COLORADO AIR RESOURCE MANAGEMENT MODELING STUDY (CARMMS) WITH UPDATED MANCOS SHALE MODELING:

2021 MODELING RESULTS FOR THE HIGH, LOW AND MEDIUM OIL AND GAS DEVELOPMENT SCENARIOS

CARMMS 1.5
Final Report

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CONTENTS

TABLES

FIGURES

APPENDICES

Appendix E: Mancos Shale Oil and Gas Emission Calculator Documentation

ATTACHMENTS

1.0 INTRODUCTION

1.1 Background

The Bureau of Land Management (BLM) is developing new Resource Management Plans (RMPs) for several Field Offices in Colorado. The approved RMP and Record of Decision (ROD) for the Grand Junction Field Office (GJFO) were released on August 24, 2015[1]. In September 2013, a draft RMP and Environmental Impact Statement (EIS) for the Dominguez-Escalante National Conservation Area (D-E NCA) was released[2]. The draft RMP for the Uncompahgre Field Office (UFO[3]), the Eastern Colorado RMP under the Royal Gorge Field Office (RGFO[4]), and the Roan Plateau Planning Area Supplemental Environmental Impact Statement (SEIS[5]) are all underway. As part of these RMPs, BLM is estimating the air quality (AQ) and air quality related value (AQRV) impacts due to the projected BLM-authorized mineral development activities. The analysis includes the cumulative AQ and AQRV impacts due to all Reasonable Foreseeable Development (RFD) sources in the region. In the past, individual RMPs have generally performed their own AQ/AQRV analysis for a long-term year (e.g., 20 years out) when the maximum RMP development is projected to occur. This has resulted in inefficiencies and potential inconsistencies in the RMP's AQ/AQRV analysis and a possibility for a failure to adequately assess the effects of cumulative development across all BLM planning areas on AQ/AQRV in the region. In addition, making emissions projections for such a long-term future year results in increased uncertainties and may create potential inconsistencies in the RMP planned and actual development activities. Thus, the BLM GJFO RMP Air Resource Management Plan (ARMP[6]) contains a commitment to perform a unified regional air quality modeling study to address the AQ/AQRV impacts due to development activities within the GJFO planning area as well as all of BLM Colorado's development activities for a short-term year approximately 10 years in the future.

To address this commitment, the BLM previously conducted the Colorado Air Resource Management Modeling Study (CARMMS) (referred to hereafter as CARMMS 1.0) wherein the AQ and AQRV impacts of High, Medium and Low oil and gas (O&G) development emissions, mining and other cumulative sources in 2021 were modeled by Ramboll Environ US Corporation (Ramboll Environ) under sub-contract to Environmental Management Planning and Solutions Inc. (EMPSi). The final CARMMS 1.0 report under this contract entitled "Colorado Air Resource Management Modeling Study (CARMMS), 2021 Modeling Results for the High, Low and Medium Oil and Gas Development Scenarios" (ENVIRON et al., 2015) and associated attachments are available on the BLM website[7] as of January 2015.

[1] http://www.blm.gov/co/st/en/fo/gjfo/rmp/rmp.html
[2] http://www.blm.gov/co/st/en/nca/denca/denca_rmp.html
[3] http://www.blm.gov/co/st/en/fo/ufo/uncompahgre_rmp.html
[4] http://www.blm.gov/pgdata/etc/medialib/blm/co/field_offices/royal_gorge_field/oil_and_gas.Par.16932.File.dat/RoyalGorgeFinal_RFD_August_2012%20web.pdf
[5] http://www.blm.gov/co/st/en/BLM_Programs/land_use_planning/rmp/roan_plateau.html
[6] http://www.blm.gov/pgdata/etc/medialib/blm/co/field_offices/grand_junction_field/Draft_RMP/appdx.Par.47942.File.dat/AppdxG_Draft%20GJFO%20Air%20Plan_508.pdf
[7] http://www.blm.gov/co/st/en/BLM_Information/nepa/air_quality/carmms.html

During CARMMS, the BLM Colorado State Office (COSO) convened an Interagency Air Quality Review Team (IAQRT) that consists of U.S. Environmental Protection Agency (EPA) Region 8, Colorado Department of Health and Environment (CDPHE) Air Pollution Control Division (APCD), National Park Service (NPS), Fish and Wildlife Service (FWS) and United States Forest Service (USFS) to review and comment on the CARMMS Modeling Protocol in accordance with the June 23, 2011 Memorandum of Understanding (MOU[8]) between the United States Department of Interior (USDOI), United States Department of Agriculture (USDA) and United States Environmental Protection Agency (EPA) on procedures for assessing the AQ and AQRV impacts due to on-land oil and gas development activities on Federal lands under the National Environmental Policy Act (NEPA). With the addition of the BLM New Mexico Farmington Field Office (NMFFO) Mancos Shale development to CARMMS as discussed below, the IAQRT was expanded to include EPA Region 6 and the New Mexico Environmental Department (NMED).

The BLM New Mexico State Office (NMSO) was preparing a RMP for oil and gas development within the Mancos Shale development area in north-western New Mexico that resides primarily within the BLM NMFFO. Given that the Mancos Shale development area is adjacent to some of the Colorado BLM Planning Areas and is within the CARMMS modeling domain, the BLM decided to add the Mancos Shale oil and gas development area to the CARMMS analysis.

Kleinfelder, Inc. (Kleinfelder) and subcontractor, Ramboll Environ, responded to BLM's Performance Work Statement regarding "Ozone and Far-Field Air Quality and AQRV Assessment of the Mancos Shale Oil Development through Expansion of the West CARMMS" and submitted a Proposal and Cost Sheet dated March 7, 2014 which was approved by BLM Call Order No L14BP00246 under Blanket Purchase Agreement (BPA) Contract No. L12PA00050. The March 7, 2014 Work Order (labelled Modification 0002) added the Mancos Shale O&G development AQ and AQRV impact assessment to CARMMS; this assessment has been described in the CARMMS 1.0 report.

The current study builds upon the CARMMS 1.0 analysis in four major areas:

1. At the time modeling was initiated for CARMMS 1.0, only the Mancos Shale 2021 High Development scenario emissions were available, so they were used in the original CARMMS 2021 Low development scenario. Modification 0003 to BLM Call Order No L14BP00246 added the evaluation of the 2021 Low Development scenario using the new Mancos Low Development emissions inventory. Also, an error was identified in the CARMMS 1.0 ozone calculations, so those are redone in CARMMS 1.5 for the Low, Medium and High Development scenarios. More information may be found in Section 4.1.1.

2. Modification 0003 also added an assessment of the impact of ozone precursor emissions with respect to the new October 2015 ozone National Ambient Air Quality Standard (NAAQS) of 0.070 ppm.

3. In addition to the analyses required under Modification 0003, the BLM recently (December 2015) identified a need to provide analyses of indirect impacts of oil and gas and coal-

[8] http://www.epa.gov/compliance/resources/policies/nepa/air-quality-analyses-mou-2011.pdf

related projects in Colorado and New Mexico. The AQ and AQRV contributions of coal, oil and gas-fired Electrical Generating Units (EGUs) are assessed in the current study.

4. Excessive primary sulfate emissions were identified in the EPA mining $PM_{2.5}$ speciation profile that was applied to Colorado mines in the CARMMS 1.0 study. This resulted in an over-estimation of sulfur deposition and visibility impacts due to Colorado mines. A more appropriate $PM_{2.5}$ speciation profile for mining emissions, with lower primary sulfate and correspondingly higher primary ("other") $PM_{2.5}$, is applied in the current study.

Although O&G emissions in the current study differ from CARMMS 1.0 only in the Low Development scenario, new analyses are also required for the High and Medium Development scenarios for the reasons mentioned in items #2 to #4 above.

For convenience and to allow for easy distinction from CARMMS 1.0, the current CARMMS/Mancos study is referred to as CARMMS 1.5 hereafter in this report. As discussed in Section 4, although only the Mancos Low Development Scenario was re-run in CARMMS 1.5, AQ and AQRV analyses were performed again for the High, Low and Medium Development Scenarios because of the other three changes between 1.0 and 1.5 described above.

The CARMMS 1.0 also included current year 2008 base case modeling and model performance evaluation as well as a description of model inputs. Those results, inputs descriptions and other items that do not change from 1.0 are reproduced in the current report to make this a stand-alone document. Thus, the CARMMS 1.0 report and attachments are completely superseded by the current CARMMS 1.5 report and attachments.

1.2 Purpose

This document presents the 2021 modeling results for the CARMMS High, Low and Medium Development Scenarios source apportionment modeling including the Mancos Shale O&G development emission updates and the other three updates mentioned above, collectively referred to as CARMMS 1.5. Presented are the individual AQ and AQRV impacts due to O&G development on Federal lands within 13 separate Colorado BLM planning areas and the NMFFO Mancos Shale development area as well as the combined assessment of O&G development on Federal and non-Federal lands. In addition, the AQ and AQRV impacts due to mining within the 13 Colorado BLM planning areas and all O&G development within the 4 km CARMMS domain is presented. The 2021 modeling results are compared against NAAQS and State Ambient Air Quality Standards (SAAQS) throughout the 4 km modeling domain. The contributions of O&G development to AQ and AQRV at Class I and sensitive Class II areas are presented and compared to PSD increment concentrations and visibility and deposition thresholds of concern. The contributions of coal-fired and oil/gas-fired EGUs to AQ and AQRV impacts are also presented.

1.3 Overview of Modeling Approach

A photochemical grid model (PGM) is used in CARMMS to assess the AQ and AQRV impacts associated with BLM-authorized mineral development on Federal lands within BLM Colorado and the New Mexico Farmington Field Office Planning Areas. CARMMS does not assess the near-source AQ impacts of the O&G and other development activities; that will be addressed at the Project level in the future. The development of a PGM database is quite resource-intensive. Thus, to the extent possible, CARMMS has leveraged two studies that have PGM modeling databases for the western states:

1. The West-wide Jump-start Air Quality Modeling Study (WestJumpAQMS) has performed meteorological, emissions and air quality modeling using a 36 km CONUS, 12 km WESTUS and 4 km Intermountain West modeling domains for the 2008 calendar year. Details on the WestJumpAQMS modeling approach, the PGM 2008 base case modeling and model performance evaluation are available on the WestJumpAQMS website[9] and contained within the WestJumpAQMS Modeling Protocol (ENVIRON, Alpine and UNC, 2013a[10]) and final report (ENVIRON, Alpine and UNC, 2013b[11]).

2. The Three-State Air Quality Study (3SAQS) used the WestJumpAQMS 2008 PGM modeling platform and included the development of a new PGM modeling database for the western U.S. and the 2011 calendar year. Year 2020 emissions scenario modeling was performed in the 3SAQS on the 36/12 CONUS/WESTUS domains using the 2008 modeling platform. A 2011 modeling platform was also developed and 2011 and 2020 emission scenario modeling was performed with the 2011 modeling platform. The 3SAQS 2011 modeling platform was not ready at the initiation of the current study.

For CARMMS, WestJumpAQMS developed a stand-alone 2008 4 km CAMx PGM modeling database for the CARMMS 4 km modeling domain shown in Figure 2-1. Boundary Conditions (BCs) for the 4 km CARMMS domain were obtained from a CAMx 2008 36/12 km simulation conducted by WestJumpAQMS. WestJumpAQMS has conducted a model performance evaluation for the WRF 2008 36/12/4 km meteorological simulation and the CAMx 2008 36/12/4 km base case simulation that are summarized for the CARMMS 4 km domain in, respectively, Appendices A and B with more details available on the WestJumpAQMS website[12].

The CARMMS CAMx modeling of the CARMMS 4 km modeling domain (Figure 2-1) for a 2021 future year emission scenario using the WestJumpAQMS 2008 meteorological inputs involved the following activities:

- Develop a 2021 Future Year emissions scenario using the CARMMS estimates of oil and gas and other mineral development within the Colorado and northern New Mexico BLM planning areas and the EPA/3SAQS 2020 emission estimates for all other source categories.
  - For O&G emissions in the western Colorado BLM Planning Areas, CARMMS developed emissions calculators (Appendix C) with data specific to each area. BLM COSO provided 2021 oil and gas activity projections for a High, Low and Medium Development Scenarios.

[9] http://www.wrapair2.org/WestJumpAQMS.aspx
[10] http://www.wrapair2.org/pdf/WestJumpAQMS_Modeling_Protocol_and_Source%20Apportionment_Design_FinalMay.pdf
[11] http://www.wrapair2.org/pdf/WestJumpAQMS_FinRpt_Finalv2.pdf
[12] http://www.wrapair2.org/WestJumpAQMS.aspx

- 2021 mining emissions within western Colorado BLM Planning Areas were also estimated using CARMMS emissions calculators (Appendix D). The EPA $PM_{2.5}$ emissions speciation profile for mining emissions was adjusted to remove the over-estimation of primary sulfate emissions from mining in Colorado (Section 3.7.1).
- O&G emissions for eastern Colorado BLM Planning Areas were developed in a study for the BLM Royal Gorge Field Office (RGFO) and provided by the BLM COSO.
- The CARMMS emissions calculators were adapted to estimate emissions for the Mancos Shale development area using information provided by the BLM NMFFO. In particular, the new Low Development inventory for Mancos Shale was applied (Section 3.2.2 and Appendix E).
- O&G emissions for the Uinta Basin were developed for the Air Resource Management Study (ARMS) and were provided by the BLM Utah State Office (UTSO).
- O&G emissions for the Wyoming were based on recent future year emission developed for the BLM Wyoming State Office (WYSO) Continental Divide-Creston Draft EIS[13] modeling.
- O&G emissions for the remainder of the region were based on recent 2020 emission projections developed by the Three State Air Quality Study (3SAQS)
- Future year anthropogenic emissions for the remainder of the source categories were based on a 2020 emissions inventory developed by EPA for the $PM_{2.5}$ NAAQS rulemaking and updated by 3SAQS.
- Future year emissions for biogenic sources, fires, windblown dust, sea salt and lightning were kept constant at 2008 levels and were based on the WestJumpAQMS.

* The future year emissions were processed using the SMOKE emissions model to generate 2020/2021 emissions for the WestJumpAQMS 36/12 km domain and 4 km CARMMS domain.
* CAMx modeling was performed for the 36/12 km domains and the 2020/2021 emissions scenario using the 2008 WestJumpAQMS modeling platform.
* 2020/2021 Boundary Condition (BC) inputs for the CARMMS 4 km modeling domain were generated using output from the 36/12 km CAMx model simulation for the 2020/2021 emissions scenario using the 2008 WestJumpAQMS 2008 meteorological inputs.
* CAMx ozone and particulate matter source apportionment simulations were performed for the 2021 High, Low and Medium Development Scenarios and 4 km CARMMS modeling domain using the 2008 CARMMS modeling platform.
    - The CAMx 2021 4 km CARMMS domain source apportionment output for the High, Low and Medium Development Scenarios were post-processed to obtain the separate AQ and AQRV impacts due to mineral development activities on Federal lands within the BLM New Mexico FFO planning area and each of the 13 Colorado BLM planning areas.

[13] http://www.blm.gov/wy/st/en/info/NEPA/documents/rfo/cd_creston.html

- The CAMx 2021 High, Low and Medium O&G Development Scenarios output was also post-processed to obtain the cumulative AQ and AQRV impacts due to mineral development on Federal and non-Federal lands within the BLM New Mexico FFO planning area and 13 BLM planning areas in Colorado as well as O&G development throughout the CARMMS 4 km modeling domain.
- Additional CAMx emission source apportionment groups were added for coal and oil/gas EGUs as follows: (1) coal-fired EGUs in Colorado and other states north of CO-NM border; (2) oil/natural gas EGUs in Colorado and states north of the CO-NM border; (3) coal-fired EGUs south of CO-NM border; and (4) oil/natural gas EGUs south of CO-NM border.

- The AQ and AQRV impacts of BLM-authorized oil and gas development on Federal lands within the BLM NMFFO and each BLM Colorado planning area and cumulative impacts across all planning areas for the 2021 High, Low and Medium Development Scenarios are summarized in this report.

1.4 Air Quality Standards and AQRV Thresholds

1.4.1 Federal and State Air Quality Standards and PSD Increments

EPA sets National Ambient Air Quality Standards NAAQS for six pollutants, which are called criteria air pollutants (CAPs). The CAPs are: ozone (O_3), nitrogen dioxide (NO_2), carbon monoxide (CO), suspended Particle Pollution (particulate matter with a mean aerodynamic diameter of less than or equal to 10 and 2.5 microns; PM_{10} and $PM_{2.5}$), sulfur dioxide (SO_2) and lead (Pb). States may also set their own ambient air quality standards, which must be as stringent as the NAAQS but may be more stringent.

Federal air quality regulations adopted and enforced by the states limit incremental emission increases to specific levels defined by the classification of air quality in an area. The Prevention of Significant Deterioration (PSD) Program is designed to limit the incremental increase of specific air pollutant concentrations above a legally defined baseline level. Incremental increases in PSD Class I areas are strictly limited, while increases allowed in Class II areas are less strict. PSD Class I and Class II increments are defined for NO_2, PM_{10}, $PM_{2.5}$ and SO_2. Note the PSD increments are project level thresholds, and are not an appropriate metric for reference against field office level impacts.

Table 1-1 summarizes the NAAQS, the Colorado Ambient and Quality Standards (CAAQS) and the New Mexico Ambient Air Quality Standards (NMAAQS). PSD Class I and Class II increments are also shown in Table 1-1.

Table 1-1. Applicable National and State Ambient Air Quality Standards and PSD concentration increments.

Pollutant/Averaging Time	NAAQS	CAAQS[13]	NMAAQS[14]	PSD Class I Increment[1]	PSD Class II Increment[1]
CO					
1-hour[2]	35 ppm	--	13.1 ppm	--	--
8-hour[2]	9 ppm	--	8.7ppm	--	--
NO_2					
1-hour[3]	100 ppb	--	--	--	--
24-hour	--	--	0.10 ppm	--	--
Annual[4]	53 ppb	--	0.05 ppm	2.5	25
O_3[15]					
8-hour[5]	0.070 ppm	--	--	--	--
PM_{10}					
24-hour[6]	150 µg/m^3	--	--	8	30
Annual[7]	--	--	--	4	17
$PM_{2.5}$					
24-hour[8]	35 µg/m^3	--	--	2	9
Annual[9]	12 µg/m^3	--	--	1	4
SO_2					
1-hour[10]	75 ppb	--	--		
3-hour[11]	0.5 ppm	700 µg/m^3	--	25	512
24-hour[12]	--	--	0.10 ppm	5	91
Annual[4]	--	--	0.02 ppm	2	20

1. The PSD demonstrations serve information purposes only and do not constitute a regulatory PSD increment consumption analysis.
2. No more than one exceedance per calendar year; for NMAAQS - No more than one exceedance per consecutive 12 months
3. 98th percentile, averaged over 3 year; for NMAAQS - not to be exceeded more than once over any 12 consecutive months
4. Annual mean not to be exceeded; for NMAAQS - arithmetic average over any four consecutive quarters not to be exceeded
5. Fourth-highest daily maximum 8-hour ozone concentrations in a year, averaged over 3 years
6. Not to be exceeded more than once per calendar year on average over 3 years.
7. 3 year average of the arithmetic means over a calendar year
8. 98th percentile, averaged over 3 years
9. Annual mean, averaged over 3 years, NAAQS promulgated December 14, 2012
10. 99th percentile of daily maximum 1-hour concentrations in a year, averaged over 3 years
11. No more than one exceedance per calendar year (secondary NAAQS) and no more than one exceedance in 12 consecutive months (CAAQS)
12. For areas in New Mexico not within 3.5 miles of the Chino Mines Company
13. http://www.colorado.gov/cs/Satellite/CDPHE-Main/CBON/1251601911433
14. http://www.nmcpr.state.nm.us/nmac/parts/title20/20.002.0003.htm
15. Finalized on October 1, 2015.

1.4.2 Air Quality Related Value (AQRV) Thresholds

The impacts of each BLM authorized oil and gas and other activities within each BLM Planning area, as well as cumulative impacts of all activities together, at Class I and sensitive Class II areas will be assessed for three AQRVs: visibility, deposition and acid neutralizing capacity (ANC). The June 23, 2011 MOU between EPA, USDOI and USDA states that the project and cumulative AQRV impacts at Class I and sensitive Class II areas should be assessed by comparing against thresholds of concern defined by the Federal Land Manager (FLM) for the given Class I or sensitive Class II area in question. In the CARMMS first draft Modeling Protocol and at the October 30, 2013 meeting with the Interagency Air Quality Review Team (IAQRT) we presented the following threshold of concern for AQRVs in Class I and sensitive Class II areas and there were no disagreements in the comments received from the IAQRT:

- Visibility impacts for BLM-authorized oil and gas sources within each BLM Planning Area are assessed using the FLAG (2010) procedures that use the new IMPROVE equation, annual average natural visibility background and monthly relative humidity adjustment factors [f(RH)] (see Section 4.6.1). The visibility impacts from mineral development on Federal lands within each separate BLM planning area are compared against a 0.5 and 1.0 change in deciview (dv) haze index threshold of concern and any exceedances will be reported. Please note the dv thresholds are project level thresholds, and not an appropriate metric to reference against field office level or cumulative impacts.
- Cumulative sources visibility impacts from multiple BLM Planning Areas are assessed using a new visibility approach and metrics developed by the FLMs based on the regional haze rule visibility metrics for the best and worst 20% visibility days as discussed in Section 4.6.2.
- Acid deposition impacts due to mineral development on Federal lands within each separate BLM Planning Area for annual total sulfur (S) and total nitrogen (N) deposition are compared against the 0.005 kg/ha-yr Deposition Analysis Threshold (DAT) for the western states. Please note the DAT is a project level threshold, and not an appropriate metric to reference against field office level or cumulative impacts.
- Total N and S deposition impacts due to all emissions in the 2008 and 2021 emissions scenarios (i.e., cumulative) are compared to Critical Load values of 2.2 kg/ha-yr for N in Wyoming, 2.3 kg/ha-yr for N in Colorado except for Dinosaur National Monument where a 3.0 kg/ha-yr Critical Load value for N is used. For S, a 5.0 kg/ha-yr critical load value is used everywhere (see Section 4.7).
- The predicted annual deposition fluxes of sulfur and nitrogen at sensitive lake receptors due to Federal O&G development from individual BLM Planning Areas are used to estimate the change in ANC in accordance with the January 2000, USFS Rocky Mountain Region's Screening Methodology for Calculating ANC Change to High Elevation Lakes, User's Guide (USFS, 2000). The predicted changes in ANC are compared with the USFS's Level of Acceptable Change (LAC) thresholds of 10% for lakes with ANC values greater than 25 μeq/l and 1 μeq/l for lakes with background ANC values of 25 μeq/l and less (see Section 4.8). Please note the LAC is a project level threshold, and not an appropriate metric to reference against field office level or cumulative impacts.

2.0 CARMMS DATABASE DEVELOPMENT

2.1 Modeling System

The CARMMS 2008 modeling database was based on the WestJumpAQMS so the same modeling system was adopted. The justification for the model selection is given in the CARMMS Modeling Protocol (ENVIRON, Cater Lake and EMPSi, 2014). Table 2-1 lists the main models selected for the BLM CARMMS modeling with a brief summary of the reasons for their selection as follows:

- The WRF meteorological model was selected because it contains more recent updates and features compared to the MM5 alternative that is no longer supported by its developer.
- The SMOKE emissions model is the most current and up-to-date emissions modeling system and has performance improvements over the alternatives.
- The MOVES on-road mobile emissions modeling system is the recommended modeling system by the EPA.
- The MEGAN biogenic emissions model has been updated by WRAP specifically for simulating biogenic emissions in the western states.
- The CAMx PGM includes a source apportionment capability that is critically important for the CARMMS and was not available in the version of CMAQ PGM alternative at the time the study was initiated.

Table 2-1. Summary of models selected for the BLM CARMMS modeling*.

Model Type	Selected Model
Meteorological Model	Weather Research Forecasting (WRF)
Emissions Model	Sparse Matrix Operator Kernel Emissions (SMOKE)
Emissions Model – On Road Sources	Motor Vehicle Emissions Simulator (MOVES2010)
Emissions Model – Biogenic Sources	Model for Emissions of Gases and Aerosols in Nature (MEGAN)
Photochemical Grid Model	Comprehensive Air-quality Model with extensions (CAMx)

* See descriptions below for more information on the models used

2.2 Episode Selection

Since the CARMMS will need to address annual average air quality issues (e.g., $PM_{2.5}$) and deposition issues, a full year is selected for modeling. Due to computational requirements and resource constraints, a single meteorological baseline year will be modeled. The entire 2008 calendar year was selected for the CARMMS modeling because it satisfied the most episode selection criteria of recent years:

1. The entire 2008 calendar year includes a variety of meteorological conditions. The year appears to have higher than average photochemical production potential so was not an atypical low year for secondary ozone and PM formation.

2. 2008 had observed ozone and $PM_{2.5}$ concentrations that were close to and even above the ozone and $PM_{2.5}$ Design Values in Colorado.

3. The 2008 year did not include any special study data in Colorado. Note that enhanced monitoring of the Front Range region and vicinity was collected for the summer of 2014, but that was after most of the CARMMS modeling was completed.

4. By modeling a full year (366 days) there should be sufficient number of days to calculate Relative Response Factors (RRFs) following EPA's guidance document (EPA, 2007).

5. The 2008 calendar year was already modeled as part of the Denver ozone modeling and in the WestJumpAQMS and 3SAQS. In particular, the ability to leverage the CARMMS database development off of WestJumpAQMS is critical to the success of the study.

6. The entire 2008 calendar year dataset includes both weekdays and weekend days.

7. Of the recent years, 2008 fulfils more of the episode selection criteria than other recent years available at the time the project was initiated.

2.3 CARMMS Modeling Domains

To leverage modeling data from other studies, the CARMMS adopted the so-called RPO Lambert projection that uses a longitude/latitude origin at (-97, 40) and standard latitude parallels of 33 and 45 degrees. Figure 2-1 displays the 4 km modeling domain used in the CARMMS emissions and photochemical modeling. An initial 4 km modeling domain was identified by including all Class I areas for which any part of the Class I area is within 200 km of a western Colorado BLM Field Office Planning Area. While developing the Modeling Protocol, the BLM New Mexico State Office (NMSO) indicated that they would like to include their Mancos Shale Oil development in the CARMMS modeling. The Mancos Shale Oil development area would be within the New Mexico BLM Farmington Field Office area, but would primarily reside in San Juan County with portions potentially stretching into neighboring Rio Arriba, Sandoval and McKinley Counties. Thus, the CARMMS 4 km domain was extended southward to include all Class I areas within 300 km of the Mancos Shale development area.

Figure 2-1 also shows the Class I areas throughout the domain that were analyzed for air quality and AQRV impacts. More details on the Class I and sensitive Class II areas where the AQ and AQRV impacts due to oil and gas and other activities within the BLM planning areas will be assessed are given in Chapter 4.

The CAMx vertical domain definitions will depend on the definition of the WRF vertical layer structure. WRF was run with 37 vertical levels (36 vertical layers using CAMx definition of layer thicknesses) from the surface up to 50 mb (~19-km high above mean sea level) (ENVIRON and Alpine, 2012[14]). The WRF model employs a terrain following coordinate system defined by pressure, using multiple layers that extend from the surface to 50 mb (approximately 19 km above mean sea level). CARMMS is adopting the same layer collapsing strategy as used by WestJumpAQMS whereby multiple WRF layers are combined into one CAMx layer to reduce the air quality model computational time. Table 2-2 displays the approach for collapsing the WRF 36 vertical layers to 25 vertical layers in CAMx for CARMMS and WestJumpAQMS. The WRF

[14] http://www.wrapair2.org/pdf/WestJumpAQMS_2008_Annual_WRF_Final_Report_February29_2012.pdf

layer collapsing scheme in Table 2-2 is collapsing two WRF layers into one CAMx/CMAQ layer for the lowest four layers in CAMx/CMAQ. In the past, the lowest layers of MM5/WRF were mapped directly into CAMx/CMAQ with no layer collapsing. However, in those applications the MM5/WRF layer 1 was much thicker (20-40 m) than used in this WRF application (12 m). Use of a 12 m lowest layer may trap emissions in a too shallow layer and may result in overstated surface concentrations. For example, NO_X emissions are caused by combustion so are buoyant and have plume rise that in reality could take them out of the first layer if it is defined too shallow.

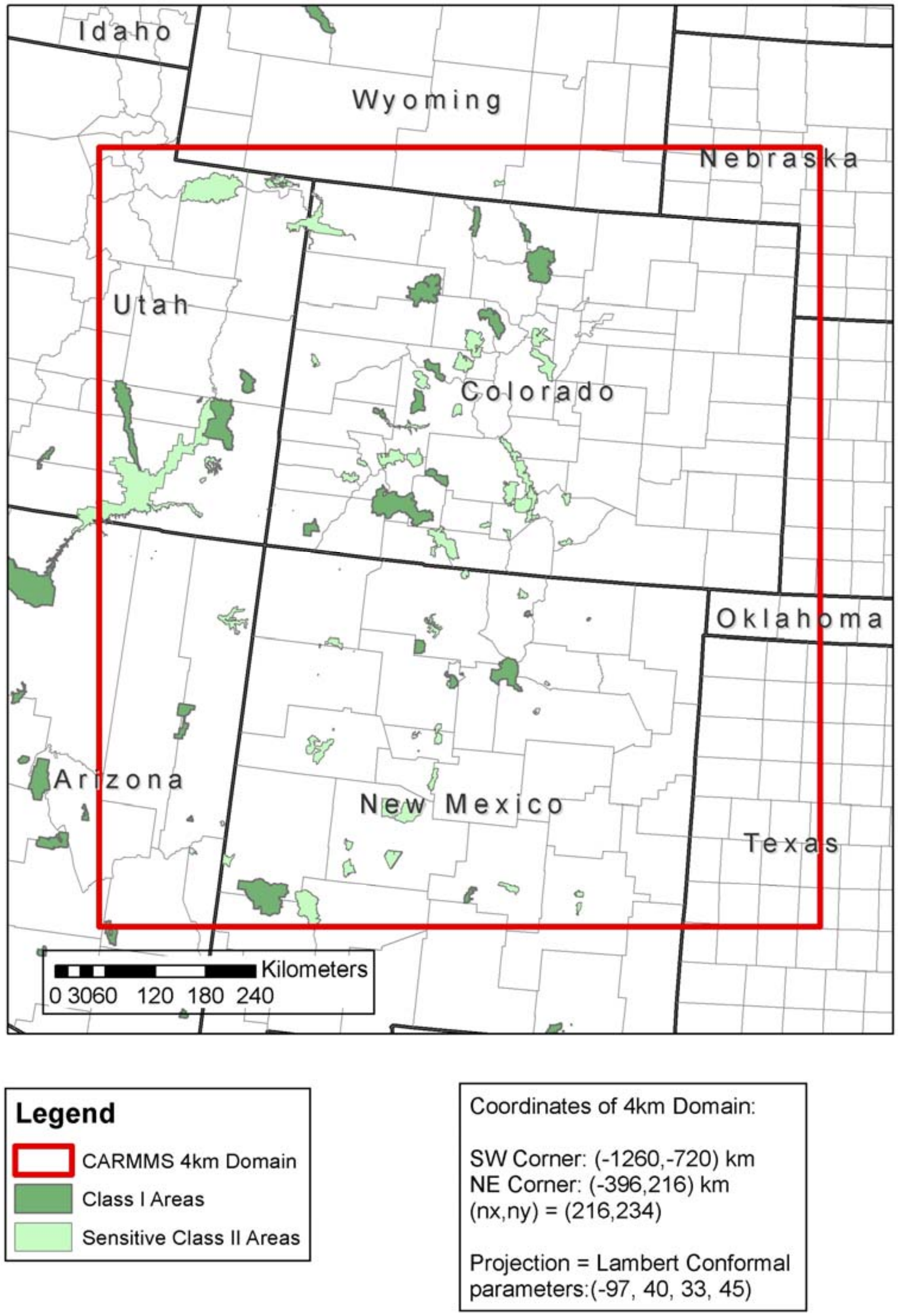

Figure 2-1. 4 km modeling domain used in the Colorado Air Resource Management Modeling Study (CARMMS).

Table 2-2. 37 Vertical layer interface definition for WRF simulations (left most columns), and approach for reducing to 25 vertical layers for CAMx by collapsing multiple WRF layers (right columns).

WRF Meteorological Model					CAMx Air Quality Model		
WRF Layer	Sigma	Pressure (mb)	Height (m)	Thickness (m)	CAMx Layer	Height (m)	Thickness (m)
37	0.0000	50.00	19260	2055	25	19260.0	3904.9
36	0.0270	75.65	17205	1850			
35	0.0600	107.00	15355	1725	24	15355.1	3425.4
34	0.1000	145.00	13630	1701			
33	0.1500	192.50	11930	1389	23	11929.7	2569.6
32	0.2000	240.00	10541	1181			
31	0.2500	287.50	9360	1032	22	9360.1	1952.2
30	0.3000	335.00	8328	920			
29	0.3500	382.50	7408	832	21	7407.9	1591.8
28	0.4000	430.00	6576	760			
27	0.4500	477.50	5816	701	20	5816.1	1352.9
26	0.5000	525.00	5115	652			
25	0.5500	572.50	4463	609	19	4463.3	609.2
24	0.6000	620.00	3854	461	18	3854.1	460.7
23	0.6400	658.00	3393	440	17	3393.4	439.6
22	0.6800	696.00	2954	421	16	2953.7	420.6
21	0.7200	734.00	2533	403	15	2533.1	403.3
20	0.7600	772.00	2130	388	14	2129.7	387.6
19	0.8000	810.00	1742	373	13	1742.2	373.1
18	0.8400	848.00	1369	271	12	1369.1	271.1
17	0.8700	876.50	1098	177	11	1098.0	176.8
16	0.8900	895.50	921	174	10	921.2	173.8
15	0.9100	914.50	747	171	9	747.5	170.9
14	0.9300	933.50	577	84	8	576.6	168.1
13	0.9400	943.00	492	84			
12	0.9500	952.50	409	83	7	408.6	83.0
11	0.9600	962.00	326	82	6	325.6	82.4
10	0.9700	971.50	243	82	5	243.2	81.7
9	0.9800	981.00	162	41	4	161.5	64.9
8	0.9850	985.75	121	24			
7	0.9880	988.60	97	24	3	96.6	40.4
6	0.9910	991.45	72	16			
5	0.9930	993.35	56	16	2	56.2	32.2
4	0.9950	995.25	40	16			
3	0.9970	997.15	24	12	1	24.1	24.1
2	0.9985	998.58	12	12			
1	1.0000	1000	0			0	

2.4 Meteorological Modeling Approach

The CARMMS meteorological inputs for the CAMx modeling are based on the WRF modeling performed as part of the WestJumpAQMS. The WRF computational domains were defined to be slightly larger than the CAMx and SMOKE modeling domains to eliminate the occurrence of boundary artifacts in the CAMx meteorological inputs. Such boundary artifacts can occur when the boundary conditions (BCs) for the meteorological variables come into dynamic balance with WRF's atmospheric equations and numerical methods.

The WRF model contains many different physics options, and achieving the best model performance for any particular year and region is accomplished by performing model sensitivity tests using different options. As part of the post-2008 Denver ozone SIP modeling, Alpine Geophysics, LLC and ENVIRON conducted numerous WRF meteorological sensitivity simulations to determine the best performing configuration for simulating meteorology in the Inter-Mountain West region (Morris et al., 2011). The final WRF configuration was used for the 2008 Denver ozone modeling as well as for the WestJumpAQMS WRF modeling results that are used in CARMMS.

2.4.1 2008 WRF Modeling Methodology

The WestJumpAQMS 2008 WRF modeling methodology is described below. More details are provided in the WestJumpAQMS WRF Application/Evaluation report (ENVIRON and Alpine, 2012[15]).

Horizontal Domain Definition: The computational domain on which WRF was applied for WestJumpAQMS included a 36 km CONUS, 12 km WESTUS and 4 km Inter-Mountain West Domain (IMWD). The 4 km domain includes the 4 km CARMMS domain shown in Figure 2-1. The grid projection is Lambert Conformal with a pole of projection of 40 degrees North, -97 degrees East and standard parallels of 33 and 45 degrees, the RPO projection. The datum (size and shape of earth) is a perfect sphere with radius 6370.0 km.

Vertical Domain Definition: The WRF modeling was based on 37 vertical layers with an approximately 12 meter deep surface layer. The vertical domain is presented in both sigma and height coordinates in Table 2-2.

Topographic Inputs: Topographic information for WRF were developed using the standard WRF terrain databases. The 36 km domain is based on the 10 minute (18 km) global data. The 12 km domain is based on the 2 minute (~4 km) data. The 4 km domain is based on 30 second (~900 m) data.

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

Atmospheric Data Inputs: The first guess fields were taken from the 12 km North American Model (NAM) database.

[15] http://www.wrapair2.org/pdf/WestJumpAQMS_2008_Annual_WRF_Final_Report_February29_2012.pdf

Diffusion Options: Horizontal Smagorinsky first-order closure (km_opt = 4) with sixth-order numerical diffusion and suppressed up-gradient diffusion (diff_6th_opt = 2) were used.

Lateral Boundary Conditions: Lateral boundary conditions were specified from the initialization dataset (12 km NAM) on the 36 km domain with continuous updates nested from the 36 km domain to the 12 km domain and continuous updates nested from the 12 km domain to the 4 km domain, using one-way nesting (feedback = 0).

Top and Bottom Boundary Conditions: The top boundary condition was selected as an implicit Rayleigh dampening for the vertical velocity. Consistent with the model application for non-idealized cases, the bottom boundary condition was selected as physical, not free-slip.

Water Temperature Inputs: The water temperature data were taken from the National Centers for Environmental Prediction (NCEP) Real Time Global (RTG) global one-twelfth degree analysis[16].

FDDA Data Assimilation: The WRF model was run with a combination of analysis and observation nudging (i.e., Four Dimensional Data assimilation [FDDA]). Analysis nudging was used on the 36 km and 12 km domain using the 12 km NAM dataset. For winds and temperature, analysis nudging coefficients of $5x10^{-4}$ and $3.0x10^{-4}$ were used on the 36 km and 12 km domains, respectively. For mixing ratio, an analysis nudging coefficient of $1.0x10^{-5}$ was used for both the 36 km and 12 km domains. The nudging uses both surface and aloft nudging with nudging for temperature and mixing ratio not performed in the lower atmosphere (i.e., within the boundary layer and at the surface). Observation nudging was performed on the 4 km grid domain using the Meteorological Assimilation Data Ingest System (MADIS)[17] observation archive. The MADIS archive includes the National Climatic Data Center (NCDC)[18] observations and the National Data Buoy Center (NDBC) Coastal-Marine Automated Network C-MAN[19] stations. The observational nudging coefficients for winds, temperatures and mixing ratios were $1.0x10^{-4}$, $1.0x10^{-4}$, and $1.0x10^{-5}$, respectively and the radius of influence was set to 50 km.

Physics Options: The WRF model contains many different physics options. The physics options chosen for the WestJumpAQMS application are presented in Table 2-3.

Application Methodology: The WRF model was executed in 5½ day blocks initialized at 12Z every 5 days. Model results were output every 60 minutes. The first twelve (12) hours of each 5 ½ day block is used for model spin-up and not used in the PGM model inputs or in the WRF model performance evaluation. WRF was configured to run in distributed memory parallel mode.

[16] Real-time, global, sea surface temperature (RTG-SST) analysis. http://polar.ncep.noaa.gov/sst/oper/Welcome.html
[17] Meteorological Assimilation Data Ingest System. http://madis.noaa.gov/
[18] National Climatic Data Center. http://lwf.ncdc.noaa.gov/oa/ncdc.html
[19] National Data Buoy Center. http://www.ndbc.noaa.gov/cman.php

Table 2-3. Physics options used in the WestJumpAQMS WRF 2008 simulation modeling.

WRF Treatment	Option Selected	Notes
Microphysics	Thompson scheme	New with WRF 3.1.
Longwave Radiation	RRTMG	Rapid Radiative Transfer Model for GCMs includes random cloud overlap and improved efficiency over RRTM.
Shortwave Radiation	RRTMG	Same as above, but for shortwave radiation.
Land Surface Model (LSM)	NOAH	Two-layer scheme with vegetation and sub-grid tiling.
Planetary Boundary Layer (PBL) scheme	YSU	Yonsie University (Korea) Asymmetric Convective Model with non-local upward mixing and local downward mixing.
Cumulus parameterization	Kain-Fritsch in the 36 km and 12 km domains. None in the 4 km domain.	4 km can explicitly simulate cumulus convection so parameterization not needed.
Analysis nudging	Nudging applied to winds, temperature and moisture in the 36 km and 12 km domains	Temperature and moisture nudged above PBL only.
Observation Nudging	Nudging applied to surface wind only in the 4 km domain	Surface temperature and moisture observation nudging can introduce instabilities.
Initialization Dataset	12 km North American Model (NAM)	Also used in analysis nudging

2.4.2 Meteorological Model Performance Evaluation

The WestJumpAQMS performed a comprehensive and detailed model performance evaluation of the 2008 WRF 36/12/4 km model simulation. The WestJumpAQMS WRF model performance evaluation is documented in a WRF Application/Evaluation report that is available on its website (ENVIRON and Alpine, 2012[20]). The WRF evaluation consisted of the following:

- Evaluation against surface meteorological observations of wind direction, wind speed, temperature and water vapor mixing ratio (humidity) with monthly performance statistics calculated using the METSTAT program:
  - Surface meteorological performance statistics were calculated across the 36 km CONUS, 12 km WESTUS and 4 km Inter-Mountain West domains, across each individual western state and at individual monitoring sites within each western state, including Colorado[21] that is the main focus of the CARMMS.
  - The surface meteorological model performance statistics were compared against model performance evaluation benchmarks in order to help interpret the WRF model performance and compare it with other studies that were used to develop the benchmarks. The 2008 WRF model performance was compared against both the

[20] http://www.wrapair2.org/pdf/WestJumpAQMS_2008_Annual_WRF_Final_Report_February29_2012.pdf

[21] http://www.wrapair2.org/pdf/westjump.wrf.site.co.2012-04-04.pdf

simple (simple terrain and/or simple meteorological conditions) and complex (complex terrain and/or more complex meteorological conditions) model performance benchmarks.

- The WRF 2008 precipitation estimates were compared with monthly analysis fields generated by the Climate Prediction Center (CPC) in a qualitative evaluation.

Appendix A summarizes some of the WestJumpAQMS WRF model performance evaluation products as they relate to WRF performance within the CARMMS 4 km modeling domain. The WestJumpAQMS 2008 WRF model performance within the CARMMS region is as good or better than meteorological model performance seen in past photochemical modeling studies of the region (e.g., WRAP regional haze modeling and Denver 2008 ozone State Implementation Plan modeling). Thus, the WestJumpAQMS 2008 WRF meteorological fields were judged to be appropriate for use in the CARMMS.

2.5 2008 Base Case Emissions

The 2008 Base Case emissions were developed by the WestJumpAQMS. The primary source for the 2008 Base Case emissions is Version 2.0 of the National Emissions Inventory (NEIv2.0[22]). For most source categories, the SMOKE emissions modeling system was used to process the emissions into the hourly gridded speciated emissions needed as input for CAMx. The comprehensive and detailed documentation for the WestJumpAQMS 2008 Base Case emissions inventory is available on the WestJumpAQMS website[23] and includes a final report (ENVIRON, Alpine and UNC, 2013) and 16 Emissions Technical Memorandums that provide details on the 2008 emissions for each source category as well as for the parameters used in the emissions modeling.

2.5.1 Source of 2008 Base Case Emissions

Table 2-4 summarizes the emission models and sources of 2008 Base Case emissions that are based primarily on the 2008 NEIv2.0 with the following enhancements:

- Major (≥25 MW) Electrical Generating Units (EGUs) point source SO_2 and NO_X emissions used Continuous Emissions Monitor (CEM) measurement data that are available online from the EPA Clean Air Markets Division (CAMD[24]). These data are hour-specific for SO_2, NO_x and heat input. The temporal variability of other pollutant emissions (e.g., PM) for the CEM sources were estimated using the hourly CEM heat input data to allocate the annual emissions from the NEIv2.0 to each hour of the year. Emissions, locations and stack parameters for point sources without CEM devices were based on the 2008 NEIv2.0.
- The WRAP-IPAMS Phase III 2006 oil and gas emission inventories were projected to 2008 for all Phase III basins that were available at the time of the WestJumpAQMS 2008 emissions development. In addition, under WestJumpAQMS new oil and gas emissions

[22] http://www.epa.gov/ttnchie1/net/2008inventory.html
[23] http://www.wrapair2.org/WestJumpAQMS.aspx
[24] http://www.epa.gov/airmarkets/

inventory was developed for the Permian Basin in southeastern New Mexico/northwestern Texas.

- On-road mobile source emissions were based on the MOVES2010[25] model with county-specific weekday and weekend day VMT and monthly meteorology for the 2008 base case modeling year.
- The WRAP windblown dust (WBD) model [26] was used to generate WBD emissions using day-specific hourly meteorology from the 2008 WRF simulation.
- Sea salt and lightning emissions were generated using the 2008 WRF model hourly gridded output.
- Emissions from fires (wildfires, prescribed burns and agricultural burning) are based on the 2008 fire emissions inventory developed in the Joint Fire Sciences Program (JFSP) Deterministic and Empirical Assessment of Smoke's Contribution to Ozone (DEASCO3[27]) study.
- Biogenic emissions were generated using an enhanced version of the Model of Emissions of Gases and Aerosols in Nature (MEGAN[28]) that was updated by WRAP to better represent biogenic emissions for the western states.
- Mexico emissions were based on the 2008 projections from the 1999 Mexico national emissions inventory.
- The Environment Canada 2006 emissions inventory based on the National Pollutant Release Inventory (NPRI) was used for Canada.
- New spatial surrogates for the emissions were developed using the latest 2010 Census and other data that are now available and includes population and housing statistics for 2010. Details on the new spatial surrogates used for allocating county-level emissions to the 4 km grid cells can be found in the WestJumpAQMS Emissions Technical Memorandum Number 13[29].

[25] http://www.epa.gov/otaq/models/moves/
[26] http://www.wrapair.org/forums/dejf/fderosion.html
[27] https://www.firescience.gov/projects/11-1-6-6/proposal/11-1-6-6_11-1-6_attachment_1_primary.pdf
[28] http://acd.ucar.edu/~guenther/MEGAN/MEGAN.htm
[29] http://www.wrapair2.org/pdf/Memo13_Parameters_Sep30_2013.pdf

Table 2-4. Summary of sources of emissions and emission models used to generate 2008 base case emissions for use in CARMMS.

Emissions Component	Configuration	Details
Model Code	SMOKE Version 3.1	http://www.smoke-model.org/index.cfm
Oil and Gas Emissions	Update WRAP Phase III 2006 to 2008	Seven WRAP Phase III Basins in CO, NM, UT and WY plus add 2008 Permian Basin O&G Emissions
Area Source Emissions	2008 NEI Version 2.0	Western state updates, then SMOKE processing of http://www.epa.gov/ttn/chief/net/2008inventory.html
On-Road Mobile Sources	MOVES2010	County specific emissions run for monthly weekday and weekend days. California based on EMFAC2011.
Point Sources	2008 CEM and Non-CEM Sources	Use 2008 day-specific hourly measured CEM for SO_2 and NO_X emissions for CEM sources, 2008 NEIv2.0 for other pollutants and non-CEM sources
Off-Road Mobile Sources	2008 NEIv2.0	Based on EPA NONROAD model http://www.epa.gov/oms/nonrdmdl.htm
Wind Blown Dust Emissions	WRAP Wind Blown Dust (WBD)	WRAP WBD Model with 2008 WRF meteorology adjusted to be consistent with 2002 WBD modeling
Ammonia Emissions	NEIv2.0	Based on CMU Ammonia Model. Review and update spatial allocation if appropriate.
Biogenic Sources	MEGAN	Enhanced version of MEGAN Version 2.1 from WRAP Biogenics study http://www.wrapair2.org/pdf/WGA_BiogEmisInv_FinalReport_March20_2012.pdf
Fires	2008 DEASCO3	2008 DEASCO3 fire inventory used. http://www.wrapair2.org/pdf/JSFP_DEASCO3_TechnicalProposal_November19_2010.pdf
Temporal Adjustments	Seasonal, day, hour	Based on latest collected information
Chemical Speciation	CB05 Chemical Speciation	CB6 considered but was too new at time study was initiated.
Gridding	Spatial Surrogates based on landuse	Develop new spatial surrogates using 2010 census data and other data
Quality Assurance	SMOKE QA Tools; PAVE, VERDI plots; Summary reports	Follow WRAP emissions QA/QC plan.

2.5.2 On-Road Mobile Sources

The Motor Vehicle Emissions Simulator (MOVES[30]) is EPA's current tool to construct on-road mobile source emissions estimates for national, state, and county level inventories of criteria air pollutants, greenhouse gas emissions, and some mobile source air toxics from highway vehicles. In addition, MOVES can make projections for energy consumption (total, petroleum-based, and fossil-based). EPA requires that all new regulatory modeling studies use the MOVES model for mobile source emissions and MOVES is also recommended for NEPA studies (EPA, 2012c).

The CARMMS/WestJumpAQMS 2008 on-road mobile source emission modeling was conducted using MOVES2010 (EPA, 2012a). On July 31, 2014, EPA released a new version of MOVES (MOVES2014; EPA, 2014a,b). The CARMMS mobile source emissions modeling was conducted in 2013 using MOVES2010, well before the release of MOVES2014. As stated in EPA's MOVES2014 Policy Guidance (EPA, 2014c) "All states other than California should use MOVES2014 for future SIPs in order to take full advantage of the improvements incorporated in this version. However, state and local agencies that have already completed significant work on a SIP with MOVES2010 can continue to use it"[31] (EPA, 2014c). Thus, MOVES 2010 was used instead of MOVES 2014 in this study.

The WestJumpAQMS ran MOVES2010 configured to estimate 2008 mobile source emissions directly (i.e., emissions inventory mode) at a county level basis by month using the monthly average diurnally varying 2008 WRF meteorological conditions. However, the 3SAQS updated the 2008 and 2020 mobile source emissions using MOVES2010 in the emissions factor mode to generate a lookup table of emissions factors that was used with SMOKE-MOVES and the 2008 WRF gridded hourly meteorological data to generate day-specific hourly gridded on-road mobile source emission inputs. The CARMMS 2021 High, Low and Medium Development Scenarios CAMx source apportionment modeling used the 3SAQS 2020 SMOKE-MOVES on-road mobile source emissions. SMOKE-MOVES spatially allocated the mobile source activity data to the 36/12/4 km modeling domains using spatial surrogates developed using the 2010 census and other data. This includes new spatial surrogate categories specific to new source categories in MOVES (e.g., heavy duty truck idling at rest stops). SMOKE-MOVES also chemically speciated the emissions to the CB05 chemical mechanism using CB05 chemical speciation profiles based on the SPECIATE4.3 database. More details on the 2008 on-road mobile source emissions can be found in the 3SAQS 2008 base case modeling report (Adelman, Shanker, Yang and Morris, 2014).

2.5.3 Area and Non-Road Mobile Sources

The 2008 NEIv2.0 area and non-road emissions were processed using the SMOKE emissions model with new 2010 census spatial surrogates and default temporal and CB05 speciation adjustments. Several source categories within the area and non-road category were removed from the NEIv2.0 so that they could be replaced or updated and separately processed, which allows a more thorough QA/QC analysis. The source categories that were extracted from the NEIv2.0 area and non-road sources for separate treatment or replacement were as follows:

[30] http://www.epa.gov/otaq/models/moves/
[31] http://www.epa.gov/otaq/models/moves/documents/420b14008.pdf

- Oil and gas (O&G) exploration and production sources for locations covered by most of the WRAP Phase III O&G Basins and the Permian Basin were removed from the 2008 NEIv2. They were replaced by the WRAP Phase III 2006 emissions projected to 2008 (see Section 2.5.4). New 2008 O&G emissions were developed for the Permian Basin in southeastern New Mexico/northwestern Texas. The 2008 NEIv2.0 O&G emissions were used for the remainder of the U.S. locations, which includes the Williston and Great Plains Basins (North Dakota and Montana) whose WRAP Phase III emissions were not available at the time of the 2008 emissions inventory development.
- Ammonia emissions due to livestock and fertilizer sources were removed from the NEIv2.0 and processed separately.
- Aircraft, locomotive and marine (ALM) sources were processed separately as their own source group in the emissions modeling. The marine sources do not include large ocean going (Class 3) vessels (Commercial Marine Vessels, CMV) that were processed under the off-shore shipping category.
- Fire emissions were removed from the NEIv2.0 and were replaced by 2008 fire emissions developed as part of the DEASCO3 study.
- Fugitive dust emissions were removed from the NEIv2.0 for separate processing.

Below we summarize the processing area and non-road emissions used from the 2008 NEIv2 in the CARMMS 2008 base case, more details can be found in WestJumpAQMS Technical Memorandum No.2 Area and Non-Road Emissions (Loomis, Morris and Adelman, 2013[32]).

2.5.3.1 Area Sources

The NEI Area (or Non-Point) data category contains emission estimates for sources which individually are too small in magnitude or too numerous to inventory as individual point sources, and which can often be estimated more accurately as a single aggregate source for a County or Tribal area. Area source (non-point) emissions are emissions sources that are summed over a geographic region, rather than specifically located. Examples of area sources include small industrial, residential, consumer product, and agricultural emissions. For emissions modeling purposes, these types of emissions are defined by state and county (or tribal) identifiers, and SCC codes. After extracting the area source categories from the NEIv2.0 as indicated above, the remaining area sources in the NEIv2.0 were processed by SMOKE as their own source category.

2.5.3.2 Non-Road Sources

The NEI Non-Road data categories contain mobile sources which are estimated for version 2.0 of the 2008 NEI using the EPA NONROAD[33] model, run within the National Mobile Inventory Model (NMIM[34]). The non-road emissions have been compiled as both annual total emissions, and average day emissions by month. In order to take the best advantage of the monthly and seasonal variability of the non-road emissions sources, we used the monthly options for SMOKE modeling inputs.

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32 http://www.wrapair2.org/pdf/Memo_2_Area_Jan22_2013%20review%20draft.pdf
33 http://www.epa.gov/otaq/nonrdmdl.htm
34 http://www.epa.gov/otaq/nmim.htm

Note that emissions data for aircraft, locomotives, and commercial marine vessels are not included in the NEI non-road data category starting with the 2008 NEI. These three non-road mobile source categories were handled as special cases, with separate input processing streams. Aircraft engine emissions occurring during Landing and Takeoff Operations (LTO) and the Ground Support Equipment (GSE) and Auxiliary Power Units (APU) associated with the aircraft are now included in the point data category at individual airports in the 2008 NEI. Emissions from locomotives that occur at rail yards are also included in the point data category. In-flight aircraft emissions, locomotive emissions outside of the rail yards, and commercial marine vessel emissions (both underway and port emissions) are included in the Non-Point data category.

2.5.4 2008 Oil and Gas Emissions

For Basins covered by the WRAP-IPAMS Phase III 2006 oil and gas (O&G) emissions available at the time of the 2008 base case emissions development, the WRAP Phase III O&G 2006 emissions were projected to 2008. WestJumpAQMS also developed new 2008 O&G emissions for the Permian Basin in southeastern New Mexico/northwestern Texas. For all other Basins in the U.S. (including Williston and Great Plains Basins whose WRAP Phase III emissions were not available at the time of the 2008 base case development) the 2008 O&G emissions from the NEIv2.0 were used and processed as area and point sources.

2.5.4.1 2008 Phase III O&G Emissions Update

The WRAP Phase III 2006 baseline O&G inventories were projected to 2008 for the following eight WRAP Phase III Basins:

- Denver-Julesburg Basin (CO)
- Piceance Basin (CO)
- Uinta Basin (UT)
- North San Juan Basin (CO)
- South San Juan Basin (NM)
- Wind River Basin (WY)
- Powder River Basin (WY)
- Greater Green River Basin (WY)

The 2008 O&G emission update for the WRAP Phase III and Permian Basins used 2008 O&G production statistics from the Enerdeq database published by IHS Global, also referred to as the “PI Dwight’s” database. This database contains production statistics that are consistent and typically of higher quality than the primary data in individual state O&G Commission databases.

Processing of the IHS data for the 2008 projections followed the same methodology as used in the WRAP Phase III study[35]. Summaries of production statistics were extracted from the IHS database, including well count by well type and location, spud count, production of gas by well type and well location, production of liquid petroleum (oil or condensate) by well type and well

[35] http://www.wrapair2.org/PhaseIII.aspx

location, and production of water by well type and well location. All data were summarized at the county and basin level, for tribal and non-tribal land separately as applicable to each basin. No new survey work was conducted for the 2008 O&G emissions update so the analysis did not include any updates of company-specific production statistics as was done in the development of the Phase III 2006 O&G emission inventories. The resulting production statistics data were summarized at the county, tribal and basin levels for all basins including the Permian Basin.

The 2008 production statistics from the IHS database were used to project the Phase III baseline 2006 O&G inventories. The projections were developed as scaling factors that represented the ratio of the value of a specific activity parameter in 2008 to the value in 2006. The scaling factors were developed at the county and tribal levels for all basins. Scaling factors were then matched to all source categories considered as part of the Phase III inventories, using the same cross-referencing analysis conducted as part of the midterm (2012) projections in the Phase III study. The 2008 to 2006 scaling factors were used to adjust the activity data for the oil and gas emissions.

Where specific scaling factors are estimated to be less than one (1), indicating a reduction in an activity parameter from 2006 to 2008, all emissions factors and activity data were assumed to be identical in 2008 as in 2006 and no emission controls assessment is needed (i.e., when activity is reduced between 2006 and 2008 we are assuming that the same equipment is being used in the field, it is just producing less). In this case, the 2008 emissions were developed assuming the direct application of the scaling factor with no additional controls.

Where scaling factors are estimated to be greater than one (1), it is assumed that some growth in activity has occurred in the 2006-2008 time period and that new equipment may have been deployed in the field. A controls analysis was conducted specific to each basin and utilized the control measures identified as part of the WRAP Phase III midterm O&G projections work. The controls analysis only considered broad control factors, rather than detailed analyses as conducted in the Phase III midterm projections. Where no significant impact of controls from federal or state regulations are anticipated in the 2006-2008 time period, no control factors for the specific source category will be assumed.

For Colorado Basins, the permitted O&G 2008 emissions were based on the CDPHE 2008 APEN database rather than projected from the WRAP Phase III 2006 O&G emissions, whose permitted O&G emissions were based on the CDPHE 2006 APEN database. In addition, the Colorado Department of Health and Development (CDPHE) has determined that not all condensate flash VOC emissions that were assumed to be controlled 95% by flares make it to the flare and are instead vented to the atmosphere. Thus, CDPHE has introduced the concept of a Capture Efficiency (CE) for condensate flare control that assumes only 75% of the condensate flash VOC emissions are actually controlled by the flare and the other 25% is released directly to the atmosphere. The CDPHE 75% CE assumption was adopted in the CARMMS/WestJumpAQMS 2008 base case O&G emissions in Colorado. The WRAP Phase III 2006 unpermitted condensate tank O&G emissions are either projected to 2008 (D-J Basin) or the 2008 APEN condensate tank emissions are reduced (Piceance Basin) in order for the total 2008 condensate production in the inventory to match the 2008 IHS database production statistics.

Details on the development of the 2008 O&G emissions for the Colorado Basins, the Uinta and South San Juan Basins and the Wyoming Basins can be found in three WestJumpAQMS Technical Memorandums by, respectively, Bar-Ilan and Morris (2012a[36]), Bar-Ilan and Morris (2012b[37]) and Bar-Ilan and Morris (2012c[38]).

2.5.4.2 2008 Emission Inventory for the Permian Basin

A study prepared by Applied EnviroSolutions, Inc. (AES) on 2007 O&G emissions in the New Mexico portion of the Permian Basin along with 2008 O&G emissions from the Texas Commission on Environmental Quality (TCEQ) was used to develop a comprehensive O&G emissions inventory of the Permian Basin. The Permian Basin lies outside of the CARMMS modeling domain, although Permian Basin emissions are used in the CAMx 36/12 km modeling to provide BCs for the CARMMS 4 km domain. Details on the development of the 2008 O&G emissions for the Permian Basin can be found in WestJumpAQMS Emissions Technical Memorandum Number 4d (Bar-Ilan and Morris, 2013[39]).

2.5.4.3 2008 O&G Emissions for the Remainder of the U.S.

The WRAP Phase III Basins and Permian Basin O&G emissions described above covers most of an area including northwestern TX, NM, CO, UT and WY and all of the 4 km CARMMS domain. For areas within these states not covered by the WRAP Phase III and Permian Basins, and O&G emissions outside of this region, the O&G emissions from the 2008 NEIv2.0 were used. Details on the O&G emissions used in the 2008 base case not covered by the WRAP Phase III Basins can be found in WestJumpAQMS Technical Memorandum No. 4e (Loomis, Adelman, Morris and Bar-Ilan, 2013[40]).

2.5.5 Fire Emissions

2008 emissions from wild fires, prescribed burns and agricultural burning were based on the comprehensive 2008 fire emissions inventory developed as part of the DEASCO3[41] project sponsored by the Joint Fire Science Program (JFSP). The WestJumpAQMS emissions Technical Memorandum Number 5 (Morris, Tai, Loomis and Adelman, 2012[42]) discusses and compares available fire emissions data for 2008. Details on the DEASCO3 fire emissions development methodology[43] and the methodology for fire plume rise and speciation[44] is available on the DEASCO3 website.

2.5.6 Ammonia Emissions

Ammonia emissions were based on the 2008 NEIv2.0 emissions inventory. A vast majority of the ammonia emissions in the 2008 NEIv2.0 were from livestock and fertilizer application that

[36] http://www.wrapair2.org/pdf/Memo_4a_OG_Jun06_2012_Final.pdf
[37] http://www.wrapair2.org/pdf/Memo_4b_OG_June06_2012_Final.pdf
[38] http://www.wrapair2.org/pdf/Memo_4c_OG_Jan23_2013_RevisedFinal.pdf
[39] http://www.wrapair2.org/pdf/Memo_4d_OG_Apr24_2013_Final.pdf
[40] http://www.wrapair2.org/pdf/Final_Memo_4e_RemainderOG_Mar6_2013.pdf
[41] http://www.wrapair2.org/pdf/JSFP_DEASCO3_TechnicalProposal_November19_2010.pdf
[42] http://www.wrapair2.org/pdf/Memo_5_Fires_Apr27_2012_Final.pdf
[43] https://wraptools.org/pdf/ei_methodology_20130930.pdf
[44] https://wraptools.org/pdf/DEASCO3_Plume_Rise_Memo_20131210.pdf

were based on the CMU ammonia model[45]. Updated spatial surrogates for locations of Concentrated Animal Feeding Operations (CAFOs) in Colorado developed as part of the NPS ROMANS study were used to spatially allocate the NEIv2.0 livestock ammonia emissions in Colorado, which greatly improves the ammonia emissions within the CARMMS domain. Details on the development of the ammonia emissions used in the CARMMS 2008 base case can be found in the WestJumpAQMS Technical Memorandum No. 8 (Loomis, Wilkinson, Adelman and Morris, 2013[46]).

2.5.7 Ocean Going Vessels

The 2008 off-shore shipping emissions inventory was based on the 2008 NEIv2.0. These emissions are developed and carried as point sources, rather than the area-level files generally used for off-road mobiles sources, including marine emissions sources. Details on the Off-Shore Shipping emissions are provided in a report "Documentation for the Commercial Marine Vessel Component of the National Emissions Inventory – Methodology" prepared by Eastern Research Group (ERG, 2010[47]) dated March 30, 2010. The WestJumpAQMS emissions Technical Memorandum Number 7 (Loomis, Morris and Adelman, 2012[48]) describes the off-shore shipping emissions and how they were processed for input into the photochemical grid model.

2.5.8 Biogenic Emissions

WRAP performed a Western Biogenic Emissions Update Study that enhanced the MEGAN biogenic emissions model to better simulate biogenic emissions in the western U.S. The CARMMS used the new enhanced version of MEGAN along with the 2008 WRF 36/12/4 km data to generate hourly gridded speciated biogenic emission inputs for 2008 and the CARMMS 4 km domain. Details on the WRAP Biogenic Emissions Update Study can be found in the study's final report (Sakulyanontvittaya, Yarwood and Guenther, 2012[49]) with a summary provided in the WestJumpAQMS emissions Technical Memorandum Number 9 on biogenic emissions (Sakulyanontvittaya et al., 2012[50]).

2.5.9 Spatial Allocation

New spatial allocation surrogates were developed at 4 km resolution for the CONUS domain using the latest 2010 CENSUS and other new data. The 4 km surrogate distributions were used directly for disaggregating the county-level emissions to the 4 km grid cells in the CARMMS modeling domain, as well as collapsed to 36 and 12 km resolution for spatial allocation to the 36 km CONUS and 12 km WESTUS domains used in WestJumpAQMS modeling. Table 2-5 summarizes the spatial surrogates to be used for spatial allocation in the CARMMS/WestJumpAQMS SMOKE emissions modeling. More details are provided in the WestJumpAQMS emissions Technical Memorandum Number 13 on SMOKE modeling parameters (Adelman, Loomis and Morris, 2013[51]).

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45 http://www.cmu.edu/ammonia/
46 http://www.wrapair2.org/pdf/Memo8_AmmoniaSources_Feb28_2013review_draft.pdf
47 http://www.epa.gov/ttn/chief/net/nei08_alm_popup.html
48 http://www.wrapair2.org/pdf/OffshoreShippingEmissionsMemo_7WestJumpAQMS_Jan23_2012.pdf
49 http://www.wrapair2.org/pdf/WGA_BiogEmisInv_FinalReport_March20_2012.pdf
50 http://www.wrapair2.org/pdf/Memo_9_Biogenics_May9_2012_Final.pdf
51 http://www.wrapair2.org/pdf/Memo13_Parameters_Feb28_2013review_draft.pdf

Table 2-5. Spatial surrogate distributions to be used in the SMOKE emissions modeling spatial allocations.

Shapefile	Description	Type	Year	Source
cty_pophu2k_revised	U.S. County Boundaries	Polygon	2005	U.S. Census Bureau
pophu_bg2010	Population/ Housing	Polygon	2010	U.S. Census Bureau
rd_ps_tiger2010	Roadways	Line	2010	U.S. Census Bureau
waterway_ntad2011	Waterways	Line	2010	U.S. Bureau of Transport Statistics
rail_tiger2010	Railways	Line	2010	U.S. Census Bureau
exits**	Highway Exits	Point	2010	ESRI
mjrrds**	Major Roads	Line	2010	ESRI
transterm**	Transportation Terminals	Point	2010	ESRI
fema_bsf_2002bnd	Building footprints	Polygon	2010	FEMA
heating_fuels_acs0510_c2010	Home heating fuels	Polygon	2010	U.S. Census Bureau

2.5.10 Temporal Allocation

Temporal profiles are available from the U.S. EPA for a wide range of emissions sources. While the majority of the temporal profiles available from the EPA represent nationally averaged emissions sources, state-specific monthly profiles exist for prescribed fires, wildfires, livestock, and some mobile sources. For most sources the emissions modeling temporal allocations were based on the U.S. EPA temporal profiles distributed with the 2008 NEIv2.0[52] (filename: amptpro_2008aa_us_can_revised_06oct2011_v0.txt). Several source categories use episode emissions that already have hourly emissions so will not use the temporal allocation profiles. These emissions categories include: large point sources with measured hourly CEM emissions; on-road mobile sources that use the MOVES monthly weekday/weekend day hourly emissions; biogenic emissions from MEGAN; and fire emissions from DEASCO3. The EPA default cross walk file between SCC codes and temporal allocations is available on the NEIv2.0 website[53].

2.5.11 Chemical Speciation

The U.S. EPA develops speciation profiles from information stored in the SPECIATE database[54]. The SPECIATE database is the official repository of volatile organic compound (VOC) and particulate matter (PM) emissions source profiles for different categories of emissions sources. CARMMS SMOKE emissions modeling used the SPECIATE Version 4.3 database released in September 2011 that contains 5,592 profiles of chemical mass fractions from source testing conducted by EPA, state agencies, or published in the literature since the 1970's. Of the profiles in SPECIATE V4.3, 3,570 are for PM sources, 1,775 are for VOC sources, and 247 are for other gases, such as mercury. The most recent update to the SPECIATE database occurred with the release of version 4.4 in February 2014 that includes 5,728 speciation profiles for VOC, PM and mercury. SPECIATE 4.4 was released after CARMMS conducted most of its emissions modeling and thus was not used.

Part of the speciation process for VOCs includes converting inventory reactive organic gases (ROG) to total organic gases (TOG). This step is required because inventoried VOC excludes

[52] http://www.epa.gov/ttnchie1/net/2008inventory.html
[53] ftp://ftp.epa.gov/EmisInventory/2008v2/doc/scc_eissector_xwalk_2008neiv2.xlsx
[54] http://www.epa.gov/ttnchie1/software/speciate/

ethane and methane in the mass of total VOC while the speciation profiles include ethane and methane. Before the speciation profiles can be applied to the inventory, the inventory VOC must be scaled up to account for the missing methane mass. SCC-specific ROG-to-TOG conversion factors are included with the speciation profiles to prepare the inventories for speciation.

The CARMMS CAMx photochemical grid modeling used the Carbon Bond version 05 (CB05) chemical mechanism (Yarwood et al., 2005[55]). The SMOKE emissions modeling was performed using CB05 speciation profiles, based on the SPECIATE V4.3 database, and ROG-to-TOG conversion factors. The Speciation Tool is an interface to the SPECIATE database that develops CB05 VOC speciation profiles for use in the SMOKE emissions modeling. The exception to using the SPECIATE V4.3 VOC speciation profiles was for the WRAP Phase III Basins where Basin-specific CB05 VOC speciation profiles were used for O&G VOC emissions.

2.5.12 Emissions Quality Assurance and Quality Control

The emissions modeling quality assurance (QA) and quality control (QC) procedures developed as part of the WRAP Regional Modeling Center are being used in the CARMMS and WestJumpAQMS emissions modeling (Adelman, 2004). The 2008 base case emissions are processed by major source category in several different "streams" of emissions modeling. This is done in order to assist in the QA/QC of the emissions modeling as it is much easier to identify potential issues in the emissions fields when analyzing single source categories at a time. Each stream of emissions modeling generates a pre-merged CAMx-ready emissions model input with all pre-merged emissions inputs merged together to generate the final CAMx-ready two-dimensional gridded low-level (layer 1) and point source emission inputs. Table 2-6 lists an example of separate streams of emissions modeling by source category that can be used. Also shown in Table 2-6 are the source of the emissions, processing comments and the temporal allocation strategy whose options are as follows:

- Single day per year (aveday_yr)
- Single day per month (aveday_mon)
- Typical Monday, Weekday, Saturday, Sunday per year (mwdss_yr)
- Typical Monday, Weekday, Saturday, Sunday per month (mwdss_mon)
- Emissions estimated for each model simulation day (daily)
- Emissions estimated for each model simulation day with temporal profiles generated with average daily meteorology (daily met)
- Emissions estimated for each model simulation day with temporal profiles generated with hourly meteorology (hourly met)

[55] http://www.camx.com/publ/pdfs/cb05_final_report_120805.aspx

Table 2-6. Emissions processing categories and temporal allocation approach for 2008 Base Case emissions modeling.

No.	Emissions Processing Category (Abbr)	Inventory Source	Temporal	Processing Comments
1	Nonpoint/Area (nonpt)	NEI	mwdss_mon	Remove oil & gas, agricultural NH3, and dust,; includes commercial marine and rail
2	Livestock NH3 (lv)	NEI	mwdss_mon	Do not apply met-based temporal profiles; separate out for possible sensitivity later
3	Fertilizer NH3 (ft)	NEI	mwdss_mon	Group with lv as a full agricultural NH3 sector (ag)
4	Fugitive and Road Dust (fd)	NEI	mwdss_mon	Includes paved and unpaved road dust; apply transport factors but not met factors
5	Residential Wood Combustion (rwc)	NEI	mwdss_mon	Do not apply met-based temporal profiles; separate out for possible sensitivity later
6	Area Oil & Gas from P3 (ogp3)	WRAP P3	mwdss_mon	Basin specific speciation profiles and spatial surrogates (includes Permian Basin)
7	Area Oil and Gas from NEI (ognei)	NEI	MWDSS_mon	Use default speciation and allocations
8	Nonroad mobile (nr)	NEI	mwdss_mon	Includes NMIM commercial marine and rail
9	MOVES RPD (rpd)	MOVES	hourly met	
10	CEM Point (ptcem)	NEI08/CAMD	daily	Anomalies removed from 2008 CAMD data
11	Non-CEM Point (ptncem)	NEI08	mwdss_mon	Removed oil & gas sources from NEI and transferred to ptognei sector
12	Point Oil & Gas from P3 (ptogp3)	WRAP P3	mwdss_mon	WRAP Phase III inventory and Permian Basin
13	Point Oil & Gas from NEI (ptognei)	WRAP NEI	mwdss_mon	Remove NEI oil and gas emissions for counties in WRAP P3/Permian Basins
14	Point Fires (ptfire)	FINN or SMARTFIRE	daily	
15	Commercial Marine (ptseca)	NEI	aveday_mon	Latest version from Emissions Control Area (ECA) rule
16	Lightning NO_X (lnox)		hourly met	Gridded hourly NO emissions tied to WRF convective rainfall (optional)
17	Sea salt (ss)		hourly met	Surf zone and open ocean PM emissions (Optional)
18	Windblown Dust (wbd)	TBD	hourly met	WRAP WBD model one option
19	MEGAN Biogenic (bg)	MEGAN2.1	hourly met	Use new versions of MEGAN V2.10 updated by WRAP for the western U.S.
20	Mexico Area (mexar)	Mexico NEI	mwdss_mon	Mexico inventory projected from 1999 to 2008
21	Mexico Point (mexpt)	Mexico NEI	mwdss_mon	Mexico inventory projected from 1999 to 2013
22	Mexico Mobile (mexmb)	Mexico NEI	mwdss_mon	Mexico inventory projected from 1999 to 2013
23	Canada Area (canar)	Canada NPRI	mwdss_mon	Latest Environment Canada Inventory
24	Canada Point (canpt)	Canada NPRI	mwdss_mon	Latest Environment Canada Inventory
25	Canada Mobile (canmb)	Canada NPRI	mwdss_mon	Latest Environment Canada Inventory
26+	BLM Planning Areas	BLM	Mwdss_mon	Separate processing of O&G and mining emissions in each BLM Planning Area

Separate QA/QC is performed for each separate stream of emissions processing and in each step. SMOKE includes advanced quality assurance features that include error logs when emissions are dropped or added. The QA/QC procedures developed under the WRAP RMC were used (Adelman, 2004) that includes visual displays such as:

- Spatial plots of the hourly emissions for each major species (e.g., NO_X, VOC, some speciated VOC, SO_2, NH_3, PM and CO);
- Vertical average emissions plots for major species and each of the grids;
- Diurnal plots of total emissions by major species and by state; and
- Summary tables of emissions for major species for each grid and by major source category.

This QA information was examined against the original point and area source data and summarized in an overall QA/QC assessment.

Scripts to perform the emissions merging of the appropriate biogenic, on-road, non-road, area, low-level, fire, and point emission files were written to generate the CAMx-ready two-dimensional day-specific hourly speciated gridded emission inputs. The point source and, as available, elevated fire emissions were processed into the day-specific hourly speciated emissions in the CAMx-ready point source format.

The resultant CAMx model-ready emissions were subjected to a final QA using spatial maps, vertical plots and diurnal plots to assure that: (1) the emissions were merged properly; (2) CAMx inputs contain the same total emissions; and (3) to provide additional QA/QC information.

2.6 2008 Base Case Modeling and Model Performance Evaluation

WestJumpAQMS performed a CAMx 2008 4 km Base Case simulation for the CARMMS 4 km modeling domain and conducted a model performance evaluation. The CARMMS model performance evaluation was documented in Section 4.5.3 in the WestJumpAQMS final report (ENVIRON, Alpine and UNC, 2013[56]). The CARMMS study intended to rely on the WestJumpAQMS CAMx model performance evaluation that focused on monthly and annual model performance statistics across the 4 km CARMMS domain for ozone, $PM_{2.5}$ and related species. However, when presenting the CARMMS 2008 Base Case modeling and model performance evaluation results to the IAQRT at a February 28, 2014 meeting, the IAQRT requested that more model performance information be provided. In particular, the IAQRT requested that ozone model performance statistics be calculated using a 60 ppb observed ozone cut-off concentration instead of 40 ppb as used by WestJumpAQMS, and that model performance statistics be provided down to an individual monitoring site. Thus, CARMMS calculated additional ozone model performance statistics using the 60 ppb ozone cut-off and packaged up all of the WestJumpAQMS model performance products for the 4 km CARMMS domain and 2008 Base Case simulation. The result was a 72 Mb zipped file of model performance products that had over 4,500 model performance statistics and displays that

[56] http://www.wrapair2.org/pdf/WestJumpAQMS_FinRpt_Finalv2.pdf

summarized model performance down to the individual monitoring site for each month and for each day of 2008 across the 4 km CARMMS domain. The zipped file of model performance products was provided to the IAQRT.

Appendix B summarizes the CARMMS CAMx 2008 Base Case simulation and model performance evaluation across the 4 km CARMMS domain, including ozone model performance statistics using a 60 ppb observed ozone cut-off threshold as recommended by EPA. The CARMMS CAMx Base Case simulation achieved EPA's ozone model performance goals, except in the winter months (Jan, Feb, Nov and Dec) when a 60 ppb observed ozone cut-off is used. The highest winter ozone events in the CARMMS 4 km domain occur during the winter ozone episodes in the Uinta Basin under cold pool shallow inversion conditions or stratospheric ozone intrusions events that the CARMMS modeling system was either not configured to simulate or has difficulty simulating, respectively. The CARMMS CAMx Base Case simulation also mostly achieved the PM Model Performance Criteria. More details on the CARMMS 2008 4 km base case simulation and model performance evaluation are provided in Appendix B.

3.0 FUTURE YEAR EMISSIONS

The meteorological base year for the CARMMS modeling is 2008. The development of the 2008 Base Case modeling database and emissions scenario was described in Chapter 2. In this section, we describe the development of the future year emissions scenario. The future year emissions scenario modeled is 2021. Projecting future year oil and gas (O&G) emissions has many uncertainties as it depends on economic conditions (e.g., price of natural gas and oil), identification of new O&G plays, availability of exploration and development equipment and regulatory requirements. For CARMMS, future year O&G emissions were developed for a range of potential outcomes that would hopefully bound the actual future year O&G development in the region. CARMMS developed three levels of 2021 future year O&G development within the BLM Colorado Planning Areas:

- High Development Scenario;
- Low Development Scenario; and
- Medium Development Scenario, which is a mitigated version of the High Development Scenario.

Similarly, High, Low and Medium Development Scenario emissions were developed for the Mancos Shale. There are four general types of future year emissions addressed in CARMMS:

1. BLM-authorized (Federal lands) and other (non-Federal lands) oil and gas and mining emissions within the Colorado BLM planning areas (as well as the BLM Farmington Field Office in northern New Mexico);
2. Oil and gas and other development areas outside of Colorado/northern New Mexico BLM Planning Areas;
3. Remainder future year anthropogenic emissions; and
4. Emissions related to the 2008 base year that remained unchanged in the future year scenarios.

3.1 Western Colorado BLM Planning Area Oil and Gas Emissions Calculators

To address emissions from future BLM-authorized (Federal lands) and non-BLM-authorized (non-Federal lands) oil and gas development in the western Colorado planning areas, CARMMS has developed several emission calculators. Existing emissions calculators were improved under CARMMS and representative calculators for “typical” crude oil, conventional gas (with condensate), coal bed natural gas (CBNG), and shale gas within the region have been developed. New information has been incorporated for drilling times; engine configurations; condensate and produced water production; well pad versus offsite gas treatment and storage; well-head, infield, and pipeline compression; and gas/oil production. The ability to readily modify input assumptions, such as production parameters, emission control assumptions, and wellhead equipment configurations, has also been incorporated into the calculators.

The refined emission calculators were used to develop the 2021 future-year O&G emissions inventories for the eight western Colorado BLM planning areas.

The following sections summarize the emission calculators used to estimate the O&G and mining emissions for western Colorado and northern New Mexico. Details on the emission calculators are provided in two Technical Memoranda (Grant, Zapert and Morris, 2013a,b) that are included as Appendices C and D.

3.1.1 Overview of Calculators

Emission calculators have been developed for each of the following well types.

- Conventional gas
- Conventional oil
- Shale gas
- Coalbed natural gas (CBNG)

For each well type, a separate self-contained emission calculator spreadsheet contains all of the inputs and calculations need to generate well site emissions.

Additionally, a calculator has been developed to estimate midstream emissions for each area. The midstream emission calculator draws upon Colorado Department of Public Health (CDPHE) Air Pollutant Emission Notice (APEN) emissions for base year emission estimates. Future year midstream emission projections are dependent on the change in oil and gas production in a given planning area which can be updated based on linkages to the by well type emission calculators.

3.1.2 Pollutants

The emission calculators include estimates of emissions of criteria air pollutants (CAPs), greenhouse gases (GHGs), and hazardous air pollutants (HAPs) as follows:

- Criteria Pollutants
  - Carbon monoxide (CO)
  - Nitrogen oxides (NO_X)
  - Particulate matter less than or equal to 10 microns in diameter (PM_{10})
  - Particulate matter less than or equal to 2.5 microns in diameter ($PM_{2.5}$)
  - Sulfur dioxide (SO_2)
  - Volatile Organic Compounds (VOCs)
- Greenhouse Gases[57]
  - Carbon dioxide (CO_2)
  - Methane (CH_4)
  - Nitrous oxide (N_2O)
- Hazardous Air Pollutants (HAPs)[58]

[57] Note that the CARMMS PGM modeling does not use Greenhouse Gas (GHG) emissions, but the emission calculators provide GHG emission estimates so they can be reported in the RMPs.

While lead (Pb) is a criteria pollutant, emissions of lead in the BLM western Colorado planning areas due to O&G and mining activities are extremely low and are therefore not included in this analysis.

HAP emissions were estimated for each emissions source. For oil and gas emissions sources, HAP emissions from venting and combustion source categories were estimated for formaldehyde, n-hexane, benzene, toluene, ethylbenzene, and xylenes (BTEX).

Anthropogenic greenhouse gas emission inventories typically include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases. Fluorinated gases are not expected to be emitted in appreciable quantities by any category considered in this emission inventory and were therefore not included in this analysis.

Although the CARMMS emissions calculators calculate HAP and GHG emissions for oil and gas sources, the CARMMS PGM modeling do not use these emissions so they are not included in this report.

3.1.3 Temporal

The calculators estimate annual emissions associated with oil and gas exploration. Baseline emissions are estimated for 2011 with annual emission forecasts made for every year out to 10 years (2021).

3.1.4 Calculator Inputs

The emission calculator for each well type allows for specification of the following inputs.

- Base year oil and gas activity (gas production, oil production, spud counts, active well counts)
- Well decline estimates
- Level of control by source category
- Gas composition
- Equipment configurations (e.g. drill rigs, fracing rigs)
- Gas venting activity (e.g. completions, blowdowns)

The midstream emission calculator includes estimates of base year 2011 gas plant and compressor station emissions are taken from CDPHE APEN data. Base year midstream emissions are projected to future years based upon the gas production in each planning area.

3.1.5 Emission Calculations

Emission calculations for all emission-generating activities were developed based on typical emission inventory methodology. Methods used to estimate emissions from each source category are explained in detail in Appendix C (Grant, Zapert and Morris, 2013a). For each source category, emissions for the 2011 baseline were estimated. Emissions were then

[58] Note that the CARMMS PGM modeling does not use HAPs emissions, but the emission calculators provide HAPs emission estimates so they can be reported in the RMPs.

forecasted to future years, accounting for activity growth and for applicable sources emissions controls.

The methodologies described here are used consistently in all four calculators by well type; however the input data of each calculator was selected to best reflect the operational characteristics of each well type (oil, gas, CBNG, and shale gas) and thus obtained from literature sources including the following Air Quality Technical Support Documents (AQTSD) from Colorado field office planning areas and BLM emission calculators:

- White River AQTSD (URS, 2012a)
- Colorado River Valley AQTSD (URS, 2012b)
- Grand Junction AQTSD (BLM, 2012b)
- Uncompahgre AQTSD (in preparation)
- BLM Crude Oil Well Gas Emission Calculator
- BLM Coalbed Natural Gas Well Emission Calculator

Emissions are generated in three main phases of oil and gas systems:

- Emissions from Well Construction and Development
- Emissions from the Production Phase (occurring at-or-nearby the well pad)
- Emissions from Midstream Sources (Central Gas Compression and Processing)

The methodologies implemented to estimate base year and future year emissions from oil and gas sources are explained in Appendix C (Grant, Zapert and Morris, 2013a) and covered the following source categories:

- Well pad construction and development:
  - Well pad, access road and pipeline construction equipment;
  - Well pad, access road and pipeline construction traffic;
  - Drilling and completion equipment;
  - Fracing equipment;
  - Refracing equipment;
  - Drilling and well completion traffic;
  - Well pad, access road and pipeline construction wind erosion; and
  - Well completion venting.

- Production phase emissions:
  - Well workover equipment;
  - Production traffic;
  - Blowdown venting;
  - Well recompletion venting;
  - Pneumatic devices and fugitive components;

  - Water injection pumps;
  - Compressor station maintenance traffic exhaust and fugitive dust;
  - Condensate or oil tanks flashing and working and breathing losses;
  - Loading emissions from condensate and oil tanks;
  - Haul trucks traffic emissions;
  - Heaters; and
  - Dehydrators;

- Midstream sources:
  - Natural gas processing facilities;
  - Natural gas compressor stations; and
  - Gas sweetening.

