36.0	12.4	18.1	36.2	9.1
CBM	BP	Salvador			Waukesha L7042GL	1478	1285	1.5	2.9	1	LB	19	36.0	12.4	18.1	36.2	9.1
CBM	BP	Salvador			Waukesha L7042GL	1478	1285	1.5	1.5	1	LB	19	18.6	12.4	0.0	0.0	9.1
CBM	BP	Salvador			Arrow VRG330	68	61	11.6	11.6	1	--	7	6.8	0.6	0.4	0.6	0.4
CBM	BP	Southern Ute 2-2	?	?	Caterpillar 3306	109	109	16.8	16.8	1	--	18	17.7	1.1	0.1	0.0	0.8
CBM	BP	Tiffany	37.08886111	-107.8820278	Waukesha L7042GL	1478	1285	1.5	1.5	1	LB	19	18.6	12.4	18.1	18.6	9.1
CBM	BP	Treating Site 1	263139	4099660	Waukesha L5790GSI	1215	1166	1.0	1.0	1	RB w/NSCR w/AFR	11	11.2	11.2	10.1	11.2	8.2
CBM	BP	Treating Site 1			Waukesha L5790GSI	1215	1166	1.0	1.0	1	RB w/NSCR w/AFR	11	11.2	11.2	10.0	11.2	8.2
CBM	BP	Treating Site 1			Waukesha VRG330	68	61	7.5	7.5	1	--	4	4.4	0.6	2.0	4.4	0.4
CBM	BP	Treating Site 1			Waukesha F11-G	105	91	20.7	20.7	1	--	18	18.2	0.9	10.9	17.9	0.6
CBM	BP	Treating Site 1			Waukesha F18-GL	375	300	2.6	2.6	1	LB	8	7.5	2.9	0.0	0.0	2.1
CBM	BP	Treating Site 2	37.03602778	-107.84675	Waukesha L5790GSI	1215	1166	1.0	1.8	1	RB w/NSCR w/AFR	11	20.2	11.2	10.0	20.1	8.2
CBM	BP	Treating Site 2			Waukesha L5790GSI	1215	1166	1.0	1.8	1	RB w/NSCR w/AFR	11	20.2	11.2	10.3	20.6	8.2
CBM	BP	Treating Site 2			Waukesha VRG330	68	61	7.5	40.0	1	--	4	23.5	0.6	4.0	23.9	0.4
CBM	BP	Treating Site 2			Waukesha L7042GL	1478	1285	1.5	1.5	1	--	19	18.6	12.4	16.5	18.6	9.1
CBM	BP	Treating Site 4	37.05805556	-107.5461111	Waukesha F3521GSI	738	708	1.0	1.0	1	LB	7	6.8	6.8	6.3	6.8	5.0
CBM	BP	Treating Site 4			Waukesha F3521GSI	738	708	1.0	1.0	1	LB	7	6.8	6.8	6.1	6.8	5.0
CBM	BP	Treating Site 4			Waukesha L5790GSI	1215	1166	1.0	1.0	1	RB w/NSCR	11	11.2	11.2	10.0	11.2	8.2
CBM	BP	Treating Site 4			Waukesha F11-GSI	225	196	24.0	24.0	1	--	45	45.4	1.9	0.0	45.4	1.4
CBM	BP	Treating Site 4			Waukesha F1197-G	162	110	20.0	20.0	1	--	21	21.2	1.1	19.2	21.2	0.8
CBM	BP	Treating Site 4			Waukesha F18 - GL	375	300	2.6	2.6	1	LB	8	7.5	2.9	6.5	7.5	2.1
CBM	BP	Treating Site 4A	37.11107667	-107.6986981	Waukesha L7042GL	1478	1285	1.5	1.5	1	LB	19	18.6	12.4	17.2	18.6	9.1
CBM	BP	Treating Site 4A			Caterpillar G3606LE	1775	1714	0.7	0.7	1	LB	12	11.6	16.5	10.8	11.6	12.1
CBM	BP	Treating Site 4A			Waukesha VRG330	68	61	11.0	11.0	1	--	6	6.5	0.6	5.8	6.5	0.4
CBM	BP	Treating Site 5A	37.05805556	-107.5461111	Caterpillar G3606LE	1895	1864	0.7	0.7	1	LB	13	12.6	18.0	11.8	12.6	13.2
CBM	BP	Treating Site 5A			Caterpillar G3606LE	1895	1864	0.7	0.7	1	LB	13	12.6	18.0	11.7	12.6	13.2
CBM	BP	Treating Site 5A			Waukesha F817-G	108	92	18.0	18.0	1	--	16	16.0	0.9	10.8	16.0	0.7
CBM	BP	Treating Site 6	37.05805556	-107.5461111	Waukesha L5790GSI	1215	1166	1.0	1.0	1	RB w/NSCR	11	11.2	11.2	8.0	11.2	8.2
CBM	BP	Treating Site 6			Waukesha L5790GSI	1215	1166	1.0	1.0	1	RB w/NSCR	11	11.2	11.2	8.1	11.2	8.2
CBM	BP	Treating Site 6			Waukesha F18-GL	375	300	2.6	2.6	1	LB	8	7.5	2.9	0.0	0.0	2.1
CBM	BP	Treating Site 6			Waukesha F11-GSI	225	196	24.0	24.0	1	--	45	45.4	1.9	7.2	9.1	1.4

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Engine Type	Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp hr)	VOC Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)
CBM	BP	Treating Site 6			Waukesha VRG330	68	61	7.5	7.5	1	--	4	4.4	0.6	4.0	4.4	0.4
CBM	BP	Treating Site 6B	37.02527778	-107.6802778	Waukesha P9390-GSI	1970	1891	2.0	2.0	1	RB w/NSCR	36	36.5	18.2	33.9	36.5	13.4
CBM	BP	Treating Site 6B			Waukesha F11-G	135	117	28.0	28.0	1	--	32	31.6	1.1	28.5	31.6	0.8
CBM	BP	Treating Site 7	37.17361111	-107.7783333	Waukesha F817-G	108	108	16.0	16.0	1	--	17	16.7	1.0	15.0	16.7	0.8
CBM	BP	Treating Site 7			Waukesha F2895-G	421	404	18.0	18.0	1	--	70	70.2	3.9	16.4	25.6	2.9
CBM	BP	Treating Site 7			Waukesha F2895-G	421	404	18.0	18.0	1	RB w/NSCR	70	70.2	3.9	0.0	0.0	2.9
CBM	BP	Treating Site 7			Waukesha F11-G	225	196	24.0	24.0	1	--	45	45.4	1.9	1.2	1.5	1.4
CBM	BP	Treating Site 7			Waukesha L5790GSI	1215	1166	1.0	1.0	1	RB w/NSCR	11	11.2	11.2	2.6	5.3	8.2
CBM	BP	Treating Site 7B	37.13538889	-107.9054444	Waukesha P9390-GSI	1970	1891	2.0	2.0	1	RB w/NSCR	36	36.5	18.2	34.0	36.5	13.4
CBM	BP	Treating Site 7B			Waukesha L7042GL	1478	1285	1.5	1.5	1	LB	19	18.6	12.4	4.4	8.8	9.1
CBM	BP	Treating Site 7B			Waukesha VRG330	68	61	11.0	11.0	1	--	6	6.5	0.6	5.8	6.5	0.4
CBM	BP	Treating Site 8	37.08886111	-107.8820278	Waukesha 5790GL	1215	1166	2.3	2.3	1	LB w/Oxicat	26	25.9	11.2	23.7	3.1	8.2
CBM	BP	Treating Site 8			Waukesha 5790GL	1215	1166	2.3	2.3	1	LB	26	25.9	11.2	19.4	25.7	8.2
CBM	BP	Treating Site 8			Waukesha P9390-GSI	1970	1891	2.0	2.0	1	RB w/NSCR	36	36.5	18.2	34.4	36.5	13.4
CBM	BP	Treating Site 8			Caterpillar G3608LE	2520	2419	0.7	0.7	1	LB	16	16.3	23.3	0.0	0.0	17.1
CBM	BP	Treating Site 8			Waukesha F18 GL	400	320	2.6	2.6	1	LB	8	8.0	3.1	0.3	0.2	2.3
CBM	BP	Treating Site 8			Waukesha VRG330	68	61	11.0	11.0	1	--	6	6.5	0.6	5.8	6.5	0.4
CBM	BP	Treating Site 9	236735	4106828	Waukesha F3521GSI	738	708	1.0	1.0	1	RB w/NSCR w/AFR	7	6.8	6.8	3.2	6.4	5.0
CBM	BP	Treating Site 9			Waukesha F3521GSI	738	708	1.0	1.0	1	RB w/NSCR w/AFR	7	6.8	6.8	1.6	3.2	5.0
CBM	BP	Treating Site 9			Waukesha VRG330	68	61	7.5	7.5	1	--	4	4.4	0.6	4.0	4.4	0.4
CBM	BP	Wolf Point	37.053575	-107.6277611	Waukesha L7042GL	1478	1285	1.5	2.0	1	LB	19	24.8	12.4	18.6	24.8	9.1
CBM Totals							**202,308**					**4,696**	**5,553**		**3,319**	**4,216**	**1,431**
											Ratio of actual/ pte				**0.71**	**0.76**	

Conventional	Universal	BOX CANYON BOOSTER	37.0132222	-107.7999722	Wauk VRG 330 (Arrow)	68	50	11	45	1	None	5	21.7	0.5	5	21.8	0.4
Conventional	Universal	SUTE 33-10 #23-1 Mv	37.0939700	-107.9081600	Wauk VRG 330 (Arrow)	68	50	11	45	1	None	5	21.7	0.5	5	21.8	0.4
Conventional	Universal	SUTE 33-10 #22-2 Mv	37.0940400	-107.9239100	Wauk VRG 330 (Arrow)	68	50	11	45	1	None	5	21.7	0.5	5	21.8	0.4
Conventional	Universal	SUTE 33-10 #23-2 Mv	37.0935870	-107.8969230	Wauk VRG 330 (Arrow)	68	50	11	45	1	None	5	21.7	0.5	5	21.8	0.4
Conventional	Universal	SUTE 33-10 #24-2 Mv	37.0851950	-107.8883990	Wauk VRG 330 (Arrow)	68	50	11	45	1	None	5	21.7	0.5	5	21.8	0.4
Conventional	Universal	SUTE 32-7 #12-2 Mv	37.0359700	-107.5537200	Wauk VRG 330 (Arrow)	68	50	11	45	1	None	5	21.7	0.5	5	21.8	0.4
Conventional	Universal	SUTE United 34-10 #35-1 Mv	37.1444800	-107.9065400	Wauk VRG 330 (Arrow)	68	50	11	45	1	None	5	21.7	0.5	5	21.8	0.4
Conventional	Universal	TIFFANY (32-7 #12-3 Mv)	37.0359400	-107.5639500	CAT G3304 NA LCR	83	68	14.8	1.5	1	None	10	1.0	0.7	10	1.0	0.5
Conventional	Universal	SUTE 32-10 #10-1 Mv	37.0288240	-107.9239780	Wauk VRG 330 (Arrow)	68	50	11	45	1	None	5	21.7	0.5	5	21.8	0.4
Conventional	Universal	Soute 32-10 #2-2 Mv	37.0419100	-107.8989700	Wauk VRG 330 (Arrow)	68	50	11	45	1	None	5	21.7	0.5	5	21.8	0.4
Conventional	Red Willow	FMOA #2	37.1072777	-107.8063888	G342TAW CAT	265	250	1.5	1.5	1	LB	4	3.6	2.4	4	3.6	1.8
Conventional	Red Willow	SUTE 33-10 #15-1	37.1084700	-107.9261900	G3306 CAT	95	95	19.5	1.7	1	None	18	1.6	0.9	18	1.6	0.7
Conventional	Red Willow	SUTE 33-10 #27-2 Mv	37.0704700	-107.9255200	Wauk 155 (Arrow)	26	22	45	11	1	None	10	2.3	0.2	10	2.3	0.2
Conventional	Williams Production	NWCH 32-10 #021 PC	37.0046	-107.9394	Cat G3304 NA HCR	95	81	14.8	12	1		12	9.3	0.8	12	9.3	0.6
Conventional	Williams Production	NWCH 32-10 #018 MV	37.00707	-107.96218	Cat G3304 NA HCR	95	80	14.8	12	1		11	9.3	0.8	11	9.3	0.6
Conventional	Williams Production	NWCH 32-10 #015A	37.02938	-107.97169	Arrow VRG 330-B	80	68	12.05	33.58	1		8	21.9	0.7	8	21.9	0.5
Conventional	Williams Production	NWCH 32-10 #017A	37.01523	-107.97404	Cat G3304 NA HCR	95	80	14.8	12	1		11	9.3	0.8	11	9.3	0.6
Conventional	Williams Production	NWCH 32-10 #013	37.02768	-107.98014	Cat G3304 NA HCR	95	81	14.8	12	1		12	9.4	0.8	12	9.4	0.6

Table A-2. 2005 SUIT Engine Inventory Sorted by Usage

Engine Type	Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp hr)	VOC Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)
Conventional	Williams Production	NWCH 32-10 #009	37.00388	-107.9776	Arrow VRG 330	68	58	11.9	28.7	1		7	16.0	0.6	7	16.0	0.4
Conventional	Williams Production	NWCH 32-10 #007	37.03721	-107.8773	Arrow VRG 330	68	59	11.9	28.7	1		7	16.3	0.6	7	16.3	0.4
Conventional	Williams Production	NWCH 32-10 #003	37.00637	-107.95151	Cat G3306 NA HCR	150	127	15.1	12.5	1		18	15.3	1.2	18	15.3	0.9
Conventional	Williams Production	NWCH 32-10 #002	37.00218	-107.96221	Arrow VRG 330	68	58	11.9	28.7	1		7	16.0	0.6	7	16.0	0.4
Conventional	Williams Production	NWCH 32-10 #001	37.01302	-107.98119	Waukesha VRG 330	68	58	10.8	1.96	1		6	1.1	0.6	6	1.1	0.4
Conventional	Williams Production	McCarville #1	37.09275	-107.80135	Cat G3304 NA HCR	95	80	14.8	12	1		11	9.3	0.8	11	9.3	0.6
Conventional	Williams Production	Ignacio 33-8 #014	37.10626	-107.7106	Arrow VRG 330	68	57	11.9	28.7	1		7	15.9	0.6	7	15.9	0.4
Conventional	Williams Production	Ignacio 33-7 #018DK	37.10145	-107.61744	Cat G3304 NA HCR	95	81	14.8	12	1		12	9.4	0.8	12	9.4	0.6
Conventional	Williams Production	Docar #002A	37.07796	-107.6821	Arrow VRG 330	68	58	11.9	28.7	1		7	16.0	0.6	7	16.0	0.4
Conventional	Williams Production	Docar #002	37.07772	-107.69094	Ariel E-97	50	42	4.2	3.6	1		2	1.5	0.4	2	1.5	0.3
Conventional	Williams Production	Docar #001	37.07026	-107.68365	Waukesha VRG 330	68	58	10.8	1.96	1		6	1.1	0.6	6	1.1	0.4
Conventional	Williams Production	Carr #001M	37.08443	-107.85345	Cat G3304 NA HCR	95	82	14.7	2	1		12	1.6	0.8	12	1.6	0.6
Conventional	Williams Production	Bondad 33-9 #051	37.12035	-107.8703	Cat G3304 NA HCR	95	81	14.7	2	1		11	1.6	0.8	11	1.6	0.6
Conventional	Williams Production	Bondad 33-9 #032	37.0859	-107.74144	Arrow VRG 330	68	58	11.9	28.7	1		7	16.2	0.6	7	16.2	0.4
Conventional	Williams Production	Bondad 33-9 #031A	37.08629	-107.87056	Waukesha VRG 330	68	58	10.8	1.96	1		6	1.1	0.6	6	1.1	0.4
Conventional	Williams Production	Bondad 33-9 #031	37.09247	-107.87233	Cat G3304 NA HCR	95	82	14.7	2	1		12	1.6	0.8	12	1.6	0.6
Conventional	Williams Production	Bondad 33-9 #026A	37.09966	-107.80107	Cat G3304 NA HCR	95	80	14.8	12	1		11	9.3	0.8	11	9.3	0.6
Conventional	Williams Production	Bondad 33-9 #026	37.10567	-107.7986	Arrow VRG 220	45	38	12.95	1.104	1		5	0.4	0.4	5	0.4	0.3
Conventional	Williams Production	Bondad 33-9 #023A	37.09963	-107.86906	Cat G3304 NA HCR	95	81	14.7	2	1		11	1.6	0.8	11	1.6	0.6
Conventional	Williams Production	Bondad 33-9 #022A	37.12901	-107.79947	Arrow VRG 330	68	58	11.9	28.7	1		7	16.1	0.6	7	16.1	0.4
Conventional	Williams Production	Bondad 33-9 #018A	37.0423	-107.5204	Cummins G5.9C	84	72	9	15.2	1		6	10.5	0.7	6	10.5	0.5
Conventional	Williams Production	Bondad 33-9 #015A	37.08638	-107.78309	Arrow VRG 330	68	57	11.9	28.7	1		7	15.9	0.6	7	15.9	0.4
Conventional	Williams Production	Bondad 33-9 #014	37.10697	-107.87111	Arrow VRG 330	68	58	11.9	28.7	1		7	16.1	0.6	7	16.1	0.4
Conventional	Williams Production	Bondad 33-9 #011	37.11532	-107.80811	Cat G3304 NA HCR	95	80	14.8	12	1		11	9.3	0.8	11	9.3	0.6
Conventional	Williams Production	Bondad 33-9 #010A	37.13575	-107.82483	Cat G3304 NA HCR	95	81	14.7	2	1		11	1.6	0.8	11	1.6	0.6
Conventional	Williams Production	Bondad 33-9 #010	37.13581	-107.83386	Cat G3304 NA HCR	95	81	14.8	12	1		12	9.4	0.8	12	9.4	0.6
Conventional	Williams Production	Bondad 33-9 #008	37.0872	-107.86452	Cat G3304 NA HCR	95	81	14.8	12	1		12	9.4	0.8	12	9.4	0.6
Conventional	Williams Production	Bondad 33-9 #007A	37.10082	-107.78327	Arrow VRG 330	68	57	11.9	28.7	1		7	15.9	0.6	7	15.9	0.4
Conventional	Williams Production	Bondad 33-9 #007	37.10676	-107.78203	Cat G3304 NA HCR	95	80	14.8	12	1		11	9.3	0.8	11	9.3	0.6
Conventional	Williams Production	Bondad 33-9 #006	37.12154	-107.86372	Cat G3306TA	220	187	20.5	1.6	1		37	2.9	1.8	37	2.9	1.3
Conventional	Williams Production	Bondad 33-9 #005	37.1318	-107.81898	Cat G3304 NA HCR	95	81	14.7	2	1		12	1.6	0.8	12	1.6	0.6
Conventional	Williams Production	Bondad 33-10 #026	37.10806	-107.91766	Arrow VRG 330	68	58	11.9	28.7	1		7	16.1	0.6	7	16.1	0.4
Conventional	Williams Production	Bondad 33-10 #020A	37.10114	-107.90666	Arrow VRG 330	68	58	11.9	28.7	1		7	16.2	0.6	7	16.2	0.4
Conventional	Williams Production	Bondad 33-10 #017A	37.10733	-107.90131	Arrow VRG 330	68	58	11.9	28.7	1		7	16.1	0.6	7	16.1	0.4
Conventional	Williams Production	Bondad 33-10 #017	37.10141	-107.9008	Arrow VRG 330	68	58	11.9	28.7	1		7	16.2	0.6	7	16.2	0.4
Conventional	Williams Production	Bondad 33-10 #016A	37.13595	-107.89459	Cat G3304 NA HCR	95	81	14.8	12	1		12	9.4	0.8	12	9.4	0.6
Conventional	Williams Production	Bondad 33-10 #005A	37.12168	-107.90205	Cat G3304 NA HCR	95	81	14.8	12	1		12	9.4	0.8	12	9.4	0.6
Conventional Totals							**3,941**					**495**	**615.2**	**38.0**	**495**	**616.3**	**27.9**

Table A-2. 2005 SUIT Engine Inventory Sorted by Usage

Engine Type	Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp hr)	VOC Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)
Gas Plant	Red Cedar	Arkansas Loop	37° 03' 08.8"	107° 47' 01.2"	Superior 8 SGTB	1350	1,283	1.5	3	1	Lean Burn Technology	19	37.1	12.4	16	32.8	9.1
Gas Plant	Red Cedar	Arkansas Loop	37° 03' 08.8"	107° 47' 01.2"	Superior 8 SGTB	1350	1,283	1.5	3	1	Lean Burn Technology	19	37.1	12.4	13	26.4	9.1
Gas Plant	Red Cedar	Arkansas Loop	37° 03' 08.8"	107° 47' 01.2"	Superior 16 SGTB	2650	2,518	1.5	1.6	1	Lean Burn Technology	36	38.9	24.3	34	35.9	17.8
Gas Plant	Red Cedar	Arkansas Loop	37° 03' 08.8"	107° 47' 01.2"	Superior 16 SGTB	2650	2,518	1.5	1.6	1	Lean Burn Technology	36	38.9	24.3	35	37.2	17.8
Gas Plant	Red Cedar	Arkansas Loop	37° 03' 08.8"	107° 47' 01.2"	Superior 16 SGTB	2650	2,518	1.5	1.6	1	Lean Burn Technology	36	38.9	24.3	35	37.5	17.8
Gas Plant	Red Cedar	Arkansas Loop	37° 03' 08.8"	107° 47' 01.2"	Superior 16 SGTB	2650	2,518	1.5	1.6	1	Lean Burn Technology	36	38.9	24.3	35	37.3	17.8
Gas Plant	Red Cedar	Arkansas Loop	37° 03' 08.8"	107° 47' 01.2"	Waukesha 5790 GL	1215	1,074	1.5	2.65	1	Lean Burn Technology	16	27.5	10.4	15	26.9	7.6
Gas Plant	Red Cedar	Arkansas Loop	37° 03' 08.8"	107° 47' 01.2"	Waukesha 5790 GL	1215	1,074	1.5	2.65	1	Lean Burn Technology	16	27.5	10.4	15	27.3	7.6
Gas Plant	Red Cedar	Arkansas Loop	37° 03' 08.8"	107° 47' 01.2"	Waukesha 5790 GL	1215	1,074	1.5	2.65	1	Lean Burn Technology	16	27.5	10.4	16	27.4	7.6
Gas Plant	Red Cedar	Coyote Gulch TP	37° 01' 07.0"	107° 04' 40.0"	Cat. - 3616LE	4445	4,334	0.7	1.9	1	Lean Burn Technology	29	79.4	41.8	21	58.1	30.6
Gas Plant	Red Cedar	Coyote Gulch TP	37° 01' 07.0"	107° 04' 40.0"	Cat. - 3616LE	4445	4,334	0.7	1.9	1	Lean Burn Technology	29	79.4	41.8	19	52.5	30.6
Gas Plant	Red Cedar	Coyote Gulch TP	37° 01' 07.0"	107° 04' 40.0"	Cat. - 3612LE	3550	3,252	0.7	1.9	1	Lean Burn Technology	22	59.6	31.4	8	22.5	23.0
Gas Plant	Williams Four Corners LLC	Ignacio	37° 8; 43.000"	-107° 47' 4.000"	Clark TLA-6		2,000	11.28	2.4	1	none	218	46.3	19.3	218	46.3	14.1
Gas Plant	BP	Florida River	37.09777778	-107.7691667	Solar Centaur H	5 mmBtu/h	--	--	--		--	n/a	n/a	n/a	91.2	35.0	0.0
Gas Plant	BP	Florida River			Solar Centaur H	5 mmBtu/h	--	--	--		--	n/a	n/a	n/a	100.4	55.6	0.0
Gas Plant	BP	Florida River			Cummins QSK-60	2922	2,922	0.7	0.7		SCR and Oxicat	n/a	n/a	n/a	0.3	0.4	0.0
Gas Plant	BP	Florida River			Cummins QSK-60	2922	2,922	0.7	0.7		SCR and Oxicat	n/a	n/a	n/a	0.3	0.4	0.0
Gas Plant	BP	Florida River			Cummins QSK-60	2922	2,922	0.7	0.7		SCR and Oxicat	n/a	n/a	n/a	0.3	0.4	0.0
Gas Plant	BP	Florida River			Cummins QSK-60	2922	2,922	0.7	0.7		SCR and Oxicat	n/a	n/a	n/a	0.3	0.4	0.0
Gas Plant	BP	Florida River			Cummins QSK-60	2922	2,922	0.7	0.7		SCR and Oxicat	n/a	n/a	n/a	0.3	0.4	0.0
Gas Plant	BP	Florida River			Cummins QSK-60	2922	2,922	0.7	0.7		SCR and Oxicat	n/a	n/a	n/a	0.3	0.4	0.0
Gas Plant	BP	Florida River			Cummins QSK-60	2922	2,922	0.7	0.7		SCR and Oxicat	n/a	n/a	n/a	0.3	0.4	0.0
Gas Plant	BP	Florida River			Cummins QSK-60	2922	2,922	0.7	0.7		SCR and Oxicat	n/a	n/a	n/a	0.3	0.4	0.0
Gas Plant	BP	Florida River			Cummins QSK-60	2922	2,922	0.7	0.7		SCR and Oxicat	n/a	n/a	n/a	0.3	0.4	0.0
Gas Plant	BP	Florida River			Cummins QSK-60	2922	2,922	0.7	0.7		SCR and Oxicat	n/a	n/a	n/a	0.3	0.4	0.0
Gas Plant	BP	Florida River			Cummins QSK-60	2922	2,922	0.7	0.7		SCR and Oxicat	n/a	n/a	n/a	0.3	0.4	0.0
Gas Plant	BP	Florida River			Cummins QSK-60	2922	2,922	0.7	0.7		SCR and Oxicat	n/a	n/a	n/a	0.3	0.4	0.0
Gas Plant Totals							**64,844**					**528**	**576.9**	**287.3**	**676**	**563**	**211**

Table A-2. 2005 SUIT Engine Inventory Sorted by Usage page 11 of 11

Engine Type	Company	Facility	Latitude	Longitude	Make and Model	Name Plate HP	Derated HP	NOx Emission Factor (g/hp)	CO Emission Factor (g/hp hr)	VOC Emission Factor (g/hp-hr)	Emission Control (ie. AFR/NSCR, lean burn/OC)	Potential NOx Emissions (t/yr)	Potential CO Emissions (t/yr)	Potential VOC Emissions (t/yr)	Actual NOx Emissions (t/yr)	Actual CO Emissions (t/yr)	Actual VOC Emissions (t/yr)
Transmission	El Paso Natural Gas Company	Bondad Compressor Station	37°05'52"	107°46'09"	Solar Centaur 50-6200L	6130	5,238				N/A (turbine)	92	23		49	1.6	
Transmission	El Paso Natural Gas Company	Bondad Compressor Station	37°05'52"	107°46'09"	Solar Centaur 50-6200L	6130	5,238				N/A (turbine)	92	23		57	1.9	
Transmission	El Paso Natural Gas Company	Bondad Compressor Station	37°05'52"	107°46'09"	Solar Centaur 50-6200LS	6130	5,238				N/A (turbine)	19	23		9	0.9	
Transmission	Transwestern Pipeline Company	LaPlata A Compressor Station	37° 08.26'	107° 47.07'	Solar Centaur 50-H	5,478	4,006	0.41	0.28		Water Injection	32	55		14	11.25	
Transmission	Transwestern Pipeline Company	LaPlata A Compressor Station	37° 08.26'	107° 47.07'	Solar Taurus 60-T7002	6,937	5,548	0.31	0.29		Solonox or Lean Premix	19	24		18	13.01	
Transmission Totals												**19**	**24**		**147**	**13**	

Table A-3. Estimated Emissions by Year

NOx

	Existing				Conventional				Gas Plant				Transmission			
Year	Heater Emissions NOx (t/yr)	Engine Total NOx (t/yr)	Drilling NOx (t/yr)	Total Existing CBM NOx (t/yr)	Heater Emissions NOx (t/yr)	Engine Total NOx (t/yr)	Drilling NOx (t/yr)	Total Conventional NOx (t/yr)	Heater Emissions NOx (t/yr)	Engine Total NOx (t/yr)	Drilling NOx (t/yr)	Total Gas Plants NOx (t/yr)	Heater Emissions NOx (t/yr)	Engine Total NOx (t/yr)	Drilling NOx (t/yr)	Total Transmissions NOx (t/yr)
2005	137	3,318	213	3,668	0	495	0	495	61	676	0	737	0	147	0	147
2006	140	3,178	78	3,396	0	495	0	495	61	676	0	737	0	147	0	147
2007	141	2,872	0	3,013	0	495	0	495	61	676	0	737	0	147	0	147
2008	140	2,523	0	2,662	0	495	0	495	61	676	0	737	0	147	0	147
2009	139	2,220	0	2,359	0	495	0	495	61	676	0	737	0	147	0	147
2010	138	1,954	0	2,091	0	495	0	495	61	676	0	737	0	147	0	147
2011	137	1,719	0	1,856	0	495	0	495	61	676	0	737	0	147	0	147
2012	136	1,513	0	1,649	0	495	0	495	61	676	0	737	0	147	0	147
2013	135	1,331	0	1,467	0	495	0	495	61	676	0	737	0	147	0	147
2014	134	1,172	0	1,306	0	495	0	495	61	676	0	737	0	147	0	147
2015	134	1,031	0	1,165	0	495	0	495	61	676	0	737	0	147	0	147
2016	133	907	0	1,040	0	495	0	495	61	676	0	737	0	147	0	147
2017	132	798	0	930	0	495	0	495	61	676	0	737	0	147	0	147
2018	131	797	0	928	0	495	0	495	61	676	0	737	0	147	0	147
2019	130	824	0	955	0	495	0	495	61	676	0	737	0	147	0	147
2020	130	1,332	0	1,461	0	495	0	495	61	676	0	737	0	147	0	147
2021	129	1,224	0	1,352	0	495	0	495	61	676	0	737	0	147	0	147
2022	128	1,077	0	1,205	0	495	0	495	61	676	0	737	0	147	0	147
2023	127	948	0	1,075	0	495	0	495	61	676	0	737	0	147	0	147
2024	127	834	0	960	0	495	0	495	61	676	0	737	0	147	0	147
2025	126	734	0	860	0	495	0	495	61	676	0	737	0	147	0	147
2026	125	646	0	771	0	495	0	495	61	676	0	737	0	147	0	147
2027	124	568	0	693	0	495	0	495	61	676	0	737	0	147	0	147

	Existing Total Emissions (Actual)				Tribal Infill Emissions (Actual)				Fee Infill Emissions (Actual)				Total			
Year	Existing Heater Emissions NOx (t/yr)	Existing Engine Total NOx (t/yr)	Existing Drilling NOx (t/yr)	Total Existing NOx (t/yr)	Heater Emissions NOx (t/yr)	Engine Total NOx (t/yr)	Drilling NOx (t/yr)	Total Tribal Infill NOx (t/yr)	Heater Emissions NOx (t/yr)	Engine Total NOx (t/yr)	Drilling NOx (t/yr)	Total Infill NOx (t/yr)	Total Heater Emissions NOx (t/yr)	Engine Total NOx (t/yr)	Drilling	Total
2005	197	4,636	213	5,046	0	0	0	0	0	0	0	0	197	4,636	213	5,046
2006	200	4,496	78	4,775	0	0	0	0	0	0	0	0	200	4,496	78	4,775
2007	201	4,190	0	4,392	0	0	30	30	1	0	55	56	201	4,190	85	4,422
2008	200	3,841	0	4,041	1	16	210	227	3	0	108	111	201	3,856	318	4,268
2009	199	3,538	0	3,737	5	166	240	411	3	0	18	21	204	3,704	258	4,149
2010	199	3,271	0	3,470	9	307	240	557	3	0	0	4	208	3,579	240	4,027
2011	198	3,037	0	3,235	14	399	240	653	3	0	0	4	211	3,436	240	3,888
2012	197	2,831	0	3,028	18	463	205	687	3	0	0	4	215	3,294	205	3,714
2013	196	2,649	0	2,845	23	508	188	719	3	0	0	4	219	3,158	188	3,565
2014	195	2,489	0	2,685	27	540	188	755	3	0	0	3	222	3,029	188	3,440
2015	194	2,349	0	2,543	32	562	188	782	3	0	0	3	226	2,911	188	3,325
2016	193	2,225	0	2,419	36	577	200	814	3	0	0	3	230	2,803	200	3,232
2017	193	2,116	0	2,309	41	597	106	744	3	0	0	3	234	2,714	106	3,053
2018	192	2,114	0	2,306	44	607	0	651	3	0	0	3	236	2,721	0	2,957
2019	191	2,142	0	2,333	44	507	0	550	3	0	0	3	235	2,649	0	2,884
2020	190	2,650	0	2,840	44	637	0	681	3	0	0	3	234	3,286	0	3,520
2021	189	2,541	0	2,731	39	455	0	494	3	0	0	3	228	2,996	0	3,225
2022	189	2,395	0	2,583	23	296	0	319	0	0	0	0	212	2,690	0	2,902
2023	188	2,265	0	2,453	23	212	0	235	0	0	0	0	211	2,478	0	2,689
2024	187	2,152	0	2,339	23	151	0	174	0	0	0	0	211	2,303	0	2,513
2025	187	2,052	0	2,238	23	102	0	125	0	0	0	0	210	2,154	0	2,364
2026	186	1,964	0	2,149	23	59	0	82	0	0	0	0	209	2,022	0	2,231
2027	185	1,886	0	2,071	0	17	0	17	0	0	0	0	185	1,903	0	2,088

CO

	Existing				Conventional				Gas Plant				Transmission			
Year	Heater Emissions CO (t/yr)	Engine Total CO (t/yr)	Drilling CO (t/yr)	Total Existing CBM CO (t/yr)	Heater Emissions CO (t/yr)	Engine Total CO (t/yr)	Drilling `	Total Conventional CO (t/yr)	Heater Emissions CO (t/yr)	Engine Total CO (t/yr)	Drilling CO (t/yr)	Total Gas Plants CO (t/yr)	Heater Emissions CO (t/yr)	Engine Total CO (t/yr)	Drilling CO (t/yr)	Total Transmissions CO (t/yr)
2005	8	5,055	0	5,063	0	616	0	616	61	563	0	624	0	13	0	13
2006	8	4,842	46	4,896	0	616	0	616	61	563	0	624	0	13	0	13
2007	8	4,376	17	4,401	0	616	0	616	61	563	0	624	0	13	0	13
2008	8	3,843	0	3,851	0	616	0	616	61	563	0	624	0	13	0	13
2009	8	3,382	0	3,390	0	616	0	616	61	563	0	624	0	13	0	13
2010	8	2,976	0	2,984	0	616	0	616	61	563	0	624	0	13	0	13
2011	8	2,619	0	2,627	0	616	0	616	61	563	0	624	0	13	0	13
2012	8	2,305	0	2,313	0	616	0	616	61	563	0	624	0	13	0	13
2013	8	2,028	0	2,036	0	616	0	616	61	563	0	624	0	13	0	13
2014	8	1,785	0	1,792	0	616	0	616	61	563	0	624	0	13	0	13
2015	8	1,571	0	1,578	0	616	0	616	61	563	0	624	0	13	0	13
2016	8	1,382	0	1,390	0	616	0	616	61	563	0	624	0	13	0	13
2017	7	1,216	0	1,224	0	616	0	616	61	563	0	624	0	13	0	13
2018	7	1,214	0	1,221	0	616	0	616	61	563	0	624	0	13	0	13
2019	7	1,256	0	1,263	0	616	0	616	61	563	0	624	0	13	0	13
2020	7	2,029	0	2,036	0	616	0	616	61	563	0	624	0	13	0	13
2021	7	1,864	0	1,871	0	616	0	616	61	563	0	624	0	13	0	13
2022	7	1,640	0	1,648	0	616	0	616	61	563	0	624	0	13	0	13
2023	7	1,444	0	1,451	0	616	0	616	61	563	0	624	0	13	0	13
2024	7	1,270	0	1,278	0	616	0	616	61	563	0	624	0	13	0	13
2025	7	1,118	0	1,125	0	616	0	616	61	563	0	624	0	13	0	13
2026	7	984	0	991	0	616	0	616	61	563	0	624	0	13	0	13
2027	7	866	0	873	0	616	0	616	61	563	0	624	0	13	0	13

	Existing Total Emissions (Actual)				Tribal Infill Emissions (Actual)				Fee Infill Emissions (Actual)				Total			
Year	Existing Heater Emissions CO (t/yr)	Existing Engine Total CO (t/yr)	Existing Drilling CO (t/yr)	Total Existing CO (t/yr)	Heater Emissions CO (t/yr)	Engine Total CO (t/yr)	Drilling CO (t/yr)	Total Infill CO (t/yr)	Heater Emissions CO (t/yr)	Engine Total CO (t/yr)	Drilling CO (t/yr)	Total Infill CO (t/yr)	Total Heater Emissions CO (t/yr)	Engine Total CO (t/yr)	Drilling CO (t/yr)	Total CO (t/yr)
2005	68	6,248	0	6,316	0	0	0	0	0	0	0	0	68	6,248	0	6,316
2006	69	6,035	46	6,149	0	0	0	0	0	0	0	0	69	6,035	46	6,149
2007	69	5,569	17	5,654	0	0	0	0	0	0	15	15	69	5,569	32	5,654
2008	69	5,036	0	5,104	0	34	8	42	0	0	29	29	69	5,070	37	5,147
2009	69	4,575	0	4,643	0	361	56	417	0	0	5	5	69	4,935	61	5,061
2010	68	4,169	0	4,237	1	624	65	689	0	0	0	0	69	4,793	65	4,927
2011	68	3,812	0	3,880	1	806	65	871	0	0	0	0	69	4,618	65	4,751
2012	68	3,497	0	3,566	1	933	65	998	0	0	0	0	69	4,430	65	4,564
2013	68	3,221	0	3,289	1	1,022	63	1,087	0	0	0	0	70	4,243	63	4,376
2014	68	2,977	0	3,046	2	1,084	63	1,149	0	0	0	0	70	4,062	63	4,195
2015	68	2,763	0	2,831	2	1,128	63	1,193	0	0	0	0	70	3,891	63	4,024
2016	68	2,575	0	2,643	2	1,158	63	1,224	0	0	0	0	70	3,733	63	3,867
2017	68	2,409	0	2,477	2	1,198	67	1,268	0	0	0	0	70	3,607	67	3,745
2018	68	2,406	0	2,474	2	1,217	36	1,255	0	0	0	0	71	3,623	36	3,729
2019	68	2,448	0	2,516	2	1,018	0	1,021	0	0	0	0	71	3,467	0	3,537
2020	68	3,221	0	3,289	2	1,276	0	1,278	0	0	0	0	70	4,497	0	4,568
2021	68	3,057	0	3,125	2	916	0	918	0	0	0	0	70	3,973	0	4,043
2022	68	2,833	0	2,901	1	601	0	603	0	0	0	0	69	3,434	0	3,504
2023	68	2,636	0	2,704	1	436	0	437	0	0	0	0	69	3,072	0	3,141
2024	68	2,463	0	2,531	1	315	0	317	0	0	0	0	69	2,778	0	2,847
2025	68	2,310	0	2,378	1	218	0	220	0	0	0	0	69	2,529	0	2,598
2026	68	2,176	0	2,244	1	133	0	134	0	0	0	0	69	2,309	0	2,378
2027	68	2,058	0	2,126	0	50	0	50	0	0	0	0	68	2,108	0	2,176

VOC

Year	Existing: Heater Emissions VOC (t/yr)	Existing: Engine Total VOC (t/yr)	Existing: Drilling VOC (t/yr)	Existing: Total Existing CBM VOC (t/yr)	Conventional: Heater Emissions VOC (t/yr)	Conventional: Engine Total VOC (t/yr)	Conventional: Drilling VOC (t/yr)	Conventional: Total Conventional VOC (t/yr)	Gas Plant: Heater Emissions VOC (t/yr)	Gas Plant: Engine Total VOC (t/yr)	Gas Plant: Drilling VOC (t/yr)	Gas Plant: Total Gas Plants VOC (t/yr)
2005	0.4	1,952	0	1,952	0	28	0	28	13	211	0	223
2006	0.5	1,870	17	1,887	0	28	0	28	13	211	0	223
2007	0.5	1,690	6	1,696	0	28	0	28	13	211	0	223
2008	0.5	1,484	0	1,484	0	28	0	28	13	211	0	223
2009	0.4	1,306	0	1,306	0	28	0	28	13	211	0	223
2010	0.4	1,149	0	1,150	0	28	0	28	13	211	0	223
2011	0.4	1,011	0	1,012	0	28	0	28	13	211	0	223
2012	0.4	890	0	890	0	28	0	28	13	211	0	223
2013	0.4	783	0	784	0	28	0	28	13	211	0	223
2014	0.4	689	0	690	0	28	0	28	13	211	0	223
2015	0.4	606	0	607	0	28	0	28	13	211	0	223
2016	0.4	534	0	534	0	28	0	28	13	211	0	223
2017	0.4	470	0	470	0	28	0	28	13	211	0	223
2018	0.4	469	0	469	0	28	0	28	13	211	0	223
2019	0.4	485	0	485	0	28	0	28	13	211	0	223
2020	0.4	783	0	784	0	28	0	28	13	211	0	223
2021	0.4	720	0	720	0	28	0	28	13	211	0	223
2022	0.4	633	0	634	0	28	0	28	13	211	0	223
2023	0.4	557	0	558	0	28	0	28	13	211	0	223
2024	0.4	490	0	491	0	28	0	28	13	211	0	223
2025	0.4	432	0	432	0	28	0	28	13	211	0	223
2026	0.4	380	0	380	0	28	0	28	13	211	0	223
2027	0.4	334	0	335	0	28	0	28	13	211	0	223

Year	Transmission: Heater Emissions VOC (t/yr)	Transmission: Engine Total VOC (t/yr)	Transmission: Drilling VOC (t/yr)	Transmission: Total Transmissions VOC (t/yr)	Existing Total Emissions (Actual): Existing Heater Emissions VOC (t/yr)	Existing Total Emissions (Actual): Existing Engine Total VOC (t/yr)	Existing Total Emissions (Actual): Existing Drilling VOC (t/yr)	Existing Total Emissions (Actual): Total Existing VOC (t/yr)	Tribal Infill Emissions (Actual): Heater Emissions VOC (t/yr)	Tribal Infill Emissions (Actual): Engine Total VOC (t/yr)	Tribal Infill Emissions (Actual): Drilling VOC (t/yr)	Tribal Infill Emissions (Actual): Total Infill VOC (t/yr)
2005	0	13	0	13	13	2,203	0	2,216	0.0	0	0	0
2006	0	13	0	13	13	2,121	17	2,151	0.0	0	0	0
2007	0	13	0	13	13	1,941	6	1,961	0.0	0	0	0
2008	0	13	0	13	13	1,735	0	1,749	0.0	14	2	16
2009	0	13	0	13	13	1,557	0	1,570	0.0	149	16	165
2010	0	13	0	13	13	1,401	0	1,414	0.0	239	18	257
2011	0	13	0	13	13	1,263	0	1,276	0.0	300	18	318
2012	0	13	0	13	13	1,141	0	1,155	0.1	343	18	361
2013	0	13	0	13	13	1,035	0	1,048	0.1	373	15	388
2014	0	13	0	13	13	941	0	954	0.1	394	15	409
2015	0	13	0	13	13	858	0	871	0.1	409	15	424
2016	0	13	0	13	13	785	0	798	0.1	419	15	434
2017	0	13	0	13	13	721	0	734	0.1	433	16	449
2018	0	13	0	13	13	720	0	733	0.1	439	8	448
2019	0	13	0	13	13	736	0	750	0.1	372	0	372
2020	0	13	0	13	13	1,035	0	1,048	0.1	459	0	459
2021	0	13	0	13	13	971	0	984	0.1	337	0	337
2022	0	13	0	13	13	885	0	898	0.1	231	0	231
2023	0	13	0	13	13	809	0	822	0.1	175	0	175
2024	0	13	0	13	13	742	0	755	0.1	134	0	134
2025	0	13	0	13	13	683	0	696	0.1	101	0	101
2026	0	13	0	13	13	631	0	644	0.1	72	0	72
2027	0	13	0	13	13	586	0	599	0.0	44	0	44

Year	Fee Infill Emissions (Actual): Heater Emissions VOC (t/yr)	Fee Infill Emissions (Actual): Engine Total VOC (t/yr)	Fee Infill Emissions (Actual): Drilling VOC (t/yr)	Fee Infill Emissions (Actual): Total Infill VOC (t/yr)	Total: Total Heater Emissions VOC (t/yr)	Total: Engine Total VOC (t/yr)	Total: Drilling VOC (t/yr)	Total: Total VOC (t/yr)
2005	0.0	0	0	0	13	2,203	0	2,216
2006	0.0	0	0	0	13	2,121	17	2,151
2007	0.0	0	4	4	13	1,941	11	1,961
2008	0.0	0	8	8	13	1,750	10	1,765
2009	0.0	0	1	1	13	1,707	17	1,736
2010	0.0	0	0	0	13	1,639	18	1,671
2011	0.0	0	0	0	13	1,563	18	1,594
2012	0.0	0	0	0	13	1,484	18	1,516
2013	0.0	0	0	0	13	1,408	15	1,436
2014	0.0	0	0	0	13	1,335	15	1,363
2015	0.0	0	0	0	13	1,267	15	1,295
2016	0.0	0	0	0	13	1,205	15	1,233
2017	0.0	0	0	0	13	1,154	16	1,183
2018	0.0	0	0	0	13	1,159	8	1,181
2019	0.0	0	0	0	13	1,108	0	1,122
2020	0.0	0	0	0	13	1,494	0	1,507
2021	0.0	0	0	0	13	1,309	0	1,322
2022	0.0	0	0	0	13	1,116	0	1,129
2023	0.0	0	0	0	13	984	0	997
2024	0.0	0	0	0	13	876	0	889
2025	0.0	0	0	0	13	784	0	797
2026	0.0	0	0	0	13	703	0	716
2027	0.0	0	0	0	13	630	0	643

2.0 Oil & Gas Emissions Inventory Development

Oil & Gas Emissions – 2005

The main basis for the oil and gas emissions inventory was the year 2002 WRAP Phase II inventory prepared by ENVIRON under contract to the WRAP (Bar-Ilan et al., 2007). All four states in the 4 km modeling domain were included in the WRAP inventory. The WRAP Phase II inventory was focused on improving compressor and drill rigs emissions from the previous WRAP inventory. In addition, the Phase II inventory incorporated the oil and gas emissions for San Juan and Rio Arriba Counties from the New Mexico Environmental Department (NMED) ozone precursors study (Pollack, et al., 2006), as well as updated emissions for oil and gas sources on SUIT lands. The WRAP Phase II emissions inventory for year 2005 were developed by applying scaling factors, derived on the basis of the state OGC databases for spuds, well location and production, to the 2002 emission inventory (Bar-Ilan et al., 2007).

The NMED oil and gas inventory was developed by ENVIRON based on detailed surveys of oil and gas producers (Pollack, et al., 2006). The producers provided activity data and emissions factors that were used to generate more refined emissions estimates in San Juan and Rio Arriba counties, New Mexico. Oil and gas source categories in the NMED inventory include drill rigs, compressors, heaters, tanks, pneumatic devices, fugitives, truck loading, dehydration, completion and venting, CBM pump engines, artificial lift engines, and saltwater disposal engines.

After the WRAP Phase II inventory project was completed, an error was identified in the heater emissions calculations for Colorado. For the inventory used in this project, the Colorado heater emissions were corrected.

<u>SUIT 2005 Inventory</u>
The new SUIT emissions inventory is the result of a detailed survey and inventory effort for all sources on the SUIT land, whereas the previous WRAP Phase II inventory used broader assumptions for estimating the emissions in the counties that contain the SUIT lands. In order to incorporate these updated and more detailed 2005 SUIT emissions into the modeling inventory, the 2002 SUIT emissions in the WRAP Phase II inventory were removed using GIS analysis. Table A-4 summarizes 2005 SUIT emissions by county and SCC tpd).

Table A-4. SUIT 2005 emissions by county and SCC (tpd).

County Code	SCC	SCC Description	County Emissions	SUIT Emissions
Archuletta	2310000220	Industrial Processes, Oil and Gas Production, All Processes, Drill Rigs	0.0136	0.0130
Archuletta	2310010100	Industrial Processes, Oil and Gas Production, Crude Petroleum, Heaters	0.0000	0.0000
Archuletta	2310010200	Industrial Processes, Oil and Gas Production, Crude Petroleum, Tanks - Flashing & Standing/Working/Breathing	0.0000	0.0000
Archuletta	2310010300	Industrial Processes, Oil and Gas Production, Crude Petroleum, Pneumatic Devices	0.0000	0.0000
Archuletta	2310020600	Industrial Processes, Oil and Gas Production, Natural Gas, Compressor Engines	0.1639	0.1619
Archuletta	2310021100	Industrial Processes, Oil and Gas Production, Natural Gas, Heaters	0.0039	0.0038
Archuletta	2310021300	Industrial Processes, Oil and Gas Production, Natural Gas, Pneumatic Devices	0.0000	0.0000
Archuletta	2310023000	Industrial Processes, Oil and Gas Production, Natural Gas, CBM - Dewatering pump engines	0.0133	0.0130
La Plata	2310000220	Industrial Processes, Oil and Gas Production, All Processes, Drill Rigs	0.1269	0.1033
La Plata	2310010100	Industrial Processes, Oil and Gas Production, Crude Petroleum, Heaters	0.0002	0.0001
La Plata	2310010200	Industrial Processes, Oil and Gas Production, Crude Petroleum, Tanks - Flashing & Standing/Working/Breathing	0.0000	0.0000
La Plata	2310010300	Industrial Processes, Oil and Gas Production, Crude Petroleum, Pneumatic Devices	0.0000	0.0000
La Plata	2310020600	Industrial Processes, Oil and Gas Production, Natural Gas, Compressor Engines	8.8824	8.2431
La Plata	2310021100	Industrial Processes, Oil and Gas Production, Natural Gas, Heaters	2.4708	2.2930
La Plata	2310021300	Industrial Processes, Oil and Gas Production, Natural Gas, Pneumatic Devices	0.0000	0.0000
La Plata	2310021400	Industrial Processes, Oil and Gas Production, Natural Gas, Dehydrators	0.0000	0.0000
La Plata	2310021500	Industrial Processes, Oil and Gas Production, Natural Gas, Completion - Flaring & Venting	0.0239	0.0222
La Plata	2310023000	Industrial Processes, Oil and Gas Production, Natural Gas, CBM - Dewatering pump engines	1.0473	0.5672
La Plata	2310030210	Industrial Processes, Oil and Gas Production, Natural Gas Liquids, Tanks - Flashing & Standing/Working/Breathing, Uncontrolled	0.0000	0.0000

Overall change in Oil & Gas Emissions from the WRAP Phase II Inventory

The overall change in the oil & gas NOx emissions between the WRAP Phase II inventory and the revised inventory was an increase of 300 tons from 2002 to 2005 over the entire 4k modeling domain. The changes are shown in Table A-5 by source category. Although the emissions reported in the table are for the entire 4k domain, most of the changes are a result of changes made to emissions estimates for sources on SUIT lands, except that heater emissions were revised for all of Colorado. For the heaters on SUIT lands, the previous inventory had about 1,000 tpy NOx, and the revised inventory has about 200 tpy NOx.

Table A-5. Changes in emissions estimates between WRAP Phase II inventory and revised inventory

Source	Current version (tpy)	Previous version (tpy)	Current – Previous (tpy)
Compressor engines	4,694	3,067	1,627
Fugitives and flaring	3.4	220	-216.6
Drilling rigs	207	42.5	164.5
Heaters	7,410	8,272	-862
Removal of duplicate point sources	-1,013		-1,013
Total	**11,301**	**11,601**	**-300**

VOC Speciation

Photochemical modeling requires that the chemical composition VOC emissions included in the emissions inventory be identified. The process of allocating the reported VOC emissions into individual VOC species is known as VOC speciation. Different VOC speciation profiles were used for each of the various oil & gas source categories as described below. Speciation profiles were chosen using best engineering judgment and were reviewed by the Four Corners Air Quality Task Force modeling group.