The oil and gas emission calculators are designed to estimate emissions from both BLM-authorized and non-BLM-authorized activities within the western Colorado BLM planning areas. Emissions were also estimated for coal and uranium mines on federal lands in the western Colorado BLM planning areas. However, unlike the oil and gas emissions, emissions from mines not on federal lands were not estimated and were obtained from the EPA 2020 projections. The emissions for mines on federal lands were estimated for the baseline (2011) and future years and were based on the CDPHE APEN database and available EISs and EAs. Details on the mining emissions are given in Appendix D (Grant, Zapert and Morris, 2013b). Emissions were estimated for the following mines (BLM field office in parenthesis):

- Book Cliffs Area (Grand Junction).
- McClane (Grand Junction).
- Oak Mesa Area (Uncompahgre).
- King (Tres Rios).
- Foidel (Kremmling).
- Deserado (White River).
- Trapper (Little Snake).
- Colowyo (Little Snake).
- Sage Creek (Little Snake).
- West Elk (Uncompahgre).
- Elk Creek (Uncompahgre).

3.2 Oil and Gas Emissions outside of the BLM Western Colorado Planning Areas

The following three sections describe the procedures for estimating baseline and future year oil and gas emissions for areas within the CARMMS 4 km modeling domain but outside of the western Colorado BLM planning areas.

3.2.1 Colorado Royal Gorge Field Office

Baseline and future year oil and gas emissions for the BLM Royal Gorge Field Office[59] (RGFO) planning area in eastern Colorado were developed by the BLM COSO using RGFO specific oil and gas RFD estimates and air pollutant emissions calculators designed specifically for eastern Colorado oil and gas development / operations. Due to the geographic size and diversity of the RGFO, the RGFO was divided into four unique geographic areas and baseline and projected emissions inventories were developed for each RGFO area. Future year 2021 oil and gas emissions estimates were developed for future "permitted" and "non-permitted" activities. To develop the year 2021 "permitted" oil and gas emissions estimates, the year 2011 APENs emissions for each RGFO area was scaled using the year 2011 oil and gas production data with projected year 2021 oil and gas production data. The APENs based projections account for all permitted source types but do not include non-permitted sources such as pneumatics, small tanks and some fugitives. To account for "non-permitted" activities in the DJ Basin, WRAP Phase III emissions inventories for non-permitted sources and production data were used to develop production average emissions factors for non-permitted sources / activities and these emissions factors were then used with future projected year 2021 production rates to develop a future year 2021 non-permitted oil and gas emissions inventory for the DJ Basin. For eastern and south-eastern portions of the RGFO, a CENRAP oil and gas emissions inventory report was used with projected future year 2021 production data to develop future non-permitted oil and gas emissions estimates similar to what was completed for the DJ Basin. For the Raton Basin, oil and gas operators were specifically queried for operations / activities that are not routinely permitted and future projected year 2021 non-permitted emissions estimates for these activities were made using that information. In addition to the "permitted" and "non-permitted" RGFO emissions inventories described above, oil and gas development and production related traffic emissions were developed for year 2021. The "RFD / High" and "Low" emissions scenarios assumed on-the-books controls and the "RFD-Controlled / Medium" scenario assumes the following enhanced emissions controls for future projected Federal oil and gas: no venting during blow-downs, 30% electrification, Tier 4 drill and completion engines, 80% dust control to unpaved roads, 50% dust controls for well-pad and road construction disturbed areas and 50% of small non-permitted condensate tanks are assumed controlled.

The following charts show year 2011 and projected year 2021 RGFO NOx and VOC emissions estimates and well counts for the CARMMS Low and High modeling scenarios. As shown in the plots, projected year 2021 Federal O&G related emissions for the RFD / High Scenario are higher than projected year 2021 Federal O&G emissions estimates for the Low scenario. For the cumulative plots, future year 2021 cumulative (Federal and non-Federal) emission estimates for the Low Scenario (projected development based on recent development rates) are higher than the RFD / High Scenario and are being driven by the non-Federal oil and gas projection estimates. The current annual non-Federal oil and gas development rates are higher than the

[59] http://www.blm.gov/co/st/en/fo/rgfo.html

RFD projected estimates primarily because the RFD analysis assumes that current annual non-Federal development rates are not sustainable.

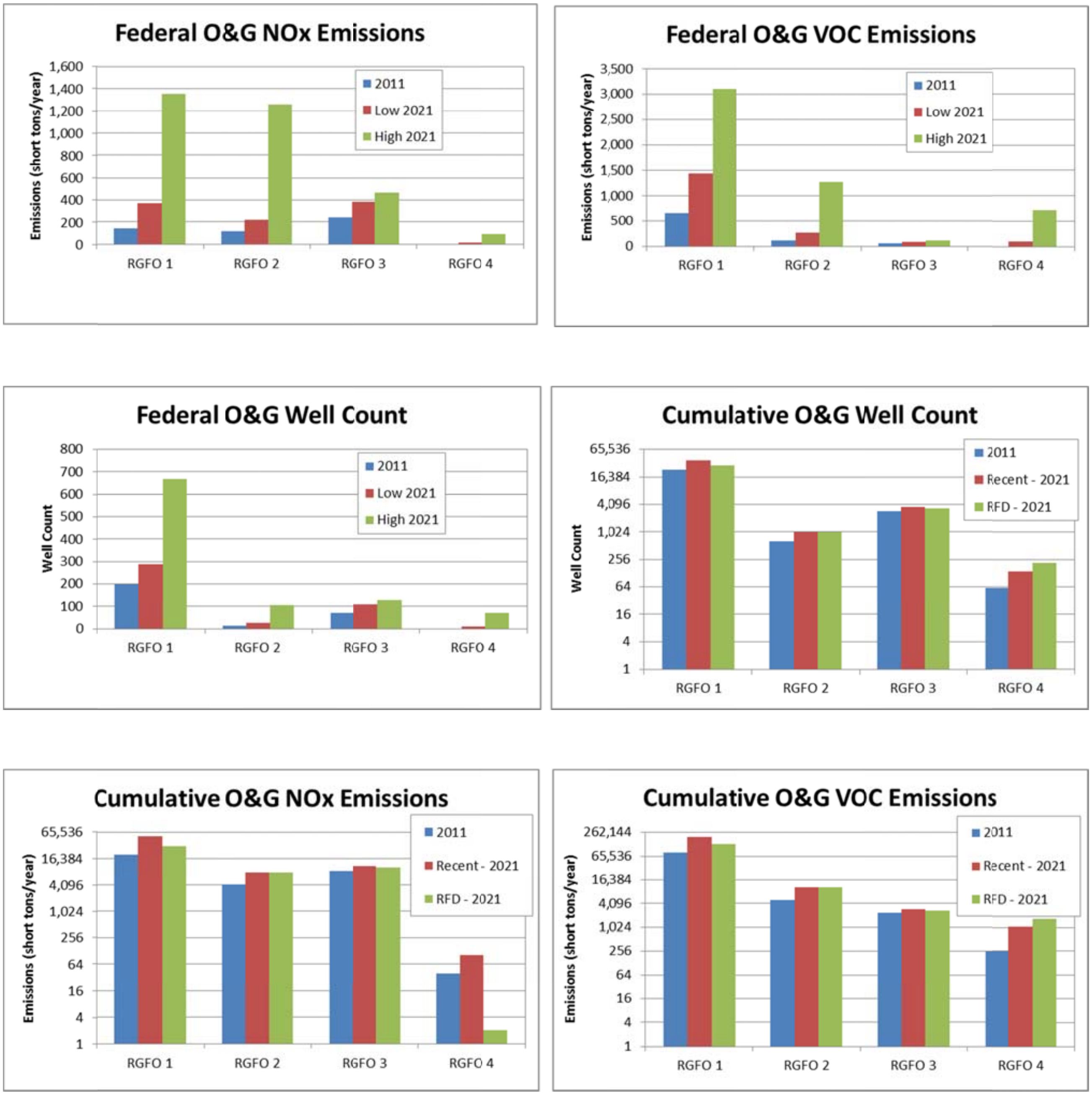


Figure 3-1. Year 2011 and projected year 2021 RGFO NOx and VOC emissions and well counts for the low and high development scenarios.

3.2.2 South San Juan Basin, New Mexico

Oil and gas emissions for the New Mexico BLM Farmington Field Office in the South San Juan Basin that includes San Juan, Rio Arriba, Sandoval and McKinley Counties were estimated based on oil and gas activity provided by the New Mexico BLM State and Farmington Field Office for the Mancos Shale Play and 2012 WRAP Phase III inventories for oil and gas emissions in the South San Juan basin. Figure 3-2a displays the Mancos Shale oil and gas development area in northwestern New Mexico in relation to BLM Planning Areas (note that the Mancos Shale extends into southern Colorado Tres Rios Field Office Planning Area). Figure 3-2b displays a detailed map of the Mancos Shale development area; the formation includes an oil prone area in the south and a gas prone area to the north.

70% of the new O&G emissions due to the Mancos Shale development are assumed to occur on Federal lands (i.e., BLM-authorized) and these emissions will be attributed to the New Mexico BLM Farmington Field Office even though there are small amounts of emissions within the BLM Colorado Tres Rios Field Office Planning Area.

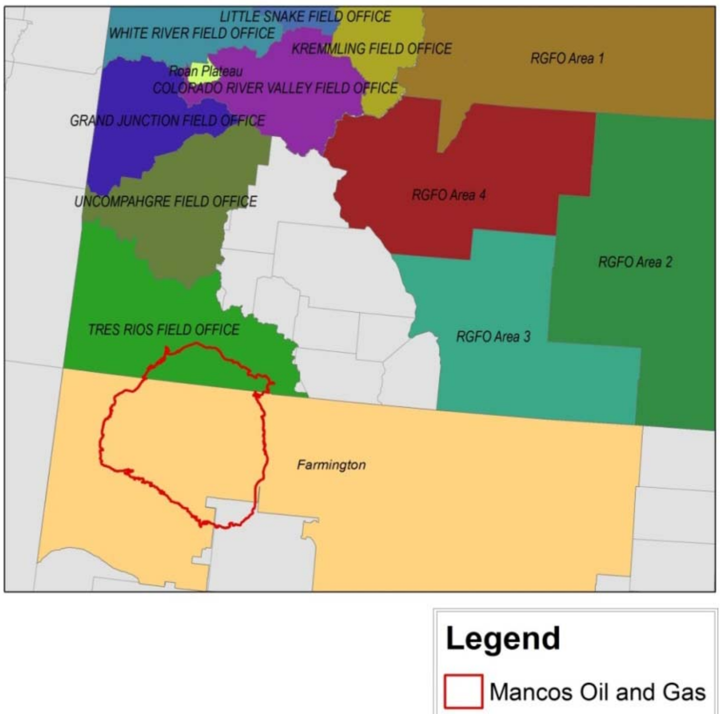


Figure 3-2a. Mancos Shale development area (shown with other oil and gas source areas from CARMMS).

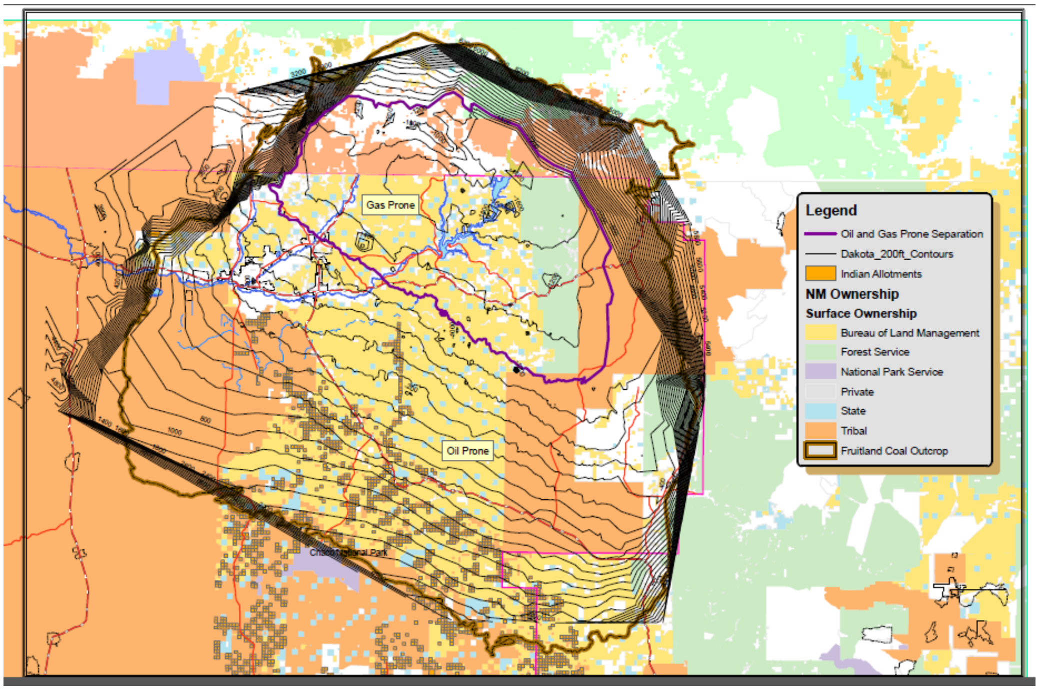


Figure 3-2b. Map of oil and gas prone development areas within the Mancos Shale Oil formation primarily in the New Mexico BLM FFO planning area.

3.2.2.1 2021 High, Low and Medium Development Scenarios for the Mancos Shale

As part of CARMMS 1.0, Mancos Shale oil and gas well development and production information was incorporated in emission calculators to the extent that Mancos Shale specific data was available based on information provided by the BLM New Mexico Farmington Field Office (NMFFO) petroleum engineers. Based on the data available at the time that emissions were developed for the CARMMS 1.0 study, a single set of Mancos Shale emissions were available to characterize emissions for the Low, Medium, and High Development scenarios. Thus, the same emissions were included in CARMMS 1.0 for the Low, Medium, and High scenarios. As part of a subsequent study commissioned by the BLM New Mexico State Office (Grant, Morris and Steyksal, 2014), Mancos Shale emissions calculators were refined and development scenarios were updated; separate emissions for the High, Low and Medium Development scenarios were developed.

Pollutants included in CARMMS 1.0 and Grant, Morris and Steyksal (2014) Mancos Shale calculators, temporal considerations, and calculator input parameters are all consistent with the CARMMS Western Colorado Planning Area calculators as described in Sections 3.1.2, 3.1.3, and 3.1.4, respectively. Methods used to estimate emissions from each source category are also consistent with the CARMMS Western Colorado Planning Area calculators. The Grant, Morris and Steyksal (2014) memorandum is included in Appendix E and documents the assumptions and methodology for the Mancos Shale calculators. For each source category, emissions were estimated for all years of activity, accounting for activity growth and for applicable sources, emissions controls.

As described in Grant, Morris and Steyksal (2014; Appendix E), recent trends in gas production in the South San Juan Basin show consistent decline since 2006. Given existing midstream capacity and recent declines in gas production in the South San Juan Basin, additional emissions at midstream sources (i.e. compressor stations and gas plants) were assumed negligible for the Mancos Shale development in CARMMS 1.0 and in the calculators developed as part of Grant, Morris and Steyksal (2014).

Estimates of Mancos Shale development by scenario are as follows:

- The High Development Scenario assumes 1,866 and 934 total active oil and gas wells, respectively, in 2021, with 70% of oil well and gas well activity on federally-owned mineral estate.
- The Low Development Scenario assumes 700 and 300 total active oil and gas wells, respectively, in 2021, with 70% of oil well and gas well activity on federally-owned mineral estate.
- The 2021 Medium Development Scenario assumes 1,400 and 600 total active oil and gas wells, respectively, in 2021, with 70% of oil well and gas well activity on federally-owned mineral estate.

The Medium Development Scenario assumes additional control of engine and fugitive emission sources for all phases of well-site operation for Federal wells as follows:

- Drill rig engines will be assumed to be split equally among the following technology types: Tier 2 diesel, Tier 3 diesel, Tier 4 diesel, and mixed-fuel rigs.
- All completion and fracing engines will be assumed split equally among Tier 2, Tier 3, and Tier 4 diesel engines.
- Assume 80% dust control for unpaved road traffic.

Table 3-0 and Figure 3-3 show the total emissions from the Mancos Shale areas for the 2021 High, Low and Medium Development emission scenarios.

Table 3-0. Comparison of oil and gas emissions (tons per year, TPY) from the Mancos Shale Areas for 2021 High, Low and Medium Development emission scenarios.

Scenario	VOC	CO	NO_X	PM_{10}	$PM_{2.5}$	SO_2	Basis
All Wells							
Low	3,949	2,312	2,276	1,199	214	3	Grant, Morris and Steyksal (2014)
Medium	7,923	4,695	3,914	1,462	312	6	
High*	10,037	4,478	4,736	2,598	447	7	CARMMS 1.0
Federal Emissions							
Low	2,765	1,618	1,593	839	150	2	Grant, Morris and Steyksal (2014)
Medium	5,553	3,308	2,548	742	184	4	
High*	7,026	3,135	3,315	1,818	313	5	CARMMS 1.0
Non-Federal Emissions							
Low	1,185	694	683	360	64	1	Grant, Morris and Steyksal (2014)
Medium	2,370	1,387	1,366	719	128	2	
High*	3,011	1,344	1,421	779	134	2	CARMMS 1.0

*High scenario emissions are based on CARMMS 1.0 Study estimates, Low and Medium scenario emissions are based on Grant, Morris and Steyksal (2014)

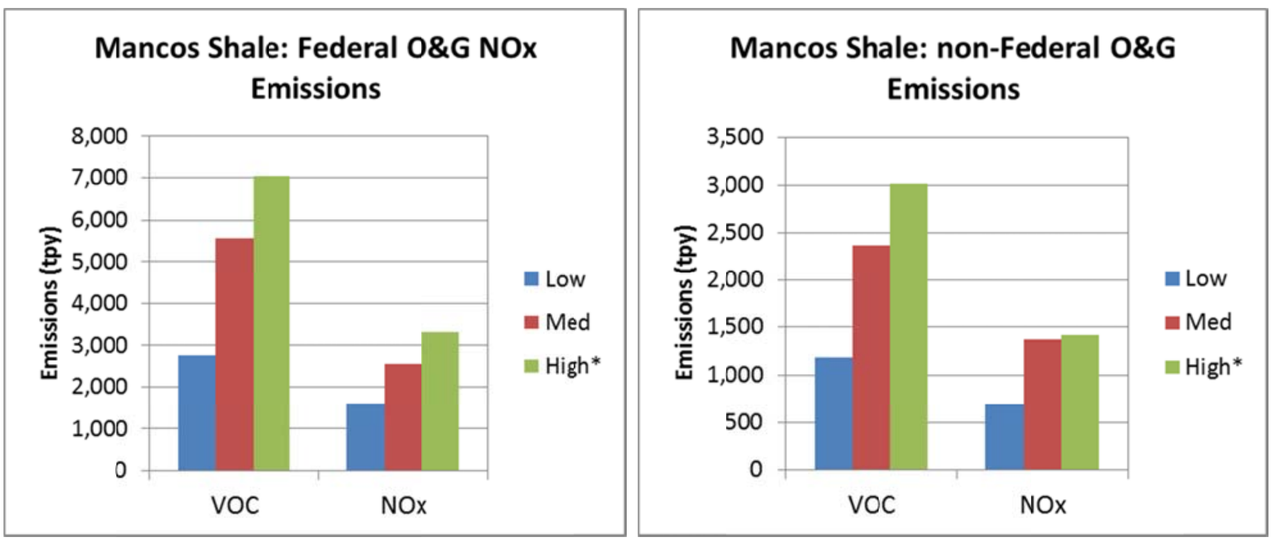


Figure 3-3. Comparison of total oil and gas emissions from the Mancos Shale formation for the 2021 High*, Low and Medium Development Scenarios (*High scenario emissions are based on CARMMS 1.0 Study estimates; Low and Medium scenario emissions are based on Grant, Morris and Steyksal (2014)).

3.2.3 Uinta Basin, Utah

Baseline and future year emissions associated with oil and gas development in the Uinta Basin have been estimated by AECOM for the BLM Utah State Office (UTSO[60]) under the UTSO Air Resource Management Study (ARMS). The UTSO ARMS is using a 2010 baseline year. More

[60] http://www.blm.gov/ut/st/en.html

details on the oil and gas emissions for the Uinta Basin are available in the UTSO ARMS documentation (AECOM, 2013[61]).

3.2.4 Southwestern Wyoming

Oil and gas development emissions for southwestern Wyoming were based on recent BLM Environmental Impact Statements (EISs), including those compiled as part of the draft EIS for the Continental Divide-Creston Natural Gas Project[62].

3.3 Other Anthropogenic Emissions

Other anthropogenic emissions (i.e., non O&G and BLM authorized mining sources) for the 2021 future year were based on 2020 emission projections compiled by the 3SAQS that were based on EPA's 2020 projections used in the $PM_{2.5}$ NAAQS rulemaking, which used EPA's 2007v5 modeling platform[63]. Emissions associated with oil and gas emissions within the western Colorado, Royal Gorge, North San Juan Basin, Uinta Basin and southwest Wyoming Basin described in Section 3.2 above were removed from the 2020 3SAQS/NEI to avoid double counting. Similarly, mining emissions on federal lands in the western Colorado BLM planning areas were also removed from the 2020 NEIs and replaced by estimates from the CARMMS calculators.

Details on the development of the 2020 NEI can be found in the 2020 Emissions Technical Support Document (TSD) for the $PM_{2.5}$ NAAQS rule (EPA, 2012d[64]).

3.4 Emissions that Remain at 2008 Levels

The following emission categories from the 2008 Base Case emissions scenario (see Section 2.5) were assumed to remain unchanged for the 2021 future year emission scenarios:

- Biogenic emissions.
- Wildfires, Prescribed Burns and Agricultural Burning emissions.
- Lightning emissions.
- Sea Salt emissions.
- Windblown Dust emissions.
- Emissions from Canada, Mexico and offshore sources (used in the 2021 36/12 km simulation used to provide boundary conditions for the 4 km CARMMS domain).

3.5 Western Colorado BLM Planning Area Oil and Gas Emissions

The emission calculators were used to generate O&G emissions for the eleven-year period of 2011-2021 for 8 western Colorado BLM Planning Areas:

- Roan Plateau portion of the Colorado River Valley Field Office (CRVFO)
- CRVFO outside of the Roan Plateau

[61] http://www.blm.gov/pgdata/etc/medialib/blm/ut/natural_resources/airQuality.Par.34346.File.dat/UTSO_EmissionsTSD121913.pdf
[62] http://www.blm.gov/wy/st/en/info/NEPA/documents/rfo/cd_creston.html
[63] http://www.epa.gov/ttnchie1/emch/
[64] http://epa.gov/ttn/chief/emch/2007v5/2007v5_2020base_EmisMod_TSD_13dec2012.pdf

- Grand Junction Field Office (GJFO)
- Kremmling Field Office (KFO)
- Little Snake Field Office (LSFO)
- Tres Rios Field Office (TRFO)
- Uncompahgre Field Office (UFO)
- White River Field Office (WRFO)

For each year between 2011-2021, the emissions calculators were used to estimate O&G emissions for upstream (well site) and midstream emission sources and for O&G development on Federal and non-Federal lands within in each of the 8 western Colorado BLM Planning Areas listed above.

3.5.1 2021 High, Low and Medium Development Scenarios Emissions Overview

The emissions calculators were used to generate O&G emissions within the 8 western Colorado BLM Planning Areas for 2021 High, Low and Medium Development Scenarios. The High Development Scenario is based on BLM COSOs estimates of RFD O&G future development within these 8 BLM Planning Areas. The Low Development Scenario is based on historical 5-year average O&G development over the 2008-2012 period that was used to grow O&G emissions to each year between 2011-2021. Applicable State and Federal controls are applied to the O&G emissions starting in the year that they are required.

The Low Development Scenario assumes 25,710 total active wells in 2021 within the 8 western Colorado BLM Planning Areas with 8,121 wells (32%) on Federal and 17,589 wells (68%) on non-Federal lands. The High Development Scenario assumes 41,033 total active wells, 1.6 times higher than the Low Development Scenario, that are split as 18,347 on Federal (45%) and 22,686 (55%) on non-Federal lands. The 2021 Medium Development Scenario has the same number of wells as the High Development Scenario but assumes additional levels of controls beyond the application of existing state and federal requirements. The Medium Development Scenario assumes additional control of engine and fugitive emission sources for all phases of well-site operation for wells drilled on Federal land after 2015 as follows:

- All development (drilling / completion / fracing) engines will be Tier 4. Tier 4 gen-set standards will be applied for all engines with a horsepower >750; final Tier 4 standards will be applied to all engines with horsepower <750.
- All condensate tank, oil tank, and dehydrator emissions are captured and controlled by VRUs (assumed 95% control efficiency attained by vapor recovery).
- All pneumatic devices are low-bleed or no bleed. Assumed 50% of devices are low-bleed (6 cfh) and 50% of devices are no-bleed.
- Assume that 30% of production engines are powered by electricity (applies to all well-site engines).
- Assume 80% dust control for unpaved road traffic.
- All truck loading emissions are captured and controlled by VRU.

Table 3-1 and Figure 3-4 compare the total emissions from the 8 western Colorado BLM Planning Areas for the 2021 High, Low and Medium Development emission scenarios.

Table 3-1. Comparison of oil and gas emissions (tons per year, TPY) from the 8 western Colorado BLM Planning Areas for 2021 High, Low and Medium Development emission scenarios.

Scenario	VOC	CO	NO_X	PM_{10}	$PM_{2.5}$	SO_2
All Wells						
Low	44,025	22,715	25,078	4,425	1,270	259
Medium	78,654	45,453	51,983	7,224	2,355	1,145
High	95,427	46,014	56,666	9,482	2,714	1,145
Federal Emissions						
Low	13,950	7,369	7,939	1,233	424	190
Medium	30,254	22,811	26,003	2,763	1,118	971
High	47,007	23,371	29,879	4,996	1,452	972
Non-Federal Emissions						
Low	30,075	15,346	17,139	3,191	846	69
Medium	48,399	22,642	25,979	4,461	1,237	174
High	48,420	22,642	26,787	4,486	1,262	174

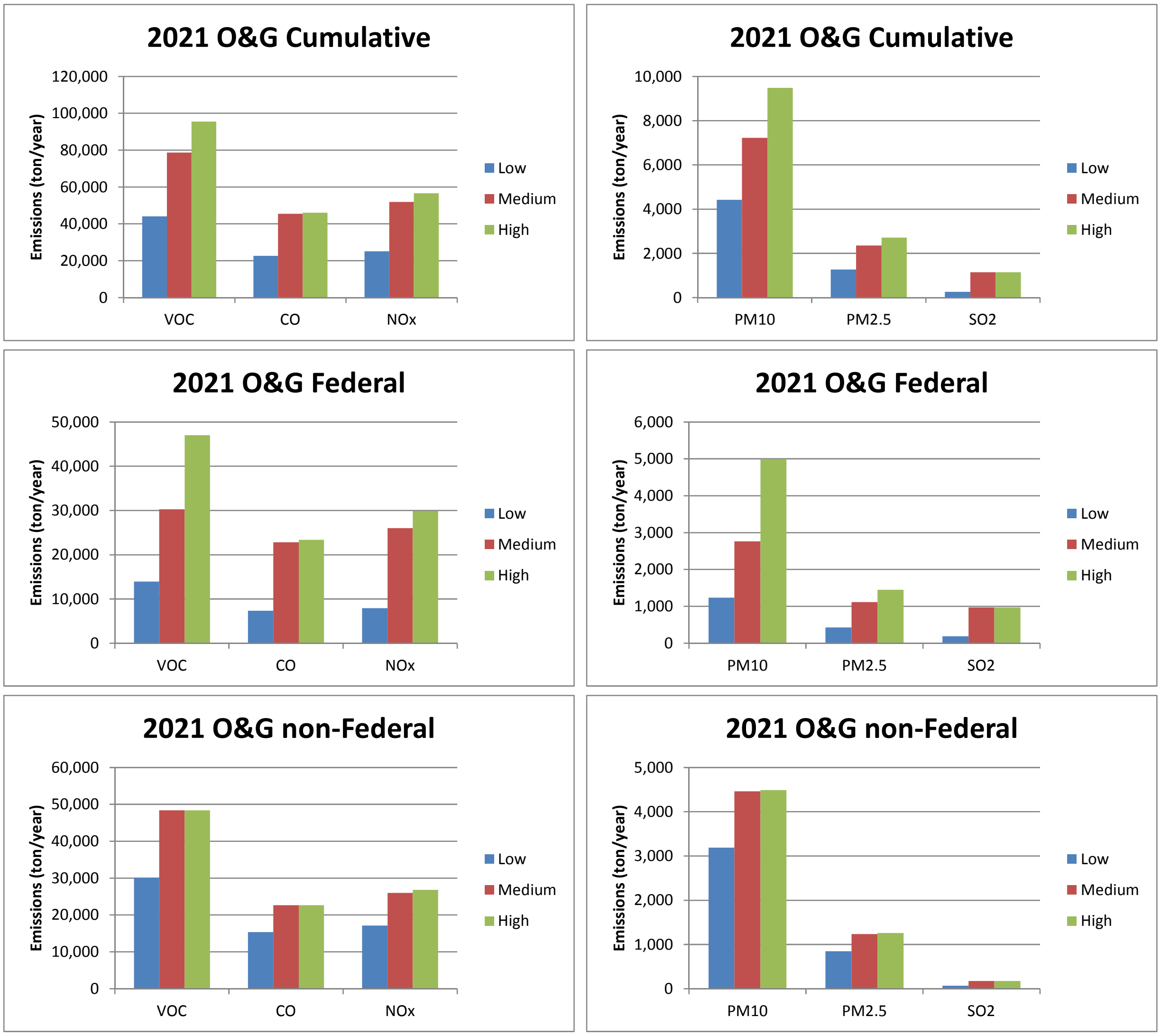


Figure 3-4. Comparison of total oil and gas emissions from the 8 western Colorado BLM Planning Areas for the 2021 High, Low and Medium Development Scenarios.

3.5.2 2021 High, Low and Medium Development Scenarios Emissions

The CARMMS air quality modeling results for the 2021 High, Low and Medium Development Scenarios are presented in Chapter 5. In this section we summarize the emissions for the 8 western Colorado BLM Planning Areas and the three 2021 emission scenarios. Figure 3-5 and Table 3-2 display the NO_X and VOC O&G emissions for the 8 western Colorado BLM Planning Areas and the 2011 current year emissions and the three 2021 emission scenarios stratified by O&G emissions on Federal and non-Federal lands. Summary spreadsheets (not shown) also include emissions stratified by upstream vs. midstream and provide emissions per well. Across the 8 Colorado Planning Areas, the 2021 High Development Scenario O&G NO_X and VOC emissions are, respectively, 2.6 and 2.7 times greater than in 2011, whereas the 2021 Low Development Scenario are 1.1 and 1.3 times greater than 2011, so the 2021 Low Development Scenario emissions are very similar to 2011 O&G emission levels. The controls assumed in the

2021 Medium Development Scenario reduce O&G NO_X and VOC emissions by -8.2% and -17.6% from the 2021 High Development Scenario.

Table 3-2a. Summary of oil and gas NO_X and VOC emissions within the 8 western Colorado BLM Planning Areas for the 2011 current year and 2021 High Development emission scenarios (2021 emissions include both existing and new O&G sources).

2011	NO_X Emissions (TPY)			VOC Emissions (TPY)		
BLM Area	Federal	non-Fed	Total	Federal	non-Fed	Total
CRVFO (No Roan)	1,036	3,575	4,611	2,596	10,407	13,003
Roan (CRVFO)	1,280	2,158	3,438	1,962	3,356	5,318
GJFO	535	2,976	3,511	634	4,032	4,665
KFO	69	40	108	150	138	288
LSFO	741	189	930	1,493	415	1,907
TRFO	879	4,551	5,431	837	3,243	4,080
UFO	61	76	137	55	65	120
WRFO	3,296	736	4,032	4,433	1,052	5,485
Grand Total	7,896	14,301	22,198	12,159	22,708	34,867
2021 High Scenario	**NO_X Emissions (TPY)**			**VOC Emissions (TPY)**		
BLM Area	**Federal**	**non-Fed**	**Total**	**Federal**	**non-Fed**	**Total**
CRVFO (No Roan)	1,679	4,639	6,318	5,070	14,287	19,357
Roan (CRVFO)	1,835	1,856	3,692	2,971	3,425	6,395
GJFO	7,670	10,291	17,961	13,744	20,230	33,974
KFO	236	221	458	424	326	750
LSFO	2,320	1,723	4,042	3,334	2,349	5,683
TRFO	3,386	5,096	8,482	2,289	3,861	6,150
UFO	612	1,067	1,679	620	1,082	1,702
WRFO	12,141	1,893	14,034	18,556	2,859	21,415
Grand Total	29,879	26,787	56,666	47,007	48,420	95,427
Difference	**NO_X Emissions (TPY)**			**VOC Emissions (TPY)**		
BLM Area	**Federal**	**non-Fed**	**Total**	**Federal**	**non-Fed**	**Total**
CRVFO (No Roan)	62%	30%	37%	95%	37%	49%
Roan (CRVFO)	43%	-14%	7%	51%	2%	20%
GJFO	1333%	246%	412%	2069%	402%	628%
KFO	244%	455%	322%	183%	136%	160%
LSFO	213%	813%	335%	123%	467%	198%
TRFO	285%	12%	56%	173%	19%	51%
UFO	903%	1302%	1124%	1025%	1565%	1317%
WRFO	268%	157%	248%	319%	172%	290%
Grand Total	278%	87%	155%	287%	113%	174%

Table 3-2b. Summary of oil and gas NO_X and VOC emissions within the 8 western Colorado BLM Planning Areas for the 2011 current year and 2021 Medium Development emission scenarios (2021 emissions include both existing and new O&G sources).

2011	NO_X Emissions (TPY)			VOC Emissions (TPY)		
BLM Area	Federal	non-Fed	Total	Federal	non-Fed	Total
CRVFO (No Roan)	1,036	3,575	4,611	2,596	10,407	13,003
Roan (CRVFO)	1,280	2,158	3,438	1,962	3,356	5,318
GJFO	535	2,976	3,511	634	4,032	4,666
KFO	69	40	109	150	138	288
LSFO	741	189	930	1,493	415	1,908
TRFO	879	4,551	5,430	837	3,243	4,080
UFO	61	76	137	55	65	120
WRFO	3,296	736	4,032	4,433	1,052	5,485
Grand Total	7,896	14,301	22,197	12,159	22,708	34,867
2021 Medium Scenario	**NO_X Emissions (TPY)**			**VOC Emissions (TPY)**		
BLM Area	**Federal**	**non-Fed**	**Total**	**Federal**	**non-Fed**	**Total**
CRVFO (No Roan)	1,428	4,459	5,887	3,174	14,283	17,457
Roan (CRVFO)	1,613	1,820	3,433	2,438	3,424	5,862
GJFO	6,517	9,927	16,444	6,158	20,221	26,379
KFO	197	213	410	245	326	571
LSFO	2,092	1,680	3,772	2,690	2,348	5,038
TRFO	2,984	5,033	8,017	1,876	3,860	5,735
UFO	486	1,012	1,498	531	1,081	1,611
WRFO	10,686	1,835	12,522	13,142	2,857	15,999
Grand Total	26,003	25,979	51,983	30,254	48,399	78,654
Difference	**NO_X Emissions (TPY)**			**VOC Emissions (TPY)**		
BLM Area	**Federal**	**non-Fed**	**Total**	**Federal**	**non-Fed**	**Total**
CRVFO (No Roan)	38%	25%	28%	22%	37%	34%
Roan (CRVFO)	26%	-16%	0%	24%	2%	10%
GJFO	1118%	234%	368%	871%	402%	465%
KFO	185%	433%	276%	63%	136%	98%
LSFO	182%	789%	306%	80%	466%	164%
TRFO	239%	11%	48%	124%	19%	41%
UFO	696%	1232%	993%	865%	1563%	1243%
WRFO	224%	149%	211%	196%	172%	192%
Grand Total	229%	82%	134%	149%	113%	126%

Table 3-2c. Summary of oil and gas NO_X and VOC emissions within the 8 western Colorado BLM Planning Areas for the 2011 current year and 2021 Low Development emission scenarios (2021 emissions include both existing and new O&G sources).

2011	NO_X Emissions (TPY)			VOC Emissions (TPY)		
BLM Area	Federal	non-Fed	Total	Federal	non-Fed	Total
CRVFO (No Roan)	1,036	3,575	4,611	2,596	10,407	13,003
Roan (CRVFO)	1,280	2,158	3,438	1,962	3,356	5,318
GJFO	535	2,976	3,511	634	4,032	4,666
KFO	69	40	109	150	138	288
LSFO	741	189	930	1,493	415	1,908
TRFO	879	4,551	5,430	837	3,243	4,080
UFO	61	76	137	55	65	120
WRFO	3,296	736	4,032	4,433	1,052	5,485
Grand Total	7,896	14,301	22,197	12,159	22,708	34,867
2021 Low Scenario	**NO_X Emissions (TPY)**			**VOC Emissions (TPY)**		
BLM Area	**Federal**	**non-Fed**	**Total**	**Federal**	**non-Fed**	**Total**
CRVFO (No Roan)	1,212	3,334	4,546	3,701	10,456	14,157
Roan (CRVFO)	1,248	1,856	3,104	2,208	3,425	5,633
GJFO	819	5,229	6,049	1,203	10,107	11,310
KFO	80	94	175	127	145	272
LSFO	592	389	980	972	536	1,508
TRFO	1,051	5,261	6,313	782	3,931	4,712
UFO	176	127	303	200	140	340
WRFO	2,760	849	3,609	4,758	1,336	6,093
Grand Total	7,939	17,139	25,078	13,950	30,075	44,025
Difference	**NO_X Emissions (TPY)**			**VOC Emissions (TPY)**		
BLM Area	**Federal**	**non-Fed**	**Total**	**Federal**	**non-Fed**	**Total**
CRVFO (No Roan)	17%	-7%	-1%	43%	0%	9%
Roan (CRVFO)	-3%	-14%	-10%	13%	2%	6%
GJFO	53%	76%	72%	90%	151%	142%
KFO	16%	136%	60%	-16%	5%	-6%
LSFO	-20%	106%	5%	-35%	29%	-21%
TRFO	20%	16%	16%	-7%	21%	15%
UFO	189%	67%	121%	264%	116%	184%
WRFO	-16%	15%	-11%	7%	27%	11%
Grand Total	1%	20%	13%	15%	32%	26%

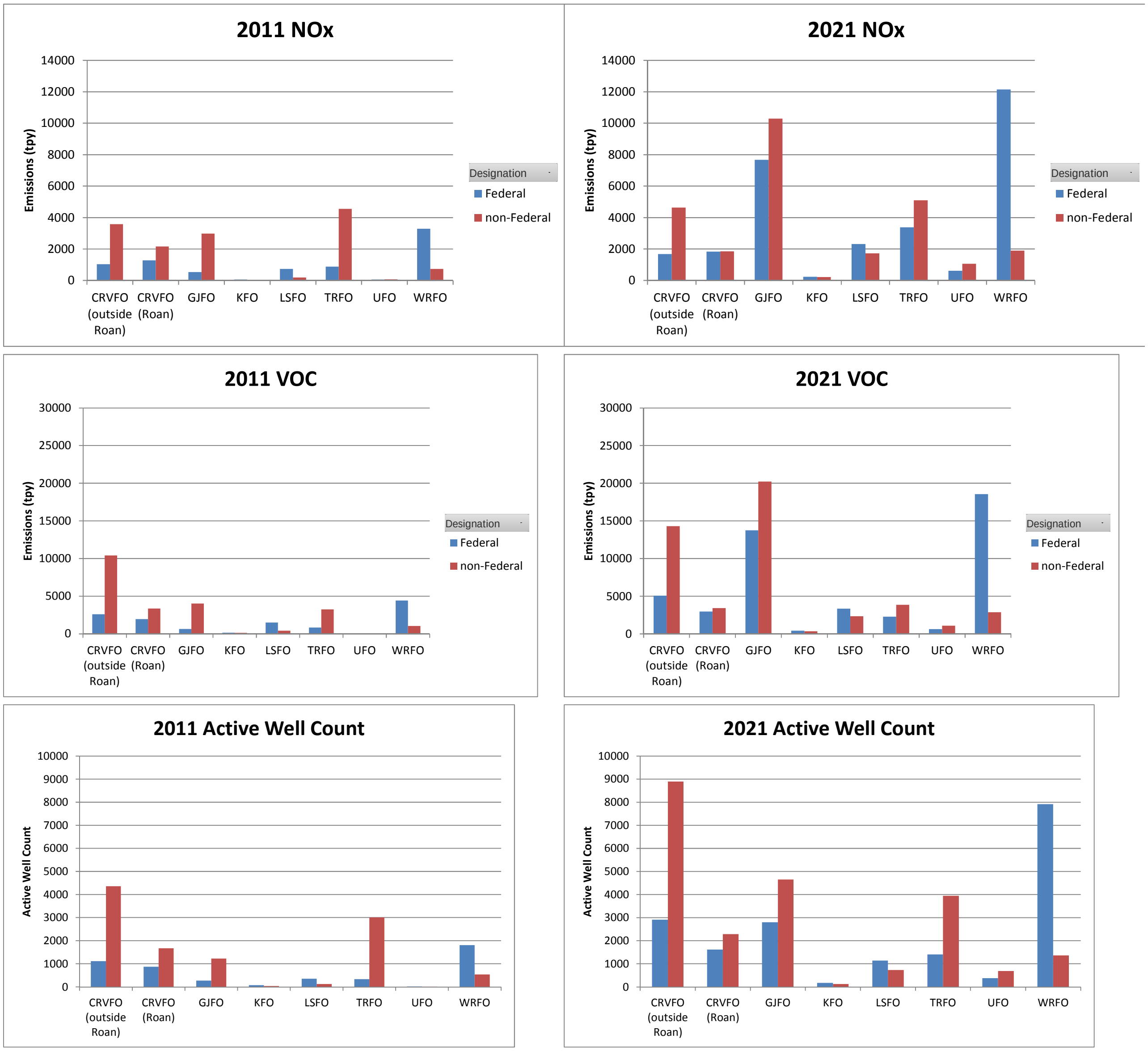


Figure 3-5. NO_X and VOC emissions and well counts from oil and gas development within the 8 western Colorado BLM Planning Areas and for the 2011 current (left) and 2021 High Development Scenario (right) emissions scenarios.

3.6 Future Year Emissions Modeling Procedures

The 2021 future year emissions were processed using the SMOKE emissions model in a similar manner as used for the 2008 Base Case emissions scenario described in Section 2.5. One difference in the 2021 SMOKE emissions modeling was that each source category for which separate ozone and particulate matter contributions are needed was processed in a separate stream in the SMOKE emissions modeling. This resulted in many different streams of SMOKE emissions processing for the three 2021 emission scenarios to provide separate source groups so that the AQ/AQRV impacts can be isolated in the source apportionment modeling.

3.6.1 Non-Oil and Gas Future-Year Emissions Data

For most of the inventory sectors, the 2020 inventory and ancillary emissions data were obtained directly from the 3SAQS modeling platform, which in turn uses data from EPA's 2007v5 modeling platform (EPA, 2012d). Developed by EPA for use in the $PM_{2.5}$ NAAQS RIA, the 2020 inventory represent the best estimate of future year emissions without the implementation of any new controls necessary to attain the current $PM_{2.5}$ annual and 24-hr (35 $\mu g/m^3$ and 15 $\mu g/m^3$) and ozone 8-hr (75 ppb) standards (EPA, 2012d). These emissions reflect rule promulgated or under reconsideration as of July 2012.

A summary of the 2007v5 modeling platform 2020 inventory is provided below and additional details are available from EPA (EPA, 2012d).

CEM Point: For Electric Generating Units (EGUs) with Continuous Emissions Monitors (CEMs), EGU-specific emissions estimates were obtained from the Integrated Planning Model (IPM®[65]), version 4.10 accounting for controls from the Cross-State Air Pollution Rule (CSAPR[66]) and Mercury and Air Toxics Standard (MATS[67]) rulemakings.

Non-CEM Point: Projection factors and percent reductions reflect CSAPR comments and emission reductions due to national rules, control programs, plant closures, consent decrees and settlements and 1997 and 2001 ozone State Implementation Plans in NY, CT, and VA. EPA used projection approaches for corn ethanol and biodiesel plants, refineries and upstream impacts from the Energy Independence and Security Act of 2007 (EISA). Terminal area forecast (TAF) data aggregated to the national level were used for aircraft to account for projected changes in landing/takeoff activity.

Nonpoint/Area: Agricultural sector projection factors for livestock estimates based on expected changes in animal population from 2005 Department of Agriculture data, updated based on personal communication with EPA experts in July 2012; fertilizer application NH_3 emissions projections include upstream impacts EISA. Fugitive dust projection factors for dust categories related to livestock estimates based on expected changes in animal population and upstream impacts from EISA. Other nonpoint source projection factors that implement CSAPR comments and reflect emission reductions due to control programs. Residential wood combustion projections are based on growth in lower-emitting stoves and a reduction in higher emitting stoves. PFC projection factors reflecting impact of the final Mobile Source Air Toxics (MSAT 2) rule. Upstream impacts from EISA, including post-2007 cellulosic ethanol plants are also reflected.

Off-road Mobile: Other than for California, this sector uses data from a run of NMIM that utilized NONROAD2008a, using future-year equipment population estimates and control programs to the year 2020 and using national level inputs. Final controls from the final locomotive-marine and small spark ignition OTAQ rules are included. California-specific data were provided by California Air Resources Board (CARB).

[65] http://www.icfi.com/insights/products-and-tools/ipm
[66] http://www.epa.gov/crossstaterule/
[67] http://www.epa.gov/mats/

Aircraft/locomotive/marine: For all states except California, projection factors for Class 1 and Class 2 commercial marine and locomotives, which reflect final locomotive-marine controls. California projected year-2020 inventory data were provided by CARB.

Offshore shipping: Base-year 2007 emissions grown and controlled to 2020, incorporating controls based on Emissions Control Area (ECA) and International Marine Organization (IMO) global NO_X and SO_2 controls.

On-road Mobile, not including refueling: MOVES2010b emissions factors for year 2020 were developed using the same representative counties, state-supplied data, meteorology, and procedures that were used to produce the 2007 emission factors. California-specific data were provided by CARB. Other than California, this sector includes all non-refueling on-road mobile emissions (exhaust, evaporative, evaporative permeation, brake wear and tire wear modes).

On-road Refueling: Uses the same projection and processing approach as the on-road sector, except for California where EPA projected using MOVES2010b and did not include CARB data.

Canada Sources: Held constant at 2006 levels.

Mexico Sources: Projections from 1999 to 2018.

The ancillary data (spatial/temporal/chemical) were held unchanged from the 3SAQS platform for preparing the 2021 emissions for CAMx. In the 3SAQS platform, the base sets of ancillary data were taken directly from the EPA 2007v5 modeling platform. The 3SAQS made targeted improvements to the ancillary files for counties in the 3-state study region (Figure 3-6). The improvements were focused on the assignments of spatial/chemical/temporal profiles to inventory sources and on developing profiles that best represent the emissions patterns in the 3-state study region.

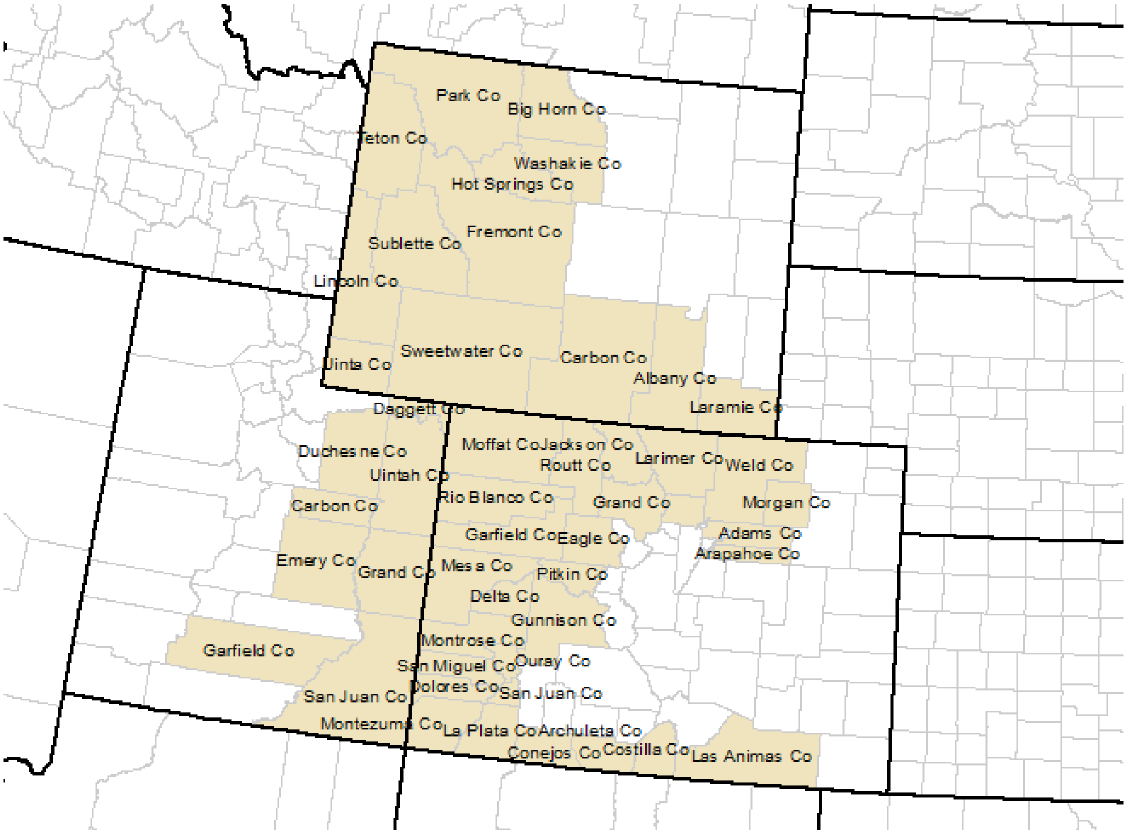


Figure 3-6. List of counties where the 3SAQS made targeted emission improvements to the EPA NEI.

The 3SAQS improvements over the EPA 2008, 2011 and 2020 National Emissions Inventory (NEI) for the CO/UT/WY counties include the following:

<u>Utah</u>

- Updated the 2007v5 spatial surrogates for land cover and building square footage with NLCD2006 and FEMA-HAZUS data
- Changed the ATV/ORV/Snowmobile surrogate assignment from rural land area to forest land
- Changed the livestock surrogate assignment from total agricultural land to pasture land
- Changed the fertilizer surrogate assignment from total agricultural land to crop land
- Created a state-specific, year 2011 monthly temporal profile for residential natural gas heating fuel use with Energy Information Administration data (Figure 3-7).
- Used point locations of rest areas and truck stops to allocation MOVES extended idling emissions to the modeling grid

Colorado

- Updated the 2007v5 spatial surrogates for land cover and building square footage with NLCD2006 and FEMA-HAZUS data
- Changed the ATV/ORV/Snowmobile surrogate assignment from rural land area to forest land
- Created CAFO spatial surrogates from data provided by CDPHE for livestock ammonia sources
- Changed the livestock surrogate assignment from total agricultural land to pasture land
- Changed the fertilizer surrogate assignment from total agricultural land to crop land
- Created a state-specific, year 2011 monthly temporal profile for residential natural gas heating fuel use with Energy Information Administration data (Figure 3-7).
- Developed 2008 vehicle miles traveled (VMT)-based spatial surrogates for on-road mobile sources. Figure 3-8 compares the U.S. Census year 2010 TIGER line roadway data with link-based VMT data from CO.
- Used point locations of rest areas and truck stops to allocation MOVES extended idling emissions to the modeling grid

Wyoming

- Updated the NEI08v2 spatial surrogates for land cover and building square footage with NLCD2006 and FEMA-HAZUS data
- Changed the ATV/ORV/Snowmobile surrogate assignment from rural land area to forest land
- Changed the livestock surrogate assignment from total agricultural land to pasture land
- Changed the fertilizer surrogate assignment from total agricultural land to crop land
- Created a state-specific, year 2011 monthly temporal profile for residential natural gas heating fuel use with Energy Information Administration data (Figure 3-7).
- Developed confined animal feeding operation (CAFO) spatial surrogates for livestock sources. The CAFOs locations data were provided by the state of Wyoming (Figure 3-9). The 3SAQS generated WY livestock surrogates for cattle, poultry, and swine.
- Used point locations of rest areas and truck stops to allocation MOVES extended idling emissions to the modeling grid

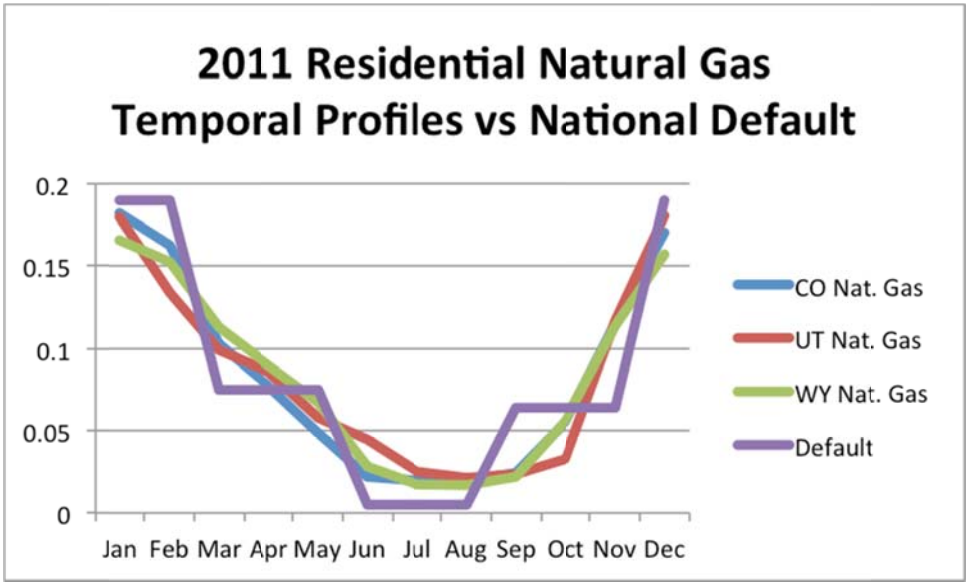


Figure 3-7. 3SAQS 2011 residential natural gas consumption monthly temporal profiles.

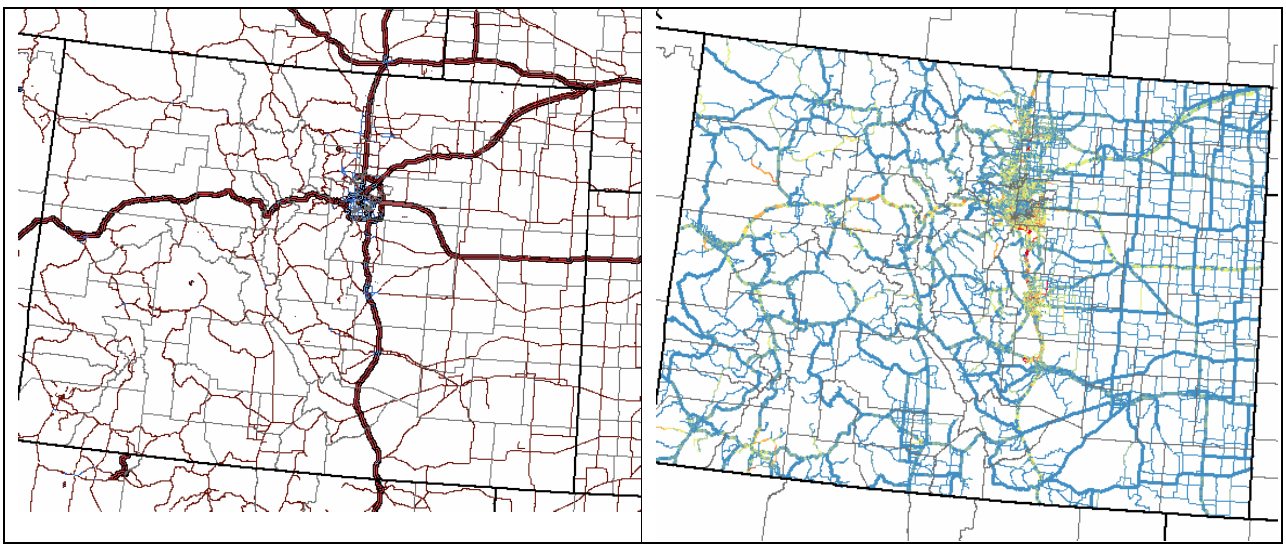


Figure 3-8. Colorado roadway spatial data improvement plots. Left: TIGER 2010 Shapefile of urban/rural primary/secondary roads. Right: CO 2008 VMT-based roadways.

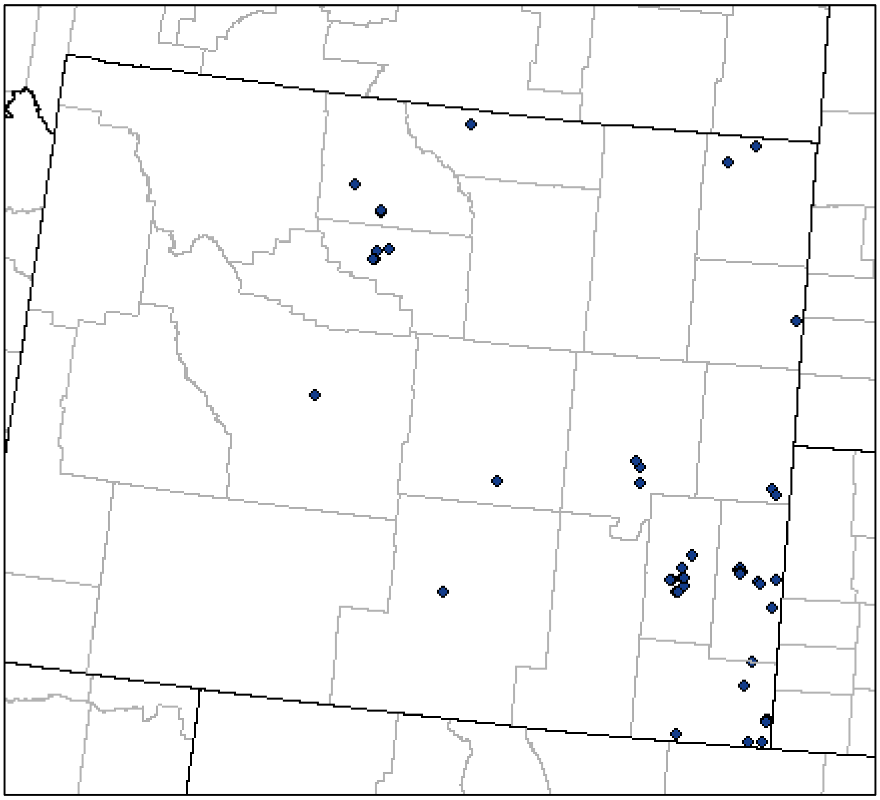


Figure 3-9. Wyoming CAFO locations.

3.6.2 Oil and Gas Future-Year Emissions Data

For oil and gas sources, Ramboll Environ developed emissions inventories for the western Colorado BLM planning areas as described in Section 3.1 and South San Juan basin, NM as described in Section 3.2.2. The oil and gas emissions for all other planning areas were provided by BLM as described in Section 3.2.

For oil and gas sources within the 14 BLM planning areas, emissions were divided into existing and RFD (new) source categories to facilitate CAMx source apportionment processing. The RFD sources were further divided into oil and gas development on the BLM-authorized land (Federal) and other (non-Federal) lands. The South San Juan basin existing emissions were obtained from the WRAP Phase III midterm projection.

For processing oil and gas emissions, we developed ancillary data (spatial/temporal/chemical) specific to planning areas. The area-specific spatial allocation profiles were developed from the data provided by BLM and chemical speciation profiles were prepared from the gas composition available in the emission calculator. Table 3-3 provides a list of speciation and gridding profiles developed by planning areas. The conventional (CG) and CBM gas speciation profile are assigned to source categories associated with the respective well type. For spatial allocation, gridding profiles were developed for each well type (i.e., conventional, CBM) and land type (Federal, non-Federal) combination.

Table 3-3. Source of VOC speciation profile and spatial surrogates used for gridding oil and gas emissions in the 14 CO/NM BLM Planning Areas.

Source Region	Speciation Profiles	Gridding Profiles
Colorado		
Colorado River Valley, without Roan	CRV{CG}	CRVFO {CG}{Fed,non-Fed}
Grand Junction FO	GJ {CBM,CG,SG}	GJFO {CG,CBM}{Fed,non-Fed}
Kremmling FO	K {CBM,CG,CO}	KFO shapefile
Little Snake FO	LS {CG,CO}	CRVFO {CG}{Fed,non-Fed}
Roan Plateau	CRV{CG}	CRVFO_Roan_Plateau.
Tres Rios FO	TR {CBM,CG,CO,SHL}	TRFO {CG,CBM}{Fed,non-Fed}
Uncompahgre FO	U {CBM,CG}	UFO {CG,CBM}{Fed,non-Fed}
White River FO	WR {CG,CO}	WRVFO {CG}{Fed,non-Fed}
Pawnee National Grasslands	DJ{FLA ,VNT}	RGFO {CG}{Fed}
Royal Gorge FO Area1	DJ{FLA ,VNT}	RGFO {CG}{Fed,non-Fed}
Royal Gorge FO Area2	DJ{FLA ,VNT}	RGFO {CG}{Fed,non-Fed}
Royal Gorge FO Area3	DJ{FLA ,VNT}	RGFO {CG}{Fed,non-Fed}
Royal Gorge FO Area4	DJ{FLA ,VNT}	RGFO {CG}{Fed,non-Fed}
New Mexico		
Farmington FO	MAN{SG, SO}	Shapefile

3.6.3 Mining Future-Year Emissions Data

For mining sources, emissions were estimated for coal and uranium mines on Federal lands in the western Colorado BLM Planning Areas. The emissions for mines on Federal lands were estimated based on the CDPHE APEN database and available EISs and EAs. The mining emissions not on federal lands were obtained from the 2020 EPA/3SAQS inventory. EPA default chemical speciation profiles were used in the SMOKE emissions modeling for mining except that the EPA mining $PM_{2.5}$ speciation profile was adjusted as described in Section 3.7.1.

The estimated coal mining sources were consolidated with the 2020 EPA/3SAQS inventory to avoid potential double counting. The western Colorado uranium mining emissions were modeled as “area” and spatially allocated using spatial surrogates developed from the data provided by BLM in a shapefile format.

3.7 Emissions Modeling Results

The CARMMS 1.0 CAMx source apportionment modeling used 20 emission source categories plus three combined O&G source groups as well as total anthropogenic and all emissions within the 4 km CARMMS domain (ENVIRON et al., 2015). Table 3-4 lists the total NO_X, VOC, SO_2 and $PM_{2.5}$ emissions for these source categories/groups as applied in the CARMMS 1.0 2021 High Development Scenario source apportionment simulation. These emissions are also applicable to the current study (CARMMS 1.5). In particular, we note that total $PM_{2.5}$ emissions from mining are the same as in CARMMS 1.0 although the $PM_{2.5}$ speciation is different now (Section 3.7.1). We note that natural emissions were indicated as source group #19 in Table 3-4 in the CARMMS 1.0 report but are now indicated as group #1, so the BLM Field Offices all have a source group number now that is one lower than that used in the CARMMS 1.0 report. Also, new source apportionment groups were added for EGUs in CARMMS 1.5, but these are the same as in the Low Development Scenario and are discussed in detail below in the context of that scenario.

These emissions were obtained from CAMx source apportionment diagnostic output file for each day of the annual simulation and summed to obtain total annual emissions. The emissions in Table 3-4 differ from the ones presented earlier in Tables 3-1 and 3-2a in that they represent emissions after processing by SMOKE emissions model that performs spatial and temporal allocation and chemical speciation. Another important differences in the emissions presented in Table 3-4 from those in Tables 3-1 and 3-2a is that for the BLM Planning Areas (Numbers 1-14) the emissions are in Table 3-4 are just for new O&G emissions on Federal lands, whereas Tables 3-1 and 3-2 Federal O&G emissions are for new and existing sources. For VOC, the differences in emissions between Tables 3-2a and Table 3-4 are even greater because SMOKE also does chemical speciation of the VOCs into the CB05 chemical mechanism that drops the unreactive portions of VOCs that do not participate in photochemistry.

When considering new Federal O&G within the 14 BLM Planning Areas and the 2021 High Development Scenario (Table 3-4), the WRFO has the highest NO_X emissions (11,264 tons per year, TPY) followed by GJFO (7,293 TPY), FFO (3,321 TPY) and TRFO (2,665 TPY). Total 2021 O&G NO_X emissions in the 14 BLM Planning Areas is 178,447 TPY that is split into 18 percent new Federal (32,566 TPY), 37 percent new non-Federal (65,713 TPY) and 45 percent existing O&G emissions (81,168 TPY). Outside of the 14 BLM Planning Areas, there is an additional 61,220 TPY O&G NO_X emissions for a total 2021 High Development Scenario O&G NO_X emissions across the entire 4 km CARMMS domain of 240,667 TPY that represents 34 percent of the total anthropogenic and 30 percent of the total (anthropogenic plus natural) NO_X emissions in the 4 km domain.

Total O&G VOC emissions in the 4 km CARMMS domain for the 2021 High Development Scenario are 835,785 TPY that represents 73 percent of the total anthropogenic and 39 percent of the total anthropogenic plus natural VOC emissions across the domain. Natural VOC emissions represent 46 percent of the annual VOC emissions across the 4 km CARMMS domain. Note that biogenic emissions are highly day-specific with higher emissions under warmer temperatures and higher light intensity. Thus, the contributions of biogenic VOC emissions to the total annual VOC emissions (46 percent) would be expected to be lower on cooler and higher on warmer days. Also note that the VOC emissions in Table 3-4 were obtained from the Carbon Bond chemical mechanism species that will be different than the VOC species input into the SMOKE emissions modeling system (for example, includes ethane and excludes nonreactive carbon in VOCs).

With one exception, SO_2 emissions from Federal O&G within the 14 BLM Planning Areas are fairly low (< 20 TPY). The exception is the WRFO Planning Area where the 904 TPY SO_2 emissions represent 95 percent of the 950 TPY SO_2 emissions from all 14 BLM Planning Areas combined in the 2021 High Development Scenario. A majority of the 2021 SO_2 emissions in the WRFO Planning Area come from two gas plants: the Enterprise Gas Proc – Meeker Gas Plant and the Williams Field – Willow Creek Gas Plant. These gas plant emissions were based on the

CDPHE 2008 Air Pollution Emission Notice (APEN) database grown to 2021 using the change in gas production between 2008 and 2021 for the 2021 High, Low and Medium Development Scenarios. Total O&G SO_2 emissions across the CARMMS domain is 6,071 TPY that is primarily (75 percent) due to O&G from outside of the 14 BLM Planning Areas, these areas in the 4 km CARMMS domain outside of the 14 BLM Planning Areas includes the Uinta Basin where sour gas reserves occur.

Total $PM_{2.5}$ emissions from O&G in the 14 BLM Planning Areas and the 2021 High Development Scenario is 7,849 TPY of which over half (58 percent) is due to new non-Federal O&G and the rest approximately split equally between new Federal and existing O&G. Mining within the 14 BLM Planning Areas contributes 6,957 TPY. By far the largest contribution of primary $PM_{2.5}$ emissions is the other (non O&G and mining) anthropogenic emissions category that contributes 74 percent of the region-wide total with natural emissions (mostly due to wildfires) contributing most of the rest (23 percent).

Table 3-5a is like Table 3-4 but for the 2021 Low Development Scenario, with the percent reductions of emissions between the Low and High development Scenarios shown in Table 3-5b. New source groups are added for coal and oil/gas-fired EGUs. The groups and method for source apportionment are described in detail in Section 4.1.

With the revisions made to the Mancos Shale Low Development Scenario inventory in the current study (CARMMS 1.5), the 2021 emissions from new Federal sources in the FFO are 52% to 68% lower than in the High Development Scenario, depending on pollutant (Table 3-5b). The total new Federal O&G NO_X emissions across the 14 BLM Planning Areas for the low scenario (8,385 TPY) is 74% lower than the high scenario (32,566 TPY). Similar reductions are seen for the other species (-63 to -83 percent). The annual emissions for the 2021 Medium Development Scenario are shown in Table 3-6a with the percent reduction from the 2021 High Development Scenario given in Table 3-6b. The numbers in these two tables are the same as in the CARMMS 1.0 report as the Medium Development scenario is not altered from CARMMS 1.0 to 1.5. Total O&G NO_X emissions across the 14 BLM Planning Areas for the 2021 Medium Development Scenario is 27,071 TPY that is -17% lower than the 201 High Development Scenario (Table 3-6b). Similarly, 2021 Medium Development Scenario O&G VOC emissions across the 14 BLM Planning Areas are 35% lower than the 2021 High Development Scenario.

Table 3-4. Total emissions (tons per year) for each Source Category (see Section 4.1) and combinations of Source Categories for the 2021 High Development Scenario from the CAMx source apportionment diagnostic output files after processing by SMOKE.

CARMMS 2021 High Development Scenario (tpy)						
Number	Group	NO_X	VOC	SO_2	$PM_{2.5}$	PM_{10}
1	Natural (Biogenics + Fires)	113,165	992,560	1,132	79,453	574,255
2	LSFO	2,007	4,648	13	73	170
3	WRFO	11,264	27,258	904	597	1,368
4	CRVFO	1,311	6,076	2	71	250
5	RPPA	1,245	2,739	1	48	135
6	GJFO	7,293	18,108	15	310	1,496
7	UFO	586	870	1	35	140
8	TRFO	2,665	1,715	2	125	855
9	KFO	177	412	0	10	50
10	RGFO #1	303	875	1	29	225
11	PGPA	930	2,682	3	90	689
12	RGFO #2	1,151	1,526	1	22	58
13	RGFO #3	224	77	0	3	16
14	RGFO #4	90	944	0	16	134
15	FFO	3,321	8,747	5	314	1,824
16	New O&G from non-Fed BLM PAs	65,713	228,655	297	4,548	30,790
17	Existing O&G from BLM PAs	81,169	228,749	252	1,558	2,838
18	Mining from BLM PAs	686	46	8	6,957	6,977
19	All O&G outside 14 BLM PAs	61,220	301,705	4,572	2,680	2,822
20*	Remaining anthro. emissions	459,907	312,498	95,720	242,828	1,400,504
	14 BLM PAs new Fed O&G	32,566	76,676	950	1,744	7,409
	14 PAs Total O&G	179,447	534,080	1,499	7,849	41,038
	Total O&G	240,667	835,785	6,071	10,530	43,859
	Total Anthropogenic	701,260	1,148,329	101,799	260,315	1,451,340
	Total All Emissions	814,425	2,140,889	102,931	339,768	2,025,594

*Remaining anthropogenic emissions in this table includes the EGUs which are separated out as new source groups in the current study. See Table 3-5a for a summary of those emissions.

Table 3-5a. Total emissions (tons per year) for each Source Category (see Section 4.1) and combinations of Source Categories for the 2021 Low Development Scenario from the CAMx source apportionment diagnostic output files after processing by SMOKE.

CARMMS 2021 Low Development Scenario (tpy)						
Number	Group	NO_X	VOC	SO_2	$PM_{2.5}$	PM_{10}
1	Natural (Biogenics + Fires)	113,165	992,560	1,132	79,453	574,255
2	LSFO	275	638	2	10	23
3	WRFO	1,861	4,502	149	99	226
4	CRVFO	844	3,916	1	46	161
5	RPPA	656	1,552	1	26	70
6	GJFO	425	965	1	20	72
7	UFO	150	270	0	10	45
8	TRFO	326	227	0	16	89
9	KFO	21	34	0	1	5
10	RGFO #1	61	262	0	5	42
11	PGPA	188	804	1	17	129
12	RGFO #2	104	191	0	2	6
13	RGFO #3	141	51	0	2	11
14	RGFO #4	14	135	0	2	20
15	FFO	1,597	2,780	2	141	832
16	New O&G from non-Fed BLM PAs	30,509	102,337	112	1,993	13,350
17	Existing O&G from BLM PAs	81,169	228,749	252	1,558	2,838
18	Mining from BLM PAs	686	46	8	6,957	6,977
19	All O&G outside 14 BLM PAs	61,220	301,705	4,572	2,680	2,822
	14 BLM PAs new Fed O&G	6,663	16,327	157	397	1,731
	14 PAs Total O&G	118,341	347,413	521	3,948	17,919
	Total O&G	179,561	649,118	5,093	6,628	20,741
(a)	Coal EGU ANTO(b)	100,488	1,349	46,101	6,318	7,299
(a)	Coal EGU CUKNW(c)	81,199	999	29,523	5,460	6,697
(a)	Oil/Gas EGU ANTO(b)	1,119	51	109	6	9
(a)	Oil/Gas EGU CUKNW(c)	1,850	26	-	5	8
	Remainder Anthropogenic	275,252	310,072	19,987	231,040	1,386,491
	Total Anthropogenic	640,154	961,662	100,821	256,407	1,428,222
	Grand Total	753,319	1,954,222	101,953	335,860	2,002,477

(a) New source groups modeled in the current study
(b) ANTO = Parts of Arizona, New Mexico, Texas, Oklahoma within 4 km CARMMS domain
(c) CUKNW = Parts of Colorado, Utah, Kansas, Nebraska, Wyoming within 4 km CARMMS domain

Table 3-5b. Percent difference in 2021 High and Low Development Scenario emissions (High – Low) for each Source Category (see Section 4.1) and combinations of Source Categories from the CAMx source apportionment diagnostic output after processing by SMOKE.

CARMMS 2021 Low Development Scenario (tpy)						
Number	Group	NO_X	VOC	SO_2	$PM_{2.5}$	PM_{10}
1	Natural (Biogenics + Fires)	0.0%	0.0%	0.0%	0.0%	0.0%
2	LSFO	-86.3%	-86.3%	-86.4%	-86.3%	-86.4%
3	WRFO	-83.5%	-83.5%	-83.5%	-83.5%	-83.5%
4	CRVFO	-35.6%	-35.5%	-35.7%	-35.2%	-35.5%
5	RPPA	-47.3%	-43.3%	-46.8%	-46.3%	-48.2%
6	GJFO	-94.2%	-94.7%	-94.1%	-93.6%	-95.2%
7	UFO	-74.5%	-69.0%	-76.5%	-70.6%	-67.7%
8	TRFO	-87.8%	-86.8%	-83.8%	-87.1%	-89.6%
9	KFO	-88.2%	-91.7%	-88.8%	-89.2%	-89.8%
10	RGFO #1	-79.8%	-70.0%	-81.9%	-81.6%	-81.3%
11	PGPA	-79.8%	-70.0%	-81.9%	-81.2%	-81.2%
12	RGFO #2	-91.0%	-87.5%	-90.8%	-90.5%	-89.3%
13	RGFO #3	-37.0%	-34.0%	-37.5%	-33.0%	-31.0%
14	RGFO #4	-85.0%	-85.7%	-85.0%	-85.4%	-85.4%
15	FFO	-51.9%	-68.2%	-60.0%	-55.1%	-54.4%
16	New O&G from non-Fed BLM PAs	-53.6%	-55.2%	-62.3%	-56.2%	-56.6%
17	Existing O&G from BLM PAs	0.0%	0.0%	0.0%	0.0%	0.0%
18	Mining from BLM PAs	0.0%	0.0%	0.0%	0.0%	0.0%
19	All O&G outside 14 BLM PAs	0.0%	0.0%	0.0%	0.0%	0.0%
	14 BLM PAs new Fed O&G	-79.5%	-78.7%	-83.5%	-77.2%	-76.6%
	14 PAs Total O&G	-34.1%	-35.0%	-65.2%	-49.7%	-56.3%
	Total O&G	-25.4%	-22.3%	-16.1%	-37.1%	-52.7%
	Total Anthropogenic	-8.7%	-16.3%	-1.0%	-1.5%	-1.6%
	Total All Emissions	-7.5%	-8.7%	-1.0%	-1.2%	-1.1%

Table 3-6a. Total emissions (tons per year) for each Source Category (see Section 4.1) and combinations of Source Categories for the 2021 Medium Development Scenario from the CAMx source apportionment diagnostic output files after processing by SMOKE.

CARMMS 2021 Medium Development Scenario (tpy)						
Number	Group	NO_X	VOC	SO_2	$PM_{2.5}$	PM_{10}
19	Natural (Biogenics + Fires)	113,165	992,560	1,132	79,453	574,255
1	LSFO	1,779	3,633	13	58	98
2	WRFO	9,809	18,803	904	500	810
3	CRVFO	1,060	3,253	2	51	123
4	RPPA	1,023	1,848	1	35	70
5	GJFO	6,149	8,345	15	196	673
6	UFO	460	733	1	24	66
7	TRFO	2,263	1,253	2	65	361
8	KFO	137	210	0	6	23
9	RGFO #1	193	679	1	10	52
10	PGPA	593	2,081	3	29	158
11	RGFO #2	846	1,468	1	15	25
12	RGFO #3	156	54	0	2	5
13	RGFO #4	51	679	0	5	30
14	FFO	2,552	6,808	4	185	745
15	New O&G from non-Fed BLM PAs	64,849	227,796	297	4,517	30,722
16	Existing O&G from BLM PAs	81,169	228,749	252	1,558	2,838
17	Mining from BLM PAs	686	46	8	6,957	6,977
18	All O&G outside 14 BLM PAs	61,220	301,705	4,572	2,680	2,822
20	Remaining anthro emissions	459,907	312,498	95,720	242,828	1,400,504
	14 BLM PAs new Fed O&G	27,071	49,849	947	1,180	3,239
	14 PAs Total O&G	173,089	506,394	1,496	7,254	36,800
	Total O&G	234,309	808,100	6,068	9,935	39,621
	Total Anthropogenic	694,902	1,120,643	101,796	259,720	1,447,102
	Total All Emissions	808,067	2,113,203	102,928	339,173	2,021,356

Table 3-6b. Percent difference in 2021 High and Medium Development Scenario emissions (High – Medium) for each Source Category (see Section 4.1) and combinations of Source Categories from the CAMx source apportionment diagnostic output files after processing by SMOKE.

CARMMS 2021 Medium Scenario Percent Change from High Scenario (%)						
Number	Group	NO_X	VOC	SO_2	$PM_{2.5}$	PM_{10}
19	Natural (Biogenics + Fires)	0.0%	0.0%	0.0%	0.0%	0.0%
1	LSFO	-11.3%	-21.8%	-1.4%	-20.7%	-42.7%
2	WRFO	-12.9%	-31.0%	0.0%	-16.4%	-40.8%
3	CRVFO	-19.1%	-46.5%	-0.4%	-27.9%	-50.6%
4	RPPA	-17.9%	-32.5%	-0.3%	-26.9%	-48.1%
5	GJFO	-15.7%	-53.9%	-0.6%	-36.8%	-55.0%
6	UFO	-21.5%	-15.7%	-5.2%	-32.4%	-52.5%
7	TRFO	-15.1%	-26.9%	-4.1%	-47.9%	-57.8%
8	KFO	-22.5%	-48.9%	-7.2%	-40.1%	-55.3%
9	RGFO #1	-36.2%	-22.4%	-20.6%	-67.0%	-77.0%
10	PGPA	-36.2%	-22.4%	-20.6%	-67.2%	-77.0%
11	RGFO #2	-26.5%	-3.8%	-24.8%	-33.2%	-56.2%
12	RGFO #3	-30.2%	-29.8%	-28.3%	-50.5%	-68.3%
13	RGFO #4	-43.5%	-28.0%	-1.0%	-71.0%	-77.4%
14	FFO	-23.1%	-22.2%	-21.4%	-41.0%	-59.2%
15	New O&G from non-Fed BLM PAs	-1.3%	-0.4%	-0.1%	-0.7%	-0.2%
16	Existing O&G from BLM PAs	0.0%	0.0%	0.0%	0.0%	0.0%
17	Mining from BLM PAs	0.0%	0.0%	0.0%	0.0%	0.0%
18	All O&G outside 14 BLM PAs	0.0%	0.0%	0.0%	0.0%	0.0%
20	Remaining anthro emissions	0.0%	0.0%	0.0%	0.0%	0.0%
	14 BLM PAs new Fed O&G	-16.9%	-35.0%	-0.3%	-32.3%	-56.3%
	14 PAs Total O&G	-3.5%	-5.2%	-0.2%	-7.6%	-10.3%
	Total O&G	-2.6%	-3.3%	-0.1%	-5.7%	-9.7%
	Total Anthropogenic	-0.9%	-2.4%	0.0%	-0.2%	-0.3%
	Total All Emissions	-0.8%	-1.3%	0.0%	-0.2%	-0.2%

Figure 3-10 displays spatial maps of NO_X, VOC and $PM_{2.5}$ emissions across the 4 km CARMMS domain by different source types for the 2021 High Development Scenario. The spatial maps for the Low and Medium Development Scenarios have the same locations as the High Development Scenario just with lower intensity. Figure 3-10a displays the total new Federal and new non-Federal O&G emissions across the 14 CO/NM BLM Planning Areas that shows a mixture of Federal and non-Federal O&G emissions in the western Colorado Planning Areas. Most of the new O&G emissions in the eastern Colorado Planning Areas (e.g., Weld County) are due to non-Federal O&G, except for the development within the Pawnee Grassland Planning Area. The differences in the new Federal and non-Federal O&G emissions for the Mancos Shale Development area in northern New Mexico reflects the assumption that new O&G was split 70 percent Federal and 30 percent non-Federal.

Figure 3-10b top panel displays the spatial distribution of emissions that combines the existing O&G within the 14 CO/NM BLM Planning Areas with the remainder O&G (new Federal and non-Federal plus existing) within the 4 km CARMMS domain but outside of the 14 CO/NM BLM

Planning Areas. In addition to the familiar Basins within the 14 CO/NM Planning Areas (Denver-Julesburg, Piceance and North and South San Juan), the Uinta Basin is clearly evident along with O&G emissions in southwest Wyoming and in the Texas panhandle. Mining within the Colorado BLM Planning Areas consist of mainly isolated grid cells that can have very high $PM_{2.5}$ emissions (Figure 3-10b, bottom panel). Figure 3-10c displays the other (remainder) anthropogenic emissions and natural emissions. Roadways and the major urban areas of Denver, Salt Lake City, Colorado Springs and Albuquerque are clearly evident in the other anthropogenic emissions NO_X and VOC maps. Whereas the spatial maps of other anthropogenic $PM_{2.5}$ emissions is more reflective of agricultural sources. Natural VOC emissions are dominated by forested areas, whereas the natural NO_X emissions are higher in agricultural areas and the locations of fires in 2008.

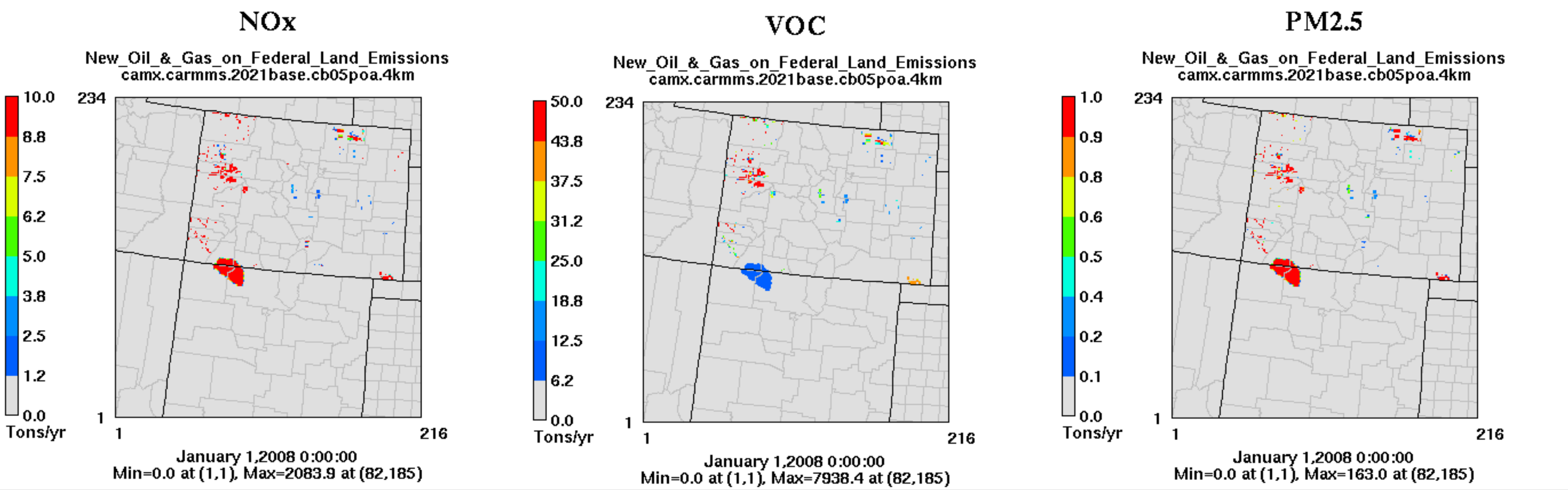
Figure 3-11 shows the spatial distribution of total low and elevated source emissions in the 2021 Low Development Scenario. The spatial patterns are due to a combination of oil and gas basins, mining, EGUs, urban areas, transportation and other sources. Figure 3-12 shows the spatial distribution of future federal Mancos Shale emissions. Generally oil dominant wells are expected to be located in the southerly part of the Mancos Shale play while gas dominant wells are expected in the northern part of the play. VOC emissions have a large spatial footprint reflecting the contributions from both oil and gas dominant wells in the Mancos Shale. The spatial distributions of annual coal-fired and oil/gas-fired EGU emissions in the CARMMS 4 km domain are illustrated in Figures 3-13 to 3-16, with coal-fired EGUs having a much larger contribution than oil/gas-fired EGUs to emissions of NOx, SO_2 and $PM_{2.5}$.