Four VOC speciation groupings was identified, each of which used different VOC speciation profiles:

1. Drilling Rigs – drilling rigs were assumed to all use large diesel-powered internal combustion engines. For drilling rigs, ENVIRON used an EPA speciation profile for a diesel-powered internal combustion engine (see Table A-6 - SPECIATE4 profile#0009). Although this speciation profile contains no formaldehyde emissions, these were expected to be negligible from this type of engine.

2. Compressor Engines, Artificial Lift Engines, Salt-Water Disposal Engines, CBM Pump Engines – these engines were all assumed to be natural-gas fired spark-ignition engines. ENVIRON used an EPA speciation profile for a natural gas-fired internal combustion engine (see Table A-6 - SPECIATE4 profile#1001).

3. Heaters – these were assumed to be natural-gas fired external combustion sources. ENVIRON used an EPA speciation profile for natural gas-fired external combustion (see Table A-6 - SPECIATE4 profile#0003).

4. Venting, Flaring, Pneumatics, Fugitive, Tank, Dehydrators and Truck Loading

   Speciation profiles for these source categories were derived from gas composition analyses. Although tank, truck loading, dehydrator and flaring VOC speciation was expected to be somewhat different from VOC speciation for fugitives, pneumatics and venting, accounting for this difference was not feasible.

   VOC speciation was handled differently for CBM versus conventional (non-CBM) gas wells. There are few true oil wells in the modeling domain, therefore gas well speciation profiles were used throughout.

   - COLORADO – In Colorado it was assumed that all wells in the 4 km modeling domain were CBM wells, therefore there are only minimal VOC emissions from venting, flaring, pneumatics, and fugitives. Gas composition analysis files provided by Doug Blewitt from BP-operated wells on SUIT land (Blewitt, 2007) were averaged to represent a single CBM VOC speciation profile for all Colorado CBM wells. There are no emissions from tanks, dehydrators, and truck loading, as there is no condensate production at these wells (See Table A-7 – VOC speciation for CBM wells in Colorado).

   - NEW MEXICO – In New Mexico it was assumed that all wells in the 4 km modeling domain are conventional gas wells. A conventional gas well VOC speciation profile was developed based on averaging gas composition analyses provided by BP for several formations in San Juan and Rio Arriba counties, and gas composition analyses provided by NMOGA for this same region (Pollack et al., 2006). Table A-8 lists the VOC speciation for conventional gas wells in New Mexico.

Table A-6. SPECIATE4 profiles used for oil & gas sources.

POLLUTANT	**SPECIATE4 - 0003 External Combustion Boiler - Natural Gas**	**SPECIATE4 - 0009 Reciprocating Distillate Oil Engine**	**SPECIATE4 - 1001 Internal Combustion Engine - Natural Gas**
1,2,3-TRIMETHYLBENZENE			0.01
1,2,4-TRIMETHYLBENZENE			0.01
1,3-BUTADIENE		7.00	
1,3,5-TRIMETHYLBENZENE			0.02
1-BUTENE		13.40	
1-NONENE			0.01
1-PENTENE			0.01
2,2-DIMETHYLBUTANE			0.01

POLLUTANT	SPECIATE4 - 0003 External Combustion Boiler - Natural Gas	SPECIATE4 - 0009 Reciprocating Distillate Oil Engine	SPECIATE4 - 1001 Internal Combustion Engine - Natural Gas
2,4-DIMETHYLPENTANE			0.01
2-METHYL-1-PENTENE			0.02
2-METHYL-2-BUTENE			0.01
3-METHYLHEPTANE			0.02
3-METHYLHEXANE			0.01
3-METHYLPENTANE			0.02
ACETALDEHYDE			0.03
ACETONE			
ACETYLENE		11.30	0.32
BENZENE	4.00	7.90	0.11
C10 AROMATIC			0.01
C10 OLEFINS			0.02
C3/C4/C5 ALKYLBENZENES			0.01
C-7 CYCLOPARAFFINS			
C-8 CYCLOPARAFFINS			
C-9 CYCLOPARAFFINS			
C9 OLEFINS			0.04
CIS-2-BUTENE			0.02
CYCLOHEXANE	1.00		0.01
CYCLOPENTANE			0.02
ETHANE		2.80	14.00
ETHYLBENZENE			0.01
ETHYLENE		28.70	0.63
FORMALDEHYDE	8.00		0.81
HEPTENE			0.01
ISOBUTANE			0.43
ISOBUTYLENE			0.02
ISOBUTYRALDEHYDE			0.02
ISOMERS OF BUTENE			0.26
ISOMERS OF DECANE			0.02
ISOMERS OF HEPTANE			0.04
ISOMERS OF HEXANE	1.00		0.02
ISOMERS OF NONANE			0.01
ISOMERS OF OCTANE			0.02
ISOMERS OF PENTANE	9.00		0.13
ISOMERS OF XYLENE			0.02
METHANE	56.00	11.60	76.69
METHYLCYCLOHEXANE			0.02
METHYLCYCLOPENTANE			0.04
M-ETHYLTOLUENE			0.01
M-XYLENE			0.01
N-BUTANE	9.00		1.00

POLLUTANT	SPECIATE4 - 0003 External Combustion Boiler - Natural Gas	SPECIATE4 - 0009 Reciprocating Distillate Oil Engine	SPECIATE4 - 1001 Internal Combustion Engine - Natural Gas
N-DECANE			0.01
N-HEPTANE			0.02
N-HEXANE			0.02
N-NONANE			0.01
N-OCTANE			0.02
N-PENTANE	6.00		0.13
N-UNDECANE			0.01
OCTENE			0.01
O-ETHYLTOLUENE			0.01
O-XYLENE			0.01
PROPANE	4.00		2.91
PROPYLENE		17.30	1.69
TOLUENE	2.00		0.04
TRANS-2-BUTENE			0.13
TRANS-2-PENTENE			0.01
Total	**100.00**	**100.00**	**100.00**

Table A-7. VOC Speciation for venting, flaring, pneumatic devices and fugitive emissions from CBM wells in Colorado.

COMPONENT	SPECID	Normalized Weight Percentage
Methane C1	529	99.6%
Ethane C2	438	0.34%
Propane C3	671	0.03%
i-Butane i-C4	491	0.01%
n-Butane n-C4	592	0.01%
i-Pentane iC5	508	0.01%
n-Pentane nC5	605	0.00%
Hexane+	2127	0.03%
Benzene	302	0.00%
Toluene	717	0.00%
Ethyl Benzene	449	0.00%
Xylene	522	0.00%

Table A-8. VOC Speciation for venting, flaring, pneumatic devices, fugitive emissions, and condensate tanks from conventional gas wells in New Mexico.

COMPONENT	SPECID	Normalized Weight Percentage
Methane C1	529	68.54%
Ethane C2	438	13.10%
Propane C3	671	9.00%
i-Butane i-C4	491	1.98%
n-Butane n-C4	592	3.02%
i-Pentane iC5	508	1.33%
n-Pentane nC5	605	0.99%
n-Hexane n-C6	601	2.01%
Benzene	302	0.02%
Toluene	717	0.01%
Ethyl Benzene	449	0.00%
Xylene	522	0.00%

Oil & Gas Emissions – 2018

To project 2005 oil & gas emissions to 2018, different methodologies were used for each of the following areas shown in Figure A-1:

- SUIT EIS area
- Farmington RMP area
- New Mexico portion of the 4km domain outside the Farmington RMP area
- Northern San Juan Basin (NSJB) EIS area
- Colorado portion of the 4km domain outside NSJB and SUIT EIS areas
- Utah and Arizona

The approach used in each area is described below.

<u>SUIT EIS area</u>

Based on operator data that included:

- Company;
- Site;
- Location;
- Type of equipment;
- Site rated capacity;
- Emission factors;
- Type of air pollution controls;
- Potential NOx and CO emissions; and
- Actual NOx and CO emissions.

Actual NOx and CO emissions.

Farmington RMP area

In the Farmington area, there were several sources of data used to generate the 2018 growth inventory:

- The WRAP Phase II emissions from NOx sources were held constant at 2005 levels.
- Compressors (with NSPS incorporated), separators and dehydrators were added and modeled as point sources (with unique coordinates and appropriate stack parameters).
- For drill rigs, WRAP 2005 emissions were grown based on the ratio of the number of wells drilled in 2018 (per the RMP) to the number of wells drilled in 2005, adjusted for an assumed 90% success rate.
- VOC emissions were grown using the 2007 Energy Information Agency Annual Energy Outlook (http://www.eia.doe.gov/oiaf/forecasting.html) gas production growth factor of 1.21.

New Mexico portion of the 4km domain outside the Farmington RMP area

The 2005 oil & gas emissions in New Mexico outside the Farmington RMP area were grown using the 2007 Annual Energy Outlook (AEO) projections. Emissions from sources related to gas production were grown using the AEO growth factor of 1.21, and sources related to oil production were grown using the AEO growth factor of 1.55. Drilling rig emissions were grown using growth factor of 1.07 (this AEO growth factor is for all well drilling in the continental U.S., as regional forecasts were not available).

The resulting area source NOx emissions were then reduced to account for implementation of the small stationary source New Source Performance Standard (NSPS) finalized in December, 2007 (71 FR 38482). To do so, it was assumed that small wellhead compressor engines would be installed on 50 percent of the new wells, each with a capacity of 69 hp, running at 54% load, with a NOx emission factor of 2 g/hp-hr as required by the NSPS. The number of new wells was estimated based on the average production per well for 2002-2005 in San Juan and Rio Arriba Counties, grown by the EIA gas production factor (1.21), and calculating the number of wells required to sustain that production (*using the calculated production/well).*

Northern San Juan Basin (NSJB) EIS area

In this area, WRAP Phase II oil & gas area and point source emissions were held constant at 2005 levels. Additional emissions for all sources, except drilling, reflecting growth were provided and modeled as individual point sources in a spreadsheet from the NSJB EIS development (BLM, 2004) as points except drilling. Drilling emissions in the NSJB growth inventory were small and no stack parameters or location information was included in the RMP spreadsheet, and they were therefore modeled as area sources.

Colorado portion of 4km domain - Outside northern San Juan Basin and SUIT EIS areas

The oil & gas area and point source emissions in this area were left constant at 2005 emissions levels. As a conservative assumption, no turnover of engines was assumed, and so no NSPS reduction was applied.

Utah and Arizona

Oil & gas emissions estimates in the 2005 inventory are very small in the Utah and Arizona portion of the 4km modeling domain and were kept constant at WRAP Phase II 2005 levels.

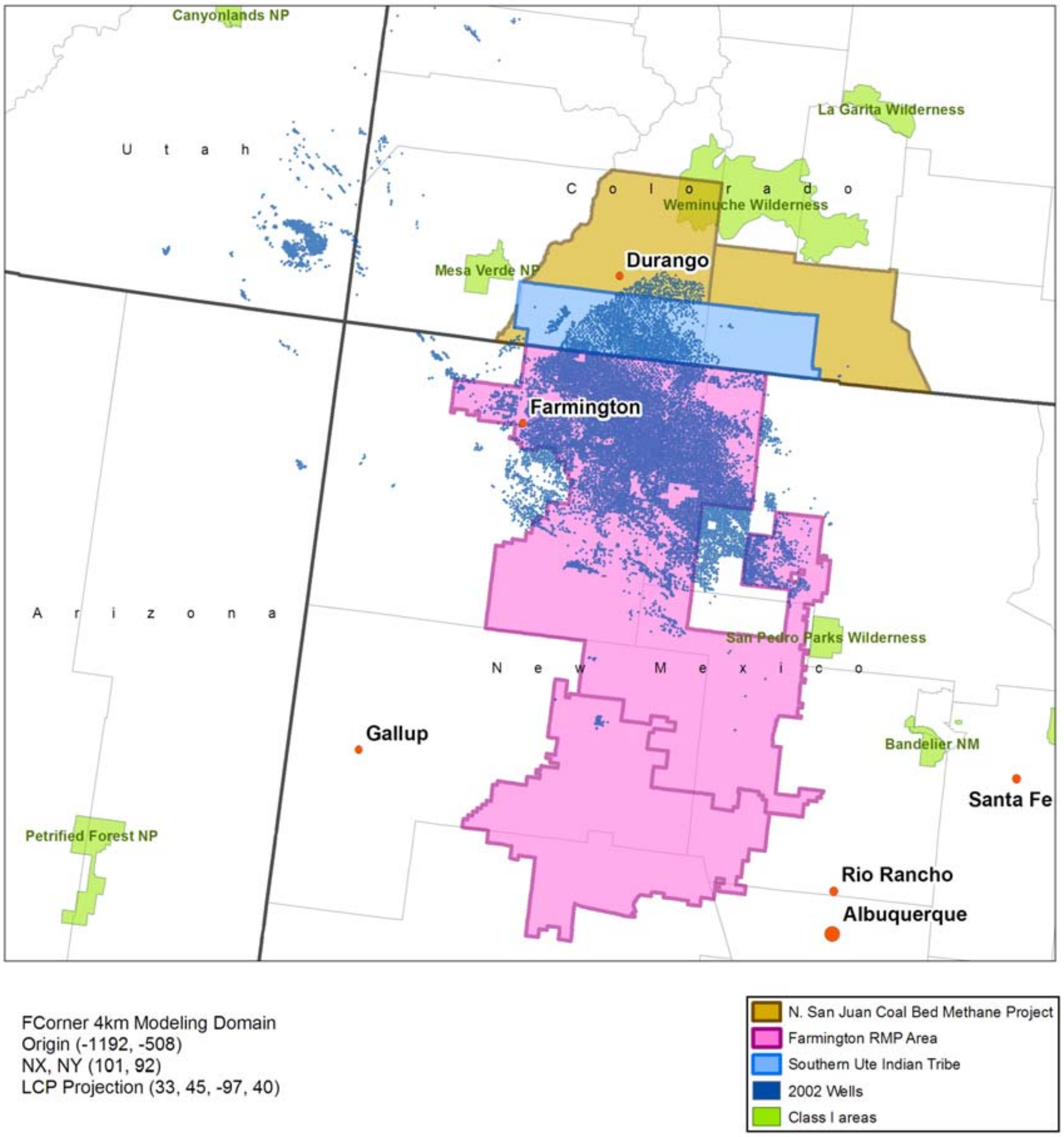

Figure A-1. Modeling domain showing regions for which different growth methodologies were applied to estimate 2018 oil & gas emissions.

3.0 Far Field Emission Inventory Development

3.1 Point Source Emissions

3.1.1 Electric Generating Units

Hourly emissions in 2005 for electric generating units (EGUs) in the Four Corners states were obtained from EPA's Clean Air Markets Division (CAMD) database of Continuous Emissions Monitoring (CEM) data (http://camddataandmaps.epa.gov/gdm/). The CEM database provides hourly values of NO_x and SO_2 emissions as measured by in-stack monitoring equipment. Table A-4 lists the resulting total annual emissions from all EGUs located within the 4km modeling domain. EGU emissions of other pollutants not reported in the CAMD database were estimated by linearly interpolating between the WRAP 2002 (Base02b[3]) and 2018 (PRP18[4]) emissions for these sources to 2005 and temporally allocating the resulting interpolated annual emissions to hourly values using ratios of hourly heat input reported in CAMD to the annual heat input.

EGU emissions for 2018 were provided by the New Mexico Environmental Department (Jones, 2008). EGU temporal emission profiles by state, fuel type, and technology category developed for use in WRAP modeling (Fields, et al., 2006) were used to temporally allocate the 2018 EGU emissions within the SMOKE emissions processing system. As shown in Table A-9, the 2018 future year inventory includes the proposed new coal-fired Desert Rock Energy Facility. In addition to Desert Rock, the WRAP PRP18 inventory includes new generic coal-fired units that are assumed to have been built and begun operation by 2018. The assumed new units are intended to represent additional capacity needed to meet future projected electricity demand as determined from analysis of Energy Information Administration (EIA) projections released in February 2007 (http://www.wrapair.org/forums/ssjf/documents/eictts/Projections/PRP18_EI_tech%20memo_061607.pdf). WRAP assumed that a typical future coal-fired EGU has a nameplate capacity of 500 MW and operates at the capacity threshold of 85%. A total of 11 such new EGUs were estimated to be required in the WRAP states to meet future demand. The state-level allocation of the future coal-fired EGUs were based upon current state-level capacity (i.e., sum of capacity at existing, under construction, and permitted facilities); county-level allocations were based upon announcements of plans to build coal-fired EGUs and locations of existing coal-fired EGUs and associated infrastructure.

[3] BASE02b is the WRAP 2002 version b base case inventory.
[4] PRP18 is the WRAP 2018 projected point emissions inventory developed by ERG for the Preliminary Reasonable Progress analysis.

TABLE A-9. Annual emissions from electric generating units located within the 4 km modeling domain.

Facility Name	2005		2018	
	NOx	SO2	NOx	SO2
Four Corners Power Plant	41,743[1a]	12,653[1a]	50,981[2a]	17,935[2a]
San Juan	26,809[1a]	16,569[1a]	16,546[2b**]	9,352[2b**]
Prewitt Escalante Generating Station	3,797[1a]	1,293[1a]	3,729[2c**]	1,796[2c**]
Reeves Generating Station	151[1a]	0[1a*]	151[2d]	0[2d]
Milagro	110[1a]	3[1a]	110[2d]	3[2d]
Animas	54[1b]	0[1b]	54[2d]	0[2d]
Person Generating Project	4[1a]	0[1a*]	4[2d]	0[2d]
Desert Rock	n/a	n/a	3,325[2e]	3,319[2e]
Future Coal Units	n/a	n/a	2,680[2f]	2,904[2f]
Total Emissions (tons)	72,668	30,518	77,580	35,310

1. 2005 base case emissions data are from: (a) EPA Facility & Unit Emissions reports 2005 (CEMS) data, (b) NMED 2005 emissions inventory, & (c) EPA 9 emissions 2005 inventory info estimate for PM emissions.

* for Reeves & Person SO2 is <0.5 Tons (gas turbine plants)

2. 2018 base case emissions data are estimated using: (a) per EPA9/Steve Frey, NOx from Acid Rain Permit, SO2 conservative estimate from FIP with 88% control; (b) Presumptive BART limits; (c) WRAP PRP18a; (d) assuming constant emissions rate from 2005 to 2018, gas plants,(e) Desert Rock Energy Facility PSD Permit Application; (f) WRAP PRP based on EIA projections.

**Prorated heat input 2005-2018 is accounted for in the calculations for San Juan Generating Station

3.1.2 Non-EGU Point Sources

Non-EGU point source emissions for 2005 in the Four Corner states were obtained by linearly interpolating between the WRAP region 2002 (Base02b) and latest 2018 (PRP18) point source inventories as described for EGUs above. Emission source records in the two inventories were matched on state/county code, plant ID, point ID, stack ID, point segment and SCC fields for interpolation. Emissions were processed using the same SMOKE settings used in WRAP regional modeling (Tonnesen et al., 2005). Point sources associated with the oil & gas sector were extracted and processed separately so that appropriate basin-specific VOC speciation profiles could be applied.

3.1.3 MOBILE SOURCES

Mobile sources include on-road and off-road vehicles and engines. On-road mobile sources include vehicles certified for highway use – cars, buses, trucks, and motorcycles. Off-road mobile equipment encompasses a wide variety of equipment types that either move under their own power or are capable of being moved from site to site. Off-road mobile sources consist of vehicles and engines in the following categories:

- Agricultural equipment, such as tractors, combines, and balers;
- Aircraft, jet and piston engines;
- Airport ground support equipment, such as terminal tractors;
- Commercial and industrial equipment, such as fork lifts and sweepers;
- Construction and mining equipment, such as graders and back hoes;
- Lawn and garden equipment, such as leaf and snow blowers;
- Locomotives, switching and line-haul trains;
- Logging equipment, such as shredders and large chain saws;
- Pleasure craft, such as power boats and personal watercraft;
- Railway maintenance equipment, such as rail straighteners;
- Recreational equipment, such as all-terrain vehicles and off-road motorcycles; and
- Underground mining and oil field equipment, such as mechanical drilling engines.

Mobile source emissions used in the far-field analysis were taken from the 2005 and 2018 mobile source inventories originally developed for WRAP regional modeling (Pollack et al., 2006). Emissions were estimated by county for an average weekday in each of the four seasons, and for an average annual weekday. Seasons were defined as: Spring (March–May), Summer (June-August), Fall (September-November), and Winter (December-January). Emissions were estimated for PM_{10}, $PM_{2.5}$, NO_x, SO_x, VOCs, carbon monoxide (CO), NH_3, elemental and organic carbon (EC/OC), and sulfate (SO4). For all pollutants, emissions were estimated separately for gasoline and diesel-fueled engines. Details of the emission inventory development methodology are provided in (Pollack et al., 2006).

After the WRAP on-road mobile source emissions were generated and compiled, an error was discovered for three counties in New Mexico: San Juan, Sandoval, and San Miguel. For these three counties, for both the 2002 and 2018 on-road emissions, the vehicle miles traveled (VMT) data were applied incorrectly in generating the emissions. Specifically, Sandoval County VMT was applied to generate San Miguel County emissions, San Juan County VMT was applied to generate Sandoval County emissions, and San Miguel County VMT was applied to generate San Juan County emissions. These errors were fixed and the emissions recalculated for use in this modeling project.

The 2018 WRAP regional modeling (PRP18) inventories were used for both on-road and off-road source categories. The WRAP PRPa8 locomotive emissions in 2018 were reduced to account for the effects of new standards for locomotive and marine diesel emissions (finalized in March, 2008), based on EPA's estimate of emissions reductions in their Regulatory Impact Analysis (EPA, 2008).

All of the mobile source seasonal county-level emissions were processed using SMOKE to generate gridded model-ready emissions.

3.2 Area Sources

Area source emissions (aside from oil & gas sources that are modeled as area sources) include ammonia source categories, windblown dust and other area sources such as fugitive dust, residential fuel combustion, etc. Development of emissions inventories for each of these source categories is described in the following subsections.

3.2.2 Ammonia Emissions

Ammonia emissions for Four Corners 4km domain were estimated using a GIS-based ammonia emissions modeling system developed for the Western Regional Air Partnership (WRAP). The development of the model, including data sources and estimation methodology, is documented in Chitjian and Mansell (2004). The model treats the source categories of primary significance in the overall emission inventory (excluding the mobile, industrial point and fire source categories) as described below. Ammonia emission source categories include livestock, fertilizer application, natural soils and domestic sources. Where possible, the model considers environmental conditions (wind speed, temperature, soil moisture and pH) in developing the emission factors as well as the temporal allocation of the ammonia emissions. Meteorological data was obtained from the 2005 MM5 output. Spatial allocation was based on application of EPA gridding surrogates (EPA, 2006).

Livestock: Ammonia emissions from livestock were developed using county-level head counts and emission factors based on a literature review performed by Chinkin, et al. (2003). Estimates were developed for beef and dairy cattle, poultry, swine, sheep and horses. Animal headcounts for 2002 are based on the National Agricultural Statistics Service (NASS) county livestock files (NASS, 2003).

Fertilizer Application: Ammonia emission estimates from fertilizer application were developed using emission factors from the European Environment Agency (EEA, 2002) as recommended in the development and application of the WRAP NH_3 model. Ammonia emissions from fertilizer application were developed using county-level fertilizer sales data obtained from the latest release of the CMU model.

Natural Soils: Natural soils can be both a source and a sink of ammonia emissions depending on the ambient NH_3 concentrations, climatic conditions and the conditions of the soils. While there are a number of researchers considering this issue, ammonia emission from natural soils remains highly uncertain. For the current inventory, ammonia emission from natural soils were estimated based on emission factors developed or recommended by Battye et al., (2003) and Chinkin et al., (2003). Landuse data used for the inventory were developed from the North American Land Cover Database (www.gvm.jrv.it/glc2000)

Domestic Sources: Ammonia emissions from domestic source considered in the current inventory include human respiration and perspiration, disposable and cloth diapers and domestic pets (cats and dogs). The emission factors are from the report by Chitjian and Mansell (2004). Activity data for domestic sources are based on the most recent US Census (2000), and pet ratios based on recommendations of Dickson et al. (1991).

3.2.3 Windblown Dust Emissions

The windblown fugitive dust PM emission inventory for the 4 km modeling domain was developed using the estimation methodology developed for the Western Regional Air Partnership (WRAP) by a team of contractors led by ENVIRON and subsequently revised by Mansell and others (Chitjian and Mansell, 2003a; 2003b; Mansell, 2005). The methodology is based on the results of wind tunnel studies and a detailed characterization of vacant lands. Windblown dust emissions are estimated hourly on a gridded modeling domain using hourly averaged wind speeds and other meteorological parameters. Estimates are developed for every hour of the year 2005.

There are two important factors for characterizing the dust emission process from an erodible surface. They are (a) the threshold friction velocity that defines the inception of the emission process as a function of the wind speed as influenced by the surface characteristics, and (b) the strength of the emissions that follow the commencement of particle movement. The two critical factors affecting emission strength are the wind speed (wind friction velocity) that drives the saltation system, and the soil characteristics.

Friction Velocities

Surface friction velocities are determined from the aerodynamic surface roughness lengths and the 10-meter wind speeds based on MM5 model simulations. Friction velocity, u_*, is related to the slope of the velocity versus the natural logarithm of height through the relationship:

$$\frac{u_z}{u_*} = \frac{1}{\kappa} \ln \frac{z}{z_o}$$

where u_z = wind velocity at height z (m/s)
u_* = friction velocity (m/s)
κ = von Karman's constant (0.4)
z_0 = aerodynamic roughness height (m)

The threshold friction velocities, u_{*t}, are determined from the relationships developed by Marticorena et al. (1997) as a function of the aerodynamic surface roughness length, z_0. Surface friction velocities, including the threshold friction velocity, are a function of the aerodynamic surface roughness lengths. The surface friction velocities are in turn dependent on surface characteristics, particularly land use/land cover.

Emission Fluxes

Emission fluxes, or emission rates, are determined as a function of surface friction velocity and soil texture. The relationships that Chatenet et al, (1996) established between the 12 soil types in the classical soil texture triangle and their four dry soil types (silt [FSS], sandy silt [FS], silty sand [MS], and sand [CS]) are of key importance. The relationships developed by Alfaro et al, (2001; 2003) for each of the soil texture groups are used to estimate dust emission fluxes.

Reservoir Characteristics

Reservoirs are classified as limited for stable land parcels and unlimited for unstable land parcels. Classification of reservoirs as limited or unlimited has implications with respect to the duration of time over which the dust emissions are generated. In general, the reservoirs should be classified in terms of the type of soils, the depth of the soil layer, soil moisture content and meteorological parameters. Finally, the time required for a reservoir to recharge following a wind event is influenced by a number of factors including precipitation and snow events and freezing conditions of the soils. A recharge time of 24 hours is assigned to all surfaces. In addition, it is assumed that no surface will generate emissions for more than 10 hours in any 24-hour period.

The duration and amount of precipitation and snow and freeze events will also affect the dust emissions from wind erosion. Barnard (2003) has compiled a set of conditions for treating these events based on seasons, soil characteristics and the amounts of rainfall and snow cover. The time necessary to re-initiate wind erosion after a precipitation event ranges from 1 to 10 days, depending on the soil type, season of the year and whether the rainfall amount exceeds 2 inches.

Soil Disturbance

The disturbance level of a surface more appropriately has the effect of lowering the threshold surface friction velocity. Except for agricultural lands, which are treated separately in the model as described below, vacant land parcels are typically undisturbed unless some activity is present such as to cause a disturbance (e.g., off-road vehicle activity in desert lands, or animal grazing on rangelands). It is recommended that all non-agricultural land types be considered undisturbed, since there is no *a priori* information to indicate otherwise for the regional scale modeling domain to be considered.

Soil Characteristics

Application of the emission factor relations described above requires the characterization of soil texture in terms of the four soil groups considered by the model. The characteristics or type of soil is one of the parameters of primary importance for the application of the emission estimation relations derived from wind tunnel study results. The State Soil Geographic Database (STATSGO) available from the USDA (1994) is used to determine the type of soils present in the modeling domain for which the emission inventory is developed. The classification of soil textures and soil group codes is based on the standard soil triangle that classifies soil texture in terms of percent sand, silt and clay. Combining the soil groups defined by the work of Alfaro et al, (2001; 2003) and Chatenet et al, (1996) and the standard soil triangle provides the mapping of the 12 soil textures to the four soil groups considered in their study. The soil texture mappings are summarized in Table A-10.

Table A-10. STATSGO Soil Texture and Soil Group Codes

STATSGO Soil Texture	Soil Texture Code	Soil Group	Soil Group Code
No Data	0	N/A	0
Sand	1	CS	4
Loamy Sand	2	CS	4
Sandy Loam	3	MS	3
Silt Loam	4	FS	1
Silt	5	FSS	2
Loam	6	MS	3
Sandy Clay Loam	7	MS	3
Silty Clay Loam	8	FSS	1
Clay Loam	9	MS	3
Sandy Clay	10	MS	3
Silty Clay	11	FSS	1
Clay	12	FS	2

Surface Roughness Lengths

Surface roughness lengths can vary considerably for a given land type, and are assigned as a function of land use type based on a review of information reported in the literature. The disturbance level of various surfaces has the effect of altering the surface roughness lengths, which in turn impact the potential for vacant lands to emit dust from wind erosion

An examination of the relationship between the threshold surface friction velocity and the aerodynamic surface roughness length, reveals that for surface roughness lengths larger than approximately 0.1 cm, the threshold friction velocities increase rapidly above values that can be realistically expected to occur in the meteorological data used in the model implementation. Therefore to simplify the model implementation, only those land types with roughness length less than or equal to 0.1 cm are considered as potentially erodible surfaces.

For a given surface roughness, as determined by the land use type, the threshold friction velocity has a constant value. Thus, the land use data is mapped to an internal dust code used within the model to minimize computer resource requirements and coding efforts. The mapping of land use types to dust codes 3 and above (except for code 5 that applies to orchards and vineyards) is presented in Table A-11, which summarizes the surface characteristics by dust code. [Note: Dust codes 1 and 2 refer to water/wetlands and forest/urban, respectively.]

Table A-11. Surface Characteristics by Dust Code and Land Use Category

Dust Code	3	4	6	7
Land use category	Agricultural	Grassland	Shrubland	Barren
Surface roughness length, $Z_{0\ (cm)}$	0.031	0.1	0.05	0.002
Threshold friction velocity (m/s)	3.72	6.17	4.30	3.04
Threshold wind velocity at 10 meter height (m/s [mph])	13.2 [29.5]	19.8 [44.3]	14.6 [32.8]	12.7 [28.5]

Meteorology

Gridded hourly meteorological data, which is required for the dust estimation methodology is based on MM5 model simulation results. Data fields required include wind speeds, precipitation rates, soil temperatures and ice/snow cover.

Agricultural Land Adjustments

Unlike other types of vacant land, windblown dust emissions from agricultural land are subject to a number of non-climatic influences, including irrigation and seasonal crop growth. As a result, several non-climatic correction or adjustment factors were developed for applicability to the agricultural wind erosion emissions. These factors included:

- Long-term effects of irrigation (i.e., soil "clodiness")
- Crop canopy cover
- Post-harvest vegetative cover (i.e., residue)
- Bare soil (i.e., barren areas within an agriculture field that do not develop crop canopy for various reasons, etc.)
- Field borders (i.e., bare areas surrounding and adjacent to agricultural fields)

The methodology used to develop individual non-climatic correction factors was based upon previous work performed by the California Air Resources Board in their development of California-specific adjustment factors for the USDA's Wind Erosion Equation (CARB, 1997)

Other Adjustments

Two other adjustments to modeled air quality impacts relate to fugitive dust transportability and partitioning between fine and coarse fractions of PM10. Transportability fractions as a function of land use are assigned on the basis of the methodology described by Pace (2003; 2005). New fine fraction values developed by Cowherd (MRI, 2005) from controlled wind tunnel studies of western soils are applied to determine the fine and coarse fractions of wind-generated fugitive dust emissions.

Model Application

The windblown fugitive dust model was applied for the calendar year 2005 at a spatial resolution of 4-km for Four Corners. The model generates estimates of PM_{10} dust emissions. The fine fraction of dust is obtained by using a nominal $PM_{2.5}$ of 0.10, as used in the implementation of the model for the WRAP.

3.2.4 **Other Area Source Emissions**

Emissions from numerous small sources treated as area sources such as commercial and residential fuel combustion, architectural coatings, etc. that are not included in the other source categories described above, were obtained from the WRAP inventories. This category of emissions includes road dust and fugitive dust but not wind blown dust. Area source emissions for 2005 were estimated via linear interpolation between the WRAP 2002 and latest WRAP 2018 (PRP18) emission inventories at the county level. The WRAP 2018 (PRP18) inventory was used to represent 2018 area source emissions.

Spatial allocation of area source emissions to model grid cells requires the use of spatial gridding surrogates. Within the 4 km domain, a new set of gridding surrogates were developed from the EPA population and landuse/landcover distributions (EPA, 2006) that had previously been aggregated by WRAP to 36 km resolution. These 4 km gridding surrogates were then applied to the interpolated 2005 county-level WRAP area source inventory. Temporal allocations were then applied as in the WRAP modeling to obtain hourly gridded emissions for input to CAMx. All emissions processing was done using SMOKE.

4.0 Construction Emissions

Construction emissions associated with the proposed project will occur mainly due to the installation of new wells, which involves three separate, sequential phases:

1. Resource road and well pad construction;
2. Rig-up, drill, and rig-down; and
3. Completion and testing.

For this PEA analysis, no information is available regarding the actual locations of new wells that would result from the proposed action nor the likely chronological sequence of their construction. This means that it is not possible to prepare a meaningful evaluation of the combined effects of multiple well construction activities that may or may not overlap in time. Accordingly, the present analysis focuses on pollutant emissions estimates for construction of individual well pads and evaluation of the associated air quality impacts. However, because of the spacing rules that would be in effect for new wells, significant cumulative impacts from concurrent multiple well constructions will not occur.

4.1 Resource Road and Well Pad Construction

A well pad and its resource road would be constructed concurrently, and would take an average of 3 days to complete. Types of pollutant emissions during this phase of construction will include (a) fugitive dust from the traffic of heavy construction equipment working at the pad site, the resource road and haul roads, and (b) diesel combustion exhaust from haul trucks and heavy construction equipment. The calculation of emissions from each of these sources is summarized below.

4.1.1 Dust Generated by Well Pad Construction

The working area for a well pad was assumed to be 300 ft x 300 ft (2.07 acres). The well pad would require 3 days to complete (1 day to strip vegetation and 2 days for earth moving).

The emission factor for this activity is 1.2 tons/acre of total suspended particulate matter (TSP) per month of construction from *Compilation of Air Pollutant Emission Factors (AP-42) (EPA 1995), Section 13.2.3*. Dust control efficiency was estimated at 50% based on an assumption that water will be applied to the site twice daily.

Particulate matter emissions expressed as TSP, are calculated as follows:

$$
\begin{aligned}
E_{TSP} &= (1.2 \text{ ton/acre-mo.})(2.07 \text{ acre})(2000 \text{ lb/ton})(0.50 \text{ control})(3/30 \text{ days}) \\
&= 247.93 \text{ lb TSP per well site} \\
&= 82.64 \text{ lb/day TSP, assuming 3 construction days per well site:}
\end{aligned}
$$

$= 10.33$ lb/hr TSP , assuming an 8-hour construction workday

The corresponding emission rates for PM_{10} emissions were estimated to be 36% of TSP emissions (see AP-42 (EPA 1995), Table 13.2.2-1):

E_{PM10} = (247.93 lb)(0.36)
= 89.26 lb/day
= 3.72 lb/hr

$E_{PM2.5}$ = 9.5 % of TSP
= (0.095)(247.93 lb)
= 89.26 lbs/day
= 0.98 lbs/hr

(AP-42, 2004), Section 13.2.2 “Unpaved Roads” Background Document

4.1.2 Dust Generated by Resource Road Construction

It is assumed that an unpaved resource road approximately 0.5 miles in length (average) will connect the well pad site with access roads (unpaved haul roads). The resource road would be constructed at the same time as the well pad, and would also require 3 days total to clear, grade, and compact. Assumptions used in estimating dust emissions from this activity are as follows:

- Resource road area: 0.5 miles x 40 ft (width) = 2640 ft x 40 ft = 2.42 acres
- Emission Factor: 1.2 tons/acre-month construction from AP-42 (EPA, 1995), Section 13.2.3.
- A watering program will be applied as necessary to achieve 50% dust control efficiency.

The calculation for total particulate matter emissions, E_{TSP}, is:

E_{TSP} = (1.2 ton/ac-mo.)(2.42 ac)(2000 lb/ton)(0.50 control)(3/30 days)
= 290.91 lb per well site
= 96.97 lb/day, assuming 3 construction days per well site
= 12.12 lb/hr, assuming 8 hours construction per day

Assuming that 36% of the TSP are in the PM_{10} size range (see AP-42 (EPA 1995), Table 13.2.2-1), the PM_{10} emissions from construction of one resource road would be:

E_{PM10} = 104.73 lb per site
= 34.91 lb/day
= 4.36 lb/hr

$E_{PM2.5}$ = 9.5 % of TSP
= (0.095)(290.91 lb)

= 27.63 lbs/day
= 1.15 lbs/hr

(AP-42, 2004), Section 13.2.2 “Unpaved Roads” Background Document

4.1.3 Dust Generated by Unpaved Haul Road Traffic

An existing unpaved haul road will be used by flatbed (haul) trucks, pickup trucks, and some heavy construction equipment to access the construction sites for new well pads and resource roads. Here it was assumed that the length of the unpaved haul road would average 4.5 miles, and that watering of this road up to twice daily would be used as required to achieve 50% dust emission control.

The sequence of traffic on the haul road during construction of the well pad/resource road would be as follows: first, the construction equipment would be hauled to the well pad site by truck, and would remain there while the pad is constructed. Second, because construction would likely occur only during daylight hours, the construction crew would be ferried to and from the site in the morning and evening by pick-up trucks. At the end of the construction effort the heavy equipment would again be transported from the site over the haul road.

It was assumed that each well pad construction effort would be preceded and followed by full transport (“mobilization”) of the heavy equipment. This assumption may overestimate the number of trips and total miles traveled by the heavy equipment, because, in practice, the heavy equipment may be transported to the next well pad construction site, rather than being transported back over the total distance of the haul road.

The computation of particulate emissions assumed 5 round trips of flatbed haul trucks in connection with each well pad over a 4.5-mile (one-way) distance. Each truck was assumed to be an 18-wheeler “low-boy”. In addition, it was assumed that pick-up trucks transport the construction crew to and from the pad site for each day of the 3-day construction effort associated with a pad/resource road.

Particulate emissions, E_{TSP}, per vehicle mile traveled (VMT) over unpaved roads are estimated by the following formula (AP-42, 2004), Section 13.2.2 “Unpaved Roads” Background Document:

$$E_{TSP} = (k)(5.9)(s/12)(S/30)(W/3)^{0.7}(w/4)^{0.5}((365-p)/365) \text{ lb/VMT}$$

where:
k = 0.36 for PM_{10}; = 0.8 for TSP =0.092 for $PM_{2.5}$
s = silt content, 5.1% [see AP-42 (EPA 1995), Table 13.2.2-1]
S = speed, mph; various speeds depending upon vehicle type
W = weight, tons; differs for mix of vehicles
w = average number of wheels; differs for mix of vehicles

p = number of days with at least 0.1 inch (0.254 mm) of precipitation per year, 70 (EPA AP-42)

The computation of road emissions was made individually for each vehicle type as presented in Table A-12. It should be noted that it was assumed for combustion sources that $PM_{2.5}$ is equivalent to PM_{10}.

4.2 Tailpipe Emissions

Tailpipe emissions would be generated primarily by two types of vehicles during the construction of the well pad and resource road: haul trucks and heavy construction equipment. All of these vehicles are diesel-powered, and the corresponding emissions of $PM_{2.5}$, PM_{10}, CO, NO_x, SO_2, and VOCs were estimated as follows.

(A) Haul Trucks

Haul trucks will carry the dozers, graders, and backhoes to the well pad site. Additional haul trucks would make 48 round-trips, carrying gravel for road and pad surfacing, and 3 round-trips carrying fuel during the construction of the well site pad and resource road. The access road and resource road to the well pad site were assumed to be 4.5 miles and 0.5 miles in length, respectively. Based on 5 round-trips for equipment haul trucks and 51 round-trips for gravel and fuel haul trucks, and a total round-trip distance of 10 miles, the total miles traveled by haul trucks per site would equal 504 miles.

Table A-12. Dust Emissions from Unpaved Haul Road Traffic

Campaign: Well Pad & Resource Road Construction

Assumptions

Avg. Rd Silt (%):	5.1
RT distance (mi.):	9.0
Assumed Control Factor:	0.5

Truck	Activity	Avg. Weight. (lb.)	No. of Wheels	RTs per Campaign	Average Speed (mph)	PM_{10} Emissions per Well (lb)	PM2.5 Emissions per well (lb)	TSP Emissions per Well (lb)
Semi	Heavy equipment hauler	74,000	18	5	20	135	36	299
Haul	Gravel Haul	48,000	10	48	20	720	188	1,583
Haul	Fuel truck	48,000	10	3	20	45	11	90
Pickup	Equipment/Operator crew	7,000	4	56	30	205	54	455
					Total per Well (lb)	1,105	288	2,427
					Total per Well (lb/hr)	46	12	101
					@ 8 hrs/day, 3 days			

Exhaust emissions for the haul trucks were calculated using emission factors from EPA "Nonroad Engine and Vehicle Emission Study" (EPA 1995) AP-42. Emission factors for individual pollutants are as follows:

$PM_{2.5}$ = 0.80 g/hp-hr
PM_{10} = 0.80 g/hp-hr
SO_x = 0.89 g/hp-hr
NO_x = 9.60 g/hp-hr
CO = 2.80 g/hp-hr
VOC = 0.84 g/hp-hr

The power rating for haul trucks was assumed to be 489 hp (SCAQMD 1993). The total hours of operation per truck is estimated as follows:

Total hours = (504 miles)/(20 miles/hr) = 25.2 hours

Emissions per well site:
$PM_{2.5}$: (0.80 g/hp-hr)(489 hp)(25.2 hrs)(lb/453.6 g) = 21.73 lb
PM_{10}: (0.80 g/hp-hr)(489 hp)(25.2 hrs)(lb/453.6 g) = 21.73 lb
SO_x: (0.89 g/hp-hr)(489 hp)(25.2 hrs)(lb/453.6 g) = 24.18 lb
NO_x: (9.60 g/hp-hr)(489 hp)(25.2 hrs)(lb/453.6 g) = 260.80 lb
CO: (2.80 g/hp-hr)(489 hp)(25.2 hrs)(lb/453.6 g) = 76.07 lb
VOC: (0.84 g/hp-hr)(489 hp)(25.2 hrs)(lb/453.6 g) = 22.82 lb

(b) Heavy Equipment

Three different types of construction equipment were assumed to be used in building the well pad and resource road. A 150 hp dozer, 135 hp grader, and 70 hp backhoe would operate 8 hours per day for 3 days, or 24 hrs total.

Tailpipe emissions for these sources were calculated using emission factors from "Nonroad Engine and Vehicle Emission Study" (EPA 1995) AP-42. A load factor of 0.40 was assumed in calculating equipment emission rates. Emission factors, expressed in grams per horsepower-hour, and the corresponding calculations of emissions per well site, are shown below for each equipment category.

<u>Dozer emission factors and emissions per well site</u>
$PM_{2.5}$ = (0.93 g/hp-hr)(150 hp)(24 hr)(0.4 load)/(453.6 g/lb) = 2.95 lb/site
PM_{10} = (0.93 g/hp-hr)(150 hp)(24 hr)(0.4 load)/(453.6 g/lb) = 2.95 lb/site
SO_2 = (0.66 g/hp-hr)(150 hp)(24 hr)(0.4 load)(453.6 g/lb) = 2.10 lb/site
NO_x = (9.6 g/hp-hr)(150 hp)(24 hr)(0.4 load)(453.6 g/lb) = 30.48 lb/site
CO = (2.8 g/hp-hr)(150 hp)(24 hr)(0.4 load)(453.6 g/lb) = 8.89 lb/site
VOC = (0.84 g/hp-hr)(150 hp)(24 hr)(0.4 load)(453.6 g/lb) = 2.67 lb/site

<u>Grader emission factors and emissions per well site</u>
$PM_{2.5}$ = (1.00 g/hp-hr)(135 hp)(24 hr)(0.4 load)/(453.6 g/lb) = 2.86 lb/site
PM_{10} = (1.00 g/hp-hr)(135 hp)(24 hr)(0.4 load)/(453.6 g/lb) = 2.86 lb/site
SO_2 = (0.87 g/hp-hr)(135 hp)(24 hr)(0.4 load)(453.6 g/lb) = 2.49 lb/site
NO_x = (9.6 g/hp-hr)(135 hp)(24 hr)(0.4 load)(453.6 g/lb) = 27.43 lb/site
CO = (3.8 g/hp-hr)(135 hp)(24 hr)(0.4 load)(453.6 g/lb) = 10.86 lb/site
VOC = (1.54 g/hp-hr)(135 hp)(24 hr)(0.4 load)(453.6 g/lb) = 4.40 lb/site

<u>Backhoe emission factors and emissions per well site</u>
$PM_{2.5}$ = (1.00 g/hp-hr)(135 hp)(24 hr)(0.4 load)/(453.6 g/lb) = 2.86 lb/site
PM_{10} = (1.00 g/hp-hr)(135 hp)(24 hr)(0.4 load)/(453.6 g/lb) = 2.86 lb/site
SO_2 = (0.85 g/hp-hr)(70 hp)(24 hr)(0.4 load)(453.6 g/lb) = 1.26 lb/site
NO_x = (10.1 g/hp-hr)(70 hp)(24 hr)(0.4 load)(453.6 g/lb) = 14.96 lb/site
CO = (6.8 g/hp-hr)(70 hp)(24 hr)(0.4 load)(453.6 g/lb) = 10.07 lb/site
VOC = (1.40 g/hp-hr)(70 hp)(24 hr)(0.4 load)(453.6 g/lb) = 2.07 lb/site

Total emissions of PM_{10}, CO, NO_x, VOC and SO_2 are summarized in Table A-13.

4.3 Rig-up, Drilling, and Rig-Down

Once each well pad has been prepared, the rigging-up and drilling operations begin. Here, drill pipe, drilling fluids, and other equipment will be transported by trucks over an assumed 5 miles of combined resource and haul roads. Drilling involves boring a hole to the desired depth, and periodically adding drill pipe and replacing the drill bit during the drilling operation.

The drill is powered by two large diesel-fuel fired reciprocating internal combustion engines – one for drilling and one for mud pumping. Pollutant emissions from this activity would include road dust emissions from trucks; tailpipe emissions from the trucks; and combustion exhaust from operation of the two drill rig engines. Completion of each rig-up, drilling, and rig-down operation would be expected to require 8 days.

Table A-13. Total Emissions from Heavy Equipment Tailpipe Exhaust

Pollutant	Dozer (lb)	Grader (lb)	Backhoe (lb)	Total (lb)
PM_{10} and $PM_{2.5}$	2.95	2.86	1.56	7.37
SO_2	2.10	2.49	1.26	5.84
NO_x	30.48	27.43	14.96	72.87
3.3 CO	8.89	10.86	10.07	29.82
VOC	2.67	4.40	2.07	9.14

4.4 Drill Truck and Supply Traffic

It was assumed that 241 round-trips (RTs) will occur over 5 miles of unpaved roads by 18-wheeler semi-trailer trucks, as well as smaller support and pick-up trucks. All travel was assumed to occur on unpaved roads, because the resource road typically is not graveled until the well is shown to be productive.

The PM_{10} emission formula, E_{PM10}, in lb per vehicle mile traveled (VMT) over unpaved road is given by (EPA 1995):

$$E_{PM10} = (k)(5.9)(s/12)(S/30)(W/3)^{0.7}(w/4)^{0.5}((365\text{-}p)/365) \text{ lb/VMT}$$

where, k = 0.36 for PM_{10}; = 0.8 for TSP, 0.095 for $PM_{2.5}$
s = silt content, 5.1% [see AP-42 (EPA 1995), Table 13.2.2-1]
S = speed, mph; various speeds depending upon vehicle type
W = weight, tons; differs for mix of vehicles
w = average number of wheels; differs for mix of vehicles

p = number of days with at least o.1 inch (0.254 mm) of precipitation per year, 70 (EPA AP-42)

The computation of road dust emissions was performed individually for each vehicle type as shown in Table A-14.

Table A-14. Dust Emissions from Rig-up, Drilling, & Rig-down Construction Phase

Campaign: Drilling (Rig-Up, Drilling, Rig-Down)
Avg. Rd Silt (%): 5.1
RT distance (mi.): 10.0
Assumed Control Factor: 0.5

Truck	Activity	Avg. Weight. (lb.)	No. of Wheels	RTs per Campaign	Average Speed (mph)	PM10 Emissions per Well (lb)	PM2.5 Emissions per well (lb)	TSP Emissions per Well (lb)
Semi	Rig Transport	60,000	18	13	20	336	89	747
Haul	Fuel Truck	48,000	10	12	20			
Haul	Mud Truck	48,000	10	2	20			
Haul	Logging Truck	20,000	6	1	20			
					Total Trucks	247	65	549
Pickup	Rig Crews	8,000	4	75	30			
Pickup	Rig Mechanic	8,000	4	4	30			
Pickup	Company Supervisor	7,000	4	25	30			
Pickup	Tool Pusher	8,000	4	25	30			
Pickup	Mud Logger	8,000	4	50	30			
Pickup	Mud Engineers	8,000	4	25	30			
Pickup	Engineers' truck	8,000	4	1	30			
Pickup	Drill Bit Deliveries	8,000	4	8	30			
					Total Pickups	950	251	2112
					Total per Well (lb)	1534	405	3408
					Total per Well (lb/hr) @8hr/day, 8 days	0	6	53

Equipment Tailpipe Emissions

As a worst-case, 100 round-trips (RTs) of heavy-duty diesel engine powered trucks were assumed to occur over a combined 5-mile length of unpaved resource and access roads, with an average travel speed at 20 miles per hour. The power rating for haul trucks was assumed to be 489 hp (SCAQMD 1993). Total hours of operation for each truck were computed as (1000 miles)/(20 miles/hr) = 50 hours.

Truck exhaust emissions per well site were calculated as follows using emission factors from EPA "Nonroad Engine and Vehicle Emission Study" (EPA 1995) AP-42:

$PM_{2.5}$: (0.80 g/hp-hr)(489 hp)(50 hrs)(lb/453.6 g) = 43.12 lb
PM_{10}: (0.80 g/hp-hr)(489 hp)(50 hrs)(lb/453.6 g) = 43.12 lb
SO_x: (0.89 g/hp-hr)(489 hp)(50 hrs)(lb/453.6 g) = 47.97 lb
NO_x: (9.60 g/hp-hr)(489 hp)(50 hrs)(lb/453.6 g) = 517.46 lb
CO: (2.80 g/hp-hr)(489 hp)(50 hrs)(lb/453.6 g) = 150.93 lb
VOC: (0.84 g/hp-hr)(489 hp)(50 hrs)(lb/453.6 g) = 45.28 lb

4.5 Well Completion and Testing

Completion and testing involves casing (running steel casing pipe into the open borehole); cementing the casing into place; fracturing ("fracing") the rock formation to stimulate gas flow; and flaring small quantities of gas at the surface to evaluate productivity of the well.

The pollutant emissions that occur during well completion and testing include road dust emissions from truck traffic; tailpipe emissions from the trucks; and products of combustion emissions from flaring natural gas over a maximum time period of 7 days for 24 hours per day. Each well completion and testing effort would occur over a period of about 25 days.

4.5.1 Dust Generation from Well Completion Traffic

It was assumed that there would be 245 round-trips (RTs) over a combined 5-mile length of unpaved resource and access roads by 18-wheeler semi-trailer trucks, as well as smaller support and pick-up trucks. All travel was assumed to occur on unpaved roads, because the resource road typically is not graveled until the well is shown to be productive.

PM_{10} emissions, E_{PM10}, in pounds per vehicle mile traveled (VMT) over unpaved road are given by EPA (1995):

$$E_{PM10} = (k)(5.9)(s/12)(S/30)(W/3)^{0.7}(w/4)^{0.5}((365-p)/365) \text{ lb/VMT}$$

where, k = 0.36 for PM_{10}; = 0.8 for TSP, 0.095 for $PM_{2.5}$
s = silt content, 5.1% [see AP-42 (EPA 1995), Table 13.2.2-1]
S = speed, mph; various speeds depending upon vehicle type
W = weight, tons; differs for mix of vehicles
w = average number of wheels; differs for mix of vehicles
p = number of days with at least 0.1 inch (0.254 mm) of precipitation per year, 70

The computation of road emissions was made individually for each vehicle type, as presented in Table A-15.

Tailpipe Emissions

As a worst-case, it was assumed that heavy-duty diesel engine powered trucks will make 75 round-trips (RTs) over a 5-mile unpaved length of resource and access roads. The power for haul trucks was assumed to be 489 hp (SCAQMD 1993). The total operating hours for individual haul trucks was estimated as (750 miles)/(20 miles/hr) = 37.5 hours.

Tailpipe emissions from these vehicles were calculated using emission factors from EPA "Nonroad Engine and Vehicle Emission Study" (EPA 1995) AP-42.
Vehicle tailpipe emissions per well site for this phase of construction are calculated from these factors as follows.:

$PM_{2.5}$: (0.80 g/hp-hr)(489 hp)(37.5 hrs)(lb/453.6 g) = 32.34 lb
PM_{10}: (0.80 g/hp-hr)(489 hp)(37.5 hrs)(lb/453.6 g) = 32.34 lb
SO_x: (0.89 g/hp-hr)(489 hp)(37.5 hrs)(lb/453.6 g) = 35.98 lb
NO_x: (9.60 g/hp-hr)(489 hp)(37.5 hrs)(lb/453.6 g) = 388.10 lb
CO: (2.80 g/hp-hr)(489 hp)(37.5 hrs)(lb/453.6 g) = 113.19 lb
VOC: (0.84 g/hp-hr)(489 hp)(37.5 hrs)(lb/453.6 g) = 33.96 lb

Table A-15. Dust Emissions from Completion & Testing

Campaign: Completion and Testing

Avg Road Silt (%): 5.1
Round Trip distance (mi.): 10.0
Dust Control Factor: 0.5

Truck	Activity	Avg. Weight. (lb.)	No. of Wheels	RTs per Campaign	Average Speed (mph)	PM_{10} Emissions per Well (lb)	$PM_{2.5}$ Emissions per Well (lb)	TSP Emissions per Well (lb)
Semi	Casing haulers	74,000	18	9	20			
Semi	Cementer, cement truck	74,000	18	6	20			
Semi	Completion, unit rig	74,000	18	3	20			
Semi	Fracing, blender	80,000	18	2	20			
Semi	Pumping/tank battery	74,000	18	5	20			
Semi	Pumping/tank battery	80,000	18	20	20			
					Total Semi-Trucks	1,373	362	3,051
Haul	Cementer, pump truck	48,000	10	3	20			
Haul	Completion, equip truck	48,000	10	3	20			
Haul	Tubing truck	48,000	10	13	20			
Haul	Service tools	20,000	6	8	20			
Haul	Perforators, logging truck	20,000	6	2	20			
Haul	Anchor, installation	48,000	10	1	20			
Haul	Anchor, testing	48,000	10	1	20			
Haul	Fracing, tank	48,000	10	12	20			
Haul	Fracing, pump	48,000	10	8	20			

Table A-15. (continued)

Truck	Activity	Avg. Weight. (lb.)	No. of Wheels	RTs per Campaign	Average Speed (mph)	PM_{10} Emissions per Well (lb)	$PM_{2.5}$ Emissions per Well (lb)	TSP Emissions per Well (lb)
Haul	Fracing, chemical	44,000	10	1	20			
Haul	Fracing, sand	44,000	10	12	20			
Haul	Fracing, other	44,000	10	9	20			
Haul	Welders	48,000	10	8	20			
					Total Haul Trucks	1,170	309	2,601
Pickup	Cementer, engineer	7,000	4	6	30			
Pickup	Casing crew	7,000	4	3	30			
Pickup	Completion crew	7,000	4	25	30			
Pickup	Completion, pusher	7,000	4	25	30			
Pickup	Perforators, engineer	7,000	4	2	30			
Pickup	Fracing, engineer	7,000	4	2	30			
Pickup	Company supervisor	7,000	4	25	30			
Pickup	Miscellaneous supplies	7,000	4	16	30			
Pickup	Roustabout crew	7,000	4	25	30			
					Total Pickups	524.2		1164.88
					Total per Well (lb)	3,068	671	6,817
					Total per Well (lb/hr) @ 8 hr/day, 25 days	15	4	34

4.5.2 Well Completion Flaring

During well completion, some wells in the project area will flare natural gas, allowing operators to evaluate the well's performance. To conservatively estimate emissions from this flaring process, it was assumed that 5 million cubic feet of gas (equivalent to 5,000 10^6 Btu heat release) would be burned in a pit flare at each well for a maximum of 7 days, 24 hours per day. Pollutant emissions from combustion of natural gas were calculated according to AP-42 (EPA 1995), Section 13.5. Computed flaring emission rates are shown in Table A-16.

Table A-16 Emissions from Flaring

Pollutant	Gas Burned per well (10^6 Btu)	Emission Factor (lbs/10^6 BTU)	Emissions per Well (lbs/well)	Emissions (lbs/hr)
$PM_{2.5}$	5,000	0.0062	31	0.2
PM_{10}	5,000	0.0062	31	0.2
SO2	5,000	0	0	0.0
NOx	5,000	0.068	340	2.0
CO	5,000	0.37	1,850	11.0
VOC	5,000	0.0063	32	1.9

4.6 Summary of Calculated Construction Emissions

The combined emissions per well pad site for all three phases of construction are presented below.

PM_{10} (lbs/well)	PM_{10} (lbs/well)	SO_2 (lbs/well)	NO_x (lbs/well)	CO (lbs/well)	VOC (lbs/well)
1,446	5,788	54	930	2031	86

Appendix B
Biogenic Emissions

Gridded hourly biogenic emission inventories suitable for input to CAMx were developed using the Model of Emissions of Gases and Aerosols from Nature (MEGAN) version 2.0 emissions model, with modifications made by ENVIRON (Guenther et al, 2006; Guenther and Wiedinmyer, 2007; Mansell et al, 2007). MEGAN accounts for spatial variability by using high resolution estimates of vegetation type and quantity. Key MEGAN variables include weather data, Leaf Area Index (LAI), plant functional type (PFT) cover, and compound specific emission factors that are based on plant species composition. All of these variables are provided in a geo-referenced gridded database in several formats (e.g., netcdf, ESRI GRID). The inputs to MEGAN model are:

- Landcover: The land cover available in MEGAN database has global coverage at 30 sec (~ 1km) spatial resolution (Guenther et al, 2006).
- Surface Temperature Data: Gridded, hourly temperature fields were extracted from the 2005 MM5 predictions for each day for each grid resolution.
- Photosynthetically active radiation (PAR): The PAR data represents the spectral range of solar radiation that is used by plants for the photosynthesis process. The data were downloaded from the University of Maryland (UMD; 2006) and a FORTRAN program was used to reformat the data. Some of the PAR data were missing. As part of the QA process, the PAR data were inspected, and the missing data were replaced by interpolating the missing data between hours.

Biogenic emissions were generated as described above for all three modeling domains. Spatial distributions of the annual total organic compounds (TOG) and NOx in the 4-km domain are shown in Figure B-1 and B-2, respectively. Biogenic emissions are generally highest in the higher elevation areas, including the San Juan Mountains of southwestern Colorado, and lowest in the arid lower elevation mesas and plains, including much of San Juan County in northwestern New Mexico. Annual biogenic emissions are summarized in Table B-1.

Table B-1. Annual biogenic emissions (t/yr) within the 4 km modeling domain by state/tribal area.

STATE/Tribe	VOC	NOx
Arizona	29,202	211
Colorado	84,822	659
New Mexico	108,515	833
Utah	15,931	130
Tribes		
Grand Total	**238,471**	**1,834**

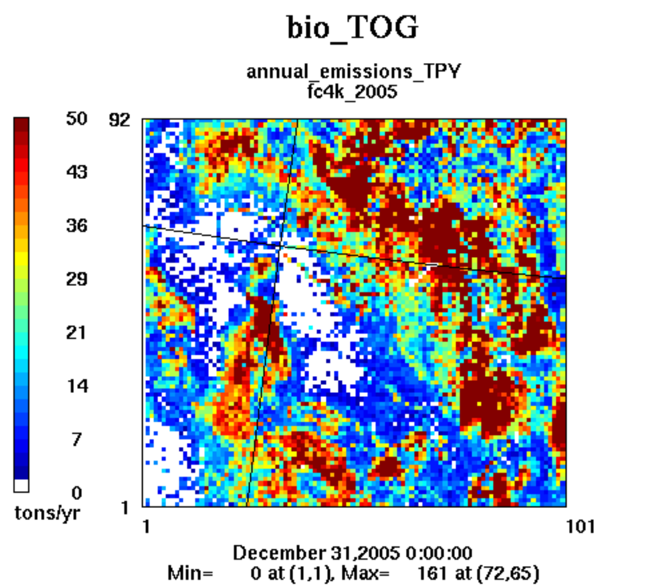 	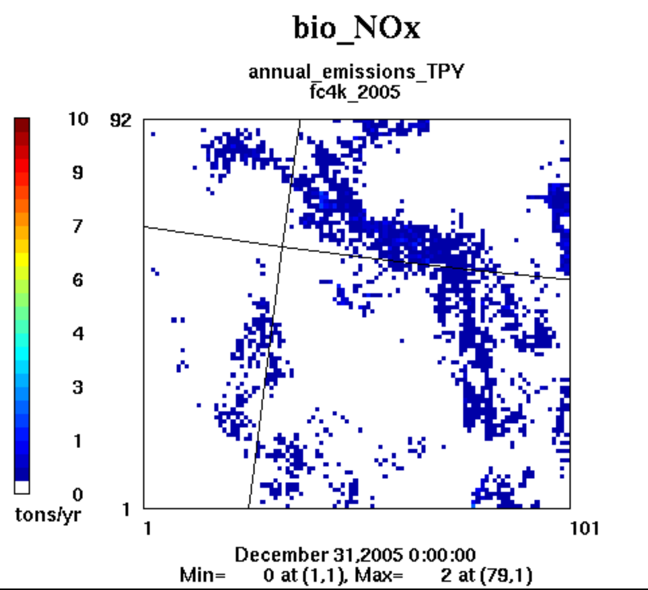
Figure B-1. Annual TOG (tpy) in 4-km domain	Figure B-2. Annual NOx (tpy) in 4-km domain

Appendix C
Development of Western U.S. Fire Emissions Inventory

Appendix C
Development of Western U.S. Fire Emissions Inventory

The National Center for Atmospheric Research (NCAR) generates annual fire databases that are derived from MODIS satellite data. The MODIS platform is a polar-orbiting satellite that passes over a given point on the globe four times per day. The raw infrared data are processed at 1-km pixel resolution to identify "hot" pixels that indicate significant fire activity. High resolution land coverage and fuel type databases are overlaid onto the 1-km fire pixel data to determine fuel loading, and in combination with fuel-specific emission factors, daily fire emission estimates are estimated for criteria pollutants (CO, NOx, VOC, SO_2, PM) and greenhouse gasses.

The 2005 NCAR/MODIS fire emissions dataset was processed to generate emission inputs for CAMx. For each day, the 1-km fire pixels were aggregated to the 12-km Four Corners modeling grid. Each 12-km "fire" cell was assigned multiple co-located point sources that inject a fraction of each fire's emissions into each CAMx vertical layer. The plume rise and diurnal activity profiles were determined from the approach developed by the WRAP Fire Emissions Joint Forum (FEJF). The FEJF approach assigns diurnal intensity profiles and plume rise according to fire size in acres; since size is not given in the NCAR fire dataset, fire size was determined from daily PM emissions rates aggregated to each 12-km "fire" cell. VOC emissions were speciated to CB05 according to profiles derived from the TROFEE study (Karl et al., 2007). Resulting hourly point source emissions for speciated SO_2, NOx, VOC, CO, and PM (primary EC and OC) were compiled into a CAMx point source file format and merged with the anthropogenic point source inventory.

Fire emissions vary widely from day to day and month to month. During 2005, fires were most prevalent in the general vicinity of the Four Corners region during June and July. Emissions of NOx and PM for these months are shown in Figure C-1.

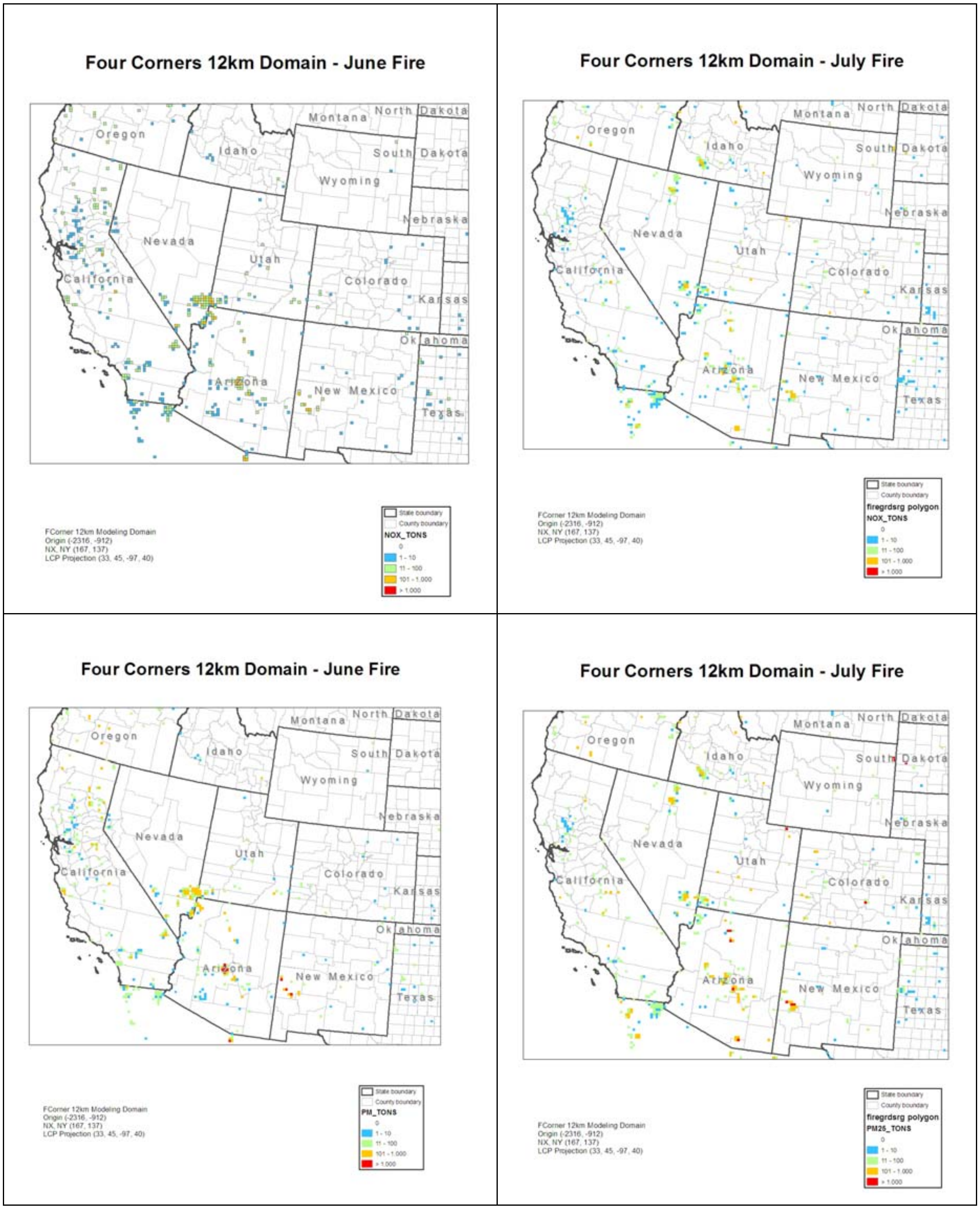

Figure C-2. Fire emissions during June (left column) and July (right column) 2005 for NOx (top row) and PM (bottom row).

Appendix D

Meteorological Modeling

Draft Topical Report

Evaluation of 36/12/4 km MM5 for Calendar Year 2005

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19 October 2006

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1 INTRODUCTION

Over the past half decade, emergent requirements for direct numerical simulation of urban and regional scale photochemical and secondary aerosol air quality—spawned largely by the new particulate matter (PM2.5) and regional haze regulations—have led to intensified efforts to construct high-resolution emissions, meteorological and air quality data sets. The concomitant increase in computational throughput of low-cost modern scientific workstations has ushered in a new era of regional air quality modeling. It is now possible, for example, to exercise sophisticated mesoscale prognostic meteorological models and Eulerian and Lagrangian photochemical/aerosol models for the full annual period, simulating ozone, sulfate and nitrate deposition, and secondary organic aerosols (SOA) across the entire United States (U.S.) or over discrete subregions.

One such model is the Pennsylvania State University/National Center for Atmospheric Research (PSU/NCAR) Mesoscale Model (MM5) (Dudhia, 1993; Grell et al., 1994: www.mmm.ucar.edu/mm5). MM5 is a limited-area, non-hydrostatic, terrain-following model designed to simulate mesoscale atmospheric circulation. The model is supported by several pre- and post-processing programs which are referred to collectively as the MM5 modeling system. This report describes an application and performance evaluation of MM5 for an atmospheric simulation for calendar 2005 over a modeling domain that covers the continental United States at a 36km grid spacing, the southwestern United States at a 12km spacing, and the Four Corners region (New Mexico, Utah, Arizona, and Colorado) at a 4km spacing.

2 METHODOLOGY

The methodology for this approach is very straightforward. The basic methodology was to apply the MM5 model for the annual period (2005 in this case) and the model results (wind speeds, wind directions, temperatures, etc.) were compared with available surface meteorological observations.

2.1 Model Selection and Application

Below we give a brief summary of the MM5 input data preparation procedure used for this annual modeling exercise.

Model Selection: The publicly available non-hydrostatic version of MM5 (version 3.7.2) was used for this modeling study. Preprocessor programs of the MM5 modeling system including TERRAIN, REGRID, LITTLE_R, and INTERPF were used to develop model inputs.

Horizontal Domain Definition: The computational grids are presented in Figure 2-1. The outer 36km domain (D01) has 165 x 129 grid cells, selected to maximize the coverage of the ETA analysis region. The 12km nested grid domain (D02) has 178 x 157 grid cells and the 4km nested grid domain (D03) has 172 x 169 grid cells. The projection is Lambert Conformal with the "national RPO" grid projection pole of 40°, -97° with true latitudes of 33° and 45°.

Vertical Domain Definition: The MM5 modeling was based on 34 vertical layers with an approximately 38 meter deep surface layer. The MM5 vertical domain is presented in both sigma and height coordinates in Table 2-1.

Topographic Inputs: Topographic information for the MM5 was developed using the NCAR and the United States Geological Survey (USGS) terrain databases. The grid was based on the 2 min (~4 km) Geophysical Data Center global data. Terrain data was interpolated to the model grid using a Cressman-type objective analysis scheme. To avoid interpolating elevated terrain over water bodies, after the terrain databases were interpolated onto the MM5 grid, the NCAR graphic water body database was used to correct elevations over water bodies.

Vegetation Type and Land Use Inputs: Vegetation type and land use information was developed using the most recently released PSU/NCAR databases provided with the MM5 distribution. Standard MM5 surface characteristics corresponding to each land use category were employed.

Atmospheric Data Inputs: The first guess fields were taken from the NCAR ETA archives. Surface and upper-air observations used in the objective analyses, following the procedures outlined by Stauffer and Seaman at PSU, were quality-inspected by MM5 pre-processors using automated gross-error checks and "buddy" checks. In addition, rawinsonde soundings were subject to vertical consistency checks. The synoptic-scale data used for this initialization (and in the analysis nudging discussed below) were obtained from the conventional National Weather Service (NWS) twice-daily radiosondes and 3-hr NWS surface observations.

Water Temperature Inputs: The ETA database contains a "skin temperature" field. This can be and was used as the water temperature input to these MM5 simulations. Past studies have shown that these skin temperatures, the water temperature surrogates, can lead to temperature errors along coastlines. However, for this analysis which focuses on bulk continental scale transport in the Four Corners area, this issue is likely not important and the skin temperatures were used.

FDDA Data Assimilation: This simulation used a combination of analysis and observation-based nudging. For these simulations analysis nudging coefficients of $2.5x10^{-4}$ and $1.0x10^{-4}$ were used for winds and temperature at 36km and 12km, respectively. An analysis nudging coefficient of $1x10^{-5}$ was used for mixing ratio. Thermodynamic variables were not nudged within the boundary layer. For January through November, observation nudging of the NOAA Techniques Development Lab (TDL) surface observation database (NCAR DS472.0) was used for winds with a nudging coefficient of $4x10^{-4}$. No observation nudging was performed for December because the TDL dataset was not available.

Physics Options: The MM5 model physics options in this simulation were as follows:

Betts-Miller Cumulus Parameterization Pleim-
Xiu PBL and Land Surface Schemes Reisner 1
Mixed Phase Moisture Scheme RRTM
Atmospheric Radiation Scheme

Application Methodology: The MM5 model was executed in 5-day blocks initialized at 12Z every 5 days with a 90 second time step. Model results were output every 60 minutes and output files were split at 24 hour intervals. Twelve (12) hours of spin-up is included in each 5-day block before the data was used in this evaluation.

2.2 Evaluation Approach

The model evaluation approach was based on a combination of qualitative and quantitative analyses. The qualitative approach was to compare the model estimated monthly total precipitation with the monthly Center for Prediction of Climate (CPC) precipitation analysis. The statistical approach was to examine the model bias and error for temperature, and mixing ratio and the Index of Agreement for the wind fields.

Interpretation of bulk statistics over a continental scale domain is problematic. To detect if the model is missing important sub-regional features is difficult. For this analysis the statistics are performed on a state by state basis, a Regional Planning Organization (RPO) basis for the continental 36km domain, and on a domain-wide basis.

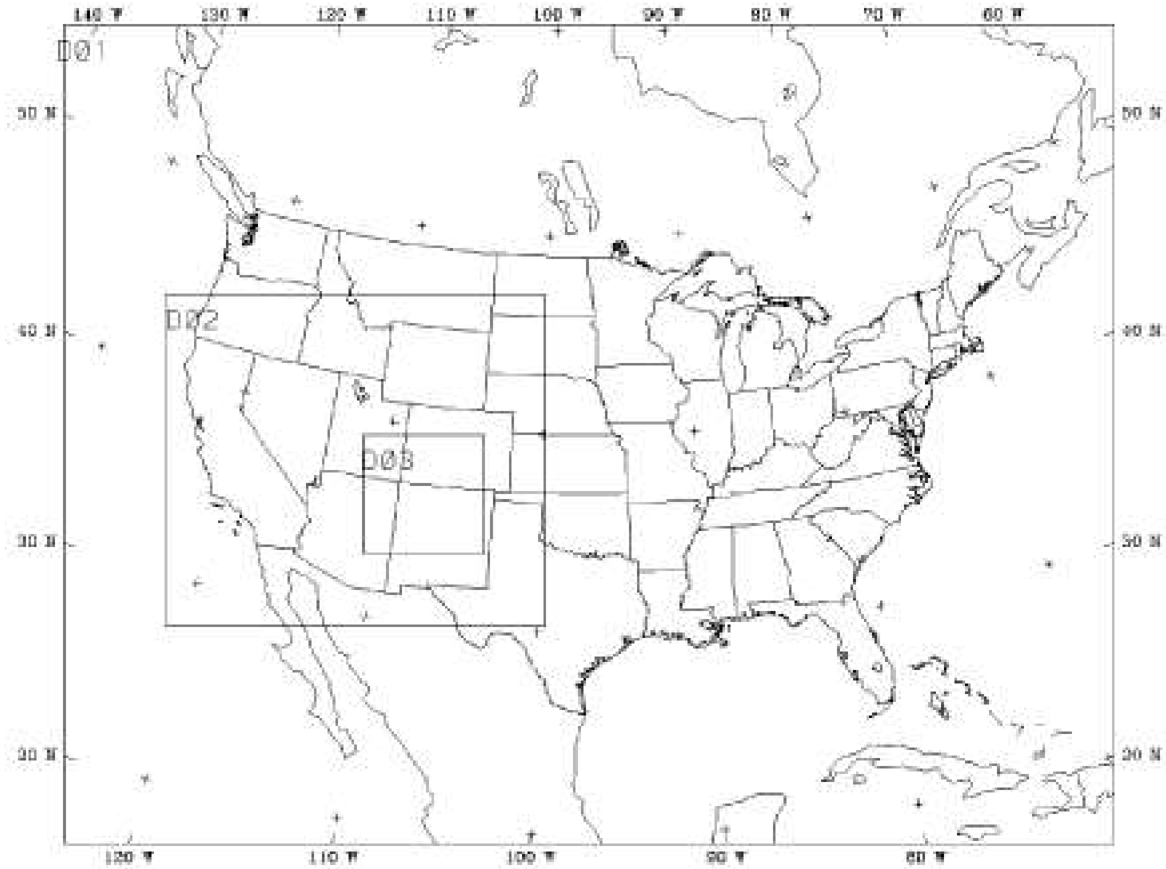
The observed database for winds, temperature, and water mixing ratio used in this analysis was the NOAA Techniques Development Lab (TDL) Surface Hourly Observation database obtained from the NCAR archives. The TDL data for December 2005 was not available in time to be used for this analysis. The rain observations are taken from the CPC retrospective rainfall archives available at:

http://www.cpc.ncep.noaa.gov/products/precip/realtime/retro.shtml.

Table 2-1: MM5 Vertical Domain in Specification.

k(MM5)	sigma	press.(mb)	height(m)	depth(m)
34	0.000	10000	15674	2004
33	0.050	14500	13670	1585
32	0.100	19000	12085	1321
31	0.150	23500	10764	1139
30	0.200	28000	9625	1004
29	0.250	32500	8621	900
28	0.300	37000	7720	817
27	0.350	41500	6903	750
26	0.400	46000	6153	693
25	0.450	50500	5461	645
24	0.500	55000	4816	604
23	0.550	59500	4212	568
22	0.600	64000	3644	536
21	0.650	68500	3108	508
20	0.700	73000	2600	388
19	0.740	76600	2212	282
18	0.770	79300	1930	274
17	0.800	82000	1657	178
16	0.820	83800	1478	175
15	0.840	85600	1303	172
14	0.860	87400	1130	169
13	0.880	89200	961	167
12	0.900	91000	794	82
11	0.910	91900	712	82
10	0.920	92800	631	81
9	0.930	93700	550	80
8	0.940	94600	469	80
7	0.950	95500	389	79
6	0.960	96400	310	78
5	0.970	97300	232	78
4	0.980	98200	154	39
3	0.985	98650	115	39
2	0.990	99100	77	38
1	0.995	99550	38	38
0	1.000	100000	0	0

Figure 2-1: 36km (D01) and 12km (D02) and 4km (D03) MM5 Domains.



3 MM5 PERFORMANCE EVALUATION RESULTS

3.1 Quantitative Model Evaluation Results

Statistical model evaluation results are presented in this section. A full annual model evaluation is very difficult to summarize in a single document, especially a simulation that could be used for many different purposes. With this in mind, this section presents results so potential data users can independently judge the adequacy of the model simulation.

The tables present the statistical metric for each state, for each Regional Planning Organization (RPO), and for the United States portion of the modeling domain. A graphic of RPO boundaries is presented if Figure 3-1. In this comparison the vertical level 1 (~19m) model estimates are compared directly with the nominal ~2m temperature and moisture and ~10m wind measurements.

3.1.1 Temperature Bias and Error

Temperature bias statistics are presented in Tables 3-1, 3-2 and 3-3 for the 36km, 12km and 4km domains, respectively. As can be seen in Table 3-1, when the temperatures are averaged over the entire 2005 period and the entire modeling domain (ALL), the model has a bias of 0.52 °C for the 36km domain and 0.14 °C for the 12km domain. The model tends to have positive bias (overestimate) temperatures throughout the year on the 36km domain, and to underestimate temperatures from March through July in the NMED4KM region. Temperatures are overestimated the remainder of the year on the 12km domain for the NMED4KM region. Table 3-3 shows that temperatures are generally overestimated for the 4KM grid for all months except March.

Temperature error data are presented in Tables 3-4 through 3-6 for the 36km, 12km, and 4km grids, respectively. The overall temperature error (ALL category) is 2.28°C on the 36km domain, 2.72°C on the 12km domain, and 3.34°C on the 4km domain. The mean error of 3.34°C for the 4km grid was somewhat consistent across all 12 months with February being the lowest temperature error at 2.59°C. All temperature errors were typically greater than 3.0°C for the 4km domain, 2.0°C for the 12km domain, and greater than about 1.5°C for the 36km domain.

3.1.2 Mixing Ratio Bias and Error

Mixing ratio bias data are presented in Tables 3-7 through 3-9 for the three modeling domains. Averaged over the entire year, at all stations, the model has a bias of 0.17 g/kg and 0.03 g/kg for the 36km and 12km domains, respectively, as shown by the "ALL" category shown in Tables 3-7 and 3-8.. For the 36km domain, the model tends to perform better in the western (WRAP) and Central States (CENRAP) than for the southeast (VISTAS) and east (MANE_VU). For the 4km grid the mixing ratio bias 0.24 g/kg with underestimates h January through April and overestimates in May through November (except October where the bias was 0.0 g/kg).

Mixing ratio error results are presented in Tables 3-10 through 3.12. The mean error is 1.12 g/kg for the 36km domain, 1.07 g/kg for the 12km domain, and 1.10 g/kg for the 4km domain. The model has a positive error (overestimates) throughout the year in each domain and shows the highest error values in the more moist summertime months of June through August in all cases.

3.1.3 Wind Index of Agreement

Comparisons of the Wind Index of Agreement (IA) are presented in Tables 3-13 through 3-15. The domain-wide episode average IA is 0.87 for both the 36km and 12km domains and 0.8 for the 4km domain. No significant monthly trends were discerned in any of the month to month variations or by State, Region, or area reviewed. For the 36km domain, the model is tending to perform better in the western portion of the domain than the eastern portion. Performance across the 12km domain is consistent and commensurate with the 4km performance.

3.2 Monthly Precipitation Analysis

This section presents qualitative comparisons of MM5 estimated precipitation with the CPC retrospective analysis data. When comparing the CPC and MM5 precipitation data, note should be taken that the CPC analysis covers only the Continental U.S. and does not extend offshore or into Canada or Mexico. The MM5 fields cover the entire domain. Also note that the CPC analysis is based on a 0.25 x 0.25 degree (~40 x 40 km) grid which does not capture small precipitation features.

Monthly total precipitation comparisons for the 36km domain are presented in Figures 3-2 through 3-25. For each month, the first plot presents the CPC analysis data (i.e., Figure 3-2) and the second plot represents the MM5 total precipitation (i.e., Figure 3-3). If the CPC analysis data are considered to be the standard for precipitation, MM5 does a reasonably good job representing both the spatial coverage and magnitude of the precipitation in the Western U.S. throughout the year. The MM5 model did tend to overestimate precipitation in Arizona and New Mexico in July and August especially in the Four Corners region. In the Central and Eastern U.S., MM5 performs well during the fall, winter and spring which are the cooler months (Sept. through May), but overestimates precipitation from June through August especially in the southeast U.S.

Monthly total precipitation comparisons for the 12km domain are presented in Figures 3-26 through 3-49. As with the 36km grid, MM5 does a reasonably good job representing both the spatial coverage and magnitude of the precipitation in the Western U.S. throughout the year. The refinement of the 12km grid size is obvious when comparing the CPC precipitation to that of MM5. The tendency is for the MM5 precipitation data to have a smaller, more well defined footprint than the CPC data which is at the 40km by 40km spacing. Features like terrain appear more well defined in the MM5 data where the terrain elevations are considered.

Comparison of the CPC data and the 12km MM5 data indicates that MM5 precipitation is somewhat representative of the western region. Where MM5 does not agree well with the CPC data is in the summer months. The MM5 modeling indicates more precipitation in the Four Corners region than the CPC data for May through July as shown in Figures 3-34 through 3-39. A comparison of Figures 3-38 and 3-40 for CPC and 3-39 and 3-41 for MM5 show a marked overestimate by MM5 over the Colorado River basin in southeast Nevada, in eastern New Mexico, and across Arizona. Other months are comparable for the study area.

Figures 3-50 through 3-73 present the monthly total precipitation comparisons for the 4km domain. While the general patterns of precipitation over the Four Corners region are similar between the CPC and MM5 data, the magnitude of the precipitation is highly variable between the two data sets. Generally the MM5 model overestimated monthly total precipitation when compared to that of the CPC analysis. Review of Figures 3-57 through 3-67 for April through September show much higher precipitation in New Mexico and Colorado in the MM5 over the CPC data. Even the late fall and winter months show more precipitation although the spatial extent is reduced where the differences appear. January, November, and December show the most representative results from MM5 versus CPC. Considering that this area in the Four Corners is the focal point of the intended dispersion modeling analysis, the use of the MM5 data may not be the best representation of the precipitation. The higher precipitation could lead to higher deposition due to precipitation and subsequent lower air concentrations at the nearby Class I areas. Comparative review of the other meteorological data sets (other years and at all spatial grid sizes) should be considered prior to the decision to use or not use the 4km data in modeling studies.

Table 3-1: Temperature Bias (K) by Month and by State and Region in the 36km Domain.

Region	Jan '05	Feb '05	Mar '05	Apr '05	May '05	Jun '05	Jul '05	Aug '05	Sep '05	Oct '05	Nov '05	Mean
AK	-0.46	0.73	-0.36	-0.09	-1.03	-1.22	-0.74	0.28	-0.07	0.43	0.34	-0.20
AL	0.84	1.31	1.02	1.02	1.51	1.21	1.45	1.11	1.12	1.23	0.99	1.16
ALL	0.30	0.54	0.19	0.50	0.80	0.40	0.45	0.65	0.54	0.73	0.65	0.52
AR	0.66	1.65	1.12	0.95	1.45	1.19	1.53	1.22	1.11	1.30	0.59	1.16
AZ	0.98	0.28	-0.04	-0.82	-1.36	-1.57	-1.20	-0.33	-0.34	-0.34	1.08	-0.33
CA	1.76	0.42	0.29	-0.46	-1.13	-1.73	-0.85	-0.30	-0.07	0.36	1.65	-0.01
CENRAP	0.27	0.95	0.64	1.10	1.31	0.92	0.98	1.08	0.80	0.82	0.55	0.86
CO	0.33	-0.46	-1.67	-0.98	-0.28	-0.21	-0.46	0.07	0.02	0.14	-0.08	-0.33
CT	-0.20	-0.77	-1.26	0.60	1.08	0.54	0.36	0.25	0.24	0.52	0.64	0.18
DC	-0.25	-0.06	-0.22	0.48	0.74	0.28	0.27	0.07	-0.68	-0.22	0.23	0.06
DE	-1.00	0.05	0.20	0.06	1.26	0.24	-0.23	0.05	-0.05	0.38	0.54	0.14
FL	0.85	0.74	0.44	0.09	-0.08	0.51	-0.04	0.40	0.26	0.62	1.00	0.44
GA	0.86	1.27	0.96	0.78	1.24	1.00	1.15	1.05	0.76	1.08	1.25	1.04
IA	-1.01	0.20	0.90	1.72	1.81	1.10	1.40	1.70	1.13	0.89	0.54	0.94
ID	0.92	0.52	-0.31	-0.45	0.46	0.59	0.44	0.78	1.34	1.27	1.26	0.62
IL	-0.19	0.72	0.96	1.47	1.67	1.16	1.34	1.83	1.49	1.18	0.13	1.07
IN	-1.06	0.41	0.87	1.33	1.65	0.88	1.03	1.39	1.08	1.07	0.30	0.81
KS	0.88	1.90	1.71	1.16	1.02	0.68	0.45	0.69	0.26	0.39	0.37	0.86
KY	-0.38	1.28	1.11	0.99	1.08	0.73	0.78	1.05	0.88	1.14	0.43	0.83
LA	0.58	1.04	0.84	0.22	0.49	0.52	0.56	0.90	0.46	1.06	0.85	0.68
MA	-0.52	-0.75	-1.66	0.46	0.99	0.32	0.03	0.12	0.56	0.59	0.55	0.06
MANE VU	-0.28	-0.46	-0.98	0.16	1.02	0.48	0.28	0.34	0.31	0.50	0.27	0.15
MD	-0.05	0.48	0.16	0.44	1.10	0.34	0.25	0.46	0.07	0.45	0.67	0.40
ME	-0.43	-0.64	-1.61	-0.45	1.15	0.87	0.53	0.57	0.70	0.40	0.30	0.13
MI	-0.09	-0.48	-0.32	0.45	1.22	0.45	0.50	0.55	0.58	1.08	0.41	0.40
MN	-1.36	-1.03	-1.46	1.28	1.92	1.40	0.96	1.03	1.00	0.81	0.47	0.46
MO	0.42	1.28	1.15	0.97	0.96	0.91	0.64	1.18	1.00	0.86	-0.06	0.85
MS	1.23	1.70	1.53	1.14	1.59	1.35	1.64	1.41	1.17	1.49	1.30	1.41
MT	1.13	0.39	-0.14	-0.50	0.38	0.37	-0.05	0.38	0.18	0.77	-0.24	0.24
MW	-0.61	-0.28	-0.05	1.01	1.48	0.79	0.87	1.03	0.92	1.04	0.22	0.58

NC	0.56	0.98	0.75	0.35	0.97	0.45	0.59	0.55	0.46	0.82	1.30	0.71
ND	-0.73	0.64	0.74	1.86	1.74	1.41	1.28	1.06	1.13	1.35	0.81	1.03
NE	0.41	1.91	1.72	1.95	1.33	0.72	0.58	1.15	0.49	0.79	0.97	1.09
NH	-0.72	-0.41	-1.62	0.89	1.77	1.29	0.76	1.01	0.90	0.45	0.65	0.45
NJ	-0.20	-0.58	-0.51	0.12	0.75	0.10	0.18	0.24	0.08	0.42	0.34	0.09
NM	1.10	0.81	0.23	0.14	0.30	-0.30	-0.43	0.32	0.25	0.57	1.01	0.36
NMED4KM	0.16	-0.47	-1.19	-0.96	-0.42	-0.52	-0.71	0.07	-0.02	0.22	0.59	-0.30
NV	0.64	-1.15	-1.68	-2.19	-1.83	-2.47	-2.19	-1.60	-1.28	-0.65	0.25	-1.29
NY	0.06	-0.48	-1.27	-0.10	0.63	0.19	-0.02	0.07	0.06	0.48	-0.15	-0.05
OH	-0.78	0.16	0.10	1.00	1.62	0.71	0.76	1.04	0.97	1.37	0.34	0.66
OK	1.55	1.86	1.14	0.73	1.34	1.15	1.07	1.18	0.85	0.56	-0.04	1.04
OR	0.62	1.35	0.50	-0.48	-0.54	-1.23	-1.31	-1.12	-0.16	0.60	1.43	-0.03
PA	-0.15	-0.25	-0.04	0.03	1.11	0.60	0.56	0.46	0.15	0.63	0.31	0.31
RI	-0.39	-0.85	-0.95	0.79	1.24	0.36	0.43	0.35	0.67	0.81	0.32	0.25
SC	1.08	1.59	0.86	0.52	1.17	0.88	0.87	0.82	0.41	0.91	1.53	0.97
SD	0.04	1.89	1.13	1.93	1.80	1.33	1.07	1.29	0.87	1.18	1.04	1.23
TN	0.13	1.29	0.43	0.74	0.97	0.76	0.97	0.95	0.88	0.86	0.50	0.77
TX	1.28	1.72	1.12	0.77	0.86	0.54	1.02	0.89	0.67	0.86	0.76	0.95
UT	0.74	0.27	-0.76	-1.10	-0.42	-0.47	-0.32	0.21	0.33	0.61	1.31	0.04
VA	-0.05	0.55	0.32	0.36	0.89	0.39	0.57	0.64	0.39	0.48	0.62	0.47
VISTAS	0.56	1.01	0.71	0.51	0.89	0.69	0.71	0.74	0.57	0.84	1.01	0.75
VT	-0.79	-0.84	-2.22	0.05	1.00	0.78	0.18	0.49	0.39	0.08	-0.89	-0.16
WA	0.70	1.57	0.57	0.17	0.01	-0.59	-0.44	-0.03	0.17	0.74	1.05	0.36
WI	-1.48	-1.69	-1.32	1.09	1.45	0.83	0.78	0.59	0.62	0.62	-0.03	0.13
WRAP	0.92	0.64	-0.04	-0.31	-0.30	-0.65	-0.48	0.04	0.16	0.51	0.97	0.13
WV	-0.25	0.34	0.26	0.38	1.36	0.74	0.67	0.60	0.53	0.49	0.28	0.49
WY	0.67	0.70	-1.54	-1.48	-0.24	-0.14	-0.65	0.42	-0.07	0.25	-0.68	-0.25

Table 3-2: Temperature Bias (K) by Month and by State and Region in the 12km Domain.

Region	Jan '05	Feb '05	Mar '05	Apr '05	May '05	Jun '05	Jul '05	Aug '05	Sep '05	Oct '05	Nov '05	Mean
ALL	0.94	0.41	-0.16	-0.42	-0.41	-0.53	-0.21	0.32	0.26	0.39	0.90	0.14
AZ	0.59	-0.30	-0.36	-0.97	-1.43	-1.70	-1.44	-0.48	-0.44	-0.52	0.77	-0.57
CA	1.36	0.16	0.20	-0.34	-0.83	-1.15	-0.03	0.40	0.15	0.44	1.38	0.16
CO	0.68	-0.06	-1.42	-0.94	-0.30	-0.01	-0.14	0.45	0.38	0.32	0.46	-0.05
ID	1.37	0.32	-0.92	-1.14	-0.05	0.29	0.58	0.70	1.64	1.20	1.39	0.49
NM	0.64	0.08	-0.15	-0.06	-0.07	-0.40	-0.66	0.12	0.03	0.25	0.89	0.06
NMED4KM	0.25	-0.43	-1.19	-0.90	-0.39	-0.33	-0.48	0.27	0.21	0.31	0.86	-0.17
NV	0.72	-1.09	-1.55	-2.01	-1.75	-2.20	-1.61	-1.19	-0.79	-0.39	0.27	-1.05
UT	0.76	0.34	-0.63	-0.97	-0.25	-0.32	0.07	0.45	0.87	1.00	1.40	0.25
WY	0.73	1.56	-0.80	-0.93	0.09	0.45	0.17	1.05	0.68	0.78	0.20	0.36

Table 3-3 **Temperature Bias** (K) by Month for **the 4km Domain.**

Region	Jan '05	Feb '05	Mar '05	Apr '05	May '05	Jun 05	Jul '05	Aug '05	Sep '05	Oct '05	Nov '05	Mean
ALL	1.45	0.95	-0.03	0.72	1.19	0.94	0.58	1.22	1.27	1.54	1.91	1 .07

Table 3-4: Temperature Error (K) by Month and by State and Region in the 36km Domain.

Region	Jan '05	Feb '05	Mar '05	Apr '05	May '05	Jun '05	Jul '05	Aug '05	Sep '05	Oct '05	Nov '05	Mean
AK	1.94	1.52	1.35	1.74	1.88	1.86	1.29	1.65	1.14	1.24	1.62	1.57
AL	2.17	2.11	2.35	2.27	2.41	1.95	2.08	2.07	2.23	2.44	2.33	2.22
ALL	2.36	2.32	2.41	2.37	2.26	2.10	2.17	2.20	2.26	2.26	2.36	2.28
AR	1.99	2.35	2.14	2.03	2.18	1.99	2.19	2.14	2.02	2.19	2.03	2.11
AZ	2.27	1.98	2.50	2.97	3.12	3.26	3.28	2.81	2.88	2.82	3.10	2.82
CA	2.94	2.28	2.49	2.63	2.66	2.86	2.94	2.89	2.96	2.86	3.30	2.80
CENRAP	2.35	2.40	2.40	2.27	2.18	1.90	1.99	2.09	2.08	2.25	2.29	2.20
CO	3.44	3.29	3.58	3.43	3.09	2.90	3.23	2.88	3.02	2.91	3.33	3.19
CT	1.82	2.13	2.37	1.97	1.71	1.75	1.51	1.55	1.88	1.76	2.17	1.87
DC	2.26	1.23	1.36	1.43	1.48	1.15	1.21	1.22	1.33	1.41	1.43	1.41
DE	2.59	2.40	1.77	2.22	2.25	1.65	1.81	1.56	1.72	1.61	1.85	1.95
FL	2.07	2.05	2.11	1.94	1.87	1.75	1.72	1.91	1.74	1.94	2.06	1.92
GA	2.41	2.28	2.51	2.39	2.44	1.91	2.08	1.92	2.10	2.31	2.50	2.26
IA	2.06	1.94	2.17	2.48	2.49	1.98	2.03	2.25	2.27	2.26	2.10	2.18
ID	2.92	2.87	2.99	2.97	2.73	2.80	3.44	3.42	3.22	2.90	2.91	3.02
IL	1.86	1.73	1.95	2.23	2.24	2.01	1.89	2.27	2.26	2.11	1.69	2.02
IN	2.07	1.67	1.85	2.28	2.22	1.80	1.75	1.91	1.97	1.97	1.59	1.92
KS	2.52	2.62	2.56	2.16	2.05	1.86	1.90	1.93	1.89	2.24	2.47	2.20
KY	1.73	1.87	1.85	1.94	1.79	1.69	1.49	1.96	1.83	2.02	1.96	1.83
LA	2.26	2.14	2.14	2.15	2.03	1.99	2.01	2.20	2.00	2.52	2.46	2.17
MA	2.11	2.42	2.53	2.23	1.88	2.11	1.81	1.85	2.13	1.85	2.06	2.09
MANE_VU	2.11	2.25	2.30	2.32	1.97	1.94	1.78	1.88	2.08	1.87	2.08	2.05
MD	2.27	1.96	1.80	2.06	2.11	1.66	1.58	1.79	2.16	2.03	2.25	1.97
ME	2.36	2.60	2.47	2.64	1.88	2.13	1.94	1.89	1.98	1.77	1.87	2.14
MI	1.96	1.83	2.19	2.42	2.29	2.07	2.16	2.00	2.14	2.01	1.80	2.08
MN	2.49	2.56	2.86	2.62	2.50	2.16	1.87	2.00	2.18	2.25	2.05	2.32
MO	2.00	2.11	2.23	2.02	1.95	1.83	1.82	2.05	1.87	2.02	1.90	1.98
MS	2.14	2.29	2.37	2.21	2.40	2.06	2.23	2.25	2.18	2.63	2.44	2.29

MT	4.07	3.40	3.40	2.97	2.50	2.16	2.95	2.75	2.70	2.79	2.67	2.94
MW	2.03	1.90	2.15	2.32	2.25	2.00	1.94	2.05	2.13	2.05	1.73	2.05
NC	2.21	2.21	2.38	2.18	2.17	1.89	1.90	1.79	1.90	2.13	2.71	2.13
ND	2.59	2.40	2.61	2.76	2.46	1.97	2.09	2.21	2.40	2.50	2.07	2.37
NE	2.71	2.84	2.70	2.61	2.38	1.83	2.06	2.23	2.32	2.53	2.70	2.45
NH	2.80	3.23	3.57	3.31	2.68	2.80	2.54	2.59	2.84	2.36	2.67	2.85
NJ	1.82	2.02	1.94	2.13	1.86	1.65	1.51	1.74	2.16	1.85	2.16	1.89
NM	2.79	2.21	2.61	2.86	2.64	2.67	2.58	2.41	2.57	2.47	3.13	2.63
NMED4KM	3.02	2.67	3.24	3.32	3.08	3.05	3.17	2.77	2.91	2.76	3.34	3.03
NV	2.95	2.68	3.13	3.39	3.37	3.92	4.29	3.92	4.20	3.56	3.26	3.52
NY	1.96	2.22	2.28	2.29	1.84	1.88	1.75	1.92	2.02	1.88	2.11	2.01
OH	1.95	1.73	1.98	2.17	2.26	1.95	1.71	1.95	2.00	2.04	1.70	1.95
OK	2.68	2.57	2.20	1.96	2.05	1.99	2.04	2.18	2.15	2.20	2.43	2.22
OR	2.59	2.96	2.67	2.08	2.11	2.54	3.11	3.14	2.98	2.46	2.82	2.68
PA	1.94	1.83	1.92	2.20	2.00	1.76	1.67	1.81	1.96	1.79	1.90	1.89
RI	1.85	1.96	1.95	1.88	1.91	1.84	1.75	1.85	1.82	1.72	1.57	1.83
SC	2.28	2.35	2.36	2.10	2.09	1.74	1.85	1.74	1.73	2.12	2.65	2.09
SD	2.41	2.87	2.67	2.69	2.46	2.04	2.21	2.28	2.36	2.53	2.51	2.46
TN	1.80	2.11	2.02	2.07	2.09	1.77	1.68	2.03	2.13	2.13	2.29	2.01
TX	2.28	2.38	2.24	2.06	1.93	1.68	2.04	2.02	1.93	2.20	2.42	2.11
UT	2.72	2.72	2.95	2.89	2.57	2.78	3.07	2.92	3.07	2.77	3.00	2.86
VA	2.14	1.97	2.17	2.20	2.11	1.89	1.82	1.85	2.18	2.08	2.46	2.08
VISTAS	2.15	2.13	2.27	2.16	2.15	1.86	1.88	1.91	1.98	2.15	2.41	2.10
VT	2.51	2.61	3.01	2.63	2.02	2.16	1.83	2.01	2.26	2.05	2.51	2.33
WA	2.20	2.75	2.25	1.94	1.97	2.03	2.40	2.65	2.37	1.89	1.92	2.22
WI	2.34	2.40	2.54	2.41	2.23	2.01	1.94	1.96	2.09	2.06	1.75	2.16
WRAP	2.86	2.67	2.73	2.71	2.57	2.62	2.87	2.79	2.80	2.64	2.89	2.74
WV	2.11	1.92	2.21	2.30	2.35	1.98	1.87	1.94	2.22	2.01	2.33	2.11
WY	3.55	3.59	3.20	3.19	2.40	2.53	3.04	2.92	3.00	2.75	2.92	3.01

Table 3-5: Temperature **Error** (K) by Month and by State and Region in the 12km Domain.

Region	Jan '05	Feb '05	Mar '05	Apr '05	May '05	Jun '05	Jul '05	Aug '05	Sep '05	Oct '05	Nov '05	Mean
ALL	2.83	2.56	2.70	2.69	2.47	2.52	2.77	2.64	2.81	2.78	3.12	2.72
AZ	2.21	1.85	2.48	2.88	3.04	3.19	3.16	2.57	2.77	2.77	3.08	2.73
CA	2.73	2.20	2.38	2.43	2.33	2.35	2.56	2.56	2.73	2.72	3.25	2.57
CO	3.26	3.06	3.29	3.17	2.93	2.80	3.11	2.69	2.93	2.90	3.32	3.04
ID	3.06	3.09	3.05	3.06	2.58	2.64	3.38	3.45	3.35	3.02	3.11	3.07
NM	2.75	2.11	2.58	2.86	2.54	2.66	2.55	2.37	2.65	2.55	3.30	2.63
NMED4KM	3.01	2.53	3.12	3.28	3.02	3.02	3.04	2.63	2.90	2.85	3.51	2.99
NV	3.10	2.73	3.14	3.23	3.06	3.58	3.89	3.61	4.00	3.63	3.67	3.42
UT	2.74	2.70	2.88	2.75	2.46	2.68	3.15	2.90	3.19	2.96	3.11	2.87
WY	3.30	3.57	2.81	2.75	2.17	2.36	2.86	2.92	2.90	2.72	2.72	2.83

Table 3-6 Temperature **Error** (K) by Month **for t he 4km Domain.**

Region	Jan '05	Feb '05	Mar '05	Apr 05	May '05	Jun '05	Jul '05	Aug '05	Sep '05	Oct '05	Nov '05	Mean
ALL	3.09	2.59	3.03	3.26	3.32	3.51	3.71	3.25	3.55	3.50	3.98	3 .34

Table 3-7: Mixing Ratio Bias (g/kg) by Month and by State and Region in the 36km Domain.