3.7.1 Mining PM Speciation Issues

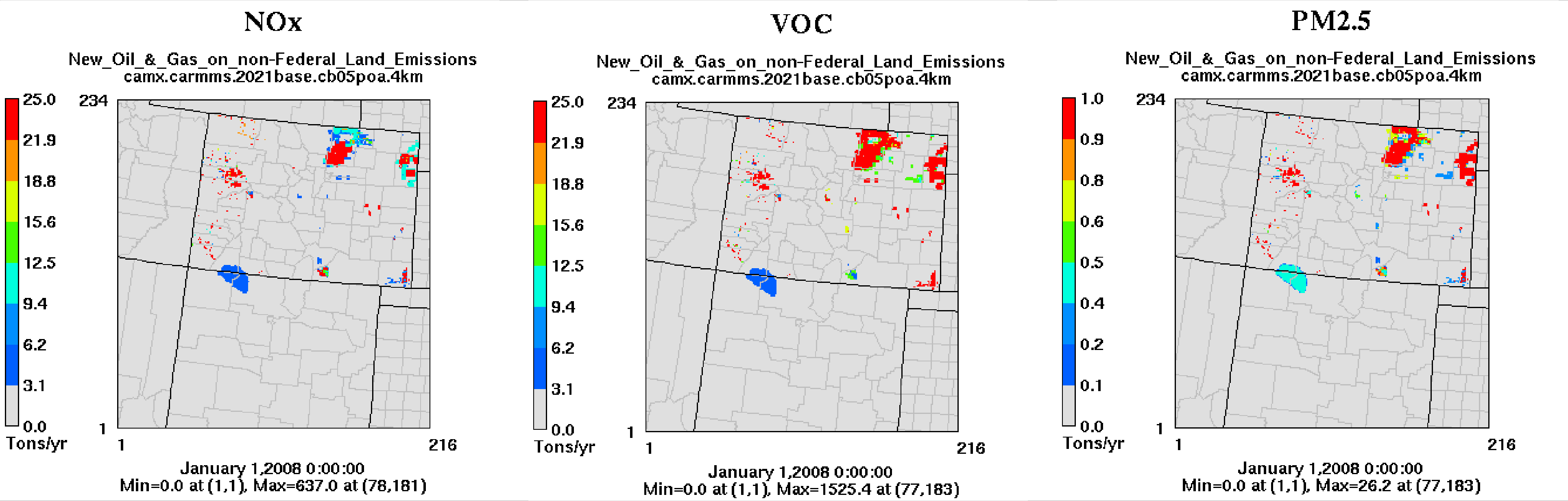
In CARMMS 1.0, the EPA default PM speciation profiles as provided with the SMOKE emissions modeling system were used to speciate PM emissions for mining sources. These PM speciation profiles convert total $PM_{2.5}$ emissions into particulate SO4, NO3, NH4, EC, OA and OPM2.5 (other $PM_{2.5}$) for the PGM modeling. In analyzing the AQ and AQRV impacts associated with mining on Federal lands in the CARMMS 1.0 2021 modeling results, we noticed sulfur deposition impacts and visibility impairment impacts due to SO4 that were higher than expected given the low SO_2 emissions from mining for the 2021 emission scenarios (8 TPY). These higher than expected sulfur impacts from mining were due to primary sulfate emissions. Of the 6,957 TPY $PM_{2.5}$ emissions from mining, 12.5% was due to primary SO4 emissions in CARMMS 1.0.

Table 3-7 lists the mining source categories and emissions by Source Classification Code (SCC) and the PM speciation profile code used in the SMOKE modeling system that is used to speciate the mining PM emissions using a cross-reference with the SCC number. In CARMMS 1.0, most of the mining PM emissions are speciated using the 92047 PM speciation profile that is for "Mineral Products – Avg – Simplified." Table 3-8 lists the $PM_{2.5}$ speciation profiles for various profiles used to speciate the mining emissions in SMOKE. For the dominant 92047 PM profile for mining, 14.1% of the $PM_{2.5}$ emissions are speciated as primary SO4. The reference for the 92047 PM speciation profile in the SPECIATE database is "Shareef, G.S. Engineering Judgment, Radian Corporation. September 1987." In our search we could not find this reference.

For some types of above ground mining that uses blasting, higher sulfur emissions may be expected. However, in Colorado most of the mining is underground that would not include blasting so would be expected to have lower sulfur emissions, which is reflected in the low mining SO_2 emissions. Thus, mining primary SO4 emissions were overstated in the CARMMS 1.0 2021 modeling, resulting in overstated sulfur deposition and visibility impacts associated with mining. In the current study (CARMMS 1.5), we re-processed the mining emissions using more appropriate $PM_{2.5}$ speciation profiles for mines in Colorado as shown in Table 3-7.

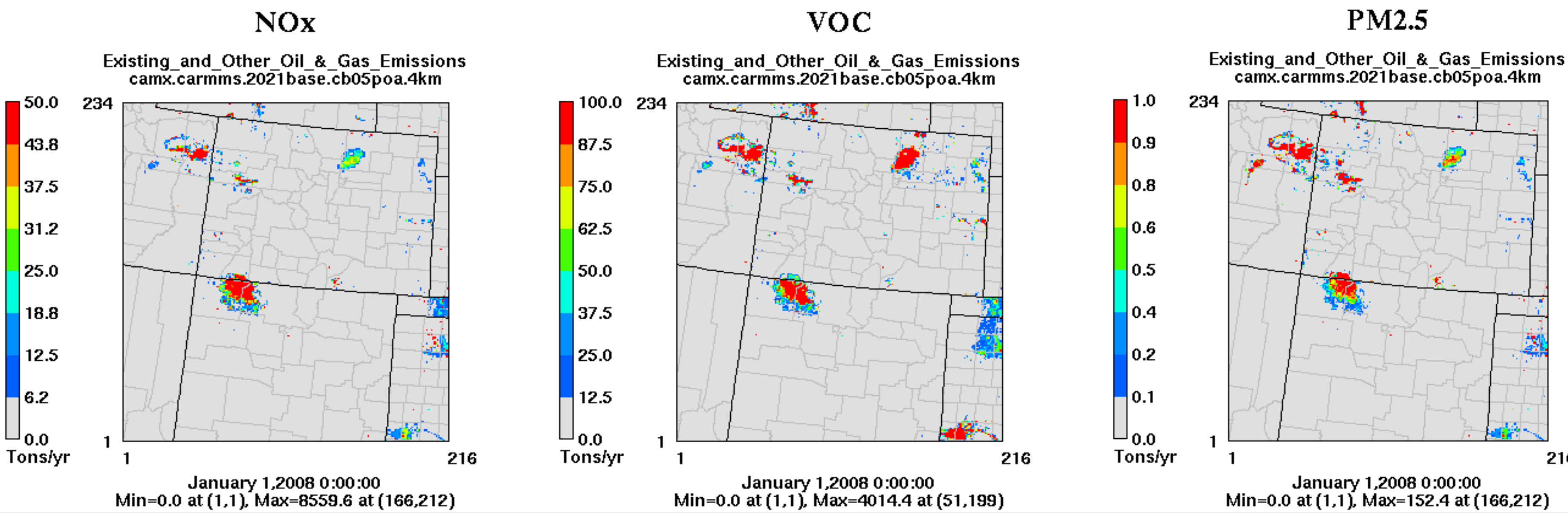


Combined New Federal O&G NOx | Combined New Federal O&G VOC | Combined New Federal O&G PM

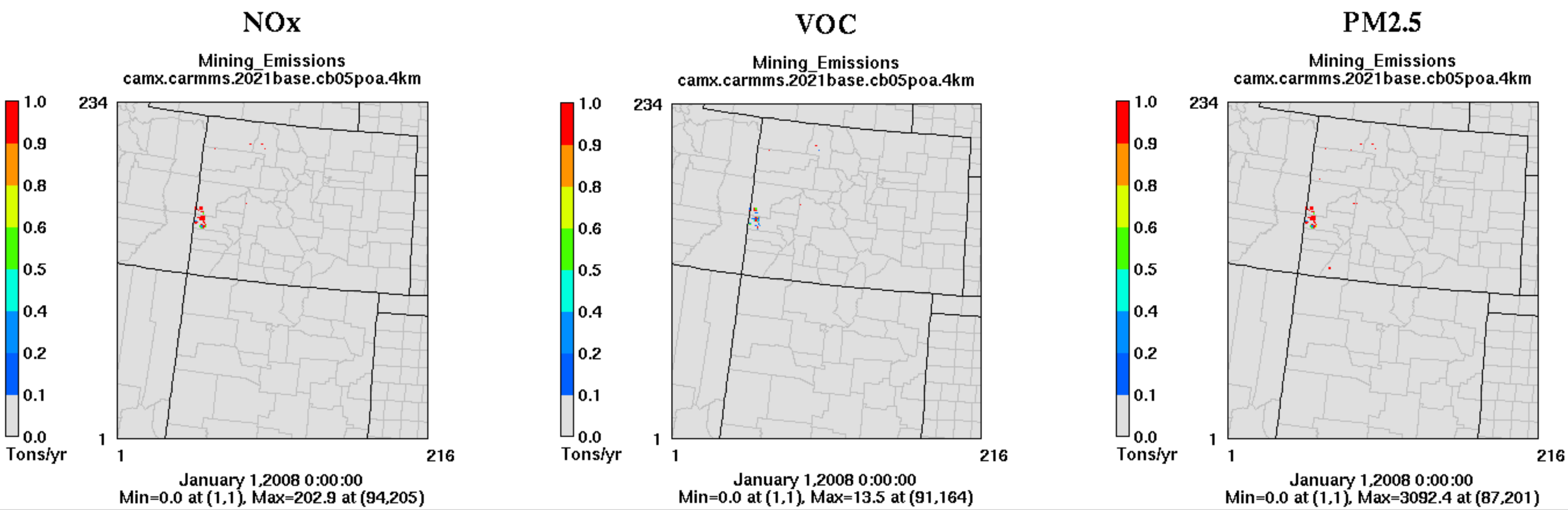


Combined New non-Federal O&G NOx | Combined New non-Federal O&G VOC | Combined New non-Federal O&G PM

Figure 3-10a. Spatial distribution of Federal (top) and non-Federal oil and gas NO_X, VOC and $PM_{2.5}$ emissions (tons per year) for the 14 BLM Planning Areas in the 2021 High Development Scenario.



Combined Existing O&G NOx	Combined Existing O&G VOC	Combined Existing O&G PM



Mining NOx	Mining VOC	Mining PM

Figure 3-10b. Spatial distribution of existing oil and gas (top) and mining on Federal lands NO_X, VOC and $PM_{2.5}$ emissions (tons per year) for the 14 BLM Planning Areas in the 2021 High Development Scenario.

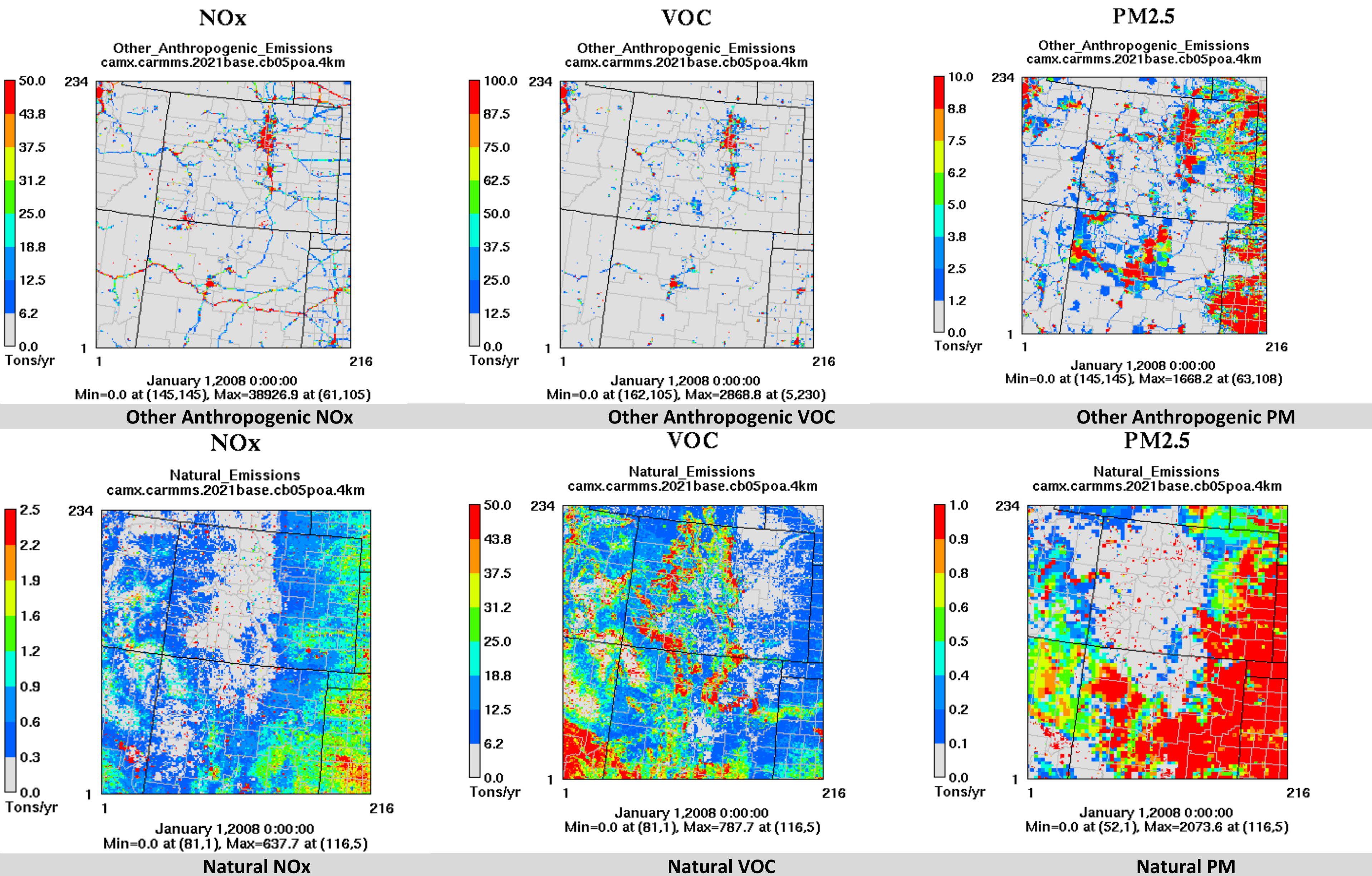


Figure 3-10c. Spatial distribution of other anthropogenic (top) and natural (biogenic, fires, lightning, sea salt and windblown dust) NOX, VOC and PM2.5 emissions (tons per year) for the 14 BLM Planning Areas in the 2021 High Development Scenario.

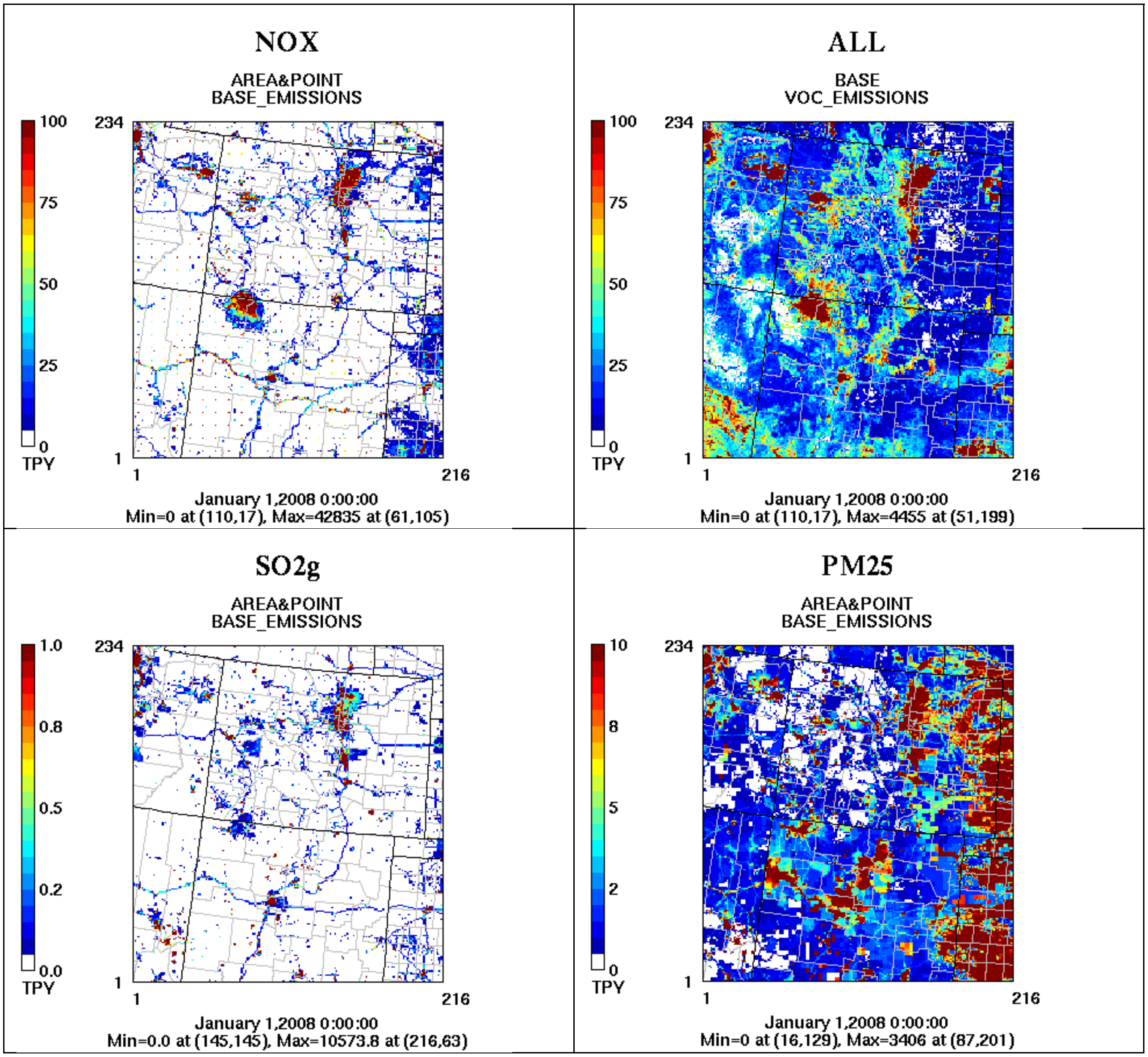


Figure 3-11. Spatial distribution of total low and elevated source emissions in tons per year in the 2021 Low Development Scenario.

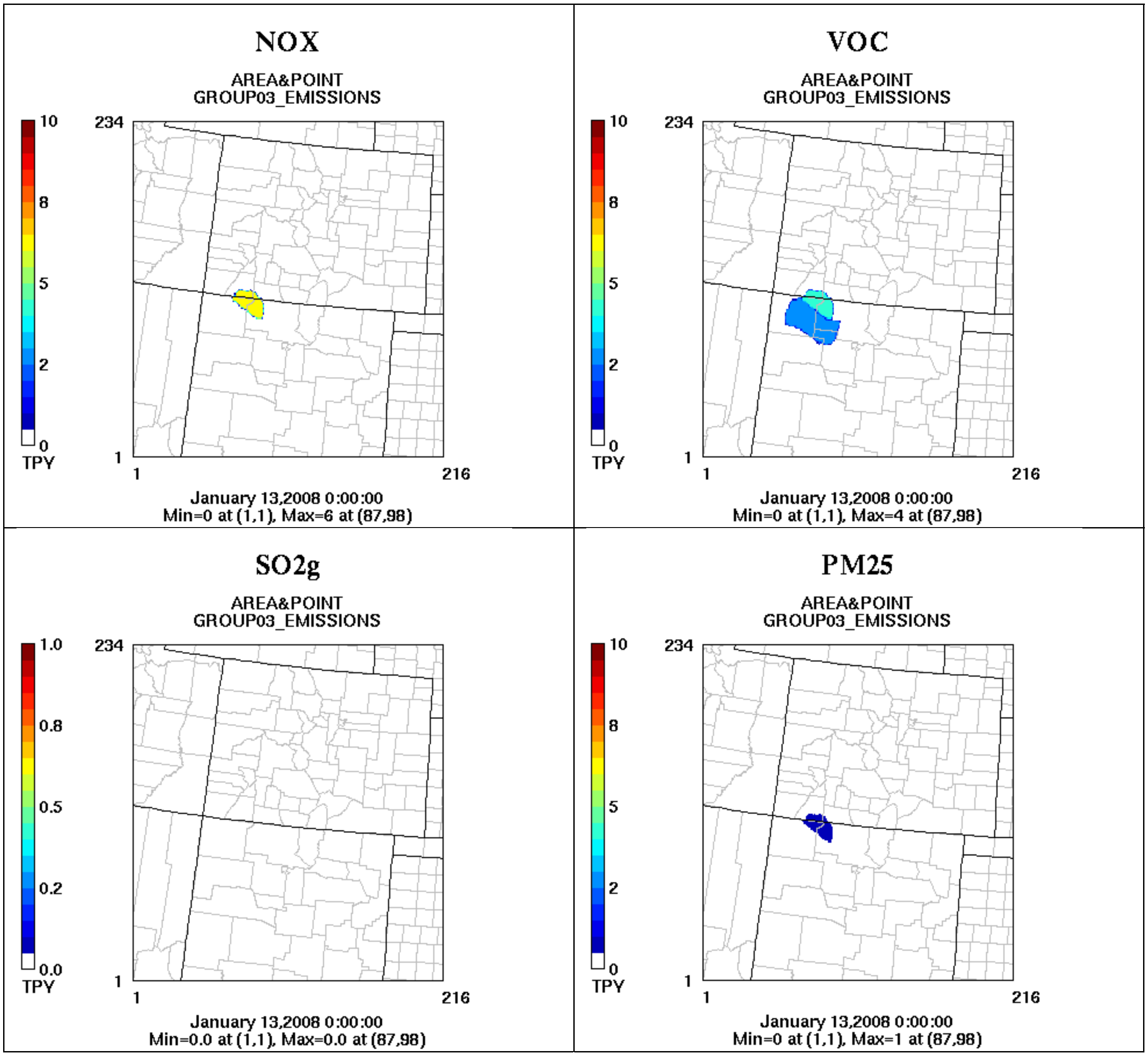


Figure 3-12. Spatial distribution of Mancos Shale emissions in tons per year in the 2021 Low Development Scenario.

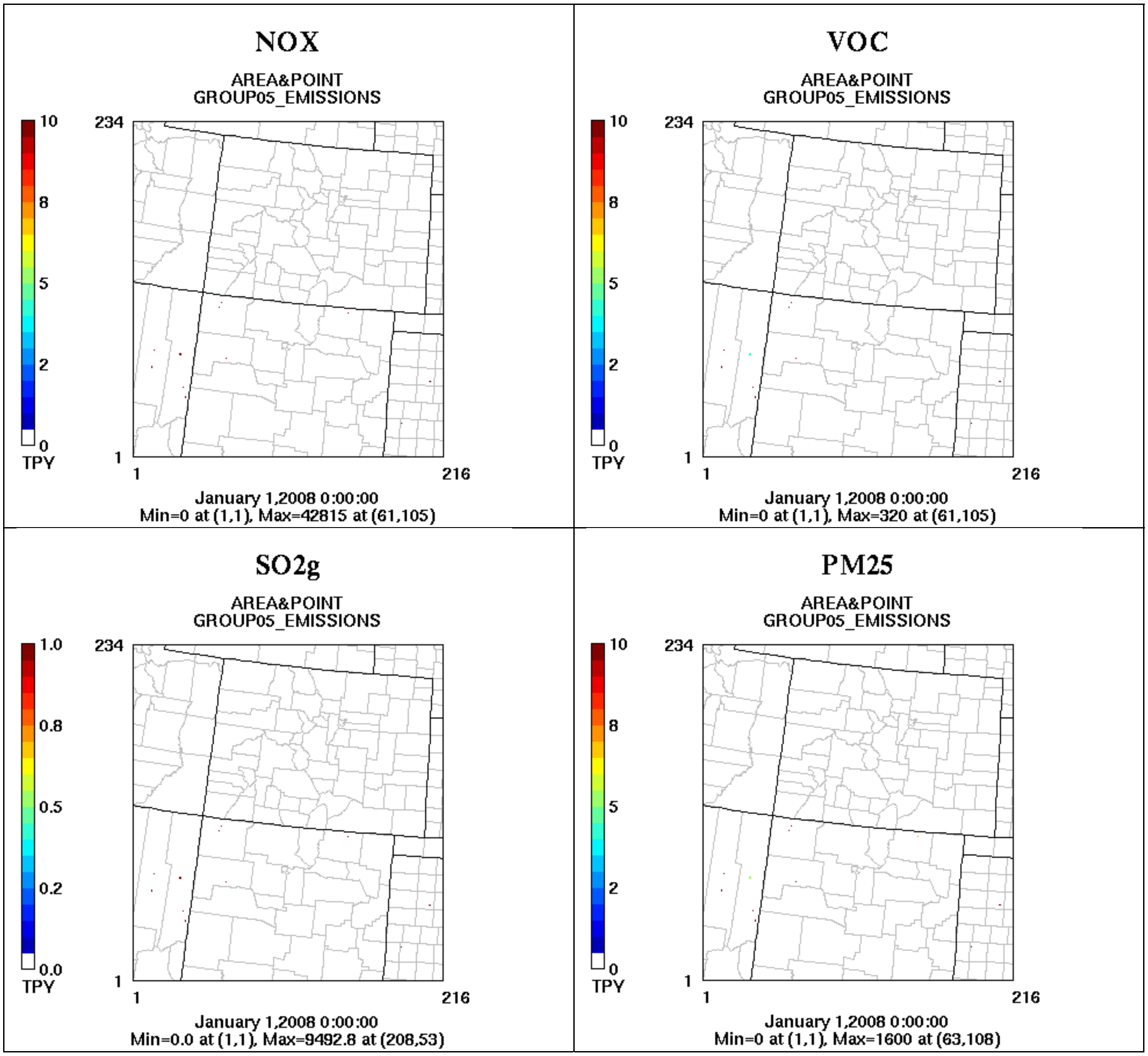


Figure 3-13. Spatial distribution of coal-fired EGU emissions in the 2021 Low Development Scenario in Arizona, New Mexico, Texas and Oklahoma ("ANTO" area in 4 km domain).

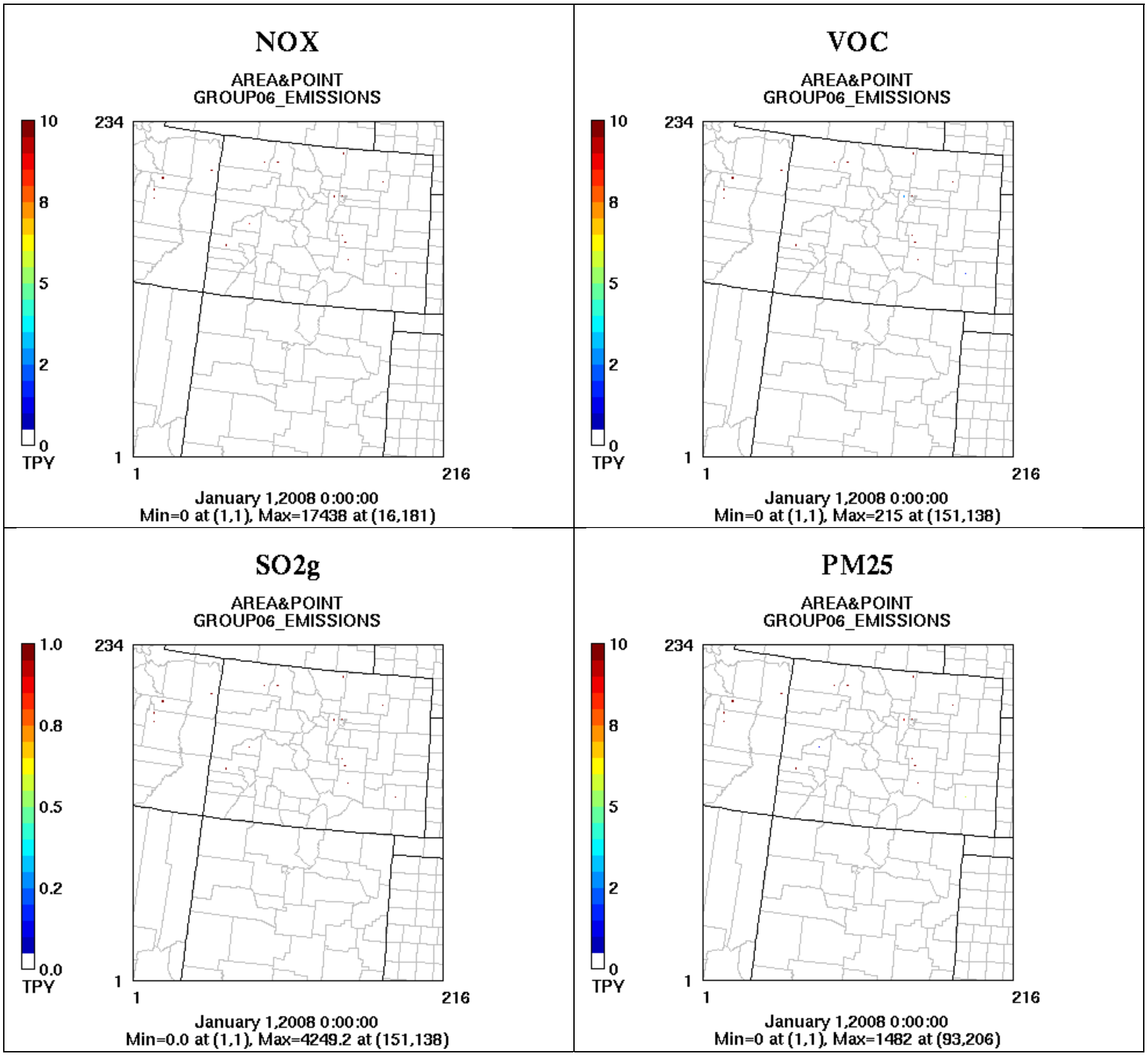


Figure 3-14. Spatial distribution of coal-fired EGU emissions in the 2021 Low Development Scenario in Colorado, Utah, Kansas, Nebraska and Wyoming ("CUKNW" area in 4 km domain).

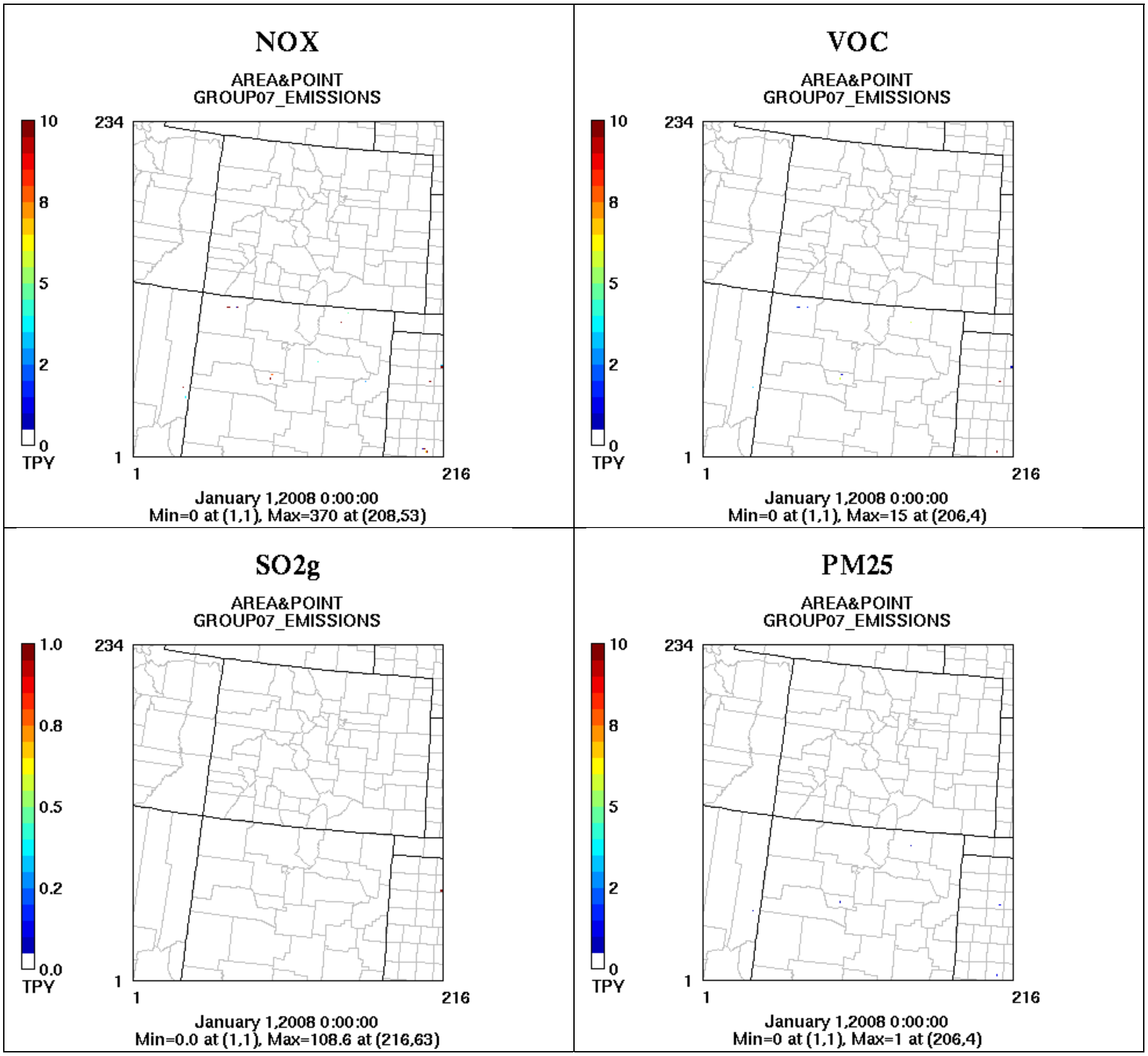


Figure 3-15. Spatial distribution of oil and gas-fired EGU emissions in the 2021 Low Development Scenario in Arizona, New Mexico, Texas and Oklahoma ("ANTO" area in 4 km domain).

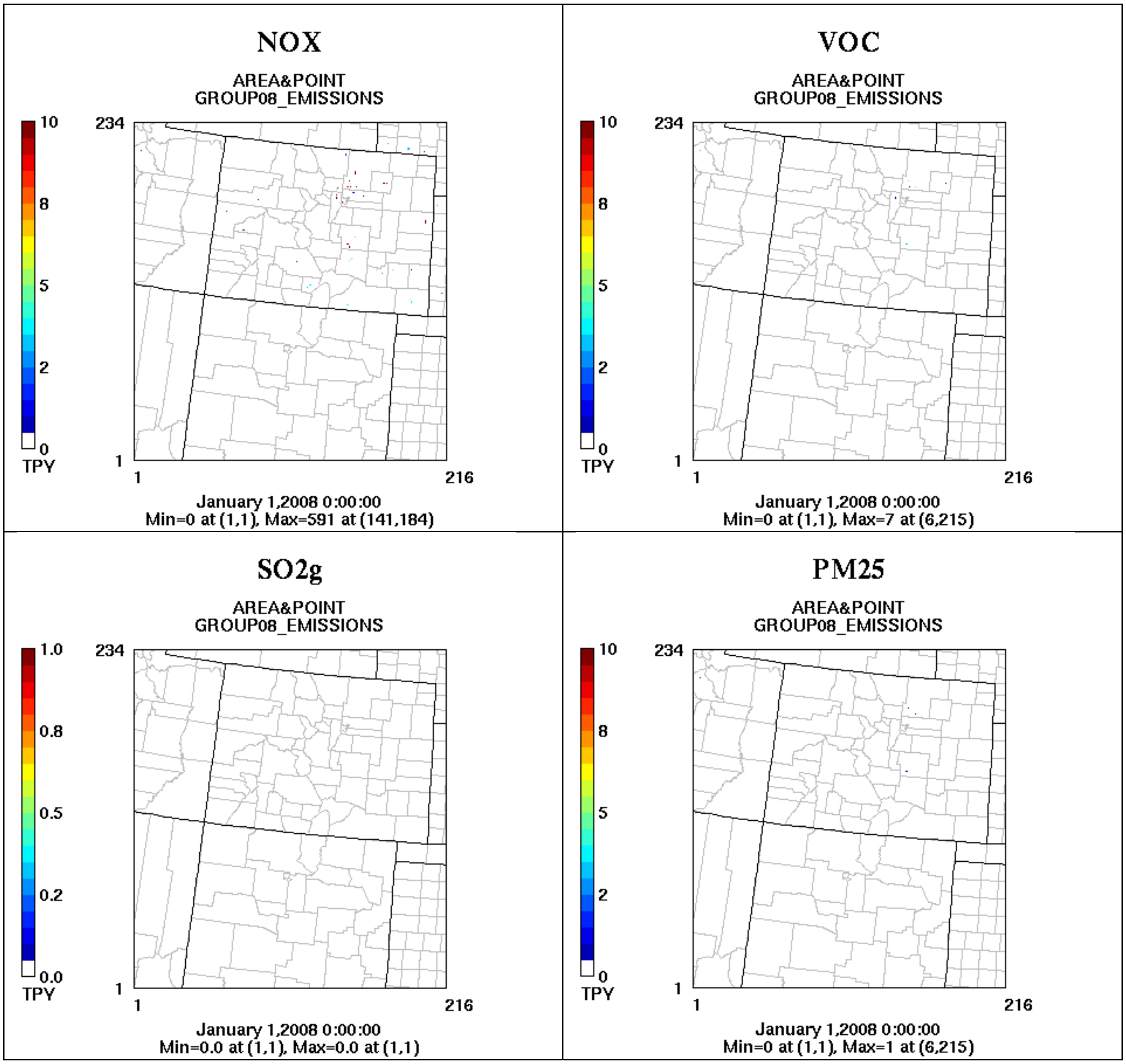


Figure 3-16. Spatial distribution of oil and gas-fired EGU emissions in the 2021 Low Development Scenario in Colorado, Utah, Kansas, Nebraska and Wyoming ("CUKNW" area in 4 km domain).

Table 3-7. SCC number and description, $PM_{2.5}$ speciation profile code and name, and PM emissions for 95% of the mining emissions on Federal lands used in the CARMMS 2021 modeling

SCC	SCC Description	Profile in CARMMS 1.0	Profile in CARMMS 1.5	PM2.5 (tpy)
30501099	Coal Mining, Cleaning & Material Handling /Other Not Classified	92047	92022	1,717
30501022	Coal Mining, Cleaning & Material Handling /Drilling/Blasting	92047	92022	1,460
30501011	Coal Mining, Cleaning & Material Handling /Coal Transfer	92047	92022	1,449
30501015	Coal Mining, Cleaning & Material Handling /Loading	92047	92022	457
30501049	Coal Mining, Cleaning & Material Handling /Wind Erosion: Exposed Areas	92022	92022	403
30501038	Coal Mining, Cleaning & Material Handling /Truck Loading: Coal	92047	92022	333
30501043	Coal Mining, Cleaning & Material Handling /Open Storage Pile: Coal	92047	92022	113
30501024	Coal Mining, Cleaning & Material Handling /Hauling	92047	92022	105
30504010	Mining & Quarrying Nonmetallic Minerals /Underground Ventilation	92073	92073	72
30501040	Coal Mining, Cleaning & Material Handling /Truck Unloading: End Dump – Coal	92047	92022	68
30501046	Coal Mining, Cleaning & Material Handling /Bulldozing: Coal	92047	92022	67
30501009	Coal Mining, Cleaning & Material Handling /Raw Coal Storage	92047	92022	61

Table 3-8. $PM_{2.5}$ emissions speciation profiles available for mining PM emissions.

Profile	Pol	Species	Fraction
Mineral Products - Avg - Simplified			
92047	PM2_5	POA	7.4%
92047	PM2_5	PEC	1.5%
92047	PM2_5	PNO3	0.3%
92047	PM2_5	PSO4	14.1%
92047	PM2_5	PMFINE	76.8%
Crustal Material - Simplified			
92022	PM2_5	POA	7.5%
92022	PM2_5	PEC	0.2%
92022	PM2_5	PNO3	0.1%
92022	PM2_5	PSO4	0.2%
92022	PM2_5	PMFINE	92.0%
Sand & Gravel - Simplified			
92073	PM2_5	POA	0.0%
92073	PM2_5	PEC	0.0%
92073	PM2_5	PNO3	0.1%
92073	PM2_5	PSO4	0.3%
92073	PM2_5	PMFINE	99.7%

4.0 FUTURE YEAR MODELING APPROACH

The CAMx source apportionment tool was used to obtain separate contributions of BLM authorized oil and gas development on Federal lands within 13 Colorado BLM Planning Areas plus the Mancos Shale Development area in northwestern New Mexico. This report addresses the contributions to air quality (AQ) and air quality related value (AQRV) impacts associated with the 2021 High, Low and Medium Development Scenarios. Emphasis is laid on the Farmington Field Office (Mancos Shale) sources but the contributions of other source groups are also analyzed. The following sections describe how the CARMMS 2021 CAMx source apportionment modeling was conducted for the new Low Development Scenario and combined with results from the CARMMS 1.0 High and Medium Development Scenarios. The results are presented in Chapter 5.

4.1 CARMMS Source Apportionment Modeling Approach

The CAMx Anthropogenic Precursor Culpability Assessment (APCA) version of the Ozone Source Apportionment Technology (OSAT) and the Particulate Source Apportionment Technology (PSAT) were used to obtain separate AQ and AQRV contributions due to BLM-authorized new oil and gas development on Federal lands for each of the 13 Colorado BLM Planning Areas and the Mancos Shale O&G development area within the BLM NMFFO Planning Area (i.e., the 14 BLM Planning Areas). Separate source apportionment contributions from new oil and gas emissions on non-Federal lands and existing oil and gas within the combined 14 BLM Planning Areas was also obtained. Separate source apportionment of AQ/AQRV impacts associated with the 10 mines located within Colorado BLM Planning Areas discussed at in Section 3.6.3 was also obtained. Separate source apportionment contributions were also obtained for oil and gas emissions within the 4 km CARMMS domain outside of the 14 BLM Planning Areas, remainder anthropogenic emissions and natural emissions (i.e., biogenic sources, fires, lightning, windblown dust and sea salt). Source contributions of coal-fired and oil/gas-fired EGUs were also obtained as described below.

4.1.1 Overview of Source Apportionment Tools

The CAMx OSAT/APCA ozone and PSAT PM source apportionment tools use reactive tracers that are released from each Source Group for which contributions are desired. These reactive tracers operate in parallel to the host photochemical grid model accessing the model's transport, dispersion, chemistry and deposition algorithms. For example, the OSAT/APCA ozone source apportionment tools represents each Source Group's ozone contributions using four reactive tracers that represent the Source Groups VOC emissions (V), NO_X emissions (N) and ozone attributed to the Source Group that is formed under more VOC-limited (O3V) and NO_X-limited (O3N) conditions. At each time step and in each grid cell, ozone formed is allocated to the Source Groups based on the Source Groups relative contribution of VOC or more NO_X emissions to the total VOC or NO_X concentrations after determination of whether ozone formation is more VOC-limited or more NO_X-limited. The APCA ozone source apportionment tool differs from OSAT in that it recognizes that some precursor emissions are not controllable so redirects ozone formed from the uncontrollable to the controllable Source Group. For example, when ozone is formed under VOC-limited conditions due to the interaction between biogenic VOC and anthropogenic NO_X emissions, a case OSAT would assign the ozone formed to the biogenic emissions Source Group, APCA redirects the ozone formed to the anthropogenic emissions Source Group recognizing that biogenic VOC emissions are not controllable and without the anthropogenic NO_X the ozone would not have been generated. In a CAMx APCA source apportionment run, the first Source Category specified in the run is assumed to be the uncontrollable Source Group (typically natural emissions) and ozone will only be allocated to natural emissions when it is due to natural VOC and NO_X emissions interacting with each other (e.g., ozone formed due to reactions between biogenic VOC and biogenic NOx). For the CARMMS modeling, the natural emissions Source Group included biogenic, fires (wildfires, prescribed burns and agricultural burning), lightning, windblown dust and sea salt emissions. Although one could argue that emissions from prescribed burns and agricultural burning are not natural, emissions from wildfires dominate the fire emissions especially within the CARMMS 4 km domain.

For the CAMx PSAT PM source apportionment tool there are several families of PM source apportionment tracers that can be run separately or together that track the different components of PM. Each of these families has a different number of reactive tracers to track the pathway from the PM precursor emissions to the ultimate PM compounds. The five different families of PSAT source apportionment are as follows (number of tracers in parenthesis): Sulfate-SO4 (2); Nitrate/Ammonium-NO3/NH4 (7); Primary PM (6); Secondary Organic Aerosol-SOA (20) and Mercury-Hg (3). For CARMMS, we used the SO4, NO3/NH4 and Primary PM PSAT families of tracers so that 15 total reactive tracers are needed to track PM contribution for each Source Group. The Hg PSAT family was not used because mercury is not a focus of CARMMS and O&G sources typically have negligible Hg emissions. There are five SOA precursors treated in CAMx: toluene and xylene (aromatics), isoprene, terpene and sesquiterpene with biogenic sources contributing a majority of the SOA. O&G VOC emissions are dominated by light VOCs that do not form any SOA. We examined the speciation of the O&G emissions and found the five VOC species that are SOA precursors account for approximately 0.1 percent of the O&G VOC emissions. Thus, O&G emission VOCs would have a negligible contribution to SOA so the SOA family of PSAT source apportionment tracers was not used. The CARMMS annual source apportionment runs take over a month to complete and use of the SOA PSAT family would have more than doubled the number of tracers.

Thus, SOA is not included in the $PM_{2.5}$ and visibility impacts associated with Source Groups A through V that are based on the PSAT source apportionment modeling results. But SOA is included in the $PM_{2.5}$ and visibility impacts of Source Groups W and X that represents total emissions from the 2021 and 2008 emission scenarios.

While initiating the current study, we identified an error in the ozone source apportionment in CARMMS 1.0 (we note that the error is in the post-processing of CARMMS 1.0 rather than the 1.0 outputs themselves). Rather than adding the ozone source contribution under more NOx-limited conditions (O3N) to the ozone formed under more VOC-limited conditions (O3V), the O3N value was double-counted. This resulted in an overestimation or underestimation of ozone contributions from sources in the Planning Areas, with more grid cells showing an overestimation rather than an underestimation. The problem does not affect the total ozone predictions or the ozone due to natural or boundary sources. For the reason mentioned above, we recommend that ozone concentrations from the current study (CARMMS 1.5) not be compared with the results of CARMMS 1.0. We have repeated all the analyses performed in CARMMS 1.0 in the current study after correcting this problem.

4.1.2 CARMMS Source Apportionment Configuration

The APCA version of the OSAT and the SO4, NO3/NH4 and Primary PM (i.e., no SOA) families of PSAT source apportionment was used to track the AQ/AQRV contributions of new O&G development on Federal lands in 14 separate BLM Planning Areas for the 2021 High, Low and Medium Development Scenarios using the CARMMS 2008 4 km modeling platform. The 14 BLM Planning Areas where separate AQ/AQRV impacts due to new O&G development on Federal lands were simulated are shown in Figure 4-1. In total, in CARMMS 1.0, the 2021 CAMx source apportionment modeling tracked AQ/AQRV contributions for 20 separate Source Categories in the order listed in Table 4-1. These are supplemented with additional source categories for EGUs as described in Section 4.2.

Because the APCA version of OSAT is being used, the first Source Category has to be natural emissions. The 2nd through 15th Source Categories correspond to new O&G emissions on Federal lands within the 13 Colorado BLM planning areas and the Mancos Shale development area within the BLM NMFFO lands (the 14 BLM Planning Areas). The 16th Source Category is the combined emissions from all new O&G within the 14 BLM Planning Areas on non-Federal lands. The 17th and 18th Source Categories are, respectively, existing O&G within the 14 BLM Planning Areas and mining on Federal lands within the 14 BLM Planning Areas[68]. The 19th Source Category is all O&G emissions (existing, new Federal and new non-Federal) outside of the 14 BLM Planning Areas (i.e., the yellow area in Figure 4-1). And the final (20th) Source Category is remaining anthropogenic emissions (e.g., point, mobile and area sources that are not O&G everywhere or mining on Federal lands within the 14 BLM Planning Areas).

[68] There were no mining emissions within the northern New Mexico Mancos Shale development area.

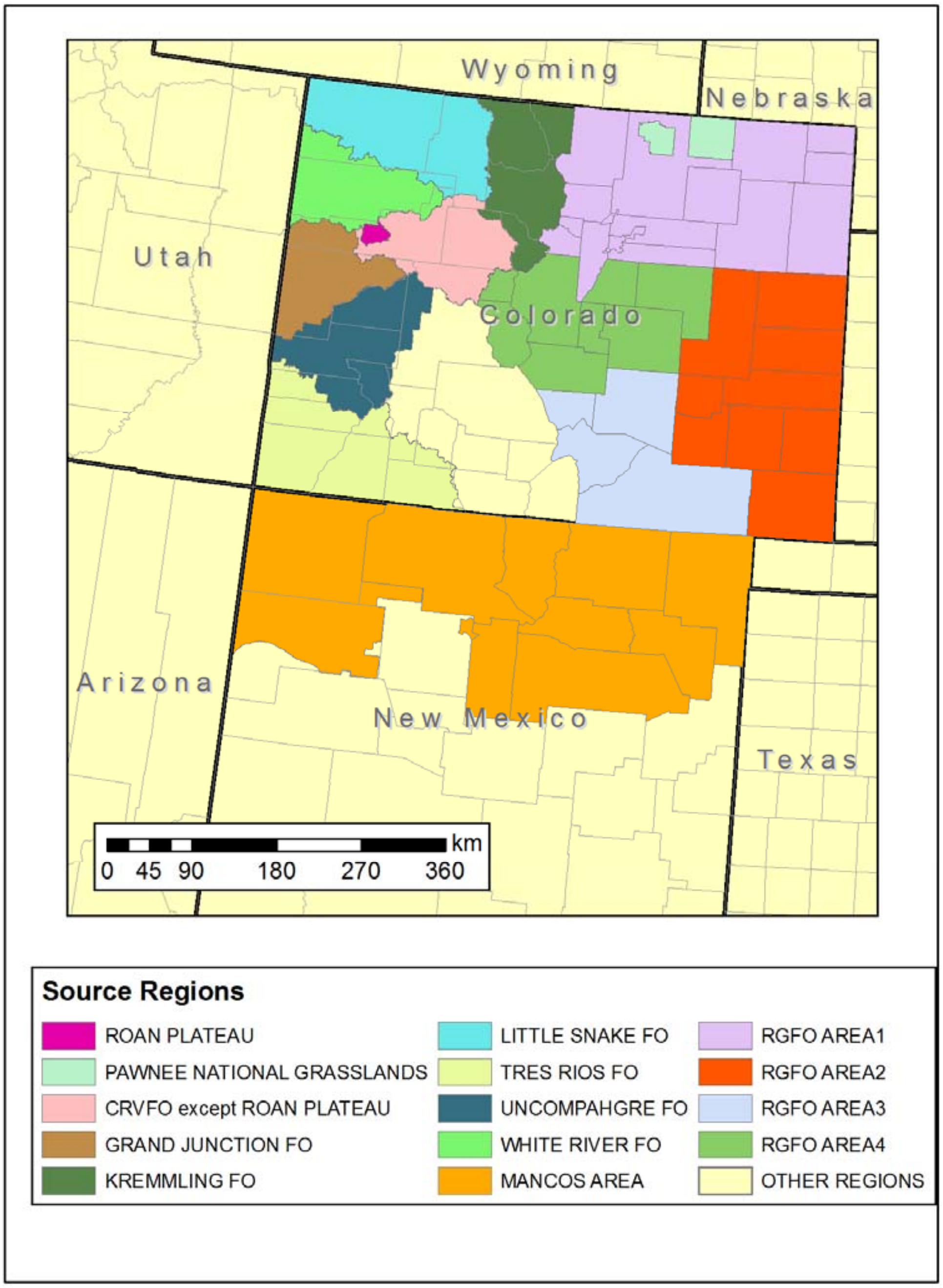


Figure 4-1. 13 Colorado BLM planning areas and 1 New Mexico planning area (the 14 BLM Planning Areas) where separate contributions of new O&G development on Federal lands were obtained for 2021 source apportionment modeling.

Table 4-1. Ordering of the 20 Source Categories used in the CAMx 2021 source apportionment modeling in CARMMS 1.0.

1	Natural emissions (combined biogenic, fires, lightning, sea salt and WBD).
2	Little Snake FO
3	White River FO
4	Colorado River Valley FO (CRVFO)
5	Roan Plateau Planning area portion of CRVFO
6	Grand Junction FO
7	Uncompahgre FO
8	Tres Rios FO
9	Kremmling FO
10	Royal Gorge FO Area#1 (RGFO#1) – North
11	Pawnee Grasslands portion of RGFO#1
12	RGFO#2 – West-Central/South
13	RGFO#3 – South
14	RGFO#4 – East-Central
15	New Mexico Farmington Field Office
16	Combined New O&G from non-Federal lands within the 14 BLM Planning Areas
17	Combined Existing O&G from 14 BLM Planning Areas
18	Mining from 14 BLM Planning Areas
19	All O&G (existing and new on Federal and non-Federal lands) in 4 km domain outside of the 14 BLM Planning Areas (see yellow region in Figure 1)
20	Remaining anthropogenic emissions (on-road and non-road mobile, point and area sources everywhere in 4 km domain)

* These categories were used in CARMMS 1.0 and were supplemented with additional source categories in the current study as discussed in Section 4.2.

4.2 Post-Processing of the CAMx 2021 Source Apportionment Modeling Results

The CAMx 2021 total concentrations results were post-processed for comparison to the applicable ambient air quality standards as listed in Table 4-3. With the exception of ozone, where results are reported in concentration units of part per billion by volume (ppb), all concentrations are reported in units of micrograms per cubic meter (µg/m^3). Gas-phase species were converted from parts per million (ppm) to µg/m^3 using the conversion factor recommended in the Colorado Department of Health and Environment (CDPHE) air permit modeling guidance[69]. The incremental AQ and AQRV impacts due to each of the 24 Source Groups listed in Table 4-2a were reported in CARMMS 1.0.

Table 4-2a. 24 Source apportionment post-processing Source Groups that separate AQ/AQRV impacts at Class I and sensitive Class II areas that were disclosed for the 2021 emission scenarios in CARMMS 1.0.

Processing Source Group	Source Group Name	Source Category No. (See Table 4-1)
A through N	See Table 4-1 for names of the new Federal O&G from the 14 BLM Planning Areas Source Categories #2 through #15	Separately #2 - #15
O	Total Colorado River Field Office	#4 and #5
P	Total Royal Gorge Field Office	#10, #11, #12 #13 and #14
Q	Mining from 13 Colorado BLM Planning Areas	#18
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	#2 -#14 and #18
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	#2 - #14 plus #16 and #18
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	#2 - #16 and #18
U	Combined O&G and Mining in 4 km domain	#2 - #19
V	Natural Emissions	#1
W	2021 All Emissions	#1 - #20
X	2008 Base Case All Emissions	--

The 24 Source Groups labelled A through X consist of the following sources:

(A - N) New Federal O&G from each of the 14 BLM Planning Areas as shown in Figure 4-1 and listed as Source Categories No. 2 through 15 in Table 4-1.

(O) Total Federal O&G from the CRVFO that combines the Roan Plateau and non-Roan Plateau portions of the CRVFO.

(P) Total Federal O&G from the RGFO that combines the four RGFO subregions plus the Pawnee Grassland portion of the RGFO.

(Q) Mining on Federal land within the 13 Colorado BLM Planning Areas.

[69] C [ppm] = C [µg/m^3] / (40.9 x MW), where MW = molecular weight in g/mole. This formula assumes 1 atmosphere pressure and 298 K temperature. http://www.colorado.gov/airquality/permits/guide.pdf

(R) Combined O&G and mining development on Federal lands within all of the 13 Colorado BLM Planning Areas.

(S) Combined new O&G and mining development on Federal lands and new O&G development non-Federal lands within the 13 Colorado BLM Planning Areas.

(T) The Cumulative Emissions scenario that includes new O&G development on Federal and non-Federal lands and mining development on Federal lands within the 13 Colorado BLM Planning areas plus new O&G development for the Mancos Shale area in northern New Mexico.

(U) Emissions from all O&G development throughout the 4 km CARMMS domain (new Federal and non-Federal O&G through the domain plus Federal mining in Colorado).

(V) Natural emissions (biogenic, fires, lightning, WBD and sea salt).

(W) All emissions from the 2021 CAMx simulation (total concentrations).

(X) All emissions from the 2008 CAMx base case simulation (total concentrations).

These source groups are supplemented with additional source groups in the current study (CARMMS 1.5) as shown in Tables 4-2b and 4-2c. To reduce computational time, only a sub-set of source groups (shown in Table 4-2b) was run in the CAMx source apportionment modeling and then re-combined as shown in Table 4-2c to produce the full set of source apportionment results required.

The coal EGU source apportionment group “ANTO” (Arizona, New Mexico, Texas and Oklahoma) (Table 3-5a) is represented as group S5 in Table 4-2b. For convenience, we refer to this group as “Coal EGU NM” in the results spreadsheets and related tables in this report but note that this actually refers to the contribution of all coal EGUs in NM and other states south of CO-NM border (AZ, TX, OK) that are in the 4 km domain. The same is also true of oil/gas EGUs and group S7. We note that there is uncertainty regarding where the coal mined in NM will be burned and where the oil and gas produced in NM will be used.

Similarly, the coal and oil/gas EGU source apportionment groups for “CUKNW” (Colorado, Utah, Kansas, Nebraska and Wyoming) (Table 3-5a) are represented as groups S6 and S8 in Table 4-2b and are just referred to as “Coal EGU CO” and “Oil/Gas EGU CO” for convenience in the results tables in this document and attachments.

Table 4-2b. Ordering of the 9 Source Categories modeled in the current CARMMS CAMx 2021 Low Development Scenario source apportionment modeling (also see Table 4-2c).

S1	Natural emissions (combined biogenic, fires, lightning, sea salt and WBD).
S2	All O&G except Mancos Low
S3	Mancos Low Scenario (old #15)
S4	Mining (old #18)
S5	Coal EGUs in NM and other states south of CO-NM border (AZ, TX, OK) that are in 4 km domain
S6	Coal EGUs in CO and other states north of CO-NM border (UT, KS, NE, WY) that are in 4 km domain
S7	Oil/Gas EGUs in NM and parts of other states south of CO-NM border that are in 4 km domain
S8	Oil/Gas EGUs in CO and parts of other states north of CO-NM border that are in 4 km domain
S9	Remainder Anthropogenic (old #20 w/o EGUs)

Table 4-2c. 32 Source apportionment post-processing Source Groups that separate AQ/AQRV impacts at Class I and sensitive Class II areas that are disclosed for the 2021 emission scenarios in the current study (CARMMS 1.5).

Processing Source Group	Source Group Name	Source Category No. (See Tables 4-1 and 4-3)
A through N	See Table 4-1 for names of the new Federal O&G from the 14 BLM Planning Areas Source Categories #2 through #15	Separately #2 to #15
O	Total Colorado River Field Office	#4 plus #5
P	Total Royal Gorge Field Office	Sum of #10, #11, #12 #13 and #14
Q	Mining from 13 Colorado BLM Planning Areas	#18
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	#2 to #14 plus #18
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	#2 to #14 plus #16 and #18
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	#2 to #16 plus #18
U	Combined O&G and Mining in 4 km domain	#2 to #19
V	Natural Emissions	#1
W	2021 All Emissions	--
X	2008 Base Case All Emissions	--
Y	Coal EGUs in NM and parts of other states south of CO-NM border that are in 4 km domain	S5
Z	Coal EGUs in CO and parts of other states north of CO-NM border that are in 4 km domain	S6
AA	Oil/Gas EGUs in NM and parts of other states south of CO-NM border that are in 4 km domain	S7
AB	Oil/Gas EGUs in CO and parts of other states north of CO-NM border that are in 4 km domain	S8
AC	All EGUs in 4 km domain	S5+S6+S7+S8
AD	CO Mining plus Coal EGUs CO	#18 + S6
AE	CO O&G plus Oil/Gas EGUs CO	#2 to #14 + #16 + S8
AF	NM O&G + Oil/Gas EGU NM	#15 + S7

Table 4-3. Applicable National and State Ambient Air Quality Standards and PSD concentration increments (bold indicates units in which standard was defined, conversion to ppm/ppb following CDPHE modeling guidance and with the exception of ozone that will be reported in ppb, all modeled concentrations will be reported in µg/m^3).

Pollutant/Averaging Time	NAAQS	CAAQS[13]	NMAAQS[14]	PSD Class I Increment[1]	PSD Class II Increment[1]
		CO			
1-hour[2]	**35 ppm** 40,000 µg/m^3	--	**13.1 ppm** 1,100 µg/m^3	--	--
8-hour[2]	**9 ppm** 10,000 µg/m^3	--	**8.7 ppm** 10,000 µg/m^3	--	--
		NO_2			
1-hour[3]	**100 ppb** 188 µg/m^3	--	--	--	--
24-hour	--	--	**0.10 ppm** 1,953 µg/m^3	--	--
Annual[4]	**53 ppb** 100 µg/m^3	--	**0.05 ppm** 98 µg/m^3	2.5 µg/m^3	25 µg/m^3
		O_3			
8-hour[5]	**0.070 ppm** 137 µg/m^3	--	--	--	--
		PM_{10}			
24-hour[6]	**150 µg/m^3**	--	--	8 µg/m^3	30 µg/m^3
Annual[7]	--	--	--	4 µg/m^3	17 µg/m^3
		$PM_{2.5}$			
24-hour[8]	**35 µg/m^3**	--	--	2 µg/m^3	9 µg/m^3
Annual[9]	**12 µg/m^3**	--	--	1 µg/m^3	4 µg/m^3
		SO_2			
1-hour[10]	**75 ppb** 196 µg/m^3	--	--		
3-hour[11]	**0.5 ppm** 1,300 µg/m^3	**700 µg/m^3**	--	25 µg/m^3	512 µg/m^3
24-hour[12]	--	--	**0.10 ppm** 262 µg/m^3	5 µg/m^3	91 µg/m^3
Annual[4]	--	--	**0.02 ppm** 52 µg/m^3	2 µg/m^3	20 µg/m^3

1. The PSD demonstrations serve information purposes only and do not constitute a regulatory PSD increment consumption analysis.
2. No more than one exceedance per calendar year; for NMAAQS - No more than one exceedance per consecutive 12 months
3. 98th percentile, averaged over 3 year; for NMAAQS - not to be exceeded more than once over any 12 consecutive months
4. Annual mean not to be exceeded; for NMAAQS - arithmetic average over any four consecutive quarters not to be exceeded
5. Fourth-highest daily maximum 8-hour ozone concentrations in a year, averaged over 3 years
6. Not to be exceeded more than once per calendar year on average over 3 years.
7. 3 year average of the arithmetic means over a calendar year
8. 98th percentile, averaged over 3 years
9. Annual mean, averaged over 3 years, NAAQS promulgated December 14, 2012
10. 99th percentile of daily maximum 1-hour concentrations in a year, averaged over 3 years
11. No more than one exceedance per calendar year (secondary NAAQS) and no more than one exceedance in 12 consecutive months (CAAQS)
12. For areas in New Mexico not within 3.5 miles of the Chino Mines Company
13. http://www.colorado.gov/cs/Satellite/CDPHE-Main/CBON/1251601911433
14. http://www.nmcpr.state.nm.us/nmac/parts/title20/20.002.0003.htm

4.3 Class I and Sensitive Class II Areas for Analysis

The BLM COSO and NMSO and their contractors worked with the IAQRT to identify the Class I and sensitive Class II areas where the AQ/AQRV impacts due to O&G development on Federal lands within the Colorado BLM Planning Areas would be assessed. With the addition of the Mancos Shale development area in northwest New Mexico in the CARMMS analysis, the BLM NMSO reached out to the IAQRT to assist in identifying additional Class I and sensitive Class II areas to analyze in the analysis. Responses were received from NPS, USFS and FWS and a Technical Memorandum was prepared dated September 2, 2014 (Parker and Morris, 2014) for the NMSO that identified the Class I and sensitive Class II areas for the CARMMS analysis. Although the Class I area list did not change, several additional sensitive Class II areas were added to the CARMMS post-processing list that were within 300 km of the Mancos Shale development area.

The Class I and sensitive Class II areas were also analyzed and a few areas that overlapped or were adjacent were consolidated. In addition, new shapefiles of the Class I/II areas were acquired and GIS analysis was performed to define the grid cell definition of the Class I/II areas. This resulted in changes to the grid cell definitions of the Class I/II areas (i.e., receptors) from what was used in the CARMMS May 2014 preliminary draft report. Section 4.3.1 describes the procedures used and examples on how the grid cell definitions of the Class II/II areas were performed.

4.3.1 Final Class I and Sensitive Class II Areas

The Class I areas where air quality and AQRV impacts were calculated within the 4 km CARMMS modeling domain are displayed in Figure 4-2 and listed in Table 4-4. The sensitive Class II areas used in the CARMMS post-processing are displayed in Figure 4-3 by FLM ownership and listed in Table 4-5. Note that several of the Class I areas are portions of a sensitive Class II area. In total, the CARMMS modeling results were post-processed using 27 and 58 Class I and sensitive Class II areas, respectively. Details on how the sensitive Class II areas were defined are provided in Parker and Morris (2014). Note that the Colorado side of Dinosaur National Monument is considered PSD Class I for just SO_2. Sensitive lakes in the region where acid neutralizing capacity (ANC) calculations will be made are listed in Table 4-6.

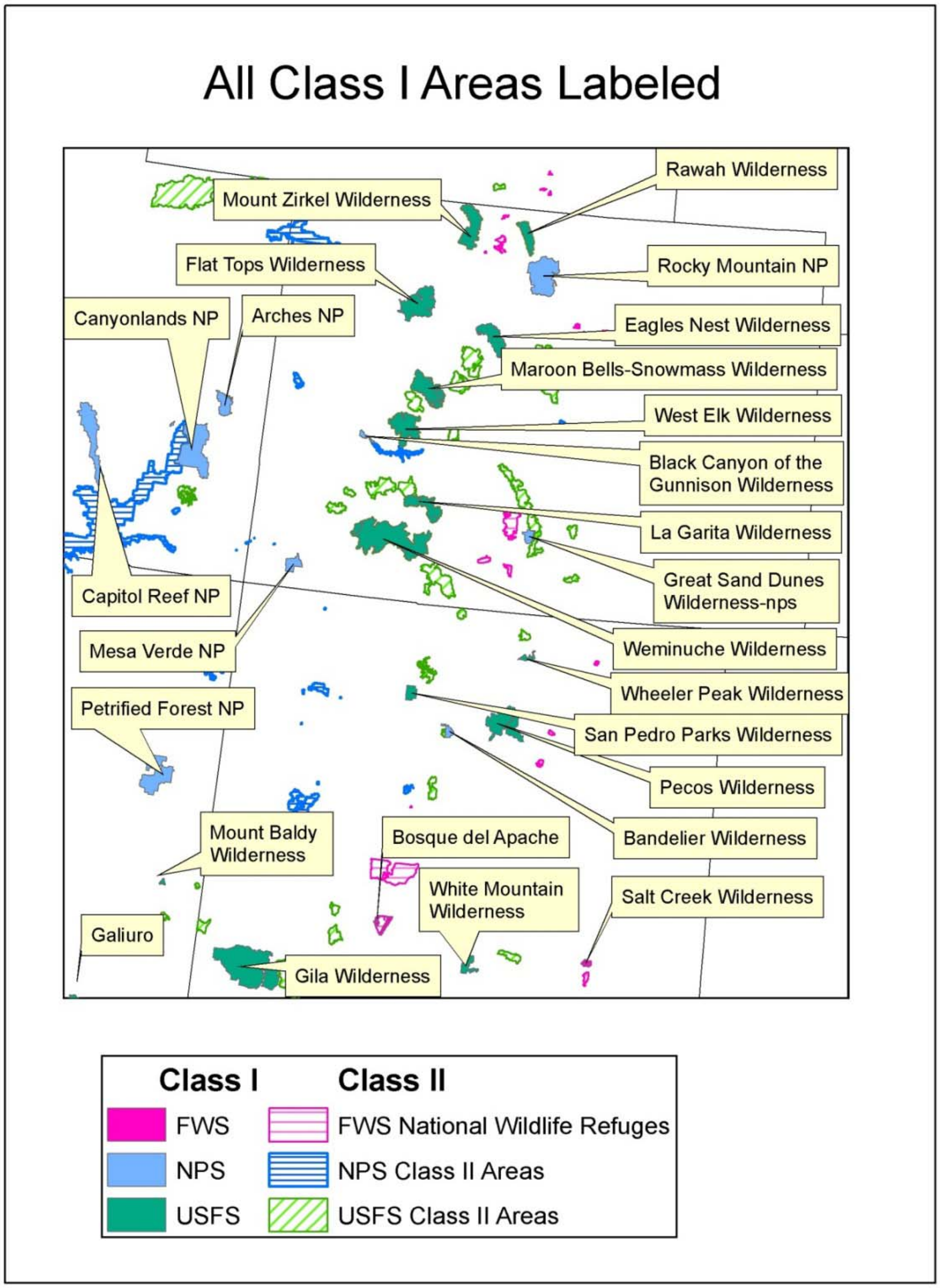


Figure 4-2. Locations of Class I (dark green) and sensitive Class II (light green) areas where air quality and AQRV impacts were assessed as well as sensitive lakes (blue dots) where ANC calculations will be made (Class I areas are labeled).

Table 4-4. List of Class I Areas for Impact Analysis

Class I Area	State	FLM
Arches NP	UT	NPS
Bandelier Wilderness	NM	NPS
Black Canyon of the Gunnison National Park	CO	NPS
Bosque del Apache Wilderness	NM	FWS
Canyonlands NP	UT	NPS
Capitol Reef NP	UT	NPS
Eagles Nest Wilderness	CO	USFS
Flat Tops Wilderness	CO	USFS
Galiuro Wilderness	AZ	USFS
Gila Wilderness	NM	USFS
Great Sand Dunes Wilderness-NPS	CO	NPS
La Garita Wilderness	CO	USFS
Maroon Bells-Snowmass Wilderness	CO	USFS
Mesa Verde NP	CO	NPS
Mount Baldy Wilderness	AZ	USFS
Mount Zirkel Wilderness	CO	USFS
Pecos Wilderness	NM	USFS
Petrified Forest NP	AZ	NPS
Rawah Wilderness	CO	USFS
Rocky Mountain NP	CO	NPS
Salt Creek Wilderness	NM	FWS
San Pedro Parks Wilderness	NM	USFS
Weminuche Wilderness	CO	USFS
West Elk Wilderness	CO	USFS
Wheeler Peak Wilderness	NM	USFS
White Mountain Wilderness	NM	USFS
Dinosaur NM[1]	UT & CO	NPS

1. The Colorado side of Dinosaur NM is PSD Class I for SO_2

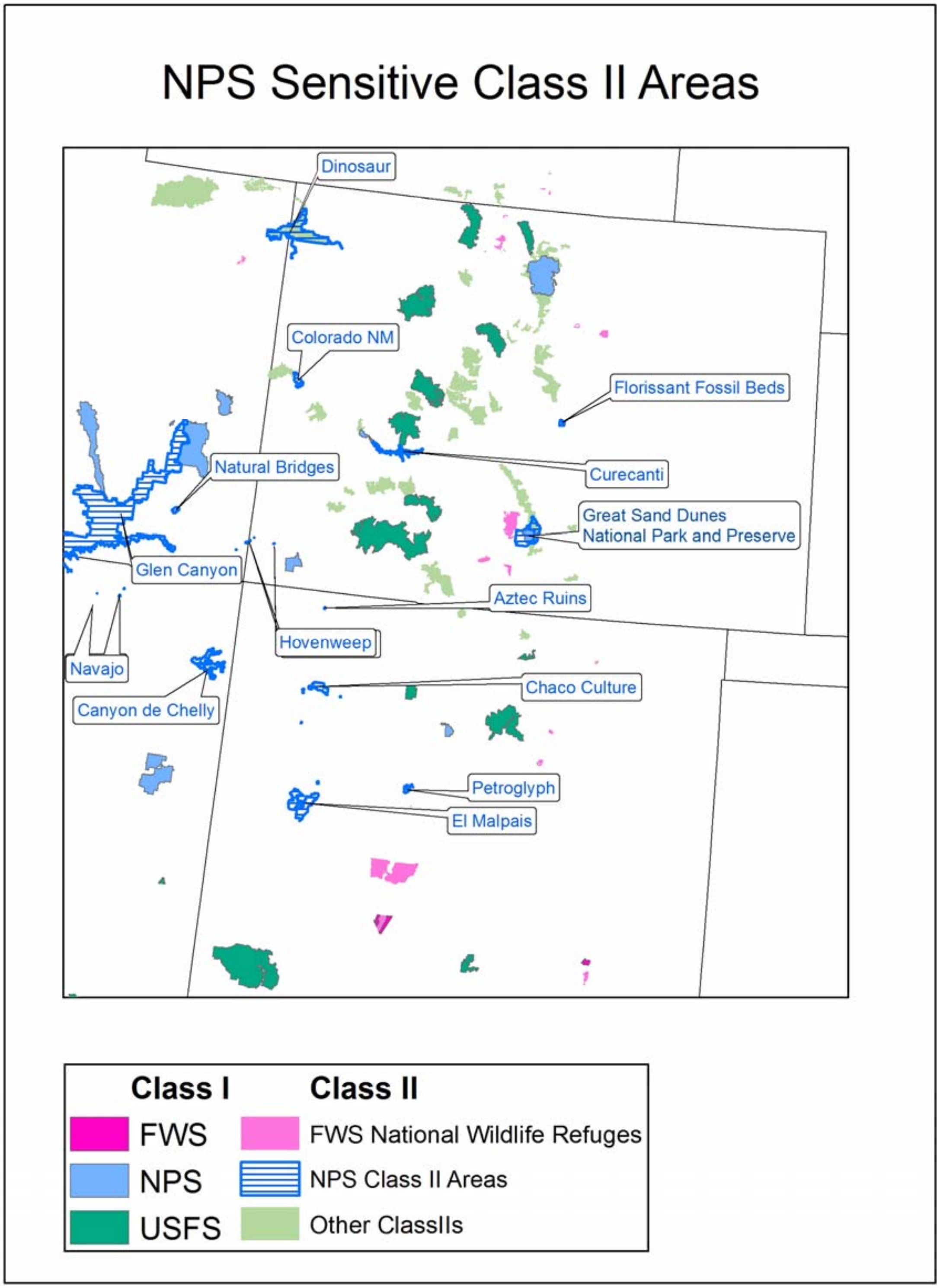


Figure 4-3a. NPS sensitive Class II areas for the CARMMS analysis labeled. Class I areas and non-NPS sensitive Class II areas unlabelled.

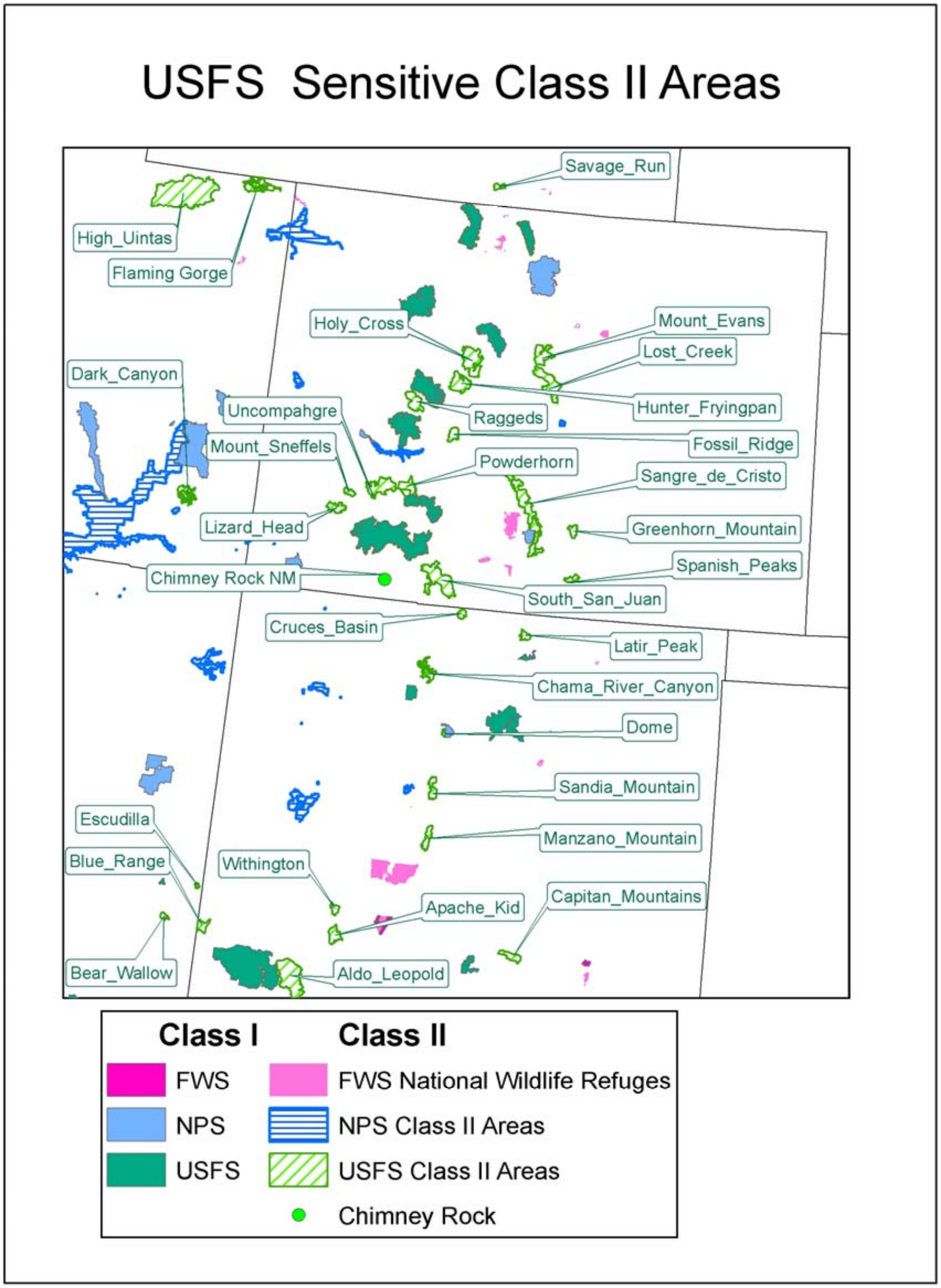


Figure 4-3b. USFS sensitive Class II areas for the CARMMS analysis labeled. Class I area and non-USFS Class II areas displayed but not labeled.

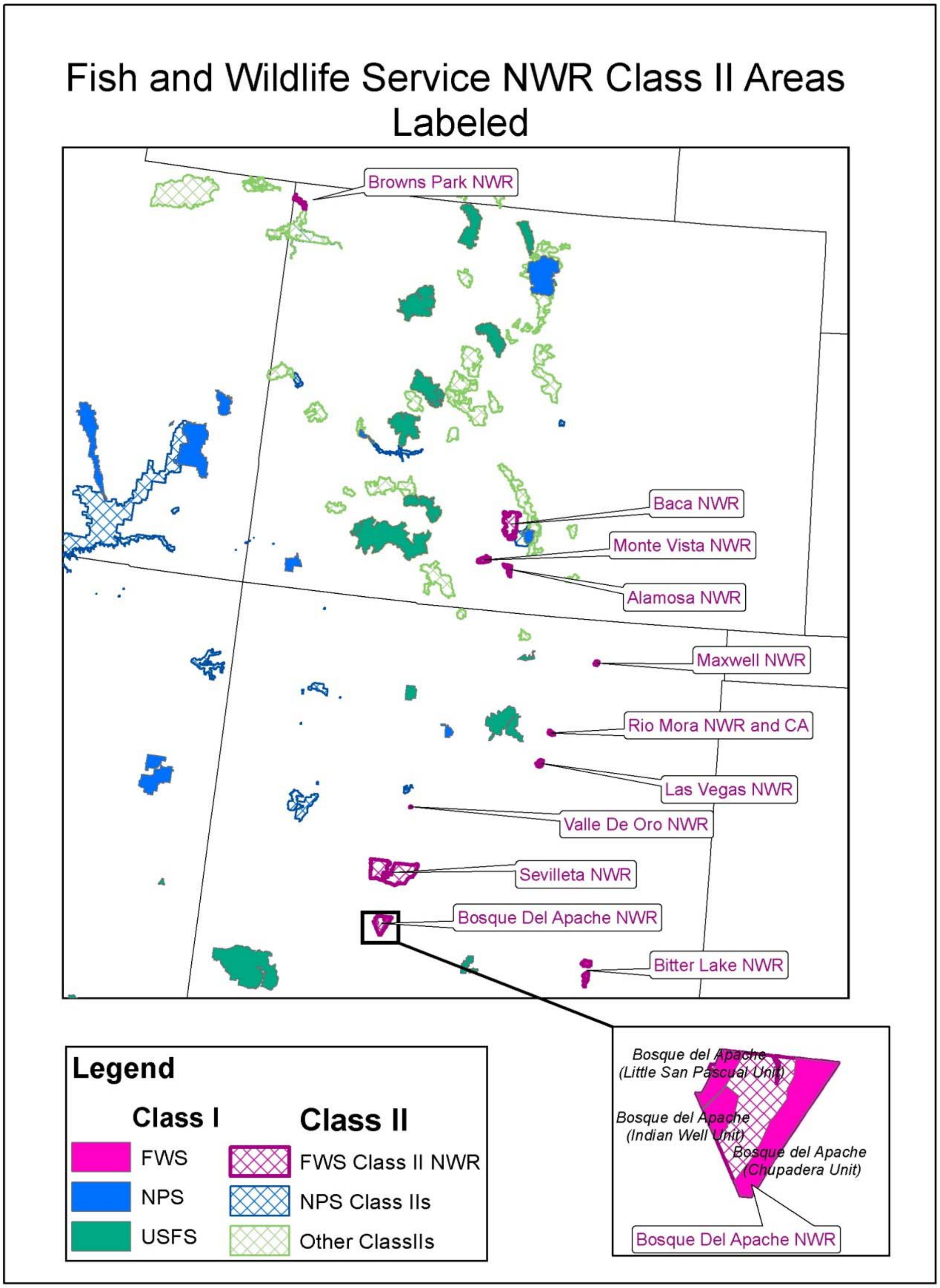


Figure 4-3c. FWS sensitive Class II areas for the CARMMS analysis labeled. Class me areas and non-FWS areas shown but not labeled.

Table 4-5. Sensitive Class II areas where air quality and AQRV impacts were assessed.

Sensitive Class II Area	State	FLM
Alamosa NWR	CO	FWS
Aldo Leopold Wilderness	NM	USFS
Apache Kid Wilderness	NM	USFS
Aztec Ruins NM	NM	NPS
Baca NWR	CO	FWS
Bear Wallow Wilderness	AZ	USFS
Bitter Lake NWR	NM	FWS
Blue Range Wilderness	NM	USFS
Bosque Del Apache NWR	NM	FWS
Browns Park NWR	CO	FWS
Canyon de Chelly NM	AZ	NPS
Capitan Mountains Wilderness	NM	USFS
Chaco Culture NHP	NM	NPS
Chama River Canyon Wilderness	NM	USFS
Chimney Rock NM	CO	USFS
Colorado NM	CO	NPS
Cruces Basin Wilderness	NM	USFS
Curecanti NRA	CO	NPS
Dark Canyon Wilderness	UT	USFS
Dinosaur NM	CO	NPS
Dome Wilderness	NM	USFS
El Malpais NM	NM	NPS
Escudilla Wilderness	AZ	USFS
Flaming Gorge	UT	USFS
Florissant Fossil Beds NM	CO	NPS
Fossil Ridge Wilderness	CO	USFS
Glen Canyon NRA	UT	NPS
Great Sand Dunes National Park	CO	NPS
Great Sand Dunes National Preserve	CO	NPS
Greenhorn Mountain Wilderness	CO	USFS
High Uintas Wilderness	UT	USFS
Holy Cross Wilderness	CO	USFS
Hovenweep NM	CO	NPS
Hunter-Fryingpan Wilderness	CO	USFS
Las Vegas NWR	NM	FWS
Latir Peak Wilderness	NM	USFS
Lizard Head Wilderness	CO	USFS
Lost Creek Wilderness	CO	USFS
Manzano Mountain Wilderness	NM	USFS
Maxwell NWR	NM	FWS
Monte Vista NWR	CO	FWS
Mount Evans Wilderness	CO	USFS
Mount Sneffels Wilderness	CO	USFS
Natural Bridges NM	UT	NPS
Navajo NM	AZ	NPS

Table 4-6. Sensitive lakes where ANC calculations were made.