Region	Jan '05	Feb '05	Mar '05	Apr '05	May '05	Jun '05	Jul '05	Aug '05	Sep '05	Oct '05	Nov '05	Mean
AK	0.05	0.15	0.29	0.19	0.55	0.53	0.17	0.37	0.42	0.54	0.20	0.31
AL	1.29	1.16	1.12	1.16	0.83	-0.07	0.03	-0.15	0.39	0.26	0.39	0.58
ALL	0.39	0.39	0.35	0.44	0.05	0.06	-0.17	-0.24	0.19	0.11	0.25	0.17
AR	0.86	0.76	0.41	0.59	0.17	0.00	-0.32	-0.59	-0.04	-0.24	0.10	0.15
AZ	-0.31	-0.34	-0.34	0.40	1.04	1.41	1.37	0.22	1.07	0.54	0.61	0.52
CA	0.02	-0.21	-0.40	-0.39	-0.32	-0.48	-0.34	-0.03	-0.48	-0.48	-0.33	-0.31
CENRAP	0.36	0.36	0.15	0.19	-0.08	-0.09	-0.51	-0.55	0.06	-0.09	-0.02	-0.02
CO	0.15	0.06	0.10	0.13	-0.33	-0.89	-0.25	-0.85	-0.34	-0.57	-0.15	-0.27
CT	0.37	0.44	0.54	0.59	0.27	0.60	0.10	0.22	0.56	0.69	0.94	0.48
DC	0.98	0.86	0.81	0.45	0.16	0.13	-0.49	-0.35	0.24	0.55	0.49	0.35
DE	0.43	0.53	0.55	0.48	0.22	-0.11	-0.49	-0.17	0.29	0.41	0.61	0.25
FL	1.07	0.93	0.88	0.84	0.68	0.01	-0.10	0.19	0.55	0.31	0.78	0.56
GA	1.16	1.05	1.23	0.99	0.62	-0.25	-0.16	-0.33	0.21	0.09	0.34	0.45
IA	0.09	0.25	0.03	-0.16	-0.33	0.26	-0.69	-0.85	0.04	-0.06	-0.01	-0.13
ID	0.23	0.11	0.47	-0.01	-0.60	-0.69	-0.38	-0.06	-0.46	-0.21	0.16	-0.13
IL	0.31	0.43	0.21	0.38	-0.08	0.51	-0.60	-1.08	-0.32	-0.04	0.15	-0.01
IN	0.00	0.50	0.44	0.65	-0.14	0.46	-0.15	-0.66	0.29	0.16	0.27	0.17
KS	0.35	0.28	-0.16	-0.03	0.17	0.27	-0.19	0.11	0.34	0.18	0.12	0.13
KY	0.46	0.70	0.46	1.10	0.23	0.48	0.37	0.08	0.44	0.18	0.50	0.45
LA	0.96	0.96	0.85	0.72	0.43	0.41	0.14	-0.04	0.77	0.20	0.18	0.51
MA	0.19	0.24	0.35	0.64	0.30	0.73	0.48	0.80	0.96	0.87	0.94	0.59
MANE VU	0.35	0.39	0.51	0.82	0.24	0.66	0.22	0.49	0.73	0.72	0.77	0.54
MD	0.65	0.75	0.64	0.38	-0.17	0.09	-0.55	-0.41	0.44	0.58	0.63	0.28
ME	0.11	0.15	0.39	0.92	0.56	1.22	0.70	0.62	0.85	0.79	0.66	0.63
MI	0.12	0.20	0.45	1.04	0.10	0.71	0.22	0.04	0.45	0.46	0.30	0.37
MN	-0.07	0.02	0.02	0.67	-0.05	0.41	0.22	-0.17	0.32	0.14	0.02	0.14
MO	0.62	0.66	0.15	0.22	0.27	0.64	0.06	-0.17	0.10	-0.06	0.32	0.26

MS	1.06	0.96	0.90	0.83	0.45	0.06	-0.14	-0.09	0.37	0.13	0.28	0.44
MT	0.29	0.34	0.45	0.03	-0.42	-0.90	-0.73	-0.10	-0.09	-0.07	0.33	-0.08
MW	0.14	0.31	0.38	0.76	0.04	0.73	0.00	-0.35	0.15	0.22	0.22	0.24
NC	1.12	0.89	1.10	1.20	0.83	0.13	0.10	-0.21	0.54	0.52	0.73	0.63
ND	-0.04	0.14	0.05	0.05	-0.35	-0.31	-0.16	0.06	0.45	0.14	0.17	0.02
NE	0.23	0.29	0.01	0.05	0.08	0.36	0.22	0.05	0.69	0.15	0.03	0.20
NH	0.13	0.16	0.32	0.96	0.26	1.08	0.56	0.56	0.73	0.79	0.86	0.58
NJ	0.59	0.62	0.76	1.12	0.23	0.30	-0.10	0.44	0.77	0.76	0.94	0.58
NM	0.08	-0.07	-0.17	0.05	-0.04	0.38	0.11	-1.02	0.34	-0.16	0.42	-0.01
NMED4KM	0.23	0.09	0.17	0.22	-0.08	-0.08	0.10	-0.76	0.21	-0.24	0.11	0.00
NV	0.17	0.10	0.39	-0.03	-0.23	0.16	0.88	0.51	0.85	0.13	0.34	0.30
NY	0.27	0.30	0.37	0.85	0.07	0.41	0.05	0.36	0.64	0.69	0.72	0.43
OH	0.13	0.52	0.50	0.66	-0.01	0.80	0.27	0.18	0.54	0.42	0.47	0.41
OK	0.57	0.19	-0.24	-0.33	-0.67	-1.34	-2.22	-1.19	-0.68	-0.61	-0.10	-0.60
OR	0.20	0.39	0.25	-0.10	-0.47	-0.48	0.27	0.34	0.08	0.00	0.40	0.08
PA	0.58	0.63	0.75	0.96	0.30	0.74	0.17	0.66	0.77	0.66	0.74	0.63
RI	0.25	0.30	0.46	0.52	0.41	1.04	1.00	0.90	0.82	0.84	0.79	0.67
SC	1.13	1.00	1.35	1.28	0.78	0.15	0.12	-0.24	0.63	0.35	0.65	0.65
SD	0.12	0.22	0.03	-0.01	-0.38	-0.08	0.01	-0.18	0.29	0.02	0.06	0.01
TN	0.85	0.84	0.64	0.91	0.29	0.12	-0.04	-0.37	0.32	0.21	0.31	0.37
TX	0.49	0.50	0.36	0.04	-0.13	-0.61	-0.96	-0.97	-0.20	-0.23	-0.17	-0.17
UT	0.21	0.18	0.37	-0.05	-0.62	-0.54	0.27	-0.19	-0.02	-0.32	-0.25	-0.09
VA	0.71	0.70	0.62	0.52	-0.17	-0.51	-0.86	-1.12	-0.04	0.25	0.43	0.05
VISTAS	1.01	0.91	0.95	0.96	0.53	-0.03	-0.14	-0.27	0.39	0.30	0.56	0.47
VT	0.11	0.17	0.30	0.88	0.19	0.96	0.58	0.60	0.70	0.70	0.62	0.53
WA	0.16	0.19	0.33	0.04	-0.31	-0.52	-0.11	-0.03	-0.10	0.02	0.31	0.00
WI	0.03	0.11	0.39	0.97	0.20	1.07	0.30	-0.19	0.01	0.14	0.03	0.28
WRAP	0.10	0.04	0.01	-0.05	-0.26	-0.37	-0.07	-0.15	-0.06	-0.18	0.07	-0.08
WV	0.77	0.80	0.75	1.19	0.44	0.31	-0.08	-0.17	0.64	0.54	0.75	0.54
WY	0.31	0.25	0.16	0.09	-0.74	-1.33	-0.42	-0.25	-0.07	-0.36	0.03	-0.21

Table 3-8: Mixing Ratio Bias (g/kg) by Month and by State and Region in the 12km Domain.

Region	Jan '05	Feb '05	Mar '05	Apr '05	May '05	Jun '05	Jul '05	Aug '05	Sep '05	Oct '05	Nov '05	Mean
ALL	0.11	0.02	0.01	0.01	-0.07	-0.10	0.29	0.03	0.13	-0.10	0.02	0.03
AZ	-0.24	-0.16	-0.13	0.54	1.17	1.55	1.75	0.32	1.07	0.70	0.71	0.66
CA	0.02	-0.19	-0.29	-0.35	-0.20	-0.36	-0.03	0.23	-0.26	-0.36	-0.45	-0.20
CO	0.15	0.08	0.10	0.23	-0.12	-0.46	0.24	-0.57	-0.10	-0.37	-0.08	-0.08
ID	0.25	-0.01	0.49	0.20	-0.60	-0.47	-0.22	0.29	-0.32	-0.15	0.15	-0.04
NM	0.10	-0.08	-0.07	0.22	0.22	0.60	0.60	-0.81	0.43	-0.08	0.47	0.15
NMED4KM	0.21	0.08	0.20	0.34	0.17	0.27	0.69	-0.42	0.41	-0.05	0.18	0.19
NV	0.07	-0.06	0.34	0.12	-0.09	0.45	0.87	0.69	0.96	0.23	0.28	0.35
UT	0.10	0.04	0.37	0.11	-0.35	-0.13	0.68	0.25	0.22	-0.07	-0.14	0.10
WY	0.23	0.22	0.19	0.13	-0.59	-0.89	-0.10	0.00	0.11	-0.23	0.06	-0.08

Table 3-9 Mixing Ratio Bias (g/kg) by Month for the 4km Domain.

Region	Jan '05	Feb '05	Mar '05	Apr '05	May '05	Jun '05	Jul '0	Aug '05	Sep '05	Oct '05	Nov '05	Mean
ALL	-0.10	-0.29	-0.28	-0.20	0.05	0.52	1 37	0.33	1.08	0.00	0.14	0 .24

Table 3-10: Mixing Ratio Error (g/kg) by Month and Stat and Region the 36km Domain.

Region	Jan '05	Feb '05	Mar '05	Apr '05	May '05	Jun '05	Jul ' 05	Aug '05	Sep '05	Oct '05	Nov '05	Mean
AK	0.45	0.39	0.46	0.54	1.05	0.98	0.60	0.70	0.64	0.68	0.44	0.63
AL	1.35	1.26	1.27	1.36	1.39	1.45	1.59	1.60	1.37	0.96	1.02	1.33
ALL	0.71	0.74	0.81	1.11	1.16	1.49	1.59	1.52	1.33	1.00	0.86	1.12
AR	0.97	1.02	0.91	1.16	1.28	1.53	1.81	1.86	1.43	0.96	0.93	1.26
AZ	0.95	0.94	0.94	0.88	1.43	1.83	2.54	2.00	2.06	1.29	0.95	1.44
CA	0.79	0.85	1.07	1.03	1.01	1.12	1.44	1.48	1.41	1.18	1.24	1.15
CENRAP	0.67	0.77	0.76	1.15	1.33	1.70	1.84	1.69	1.43	1.02	0.82	1.20
CO	0.55	0.59	0.59	0.83	1.05	1.53	1.53	1.53	1.24	1.01	0.65	1.01
CT	0.46	0.54	0.61	0.84	0.87	1.14	1.24	1.14	1.12	0.88	1.02	0.90
DC	1.03	0.90	0.88	1.01	0.99	1.36	1.50	1.34	1.10	0.96	0.94	1.09
DE	0.54	0.62	0.62	0.83	0.87	1.06	1.26	1.17	1.10	0.74	0.80	0.87
FL	1.38	1.30	1.34	1.28	1.49	1.41	1.52	1.44	1.55	1.21	1.40	1.39
GA	1.31	1.23	1.41	1.34	1.32	1.57	1.72	1.56	1.61	1.16	1.15	1.40
IA	0.35	0.57	0.65	1.16	1.37	1.84	1.90	1.91	1.35	0.89	0.64	1.15
ID	0.55	0.52	0.81	0.79	1.16	1.28	1.31	1.34	1.02	0.84	0.69	0.94
IL	0.55	0.58	0.61	1.11	1.12	1.52	1.70	1.82	1.38	0.96	0.69	1.09
IN	0.58	0.61	0.66	1.20	1.04	1.44	1.35	1.51	1.21	0.90	0.72	1.02
KS	0.60	0.71	0.62	0.99	1.32	1.51	1.48	1.41	1.25	0.92	0.65	1.04
KY	0.80	0.81	0.82	1.44	1.11	1.45	1.46	1.51	1.21	0.91	0.87	1.13
LA	1.23	1.23	1.23	1.23	1.42	1.63	1.68	1.54	1.60	1.04	1.30	1.38
MA	0.42	0.41	0.49	0.89	0.78	1.28	1.21	1.34	1.26	0.98	1.02	0.92
MANE_VU	0.50	0.52	0.61	1.03	0.88	1.32	1.29	1.29	1.23	0.93	0.92	0.96
MD	0.79	0.83	0.79	0.98	1.03	1.42	1.47	1.52	1.44	1.00	0.96	1.11
ME	0.31	0.33	0.48	1.03	0.84	1.53	1.27	1.18	1.17	0.89	0.76	0.89
MI	0.35	0.35	0.55	1.20	0.79	1.38	1.29	1.18	1.09	0.83	0.63	0.88
MN	0.23	0.36	0.42	1.23	1.07	1.52	1.47	1.28	1.27	0.88	0.51	0.93
MO	0.73	0.80	0.64	1.07	1.24	1.57	1.48	1.59	1.29	0.94	0.78	1.10
MS	1.22	1.18	1.20	1.24	1.33	1.54	1.72	1.64	1.55	1.03	1.09	1.34

MT	0.47	0.51	0.73	0.75	0.98	1.48	1.36	1.22	0.92	0.86	0.63	0.90
MW	0.43	0.46	0.58	1.16	0.94	1.48	1.44	1.41	1.21	0.89	0.64	0.97
NC	1.19	0.99	1.23	1.53	1.37	1.56	1.69	1.57	1.41	1.14	1.15	1.35
ND	0.25	0.36	0.45	0.86	1.03	1.28	1.39	1.20	1.13	0.82	0.52	0.84
NE	0.49	0.59	0.56	1.02	1.22	1.47	1.66	1.60	1.32	0.88	0.58	1.04
NH	0.37	0.38	0.48	1.12	0.94	1.61	1.29	1.26	1.22	0.89	0.99	0.96
NJ	0.65	0.71	0.79	1.22	0.85	1.15	1.19	1.21	1.32	1.00	1.02	1.01
NM	0.77	0.78	0.80	0.79	1.15	1.57	1.78	1.84	1.65	1.01	0.68	1.17
NMED4KM	0.60	0.59	0.66	0.80	1.00	1.45	1.56	1.52	1.41	0.99	0.62	1.02
NV	0.65	0.61	0.97	0.70	1.22	1.10	1.73	1.46	1.25	0.88	0.80	1.03
NY	0.42	0.43	0.51	1.01	0.84	1.19	1.30	1.24	1.17	0.90	0.85	0.90
OH	0.55	0.64	0.65	1.03	0.95	1.41	1.28	1.34	1.17	0.91	0.75	0.97
OK	0.88	0.85	0.79	1.09	1.51	2.17	2.61	1.96	1.56	1.12	0.85	1.40
OR	0.66	0.68	0.80	0.77	0.95	0.90	1.16	1.16	0.91	0.93	0.71	0.88
PA	0.67	0.70	0.82	1.14	0.91	1.34	1.29	1.39	1.26	0.94	0.90	1.03
RI	0.41	0.46	0.55	0.78	0.93	1.32	1.57	1.51	1.29	1.06	0.93	0.98
SC	1.21	1.10	1.43	1.46	1.29	1.36	1.43	1.41	1.35	1.12	1.14	1.30
SD	0.33	0.52	0.52	0.89	1.07	1.54	1.58	1.44	1.15	0.81	0.53	0.94
TN	0.96	0.96	0.93	1.33	1.09	1.33	1.61	1.68	1.30	0.99	0.88	1.19
TX	0.94	1.05	1.05	1.17	1.51	1.80	2.06	1.90	1.63	1.21	1.12	1.40
UT	0.56	0.54	0.74	0.75	1.22	1.48	1.58	1.41	1.10	0.92	0.77	1.01
VA	0.88	0.83	0.84	1.20	1.25	1.64	1.86	1.87	1.43	1.03	0.91	1.25
VISTAS	1.17	1.08	1.18	1.36	1.33	1.50	1.65	1.58	1.44	1.09	1.12	1.32
VT	0.33	0.33	0.46	1.18	0.96	1.55	1.24	1.23	1.17	0.90	0.92	0.93
WA	0.56	0.56	0.72	0.72	0.79	0.89	1.02	1.04	0.89	0.81	0.61	0.78
WI	0.27	0.30	0.51	1.26	0.90	1.64	1.44	1.22	1.19	0.87	0.52	0.92
WRAP	0.64	0.67	0.80	0.85	1.05	1.31	1.47	1.42	1.25	1.00	0.82	1.03
WV	0.85	0.88	0.84	1.48	1.09	1.43	1.53	1.52	1.13	0.94	0.94	1.15
WY	0.54	0.51	0.55	0.75	1.14	1.74	1.41	1.31	1.02	0.82	0.60	0.94

Table 3-11 Mixing Ratio Error (g/kg) by Month and by State and Region in the 12km Domain.

Region	Jan '05	Feb '05	Mar '05	Apr '05	May '05	Jun '05	Jul '05	Aug '05	Sep '05	Oct '05	Nov '05	Mean
ALL	0.66	0.68	0.77	0.86	1.09	1.38	1.67	1.52	1.34	0.99	0.85	1.07
AZ	0.88	0.79	0.95	0.89	1.46	1.88	2.69	1.84	2.02	1.30	1.00	1.43
CA	0.79	0.83	0.97	1.01	0.98	1.06	1.48	1.49	1.35	1.14	1.22	1.12
CO	0.51	0.58	0.56	0.80	0.95	1.39	1.57	1.46	1.19	0.88	0.62	0.96
ID	0.48	0.45	0.74	0.69	1.09	1.22	1.26	1.38	0.95	0.71	0.61	0.87
NM	0.74	0.70	0.75	0.79	1.12	1.59	1.91	1.89	1.67	1.01	0.68	1.17
NMED4KM	0.57	0.56	0.64	0.80	0.93	1.42	1.71	1.53	1.42	0.89	0.62	1.01
NV	0.60	0.57	0.95	0.68	1.12	1.22	1.77	1.56	1.29	0.95	0.77	1.04
UT	0.55	0.52	0.71	0.72	1.12	1.38	1.74	1.54	1.16	0.87	0.69	1.00
WY	0.46	0.51	0.55	0.73	1.01	1.52	1.39	1.28	1.03	0.75	0.55	0.89

Table 3-12 Mixing Ratio Error (g/kg) by Month for the 4km Domain.

Region	Jan '05	Feb '05	Mar '05	Apr '05	May '05	Jun '05	Jul '05	Aug '05	Sep '05	Oct '05	Nov '05	Mean
ALL	0.59	0.70	0.68	0.82	1.01	1.49	1.91	1.49	1.70	1.01	0.69	1.10

Table 3-13: Wind Index of Agreement by Month and State and Region the 36km Domain.

Region	Jan '05	Feb '05	Mar '05	Apr '05	May '05	Jun '05	Jul ' 05	Aug '05	Sep '05	Oct '05	Nov '05	Mean
AK	0.55	0.59	0.55	0.60	0.50	0.47	0.53	0.52	0.52	0.48	0.50	0.53
ALL	0.85	0.87	0.87	0.87	0.86	0.88	0.88	0.90	0.87	0.89	0.87	0.87
AL	0.64	0.64	0.64	0.63	0.65	0.61	0.64	0.63	0.65	0.67	0.65	0.64
AR	0.66	0.68	0.68	0.68	0.67	0.67	0.71	0.72	0.70	0.70	0.73	0.69
AZ	0.72	0.67	0.72	0.72	0.73	0.71	0.68	0.75	0.73	0.74	0.74	0.72
CA	0.73	0.75	0.76	0.73	0.76	0.76	0.77	0.78	0.78	0.79	0.80	0.76
CENRAP	0.81	0.83	0.84	0.86	0.82	0.85	0.85	0.87	0.83	0.84	0.85	0.84
CO	0.79	0.75	0.76	0.79	0.78	0.77	0.78	0.78	0.76	0.73	0.76	0.77
CT	0.55	0.55	0.54	0.56	0.52	0.56	0.57	0.57	0.52	0.51	0.50	0.54
DE	0.74	0.79	0.76	0.73	0.71	0.74	0.79	0.79	0.73	0.74	0.75	0.75
FL	0.71	0.77	0.71	0.72	0.71	0.73	0.69	0.70	0.68	0.70	0.73	0.71
GA	0.61	0.58	0.61	0.62	0.58	0.57	0.53	0.59	0.56	0.59	0.60	0.59
IA	0.61	0.66	0.66	0.61	0.68	0.67	0.62	0.68	0.69	0.69	0.68	0.66
ID	0.74	0.77	0.65	0.72	0.67	0.77	0.76	0.75	0.67	0.78	0.73	0.73
IL	0.63	0.64	0.63	0.65	0.59	0.68	0.67	0.67	0.66	0.69	0.67	0.65
IN	0.59	0.58	0.62	0.55	0.60	0.63	0.62	0.62	0.66	0.65	0.60	0.61
KS	0.73	0.68	0.70	0.73	0.73	0.75	0.75	0.76	0.74	0.72	0.75	0.73
KY	0.52	0.56	0.52	0.57	0.56	0.56	0.58	0.59	0.62	0.53	0.57	0.56
LA	0.66	0.66	0.67	0.67	0.63	0.65	0.66	0.66	0.67	0.66	0.66	0.66
MA	0.61	0.69	0.58	0.62	0.68	0.60	0.59	0.65	0.57	0.61	0.56	0.61
MANE VU	0.70	0.76	0.72	0.66	0.77	0.70	0.76	0.69	0.70	0.67	0.69	0.71
MD	0.58	0.60	0.59	0.59	0.61	0.56	0.56	0.52	0.58	0.61	0.54	0.58
ME	0.55	0.57	0.60	0.53	0.53	0.54	0.59	0.53	0.56	0.56	0.52	0.55
MI	0.66	0.63	0.67	0.63	0.65	0.68	0.59	0.66	0.70	0.65	0.63	0.65
MN	0.66	0.67	0.71	0.68	0.66	0.70	0.69	0.64	0.70	0.68	0.69	0.68
MO	0.67	0.67	0.67	0.68	0.62	0.70	0.68	0.67	0.68	0.65	0.71	0.67
MS	0.62	0.59	0.60	0.61	0.60	0.54	0.56	0.63	0.65	0.61	0.59	0.60
MT	0.77	0.79	0.80	0.77	0.73	0.76	0.77	0.79	0.76	0.78	0.75	0.77

MW	0.70	0.72	0.70	0.72	0.67	0.75	0.72	0.79	0.74	0.76	0.73	0.73
NC	0.56	0.60	0.59	0.58	0.54	0.63	0.61	0.59	0.58	0.62	0.62	0.59
ND	0.72	0.72	0.69	0.72	0.73	0.75	0.67	0.70	0.72	0.72	0.73	0.72
NE	0.73	0.74	0.75	0.76	0.76	0.75	0.77	0.78	0.76	0.75	0.79	0.76
NH	0.56	0.48	0.43	0.51	0.42	0.34	0.36	0.28	0.39	0.35	0.39	0.41
NJ	0.56	0.58	0.54	0.61	0.59	0.52	0.52	0.54	0.53	0.61	0.57	0.56
NMED4KM	0.79	0.77	0.77	0.79	0.79	0.78	0.78	0.79	0.78	0.79	0.77	0.78
NM	0.77	0.79	0.77	0.77	0.78	0.78	0.78	0.77	0.78	0.76	0.75	0.77
NV	0.72	0.74	0.77	0.72	0.74	0.71	0.74	0.74	0.74	0.74	0.78	0.74
NY	0.71	0.71	0.73	0.69	0.75	0.72	0.74	0.69	0.71	0.69	0.69	0.71
OH	0.62	0.60	0.61	0.62	0.62	0.64	0.60	0.66	0.63	0.65	0.64	0.63
OK	0.68	0.67	0.71	0.66	0.65	0.67	0.69	0.72	0.71	0.67	0.70	0.68
OR	0.75	0.72	0.74	0.73	0.72	0.75	0.77	0.77	0.73	0.77	0.77	0.75
PA	0.62	0.64	0.62	0.64	0.65	0.65	0.66	0.68	0.66	0.66	0.66	0.65
RI	0.68	0.68	0.67	0.67	0.69	0.71	0.71	0.76	0.72	0.70	0.70	0.70
SC	0.58	0.61	0.61	0.64	0.55	0.57	0.61	0.59	0.58	0.57	0.57	0.59
SD	0.76	0.75	0.76	0.77	0.77	0.77	0.77	0.76	0.73	0.75	0.77	0.76
TN	0.57	0.57	0.61	0.60	0.61	0.55	0.66	0.64	0.60	0.63	0.67	0.61
TX	0.73	0.76	0.77	0.76	0.79	0.76	0.75	0.77	0.81	0.75	0.78	0.77
UT	0.66	0.66	0.73	0.75	0.74	0.69	0.75	0.74	0.73	0.74	0.75	0.72
VA	0.58	0.61	0.63	0.61	0.65	0.62	0.65	0.65	0.58	0.66	0.64	0.63
VISTAS	0.71	0.76	0.77	0.73	0.75	0.73	0.74	0.76	0.79	0.76	0.77	0.75
VT	0.49	0.51	0.50	0.50	0.49	0.50	0.50	0.51	0.51	0.51	0.50	0.50
WA	0.71	0.78	0.74	0.80	0.72	0.72	0.79	0.76	0.80	0.79	0.75	0.76
WI	0.61	0.62	0.60	0.59	0.64	0.62	0.63	0.61	0.65	0.59	0.62	0.62
WRAP	0.85	0.84	0.86	0.85	0.86	0.85	0.84	0.87	0.86	0.86	0.87	0.86
WV	0.53	0.49	0.55	0.52	0.54	0.55	0.57	0.58	0.58	0.56	0.54	0.55
WY	0.77	0.72	0.76	0.75	0.69	0.74	0.76	0.76	0.71	0.74	0.72	0.74

Table 3-14: Wind Index of Agreement by Month and by State and Region in the in 12km Domain.

Region	Jan '05	Feb '05	Mar '05	Apr '05	May '05	Jun '05	Jul '05	Aug '05	Sep '05	Oct '05	Nov '05	Mean
ALL	0.87	0.86	0.88	0.87	0.85	0.87	0.89	0.85	0.88	0.87	0.88	0.87
AZ	0.73	0.67	0.73	0.72	0.72	0.71	0.68	0.74	0.72	0.73	0.74	0.72
CA	0.77	0.79	0.78	0.76	0.79	0.80	0.80	0.81	0.81	0.83	0.83	0.80
CO	0.83	0.82	0.81	0.83	0.81	0.81	0.80	0.81	0.79	0.79	0.79	0.81
ID	0.73	0.65	0.71	0.76	0.61	0.78	0.66	0.76	0.75	0.75	0.69	0.71
NMED4KM	0.81	0.80	0.81	0.81	0.82	0.80	0.83	0.82	0.80	0.81	0.80	0.81
NM	0.77	0.81	0.78	0.80	0.79	0.81	0.81	0.81	0.80	0.79	0.78	0.80
NV	0.71	0.71	0.76	0.71	0.75	0.71	0.76	0.74	0.74	0.75	0.78	0.74
UT	0.71	0.72	0.77	0.77	0.74	0.76	0.78	0.76	0.74	0.76	0.78	0.75
WY	0.78	0.79	0.79	0.78	0.78	0.79	0.80	0.78	0.75	0.77	0.80	0.78

Table 3-15 : Wind Inde of Agreement by Month **in the 4km Domain.**

Region	Jan '05	Feb '05	Mar '05	Apr '05	May '05	Jun '05	Jul '05	Aug '05	Sep '05	Oct '05	Nov '05	Mean
ALL	0.83	0.82	0.79	0.78	0.80	0.80	0.80	0.81	0.80	0.81	0.79	0 .80

Figure 3-1: Regional Planning Organization (RPO) Boundaries.

Figure 3-2: CPC Analyzed Precipitation for January 2005 over the 36km Domain.

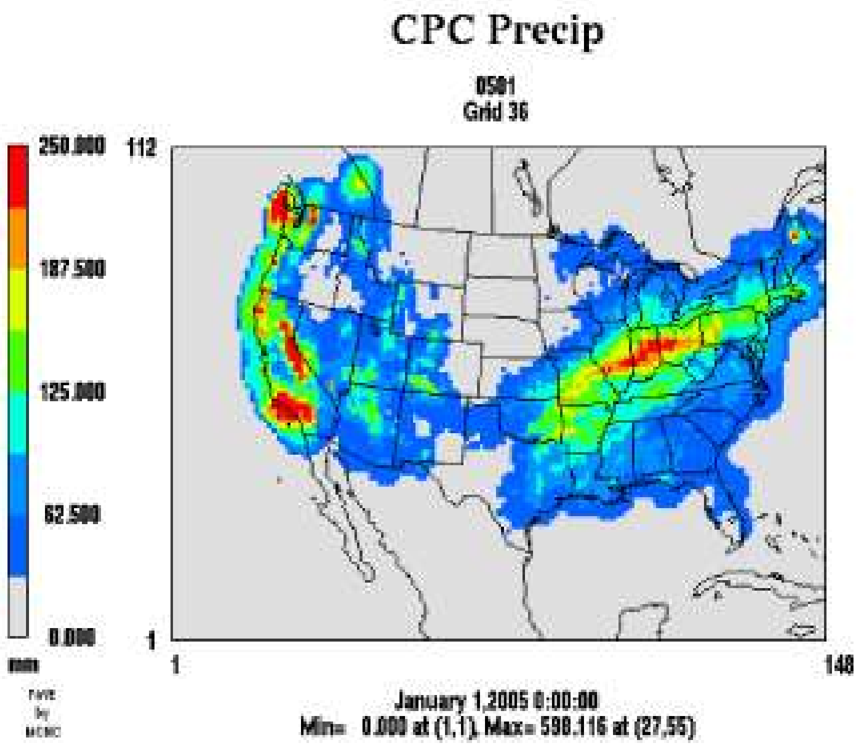


Figure 3-3: MM5 Estimated Precipitation for January 2005 over the 36km Domain.

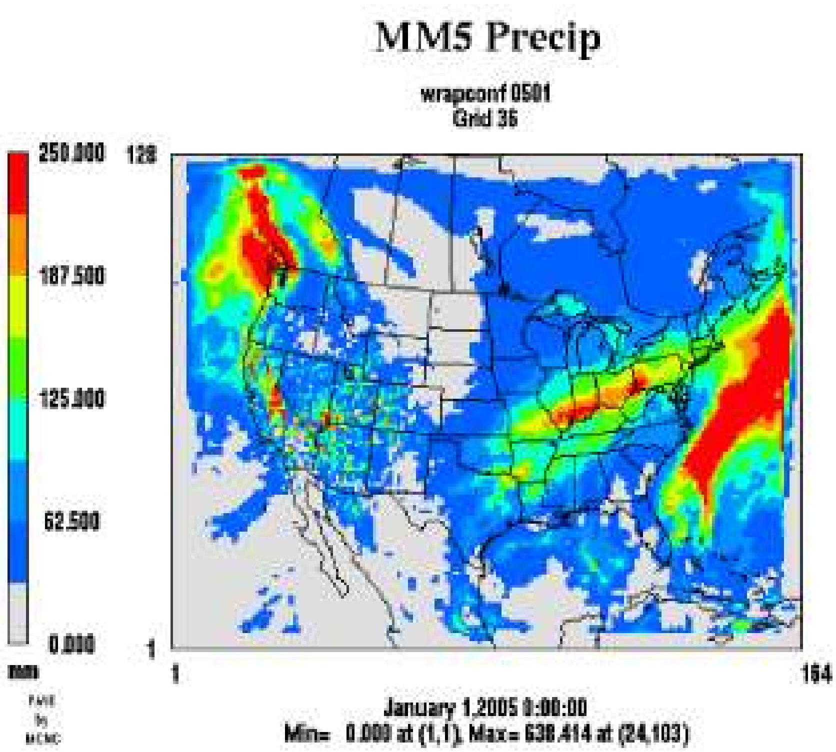


Figure 3-4: CPC Analyzed Precipitation for February 2005 over the 36km Domain.

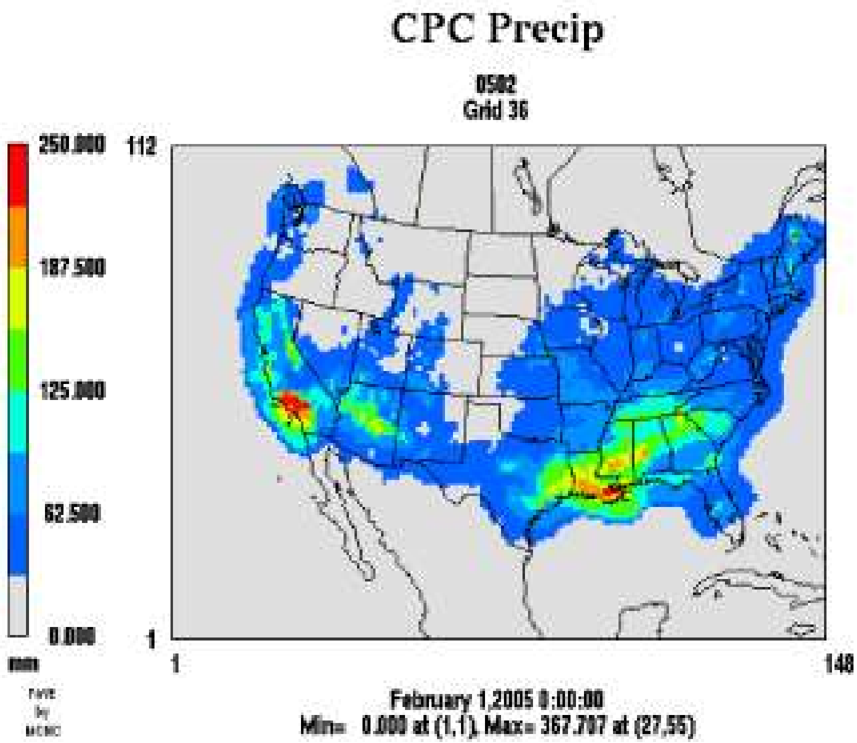


Figure 3-5: MM5 Estimated Precipitation for February 2005 over the 36km Domain.

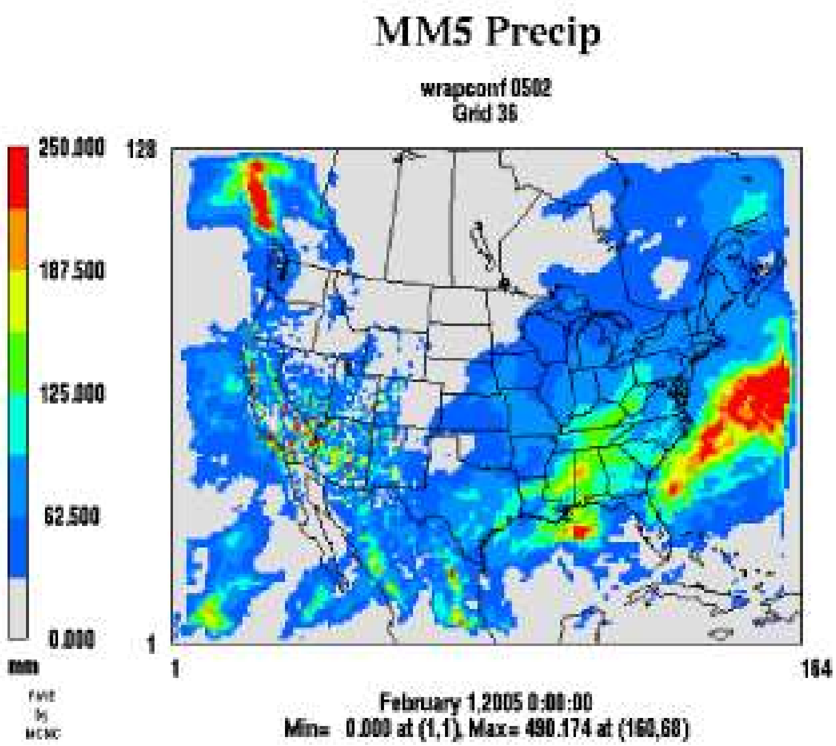


Figure 3-6: CPC Analyzed Precipitation for March 2005 over the 36km Domain.

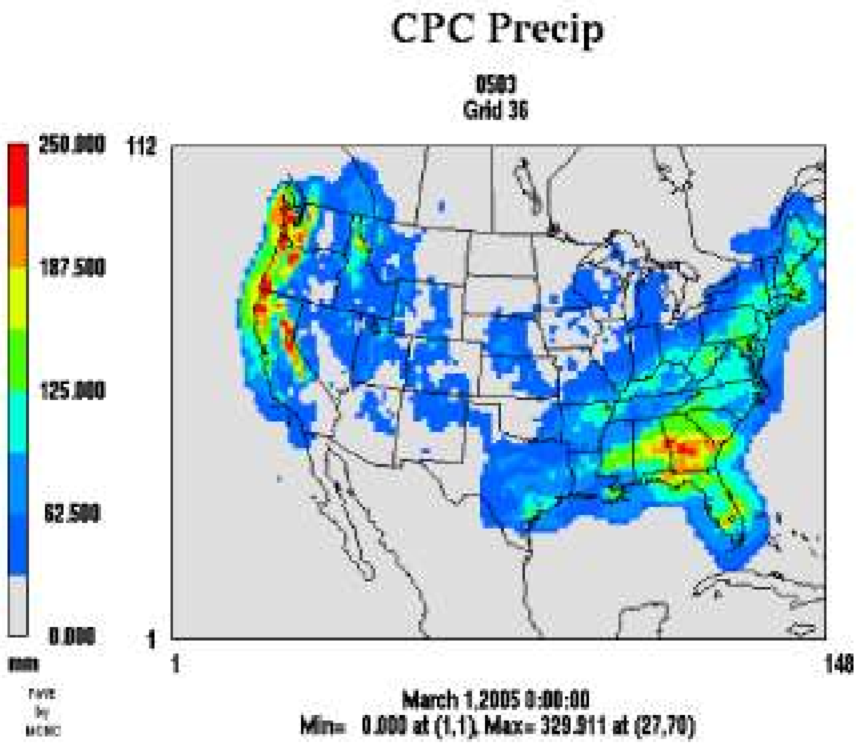


Figure 3-7: MM5 Estimated Precipitation for March 2005 over the 36km Domain.

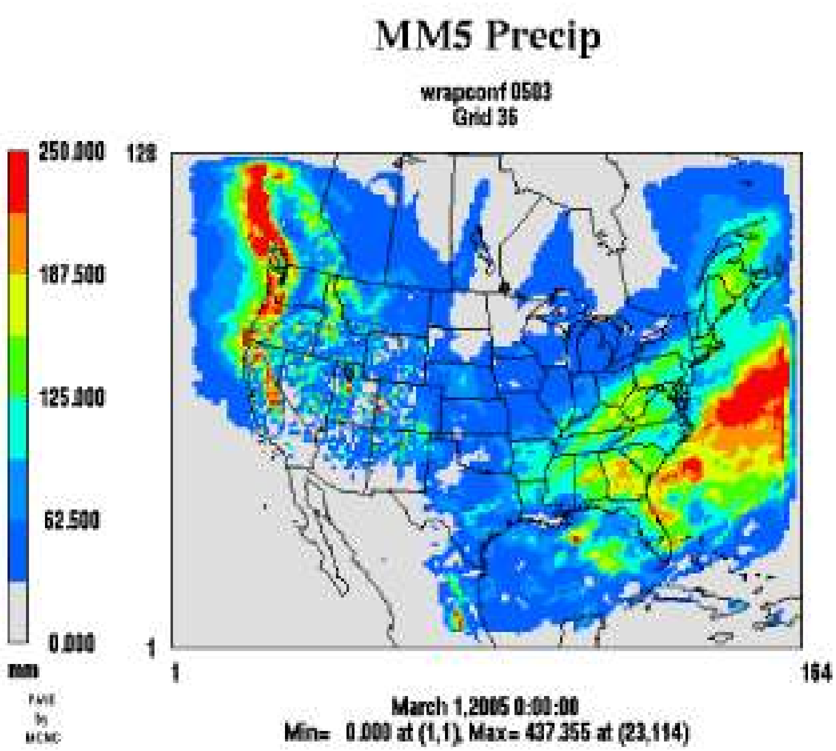


Figure 3-8: CPC Analyzed Precipitation for April 2005 over the 36km Domain.

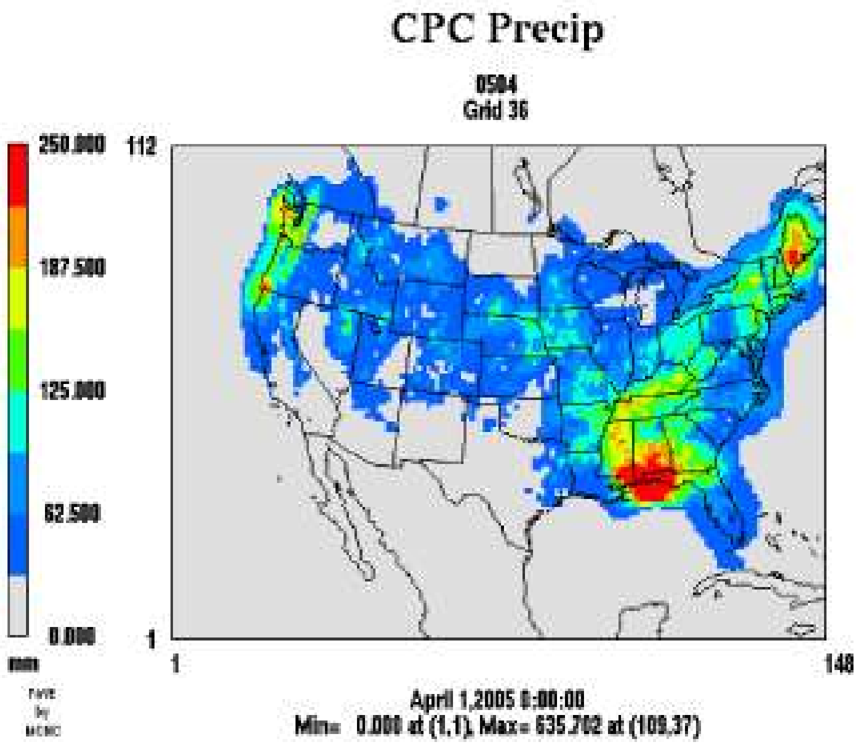


Figure 3-9: MM5 Estimated Precipitation for April 2005 over the 36km Domain.

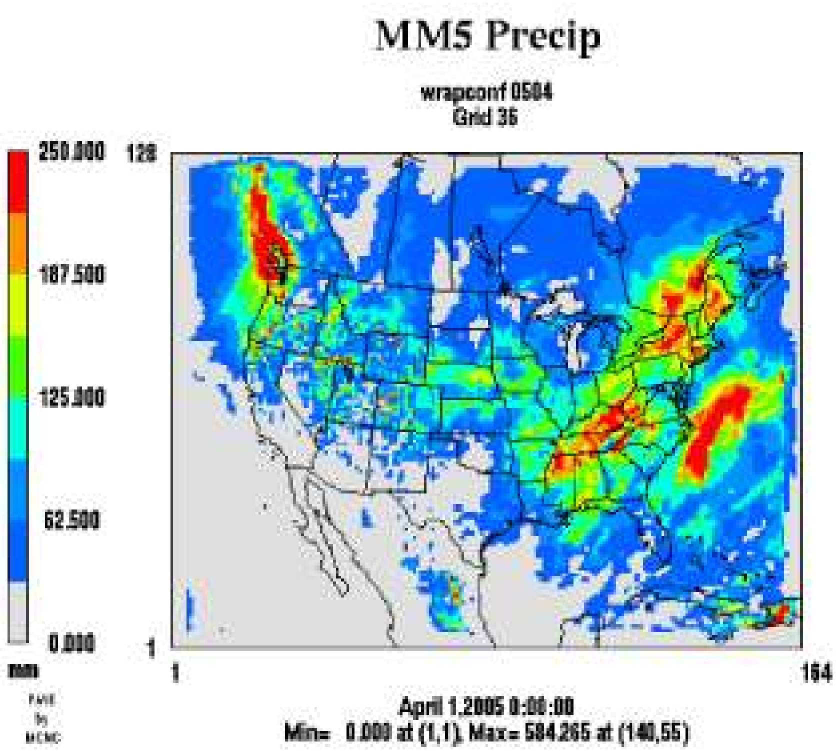


Figure 3-10: CPC Analyzed Precipitation for May 2005 over the 36km Domain.

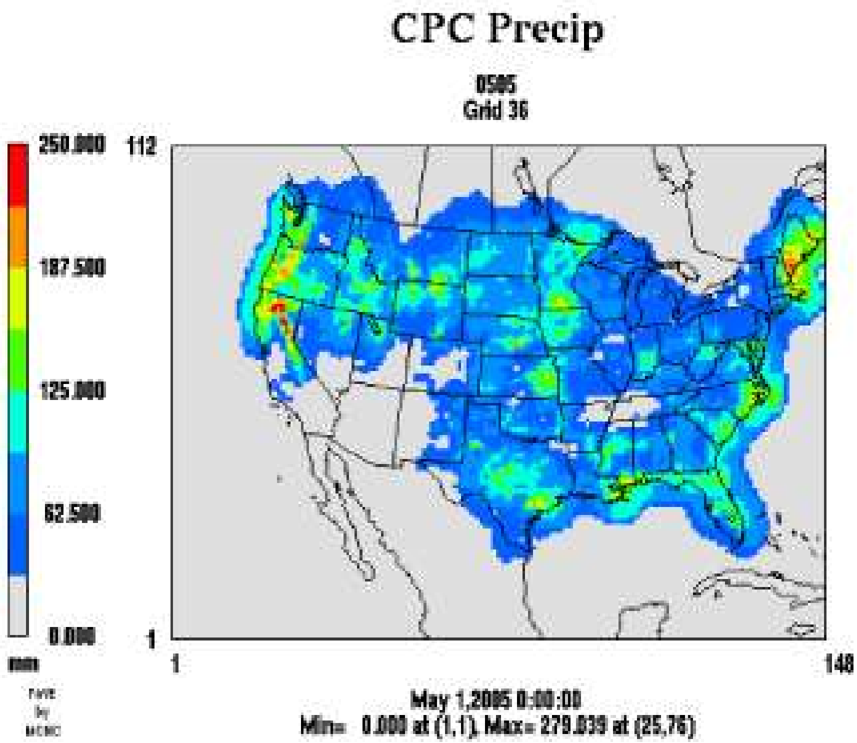


Figure 3-11: MM5 Estimated Precipitation for May 2005 over the 36km Domain.

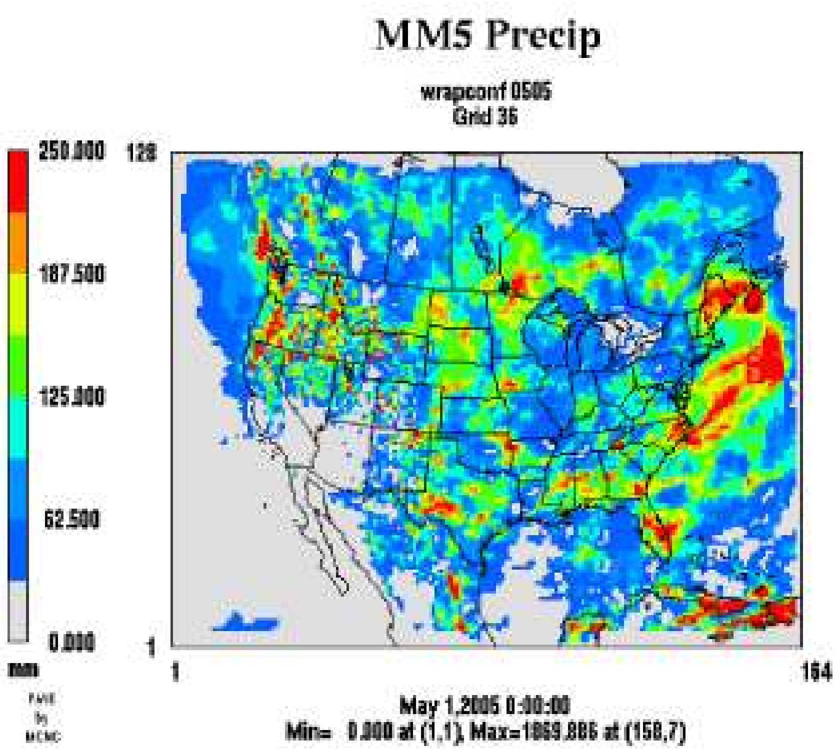


Figure 3-12: CPC Analyzed Precipitation for June 2005 over the 36km Domain.

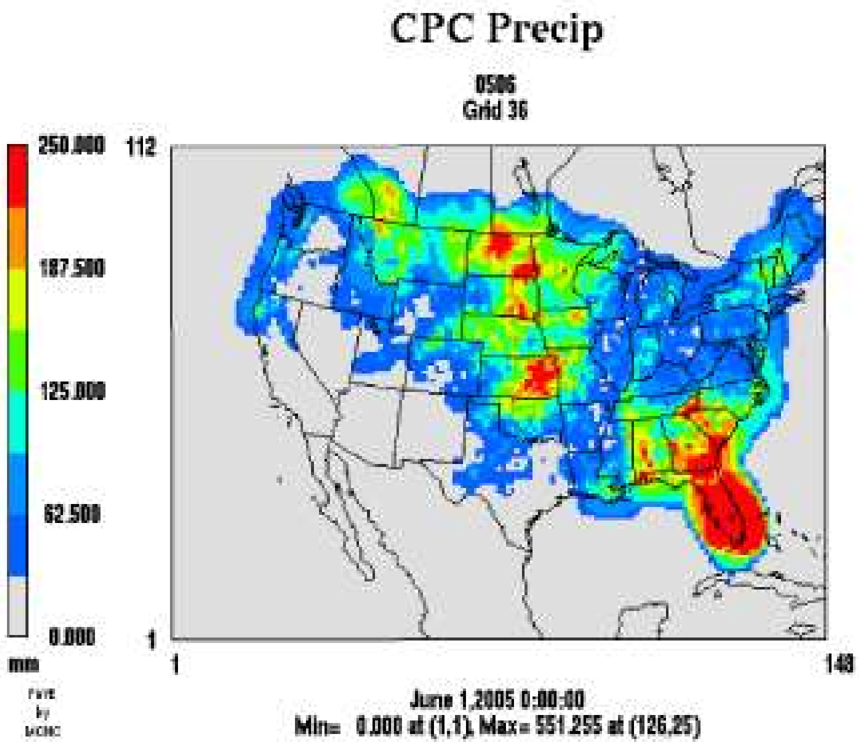


Figure 3-13: MM5 Estimated Precipitation for June 2005 over the 36km Domain.