Lake	National Forest Name	Wilderness Name
Walk Up Lake	Ashley National Forest	
Tabor Lake	White River National Forest	Collegiate Peaks Wilderness
Brooklyn Lake	White River National Forest	Collegiate Peaks Wilderness
Booth Lake	White River National Forest	Eagles Nest Wilderness
Upper Willow Lake	White River National Forest	Eagles Nest Wilderness
Upper Ned Wilson Lake	White River National Forest	Flat Tops Wilderness
Lower Nwl Packtrail Pothole	White River National Forest	Flat Tops Wilderness
Ned Wilson Lake	White River National Forest	Flat Tops Wilderness
Upper Nwl Packtrail Pothole	White River National Forest	Flat Tops Wilderness
Dean Lake	Ashley National Forest	High Uintas Wilderness
No Name (Utah; Duchesne - 4d2-039)	Ashley National Forest	High Uintas Wilderness
Fish Lake	Wasatch-Cache National Forest	High Uintas Wilderness
Bluebell	ASHLEY NATIONAL FOREST	HIGH UINTAS WILDERNESS
Upper Coffin	Ashley National Forest	High Uintas Wilderness
Blodgett Lake, Colorado	White River National Forest	Holy Cross Wilderness
Upper Turquoise Lake	White River National Forest	Holy Cross Wilderness
Upper West Tennessee Lake	San Isabel National Forest	Holy Cross Wilderness
Blue Lake (Colorado; Boulder - 4e1-040)	Arapaho And Roosevelt National Forests	Indian Peaks Wilderness
No Name (Colorado; Boulder - 4e1-055)	Arapaho And Roosevelt National Forests	Indian Peaks Wilderness
King Lake (Colorado; Grand - 4e1-049)	Arapaho And Roosevelt National Forests	Indian Peaks Wilderness
Crater Lake (Colorado; Grand - 4e1-041)	Arapaho And Roosevelt National Forests	Indian Peaks Wilderness
Upper Lake	Arapaho And Roosevelt National Forests	Indian Peaks Wilderness
Small Lake Above U-Shaped Lake	Rio Grande National Forest	La Garita Wilderness
U-Shaped Lake	Rio Grande National Forest	La Garita Wilderness
Moon Lake (Upper)	White River National Forest	Maroon Bells-Snowmass Wilderness
Avalanche Lake	White River National Forest	Maroon Bells-Snowmass Wilderness
Capitol Lake	White River National Forest	Maroon Bells-Snowmass Wilderness
Upper Middle Beartrack Lake	Arapaho And Roosevelt National Forests	Mount Evans Wilderness
South Lake (Colorado)	Pike And San Isabel National Forests	Mount Evans Wilderness
Abyss Lake	Pike And San Isabel National Forests	Mount Evans Wilderness
North Lake (Colorado)	Pike And San Isabel National Forests	Mount Evans Wilderness
Frozen Lake	Pike And San Isabel National Forests	Mount Evans Wilderness
Seven Lakes (Lg.East)	Medicine Bow-Routt National Forest	Mount Zirkel Wilderness
Summit Lake (Colorado; Jackson - 4e2-060)	Medicine Bow-Routt National Forest	Mount Zirkel Wilderness
Lake Elbert	Medicine Bow-Routt National Forest	Mount Zirkel Wilderness
Deep Creek Lake, Colorado	Gunnison National Forest	Raggeds Wilderness
Rawah Lake #4	Arapaho And Roosevelt National Forests	Rawah Wilderness
Island Lake	Arapaho And Roosevelt National	Rawah Wilderness

Lake	National Forest Name	Wilderness Name
	Forests	
Kelly Lake (Colorado)	Arapaho And Roosevelt National Forests	Rawah Wilderness
Upper Stout Lake	San Isabel National Forest	Sangre De Cristo Wilderness
Upper Little Sand Creek Lake	San Isabel National Forest	Sangre De Cristo Wilderness
Lower Stout Lake	San Isabel National Forest	Sangre De Cristo Wilderness
Crater Lake (Sangre De Cristo)	Rio Grande National Forest	Sangre De Cristo Wilderness
Lake South Of Blue Lakes	San Juan-Rio Grande National Forest	South San Juan Wilderness
Glacier Lake (Colorado)	San Juan-Rio Grande National Forest	South San Juan Wilderness
Little Eldorado Lake	San Juan-Rio Grande National Forest	Weminuche Wilderness
White Dome Lake	San Juan-Rio Grande National Forest	Weminuche Wilderness
Lake Due South Of Ute Lake	San Juan-Rio Grande National Forest	Weminuche Wilderness
Big Eldorado Lake	San Juan-Rio Grande National Forest	Weminuche Wilderness
Small Pond Above Trout Lake	San Juan-Rio Grande National Forest	Weminuche Wilderness
Upper Sunlight Lake	San Juan-Rio Grande National Forest	Weminuche Wilderness
Upper Grizzly Lake	San Juan-Rio Grande National Forest	Weminuche Wilderness
West Snowdon Lake	San Juan-Rio Grande National Forest	Weminuche Wilderness
Middle Ute Lake	San Juan-Rio Grande National Forest	Weminuche Wilderness
Little Granite Lake	San Juan-Rio Grande National Forest	Weminuche Wilderness
Lower Sunlight Lake	San Juan-Rio Grande National Forest	Weminuche Wilderness
Four Mile Pothole	San Juan-Rio Grande National Forest	Weminuche Wilderness
South Golden Lake	Grand Mesa, Uncompahgre And Gunnison National Forests	West Elk Wilderness

4.3.2 Class I and Sensitive Class II Area Grid Cell Assignments

The list of CAMx grid cells that represent each Class I/II area changed slightly between the preliminary analysis as documented in the May 2014 report and the final analysis reported here. For some of the Class I/II areas, the CAMx grid cells used to represent the areas are identical in the preliminary and final analyses, these areas include Galiuro Wilderness, Mt Baldy Wilderness and Colorado NM. For some other Class I/II areas, the CAMx grid cells used to represent the areas differ by a single grid cell (of about 100 total grid cells). The final results for these areas are usually expected to be very close to the preliminary results, those areas include Canyonlands National Park and Rocky Mountain National Park. Some of the other Class I/II areas have more grid cell differences between the preliminary and final analysis.

Determining the grid cells that represent the Class I/II areas is achieved with Graphical Information System (GIS) software, and is performed by intersecting the CAMx model grid cells with GIS shapefiles that define the Class I/II boundaries. Different GIS tools are available to perform the intersection that assigns a Class I/II designation to each grid cell, and different input shapefiles defining the boundaries are also available.

To generate the grid cells for the final analysis, we used official Class I boundary shapefiles that are available for download from the NPS website[70]. The GIS tool "spatial join" was used to assign a Class I/II area to each CAMx grid cell if any part of the Class I/II area intersects the grid cell, even if the Class I/II area only covers a small fraction of the grid cell. For example, Figure 4-

[70] http://www.nature.nps.gov/air/maps/classiloc.cfm

4 displays the La Garita Wilderness Class I area boundary and grid cells (receptors) representing that area, the numbers displayed in the grid cells are the i and j coordinates of the CARMMS 4 km domain modeling grid. In Figure 4-4 it can be seen that many of the grid cells covering the boundary of La Garita have more than 50% of the grid cell area outside of the La Garita boundary, these grid cells may not have been used in the preliminary analysis. In fact there are numerous grid cells assigned to the La Garita Wilderness where the Class I area covers less than 10 percent of the grid cell. The inclusion of any grid cell that intersects any part of the Class I area no matter how small introduces conservatisms in the analysis. In addition, for the final processing, attention was paid to grid cells that cover more than one Class I/II area, in those cases, a particular grid cell was used twice to represent 2 different neighboring Class I/II areas. Figure 4-5 provides an example of a grid cell (56_153) that is used to represent both Black Canyon of the Gunnison Class I area and Curecanti NPS Class II area. Figure 4-6 displays a quality assurance (QA) plot showing all the Class I areas (including the Colorado side of Dinosaur NM, since it is considered a Class I area for SO_2), overlaid with the grid cells used to represent the Class I/II areas in the final analysis.

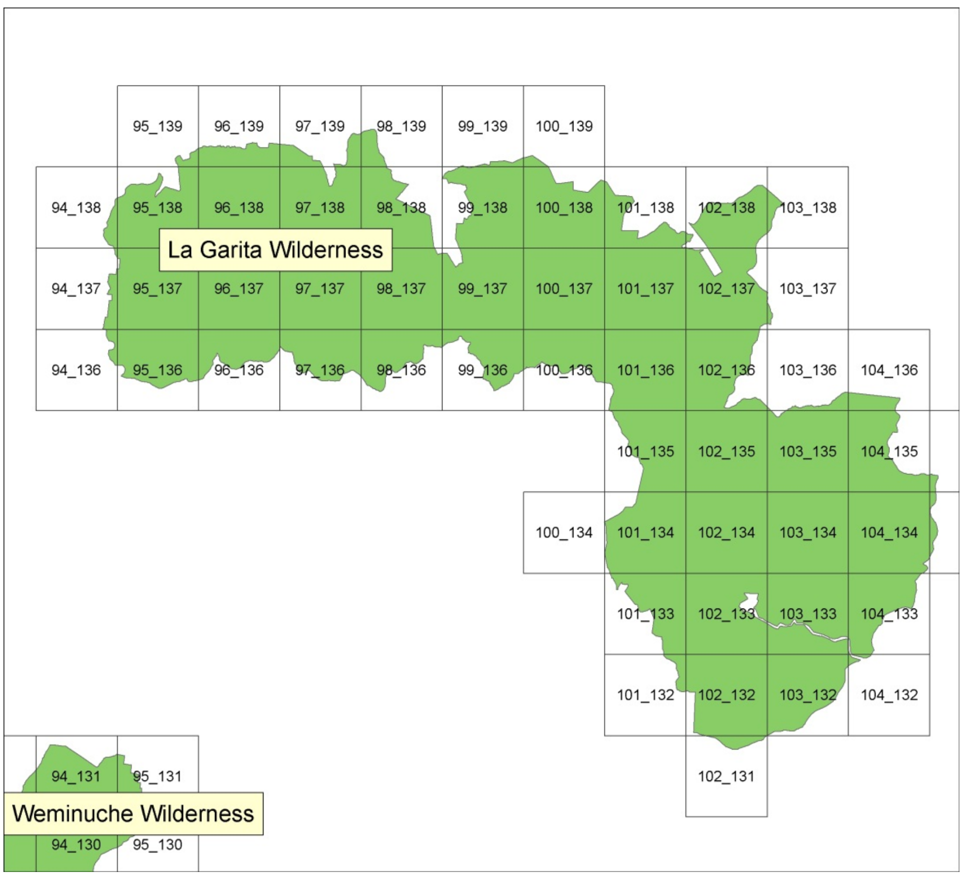


Figure 4-4. La Garita Wilderness Area represented by 4 km grid cells.

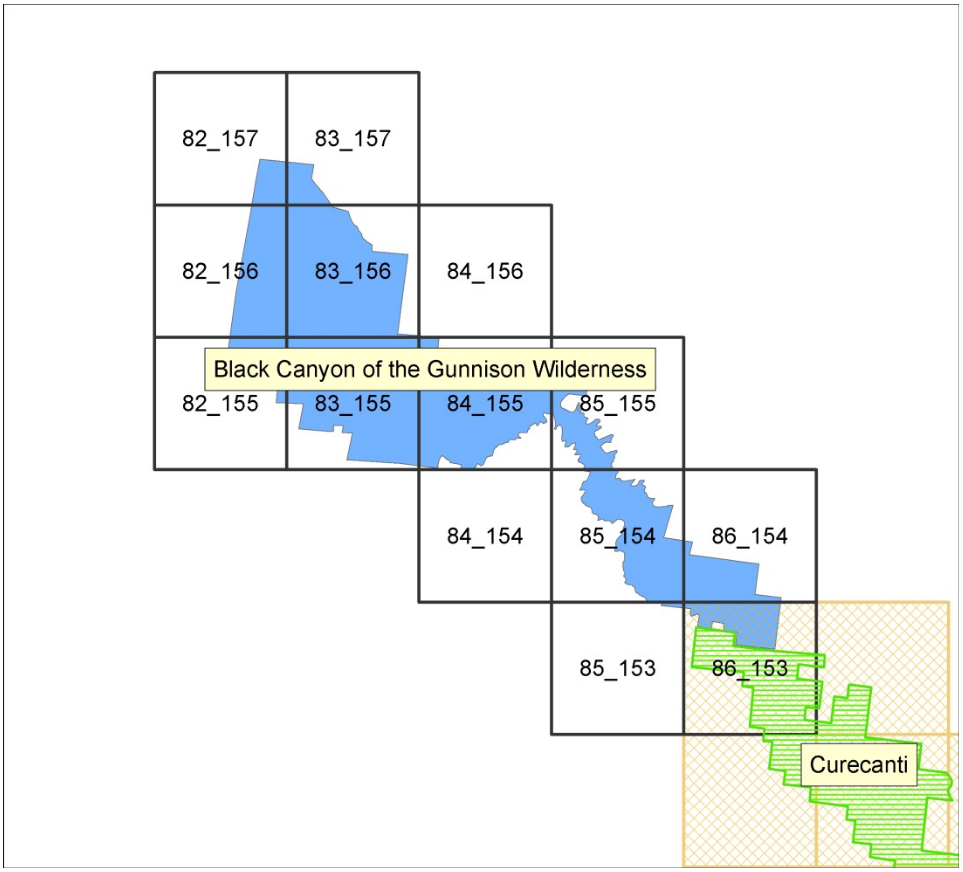


Figure4-5. Example of Black Canyon of the Gunnison Class I area grid cell overlap with Curecanti Class II area.

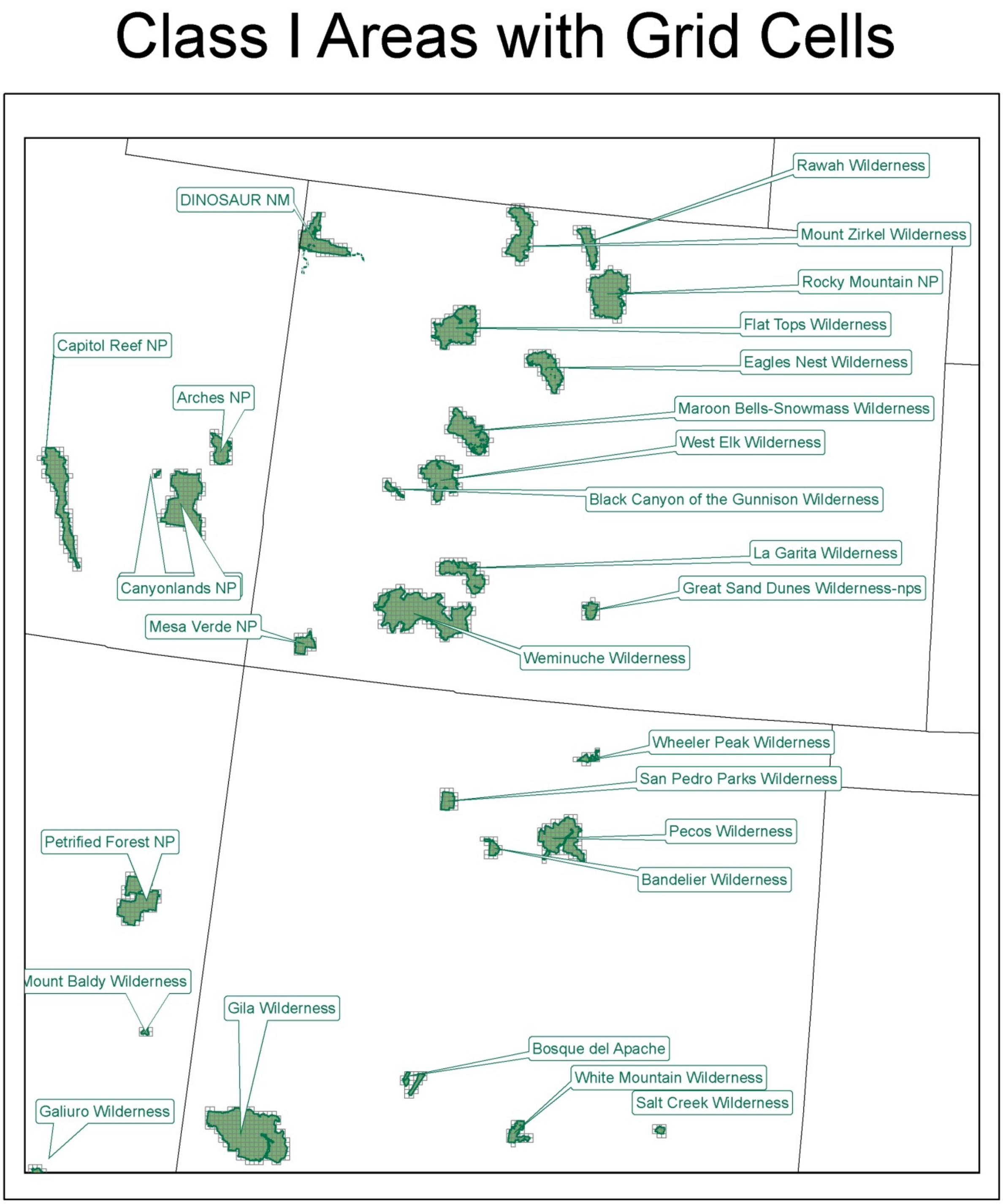


Figure 4-6. QA Plot showing all Class I Areas and CARMMS 4 km grid cell receptors that represent the areas.

4.4 Ambient Concentration Analysis using Absolute Modeling Results

Modeled concentrations predicted by the CAMx due to all sources were compared against national and state standards (NAAQS, CAAQS and NMAAQS, see Table 4-3) throughout the 4 km modeling domain. When exceedances of the ozone or $PM_{2.5}$ NAAQS are estimated, the APCA and PSAT source apportionment results was used to determine the contribution of emissions from each of the Source Groups to determine the major cause of the modeled exceedance. The incremental air quality concentration contribution due to emissions from oil and gas on Federal lands at Class I and sensitive Class II areas for each BLM planning area were compared to applicable PSD increments (see Table 4-3). The PSD demonstrations are for information only and are not regulatory PSD Increment consumption analyses, which would be completed as necessary by the relevant state or other agency.

4.5 Ambient Concentration Analysis using Relative Modeling Results

EPA's modeling guidance recommends using the PGM modeling results in a relative fashion when comparing future year modeling results to the ozone and $PM_{2.5}$ NAAQS (EPA, 2007). The relative change in the PGM concentrations between the current and future year simulations are used to scale the observed current year ozone or $PM_{2.5}$ Base Design Value (DVB) to obtain a projected future year Design Value (DVF). The model derived scaling factors are called Relative Response Factors (RRFs) and are based on the ratio of future year to current year modeling results:

$$DVF = DVB \times RRF$$

EPA's PGM modeling guidance provides recommended procedures for calculating DVBs and RRFs (EPA, 2007) that have been implemented in EPA's Modeled Attainment Test Software (MATS[71]; Abt, 2012). The MATS projection tool was used with the CAMx 2008 Base Case and 2021 High, Low and Medium Development Scenarios modeling results to project future year ozone DVFs that were compared to the NAAQS. MATS also has a capability of projecting $PM_{2.5}$ DVFs but there is much less observed $PM_{2.5}$ data in the region so such projections would be extremely limited, so MATS was not used for $PM_{2.5}$. The MATS default settings for making future year ozone projections were used that includes using a DVB based on an average of three-years of Design Values (DVs) centered on the Base Case modeling year (2008) and constructing RRFs using at least 10 days of modeling results. As the Base Case year is 2008, then this means using a DVB based on DVs from the following 3-year periods, 2006-2008, 2007-2009 and 2008-2010.

4.6 Visibility Analysis

Visibility impacts were calculated for new oil and gas and mining emissions on Federal lands within each BLM Planning Areas as well as for cumulative emissions sources. The approach used the incremental concentrations as quantified by the CAMx PSAT tool simulation of oil and gas and mining activities within each BLM planning area. Changes in light extinction from CAMx

[71] http://www.epa.gov/ttn/scram/modelingapps_mats.htm

model concentration increments due to emissions from oil and gas and other activity emissions were calculated for each day at grid cells that intersect Class I and sensitive Class II areas within the 4 km modeling domain (see Section 4.3.2). The FLAG (2010) procedures were used in the incremental BLM planning area-specific visibility assessment analysis.

The visibility evaluation metric used in this analysis is based on the Haze Index which is measured in deciview (dv) units and is defined as follows:

$$HI = 10 \times \ln[b_{ext}/10] .$$

b_{ext} is the atmospheric light extinction measured in inverse megameters (Mm^{-1}) and is calculated primarily from atmospheric concentrations of particulates. A more intuitive measure of haze is visual range (VR), which is defined as the distance at which a large black object just disappears from view, and is measured in km. Visual range is related to b_{ext} by the formula VR = 3912 / b_{ext}. Visual range will not be used as a threshold in the analysis, but could be back-calculated from extinction to give a more easily understood visibility metric.

The incremental concentrations due to BLM planning area emissions were added to background concentrations in the extinction equation (b_{ext}) and the difference between the Haze Index with added BLM planning area concentrations to the Haze Index based solely on background concentrations is calculated. This quantity is the change in Haze Index, which is referred to as "delta deciview" (Δdv) :

$$\Delta dv = 10 \times \ln[b_{ext(BLM+background)}/10] - 10 \times \ln[b_{ext(background)}/10]$$

$$\Delta dv = 10 \times \ln[b_{ext(BLM+background)}/b_{ext(background)}]$$

Here $b_{ext(BLM+background)}$ refers to atmospheric light extinction due to oil and gas and other activities in each BLM planning area plus background concentrations, and $b_{ext(background)}$ refers to atmospheric light extinction due to background concentrations only.

For each individual BLM Planning Areas, the estimated visibility degradation at the Class I areas and sensitive Class II areas due to new O&G emissions on Federal lands are presented in terms of the number of days that exceed a threshold change in deciview (Δdv) relative to background conditions. In the next section we describe the method for calculating the extinction, b_{ext}.

4.6.1 IMPROVE Reconstructed Mass Extinction Equations

The FLAG (2010) procedures for evaluating visibility impacts at Class I areas use the revised IMPROVE reconstructed mass extinction equation to convert PM species in μgm^{-3} to light extinction (b_{ext}) in inverse megameters (Mm^{-1}) as follows:

$$b_{ext} = b_{SO4} + b_{NO3} + b_{EC} + b_{OCM} + b_{Soil} + b_{PMC} + b_{SeaSalt} + b_{Rayleigh} + b_{NO2}$$

where

$$b_{SO4} = 2.2 \times f_S(RH) \times [\text{Small Sulfate}] + 4.8 \times f_L(RH) \times [\text{Large Sulfate}]$$

$$b_{NO3} = 2.4 \times f_S(RH) \times [\text{Small Nitrate}] + 5.1 \times f_L(RH) \times [\text{Large Nitrate}]$$

$$b_{OCM} = 2.8 \times [\text{Small Organic Mass}] + 6.1 \times [\text{Large Organic Mass}]$$

$$b_{EC} = 10 \times [\text{Elemental Carbon}]$$

$$b_{Soil} = 1 \times [\text{Fine Soil}]$$

$$b_{CM} = 0.6 \times [\text{Coarse Mass}]$$

$$b_{SeaSalt} = 1.7 \times f_{SS}(RH) \times [\text{Sea Salt}]$$

$$b_{Rayleigh} = \text{Rayleigh Scattering (Site-specific)}$$

$$b_{NO2} = 0.33 \times [NO_2 \text{ (ppb)}] \{\text{or as: } 0.1755 \times [NO_2 \text{ }(\mu g/m^3)]\}.$$

f(RH) are relative humidity adjustment factors that account for the fact that sulfate, nitrate and sea salt aerosols are hygroscopic and are more effective at scattering radiation at higher relative humidity. FLAG (2010) recommends using monthly average f(RH) values rather than the hourly averages recommended in the previous FLAG (2000) guidance document in order to moderate the effects of extreme weather events on the visibility results.

The revised IMPROVE equation treats "large sulfate" and "small sulfate" separately because large and small aerosols affect an incoming beam of light differently. However, the IMPROVE measurements do not separately measure large and small sulfate; they measure only the total $PM_{2.5}$ sulfate. Similarly, CAMx writes out a single concentration of particulate sulfate for each grid cell. Part of the definition of the new IMPROVE equation is a procedure for calculating the large and small sulfate contributions based on the magnitude of the model output sulfate concentrations; the procedure is documented in FLAG (2010). The sulfate concentration magnitude is used as a surrogate for distinguishing between large and small sulfate concentrations. For a given grid cell, the large and small sulfate contributions are calculated from the model output sulfate (which is the "Total Sulfate" referred to in the FLAG (2010) guidance) as:

For Total Sulfate < 20 $\mu g/m^3$:

$$[\text{Large Sulfate}] = ([\text{Total Sulfate}] / 20\ \mu g/m^3) \times [\text{Total Sulfate}]$$

For Total Sulfate ≥ 20 $\mu g/m^3$:

$$[\text{Large Sulfate}] = [\text{Total Sulfate}]$$

For all values of Total Sulfate:

$$[\text{Small Sulfate}] = [\text{Total Sulfate}] - [\text{Large Sulfate}]$$

The procedure is identical for nitrate and organic mass. Sulfate, nitrate and organic mass concentrations for the western U.S. are expected to be mainly in the small fraction.

The PSAT source apportionment algorithm does not separately track NO_2 concentrations but instead tracks total reactive nitrogen (RGN) that consistent mainly of NO plus NO_2. Thus for each hour and each grid cell representing a Class I/II area, a Source Group's incremental PSAT RGN contribution is converted to NO_2 by multiplying by the total (all emissions) CAMx model NO_2/RGN concentration ratio, which is then used in the IMPROVE visibility equation.

Although sodium and particulate chloride are treated in the CAMx core model, these species are not carried in the CAMx PSAT tool; neglecting sea salt in the visibility calculations in the 4 km CARMMS impact assessment domains does not compromise the accuracy of the analysis as IMPROVE measurements show that sea salt concentrations are negligible in this inland area and there would be no sea salt associated with any of the O&G emissions.

Predicted daily average modeled concentrations due to each BLM planning area for grid cells containing Class I and sensitive Class II area receptors were processed using the revised IMPROVE reconstructed mass extinction equation FLAG (2010) to obtain changes in b_{ext} at each sensitive receptor area that are converted to deciview and reported.

The FLAG (2010) method was used to estimate the visibility impacts from each Colorado and northern New Mexico BLM Planning Area. This method used the revised IMPROVE equation together with annual average natural conditions (see Table 6 in FLAG, 2010) and monthly relative humidity factors for each Class I area (see Tables 7-9 in FLAG, 2010). The Δdv was calculated for each grid cell that overlaps a Class I or sensitive Class II area for each day of the annual CAMx run. The highest Δdv across all grid cells overlapping a Class I or sensitive Class II area was selected to represent the daily value at that Class I/II area. Visibility impacts due to new O&G emissions on Federal lands within each BLM Planning Areas that are more than 0.5 and 1.0 dv will be reported.

4.6.2 Cumulative Visibility

The cumulative visibility impacts due to the development of oil and gas and other (e.g., mining) activities on all BLM Planning Areas were assessed following the recommendations from the FWS and NPS that was outlined in their February 10, 2012 letter to the Wyoming Department of Environmental Quality on recommended cumulative visibility method for the Continental Divide-Creston gas infill development EIS (FWS and NPS, 2012) and subsequent conversations with the FLMs. This approach is based on an abbreviated regional haze rule method that estimates the future year visibility at Class I and sensitive Class II areas for the average of the Worst 20% (W20%) and Best 20% (B20%) visibility days with and without the effects of the cumulative emissions on visibility impairment. The cumulative visibility impacts used CAMx model output from the 2008 Base Case and 2021 emissions scenarios in conjunction with monitoring data to produce cumulative visibility impacts at each Class I area in the CARMMS domain. EPA's Modeled Attainment Test Software (MATS[72]) was used to make the 2021 visibility projections for the W20% and B20% days. The basic steps in the recommended cumulative visibility method are as follows (FWS and NPS, 2012):

[72] http://www.epa.gov/ttn/scram/modelingapps_mats.htm

1. Calculate the observed average 2008 current year cumulative visibility impact using the Haze Index (HI, in deciviews) at each Class I or associated sensitive Class II area to determine the 20% of days with the worst and 20% of days with the best visibility. The intent is to incorporate 5 years of monitoring data surrounding the 2008 Base Case year, which would include 2006-2010. MATS uses the IMPROVE data associate with each Class I area and modeling results at the location of the IMPROVE monitoring site will be used.

2. Estimate the relative response factors (RRFs) for each component of $PM_{2.5}$ and for coarse mass (CM) corresponding to the new IMPROVE visibility algorithm using the CAMx 2008 and 2021 model output.

3. Using the RRFs and ambient data, calculate 2021 future-year daily concentration data for the B20% and W20% days using the CAMx 2008 Base Case and 2021 standard model concentration estimates and PSAT source apportionment modeling results two ways:

    a. 2021 Total Emissions: Use total 2021 High, Low and Medium Development Scenario CAMx concentration results due to all emissions;

    b. 2021 No Cumulative Emissions: Use PSAT source apportionment results to eliminate contributions of PM concentrations associated with combined emission scenarios corresponding to Source Groups R,S,T and U in Table 4-2c.

4. Use the information in step 3 to calculate the average 2021 visibility for the 20% Best and 20% Worst visibility days and the 2021 emissions.

5. Assess the average differences in cumulative visibility impacts for the four combined scenarios and also compare with the current observed Baseline visibility conditions.

We conservatively re-used the cumulative MATS visibility results from CARMMS 1.0 as discussed in Section 5.3.

4.7 Sulfur and Nitrogen Deposition

CAMx-predicted wet and dry fluxes of sulfur- and nitrogen-containing species were processed to estimate total annual sulfur (S) and nitrogen (N) deposition values at each Class I and sensitive Class II area as well as at each acid sensitive lake. The Maximum annual S and N deposition values from any grid cell that intersects a Class I or sensitive Class II receptor area was used to represent deposition for that area, in addition to the Average annual deposition values of all grid cells that intersect a Class I or sensitive Class II receptor area. Maximum and Average predicted S and N deposition impacts were estimated separately for each BLM planning area and together across all BLM planning areas using the Source Groups in Table 4-2c.

Nitrogen deposition impacts were calculated by taking the sum of the nitrogen contained in the fluxes of all nitrogen species modeled by CAMx PSAT source apportionment tool. CAMx species used in the nitrogen deposition flux calculation are: reactive gaseous nitrate species, RGN (NO, NO_2, NO_3 radical, HONO, N_2O_5), TPN (PAN, PANX, PNA), organic nitrates (NTR), particulate nitrate formed from primary emissions plus secondarily formed particulate nitrate (NO_3), gaseous nitric acid (HNO_3), gaseous ammonia (NH_3) and particulate ammonium (NH_4). CAMx species used in the sulfur deposition calculation are primarily sulfur dioxide emissions (SO_2) and particulate sulfate ion from primary emissions plus secondarily formed sulfate (SO_4).

FLAG (2010) recommends that applicable sources assess impacts of nitrogen and sulfur deposition at Class I areas. This guidance recognizes the importance of establishing critical deposition loading values ("Critical Loads") for each specific Class I area as these Critical Loads are completely dependent on local atmospheric, aquatic and terrestrial conditions and chemistry. Critical Load thresholds are essentially a level of atmospheric pollutant deposition below which negative ecosystem effects are not likely to occur. FLAG (2010) does not include any Critical Load levels for specific Class I areas and refers to site-specific critical load information on FLM websites for each area of concern. This guidance does, however recommend the use of deposition analysis thresholds (DATs[73]) developed by the National Park Service and the Fish and Wildlife Service. The DATs represent screening level values for nitrogen and sulfur deposition for individual projects with deposition impacts below the DATS considered negligible. Note that DATs are Project-level thresholds. DAT have been established for both nitrogen and sulfur deposition and in western Class I areas they are 0.005 kilograms per hectare per year (kg/ha-yr) for both nitrogen and sulfur deposition. As a screening analysis, results for oil and gas and mining activities for each BLM planning area, which is Source Groups A through P were separately compared to the DATs. Comparison of deposition impacts from combined Source Groups to the DAT is not appropriate.

For the combined Source Groups and total 2008 and 2021 emissions Source Groups W and X, the annual nitrogen and sulfur deposition were compared against Critical Load values established for the Rocky Mountain region to assess total deposition impacts. The NPS has provided recent information on nitrogen critical load values applicable for Wyoming and Colorado Class I and sensitive Class II areas (NPS, 2014). For Class I and sensitive Class II areas in Wyoming a critical load value of 2.2 kg/ha-yr for nitrogen deposition (estimated from a wet deposition critical load value of 1.4 kg N/ha-yr) is applicable, based on research conducted by Saros et. al.(2010) in the eastern Sierra Nevada and Greater Yellowstone ecosystems. This is a critical load value that is protective of high elevation surface waters. For Colorado Class I and sensitive Class II areas (with the exception of Dinosaur National Monument) a critical load value 2.3 kg N/ha-yr is applicable for total nitrogen deposition, based on research conducted by Jill Baron (Baron 2006) that estimated 1.5 kg/ha-yr as a critical loading value for wet nitrogen deposition for high-elevation lakes in Rocky Mountain National Park, Colorado. For Dinosaur National Monument, which is an arid region, a nitrogen deposition critical load value is based on research conducted by Pardo et al. (2011) which concluded that the cumulative critical load necessary to protect shrublands and lichen communities in Dinosaur NM is 3 kg N/ha/year.

For sulfur deposition, the critical load threshold published by Fox et al. (Fox 1989) for total sulfur deposition of 5 kg/ha-yr, for the Bob Marshall Wilderness Area in Montana and Bridger Wilderness Area in Wyoming, was used as critical load threshold for each of the Class I and sensitive Class II areas.

[73] http://www.nature.nps.gov/air/Pubs/pdf/flag/nsDATGuidance.pdf

In summary, we will compare the total annual sulfur and nitrogen deposition amounts for the cumulative Source Groups Q through X to the following Critical Load values:

Nitrogen

- Wyoming – 2.2 kg/ha-yr
- Colorado – 2.3 kg/ha-yr, except for Dinosaur Monument that will use 3.0 kg/ha-yr

Sulfur

- 5.0 kg/ha-yr – all areas

4.8 Acid Neutralizing Capacity

In addition to calculation of total deposition fluxes, an additional analysis was performed to assess the change in water chemistry associated with atmospheric deposition from BLM oil and gas and mining activities and cumulative sources for each of the sensitive lakes listed in Table 4-5. This analysis assesses the change in the acid neutralizing capacity (ANC) of sensitive lakes. An estimate of potential changes in ANC was made by following the procedure developed by the USFS Rocky Mountain Region (USFS, 2000). Predicted changes in ANC are compared with the threshold (10 percent change in ANC for lakes with background ANC values greater than 25 micro equivalents per liter [μeq/L], and no more than a 1 μeq/L change in ANC for lakes with background ANC values equal to or less than 25 μeq/L). A list of sensitive lakes was obtained from the USFS (Table 4-5). The most recent lake chemistry background ANC data was obtained from the VIEWS website for each of the sensitive lakes in the 4 km CARMMS modeling domain.

5.0 2021 MODELING RESULTS

In this Chapter we present the CARMMS modeling results for the 2021 High, Low and Medium Development Scenarios following the procedures given in Chapter 4 using examples from the 32 Source Group contributions given in Table 4-2c. Electronic attachments are provided that contain modeling results for all of the Source Groups with summaries provided in this Chapter. In this Chapter we present results for:

(N) New O&G on Federal lands within the BLM New Mexico Farmington Field Office (identified as source group #15 in Table 4-1).

and one or more of the following Source Groups:

(E) New O&G on Federal lands within the BLM Grand Junction Field Office (GJFO) Planning Area;

(F) New O&G on Federal lands in the BLM Uncompahgre Field Office (UFO) Planning Area;

(J) New O&G on Federal lands within the U.S. Forest Service Pawnee Grasslands Planning Area (USFS-PG);

(R) New O&G and mining on Federal lands within the 13 Colorado Planning Areas;

(T) New O&G on Federal and non-Federal lands and mining on Federal lands within the 14 BLM Planning Areas (Colorado and northern New Mexico BLM Planning Areas0; and

(U) All O&G (new Federal and non-Federal as well as existing) and Federal mining in Colorado within the 4 km CARMMS domain.

The contributions from coal EGUs, oil/gas EGUs and the rest of the Source Groups are provided in the interactive electronic attachments.

5.1 PSD Pollutant Concentration Impacts at Class I and Sensitive Class II Areas

Attachment A-1, A-2 and A-3 are three Excel spreadsheets that contain the contributions of emissions from each Source Group listed in Table 4-2c to pollutant concentrations at the 27 Class I (Table 4-4) and 58 sensitive Class II (Table 4-5) areas for the 2021 High, Low and Medium Development Scenarios, respectively. Results are presented for each PSD pollutant and averaging time given in Table 4-3. Attachment A contains two pivot table sheets:

The first pivot table sheet is "Summary" that lists the impacts of a user selected Source Group to all PSD pollutants across all Class I/II areas. It is controlled by selecting the Source Group in cell B1 and whether contributions of the maximum receptor or average across all receptors in a Class I/II area is desired in cell B2; we always select the "Maximum" option.

If a concentration at a Class I or sensitive Class II area is above the, respectively, PSD Class I or II Increments, the cell is shaded yellow.

The second pivot table sheet is "MaxImpact" and for a user-selected PSD pollutant it lists the maximum concentration impact at any Class I and sensitive Class II area due to emissions from each Source Group along with the percentage the concentration is of the PSD Increment and the Class I and II area where the maximum occurs. The pivot table is controlled by selecting the pollutant and averaging time in cell B1 and whether maximum or average concentrations across the Class I/II area is desired in cell B2.

The sheet "Readme" has a brief explanation of the sheets in the spreadsheet and maps for the locations of the Class I and sensitive Class II areas.

The PSD incremental concentrations are reported for informational purposes only and the analyses presented in this section are not a comprehensive PSD increment consumption assessment; that assessment must be performed by the appropriate state or federal agency.

5.1.1 Maximum PSD Concentration Impacts at any Class I or II Area

EPA has defined PSD Concentrations Increments for Class I and II areas for 8 different pollutant concentration/averaging time combinations (see Table 4-3). In this section we present the "Maximum" PSD concentration impacts at Class I and sensitive Class II areas due to each of the relevant 32 Source Groups from Table 4-2c (i.e., from the MaxImpact sheet in Attachments A-1 and A-2). The modeled impacts are based on the CAMx PSAT source apportionment contributions. For short-term averaging times (i.e., not annual), the highest second high concentration at each Class I/II area is selected for comparison with the PSD increment.

5.1.1.1 Annual NO_2 PSD Concentrations

The maximum contribution to annual NO_2 concentrations at any Class I or sensitive Class II area due to emissions from the 32 Source Groups for the 2021 High, Low and Medium Development Scenarios are shown in Table 5-1, which was obtained from the MaxImpact sheet in Attachments A-1, A-2 and A-3. The Class I and II PSD Increments for annual NO_2 are 2.5 and 25 $\mu g/m^3$, respectively. The annual NO_2 contributions from each of the individual BLM Planning Areas in Colorado and northern New Mexico (i.e., Source Groups A through P) are all below the annual NO_2 PSD Increment in all Class I and sensitive Class II areas for all three 2021 emission scenarios. The BLM Planning Area with the highest annual NO_2 concentration contribution to any Class I area is the BLM Colorado Tres Rios Field Office (TRFO) Planning Area whose annual NO_2 concentration contribution at Mesa Verde National Park for the 2021 High Development Scenarios is 1.96 $\mu g/m^3$, which represents 78% of the Class I area Increment. The mitigation in the 2021 Medium Development Scenario reduces this impact by 16% to 1.65 $\mu g/m^3$; this represents 66% of the PSD Class I area annual NO_2 increment. The corresponding TRFO annual NO_2 impact for the Low Development Scenario is 0.24 $\mu g/m^3$; this represents 9% of the Class I increment. The maximum annual NO_2 contribution at any Class I area from any other of the 14 BLM Planning Areas are less than 5% of the Class I area NO_2 PSD Increment. In particular, the maximum annual NO_2 contribution of the NMFFO at any Class I area in the High Development Scenario is 0.04 $\mu g/m^3$ (1.6% of the Class I increment) and is halved in the Low Development Scenario.

The highest annual NO_2 concentration at any sensitive Class II area due to new O&G emissions on Federal lands in any of the 14 BLM Planning Areas in the High Development Scenario is due the New Mexico Farmington Field Office (NMFFO) with a 2.0 $\mu g/m^3$ annual NO_2 concentration at the Aztec Ruins Class II area that represents 8% of the PSD Class II area Increment. This value drops to 1.6 $\mu g/m^3$ and 1.0 $\mu g/m^3$ in the Medium and Low Development Scenarios, respectively.

The maximum annual NO_2 contribution due to all new O&G and mining on Federal lands within the 13 Colorado BLM Planning Areas combined (i.e., Source Group R) for the High, Low and Medium Development Scenarios are, respectively, 1.97, 0.24 and 1.66 $\mu g/m^3$at Mesa Verde National Park, which represents 79%, 10% and 66% of the NO_2 PSD Class I increment and is primarily due to Federal O&G emissions from the Tres Rios FO Planning Area as discussed above. For the Cumulative Emissions Scenario that represents all new O&G on both Federal and non-Federal lands and mining within the 14 CO/NM BLM Planning Areas (Source Group T) the maximum NO_2 contribution are 4.5, 2.8 and 4.1 $\mu g/m^3$ for the High, Low and Medium Development Scenarios, respectively, that are all above the annual NO_2 PSD Class I Increment (2.5 $\mu g/m^3$). The maximum contribution of the Cumulative Emissions in Group T to annual NO_2 at any sensitive Class II area in all scenarios is at the South San Juan Class II area: 4.1 $\mu g/m^3$ for the High Scenario, 2.5 $\mu g/m^3$ in the Low Scenario and 3.7 $\mu g/m^3$ in the Medium Development Scenario, all of which are below the Class II area annual NO_2 PSD Increment. The maximum annual NO_2 contribution at any Class I area due to the combined effects of all O&G development in the 4 km CARMMS domain plus Federal mining in Colorado (Source Group U) is 4.7 $\mu g/m^3$ for the High, 3.1 $\mu g/m^3$ for the Low and 4.4 $\mu g/m^3$ for the Medium Development Scenarios, all occurring at Mesa Verde.

The contributions of the defined coal and oil/gas EGU source groups are all below the annual PSD Class I and Class II Increments.

Table 5-1a. Maximum annual NO_2 concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 High Development Scenario.

Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	2.5	0.018	0.7%	Mount_Zirkel	25	0.030	0.1%	Dinosaur_all
B	White River FO	2.5	0.113	4.5%	Flat_Tops	25	0.434	1.7%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	2.5	0.024	1.0%	Flat_Tops	25	0.010	0.0%	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	2.5	0.024	1.0%	Flat_Tops	25	0.009	0.0%	Holy_Cross
E	Grand Junction FO	2.5	0.076	3.0%	Arches	25	0.147	0.6%	Colorado
F	Uncompahgre FO	2.5	0.103	4.1%	Maroon_Bells	25	0.160	0.6%	Raggeds
G	Tres Rios FO	2.5	1.956	78.2%	Mesa_Verde	25	1.911	7.6%	South_San_Juan
H	Kremmling FO	2.5	0.035	1.4%	Rawah	25	0.011	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	2.5	0.000	0.0%	Rocky_Mountain	25	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	2.5	0.001	0.0%	Rocky_Mountain	25	0.001	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	2.5	0.000	0.0%	Salt_Creek	25	0.001	0.0%	Maxwell_NWR
L	RGFO#3 – South	2.5	0.003	0.1%	Great_Sand_Dunes	25	0.188	0.8%	Greenhorn_Mounta
M	RGFO#4 – East-Central	2.5	0.000	0.0%	Eagles_Nest	25	0.014	0.1%	Lost_Creek
N	New Mexico Farmington FO	2.5	0.041	1.6%	Mesa_Verde	25	2.037	8.1%	Aztec_Ruins
O	Total Colorado River Field Office	2.5	0.048	1.9%	Flat_Tops	25	0.019	0.1%	Holy_Cross
P	Total Royal Gorge Field Office	2.5	0.003	0.1%	Great_Sand_Dunes	25	0.188	0.8%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	2.5	0.011	0.4%	West_Elk	25	0.017	0.1%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	2.5	1.966	78.6%	Mesa_Verde	25	1.916	7.7%	South_San_Juan
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	2.5	4.448	177.9%	Mesa_Verde	25	4.012	16.0%	South_San_Juan
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	2.5	4.469	178.8%	Mesa_Verde	25	4.064	16.3%	South_San_Juan
U	Combined O&G and Mining in 4 km domain	2.5	4.748	189.9%	Mesa_Verde	25	20.497	82.0%	Aztec_Ruins
V	Natural Emissions	2.5	2.697	107.9%	Bandelier	25	1.225	4.9%	Dome
W	2021 All Emissions	2.5	6.101	244.1%	Mesa_Verde	25	26.457	105.8%	Aztec_Ruins
X	2008 All Emissions	2.5	15.638	625.5%	Eagles_Nest	25	23.759	95.0%	Aztec_Ruins
Y	Coal EGU NM	2.5	1.493	59.7%	Petrified_Forest	25	1.546	6.2%	Aztec_Ruins
Z	Coal EGU CO	2.5	0.952	38.1%	Mount_Zirkel	25	0.588	2.4%	Dinosaur_all
AA	Oil/Gas EGU NM	2.5	0.001	0.1%	Bandelier	25	0.027	0.1%	Petroglyph
AB	Oil/Gas EGU CO	2.5	0.007	0.3%	Rocky_Mountain	25	0.016	0.1%	Mount_Evans
AC	All EGUs in 4km Domain	2.5	1.499	59.9%	Petrified_Forest	25	1.576	6.3%	Aztec_Ruins
AD	CO Mining + Coal EGUs CO	2.5	0.959	38.4%	Mount_Zirkel	25	0.589	2.4%	Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	2.5	4.447	177.9%	Mesa_Verde	25	4.012	16.0%	South_San_Juan
AF	NM O&G + Oil/Gas EGU NM	2.5	0.043	1.7%	Mesa_Verde	25	2.049	8.2%	Aztec_Ruins

Table 5-1b. Maximum annual NO_2 concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Low Development Scenario.

Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	2.5	0.003	0.1%	Mount_Zirkel	25	0.004	0.0%	Dinosaur_all
B	White River FO	2.5	0.018	0.7%	Flat_Tops	25	0.068	0.3%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	2.5	0.015	0.6%	Flat_Tops	25	0.006	0.0%	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	2.5	0.013	0.5%	Flat_Tops	25	0.005	0.0%	Holy_Cross
E	Grand Junction FO	2.5	0.004	0.2%	Maroon_Bells	25	0.008	0.0%	Colorado
F	Uncompahgre FO	2.5	0.031	1.2%	Maroon_Bells	25	0.048	0.2%	Raggeds
G	Tres Rios FO	2.5	0.235	9.4%	Mesa_Verde	25	0.235	0.9%	South_San_Juan
H	Kremmling FO	2.5	0.004	0.2%	Rawah	25	0.001	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	2.5	0.000	0.0%	Rocky_Mountain	25	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	2.5	0.000	0.0%	Rocky_Mountain	25	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	2.5	0.000	0.0%	Salt_Creek	25	0.000	0.0%	Maxwell_NWR
L	RGFO#3 – South	2.5	0.002	0.1%	Great_Sand_Dunes	25	0.116	0.5%	Greenhorn_Mounta
M	RGFO#4 – East-Central	2.5	0.000	0.0%	Eagles_Nest	25	0.002	0.0%	Lost_Creek
N	New Mexico Farmington FO	2.5	0.020	0.8%	Mesa_Verde	25	0.986	3.9%	Aztec_Ruins
O	Total Colorado River Field Office	2.5	0.028	1.1%	Flat_Tops	25	0.011	0.0%	Holy_Cross
P	Total Royal Gorge Field Office	2.5	0.002	0.1%	Great_Sand_Dunes	25	0.116	0.5%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	2.5	0.011	0.4%	West_Elk	25	0.017	0.1%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	2.5	0.237	9.5%	Mesa_Verde	25	0.236	0.9%	South_San_Juan
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	2.5	2.830	113.2%	Mesa_Verde	25	2.482	9.9%	South_San_Juan
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	2.5	2.840	113.6%	Mesa_Verde	25	2.507	10.0%	South_San_Juan
U	Combined O&G and Mining in 4 km domain	2.5	3.113	124.5%	Mesa_Verde	25	19.404	77.6%	Aztec_Ruins
V	Natural Emissions	2.5	2.697	107.9%	Bandelier	25	1.225	4.9%	Dome
W	2021 All Emissions	2.5	5.643	225.7%	Petrified_Forest	25	25.106	100.4%	Aztec_Ruins
X	2008 All Emissions	2.5	15.638	625.5%	Eagles_Nest	25	23.759	95.0%	Aztec_Ruins
Y	Coal EGU NM	2.5	1.493	59.7%	Petrified_Forest	25	1.546	6.2%	Aztec_Ruins
Z	Coal EGU CO	2.5	0.952	38.1%	Mount_Zirkel	25	0.588	2.4%	Dinosaur_all
AA	Oil/Gas EGU NM	2.5	0.001	0.1%	Bandelier	25	0.027	0.1%	Petroglyph
AB	Oil/Gas EGU CO	2.5	0.007	0.3%	Rocky_Mountain	25	0.016	0.1%	Mount_Evans
AC	All EGUs in 4km Domain	2.5	1.499	59.9%	Petrified_Forest	25	1.576	6.3%	Aztec_Ruins
AD	CO Mining + Coal EGUs CO	2.5	0.959	38.4%	Mount_Zirkel	25	0.589	2.4%	Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	2.5	2.828	113.1%	Mesa_Verde	25	2.482	9.9%	South_San_Juan
AF	NM O&G + Oil/Gas EGU NM	2.5	0.021	0.8%	Mesa_Verde	25	0.998	4.0%	Aztec_Ruins

Table 5-1c. Maximum annual NO_2 concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Medium Development Scenario.

Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	2.5	0.016	0.6%	Mount_Zirkel	25	0.026	0.1%	Dinosaur_all
B	White River FO	2.5	0.086	3.5%	Flat_Tops	25	0.408	1.6%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	2.5	0.018	0.7%	Flat_Tops	25	0.008	0.0%	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	2.5	0.020	0.8%	Flat_Tops	25	0.007	0.0%	Holy_Cross
E	Grand Junction FO	2.5	0.073	2.9%	Arches	25	0.135	0.5%	Colorado
F	Uncompahgre FO	2.5	0.070	2.8%	Maroon_Bells	25	0.108	0.4%	Raggeds
G	Tres Rios FO	2.5	1.649	66.0%	Mesa_Verde	25	1.618	6.5%	South_San_Juan
H	Kremmling FO	2.5	0.031	1.2%	Eagles_Nest	25	0.006	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	2.5	0.000	0.0%	Rocky_Mountain	25	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	2.5	0.001	0.0%	Rocky_Mountain	25	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	2.5	0.000	0.0%	Salt_Creek	25	0.000	0.0%	Maxwell_NWR
L	RGFO#3 – South	2.5	0.002	0.1%	Great_Sand_Dunes	25	0.130	0.5%	Greenhorn_Mounta
M	RGFO#4 – East-Central	2.5	0.000	0.0%	Eagles_Nest	25	0.008	0.0%	Lost_Creek
N	New Mexico Farmington FO	2.5	0.032	1.3%	Mesa_Verde	25	1.569	6.3%	Aztec_Ruins
O	Total Colorado River Field Office	2.5	0.038	1.5%	Flat_Tops	25	0.016	0.1%	Holy_Cross
P	Total Royal Gorge Field Office	2.5	0.002	0.1%	Great_Sand_Dunes	25	0.130	0.5%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	2.5	0.011	0.4%	West_Elk	25	0.017	0.1%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	2.5	1.659	66.3%	Mesa_Verde	25	1.622	6.5%	South_San_Juan
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	2.5	4.061	162.4%	Mesa_Verde	25	3.658	14.6%	South_San_Juan
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	2.5	4.077	163.1%	Mesa_Verde	25	3.699	14.8%	South_San_Juan
U	Combined O&G and Mining in 4 km domain	2.5	4.354	174.2%	Mesa_Verde	25	20.040	80.2%	Aztec_Ruins
V	Natural Emissions	2.5	2.697	107.9%	Bandelier	25	1.225	4.9%	Dome
W	2021 All Emissions	2.5	5.704	228.1%	Mesa_Verde	25	26.015	104.1%	Aztec_Ruins
X	2008 All Emissions	2.5	15.638	625.5%	Eagles_Nest	25	23.759	95.0%	Aztec_Ruins
Y	Coal EGU NM	2.5	1.493	59.7%	Petrified_Forest	25	1.546	6.2%	Aztec_Ruins
Z	Coal EGU CO	2.5	0.952	38.1%	Mount_Zirkel	25	0.588	2.4%	Dinosaur_all
AA	Oil/Gas EGU NM	2.5	0.001	0.1%	Bandelier	25	0.027	0.1%	Petroglyph
AB	Oil/Gas EGU CO	2.5	0.007	0.3%	Rocky_Mountain	25	0.016	0.1%	Mount_Evans
AC	All EGUs in 4km Domain	2.5	1.499	59.9%	Petrified_Forest	25	1.576	6.3%	Aztec_Ruins
AD	CO Mining + Coal EGUs CO	2.5	0.959	38.4%	Mount_Zirkel	25	0.589	2.4%	Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	2.5	4.060	162.4%	Mesa_Verde	25	3.658	14.6%	South_San_Juan
AF	NM O&G + Oil/Gas EGU NM	2.5	0.033	1.3%	Mesa_Verde	25	1.581	6.3%	Aztec_Ruins

5.1.1.2 SO_2 PSD Concentrations

Tables 5-2 through 5-4 presents the comparison of the maximum annual, 24-hour and 3-hour SO_2 concentrations, respectively, at Class I/II areas with the PSD SO_2 increments for the 32 Source Groups. Note that the Colorado portion of the Dinosaur National Monument is Class I for SO_2 only, so it is included in the Class I area grouping in these Tables. None of the Source Groups exceed the annual PSD Class I Increment at any Class I/II area in any of the scenarios (Tables 5-2a, b, c). For 24-hour and 3-hour SO_2 contributions, there are wildfires that cause exceedances of the PSD Class I increment at the Bandelier Class I area for the Natural, total 2021 and total 2008 (Source Groups V, X and W) emission groups, but none of the other Source Groups except EGUs exhibit any exceedances of the 24-hour and 3-hour SO_2 PSD Increments at any Class I or sensitive Class II area. Note that PSD Increments are not applicable for Natural or Total emissions or for cumulative EGU emissions in the 4 km domain. The contributions of the 14 BLM Planning Areas to SO_2 concentrations at Class I/II areas are extremely small, mostly much less than 1% of the PSD Increments. Of the 14 BLM Planning Areas, Federal O&G from the White River Field Office (WRFO) Planning Area has by far the largest contribution to annual, 24-hour and 3-hour SO_2 concentrations at any Class I area with maximum contributions of 5, 8 and 5 percent of the PSD Increment for the High and Medium Development Scenarios (the mitigation in the Medium Development Scenario did not address SO_2 emissions) and approximately 1 percent of the PSD Increment for the Low Development Scenarios that occurs at the Colorado portion of Dinosaur National Monument.

Table 5-2a. Maximum annual SO_2 concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 High Development Scenario.

Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	2	0.000	0.0%	Mount_Zirkel	20	0.000	0.0%	Dinosaur_all
B	White River FO	2	0.089	4.5%	Dinosaur_CO	20	0.089	0.4%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	2	0.000	0.0%	Flat_Tops	20	0.000	0.0%	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	2	0.000	0.0%	Flat_Tops	20	0.000	0.0%	Holy_Cross
E	Grand Junction FO	2	0.000	0.0%	Arches	20	0.001	0.0%	Colorado
F	Uncompahgre FO	2	0.000	0.0%	Maroon_Bells	20	0.000	0.0%	Raggeds
G	Tres Rios FO	2	0.001	0.1%	Mesa_Verde	20	0.001	0.0%	South_San_Juan
H	Kremmling FO	2	0.000	0.0%	Rawah	20	0.000	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	2	0.000	0.0%	Rocky_Mountain	20	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	2	0.000	0.0%	Rocky_Mountain	20	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	2	0.000	0.0%	Salt_Creek	20	0.000	0.0%	Maxwell_NWR
L	RGFO#3 – South	2	0.000	0.0%	Great_Sand_Dunes	20	0.000	0.0%	Greenhorn_Mounta
M	RGFO#4 – East-Central	2	0.000	0.0%	Eagles_Nest	20	0.000	0.0%	Lost_Creek
N	New Mexico Farmington FO	2	0.000	0.0%	Mesa_Verde	20	0.003	0.0%	Aztec_Ruins
O	Total Colorado River Field Office	2	0.000	0.0%	Flat_Tops	20	0.000	0.0%	Holy_Cross
P	Total Royal Gorge Field Office	2	0.000	0.0%	Rocky_Mountain	20	0.000	0.0%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	2	0.000	0.0%	West_Elk	20	0.000	0.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	2	0.090	4.5%	Dinosaur_CO	20	0.090	0.4%	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	2	0.102	5.1%	Dinosaur_CO	20	0.102	0.5%	Dinosaur_all
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	2	0.102	5.1%	Dinosaur_CO	20	0.102	0.5%	Dinosaur_all
U	Combined O&G and Mining in 4 km domain	2	0.108	5.4%	Dinosaur_CO	20	0.108	0.5%	Dinosaur_all
V	Natural Emissions	2	0.410	20.5%	Bandelier	20	0.171	0.9%	Dome
W	2021 All Emissions	2	1.854	92.7%	Galiuro	20	0.964	4.8%	Bitter_Lake_NWR
X	2008 All Emissions	2	1.240	62.0%	Petrified_Forest	20	1.143	5.7%	Aztec_Ruins
Y	Coal EGU NM	2	1.138	56.9%	Petrified_Forest	20	0.356	1.8%	Aztec_Ruins
Z	Coal EGU CO	2	0.335	16.8%	Mount_Zirkel	20	0.187	0.9%	Dinosaur_all
AA	Oil/Gas EGU NM	2	0.000	0.0%	White_Mountain	20	0.000	0.0%	Capitan_Mountain
AB	Oil/Gas EGU CO	2	0.000	0.0%	White_Mountain	20	0.000	0.0%	Capitan_Mountain
AC	All EGUs in 4km Domain	2	1.145	57.3%	Petrified_Forest	20	0.371	1.9%	Aztec_Ruins
AD	CO Mining + Coal EGUs CO	2	0.335	16.8%	Mount_Zirkel	20	0.187	0.9%	Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	2	0.102	5.1%	Dinosaur_CO	20	0.102	0.5%	Dinosaur_all
AF	NM O&G + Oil/Gas EGU NM	2	0.000	0.0%	Mesa_Verde	20	0.003	0.0%	Aztec_Ruins

Table 5-2b. Maximum annual SO_2 concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Low Development Scenario.

Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	2	0.000	0.0%	Mount_Zirkel	20	0.000	0.0%	Dinosaur_all
B	White River FO	2	0.014	0.7%	Dinosaur_CO	20	0.014	0.1%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	2	0.000	0.0%	Flat_Tops	20	0.000	0.0%	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	2	0.000	0.0%	Flat_Tops	20	0.000	0.0%	Holy_Cross
E	Grand Junction FO	2	0.000	0.0%	Arches	20	0.000	0.0%	Colorado
F	Uncompahgre FO	2	0.000	0.0%	Maroon_Bells	20	0.000	0.0%	Raggeds
G	Tres Rios FO	2	0.000	0.0%	Mesa_Verde	20	0.000	0.0%	South_San_Juan
H	Kremmling FO	2	0.000	0.0%	Rawah	20	0.000	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	2	0.000	0.0%	Rocky_Mountain	20	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	2	0.000	0.0%	Rocky_Mountain	20	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	2	0.000	0.0%	Pecos	20	0.000	0.0%	Maxwell_NWR
L	RGFO#3 – South	2	0.000	0.0%	Great_Sand_Dunes	20	0.000	0.0%	Greenhorn_Mounta
M	RGFO#4 – East-Central	2	0.000	0.0%	Eagles_Nest	20	0.000	0.0%	Lost_Creek
N	New Mexico Farmington FO	2	0.000	0.0%	Mesa_Verde	20	0.001	0.0%	Aztec_Ruins
O	Total Colorado River Field Office	2	0.000	0.0%	Flat_Tops	20	0.000	0.0%	Holy_Cross
P	Total Royal Gorge Field Office	2	0.000	0.0%	Rocky_Mountain	20	0.000	0.0%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	2	0.000	0.0%	West_Elk	20	0.000	0.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	2	0.014	0.7%	Dinosaur_CO	20	0.014	0.1%	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	2	0.018	0.9%	Dinosaur_CO	20	0.018	0.1%	Dinosaur_all
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	2	0.018	0.9%	Dinosaur_CO	20	0.018	0.1%	Dinosaur_all
U	Combined O&G and Mining in 4 km domain	2	0.024	1.2%	Dinosaur_CO	20	0.081	0.4%	Aztec_Ruins
V	Natural Emissions	2	0.410	20.5%	Bandelier	20	0.171	0.9%	Dome
W	2021 All Emissions	2	1.858	92.9%	Galiuro	20	0.969	4.8%	Bitter_Lake_NWR
X	2008 All Emissions	2	1.240	62.0%	Petrified_Forest	20	1.143	5.7%	Aztec_Ruins
Y	Coal EGU NM	2	1.138	56.9%	Petrified_Forest	20	0.356	1.8%	Aztec_Ruins
Z	Coal EGU CO	2	0.335	16.8%	Mount_Zirkel	20	0.187	0.9%	Dinosaur_all
AA	Oil/Gas EGU NM	2	0.000	0.0%	White_Mountain	20	0.000	0.0%	Capitan_Mountain
AB	Oil/Gas EGU CO	2	0.000	0.0%	White_Mountain	20	0.000	0.0%	Capitan_Mountain
AC	All EGUs in 4km Domain	2	1.145	57.3%	Petrified_Forest	20	0.371	1.9%	Aztec_Ruins
AD	CO Mining + Coal EGUs CO	2	0.335	16.8%	Mount_Zirkel	20	0.187	0.9%	Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	2	0.018	0.9%	Dinosaur_CO	20	0.018	0.1%	Dinosaur_all
AF	NM O&G + Oil/Gas EGU NM	2	0.000	0.0%	Mesa_Verde	20	0.001	0.0%	Aztec_Ruins

Table 5-2c. Maximum annual SO_2 concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Medium Development Scenario.

Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	2	0.000	0.0%	Mount_Zirkel	20	0.000	0.0%	Dinosaur_all
B	White River FO	2	0.089	4.5%	Dinosaur_CO	20	0.089	0.4%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	2	0.000	0.0%	Flat_Tops	20	0.000	0.0%	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	2	0.000	0.0%	Flat_Tops	20	0.000	0.0%	Holy_Cross
E	Grand Junction FO	2	0.000	0.0%	Arches	20	0.001	0.0%	Colorado
F	Uncompahgre FO	2	0.000	0.0%	Maroon_Bells	20	0.000	0.0%	Raggeds
G	Tres Rios FO	2	0.001	0.1%	Mesa_Verde	20	0.001	0.0%	South_San_Juan
H	Kremmling FO	2	0.000	0.0%	Rawah	20	0.000	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	2	0.000	0.0%	Rocky_Mountain	20	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	2	0.000	0.0%	Rocky_Mountain	20	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	2	0.000	0.0%	Salt_Creek	20	0.000	0.0%	Maxwell_NWR
L	RGFO#3 – South	2	0.000	0.0%	Great_Sand_Dunes	20	0.000	0.0%	Greenhorn_Mounta
M	RGFO#4 – East-Central	2	0.000	0.0%	Eagles_Nest	20	0.000	0.0%	Lost_Creek
N	New Mexico Farmington FO	2	0.000	0.0%	Mesa_Verde	20	0.003	0.0%	Aztec_Ruins
O	Total Colorado River Field Office	2	0.000	0.0%	Flat_Tops	20	0.000	0.0%	Holy_Cross
P	Total Royal Gorge Field Office	2	0.000	0.0%	Rocky_Mountain	20	0.000	0.0%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	2	0.000	0.0%	West_Elk	20	0.000	0.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	2	0.090	4.5%	Dinosaur_CO	20	0.090	0.4%	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	2	0.102	5.1%	Dinosaur_CO	20	0.102	0.5%	Dinosaur_all
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	2	0.102	5.1%	Dinosaur_CO	20	0.102	0.5%	Dinosaur_all
U	Combined O&G and Mining in 4 km domain	2	0.108	5.4%	Dinosaur_CO	20	0.108	0.5%	Dinosaur_all
V	Natural Emissions	2	0.410	20.5%	Bandelier	20	0.171	0.9%	Dome
W	2021 All Emissions	2	1.854	92.7%	Galiuro	20	0.964	4.8%	Bitter_Lake_NWR
X	2008 All Emissions	2	1.240	62.0%	Petrified_Forest	20	1.143	5.7%	Aztec_Ruins
Y	Coal EGU NM	2	1.138	56.9%	Petrified_Forest	20	0.356	1.8%	Aztec_Ruins
Z	Coal EGU CO	2	0.335	16.8%	Mount_Zirkel	20	0.187	0.9%	Dinosaur_all
AA	Oil/Gas EGU NM	2	0.000	0.0%	White_Mountain	20	0.000	0.0%	Capitan_Mountain
AB	Oil/Gas EGU CO	2	0.000	0.0%	White_Mountain	20	0.000	0.0%	Capitan_Mountain
AC	All EGUs in 4km Domain	2	1.145	57.3%	Petrified_Forest	20	0.371	1.9%	Aztec_Ruins
AD	CO Mining + Coal EGUs CO	2	0.335	16.8%	Mount_Zirkel	20	0.187	0.9%	Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	2	0.102	5.1%	Dinosaur_CO	20	0.102	0.5%	Dinosaur_all
AF	NM O&G + Oil/Gas EGU NM	2	0.000	0.0%	Mesa_Verde	20	0.003	0.0%	Aztec_Ruins

Table 5-3a. Maximum 24-hour SO_2 concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 High Development Scenario.

Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	5	0.002	0.0%	Dinosaur_CO	91	0.002	0.0%	Dinosaur_all
B	White River FO	5	0.412	8.2%	Dinosaur_CO	91	0.412	0.5%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	5	0.000	0.0%	Flat_Tops	91	0.000	0.0%	Colorado
D	Roan Plateau Planning area portion of CRVFO	5	0.000	0.0%	Flat_Tops	91	0.000	0.0%	Colorado
E	Grand Junction FO	5	0.002	0.0%	Arches	91	0.003	0.0%	Colorado
F	Uncompahgre FO	5	0.001	0.0%	Maroon_Bells	91	0.001	0.0%	Raggeds
G	Tres Rios FO	5	0.003	0.1%	Mesa_Verde	91	0.003	0.0%	South_San_Juan
H	Kremmling FO	5	0.000	0.0%	Rawah	91	0.000	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	5	0.000	0.0%	Rocky_Mountain	91	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	5	0.000	0.0%	Rocky_Mountain	91	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	5	0.000	0.0%	Pecos	91	0.000	0.0%	Greenhorn_Mounta
L	RGFO#3 – South	5	0.000	0.0%	Great_Sand_Dunes	91	0.000	0.0%	Greenhorn_Mounta
M	RGFO#4 – East-Central	5	0.000	0.0%	Eagles_Nest	91	0.000	0.0%	Lost_Creek
N	New Mexico Farmington FO	5	0.001	0.0%	Mesa_Verde	91	0.009	0.0%	Aztec_Ruins
O	Total Colorado River Field Office	5	0.000	0.0%	Flat_Tops	91	0.000	0.0%	Colorado
P	Total Royal Gorge Field Office	5	0.000	0.0%	Rocky_Mountain	91	0.000	0.0%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	5	0.001	0.0%	West_Elk	91	0.002	0.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	5	0.412	8.2%	Dinosaur_CO	91	0.412	0.5%	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	5	0.469	9.4%	Dinosaur_CO	91	0.469	0.5%	Dinosaur_all
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	5	0.469	9.4%	Dinosaur_CO	91	0.469	0.5%	Dinosaur_all
U	Combined O&G and Mining in 4 km domain	5	0.487	9.7%	Dinosaur_CO	91	0.565	0.6%	Aztec_Ruins
V	Natural Emissions	5	50.759	1015.2%	Bandelier	91	20.048	22.0%	Dome
W	2021 All Emissions	5	51.142	1022.8%	Bandelier	91	20.774	22.8%	Dome
X	2008 All Emissions	5	50.921	1018.4%	Bandelier	91	20.894	23.0%	Dome
Y	Coal EGU NM	5	8.525	170.5%	Petrified_Forest	91	3.648	4.0%	Aztec_Ruins
Z	Coal EGU CO	5	1.716	34.3%	Mount_Zirkel	91	1.346	1.5%	Dinosaur_all
AA	Oil/Gas EGU NM	5	0.000	0.0%	White_Mountain	91	0.000	0.0%	Capitan_Mountain
AB	Oil/Gas EGU CO	5	0.000	0.0%	White_Mountain	91	0.000	0.0%	Capitan_Mountain
AC	All EGUs in 4km Domain	5	8.525	170.5%	Petrified_Forest	91	3.684	4.0%	Aztec_Ruins
AD	CO Mining + Coal EGUs CO	5	1.716	34.3%	Mount_Zirkel	91	1.346	1.5%	Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	5	0.468	9.4%	Dinosaur_CO	91	0.468	0.5%	Dinosaur_all
AF	NM O&G + Oil/Gas EGU NM	5	0.001	0.0%	Mesa_Verde	91	0.009	0.0%	Aztec_Ruins

Table 5-3b. Maximum 24-hour SO_2 concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Low Development Scenario.

Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	5	0.000	0.0%	Dinosaur_CO	91	0.000	0.0%	Dinosaur_all
B	White River FO	5	0.067	1.3%	Dinosaur_CO	91	0.067	0.1%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	5	0.000	0.0%	Flat_Tops	91	0.000	0.0%	Colorado
D	Roan Plateau Planning area portion of CRVFO	5	0.000	0.0%	Flat_Tops	91	0.000	0.0%	Colorado
E	Grand Junction FO	5	0.000	0.0%	Arches	91	0.000	0.0%	Colorado
F	Uncompahgre FO	5	0.000	0.0%	Maroon_Bells	91	0.000	0.0%	Raggeds
G	Tres Rios FO	5	0.001	0.0%	Mesa_Verde	91	0.001	0.0%	South_San_Juan
H	Kremmling FO	5	0.000	0.0%	Rawah	91	0.000	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	5	0.000	0.0%	Rocky_Mountain	91	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	5	0.000	0.0%	Rocky_Mountain	91	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	5	0.000	0.0%	Pecos	91	0.000	0.0%	Greenhorn_Mounta
L	RGFO#3 – South	5	0.000	0.0%	Great_Sand_Dunes	91	0.000	0.0%	Greenhorn_Mounta
M	RGFO#4 – East-Central	5	0.000	0.0%	Eagles_Nest	91	0.000	0.0%	Lost_Creek
N	New Mexico Farmington FO	5	0.000	0.0%	Mesa_Verde	91	0.004	0.0%	Aztec_Ruins
O	Total Colorado River Field Office	5	0.000	0.0%	Flat_Tops	91	0.000	0.0%	Colorado
P	Total Royal Gorge Field Office	5	0.000	0.0%	Rocky_Mountain	91	0.000	0.0%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	5	0.001	0.0%	West_Elk	91	0.002	0.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	5	0.067	1.3%	Dinosaur_CO	91	0.067	0.1%	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	5	0.085	1.7%	Dinosaur_CO	91	0.085	0.1%	Dinosaur_all
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	5	0.085	1.7%	Dinosaur_CO	91	0.085	0.1%	Dinosaur_all
U	Combined O&G and Mining in 4 km domain	5	0.125	2.5%	Mesa_Verde	91	0.556	0.6%	Aztec_Ruins
V	Natural Emissions	5	50.759	1015.2%	Bandelier	91	20.048	22.0%	Dome
W	2021 All Emissions	5	51.166	1023.3%	Bandelier	91	20.796	22.9%	Dome
X	2008 All Emissions	5	50.921	1018.4%	Bandelier	91	20.894	23.0%	Dome
Y	Coal EGU NM	5	8.525	170.5%	Petrified_Forest	91	3.648	4.0%	Aztec_Ruins
Z	Coal EGU CO	5	1.716	34.3%	Mount_Zirkel	91	1.346	1.5%	Dinosaur_all
AA	Oil/Gas EGU NM	5	0.000	0.0%	White_Mountain	91	0.000	0.0%	Capitan_Mountain
AB	Oil/Gas EGU CO	5	0.000	0.0%	White_Mountain	91	0.000	0.0%	Capitan_Mountain
AC	All EGUs in 4km Domain	5	8.525	170.5%	Petrified_Forest	91	3.684	4.0%	Aztec_Ruins
AD	CO Mining + Coal EGUs CO	5	1.716	34.3%	Mount_Zirkel	91	1.346	1.5%	Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	5	0.085	1.7%	Dinosaur_CO	91	0.085	0.1%	Dinosaur_all
AF	NM O&G + Oil/Gas EGU NM	5	0.000	0.0%	Mesa_Verde	91	0.004	0.0%	Aztec_Ruins

Table 5-3c. Maximum 24-hour SO_2 concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Medium Development Scenario.

Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	5	0.002	0.0%	Dinosaur_CO	91	0.002	0.0%	Dinosaur_all
B	White River FO	5	0.412	8.2%	Dinosaur_CO	91	0.412	0.5%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	5	0.000	0.0%	Flat_Tops	91	0.000	0.0%	Colorado
D	Roan Plateau Planning area portion of CRVFO	5	0.000	0.0%	Flat_Tops	91	0.000	0.0%	Colorado
E	Grand Junction FO	5	0.002	0.0%	Arches	91	0.003	0.0%	Colorado
F	Uncompahgre FO	5	0.001	0.0%	Maroon_Bells	91	0.001	0.0%	Raggeds
G	Tres Rios FO	5	0.003	0.1%	Mesa_Verde	91	0.003	0.0%	South_San_Juan
H	Kremmling FO	5	0.000	0.0%	Rawah	91	0.000	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	5	0.000	0.0%	Rocky_Mountain	91	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	5	0.000	0.0%	Rocky_Mountain	91	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	5	0.000	0.0%	Pecos	91	0.000	0.0%	Greenhorn_Mounta
L	RGFO#3 – South	5	0.000	0.0%	Great_Sand_Dunes	91	0.000	0.0%	Greenhorn_Mounta
M	RGFO#4 – East-Central	5	0.000	0.0%	Eagles_Nest	91	0.000	0.0%	Lost_Creek
N	New Mexico Farmington FO	5	0.001	0.0%	Mesa_Verde	91	0.007	0.0%	Aztec_Ruins
O	Total Colorado River Field Office	5	0.000	0.0%	Flat_Tops	91	0.000	0.0%	Colorado
P	Total Royal Gorge Field Office	5	0.000	0.0%	Rocky_Mountain	91	0.000	0.0%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	5	0.001	0.0%	West_Elk	91	0.002	0.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	5	0.412	8.2%	Dinosaur_CO	91	0.412	0.5%	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	5	0.469	9.4%	Dinosaur_CO	91	0.469	0.5%	Dinosaur_all
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	5	0.469	9.4%	Dinosaur_CO	91	0.469	0.5%	Dinosaur_all
U	Combined O&G and Mining in 4 km domain	5	0.487	9.7%	Dinosaur_CO	91	0.563	0.6%	Aztec_Ruins
V	Natural Emissions	5	50.759	1015.2%	Bandelier	91	20.048	22.0%	Dome
W	2021 All Emissions	5	51.142	1022.8%	Bandelier	91	20.774	22.8%	Dome
X	2008 All Emissions	5	50.921	1018.4%	Bandelier	91	20.894	23.0%	Dome
Y	Coal EGU NM	5	8.525	170.5%	Petrified_Forest	91	3.648	4.0%	Aztec_Ruins
Z	Coal EGU CO	5	1.716	34.3%	Mount_Zirkel	91	1.346	1.5%	Dinosaur_all
AA	Oil/Gas EGU NM	5	0.000	0.0%	White_Mountain	91	0.000	0.0%	Capitan_Mountain
AB	Oil/Gas EGU CO	5	0.000	0.0%	White_Mountain	91	0.000	0.0%	Capitan_Mountain
AC	All EGUs in 4km Domain	5	8.525	170.5%	Petrified_Forest	91	3.684	4.0%	Aztec_Ruins
AD	CO Mining + Coal EGUs CO	5	1.716	34.3%	Mount_Zirkel	91	1.346	1.5%	Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	5	0.468	9.4%	Dinosaur_CO	91	0.468	0.5%	Dinosaur_all
AF	NM O&G + Oil/Gas EGU NM	5	0.001	0.0%	Mesa_Verde	91	0.007	0.0%	Aztec_Ruins

Table 5-4a. Maximum 3-hour SO_2 concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 High Development Scenario.

Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	25	0.005	0.0%	Dinosaur_CO	512	0.005	0.0%	Dinosaur_all
B	White River FO	25	1.262	5.0%	Dinosaur_CO	512	1.262	0.2%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	25	0.001	0.0%	Flat_Tops	512	0.000	0.0%	Colorado
D	Roan Plateau Planning area portion of CRVFO	25	0.001	0.0%	Flat_Tops	512	0.000	0.0%	Colorado
E	Grand Junction FO	25	0.003	0.0%	Arches	512	0.006	0.0%	Colorado
F	Uncompahgre FO	25	0.002	0.0%	Maroon_Bells	512	0.002	0.0%	Raggeds
G	Tres Rios FO	25	0.006	0.0%	Mesa_Verde	512	0.005	0.0%	South_San_Juan
H	Kremmling FO	25	0.000	0.0%	Rawah	512	0.000	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	25	0.000	0.0%	Rocky_Mountain	512	0.000	0.0%	Lost_Creek
J	Pawnee Grasslands portion of RGFO#1	25	0.001	0.0%	Rocky_Mountain	512	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	25	0.000	0.0%	Pecos	512	0.000	0.0%	Greenhorn_Mounta
L	RGFO#3 – South	25	0.000	0.0%	Great_Sand_Dunes	512	0.000	0.0%	Greenhorn_Mounta
M	RGFO#4 – East-Central	25	0.000	0.0%	Eagles_Nest	512	0.000	0.0%	Lost_Creek
N	New Mexico Farmington FO	25	0.002	0.0%	Mesa_Verde	512	0.015	0.0%	Aztec_Ruins
O	Total Colorado River Field Office	25	0.001	0.0%	Flat_Tops	512	0.001	0.0%	Colorado
P	Total Royal Gorge Field Office	25	0.001	0.0%	Rocky_Mountain	512	0.000	0.0%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	25	0.004	0.0%	West_Elk	512	0.008	0.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	25	1.263	5.1%	Dinosaur_CO	512	1.263	0.2%	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	25	1.435	5.7%	Dinosaur_CO	512	1.435	0.3%	Dinosaur_all
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	25	1.435	5.7%	Dinosaur_CO	512	1.435	0.3%	Dinosaur_all
U	Combined O&G and Mining in 4 km domain	25	1.495	6.0%	Dinosaur_CO	512	1.495	0.3%	Dinosaur_all
V	Natural Emissions	25	95.986	383.9%	Bandelier	512	64.697	12.6%	Dome
W	2021 All Emissions	25	96.163	384.7%	Bandelier	512	65.117	12.7%	Dome
X	2008 All Emissions	25	96.190	384.8%	Bandelier	512	65.161	12.7%	Dome
Y	Coal EGU NM	25	28.303	113.2%	Petrified_Forest	512	8.709	1.7%	Aztec_Ruins
Z	Coal EGU CO	25	3.767	15.1%	Mount_Zirkel	512	2.843	0.6%	Dinosaur_all
AA	Oil/Gas EGU NM	25	0.000	0.0%	White_Mountain	512	0.000	0.0%	Capitan_Mountain
AB	Oil/Gas EGU CO	25	0.000	0.0%	White_Mountain	512	0.000	0.0%	Capitan_Mountain
AC	All EGUs in 4km Domain	25	28.303	113.2%	Petrified_Forest	512	8.716	1.7%	Aztec_Ruins
AD	CO Mining + Coal EGUs CO	25	3.767	15.1%	Mount_Zirkel	512	2.843	0.6%	Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	25	1.435	5.7%	Dinosaur_CO	512	1.435	0.3%	Dinosaur_all
AF	NM O&G + Oil/Gas EGU NM	25	0.002	0.0%	Mesa_Verde	512	0.015	0.0%	Aztec_Ruins

Table 5-4b. Maximum 3-hour SO_2 concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Low Development Scenario.

Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	25	0.001	0.0%	Dinosaur_CO	512	0.001	0.0%	Dinosaur_all
B	White River FO	25	0.189	0.8%	Dinosaur_CO	512	0.189	0.0%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	25	0.000	0.0%	Flat_Tops	512	0.000	0.0%	Colorado
D	Roan Plateau Planning area portion of CRVFO	25	0.000	0.0%	Flat_Tops	512	0.000	0.0%	Colorado
E	Grand Junction FO	25	0.000	0.0%	Arches	512	0.000	0.0%	Colorado
F	Uncompahgre FO	25	0.001	0.0%	Maroon_Bells	512	0.001	0.0%	Raggeds
G	Tres Rios FO	25	0.001	0.0%	Mesa_Verde	512	0.001	0.0%	South_San_Juan
H	Kremmling FO	25	0.000	0.0%	Rawah	512	0.000	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	25	0.000	0.0%	Rocky_Mountain	512	0.000	0.0%	Lost_Creek
J	Pawnee Grasslands portion of RGFO#1	25	0.000	0.0%	Rocky_Mountain	512	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	25	0.000	0.0%	Pecos	512	0.000	0.0%	Greenhorn_Mounta
L	RGFO#3 – South	25	0.000	0.0%	Great_Sand_Dunes	512	0.000	0.0%	Greenhorn_Mounta
M	RGFO#4 – East-Central	25	0.000	0.0%	Eagles_Nest	512	0.000	0.0%	Lost_Creek
N	New Mexico Farmington FO	25	0.001	0.0%	Mesa_Verde	512	0.006	0.0%	Aztec_Ruins
O	Total Colorado River Field Office	25	0.001	0.0%	Flat_Tops	512	0.000	0.0%	Colorado
P	Total Royal Gorge Field Office	25	0.000	0.0%	Rocky_Mountain	512	0.000	0.0%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	25	0.004	0.0%	West_Elk	512	0.008	0.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	25	0.189	0.8%	Dinosaur_CO	512	0.189	0.0%	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	25	0.240	1.0%	Dinosaur_CO	512	0.240	0.0%	Dinosaur_all
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	25	0.240	1.0%	Dinosaur_CO	512	0.240	0.0%	Dinosaur_all
U	Combined O&G and Mining in 4 km domain	25	0.497	2.0%	Mesa_Verde	512	1.327	0.3%	Aztec_Ruins
V	Natural Emissions	25	95.986	383.9%	Bandelier	512	64.699	12.6%	Dome
W	2021 All Emissions	25	96.175	384.7%	Bandelier	512	65.150	12.7%	Dome
X	2008 All Emissions	25	96.190	384.8%	Bandelier	512	65.161	12.7%	Dome
Y	Coal EGU NM	25	28.303	113.2%	Petrified_Forest	512	8.709	1.7%	Aztec_Ruins
Z	Coal EGU CO	25	3.767	15.1%	Mount_Zirkel	512	2.843	0.6%	Dinosaur_all
AA	Oil/Gas EGU NM	25	0.000	0.0%	White_Mountain	512	0.000	0.0%	Capitan_Mountain
AB	Oil/Gas EGU CO	25	0.000	0.0%	White_Mountain	512	0.000	0.0%	Capitan_Mountain
AC	All EGUs in 4km Domain	25	28.303	113.2%	Petrified_Forest	512	8.716	1.7%	Aztec_Ruins
AD	CO Mining + Coal EGUs CO	25	3.767	15.1%	Mount_Zirkel	512	2.843	0.6%	Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	25	0.240	1.0%	Dinosaur_CO	512	0.240	0.0%	Dinosaur_all
AF	NM O&G + Oil/Gas EGU NM	25	0.001	0.0%	Mesa_Verde	512	0.006	0.0%	Aztec_Ruins

Table 5-4c. Maximum 3-hour SO_2 concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Medium Development Scenario.

Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	25	0.005	0.0%	Dinosaur_CO	512	0.005	0.0%	Dinosaur_all
B	White River FO	25	1.262	5.0%	Dinosaur_CO	512	1.262	0.2%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	25	0.001	0.0%	Flat_Tops	512	0.000	0.0%	Colorado
D	Roan Plateau Planning area portion of CRVFO	25	0.001	0.0%	Flat_Tops	512	0.000	0.0%	Colorado
E	Grand Junction FO	25	0.003	0.0%	Arches	512	0.006	0.0%	Colorado
F	Uncompahgre FO	25	0.002	0.0%	Maroon_Bells	512	0.002	0.0%	Raggeds
G	Tres Rios FO	25	0.006	0.0%	Mesa_Verde	512	0.005	0.0%	South_San_Juan
H	Kremmling FO	25	0.000	0.0%	Rawah	512	0.000	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	25	0.000	0.0%	Rocky_Mountain	512	0.000	0.0%	Lost_Creek
J	Pawnee Grasslands portion of RGFO#1	25	0.000	0.0%	Rocky_Mountain	512	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	25	0.000	0.0%	Pecos	512	0.000	0.0%	Greenhorn_Mounta
L	RGFO#3 – South	25	0.000	0.0%	Great_Sand_Dunes	512	0.000	0.0%	Greenhorn_Mounta
M	RGFO#4 – East-Central	25	0.000	0.0%	Eagles_Nest	512	0.000	0.0%	Lost_Creek
N	New Mexico Farmington FO	25	0.001	0.0%	Mesa_Verde	512	0.012	0.0%	Aztec_Ruins
O	Total Colorado River Field Office	25	0.001	0.0%	Flat_Tops	512	0.001	0.0%	Colorado
P	Total Royal Gorge Field Office	25	0.000	0.0%	Rocky_Mountain	512	0.000	0.0%	Lost_Creek
Q	Mining from 13 Colorado BLM Planning Areas	25	0.004	0.0%	West_Elk	512	0.008	0.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	25	1.263	5.1%	Dinosaur_CO	512	1.263	0.2%	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	25	1.435	5.7%	Dinosaur_CO	512	1.435	0.3%	Dinosaur_all
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	25	1.435	5.7%	Dinosaur_CO	512	1.435	0.3%	Dinosaur_all
U	Combined O&G and Mining in 4 km domain	25	1.495	6.0%	Dinosaur_CO	512	1.495	0.3%	Dinosaur_all
V	Natural Emissions	25	95.986	383.9%	Bandelier	512	64.697	12.6%	Dome
W	2021 All Emissions	25	96.163	384.7%	Bandelier	512	65.116	12.7%	Dome
X	2008 All Emissions	25	96.190	384.8%	Bandelier	512	65.161	12.7%	Dome
Y	Coal EGU NM	25	28.303	113.2%	Petrified_Forest	512	8.709	1.7%	Aztec_Ruins
Z	Coal EGU CO	25	3.767	15.1%	Mount_Zirkel	512	2.843	0.6%	Dinosaur_all
AA	Oil/Gas EGU NM	25	0.000	0.0%	White_Mountain	512	0.000	0.0%	Capitan_Mountain
AB	Oil/Gas EGU CO	25	0.000	0.0%	White_Mountain	512	0.000	0.0%	Capitan_Mountain
AC	All EGUs in 4km Domain	25	28.303	113.2%	Petrified_Forest	512	8.716	1.7%	Aztec_Ruins
AD	CO Mining + Coal EGUs CO	25	3.767	15.1%	Mount_Zirkel	512	2.843	0.6%	Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	25	1.435	5.7%	Dinosaur_CO	512	1.435	0.3%	Dinosaur_all
AF	NM O&G + Oil/Gas EGU NM	25	0.001	0.0%	Mesa_Verde	512	0.012	0.0%	Aztec_Ruins

5.1.1.3 $PM_{2.5}$ PSD Concentrations

Tables 5-5 and 5-6 display the maximum annual and 24-hour $PM_{2.5}$ concentrations due the Source Groups at any Class I and II area and presents a comparison with the PSD $PM_{2.5}$ Increments for the 2021 High, Low and Medium Development Scenarios. $PM_{2.5}$ concentrations due to emissions from Federal O&G within any of the 14 BLM Planning Areas do not come close to exceeding any of the PSD $PM_{2.5}$ Increments. The BLM Planning Area with the largest Federal O&G $PM_{2.5}$ contribution at any Class I area is again the TRFO Planning Area that contributes $PM_{2.5}$ concentrations of 9 and 15 percent for the High, 5 and 9 percent for the Medium and 1 and 2 percent for the Low Development Scenarios to the annual and 24-hour $PM_{2.5}$ Class I PSD Increments at the Mesa Verde Class I area. Mining on Federal land within all of the 13 Colorado BLM Planning Areas (Source Group Q) contributes a maximum of 0.17 $\mu g/m^3$ to annual $PM_{2.5}$ at Mount Zirkel and 0.79 $\mu g/m^3$ for 24-hour $PM_{2.5}$ at Flat Tops that represents 17% and 40% of the PSD Class I Increments, respectively, for all three of the 2021 Scenarios (BLM mining emissions were not altered in the three 2021 scenarios).

The maximum contribution at any Class I area to annual $PM_{2.5}$ due to all Federal O&G and mining in the 13 Colorado BLM Planning Areas (Source Group R), the Cumulative Emissions scenario of all Federal O&G and mining and non-Federal O&G in the 14 CO/NM Planning Areas (Source Group T) and all O&G emissions throughout the 4 km CARMMS domain are, respectively, 0.18 to 0.22 $\mu g/m^3$ that represents 18 to 22 percent of the Class I area increment for the High Development Scenario with similar results seen for the Medium and slightly lower values seen for the Low Development Scenarios. Similar results are seen for 24-hour $PM_{2.5}$ with the Source Groups R, S, T and U contributing 43 to 58 percent of the 24-hour $PM_{2.5}$ Class I Increment for the High and Medium and 40 to 44 percent of the Increment for the Low Development Scenario at Flat Tops.

Extremely high maximum annual and 24-hour $PM_{2.5}$ contributions are seen due to natural emissions (Source Group V) that are also reflected in the total 2021 (W) and 2008 (X) Source Groups that are due to wildfires that occurred in 2008 for which the PSD Increments are not applicable.

Note that PSD increments are not applicable to natural emissions or existing sources, thus results from Source Groups U, V, W and X are not appropriate for comparison with PSD increments.

Table 5-5a. Maximum Annual $PM_{2.5}$ concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 High Development Scenario.

Choose	PM2.5, Annual	µg/m3							
Across grid cells	Maximum								
Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	1	0.003	0.3%	Mount_Zirkel	4	0.003	0.1%	Dinosaur_all
B	White River FO	1	0.021	2.1%	Flat_Tops	4	0.046	1.2%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	1	0.003	0.3%	Flat_Tops	4	0.002	0.1%	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	1	0.003	0.3%	Flat_Tops	4	0.002	0.0%	Holy_Cross
E	Grand Junction FO	1	0.011	1.1%	Maroon_Bells	4	0.023	0.6%	Colorado
F	Uncompahgre FO	1	0.012	1.2%	Maroon_Bells	4	0.017	0.4%	Raggeds
G	Tres Rios FO	1	0.087	8.7%	Mesa_Verde	4	0.084	2.1%	South_San_Juan
H	Kremmling FO	1	0.004	0.4%	Rawah	4	0.002	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	1	0.000	0.0%	Rocky_Mountain	4	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	1	0.001	0.1%	Rocky_Mountain	4	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	1	0.000	0.0%	Pecos	4	0.000	0.0%	Maxwell_NWR
L	RGFO#3 – South	1	0.000	0.0%	Great_Sand_Dunes	4	0.003	0.1%	Greenhorn_Mounta
M	RGFO#4 – East-Central	1	0.000	0.0%	Eagles_Nest	4	0.003	0.1%	Lost_Creek
N	New Mexico Farmington FO	1	0.007	0.7%	Weminuche	4	0.205	5.1%	Aztec_Ruins
O	Total Colorado River Field Office	1	0.006	0.6%	Flat_Tops	4	0.004	0.1%	Holy_Cross
P	Total Royal Gorge Field Office	1	0.001	0.1%	Rocky_Mountain	4	0.003	0.1%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	1	0.167	16.7%	Mount_Zirkel	4	0.169	4.2%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	1	0.184	18.4%	Mount_Zirkel	4	0.196	4.9%	Raggeds
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	1	0.216	21.6%	Mesa_Verde	4	0.225	5.6%	Raggeds
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	1	0.220	22.0%	Mesa_Verde	4	0.319	8.0%	Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	1	0.252	25.2%	Mesa_Verde	4	0.699	17.5%	Aztec_Ruins
V	Natural Emissions	1	9.730	973.0%	Bandelier	4	4.249	106.2%	Dome
W	2021 All Emissions	1	14.284	1428.4%	Bandelier	4	13.945	348.6%	Valle_De_Oro_NWR
X	2008 All Emissions	1	14.217	1421.7%	Bandelier	4	12.072	301.8%	Petroglyph
Y	Coal EGU NM	1	0.255	25.5%	Petrified_Forest	4	0.197	4.9%	Aztec_Ruins
Z	Coal EGU CO	1	0.162	16.2%	Mount_Zirkel	4	0.212	5.3%	Dinosaur_all
AA	Oil/Gas EGU NM	1	0.001	0.1%	Petrified_Forest	4	0.005	0.1%	Maxwell_NWR
AB	Oil/Gas EGU CO	1	0.001	0.1%	Rocky_Mountain	4	0.001	0.0%	Mount_Evans
AC	All EGUs in 4km Domain	1	0.262	26.2%	Petrified_Forest	4	0.226	5.7%	Dinosaur_all
AD	CO Mining + Coal EGUs CO	1	0.329	32.9%	Mount_Zirkel	4	0.225	5.6%	Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	1	0.202	20.2%	Mesa_Verde	4	0.182	4.5%	South_San_Juan
AF	NM O&G + Oil/Gas EGU NM	1	0.008	0.8%	Weminuche	4	0.206	5.2%	Aztec_Ruins

Table 5-5b. Maximum Annual $PM_{2.5}$ concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Low Development Scenario.

Choose	PM2.5, Annual	µg/m3							
Across grid cells	Maximum								

Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	1	0.000	0.0%	Mount_Zirkel	4	0.000	0.0%	Dinosaur_all
B	White River FO	1	0.004	0.4%	Flat_Tops	4	0.008	0.2%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	1	0.002	0.2%	Flat_Tops	4	0.001	0.0%	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	1	0.002	0.2%	Flat_Tops	4	0.001	0.0%	Holy_Cross
E	Grand Junction FO	1	0.001	0.1%	Maroon_Bells	4	0.001	0.0%	Colorado
F	Uncompahgre FO	1	0.004	0.4%	Maroon_Bells	4	0.005	0.1%	Raggeds
G	Tres Rios FO	1	0.011	1.1%	Mesa_Verde	4	0.011	0.3%	South_San_Juan
H	Kremmling FO	1	0.000	0.0%	Rawah	4	0.000	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	1	0.000	0.0%	Rocky_Mountain	4	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	1	0.000	0.0%	Rocky_Mountain	4	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	1	0.000	0.0%	Pecos	4	0.000	0.0%	Maxwell_NWR
L	RGFO#3 – South	1	0.000	0.0%	Great_Sand_Dunes	4	0.002	0.1%	Greenhorn_Mounta
M	RGFO#4 – East-Central	1	0.000	0.0%	Eagles_Nest	4	0.000	0.0%	Lost_Creek
N	New Mexico Farmington FO	1	0.004	0.4%	Weminuche	4	0.098	2.5%	Aztec_Ruins
O	Total Colorado River Field Office	1	0.004	0.4%	Flat_Tops	4	0.002	0.1%	Holy_Cross
P	Total Royal Gorge Field Office	1	0.000	0.0%	Rocky_Mountain	4	0.002	0.1%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	1	0.167	16.7%	Mount_Zirkel	4	0.169	4.2%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	1	0.170	17.0%	Mount_Zirkel	4	0.175	4.4%	Raggeds
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	1	0.175	17.5%	Mount_Zirkel	4	0.186	4.6%	Raggeds
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	1	0.175	17.5%	Mount_Zirkel	4	0.204	5.1%	Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	1	0.201	20.1%	Mount_Zirkel	4	0.584	14.6%	Aztec_Ruins
V	Natural Emissions	1	9.730	973.0%	Bandelier	4	4.249	106.2%	Dome
W	2021 All Emissions	1	14.608	1460.8%	Bandelier	4	14.410	360.3%	Valle_De_Oro_NWR
X	2008 All Emissions	1	14.217	1421.7%	Bandelier	4	12.072	301.8%	Petroglyph
Y	Coal EGU NM	1	0.255	25.5%	Petrified_Forest	4	0.197	4.9%	Aztec_Ruins
Z	Coal EGU CO	1	0.162	16.2%	Mount_Zirkel	4	0.212	5.3%	Dinosaur_all
AA	Oil/Gas EGU NM	1	0.001	0.1%	Petrified_Forest	4	0.005	0.1%	Maxwell_NWR
AB	Oil/Gas EGU CO	1	0.001	0.1%	Rocky_Mountain	4	0.001	0.0%	Mount_Evans
AC	All EGUs in 4km Domain	1	0.262	26.2%	Petrified_Forest	4	0.226	5.7%	Dinosaur_all
AD	CO Mining + Coal EGUs CO	1	0.329	32.9%	Mount_Zirkel	4	0.225	5.6%	Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	1	0.130	13.0%	Mesa_Verde	4	0.112	2.8%	South_San_Juan
AF	NM O&G + Oil/Gas EGU NM	1	0.004	0.4%	Mesa_Verde	4	0.099	2.5%	Aztec_Ruins

Table 5-5c. Maximum Annual $PM_{2.5}$ concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Medium Development Scenario.

Choose	PM2.5, Annual	µg/m3							
Across grid cells	Maximum								
Group	**Group Name**	**PSD Class I Increment**	**Max @ any Class I area**	**Percent of PSD Class I Increment**	**Class I Area where Max occurred**	**PSD Class II Increment**	**Max @ any Class II area**	**Percent of PSD Class II Increment**	**Class II Area where Max occurred**
A	Little Snake FO	1	0.002	0.2%	Mount_Zirkel	4	0.002	0.1%	Dinosaur_all
B	White River FO	1	0.018	1.8%	Flat_Tops	4	0.044	1.1%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	1	0.002	0.2%	Flat_Tops	4	0.002	0.0%	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	1	0.002	0.2%	Flat_Tops	4	0.001	0.0%	Holy_Cross
E	Grand Junction FO	1	0.008	0.8%	Arches	4	0.020	0.5%	Colorado
F	Uncompahgre FO	1	0.008	0.8%	Maroon_Bells	4	0.011	0.3%	Raggeds
G	Tres Rios FO	1	0.048	4.8%	Mesa_Verde	4	0.045	1.1%	South_San_Juan
H	Kremmling FO	1	0.002	0.2%	Rawah	4	0.001	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	1	0.000	0.0%	Rocky_Mountain	4	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	1	0.000	0.0%	Rocky_Mountain	4	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	1	0.000	0.0%	Pecos	4	0.000	0.0%	Maxwell_NWR
L	RGFO#3 – South	1	0.000	0.0%	Great_Sand_Dunes	4	0.002	0.0%	Greenhorn_Mounta
M	RGFO#4 – East-Central	1	0.000	0.0%	Eagles_Nest	4	0.001	0.0%	Lost_Creek
N	New Mexico Farmington FO	1	0.005	0.5%	Weminuche	4	0.122	3.1%	Aztec_Ruins
O	Total Colorado River Field Office	1	0.004	0.4%	Flat_Tops	4	0.003	0.1%	Holy_Cross
P	Total Royal Gorge Field Office	1	0.000	0.0%	Rocky_Mountain	4	0.002	0.0%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	1	0.167	16.7%	Mount_Zirkel	4	0.169	4.2%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	1	0.181	18.1%	Mount_Zirkel	4	0.189	4.7%	Raggeds
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	1	0.193	19.3%	Mount_Zirkel	4	0.217	5.4%	Raggeds
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	1	0.193	19.3%	Mount_Zirkel	4	0.230	5.7%	Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	1	0.218	21.8%	Mount_Zirkel	4	0.611	15.3%	Aztec_Ruins
V	Natural Emissions	1	9.730	973.0%	Bandelier	4	4.249	106.2%	Dome
W	2021 All Emissions	1	14.283	1428.3%	Bandelier	4	13.944	348.6%	Valle_De_Oro_NWR
X	2008 All Emissions	1	14.217	1421.7%	Bandelier	4	12.072	301.8%	Petroglyph
Y	Coal EGU NM	1	0.255	25.5%	Petrified_Forest	4	0.197	4.9%	Aztec_Ruins
Z	Coal EGU CO	1	0.162	16.2%	Mount_Zirkel	4	0.212	5.3%	Dinosaur_all
AA	Oil/Gas EGU NM	1	0.001	0.1%	Petrified_Forest	4	0.005	0.1%	Maxwell_NWR
AB	Oil/Gas EGU CO	1	0.001	0.1%	Rocky_Mountain	4	0.001	0.0%	Mount_Evans
AC	All EGUs in 4km Domain	1	0.262	26.2%	Petrified_Forest	4	0.226	5.7%	Dinosaur_all
AD	CO Mining + Coal EGUs CO	1	0.329	32.9%	Mount_Zirkel	4	0.225	5.6%	Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	1	0.160	16.0%	Mesa_Verde	4	0.140	3.5%	South_San_Juan
AF	NM O&G + Oil/Gas EGU NM	1	0.005	0.5%	Weminuche	4	0.123	3.1%	Aztec_Ruins

Table 5-6a. Maximum 24-Hour $PM_{2.5}$ concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 High Development Scenario.

Choose	PM2.5, 24-hour	µg/m3							
Across grid cells	Maximum								
Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	2	0.031	1.6%	Mount_Zirkel	9	0.030	0.3%	Dinosaur_all
B	White River FO	2	0.133	6.6%	Flat_Tops	9	0.293	3.3%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	2	0.015	0.7%	Flat_Tops	9	0.026	0.3%	Colorado
D	Roan Plateau Planning area portion of CRVFO	2	0.012	0.6%	Flat_Tops	9	0.025	0.3%	Colorado
E	Grand Junction FO	2	0.094	4.7%	Arches	9	0.242	2.7%	Colorado
F	Uncompahgre FO	2	0.060	3.0%	Maroon_Bells	9	0.062	0.7%	Raggeds
G	Tres Rios FO	2	0.302	15.1%	Mesa_Verde	9	0.260	2.9%	Hovenweep
H	Kremmling FO	2	0.011	0.5%	Mount_Zirkel	9	0.008	0.1%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	2	0.004	0.2%	Rocky_Mountain	9	0.002	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	2	0.018	0.9%	Rocky_Mountain	9	0.007	0.1%	Mount_Evans
K	RGFO#2 – West-Central/South	2	0.003	0.1%	Pecos	9	0.005	0.1%	Greenhorn_Mounta
L	RGFO#3 – South	2	0.003	0.1%	Great_Sand_Dunes	9	0.023	0.3%	Greenhorn_Mounta
M	RGFO#4 – East-Central	2	0.002	0.1%	Eagles_Nest	9	0.011	0.1%	Lost_Creek
N	New Mexico Farmington FO	2	0.053	2.6%	Mesa_Verde	9	0.799	8.9%	Aztec_Ruins
O	Total Colorado River Field Office	2	0.027	1.3%	Flat_Tops	9	0.050	0.6%	Colorado
P	Total Royal Gorge Field Office	2	0.023	1.1%	Rocky_Mountain	9	0.023	0.3%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	2	0.792	39.6%	Flat_Tops	9	1.081	12.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	2	0.863	43.2%	Flat_Tops	9	1.205	13.4%	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	2	0.884	44.2%	Rocky_Mountain	9	1.262	14.0%	Dinosaur_all
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	2	0.886	44.3%	Rocky_Mountain	9	1.263	14.0%	Dinosaur_all
U	Combined O&G and Mining in 4 km domain	2	1.164	58.2%	Rocky_Mountain	9	3.535	39.3%	Dinosaur_all
V	Natural Emissions	2	1224.899	61245.0%	Bandelier	9	481.211	5346.8%	Dome
W	2021 All Emissions	2	1228.078	61403.9%	Bandelier	9	485.862	5398.5%	Dome
X	2008 All Emissions	2	1227.070	61353.5%	Bandelier	9	485.583	5395.4%	Dome
Y	Coal EGU NM	2	1.527	76.4%	Petrified_Forest	9	1.651	18.3%	Aztec_Ruins
Z	Coal EGU CO	2	0.898	44.9%	Mount_Zirkel	9	1.238	13.8%	Dinosaur_all
AA	Oil/Gas EGU NM	2	0.008	0.4%	Petrified_Forest	9	0.036	0.4%	Petroglyph
AB	Oil/Gas EGU CO	2	0.042	2.1%	Rocky_Mountain	9	0.026	0.3%	Mount_Evans
AC	All EGUs in 4km Domain	2	1.527	76.4%	Petrified_Forest	9	1.719	19.1%	Aztec_Ruins
AD	CO Mining + Coal EGUs CO	2	1.555	77.8%	Mount_Zirkel	9	1.317	14.6%	Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	2	0.889	44.5%	Rocky_Mountain	9	0.719	8.0%	Hovenweep
AF	NM O&G + Oil/Gas EGU NM	2	0.054	2.7%	Mesa_Verde	9	0.799	8.9%	Aztec_Ruins

Table 5-6b. Maximum 24-Hour $PM_{2.5}$ concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Low Development Scenario.

Choose	PM2.5, 24-hour	µg/m3							
Across grid cells	Maximum								
Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	2	0.004	0.2%	Mount_Zirkel	9	0.005	0.1%	Dinosaur_all
B	White River FO	2	0.026	1.3%	Flat_Tops	9	0.056	0.6%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	2	0.011	0.6%	Flat_Tops	9	0.018	0.2%	Colorado
D	Roan Plateau Planning area portion of CRVFO	2	0.008	0.4%	Flat_Tops	9	0.013	0.1%	Colorado
E	Grand Junction FO	2	0.006	0.3%	Black_Canyon	9	0.014	0.2%	Colorado
F	Uncompahgre FO	2	0.021	1.0%	Maroon_Bells	9	0.020	0.2%	Raggeds
G	Tres Rios FO	2	0.041	2.0%	Mesa_Verde	9	0.034	0.4%	Hovenweep
H	Kremmling FO	2	0.001	0.1%	Mount_Zirkel	9	0.001	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	2	0.001	0.0%	Rocky_Mountain	9	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	2	0.004	0.2%	Rocky_Mountain	9	0.001	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	2	0.000	0.0%	Pecos	9	0.000	0.0%	Greenhorn_Mounta
L	RGFO#3 – South	2	0.002	0.1%	Great_Sand_Dunes	9	0.015	0.2%	Greenhorn_Mounta
M	RGFO#4 – East-Central	2	0.000	0.0%	Eagles_Nest	9	0.002	0.0%	Lost_Creek
N	New Mexico Farmington FO	2	0.025	1.3%	Mesa_Verde	9	0.381	4.2%	Aztec_Ruins
O	Total Colorado River Field Office	2	0.019	1.0%	Flat_Tops	9	0.031	0.3%	Colorado
P	Total Royal Gorge Field Office	2	0.005	0.2%	Rocky_Mountain	9	0.015	0.2%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	2	0.792	39.6%	Flat_Tops	9	1.081	12.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	2	0.804	40.2%	Flat_Tops	9	1.096	12.2%	Raggeds
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	2	0.830	41.5%	Flat_Tops	9	1.114	12.4%	Raggeds
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	2	0.832	41.6%	Flat_Tops	9	1.114	12.4%	Raggeds
U	Combined O&G and Mining in 4 km domain	2	0.872	43.6%	Flat_Tops	9	3.522	39.1%	Dinosaur_all
V	Natural Emissions	2	1224.893	61244.6%	Bandelier	9	481.209	5346.8%	Dome
W	2021 All Emissions	2	1228.156	61407.8%	Bandelier	9	486.059	5400.7%	Dome
X	2008 All Emissions	2	1227.070	61353.5%	Bandelier	9	485.583	5395.4%	Dome
Y	Coal EGU NM	2	1.527	76.4%	Petrified_Forest	9	1.651	18.3%	Aztec_Ruins
Z	Coal EGU CO	2	0.898	44.9%	Mount_Zirkel	9	1.238	13.8%	Dinosaur_all
AA	Oil/Gas EGU NM	2	0.008	0.4%	Petrified_Forest	9	0.036	0.4%	Petroglyph
AB	Oil/Gas EGU CO	2	0.042	2.1%	Rocky_Mountain	9	0.026	0.3%	Mount_Evans
AC	All EGUs in 4km Domain	2	1.527	76.4%	Petrified_Forest	9	1.719	19.1%	Aztec_Ruins
AD	CO Mining + Coal EGUs CO	2	1.555	77.8%	Mount_Zirkel	9	1.317	14.6%	Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	2	0.465	23.2%	Mesa_Verde	9	0.559	6.2%	Hovenweep
AF	NM O&G + Oil/Gas EGU NM	2	0.026	1.3%	Mesa_Verde	9	0.381	4.2%	Aztec_Ruins

Table 5-6c. Maximum 24-Hour $PM_{2.5}$ concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Medium Development Scenario.

Choose	PM2.5, 24-hour	µg/m3							
Across grid cells	Maximum								
Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	2	0.027	1.4%	Mount_Zirkel	9	0.024	0.3%	Dinosaur_all
B	White River FO	2	0.132	6.6%	Flat_Tops	9	0.272	3.0%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	2	0.012	0.6%	Maroon_Bells	9	0.021	0.2%	Colorado
D	Roan Plateau Planning area portion of CRVFO	2	0.010	0.5%	Flat_Tops	9	0.020	0.2%	Colorado
E	Grand Junction FO	2	0.092	4.6%	Arches	9	0.207	2.3%	Colorado
F	Uncompahgre FO	2	0.039	1.9%	Maroon_Bells	9	0.041	0.5%	Raggeds
G	Tres Rios FO	2	0.186	9.3%	Mesa_Verde	9	0.188	2.1%	Hovenweep
H	Kremmling FO	2	0.007	0.3%	Eagles_Nest	9	0.005	0.1%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	2	0.002	0.1%	Rocky_Mountain	9	0.001	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	2	0.010	0.5%	Rocky_Mountain	9	0.004	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	2	0.002	0.1%	Pecos	9	0.004	0.0%	Greenhorn_Mounta
L	RGFO#3 – South	2	0.002	0.1%	Great_Sand_Dunes	9	0.015	0.2%	Greenhorn_Mounta
M	RGFO#4 – East-Central	2	0.001	0.0%	Eagles_Nest	9	0.004	0.0%	Lost_Creek
N	New Mexico Farmington FO	2	0.033	1.7%	Mesa_Verde	9	0.494	5.5%	Aztec_Ruins
O	Total Colorado River Field Office	2	0.022	1.1%	Eagles_Nest	9	0.042	0.5%	Colorado
P	Total Royal Gorge Field Office	2	0.013	0.6%	Rocky_Mountain	9	0.015	0.2%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	2	0.792	39.6%	Flat_Tops	9	1.081	12.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	2	0.862	43.1%	Flat_Tops	9	1.189	13.2%	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	2	0.878	43.9%	Rocky_Mountain	9	1.245	13.8%	Dinosaur_all
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	2	0.879	43.9%	Rocky_Mountain	9	1.246	13.8%	Dinosaur_all
U	Combined O&G and Mining in 4 km domain	2	1.152	57.6%	Rocky_Mountain	9	3.534	39.3%	Dinosaur_all
V	Natural Emissions	2	1224.898	61244.9%	Bandelier	9	481.211	5346.8%	Dome
W	2021 All Emissions	2	1228.074	61403.7%	Bandelier	9	485.858	5398.4%	Dome
X	2008 All Emissions	2	1227.070	61353.5%	Bandelier	9	485.583	5395.4%	Dome
Y	Coal EGU NM	2	1.527	76.4%	Petrified_Forest	9	1.651	18.3%	Aztec_Ruins
Z	Coal EGU CO	2	0.898	44.9%	Mount_Zirkel	9	1.238	13.8%	Dinosaur_all
AA	Oil/Gas EGU NM	2	0.008	0.4%	Petrified_Forest	9	0.036	0.4%	Petroglyph
AB	Oil/Gas EGU CO	2	0.042	2.1%	Rocky_Mountain	9	0.026	0.3%	Mount_Evans
AC	All EGUs in 4km Domain	2	1.527	76.4%	Petrified_Forest	9	1.719	19.1%	Aztec_Ruins
AD	CO Mining + Coal EGUs CO	2	1.555	77.8%	Mount_Zirkel	9	1.317	14.6%	Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	2	0.882	44.1%	Rocky_Mountain	9	0.643	7.1%	Hovenweep
AF	NM O&G + Oil/Gas EGU NM	2	0.033	1.7%	Mesa_Verde	9	0.494	5.5%	Aztec_Ruins

5.1.1.4 PM_{10} PSD Concentrations

The results of the comparisons against the PM_{10} PSD increments is very similar to $PM_{2.5}$ with none of the Source Groups, except Natural Emissions (Source Group V) that are also included in the total 2021 and 2008 Source Groups, showing any exceedances of the annual or 24-hour PM_{10} PSD increment (Tables 5-7 and 5-8). Wildfires within the Natural Emissions Source Group can produce very high PM concentrations.

Of the BLM Planning Areas, Federal O&G from the TRFO has the largest annual and 24-hour PM_{10} concentrations at any Class I area with maximum values that of 12 and 16 percent for the High, 5 and 7 percent for the Medium and 1 and 2 percent for the Low Development Scenarios as a fraction of the PSD PM_{10} increment. The combined Source Groups R, S, T and U PM_{10} impacts at any Class I area are 36% or less of the PM_{10} PSD increments.

Table 5-7a. Maximum Annual PM_{10} concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 High Development Scenario.

Choose	PM10, Annual	µg/m3							
Across grid cells	Maximum								
Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	4	0.004	0.1%	Mount_Zirkel	17	0.004	0.0%	Dinosaur_all
B	White River FO	4	0.034	0.8%	Flat_Tops	17	0.054	0.3%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	4	0.007	0.2%	Flat_Tops	17	0.003	0.0%	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	4	0.004	0.1%	Flat_Tops	17	0.002	0.0%	Holy_Cross
E	Grand Junction FO	4	0.025	0.6%	Maroon_Bells	17	0.036	0.2%	Colorado
F	Uncompahgre FO	4	0.034	0.9%	Maroon_Bells	17	0.054	0.3%	Raggeds
G	Tres Rios FO	4	0.473	11.8%	Mesa_Verde	17	0.522	3.1%	South_San_Juan
H	Kremmling FO	4	0.015	0.4%	Rawah	17	0.005	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	4	0.000	0.0%	Rocky_Mountain	17	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	4	0.001	0.0%	Rocky_Mountain	17	0.001	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	4	0.000	0.0%	Pecos	17	0.000	0.0%	Maxwell_NWR
L	RGFO#3 – South	4	0.000	0.0%	Great_Sand_Dunes	17	0.009	0.1%	Greenhorn_Mounta
M	RGFO#4 – East-Central	4	0.000	0.0%	Eagles_Nest	17	0.013	0.1%	Lost_Creek
N	New Mexico Farmington FO	4	0.024	0.6%	Weminuche	17	0.900	5.3%	Aztec_Ruins
O	Total Colorado River Field Office	4	0.011	0.3%	Flat_Tops	17	0.005	0.0%	Holy_Cross
P	Total Royal Gorge Field Office	4	0.002	0.0%	Rocky_Mountain	17	0.014	0.1%	Lost_Creek
Q	Mining from 13 Colorado BLM Planning Areas	4	0.167	4.2%	Mount_Zirkel	17	0.169	1.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	4	0.492	12.3%	Mesa_Verde	17	0.530	3.1%	South_San_Juan
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	4	1.058	26.4%	Mesa_Verde	17	1.077	6.3%	South_San_Juan
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	4	1.071	26.8%	Mesa_Verde	17	1.330	7.8%	Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	4	1.108	27.7%	Mesa_Verde	17	1.796	10.6%	Aztec_Ruins
V	Natural Emissions	4	10.653	266.3%	Bandelier	17	5.251	30.9%	Sevilleta_NWR
W	2021 All Emissions	4	21.453	536.3%	Wheeler_Peak	17	65.257	383.9%	Valle_De_Oro_NWR
X	2008 All Emissions	4	17.449	436.2%	Bandelier	17	51.874	305.1%	Petroglyph
Y	Coal EGU NM	4	0.299	7.5%	Petrified_Forest	17	0.201	1.2%	Aztec_Ruins
Z	Coal EGU CO	4	0.175	4.4%	Mount_Zirkel	17	0.221	1.3%	Dinosaur_all
AA	Oil/Gas EGU NM	4	0.001	0.0%	Petrified_Forest	17	0.006	0.0%	Maxwell_NWR
AB	Oil/Gas EGU CO	4	0.001	0.0%	Rocky_Mountain	17	0.001	0.0%	Mount_Evans
AC	All EGUs in 4km Domain	4	0.306	7.7%	Petrified_Forest	17	0.236	1.4%	Dinosaur_all
AD	CO Mining + Coal EGUs CO	4	0.341	8.5%	Mount_Zirkel	17	0.234	1.4%	Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	4	1.045	26.1%	Mesa_Verde	17	1.072	6.3%	South_San_Juan
AF	NM O&G + Oil/Gas EGU NM	4	0.024	0.6%	Weminuche	17	0.901	5.3%	Aztec_Ruins

Table 5-7b. Maximum Annual PM_{10} concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Low Development Scenario.

Choose	PM10, Annual	µg/m3							
Across grid cells	Maximum								
Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	4	0.001	0.0%	Mount_Zirkel	17	0.001	0.0%	Dinosaur_all
B	White River FO	4	0.006	0.1%	Flat_Tops	17	0.010	0.1%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	4	0.004	0.1%	Flat_Tops	17	0.002	0.0%	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	4	0.002	0.1%	Flat_Tops	17	0.001	0.0%	Holy_Cross
E	Grand Junction FO	4	0.001	0.0%	Maroon_Bells	17	0.002	0.0%	Colorado
F	Uncompahgre FO	4	0.011	0.3%	Maroon_Bells	17	0.019	0.1%	Raggeds
G	Tres Rios FO	4	0.049	1.2%	Mesa_Verde	17	0.055	0.3%	South_San_Juan
H	Kremmling FO	4	0.002	0.0%	Rawah	17	0.000	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	4	0.000	0.0%	Rocky_Mountain	17	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	4	0.000	0.0%	Rocky_Mountain	17	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	4	0.000	0.0%	Pecos	17	0.000	0.0%	Maxwell_NWR
L	RGFO#3 – South	4	0.000	0.0%	Great_Sand_Dunes	17	0.006	0.0%	Greenhorn_Mounta
M	RGFO#4 – East-Central	4	0.000	0.0%	Eagles_Nest	17	0.002	0.0%	Lost_Creek
N	New Mexico Farmington FO	4	0.011	0.3%	Weminuche	17	0.417	2.5%	Aztec_Ruins
O	Total Colorado River Field Office	4	0.007	0.2%	Flat_Tops	17	0.003	0.0%	Holy_Cross
P	Total Royal Gorge Field Office	4	0.000	0.0%	Rocky_Mountain	17	0.007	0.0%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	4	0.167	4.2%	Mount_Zirkel	17	0.169	1.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	4	0.171	4.3%	Mount_Zirkel	17	0.184	1.1%	Raggeds
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	4	0.688	17.2%	Mesa_Verde	17	0.672	4.0%	South_San_Juan
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	4	0.694	17.4%	Mesa_Verde	17	0.832	4.9%	Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	4	0.732	18.3%	Mesa_Verde	17	1.298	7.6%	Aztec_Ruins
V	Natural Emissions	4	10.653	266.3%	Bandelier	17	5.251	30.9%	Sevilleta_NWR
W	2021 All Emissions	4	21.743	543.6%	Wheeler_Peak	17	65.720	386.6%	Valle_De_Oro_NWR
X	2008 All Emissions	4	17.449	436.2%	Bandelier	17	51.874	305.1%	Petroglyph
Y	Coal EGU NM	4	0.299	7.5%	Petrified_Forest	17	0.201	1.2%	Aztec_Ruins
Z	Coal EGU CO	4	0.175	4.4%	Mount_Zirkel	17	0.221	1.3%	Dinosaur_all
AA	Oil/Gas EGU NM	4	0.001	0.0%	Petrified_Forest	17	0.006	0.0%	Maxwell_NWR
AB	Oil/Gas EGU CO	4	0.001	0.0%	Rocky_Mountain	17	0.001	0.0%	Mount_Evans
AC	All EGUs in 4km Domain	4	0.306	7.7%	Petrified_Forest	17	0.236	1.4%	Dinosaur_all
AD	CO Mining + Coal EGUs CO	4	0.341	8.5%	Mount_Zirkel	17	0.234	1.4%	Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	4	0.675	16.9%	Mesa_Verde	17	0.667	3.9%	South_San_Juan
AF	NM O&G + Oil/Gas EGU NM	4	0.011	0.3%	Weminuche	17	0.418	2.5%	Aztec_Ruins

Table 5-7c. Maximum Annual PM_{10} concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Medium Development Scenario.

Choose	PM10, Annual	µg/m3							
Across grid cells	Maximum								
Group	**Group Name**	**PSD Class I Increment**	**Max @ any Class I area**	**Percent of PSD Class I Increment**	**Class I Area where Max occurred**	**PSD Class II Increment**	**Max @ any Class II area**	**Percent of PSD Class II Increment**	**Class II Area where Max occurred**
A	Little Snake FO	4	0.003	0.1%	Mount_Zirkel	17	0.003	0.0%	Dinosaur_all
B	White River FO	4	0.023	0.6%	Flat_Tops	17	0.047	0.3%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	4	0.004	0.1%	Flat_Tops	17	0.002	0.0%	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	4	0.003	0.1%	Flat_Tops	17	0.002	0.0%	Holy_Cross
E	Grand Junction FO	4	0.014	0.3%	Maroon_Bells	17	0.025	0.1%	Colorado
F	Uncompahgre FO	4	0.017	0.4%	Maroon_Bells	17	0.027	0.2%	Raggeds
G	Tres Rios FO	4	0.203	5.1%	Mesa_Verde	17	0.222	1.3%	South_San_Juan
H	Kremmling FO	4	0.007	0.2%	Rawah	17	0.002	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	4	0.000	0.0%	Rocky_Mountain	17	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	4	0.000	0.0%	Rocky_Mountain	17	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	4	0.000	0.0%	Pecos	17	0.000	0.0%	Maxwell_NWR
L	RGFO#3 – South	4	0.000	0.0%	Great_Sand_Dunes	17	0.004	0.0%	Greenhorn_Mounta
M	RGFO#4 – East-Central	4	0.000	0.0%	Eagles_Nest	17	0.003	0.0%	Lost_Creek
N	New Mexico Farmington FO	4	0.011	0.3%	Weminuche	17	0.380	2.2%	Aztec_Ruins
O	Total Colorado River Field Office	4	0.007	0.2%	Flat_Tops	17	0.004	0.0%	Holy_Cross
P	Total Royal Gorge Field Office	4	0.001	0.0%	Rocky_Mountain	17	0.004	0.0%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	4	0.167	4.2%	Mount_Zirkel	17	0.169	1.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	4	0.219	5.5%	Mesa_Verde	17	0.229	1.3%	South_San_Juan
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	4	0.776	19.4%	Mesa_Verde	17	0.772	4.5%	South_San_Juan
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	4	0.782	19.6%	Mesa_Verde	17	0.786	4.6%	South_San_Juan
U	Combined O&G and Mining in 4 km domain	4	0.820	20.5%	Mesa_Verde	17	1.241	7.3%	Aztec_Ruins
V	Natural Emissions	4	10.653	266.3%	Bandelier	17	5.251	30.9%	Sevilleta_NWR
W	2021 All Emissions	4	21.447	536.2%	Wheeler_Peak	17	65.255	383.9%	Valle_De_Oro_NWR
X	2008 All Emissions	4	17.449	436.2%	Bandelier	17	51.874	305.1%	Petroglyph
Y	Coal EGU NM	4	0.299	7.5%	Petrified_Forest	17	0.201	1.2%	Aztec_Ruins
Z	Coal EGU CO	4	0.175	4.4%	Mount_Zirkel	17	0.221	1.3%	Dinosaur_all
AA	Oil/Gas EGU NM	4	0.001	0.0%	Petrified_Forest	17	0.006	0.0%	Maxwell_NWR
AB	Oil/Gas EGU CO	4	0.001	0.0%	Rocky_Mountain	17	0.001	0.0%	Mount_Evans
AC	All EGUs in 4km Domain	4	0.306	7.7%	Petrified_Forest	17	0.236	1.4%	Dinosaur_all
AD	CO Mining + Coal EGUs CO	4	0.341	8.5%	Mount_Zirkel	17	0.234	1.4%	Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	4	0.763	19.1%	Mesa_Verde	17	0.767	4.5%	South_San_Juan
AF	NM O&G + Oil/Gas EGU NM	4	0.011	0.3%	Weminuche	17	0.381	2.2%	Aztec_Ruins

Table 5-8a. Maximum 24-Hour PM_{10} concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 High Development Scenario.

Choose	PM10, 24-hour	µg/m3							
Across grid cells	Maximum								
Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	8	0.036	0.4%	Mount_Zirkel	30	0.042	0.1%	Dinosaur_all
B	White River FO	8	0.161	2.0%	Flat_Tops	30	0.327	1.1%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	8	0.029	0.4%	Flat_Tops	30	0.031	0.1%	Colorado
D	Roan Plateau Planning area portion of CRVFO	8	0.019	0.2%	Flat_Tops	30	0.027	0.1%	Colorado
E	Grand Junction FO	8	0.130	1.6%	Arches	30	0.295	1.0%	Colorado
F	Uncompahgre FO	8	0.160	2.0%	Maroon_Bells	30	0.168	0.6%	Raggeds
G	Tres Rios FO	8	1.249	15.6%	Mesa_Verde	30	1.160	3.9%	South_San_Juan
H	Kremmling FO	8	0.038	0.5%	Rawah	30	0.020	0.1%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	8	0.009	0.1%	Rocky_Mountain	30	0.003	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	8	0.035	0.4%	Rocky_Mountain	30	0.012	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	8	0.003	0.0%	Pecos	30	0.005	0.0%	Greenhorn_Mounta
L	RGFO#3 – South	8	0.004	0.1%	Great_Sand_Dunes	30	0.035	0.1%	Greenhorn_Mounta
M	RGFO#4 – East-Central	8	0.006	0.1%	Eagles_Nest	30	0.053	0.2%	Lost_Creek
N	New Mexico Farmington FO	8	0.176	2.2%	Mesa_Verde	30	2.778	9.3%	Aztec_Ruins
O	Total Colorado River Field Office	8	0.049	0.6%	Flat_Tops	30	0.058	0.2%	Colorado
P	Total Royal Gorge Field Office	8	0.044	0.6%	Rocky_Mountain	30	0.053	0.2%	Lost_Creek
Q	Mining from 13 Colorado BLM Planning Areas	8	0.792	9.9%	Flat_Tops	30	1.081	3.6%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	8	1.284	16.1%	Mesa_Verde	30	1.248	4.2%	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	8	2.745	34.3%	Mesa_Verde	30	2.372	7.9%	South_San_Juan
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	8	2.773	34.7%	Mesa_Verde	30	4.063	13.5%	Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	8	2.879	36.0%	Mesa_Verde	30	6.475	21.6%	Aztec_Ruins
V	Natural Emissions	8	1310.765	16384.6%	Bandelier	30	512.681	1708.9%	Dome
W	2021 All Emissions	8	1318.285	16478.6%	Bandelier	30	522.713	1742.4%	Dome
X	2008 All Emissions	8	1314.400	16430.0%	Bandelier	30	520.280	1734.3%	Dome
Y	Coal EGU NM	8	1.814	22.7%	Petrified_Forest	30	1.678	5.6%	Aztec_Ruins
Z	Coal EGU CO	8	0.964	12.1%	Mount_Zirkel	30	1.280	4.3%	Dinosaur_all
AA	Oil/Gas EGU NM	8	0.008	0.1%	Petrified_Forest	30	0.037	0.1%	Petroglyph
AB	Oil/Gas EGU CO	8	0.042	0.5%	Rocky_Mountain	30	0.026	0.1%	Mount_Evans
AC	All EGUs in 4km Domain	8	1.814	22.7%	Petrified_Forest	30	1.781	5.9%	Aztec_Ruins
AD	CO Mining + Coal EGUs CO	8	1.612	20.1%	Mount_Zirkel	30	1.332	4.4%	Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	8	2.712	33.9%	Mesa_Verde	30	2.370	7.9%	South_San_Juan
AF	NM O&G + Oil/Gas EGU NM	8	0.176	2.2%	Mesa_Verde	30	2.779	9.3%	Aztec_Ruins

Table 5-8b. Maximum 24-Hour PM_{10} concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Low Development Scenario.

Choose	PM10, 24-hour	µg/m3							
Across grid cells	Maximum								
Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	8	0.005	0.1%	Mount_Zirkel	30	0.006	0.0%	Dinosaur_all
B	White River FO	8	0.029	0.4%	Flat_Tops	30	0.062	0.2%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	8	0.020	0.3%	Flat_Tops	30	0.022	0.1%	Colorado
D	Roan Plateau Planning area portion of CRVFO	8	0.011	0.1%	Flat_Tops	30	0.015	0.1%	Colorado
E	Grand Junction FO	8	0.007	0.1%	Black_Canyon	30	0.017	0.1%	Colorado
F	Uncompahgre FO	8	0.056	0.7%	Maroon_Bells	30	0.054	0.2%	Raggeds
G	Tres Rios FO	8	0.133	1.7%	Mesa_Verde	30	0.121	0.4%	South_San_Juan
H	Kremmling FO	8	0.004	0.0%	Rawah	30	0.002	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	8	0.002	0.0%	Rocky_Mountain	30	0.001	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	8	0.007	0.1%	Rocky_Mountain	30	0.002	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	8	0.000	0.0%	Pecos	30	0.000	0.0%	Greenhorn_Mounta
L	RGFO#3 – South	8	0.003	0.0%	Great_Sand_Dunes	30	0.023	0.1%	Greenhorn_Mounta
M	RGFO#4 – East-Central	8	0.001	0.0%	Eagles_Nest	30	0.008	0.0%	Lost_Creek
N	New Mexico Farmington FO	8	0.082	1.0%	Mesa_Verde	30	1.291	4.3%	Aztec_Ruins
O	Total Colorado River Field Office	8	0.031	0.4%	Flat_Tops	30	0.038	0.1%	Colorado
P	Total Royal Gorge Field Office	8	0.009	0.1%	Rocky_Mountain	30	0.023	0.1%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	8	0.792	9.9%	Flat_Tops	30	1.081	3.6%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	8	0.808	10.1%	Flat_Tops	30	1.114	3.7%	Raggeds
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	8	1.788	22.3%	Mesa_Verde	30	1.483	4.9%	South_San_Juan
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	8	1.801	22.5%	Mesa_Verde	30	2.551	8.5%	Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	8	1.911	23.9%	Mesa_Verde	30	4.910	16.4%	Aztec_Ruins
V	Natural Emissions	8	1310.759	16384.5%	Bandelier	30	512.679	1708.9%	Dome
W	2021 All Emissions	8	1318.350	16479.4%	Bandelier	30	522.905	1743.0%	Dome
X	2008 All Emissions	8	1314.400	16430.0%	Bandelier	30	520.280	1734.3%	Dome
Y	Coal EGU NM	8	1.814	22.7%	Petrified_Forest	30	1.678	5.6%	Aztec_Ruins
Z	Coal EGU CO	8	0.964	12.1%	Mount_Zirkel	30	1.280	4.3%	Dinosaur_all
AA	Oil/Gas EGU NM	8	0.008	0.1%	Petrified_Forest	30	0.037	0.1%	Petroglyph
AB	Oil/Gas EGU CO	8	0.042	0.5%	Rocky_Mountain	30	0.026	0.1%	Mount_Evans
AC	All EGUs in 4km Domain	8	1.814	22.7%	Petrified_Forest	30	1.781	5.9%	Aztec_Ruins
AD	CO Mining + Coal EGUs CO	8	1.612	20.1%	Mount_Zirkel	30	1.332	4.4%	Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	8	1.754	21.9%	Mesa_Verde	30	1.482	4.9%	South_San_Juan
AF	NM O&G + Oil/Gas EGU NM	8	0.082	1.0%	Mesa_Verde	30	1.291	4.3%	Aztec_Ruins

Table 5-8c. Maximum 24-Hour PM_{10} concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Medium Development Scenario.

Choose	PM10, 24-hour	µg/m3							
Across grid cells	Maximum								
Group	**Group Name**	**PSD Class I Increment**	**Max @ any Class I area**	**Percent of PSD Class I Increment**	**Class I Area where Max occurred**	**PSD Class II Increment**	**Max @ any Class II area**	**Percent of PSD Class II Increment**	**Class II Area where Max occurred**
A	Little Snake FO	8	0.029	0.4%	Mount_Zirkel	30	0.029	0.1%	Dinosaur_all
B	White River FO	8	0.132	1.7%	Flat_Tops	30	0.286	1.0%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	8	0.017	0.2%	Flat_Tops	30	0.023	0.1%	Colorado
D	Roan Plateau Planning area portion of CRVFO	8	0.012	0.2%	Flat_Tops	30	0.022	0.1%	Colorado
E	Grand Junction FO	8	0.096	1.2%	Arches	30	0.223	0.7%	Colorado
F	Uncompahgre FO	8	0.079	1.0%	Maroon_Bells	30	0.081	0.3%	Raggeds
G	Tres Rios FO	8	0.561	7.0%	Mesa_Verde	30	0.492	1.6%	South_San_Juan
H	Kremmling FO	8	0.017	0.2%	Rawah	30	0.010	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	8	0.003	0.0%	Rocky_Mountain	30	0.001	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	8	0.014	0.2%	Rocky_Mountain	30	0.005	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	8	0.002	0.0%	Pecos	30	0.004	0.0%	Greenhorn_Mounta
L	RGFO#3 – South	8	0.002	0.0%	Great_Sand_Dunes	30	0.018	0.1%	Greenhorn_Mounta
M	RGFO#4 – East-Central	8	0.001	0.0%	Eagles_Nest	30	0.012	0.0%	Lost_Creek
N	New Mexico Farmington FO	8	0.077	1.0%	Mesa_Verde	30	1.234	4.1%	Aztec_Ruins
O	Total Colorado River Field Office	8	0.028	0.4%	Flat_Tops	30	0.045	0.2%	Colorado
P	Total Royal Gorge Field Office	8	0.017	0.2%	Rocky_Mountain	30	0.019	0.1%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	8	0.792	9.9%	Flat_Tops	30	1.081	3.6%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	8	0.863	10.8%	Flat_Tops	30	1.206	4.0%	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	8	2.028	25.3%	Mesa_Verde	30	1.706	5.7%	South_San_Juan
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	8	2.042	25.5%	Mesa_Verde	30	2.405	8.0%	Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	8	2.149	26.9%	Mesa_Verde	30	4.742	15.8%	Aztec_Ruins
V	Natural Emissions	8	1310.765	16384.6%	Bandelier	30	512.681	1708.9%	Dome
W	2021 All Emissions	8	1318.277	16478.5%	Bandelier	30	522.705	1742.3%	Dome
X	2008 All Emissions	8	1314.400	16430.0%	Bandelier	30	520.280	1734.3%	Dome
Y	Coal EGU NM	8	1.814	22.7%	Petrified_Forest	30	1.678	5.6%	Aztec_Ruins
Z	Coal EGU CO	8	0.964	12.1%	Mount_Zirkel	30	1.280	4.3%	Dinosaur_all
AA	Oil/Gas EGU NM	8	0.008	0.1%	Petrified_Forest	30	0.037	0.1%	Petroglyph
AB	Oil/Gas EGU CO	8	0.042	0.5%	Rocky_Mountain	30	0.026	0.1%	Mount_Evans
AC	All EGUs in 4km Domain	8	1.814	22.7%	Petrified_Forest	30	1.781	5.9%	Aztec_Ruins
AD	CO Mining + Coal EGUs CO	8	1.612	20.1%	Mount_Zirkel	30	1.332	4.4%	Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	8	1.994	24.9%	Mesa_Verde	30	1.704	5.7%	South_San_Juan
AF	NM O&G + Oil/Gas EGU NM	8	0.078	1.0%	Mesa_Verde	30	1.235	4.1%	Aztec_Ruins

5.1.2 PSD Concentration across All Class I and Sensitive Class II Areas

In this section we present examples of the contributions of PSD pollutant concentrations across all PSD Class I and sensitive Class II areas for the BLM FFO Planning Area as well as several of the combined Planning Area Source Groups. The tables below were obtained from the "Summary" sheet of Attachments A-1, A-2 and A-3 Excel spreadsheet that contains results for all of the Source Groups.

5.1.2.1 Individual BLM Planning Area PSD Contributions

Tables 5-9a, 5-9b and 5-9c display the contributions of new oil and gas emissions on Federal lands to PSD pollutant concentrations at all Class I and sensitive Class II areas in the CARMMS 4 km domain for the BLM New Mexico Farmington Field Office Planning Area. All of the PSD pollutant concentrations at Class I areas due to new O&G on Federal lands within the BLM NMFFO Planning Area (as well as the other 14 BLM other Planning Areas) are well below the Class I and II PSD concentration increments. Similar tables of concentrations contributions at all of the Class I and sensitive Class II areas from each of the 32 Source Groups and the High and Low Development Scenarios can be found in Attachments A-1, A-2 and A-3.

Table 5-9a. Contributions of new oil and gas emissions on Federal lands within the New Mexico Farmington Field Office Planning Area (Source Group N) to PSD pollutant concentrations at Class I and sensitive Class II areas for the 2021 High Development Scenario.

Group	G_N	New Mexico Farmington FO
Across grid cells	Maximum	Max

		Pollutant	NO_2 (μg/m[3])	PM_{10} (μg/m[3])		PM_{25} (μg/m[3])		SO_2 (μg/m[3])			
		Averaging Time	Annual[3]	24-hour[2]	Annual[3]	24-hour[4]	Annual[3]	3-hour[2]	24-hour[2]	Annual[3]	
Class I	State	Owner	PSD Class I Increment[1]								ShortName
			2.5	8	4	2	1	25	5	2	
Arches NP	UT	NPS	0.002	0.026	0.002	0.010	0.001	0.000	0.000	0.000	CI_Arches
Bandelier NM	NM	NPS	0.010	0.073	0.009	0.033	0.003	0.001	0.000	0.000	CI_Bandelier
Black Canyon of the Gunnison NM	CO	NPS	0.002	0.025	0.002	0.019	0.001	0.000	0.000	0.000	CI_Black_Canyon
Bosque del Apache Wilderness	NM	FWS	0.000	0.026	0.001	0.008	0.000	0.000	0.000	0.000	CI_Bosque
Canyonlands NP	UT	NPS	0.006	0.041	0.004	0.017	0.001	0.000	0.000	0.000	CI_Canyonlands
Capitol Reef NP	UT	NPS	0.004	0.046	0.002	0.015	0.001	0.000	0.000	0.000	CI_Capitol_Reef
Eagles Nest Wilderness	CO	FS	0.001	0.013	0.001	0.008	0.001	0.000	0.000	0.000	CI_Eagles_Nest
Flat Tops Wilderness	CO	FS	0.001	0.015	0.001	0.010	0.000	0.000	0.000	0.000	CI_Flat_Tops
Galiuro Wilderness	AZ	FS	0.000	0.003	0.000	0.001	0.000	0.000	0.000	0.000	CI_Galiuro
Gila Wilderness	NM	FS	0.000	0.006	0.000	0.003	0.000	0.000	0.000	0.000	CI_Gila
Great Sand Dunes NM	CO	NPS	0.004	0.040	0.006	0.019	0.002	0.000	0.000	0.000	CI_Great_Sand_Dunes
La Garita Wilderness	CO	FS	0.007	0.039	0.006	0.021	0.002	0.000	0.000	0.000	CI_La_Garita
Maroon Bells-Snowmass Wilderness	CO	FS	0.001	0.020	0.002	0.013	0.001	0.000	0.000	0.000	CI_Maroon_Bells
Mesa Verde NP	CO	NPS	0.041	0.176	0.023	0.053	0.007	0.002	0.001	0.000	CI_Mesa_Verde
Mount Baldy Wilderness	AZ	FS	0.000	0.005	0.000	0.002	0.000	0.000	0.000	0.000	CI_Mount_Baldy
Mount Zirkel Wilderness	CO	FS	0.000	0.011	0.001	0.006	0.000	0.000	0.000	0.000	CI_Mount_Zirkel
Pecos Wilderness	NM	FS	0.009	0.054	0.007	0.016	0.002	0.001	0.000	0.000	CI_Pecos
Petrified Forest NP	AZ	NPS	0.001	0.022	0.001	0.011	0.000	0.000	0.000	0.000	CI_Petrified_Forest
Rawah Wilderness	CO	FS	0.000	0.008	0.001	0.004	0.000	0.000	0.000	0.000	CI_Rawah
Rocky Mountain NP	CO	NPS	0.000	0.009	0.001	0.006	0.000	0.000	0.000	0.000	CI_Rocky_Mountain
Salt Creek Wilderness	NM	FWS	0.001	0.015	0.001	0.006	0.000	0.000	0.000	0.000	CI_Salt_Creek
San Pedro Parks Wilderness	NM	FS	0.013	0.091	0.010	0.024	0.003	0.001	0.000	0.000	CI_San_Pedro
Weminuche Wilderness	CO	FS	0.036	0.106	0.024	0.038	0.007	0.001	0.000	0.000	CI_Weminuche
West Elk Wilderness	CO	FS	0.001	0.026	0.002	0.019	0.001	0.000	0.000	0.000	CI_West_Elk
Wheeler Peak Wilderness	NM	FS	0.007	0.053	0.007	0.017	0.003	0.000	0.000	0.000	CI_Wheeler_Peak
White Mountain Wilderness	NM	FS	0.000	0.012	0.001	0.006	0.000	0.000	0.000	0.000	CI_White_Mountain
Dinosaur NM[5]	CO	NPS	NA	NA	NA	NA	NA	0.000	0.000	0.000	CI_Dinosaur_CO
Class II	State	Owner	PSD Class II Increment[1]								ShortName
			25	30	17	9	4	512	91	20	
Alamosa NWR	CO	FWS	0.008	0.043	0.008	0.028	0.004	0.000	0.000	0.000	CII_Alamosa_NWR
Aldo Leopold Wilderness	NM	USFS	0.000	0.007	0.000	0.003	0.000	0.000	0.000	0.000	CII_Aldo_Leopold
Apache Kid Wilderness	NM	USFS	0.000	0.011	0.000	0.004	0.000	0.000	0.000	0.000	CII_Apache_Kid
Aztec Ruins NM	NM	NPS	2.037	2.778	0.900	0.799	0.205	0.015	0.009	0.003	CII_Aztec_Ruins
Baca NWR	CO	FWS	0.005	0.039	0.006	0.019	0.003	0.000	0.000	0.000	CII_Baca_NWR
Bear Wallow Wilderness	AZ	USFS	0.000	0.007	0.000	0.003	0.000	0.000	0.000	0.000	CII_Bear_Wallow
Bitter Lake NWR	NM	FWS	0.001	0.015	0.001	0.006	0.000	0.000	0.000	0.000	CII_Bitter_Lake_NWR
Blue Range Wilderness	NM	USFS	0.000	0.006	0.000	0.003	0.000	0.000	0.000	0.000	CII_Blue_Range
Bosque Del Apache NWR	NM	FWS	0.000	0.026	0.001	0.008	0.000	0.000	0.000	0.000	CII_Bosque_NWR
Browns Park NWR	CO	FWS	0.000	0.009	0.000	0.004	0.000	0.000	0.000	0.000	CII_Browns_Park_NWR
Canyon de Chelly NM	AZ	NPS	0.001	0.032	0.001	0.012	0.000	0.000	0.000	0.000	CII_Canyon_de_Chelly
Capitan Mountains Wilderness	NM	USFS	0.001	0.020	0.001	0.008	0.000	0.000	0.000	0.000	CII_Capitan_Mountain
Chaco Culture NHP	NM	NPS	0.007	0.063	0.004	0.029	0.002	0.001	0.000	0.000	CII_Chaco_Culture
Chama River Canyon Wilderness	NM	USFS	0.060	0.178	0.031	0.060	0.011	0.002	0.001	0.000	CII_Chama_River_Cany
Chimney Rock NM	CO	USFS	0.142	0.326	0.075	0.096	0.022	0.003	0.001	0.000	CII_Chimney_Rock
Colorado NM	CO	NPS	0.002	0.023	0.002	0.016	0.001	0.000	0.000	0.000	CII_Colorado
Cruces Basin Wilderness	NM	USFS	0.029	0.098	0.019	0.033	0.006	0.001	0.001	0.000	CII_Cruces_Basin
Curecanti NRA	CO	NPS	0.002	0.033	0.002	0.025	0.001	0.000	0.000	0.000	CII_Curecanti
Dark Canyon Wilderness	UT	USFS	0.008	0.050	0.005	0.016	0.002	0.001	0.000	0.000	CII_Dark_Canyon
Dinosaur NM	CO	NPS	0.000	0.013	0.001	0.008	0.000	0.000	0.000	0.000	CII_Dinosaur_all
Dome Wilderness	NM	USFS	0.008	0.052	0.007	0.021	0.002	0.000	0.000	0.000	CII_Dome
El Malpais NM	NM	NPS	0.001	0.016	0.001	0.007	0.000	0.000	0.000	0.000	CII_El_Malpais
Escudilla Wilderness	AZ	USFS	0.000	0.009	0.000	0.003	0.000	0.000	0.000	0.000	CII_Escudilla
Flaming Gorge	UT	USFS	0.000	0.006	0.000	0.003	0.000	0.000	0.000	0.000	CII_Flaming_Gorge
Florissant Fossil Beds NM	CO	NPS	0.001	0.015	0.001	0.008	0.001	0.000	0.000	0.000	CII_Florissant_Fossi
Fossil Ridge Wilderness	CO	USFS	0.001	0.021	0.002	0.014	0.001	0.000	0.000	0.000	CII_Fossil_Ridge
Glen Canyon NRA	UT	NPS	0.022	0.122	0.012	0.039	0.004	0.001	0.001	0.000	CII_Glen_Canyon
Great Sand Dunes National Park	CO	NPS	0.004	0.040	0.006	0.021	0.003	0.000	0.000	0.000	CII_Great_Sand_Park
Great Sand Dunes National Preserve	CO	NPS	0.004	0.040	0.005	0.018	0.002	0.000	0.000	0.000	CII_Great_Sand_Prese
Greenhorn Mountain Wilderness	CO	USFS	0.003	0.023	0.003	0.009	0.001	0.000	0.000	0.000	CII_Greenhorn_Mounta
High Uintas Wilderness	UT	USFS	0.000	0.008	0.000	0.002	0.000	0.000	0.000	0.000	CII_High_Uintas
Holy Cross Wilderness	CO	USFS	0.001	0.017	0.001	0.012	0.001	0.000	0.000	0.000	CII_Holy_Cross
Hovenweep NM	CO	NPS	0.037	0.154	0.021	0.061	0.007	0.001	0.001	0.000	CII_Hovenweep
Hunter-Fryingpan Wilderness	CO	USFS	0.001	0.017	0.001	0.010	0.001	0.000	0.000	0.000	CII_Hunter_Fryingpan
Las Vegas NWR	NM	FWS	0.003	0.024	0.003	0.015	0.001	0.000	0.000	0.000	CII_Las_Vegas_NWR
Latir Peak Wilderness	NM	USFS	0.007	0.047	0.007	0.016	0.002	0.000	0.000	0.000	CII_Latir_Peak
Lizard Head Wilderness	CO	USFS	0.006	0.045	0.004	0.029	0.002	0.001	0.000	0.000	CII_Lizard_Head
Lost Creek Wilderness	CO	USFS	0.001	0.014	0.001	0.011	0.001	0.000	0.000	0.000	CII_Lost_Creek
Manzano Mountain Wilderness	NM	USFS	0.002	0.029	0.002	0.010	0.001	0.000	0.000	0.000	CII_Manzano_Mountain
Maxwell NWR	NM	FWS	0.002	0.015	0.002	0.008	0.001	0.000	0.000	0.000	CII_Maxwell_NWR
Monte Vista NWR	CO	FWS	0.012	0.051	0.009	0.042	0.005	0.000	0.000	0.000	CII_Monte_Vista_NWR
Mount Evans Wilderness	CO	USFS	0.001	0.011	0.001	0.008	0.000	0.000	0.000	0.000	CII_Mount_Evans
Mount Sneffels Wilderness	CO	USFS	0.004	0.038	0.004	0.023	0.001	0.000	0.000	0.000	CII_Mount_Sneffels
Natural Bridges NM	UT	NPS	0.010	0.055	0.006	0.019	0.002	0.000	0.000	0.000	CII_Natural_Bridges
Navajo NM	AZ	NPS	0.001	0.017	0.001	0.007	0.000	0.000	0.000	0.000	CII_Navajo
Petroglyph NM	NM	NPS	0.003	0.045	0.003	0.020	0.001	0.000	0.000	0.000	CII_Petroglyph
Powderhorn Wilderness	CO	USFS	0.005	0.036	0.004	0.020	0.002	0.000	0.000	0.000	CII_Powderhorn
Raggeds Wilderness	CO	USFS	0.001	0.021	0.002	0.014	0.001	0.000	0.000	0.000	CII_Raggeds
Rio Mora NWR and CA	NM	FWS	0.004	0.025	0.003	0.012	0.001	0.000	0.000	0.000	CII_Rio_Mora_NWR_and
Sandia Mountain Wilderness	NM	USFS	0.003	0.039	0.003	0.016	0.001	0.000	0.000	0.000	CII_Sandia_Mountain
Sangre de Cristo Wilderness	CO	USFS	0.005	0.040	0.006	0.021	0.003	0.000	0.000	0.000	CII_Sangre_de_Cristo
Savage Run Wilderness	WY	USFS	0.000	0.006	0.000	0.003	0.000	0.000	0.000	0.000	CII_Savage_Run
Sevilleta NWR	NM	FWS	0.001	0.034	0.002	0.016	0.001	0.000	0.000	0.000	CII_Sevilleta_NWR
South San Juan Wilderness	CO	USFS	0.058	0.161	0.037	0.047	0.011	0.002	0.001	0.000	CII_South_San_Juan
Spanish Peaks Wilderness	CO	USFS	0.004	0.026	0.004	0.011	0.002	0.000	0.000	0.000	CII_Spanish_Peaks
Uncompahgre Wilderness	CO	USFS	0.004	0.041	0.003	0.023	0.001	0.000	0.000	0.000	CII_Uncompahgre
Valle De Oro NWR	NM	FWS	0.002	0.045	0.003	0.026	0.002	0.000	0.000	0.000	CII_Valle_De_Oro_NWR
Withington Wilderness	NM	USFS	0.000	0.010	0.000	0.004	0.000	0.000	0.000	0.000	CII_Withington

Table 5-9b. Contributions of new oil and gas emissions on Federal lands within the New Mexico Farmington Field Office Planning Area to PSD pollutant concentrations at Class I and sensitive Class II areas for the 2021 Low Development Scenario.

Group	G_N	New Mexico Farmington District
Across grid cells	Maximum	Max

		Pollutant	NO_2 (µg/m³)	PM_{10} (µg/m³)		PM_{25} (µg/m³)		SO_2 (µg/m³)			
		Averaging Time	Annual[3]	24-hour[2]	Annual[3]	24-hour[4]	Annual[3]	3-hour[2]	24-hour[2]	Annual[3]	
Class I	**State**	**Owner**	**PSD Class I Increment[1]**								**ShortName**
			2.5	8	4	2	1	25	5	2	
Arches NP	UT	NPS	0.001	0.012	0.001	0.005	0.000	0.000	0.000	0.000	CI_Arches
Bandelier NM	NM	NPS	0.005	0.034	0.004	0.016	0.002	0.000	0.000	0.000	CI_Bandelier
Black Canyon of the Gunnison NM	CO	NPS	0.001	0.012	0.001	0.009	0.001	0.000	0.000	0.000	CI_Black_Canyon
Bosque del Apache Wilderness	NM	FWS	0.000	0.012	0.000	0.004	0.000	0.000	0.000	0.000	CI_Bosque
Canyonlands NP	UT	NPS	0.003	0.019	0.002	0.008	0.001	0.000	0.000	0.000	CI_Canyonlands
Capitol Reef NP	UT	NPS	0.002	0.021	0.001	0.007	0.000	0.000	0.000	0.000	CI_Capitol_Reef
Eagles Nest Wilderness	CO	FS	0.000	0.006	0.000	0.004	0.000	0.000	0.000	0.000	CI_Eagles_Nest
Flat Tops Wilderness	CO	FS	0.000	0.007	0.000	0.005	0.000	0.000	0.000	0.000	CI_Flat_Tops
Galiuro Wilderness	AZ	FS	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000	CI_Galiuro
Gila Wilderness	NM	FS	0.000	0.003	0.000	0.001	0.000	0.000	0.000	0.000	CI_Gila
Great Sand Dunes NM	CO	NPS	0.002	0.018	0.003	0.009	0.001	0.000	0.000	0.000	CI_Great_Sand_Dunes
La Garita Wilderness	CO	FS	0.004	0.018	0.003	0.010	0.001	0.000	0.000	0.000	CI_La_Garita
Maroon Bells-Snowmass Wilderness	CO	FS	0.000	0.010	0.001	0.006	0.000	0.000	0.000	0.000	CI_Maroon_Bells
Mesa Verde NP	CO	NPS	0.020	0.082	0.011	0.025	0.004	0.001	0.000	0.000	CI_Mesa_Verde
Mount Baldy Wilderness	AZ	FS	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000	CI_Mount_Baldy
Mount Zirkel Wilderness	CO	FS	0.000	0.005	0.000	0.003	0.000	0.000	0.000	0.000	CI_Mount_Zirkel
Pecos Wilderness	NM	FS	0.004	0.025	0.003	0.008	0.001	0.000	0.000	0.000	CI_Pecos
Petrified Forest NP	AZ	NPS	0.000	0.010	0.000	0.005	0.000	0.000	0.000	0.000	CI_Petrified_Forest
Rawah Wilderness	CO	FS	0.000	0.004	0.000	0.002	0.000	0.000	0.000	0.000	CI_Rawah
Rocky Mountain NP	CO	NPS	0.000	0.004	0.000	0.003	0.000	0.000	0.000	0.000	CI_Rocky_Mountain
Salt Creek Wilderness	NM	FWS	0.000	0.007	0.000	0.003	0.000	0.000	0.000	0.000	CI_Salt_Creek
San Pedro Parks Wilderness	NM	FS	0.007	0.042	0.005	0.012	0.001	0.000	0.000	0.000	CI_San_Pedro
Weminuche Wilderness	CO	FS	0.017	0.049	0.011	0.018	0.004	0.001	0.000	0.000	CI_Weminuche
West Elk Wilderness	CO	FS	0.001	0.012	0.001	0.009	0.000	0.000	0.000	0.000	CI_West_Elk
Wheeler Peak Wilderness	NM	FS	0.003	0.024	0.003	0.008	0.001	0.000	0.000	0.000	CI_Wheeler_Peak
White Mountain Wilderness	NM	FS	0.000	0.006	0.000	0.003	0.000	0.000	0.000	0.000	CI_White_Mountain
Dinosaur NM[5]	CO	NPS	NA	NA	NA	NA	NA	0.000	0.000	0.000	CI_Dinosaur_CO
Class II	**State**	**Owner**	**PSD Class II Increment[1]**								**ShortName**
			25	30	17	9	4	512	91	20	
Alamosa NWR	CO	FWS	0.004	0.020	0.004	0.013	0.002	0.000	0.000	0.000	CII_Alamosa_NWR
Aldo Leopold Wilderness	NM	USFS	0.000	0.003	0.000	0.001	0.000	0.000	0.000	0.000	CII_Aldo_Leopold
Apache Kid Wilderness	NM	USFS	0.000	0.005	0.000	0.002	0.000	0.000	0.000	0.000	CII_Apache_Kid
Aztec Ruins NM	NM	NPS	0.986	1.291	0.417	0.381	0.098	0.006	0.004	0.001	CII_Aztec_Ruins
Baca NWR	CO	FWS	0.002	0.018	0.003	0.009	0.001	0.000	0.000	0.000	CII_Baca_NWR
Bear Wallow Wilderness	AZ	USFS	0.000	0.003	0.000	0.001	0.000	0.000	0.000	0.000	CII_Bear_Wallow
Bitter Lake NWR	NM	FWS	0.000	0.007	0.000	0.003	0.000	0.000	0.000	0.000	CII_Bitter_Lake_NWR
Blue Range Wilderness	NM	USFS	0.000	0.003	0.000	0.001	0.000	0.000	0.000	0.000	CII_Blue_Range
Bosque Del Apache NWR	NM	FWS	0.000	0.012	0.000	0.004	0.000	0.000	0.000	0.000	CII_Bosque_NWR
Browns Park NWR	CO	FWS	0.000	0.004	0.000	0.002	0.000	0.000	0.000	0.000	CII_Browns_Park_NWR
Canyon de Chelly NM	AZ	NPS	0.000	0.015	0.000	0.006	0.000	0.000	0.000	0.000	CII_Canyon_de_Chelly
Capitan Mountains Wilderness	NM	USFS	0.000	0.010	0.000	0.004	0.000	0.000	0.000	0.000	CII_Capitan_Mountain
Chaco Culture NHP	NM	NPS	0.003	0.029	0.002	0.014	0.001	0.000	0.000	0.000	CII_Chaco_Culture
Chama River Canyon Wilderness	NM	USFS	0.029	0.082	0.014	0.029	0.005	0.001	0.000	0.000	CII_Chama_River_Cany
Chimney Rock NM	CO	USFS	0.068	0.151	0.035	0.046	0.011	0.001	0.001	0.000	CII_Chimney_Rock
Colorado NM	CO	NPS	0.001	0.011	0.001	0.008	0.000	0.000	0.000	0.000	CII_Colorado
Cruces Basin Wilderness	NM	USFS	0.014	0.045	0.009	0.016	0.003	0.000	0.000	0.000	CII_Cruces_Basin
Curecanti NRA	CO	NPS	0.001	0.016	0.001	0.012	0.001	0.000	0.000	0.000	CII_Curecanti
Dark Canyon Wilderness	UT	USFS	0.004	0.023	0.002	0.008	0.001	0.000	0.000	0.000	CII_Dark_Canyon
Dinosaur NM	CO	NPS	0.000	0.006	0.000	0.004	0.000	0.000	0.000	0.000	CII_Dinosaur_all
Dome Wilderness	NM	USFS	0.004	0.024	0.003	0.010	0.001	0.000	0.000	0.000	CII_Dome
El Malpais NM	NM	NPS	0.000	0.008	0.000	0.004	0.000	0.000	0.000	0.000	CII_El_Malpais
Escudilla Wilderness	AZ	USFS	0.000	0.004	0.000	0.002	0.000	0.000	0.000	0.000	CII_Escudilla
Flaming Gorge	UT	USFS	0.000	0.003	0.000	0.001	0.000	0.000	0.000	0.000	CII_Flaming_Gorge
Florissant Fossil Beds NM	CO	NPS	0.000	0.007	0.001	0.004	0.000	0.000	0.000	0.000	CII_Florissant_Fossi
Fossil Ridge Wilderness	CO	USFS	0.001	0.010	0.001	0.007	0.000	0.000	0.000	0.000	CII_Fossil_Ridge
Glen Canyon NRA	UT	NPS	0.011	0.056	0.006	0.019	0.002	0.000	0.000	0.000	CII_Glen_Canyon
Great Sand Dunes National Park	CO	NPS	0.002	0.018	0.003	0.010	0.001	0.000	0.000	0.000	CII_Great_Sand_Park
Great Sand Dunes National Preserve	CO	NPS	0.002	0.018	0.002	0.009	0.001	0.000	0.000	0.000	CII_Great_Sand_Prese
Greenhorn Mountain Wilderness	CO	USFS	0.001	0.011	0.002	0.004	0.001	0.000	0.000	0.000	CII_Greenhorn_Mounta
High Uintas Wilderness	UT	USFS	0.000	0.004	0.000	0.001	0.000	0.000	0.000	0.000	CII_High_Uintas
Holy Cross Wilderness	CO	USFS	0.000	0.008	0.001	0.006	0.000	0.000	0.000	0.000	CII_Holy_Cross
Hovenweep NM	CO	NPS	0.017	0.072	0.010	0.029	0.003	0.001	0.000	0.000	CII_Hovenweep
Hunter-Fryingpan Wilderness	CO	USFS	0.000	0.008	0.001	0.005	0.000	0.000	0.000	0.000	CII_Hunter_Fryingpan
Las Vegas NWR	NM	FWS	0.001	0.011	0.001	0.007	0.001	0.000	0.000	0.000	CII_Las_Vegas_NWR
Latir Peak Wilderness	NM	USFS	0.003	0.022	0.003	0.008	0.001	0.000	0.000	0.000	CII_Latir_Peak
Lizard Head Wilderness	CO	USFS	0.003	0.021	0.002	0.014	0.001	0.000	0.000	0.000	CII_Lizard_Head
Lost Creek Wilderness	CO	USFS	0.000	0.007	0.001	0.005	0.000	0.000	0.000	0.000	CII_Lost_Creek
Manzano Mountain Wilderness	NM	USFS	0.001	0.014	0.001	0.005	0.000	0.000	0.000	0.000	CII_Manzano_Mountain
Maxwell NWR	NM	FWS	0.001	0.007	0.001	0.004	0.001	0.000	0.000	0.000	CII_Maxwell_NWR
Monte Vista NWR	CO	FWS	0.006	0.024	0.004	0.020	0.002	0.000	0.000	0.000	CII_Monte_Vista_NWR
Mount Evans Wilderness	CO	USFS	0.000	0.005	0.000	0.004	0.000	0.000	0.000	0.000	CII_Mount_Evans
Mount Sneffels Wilderness	CO	USFS	0.002	0.018	0.002	0.011	0.001	0.000	0.000	0.000	CII_Mount_Sneffels
Natural Bridges NM	UT	NPS	0.005	0.025	0.003	0.009	0.001	0.000	0.000	0.000	CII_Natural_Bridges
Navajo NM	AZ	NPS	0.000	0.008	0.000	0.003	0.000	0.000	0.000	0.000	CII_Navajo
Petroglyph NM	NM	NPS	0.001	0.021	0.002	0.009	0.001	0.000	0.000	0.000	CII_Petroglyph
Powderhorn Wilderness	CO	USFS	0.002	0.017	0.002	0.010	0.001	0.000	0.000	0.000	CII_Powderhorn
Raggeds Wilderness	CO	USFS	0.001	0.010	0.001	0.006	0.000	0.000	0.000	0.000	CII_Raggeds
Rio Mora NWR and CA	NM	FWS	0.002	0.011	0.002	0.006	0.001	0.000	0.000	0.000	CII_Rio_Mora_NWR_and
Sandia Mountain Wilderness	NM	USFS	0.001	0.018	0.002	0.008	0.001	0.000	0.000	0.000	CII_Sandia_Mountain
Sangre de Cristo Wilderness	CO	USFS	0.002	0.018	0.003	0.010	0.001	0.000	0.000	0.000	CII_Sangre_de_Cristo
Savage Run Wilderness	WY	USFS	0.000	0.003	0.000	0.001	0.000	0.000	0.000	0.000	CII_Savage_Run
Sevilleta NWR	NM	FWS	0.000	0.016	0.001	0.008	0.000	0.000	0.000	0.000	CII_Sevilleta_NWR
South San Juan Wilderness	CO	USFS	0.028	0.074	0.017	0.023	0.005	0.001	0.000	0.000	CII_South_San_Juan
Spanish Peaks Wilderness	CO	USFS	0.002	0.012	0.002	0.005	0.001	0.000	0.000	0.000	CII_Spanish_Peaks
Uncompahgre Wilderness	CO	USFS	0.002	0.019	0.002	0.011	0.001	0.000	0.000	0.000	CII_Uncompahgre
Valle De Oro NWR	NM	FWS	0.001	0.021	0.001	0.013	0.001	0.000	0.000	0.000	CII_Valle_De_Oro_NWR
Withington Wilderness	NM	USFS	0.000	0.005	0.000	0.002	0.000	0.000	0.000	0.000	CII_Withington

Table 5-9c. Contributions of new oil and gas emissions on Federal lands within the New Mexico Farmington Field Office Planning Area to PSD pollutant concentrations at Class I and sensitive Class II areas for the 2021 Medium Development Scenario.

Group	G_N	New Mexico Farmington FO									
Across grid cells	Maximum	Max									
		Pollutant	NO_2 (µg/m^3)	PM_{10} (µg/m^3)		PM_{25} (µg/m^3)		SO_2 (µg/m^3)			
		Averaging Time	Annual[3]	24-hour[2]	Annual[3]	24-hour[4]	Annual[3]	3-hour[2]	24-hour[2]	Annual[3]	
Class I	State	Owner	PSD Class I Increment[1]								ShortName
			2.5	8	4	2	1	25	5	2	
Arches NP	UT	NPS	0.002	0.012	0.001	0.007	0.001	0.000	0.000	0.000	CI_Arches
Bandelier NM	NM	NPS	0.008	0.038	0.004	0.021	0.002	0.000	0.000	0.000	CI_Bandelier
Black Canyon of the Gunnison NM	CO	NPS	0.001	0.016	0.001	0.014	0.001	0.000	0.000	0.000	CI_Black_Canyon
Bosque del Apache Wilderness	NM	FWS	0.000	0.012	0.000	0.005	0.000	0.000	0.000	0.000	CI_Bosque
Canyonlands NP	UT	NPS	0.005	0.019	0.002	0.011	0.001	0.000	0.000	0.000	CI_Canyonlands
Capitol Reef NP	UT	NPS	0.003	0.021	0.001	0.009	0.001	0.000	0.000	0.000	CI_Capitol_Reef
Eagles Nest Wilderness	CO	FS	0.000	0.008	0.001	0.006	0.000	0.000	0.000	0.000	CI_Eagles_Nest
Flat Tops Wilderness	CO	FS	0.000	0.009	0.000	0.008	0.000	0.000	0.000	0.000	CI_Flat_Tops
Galiuro Wilderness	AZ	FS	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000	CI_Galiuro
Gila Wilderness	NM	FS	0.000	0.003	0.000	0.002	0.000	0.000	0.000	0.000	CI_Gila
Great Sand Dunes NM	CO	NPS	0.003	0.020	0.003	0.013	0.002	0.000	0.000	0.000	CI_Great_Sand_Dunes
La Garita Wilderness	CO	FS	0.006	0.021	0.003	0.015	0.001	0.000	0.000	0.000	CI_La_Garita
Maroon Bells-Snowmass Wilderness	CO	FS	0.001	0.012	0.001	0.009	0.000	0.000	0.000	0.000	CI_Maroon_Bells
Mesa Verde NP	CO	NPS	0.032	0.077	0.010	0.033	0.005	0.001	0.001	0.000	CI_Mesa_Verde
Mount Baldy Wilderness	AZ	FS	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000	CI_Mount_Baldy
Mount Zirkel Wilderness	CO	FS	0.000	0.006	0.000	0.004	0.000	0.000	0.000	0.000	CI_Mount_Zirkel
Pecos Wilderness	NM	FS	0.007	0.023	0.003	0.010	0.002	0.000	0.000	0.000	CI_Pecos
Petrified Forest NP	AZ	NPS	0.001	0.010	0.000	0.006	0.000	0.000	0.000	0.000	CI_Petrified_Forest
Rawah Wilderness	CO	FS	0.000	0.004	0.000	0.003	0.000	0.000	0.000	0.000	CI_Rawah
Rocky Mountain NP	CO	NPS	0.000	0.005	0.000	0.004	0.000	0.000	0.000	0.000	CI_Rocky_Mountain
Salt Creek Wilderness	NM	FWS	0.000	0.007	0.000	0.004	0.000	0.000	0.000	0.000	CI_Salt_Creek
San Pedro Parks Wilderness	NM	FS	0.010	0.039	0.005	0.015	0.002	0.001	0.000	0.000	CI_San_Pedro
Weminuche Wilderness	CO	FS	0.028	0.048	0.011	0.028	0.005	0.001	0.000	0.000	CI_Weminuche
West Elk Wilderness	CO	FS	0.001	0.017	0.001	0.014	0.001	0.000	0.000	0.000	CI_West_Elk
Wheeler Peak Wilderness	NM	FS	0.005	0.023	0.003	0.011	0.002	0.000	0.000	0.000	CI_Wheeler_Peak
White Mountain Wilderness	NM	FS	0.000	0.006	0.000	0.004	0.000	0.000	0.000	0.000	CI_White_Mountain
Dinosaur NM[5]	CO	NPS	NA	NA	NA	NA	NA	0.000	0.000	0.000	CI_Dinosaur_CO
Class II	State	Owner	PSD Class II Increment[1]								ShortName
			25	30	17	9	4	512	91	20	
Alamosa NWR	CO	FWS	0.006	0.025	0.004	0.019	0.003	0.000	0.000	0.000	CII_Alamosa_NWR
Aldo Leopold Wilderness	NM	USFS	0.000	0.003	0.000	0.002	0.000	0.000	0.000	0.000	CII_Aldo_Leopold
Apache Kid Wilderness	NM	USFS	0.000	0.005	0.000	0.003	0.000	0.000	0.000	0.000	CII_Apache_Kid
Aztec Ruins NM	NM	NPS	1.569	1.234	0.380	0.494	0.122	0.012	0.007	0.003	CII_Aztec_Ruins
Baca NWR	CO	FWS	0.004	0.021	0.003	0.013	0.002	0.000	0.000	0.000	CII_Baca_NWR
Bear Wallow Wilderness	AZ	USFS	0.000	0.003	0.000	0.002	0.000	0.000	0.000	0.000	CII_Bear_Wallow
Bitter Lake NWR	NM	FWS	0.000	0.007	0.000	0.004	0.000	0.000	0.000	0.000	CII_Bitter_Lake_NWR
Blue Range Wilderness	NM	USFS	0.000	0.003	0.000	0.002	0.000	0.000	0.000	0.000	CII_Blue_Range
Bosque Del Apache NWR	NM	FWS	0.000	0.012	0.000	0.005	0.000	0.000	0.000	0.000	CII_Bosque_NWR
Browns Park NWR	CO	FWS	0.000	0.004	0.000	0.002	0.000	0.000	0.000	0.000	CII_Browns_Park_NWR
Canyon de Chelly NM	AZ	NPS	0.001	0.015	0.000	0.008	0.000	0.000	0.000	0.000	CII_Canyon_de_Chelly
Capitan Mountains Wilderness	NM	USFS	0.000	0.009	0.000	0.005	0.000	0.000	0.000	0.000	CII_Capitan_Mountain
Chaco Culture NHP	NM	NPS	0.005	0.030	0.002	0.020	0.001	0.001	0.000	0.000	CII_Chaco_Culture
Chama River Canyon Wilderness	NM	USFS	0.046	0.079	0.014	0.036	0.007	0.002	0.001	0.000	CII_Chama_River_Cany
Chimney Rock NM	CO	USFS	0.109	0.142	0.034	0.058	0.014	0.002	0.001	0.000	CII_Chimney_Rock
Colorado NM	CO	NPS	0.001	0.013	0.001	0.012	0.001	0.000	0.000	0.000	CII_Colorado
Cruces Basin Wilderness	NM	USFS	0.022	0.043	0.009	0.020	0.004	0.001	0.000	0.000	CII_Cruces_Basin
Curecanti NRA	CO	NPS	0.001	0.022	0.001	0.018	0.001	0.000	0.000	0.000	CII_Curecanti
Dark Canyon Wilderness	UT	USFS	0.006	0.022	0.002	0.010	0.001	0.000	0.000	0.000	CII_Dark_Canyon
Dinosaur NM	CO	NPS	0.000	0.007	0.000	0.006	0.000	0.000	0.000	0.000	CII_Dinosaur_all
Dome Wilderness	NM	USFS	0.006	0.027	0.003	0.013	0.002	0.000	0.000	0.000	CII_Dome
El Malpais NM	NM	NPS	0.000	0.008	0.000	0.005	0.000	0.000	0.000	0.000	CII_El_Malpais
Escudilla Wilderness	AZ	USFS	0.000	0.004	0.000	0.002	0.000	0.000	0.000	0.000	CII_Escudilla
Flaming Gorge	UT	USFS	0.000	0.003	0.000	0.002	0.000	0.000	0.000	0.000	CII_Flaming_Gorge
Florissant Fossil Beds NM	CO	NPS	0.001	0.008	0.001	0.006	0.001	0.000	0.000	0.000	CII_Florissant_Fossi
Fossil Ridge Wilderness	CO	USFS	0.001	0.013	0.001	0.011	0.001	0.000	0.000	0.000	CII_Fossil_Ridge
Glen Canyon NRA	UT	NPS	0.017	0.054	0.005	0.024	0.002	0.001	0.000	0.000	CII_Glen_Canyon
Great Sand Dunes National Park	CO	NPS	0.003	0.021	0.003	0.015	0.002	0.000	0.000	0.000	CII_Great_Sand_Park
Great Sand Dunes National Preserve	CO	NPS	0.003	0.020	0.003	0.013	0.001	0.000	0.000	0.000	CII_Great_Sand_Prese
Greenhorn Mountain Wilderness	CO	USFS	0.002	0.011	0.002	0.006	0.001	0.000	0.000	0.000	CII_Greenhorn_Mounta
High Uintas Wilderness	UT	USFS	0.000	0.004	0.000	0.002	0.000	0.000	0.000	0.000	CII_High_Uintas
Holy Cross Wilderness	CO	USFS	0.001	0.011	0.001	0.009	0.000	0.000	0.000	0.000	CII_Holy_Cross
Hovenweep NM	CO	NPS	0.028	0.068	0.009	0.039	0.004	0.001	0.000	0.000	CII_Hovenweep
Hunter-Fryingpan Wilderness	CO	USFS	0.001	0.010	0.001	0.007	0.000	0.000	0.000	0.000	CII_Hunter_Fryingpan
Las Vegas NWR	NM	FWS	0.002	0.014	0.002	0.011	0.001	0.000	0.000	0.000	CII_Las_Vegas_NWR
Latir Peak Wilderness	NM	USFS	0.005	0.021	0.003	0.010	0.002	0.000	0.000	0.000	CII_Latir_Peak
Lizard Head Wilderness	CO	USFS	0.004	0.028	0.002	0.022	0.001	0.000	0.000	0.000	CII_Lizard_Head
Lost Creek Wilderness	CO	USFS	0.001	0.009	0.001	0.008	0.000	0.000	0.000	0.000	CII_Lost_Creek
Manzano Mountain Wilderness	NM	USFS	0.001	0.014	0.001	0.007	0.000	0.000	0.000	0.000	CII_Manzano_Mountain
Maxwell NWR	NM	FWS	0.002	0.008	0.001	0.006	0.001	0.000	0.000	0.000	CII_Maxwell_NWR
Monte Vista NWR	CO	FWS	0.009	0.034	0.005	0.030	0.004	0.000	0.000	0.000	CII_Monte_Vista_NWR
Mount Evans Wilderness	CO	USFS	0.000	0.007	0.000	0.006	0.000	0.000	0.000	0.000	CII_Mount_Evans
Mount Sneffels Wilderness	CO	USFS	0.003	0.022	0.002	0.017	0.001	0.000	0.000	0.000	CII_Mount_Sneffels
Natural Bridges NM	UT	NPS	0.007	0.025	0.003	0.011	0.001	0.000	0.000	0.000	CII_Natural_Bridges
Navajo NM	AZ	NPS	0.001	0.008	0.000	0.004	0.000	0.000	0.000	0.000	CII_Navajo
Petroglyph NM	NM	NPS	0.002	0.022	0.002	0.013	0.001	0.000	0.000	0.000	CII_Petroglyph
Powderhorn Wilderness	CO	USFS	0.004	0.021	0.002	0.015	0.001	0.000	0.000	0.000	CII_Powderhorn
Raggeds Wilderness	CO	USFS	0.001	0.013	0.001	0.010	0.001	0.000	0.000	0.000	CII_Raggeds
Rio Mora NWR and CA	NM	FWS	0.003	0.012	0.002	0.008	0.001	0.000	0.000	0.000	CII_Rio_Mora_NWR_and
Sandia Mountain Wilderness	NM	USFS	0.002	0.019	0.002	0.012	0.001	0.000	0.000	0.000	CII_Sandia_Mountain
Sangre de Cristo Wilderness	CO	USFS	0.004	0.021	0.003	0.015	0.002	0.000	0.000	0.000	CII_Sangre_de_Cristo
Savage Run Wilderness	WY	USFS	0.000	0.003	0.000	0.002	0.000	0.000	0.000	0.000	CII_Savage_Run
Sevilleta NWR	NM	FWS	0.001	0.018	0.001	0.011	0.001	0.000	0.000	0.000	CII_Sevilleta_NWR
South San Juan Wilderness	CO	USFS	0.045	0.070	0.017	0.030	0.007	0.001	0.001	0.000	CII_South_San_Juan
Spanish Peaks Wilderness	CO	USFS	0.003	0.013	0.002	0.007	0.001	0.000	0.000	0.000	CII_Spanish_Peaks
Uncompahgre Wilderness	CO	USFS	0.003	0.024	0.002	0.017	0.001	0.000	0.000	0.000	CII_Uncompahgre
Valle De Oro NWR	NM	FWS	0.002	0.026	0.002	0.019	0.001	0.000	0.000	0.000	CII_Valle_De_Oro_NWR
Withington Wilderness	NM	USFS	0.000	0.005	0.000	0.003	0.000	0.000	0.000	0.000	CII_Withington

5.1.2.2 Combined BLM Planning Area PSD Contributions

Below we examine the contributions of emissions to concentrations at Class I areas for three of the combination Source Groups: (R) Federal O&G and mining within the 13 Colorado BLM Planning Areas; (T) the Cumulative Emissions Scenario that includes new O&G and mining on Federal lands and new O&G on non-Federal lands within the 14 NM BLM Planning Areas; and (U) all O&G (new Federal and non-Federal and existing) throughout the 4 km CARMMS domain plus Federal mining. Results for the other Source Groups as well as results for the sensitive Class II areas are contained in Attachments A-1, A-2 and A-3.