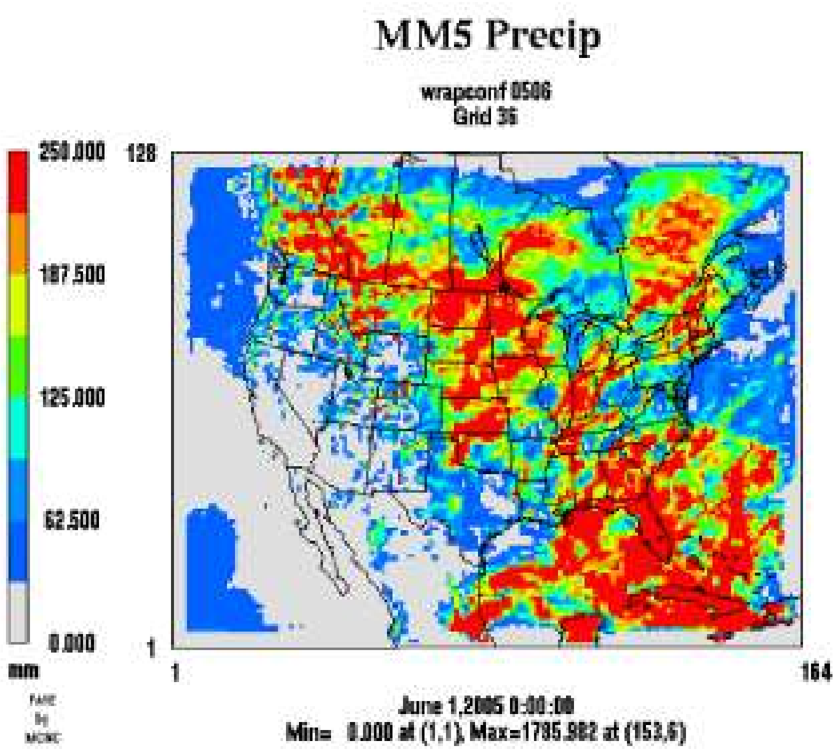


Figure 3-14: CPC Analyzed Precipitation for July 2005 over the 36km Domain.

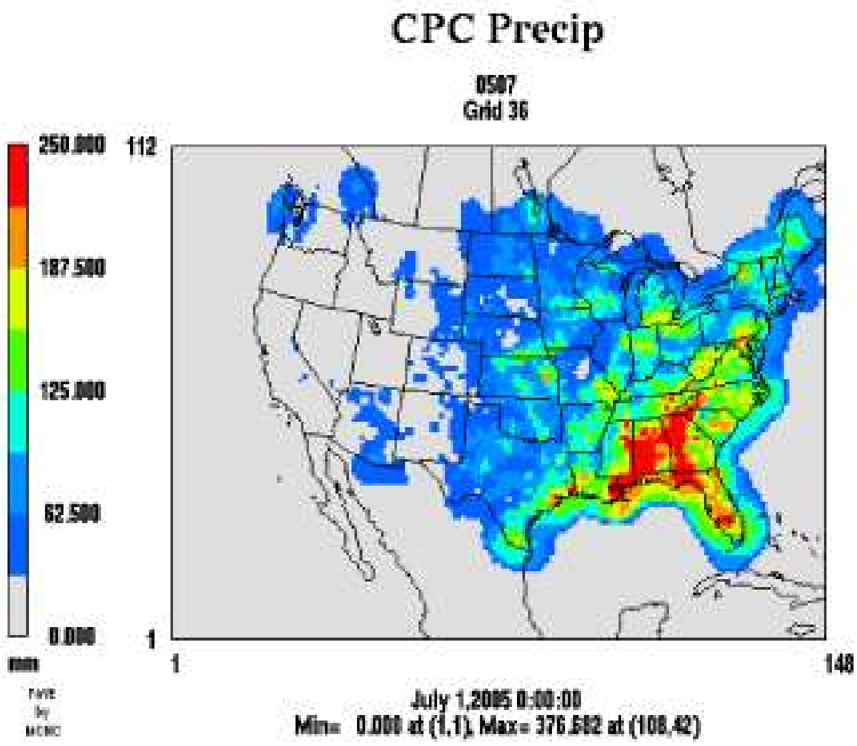


Figure 3-15: MM5 Estimated Precipitation for July 2005 over the 36km Domain.

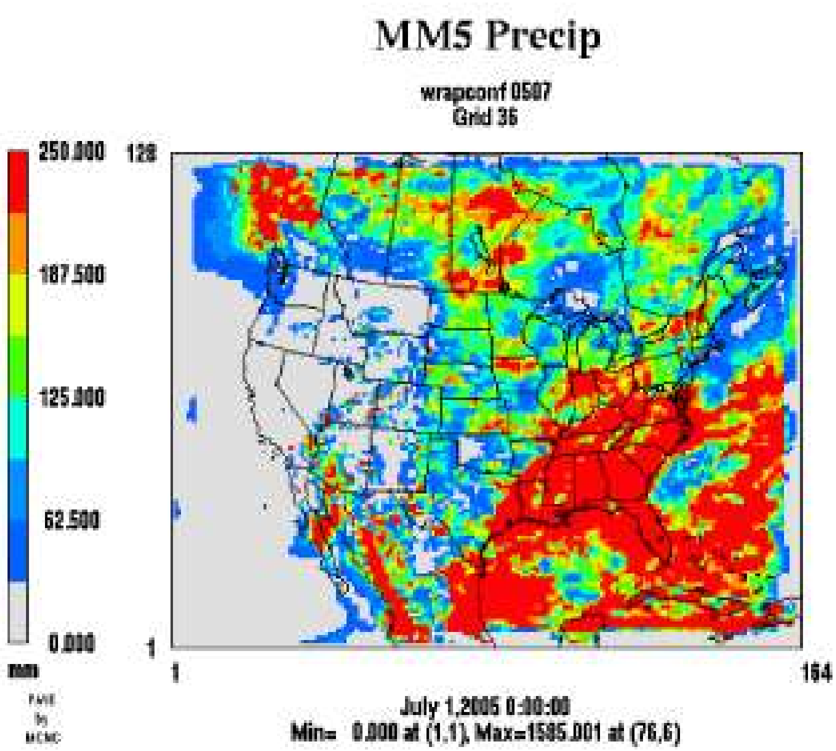


Figure 3-16: CPC Analyzed Precipitation for August 2005 over the 36km Domain.

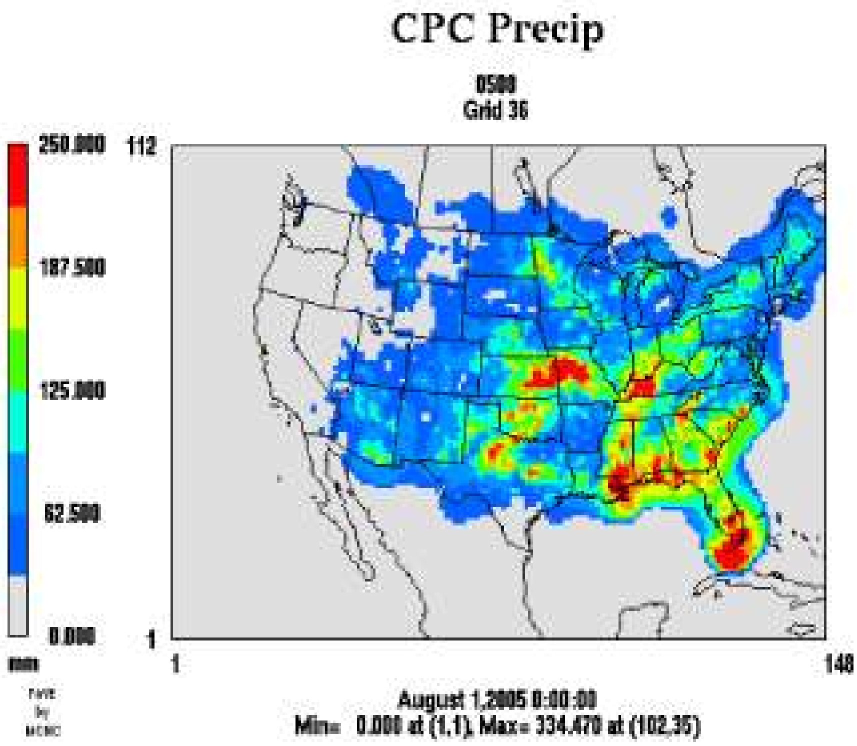


Figure 3-17: MM5 Estimated Precipitation for August 2005 over the 36km Domain.

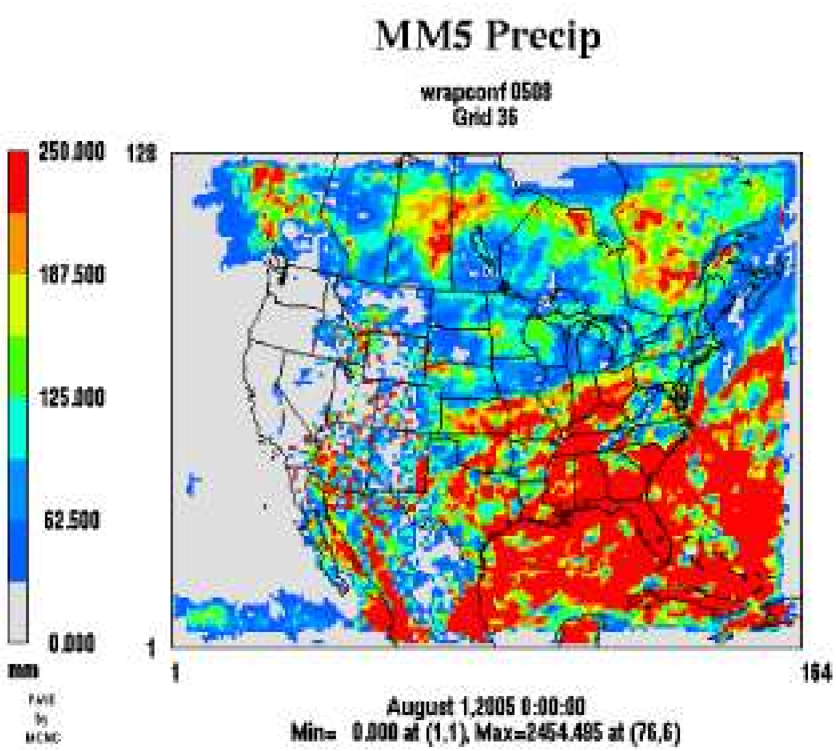


Figure 3-18: CPC Analyzed Precipitation for September 2005 over the 36km Domain.

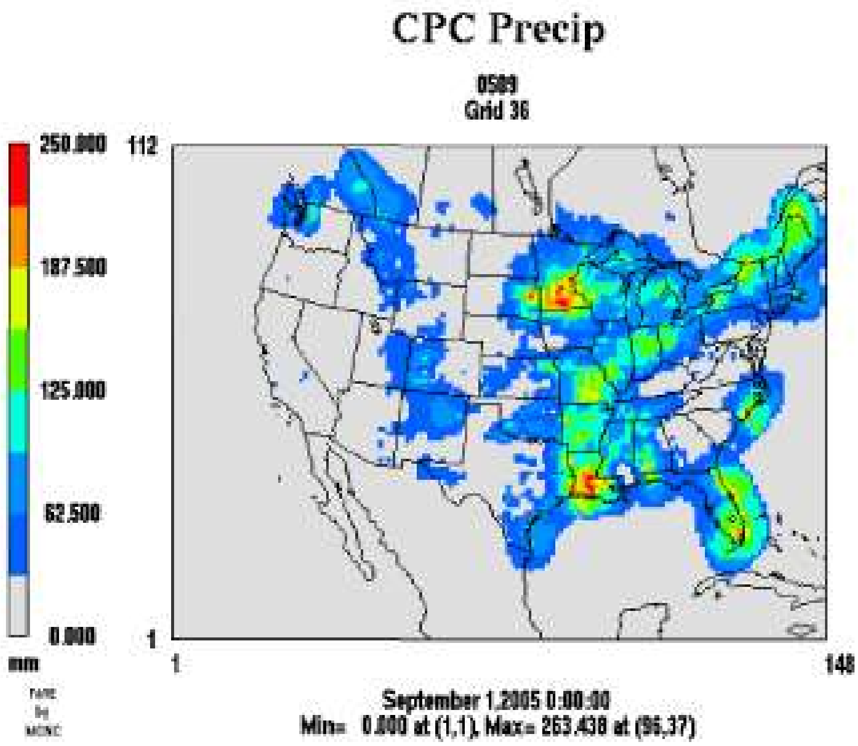


Figure 3-19: MM5 Estimated Precipitation for September 2005 over the 36km Domain.

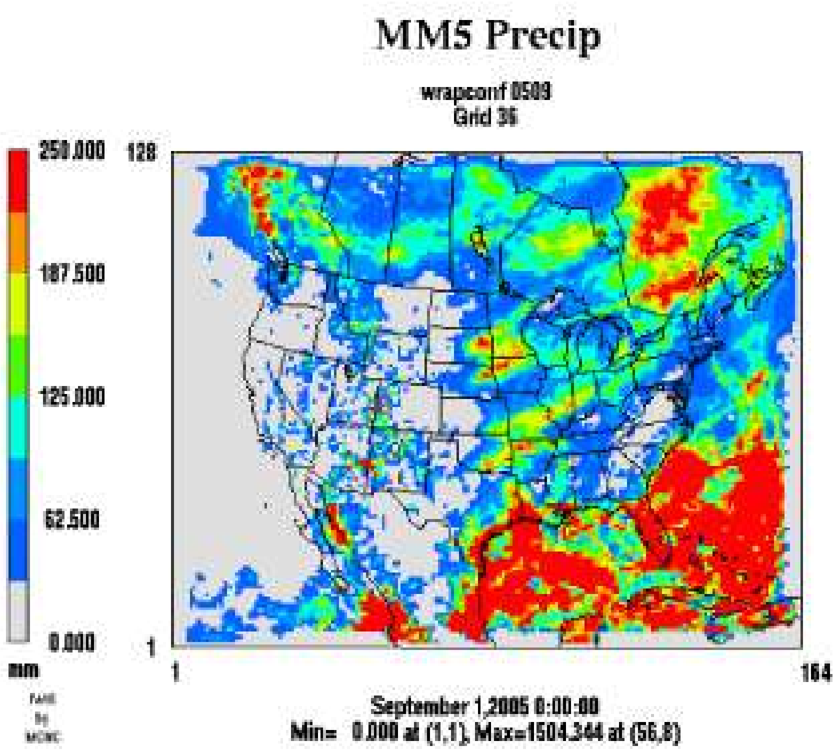


Figure 3-20: CPC Analyzed Precipitation for October 2005 over the 36km Domain.

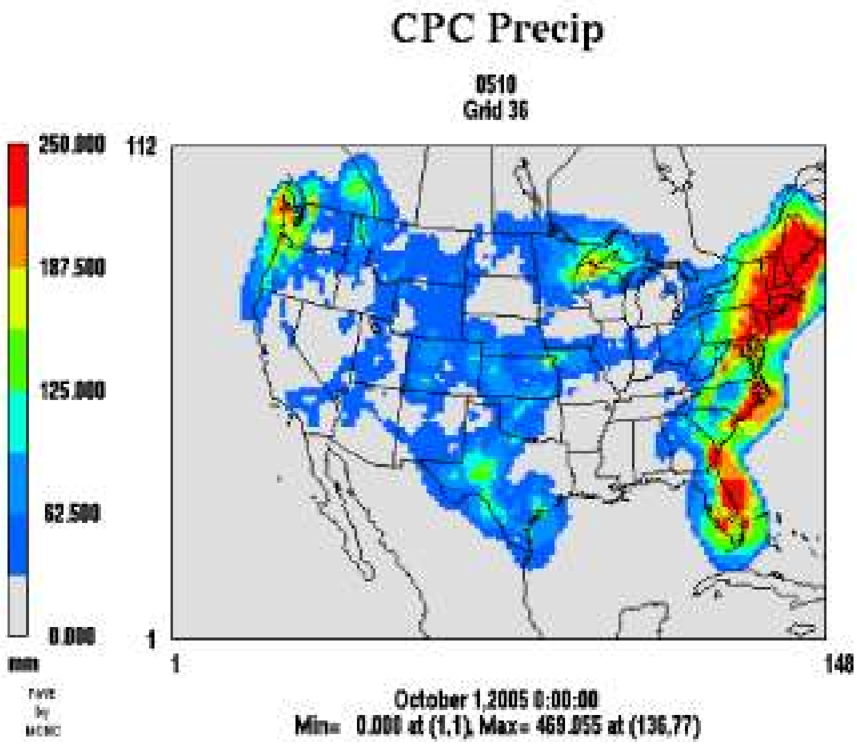


Figure 3-21: MM5 Estimated Precipitation for October 2005 over the 36km Domain.

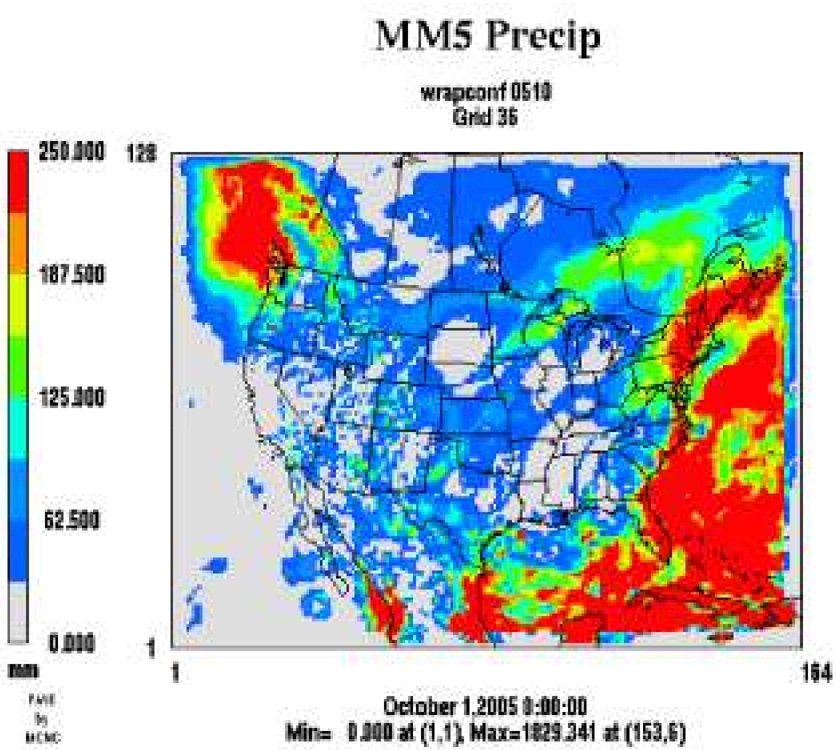


Figure 3-22: CPC Analyzed Precipitation for November 2005 over the 36km Domain.

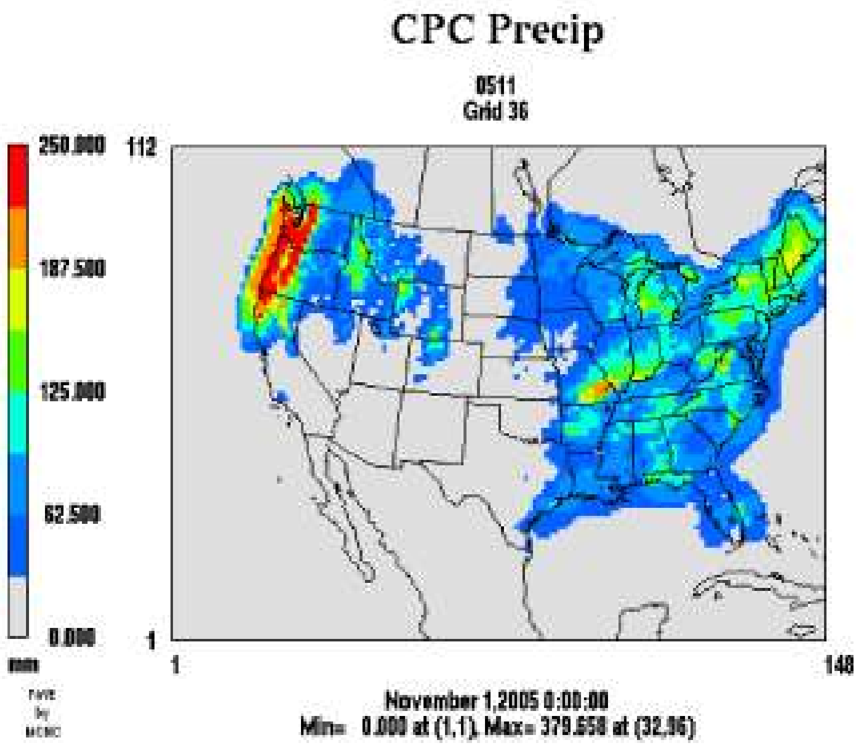


Figure 3-23: MM5 Estimated Precipitation for November 2005 over the 36km Domain.

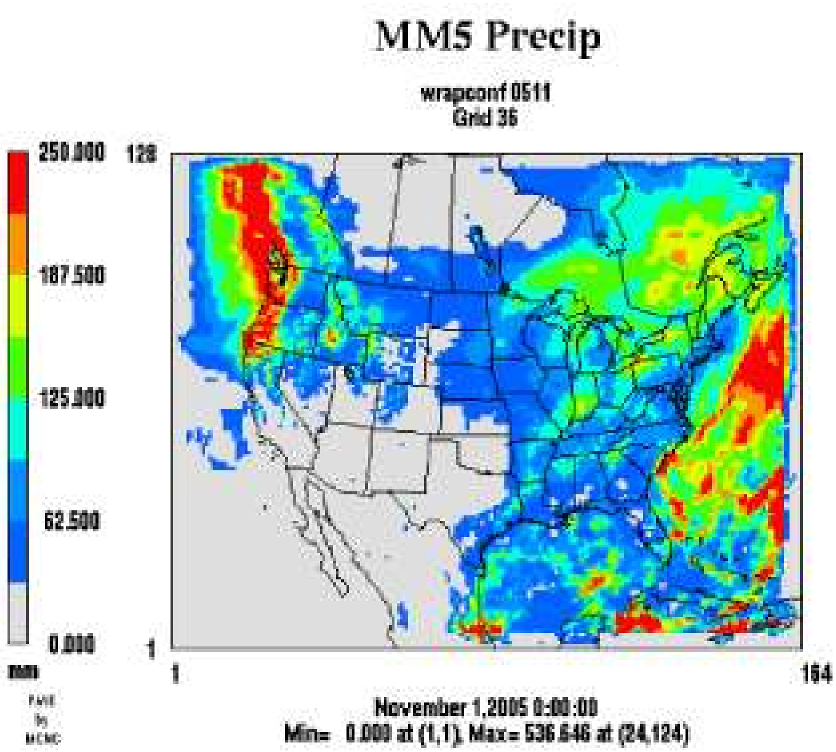


Figure 3-24: CPC Analyzed Precipitation for December 2005 over the 36km Domain.

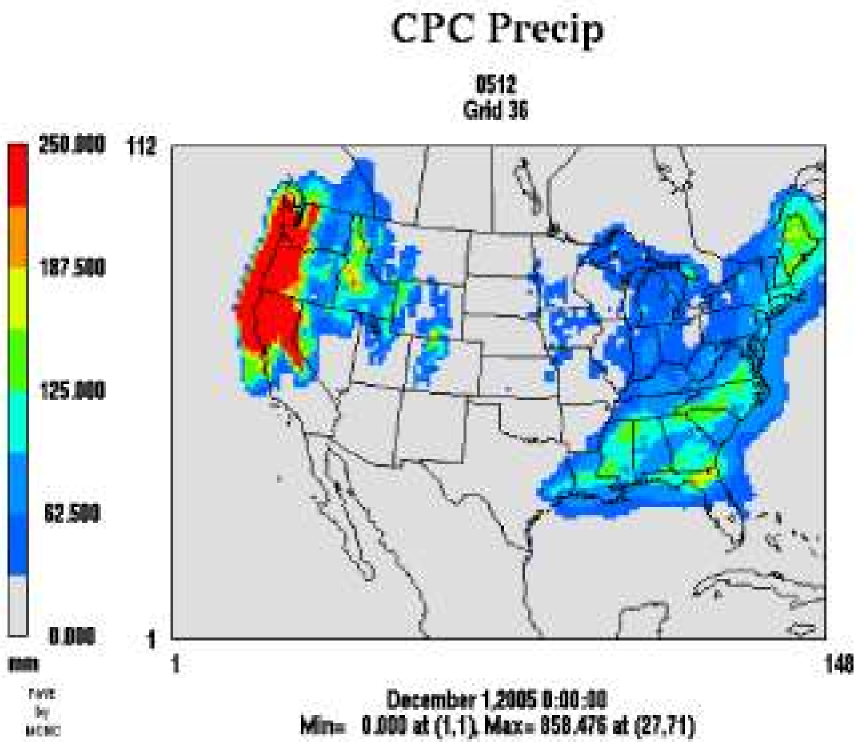


Figure 3-25: MM5 Estimated Precipitation for December 2005 over the 36km Domain.

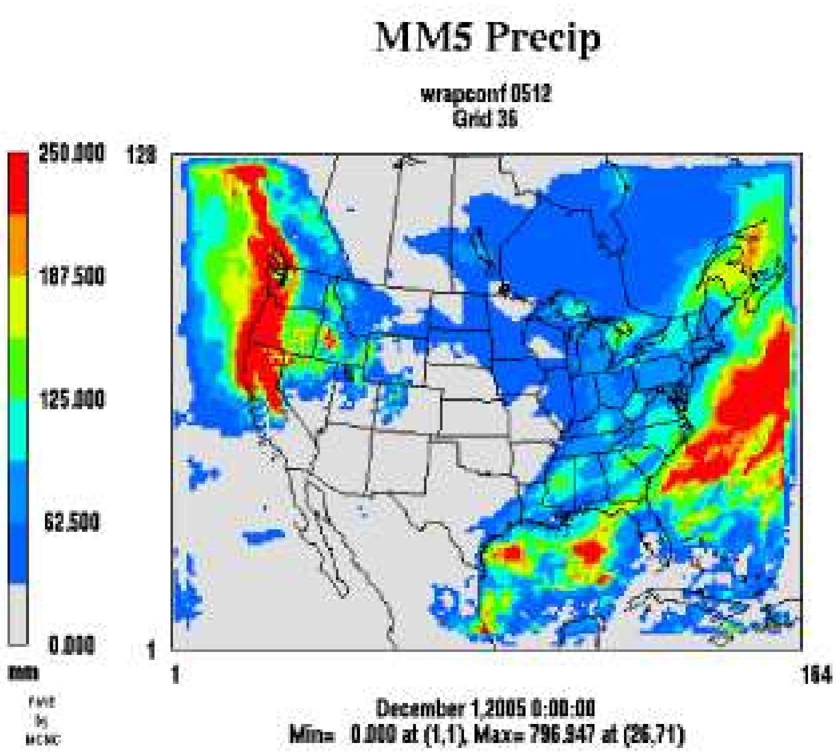


Figure 3-26: CPC Analyzed Precipitation for January 2005 over the 12km Domain.

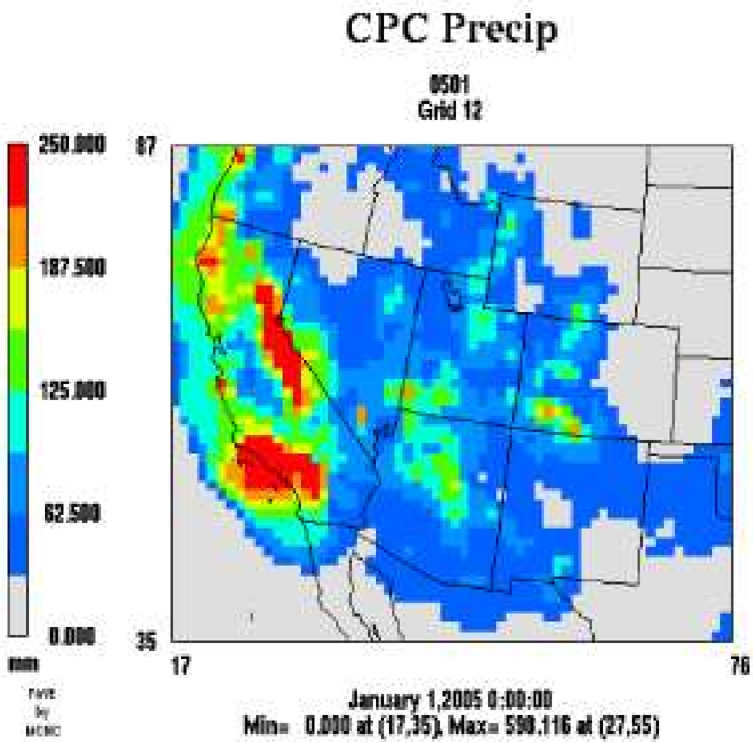


Figure 3-27: MM5 Estimated Precipitation for January 2005 over the 12km Domain.

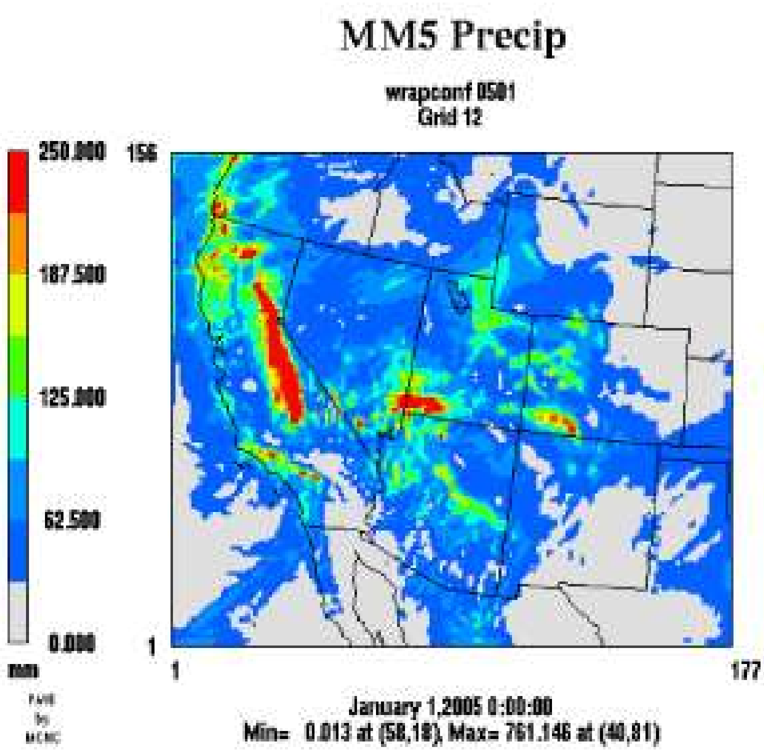


Figure 3-28: CPC Analyzed Precipitation for February 2005 over the 12km Domain.

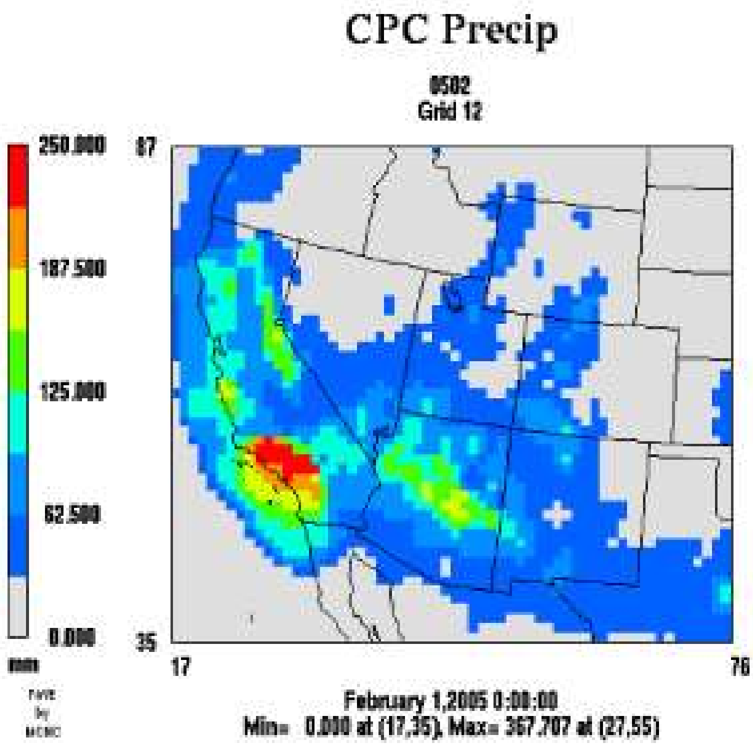


Figure 3-29: MM5 Estimated Precipitation for February 2005 over the 12km Domain.

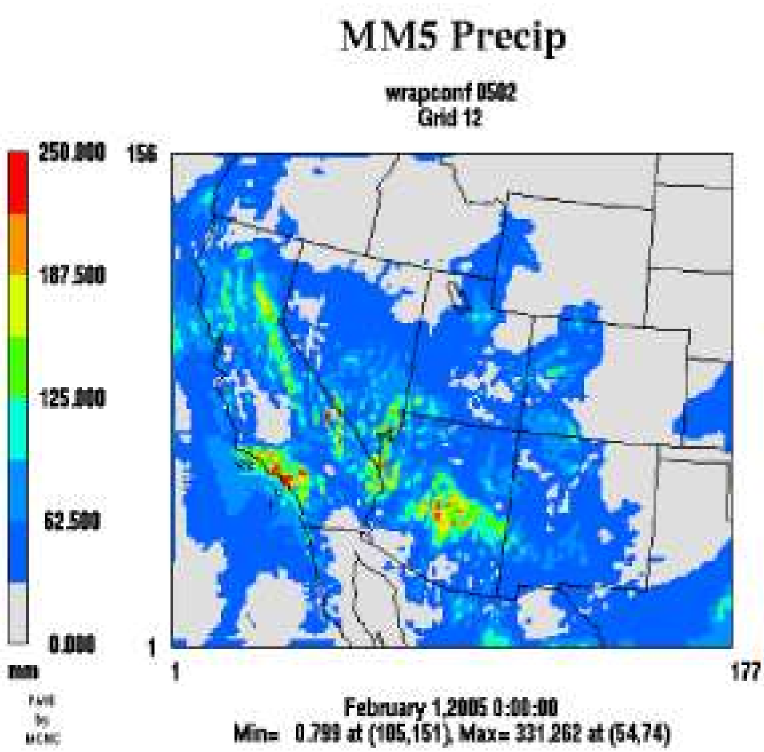


Figure 3-30: CPC Analyzed Precipitation for March 2005 over the 12km Domain.

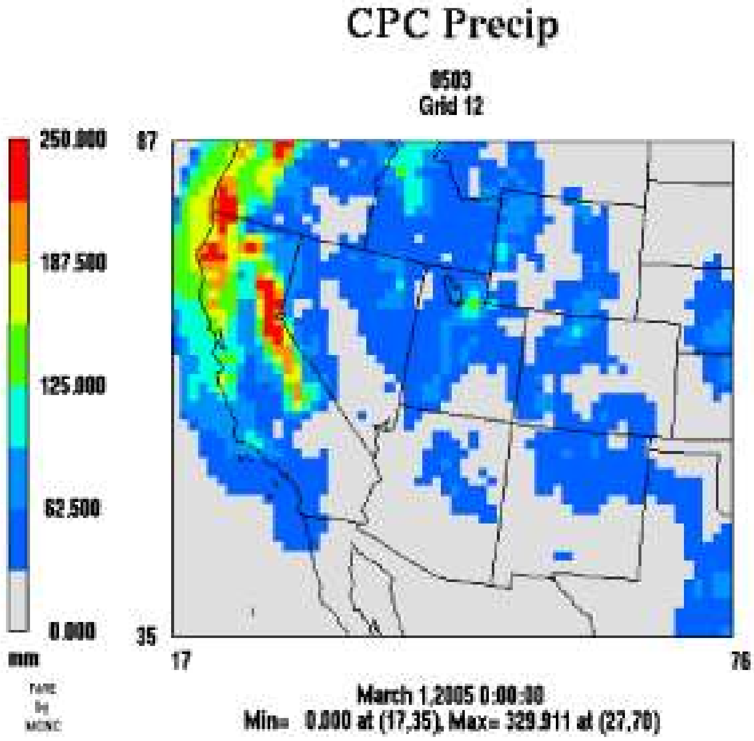


Figure 3-31: MM5 Estimated Precipitation for March 2005 over the 12km Domain.

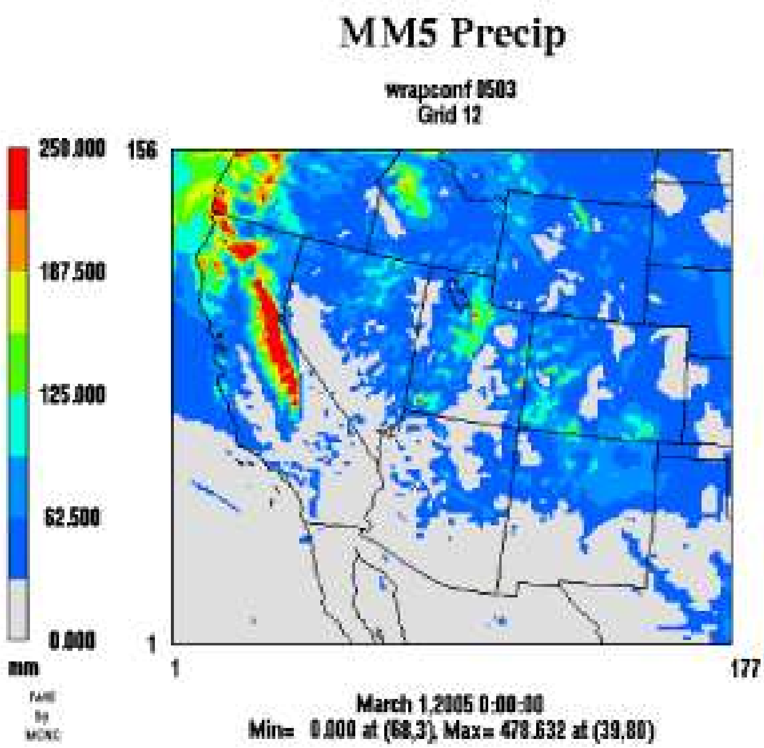


Figure 3-32: CPC Analyzed Precipitation for April 2005 over the 12km Domain.

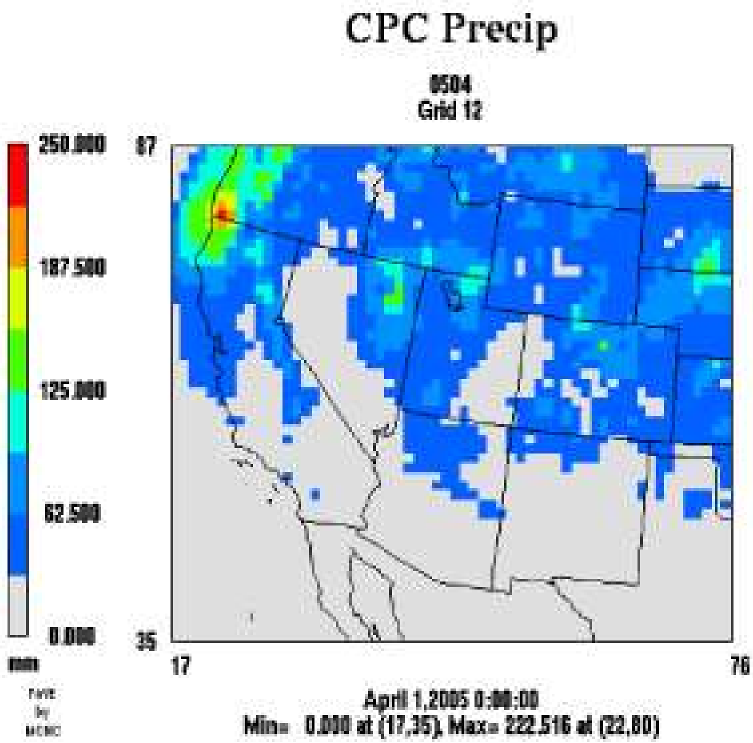


Figure 3-33: MM5 Estimated Precipitation for April 2005 over the 12km Domain.

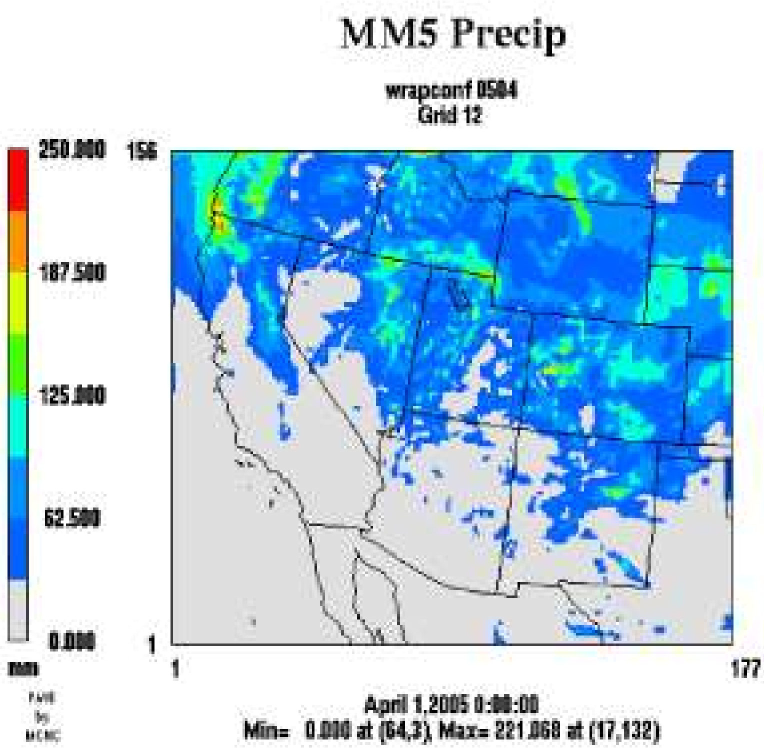


Figure 3-34: CPC Analyzed Precipitation for May 2005 over the 12km Domain.

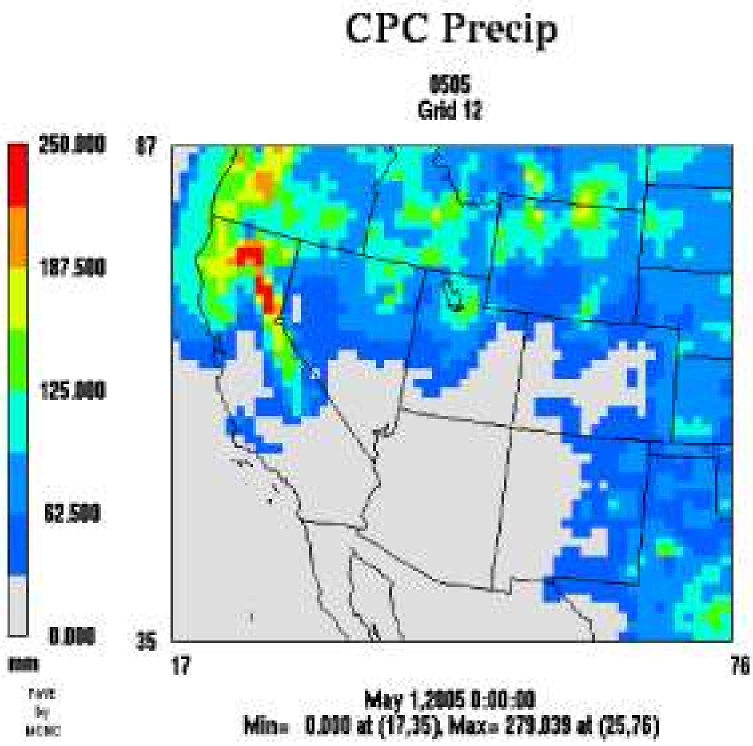


Figure 3-35: MM5 Estimated Precipitation for May 2005 over the 12km Domain.

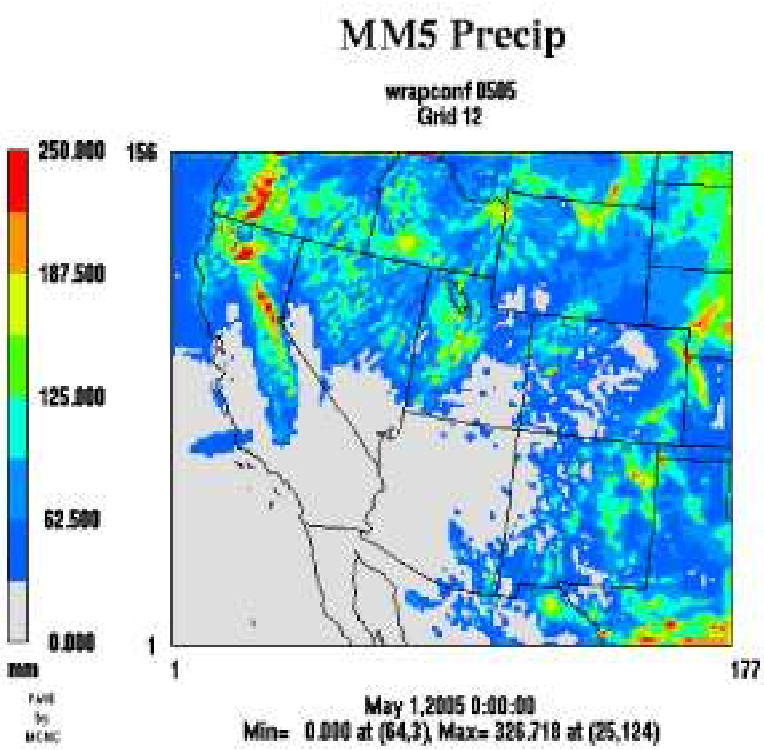


Figure 3-36: CPC Analyzed Precipitation for June 2005 over the 12km Domain.

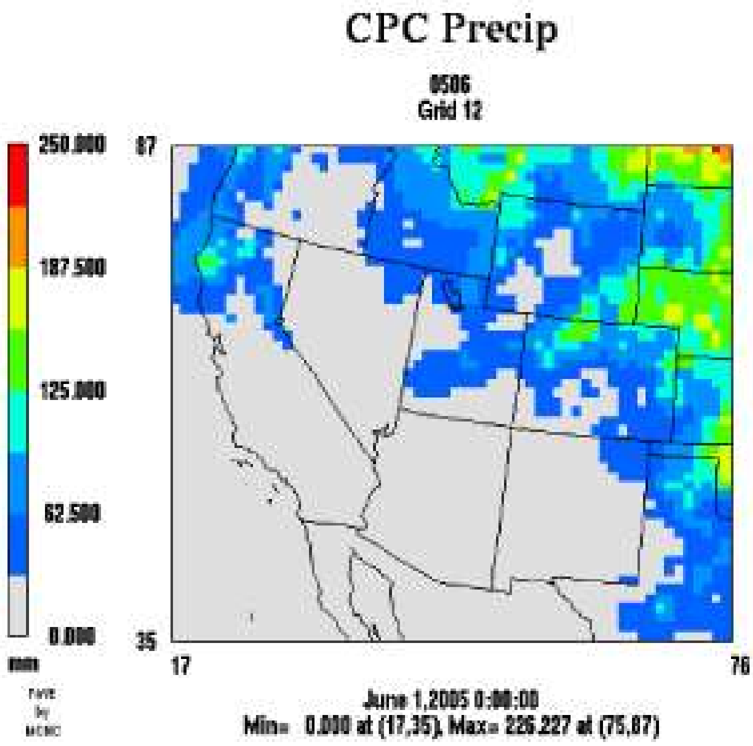


Figure 3-37: MM5 Estimated Precipitation for June 2005 over the 12km Domain.

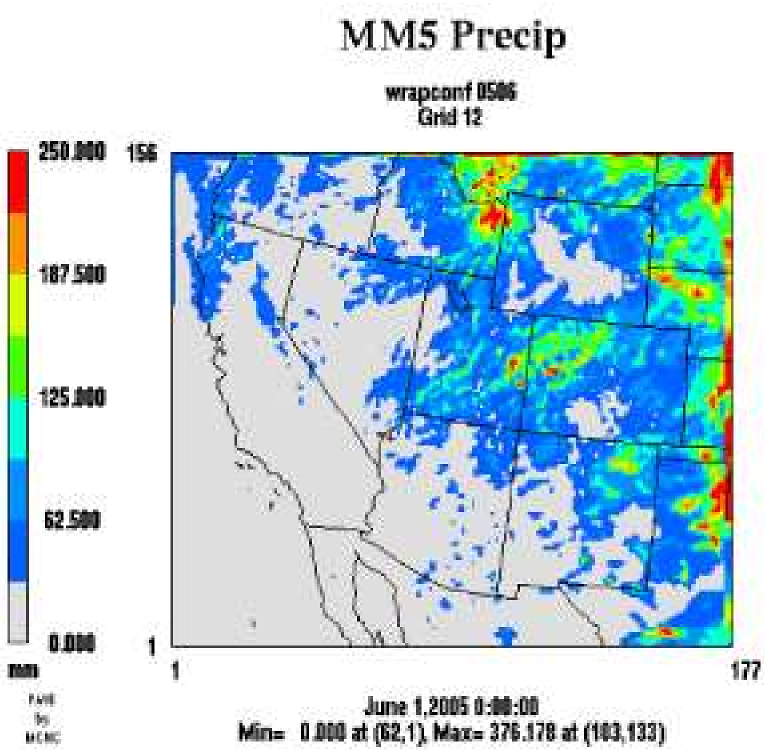


Figure 3-38: CPC Analyzed Precipitation for July 2005 over the 12km Domain.

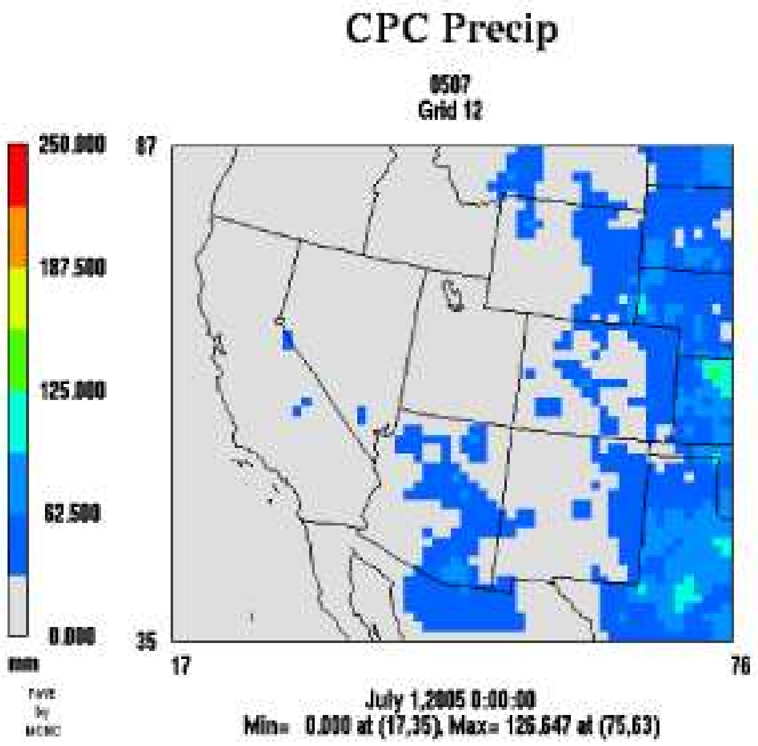


Figure 3-39: MM5 Estimated Precipitation for July 2005 over the 12km Domain.

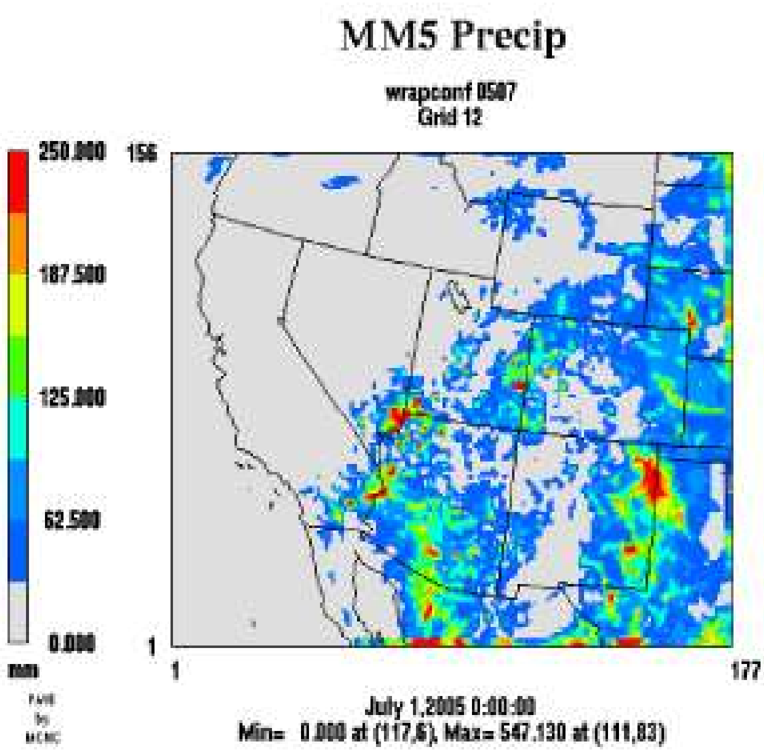


Figure 3-40: CPC Analyzed Precipitation for August 2005 over the 12km Domain.