Source Group R represents mining and new O&G development on Federal lands within the 13 Colorado BLM Planning Areas so represents potential new emissions that may be mitigated by the BLM COSO. The PSD contributions of Source Group R are below the Class I and Class II PSD increments at all Class I and sensitive Class II areas, respectively, for all PSD pollutants and averaging times and the 2021 High, Low and Medium Scenarios (Table 5-10). As a percentage of a PSD increment, the largest contribution at any Class I area due to Source Group R is 79% (1.97 $\mu g/m^3$), 10% (0.24 $\mu g/m^3$) and 67% (1.66 $\mu g/m^3$) of the 2.5 $\mu g/m^3$ annual NO_2 PSD Class I increment for the High, Low and Medium Development Scenarios, respectively, and occurs at the Mesa Verde National Park. These NO_2 impacts are primarily (99%) due to new Federal O&G emissions from the TRFO Planning Area.

The PSD pollutant concentrations contributions for the 2021 High and Low Development Scenarios are shown in Table 5-11 for Source Group T which is the Cumulative Emissions Scenario that includes new Federal and non-Federal oil and gas and Federal mining within the 14 BLM Colorado and Northern New Mexico Planning Areas. With one exception, the contribution of the Cumulative Emissions Scenario to PSD concentrations at all Class I and sensitive Class II areas are below the PSD Class I and II concentrations increments. The exception is for annual NO_2 at the Mesa Verde Class I area where the 2021 High, Low and Medium Development Scenario estimate an annual NO_2 contributions of, respectively, 4.47, 2.84 and 4.07 $\mu g/m^3$ that exceed the 2.5 $\mu g/m^3$ annual NO_2 PSD Class I area increment. Note that new Federal O&G emissions from the TRFO Planning Area contributed 1.96 $\mu g/m^3$ (High Scenario), 0.24 $\mu g/m^3$ (Low Scenario) and 1.65 $\mu g/m^3$ (Medium Scenario) to the maximum annual NO_2 at Mesa Verde and the split between new Federal and non-Federal O&G in the TRFO planning Area is 40% and 60%, respectively (see Table 3-2). Thus, the Cumulative Emissions Source Group T annual NO_2 contribution at Mesa Verde is mainly due to new Federal and non-Federal O&G development within the TRFO Planning Area.

The contributions of all O&G within the 4 km CARMMS domain plus Federal mining in Colorado (Source Group U) to PSD pollutants at Class I areas for the two 2021 emission scenarios are shown in Table 5-12. Again, with one exception, the contributions of all O&G emissions throughout the 4 km CARMMS domain produce PSD pollutant concentrations at all Class I and sensitive Class II areas that are below the PSD Class I and II area increments, respectively. The exception is the annual NO_2 at Mesa Verde Class I area where Source Group U contributes 4.75, 3.11 and 4.35 $\mu g/m^3$ for the High, Low and Medium Development Scenarios, respectively.

Table 5-10a. Contributions of new oil and gas and mining on Federal lands within the 13 Colorado BLM Planning Areas to PSD pollutant concentrations at Class I areas (Source Group R) for the 2021 High Development Scenario.

Group	G_R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas
Across grid cells	Maximum	Max

		Pollutant	NO_2 (μg/m[3])	PM_{10} (μg/m[3])		PM_{25} (μg/m[3])		SO_2 (μg/m[3])			
		Averaging Time	Annual[3]	24-hour[2]	Annual[3]	24-hour[4]	Annual[3]	3-hour[2]	24-hour[2]	Annual[3]	
			PSD Class I Increment[1]								
Class I	State	Owner	2.5	8	4	2	1	25	5	2	ShortName
Arches NP	UT	NPS	0.113	0.250	0.040	0.215	0.033	0.087	0.037	0.003	CI_Arches
Bandelier NM	NM	NPS	0.006	0.081	0.009	0.070	0.006	0.011	0.005	0.000	CI_Bandelier
Black Canyon of the Gunnison NM	CO	NPS	0.061	0.381	0.058	0.328	0.046	0.071	0.043	0.004	CI_Black_Canyon
Bosque del Apache Wilderness	NM	FWS	0.002	0.048	0.003	0.037	0.002	0.010	0.004	0.000	CI_Bosque
Canyonlands NP	UT	NPS	0.036	0.179	0.019	0.140	0.015	0.062	0.026	0.002	CI_Canyonlands
Capitol Reef NP	UT	NPS	0.003	0.061	0.003	0.048	0.003	0.021	0.007	0.000	CI_Capitol_Reef
Eagles Nest Wilderness	CO	FS	0.088	0.244	0.072	0.202	0.058	0.076	0.022	0.003	CI_Eagles_Nest
Flat Tops Wilderness	CO	FS	0.217	0.865	0.160	0.863	0.133	0.356	0.132	0.013	CI_Flat_Tops
Galiuro Wilderness	AZ	FS	0.000	0.006	0.000	0.005	0.000	0.002	0.000	0.000	CI_Galiuro
Gila Wilderness	NM	FS	0.001	0.026	0.001	0.020	0.001	0.009	0.003	0.000	CI_Gila
Great Sand Dunes NM	CO	NPS	0.014	0.129	0.023	0.112	0.019	0.023	0.009	0.001	CI_Great_Sand_Dunes
La Garita Wilderness	CO	FS	0.018	0.149	0.022	0.119	0.017	0.045	0.014	0.001	CI_La_Garita
Maroon Bells-Snowmass Wilderness	CO	FS	0.197	0.535	0.159	0.443	0.119	0.096	0.030	0.005	CI_Maroon_Bells
Mesa Verde NP	CO	NPS	1.966	1.284	0.492	0.338	0.104	0.047	0.018	0.002	CI_Mesa_Verde
Mount Baldy Wilderness	AZ	FS	0.000	0.030	0.001	0.026	0.001	0.005	0.002	0.000	CI_Mount_Baldy
Mount Zirkel Wilderness	CO	FS	0.089	0.776	0.193	0.764	0.184	0.150	0.054	0.008	CI_Mount_Zirkel
Pecos Wilderness	NM	FS	0.005	0.064	0.008	0.054	0.006	0.014	0.005	0.000	CI_Pecos
Petrified Forest NP	AZ	NPS	0.001	0.040	0.002	0.034	0.002	0.007	0.003	0.000	CI_Petrified_Forest
Rawah Wilderness	CO	FS	0.073	0.351	0.085	0.320	0.069	0.080	0.024	0.004	CI_Rawah
Rocky Mountain NP	CO	NPS	0.051	0.304	0.076	0.285	0.067	0.072	0.017	0.003	CI_Rocky_Mountain
Salt Creek Wilderness	NM	FWS	0.001	0.038	0.002	0.032	0.002	0.005	0.002	0.000	CI_Salt_Creek
San Pedro Parks Wilderness	NM	FS	0.008	0.077	0.009	0.057	0.006	0.019	0.007	0.000	CI_San_Pedro
Weminuche Wilderness	CO	FS	0.019	0.112	0.017	0.089	0.013	0.051	0.014	0.001	CI_Weminuche
West Elk Wilderness	CO	FS	0.117	0.683	0.173	0.663	0.152	0.079	0.031	0.003	CI_West_Elk
Wheeler Peak Wilderness	NM	FS	0.006	0.077	0.011	0.066	0.008	0.019	0.006	0.001	CI_Wheeler_Peak
White Mountain Wilderness	NM	FS	0.001	0.029	0.002	0.022	0.002	0.008	0.003	0.000	CI_White_Mountain
Dinosaur NM[5]	CO	NPS	NA	NA	NA	NA	NA	1.263	0.412	0.090	CI_Dinosaur_CO

Table 5-10b. Contributions of new oil and gas and mining on Federal lands within the 13 Colorado BLM Planning Areas to PSD pollutant concentrations at Class I areas (Source Group R) for the 2021 Low Development Scenario.

Group	G_R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas
Across grid cells	Maximum	Max

		Pollutant	NO_2 (μg/m[3])	PM_{10} (μg/m[3])		PM_{25} (μg/m[3])		SO_2 (μg/m[3])			
		Averaging Time	Annual[3]	24-hour[2]	Annual[3]	24-hour[4]	Annual[3]	3-hour[2]	24-hour[2]	Annual[3]	
			PSD Class I Increment[1]								
Class I	State	Owner	2.5	8	4	2	1	25	5	2	ShortName
Arches NP	UT	NPS	0.017	0.145	0.020	0.133	0.019	0.014	0.005	0.001	CI_Arches
Bandelier NM	NM	NPS	0.001	0.040	0.004	0.039	0.004	0.002	0.001	0.000	CI_Bandelier
Black Canyon of the Gunnison NM	CO	NPS	0.010	0.215	0.031	0.208	0.030	0.011	0.006	0.001	CI_Black_Canyon
Bosque del Apache Wilderness	NM	FWS	0.000	0.029	0.002	0.027	0.001	0.002	0.001	0.000	CI_Bosque
Canyonlands NP	UT	NPS	0.006	0.110	0.009	0.105	0.009	0.009	0.004	0.000	CI_Canyonlands
Capitol Reef NP	UT	NPS	0.000	0.040	0.002	0.038	0.002	0.004	0.001	0.000	CI_Capitol_Reef
Eagles Nest Wilderness	CO	FS	0.020	0.151	0.044	0.149	0.041	0.011	0.003	0.001	CI_Eagles_Nest
Flat Tops Wilderness	CO	FS	0.050	0.808	0.110	0.804	0.105	0.053	0.021	0.002	CI_Flat_Tops
Galiuro Wilderness	AZ	FS	0.000	0.003	0.000	0.003	0.000	0.000	0.000	0.000	CI_Galiuro
Gila Wilderness	NM	FS	0.000	0.016	0.001	0.015	0.001	0.001	0.001	0.000	CI_Gila
Great Sand Dunes NM	CO	NPS	0.004	0.069	0.012	0.066	0.011	0.004	0.002	0.000	CI_Great_Sand_Dunes
La Garita Wilderness	CO	FS	0.004	0.113	0.011	0.111	0.011	0.007	0.002	0.000	CI_La_Garita
Maroon Bells-Snowmass Wilderness	CO	FS	0.053	0.380	0.106	0.365	0.096	0.014	0.005	0.001	CI_Maroon_Bells
Mesa Verde NP	CO	NPS	0.237	0.160	0.063	0.131	0.031	0.007	0.003	0.000	CI_Mesa_Verde
Mount Baldy Wilderness	AZ	FS	0.000	0.013	0.001	0.012	0.000	0.001	0.000	0.000	CI_Mount_Baldy
Mount Zirkel Wilderness	CO	FS	0.021	0.735	0.171	0.733	0.170	0.022	0.008	0.001	CI_Mount_Zirkel
Pecos Wilderness	NM	FS	0.001	0.036	0.004	0.034	0.004	0.002	0.001	0.000	CI_Pecos
Petrified Forest NP	AZ	NPS	0.000	0.023	0.001	0.022	0.001	0.001	0.001	0.000	CI_Petrified_Forest
Rawah Wilderness	CO	FS	0.012	0.308	0.058	0.306	0.057	0.013	0.004	0.001	CI_Rawah
Rocky Mountain NP	CO	NPS	0.011	0.263	0.055	0.262	0.054	0.012	0.003	0.001	CI_Rocky_Mountain
Salt Creek Wilderness	NM	FWS	0.000	0.021	0.001	0.020	0.001	0.001	0.000	0.000	CI_Salt_Creek
San Pedro Parks Wilderness	NM	FS	0.001	0.040	0.004	0.038	0.004	0.003	0.001	0.000	CI_San_Pedro
Weminuche Wilderness	CO	FS	0.003	0.081	0.008	0.077	0.008	0.007	0.002	0.000	CI_Weminuche
West Elk Wilderness	CO	FS	0.033	0.649	0.139	0.644	0.135	0.011	0.005	0.001	CI_West_Elk
Wheeler Peak Wilderness	NM	FS	0.001	0.047	0.006	0.045	0.005	0.003	0.001	0.000	CI_Wheeler_Peak
White Mountain Wilderness	NM	FS	0.000	0.020	0.001	0.019	0.001	0.001	0.000	0.000	CI_White_Mountain
Dinosaur NM[5]	CO	NPS	NA	NA	NA	NA	NA	0.189	0.067	0.014	CI_Dinosaur_CO

Table 5-10c. Contributions of new oil and gas and mining on Federal lands within the 13 Colorado BLM Planning Areas to PSD pollutant concentrations at Class I areas (Source Group R) for the 2021 Medium Development Scenario.

Group	G_R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas
Across grid cells	Maximum	Max

		Pollutant	NO_2 (μg/m^3)	PM_{10} (μg/m^3)		PM_{25} (μg/m^3)		SO_2 (μg/m^3)			
		Averaging Time	Annual[3]	24-hour[2]	Annual[3]	24-hour[4]	Annual[3]	3-hour[2]	24-hour[2]	Annual[3]	
Class I	State	Owner	PSD Class I Increment[1]								ShortName
			2.5	8	4	2	1	25	5	2	
Arches NP	UT	NPS	0.107	0.213	0.034	0.199	0.031	0.087	0.037	0.003	CI_Arches
Bandelier NM	NM	NPS	0.005	0.067	0.007	0.063	0.006	0.011	0.005	0.000	CI_Bandelier
Black Canyon of the Gunnison NM	CO	NPS	0.054	0.322	0.047	0.301	0.043	0.071	0.043	0.004	CI_Black_Canyon
Bosque del Apache Wilderness	NM	FWS	0.001	0.037	0.002	0.033	0.002	0.010	0.004	0.000	CI_Bosque
Canyonlands NP	UT	NPS	0.033	0.144	0.015	0.130	0.013	0.062	0.026	0.002	CI_Canyonlands
Capitol Reef NP	UT	NPS	0.002	0.050	0.003	0.045	0.002	0.021	0.007	0.000	CI_Capitol_Reef
Eagles Nest Wilderness	CO	FS	0.076	0.195	0.059	0.184	0.053	0.076	0.022	0.003	CI_Eagles_Nest
Flat Tops Wilderness	CO	FS	0.170	0.863	0.137	0.862	0.126	0.356	0.132	0.013	CI_Flat_Tops
Galiuro Wilderness	AZ	FS	0.000	0.005	0.000	0.004	0.000	0.002	0.000	0.000	CI_Galiuro
Gila Wilderness	NM	FS	0.001	0.021	0.001	0.019	0.001	0.009	0.003	0.000	CI_Gila
Great Sand Dunes NM	CO	NPS	0.011	0.106	0.019	0.100	0.017	0.023	0.009	0.001	CI_Great_Sand_Dunes
La Garita Wilderness	CO	FS	0.016	0.119	0.018	0.116	0.016	0.045	0.014	0.001	CI_La_Garita
Maroon Bells-Snowmass Wilderness	CO	FS	0.146	0.455	0.127	0.417	0.111	0.096	0.030	0.005	CI_Maroon_Bells
Mesa Verde NP	CO	NPS	1.659	0.597	0.219	0.221	0.064	0.047	0.018	0.002	CI_Mesa_Verde
Mount Baldy Wilderness	AZ	FS	0.000	0.025	0.001	0.024	0.001	0.005	0.002	0.000	CI_Mount_Baldy
Mount Zirkel Wilderness	CO	FS	0.076	0.765	0.185	0.762	0.181	0.150	0.054	0.008	CI_Mount_Zirkel
Pecos Wilderness	NM	FS	0.004	0.053	0.006	0.049	0.005	0.014	0.005	0.000	CI_Pecos
Petrified Forest NP	AZ	NPS	0.001	0.034	0.002	0.032	0.002	0.007	0.003	0.000	CI_Petrified_Forest
Rawah Wilderness	CO	FS	0.053	0.324	0.072	0.316	0.065	0.080	0.024	0.004	CI_Rawah
Rocky Mountain NP	CO	NPS	0.041	0.282	0.067	0.275	0.064	0.072	0.017	0.003	CI_Rocky_Mountain
Salt Creek Wilderness	NM	FWS	0.001	0.031	0.002	0.029	0.002	0.005	0.002	0.000	CI_Salt_Creek
San Pedro Parks Wilderness	NM	FS	0.007	0.059	0.007	0.051	0.005	0.019	0.007	0.000	CI_San_Pedro
Weminuche Wilderness	CO	FS	0.016	0.094	0.013	0.085	0.011	0.051	0.014	0.001	CI_Weminuche
West Elk Wilderness	CO	FS	0.090	0.666	0.155	0.658	0.146	0.079	0.031	0.003	CI_West_Elk
Wheeler Peak Wilderness	NM	FS	0.005	0.065	0.009	0.061	0.008	0.019	0.006	0.001	CI_Wheeler_Peak
White Mountain Wilderness	NM	FS	0.001	0.024	0.002	0.021	0.002	0.008	0.003	0.000	CI_White_Mountain
Dinosaur NM[5]	CO	NPS	NA	NA	NA	NA	NA	1.263	0.412	0.090	CI_Dinosaur_CO

Table 5-11a. Contributions of new oil and gas and mining on Federal lands and new oil and gas on non-Federal lands within the 14 BLM Planning Areas to PSD pollutant concentrations at Class I and sensitive Class II areas (Source Group T) for the 2021 High Development Scenario.

Group	G_T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas
Across grid cells	Maximum	Max

		Pollutant	NO_2 (μg/m^3)	PM_{10} (μg/m^3)		PM_{25} (μg/m^3)		SO_2 (μg/m^3)			
		Averaging Time	Annual[3]	24-hour[2]	Annual[3]	24-hour[4]	Annual[3]	3-hour[2]	24-hour[2]	Annual[3]	
Class I	State	Owner	PSD Class I Increment[1]								ShortName
			2.5	8	4	2	1	25	5	2	
Arches NP	UT	NPS	0.225	0.445	0.063	0.346	0.049	0.103	0.044	0.004	CI_Arches
Bandelier NM	NM	NPS	0.027	0.201	0.027	0.139	0.014	0.013	0.006	0.000	CI_Bandelier
Black Canyon of the Gunnison NM	CO	NPS	0.416	0.693	0.171	0.512	0.078	0.083	0.050	0.004	CI_Black_Canyon
Bosque del Apache Wilderness	NM	FWS	0.004	0.084	0.007	0.052	0.004	0.012	0.004	0.000	CI_Bosque
Canyonlands NP	UT	NPS	0.067	0.250	0.032	0.181	0.021	0.072	0.031	0.002	CI_Canyonlands
Capitol Reef NP	UT	NPS	0.010	0.091	0.009	0.069	0.005	0.025	0.009	0.000	CI_Capitol_Reef
Eagles Nest Wilderness	CO	FS	0.181	0.391	0.105	0.313	0.077	0.088	0.026	0.004	CI_Eagles_Nest
Flat Tops Wilderness	CO	FS	0.374	0.974	0.201	0.866	0.156	0.405	0.150	0.015	CI_Flat_Tops
Galiuro Wilderness	AZ	FS	0.000	0.022	0.000	0.010	0.000	0.002	0.001	0.000	CI_Galiuro
Gila Wilderness	NM	FS	0.001	0.039	0.002	0.031	0.002	0.011	0.004	0.000	CI_Gila
Great Sand Dunes NM	CO	NPS	0.035	0.218	0.047	0.188	0.033	0.027	0.011	0.001	CI_Great_Sand_Dunes
La Garita Wilderness	CO	FS	0.042	0.241	0.038	0.181	0.026	0.052	0.016	0.002	CI_La_Garita
Maroon Bells-Snowmass Wilderness	CO	FS	0.367	0.710	0.216	0.531	0.146	0.110	0.034	0.006	CI_Maroon_Bells
Mesa Verde NP	CO	NPS	4.469	2.773	1.071	0.725	0.220	0.054	0.021	0.004	CI_Mesa_Verde
Mount Baldy Wilderness	AZ	FS	0.001	0.045	0.002	0.039	0.001	0.006	0.002	0.000	CI_Mount_Baldy
Mount Zirkel Wilderness	CO	FS	0.149	0.823	0.214	0.779	0.196	0.173	0.061	0.009	CI_Mount_Zirkel
Pecos Wilderness	NM	FS	0.024	0.145	0.024	0.102	0.012	0.017	0.006	0.001	CI_Pecos
Petrified Forest NP	AZ	NPS	0.004	0.076	0.005	0.049	0.003	0.009	0.004	0.000	CI_Petrified_Forest
Rawah Wilderness	CO	FS	0.136	0.417	0.118	0.334	0.083	0.091	0.028	0.004	CI_Rawah
Rocky Mountain NP	CO	NPS	0.184	1.612	0.183	0.886	0.094	0.083	0.020	0.004	CI_Rocky_Mountain
Salt Creek Wilderness	NM	FWS	0.004	0.069	0.007	0.048	0.004	0.005	0.003	0.000	CI_Salt_Creek
San Pedro Parks Wilderness	NM	FS	0.035	0.202	0.029	0.096	0.013	0.023	0.009	0.001	CI_San_Pedro
Weminuche Wilderness	CO	FS	0.078	0.199	0.056	0.129	0.025	0.059	0.017	0.001	CI_Weminuche
West Elk Wilderness	CO	FS	0.225	0.743	0.215	0.689	0.173	0.091	0.036	0.004	CI_West_Elk
Wheeler Peak Wilderness	NM	FS	0.024	0.128	0.028	0.095	0.016	0.022	0.007	0.001	CI_Wheeler_Peak
White Mountain Wilderness	NM	FS	0.003	0.060	0.005	0.036	0.003	0.009	0.003	0.000	CI_White_Mountain
Dinosaur NM[5]	CO	NPS	NA	NA	NA	NA	NA	1.435	0.469	0.102	CI_Dinosaur_CO

Table 5-11b. Contributions of new oil and gas and mining on Federal lands and new oil and gas on non-Federal lands within the 14 BLM Planning Areas to PSD pollutant concentrations at Class I and sensitive Class II areas (Source Group T) for the 2021 Low Development Scenario.

Group	G_T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas
Across grid cells	Maximum	Max

		Pollutant	NO_2 (µg/m[3])	PM_{10} (µg/m[3])		$PM_{2.5}$ (µg/m[3])		SO_2 (µg/m[3])			
		Averaging Time	Annual[3]	24-hour[2]	Annual[3]	24-hour[4]	Annual[3]	3-hour[2]	24-hour[2]	Annual[3]	
Class I	**State**	**Owner**	PSD Class I Increment[1]								**ShortName**
			2.5	8	4	2	1	25	5	2	
Arches NP	UT	NPS	0.068	0.202	0.033	0.172	0.028	0.019	0.008	0.001	CI_Arches
Bandelier NM	NM	NPS	0.015	0.113	0.016	0.078	0.009	0.003	0.001	0.000	CI_Bandelier
Black Canyon of the Gunnison NM	CO	NPS	0.068	0.298	0.050	0.264	0.040	0.015	0.009	0.001	CI_Black_Canyon
Bosque del Apache Wilderness	NM	FWS	0.002	0.048	0.004	0.033	0.002	0.002	0.001	0.000	CI_Bosque
Canyonlands NP	UT	NPS	0.026	0.149	0.018	0.120	0.013	0.012	0.006	0.000	CI_Canyonlands
Capitol Reef NP	UT	NPS	0.006	0.058	0.005	0.045	0.003	0.005	0.002	0.000	CI_Capitol_Reef
Eagles Nest Wilderness	CO	FS	0.062	0.191	0.062	0.175	0.052	0.015	0.005	0.001	CI_Eagles_Nest
Flat Tops Wilderness	CO	FS	0.136	0.852	0.134	0.832	0.118	0.068	0.027	0.003	CI_Flat_Tops
Galiuro Wilderness	AZ	FS	0.000	0.011	0.000	0.006	0.000	0.000	0.000	0.000	CI_Galiuro
Gila Wilderness	NM	FS	0.000	0.022	0.001	0.018	0.001	0.002	0.001	0.000	CI_Gila
Great Sand Dunes NM	CO	NPS	0.016	0.094	0.025	0.085	0.018	0.005	0.002	0.000	CI_Great_Sand_Dunes
La Garita Wilderness	CO	FS	0.017	0.120	0.021	0.115	0.016	0.009	0.003	0.000	CI_La_Garita
Maroon Bells-Snowmass Wilderness	CO	FS	0.108	0.445	0.127	0.398	0.107	0.018	0.006	0.001	CI_Maroon_Bells
Mesa Verde NP	CO	NPS	2.840	1.801	0.694	0.505	0.145	0.010	0.005	0.002	CI_Mesa_Verde
Mount Baldy Wilderness	AZ	FS	0.000	0.023	0.001	0.018	0.001	0.001	0.000	0.000	CI_Mount_Baldy
Mount Zirkel Wilderness	CO	FS	0.044	0.748	0.181	0.740	0.175	0.029	0.011	0.002	CI_Mount_Zirkel
Pecos Wilderness	NM	FS	0.013	0.083	0.014	0.056	0.008	0.003	0.001	0.000	CI_Pecos
Petrified Forest NP	AZ	NPS	0.002	0.044	0.003	0.031	0.002	0.002	0.001	0.000	CI_Petrified_Forest
Rawah Wilderness	CO	FS	0.036	0.320	0.072	0.311	0.063	0.016	0.005	0.001	CI_Rawah
Rocky Mountain NP	CO	NPS	0.067	0.678	0.090	0.397	0.063	0.016	0.004	0.001	CI_Rocky_Mountain
Salt Creek Wilderness	NM	FWS	0.002	0.038	0.004	0.025	0.002	0.001	0.001	0.000	CI_Salt_Creek
San Pedro Parks Wilderness	NM	FS	0.021	0.123	0.018	0.061	0.008	0.004	0.002	0.000	CI_San_Pedro
Weminuche Wilderness	CO	FS	0.045	0.125	0.034	0.083	0.016	0.010	0.003	0.000	CI_Weminuche
West Elk Wilderness	CO	FS	0.069	0.664	0.157	0.652	0.144	0.015	0.007	0.001	CI_West_Elk
Wheeler Peak Wilderness	NM	FS	0.012	0.079	0.016	0.060	0.010	0.004	0.001	0.000	CI_Wheeler_Peak
White Mountain Wilderness	NM	FS	0.001	0.033	0.003	0.023	0.002	0.002	0.001	0.000	CI_White_Mountain
Dinosaur NM[5]	CO	NPS	NA	NA	NA	NA	NA	0.240	0.085	0.018	CI_Dinosaur_CO

Table 5-11c. Contributions of new oil and gas and mining on Federal lands and new oil and gas on non-Federal lands within the 14 BLM Planning Areas to PSD pollutant concentrations at Class I and sensitive Class II areas (Source Group T) for the 2021 Medium Development Scenario.

Group	G_T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas
Across grid cells	Maximum	Max

		Pollutant	NO_2 (µg/m[3])	PM_{10} (µg/m[3])		$PM_{2.5}$ (µg/m[3])		SO_2 (µg/m[3])			
		Averaging Time	Annual[3]	24-hour[2]	Annual[3]	24-hour[4]	Annual[3]	3-hour[2]	24-hour[2]	Annual[3]	
Class I	**State**	**Owner**	PSD Class I Increment[1]								**ShortName**
			2.5	8	4	2	1	25	5	2	
Arches NP	UT	NPS	0.218	0.389	0.056	0.323	0.046	0.103	0.044	0.004	CI_Arches
Bandelier NM	NM	NPS	0.023	0.159	0.020	0.120	0.012	0.013	0.006	0.000	CI_Bandelier
Black Canyon of the Gunnison NM	CO	NPS	0.376	0.638	0.161	0.470	0.074	0.083	0.050	0.004	CI_Black_Canyon
Bosque del Apache Wilderness	NM	FWS	0.003	0.067	0.006	0.047	0.004	0.012	0.004	0.000	CI_Bosque
Canyonlands NP	UT	NPS	0.062	0.210	0.026	0.172	0.020	0.072	0.031	0.002	CI_Canyonlands
Capitol Reef NP	UT	NPS	0.009	0.076	0.007	0.060	0.004	0.025	0.009	0.000	CI_Capitol_Reef
Eagles Nest Wilderness	CO	FS	0.167	0.331	0.091	0.282	0.072	0.088	0.026	0.004	CI_Eagles_Nest
Flat Tops Wilderness	CO	FS	0.319	0.869	0.177	0.865	0.148	0.405	0.150	0.015	CI_Flat_Tops
Galiuro Wilderness	AZ	FS	0.000	0.018	0.000	0.008	0.000	0.002	0.001	0.000	CI_Galiuro
Gila Wilderness	NM	FS	0.001	0.034	0.002	0.028	0.002	0.011	0.004	0.000	CI_Gila
Great Sand Dunes NM	CO	NPS	0.031	0.189	0.039	0.169	0.030	0.027	0.011	0.001	CI_Great_Sand_Dunes
La Garita Wilderness	CO	FS	0.037	0.206	0.032	0.165	0.024	0.052	0.016	0.002	CI_La_Garita
Maroon Bells-Snowmass Wilderness	CO	FS	0.306	0.628	0.183	0.498	0.137	0.110	0.035	0.006	CI_Maroon_Bells
Mesa Verde NP	CO	NPS	4.077	2.042	0.782	0.600	0.176	0.054	0.021	0.004	CI_Mesa_Verde
Mount Baldy Wilderness	AZ	FS	0.001	0.039	0.002	0.035	0.001	0.006	0.002	0.000	CI_Mount_Baldy
Mount Zirkel Wilderness	CO	FS	0.133	0.798	0.205	0.776	0.193	0.172	0.061	0.009	CI_Mount_Zirkel
Pecos Wilderness	NM	FS	0.021	0.113	0.018	0.090	0.011	0.016	0.006	0.001	CI_Pecos
Petrified Forest NP	AZ	NPS	0.003	0.067	0.004	0.045	0.003	0.009	0.004	0.000	CI_Petrified_Forest
Rawah Wilderness	CO	FS	0.111	0.375	0.104	0.329	0.079	0.091	0.028	0.004	CI_Rawah
Rocky Mountain NP	CO	NPS	0.178	1.594	0.178	0.879	0.092	0.083	0.020	0.004	CI_Rocky_Mountain
Salt Creek Wilderness	NM	FWS	0.003	0.055	0.006	0.044	0.003	0.005	0.003	0.000	CI_Salt_Creek
San Pedro Parks Wilderness	NM	FS	0.031	0.138	0.021	0.086	0.011	0.022	0.009	0.001	CI_San_Pedro
Weminuche Wilderness	CO	FS	0.066	0.141	0.039	0.118	0.022	0.059	0.017	0.001	CI_Weminuche
West Elk Wilderness	CO	FS	0.192	0.715	0.195	0.683	0.167	0.091	0.036	0.004	CI_West_Elk
Wheeler Peak Wilderness	NM	FS	0.021	0.108	0.022	0.088	0.014	0.022	0.007	0.001	CI_Wheeler_Peak
White Mountain Wilderness	NM	FS	0.003	0.055	0.004	0.033	0.003	0.009	0.003	0.000	CI_White_Mountain
Dinosaur NM[5]	CO	NPS	NA	NA	NA	NA	NA	1.435	0.469	0.102	CI_Dinosaur_CO

Table 5-12a. Contributions of new Federal and non-Federal and existing oil and gas throughout the CARMMS 4 km domain and mining on Federal lands in Colorado to PSD pollutant concentrations at Class I areas (Source Group U) for the 2021 High Development Scenario.

Group	G_U	Combined O&G and Mining in 4 km domain
Across grid cells	Maximum	Max

Class I	State	Owner	NO₂ (µg/m³)	PM₁₀ (µg/m³)		PM₂₅ (µg/m³)		SO₂ (µg/m³)			ShortName
		Averaging Time	Annual[3]	24-hour[2]	Annual[3]	24-hour[4]	Annual[3]	3-hour[2]	24-hour[2]	Annual[3]	
		PSD Class I Increment[1]	2.5	8	4	2	1	25	5	2	
Arches NP	UT	NPS	0.344	0.578	0.096	0.431	0.080	0.107	0.046	0.006	CI_Arches
Bandelier NM	NM	NPS	0.335	0.612	0.063	0.562	0.048	0.106	0.039	0.005	CI_Bandelier
Black Canyon of the Gunnison NM	CO	NPS	0.471	0.764	0.199	0.619	0.105	0.086	0.052	0.006	CI_Black_Canyon
Bosque del Apache Wilderness	NM	FWS	0.021	0.151	0.013	0.126	0.010	0.047	0.019	0.001	CI_Bosque
Canyonlands NP	UT	NPS	0.155	0.357	0.052	0.287	0.041	0.176	0.070	0.006	CI_Canyonlands
Capitol Reef NP	UT	NPS	0.079	0.170	0.019	0.166	0.014	0.162	0.054	0.004	CI_Capitol_Reef
Eagles Nest Wilderness	CO	FS	0.237	0.566	0.132	0.486	0.100	0.093	0.029	0.005	CI_Eagles_Nest
Flat Tops Wilderness	CO	FS	0.497	1.095	0.241	0.881	0.190	0.422	0.157	0.017	CI_Flat_Tops
Galiuro Wilderness	AZ	FS	0.001	0.038	0.001	0.027	0.001	0.008	0.002	0.000	CI_Galiuro
Gila Wilderness	NM	FS	0.003	0.072	0.004	0.064	0.004	0.016	0.006	0.000	CI_Gila
Great Sand Dunes NM	CO	NPS	0.113	0.331	0.078	0.297	0.063	0.057	0.016	0.003	CI_Great_Sand_Dunes
La Garita Wilderness	CO	FS	0.131	0.346	0.059	0.298	0.045	0.074	0.024	0.004	CI_La_Garita
Maroon Bells-Snowmass Wilderness	CO	FS	0.435	0.827	0.242	0.588	0.168	0.114	0.036	0.007	CI_Maroon_Bells
Mesa Verde NP	CO	NPS	4.748	2.879	1.108	0.832	0.252	0.497	0.130	0.016	CI_Mesa_Verde
Mount Baldy Wilderness	AZ	FS	0.003	0.080	0.004	0.066	0.003	0.017	0.006	0.000	CI_Mount_Baldy
Mount Zirkel Wilderness	CO	FS	0.220	0.911	0.243	0.842	0.221	0.179	0.065	0.010	CI_Mount_Zirkel
Pecos Wilderness	NM	FS	0.185	0.337	0.046	0.272	0.033	0.096	0.040	0.005	CI_Pecos
Petrified Forest NP	AZ	NPS	0.027	0.112	0.008	0.089	0.007	0.137	0.018	0.001	CI_Petrified_Forest
Rawah Wilderness	CO	FS	0.203	0.494	0.149	0.385	0.103	0.095	0.029	0.005	CI_Rawah
Rocky Mountain NP	CO	NPS	0.238	1.882	0.207	1.164	0.117	0.087	0.021	0.005	CI_Rocky_Mountain
Salt Creek Wilderness	NM	FWS	0.026	0.121	0.012	0.098	0.009	0.176	0.038	0.002	CI_Salt_Creek
San Pedro Parks Wilderness	NM	FS	0.410	0.330	0.058	0.230	0.041	0.175	0.066	0.011	CI_San_Pedro
Weminuche Wilderness	CO	FS	0.429	0.494	0.097	0.459	0.062	0.171	0.046	0.006	CI_Weminuche
West Elk Wilderness	CO	FS	0.279	0.795	0.239	0.710	0.194	0.095	0.037	0.005	CI_West_Elk
Wheeler Peak Wilderness	NM	FS	0.140	0.252	0.052	0.207	0.038	0.072	0.021	0.004	CI_Wheeler_Peak
White Mountain Wilderness	NM	FS	0.014	0.116	0.010	0.095	0.008	0.025	0.010	0.001	CI_White_Mountain
Dinosaur NM[5]	CO	NPS	NA	NA	NA	NA	NA	1.495	0.487	0.108	CI_Dinosaur_CO

Table 5-12b. Contributions of new Federal and non-Federal and existing oil and gas throughout the CARMMS 4 km domain and mining on Federal lands in Colorado to PSD pollutant concentrations at Class I areas (Source Group U) for the 2021 Low Development Scenario.

Group	G_U	Combined O&G and Mining in 4 km domain
Across grid cells	Maximum	Max

Class I	State	Owner	NO₂ (µg/m³)	PM₁₀ (µg/m³)		PM₂₅ (µg/m³)		SO₂ (µg/m³)			ShortName
		Averaging Time	Annual[3]	24-hour[2]	Annual[3]	24-hour[4]	Annual[3]	3-hour[2]	24-hour[2]	Annual[3]	
		PSD Class I Increment[1]	2.5	8	4	2	1	25	5	2	
Arches NP	UT	NPS	0.185	0.374	0.067	0.311	0.060	0.066	0.032	0.003	CI_Arches
Bandelier NM	NM	NPS	0.324	0.513	0.052	0.485	0.043	0.105	0.038	0.005	CI_Bandelier
Black Canyon of the Gunnison NM	CO	NPS	0.120	0.434	0.080	0.385	0.068	0.040	0.014	0.003	CI_Black_Canyon
Bosque del Apache Wilderness	NM	FWS	0.020	0.123	0.010	0.109	0.009	0.047	0.019	0.001	CI_Bosque
Canyonlands NP	UT	NPS	0.130	0.295	0.039	0.243	0.033	0.175	0.069	0.006	CI_Canyonlands
Capitol Reef NP	UT	NPS	0.075	0.161	0.015	0.158	0.013	0.160	0.054	0.003	CI_Capitol_Reef
Eagles Nest Wilderness	CO	FS	0.123	0.401	0.090	0.360	0.076	0.020	0.014	0.002	CI_Eagles_Nest
Flat Tops Wilderness	CO	FS	0.259	0.877	0.176	0.872	0.154	0.082	0.033	0.005	CI_Flat_Tops
Galiuro Wilderness	AZ	FS	0.000	0.028	0.001	0.022	0.000	0.008	0.002	0.000	CI_Galiuro
Gila Wilderness	NM	FS	0.003	0.055	0.003	0.051	0.003	0.015	0.005	0.000	CI_Gila
Great Sand Dunes NM	CO	NPS	0.093	0.279	0.056	0.253	0.048	0.057	0.016	0.002	CI_Great_Sand_Dunes
La Garita Wilderness	CO	FS	0.110	0.263	0.042	0.250	0.035	0.074	0.024	0.003	CI_La_Garita
Maroon Bells-Snowmass Wilderness	CO	FS	0.189	0.520	0.156	0.450	0.131	0.029	0.012	0.003	CI_Maroon_Bells
Mesa Verde NP	CO	NPS	3.113	1.911	0.732	0.614	0.179	0.497	0.125	0.015	CI_Mesa_Verde
Mount Baldy Wilderness	AZ	FS	0.002	0.061	0.003	0.050	0.003	0.017	0.006	0.000	CI_Mount_Baldy
Mount Zirkel Wilderness	CO	FS	0.115	0.817	0.211	0.804	0.201	0.035	0.015	0.003	CI_Mount_Zirkel
Pecos Wilderness	NM	FS	0.175	0.228	0.036	0.198	0.029	0.096	0.039	0.004	CI_Pecos
Petrified Forest NP	AZ	NPS	0.025	0.091	0.007	0.079	0.006	0.135	0.017	0.001	CI_Petrified_Forest
Rawah Wilderness	CO	FS	0.102	0.400	0.104	0.346	0.084	0.020	0.007	0.002	CI_Rawah
Rocky Mountain NP	CO	NPS	0.118	0.997	0.115	0.714	0.083	0.020	0.009	0.002	CI_Rocky_Mountain
Salt Creek Wilderness	NM	FWS	0.024	0.096	0.009	0.083	0.008	0.176	0.038	0.002	CI_Salt_Creek
San Pedro Parks Wilderness	NM	FS	0.396	0.253	0.047	0.216	0.036	0.174	0.064	0.010	CI_San_Pedro
Weminuche Wilderness	CO	FS	0.396	0.463	0.075	0.439	0.053	0.171	0.046	0.005	CI_Weminuche
West Elk Wilderness	CO	FS	0.121	0.683	0.182	0.669	0.167	0.034	0.011	0.003	CI_West_Elk
Wheeler Peak Wilderness	NM	FS	0.128	0.209	0.040	0.186	0.032	0.071	0.021	0.003	CI_Wheeler_Peak
White Mountain Wilderness	NM	FS	0.013	0.098	0.008	0.087	0.006	0.022	0.008	0.001	CI_White_Mountain
Dinosaur NM[5]	CO	NPS	NA	NA	NA	NA	NA	0.294	0.103	0.024	CI_Dinosaur_CO

Table 5-12c. Contributions of new Federal and non-Federal and existing oil and gas throughout the CARMMS 4 km domain and mining on Federal lands in Colorado to PSD pollutant concentrations at Class I areas (Source Group U) for the 2021 Medium Development Scenario.

Group	G_U	Combined O&G and Mining in 4 km domain									
Across grid cells	Maximum	Max									
		Pollutant	NO_2 (µg/m^3)	PM_{10} (µg/m^3)		PM_{25} (µg/m^3)		SO_2 (µg/m^3)			ShortName
		Averaging Time	Annual[3]	24-hour[2]	Annual[3]	24-hour[4]	Annual[3]	3-hour[2]	24-hour[2]	Annual[3]	
Class I	State	Owner	PSD Class I Increment[1]								
			2.5	8	4	2	1	25	5	2	
Arches NP	UT	NPS	0.337	0.506	0.089	0.414	0.078	0.107	0.046	0.006	CI_Arches
Bandelier NM	NM	NPS	0.332	0.580	0.056	0.546	0.046	0.106	0.039	0.005	CI_Bandelier
Black Canyon of the Gunnison NM	CO	NPS	0.431	0.711	0.189	0.572	0.100	0.086	0.052	0.006	CI_Black_Canyon
Bosque del Apache Wilderness	NM	FWS	0.021	0.140	0.012	0.123	0.010	0.047	0.019	0.001	CI_Bosque
Canyonlands NP	UT	NPS	0.151	0.314	0.047	0.279	0.039	0.176	0.070	0.006	CI_Canyonlands
Capitol Reef NP	UT	NPS	0.078	0.166	0.017	0.163	0.014	0.162	0.054	0.004	CI_Capitol_Reef
Eagles Nest Wilderness	CO	FS	0.214	0.513	0.118	0.462	0.095	0.093	0.028	0.005	CI_Eagles_Nest
Flat Tops Wilderness	CO	FS	0.442	0.961	0.218	0.880	0.182	0.422	0.157	0.017	CI_Flat_Tops
Galiuro Wilderness	AZ	FS	0.001	0.034	0.001	0.026	0.001	0.008	0.002	0.000	CI_Galiuro
Gila Wilderness	NM	FS	0.003	0.067	0.004	0.061	0.003	0.016	0.006	0.000	CI_Gila
Great Sand Dunes NM	CO	NPS	0.108	0.303	0.071	0.279	0.060	0.057	0.016	0.003	CI_Great_Sand_Dunes
La Garita Wilderness	CO	FS	0.126	0.321	0.052	0.287	0.043	0.074	0.024	0.004	CI_La_Garita
Maroon Bells-Snowmass Wilderness	CO	FS	0.382	0.705	0.210	0.562	0.159	0.115	0.036	0.007	CI_Maroon_Bells
Mesa Verde NP	CO	NPS	4.354	2.149	0.820	0.708	0.208	0.497	0.130	0.015	CI_Mesa_Verde
Mount Baldy Wilderness	AZ	FS	0.003	0.073	0.004	0.063	0.003	0.017	0.006	0.000	CI_Mount_Baldy
Mount Zirkel Wilderness	CO	FS	0.204	0.874	0.234	0.840	0.218	0.179	0.065	0.010	CI_Mount_Zirkel
Pecos Wilderness	NM	FS	0.182	0.324	0.040	0.266	0.032	0.096	0.040	0.005	CI_Pecos
Petrified Forest NP	AZ	NPS	0.027	0.097	0.008	0.084	0.006	0.137	0.018	0.001	CI_Petrified_Forest
Rawah Wilderness	CO	FS	0.178	0.462	0.135	0.376	0.100	0.095	0.029	0.005	CI_Rawah
Rocky Mountain NP	CO	NPS	0.232	1.850	0.202	1.152	0.115	0.087	0.021	0.005	CI_Rocky_Mountain
Salt Creek Wilderness	NM	FWS	0.026	0.109	0.011	0.093	0.009	0.176	0.038	0.002	CI_Salt_Creek
San Pedro Parks Wilderness	NM	FS	0.406	0.267	0.050	0.225	0.039	0.175	0.066	0.010	CI_San_Pedro
Weminuche Wilderness	CO	FS	0.418	0.470	0.080	0.449	0.058	0.171	0.046	0.006	CI_Weminuche
West Elk Wilderness	CO	FS	0.246	0.750	0.220	0.698	0.188	0.095	0.037	0.005	CI_West_Elk
Wheeler Peak Wilderness	NM	FS	0.137	0.234	0.046	0.201	0.036	0.072	0.021	0.004	CI_Wheeler_Peak
White Mountain Wilderness	NM	FS	0.014	0.105	0.009	0.093	0.007	0.025	0.010	0.001	CI_White_Mountain
Dinosaur NM[5]	CO	NPS	NA	NA	NA	NA	NA	1.495	0.487	0.108	CI_Dinosaur_CO

5.2 Visibility Impacts at Class I/II Areas using FLAG (2010)

Attachments B-1, B-2 and B-3 are interactive Excel spreadsheets that contain the visibility impacts at Class I and sensitive Class II areas due to emissions from the 32 Source Groups using the FLAG (2010) procedures as described in Section 4.6. There are four interactive sheets in Attachment B:

> "Table1" shows maximum change in (delta) visibility (Δdv), the day of maximum Δdv and number of days that Δdv exceed the 0.5 and 1.0 dv thresholds for all Class I/II areas and a user selected Source Group that is controlled in cell B1.
>
> "Table2" shows the temporal distribution (i.e., maximum and minimum and 98th, 80th and 20th percentiles) of Δdv by user selected Source Group (controlled by cell B1) for all Class I and II areas.
>
> "Table3" shows maximum (or 98th, 80th, 20th or minimum controlled by cell B1) impact of Δdv from all Source Groups across all Class I, all Class II and combined all Class I and II areas.
>
> "Table4" shows the maximum number of days that Δdv is greater than the 0.5 and 1.0 dv thresholds at any Class I or II area for all 32 Source Groups.
>
> "Table 5" shows the number of days that Δdv is greater than the 0.5 and 1.0 dv thresholds and the maximum Δdv at each Class I and sensitive Class II area for a user-selected Source Group controlled by cell B1.

Additional information describing the Attachment B-1 and B-2 spreadsheets are contained in sheets “Readme” and “Ref.”

5.2.1 Maximum Visibility Impacts at any Class I Area for all Source Groups

Table 5-13 displays the Class I and II areas where the maximum number of days Δdv exceeds the 0.5 and 1.0 thresholds occurred for each of the Source Groups in the 2021 High Development Scenario. Tables 5-14 and 5-15 show the same information for the 2021 Low and Medium Development Scenarios, respectively. These Tables were obtained from “Table4” in Attachments B-1, B-2 and B-3. The maximum Δdv impact at any Class I and II area due to each the Source Groups for the 2021 High, Low and Medium Development Scenarios are shown in Table 5-16.

Of the 14 BLM Colorado and New Mexico Planning Areas (Source Groups A through N) plus the total CRFO (Source Group O) and RGFO (Source Group P) Planning Areas, only three have Federal O&G with Δdv visibility impacts at any Class I area that exceed the 0.5 dv threshold for the 2021 High Development Scenario as follows (Table 5-13a):

- WRFO with 6 days of Δdv > 0.5 and no days with Δdv > 1.0 (Table 5-13a) and maximum Δdv of 0.789 at Flats Tops Wilderness Area (Table 5-16a).
- GRFO with 2 days of Δdv > 0.5 and no days with Δdv > 1.0 and maximum Δdv of 0.900 at Arches National Park.
- TRFO with 35 days of Δdv > 0.5 and 4 days with Δdv > 1.0 and maximum Δdv of 1.42 at Mesa Verde National Park.

The individual Source Groups A through P of Federal O&G emissions in BLM Planning have no days with Δdv > 0.5 at any Class I area for the 2021 Low Development Scenario (Table 5-14a). The maximum Δdv at any Class I area for Federal O&G within an individual BLM Planning Area and the 2021 Low Development Scenario is 0.21 from the Tres Rios Field Office (Table 5-16b).

Results for the 2021 Medium Development Scenario are similar but lower than the High Development Scenario with WRFO, GRFO and TRFO having 4, 2 and 5 days with Δdv > 0.5 at any Class I area with TRFO having 1 day with Δdv > 1.0 at any Class I area (Table 5-15a).

When looking at the 2021 High Development Scenario visibility impacts at Sensitive Class II areas, four of the 18 BLM Planning Areas (Source Groups A through P) have maximum Δdv that exceeds the 0.5 threshold: WRFO, GJFO and TRFO, as seen for Class I areas, but also NMFFO for the Class II areas (Tables 5-13b and 5-16a).

- WRFO with 40 days of Δdv > 0.5 and 5 days with Δdv > 1.0 and maximum Δdv of 1.43 at Dinosaur National Monument.
- GRFO with 23 days of Δdv > 0.5 and 3 days with Δdv > 1.0 and maximum Δdv of 1.46 at Colorado National Monument.
- TRFO with 16 days of Δdv > 0.5 and 3 days with Δdv > 1.0 and maximum Δdv of 1.47 at Hovenweep National Monument.

- NMFFO with 210 days of Δdv > 0.5 and 50 days with Δdv > 1.0 and maximum Δdv of 2.46 at Aztec Ruins National Monument.

For the 2021 Low Development Scenario, there is only one BLM Planning Area that has visibility impacts greater than 0.5 dv at any Class II area and that is for the NMFFO. This has 60 days of Δdv > 0.5 and 3 days with Δdv > 1.0 and a maximum Δdv of 1.31 at the Aztec Ruins National Monument.

New O&G development on Federal lands result in exceedances of the 0.5 dv visibility threshold at Class II areas for the 2021 Medium Development Scenario for the same four BLM Planning Areas as seen for the 2021 High Development Scenarios only with lower number of days (Tables 5-15b and 5-16c).

- WRFO with 38 days of Δdv > 0.5 and 5 days with Δdv > 1.0 and maximum Δdv of 1.34 at Dinosaur National Monument.
- GRFO with 19 days of Δdv > 0.5 and 3 days with Δdv > 1.0 and maximum Δdv of 1.28 at Colorado National Monument.
- TRFO with 5 days of Δdv > 0.5 and 1 day with Δdv > 1.0 and maximum Δdv of 1.18 at Hovenweep National Monument.
- NMFFO with 77 days of Δdv > 0.5 and 3 days with Δdv > 1.0 and maximum Δdv of 1.60 at Aztec Ruins National Monument.

Not surprisingly, when looking at visibility impacts using the FLAG (2010) approach at Class I/II areas due to O&G emissions across combined BLM Planning Areas there are greater visibility impacts than for any individual BLM Planning Area. The FLMs have developed a Cumulative Visibility approach using the regional haze Worst 20 percent days (W20%) and Best 20 percent days (B20%) regional haze rule metric that is used to assess the visibility impacts for these combined Source Groups that is discussed in Section 5.3. The combined Source Group visibility impacts at Class I/II areas using the FLAG (2010) method in Figures 5-13 through 5-15 are provided for information only.

Table 5-13a. Class I area where each of the Source Groups have the maximum number of days that Δdv exceeds the 0.5 and 1.0 dv thresholds for the High Development Scenario.

Source Group	Group Name	>0.5		>1.0	
		Max # of Day @ Class I	Class I (Max Occurs)	Max # of Day @ Class I	Class I (Max Occurs)
A	Little Snake FO	0	NA	0	NA
B	White River FO	6	CI_Flat_Tops	0	NA
C	Colorado River Valley FO (CRVFO)	0	NA	0	NA
D	Roan Plateau Planning area portion of CRVFO	0	NA	0	NA
E	Grand Junction FO	2	CI_Arches	0	NA
F	Uncompahgre FO	0	NA	0	NA
G	Tres Rios FO	35	CI_Mesa_Verde	4	CI_Mesa_Verde
H	Kremmling FO	0	NA	0	NA
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0	NA	0	NA
J	Pawnee Grasslands portion of RGFO#1	0	NA	0	NA
K	RGFO#2 – West-Central/South	0	NA	0	NA
L	RGFO#3 – South	0	NA	0	NA
M	RGFO#4 – East-Central	0	NA	0	NA
N	New Mexico Farmington FO	0	NA	0	NA
O	Total Colorado River Field Office	0	NA	0	NA
P	Total Royal Gorge Field Office	0	NA	0	NA
Q	Mining from 13 Colorado BLM Planning Areas	14	CI_Mount_Zirkel	0	NA
R	Combined new Federal O&G and Mining from the 13 Colo	50	CI_Mesa_Verde	4	CI_Mesa_Verde
S	Combined new Federal and non-Federal O&G and Mining	281	CI_Mesa_Verde	55	CI_Mesa_Verde
T	Cumulative Emissions Scenario – New Federal and non-Fe	284	CI_Mesa_Verde	61	CI_Mesa_Verde
U	Combined O&G and Mining in 4 km domain	311	CI_Mesa_Verde	104	CI_Mesa_Verde
V	Natural Emissions	192	CI_Bosque	139	CI_Bosque
W	2021 All Emissions	365	CI_Arches	365	CI_Arches
X	2008 All Emissions	365	CI_Arches	365	CI_Arches
Y	Coal EGU NM	236	CI_Petrified_Forest	120	CI_Petrified_Forest
Z	Coal EGU CO	166	CI_Mount_Zirkel	56	CI_Mount_Zirkel
AA	Oil/Gas EGU NM	0	NA	0	NA
AB	Oil/Gas EGU CO	0	NA	0	NA
AC	All EGUs in 4km Domain	242	CI_Petrified_Forest	123	CI_Petrified_Forest
AD	CO Mining + Coal EGUs CO	219	CI_Mount_Zirkel	80	CI_Mount_Zirkel
AE	CO O&G + Oil/Gas EGUs CO	45	CI_Mesa_Verde	4	CI_Mesa_Verde
AF	NM O&G + Oil/Gas EGU NM	0	NA	0	NA

Table 5-13b. Sensitive Class II area where each of the Source Groups has the maximum number of days that Δdv exceeds the 0.5 and 1.0 dv thresholds for the High Development Scenario.

		>0.5		>1.0	
Source Group	Group Name	Max # of Day @ Class II	Class II (Max Occurs)	Max # of Day @ Class II	Class II (Max Occurs)
A	Little Snake FO	0	NA	0	NA
B	White River FO	40	CII_Dinosaur_all	5	CII_Dinosaur_all
C	Colorado River Valley FO (CRVFO)	0	NA	0	NA
D	Roan Plateau Planning area portion of CRVFO	0	NA	0	NA
E	Grand Junction FO	23	CII_Colorado	3	CII_Colorado
F	Uncompahgre FO	0	NA	0	NA
G	Tres Rios FO	16	CII_South_San_Juan	3	CII_Hovenweep
H	Kremmling FO	0	NA	0	NA
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0	NA	0	NA
J	Pawnee Grasslands portion of RGFO#1	0	NA	0	NA
K	RGFO#2 – West-Central/South	0	NA	0	NA
L	RGFO#3 – South	0	NA	0	NA
M	RGFO#4 – East-Central	0	NA	0	NA
N	New Mexico Farmington FO	210	CII_Aztec_Ruins	50	CII_Aztec_Ruins
O	Total Colorado River Field Office	0	NA	0	NA
P	Total Royal Gorge Field Office	0	NA	0	NA
Q	Mining from 13 Colorado BLM Planning Areas	20	CII_Raggeds	3	CII_Raggeds
R	Combined new Federal O&G and Mining from the 13 Colo	96	CII_Dinosaur_all	17	CII_Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining	286	CII_South_San_Juan	41	CII_Colorado
T	Cumulative Emissions Scenario – New Federal and non-Fe	298	CII_South_San_Juan	133	CII_Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	350	CII_Aztec_Ruins	278	CII_Aztec_Ruins
V	Natural Emissions	246	CII_Sevilleta_NWR	202	CII_Sevilleta_NWR
W	2021 All Emissions	365	CII_Alamosa_NWR	365	CII_Alamosa_NWR
X	2008 All Emissions	365	CII_Alamosa_NWR	365	CII_Alamosa_NWR
Y	Coal EGU NM	118	CII_Aztec_Ruins	52	CII_Aztec_Ruins
Z	Coal EGU CO	0	NA	100	CII_Dinosaur_all
AA	Oil/Gas EGU NM	5	CII_Dinosaur_all	0	NA
AB	Oil/Gas EGU CO	0	NA	0	NA
AC	All EGUs in 4km Domain	0	NA	106	CII_Dinosaur_all
AD	CO Mining + Coal EGUs CO	3	CII_Colorado	110	CII_Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	0	NA	10	CII_Colorado
AF	NM O&G + Oil/Gas EGU NM	3	CII_Hovenweep	50	CII_Aztec_Ruins

Table 5-14a. Class I area where each of the Source Groups have the maximum number of days that Δdv exceeds the 0.5 and 1.0 dv thresholds for the Low Development Scenario.

Source Group	Group Name	>0.5		>1.0	
		Max # of Day @ Class I	Class I (Max Occurs)	Max # of Day @ Class I	Class I (Max Occurs)
A	Little Snake FO	0	NA	0	NA
B	White River FO	0	NA	0	NA
C	Colorado River Valley FO (CRVFO)	0	NA	0	NA
D	Roan Plateau Planning area portion of CRVFO	0	NA	0	NA
E	Grand Junction FO	0	NA	0	NA
F	Uncompahgre FO	0	NA	0	NA
G	Tres Rios FO	0	NA	0	NA
H	Kremmling FO	0	NA	0	NA
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0	NA	0	NA
J	Pawnee Grasslands portion of RGFO#1	0	NA	0	NA
K	RGFO#2 – West-Central/South	0	NA	0	NA
L	RGFO#3 – South	0	NA	0	NA
M	RGFO#4 – East-Central	0	NA	0	NA
N	New Mexico Farmington FO	0	NA	0	NA
O	Total Colorado River Field Office	0	NA	0	NA
P	Total Royal Gorge Field Office	0	NA	0	NA
Q	Mining from 13 Colorado BLM Planning Areas	14	CI_Mount_Zirkel	0	NA
R	Combined new Federal O&G and Mining from the 13 Colo	16	CI_Mount_Zirkel	0	NA
S	Combined new Federal and non-Federal O&G and Mining	131	CI_Mesa_Verde	9	CI_Mesa_Verde
T	Cumulative Emissions Scenario – New Federal and non-Fe	138	CI_Mesa_Verde	11	CI_Mesa_Verde
U	Combined O&G and Mining in 4 km domain	197	CI_Mesa_Verde	39	CI_Mesa_Verde
V	Natural Emissions	192	CI_Bosque	139	CI_Bosque
W	2021 All Emissions	365	CI_Arches	365	CI_Arches
X	2008 All Emissions	365	CI_Arches	365	CI_Arches
Y	Coal EGU NM	236	CI_Petrified_Forest	120	CI_Petrified_Forest
Z	Coal EGU CO	166	CI_Mount_Zirkel	56	CI_Mount_Zirkel
AA	Oil/Gas EGU NM	0	NA	0	NA
AB	Oil/Gas EGU CO	0	NA	0	NA
AC	All EGUs in 4km Domain	242	CI_Petrified_Forest	123	CI_Petrified_Forest
AD	CO Mining + Coal EGUs CO	219	CI_Mount_Zirkel	80	CI_Mount_Zirkel
AE	CO O&G + Oil/Gas EGUs CO	121	CI_Mesa_Verde	8	CI_Mesa_Verde
AF	NM O&G + Oil/Gas EGU NM	0	NA	0	NA

Table 5-14b. Sensitive Class II area where each of the Source Groups has the maximum number of days that Δdv exceeds the 0.5 and 1.0 dv thresholds for the Low Development Scenario.

		>0.5		>1.0	
Source Group	Group Name	Max # of Day @ Class II	Class II (Max Occurs)	Max # of Day @ Class II	Class II (Max Occurs)
A	Little Snake FO	0	NA	0	NA
B	White River FO	0	NA	0	NA
C	Colorado River Valley FO (CRVFO)	0	NA	0	NA
D	Roan Plateau Planning area portion of CRVFO	0	NA	0	NA
E	Grand Junction FO	0	NA	0	NA
F	Uncompahgre FO	0	NA	0	NA
G	Tres Rios FO	0	NA	0	NA
H	Kremmling FO	0	NA	0	NA
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0	NA	0	NA
J	Pawnee Grasslands portion of RGFO#1	0	NA	0	NA
K	RGFO#2 – West-Central/South	0	NA	0	NA
L	RGFO#3 – South	0	NA	0	NA
M	RGFO#4 – East-Central	0	NA	0	NA
N	New Mexico Farmington FO	60	CII_Aztec_Ruins	3	CII_Aztec_Ruins
O	Total Colorado River Field Office	0	NA	0	NA
P	Total Royal Gorge Field Office	0	NA	0	NA
Q	Mining from 13 Colorado BLM Planning Areas	20	CII_Raggeds	3	CII_Raggeds
R	Combined new Federal O&G and Mining from the 13 Colo	23	CII_Raggeds	3	CII_Raggeds
S	Combined new Federal and non-Federal O&G and Mining	89	CII_South_San_Juan	16	CII_Hovenweep
T	Cumulative Emissions Scenario – New Federal and non-Fe	215	CII_Aztec_Ruins	47	CII_Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	338	CII_Aztec_Ruins	238	CII_Aztec_Ruins
V	Natural Emissions	246	CII_Sevilleta_NWR	202	CII_Sevilleta_NWR
W	2021 All Emissions	365	CII_Alamosa_NWR	365	CII_Alamosa_NWR
X	2008 All Emissions	365	CII_Alamosa_NWR	365	CII_Alamosa_NWR
Y	Coal EGU NM	118	CII_Aztec_Ruins	52	CII_Aztec_Ruins
Z	Coal EGU CO	152	CII_Dinosaur_all	100	CII_Dinosaur_all
AA	Oil/Gas EGU NM	0	NA	0	NA
AB	Oil/Gas EGU CO	0	NA	0	NA
AC	All EGUs in 4km Domain	159	CII_Dinosaur_all	106	CII_Dinosaur_all
AD	CO Mining + Coal EGUs CO	166	CII_Dinosaur_all	110	CII_Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	87	CII_South_San_Juan	14	CII_Hovenweep
AF	NM O&G + Oil/Gas EGU NM	60	CII_Aztec_Ruins	3	CII_Aztec_Ruins

Table 5-15a. Class I area where each of the Source Groups have the maximum number of days that Δdv exceeds the 0.5 and 1.0 dv thresholds for the Medium Development Scenario.

Source Group	Group Name	>0.5		>1.0	
		Max # of Day @ Class I	Class I (Max Occurs)	Max # of Day @ Class I	Class I (Max Occurs)
A	Little Snake FO	0	NA	0	NA
B	White River FO	4	CI_Flat_Tops	0	NA
C	Colorado River Valley FO (CRVFO)	0	NA	0	NA
D	Roan Plateau Planning area portion of CRVFO	0	NA	0	NA
E	Grand Junction FO	2	CI_Arches	0	NA
F	Uncompahgre FO	0	NA	0	NA
G	Tres Rios FO	5	CI_Mesa_Verde	1	CI_Mesa_Verde
H	Kremmling FO	0	NA	0	NA
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0	NA	0	NA
J	Pawnee Grasslands portion of RGFO#1	0	NA	0	NA
K	RGFO#2 – West-Central/South	0	NA	0	NA
L	RGFO#3 – South	0	NA	0	NA
M	RGFO#4 – East-Central	0	NA	0	NA
N	New Mexico Farmington FO	0	NA	0	NA
O	Total Colorado River Field Office	0	NA	0	NA
P	Total Royal Gorge Field Office	0	NA	0	NA
Q	Mining from 13 Colorado BLM Planning Areas	14	CI_Mount_Zirkel	0	NA
R	Combined new Federal O&G and Mining from the 13 Colo	26	CI_Mount_Zirkel	1	CI_Black_Canyon
S	Combined new Federal and non-Federal O&G and Mining	203	CI_Mesa_Verde	28	CI_Rocky_Mountain
T	Cumulative Emissions Scenario – New Federal and non-Fe	212	CI_Mesa_Verde	28	CI_Rocky_Mountain
U	Combined O&G and Mining in 4 km domain	264	CI_Mesa_Verde	63	CI_Mesa_Verde
V	Natural Emissions	192	CI_Bosque	139	CI_Bosque
W	2021 All Emissions	365	CI_Arches	365	CI_Arches
X	2008 All Emissions	365	CI_Arches	365	CI_Arches
Y	Coal EGU NM	236	CI_Petrified_Forest	120	CI_Petrified_Forest
Z	Coal EGU CO	166	CI_Mount_Zirkel	56	CI_Mount_Zirkel
AA	Oil/Gas EGU NM	0	NA	0	NA
AB	Oil/Gas EGU CO	0	NA	0	NA
AC	All EGUs in 4km Domain	242	CI_Petrified_Forest	123	CI_Petrified_Forest
AD	CO Mining + Coal EGUs CO	219	CI_Mount_Zirkel	80	CI_Mount_Zirkel
AE	CO O&G + Oil/Gas EGUs CO	10	CI_Black_Canyon	1	CI_Mesa_Verde
AF	NM O&G + Oil/Gas EGU NM	0	NA	0	NA

Table 5-15b. Sensitive Class II area where each of the Source Groups has the maximum number of days that Δdv exceeds the 0.5 and 1.0 dv thresholds for the Medium Development Scenario.

Source Group	Group Name	>0.5		>1.0	
		Max # of Day @ Class II	Class II (Max Occurs)	Max # of Day @ Class II	Class II (Max Occurs)
A	Little Snake FO	0	NA	0	NA
B	White River FO	38	CII_Dinosaur_all	5	CII_Dinosaur_all
C	Colorado River Valley FO (CRVFO)	0	NA	0	NA
D	Roan Plateau Planning area portion of CRVFO	0	NA	0	NA
E	Grand Junction FO	19	CII_Colorado	3	CII_Colorado
F	Uncompahgre FO	0	NA	0	NA
G	Tres Rios FO	5	CII_Hovenweep	1	CII_Hovenweep
H	Kremmling FO	0	NA	0	NA
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0	NA	0	NA
J	Pawnee Grasslands portion of RGFO#1	0	NA	0	NA
K	RGFO#2 – West-Central/South	0	NA	0	NA
L	RGFO#3 – South	0	NA	0	NA
M	RGFO#4 – East-Central	0	NA	0	NA
N	New Mexico Farmington FO	77	CII_Aztec_Ruins	3	CII_Aztec_Ruins
O	Total Colorado River Field Office	0	NA	0	NA
P	Total Royal Gorge Field Office	0	NA	0	NA
Q	Mining from 13 Colorado BLM Planning Areas	20	CII_Raggeds	3	CII_Raggeds
R	Combined new Federal O&G and Mining from the 13 Colo	84	CII_Dinosaur_all	17	CII_Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining	160	CII_South_San_Juan	37	CII_Colorado
T	Cumulative Emissions Scenario – New Federal and non-Fe	225	CII_Aztec_Ruins	56	CII_Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	341	CII_Aztec_Ruins	238	CII_Aztec_Ruins
V	Natural Emissions	246	CII_Sevilleta_NWR	202	CII_Sevilleta_NWR
W	2021 All Emissions	365	CII_Alamosa_NWR	365	CII_Alamosa_NWR
X	2008 All Emissions	365	CII_Alamosa_NWR	365	CII_Alamosa_NWR
Y	Coal EGU NM	118	CII_Aztec_Ruins	52	CII_Aztec_Ruins
Z	Coal EGU CO	152	CII_Dinosaur_all	100	CII_Dinosaur_all
AA	Oil/Gas EGU NM	0	NA	0	NA
AB	Oil/Gas EGU CO	0	NA	0	NA
AC	All EGUs in 4km Domain	159	CII_Dinosaur_all	106	CII_Dinosaur_all
AD	CO Mining + Coal EGUs CO	166	CII_Dinosaur_all	110	CII_Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	42	CII_Dinosaur_all	8	CII_Colorado
AF	NM O&G + Oil/Gas EGU NM	77	CII_Aztec_Ruins	3	CII_Aztec_Ruins

Table 5-16a. Maximum Δdv impact at any Class I and sensitive Class II area due to each of the Source Groups for the 2021 High Development Scenario.

Source Group	Group Name	Max dv @ Class I	Class I (Max Occurs)	Max dv @ Class II	Class II (Max Occurs)
A	Little Snake FO	0.21939	CI_Mount_Zirkel	0.22310	CII_Dinosaur_all
B	White River FO	0.78870	CI_Flat_Tops	1.43427	CII_Dinosaur_all
C	Colorado River Valley FO (CRVFO)	0.10714	CI_Eagles_Nest	0.15269	CII_Colorado
D	Roan Plateau Planning area portion of CRVFO	0.09446	CI_Maroon_Bells	0.14267	CII_Colorado
E	Grand Junction FO	0.90007	CI_Arches	1.46046	CII_Colorado
F	Uncompahgre FO	0.21822	CI_Maroon_Bells	0.26247	CII_Raggeds
G	Tres Rios FO	1.41540	CI_Mesa_Verde	1.46604	CII_Hovenweep
H	Kremmling FO	0.07991	CI_Eagles_Nest	0.05406	CII_Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0.02253	CI_Rocky_Mountain	0.01337	CII_Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	0.12545	CI_Rocky_Mountain	0.05321	CII_Mount_Evans
K	RGFO#2 – West-Central/South	0.02275	CI_Pecos	0.03937	CII_Greenhorn_Mounta
L	RGFO#3 – South	0.01940	CI_Great_Sand_Dunes	0.11458	CII_Greenhorn_Mounta
M	RGFO#4 – East-Central	0.00772	CI_Eagles_Nest	0.04298	CII_Lost_Creek
N	New Mexico Farmington FO	0.30608	CI_Weminuche	2.45884	CII_Aztec_Ruins
O	Total Colorado River Field Office	0.19924	CI_Eagles_Nest	0.29345	CII_Colorado
P	Total Royal Gorge Field Office	0.14801	CI_Rocky_Mountain	0.11458	CII_Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	0.74417	CI_Flat_Tops	1.13396	CII_Dinosaur_all
R	Combined new Federal O&G and Mining from the 13 Colo	1.41893	CI_Mesa_Verde	2.59579	CII_Colorado
S	Combined new Federal and non-Federal O&G and Mining	4.18806	CI_Rocky_Mountain	4.56796	CII_Colorado
T	Cumulative Emissions Scenario – New Federal and non-Fe	4.18919	CI_Rocky_Mountain	4.57345	CII_Colorado
U	Combined O&G and Mining in 4 km domain	5.53257	CI_Rocky_Mountain	11.70982	CII_Dinosaur_all
V	Natural Emissions	61.82309	CI_Bandelier	57.86500	CII_Dome
W	2021 All Emissions	61.85241	CI_Bandelier	57.91289	CII_Dome
X	2008 All Emissions	123.70431	CI_Bandelier	115.81325	CII_Dome
Y	Coal EGU NM	5.92446	CI_Petrified_Forest	5.29660	CII_Chaco_Culture
Z	Coal EGU CO	3.38543	CI_Capitol_Reef	5.33477	CII_Dinosaur_all
AA	Oil/Gas EGU NM	0.02254	CI_Mesa_Verde	0.18908	CII_Maxwell_NWR
AB	Oil/Gas EGU CO	0.31003	CI_Rocky_Mountain	0.29491	CII_Mount_Evans
AC	All EGUs in 4km Domain	6.22406	CI_Petrified_Forest	5.48607	CII_Chaco_Culture
AD	CO Mining + Coal EGUs CO	3.61711	CI_Mount_Zirkel	5.34314	CII_Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	1.41544	CI_Mesa_Verde	2.52365	CII_Colorado
AF	NM O&G + Oil/Gas EGU NM	0.31511	CI_Weminuche	2.46049	CII_Aztec_Ruins

Table 5-16b. Maximum Δdv impact at any Class I and sensitive Class II area due to each of the Source Groups for the 2021 Low Development Scenario.

Source Group	Group Name	Max dv @ Class I	Class I (Max Occurs)	Max dv @ Class II	Class II (Max Occurs)
A	Little Snake FO	0.03379	CI_Mount_Zirkel	0.03217	CII_Dinosaur_all
B	White River FO	0.17342	CI_Flat_Tops	0.35529	CII_Dinosaur_all
C	Colorado River Valley FO (CRVFO)	0.08399	CI_Eagles_Nest	0.10547	CII_Colorado
D	Roan Plateau Planning area portion of CRVFO	0.06573	CI_Maroon_Bells	0.08541	CII_Colorado
E	Grand Junction FO	0.06394	CI_Arches	0.10458	CII_Colorado
F	Uncompahgre FO	0.09830	CI_Maroon_Bells	0.08642	CII_Raggeds
G	Tres Rios FO	0.21039	CI_Mesa_Verde	0.20104	CII_Hovenweep
H	Kremmling FO	0.00866	CI_Eagles_Nest	0.00657	CII_Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0.00538	CI_Rocky_Mountain	0.00288	CII_Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	0.02803	CI_Rocky_Mountain	0.01093	CII_Mount_Evans
K	RGFO#2 – West-Central/South	0.00197	CI_Pecos	0.00361	CII_Greenhorn_Mounta
L	RGFO#3 – South	0.01214	CI_Great_Sand_Dunes	0.07568	CII_Greenhorn_Mounta
M	RGFO#4 – East-Central	0.00116	CI_Eagles_Nest	0.00677	CII_Lost_Creek
N	New Mexico Farmington FO	0.15130	CI_Weminuche	1.31054	CII_Aztec_Ruins
O	Total Colorado River Field Office	0.14638	CI_Maroon_Bells	0.19010	CII_Colorado
P	Total Royal Gorge Field Office	0.03345	CI_Rocky_Mountain	0.07568	CII_Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	0.74417	CI_Flat_Tops	1.13396	CII_Dinosaur_all
R	Combined new Federal O&G and Mining from the 13 Colo	0.77900	CI_Flat_Tops	1.15226	CII_Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining	2.33167	CI_Mesa_Verde	2.89723	CII_Hovenweep
T	Cumulative Emissions Scenario – New Federal and non-Fe	2.33666	CI_Mesa_Verde	2.90419	CII_Hovenweep
U	Combined O&G and Mining in 4 km domain	3.86360	CI_Rocky_Mountain	11.68592	CII_Dinosaur_all
V	Natural Emissions	61.82309	CI_Bandelier	57.86496	CII_Dome
W	2021 All Emissions	61.85249	CI_Bandelier	57.91223	CII_Dome
X	2008 All Emissions	123.70431	CI_Bandelier	115.81325	CII_Dome
Y	Coal EGU NM	5.92446	CI_Petrified_Forest	5.29660	CII_Chaco_Culture
Z	Coal EGU CO	3.38543	CI_Capitol_Reef	5.33477	CII_Dinosaur_all
AA	Oil/Gas EGU NM	0.02254	CI_Mesa_Verde	0.18908	CII_Maxwell_NWR
AB	Oil/Gas EGU CO	0.31003	CI_Rocky_Mountain	0.29491	CII_Mount_Evans
AC	All EGUs in 4km Domain	6.22406	CI_Petrified_Forest	5.48607	CII_Chaco_Culture
AD	CO Mining + Coal EGUs CO	3.61711	CI_Mount_Zirkel	5.34314	CII_Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	2.32848	CI_Mesa_Verde	2.89683	CII_Hovenweep
AF	NM O&G + Oil/Gas EGU NM	0.15139	CI_Weminuche	1.31066	CII_Aztec_Ruins

Table 5-16c. Maximum Δdv impact at any Class I and sensitive Class II area due to each of the Source Groups for the 2021 Medium Development Scenario.

Source Group	Group Name	Max dv @ Class I	Class I (Max Occurs)	Max dv @ Class II	Class II (Max Occurs)
A	Little Snake FO	0.18773	CI_Mount_Zirkel	0.18619	CII_Dinosaur_all
B	White River FO	0.78275	CI_Flat_Tops	1.33901	CII_Dinosaur_all
C	Colorado River Valley FO (CRVFO)	0.08876	CI_Eagles_Nest	0.12445	CII_Colorado
D	Roan Plateau Planning area portion of CRVFO	0.08081	CI_Maroon_Bells	0.12163	CII_Colorado
E	Grand Junction FO	0.83689	CI_Arches	1.28333	CII_Colorado
F	Uncompahgre FO	0.14666	CI_Maroon_Bells	0.17131	CII_Raggeds
G	Tres Rios FO	1.02858	CI_Mesa_Verde	1.18014	CII_Hovenweep
H	Kremmling FO	0.07964	CI_Eagles_Nest	0.03373	CII_Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0.01231	CI_Rocky_Mountain	0.00764	CII_Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	0.07521	CI_Rocky_Mountain	0.03252	CII_Mount_Evans
K	RGFO#2 – West-Central/South	0.01639	CI_Pecos	0.02875	CII_Greenhorn_Mounta
L	RGFO#3 – South	0.01298	CI_Great_Sand_Dunes	0.07842	CII_Greenhorn_Mounta
M	RGFO#4 – East-Central	0.00366	CI_Eagles_Nest	0.01837	CII_Lost_Creek
N	New Mexico Farmington FO	0.22871	CI_Weminuche	1.60245	CII_Aztec_Ruins
O	Total Colorado River Field Office	0.16619	CI_Eagles_Nest	0.24274	CII_Colorado
P	Total Royal Gorge Field Office	0.08758	CI_Rocky_Mountain	0.07842	CII_Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	0.74417	CI_Flat_Tops	1.13396	CII_Dinosaur_all
R	Combined new Federal O&G and Mining from the 13 Colo	1.06832	CI_Flat_Tops	2.29147	CII_Colorado
S	Combined new Federal and non-Federal O&G and Mining	4.13935	CI_Rocky_Mountain	4.29516	CII_Colorado
T	Cumulative Emissions Scenario – New Federal and non-Fe	4.14019	CI_Rocky_Mountain	4.29944	CII_Colorado
U	Combined O&G and Mining in 4 km domain	5.49271	CI_Rocky_Mountain	11.71432	CII_Dinosaur_all
V	Natural Emissions	61.82309	CI_Bandelier	57.86499	CII_Dome
W	2021 All Emissions	61.85241	CI_Bandelier	57.91282	CII_Dome
X	2008 All Emissions	123.70431	CI_Bandelier	115.81325	CII_Dome
Y	Coal EGU NM	5.92446	CI_Petrified_Forest	5.29660	CII_Chaco_Culture
Z	Coal EGU CO	3.38543	CI_Capitol_Reef	5.33477	CII_Dinosaur_all
AA	Oil/Gas EGU NM	0.02254	CI_Mesa_Verde	0.18908	CII_Maxwell_NWR
AB	Oil/Gas EGU CO	0.31003	CI_Rocky_Mountain	0.29491	CII_Mount_Evans
AC	All EGUs in 4km Domain	6.22406	CI_Petrified_Forest	5.48607	CII_Chaco_Culture
AD	CO Mining + Coal EGUs CO	3.61711	CI_Mount_Zirkel	5.34314	CII_Dinosaur_all
AE	CO O&G + Oil/Gas EGUs CO	1.02863	CI_Mesa_Verde	2.21718	CII_Colorado
AF	NM O&G + Oil/Gas EGU NM	0.23780	CI_Weminuche	1.60423	CII_Aztec_Ruins

5.2.2 Individual Planning Area Contributions to Visibility Impairment at Class I and II Areas using FLAG (2010)

In this section, we present the visibility impacts at Class I areas due to Federal O&G in five BLM Planning Areas: WRFO, GJFO, TRFO, NMFFO and USFS-PG and the 2021 High, Low and Medium Development Scenarios. The first four BLM Planning Areas were selected because they were the ones that had Δdv impacts of greater than 0.5 at any Class I or II area (see Table 5-15), whereas USFS-PG was selected as it is one of our example Planning Areas. Also, the NMFFO is of particular interest in the current study. Tables 5-17 through 5-21 display the maximum Δdv and number of days Δdv exceeds the 0.5 and 1.0 thresholds for all Class I areas due to emissions from Federal O&G development within the WRFO, GJFO, TRFO, NMFFO and USFS-PG Planning Areas, respectively. These Tables were obtained from sheet "Table1" in Attachments B-1, B-2 and B-3. The visibility results for the 2021 High, Low and Medium Development Scenario and these five BLM Planning Areas are summarized as follows, results for the other Source Groups and for sensitive Class II areas can be found in Attachments B-1, B-2 and B-3:

- Federal O&G from the WRFO Planning Area and the 2021 High Development Scenario result in 6 days at Flat Tops, 1 day at Eagles Nest and 2 days at Maroon Bells-Snowmass Class I areas with Δdv > 0.5 and no days > 1.0 and maximum Δdv of 0.789, 0.538 and 0.559 at these three Class I areas, respectively (Table 5-17a). The mitigation in the 2021 Medium Development Scenario reduces these values to 4, 0 and 0 days with Δdv > 0.5 and 0.782, 0.439 and 0.479 maximum Δdv at Flat Tops, Eagles Nest and Maroon-Bells Class I areas, respectively (Table 5-17c). For the 2021 Low Development Scenario new Federal O&G from the WRFO Planning Area cause no days with Δdv > 0.5 with maximum Δdv at Flat Tops, Eagles Nest and Maroon Bells-Snowmass of 0.173, 0.107 and 0.123, respectively (Table 5-17b).
- For the 2021 High and Medium Development Scenarios, the GJFO Planning Area has two Class I areas where new Federal O&G emissions result in Δdv greater than 0.5 with 2 days at Arches and 1 day at Black Canyon of the Gunnison that have maximum Δdv of 0.900/0.837 (High/Medium) and 0.580/0.500 (High/Medium), respectively (Table 5-18a, c). There are no days with Δdv > 0.5 at any Class I area due to new Federal O&G emissions within the GJFO Planning area for the 2021 Low Development Scenario (Table 5-18b).
- For new Federal O&G within the TRFO Planning Area the 2021 High Development Scenario has 35 days with Δdv > 0.5 and 4 days with Δdv > 1.0 at the Mesa Verde Class I area (Table 5-19a). These values are reduced to 5 days with Δdv > 0.5 and 1 day with Δdv > 1.0 at the Mesa Verde Class I area due to the mitigation in the 2021 Medium Development Scenario (Table 5-19c). There are no days greater than these thresholds for the 2021 Low Development Scenario (Table 5-19b). The maximum Δdv due to the TRFO at Mesa Verde are 1.415, 0.210 and 1.029 for the 2021 High, Low and Medium Development Scenario, respectively.
- There are no days with Δdv > 0.5 at any Class I area due to Federal O&G emissions from the NMFFO Mancos Shale Development area for all three 2021 emission scenarios (Tables 5-20a, b, c). However, as shown in Attachments B-1, B-2 and B-3, there are 210, 60 and 77 days with Δdv > 0.5 and 50, 3 and 3 days with Δdv > 1.0 at the Aztec Ruins

sensitive Class II area for the 2021 High, Low and Medium Development Scenarios, respectively.