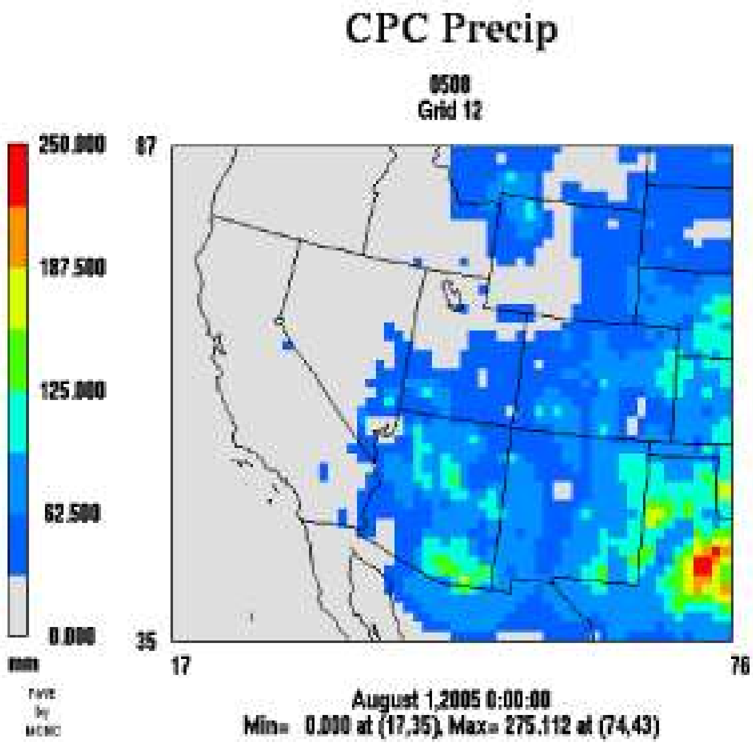


Figure 3-41: MM5 Estimated Precipitation for August 2005 over the 12km Domain.

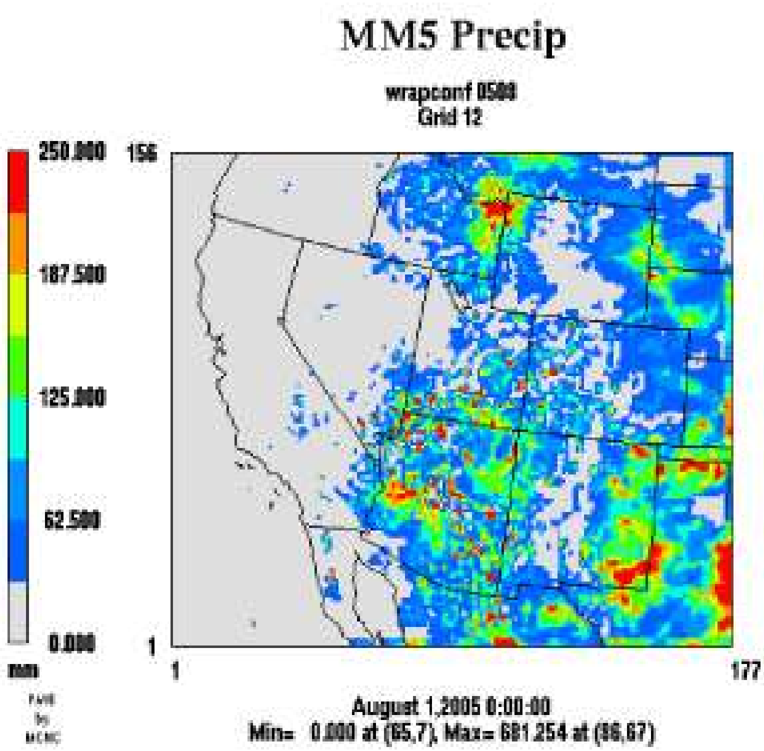


Figure 3-42: CPC Analyzed Precipitation for September 2005 over the 12km Domain.

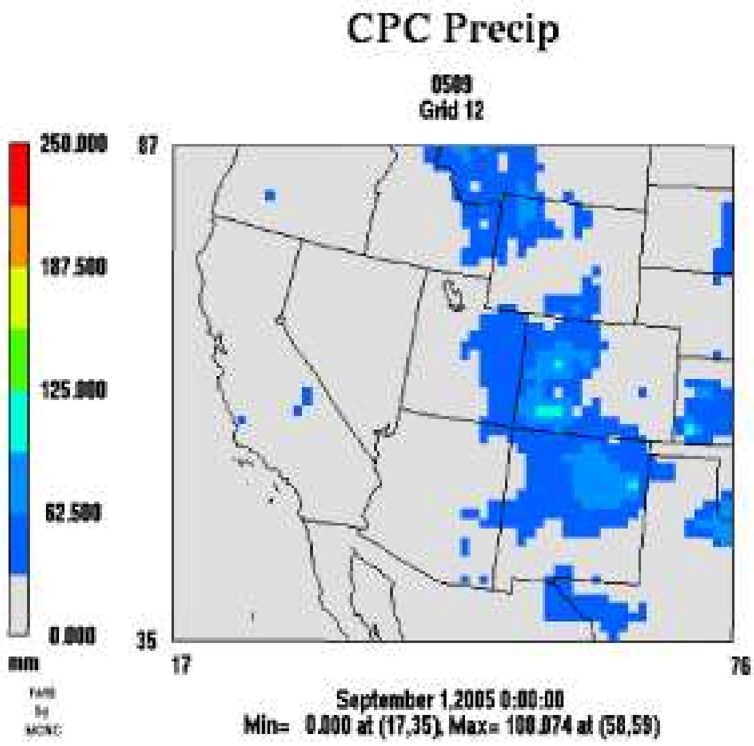


Figure 3-43: MM5 Estimated Precipitation for September 2005 over the 12km Domain.

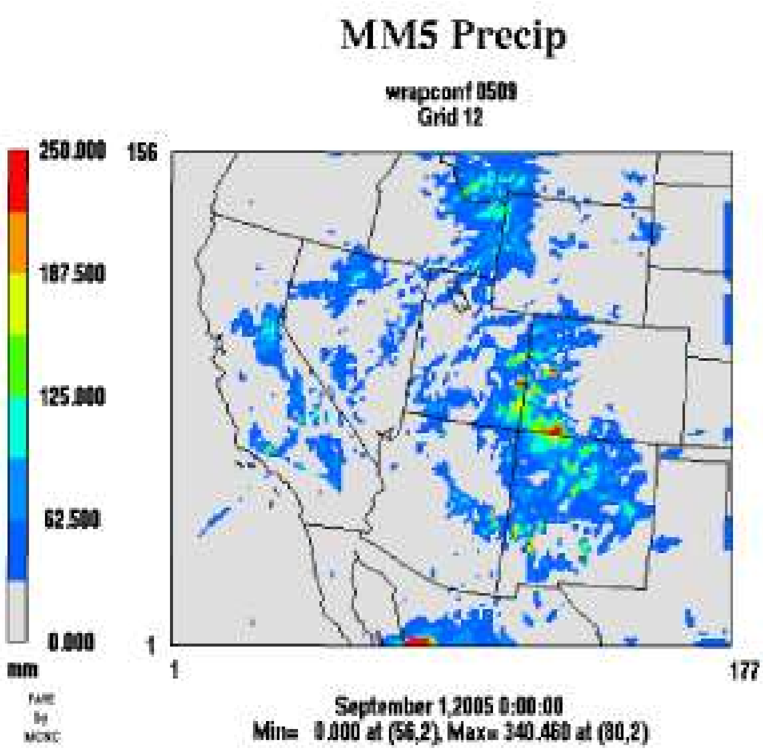


Figure 3-44: CPC Analyzed Precipitation for October 2005 over the 12km Domain.

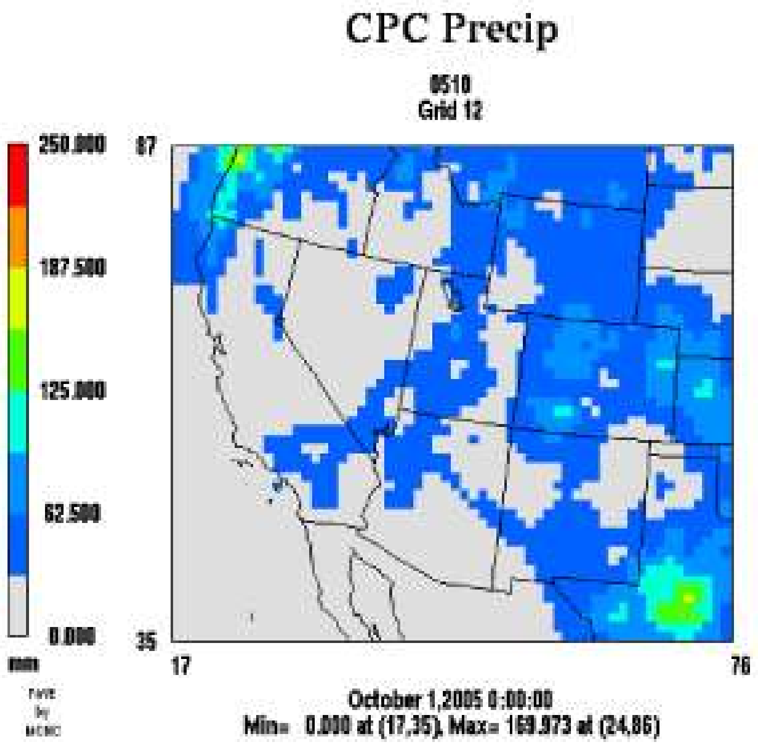


Figure 3-45: MM5 Estimated Precipitation for October 2005 over the 12km Domain.

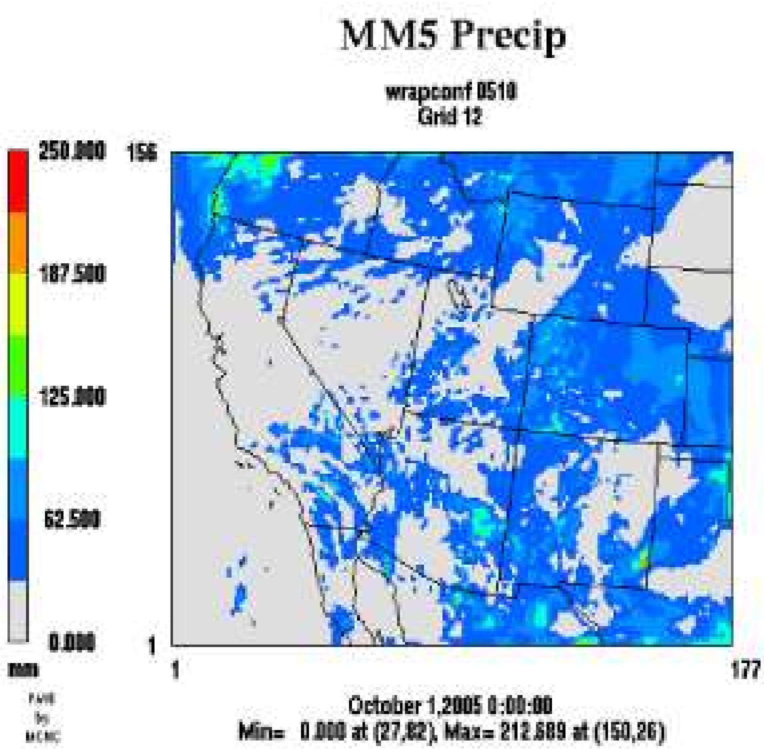


Figure 3-46: CPC Analyzed Precipitation for November 2005 over the 12km Domain.

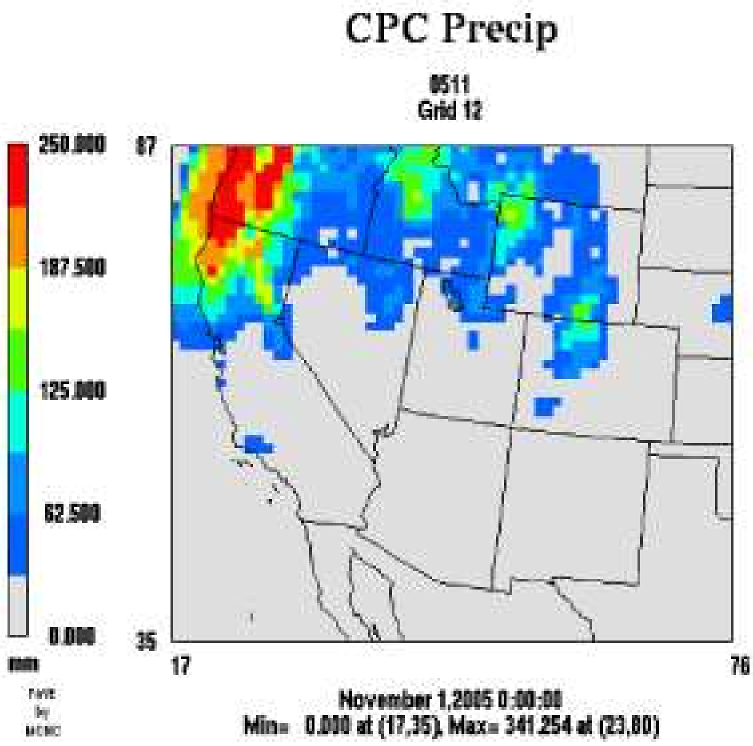


Figure 3-47: MM5 Estimated Precipitation for November 2005 over the 12km Domain.

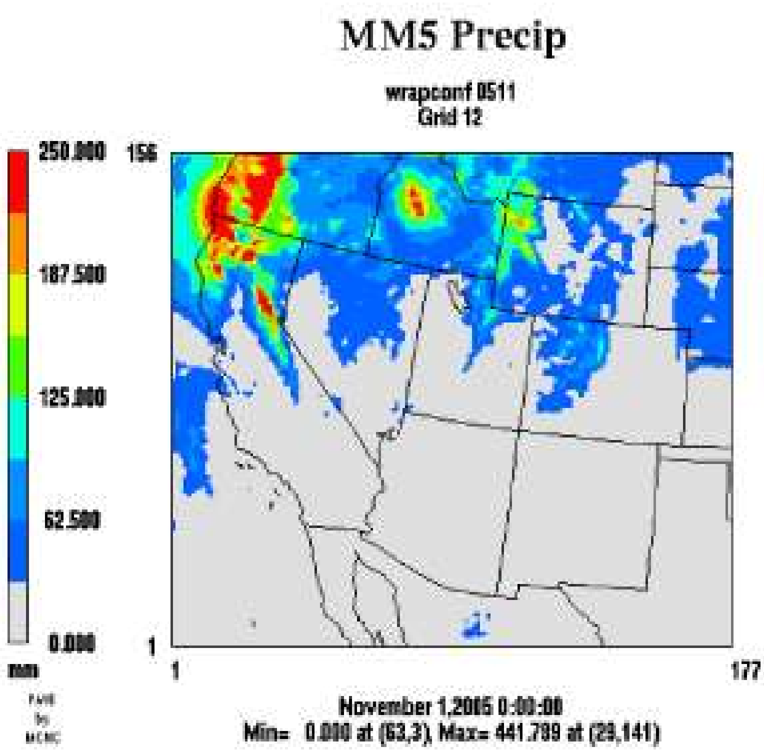


Figure 3-48: CPC Analyzed Precipitation for December 2005 over the 12km Domain.

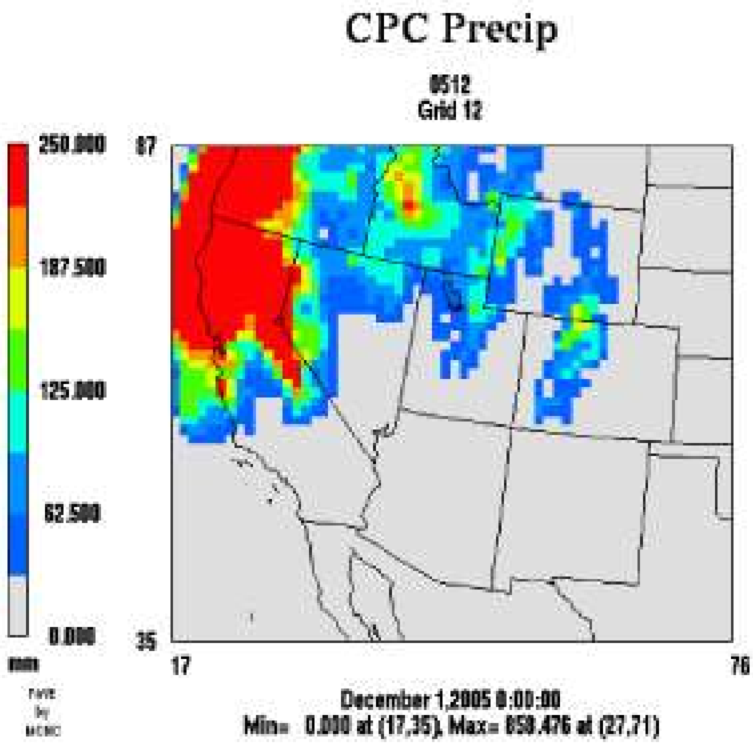


Figure 3-49: MM5 Estimated Precipitation for December 2005 over the 12km Domain.

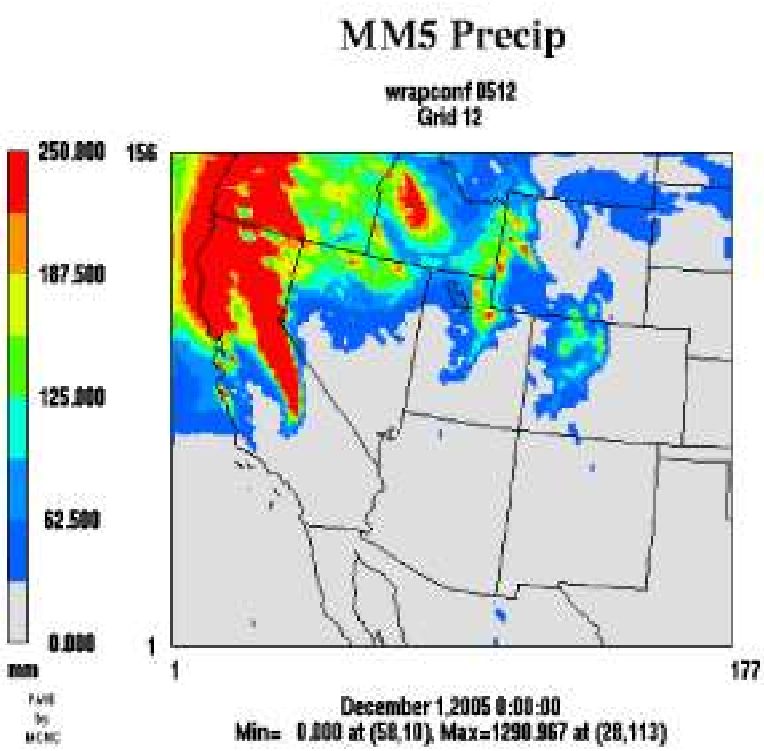


Figure 3-50: CPC Analyzed Precipitation for January 2005 over the 4km Domain.

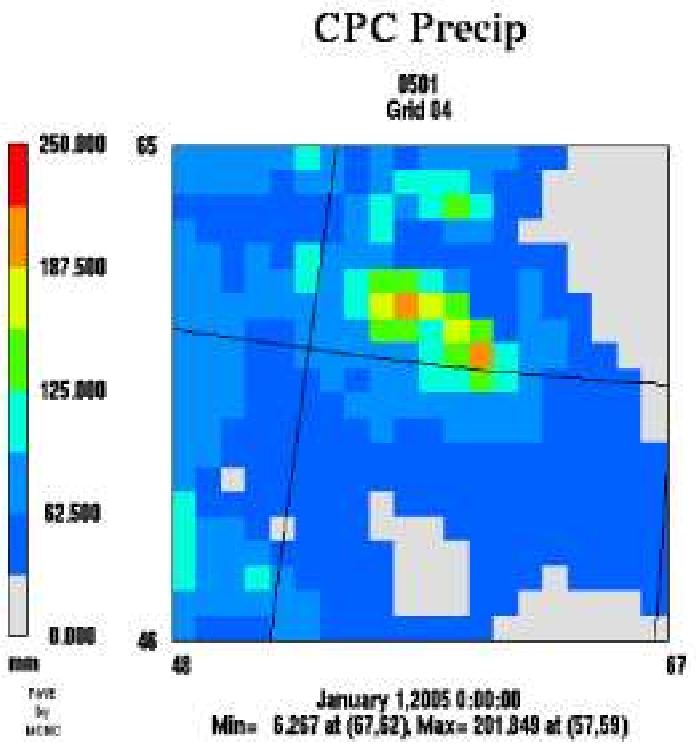


Figure 3-51: MM5 Estimated Precipitation for January 2005 over the 4km Domain.

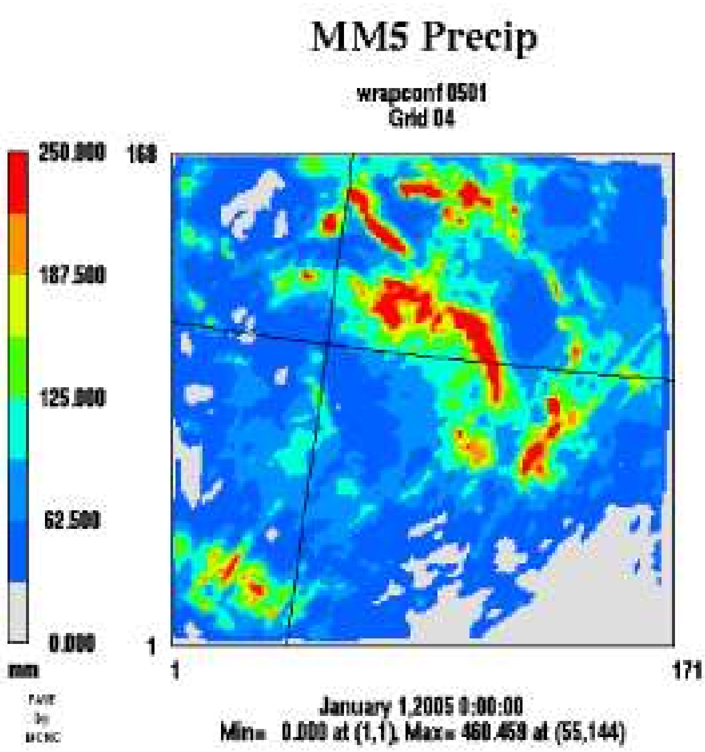


Figure 3-52: CPC Analyzed Precipitation for February 2005 over the 4km Domain.

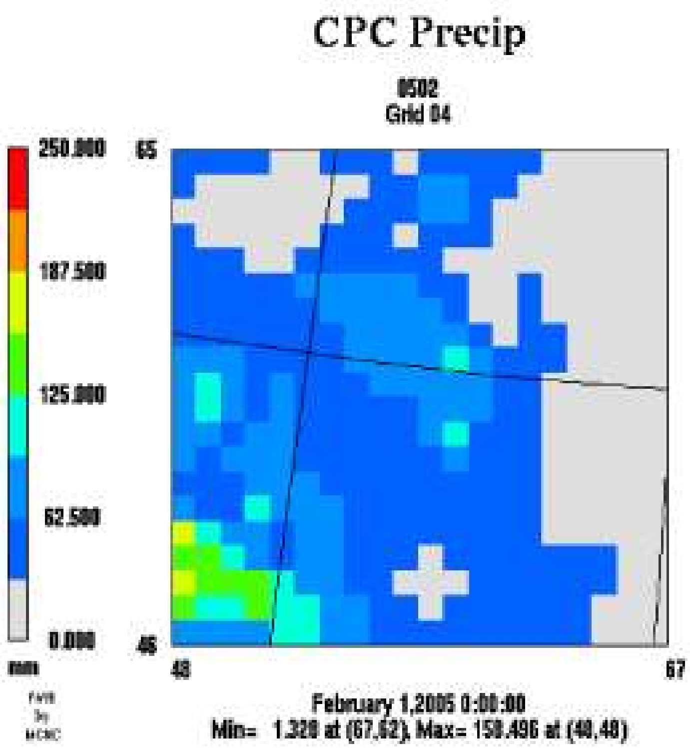


Figure 3-53: MM5 Estimated Precipitation for February 2005 over the 4km Domain.

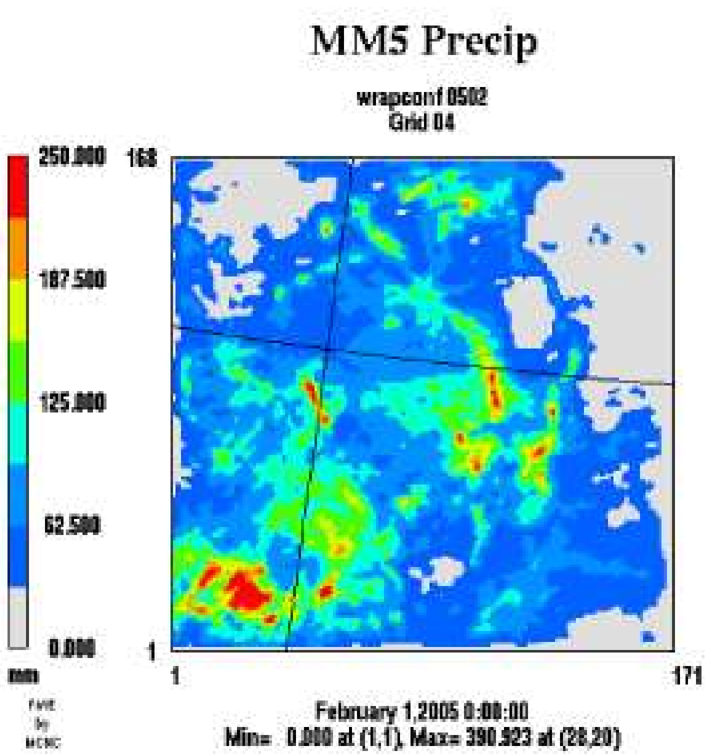


Figure 3-54: CPC Analyzed Precipitation for March 2005 over the 4km Domain.

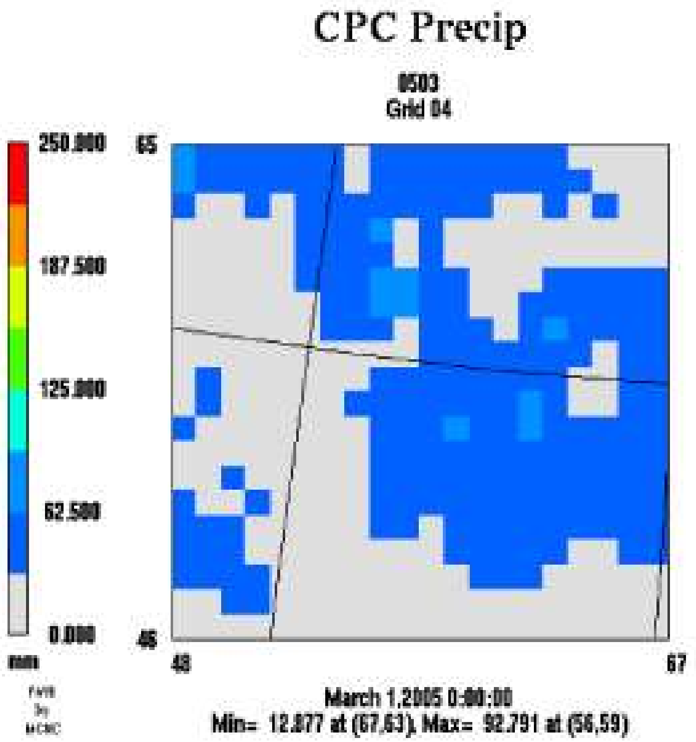


Figure 3-55: MM5 Estimated Precipitation for March 2005 over the 4km Domain.

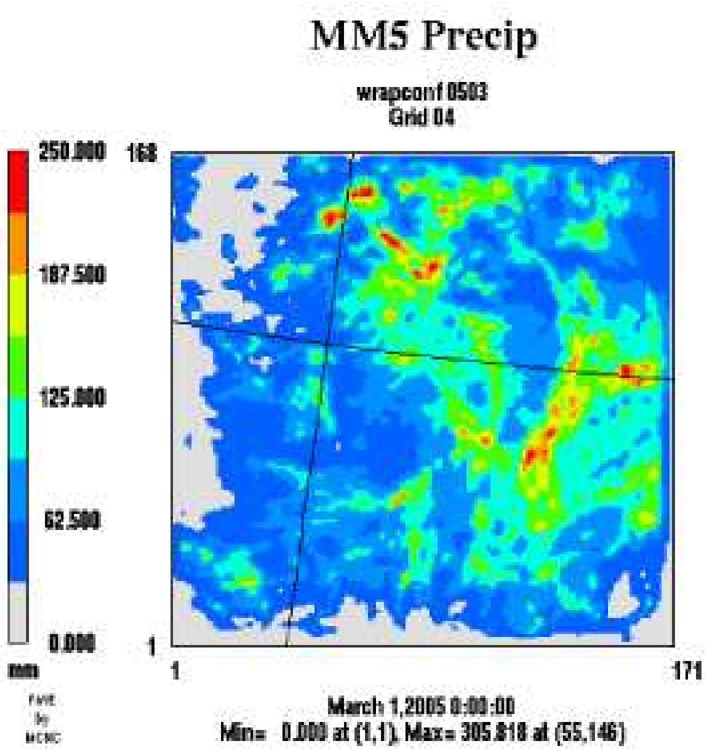


Figure 3-56: CPC Analyzed Precipitation for April 2005 over the 4km Domain.

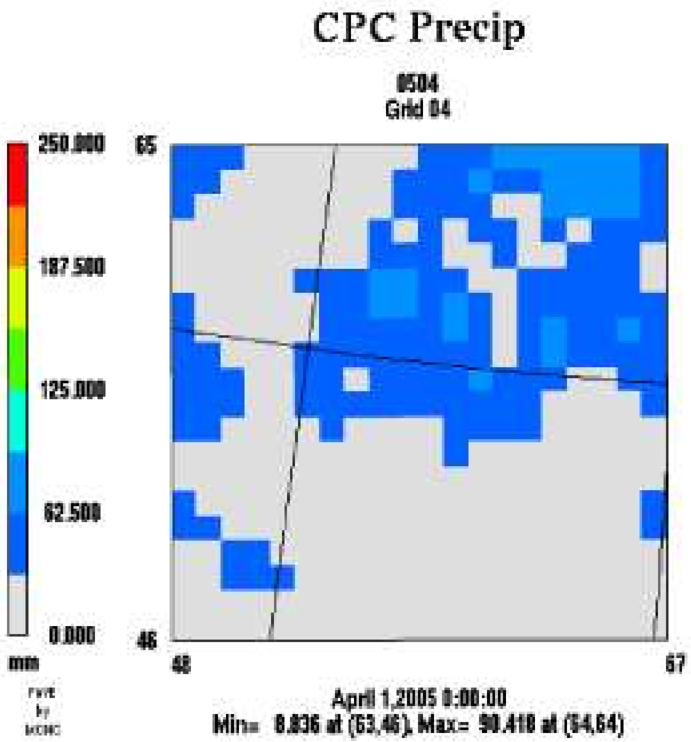


Figure 3-57: MM5 Estimated Precipitation for April 2005 over the 4km Domain.

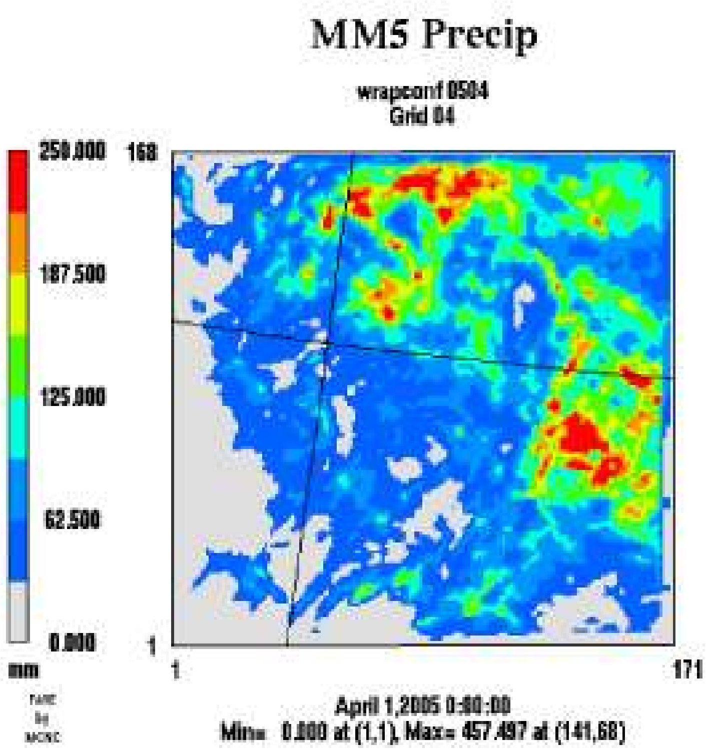


Figure 3-58: CPC Analyzed Precipitation for May 2005 over the 4km Domain.

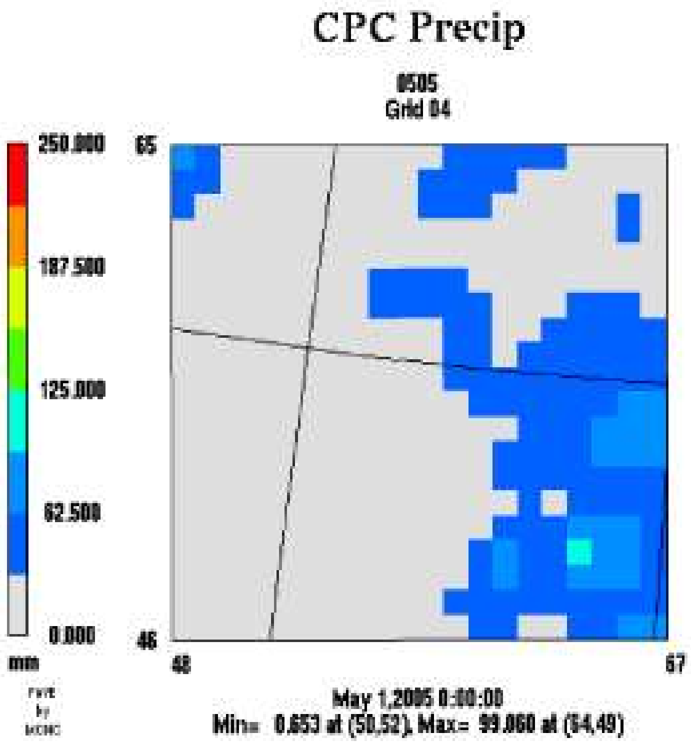


Figure 3-59: MM5 Estimated Precipitation for May 2005 over the 4km Domain.

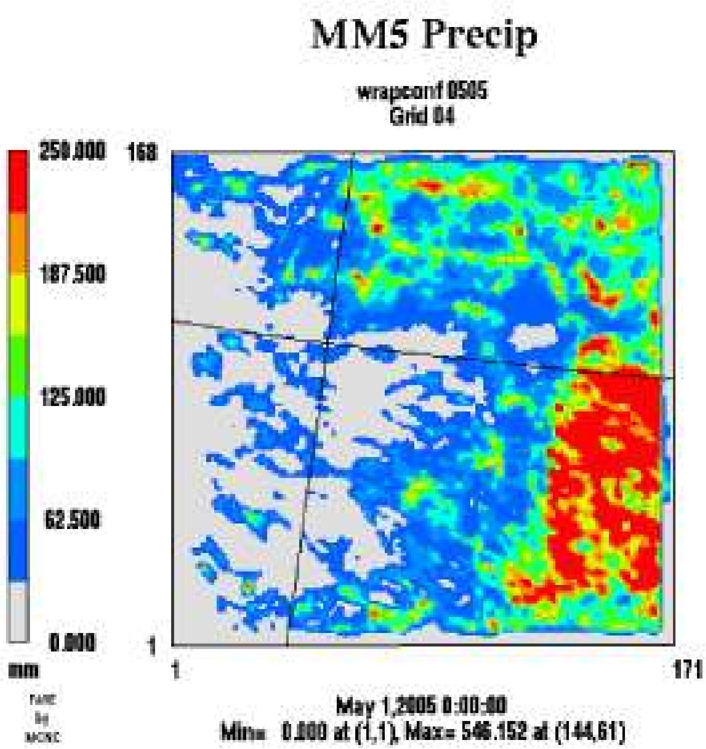


Figure 3-60: CPC Analyzed Precipitation for June 2005 over the 4km Domain.

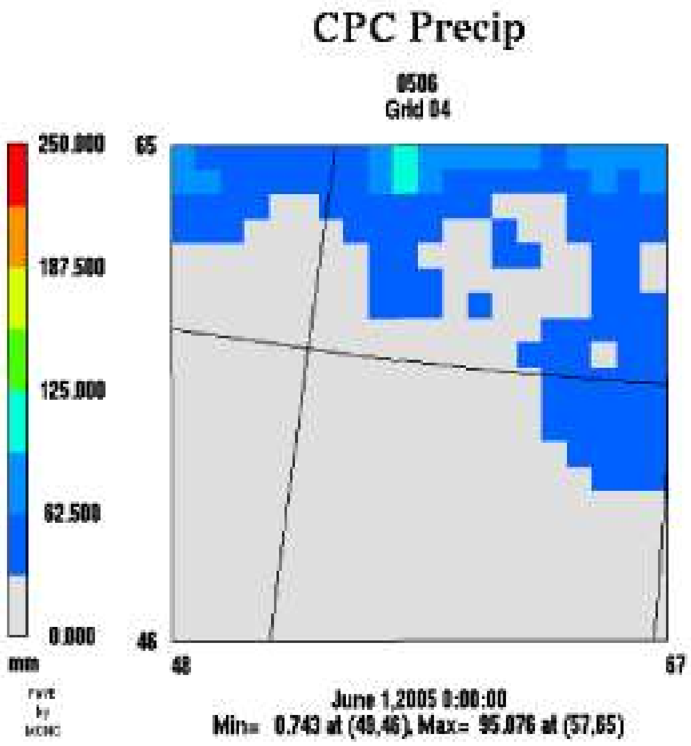


Figure 3-61: MM5 Estimated Precipitation for June 2005 over the 4km Domain.

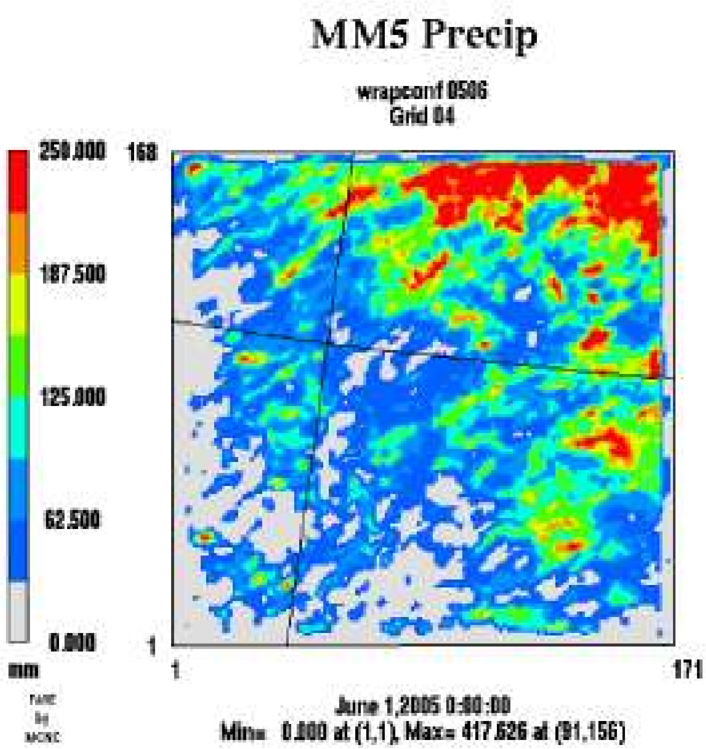


Figure 3-62: CPC Analyzed Precipitation for July 2005 over the 4km Domain.

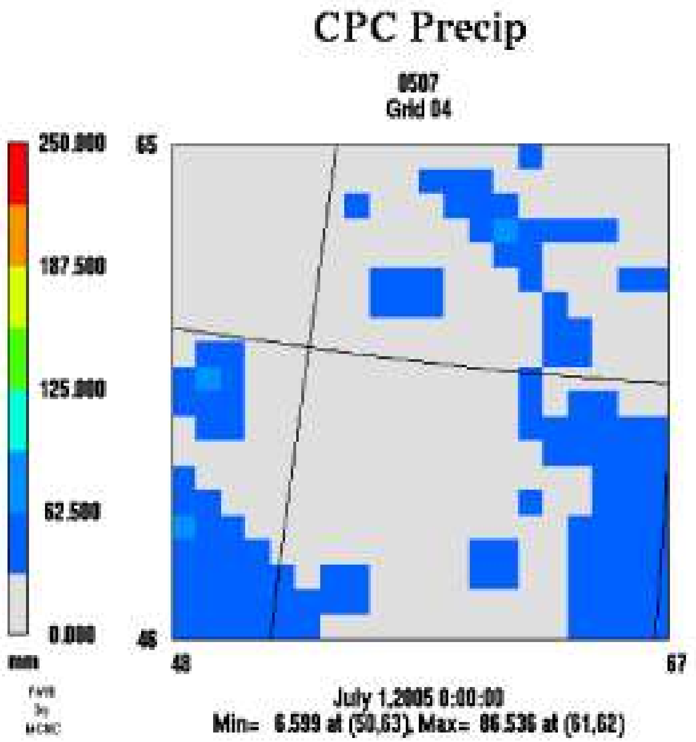


Figure 3-63: MM5 Estimated Precipitation for July 2005 over the 4 km Domain.

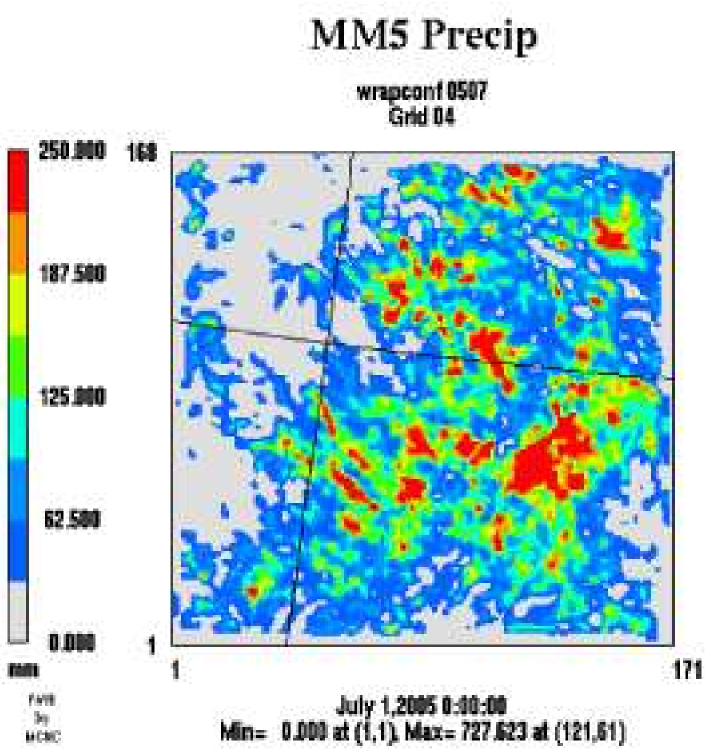


Figure 3-64: CPC Analyzed Precipitation for August 2005 over the 4km Domain.

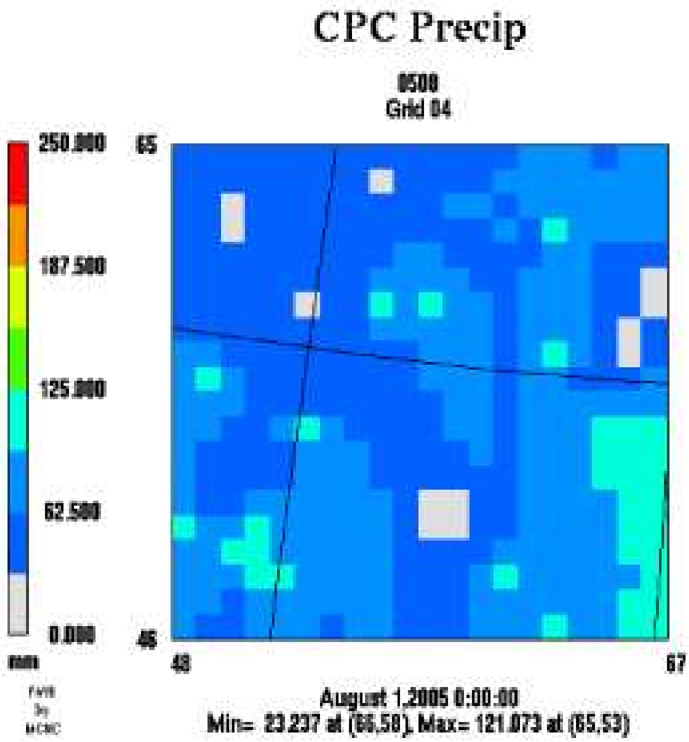


Figure 3-65: MM5 Estimated Precipitation for August 2005 over the 4km Domain.

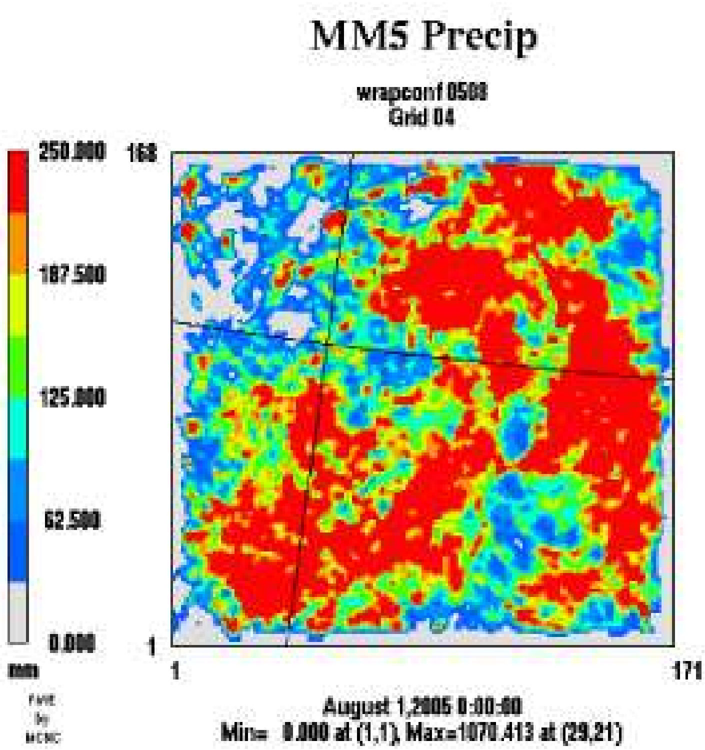


Figure 3-66: CPC Analyzed Precipitation for September 2005 over the 4km Domain.

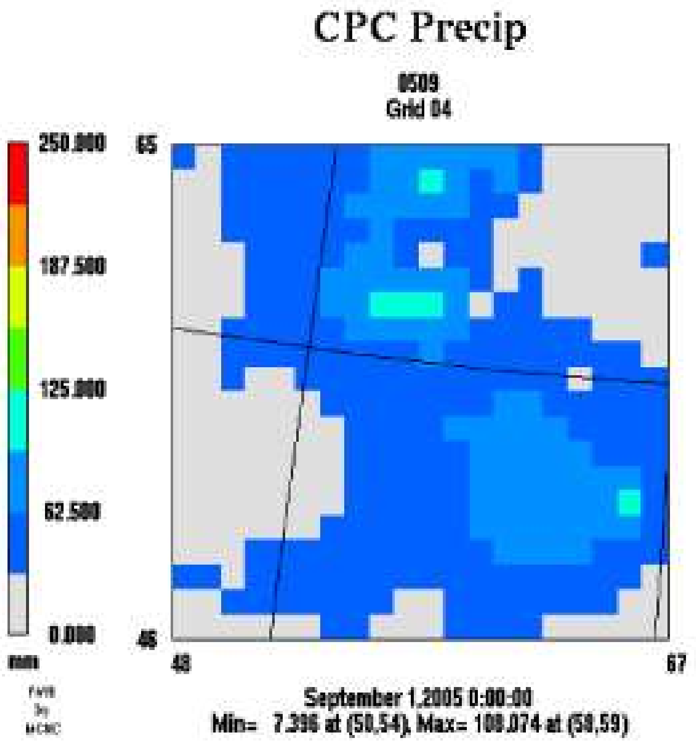


Figure 3-67: MM5 Estimated Precipitation for September 2005 over the 4km Domain.

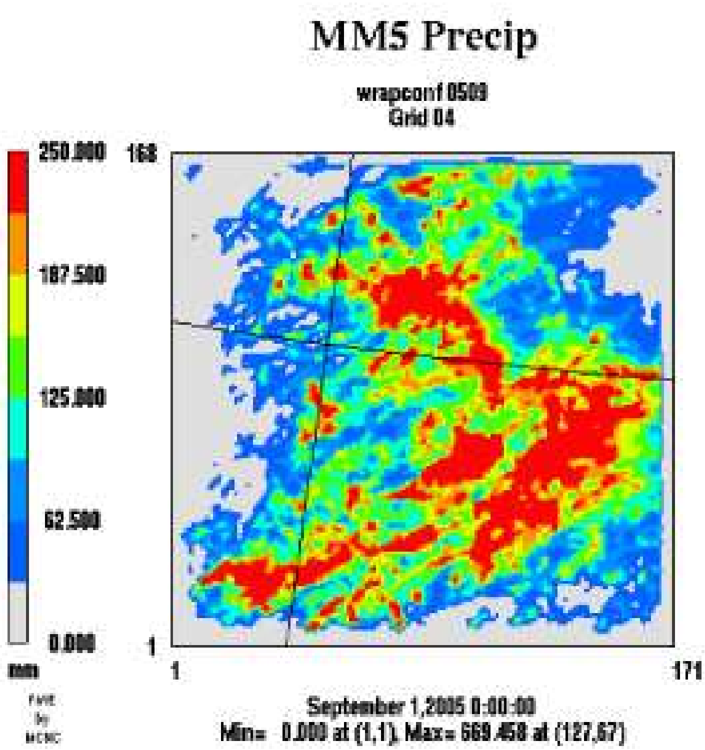


Figure 3-68: CPC Analyzed Precipitation for October 2005 over the 4km Domain.

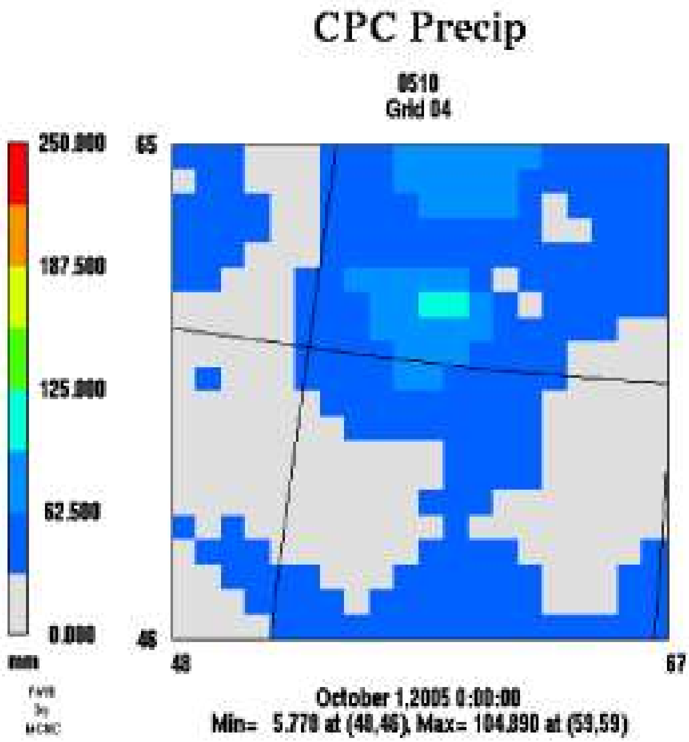


Figure 3-69: MM5 Estimated Precipitation for October 2005 over the 4km Domain.

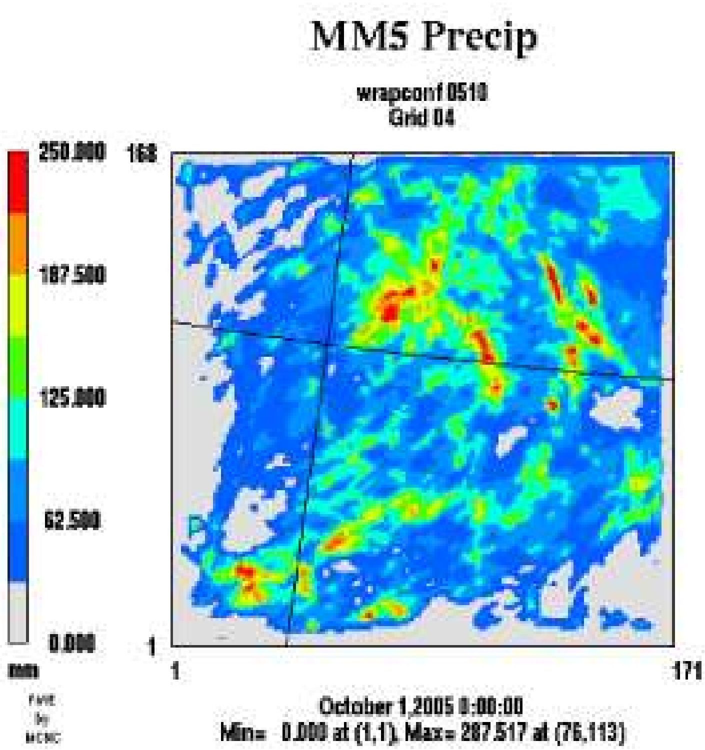


Figure 3-70: CPC Analyzed Precipitation for November 2005 over the 4km Domain.

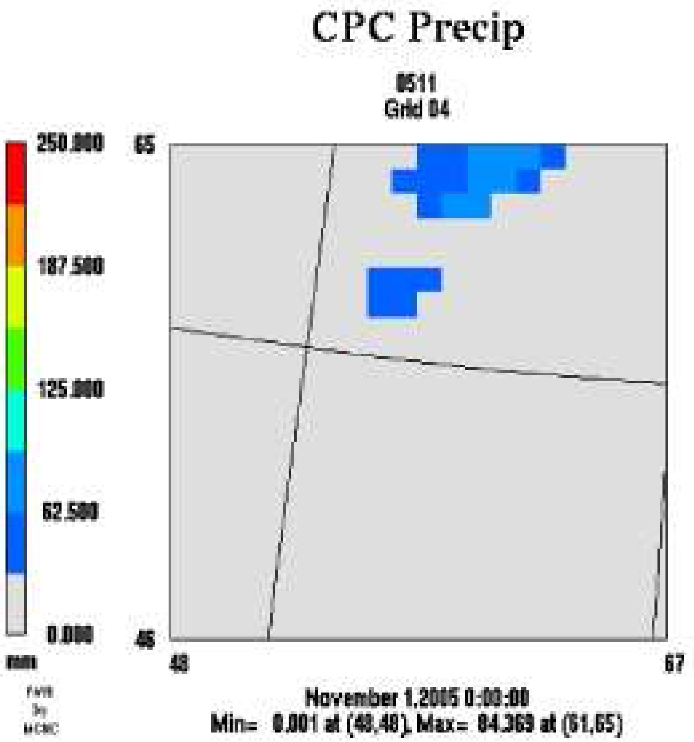


Figure 3-71: MM5 Estimated Precipitation for November 2005 over the 4km Domain.

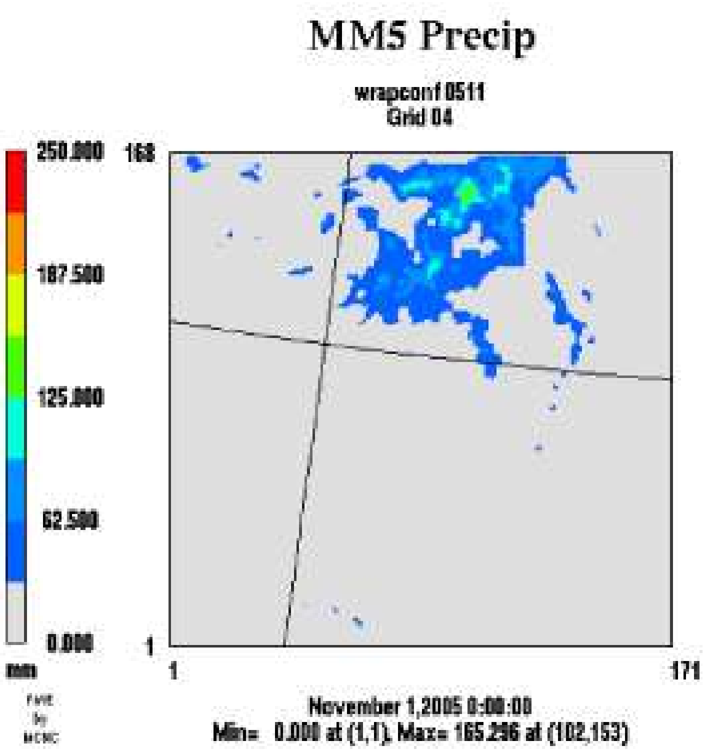


Figure 3-72: CPC Analyzed Precipitation for December 2005 over the 4km Domain.

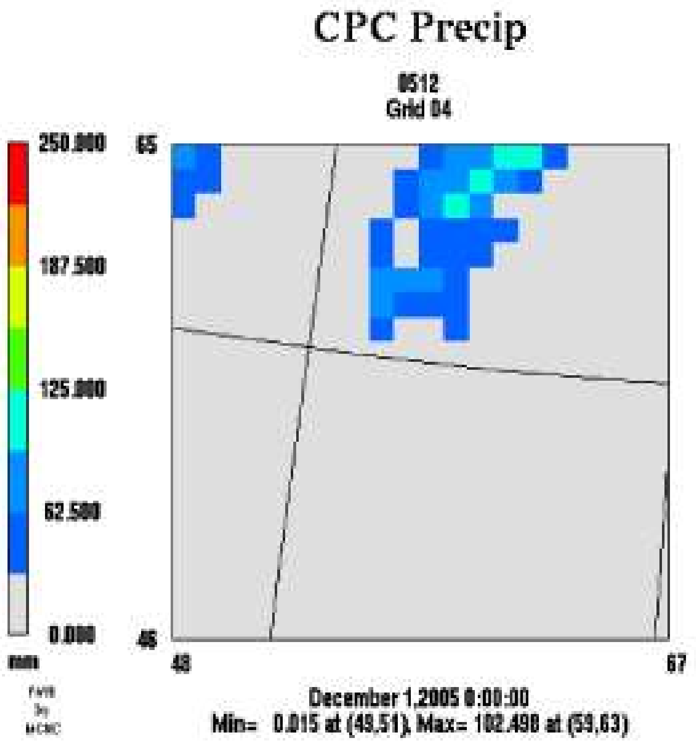
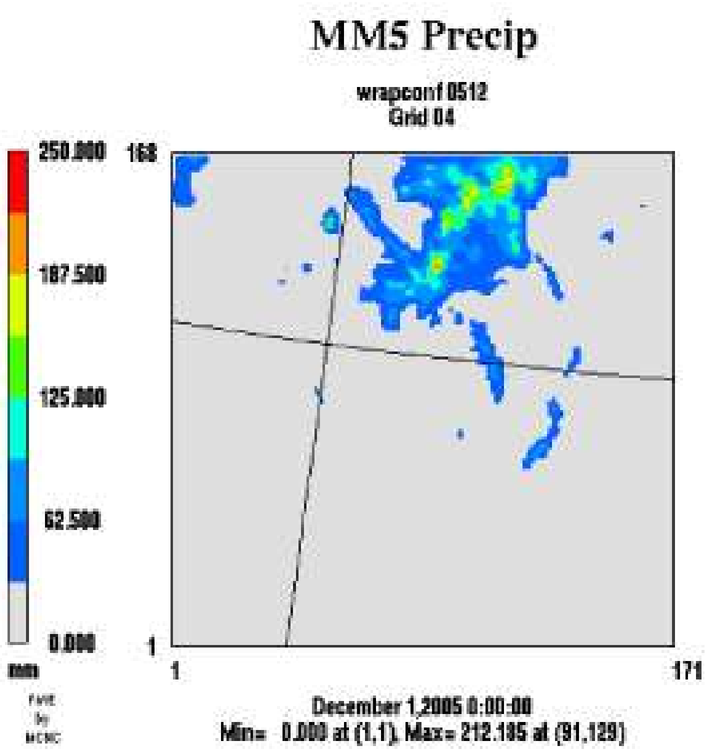


Figure 3-73: MM5 Estimated Precipitation for December 2005 over the 4km Domain.



4 Comparison with Other Annual MM5 Simulations

This section presents a comparison of this 36 km MM5 simulation with other 36km annual meteorological simulations that have been completed during the past several years by Alpine Geophysics and other researchers (Tables 4-1 through 4-5). This section also compares the performance of this 2005 simulation with two other years of MM5 simulation for 2003 and 2004 for the same 36km, 12km, and 4km grid domains (Tables 4-1 through 4-10).

4.1 Comparison to Other Annual 36km Simulations

Comparisons between the Alpine MM5 simulations and those of contemporaneous researchers were conducted. All of the Alpine MM5 simulations as well as those of the other researchers were performed at a 36km grid resolution using the same horizontal and vertical grid definitions as the 36km grid simulations presented in this report. The simulations compared include the 2001 EPA (McNally and Tesche, 2003), 2002 WRAP (Kemball-Cook, Jia, et. al., 2005), 2002 VISTAS (Olerud and Sims, 2004) and the 2003 Midwest RPO (Baker and Johnson, 2005) studies. The current study will be referred herein as the NMED 2005 study because the MM5 application was performed under contract to the New Mexico Environment Department (NMED) (and funded by GIANT Refining) and was performed for the 2005 data set. The analysis of these simulations was performed using the TDL surface observation database subdivided by region (CENRAP, MANE_VU, MW, VISTAS, and WRAP) and the Alpine Geophysics, MAPS analysis package (McNally and Tesche, 1994).

Emery and co-workers (2001), have derived and proposed a set of daily performance "benchmarks" for typical meteorological model performance. These standards were based upon the evaluation of about 30 MM5 and RAMS meteorological simulations in support of air quality applications performed over several years and reported by Tesche et al. (2001). The purpose of these benchmarks was not to give a passing or failing grade to any one particular meteorological model application, but rather to put its results into the proper context of other models and meteorological data sets. The key to the benchmarks is to understand how good or poor the results are relative to other model applications run for various areas of the U.S. These benchmarks include bias and error in temperature and mixing ratio as well the Wind Speed Index of Agreement (IA) between the models and data bases. The benchmark for acceptability for each variable was:

- Temperature bias - +/- 0.5 K
- Temperature error - 2.0 K
- Mixing ratio bias - +/- 1.0 g/kg
- Mixing ratio error - 2.0 g/kg
- Wind Speed Index of Agreement - 0 = worst, 1 = best

Temperature bias for both the entire domain and for each RPO for the five studies and the three years of NMED data is presented in Table 4-1. This NMED 2005 MM5 application was just greater than the temperature bias benchmark of +/- 0.5 K with a 0.52 K average over all of the regions (ALL in Table 4-1). When comparing the NMED 2005 performance to other study simulations, this NMED 2005 simulation slightly overestimated the temperature bias for the Western U.S., 0.13 K (see the WRAP column in Table 4-1), but within the benchmark which is important in this evaluation to determine viability of the data for use in the companion dispersion modeling that will ensue. This NMED 2005 simulation performed satisfactorily in comparison to other studies in other parts of the U.S., but was greater than the benchmark in three regions, namely, the CENRAP, MW, and VISTAS regions at 0.86, 0.58 and 0.75 K, respectively.

Temperature error is presented in Table 4-2. For this NMED 2005 application of MM5 the temperature error was generally somewhat higher than the other annual simulation studies over each region but consistent within the three years of simulation produced within this NMED study. As with the other simulations the MM5 results for this analysis are somewhat greater than the benchmark of 2.0 K. Table 4-2 shows the temperature error for the NMED 2005 MM5 simulation was 2.28 K over ALL study areas. The 2.74K for the WRAP RPO was comparable to other simulations. As with the other studies, the temperature error in this NMED 2005 study is rather consistent across all regions and varied the most in the WRAP region.

Mixing ratio bias is presented in Table 4-3. The domain-wide bias for this NMED 2005 MM5 simulation was 0.17 g/kg (see the ALL category in Table 4-3) which is much less than the benchmark of +/- 1.0 g/kg. The NMED mixing ratio bias was comparable to overall performance of the other studies and other years in this NMED study. On a sub-regional basis this NMED 2005 simulation was comparable with the other simulations.

Table 4-4 presents the mixing ratio error comparisons between the five studies, the other two years of NMED simulation, and the five regions. As with the mixing ratio bias, the domain-wide and sub-regional values for the NMED 2005 simulations are well under the benchmark of 2.0 g/kg and thus, expected to be reasonable representations of the mixing ratios. The NMED 2005 MM5 simulations resulted in mixing ratio errors that were comparable with the other annual MM5 applications by other researchers and to the other NMED simulation years.

Wind Speed Index of Agreement (IA) is presented in Table 4-5. The domain-wide IA for the NMED 2005 simulations was 0.87 (shown under ALL in Table 4-5) which is higher than the minimally acceptable benchmark of 0.6 and close to the best performing IA statistic of 1.0. This was comparable to all other annual simulations. The NMED 2005 simulation is comparable in performance to other studies over each of the sub-regions.

4.2 Comparison to Other Annual 12km Simulations

No other consistent model evaluations for 12km scale grid domain simulations over this domain were available for comparison to those conducted in this study. The results of these 2005 annual simulations could, however, be compared to other years of simulation in this study (NMED) whereby the annual temperature, mixing ratio, and wind speed indices were compared to observations. This would give an indication of the representativeness of the data in terms of the benchmarks as well as between years. Tables 4-6 through 4-10 present the comparisons for the 12 km grid MM5 simulations.

Mixing ratio bias over the 12km simulation domain is presented in Table 4-6. The domain-wide bias for this NMED 2005 MM5 simulation was 0.03 g/kg (see the ALL category under Mean for NMED 2005 in Table 4-6) which is much less than the benchmark of +/- 1.0 g/kg. The mean mixing ratio bias was within the range of the benchmark for of four of the Four corners states for NMED 2005. For Arizona the mixing ratio bias was greater than 1.0 g/kg in May, June, July, and September with an acceptable overall annual average of 0.66 g/kg. A comparison to other years of MM5 simulation data for NMED 2003 and NMED 2004 show similar results for the overall 12km domain as well as each state.

Mixing ratio error over the 12km simulation domain is presented in Table 4-7. The domain-wide bias for this NMED 2005 MM5 simulation was 1.07 g/kg (see the ALL category under Mean for NMED 2005 in Table 4-7) which is less than the benchmark of 2.0 g/kg. The mixing ratio error is well within the range of the benchmark for all of the Four Corners states. For Arizona the mixing ratio error is slightly greater than the benchmark for this NMED 2005 data set in July and September. All other months for Arizona are less than the benchmark as is the mean over all months. A comparison to other years of MM5 simulation data for NMED 2003 and NMED 2004 shows similar mixing ratio error results for the overall 12km domain as well as each state.

Temperature bias over both the entire 12km domain and for each State in the Four Corners region is presented in Table 4-8. This NMED 2005 MM5 simulation had a temperature bias on an annual average of 0.14 K (ALL and Mean in Table 4-8, well within the acceptability benchmark of +/- 0.5 K. Month-to-month variability of the temperature bias was within the benchmark with January and November being overestimated and June underestimated. Review of the state temperature bias indicated that the summer months were underestimated and the winter months overestimated for the four states. When comparing temperature bias for the NMED 2005 simulations to other years, the NMED 2005 simulations generally were closer to the temperatures than the other years. On a month-to-month comparison between the years of simulation, the NMED 2005 results were generally comparable.

Temperature error over the 12km domain is presented in Table 4-9. For this comparison of MM5 simulation the temperature error was similar for all three years of simulation across each month and for each state as well as the overall 12km domain. In all cases (except February in Arizona for the NMED 2005 MM5 simulation) the temperature error was greater than the benchmark of 2.0 K. The temperature error in this NMED 2005 simulation is consistent across the months of simulation in each State.

Wind Speed Index of Agreement (IA) is presented in Table 4-10 over the 12km domain. The domain-wide IA for the NMED 2005 12km simulations was 0.87 (shown under ALL and Mean in Table 4-10 for the NMED 2005 data set) which compares favorably with the best score of 1.0. The IA was comparable across all states for the NMED 2005 and also comparable to the NMED 2003 and NMED 2004 data sets.

4.3 Comparison to Other Annual 4km Simulations

The 4km domain covered only portions of each of the Four Corners states. Thus, no state temperature, mixing ratio, or winds were available for an individual state. Rather comparisons were made for the overall 4km domain and are shown in Tables 4-11 through 4-15.

Mixing ratio bias over the 4km simulation domain is presented in Table 4-11. The domain-wide bias for this NMED 2005 MM5 simulation was 0.24 g/kg (see NMED 2005 in Table 4-11) which is much less than the benchmark of +/- 1.0 g/kg. The mixing ratio bias means are similar for the three years of simulation. On a monthly basis the mixing ratio bias is just greater than the benchmarks for NMED 2005 in July and September and for NMED 2003 in July. All other months for the individual years of simulation are less than the benchmark of +/- 1.0 g/kg.

Mixing ratio error over the 4km simulation domain is presented in Table 4-12 The domain-wide bias for this NMED 2005 MM5 simulation was 1.10 g/kg (see NMED 2005 in Table 4-12) which is less than the benchmark of 2.0 g/kg. The mixing ratio bias is well within the range of the benchmark for all of the years of data and for each month.

Temperature bias over both the entire 4km domain is presented in Table 4-13. The NMED 2005 MM5 simulation had a temperature bias on an annual average of 1.07 K as shown in Table 4-13, greater than the guideline benchmark of+/- 0.5 K. Several months in the NMED 2005 data set had a temperature bias greater than 1.0 K. Comparison to NMED 2003 and NMED 2004 data show a similar month-to-month pattern of temperature bias.

Temperature error over the 4km domain is presented in Table 4-12. For this NMED 2005 application of MM5 the temperature error was similar over all the months of the simulation. Comparison of the means for the three years shows comparable results as does the month-to-month variation. In all cases the temperature error was greater than the benchmark of 2.0 K.

Wind Speed Index of Agreement (IA) is presented in Table 4-15 over the 4km domain. The domain-wide IA mean for the NMED 2005 4km simulations was 0.80 as it also was for the NMED 2003 and NMED 2004 simulations which compares favorably with the best score of 1.0 and is higher than the acceptability benchmark of 0.6. The IA was comparable across all three years of data simulation for each month.

Table 4-1: Temperature Bias (K) For 36km Annual MM5 Simulations.

	ALL	CENRAP	MANE_VU	MW	VISTAS	WRAP
EPA 2001	-0.51	-0.26	-0.40	-0.31	-0.25	-1.10
WRAP 2002	-0.12	0.14	-0.15	-0.11	0.05	-0.49
VISTAS 2002	-0.05	0.14	0.00	0.05	0.24	-0.55
MRPO 2003	-0.15	0.11	-0.17	-0.10	0.18	-0.67
NMED 2005	0.52	0.86	0.15	0.58	0.75	0.13
NMED 2004	0.49	0.79	0.27	0.55	0.73	0.07
NMED 2003	0.27	0.54	0.21	0.28	0.65	-0.26

Table 4-2: Temperature Error (K) for 36km Annual MM5 Simulations.

	ALL	CENRAP	MANE_VU	MW	VISTAS	WRAP
EPA 2001	2.04	1.77	1.85	1.63	1.92	2.70
WRAP 2002	2.10	1.85	1.80	1.74	1.93	2.79
VISTAS 2002	2.02	1.76	1.80	1.72	1.84	2.67
MRPO 2003	2.17	1.94	1.86	1.92	1.98	2.82
NMED 2005	2.28	2.20	2.05	2.05	2.10	2.74
NMED 2004	2.26	2.13	1.99	2.01	2.11	2.75
NMED 2003	2.23	2.07	1.97	1.97	2.06	2.73

Table 4-3: Mixing Ratio Bias (g/kg) for 36km Annual MM5 Simulations.

	ALL	CENRAP	MANE_VU	MW	VISTAS	WRAP
EPA 2001	-0.11	-0.24	-0.06	-0.22	0.06	-0.08
WRAP 2002	-0.09	-0.34	0.08	-0.11	0.20	-0.09
VISTAS 2002	0.01	-0.07	0.19	0.13	0.02	-0.04
MRPO 2003	0.22	0.11	0.30	0.29	0.49	0.05
NMED 2005	0.17	-0.02	0.54	0.24	0.47	-0.08
NMED 2004	0.07	-0.09	0.36	0.19	0.38	-0.20
NMED 2003	0.05	-0.18	0.35	0.17	0.35	-0.13

Table 4-4: Mixing Ratio Error (g/kg) for **Annual MM5 Simulations.**

	ALL	CENRAP	MANE VU	MW	VISTAS	WRAP
EPA 2001	1.02	1.09	0.80	0.85	1.13	1.04
WRAP 2002	1.03	1.17	0.82	0.93	1.16	0.94
VISTAS 2002	0.94	0.98	0.78	0.82	1.13	0.90
MRPO 2003	0.96	0.98	0.78	0.82	1.14	0.97
NMED 2005	1.12	1.20	0.96	0.97	1.32	1.03
NMED 2004	1.05	1.11	0.89	0.85	1.29	0.99
NMED 2003	1.03	1.09	0.86	0.85	1.22	1.00

Table 4-5: Wind Index of Agreement for 36km Annual MM5 Simulation.

	ALL	CENRAP	MANE VU	MW	VISTAS	WRAP
EPA 2001	0.88	0.85	0.69	0.75	0.77	0.86
WRAP 2002	0.93	0.92	0.81	0.84	0.84	0.92
VISTAS 2002	0.90	0.88	0.71	0.78	0.79	0.89
MRPO 2003	0.90	0.88	0.72	0.78	0.80	0.88
NMED 2005	0.87	0.84	0.71	0.73	0.75	0.86
NMED 2004	0.90	0.88	0.76	0.77	0.79	0.88
NMED 2003	0.90	0.88	0.76	0.77	0.79	0.88

Table 4-6: Mixing Ratio Bias (g/kg) over the 12km MM5 Domain and Four-Corner States.

Region	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
NMED 2003													
ALL	0.09	-0.04	-0.01	0.08	-0.14	-0.18	0.08	-0.02	-0.34	-0.12	-0.19	0.02	-0.06
AZ	-0.12	-0.15	-0.26	0.26	0.53	0.57	0.54	0.26	0.18	0.48	-0.20	0.03	0.18
CO	0.26	0.04	0.10	0.15	-0.09	-0.14	0.63	-0.05	-0.36	0.04	-0.15	0.01	0.04
NM	0.48	0.29	0.26	0.41	0.57	0.85	0.96	0.34	0.12	0.39	0.10	0.25	0.42
UT	0.15	0.04	0.27	0.25	0.06	0.47	1.24	0.46	0.46	0.42	-0.06	0.13	0.32
NMED 2004													
ALL	-0.07	-0.08	0.03	-0.12	-0.12	-0.16	-0.23	-0.38	-0.33	-0.08	-0.15	-0.06	-0.15
AZ	-0.29	-0.14	-0.06	0.08	0.86	1.04	0.77	0.39	0.13	0.20	-0.21	-0.37	0.20
CO	-0.09	-0.09	0.26	-0.05	-0.42	-0.13	-0.54	-0.76	-0.60	-0.20	-0.10	0.01	-0.23
NM	0.03	0.08	0.20	-0.03	0.52	0.93	0.22	-0.09	-0.13	-0.06	-0.04	-0.09	0.13
UT	0.24	0.10	0.77	0.27	-0.05	0.48	0.84	0.50	0.47	0.26	-0.13	0.08	0.32
NMED 2005													
ALL	0.11	0.02	0.01	0.01	-0.07	-0.10	0.29	0.03	0.13	-0.10	0.02		0.03
AZ	-0.24	-0.16	-0.13	0.54	1.17	1.55	1.75	0.32	1.07	0.70	0.71		0.66
CO	0.15	0.08	0.10	0.23	-0.12	-0.46	0.24	-0.57	-0.10	-0.37	-0.08		-0.08
NM	0.10	-0.08	-0.07	0.22	0.22	0.60	0.60	-0.81	0.43	-0.08	0.47		0.15
UT	0.10	0.04	0.37	0.11	-0.35	-0.13	0.68	0.25	0.22	-0.07	-0.14		0.10

Table 4-7: Mixing Ratio Error (g/kg) over the 12km MM5 Domain and Four-Corner States.

Region	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
NMED 2003													
ALL	0.68	0.63	0.75	0.79	1.07	1.30	1.73	1.53	1.31	1.15	0.76	0.65	1.03
AZ	0.74	0.76	0.84	0.75	1.17	1.38	1.99	2.04	1.73	1.44	0.80	0.66	1.19
CO	0.55	0.47	0.61	0.85	1.14	1.23	1.73	1.46	1.05	0.79	0.56	0.46	0.91
NM	0.72	0.66	0.73	0.86	1.19	1.59	1.94	1.51	1.34	1.18	0.85	0.51	1.09
UT	0.57	0.51	0.62	0.66	0.99	1.25	2.13	1.64	1.16	0.93	0.61	0.50	0.96
NMED 2004													
ALL	0.63	0.61	0.97	0.92	1.08	1.36	1.61	1.45	1.31	0.94	0.72	0.64	1.02
AZ	0.74	0.64	1.00	0.91	1.19	1.49	1.81	1.80	1.59	1.02	0.76	0.71	1.14
CO	0.46	0.48	0.77	0.78	1.05	1.27	1.64	1.47	1.15	0.79	0.56	0.45	0.91
NM	0.53	0.61	0.86	0.95	1.30	1.75	1.79	1.53	1.34	1.10	0.66	0.60	1.09
UT	0.45	0.40	1.11	0.78	0.92	1.44	1.74	1.42	1.20	0.77	0.59	0.46	0.94
NMED 2005													
ALL	0.66	0.68	0.77	0.86	1.09	1.38	1.67	1.52	1.34	0.99	0.85		1.07
AZ	0.88	0.79	0.95	0.89	1.46	1.88	2.69	1.84	2.02	1.30	1.00		1.43
CO	0.51	0.58	0.56	0.80	0.95	1.39	1.57	1.46	1.19	0.88	0.62		0.96
NM	0.74	0.70	0.75	0.79	1.12	1.59	1.91	1.89	1.67	1.01	0.68		1.17
UT	0.55	0.52	0.71	0.72	1.12	1.38	1.74	1.54	1.16	0.87	0.69		1.00

Table 4-8: Temperature Bias (K) over the 12km MM5 Domain and Four-Corner States.

Region	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
NMED 2003													
ALL	0.66	-0.10	-0.68	-1.15	-0.71	-0.88	-0.91	-0.85	0.17	0.87	0.19	0.83	-0.21
AZ	0.65	-0.12	-0.25	-1.49	-1.20	-1.59	-1.66	-1.36	-0.36	0.29	0.15	0.96	-0.50
CO	0.55	-0.68	-2.11	-2.20	-0.75	-0.59	-0.75	-0.63	0.33	0.80	-0.14	0.99	-0.43
NM	0.32	-0.13	-0.53	-1.06	-0.81	-1.05	-1.32	-0.96	-0.45	0.52	0.11	1.08	-0.36
UT	0.91	-1.04	-1.78	-1.35	-0.61	-1.20	-1.27	-0.70	0.54	1.51	-0.02	0.93	-0.34
NMED 2004													
ALL	1.02	0.20	-0.08	-0.34	-0.66	-0.59	-0.27	-0.02	0.11	0.22	0.72	0.84	0.10
AZ	0.73	0.14	-0.03	-0.98	-1.63	-1.32	-0.87	-0.52	-0.78	-0.41	-0.07	0.61	-0.43
CO	1.47	-0.04	-1.04	-1.08	-0.17	0.00	0.25	0.22	0.07	-0.17	0.26	0.58	0.03
NM	0.70	0.48	0.17	-0.03	-0.24	-0.68	-0.11	0.19	-0.09	0.02	0.34	1.01	0.15
UT	1.90	0.14	-0.72	-0.45	-0.53	-0.45	-0.44	-0.16	0.18	0.33	1.03	1.09	0.16
NMED 2005													
ALL	0.94	0.41	-0.16	-0.42	-0.41	-0.53	-0.21	0.32	0.26	0.39	0.90		0.14
AZ	0.59	-0.30	-0.36	-0.97	-1.43	-1.70	-1.44	-0.48	-0.44	-0.52	0.77		-0.57
CO	0.68	-0.06	-1.42	-0.94	-0.30	-0.01	-0.14	0.45	0.38	0.32	0.46		-0.05
NM	0.64	0.08	-0.15	-0.06	-0.07	-0.40	-0.66	0.12	0.03	0.25	0.89		0.06
UT	0.76	0.34	-0.63	-0.97	-0.25	-0.32	0.07	0.45	0.87	1.00	1.40		0.25

Table 4-9: Temperature Error (K) over the 12km MM5 Domain and Four-Corner States.

Region	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
NMED 2003													
ALL	2.98	2.48	2.68	2.67	2.52	2.57	2.84	2.64	2.84	3.27	2.62	2.79	2.74
AZ	3.00	2.20	2.39	2.71	2.75	2.75	2.83	2.77	2.88	3.06	2.62	2.94	2.74
CO	3.69	2.79	3.50	3.64	2.82	2.73	3.23	2.62	2.86	3.50	2.94	3.53	3.15
NM	3.14	2.40	2.70	2.94	2.76	2.73	2.70	2.46	2.49	2.89	2.78	3.10	2.76
UT	2.93	2.46	2.87	2.85	2.81	3.06	3.52	2.85	3.31	3.62	2.17	2.79	2.94
NMED 2004													
ALL	2.99	2.52	2.93	2.57	2.69	2.62	2.61	2.60	2.74	2.55	2.61	3.02	2.70
AZ	2.36	2.26	2.64	2.43	2.98	2.79	2.59	2.56	2.61	2.53	2.24	2.69	2.56
CO	3.71	2.92	3.33	2.91	3.04	2.88	2.85	2.78	2.75	2.82	2.73	3.48	3.02
NM	2.74	2.51	2.52	2.24	2.79	2.78	2.62	2.38	2.46	2.51	2.36	3.12	2.59
UT	3.67	2.58	3.42	2.42	2.78	3.02	3.05	2.95	3.04	2.55	2.53	3.04	2.92
NMED 2005													
ALL	2.83	2.56	2.70	2.69	2.47	2.52	2.77	2.64	2.81	2.78	3.12		2.72
AZ	2.21	1.85	2.48	2.88	3.04	3.19	3.16	2.57	2.77	2.77	3.08		2.73
CO	3.26	3.06	3.29	3.17	2.93	2.80	3.11	2.69	2.93	2.90	3.32		3.04
NM	2.75	2.11	2.58	2.86	2.54	2.66	2.55	2.37	2.65	2.55	3.30		2.63
UT	2.74	2.70	2.88	2.75	2.46	2.68	3.15	2.90	3.19	2.96	3.11		2.87

Table 4-10: Wind Index of Agreement over ; 12km MM5 Domain and Four-Corner States.

Region	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
NMED 2003													
ALL	0.88	0.89	0.88	0.89	0.90	0.90	0.90	0.90	0.89	0.89	0.88	0.88	0.89
AZ	0.73	0.77	0.77	0.78	0.74	0.76	0.74	0.72	0.73	0.74	0.75	0.75	0.75
CO	0.84	0.83	0.83	0.80	0.83	0.84	0.85	0.84	0.85	0.87	0.84	0.85	0.84
NM	0.86	0.83	0.83	0.80	0.80	0.81	0.80	0.80	0.84	0.84	0.82	0.83	0.82
UT	0.79	0.76	0.77	0.80	0.79	0.81	0.78	0.80	0.81	0.81	0.78	0.80	0.79
NMED 2004													
ALL	0.88	0.89	0.89	0.9	0.9	0.91	0.89	0.89	0.89	0.88	0.89	0.88	0.89
AZ	0.75	0.77	0.76	0.77	0.76	0.72	0.71	0.7	0.73	0.75	0.75	0.78	0.75
CO	0.84	0.84	0.82	0.8	0.84	0.85	0.83	0.82	0.82	0.82	0.84	0.85	0.83
NM	0.85	0.83	0.85	0.82	0.82	0.82	0.8	0.8	0.82	0.82	0.86	0.86	0.83
UT	0.72	0.78	0.78	0.81	0.81	0.79	0.77	0.79	0.79	0.79	0.78	0.77	0.78
NMED 2005													
ALL	0.87	0.86	0.88	0.87	0.85	0.87	0.89	0.85	0.88	0.87	0.88		0.87
AZ	0.73	0.67	0.73	0.72	0.72	0.71	0.68	0.74	0.72	0.73	0.74		0.72
CO	0.83	0.82	0.81	0.83	0.81	0.81	0.80	0.81	0.79	0.79	0.79		0.81
NM	0.77	0.81	0.78	0.80	0.79	0.81	0.81	0.81	0.80	0.79	0.78		0.80
UT	0.71	0.72	0.77	0.77	0.74	0.76	0.78	0.76	0.74	0.76	0.78		0.75

Table 4-11: Mixing Ratio Bias (g/kg) over 4km MM5 Domain.

Simulation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
NMED 2003	0 .0	-0.09	-0. 20	0 .0	0.43	0.51	1.24	0 .76	0.32	0.49	-0.21	-0 .0	0.27
NMED 2004	-0 .1	-0.12	-0. 18	-0 .2	-0.07	0.72	0.62	0 .15	0.13	-0.05	-0.25	-0 .1	0.03
NMED 2005	-0 .1	-0.29	-0. 28	-0 .2	0.05	0.52	1.37	0 .33	1.08	0.00	0.14		0.24

Table 4-12: Mixin Ratio Error (g/kg) over the 4km MM5 Domain.

Simulation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
NMED 2003	0 .5	0.55	0.67	0 .7	1.18	1.37	1.88	1 .56	1.18	1.05	0 72	0 .5	0.99
NMED 2004	0 .5	0.55	0.78	0 .8	0.99	1.50	1.73	1 .48	1.24	0.84	0 66	0 .5	0.98
NMED 2005	0 .5	0.70	0.68	0 .8	1.01	1.49	1.91	1 .49	1.70	1.01	0 69		1.10

Table 4-13: Temperature Bias (K) over the 4km MM5 Domain.

Simulation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
NMED 2003	0 .9	0.73	-0. 24	-0.48	0.58	0.49	-0.11	0 .27	1.49	2.06	1 27	2 .0	0.75
NMED 2004	1 .8	0.89	0. 50	0.83	1.26	0.87	0.97	1 .31	1.26	1.39	1 40	1 .4	1.16
NMED 2005	1 .4	0.95	-0. 03	0.72	1.19	0.94	0.58	1 .22	1.27	1.54	1 91		1.07

Table 4-14: Temperature Error (K) over the 4km MM5 Domain.

Simulation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
NMED 2003	3.82	2.70	3.23	3.50	3.36	3.36	3.70	3.06	3.69	4.20	3.22	3.71	3.46
NMED 2004	3.58	2.80	3.37	3.01	3.54	3.51	3.28	3.23	3.38	3.13	2.87	3.49	3.27
NMED 2005	3.09	2.59	3.03	3.26	3.32	3.51	3.71	3.25	3.55	3.50	3.98		3.34

Table 4-15: Wind Index of Agreement over the 4km MM5 Domain.

Simulation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
NMED 2003	0 .8	0.81	0. 79	0 .7	0.79	0.80	0.80	0 .80	0.82	0.82	0 79	0 .8	0.80
NMED 2004	0 .8	0.82	0. 80	0 .7	0.80	0.81	0.81	0 .77	0.75	0.79	0 81	0 .8	0.80
NMED 2005	0 .8	0.82	0. 79	0 .7	0.80	0.80	0.80	0 .81	0.80	0.81	0 79		0.80

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Appendix E
Procedures for Design Value Projections Using the Modeled Attainment Test Software (MATS)

The EPA has developed the Model Attainment Test Software (MATS) tool to facilitate the process of projecting base year measured design values (DV) to a future year according to modeling results (Abt, 2008). The DV projection is determined by multiplying the base year DV at a particular monitoring site by a Relative Response Factor (RRF), which is simply defined as the ratio of the future year model concentration to the base year model concentration at that site. Hence, the DV projection uses the model results in a relative sense. Different approaches are used to define the DV and the RRF for the 8-hour ozone and 24-hour and annual PM2.5 standards. The MATS tool can determine future year concentration levels at specific monitoring sites, and for "un-monitored" areas throughout the modeling domain. MATS contains datasets of annual ozone and total PM2.5 DVs at AQS and FRM sites, respectively, throughout the entire U.S. MATS also contains PM2.5 species data at IMPROVE and STN sites for the same period. These data are used to infer the relative contributions of different PM species to the FRM total PM2.5 concentrations (RRFs are applied to each component of PM2.5, not total PM2.5 mass). Currently, data are available in MATS from 1999 through 2006. A complete description of the procedures used by MATS is provided in EPA's most recent modeling guidance (EPA, 2007).

For the Four Corners modeling, MATS was used to project 2005 DVs for 8-hour ozone and annual PM2.5 to the 2018 future year at the various AQS, IMPROVE, and FRM monitoring sites in the 4-km modeling grid. MATS was not used to project ozone and PM2.5 in "un-monitored" areas; separate analyses were performed for un-monitored areas given uncertainties associated with model performance at high elevations, the low density and distribution patterns of monitoring sites in this rural area, and the assumptions that MATS must make to spatially interpolate DV values that do not make sense in complex terrain. Here we describe the configuration of MATS for this project.

MATS must first define the 3-year DV averaging period. The base year is 2005, so annual DVs from 2005 through 2007 were needed. Annual ozone and PM2.5 DVs are themselves based on 3-year averages, which means that a five-year weighted average, centered on 2005 (2003 – 2007), is used to determine the average base year DV. For 8-hour ozone, the annual 4th highest ozone at a given site is used in the 5-year weighted average. Since the annual PM2.5 DV and its projection are determined on a quarterly basis, the 5-year weighted average PM2.5 DV is determined from each quarter of the 2003 – 2007 period. Ozone DVs from 2007 were added to the MATS observation datasets to obtain the correct 2005 average DV. However, PM2.5 DVs from 2007 were not added, and thus a 2003-2005 period was used to calculate the average DV (i.e., the 5-year weighted average centered on 2003). Specifying a 2004-2006 period for PM2.5 caused MATS to crash for unknown reasons.

The following specifications were set in MATS to project the 8-hour ozone DV to 2018:

- For each air quality monitoring site, MATS searched the maximum daily ozone from a 7x7 array of model grid cells surrounding the site and selected the maximum among those 49 values each day for the development of the RRF (this is the default procedure as per EPA guidance for a 4-km grid resolution);
- A monitoring site was considered to have a valid DV if a minimum of 1 year of data sufficient to calculate a valid DV is available (corresponds to default EPA guidance);
- The ozone RRF at each site was determined from the average of the modeled daily ozone values (from the 7x7 array) in 2018, divided by the same for 2005;
    - Initially, only days with predicted concentrations above 85 ppb in 2005 were used to compute the average (default setting as per EPA guidance);
    - A minimum of 10 days over the year were required to form a valid average (default setting as per EPA guidance). If fewer than 10 days were found above the 85 ppb threshold, the threshold was reduced in 1 ppb increments until at least 10 days were found or the threshold was reduced to 60 ppb (initially, the minimum threshold was set to the EPA guidance default value of 70 ppb but this resulted in the calculation of valid RRFs at just two monitoring sites);
    - If 10 days were still not found at the 60 ppb minimum, then the number of required days was relaxed successively to a minimum of 5 days (default setting as per EPA guidance).

Ozone DV data from the newly established Navajo Lake site was added to MATS at the same time that 2007 DVs from other AQS sites were added. However, data from Navajo Lake extends back to only 2005, thus the Navajo Lake average DV used in MATS is not centered on 2005 and is not based on a 5-year weighted average. Normally, EPA guidance procedures would preclude the use of data from this site in MATS but it was nevertheless included in this analysis because it is the only monitoring site within the 4 km domain which recorded a violation of the ozone standard. Ozone DV projections for Navajo Lake should therefore be used with caution.

The following specifications were set in MATS to project the annual PM2.5 DV to 2018:

- Speciation data from IMPROVE and STN sites were spatially interpolated to the FRM sites (default per EPA guidance);
- For each monitor, MATS searched the daily 24-hour average PM2.5 from a 7x7 array of grid cells surrounding that site and calculated the average among those 49 values each day for the development of the speciated RRFs (default per EPA guidance for a 4-km grid resolution);
- Speciation data from 2003-2005 were used (the MATS program crashed for unknown reasons when the end year was set to 2006);
- A minimum of 11 days of valid speciation data were needed per quarter (default per EPA guidance);
- A season was considered valid if it contained valid speciation data from at least 1 year of the averaging period (default per EPA guidance);

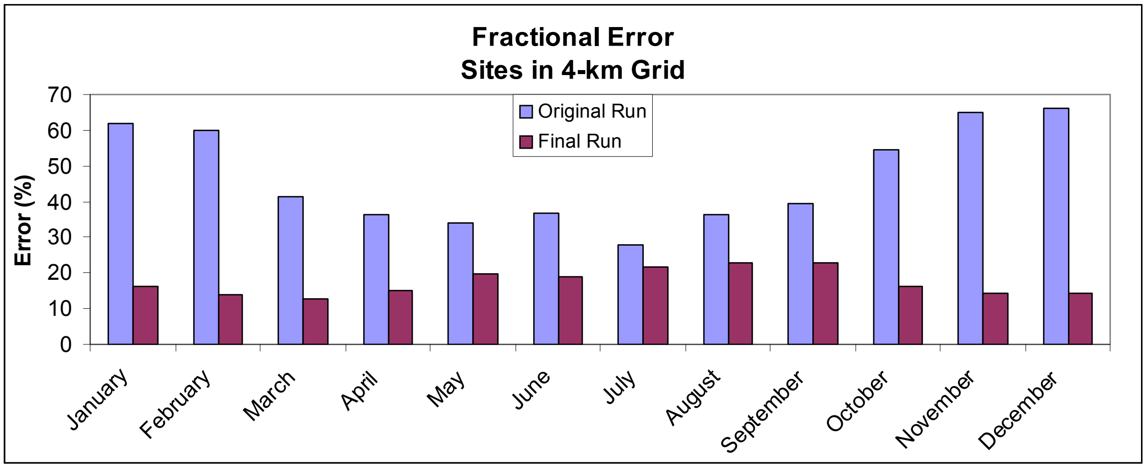
- A minimum of 1 valid season was needed for a valid speciation monitor (default per EPA guidance);
- Inverse distance-squared weighting was used for speciation interpolation to FRM sites (default per EPA guidance);
- MATS calculated the degree of neutralization (DON) values to set ammonium concentrations, measurements were not used (default per EPA guidance);
- A 0.5 $\mu g/m^3$ blank mass was assumed (default per EPA guidance);
- A minimum of 11 days of valid FRM PM2.5 data were needed per quarter (default per EPA guidance);
- A season was considered valid if it contained valid FRM PM2.5 data from at least 1 year of the averaging period (default per EPA guidance);
- A minimum of 4 valid seasons was needed for a valid FRM PM2.5 monitor (default per EPA guidance);
- A monitoring site was considered to have a valid DV is if contained a minimum of 1 year of DV data (default per EPA guidance);
- A minimum of 12 valid quarters were needed for the DV averaging period (default per EPA guidance);
- The base year DON was used for the future year (default per EPA guidance);

Appendix F: CAMx Performance

Table 1. MM5 vertical layer definitions and mapping to CAMx vertical layers.