- New Federal O&G from the USFS-PG Planning Area has no days with Δdv > 0.5 at any Class I area for all three 2021 emissions scenarios (Table 5-21). The maximum Δdv impact due to new Federal O&G development in the USGS-PG Planning Area is 0.125, 0.028 and 0.075 at Rocky Mountain National Park for the 2021 High, Low and Medium Development Scenarios, respectively (Tables 5-21a, b, c).

Table 5-17a. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the WRFO Planning Area (2021 High Development Scenario).

White River FO					
				Number of Day	
Short Name	Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I					
CI_Arches	Arches NP	0.43533	1/14/2008	0	0
CI_Bandelier	Bandelier NM	0.11148	1/17/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.47587	2/17/2008	0	0
CI_Bosque	Bosque del Apache Wilderness	0.03747	3/7/2008	0	0
CI_Canyonlands	Canyonlands NP	0.26536	1/14/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.07285	2/15/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.53773	1/12/2008	0	1
CI_Flat_Tops	Flat Tops Wilderness	0.78870	1/22/2008	0	6
CI_Galiuro	Galiuro Wilderness	0.00336	5/14/2008	0	0
CI_Gila	Gila Wilderness	0.02166	1/17/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.20730	2/17/2008	0	0
CI_La_Garita	La Garita Wilderness	0.14817	3/6/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.55850	1/12/2008	0	2
CI_Mesa_Verde	Mesa Verde NP	0.17805	3/6/2008	0	0
CI_Mount_Baldy	Mount Baldy Wilderness	0.04517	1/17/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.32817	1/12/2008	0	0
CI_Pecos	Pecos Wilderness	0.08404	4/13/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.04465	3/23/2008	0	0
CI_Rawah	Rawah Wilderness	0.22532	12/17/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.20118	3/27/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.03710	5/19/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.07923	3/7/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.12011	5/14/2008	0	0
CI_West_Elk	West Elk Wilderness	0.32166	1/12/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.09681	5/20/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.02573	1/14/2008	0	0

Table 5-17b. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the WRFO Planning Area (2021 Low Development Scenario).

White River FO					
				Number of Day	
Short Name	Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I					
CI_Arches	Arches NP	0.09570	1/14/2008	0	0
CI_Bandelier	Bandelier NM	0.01819	1/17/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.08959	2/17/2008	0	0
CI_Bosque	Bosque del Apache Wilderness	0.00606	3/7/2008	0	0
CI_Canyonlands	Canyonlands NP	0.05029	1/14/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.01199	2/15/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.10731	1/12/2008	0	0
CI_Flat_Tops	Flat Tops Wilderness	0.17342	1/22/2008	0	0
CI_Galiuro	Galiuro Wilderness	0.00057	5/14/2008	0	0
CI_Gila	Gila Wilderness	0.00357	1/14/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.03269	1/12/2008	0	0
CI_La_Garita	La Garita Wilderness	0.02915	3/6/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.12272	1/12/2008	0	0
CI_Mesa_Verde	Mesa Verde NP	0.02813	3/6/2008	0	0
CI_Mount_Baldy	Mount Baldy Wilderness	0.00755	1/17/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.06246	1/12/2008	0	0
CI_Pecos	Pecos Wilderness	0.01509	4/13/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.00758	3/23/2008	0	0
CI_Rawah	Rawah Wilderness	0.03847	3/25/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.03799	3/27/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.00666	5/19/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.01379	3/7/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.02257	3/6/2008	0	0
CI_West_Elk	West Elk Wilderness	0.06922	1/12/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.01743	5/20/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.00433	1/14/2008	0	0

Table 5-17c. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the WRFO Planning Area (2021 Medium Development Scenario).

White River FO					
				Number of Day	
Short Name	Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I					
CI_Arches	Arches NP	0.38770	1/14/2008	0	0
CI_Bandelier	Bandelier NM	0.09901	1/17/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.46855	2/17/2008	0	0
CI_Bosque	Bosque del Apache Wilderness	0.03146	3/7/2008	0	0
CI_Canyonlands	Canyonlands NP	0.23310	1/14/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.06555	2/15/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.43903	1/12/2008	0	0
CI_Flat_Tops	Flat Tops Wilderness	0.78275	1/12/2008	0	4
CI_Galiuro	Galiuro Wilderness	0.00308	5/14/2008	0	0
CI_Gila	Gila Wilderness	0.01893	1/17/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.18367	2/17/2008	0	0
CI_La_Garita	La Garita Wilderness	0.12817	3/6/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.47918	11/11/2008	0	0
CI_Mesa_Verde	Mesa Verde NP	0.15716	3/6/2008	0	0
CI_Mount_Baldy	Mount Baldy Wilderness	0.03930	1/17/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.32707	1/12/2008	0	0
CI_Pecos	Pecos Wilderness	0.07481	4/13/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.04403	3/23/2008	0	0
CI_Rawah	Rawah Wilderness	0.18687	12/17/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.19646	3/27/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.03306	5/19/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.06799	3/7/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.10672	5/14/2008	0	0
CI_West_Elk	West Elk Wilderness	0.30428	2/17/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.08643	5/20/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.02139	1/14/2008	0	0

Table 5-18a. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the GJFO Planning Area (2021 High Development Scenario).

Grand Junction FO					
				Number of Day	
Short Name	Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I					
CI_Arches	Arches NP	0.90007	1/13/2008	0	2
CI_Bandelier	Bandelier NM	0.07374	1/17/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.58026	2/16/2008	0	1
CI_Bosque	Bosque del Apache Wilderness	0.02721	3/7/2008	0	0
CI_Canyonlands	Canyonlands NP	0.34965	1/13/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.13423	1/2/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.29818	1/22/2008	0	0
CI_Flat_Tops	Flat Tops Wilderness	0.34568	5/25/2008	0	0
CI_Galiuro	Galiuro Wilderness	0.00199	5/18/2008	0	0
CI_Gila	Gila Wilderness	0.01637	1/14/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.18116	1/12/2008	0	0
CI_La_Garita	La Garita Wilderness	0.15510	1/12/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.43962	1/12/2008	0	0
CI_Mesa_Verde	Mesa Verde NP	0.14631	1/17/2008	0	0
CI_Mount_Baldy	Mount Baldy Wilderness	0.02719	1/17/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.28359	5/25/2008	0	0
CI_Pecos	Pecos Wilderness	0.07952	1/13/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.02661	3/9/2008	0	0
CI_Rawah	Rawah Wilderness	0.14821	5/25/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.16054	3/24/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.02422	1/13/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.05123	3/6/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.09183	3/5/2008	0	0
CI_West_Elk	West Elk Wilderness	0.40600	1/12/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.10652	1/12/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.01722	1/14/2008	0	0

Table 5-18b. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the GJFO Planning Area (2021 Low Development Scenario).

Grand Junction FO					
				Number of Day	
Short Name	Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I					
CI_Arches	Arches NP	0.06394	1/13/2008	0	0
CI_Bandelier	Bandelier NM	0.00426	1/17/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.03463	2/16/2008	0	0
CI_Bosque	Bosque del Apache Wilderness	0.00157	3/7/2008	0	0
CI_Canyonlands	Canyonlands NP	0.02204	1/13/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.00678	1/2/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.02113	1/22/2008	0	0
CI_Flat_Tops	Flat Tops Wilderness	0.01884	5/25/2008	0	0
CI_Galiuro	Galiuro Wilderness	0.00012	5/18/2008	0	0
CI_Gila	Gila Wilderness	0.00099	1/14/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.01113	1/13/2008	0	0
CI_La_Garita	La Garita Wilderness	0.01015	3/22/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.03801	1/12/2008	0	0
CI_Mesa_Verde	Mesa Verde NP	0.00879	1/17/2008	0	0
CI_Mount_Baldy	Mount Baldy Wilderness	0.00165	1/17/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.01705	5/25/2008	0	0
CI_Pecos	Pecos Wilderness	0.00503	1/13/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.00157	3/9/2008	0	0
CI_Rawah	Rawah Wilderness	0.00923	4/22/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.01079	3/24/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.00146	1/13/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.00328	3/6/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.00642	3/5/2008	0	0
CI_West_Elk	West Elk Wilderness	0.03084	1/12/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.00653	1/13/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.00101	1/14/2008	0	0

Table 5-18c. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the GJFO Planning Area (2021 Medium Development Scenario).

Grand Junction FO					
				Number of Day	
Short Name	Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I					
CI_Arches	Arches NP	0.83689	1/13/2008	0	2
CI_Bandelier	Bandelier NM	0.06171	1/17/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.50011	2/16/2008	0	1
CI_Bosque	Bosque del Apache Wilderness	0.02177	3/7/2008	0	0
CI_Canyonlands	Canyonlands NP	0.32464	1/13/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.11614	1/2/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.24399	1/22/2008	0	0
CI_Flat_Tops	Flat Tops Wilderness	0.27841	5/25/2008	0	0
CI_Galiuro	Galiuro Wilderness	0.00155	5/18/2008	0	0
CI_Gila	Gila Wilderness	0.01337	1/14/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.15145	1/12/2008	0	0
CI_La_Garita	La Garita Wilderness	0.13364	1/12/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.36723	1/12/2008	0	0
CI_Mesa_Verde	Mesa Verde NP	0.12182	1/17/2008	0	0
CI_Mount_Baldy	Mount Baldy Wilderness	0.02259	1/17/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.23447	5/25/2008	0	0
CI_Pecos	Pecos Wilderness	0.06703	1/13/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.02307	3/9/2008	0	0
CI_Rawah	Rawah Wilderness	0.11926	5/25/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.13008	3/24/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.02030	1/13/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.04261	3/6/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.07837	3/5/2008	0	0
CI_West_Elk	West Elk Wilderness	0.34239	1/12/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.08939	1/12/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.01405	1/14/2008	0	0

Table 5-19a. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the TRFO Planning Area (2021 High Development Scenario).

Tres Rios FO					
				Number of Day	
Short Name	Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I					
CI_Arches	Arches NP	0.08112	2/10/2008	0	0
CI_Bandelier	Bandelier NM	0.08282	1/18/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.15138	2/11/2008	0	0
CI_Bosque	Bosque del Apache Wilderness	0.03171	1/13/2008	0	0
CI_Canyonlands	Canyonlands NP	0.14171	12/21/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.02766	1/3/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.06000	5/24/2008	0	0
CI_Flat_Tops	Flat Tops Wilderness	0.08493	5/25/2008	0	0
CI_Galiuro	Galiuro Wilderness	0.00177	3/23/2008	0	0
CI_Gila	Gila Wilderness	0.01053	4/13/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.03540	11/19/2008	0	0
CI_La_Garita	La Garita Wilderness	0.05190	3/21/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.08297	5/24/2008	0	0
CI_Mesa_Verde	Mesa Verde NP	1.41540	2/10/2008	4	35
CI_Mount_Baldy	Mount Baldy Wilderness	0.01073	3/23/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.07637	5/25/2008	0	0
CI_Pecos	Pecos Wilderness	0.03618	3/11/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.03174	1/14/2008	0	0
CI_Rawah	Rawah Wilderness	0.05117	5/25/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.03678	5/24/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.01197	1/13/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.06324	1/12/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.06845	3/21/2008	0	0
CI_West_Elk	West Elk Wilderness	0.07588	12/20/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.02479	2/8/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.01629	1/13/2008	0	0

Table 5-19b. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the TRFO Planning Area (2021 Low Development Scenario).

Tres Rios FO					
				Number of Day	
Short Name	Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I					
CI_Arches	Arches NP	0.01083	2/10/2008	0	0
CI_Bandelier	Bandelier NM	0.00987	1/18/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.01743	2/11/2008	0	0
CI_Bosque	Bosque del Apache Wilderness	0.00383	1/13/2008	0	0
CI_Canyonlands	Canyonlands NP	0.01906	12/21/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.00330	1/3/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.00728	5/24/2008	0	0
CI_Flat_Tops	Flat Tops Wilderness	0.01074	5/25/2008	0	0
CI_Galiuro	Galiuro Wilderness	0.00021	3/23/2008	0	0
CI_Gila	Gila Wilderness	0.00133	4/13/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.00413	11/19/2008	0	0
CI_La_Garita	La Garita Wilderness	0.00642	3/21/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.00984	5/24/2008	0	0
CI_Mesa_Verde	Mesa Verde NP	0.21039	2/10/2008	0	0
CI_Mount_Baldy	Mount Baldy Wilderness	0.00130	3/23/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.00984	5/25/2008	0	0
CI_Pecos	Pecos Wilderness	0.00427	3/11/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.00384	1/14/2008	0	0
CI_Rawah	Rawah Wilderness	0.00634	5/25/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.00465	5/24/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.00149	1/13/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.00768	1/12/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.00834	3/21/2008	0	0
CI_West_Elk	West Elk Wilderness	0.00900	12/20/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.00302	2/8/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.00201	1/13/2008	0	0

Table 5-19c. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the TRFO Planning Area (2021 Medium Development Scenario).

Tres Rios FO					
				Number of Day	
Short Name	Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I					
CI_Arches	Arches NP	0.06784	2/10/2008	0	0
CI_Bandelier	Bandelier NM	0.06815	1/18/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.12458	2/11/2008	0	0
CI_Bosque	Bosque del Apache Wilderness	0.02502	1/13/2008	0	0
CI_Canyonlands	Canyonlands NP	0.11730	12/21/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.02288	1/3/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.04997	5/24/2008	0	0
CI_Flat_Tops	Flat Tops Wilderness	0.07172	5/25/2008	0	0
CI_Galiuro	Galiuro Wilderness	0.00146	3/23/2008	0	0
CI_Gila	Gila Wilderness	0.00855	4/13/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.02765	3/21/2008	0	0
CI_La_Garita	La Garita Wilderness	0.04270	3/21/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.06869	5/24/2008	0	0
CI_Mesa_Verde	Mesa Verde NP	1.02858	2/10/2008	1	5
CI_Mount_Baldy	Mount Baldy Wilderness	0.00885	3/23/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.06459	5/25/2008	0	0
CI_Pecos	Pecos Wilderness	0.02941	3/11/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.02271	1/14/2008	0	0
CI_Rawah	Rawah Wilderness	0.04288	5/25/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.03083	5/24/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.00975	1/13/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.05047	1/12/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.05626	3/21/2008	0	0
CI_West_Elk	West Elk Wilderness	0.06237	12/20/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.02032	2/8/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.01354	1/13/2008	0	0

Table 5-20a. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the NMFFO Planning Area (2021 High Development Scenario).

New Mexico Farmington FO					
				Number of Day	
Short Name	Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I					
CI_Arches	Arches NP	0.05561	11/25/2008	0	0
CI_Bandelier	Bandelier NM	0.15626	1/18/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.12266	5/25/2008	0	0
CI_Bosque	Bosque del Apache Wilderness	0.02491	3/7/2008	0	0
CI_Canyonlands	Canyonlands NP	0.08824	12/30/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.08109	1/3/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.07141	5/25/2008	0	0
CI_Flat_Tops	Flat Tops Wilderness	0.07557	5/25/2008	0	0
CI_Galiuro	Galiuro Wilderness	0.00596	5/17/2008	0	0
CI_Gila	Gila Wilderness	0.01445	5/18/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.12535	12/8/2008	0	0
CI_La_Garita	La Garita Wilderness	0.15074	5/24/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.09903	5/25/2008	0	0
CI_Mesa_Verde	Mesa Verde NP	0.19519	1/1/2008	0	0
CI_Mount_Baldy	Mount Baldy Wilderness	0.01094	5/17/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.04961	5/26/2008	0	0
CI_Pecos	Pecos Wilderness	0.08594	3/11/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.07565	1/14/2008	0	0
CI_Rawah	Rawah Wilderness	0.03416	5/25/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.03444	5/25/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.02992	1/13/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.13503	3/18/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.30608	5/24/2008	0	0
CI_West_Elk	West Elk Wilderness	0.11344	5/25/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.07107	3/24/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.02660	1/13/2008	0	0

Table 5-20b. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the NMFFO Planning Area (2021 Low Development Scenario).

New Mexico Farmington FO					
				Number of Day	
Short Name	Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I					
CI_Arches	Arches NP	0.02730	11/25/2008	0	0
CI_Bandelier	Bandelier NM	0.07799	1/18/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.05964	5/25/2008	0	0
CI_Bosque	Bosque del Apache Wilderness	0.01242	3/7/2008	0	0
CI_Canyonlands	Canyonlands NP	0.04327	12/30/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.03886	1/3/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.03469	5/25/2008	0	0
CI_Flat_Tops	Flat Tops Wilderness	0.03704	5/25/2008	0	0
CI_Galiuro	Galiuro Wilderness	0.00299	5/17/2008	0	0
CI_Gila	Gila Wilderness	0.00716	5/18/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.06048	12/8/2008	0	0
CI_La_Garita	La Garita Wilderness	0.07348	5/24/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.04818	5/25/2008	0	0
CI_Mesa_Verde	Mesa Verde NP	0.10196	1/1/2008	0	0
CI_Mount_Baldy	Mount Baldy Wilderness	0.00530	5/17/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.02430	5/26/2008	0	0
CI_Pecos	Pecos Wilderness	0.04195	3/11/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.03976	1/14/2008	0	0
CI_Rawah	Rawah Wilderness	0.01672	5/25/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.01646	5/25/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.01529	1/13/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.06976	3/18/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.15130	5/24/2008	0	0
CI_West_Elk	West Elk Wilderness	0.05502	5/25/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.03569	3/24/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.01330	1/13/2008	0	0

Table 5-20c. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the NMFFO Planning Area (2021 Medium Development Scenario).

New Mexico Farmington FO					
				Number of Day	
Short Name	Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I					
CI_Arches	Arches NP	0.03949	11/25/2008	0	0
CI_Bandelier	Bandelier NM	0.11621	1/18/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.09211	5/25/2008	0	0
CI_Bosque	Bosque del Apache Wilderness	0.01757	3/7/2008	0	0
CI_Canyonlands	Canyonlands NP	0.06564	12/30/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.06059	1/3/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.05397	5/25/2008	0	0
CI_Flat_Tops	Flat Tops Wilderness	0.05739	5/25/2008	0	0
CI_Galiuro	Galiuro Wilderness	0.00370	5/17/2008	0	0
CI_Gila	Gila Wilderness	0.00984	5/18/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.09241	12/8/2008	0	0
CI_La_Garita	La Garita Wilderness	0.11350	5/24/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.07456	5/25/2008	0	0
CI_Mesa_Verde	Mesa Verde NP	0.14509	12/30/2008	0	0
CI_Mount_Baldy	Mount Baldy Wilderness	0.00702	5/17/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.03725	5/26/2008	0	0
CI_Pecos	Pecos Wilderness	0.06296	3/11/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.04816	1/14/2008	0	0
CI_Rawah	Rawah Wilderness	0.02590	5/25/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.02598	5/25/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.02222	1/13/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.08660	3/18/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.22871	5/24/2008	0	0
CI_West_Elk	West Elk Wilderness	0.08529	5/25/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.04916	2/8/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.01987	1/13/2008	0	0

Table 5-21a. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the USFS-PG Planning Area (2021 High Development Scenario).

Pawnee Grasslands portion of RGFO#1					
				Number of Day	
Short Name	Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I					
CI_Arches	Arches NP	0.00006	9/30/2008	0	0
CI_Bandelier	Bandelier NM	0.00242	12/9/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.00137	3/17/2008	0	0
CI_Bosque	Bosque del Apache Wilderness	0.00144	11/15/2008	0	0
CI_Canyonlands	Canyonlands NP	0.00007	7/10/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.00004	7/10/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.00630	3/9/2008	0	0
CI_Flat_Tops	Flat Tops Wilderness	0.00154	3/17/2008	0	0
CI_Galiuro	Galiuro Wilderness	0.00008	5/17/2008	0	0
CI_Gila	Gila Wilderness	0.00096	5/17/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.00676	11/27/2008	0	0
CI_La_Garita	La Garita Wilderness	0.00159	4/17/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.00261	3/17/2008	0	0
CI_Mesa_Verde	Mesa Verde NP	0.00030	3/17/2008	0	0
CI_Mount_Baldy	Mount Baldy Wilderness	0.00039	5/16/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.00255	5/26/2008	0	0
CI_Pecos	Pecos Wilderness	0.00395	11/24/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.00056	5/16/2008	0	0
CI_Rawah	Rawah Wilderness	0.02765	5/26/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.12545	11/20/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.00225	5/18/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.00120	5/16/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.00183	4/17/2008	0	0
CI_West_Elk	West Elk Wilderness	0.00204	3/17/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.00246	5/15/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.00268	5/18/2008	0	0

Table 5-21b. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the USFS-PG Planning Area (2021 Low Development Scenario).

Pawnee Grasslands portion of RGFO#1					
				Number of Day	
Short Name	Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I					
CI_Arches	Arches NP	0.00001	12/30/2008	0	0
CI_Bandelier	Bandelier NM	0.00048	12/9/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.00032	3/17/2008	0	0
CI_Bosque	Bosque del Apache Wilderness	0.00028	11/15/2008	0	0
CI_Canyonlands	Canyonlands NP	0.00008	12/30/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.00001	7/10/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.00130	3/9/2008	0	0
CI_Flat_Tops	Flat Tops Wilderness	0.00031	3/17/2008	0	0
CI_Galiuro	Galiuro Wilderness	0.00002	5/17/2008	0	0
CI_Gila	Gila Wilderness	0.00019	5/17/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.00139	11/27/2008	0	0
CI_La_Garita	La Garita Wilderness	0.00035	3/17/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.00055	3/17/2008	0	0
CI_Mesa_Verde	Mesa Verde NP	0.00007	3/17/2008	0	0
CI_Mount_Baldy	Mount Baldy Wilderness	0.00008	5/16/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.00054	5/26/2008	0	0
CI_Pecos	Pecos Wilderness	0.00074	11/24/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.00011	5/16/2008	0	0
CI_Rawah	Rawah Wilderness	0.00556	5/26/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.02803	11/20/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.00047	5/18/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.00023	5/16/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.00038	4/17/2008	0	0
CI_West_Elk	West Elk Wilderness	0.00046	3/17/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.00049	5/15/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.00056	5/18/2008	0	0

Table 5-21c. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the USFS-PG Planning Area (2021 Medium Development Scenario).

Pawnee Grasslands portion of RGFO#1					
				Number of Day	
Short Name	Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I					
CI_Arches	Arches NP	0.00002	9/30/2008	0	0
CI_Bandelier	Bandelier NM	0.00146	12/9/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.00086	3/17/2008	0	0
CI_Bosque	Bosque del Apache Wilderness	0.00079	11/15/2008	0	0
CI_Canyonlands	Canyonlands NP	0.00003	7/10/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.00002	7/10/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.00369	3/9/2008	0	0
CI_Flat_Tops	Flat Tops Wilderness	0.00091	3/17/2008	0	0
CI_Galiuro	Galiuro Wilderness	0.00003	5/17/2008	0	0
CI_Gila	Gila Wilderness	0.00047	5/17/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.00371	11/27/2008	0	0
CI_La_Garita	La Garita Wilderness	0.00099	3/17/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.00158	3/17/2008	0	0
CI_Mesa_Verde	Mesa Verde NP	0.00018	3/17/2008	0	0
CI_Mount_Baldy	Mount Baldy Wilderness	0.00019	5/16/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.00155	5/26/2008	0	0
CI_Pecos	Pecos Wilderness	0.00234	11/24/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.00024	5/16/2008	0	0
CI_Rawah	Rawah Wilderness	0.01687	5/26/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.07521	11/20/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.00124	2/18/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.00066	11/24/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.00106	4/17/2008	0	0
CI_West_Elk	West Elk Wilderness	0.00126	3/17/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.00135	5/15/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.00146	5/18/2008	0	0

5.3 Cumulative Visibility Impacts at Class I Areas

The visibility impacts due to new oil and gas emissions from combined BLM Planning Areas were examined following the procedures provided by the FWS and NPS (FWS and NPS, 2012) and described in Section 4.6.2. These procedures use EPA's Modeled Attainment Test Software (MATS) to project current year observed visibility impairment for the observed best 20 percent (B20%) and worst 20 percent (W20%) visibility days to the future year using the CAMx 2008 Base Case and 2021 High, Low and Medium Development Scenarios modeling results with and without emissions from each of the combined emission Source Groups. The cumulative visibility analysis was conducted for the following four combined Source Groups:

- Source Group R: New oil and gas and mining on Federal lands within the 13 Colorado BLM Planning Areas;
- Source Group S: New oil and gas on Federal and non-Federal lands and mining on Federal lands within the 13 Colorado BLM Planning Areas;

- Source Group T: Cumulative Emissions Scenario of new oil and gas on Federal and non-Federal lands and mining on Federal lands within the 14 Colorado and northern New Mexico BLM Planning Areas;
- Source Group U: Existing and New Federal and non-Federal oil and gas throughout the 4 km CARMMS domain plus mining on Federal land within the 13 Colorado BLM Planning Areas.

The results presented in this section are derived from the CARMMS1.0 CAMx model outputs and not the updated CARMMS 1.5 CAMx model outputs. Note that the CARMMS 1.5 CAMx modeling was performed for the Low Development scenario only and not the Medium and High Development emissions scenarios. For most analyses in this report, the updated (CARMMS 1.5) low emissions scenario CAMx source apportionment (SA) outputs are merged with specific Medium scenario (CARMMS 1.0) SA outputs to develop updated impacts for the Medium and High scenarios, however this strategy does not work for the cumulative visibility analysis. The cumulative visibility analysis in CARMMS 1.0 was performed with MATS software using core CAMx model output rather than SA CAMx output to include impacts due to secondary organic aerosols (SOA); the SOA concentrations are not available in CAMx SA output and only available in the core CAMx output. Since the emissions changes between CARMMS 1.0 and CARMMS 1.5 result in lower visibility-impairing particulates for CARMMS 1.5 the results in this section are conservative estimates of visibility impacts with the latest CARMMS/Mancos Shale emissions inventories.

We note also that the cumulative assessment provided in this section does not focus on individual source group impacts. The updated emissions source groups (Mancos Shale and mining) are only considered combined with other emissions source groups. A discussion of the difference in visibility impacts for CARMMS 1.0 and CARMMS 1.5 as it may pertain to the cumulative results at Class I areas most impacted by Mancos Shale and mining emissions is provided at the end of this section.

Attachments C-1, C-2 and C-3 contain the 2008 observed and 2021 projected visibility for the W20% and B20% days at Class I and sensitive Class II areas for the High, Low and Medium Development Scenarios, respectively, with and without each of the combined Source Groups. Tables 5-22 through 5-27 from Attachments C-1, C-2 and C-3 display the cumulative visibility results at Class I areas for the 2021 High, Low and Medium Development Scenarios, the four combined emission Source Groups listed above and the W20% and B20% days. MATS uses observed PM species concentrations and monthly average relative humidity from IMPROVE monitoring sites to calculate daily visibility impairment from which the W20% and B20% visibility days metrics are determined. Not all Class I areas have a co-located IMPROVE monitoring site. Thus, IMPROVE observations were mapped to nearby Class I areas that did not include an IMPROVE monitor. In Tables 5-22 through 5-27, the Class I area of interest is shown in the first column and the IMPROVE site used to represent observed visibility at the Class I area is shown in the third column. For example, the IMPROVE data from Canyonlands National Park was used to represent observed visibility for both the Canyonlands and Arches National Parks. The MATS includes the IMPROVE site to Class I area mappings. However, MATS does not include mappings between IMPROVE sites and sensitive Class II areas. Thus, we assigned an

IMPROVE monitoring site to each sensitive Class II area based mainly on proximity so that MATS could calculate cumulative visibility impacts for the W20%/B20% days at sensitive Class II areas. Tables 5-22 through 5-26 include cumulative visibility impacts for just the Class I areas, the results for the sensitive Class II areas are included in Attachments C-1, C-2 and C-3.

Table 5-22a displays the observed W20% visibility metric for the current year (2008) and the projected W20% metric for the 2021 High Development Scenario with and without each of the four combined Source Groups with differences in the W20% visibility metric shown in Table 5-22b. From the 2008 current year to the 2021 High Development Scenario future year, the W20% visibility metric is estimated to improve at 24 and degrade at 2 of the 26 Class I areas. The biggest improvement in W20% visibility between 2008 and 2021 High Scenario is a reduction of 0.89 dv that occurs at Rocky Mountain National Park that goes from 12.04 dv in 2008 to 11.15 dv in the 2021 High Development Scenario. The two Class I areas with degradation are Salt Creek (0.22 dv increase) and White Mountain (0.23 dv increase).

There are even more improvements in the W20% visibility between 2008 and 2021 for the Low Development Scenario (Table 5-23). Again the Class I area with the biggest improvement between 2008 and 2021 Low Scenario is a reduction of 0.92 dv at Rocky Mountain National Park. Again 24 of the 26 Class I areas see W20% visibility improvements between 2008 and 2021 Low Scenario with the same two Class I areas showing W20% visibility degradation in the High and Low Development Scenarios. The results for the 2021 Medium Development Scenario are similar with 24 of 26 Class I areas showing improvements in the W20% visibility metric with the largest improvement (0.89 dv decrease) occurring at Rocky Mountain National Park (Table 5-24).

The Source Group R (new Federal O&G and mining in Colorado) contribution to 2021 W20% visibility ranges from a minimum of zero to maximums of 0.12 (High), 0.10 (Low) and 0.12 (Medium) dv (Tables 5-22b, 5-23b and 5-24b). Whereas, the contributions of all O&G emissions in the 4 km CARMMS domain (Source Group U) to the W20% days is always positive with maximum values of 0.50, 0.40 and 0.45 dv for the High, Low and Medium Development Scenarios, respectively.

The results for the B20% visibility days and High, Low and Medium Development Scenarios are shown in Tables 5-25 through 5-27. Between 2008 and 2021 the B20% visibility improves for approximately half and degrades for the other half of the Class I areas for all three 2021 emission scenarios. The largest improvement in B20% visibility for the High, Low and Medium Development Scenarios are 0.16, 0.20 and 0.17 dv and the largest degradation in B20% visibility is 0.61, 0.57 and 0.61 dv, respectively. The Source Groups' R, S, T and U contributions to the B20% visibility range from zero to 0.16, 0.33, 0.40 and 0.80 dv for the High and zero to 0.13, 0.16, 0.23 and 0.75 dv for the Low Development Scenarios with the 2021 Medium Development scenario results falling between the High and Low Development Scenarios.

A brief discussion is provided below on the most substantial potential differences in cumulative visibility impacts with the CARMMS 1.5 emissions compared to CARMMS 1.0. As discussed in the introduction to this section, the results presented here are based on CARMMS 1.0 CAMx model output and not the updated CARMMS 1.5 CAMx model output, and provide a conservative estimate of CARMMS 1.5 impacts. This brief discussion is provided to understand the main cumulative visibility differences between the two studies. The two emissions changes in CARMMS 1.5 from CARMMS 1.0 are updates to the Mancos Shale Low Development emission scenario and updates to mining speciation. Mining speciation changes between CARMMS 1.0 and CARMMS 1.5 occurred for all emissions scenarios (low/medium/high) but the mining emissions are constant for all the scenarios and the mining visibility impacts for each scenario are extremely close with slight differences due to secondary effects of different background concentrations due to variations in the other oil and gas emissions sources across the low/medium/high emissions scenarios.

The Class I areas with the largest visibility impacts from the mining source group (Group Q) as calculated by the FLAG 2010 method in the previous section, are: Dinosaur_co (1.105 dv), Flat Tops (0.744 dv), Mount Zirkel (0.635 dv) and West Elk (0.642), on days with maximum annual impacts. These are the only Class I areas with visibility impacts > 0.5 dv for Group Q (low scenario) in CARMMS 1.5 using the FLAG 2010 method. The corresponding Group Q visibility impacts for CARMMS 1.0 were: Dinosaur_co (1.897 dv), Flat Tops (1.275 dv), Mount Zirkel (1.044 dv) and West Elk (0.895 dv). The differences in these results show an average of 37.8 % reduction in mining visibility impacts at these most impacted Class I areas, on the highest impact days. Note that Dinosaur_co is not evaluated in the cumulative MATS analysis, so the following discussion pertains to Flat Tops, Mount Zirkel and West Elk Class I areas only.

The cumulative MATS assessment does not estimate impacts due to mining emissions sources alone, rather it combines mining emissions with other oil and gas emissions sources in Groups R, S, T, and U. Group R has the fewest other oil and gas sources and therefore mining emissions have the largest relative contribution to Group R compared to Groups S, T, and U. An examination of visibility impacts at the three Class I areas under consideration for Group R (low scenario, CARMMS 1.5, FLAG 2010 method) shows the following values: Flat Tops (0.7790 dv), Mount Zirkel 0.6547 dv) and West Elk (0.6524 dv). Compared to Group Q (low scenario, CARMMS 1.5, FLAG 2010) these impacts are only slightly higher (Flat Tops: 4.5%, Mount Zirkel: 3.0%, West Elk: 1.6%) suggesting that mining emissions may be the largest contributor to visibility impacts at these Class I areas on days with highest impacts. Note that the days on which the highest impacts occur may differ between Groups Q and Groups R and it is possible that Group R may be impacted by different emissions sources from mining on the highest impact day, but mining certainly substantially contributes to Group R impacts on some high impact days.

Next, we consider the cumulative MATS impacts from Group R at these three Class I areas. For the low scenario (using CARMMS 1.0 CAMx output) the reported contributions from group R are: Flat Tops (0.01 dv), Mount Zirkel (0.00 dv) and West Elk (0.01 dv) for the W20% days, and Flat Tops (0.00 dv), Mount Zirkel (0.01 dv) and West Elk (0.01 dv) for the B20% days. Recall that these values are calculated as averages over the 20% best and 20% worst visibility days, which explains why these values are much lower than the FLAG 2010 values which focus on the highest visibility impacts throughout the year. Given that Group R at these Class I areas likely includes a substantial contribution from the mining emissions at least on some high visibility impact days it is possible that the Group R impacts could potentially be lower by up to ~ 37.8 %. However, since the visibility equations are non-linear it is not clear how a potential ~37.8 %

reduction in visibility impacts calculated with the FLAG 2010 method could be applied to the cumulative MATS assessment. In addition, Group R cumulative MATS visibility impacts are at most 0.01 dv at the Class I areas most impacted by mining emissions implying a maximum potential over-estimate of less than 0.01 dv. In conclusion, on the question of how changes in mining emissions between CARMMS 1.0 and CARMMS 1.5 could potentially influence the cumulative MATS results, it is likely that reductions in Group R visibility impacts would be bounded by about 37.8 % and would likely be lower at Class I areas other than Flat Tops, Mount Zirkel and West Elk, since mining emissions have a smaller visibility impact at those areas. Groups S, T and U would show relatively smaller potential reductions and hence ~37.8 % can be considered as an extreme upper bound on the degree of conservatism resulting from using CARMMS 1.0 results instead of CARMMS 1.5 for the mining emissions.

Now, we consider the issue of the Mancos Shale Low Development emissions updates that are not reflected in these CARMMS 1.0 cumulative MATS results. Similar to the mining issue, the Mancos Shale visibility impacts are not considered separately in the cumulative MATS assessment but are included in Groups T and U. The difference between Group S and Group T is the inclusion of the Mancos Shale emissions in Group T but not in Group S, and hence Mancos Shale visibility impacts can be inferred by considering the difference in the Group S and Group T results. Mancos Shale emissions have been updated for the low scenario only, so this discussion pertains to the low scenario results only. The only Class I area with a difference of more than 0.01 dv (in the cumulative MATS analysis) between Groups S and T for the low scenario is Wheeler Peak Wilderness with a difference of 0.06 dv for W20% days and 0.07 dv for B20% days. The FLAG 2010 method estimates maximum visibility impacts at Wheeler Peak to be 0.072 dv for CARMMS 1.0 and 0.036 dv for CARMMS 1.5, a reduction of 50.3 %. Therefore the inferred Mancos Shale visibility impacts of 0.06 dv and 0.07 dv could potentially be 50.3 % lower at Wheeler Peak with the updated Mancos Shale emissions. Therefore, the deciview impacts of Groups T and U at Wheeler Peak as estimated by CARMMS 1.0 may be conservative by about 0.04 dv, and the impact on other Class I areas would be less following the Mancos Shale updates.

Table 5-22a. Cumulative visibility results for W20% visibility days at Class I areas for current year (2008) and 2021 High Development Scenario using all emissions and without Source Groups R, S, T and U.

Class I Name	State	IMPROVE Site	2008 Base	2021 High	2021 High w/o R	2021 High w/o S	2021 High w/o T	2021 High w/o U
Arches NP	UT	CANY1	11.02	10.37	10.34	10.26	10.26	10.19
Mount Baldy Wilderness	AZ	BALD1	11.10	10.56	10.56	10.55	10.55	10.54
Bandelier NM	NM	BAND1	11.33	10.88	10.83	10.80	10.79	10.44
Black Canyon of the Gunnison NM	CO	WEMI1	9.95	9.31	9.30	9.11	9.11	9.05
Bosque del Apache	NM	BOAP1	12.72	12.31	12.30	12.30	12.30	12.27
Canyonlands NP	UT	CANY1	12.49	11.98	11.96	11.91	11.91	11.86
Capitol Reef NP	UT	CAPI1	12.92	12.72	12.71	12.65	12.65	12.61
Eagles Nest Wilderness	CO	WHRI1	8.68	7.87	7.85	7.78	7.78	7.70
Flat Tops Wilderness	CO	WHRI1	8.68	8.07	8.06	7.89	7.89	7.85
Galiuro Wilderness[1]	AZ	CHIR1	11.58	11.19	11.19	11.19	11.19	11.18
Gila Wilderness	NM	GICL1	11.58	11.54	11.54	11.54	11.54	11.54
Great Sand Dunes NM	CO	GRSA1	10.90	10.78	10.73	10.70	10.70	10.66
La Garita Wilderness	CO	WEMI1	9.95	9.36	9.35	9.34	9.33	9.31
Maroon Bells-Snowmass Wilderness	CO	WHRI1	8.68	7.91	7.89	7.84	7.84	7.80
Mesa Verde NP	CO	MEVE1	11.20	10.82	10.79	10.77	10.76	10.71
Mount Zirkel Wilderness	CO	MOZI1	9.36	8.54	8.53	8.45	8.45	8.42
Pecos Wilderness[2]	NM	BAND1	11.33	10.86	10.80	10.76	10.75	10.51
Petrified Forest NP	AZ	PEFO1	12.49	12.06	12.04	12.02	12.02	11.89
Rawah Wilderness	CO	MOZI1	9.36	8.53	8.52	8.44	8.44	8.39
Rocky Mountain NP	CO	ROMO1	12.04	11.15	11.14	11.09	11.09	11.03
Salt Creek	NM	SACR1	16.87	17.09	17.08	17.08	17.08	17.06
San Pedro Parks Wilderness	NM	SAPE1	9.43	8.72	8.60	8.58	8.58	8.54
West Elk Wilderness	CO	WHRI1	8.68	8.08	8.06	8.01	8.01	7.97
Weminuche Wilderness	CO	WEMI1	9.95	9.49	9.46	9.45	9.45	9.42
Wheeler Peak Wilderness[2]	NM	BAND1	11.33	10.86	10.75	10.59	10.52	10.36
White Mountain Wilderness	NM	WHIT1	12.92	13.15	13.15	13.15	13.15	13.13

Table 5-22b. Differences in cumulative visibility results for W20% visibility days at Class I areas between current year (2008) and 2021 High Development Scenario (2008-2021) and contributions of Source Groups R, S, T and U to 2021 W20% day's visibility.

Class I Name	State	IMPROVE Site	2021 High Improvement from 2008	Contribution from R	Contribution from S	Contribution from T	Contribution from U
Arches NP	UT	CANY1	0.65	0.03	0.11	0.11	0.18
Mount Baldy Wilderness	AZ	BALD1	0.54	0.00	0.01	0.01	0.02
Bandelier NM	NM	BAND1	0.45	0.05	0.08	0.09	0.44
Black Canyon of the Gunnison NM	CO	WEMI1	0.64	0.01	0.20	0.20	0.26
Bosque del Apache	NM	BOAP1	0.41	0.01	0.01	0.01	0.04
Canyonlands NP	UT	CANY1	0.51	0.02	0.07	0.07	0.12
Capitol Reef NP	UT	CAPI1	0.20	0.01	0.07	0.07	0.11
Eagles Nest Wilderness	CO	WHRI1	0.81	0.02	0.09	0.09	0.17
Flat Tops Wilderness	CO	WHRI1	0.61	0.01	0.18	0.18	0.22
Galiuro Wilderness[1]	AZ	CHIR1	0.39	0.00	0.00	0.00	0.01
Gila Wilderness	NM	GICL1	0.04	0.00	0.00	0.00	0.00
Great Sand Dunes NM	CO	GRSA1	0.12	0.05	0.08	0.08	0.12
La Garita Wilderness	CO	WEMI1	0.59	0.01	0.02	0.03	0.05
Maroon Bells-Snowmass Wilderness	CO	WHRI1	0.77	0.02	0.07	0.07	0.11
Mesa Verde NP	CO	MEVE1	0.38	0.03	0.05	0.06	0.11
Mount Zirkel Wilderness	CO	MOZI1	0.82	0.01	0.09	0.09	0.12
Pecos Wilderness[2]	NM	BAND1	0.47	0.06	0.10	0.11	0.35
Petrified Forest NP	AZ	PEFO1	0.43	0.02	0.04	0.04	0.17
Rawah Wilderness	CO	MOZI1	0.83	0.01	0.09	0.09	0.14
Rocky Mountain NP	CO	ROMO1	0.89	0.01	0.06	0.06	0.12
Salt Creek	NM	SACR1	-0.22	0.01	0.01	0.01	0.03
San Pedro Parks Wilderness	NM	SAPE1	0.71	0.12	0.14	0.14	0.18
West Elk Wilderness	CO	WHRI1	0.60	0.02	0.07	0.07	0.11
Weminuche Wilderness	CO	WEMI1	0.46	0.03	0.04	0.04	0.07
Wheeler Peak Wilderness[2]	NM	BAND1	0.47	0.11	0.27	0.34	0.50
White Mountain Wilderness	NM	WHIT1	-0.23	0.00	0.00	0.00	0.02

Table 5-23a. Cumulative visibility results for W20% visibility days at Class I areas for current year (2008) and 2021 Low Development Scenario using all emissions and without Source Groups R, S, T and U.

Class I Name	State	IMPROVE Site	2008 Base	2021 Low	2021 Low w/o R	2021 Low w/o S	2021 Low w/o T	2021 Low w/o U
Arches NP	UT	CANY1	11.02	10.33	10.32	10.28	10.28	10.21
Mount Baldy Wilderness	AZ	BALD1	11.10	10.56	10.56	10.55	10.55	10.54
Bandelier NM	NM	BAND1	11.33	10.85	10.83	10.81	10.81	10.45
Black Canyon of the Gunnison NM	CO	WEMI1	9.95	9.21	9.20	9.12	9.12	9.06
Bosque del Apache	NM	BOAP1	12.72	12.31	12.31	12.30	12.30	12.27
Canyonlands NP	UT	CANY1	12.49	11.95	11.94	11.92	11.91	11.87
Capitol Reef NP	UT	CAPI1	12.92	12.69	12.69	12.66	12.66	12.62
Eagles Nest Wilderness	CO	WHRI1	8.68	7.83	7.82	7.79	7.79	7.71
Flat Tops Wilderness	CO	WHRI1	8.68	8.00	7.99	7.91	7.91	7.86
Galiuro Wilderness[1]	AZ	CHIR1	11.58	11.19	11.19	11.19	11.19	11.18
Gila Wilderness	NM	GICL1	11.58	11.54	11.54	11.54	11.54	11.54
Great Sand Dunes NM	CO	GRSA1	10.90	10.76	10.73	10.72	10.71	10.67
La Garita Wilderness	CO	WEMI1	9.95	9.35	9.35	9.34	9.34	9.31
Maroon Bells-Snowmass Wilderness	CO	WHRI1	8.68	7.88	7.87	7.85	7.85	7.81
Mesa Verde NP	CO	MEVE1	11.20	10.81	10.79	10.78	10.78	10.72
Mount Zirkel Wilderness	CO	MOZI1	9.36	8.49	8.49	8.45	8.45	8.42
Pecos Wilderness[2]	NM	BAND1	11.33	10.82	10.80	10.78	10.77	10.52
Petrified Forest NP	AZ	PEFO1	12.49	12.04	12.04	12.02	12.02	11.89
Rawah Wilderness	CO	MOZI1	9.36	8.48	8.47	8.44	8.44	8.39
Rocky Mountain NP	CO	ROMO1	12.04	11.12	11.12	11.09	11.09	11.03
Salt Creek	NM	SACR1	16.87	17.09	17.08	17.08	17.08	17.06
San Pedro Parks Wilderness	NM	SAPE1	9.43	8.70	8.60	8.59	8.59	8.55
West Elk Wilderness	CO	WHRI1	8.68	8.05	8.04	8.02	8.01	7.98
Weminuche Wilderness	CO	WEMI1	9.95	9.48	9.46	9.46	9.45	9.43
Wheeler Peak Wilderness[2]	NM	BAND1	11.33	10.75	10.70	10.61	10.55	10.38
White Mountain Wilderness	NM	WHIT1	12.92	13.15	13.15	13.15	13.15	13.13

Table 5-23b. Differences in cumulative visibility results for W20% visibility days at Class I areas between current year (2008) and 2021 Low Development Scenario (2008-2021) and contributions of Source Groups R, S, T and U to 2021 W20% day's visibility.

Class I Name	State	IMPROVE Site	2021 Low Improvement from 2008	Contribution from R	Contribution from S	Contribution from T	Contribution from U
Arches NP	UT	CANY1	0.69	0.01	0.05	0.05	0.12
Mount Baldy Wilderness	AZ	BALD1	0.54	0.00	0.01	0.01	0.02
Bandelier NM	NM	BAND1	0.48	0.02	0.04	0.04	0.40
Black Canyon of the Gunnison NM	CO	WEMI1	0.74	0.01	0.09	0.09	0.15
Bosque del Apache	NM	BOAP1	0.41	0.00	0.01	0.01	0.04
Canyonlands NP	UT	CANY1	0.54	0.01	0.03	0.04	0.08
Capitol Reef NP	UT	CAPI1	0.23	0.00	0.03	0.03	0.07
Eagles Nest Wilderness	CO	WHRI1	0.85	0.01	0.04	0.04	0.12
Flat Tops Wilderness	CO	WHRI1	0.68	0.01	0.09	0.09	0.14
Galiuro Wilderness[1]	AZ	CHIR1	0.39	0.00	0.00	0.00	0.01
Gila Wilderness	NM	GICL1	0.04	0.00	0.00	0.00	0.00
Great Sand Dunes NM	CO	GRSA1	0.14	0.03	0.04	0.05	0.09
La Garita Wilderness	CO	WEMI1	0.60	0.00	0.01	0.01	0.04
Maroon Bells-Snowmass Wilderness	CO	WHRI1	0.80	0.01	0.03	0.03	0.07
Mesa Verde NP	CO	MEVE1	0.39	0.02	0.03	0.03	0.09
Mount Zirkel Wilderness	CO	MOZI1	0.87	0.00	0.04	0.04	0.07
Pecos Wilderness[2]	NM	BAND1	0.51	0.02	0.04	0.05	0.30
Petrified Forest NP	AZ	PEFO1	0.45	0.00	0.02	0.02	0.15
Rawah Wilderness	CO	MOZI1	0.88	0.01	0.04	0.04	0.09
Rocky Mountain NP	CO	ROMO1	0.92	0.00	0.03	0.03	0.09
Salt Creek	NM	SACR1	-0.22	0.01	0.01	0.01	0.03
San Pedro Parks Wilderness	NM	SAPE1	0.73	0.10	0.11	0.11	0.15
West Elk Wilderness	CO	WHRI1	0.63	0.01	0.03	0.04	0.07
Weminuche Wilderness	CO	WEMI1	0.47	0.02	0.02	0.03	0.05
Wheeler Peak Wilderness[2]	NM	BAND1	0.58	0.05	0.14	0.20	0.37
White Mountain Wilderness	NM	WHIT1	-0.23	0.00	0.00	0.00	0.02

Table 5-24a. Cumulative visibility results for W20% visibility days at Class I areas for current year (2008) and 2021 Medium Development Scenario using all emissions and without Source Groups R, S, T and U.

Class I Name	State	IMPROVE Site	2008 Base	2021 Medium	2021 Med w/o R	2021 Med w/o S	2021 Med w/o T	2021 Med w/o U
Arches NP	UT	CANY1	11.02	10.36	10.35	10.26	10.26	10.19
Mount Baldy Wilderness	AZ	BALD1	11.10	10.56	10.56	10.55	10.55	10.54
Bandelier NM	NM	BAND1	11.33	10.87	10.83	10.80	10.79	10.44
Black Canyon of the Gunnison NM	CO	WEMI1	9.95	9.31	9.30	9.11	9.11	9.05
Bosque del Apache	NM	BOAP1	12.72	12.31	12.30	12.30	12.30	12.27
Canyonlands NP	UT	CANY1	12.49	11.98	11.96	11.91	11.91	11.86
Capitol Reef NP	UT	CAPI1	12.92	12.72	12.71	12.65	12.65	12.61
Eagles Nest Wilderness	CO	WHRI1	8.68	7.86	7.85	7.78	7.78	7.70
Flat Tops Wilderness	CO	WHRI1	8.68	8.07	8.06	7.89	7.89	7.85
Galiuro Wilderness[1]	AZ	CHIR1	11.58	11.19	11.19	11.19	11.19	11.18
Gila Wilderness	NM	GICL1	11.58	11.54	11.54	11.54	11.54	11.54
Great Sand Dunes NM	CO	GRSA1	10.90	10.77	10.73	10.71	10.70	10.66
La Garita Wilderness	CO	WEMI1	9.95	9.36	9.35	9.33	9.33	9.31
Maroon Bells-Snowmass Wilderness	CO	WHRI1	8.68	7.90	7.89	7.85	7.84	7.80
Mesa Verde NP	CO	MEVE1	11.20	10.82	10.79	10.77	10.77	10.71
Mount Zirkel Wilderness	CO	MOZI1	9.36	8.54	8.53	8.45	8.45	8.42
Pecos Wilderness[2]	NM	BAND1	11.33	10.84	10.80	10.76	10.75	10.51
Petrified Forest NP	AZ	PEFO1	12.49	12.06	12.04	12.02	12.02	11.89
Rawah Wilderness	CO	MOZI1	9.36	8.53	8.52	8.44	8.44	8.39
Rocky Mountain NP	CO	ROMO1	12.04	11.15	11.14	11.09	11.09	11.03
Salt Creek	NM	SACR1	16.87	17.09	17.08	17.08	17.08	17.06
San Pedro Parks Wilderness	NM	SAPE1	9.43	8.72	8.60	8.58	8.58	8.54
West Elk Wilderness	CO	WHRI1	8.68	8.08	8.06	8.01	8.01	7.97
Weminuche Wilderness	CO	WEMI1	9.95	9.48	9.46	9.45	9.45	9.42
Wheeler Peak Wilderness[2]	NM	BAND1	11.33	10.81	10.72	10.56	10.53	10.36
White Mountain Wilderness	NM	WHIT1	12.92	13.15	13.15	13.15	13.15	13.13

Table 5-24b. Differences in cumulative visibility results for W20% visibility days at Class I areas between current year (2008) and 2021 Medium Development Scenario (2008-2021) and contributions of Source Groups R, S, T and U to 2021 W20% day's visibility.

Class I Name	State	IMPROVE Site	2021 Med Improvement from 2008	Contribution from R	Contribution from S	Contribution from T	Contribution from U
Arches NP	UT	CANY1	0.66	0.01	0.10	0.10	0.17
Mount Baldy Wilderness	AZ	BALD1	0.54	0.00	0.01	0.01	0.02
Bandelier NM	NM	BAND1	0.46	0.04	0.07	0.08	0.43
Black Canyon of the Gunnison NM	CO	WEMI1	0.64	0.01	0.20	0.20	0.26
Bosque del Apache	NM	BOAP1	0.41	0.01	0.01	0.01	0.04
Canyonlands NP	UT	CANY1	0.51	0.02	0.07	0.07	0.12
Capitol Reef NP	UT	CAPI1	0.20	0.01	0.07	0.07	0.11
Eagles Nest Wilderness	CO	WHRI1	0.82	0.01	0.08	0.08	0.16
Flat Tops Wilderness	CO	WHRI1	0.61	0.01	0.18	0.18	0.22
Galiuro Wilderness[1]	AZ	CHIR1	0.39	0.00	0.00	0.00	0.01
Gila Wilderness	NM	GICL1	0.04	0.00	0.00	0.00	0.00
Great Sand Dunes NM	CO	GRSA1	0.13	0.04	0.06	0.07	0.11
La Garita Wilderness	CO	WEMI1	0.59	0.01	0.03	0.03	0.05
Maroon Bells-Snowmass Wilderness	CO	WHRI1	0.78	0.01	0.05	0.06	0.10
Mesa Verde NP	CO	MEVE1	0.38	0.03	0.05	0.05	0.11
Mount Zirkel Wilderness	CO	MOZI1	0.82	0.01	0.09	0.09	0.12
Pecos Wilderness[2]	NM	BAND1	0.49	0.04	0.08	0.09	0.33
Petrified Forest NP	AZ	PEFO1	0.43	0.02	0.04	0.04	0.17
Rawah Wilderness	CO	MOZI1	0.83	0.01	0.09	0.09	0.14
Rocky Mountain NP	CO	ROMO1	0.89	0.01	0.06	0.06	0.12
Salt Creek	NM	SACR1	-0.22	0.01	0.01	0.01	0.03
San Pedro Parks Wilderness	NM	SAPE1	0.71	0.12	0.14	0.14	0.18
West Elk Wilderness	CO	WHRI1	0.60	0.02	0.07	0.07	0.11
Weminuche Wilderness	CO	WEMI1	0.47	0.02	0.03	0.03	0.06
Wheeler Peak Wilderness[2]	NM	BAND1	0.52	0.09	0.25	0.28	0.45
White Mountain Wilderness	NM	WHIT1	-0.23	0.00	0.00	0.00	0.02

Table 5-25a. Cumulative visibility results for B20% visibility days at Class I areas for current year (2008) and 2021 High Development Scenario using all emissions and without Source Groups R, S, T and U.

Class I Name		IMPROVE Site	2008 Base	2021 High	2021 High w/o R	2021 High w/o S	2021 High w/o T	2021 High w/o U
Arches NP	UT	CANY1	2.86	2.86	2.85	2.81	2.81	2.78
Mount Baldy Wilderness	AZ	BALD1	2.86	2.84	2.83	2.83	2.83	2.80
Bandelier NM	NM	BAND1	4.01	4.62	4.57	4.53	4.51	3.82
Black Canyon of the Gunnison NM	CO	WEMI1	2.25	2.18	2.17	2.07	2.07	2.04
Bosque del Apache	NM	BOAP1	5.50	5.42	5.42	5.42	5.42	5.41
Canyonlands NP	UT	CANY1	4.54	4.72	4.69	4.62	4.62	4.57
Capitol Reef NP	UT	CAPI1	3.33	3.43	3.41	3.37	3.36	3.33
Eagles Nest Wilderness	CO	WHRI1	0.69	0.55	0.54	0.50	0.50	0.48
Flat Tops Wilderness	CO	WHRI1	0.69	0.55	0.53	0.41	0.41	0.38
Galiuro Wilderness[1]	AZ	GICL1	2.58	2.87	2.86	2.86	2.86	2.86
Gila Wilderness	NM	CHIR1	2.58	2.89	2.89	2.89	2.89	2.89
Great Sand Dunes NM	CO	GRSA1	3.58	3.82	3.77	3.75	3.74	3.70
La Garita Wilderness	CO	WEMI1	2.25	2.29	2.27	2.26	2.26	2.22
Maroon Bells-Snowmass Wilderness	CO	WHRI1	0.69	0.53	0.51	0.49	0.49	0.47
Mesa Verde NP	CO	MEVE1	3.12	3.28	3.24	3.21	3.21	3.14
Mount Zirkel Wilderness	CO	MOZI1	0.95	0.84	0.83	0.72	0.72	0.68
Pecos Wilderness[2]	NM	PEFO1	4.54	4.65	4.60	4.57	4.56	4.21
Petrified Forest NP	AZ	BAND1	4.01	4.51	4.45	4.40	4.39	3.94
Rawah Wilderness	CO	MOZI1	0.95	0.87	0.86	0.75	0.75	0.71
Rocky Mountain NP	CO	ROMO1	1.91	1.87	1.86	1.82	1.82	1.80
Salt Creek	NM	SACR1	6.81	7.00	7.00	7.00	7.00	6.99
San Pedro Parks Wilderness	NM	SAPE1	1.28	1.32	1.18	1.16	1.16	1.11
West Elk Wilderness	CO	WHRI1	0.69	0.57	0.56	0.54	0.54	0.52
Weminuche Wilderness	CO	WEMI1	2.25	2.43	2.40	2.38	2.38	2.35
Wheeler Peak Wilderness[2]	NM	BAND1	4.01	4.37	4.21	4.04	3.97	3.75
White Mountain Wilderness	NM	WHIT1	3.33	3.32	3.32	3.32	3.32	3.29

Table 5-25b. Differences in cumulative visibility results for B20% visibility days at Class I areas between current year (2008) and 2021 High Development Scenario (2008-2021) and contributions of Source Groups R, S, T and U to 2021 W20% day's visibility.

Class I Name		IMPROVE Site	2021 High Improvement from 2008	Contribution from R	Contribution from S	Contribution from T	Contribution from U
Arches NP	UT	CANY1	0.00	0.01	0.05	0.05	0.08
Mount Baldy Wilderness	AZ	BALD1	0.02	0.01	0.01	0.01	0.04
Bandelier NM	NM	BAND1	-0.61	0.05	0.09	0.11	0.80
Black Canyon of the Gunnison NM	CO	WEMI1	0.07	0.01	0.11	0.11	0.14
Bosque del Apache	NM	BOAP1	0.08	0.00	0.00	0.00	0.01
Canyonlands NP	UT	CANY1	-0.18	0.03	0.10	0.10	0.15
Capitol Reef NP	UT	CAPI1	-0.10	0.02	0.06	0.07	0.10
Eagles Nest Wilderness	CO	WHRI1	0.14	0.01	0.05	0.05	0.07
Flat Tops Wilderness	CO	WHRI1	0.14	0.02	0.14	0.14	0.17
Galiuro Wilderness[1]	AZ	GICL1	-0.29	0.01	0.01	0.01	0.01
Gila Wilderness	NM	CHIR1	-0.31	0.00	0.00	0.00	0.00
Great Sand Dunes NM	CO	GRSA1	-0.24	0.05	0.07	0.08	0.12
La Garita Wilderness	CO	WEMI1	-0.04	0.02	0.03	0.03	0.07
Maroon Bells-Snowmass Wilderness	CO	WHRI1	0.16	0.02	0.04	0.04	0.06
Mesa Verde NP	CO	MEVE1	-0.16	0.04	0.07	0.07	0.14
Mount Zirkel Wilderness	CO	MOZI1	0.11	0.01	0.12	0.12	0.16
Pecos Wilderness[2]	NM	PEFO1	-0.11	0.05	0.08	0.09	0.44
Petrified Forest NP	AZ	BAND1	-0.50	0.06	0.11	0.12	0.57
Rawah Wilderness	CO	MOZI1	0.08	0.01	0.12	0.12	0.16
Rocky Mountain NP	CO	ROMO1	0.04	0.01	0.05	0.05	0.07
Salt Creek	NM	SACR1	-0.19	0.00	0.00	0.00	0.01
San Pedro Parks Wilderness	NM	SAPE1	-0.04	0.14	0.16	0.16	0.21
West Elk Wilderness	CO	WHRI1	0.12	0.01	0.03	0.03	0.05
Weminuche Wilderness	CO	WEMI1	-0.18	0.03	0.05	0.05	0.08
Wheeler Peak Wilderness[2]	NM	BAND1	-0.36	0.16	0.33	0.40	0.62
White Mountain Wilderness	NM	WHIT1	0.01	0.00	0.00	0.00	0.03

Table 5-26a. Cumulative visibility results for B20% visibility days at Class I areas for current year (2008) and 2021 Low Development Scenario using all emissions and without Source Groups R, S, T and U.

Class I Name		IMPROVE Site	2008 Base	2021 Low	2021 Low w/o R	2021 Low w/o S	2021 Low w/o T	2021 Low w/o U
Arches NP	UT	CANY1	2.86	2.84	2.84	2.82	2.82	2.79
Mount Baldy Wilderness	AZ	BALD1	2.86	2.83	2.83	2.83	2.83	2.80
Bandelier NM	NM	BAND1	4.01	4.58	4.56	4.54	4.53	3.83
Black Canyon of the Gunnison NM	CO	WEMI1	2.25	2.13	2.12	2.08	2.08	2.05
Bosque del Apache	NM	BOAP1	5.50	5.42	5.42	5.42	5.42	5.41
Canyonlands NP	UT	CANY1	4.54	4.69	4.67	4.64	4.64	4.59
Capitol Reef NP	UT	CAPI1	3.33	3.41	3.40	3.37	3.37	3.34
Eagles Nest Wilderness	CO	WHRI1	0.69	0.53	0.53	0.51	0.51	0.48
Flat Tops Wilderness	CO	WHRI1	0.69	0.49	0.49	0.42	0.42	0.39
Galiuro Wilderness[1]	AZ	GICL1	2.58	2.86	2.86	2.86	2.86	2.86
Gila Wilderness	NM	CHIR1	2.58	2.89	2.89	2.89	2.89	2.89
Great Sand Dunes NM	CO	GRSA1	3.58	3.80	3.77	3.76	3.75	3.70
La Garita Wilderness	CO	WEMI1	2.25	2.28	2.27	2.26	2.26	2.22
Maroon Bells-Snowmass Wilderness	CO	WHRI1	0.69	0.51	0.51	0.50	0.50	0.48
Mesa Verde NP	CO	MEVE1	3.12	3.25	3.24	3.22	3.22	3.14
Mount Zirkel Wilderness	CO	MOZI1	0.95	0.79	0.78	0.73	0.73	0.69
Pecos Wilderness[2]	NM	PEFO1	4.54	4.61	4.60	4.58	4.57	4.21
Petrified Forest NP	AZ	BAND1	4.01	4.46	4.44	4.41	4.40	3.95
Rawah Wilderness	CO	MOZI1	0.95	0.82	0.82	0.77	0.77	0.72
Rocky Mountain NP	CO	ROMO1	1.91	1.85	1.84	1.82	1.82	1.80
Salt Creek	NM	SACR1	6.81	7.00	7.00	7.00	7.00	6.99
San Pedro Parks Wilderness	NM	SAPE1	1.28	1.30	1.17	1.17	1.17	1.12
West Elk Wilderness	CO	WHRI1	0.69	0.56	0.55	0.54	0.54	0.52
Weminuche Wilderness	CO	WEMI1	2.25	2.41	2.40	2.39	2.39	2.35
Wheeler Peak Wilderness[2]	NM	BAND1	4.01	4.22	4.16	4.06	3.99	3.76
White Mountain Wilderness	NM	WHIT1	3.33	3.32	3.32	3.32	3.32	3.29

Table 5-26b. Differences in cumulative visibility results for B20% visibility days at Class I areas between current year (2008) and 2021 Low Development Scenario (2008-2021) and contributions of Source Groups R, S, T and U to 2021 W20% day's visibility.

Class I Name		IMPROVE Site	2021 Low Improvement from 2008	Contribution from R	Contribution from S	Contribution from T	Contribution from U
Arches NP	UT	CANY1	0.02	0.00	0.02	0.02	0.05
Mount Baldy Wilderness	AZ	BALD1	0.03	0.00	0.00	0.00	0.03
Bandelier NM	NM	BAND1	-0.57	0.02	0.04	0.05	0.75
Black Canyon of the Gunnison NM	CO	WEMI1	0.12	0.01	0.05	0.05	0.08
Bosque del Apache	NM	BOAP1	0.08	0.00	0.00	0.00	0.01
Canyonlands NP	UT	CANY1	-0.15	0.02	0.05	0.05	0.10
Capitol Reef NP	UT	CAPI1	-0.08	0.01	0.04	0.04	0.07
Eagles Nest Wilderness	CO	WHRI1	0.16	0.00	0.02	0.02	0.05
Flat Tops Wilderness	CO	WHRI1	0.20	0.00	0.07	0.07	0.10
Galiuro Wilderness[1]	AZ	GICL1	-0.28	0.00	0.00	0.00	0.00
Gila Wilderness	NM	CHIR1	-0.31	0.00	0.00	0.00	0.00
Great Sand Dunes NM	CO	GRSA1	-0.22	0.03	0.04	0.05	0.10
La Garita Wilderness	CO	WEMI1	-0.03	0.01	0.02	0.02	0.06
Maroon Bells-Snowmass Wilderness	CO	WHRI1	0.18	0.00	0.01	0.01	0.03
Mesa Verde NP	CO	MEVE1	-0.13	0.01	0.03	0.03	0.11
Mount Zirkel Wilderness	CO	MOZI1	0.16	0.01	0.06	0.06	0.10
Pecos Wilderness[2]	NM	PEFO1	-0.07	0.01	0.03	0.04	0.40
Petrified Forest NP	AZ	BAND1	-0.45	0.02	0.05	0.06	0.51
Rawah Wilderness	CO	MOZI1	0.13	0.00	0.05	0.05	0.10
Rocky Mountain NP	CO	ROMO1	0.06	0.01	0.03	0.03	0.05
Salt Creek	NM	SACR1	-0.19	0.00	0.00	0.00	0.01
San Pedro Parks Wilderness	NM	SAPE1	-0.02	0.13	0.13	0.13	0.18
West Elk Wilderness	CO	WHRI1	0.13	0.01	0.02	0.02	0.04
Weminuche Wilderness	CO	WEMI1	-0.16	0.01	0.02	0.02	0.06
Wheeler Peak Wilderness[2]	NM	BAND1	-0.21	0.06	0.16	0.23	0.46
White Mountain Wilderness	NM	WHIT1	0.01	0.00	0.00	0.00	0.03

Table 5-27a. Cumulative visibility results for B20% visibility days at Class I areas for current year (2008) and 2021 Medium Development Scenario using all emissions and without Source Groups R, S, T and U.

Class I Name		IMPROVE Site	2008 Base	2021 Medium	2021 Med w/o R	2021 Med w/o S	2021 Med w/o T	2021 Med w/o U
Arches NP	UT	CANY1	2.86	2.86	2.85	2.81	2.81	2.78
Mount Baldy Wilderness	AZ	BALD1	2.86	2.83	2.83	2.83	2.83	2.80
Bandelier NM	NM	BAND1	4.01	4.62	4.57	4.52	4.52	3.82
Black Canyon of the Gunnison NM	CO	WEMI1	2.25	2.18	2.17	2.07	2.07	2.04
Bosque del Apache	NM	BOAP1	5.50	5.42	5.42	5.42	5.42	5.41
Canyonlands NP	UT	CANY1	4.54	4.72	4.69	4.62	4.62	4.58
Capitol Reef NP	UT	CAPI1	3.33	3.43	3.41	3.37	3.36	3.33
Eagles Nest Wilderness	CO	WHRI1	0.69	0.55	0.54	0.50	0.50	0.48
Flat Tops Wilderness	CO	WHRI1	0.69	0.54	0.53	0.41	0.41	0.38
Galiuro Wilderness[1]	AZ	GICL1	2.58	2.87	2.86	2.86	2.86	2.86
Gila Wilderness	NM	CHIR1	2.58	2.89	2.89	2.89	2.89	2.89
Great Sand Dunes NM	CO	GRSA1	3.58	3.81	3.77	3.75	3.75	3.70
La Garita Wilderness	CO	WEMI1	2.25	2.29	2.27	2.26	2.26	2.22
Maroon Bells-Snowmass Wilderness	CO	WHRI1	0.69	0.52	0.51	0.49	0.49	0.47
Mesa Verde NP	CO	MEVE1	3.12	3.27	3.24	3.21	3.21	3.14
Mount Zirkel Wilderness	CO	MOZI1	0.95	0.83	0.83	0.72	0.72	0.68
Pecos Wilderness[2]	NM	PEFO1	4.54	4.64	4.60	4.57	4.56	4.21
Petrified Forest NP	AZ	BAND1	4.01	4.50	4.44	4.40	4.39	3.94
Rawah Wilderness	CO	MOZI1	0.95	0.87	0.86	0.75	0.75	0.71
Rocky Mountain NP	CO	ROMO1	1.91	1.87	1.86	1.82	1.82	1.80
Salt Creek	NM	SACR1	6.81	7.00	7.00	7.00	7.00	6.99
San Pedro Parks Wilderness	NM	SAPE1	1.28	1.32	1.18	1.16	1.16	1.11
West Elk Wilderness	CO	WHRI1	0.69	0.57	0.56	0.54	0.54	0.52
Weminuche Wilderness	CO	WEMI1	2.25	2.43	2.40	2.38	2.38	2.35
Wheeler Peak Wilderness[2]	NM	BAND1	4.01	4.32	4.19	4.02	3.97	3.75
White Mountain Wilderness	NM	WHIT1	3.33	3.32	3.32	3.32	3.32	3.29

Table 5-27b. Differences in cumulative visibility results for B20% visibility days at Class I areas between current year (2008) and 2021 Medium Development Scenario (2008-2021) and contributions of Source Groups R, S, T and U to 2021 W20% day's visibility.

Class I Name		IMPROVE Site	2021 Med Improvement from 2008	Contribution from R	Contribution from S	Contribution from T	Contribution from U
Arches NP	UT	CANY1	0.00	0.01	0.05	0.05	0.08
Mount Baldy Wilderness	AZ	BALD1	0.03	0.00	0.00	0.00	0.03
Bandelier NM	NM	BAND1	-0.61	0.05	0.10	0.10	0.80
Black Canyon of the Gunnison NM	CO	WEMI1	0.07	0.01	0.11	0.11	0.14
Bosque del Apache	NM	BOAP1	0.08	0.00	0.00	0.00	0.01
Canyonlands NP	UT	CANY1	-0.18	0.03	0.10	0.10	0.14
Capitol Reef NP	UT	CAPI1	-0.10	0.02	0.06	0.07	0.10
Eagles Nest Wilderness	CO	WHRI1	0.14	0.01	0.05	0.05	0.07
Flat Tops Wilderness	CO	WHRI1	0.15	0.01	0.13	0.13	0.16
Galiuro Wilderness[1]	AZ	GICL1	-0.29	0.01	0.01	0.01	0.01
Gila Wilderness	NM	CHIR1	-0.31	0.00	0.00	0.00	0.00
Great Sand Dunes NM	CO	GRSA1	-0.23	0.04	0.06	0.06	0.11
La Garita Wilderness	CO	WEMI1	-0.04	0.02	0.03	0.03	0.07
Maroon Bells-Snowmass Wilderness	CO	WHRI1	0.17	0.01	0.03	0.03	0.05
Mesa Verde NP	CO	MEVE1	-0.15	0.03	0.06	0.06	0.13
Mount Zirkel Wilderness	CO	MOZI1	0.12	0.00	0.11	0.11	0.15
Pecos Wilderness[2]	NM	PEFO1	-0.10	0.04	0.07	0.08	0.43
Petrified Forest NP	AZ	BAND1	-0.49	0.06	0.10	0.11	0.56
Rawah Wilderness	CO	MOZI1	0.08	0.01	0.12	0.12	0.16
Rocky Mountain NP	CO	ROMO1	0.04	0.01	0.05	0.05	0.07
Salt Creek	NM	SACR1	-0.19	0.00	0.00	0.00	0.01
San Pedro Parks Wilderness	NM	SAPE1	-0.04	0.14	0.16	0.16	0.21
West Elk Wilderness	CO	WHRI1	0.12	0.01	0.03	0.03	0.05
Weminuche Wilderness	CO	WEMI1	-0.18	0.03	0.05	0.05	0.08
Wheeler Peak Wilderness[2]	NM	BAND1	-0.31	0.13	0.30	0.35	0.57
White Mountain Wilderness	NM	WHIT1	0.01	0.00	0.00	0.00	0.03

5.4 Sulfur and Nitrogen Deposition at Class I and Sensitive Class II Areas

Attachments D-1, D-2 and D-3 are interactive Excel spreadsheets that display Maximum and Average sulfur and nitrogen deposition due to emissions from each of the 32 Source Groups shown in Table 4-2c. As for the PSD concentrations Attachment A spreadsheet, there is a "Summary" sheet that displays the sulfur and nitrogen deposition across all Class I and sensitive Class II areas for a user selected Source Group that is controlled by a drop down menu in cell B5. And a "MaxImpact" sheet that gives the highest sulfur or nitrogen deposition that occurred at any Class I area or sensitive Class II area that is controlled by cell B3 to select Sulfur or Nitrogen and cell B4 to select either Maximum or Average. Here Maximum represents the maximum deposition in any grid cell covering the Class I/II area, whereas Average provides the average of deposition across all grid cells covering a Class I/II area. Although the convention in the past has been to report the Maximum deposition in any receptor in a Class I/II area, since deposition relates to the total amount deposited across an entire watershed, the Average metric is probably a more relevant parameter for evaluating potential environment effects. Both Maximum and Average deposition metrics are reported.

For the deposition impacts associated with Federal O&G within each of the individual BLM Planning Areas (i.e., Source Groups A through P), the sulfur and nitrogen deposition amounts are compared against the 0.005 kg/ha-yr Deposition Analysis Threshold (DAT) for the western United States. The DAT is a screening threshold such that if a Project's deposition amount is below the DAT its deposition impacts is considered insignificant. The deposition due to the total emissions, that is Source Groups W (2021) and X (2008), are compared against the Critical Load Values, which for nitrogen is 2.2 kg/ha-yr in Wyoming and 2.3 kg/ha-yr in Colorado except for 3.0 kg/ha-yr for Dinosaur NM. The Critical Load of atmospheric deposition for sulfur in this analysis is 5.0 kg/ha-yr everywhere.

5.4.1 Highest Deposition Impacts at Class I/II Areas

Tables 5-29 through 5-31 display the highest Maximum and Average nitrogen and sulfur deposition in any Class I or sensitive Class II area due to emissions from each of the 32 Source Groups for the 2021 High, Low and Medium Development Scenarios, respectively. The results for the GJFO, UFO and NMFFO Planning Areas are summarized in Tables 5-28a and 5-28b. In particular, the Class I and II areas with highest nitrogen deposition impact due to the NMFFO Planning Area are Weminuche and Aztec Ruins, respectively, with peak and average nitrogen deposition values above the DAT in all three scenarios, expect for average values in the Low Development Scenario which are below the DAT. Note that DATs are Project-level thresholds and thus, Planning Area-level exceedances are less relevant than Project-level exceedances. Table 5-28b displays the highest maximum and average sulfur deposition results at any Class I or II area due to new Federal O&G emissions from the GJFO, UFO and NMFFO Planning Areas. All sulfur deposition contributions are approximately a factor of five to ten (or more) below the DAT.

5.4.1.1 <u>Individual BLM Planning Area Comparison to DATs</u>

Individual BLM Planning Area (i.e., Source Groups A through P) annual nitrogen and sulfur deposition are compared against the 0.005 kg/ha-yr western U.S. DAT. All deposition flux values reported below have units of kg/ha-yr.

The two BLM Planning Area with Federal O&G typically having the highest annual nitrogen deposition impact are the TRFO and WRFO with maximum deposition fluxes of 0.126 and 0.108 and average values of 0.043 and 0.068 for the High Scenario, maximum values of 0.106 and 0.134 and average values of 0.036 and 0.056 for the Medium Scenario, and maximum values of 0.015 and 0.017 and average values of 0.005 and 0.011 for the Low Development Scenario, all of which are above the DAT (Tables 5-29 through 5-31). The maximum annual nitrogen deposition impacts due to the NMFFO Planning Area range from 0.037 in the High Development Scenario to 0.018 in the Low Development Scenario.

The annual sulfur deposition from new Federal O&G in the BLM Planning Areas tends to be much lower than seen for the nitrogen deposition so results for just the 2021 High Development Scenario and maximum sulfur deposition metric are presented in Table 5-32 with the other results provided in Attachments D-1, D-2 and D-3. The only individual BLM Planning Area whose new Federal O&G emissions results in its sulfur deposition exceeding the DAT is the WRFO with a maximum of 0.011 kg/ha-yr in the High Development Scenario. The maximum (0.021 kg/ha-yr) and average (0.008 kg/ha-yr) sulfur deposition due to WRFO for the 2021 Medium Development Scenario are also above the DAT. However, the highest WRFO sulfur deposition for the maximum (0.002 kg/ha-yr) and average (0.001 kg/ha-yr) values in the 2021 Low Development Scenario are below the DAT. The sulfur deposition results for all the other individual BLM Planning areas are below the DAT.

Table 5-28a. Highest maximum and average nitrogen deposition (kg/ha-yr) at any Class I or sensitive Class II area due to new Federal oil and gas emissions from the BLM Grand Junction Field Office and Uncompahgre Field Office and the New Mexico Farmington FFO Areas for the 2021 High, Low and Medium Development Scenarios.

Source Group	Class I Areas			Sensitive Class II Areas		
	Max	Avg	Area	Max	Avg	Area
2021 High Development Scenario						
GJFO	0.0679	0.0417	Maroon-B	0.0679	0.0543	Colorado NM
UFO	0.0240	0.0104	Maroon-B	0.0347	0.0151	Raggeds
NMFFO	0.0371	0.0198	Weminuche	0.1610	0.1505	Aztec Ruins
2021 Low Development Scenario						
GJFO	0.0037	0.0023	Maroon-B	0.0037	0.0029	Colorado NM
UFO	0.0065	0.0027	Maroon-B	0.0100	0.0400	Raggeds Gun
NMFFO	0.0177	0.0095	Weminuche	0.0776	0.0009	Aztec Ruins
2021 Medium Development Scenario						
GJFO	0.0558	0.0344	Maroon-B	0.06071	0.0483	Colorado NM
UFO	0.0167	0.0076	Maroon-B	0.0241	0.0109	Raggeds Gun
NMFFO	0.0285	0.0152	Weminuche	0.1240	0.1155	Aztec Ruins

Table 5-28b. Highest maximum and average sulfur deposition (kg/ha-yr) at any Class I or sensitive Class II area due to new Federal oil and gas emissions from the BLM Grand Junction Field Office and Uncompahgre Field Office and the New Mexico Farmington FFO Planning Areas for the 2021 High, Low and Medium Development Scenarios.

Source Group	Class I Areas			Sensitive Class II Areas		
	Max	Avg	Area	Max	Avg	Area
2021 High Development Scenario						
GJFO	0.0006	0.0004	Maroon-B	0.0005	0.0003	Raggeds
UFO	0.0004	0.0002	Maroon-B	0.0008	0.0003	Raggeds
NMFFO	0.0009	0.0004	Weminuche	0.0019	0.0018	Aztec Ruins
2021 Low Development Scenario						
GJFO	0.0001	0.0000	Maroon-B	0.0000	0.0000	Raggeds
UFO	0.0001	0.0001	Maroon-B	0.0002	0.0001	Raggeds
NMFFO	0.0004	0.0002	Weminuche	0.0009	0.0009	Aztec Ruins
2021 Medium Development Scenario						
GJFO	0.0005	0.0003	Maroon-B	0.0004	0.0002	Raggeds
UFO	0.0003	0.0001	Maroon-B	0.0006	0.0002	Raggeds
NMFFO	0.0007	0.0003	Weminuche	0.0016	0.0015	Aztec Ruins

Table 5-29a. Highest nitrogen deposition at any Class I area or sensitive Class II area for each of the 32 Source Groups and the 2021 High Development Scenario using the Maximum deposition in any receptor in the Class I/II area.

Choose	Nitrogen				
Across grid cells	Maximum				
Group	**Group Name**	**Max @ any Class I area**	**Class I Area where Max occurred**	**Max @ any Class II area**	**Class II Area where Max occurred**
A	Little Snake FO	0.0169	Mount_Zirkel	0.0136	Dinosaur_all
B	White River FO	0.1080	Flat_Tops	0.1420	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	0.0198	Flat_Tops	0.0118	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	0.0200	Flat_Tops	0.0107	Holy_Cross
E	Grand Junction FO	0.0679	Maroon_Bells	0.0679	Colorado
F	Uncompahgre FO	0.0240	Maroon_Bells	0.0347	Raggeds
G	Tres Rios FO	0.1260	Mesa_Verde	0.1450	South_San_Juan
H	Kremmling FO	0.0065	Rawah	0.0022	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0.0004	Rocky_Mountain	0.0003	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	0.0017	Rocky_Mountain	0.0013	Mount_Evans
K	RGFO#2 – West-Central/South	0.0005	Pecos	0.0008	Las_Vegas_NWR
L	RGFO#3 – South	0.0017	Great_Sand_Dunes	0.0272	Greenhorn_Mounta
M	RGFO#4 – East-Central	0.0002	Eagles_Nest	0.0028	Lost_Creek
N	New Mexico Farmington FO	0.0371	Weminuche	0.1610	Aztec_Ruins
O	Total Colorado River Field Office	0.0398	Flat_Tops	0.0225	Holy_Cross
P	Total Royal Gorge Field Office	0.0024	Rocky_Mountain	0.0279	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	0.0081	Mount_Zirkel	0.0059	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	0.2118	Flat_Tops	0.1759	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	0.3659	Flat_Tops	0.3390	South_San_Juan
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	0.3679	Flat_Tops	0.3750	South_San_Juan
U	Combined O&G and Mining in 4 km domain	0.5950	Mesa_Verde	1.9400	Aztec_Ruins
V	Natural Emissions	6.6500	Bandelier	1.4500	Chama_River_Cany
W	All 2021 Emissions	8.4700	Bandelier	11.3000	Valle_De_Oro_NWR
X	All 2008 Emissions	9.0012	Bandelier	12.6927	Bitter_Lake_NWR
Y	Coal EGU NM	0.6100	Mesa_Verde	0.6300	Aztec_Ruins
Z	Coal EGU CO	0.8330	Mount_Zirkel	0.3700	Dinosaur_all
AA	Oil/Gas EGU NM	0.0034	Bandelier	0.0810	Petroglyph
AB	Oil/Gas EGU CO	0.0201	Rocky_Mountain	0.0330	Mount_Evans
AC	All EGUs in 4km domain	0.8955	Mount_Zirkel	0.6668	Aztec_Ruins
AD	CO Mining plus Coal EGUs CO	0.8411	Mount_Zirkel	0.3707	Dinosaur_all
AE	CO O&G plus Oil/Gas EGUs CO	0.3652	Flat_Tops	0.3389	South_San_Juan
AF	NM O&G plus Oil/Gas EGUs NM	0.0392	Weminuche	0.1698	Aztec_Ruins

Table 5-29b. Highest nitrogen deposition at any Class I area or sensitive Class II area for each of the 32 Source Groups and the 2021 High Development Scenario using the Average deposition in any receptor in the Class I/II area.