MM5 Layer	Sigma	Pressure (mb)	Height (m)	Depth (m)	CAMx 19L Layer	Sigma	Pressure (mb)	Height (m)	Depth (m)
34	**0.000**	**100**	**14662**	**1841**	**19**	**0.000**	**100**	**14662**	**6536**
33	0.050	145	12822	1466		0.050	145		
32	0.100	190	11356	1228		0.100	190		
31	0.150	235	10127	1062		0.150	235		
30	0.200	280	9066	939		0.200	280		
29	**0.250**	**325**	**8127**	**843**	**18**	**0.250**	**325**	**8127**	**2966**
28	0.300	370	7284	767		0.300	370		
27	0.350	415	6517	704		0.350	415		
26	0.400	460	5812	652		0.400	460		
25	**0.450**	**505**	**5160**	**607**	**17**	**0.450**	**505**	**5160**	**1712**
24	0.500	550	4553	569		0.500	550		
23	0.550	595	3984	536		0.550	595		
22	**0.600**	**640**	**3448**	**506**	**16**	**0.600**	**640**	**3448**	**986**
21	0.650	685	2942	480		0.650	685		
20	**0.700**	**730**	**2462**	**367**	**15**	**0.700**	**730**	**2462**	**633**
19	0.740	766	2095	266		0.740	766		
18	**0.770**	**793**	**1828**	**259**	**14**	**0.770**	**793**	**1828**	**428**
17	0.800	820	1569	169		0.800	820		
16	**0.820**	**838**	**1400**	**166**	**13**	**0.820**	**838**	**1400**	**329**
15	0.840	856	1235	163		0.840	856		
14	**0.860**	**874**	**1071**	**160**	**12**	**0.860**	**874**	**1071**	**160**
13	0.880	892	911	158	**11**	**0.880**	**892**	**911**	**158**
12	**0.900**	**910**	**753**	**78**	**10**	**0.900**	**910**	**753**	**155**
11	0.910	919	675	77		0.910	919		
10	**0.920**	**928**	**598**	**77**	**9**	**0.920**	**928**	**598**	**153**
9	0.930	937	521	76		0.930	937		
8	**0.940**	**946**	**445**	**76**	**8**	**0.940**	**946**	**445**	**76**
7	**0.950**	**955**	**369**	**75**	**7**	**0.950**	**955**	**369**	**75**
6	**0.960**	**964**	**294**	**74**	**6**	**0.960**	**964**	**294**	**74**
5	**0.970**	**973**	**220**	**74**	**5**	**0.970**	**973**	**220**	**74**
4	**0.980**	**982**	**146**	**37**	**4**	**0.980**	**982**	**146**	**37**
3	**0.985**	**986.5**	**109**	**37**	**3**	**0.985**	**986.5**	**109**	**37**
2	**0.990**	**991**	**73**	**36**	**2**	**0.990**	**991**	**73**	**36**
1	**0.995**	**995.5**	**36**	**36**	**1**	**0.995**	**995.5**	**36**	**36**
0	**1.000**	**1000**	**0**	**0**	**0**	**1.000**	**1000**	**0**	**0**

Figure 1. Monthly Mean Fractional Errors for Ozone Monitoring Sites in the 4 Km Domain (Top) and 12 Km Domain (Bottom)



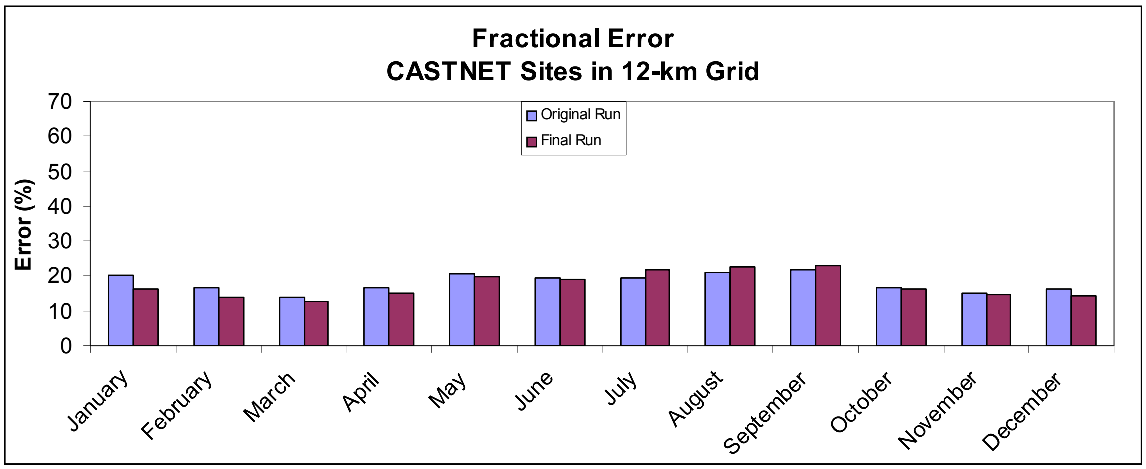
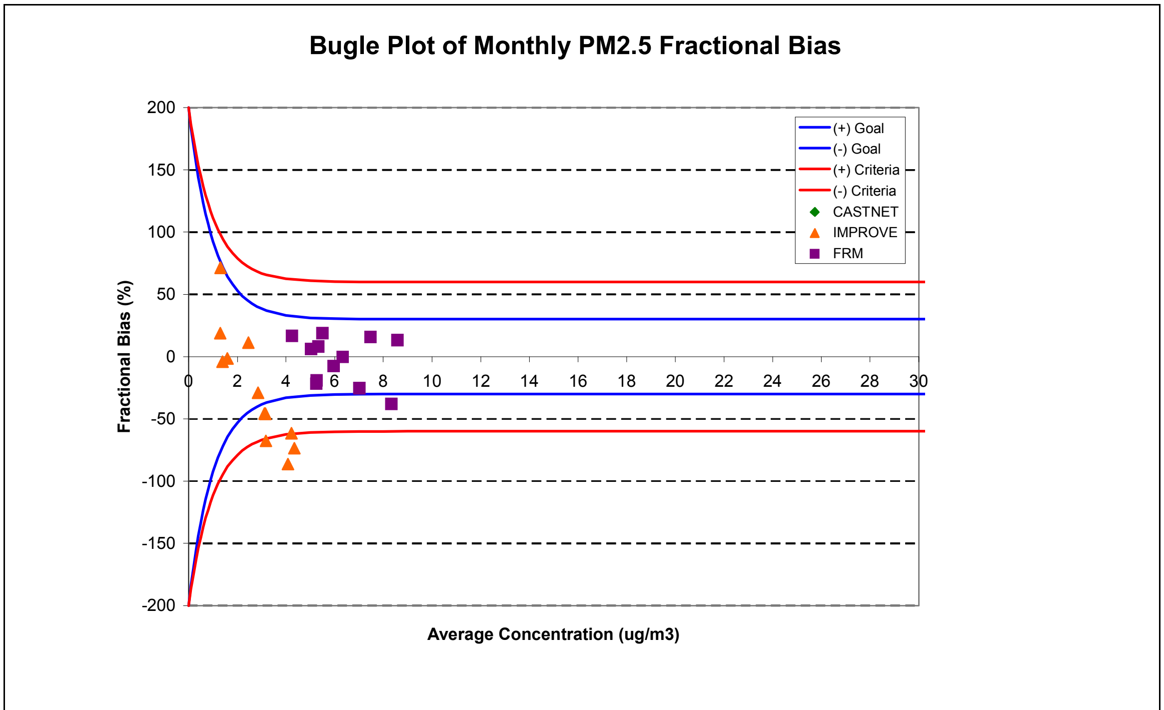


Figure 2. Monthly Fractional Bias (Top) and Error (Bottom) for PM2.5 by Site Relative to Monthly-Mean Observations and to RPO Performance Goals and Criteria


Bugle Plot of Monthly PM2.5 Fractional Bias
Fractional Bias (%)
Average Concentration (ug/m3)
(+) Goal
(-) Goal
(+) Criteria
(-) Criteria
CASTNET
IMPROVE
FRM

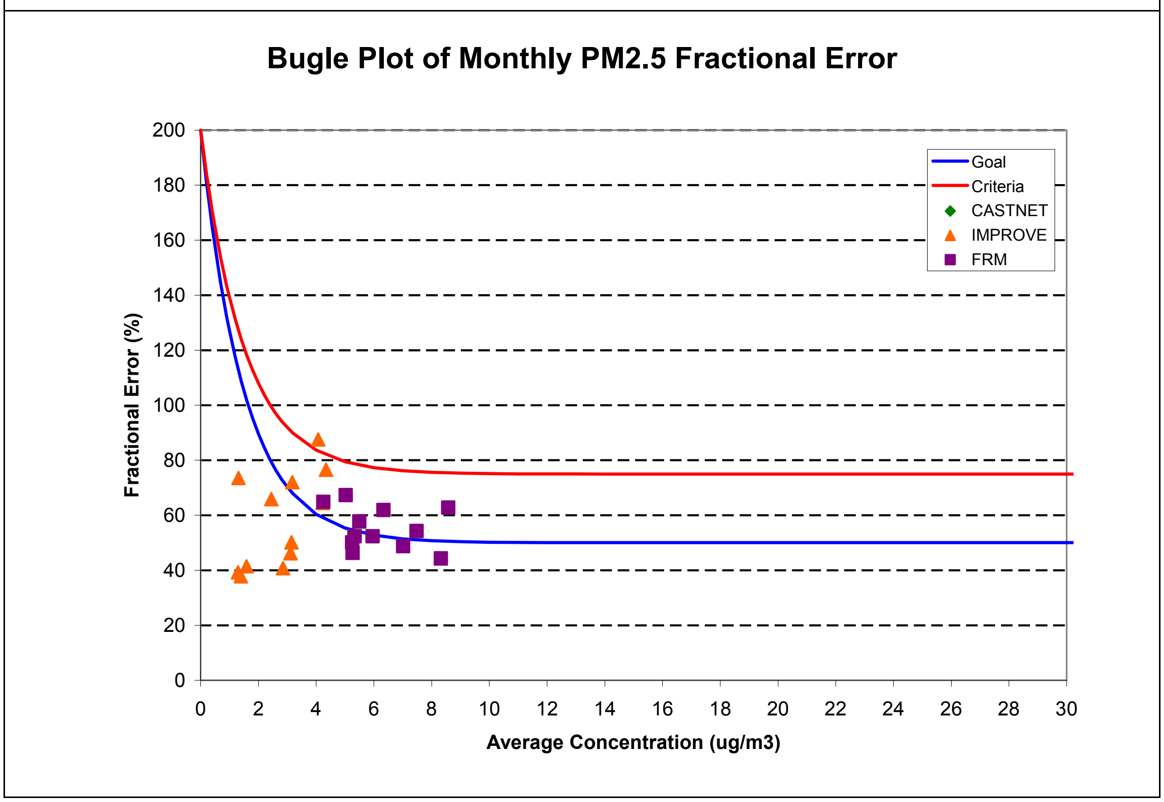
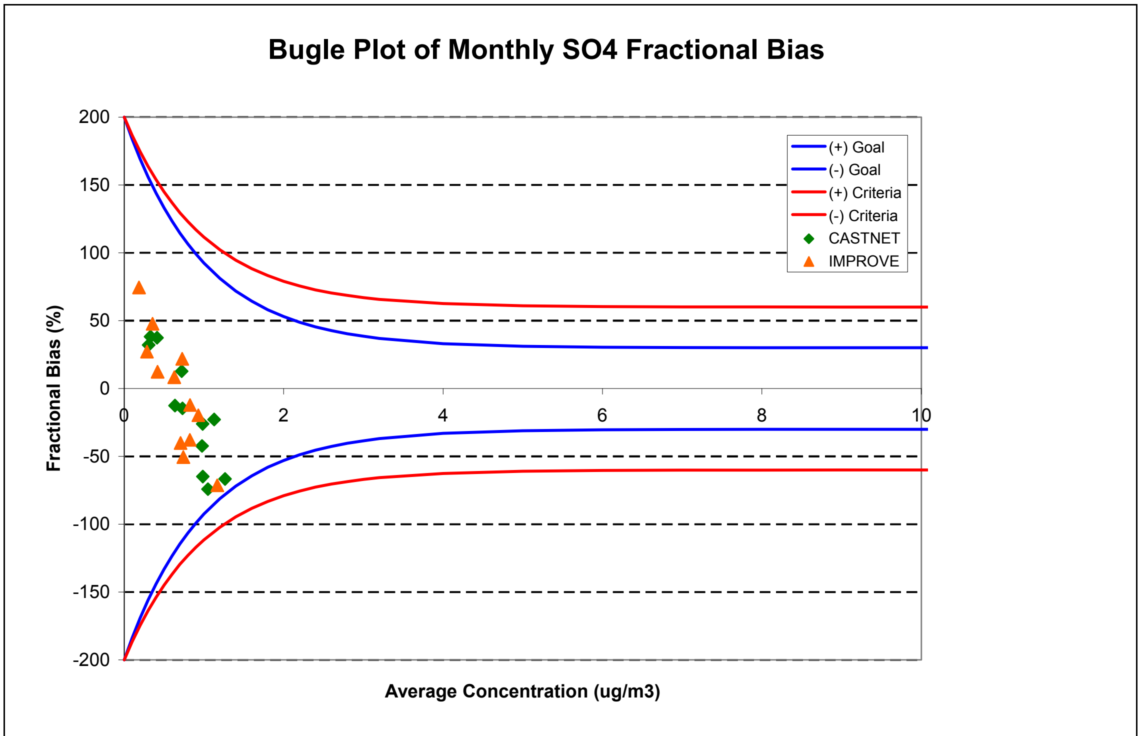

Bugle Plot of Monthly PM2.5 Fractional Error
Fractional Error (%)
Average Concentration (ug/m3)
Goal
Criteria
CASTNET
IMPROVE
FRM

Figure 3. Monthly Fractional Bias (Top) and Error (Bottom) for Sulfate by Site Relative to Monthly-Mean Observations and to RPO Performance Goals and Criteria



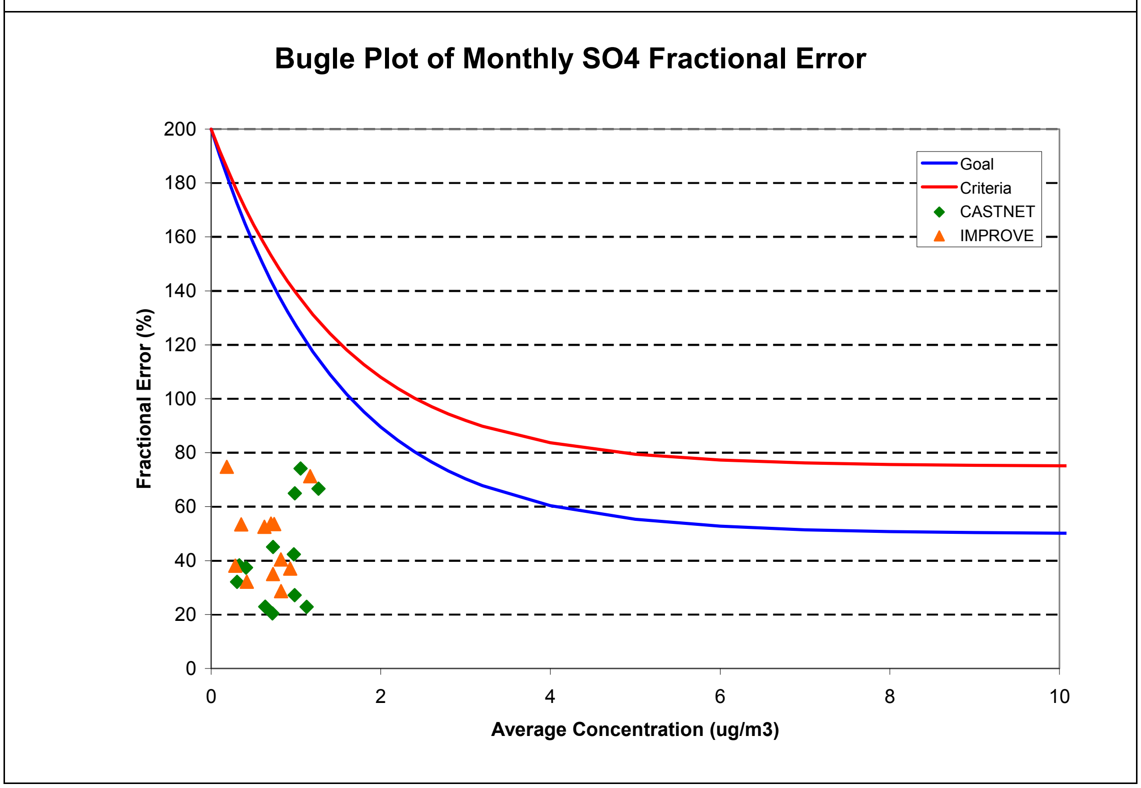
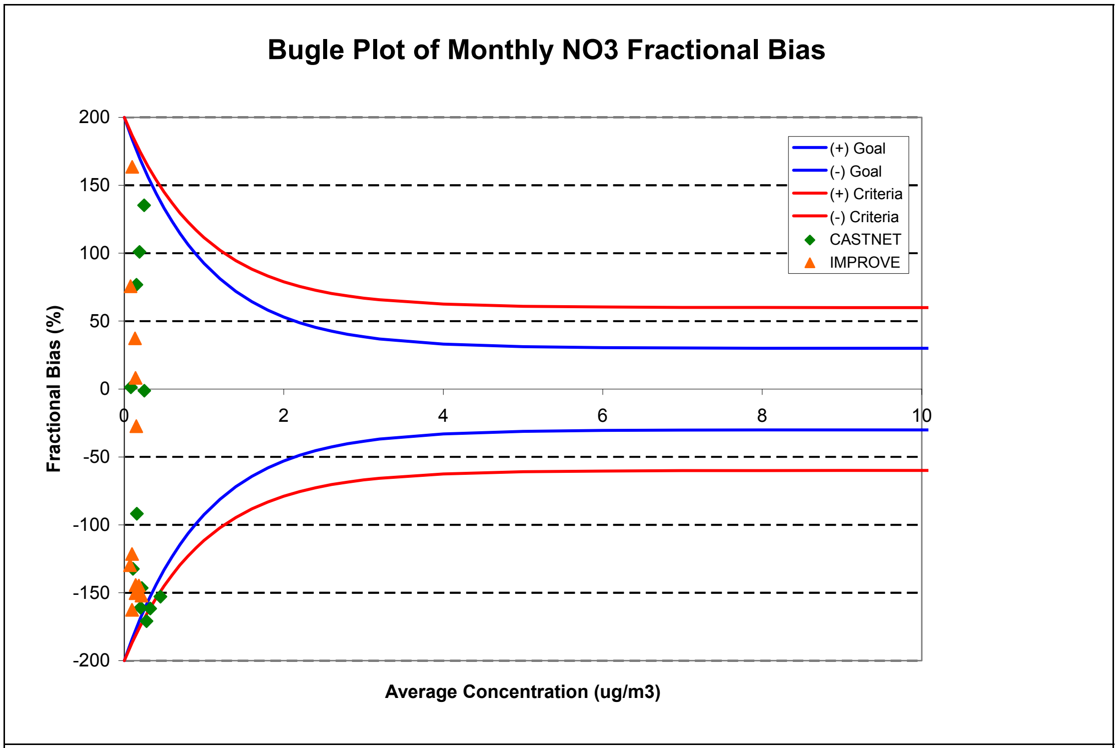


Figure 4. Monthly Fractional Bias (Top) and Error (Bottom) for Nitrate by Site Relative to Monthly-Mean Observations and to RPO Performance Goals and Criteria



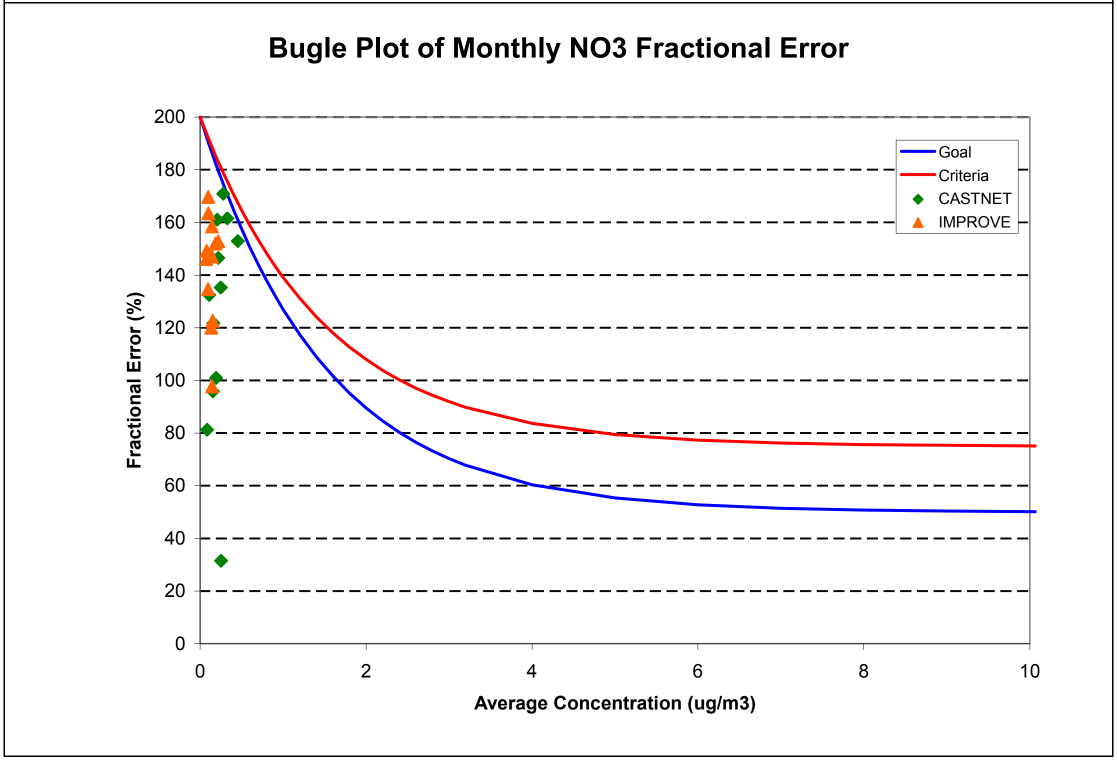
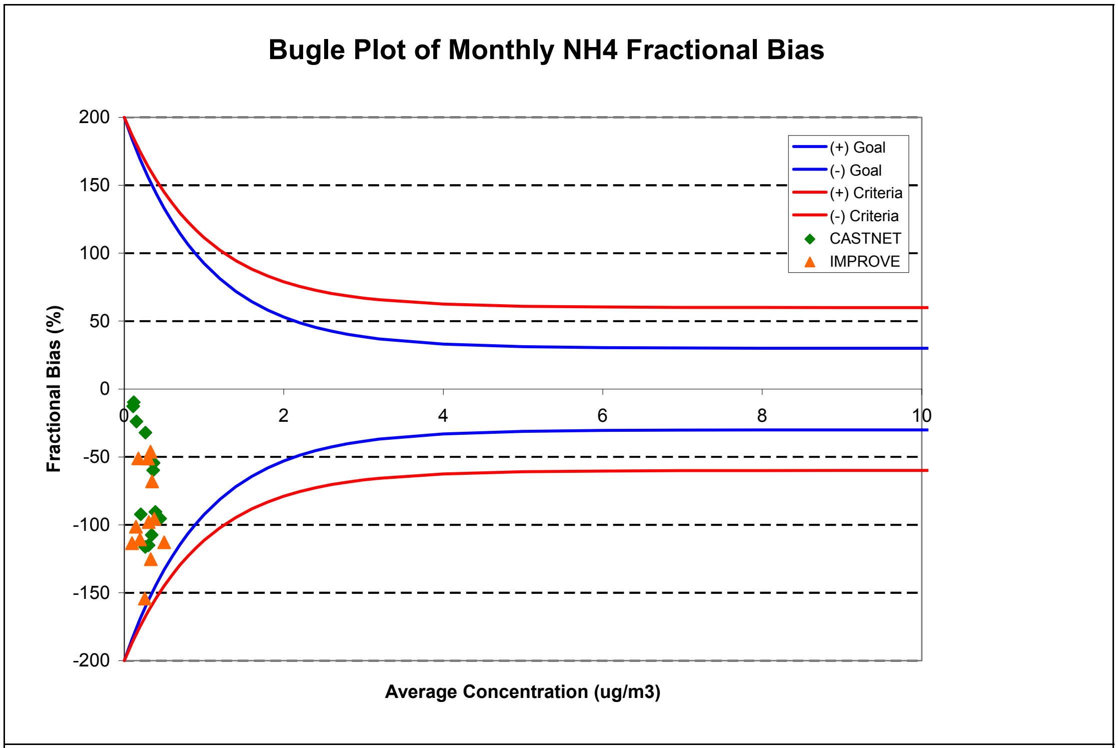


Figure 5. Monthly Fractional Bias (Top) and Error (Bottom) for Ammonium by Site Relative to Monthly-Mean Observations and to RPO Performance Goals and Criteria



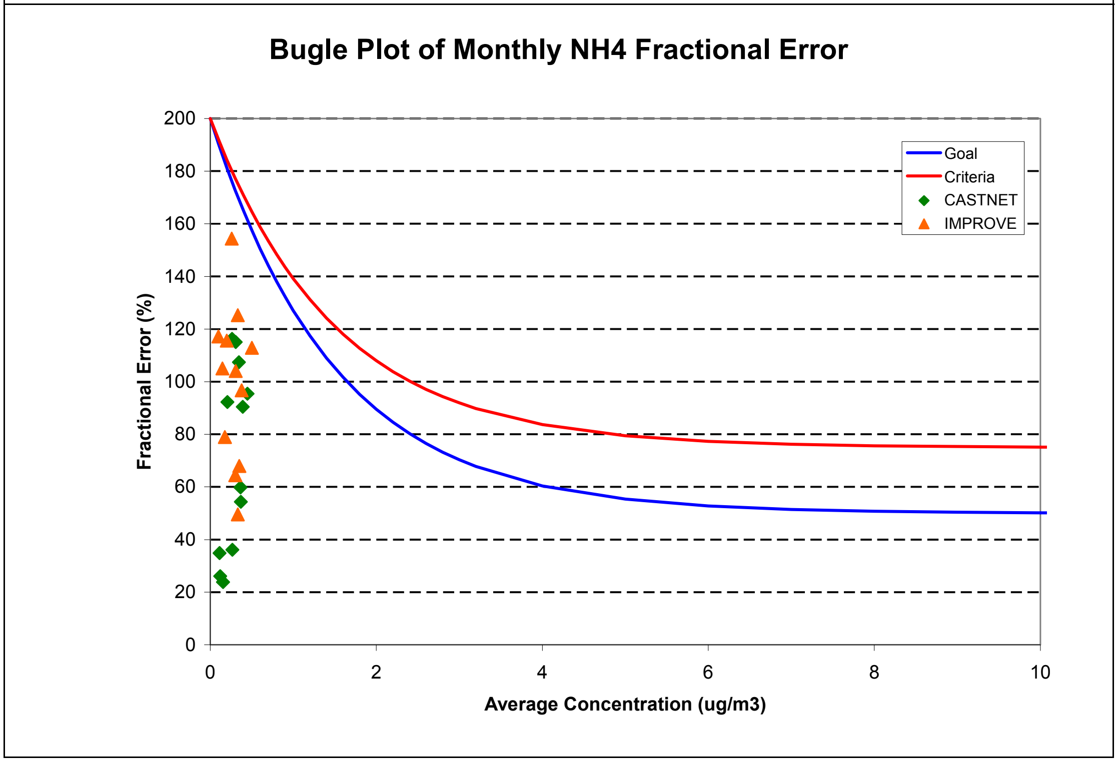
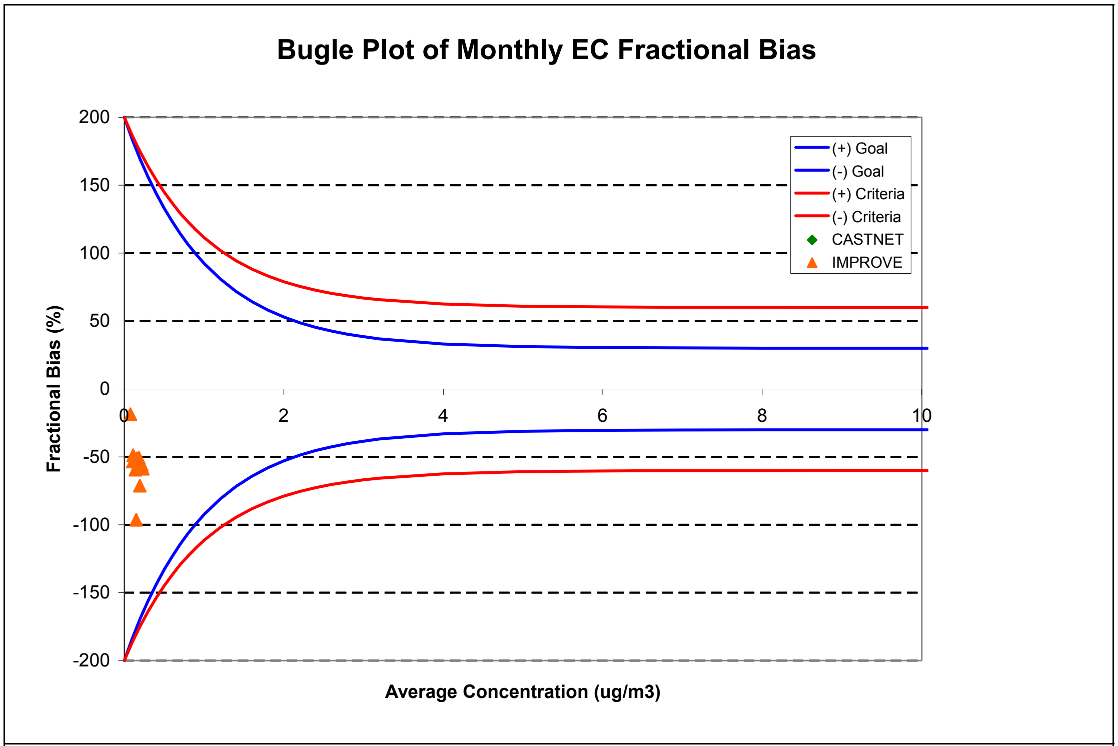


Figure 6. Monthly Fractional Bias (Top) and Error (Bottom) for Elemental Carbon by Site Relative to Monthly-Mean Observations and to RPO Performance Goals and Criteria



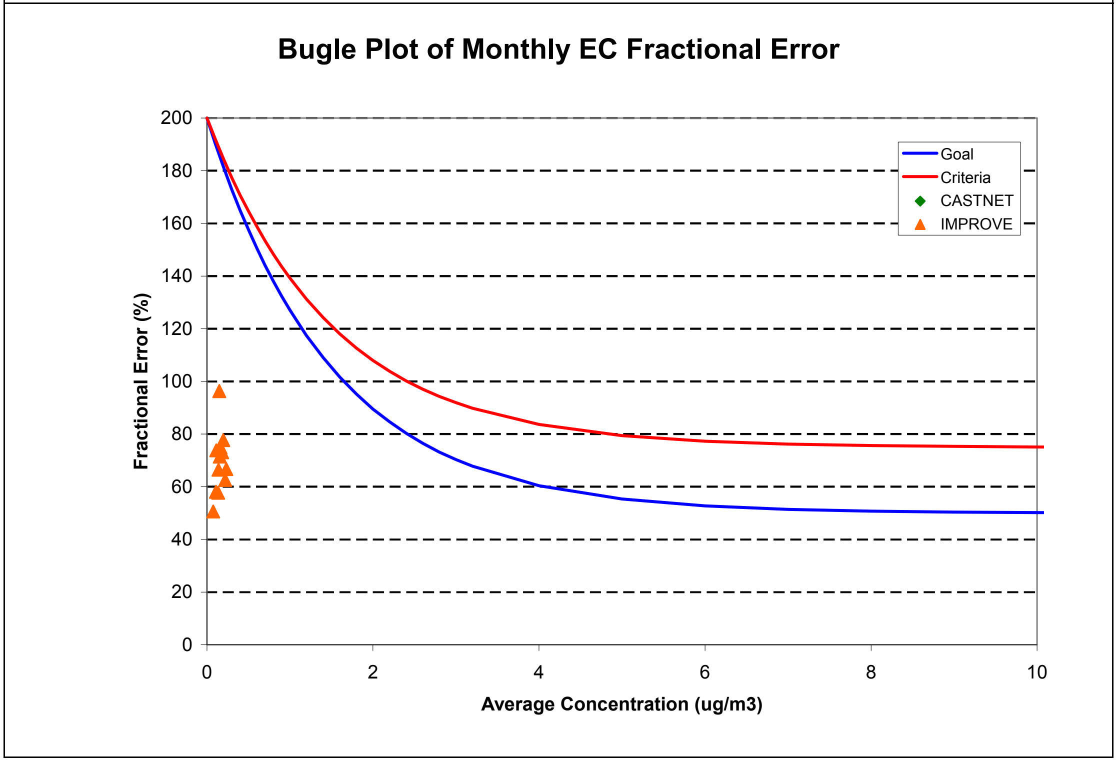
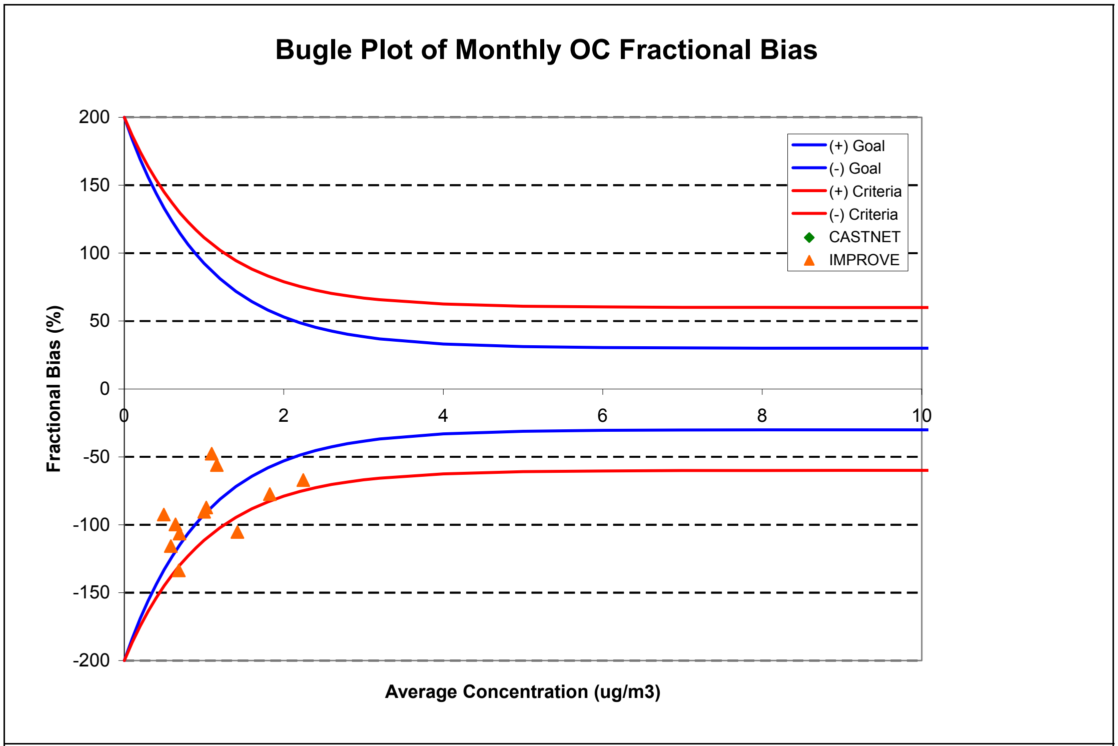


Figure 7. Monthly Fractional Bias (Top) and Error (Bottom) for Organic Carbon by Site Relative to Monthly-Mean Observations and to RPO Performance Goals and Criteria



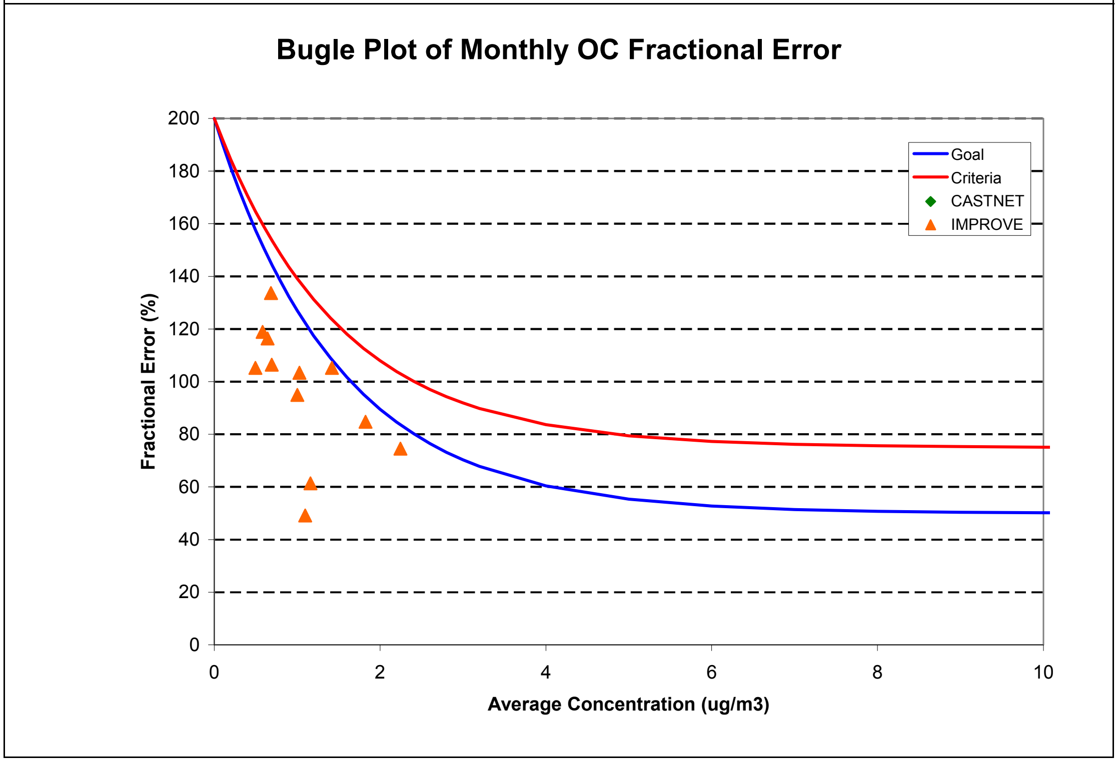
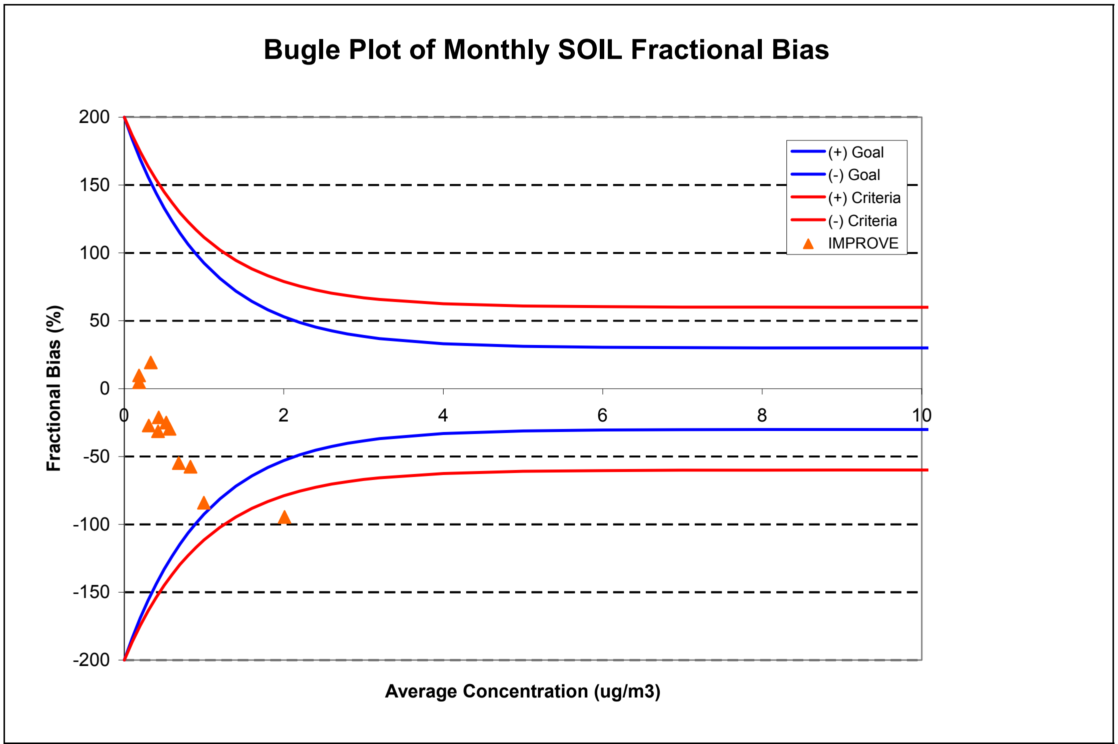


Figure 8. Monthly Fractional Bias (Top) and Error (Bottom) for Soil by Site Relative to Monthly-Mean Observations and to RPO Performance Goals and Criteria



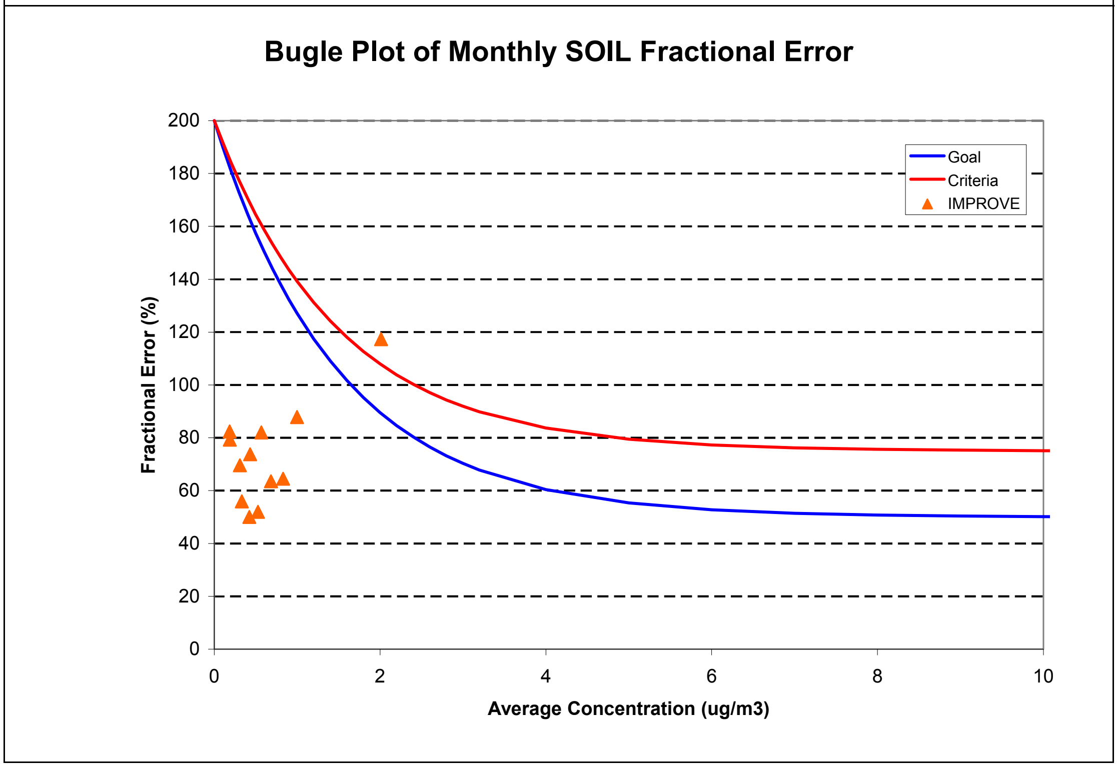
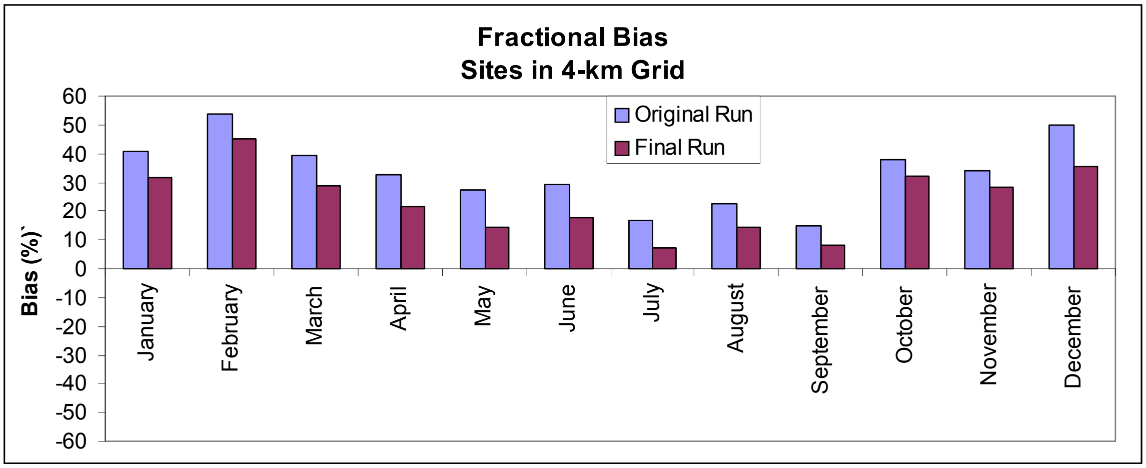


Figure 9. Monthly Mean Fractional Bias for Ozone Monitoring Sites in the 4 Km Domain (Top) and 12 Km Domain (Bottom)



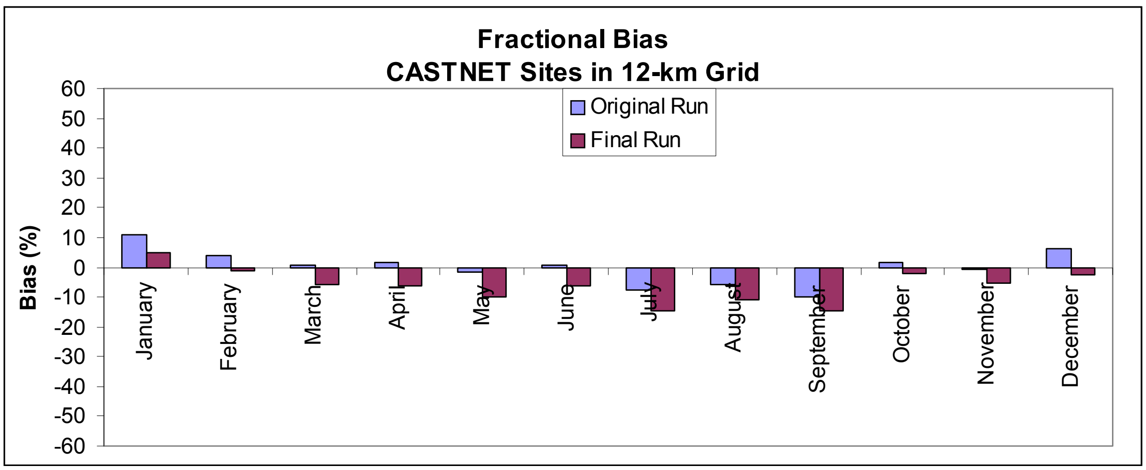


Figure 10. Monthly Mean Gross Bias (Top) and Error (Bottom) for Ozone Monitoring Sites in the 4 Km Domain.

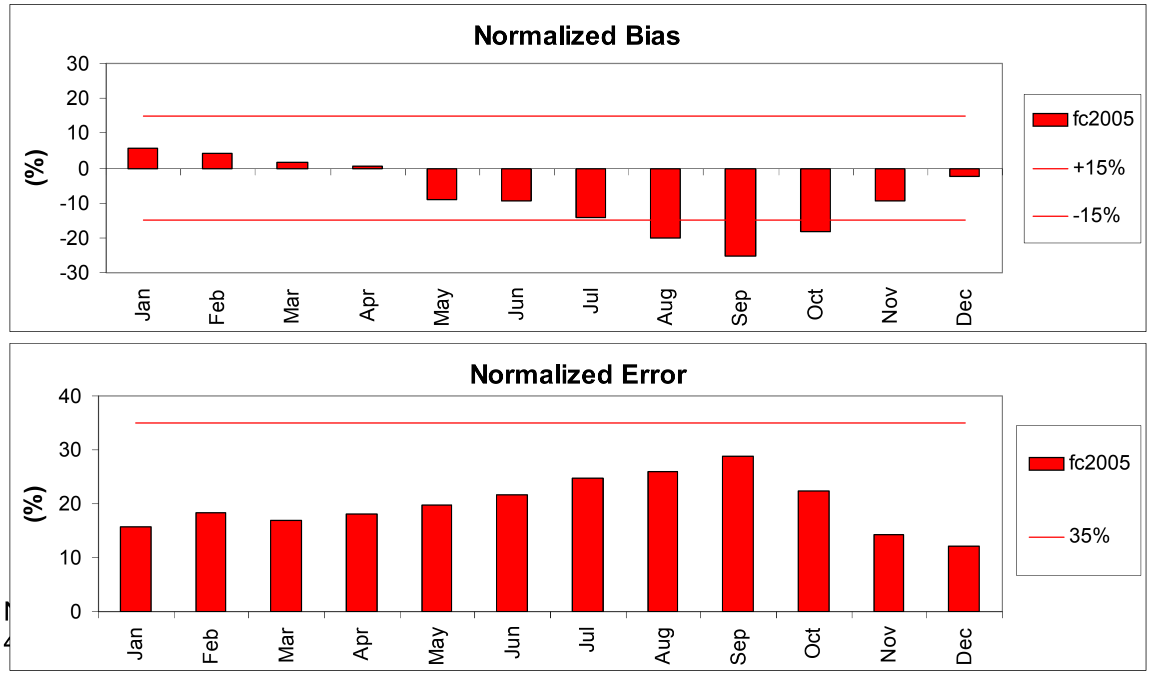
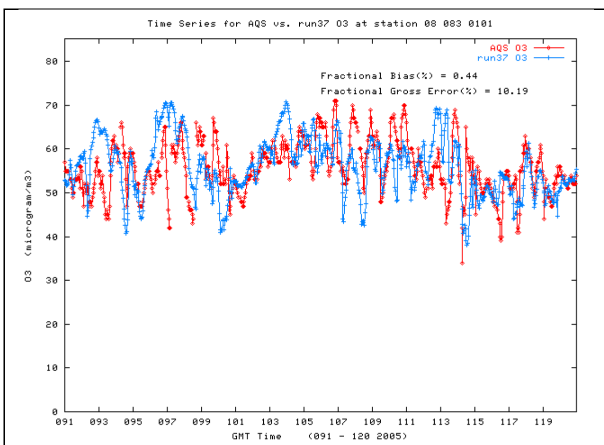
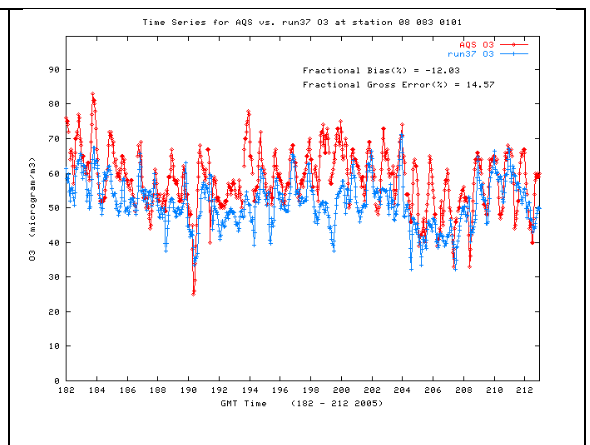


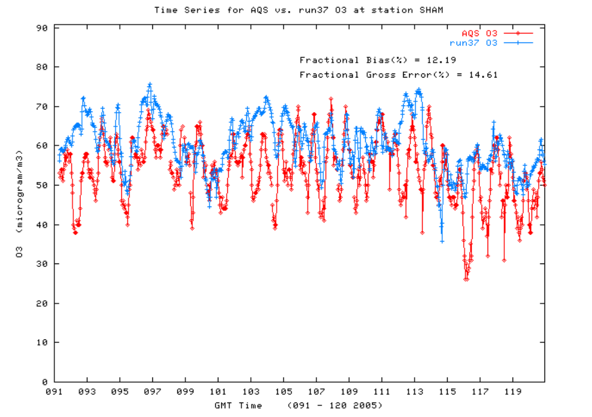
Figure 11. Ozone Time Series from Each Monitoring Location in the 4-Km Domain and Associated CAMX Prediction for the Months of April (Left) and July (Right), 2005



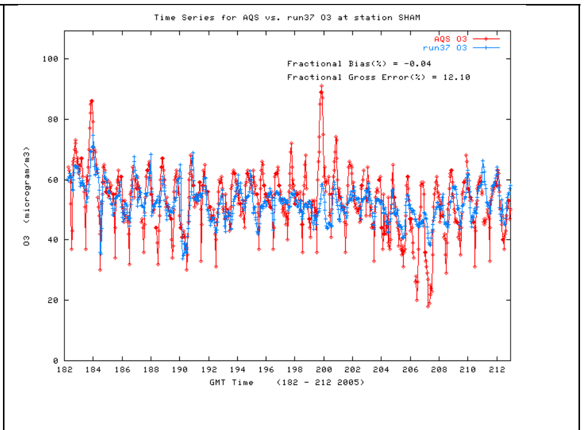
Mesa Verde: April



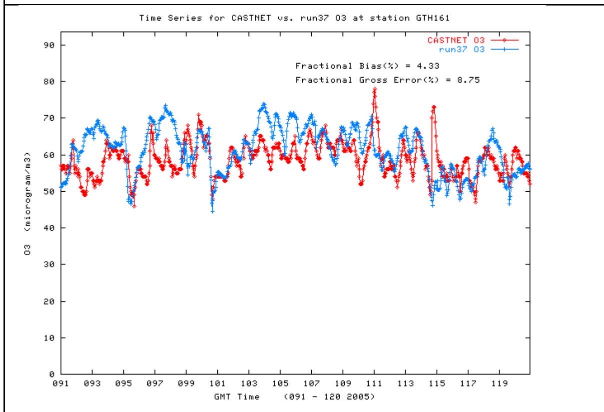
Mesa Verde: July



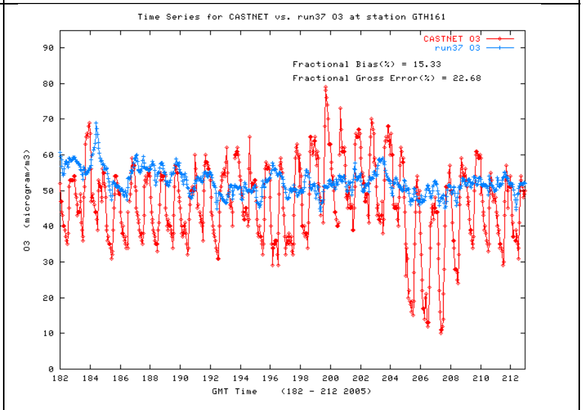
Shamrock: April



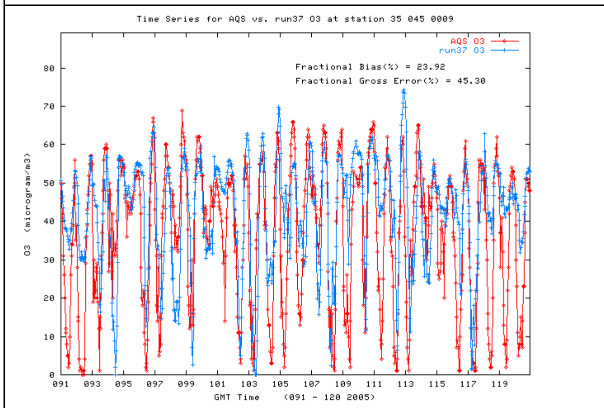
Shamrock: July



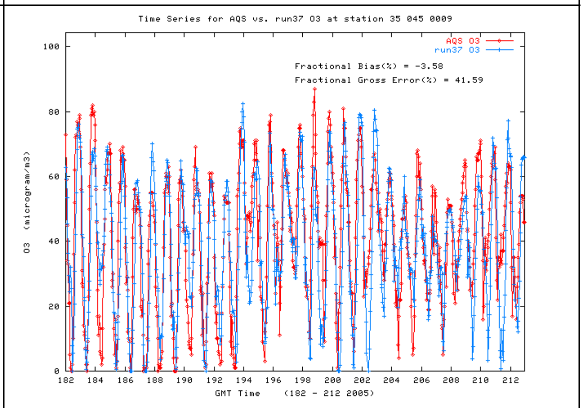
Gothic: April



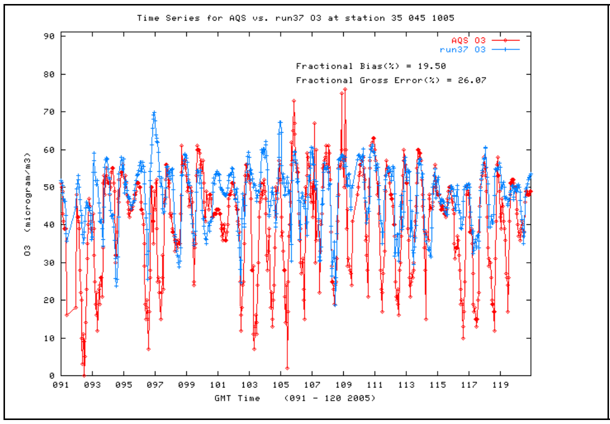
Gothic: July



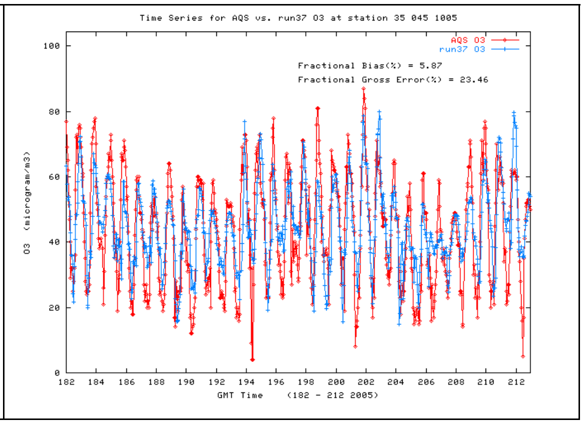
San Juan 0009: April



San Juan 0009: July



Time Series for AQS vs. run37 O3 at station 35 045 1005
AQS O3
run37 O3
Fractional Bias(%) = 19.50
Fractional Gross Error(%) = 26.07
O3 (microgram/m3)
GMT Time (091 - 120 2005)



Time Series for AQS vs. run37 O3 at station 35 045 1005
AQS O3
run37 O3
Fractional Bias(%) = 5.87
Fractional Gross Error(%) = 23.46
O3 (microgram/m3)
GMT Time (182 - 212 2005)