Choose	Nitrogen				
Across grid cells	Average				
Group	Group Name	Max @ any Class I area	Class I Area where Max occurred	Max @ any Class II area	Class II Area where Max occurred
A	Little Snake FO	0.0133	Mount_Zirkel	0.0079	Savage_Run
B	White River FO	0.0680	Flat_Tops	0.0390	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	0.0120	Flat_Tops	0.0082	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	0.0120	Flat_Tops	0.0075	Holy_Cross
E	Grand Junction FO	0.0417	Maroon_Bells	0.0543	Colorado
F	Uncompahgre FO	0.0104	Maroon_Bells	0.0151	Raggeds
G	Tres Rios FO	0.0429	Mesa_Verde	0.0466	Hovenweep
H	Kremmling FO	0.0031	Rawah	0.0015	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0.0001	Rocky_Mountain	0.0002	Lost_Creek
J	Pawnee Grasslands portion of RGFO#1	0.0006	Rocky_Mountain	0.0007	Lost_Creek
K	RGFO#2 – West-Central/South	0.0003	Salt_Creek	0.0006	Maxwell_NWR
L	RGFO#3 – South	0.0011	Great_Sand_Dunes	0.0133	Greenhorn_Mounta
M	RGFO#4 – East-Central	0.0001	Eagles_Nest	0.0017	Lost_Creek
N	New Mexico Farmington FO	0.0242	Mesa_Verde	0.1505	Aztec_Ruins
O	Total Colorado River Field Office	0.0241	Flat_Tops	0.0157	Holy_Cross
P	Total Royal Gorge Field Office	0.0014	Great_Sand_Dunes	0.0147	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	0.0049	Mount_Zirkel	0.0049	Colorado
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	0.1452	Flat_Tops	0.1158	Colorado
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	0.2548	Flat_Tops	0.2190	Colorado
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	0.2565	Flat_Tops	0.2555	Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	0.4902	Mesa_Verde	1.9200	Aztec_Ruins
V	Natural Emissions	0.7876	Bandelier	0.4474	Dome
W	All 2021 Emissions	3.1155	Mount_Zirkel	8.8700	Valle_De_Oro_NWR
X	All 2008 Emissions	5.3938	Salt_Creek	10.0402	Valle_De_Oro_NWR
Y	Coal EGU NM	0.4420	Mesa_Verde	0.5775	Aztec_Ruins
Z	Coal EGU CO	0.4804	Mount_Zirkel	0.2506	Dinosaur_all
AA	Oil/Gas EGU NM	0.0029	Bandelier	0.0251	Valle_De_Oro_NWR
AB	Oil/Gas EGU CO	0.0065	Rocky_Mountain	0.0157	Mount_Evans
AC	All EGUs in 4km domain	0.5312	Mount_Zirkel	0.6116	Aztec_Ruins
AD	CO Mining plus Coal EGUs CO	0.4853	Mount_Zirkel	0.2512	Dinosaur_all
AE	CO O&G plus Oil/Gas EGUs CO	0.2535	Flat_Tops	0.2149	Colorado
AF	NM O&G plus Oil/Gas EGUs NM	0.0264	Mesa_Verde	0.1597	Aztec_Ruins

Table 5-30a. Highest nitrogen deposition at any Class I area or sensitive Class II area for each of the 32 Source Groups and the 2021 Low Development Scenario using the Maximum deposition in any receptor in the Class I/II area.

Choose	Nitrogen				
Across grid cells	Maximum				
Group	**Group Name**	**Max @ any Class I area**	**Class I Area where Max occurred**	**Max @ any Class II area**	**Class II Area where Max occurred**
A	Little Snake FO	0.0023	Mount_Zirkel	0.0018	Dinosaur_all
B	White River FO	0.0169	Flat_Tops	0.0228	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	0.0122	Flat_Tops	0.0072	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	0.0101	Flat_Tops	0.0054	Holy_Cross
E	Grand Junction FO	0.0037	Maroon_Bells	0.0037	Colorado
F	Uncompahgre FO	0.0065	Maroon_Bells	0.0100	Raggeds
G	Tres Rios FO	0.0153	Mesa_Verde	0.0182	South_San_Juan
H	Kremmling FO	0.0007	Rawah	0.0002	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0.0001	Rocky_Mountain	0.0001	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	0.0004	Rocky_Mountain	0.0003	Mount_Evans
K	RGFO#2 – West-Central/South	0.0000	Pecos	0.0001	Las_Vegas_NWR
L	RGFO#3 – South	0.0011	Great_Sand_Dunes	0.0169	Greenhorn_Mounta
M	RGFO#4 – East-Central	0.0000	Eagles_Nest	0.0004	Lost_Creek
N	New Mexico Farmington FO	0.0177	Weminuche	0.0776	Aztec_Ruins
O	Total Colorado River Field Office	0.0223	Flat_Tops	0.0125	Holy_Cross
P	Total Royal Gorge Field Office	0.0011	Great_Sand_Dunes	0.0170	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	0.0081	Mount_Zirkel	0.0059	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	0.0433	Flat_Tops	0.0314	Raggeds
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	0.2000	Mesa_Verde	0.2130	South_San_Juan
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	0.2078	Mesa_Verde	0.2302	South_San_Juan
U	Combined O&G and Mining in 4 km domain	0.5253	Mesa_Verde	1.8366	Aztec_Ruins
V	Natural Emissions	6.6500	Bandelier	1.4500	Chama_River_Cany
W	All 2021 Emissions	8.4466	Bandelier	11.2989	Valle_De_Oro_NWR
X	All 2008 Emissions	9.0012	Bandelier	12.6927	Bitter_Lake_NWR
Y	Coal EGU NM	0.6100	Mesa_Verde	0.6300	Aztec_Ruins
Z	Coal EGU CO	0.8330	Mount_Zirkel	0.3700	Dinosaur_all
AA	Oil/Gas EGU NM	0.0034	Bandelier	0.0810	Petroglyph
AB	Oil/Gas EGU CO	0.0201	Rocky_Mountain	0.0330	Mount_Evans
AC	All EGUs in 4km domain	0.8955	Mount_Zirkel	0.6668	Aztec_Ruins
AD	CO Mining plus Coal EGUs CO	0.8411	Mount_Zirkel	0.3707	Dinosaur_all
AE	CO O&G plus Oil/Gas EGUs CO	0.1993	Mesa_Verde	0.2129	South_San_Juan
AF	NM O&G plus Oil/Gas EGUs NM	0.0198	Weminuche	0.0864	Aztec_Ruins

Table 5-30b. Highest nitrogen deposition at any Class I area or sensitive Class II area for each of the 32 Source Groups and the 2021 Low Development Scenario using the Average deposition in any receptor in the Class I/II area.

Choose	Nitrogen				
Across grid cells	Average				
Group	Group Name	Max @ any Class I area	Class I Area where Max occurred	Max @ any Class II area	Class II Area where Max occurred
A	Little Snake FO	0.0018	Mount_Zirkel	0.0011	Savage_Run
B	White River FO	0.0107	Flat_Tops	0.0061	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	0.0074	Flat_Tops	0.0050	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	0.0060	Flat_Tops	0.0037	Holy_Cross
E	Grand Junction FO	0.0023	Flat_Tops	0.0029	Colorado
F	Uncompahgre FO	0.0027	Maroon_Bells	0.0040	Raggeds
G	Tres Rios FO	0.0052	Mesa_Verde	0.0056	Hovenweep
H	Kremmling FO	0.0003	Rawah	0.0002	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0.0000	Rocky_Mountain	0.0000	Lost_Creek
J	Pawnee Grasslands portion of RGFO#1	0.0001	Rocky_Mountain	0.0002	Lost_Creek
K	RGFO#2 – West-Central/South	0.0000	Salt_Creek	0.0001	Maxwell_NWR
L	RGFO#3 – South	0.0007	Great_Sand_Dunes	0.0083	Greenhorn_Mounta
M	RGFO#4 – East-Central	0.0000	Eagles_Nest	0.0002	Lost_Creek
N	New Mexico Farmington FO	0.0115	Mesa_Verde	0.0724	Aztec_Ruins
O	Total Colorado River Field Office	0.0134	Flat_Tops	0.0087	Holy_Cross
P	Total Royal Gorge Field Office	0.0007	Great_Sand_Dunes	0.0085	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	0.0049	Mount_Zirkel	0.0049	Colorado
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	0.0302	Flat_Tops	0.0215	Raggeds
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	0.0840	Flat_Tops	0.0973	Hovenweep
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	0.0932	Mesa_Verde	0.1568	Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	0.4218	Mesa_Verde	1.8173	Aztec_Ruins
V	Natural Emissions	0.7876	Bandelier	0.4473	Dome
W	All 2021 Emissions	2.9673	Mount_Zirkel	8.8688	Valle_De_Oro_NWR
X	All 2008 Emissions	5.3938	Salt_Creek	10.0402	Valle_De_Oro_NWR
Y	Coal EGU NM	0.4420	Mesa_Verde	0.5775	Aztec_Ruins
Z	Coal EGU CO	0.4804	Mount_Zirkel	0.2506	Dinosaur_all
AA	Oil/Gas EGU NM	0.0029	Bandelier	0.0251	Valle_De_Oro_NWR
AB	Oil/Gas EGU CO	0.0065	Rocky_Mountain	0.0157	Mount_Evans
AC	All EGUs in 4km domain	0.5312	Mount_Zirkel	0.6116	Aztec_Ruins
AD	CO Mining plus Coal EGUs CO	0.4853	Mount_Zirkel	0.2512	Dinosaur_all
AE	CO O&G plus Oil/Gas EGUs CO	0.0827	Flat_Tops	0.0965	Hovenweep
AF	NM O&G plus Oil/Gas EGUs NM	0.0137	Mesa_Verde	0.0815	Aztec_Ruins

Table 5-31a. Highest nitrogen deposition at any Class I area or sensitive Class II area for each of the 32 Source Groups and the 2021 Medium Development Scenario using the Maximum deposition in any receptor in the Class I/II area.

Choose	Nitrogen				
Across grid cells	Maximum				
Group	Group Name	Max @ any Class I area	Class I Area where Max occurred	Max @ any Class II area	Class II Area where Max occurred
A	Little Snake FO	0.0153	Mount_Zirkel	0.0118	Dinosaur_all
B	White River FO	0.0884	Flat_Tops	0.1340	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	0.0156	Flat_Tops	0.0097	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	0.0163	Flat_Tops	0.0089	Holy_Cross
E	Grand Junction FO	0.0558	Maroon_Bells	0.0607	Colorado
F	Uncompahgre FO	0.0167	Maroon_Bells	0.0241	Raggeds
G	Tres Rios FO	0.1060	Mesa_Verde	0.1230	South_San_Juan
H	Kremmling FO	0.0041	Rawah	0.0015	Mount_Evans
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0.0003	Rocky_Mountain	0.0002	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	0.0011	Rocky_Mountain	0.0008	Mount_Evans
K	RGFO#2 – West-Central/South	0.0004	Pecos	0.0006	Las_Vegas_NWR
L	RGFO#3 – South	0.0012	Great_Sand_Dunes	0.0190	Greenhorn_Mounta
M	RGFO#4 – East-Central	0.0001	Eagles_Nest	0.0016	Lost_Creek
N	New Mexico Farmington FO	0.0285	Weminuche	0.1240	Aztec_Ruins
O	Total Colorado River Field Office	0.0320	Flat_Tops	0.0186	Holy_Cross
P	Total Royal Gorge Field Office	0.0015	Rocky_Mountain	0.0195	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	0.0081	Mount_Zirkel	0.0059	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	0.1738	Flat_Tops	0.1639	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	0.3199	Flat_Tops	0.3110	South_San_Juan
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	0.3219	Flat_Tops	0.3380	South_San_Juan
U	Combined O&G and Mining in 4 km domain	0.5760	Mesa_Verde	1.9000	Aztec_Ruins
V	Natural Emissions	6.6500	Bandelier	1.4500	Chama_River_Cany
W	All 2021 Emissions	8.4600	Bandelier	11.3000	Valle_De_Oro_NWR
X	All 2008 Emissions	9.0000	Bandelier	12.7000	Bitter_Lake_NWR
Y	Coal EGU NM	0.6100	Mesa_Verde	0.6300	Aztec_Ruins
Z	Coal EGU CO	0.8330	Mount_Zirkel	0.3700	Dinosaur_all
AA	Oil/Gas EGU NM	0.0034	Bandelier	0.0810	Petroglyph
AB	Oil/Gas EGU CO	0.0201	Rocky_Mountain	0.0330	Mount_Evans
AC	All EGUs in 4km domain	0.8955	Mount_Zirkel	0.6668	Aztec_Ruins
AD	CO Mining plus Coal EGUs CO	0.8411	Mount_Zirkel	0.3707	Dinosaur_all
AE	CO O&G plus Oil/Gas EGUs CO	0.3356	Rocky_Mountain	0.3109	South_San_Juan
AF	NM O&G plus Oil/Gas EGUs NM	0.0306	Weminuche	0.1328	Aztec_Ruins

Table 5-31b. Highest nitrogen deposition at any Class I area or sensitive Class II area for each of the 32 Source Groups and the 2021 Medium Development Scenario using the Average deposition in any receptor in the Class I/II area.

Choose	Nitrogen				
Across grid cells	Average				
Group	**Group Name**	**Max @ any Class I area**	**Class I Area where Max occurred**	**Max @ any Class II area**	**Class II Area where Max occurred**
A	Little Snake FO	0.0119	Mount_Zirkel	0.0070	Savage_Run
B	White River FO	0.0559	Flat_Tops	0.0374	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	0.0095	Flat_Tops	0.0068	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	0.0098	Flat_Tops	0.0062	Holy_Cross
E	Grand Junction FO	0.0344	Maroon_Bells	0.0483	Colorado
F	Uncompahgre FO	0.0076	Maroon_Bells	0.0109	Raggeds
G	Tres Rios FO	0.0363	Mesa_Verde	0.0396	Hovenweep
H	Kremmling FO	0.0020	Rawah	0.0010	Mount_Evans
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0.0001	Rocky_Mountain	0.0001	Lost_Creek
J	Pawnee Grasslands portion of RGFO#1	0.0004	Rocky_Mountain	0.0005	Lost_Creek
K	RGFO#2 – West-Central/South	0.0003	Salt_Creek	0.0004	Maxwell_NWR
L	RGFO#3 – South	0.0008	Great_Sand_Dunes	0.0093	Greenhorn_Mounta
M	RGFO#4 – East-Central	0.0000	Eagles_Nest	0.0009	Lost_Creek
N	New Mexico Farmington FO	0.0185	Mesa_Verde	0.1155	Aztec_Ruins
O	Total Colorado River Field Office	0.0193	Flat_Tops	0.0130	Holy_Cross
P	Total Royal Gorge Field Office	0.0010	Great_Sand_Dunes	0.0102	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	0.0049	Mount_Zirkel	0.0049	Colorado
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	0.1198	Flat_Tops	0.1025	Colorado
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	0.2239	Flat_Tops	0.2027	Colorado
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	0.2252	Flat_Tops	0.2145	Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	0.4728	Mesa_Verde	1.8800	Aztec_Ruins
V	Natural Emissions	0.7876	Bandelier	0.4474	Dome
W	All 2021 Emissions	3.0958	Mount_Zirkel	8.8700	Valle_De_Oro_NWR
X	All 2008 Emissions	5.3900	Salt_Creek	10.0000	Valle_De_Oro_NWR
Y	Coal EGU NM	0.4420	Mesa_Verde	0.5775	Aztec_Ruins
Z	Coal EGU CO	0.4804	Mount_Zirkel	0.2506	Dinosaur_all
AA	Oil/Gas EGU NM	0.0029	Bandelier	0.0251	Valle_De_Oro_NWR
AB	Oil/Gas EGU CO	0.0065	Rocky_Mountain	0.0157	Mount_Evans
AC	All EGUs in 4km domain	0.5312	Mount_Zirkel	0.6116	Aztec_Ruins
AD	CO Mining plus Coal EGUs CO	0.4853	Mount_Zirkel	0.2512	Dinosaur_all
AE	CO O&G plus Oil/Gas EGUs CO	0.2226	Flat_Tops	0.1987	Colorado
AF	NM O&G plus Oil/Gas EGUs NM	0.0208	Mesa_Verde	0.1247	Aztec_Ruins

Table 5-32. Highest sulfur deposition at any Class I area or sensitive Class II area for each of the 32 Source Groups and the 2021 High Development Scenario using the Maximum deposition in any receptor in the Class I/II area.

Choose	Sulfur				
Across grid cells	Maximum				
Group	**Group Name**	**Max @ any Class I area**	**Class I Area where Max occurred**	**Max @ any Class II area**	**Class II Area where Max occurred**
A	Little Snake FO	0.0003	Mount_Zirkel	0.0001	Savage_Run
B	White River FO	0.0111	Flat_Tops	0.0212	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	0.0003	Flat_Tops	0.0001	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	0.0002	Flat_Tops	0.0001	Holy_Cross
E	Grand Junction FO	0.0006	Maroon_Bells	0.0005	Raggeds
F	Uncompahgre FO	0.0004	Maroon_Bells	0.0008	Raggeds
G	Tres Rios FO	0.0006	Mesa_Verde	0.0012	South_San_Juan
H	Kremmling FO	0.0001	Rawah	0.0000	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0.0000	Rocky_Mountain	0.0000	Lost_Creek
J	Pawnee Grasslands portion of RGFO#1	0.0000	Rocky_Mountain	0.0000	Lost_Creek
K	RGFO#2 – West-Central/South	0.0000	Pecos	0.0000	Greenhorn_Mounta
L	RGFO#3 – South	0.0000	Great_Sand_Dunes	0.0001	Greenhorn_Mounta
M	RGFO#4 – East-Central	0.0000	Eagles_Nest	0.0000	Lost_Creek
N	New Mexico Farmington FO	0.0009	Weminuche	0.0019	Aztec_Ruins
O	Total Colorado River Field Office	0.0004	Flat_Tops	0.0002	Holy_Cross
P	Total Royal Gorge Field Office	0.0000	Rocky_Mountain	0.0001	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	0.0004	Mount_Zirkel	0.0004	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	0.0122	Flat_Tops	0.0215	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	0.0149	Flat_Tops	0.0245	Dinosaur_all
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	0.0149	Flat_Tops	0.0246	Dinosaur_all
U	Combined O&G and Mining in 4 km domain	0.0203	Flat_Tops	0.0286	Dinosaur_all
V	Natural Emissions	0.1640	Bandelier	0.0497	Dome
W	All 2021 Emissions	1.7400	Mount_Baldy	1.4096	South_San_Juan
X	All 2008 Emissions	2.3428	Mount_Zirkel	2.1000	South_San_Juan
Y	Coal EGU NM	0.2790	Petrified_Forest	0.1910	Escudilla
Z	Coal EGU CO	0.2740	Mount_Zirkel	0.1340	Greenhorn_Mounta
AA	Oil/Gas EGU NM	0.0000	Pecos	0.0000	Petroglyph
AB	Oil/Gas EGU CO	0.0000	Rocky_Mountain	0.0000	Mount_Evans
AC	All EGUs in 4km domain	0.2989	Mount_Zirkel	0.1934	Escudilla
AD	CO Mining plus Coal EGUs CO	0.2744	Mount_Zirkel	0.1340	Greenhorn_Mounta
AE	CO O&G plus Oil/Gas EGUs CO	0.0147	Flat_Tops	0.0244	Dinosaur_all
AF	NM O&G plus Oil/Gas EGUs NM	0.0009	Weminuche	0.0019	Aztec_Ruins

5.4.1.2 Comparisons Against Critical Loads

In this section we compare the total sulfur and nitrogen deposition from all sources in the 2008 Base Case and 2021 High, Low and Medium Development Scenarios with Critical Loads of atmospheric deposition. It is unclear what the sulfur and nitrogen for the combined Source Groups Q through U should be compared against given that the DAT and Critical Load LOCs were designed for single Projects and total emissions, respectively. The total nitrogen and sulfur deposition amounts for the combined Source Groups Q through U are much lower than the Critical Load values (Attachments D-1, D-2 and D-3).

Tables 5-33 and 5-34 display the total nitrogen and sulfur deposition, respectively, at Class I areas for the 2021 High, Low and Medium Development Scenarios, the 2008 Base Case, the differences between the three 2021 scenarios and the 2008 Base Case (2021 minus 2008) and the difference between the three 2021 scenarios and the natural emissions (Source Group V). As seen in Table 5-29a, the Class I area with the highest Maximum nitrogen deposition (due to all sources combined) in the 2021 High Development Scenario is the Bandelier Class I area in New Mexico with a value of 8.47 kg/ha-yr that is over 3 times the nitrogen Critical Load (2.3 kg/ha-yr). However, most (6.65 position kg/ha-yr) of this is due to natural emissions (Source Group V in Table 5-29a) and when natural emission contributions are removed the value at Bandelier for the 2021 scenarios (1.80-1.82 kg/ha-yr) drops below the nitrogen Critical Load (2.3 kg/ha-yr) (Table 5-33). After removing natural emission contributions the Maximum nitrogen deposition exceeds the 2.3 kg/ha-yr Critical Load at approximately half of the 26 Class I areas for all three 2021 emission scenarios with the highest value of 4.23, 4.04 and 4.21 kg/ha-yr at the Mount Zirkel Wilderness Area and the 2021 High, Low and Medium Development Scenarios, respectively. When examining the Average annual nitrogen deposition across Class I areas, approximately a quarter of the Class I areas exceed the 2.3 kg/ha-yr nitrogen Critical Load for the 2021 emission scenarios.

With one exception, all 26 Class I areas exhibit a reduction in annual nitrogen deposition from 2008 to 2021 with the largest reduction occurring at Salt Creek (-5.5 kg/ha-yr) and the second largest reduction occurring at Bosque del Apache (-2.6 kg/ha-yr). The exception is the Great Sand Dunes NM that saw essentially no change in nitrogen deposition between 2008 and 2021 for the three 2021 emissions scenarios (changes of -0.02 to +0.07 kg/ha-yr).

The total sulfur deposition at all of the Class I areas for the 2008 and three 2021 emission scenarios are all well below the sulfur Critical Load of 5 kg/ha-yr (Table 5-34). Sulfur deposition is reduced by 5% to 50% across the Class I areas between the 2008 and 2021 emissions scenarios. The highest sulfur deposition at any Class I area for the three 2021 emission scenarios is 1.7 kg/ha-yr at Mt. Baldy that is approximately a factor of three below the sulfur deposition Critical Load (5.0 kg/ha-yr) (Table 5-34).

Additional results, including those for sensitive Class II areas and all Source Groups, are found in Attachments D-1, D-2 and D-3.

Table 5-33a. Total annual nitrogen deposition at Class I areas for the 2021 High Development Scenario, 2008 Base Case, their differences (2021 High minus 2008) and 2021 High Development Scenario without the contributions of natural emissions (e.g., wildfires).

	2021 High		2008 Base		2021 High - 2008		2021 High - Natural	
	N-Max	N-Avg	N-Max	N-Avg	N-Max	N-Avg	N-Max	N-Avg
Class I Area	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)
Arches NP	1.67	1.56	2.20	1.81	-0.54	-0.25	1.63	1.52
Bandelier NM	8.47	2.51	9.00	2.96	-0.53	-0.45	1.82	1.72
Black Canyon of the Gunnison NM	2.85	2.30	2.99	2.57	-0.14	-0.27	2.79	2.25
Bosque del Apache Wilderness	2.49	1.64	5.08	2.46	-2.59	-0.82	2.27	1.51
Canyonlands NP	1.89	1.43	2.31	1.77	-0.42	-0.34	1.84	1.39
Capitol Reef NP	3.22	1.54	3.37	1.90	-0.15	-0.36	3.19	1.52
Eagles Nest Wilderness	2.79	2.08	3.59	2.94	-0.80	-0.85	2.73	2.03
Flat Tops Wilderness	3.00	2.39	3.71	3.09	-0.71	-0.70	2.91	2.34
Galiuro Wilderness	2.39	2.29	2.97	2.83	-0.58	-0.55	2.38	2.27
Gila Wilderness	2.07	1.36	2.69	1.68	-0.62	-0.31	1.98	1.31
Great Sand Dunes NM	2.77	1.97	2.70	1.95	0.07	0.02	2.67	1.89
La Garita Wilderness	1.97	1.55	2.75	2.11	-0.78	-0.56	1.88	1.48
Maroon Bells-Snowmass Wilderness	3.01	2.18	3.81	2.94	-0.80	-0.77	2.93	2.12
Mesa Verde NP	2.92	2.53	3.14	2.76	-0.22	-0.23	2.85	2.47
Mount Baldy Wilderness	2.38	1.94	3.24	2.69	-0.86	-0.75	2.05	1.69
Mount Zirkel Wilderness	4.29	3.12	5.13	3.95	-0.84	-0.84	4.23	3.07
Pecos Wilderness	2.98	2.27	3.95	2.99	-0.97	-0.72	2.19	2.09
Petrified Forest NP	2.04	1.72	2.66	2.16	-0.62	-0.44	1.99	1.68
Rawah Wilderness	3.23	2.51	4.07	3.27	-0.84	-0.76	3.14	2.45
Rocky Mountain NP	3.41	2.58	4.49	3.50	-1.08	-0.92	3.31	2.51
Salt Creek Wilderness	2.70	2.43	8.21	5.39	-5.51	-2.97	2.64	2.38
San Pedro Parks Wilderness	2.70	2.33	3.36	2.93	-0.66	-0.60	2.25	2.15
Weminuche Wilderness	3.03	2.14	3.80	2.84	-0.77	-0.70	2.90	2.06
West Elk Wilderness	2.58	1.98	3.34	2.63	-0.76	-0.66	2.27	1.91
Wheeler Peak Wilderness	3.10	2.55	4.11	3.44	-1.01	-0.88	2.91	2.41
White Mountain Wilderness	3.09	2.42	3.73	2.85	-0.64	-0.42	2.57	2.14

Table 5-33b. Total annual nitrogen deposition at Class I areas for the 2021 Low Development Scenario, 2008 Base Case, their differences (2021 Low minus 2008) and 2021 Low Development Scenario without the contributions of natural emissions (e.g., wildfires).

	2021 Low		2008 Base		2021 Low - 2008		2021 Low - Natural	
Class I Area	N-Max (kg/ha)	N-Avg (kg/ha)	N-Max (kg/ha)	N-Avg (kg/ha)	N-Max (kg/ha)	N-Avg (kg/ha)	N-Max (kg/ha)	N-Avg (kg/ha)
Arches NP	1.59	1.48	2.20	1.81	-0.62	-0.33	1.55	1.44
Bandelier NM	8.45	2.49	9.00	2.96	-0.55	-0.47	1.80	1.70
Black Canyon of the Gunnison NM	2.72	2.19	2.99	2.57	-0.27	-0.38	2.66	2.14
Bosque del Apache Wilderness	2.48	1.63	5.08	2.46	-2.60	-0.83	2.26	1.51
Canyonlands NP	1.86	1.40	2.31	1.77	-0.45	-0.37	1.80	1.37
Capitol Reef NP	3.22	1.54	3.37	1.90	-0.15	-0.37	3.19	1.52
Eagles Nest Wilderness	2.61	1.95	3.59	2.94	-0.98	-0.99	2.55	1.90
Flat Tops Wilderness	2.75	2.20	3.71	3.09	-0.96	-0.89	2.66	2.15
Galiuro Wilderness	2.39	2.29	2.97	2.83	-0.58	-0.55	2.38	2.27
Gila Wilderness	2.06	1.36	2.69	1.68	-0.63	-0.31	1.97	1.31
Great Sand Dunes NM	2.72	1.93	2.70	1.95	0.02	-0.02	2.61	1.85
La Garita Wilderness	1.91	1.51	2.75	2.11	-0.84	-0.61	1.81	1.43
Maroon Bells-Snowmass Wilderness	2.82	2.02	3.81	2.94	-0.99	-0.92	2.74	1.96
Mesa Verde NP	2.84	2.46	3.14	2.76	-0.29	-0.30	2.78	2.40
Mount Baldy Wilderness	2.37	1.94	3.24	2.69	-0.87	-0.76	2.04	1.69
Mount Zirkel Wilderness	4.10	2.97	5.13	3.95	-1.03	-0.98	4.04	2.92
Pecos Wilderness	2.95	2.25	3.95	2.99	-0.99	-0.74	2.17	2.06
Petrified Forest NP	2.03	1.71	2.66	2.16	-0.63	-0.44	1.98	1.67
Rawah Wilderness	3.09	2.39	4.07	3.27	-0.98	-0.88	3.00	2.33
Rocky Mountain NP	3.22	2.44	4.49	3.50	-1.27	-1.06	3.12	2.37
Salt Creek Wilderness	2.69	2.42	8.21	5.39	-5.52	-2.97	2.63	2.37
San Pedro Parks Wilderness	2.67	2.31	3.36	2.93	-0.69	-0.62	2.23	2.13
Weminuche Wilderness	2.98	2.10	3.80	2.84	-0.82	-0.74	2.85	2.02
West Elk Wilderness	2.44	1.87	3.34	2.63	-0.90	-0.77	2.13	1.80
Wheeler Peak Wilderness	3.05	2.52	4.11	3.44	-1.06	-0.92	2.86	2.37
White Mountain Wilderness	3.08	2.42	3.73	2.85	-0.66	-0.43	2.56	2.14

Table 5-33c. Total annual nitrogen deposition at Class I areas for the 2021 Medium Development Scenario, 2008 Base Case, their differences (2021 Medium minus 2008) and 2021 Medium Development Scenario without the contributions of natural emissions (e.g., wildfires).

	2021 Med		2008 Base		2021 Med - 2008		2021 Med - Natural	
	N-Max	N-Avg	N-Max	N-Avg	N-Max	N-Avg	N-Max	N-Avg
Class I Area	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)
Arches NP	1.67	1.55	2.20	1.81	-0.53	-0.26	1.63	1.52
Bandelier NM	8.46	2.50	9.00	2.96	-0.54	-0.46	1.81	1.72
Black Canyon of the Gunnison NM	2.83	2.29	2.99	2.57	-0.16	-0.29	2.77	2.23
Bosque del Apache Wilderness	2.49	1.64	5.08	2.46	-2.59	-0.82	2.27	1.51
Canyonlands NP	1.89	1.43	2.31	1.77	-0.42	-0.34	1.84	1.39
Capitol Reef NP	3.22	1.54	3.37	1.90	-0.15	-0.36	3.19	1.52
Eagles Nest Wilderness	2.76	2.06	3.59	2.94	-0.83	-0.88	2.70	2.01
Flat Tops Wilderness	2.95	2.35	3.71	3.09	-0.76	-0.74	2.86	2.30
Galiuro Wilderness	2.39	2.29	2.97	2.83	-0.58	-0.54	2.38	2.27
Gila Wilderness	2.07	1.36	2.69	1.68	-0.62	-0.32	1.98	1.31
Great Sand Dunes NM	2.76	1.96	2.70	1.95	0.06	0.01	2.66	1.89
La Garita Wilderness	1.96	1.54	2.75	2.11	-0.79	-0.57	1.87	1.47
Maroon Bells-Snowmass Wilderness	2.98	2.15	3.81	2.94	-0.83	-0.79	2.90	2.09
Mesa Verde NP	2.90	2.51	3.14	2.76	-0.24	-0.25	2.83	2.45
Mount Baldy Wilderness	2.38	1.94	3.24	2.69	-0.86	-0.75	2.05	1.69
Mount Zirkel Wilderness	4.27	3.10	5.13	3.95	-0.86	-0.86	4.21	3.05
Pecos Wilderness	2.98	2.27	3.95	2.99	-0.97	-0.72	2.19	2.08
Petrified Forest NP	2.04	1.72	2.66	2.16	-0.62	-0.44	1.99	1.68
Rawah Wilderness	3.21	2.49	4.07	3.27	-0.86	-0.78	3.12	2.43
Rocky Mountain NP	3.39	2.56	4.49	3.50	-1.10	-0.93	3.29	2.49
Salt Creek Wilderness	2.69	2.43	8.21	5.39	-5.52	-2.96	2.63	2.37
San Pedro Parks Wilderness	2.69	2.32	3.36	2.93	-0.67	-0.61	2.24	2.14
Weminuche Wilderness	3.01	2.13	3.80	2.84	-0.79	-0.71	2.88	2.05
West Elk Wilderness	2.56	1.96	3.34	2.63	-0.78	-0.67	2.25	1.89
Wheeler Peak Wilderness	3.09	2.55	4.11	3.44	-1.02	-0.89	2.90	2.40
White Mountain Wilderness	3.09	2.42	3.73	2.85	-0.64	-0.43	2.57	2.14

Table 5-34a. Total annual sulfur deposition at Class I areas for the 2021 High Development Scenario, 2008 Base Case, their differences (2021 High minus 2008) and 2021 High Development Scenario without the contributions of natural emissions (e.g., wildfires).

	2021 High		2008 Base		2021 High - 2008		2021 High - Natural	
	S-Max	S-Avg	S-Max	S-Avg	S-Max	S-Avg	S-Max	S-Avg
Class I Area	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)
Arches NP	0.22	0.20	0.36	0.33	-0.14	-0.13	0.22	0.20
Bandelier NM	0.77	0.47	1.12	0.71	-0.34	-0.24	0.61	0.45
Black Canyon of the Gunnison NM	0.36	0.31	0.62	0.53	-0.26	-0.22	0.36	0.31
Bosque del Apache Wilderness	0.38	0.35	0.41	0.36	-0.03	-0.02	0.38	0.35
Canyonlands NP	0.35	0.22	0.60	0.35	-0.25	-0.13	0.35	0.22
Capitol Reef NP	0.40	0.22	0.55	0.33	-0.15	-0.11	0.40	0.22
Eagles Nest Wilderness	0.92	0.56	1.56	1.10	-0.64	-0.54	0.92	0.56
Flat Tops Wilderness	1.04	0.71	1.72	1.33	-0.69	-0.62	1.03	0.71
Galiuro Wilderness	1.31	1.17	1.12	1.02	0.19	0.16	1.31	1.17
Gila Wilderness	1.32	0.58	1.61	0.72	-0.29	-0.13	1.32	0.58
Great Sand Dunes NM	0.57	0.33	0.94	0.56	-0.38	-0.23	0.57	0.33
La Garita Wilderness	0.67	0.43	1.25	0.88	-0.58	-0.45	0.67	0.43
Maroon Bells-Snowmass Wilderness	1.13	0.69	1.86	1.33	-0.72	-0.64	1.13	0.69
Mesa Verde NP	0.58	0.49	0.91	0.80	-0.33	-0.32	0.58	0.49
Mount Baldy Wilderness	1.74	1.14	2.06	1.52	-0.32	-0.38	1.73	1.13
Mount Zirkel Wilderness	1.46	0.92	2.34	1.73	-0.88	-0.81	1.46	0.92
Pecos Wilderness	1.42	0.83	1.95	1.30	-0.53	-0.46	1.40	0.83
Petrified Forest NP	0.58	0.47	0.80	0.68	-0.22	-0.21	0.58	0.47
Rawah Wilderness	1.00	0.64	1.77	1.29	-0.77	-0.65	1.00	0.64
Rocky Mountain NP	1.10	0.68	1.91	1.35	-0.81	-0.67	1.10	0.68
Salt Creek Wilderness	0.69	0.61	0.73	0.66	-0.04	-0.05	0.69	0.61
San Pedro Parks Wilderness	1.11	0.77	1.61	1.24	-0.51	-0.47	1.10	0.76
Weminuche Wilderness	1.50	0.80	2.06	1.36	-0.56	-0.56	1.50	0.80
West Elk Wilderness	0.90	0.53	1.48	1.01	-0.58	-0.48	0.89	0.53
Wheeler Peak Wilderness	1.54	1.07	2.23	1.66	-0.69	-0.59	1.53	1.07
White Mountain Wilderness	1.61	0.97	1.85	1.11	-0.24	-0.14	1.59	0.96

Table 5-34b. Total annual sulfur deposition at Class I areas for the 2021 Low Development Scenario, 2008 Base Case, their differences (2021 Low minus 2008) and 2021 Low Development Scenario without the contributions of natural emissions (e.g., wildfires).

	2021 Low		2008 Base		2021 Low - 2008		2021 Low - Natural	
Class I Area	S-Max (kg/ha)	S-Avg (kg/ha)	S-Max (kg/ha)	S-Avg (kg/ha)	S-Max (kg/ha)	S-Avg (kg/ha)	S-Max (kg/ha)	S-Avg (kg/ha)
Arches NP	0.22	0.20	0.36	0.33	-0.15	-0.13	0.22	0.20
Bandelier NM	0.77	0.47	1.12	0.71	-0.34	-0.24	0.61	0.45
Black Canyon of the Gunnison NM	0.36	0.31	0.62	0.53	-0.26	-0.22	0.36	0.31
Bosque del Apache Wilderness	0.38	0.35	0.41	0.36	-0.03	-0.02	0.38	0.34
Canyonlands NP	0.35	0.22	0.60	0.35	-0.25	-0.13	0.35	0.22
Capitol Reef NP	0.40	0.22	0.55	0.33	-0.15	-0.11	0.40	0.22
Eagles Nest Wilderness	0.91	0.56	1.56	1.10	-0.65	-0.55	0.91	0.56
Flat Tops Wilderness	1.03	0.70	1.72	1.33	-0.70	-0.63	1.02	0.70
Galiuro Wilderness	1.31	1.17	1.12	1.02	0.19	0.16	1.31	1.17
Gila Wilderness	1.32	0.58	1.61	0.72	-0.29	-0.13	1.32	0.58
Great Sand Dunes NM	0.57	0.33	0.94	0.56	-0.38	-0.23	0.57	0.33
La Garita Wilderness	0.67	0.43	1.25	0.88	-0.58	-0.45	0.67	0.43
Maroon Bells-Snowmass Wilderness	1.13	0.69	1.86	1.33	-0.72	-0.64	1.13	0.69
Mesa Verde NP	0.58	0.49	0.91	0.80	-0.33	-0.32	0.58	0.49
Mount Baldy Wilderness	1.74	1.14	2.06	1.52	-0.32	-0.38	1.73	1.13
Mount Zirkel Wilderness	1.45	0.91	2.34	1.73	-0.89	-0.81	1.45	0.91
Pecos Wilderness	1.42	0.83	1.95	1.30	-0.53	-0.47	1.40	0.83
Petrified Forest NP	0.58	0.47	0.80	0.68	-0.22	-0.21	0.58	0.47
Rawah Wilderness	0.99	0.64	1.77	1.29	-0.78	-0.65	0.99	0.64
Rocky Mountain NP	1.10	0.68	1.91	1.35	-0.81	-0.67	1.10	0.67
Salt Creek Wilderness	0.69	0.61	0.73	0.66	-0.04	-0.05	0.69	0.61
San Pedro Parks Wilderness	1.11	0.76	1.61	1.24	-0.51	-0.47	1.10	0.76
Weminuche Wilderness	1.50	0.80	2.06	1.36	-0.56	-0.56	1.50	0.80
West Elk Wilderness	0.89	0.53	1.48	1.01	-0.58	-0.48	0.89	0.53
Wheeler Peak Wilderness	1.54	1.07	2.23	1.66	-0.69	-0.59	1.53	1.07
White Mountain Wilderness	1.61	0.97	1.85	1.11	-0.24	-0.14	1.59	0.96

Table 5-34c. Total annual sulfur deposition at Class I areas for the 2021 Medium Development Scenario, 2008 Base Case, their differences (2021 Medium minus 2008) and 2021 Medium Development Scenario without the contributions of natural emissions (e.g., wildfires).

	2021 Med		2008 Base		2021 Med - 2008		2021 Med - Natural	
	S-Max	S-Avg	S-Max	S-Avg	S-Max	S-Avg	S-Max	S-Avg
Class I Area	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)
Arches NP	0.22	0.20	0.36	0.33	-0.14	-0.13	0.22	0.20
Bandelier NM	0.77	0.47	1.12	0.72	-0.35	-0.24	0.61	0.45
Black Canyon of the Gunnison NM	0.36	0.31	0.62	0.53	-0.26	-0.22	0.36	0.31
Bosque del Apache Wilderness	0.38	0.35	0.41	0.36	-0.03	-0.01	0.38	0.35
Canyonlands NP	0.35	0.22	0.60	0.35	-0.25	-0.13	0.35	0.22
Capitol Reef NP	0.40	0.22	0.55	0.33	-0.15	-0.11	0.40	0.22
Eagles Nest Wilderness	0.92	0.56	1.56	1.10	-0.64	-0.54	0.92	0.56
Flat Tops Wilderness	1.04	0.71	1.72	1.33	-0.69	-0.62	1.03	0.71
Galiuro Wilderness	1.31	1.17	1.12	1.02	0.19	0.16	1.31	1.17
Gila Wilderness	1.32	0.58	1.61	0.72	-0.29	-0.13	1.32	0.58
Great Sand Dunes NM	0.57	0.33	0.94	0.56	-0.38	-0.23	0.57	0.33
La Garita Wilderness	0.67	0.43	1.25	0.88	-0.58	-0.45	0.67	0.43
Maroon Bells-Snowmass Wilderness	1.13	0.69	1.86	1.33	-0.72	-0.64	1.13	0.69
Mesa Verde NP	0.58	0.49	0.91	0.81	-0.33	-0.32	0.58	0.49
Mount Baldy Wilderness	1.74	1.14	2.06	1.52	-0.32	-0.38	1.73	1.13
Mount Zirkel Wilderness	1.46	0.92	2.34	1.73	-0.88	-0.81	1.46	0.92
Pecos Wilderness	1.42	0.83	1.95	1.30	-0.53	-0.46	1.40	0.83
Petrified Forest NP	0.58	0.47	0.80	0.68	-0.22	-0.21	0.58	0.47
Rawah Wilderness	1.00	0.64	1.77	1.29	-0.77	-0.65	1.00	0.64
Rocky Mountain NP	1.10	0.68	1.91	1.35	-0.81	-0.67	1.10	0.68
Salt Creek Wilderness	0.69	0.61	0.73	0.66	-0.04	-0.05	0.69	0.61
San Pedro Parks Wilderness	1.11	0.77	1.61	1.24	-0.51	-0.47	1.10	0.76
Weminuche Wilderness	1.50	0.80	2.06	1.36	-0.56	-0.56	1.50	0.80
West Elk Wilderness	0.90	0.53	1.48	1.01	-0.58	-0.48	0.89	0.53
Wheeler Peak Wilderness	1.54	1.07	2.23	1.66	-0.69	-0.59	1.53	1.07
White Mountain Wilderness	1.61	0.97	1.85	1.11	-0.24	-0.14	1.59	0.96

5.5 Acid Neutralizing Capacity (ANC) at Sensitive Lakes

Acid Neutralizing Capacity (ANC) at sensitive lakes was calculated for each Source Group following the procedures given in Section 4.8. For a Project, the USFS ANC Level of Acceptable Change (LAC) threshold is no change greater than 10% for lakes with base ANC > 25 µeq/l and no change greater than 1 µeq/l for lakes with base ANC values < 25 µeq/l. Attachments E-1, E-2 and E-3 are interactive Excel spreadsheet that displays the change in ANC at the sensitive lakes due to emissions from each of the 32 Source Groups and the High, Low and Medium Development Scenarios, respectively. The Source Group to be displayed is controlled by cell B3 with the resultant change in ANC (Delta ANC) shown as a percent in Column N and as µeq/l in Column O with an indication of whether it is below the USFS LAC value given in Column P. Although ANC is presented for each Source Group, the ANC results for the Source Groups with existing sources (U, V, W and X) are not meaningful since their effects are contained within both the 10 percentile baseline lake acidity as well as the incremental acidity added to the baseline.

5.5.1 ANC Calculations for Individual BLM Planning Areas

For new Federal O&G from each of the 14 BLM Planning Areas (Source Groups A through P) the change in ANC were below the USFS LAC significance thresholds at all of the sensitive lakes. For example, Table 5-35 displays ANC results from Attachment E-1 (2021 High Development Scenario) for the GJFO, UFO, USFS-PG and NMFFO Planning Areas (Source Groups E, J and N). For new Federal O&G from the GJFO Planning Area and the 2021 High Scenario, the maximum change in ANC at any sensitive lake is 3.22% at the White Dome Lake in the Weminuche National Forest. This change is below both of the USFS LAC values (Table 5-35a). Note that Attachment D contains more information on the sensitive lakes than presented in Table 5-35 including the lake chemistry parameters. For new Federal O&G within the UFO Planning Area and the 2021 High Scenario, the maximum change in ANC at any sensitive lake is 1.02% at Deep Creek Lake in the Raggeds Wilderness Area - Gunnison National Forest that is below the USFS LAC thresholds (Table 5-35b). New Federal O&G development within the USFS Pawnee Grassland Planning Area has almost no effect on acidification at the sensitive lakes with maximum change in ANC values of 0.02% (Table 5-35c). New Federal O&G development within the NMFFO results in ANC impacts that are all below the threshold in the High Development Scenario with the maximum ANC change of 5.5% at the White Dome Lake. ANC results for the other BLM Planning Areas and the 2021 Low and Medium Development Scenario are contained in Attachments E-1, E-2 and E-3.

Table 5-35a. ANC calculations at sensitive lakes for new Federal oil and gas development within the BLM Grand Junction Field Office Planning Area (Source Group E) and the 2021 High Development Scenario.

Lake	National Forest	Wilderness Area	State	Latitude (Deg N)	Longitude (Deg W)	Elevation (m)	10th Percentile Lowest ANC Value (µeq/L)	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%)*	Delta ANC (µeq/L)*	USFS LAC Threshold	Below Threshold?	2021 Hi Predicted 10th Percentile Lowest ANC Value (µeq/L)
Brooklyn Lake	White River	Collegiate Peaks	CO	39.0495	-106.6569	3737	101.7	0.0003	0.0277	0.898	0.33%	0.3315	<10%	yes	101.3
Tabor Lake	White River	Collegiate Peaks	CO	39.0628	-106.6564	3746	112.4	0.0003	0.0289	0.860	0.32%	0.3611	<10%	yes	112.0
Booth Lake	White River	Eagles Nest	CO	39.6986	-106.3050	3493	86.8	0.0004	0.0442	0.844	0.65%	0.5620	<10%	yes	86.2
Upper Willow Lake	White River	Eagles Nest	CO	39.6458	-106.1747	3469	134.1	0.0002	0.0295	0.741	0.32%	0.4271	<10%	yes	133.7
Ned Wilson Lake	White River	Flat Tops	CO	39.9614	-107.3239	3385	39.0	0.0004	0.0438	1.158	1.04%	0.4062	<10%	yes	38.6
Upper Ned Wilson Lake	White River	Flat Tops	CO	39.9628	-107.3236	3386	12.9	0.0004	0.0438	1.158	3.15%	0.4062	<1(µeq/L)	yes	12.5
Lower NWL Packtrail Pothole	White River	Flat Tops	CO	39.9682	-107.3241	3379	29.7	0.0004	0.0438	1.158	1.37%	0.4062	<10%	yes	29.2
Upper NWL Packtrail Pothole	White River	Flat Tops	CO	39.9656	-107.3238	3380	48.7	0.0004	0.0438	1.158	0.83%	0.4062	<10%	yes	48.3
Walk Up Lake	Ashley	--	UT	40.8110	-110.0383	---	55.2	0.0000	0.0008	0.878	0.02%	0.0101	<10%	yes	55.2
Bluebell Lake	Ashley	High Uintas	UT	40.6970	-110.4822	3322	55.5	0.0000	0.0005	0.883	0.01%	0.0066	<10%	yes	55.5
Dean Lake	Ashley	High Uintas	UT	40.6785	-110.7616	3275	48.9	0.0000	0.0005	1.061	0.01%	0.0050	<10%	yes	48.9
No Name (Utah, Duchesne - 4D2-039)	Ashley	High Uintas	UT	40.6710	-110.2758	3302	67.0	0.0000	0.0008	0.844	0.02%	0.0105	<10%	yes	67.0
Upper Coffin Lake	Ashley	High Uintas	UT	40.8342	-110.2383	3361	64.9	0.0000	0.0006	0.960	0.01%	0.0070	<10%	yes	64.8
Fish Lake	Wasatch-Cache	High Uintas	UT	40.8361	-110.0676	---	105.8	0.0000	0.0008	0.869	0.01%	0.0101	<10%	yes	105.7
Blodgett Lake, Colorado	White River	Holy Cross	CO	39.4062	-106.5352	3558	47.7	0.0004	0.0471	0.928	1.14%	0.5450	<10%	yes	47.1
Upper Turquoise Lake	White River	Holy Cross	CO	39.5098	-106.5332	3450	104.0	0.0004	0.0475	0.809	0.61%	0.6313	<10%	yes	103.4
Upper West Tennessee Lake	San Isabel	Holy Cross	CO	39.3445	-106.4250	3649	114.2	0.0003	0.0374	0.904	0.39%	0.4439	<10%	yes	113.8
Blue Lake (Colorado; Boulder - 4E1-040)	Arapaho and Roosevelt	Indian Peaks	CO	40.0876	-105.6169	3446	19.3	0.0003	0.0360	1.128	1.78%	0.3426	<1(µeq/L)	yes	18.9
Crater Lake	Arapaho and Roosevelt	Indian Peaks	CO	40.0755	-105.6639	3141	53.1	0.0003	0.0314	1.071	0.59%	0.3149	<10%	yes	52.8
King Lake (Colorado; Grand - 4E1-049)	Arapaho and Roosevelt	Indian Peaks	CO	39.9441	-105.6858	3486	52.3	0.0002	0.0331	0.959	0.71%	0.3703	<10%	yes	51.9
No Name Lake (Colorado; Boulder - 4E1-055)	Arapaho and Roosevelt	Indian Peaks	CO	40.0375	-105.6269	3422	25.6	0.0003	0.0370	1.126	1.38%	0.3527	<10%	yes	25.3
Upper Lake	Arapaho and Roosevelt	Indian Peaks	CO	40.1545	-105.6805	3271	69.0	0.0003	0.0340	1.139	0.46%	0.3207	<10%	yes	68.7
Small Lake Above U-Shaped Lake	Rio Grande	La Garita	CO	37.9436	-106.8639	3932	59.9	0.0001	0.0100	0.927	0.19%	0.1152	<10%	yes	59.8
U-Shaped Lake	Rio Grande	La Garita	CO	37.9422	-106.8606	3566	81.4	0.0001	0.0100	0.927	0.14%	0.1152	<10%	yes	81.2
Avalanche Lake	White River	Maroon Bells	CO	39.1439	-107.0998	3260	158.8	0.0006	0.0526	1.282	0.28%	0.4416	<10%	yes	158.4
Capitol Lake	White River	Maroon Bells	CO	39.1630	-107.0820	3530	154.4	0.0006	0.0519	1.110	0.33%	0.5035	<10%	yes	153.9
Moon Lake (Upper)	White River	Maroon Bells	CO	39.1644	-107.0589	3578	53.0	0.0006	0.0519	1.110	0.95%	0.5035	<10%	yes	52.5
Upper Middle Beartrack Lake	Arapaho and Roosevelt	Mount Evans	CO	39.5711	-105.6067	3542	50.9	0.0002	0.0209	0.869	0.51%	0.2584	<10%	yes	50.6
Abyss Lake	Pike and San Isabel	Mount Evans	CO	39.5858	-105.6592	3856	81.1	0.0001	0.0218	0.896	0.32%	0.2610	<10%	yes	80.8
Frozen Lake	Pike and San Isabel	Mount Evans	CO	39.5775	-105.6583	3944	93.3	0.0001	0.0218	0.896	0.28%	0.2610	<10%	yes	93.0
North Lake	Pike and San Isabel	Mount Evans	CO	39.5914	-105.6733	3420	80.9	0.0001	0.0218	0.896	0.32%	0.2610	<10%	yes	80.7
South Lake	Pike and San Isabel	Mount Evans	CO	39.5903	-105.6714	3432	66.7	0.0001	0.0218	0.896	0.39%	0.2610	<10%	yes	66.5
Lake Elbert	Medicine Bow-Routt	Mount Zirkel	CO	40.6342	-106.7069	3289	56.6	0.0003	0.0299	1.726	0.33%	0.1862	<10%	yes	56.4
Seven Lakes (LG East)	Medicine Bow-Routt	Mount Zirkel	CO	40.8958	-106.6819	3273	36.2	0.0002	0.0246	1.546	0.47%	0.1710	<10%	yes	36.1
Summit Lake	Medicine Bow-Routt	Mount Zirkel	CO	40.5453	-106.6819	3146	48.0	0.0003	0.0290	1.449	0.45%	0.2150	<10%	yes	47.8
Deep Creek Lake	Gunnison	Raggeds	CO	39.0089	-107.2400	3359	20.6	0.0003	0.0409	0.887	2.40%	0.4951	<1(µeq/L)	yes	20.1
Island Lake	Arapaho and Roosevelt	Rawah	CO	40.6272	-105.9411	3392	71.0	0.0002	0.0222	1.079	0.31%	0.2212	<10%	yes	70.8
Kelly Lake	Arapaho and Roosevelt	Rawah	CO	40.6256	-105.9594	3293	179.9	0.0002	0.0222	1.079	0.12%	0.2212	<10%	yes	179.6
Rawah Lake #4	Arapaho and Roosevelt	Rawah	CO	40.6711	-105.9578	3497	41.3	0.0002	0.0225	1.098	0.53%	0.2202	<10%	yes	41.1
Crater Lake (Sangre de Cristo)	Rio Grande	Sangre de Cristo	CO	37.5756	-105.4951	3871	162.9	0.0001	0.0097	0.959	0.07%	0.1084	<10%	yes	162.8
Lower Stout Lake	San Isabel	Sangre de Cristo	CO	38.3528	-105.8892	3585	145.2	0.0001	0.0123	0.671	0.14%	0.1968	<10%	yes	145.0
Upper Little Sand Creek Lake	San Isabel	Sangre de Cristo	CO	37.9039	-105.5356	3773	129.5	0.0001	0.0092	1.064	0.07%	0.0926	<10%	yes	129.4
Upper Stout Lake	San Isabel	Sangre de Cristo	CO	38.3503	-105.8908	3609	76.3	0.0001	0.0123	0.671	0.26%	0.1968	<10%	yes	76.1
Glacier Lake (Colorado)	San Juan-Rio Grande	South San Juan	CO	37.2594	-106.5879	3639	63.4	0.0000	0.0042	1.145	0.06%	0.0397	<10%	yes	63.4
Lake South of Blue Lakes	San Juan-Rio Grande	South San Juan	CO	37.2243	-106.6307	3615	16.9	0.0000	0.0050	1.312	0.24%	0.0406	<1(µeq/L)	yes	16.9
Big Eldorado Lake	San Juan-Rio Grande	Weminuche	CO	37.7133	-107.5433	3811	19.6	0.0000	0.0070	1.128	0.34%	0.0664	<1(µeq/L)	yes	19.6
Four Mile Pothole	San Juan-Rio Grande	Weminuche	CO	37.4684	-107.0525	---	123.4	0.0001	0.0069	1.173	0.05%	0.0633	<10%	yes	123.3
Lake Due South of Ute Lake	San Juan-Rio Grande	Weminuche	CO	37.6361	-107.4428	---	13.2	0.0000	0.0059	1.067	0.45%	0.0597	<1(µeq/L)	yes	13.1
Little Eldorado	San Juan-Rio Grande	Weminuche	CO	37.7133	-107.5458	3812	-3.3	0.0000	0.0070	1.128	2.01%	0.0664	<1(µeq/L)	yes	-3.4
Little Granite Lake	San Juan-Rio Grande	Weminuche	CO	37.6205	-107.3317	3304	80.7	0.0000	0.0069	0.830	0.11%	0.0890	<10%	yes	80.6
Lower Sunlight Lake	San Juan-Rio Grande	Weminuche	CO	37.6331	-107.5830	3668	80.9	0.0001	0.0073	1.177	0.08%	0.0670	<10%	yes	80.8
Middle Ute Lake	San Juan-Rio Grande	Weminuche	CO	37.6483	-107.4752	3644	42.8	0.0000	0.0059	1.052	0.14%	0.0604	<10%	yes	42.7
Small Pond Above Trout Lake	San Juan-Rio Grande	Weminuche	CO	37.6519	-107.1564	3562	25.5	0.0000	0.0069	1.087	0.27%	0.0682	<10%	yes	25.4
Upper Grizzly Lake	San Juan-Rio Grande	Weminuche	CO	37.6200	-107.5836	3993	29.9	0.0001	0.0075	1.177	0.23%	0.0689	<10%	yes	29.8
Upper Sunlight Lake	San Juan-Rio Grande	Weminuche	CO	37.6278	-107.5797	3824	28.0	0.0001	0.0075	1.177	0.25%	0.0689	<10%	yes	27.9
West Snowdon Lake	San Juan-Rio Grande	Weminuche	CO	37.7103	-107.6935	3652	39.4	0.0000	0.0070	0.978	0.20%	0.0771	<10%	yes	39.3
White Dome Lake	San Juan-Rio Grande	Weminuche	CO	37.7089	-107.5525	3822	2.1	0.0000	0.0070	1.128	3.22%	0.0664	<1(µeq/L)	yes	2.0
South Golden Lake	Grand Mesa, Uncompahgre and Gunnison	West Elk	CO	38.7776	-107.1828	3371	111.4	0.0002	0.0317	0.984	0.31%	0.3454	<10%	yes	111.1

Table 5-35b. ANC calculations at sensitive lakes for new Federal oil and gas development within the BLM Uncompahgre Field Office Planning Area (Source Group F) and the 2021 High Development Scenario.

Lake	National Forest	Wilderness Area	State	Latitude (Deg N)	Longitude (Deg W)	Elevation (m)	10th Percentile Lowest ANC Value (μeq/L)	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%)*	Delta ANC (μeq/L)*	USFS LAC Threshold	Below Threshold?	2021 Hi Predicted 10th Percentile Lowest ANC Value (μeq/L)
Brooklyn Lake	White River	Collegiate Peaks	CO	39.0495	-106.6569	3737	101.7	0.0001	0.0045	0.898	0.05%	0.0543	<10%	yes	101.6
Tabor Lake	White River	Collegiate Peaks	CO	39.0628	-106.6564	3746	112.4	0.0001	0.0044	0.860	0.05%	0.0559	<10%	yes	112.3
Booth Lake	White River	Eagles Nest	CO	39.6986	-106.3050	3493	86.8	0.0000	0.0030	0.844	0.04%	0.0389	<10%	yes	86.7
Upper Willow Lake	White River	Eagles Nest	CO	39.6458	-106.1747	3469	134.1	0.0000	0.0022	0.741	0.02%	0.0325	<10%	yes	134.1
Ned Wilson Lake	White River	Flat Tops	CO	39.9614	-107.3239	3385	39.0	0.0000	0.0015	1.158	0.04%	0.0137	<10%	yes	39.0
Upper Ned Wilson Lake	White River	Flat Tops	CO	39.9628	-107.3236	3386	12.9	0.0000	0.0015	1.158	0.11%	0.0137	<1(μeq/L)	yes	12.9
Lower NWL Packtrail Pothole	White River	Flat Tops	CO	39.9682	-107.3241	3379	29.7	0.0000	0.0015	1.158	0.05%	0.0137	<10%	yes	29.6
Upper NWL Packtrail Pothole	White River	Flat Tops	CO	39.9656	-107.3238	3380	48.7	0.0000	0.0015	1.158	0.03%	0.0137	<10%	yes	48.7
Walk Up Lake	Ashley	--	UT	40.8110	-110.0383	---	55.2	0.0000	0.0000	0.878	0.00%	0.0003	<10%	yes	55.2
Bluebell Lake	Ashley	High Uintas	UT	40.6970	-110.4822	3322	55.5	0.0000	0.0000	0.883	0.00%	0.0002	<10%	yes	55.5
Dean Lake	Ashley	High Uintas	UT	40.6785	-110.7616	3275	48.9	0.0000	0.0000	1.061	0.00%	0.0001	<10%	yes	48.9
No Name (Utah, Duchesne - 4D2-039)	Ashley	High Uintas	UT	40.6710	-110.2758	3302	67.0	0.0000	0.0000	0.844	0.00%	0.0003	<10%	yes	67.0
Upper Coffin Lake	Ashley	High Uintas	UT	40.8342	-110.2383	3361	64.9	0.0000	0.0000	0.960	0.00%	0.0002	<10%	yes	64.8
Fish Lake	Wasatch-Cache	High Uintas	UT	40.8361	-110.0676	---	105.8	0.0000	0.0000	0.869	0.00%	0.0003	<10%	yes	105.8
Blodgett Lake, Colorado	White River	Holy Cross	CO	39.4062	-106.5352	3558	47.7	0.0001	0.0045	0.928	0.11%	0.0519	<10%	yes	47.6
Upper Turquoise Lake	White River	Holy Cross	CO	39.5098	-106.5332	3450	104.0	0.0001	0.0038	0.809	0.05%	0.0506	<10%	yes	103.9
Upper West Tennessee Lake	San Isabel	Holy Cross	CO	39.3445	-106.4250	3649	114.2	0.0001	0.0041	0.904	0.04%	0.0493	<10%	yes	114.2
Blue Lake (Colorado; Boulder - 4E1-040)	Arapaho and Roosevelt	Indian Peaks	CO	40.0876	-105.6169	3446	19.3	0.0000	0.0025	1.128	0.12%	0.0234	<1(μeq/L)	yes	19.2
Crater Lake	Arapaho and Roosevelt	Indian Peaks	CO	40.0755	-105.6639	3141	53.1	0.0000	0.0021	1.071	0.04%	0.0212	<10%	yes	53.1
King Lake (Colorado; Grand - 4E1-049)	Arapaho and Roosevelt	Indian Peaks	CO	39.9441	-105.6858	3486	52.3	0.0000	0.0021	0.959	0.05%	0.0236	<10%	yes	52.2
No Name Lake (Colorado; Boulder - 4E1-055)	Arapaho and Roosevelt	Indian Peaks	CO	40.0375	-105.6269	3422	25.6	0.0000	0.0025	1.126	0.09%	0.0240	<10%	yes	25.6
Upper Lake	Arapaho and Roosevelt	Indian Peaks	CO	40.1545	-105.6805	3271	69.0	0.0000	0.0024	1.139	0.03%	0.0230	<10%	yes	69.0
Small Lake Above U-Shaped Lake	Rio Grande	La Garita	CO	37.9436	-106.8639	3932	59.9	0.0000	0.0013	0.927	0.03%	0.0154	<10%	yes	59.9
U-Shaped Lake	Rio Grande	La Garita	CO	37.9422	-106.8606	3566	81.4	0.0000	0.0013	0.927	0.02%	0.0154	<10%	yes	81.3
Avalanche Lake	White River	Maroon Bells	CO	39.1439	-107.0998	3260	158.8	0.0004	0.0147	1.282	0.08%	0.1249	<10%	yes	158.7
Capitol Lake	White River	Maroon Bells	CO	39.1630	-107.0820	3530	154.4	0.0003	0.0132	1.110	0.08%	0.1295	<10%	yes	154.3
Moon Lake (Upper)	White River	Maroon Bells	CO	39.1644	-107.0589	3578	53.0	0.0003	0.0132	1.110	0.24%	0.1295	<10%	yes	52.9
Upper Middle Beartrack Lake	Arapaho and Roosevelt	Mount Evans	CO	39.5711	-105.6067	3542	50.9	0.0000	0.0017	0.869	0.04%	0.0205	<10%	yes	50.9
Abyss Lake	Pike and San Isabel	Mount Evans	CO	39.5858	-105.6592	3856	81.1	0.0000	0.0018	0.896	0.03%	0.0211	<10%	yes	81.1
Frozen Lake	Pike and San Isabel	Mount Evans	CO	39.5775	-105.6583	3944	93.3	0.0000	0.0018	0.896	0.02%	0.0211	<10%	yes	93.2
North Lake	Pike and San Isabel	Mount Evans	CO	39.5914	-105.6733	3420	80.9	0.0000	0.0018	0.896	0.03%	0.0211	<10%	yes	80.9
South Lake	Pike and San Isabel	Mount Evans	CO	39.5903	-105.6714	3432	66.7	0.0000	0.0018	0.896	0.03%	0.0211	<10%	yes	66.7
Lake Elbert	Medicine Bow-Routt	Mount Zirkel	CO	40.6342	-106.7069	3289	56.6	0.0000	0.0011	1.726	0.01%	0.0066	<10%	yes	56.6
Seven Lakes (LG East)	Medicine Bow-Routt	Mount Zirkel	CO	40.8958	-106.6819	3273	36.2	0.0000	0.0007	1.546	0.01%	0.0052	<10%	yes	36.2
Summit Lake	Medicine Bow-Routt	Mount Zirkel	CO	40.5453	-106.6819	3146	48.0	0.0000	0.0011	1.449	0.02%	0.0084	<10%	yes	48.0
Deep Creek Lake	Gunnison	Raggeds	CO	39.0089	-107.2400	3359	20.6	0.0003	0.0173	0.887	1.03%	0.2112	<1(μeq/L)	yes	20.4
Island Lake	Arapaho and Roosevelt	Rawah	CO	40.6272	-105.9411	3392	71.0	0.0000	0.0014	1.079	0.02%	0.0141	<10%	yes	71.0
Kelly Lake	Arapaho and Roosevelt	Rawah	CO	40.6256	-105.9594	3293	179.9	0.0000	0.0014	1.079	0.01%	0.0141	<10%	yes	179.8
Rawah Lake #4	Arapaho and Roosevelt	Rawah	CO	40.6711	-105.9578	3497	41.3	0.0000	0.0014	1.098	0.03%	0.0138	<10%	yes	41.3
Crater Lake (Sangre de Cristo)	Rio Grande	Sangre de Cristo	CO	37.5756	-105.4951	3871	162.9	0.0000	0.0012	0.959	0.01%	0.0135	<10%	yes	162.9
Lower Stout Lake	San Isabel	Sangre de Cristo	CO	38.3528	-105.8892	3585	145.2	0.0000	0.0019	0.671	0.02%	0.0309	<10%	yes	145.2
Upper Little Sand Creek Lake	San Isabel	Sangre de Cristo	CO	37.9039	-105.5356	3773	129.5	0.0000	0.0012	1.064	0.01%	0.0118	<10%	yes	129.5
Upper Stout Lake	San Isabel	Sangre de Cristo	CO	38.3503	-105.8908	3609	76.3	0.0000	0.0019	0.671	0.04%	0.0309	<10%	yes	76.3
Glacier Lake (Colorado)	San Juan-Rio Grande	South San Juan	CO	37.2594	-106.5879	3639	63.4	0.0000	0.0005	1.145	0.01%	0.0044	<10%	yes	63.4
Lake South of Blue Lakes	San Juan-Rio Grande	South San Juan	CO	37.2243	-106.6307	3615	16.9	0.0000	0.0005	1.312	0.02%	0.0042	<1(μeq/L)	yes	16.9
Big Eldorado Lake	San Juan-Rio Grande	Weminuche	CO	37.7133	-107.5433	3811	19.6	0.0000	0.0007	1.128	0.03%	0.0065	<1(μeq/L)	yes	19.6
Four Mile Pothole	San Juan-Rio Grande	Weminuche	CO	37.4684	-107.0525	---	123.4	0.0000	0.0006	1.173	0.00%	0.0057	<10%	yes	123.4
Lake Due South of Ute Lake	San Juan-Rio Grande	Weminuche	CO	37.6361	-107.4428	---	13.2	0.0000	0.0006	1.067	0.04%	0.0057	<1(μeq/L)	yes	13.2
Little Eldorado	San Juan-Rio Grande	Weminuche	CO	37.7133	-107.5458	3812	-3.3	0.0000	0.0007	1.128	0.20%	0.0065	<1(μeq/L)	yes	-3.3
Little Granite Lake	San Juan-Rio Grande	Weminuche	CO	37.6205	-107.3317	3304	80.7	0.0000	0.0007	0.830	0.01%	0.0092	<10%	yes	80.7
Lower Sunlight Lake	San Juan-Rio Grande	Weminuche	CO	37.6331	-107.5830	3668	80.9	0.0000	0.0007	1.177	0.01%	0.0063	<10%	yes	80.9
Middle Ute Lake	San Juan-Rio Grande	Weminuche	CO	37.6483	-107.4752	3644	42.8	0.0000	0.0006	1.052	0.01%	0.0059	<10%	yes	42.8
Small Pond Above Trout Lake	San Juan-Rio Grande	Weminuche	CO	37.6519	-107.1564	3562	25.5	0.0000	0.0007	1.087	0.03%	0.0071	<10%	yes	25.5
Upper Grizzly Lake	San Juan-Rio Grande	Weminuche	CO	37.6200	-107.5836	3993	29.9	0.0000	0.0007	1.177	0.02%	0.0063	<10%	yes	29.9
Upper Sunlight Lake	San Juan-Rio Grande	Weminuche	CO	37.6278	-107.5797	3824	28.0	0.0000	0.0007	1.177	0.02%	0.0063	<10%	yes	28.0
West Snowdon Lake	San Juan-Rio Grande	Weminuche	CO	37.7103	-107.6935	3652	39.4	0.0000	0.0007	0.978	0.02%	0.0074	<10%	yes	39.3
White Dome Lake	San Juan-Rio Grande	Weminuche	CO	37.7089	-107.5525	3822	2.1	0.0000	0.0007	1.128	0.32%	0.0065	<1(μeq/L)	yes	2.1
South Golden Lake	Grand Mesa, Uncompahgre and Gunnison	West Elk	CO	38.7776	-107.1828	3371	111.4	0.0001	0.0090	0.984	0.09%	0.0989	<10%	yes	111.3

Table 5-35c. ANC calculations at sensitive lakes for new Federal oil and gas development within the USFS Pawnee Grasslands Planning Area (Source Group J) and the 2021 High Development Scenario.

Lake	National Forest	Wilderness Area	State	Latitude (Deg N)	Longitude (Deg W)	Elevation (m)	10th Percentile Lowest ANC Value (µeq/L)	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%)*	Delta ANC (µeq/L)*	USFS LAC Threshold	Below Threshold?	2021 Hi Predicted 10th Percentile Lowest ANC Value (µeq/L)
Brooklyn Lake	White River	Collegiate Peaks	CO	39.0495	-106.6569	3737	101.7	0.0000	0.0000	0.898	0.00%	0.0005	<10%	yes	101.7
Tabor Lake	White River	Collegiate Peaks	CO	39.0628	-106.6564	3746	112.4	0.0000	0.0000	0.860	0.00%	0.0005	<10%	yes	112.4
Booth Lake	White River	Eagles Nest	CO	39.6986	-106.3050	3493	86.8	0.0000	0.0001	0.844	0.00%	0.0006	<10%	yes	86.8
Upper Willow Lake	White River	Eagles Nest	CO	39.6458	-106.1747	3469	134.1	0.0000	0.0001	0.741	0.00%	0.0015	<10%	yes	134.1
Ned Wilson Lake	White River	Flat Tops	CO	39.9614	-107.3239	3385	39.0	0.0000	0.0000	1.158	0.00%	0.0001	<10%	yes	39.0
Upper Ned Wilson Lake	White River	Flat Tops	CO	39.9628	-107.3236	3386	12.9	0.0000	0.0000	1.158	0.00%	0.0001	<1(µeq/L)	yes	12.9
Lower NWL Packtrail Pothole	White River	Flat Tops	CO	39.9682	-107.3241	3379	29.7	0.0000	0.0000	1.158	0.00%	0.0001	<10%	yes	29.6
Upper NWL Packtrail Pothole	White River	Flat Tops	CO	39.9656	-107.3238	3380	48.7	0.0000	0.0000	1.158	0.00%	0.0001	<10%	yes	48.7
Walk Up Lake	Ashley	--	UT	40.8110	-110.0383	---	55.2	0.0000	0.0000	0.878	0.00%	0.0000	<10%	yes	55.2
Bluebell Lake	Ashley	High Uintas	UT	40.6970	-110.4822	3322	55.5	0.0000	0.0000	0.883	0.00%	0.0000	<10%	yes	55.5
Dean Lake	Ashley	High Uintas	UT	40.6785	-110.7616	3275	48.9	0.0000	0.0000	1.061	0.00%	0.0000	<10%	yes	48.9
No Name (Utah, Duchesne - 4D2-039)	Ashley	High Uintas	UT	40.6710	-110.2758	3302	67.0	0.0000	0.0000	0.844	0.00%	0.0000	<10%	yes	67.0
Upper Coffin Lake	Ashley	High Uintas	UT	40.8342	-110.2383	3361	64.9	0.0000	0.0000	0.960	0.00%	0.0000	<10%	yes	64.8
Fish Lake	Wasatch-Cache	High Uintas	UT	40.8361	-110.0676	---	105.8	0.0000	0.0000	0.869	0.00%	0.0000	<10%	yes	105.8
Blodgett Lake, Colorado	White River	Holy Cross	CO	39.4062	-106.5352	3558	47.7	0.0000	0.0000	0.928	0.00%	0.0003	<10%	yes	47.7
Upper Turquoise Lake	White River	Holy Cross	CO	39.5098	-106.5332	3450	104.0	0.0000	0.0000	0.809	0.00%	0.0005	<10%	yes	104.0
Upper West Tennessee Lake	San Isabel	Holy Cross	CO	39.3445	-106.4250	3649	114.2	0.0000	0.0000	0.904	0.00%	0.0006	<10%	yes	114.2
Blue Lake (Colorado; Boulder - 4E1-040)	Arapaho and Roosevelt	Indian Peaks	CO	40.0876	-105.6169	3446	19.3	0.0000	0.0003	1.128	0.02%	0.0032	<1(µeq/L)	yes	19.2
Crater Lake	Arapaho and Roosevelt	Indian Peaks	CO	40.0755	-105.6639	3141	53.1	0.0000	0.0003	1.071	0.01%	0.0027	<10%	yes	53.1
King Lake (Colorado; Grand - 4E1-049)	Arapaho and Roosevelt	Indian Peaks	CO	39.9441	-105.6858	3486	52.3	0.0000	0.0004	0.959	0.01%	0.0042	<10%	yes	52.3
No Name Lake (Colorado; Boulder - 4E1-055)	Arapaho and Roosevelt	Indian Peaks	CO	40.0375	-105.6269	3422	25.6	0.0000	0.0005	1.126	0.02%	0.0044	<10%	yes	25.6
Upper Lake	Arapaho and Roosevelt	Indian Peaks	CO	40.1545	-105.6805	3271	69.0	0.0000	0.0003	1.139	0.00%	0.0024	<10%	yes	69.0
Small Lake Above U-Shaped Lake	Rio Grande	La Garita	CO	37.9436	-106.8639	3932	59.9	0.0000	0.0000	0.927	0.00%	0.0004	<10%	yes	59.9
U-Shaped Lake	Rio Grande	La Garita	CO	37.9422	-106.8606	3566	81.4	0.0000	0.0000	0.927	0.00%	0.0004	<10%	yes	81.4
Avalanche Lake	White River	Maroon Bells	CO	39.1439	-107.0998	3260	158.8	0.0000	0.0000	1.282	0.00%	0.0001	<10%	yes	158.8
Capitol Lake	White River	Maroon Bells	CO	39.1630	-107.0820	3530	154.4	0.0000	0.0000	1.110	0.00%	0.0002	<10%	yes	154.4
Moon Lake (Upper)	White River	Maroon Bells	CO	39.1644	-107.0589	3578	53.0	0.0000	0.0000	1.110	0.00%	0.0002	<10%	yes	53.0
Upper Middle Beartrack Lake	Arapaho and Roosevelt	Mount Evans	CO	39.5711	-105.6067	3542	50.9	0.0000	0.0005	0.869	0.01%	0.0064	<10%	yes	50.9
Abyss Lake	Pike and San Isabel	Mount Evans	CO	39.5858	-105.6592	3856	81.1	0.0000	0.0004	0.896	0.01%	0.0044	<10%	yes	81.1
Frozen Lake	Pike and San Isabel	Mount Evans	CO	39.5775	-105.6583	3944	93.3	0.0000	0.0004	0.896	0.00%	0.0044	<10%	yes	93.3
North Lake	Pike and San Isabel	Mount Evans	CO	39.5914	-105.6733	3420	80.9	0.0000	0.0004	0.896	0.01%	0.0044	<10%	yes	80.9
South Lake	Pike and San Isabel	Mount Evans	CO	39.5903	-105.6714	3432	66.7	0.0000	0.0004	0.896	0.01%	0.0044	<10%	yes	66.7
Lake Elbert	Medicine Bow-Routt	Mount Zirkel	CO	40.6342	-106.7069	3289	56.6	0.0000	0.0000	1.726	0.00%	0.0002	<10%	yes	56.6
Seven Lakes (LG East)	Medicine Bow-Routt	Mount Zirkel	CO	40.8958	-106.6819	3273	36.2	0.0000	0.0000	1.546	0.00%	0.0002	<10%	yes	36.2
Summit Lake	Medicine Bow-Routt	Mount Zirkel	CO	40.5453	-106.6819	3146	48.0	0.0000	0.0000	1.449	0.00%	0.0002	<10%	yes	48.0
Deep Creek Lake	Gunnison	Raggeds	CO	39.0089	-107.2400	3359	20.6	0.0000	0.0000	0.887	0.00%	0.0002	<1(µeq/L)	yes	20.6
Island Lake	Arapaho and Roosevelt	Rawah	CO	40.6272	-105.9411	3392	71.0	0.0000	0.0001	1.079	0.00%	0.0012	<10%	yes	71.0
Kelly Lake	Arapaho and Roosevelt	Rawah	CO	40.6256	-105.9594	3293	179.9	0.0000	0.0001	1.079	0.00%	0.0012	<10%	yes	179.8
Rawah Lake #4	Arapaho and Roosevelt	Rawah	CO	40.6711	-105.9578	3497	41.3	0.0000	0.0002	1.098	0.00%	0.0015	<10%	yes	41.3
Crater Lake (Sangre de Cristo)	Rio Grande	Sangre de Cristo	CO	37.5756	-105.4951	3871	162.9	0.0000	0.0002	0.959	0.00%	0.0024	<10%	yes	162.9
Lower Stout Lake	San Isabel	Sangre de Cristo	CO	38.3528	-105.8892	3585	145.2	0.0000	0.0003	0.671	0.00%	0.0042	<10%	yes	145.2
Upper Little Sand Creek Lake	San Isabel	Sangre de Cristo	CO	37.9039	-105.5356	3773	129.5	0.0000	0.0002	1.064	0.00%	0.0025	<10%	yes	129.5
Upper Stout Lake	San Isabel	Sangre de Cristo	CO	38.3503	-105.8908	3609	76.3	0.0000	0.0003	0.671	0.01%	0.0042	<10%	yes	76.3
Glacier Lake (Colorado)	San Juan-Rio Grande	South San Juan	CO	37.2594	-106.5879	3639	63.4	0.0000	0.0001	1.145	0.00%	0.0005	<10%	yes	63.4
Lake South of Blue Lakes	San Juan-Rio Grande	South San Juan	CO	37.2243	-106.6307	3615	16.9	0.0000	0.0001	1.312	0.00%	0.0005	<1(µeq/L)	yes	16.9
Big Eldorado Lake	San Juan-Rio Grande	Weminuche	CO	37.7133	-107.5433	3811	19.6	0.0000	0.0000	1.128	0.00%	0.0001	<1(µeq/L)	yes	19.6
Four Mile Pothole	San Juan-Rio Grande	Weminuche	CO	37.4684	-107.0525	---	123.4	0.0000	0.0000	1.173	0.00%	0.0003	<10%	yes	123.4
Lake Due South of Ute Lake	San Juan-Rio Grande	Weminuche	CO	37.6361	-107.4428	---	13.2	0.0000	0.0000	1.067	0.00%	0.0001	<1(µeq/L)	yes	13.2
Little Eldorado	San Juan-Rio Grande	Weminuche	CO	37.7133	-107.5458	3812	-3.3	0.0000	0.0000	1.128	0.00%	0.0001	<1(µeq/L)	yes	-3.3
Little Granite Lake	San Juan-Rio Grande	Weminuche	CO	37.6205	-107.3317	3304	80.7	0.0000	0.0000	0.830	0.00%	0.0002	<10%	yes	80.7
Lower Sunlight Lake	San Juan-Rio Grande	Weminuche	CO	37.6331	-107.5830	3668	80.9	0.0000	0.0000	1.177	0.00%	0.0001	<10%	yes	80.9
Middle Ute Lake	San Juan-Rio Grande	Weminuche	CO	37.6483	-107.4752	3644	42.8	0.0000	0.0000	1.052	0.00%	0.0001	<10%	yes	42.8
Small Pond Above Trout Lake	San Juan-Rio Grande	Weminuche	CO	37.6519	-107.1564	3562	25.5	0.0000	0.0000	1.087	0.00%	0.0003	<10%	yes	25.5
Upper Grizzly Lake	San Juan-Rio Grande	Weminuche	CO	37.6200	-107.5836	3993	29.9	0.0000	0.0000	1.177	0.00%	0.0001	<10%	yes	29.9
Upper Sunlight Lake	San Juan-Rio Grande	Weminuche	CO	37.6278	-107.5797	3824	28.0	0.0000	0.0000	1.177	0.00%	0.0001	<10%	yes	28.0
West Snowdon Lake	San Juan-Rio Grande	Weminuche	CO	37.7103	-107.6935	3652	39.4	0.0000	0.0000	0.978	0.00%	0.0001	<10%	yes	39.3
White Dome Lake	San Juan-Rio Grande	Weminuche	CO	37.7089	-107.5525	3822	2.1	0.0000	0.0000	1.128	0.01%	0.0001	<1(µeq/L)	yes	2.1
South Golden Lake	Grand Mesa, Uncompahgre and Gunnison	West Elk	CO	38.7776	-107.1828	3371	111.4	0.0000	0.0000	0.984	0.00%	0.0002	<10%	yes	111.4

Table 5-35d. ANC calculations at sensitive lakes for new Federal oil and gas development within the New Mexico Farmington Field Office (Source Group N) and the 2021 High Development Scenario.

Lake	National Forest	Wilderness Area	State	Latitude (Deg N)	Longitude (Deg W)	Elevation (m)	10th Percentile Lowest ANC Value (μeq/L)	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%)*	Delta ANC (μeq/L)*	USFS LAC Threshold	Below Threshold?	2021 Hi Predicted 10th Percentile Lowest ANC Value (μeq/L)
Brooklyn Lake	White River	Collegiate Peaks	CO	39.0495	-106.6569	3737	101.7	0.0000	0.0029	0.898	0.03%	0.0348	<10%	yes	101.6
Tabor Lake	White River	Collegiate Peaks	CO	39.0628	-106.6564	3746	112.4	0.0000	0.0024	0.860	0.03%	0.0298	<10%	yes	112.4
Booth Lake	White River	Eagles Nest	CO	39.6986	-106.3050	3493	86.8	0.0000	0.0020	0.844	0.03%	0.0257	<10%	yes	86.8
Upper Willow Lake	White River	Eagles Nest	CO	39.6458	-106.1747	3469	134.1	0.0000	0.0017	0.741	0.02%	0.0244	<10%	yes	134.1
Ned Wilson Lake	White River	Flat Tops	CO	39.9614	-107.3239	3385	39.0	0.0000	0.0018	1.158	0.04%	0.0169	<10%	yes	39.0
Upper Ned Wilson Lake	White River	Flat Tops	CO	39.9628	-107.3236	3386	12.9	0.0000	0.0018	1.158	0.13%	0.0169	<1(μeq/L)	yes	12.9
Lower NWL Packtrail Pothole	White River	Flat Tops	CO	39.9682	-107.3241	3379	29.7	0.0000	0.0018	1.158	0.06%	0.0169	<10%	yes	29.6
Upper NWL Packtrail Pothole	White River	Flat Tops	CO	39.9656	-107.3238	3380	48.7	0.0000	0.0018	1.158	0.03%	0.0169	<10%	yes	48.7
Walk Up Lake	Ashley	--	UT	40.8110	-110.0383	---	55.2	0.0000	0.0004	0.878	0.01%	0.0050	<10%	yes	55.2
Bluebell Lake	Ashley	High Uintas	UT	40.6970	-110.4822	3322	55.5	0.0000	0.0004	0.883	0.01%	0.0044	<10%	yes	55.5
Dean Lake	Ashley	High Uintas	UT	40.6785	-110.7616	3275	48.9	0.0000	0.0003	1.061	0.01%	0.0028	<10%	yes	48.9
No Name (Utah, Duchesne - 4D2-039)	Ashley	High Uintas	UT	40.6710	-110.2758	3302	67.0	0.0000	0.0006	0.844	0.01%	0.0082	<10%	yes	67.0
Upper Coffin Lake	Ashley	High Uintas	UT	40.8342	-110.2383	3361	64.9	0.0000	0.0003	0.960	0.00%	0.0032	<10%	yes	64.8
Fish Lake	Wasatch-Cache	High Uintas	UT	40.8361	-110.0676	---	105.8	0.0000	0.0003	0.869	0.00%	0.0044	<10%	yes	105.8
Blodgett Lake, Colorado	White River	Holy Cross	CO	39.4062	-106.5352	3558	47.7	0.0000	0.0023	0.928	0.06%	0.0267	<10%	yes	47.6
Upper Turquoise Lake	White River	Holy Cross	CO	39.5098	-106.5332	3450	104.0	0.0000	0.0022	0.809	0.03%	0.0290	<10%	yes	104.0
Upper West Tennessee Lake	San Isabel	Holy Cross	CO	39.3445	-106.4250	3649	114.2	0.0000	0.0021	0.904	0.02%	0.0253	<10%	yes	114.2
Blue Lake (Colorado; Boulder - 4E1-040)	Arapaho and Roosevelt	Indian Peaks	CO	40.0876	-105.6169	3446	19.3	0.0000	0.0020	1.128	0.10%	0.0187	<1(μeq/L)	yes	19.2
Crater Lake	Arapaho and Roosevelt	Indian Peaks	CO	40.0755	-105.6639	3141	53.1	0.0000	0.0017	1.071	0.03%	0.0166	<10%	yes	53.1
King Lake (Colorado; Grand - 4E1-049)	Arapaho and Roosevelt	Indian Peaks	CO	39.9441	-105.6858	3486	52.3	0.0000	0.0018	0.959	0.04%	0.0200	<10%	yes	52.2
No Name Lake (Colorado; Boulder - 4E1-055)	Arapaho and Roosevelt	Indian Peaks	CO	40.0375	-105.6269	3422	25.6	0.0000	0.0022	1.126	0.08%	0.0211	<10%	yes	25.6
Upper Lake	Arapaho and Roosevelt	Indian Peaks	CO	40.1545	-105.6805	3271	69.0	0.0000	0.0019	1.139	0.03%	0.0183	<10%	yes	69.0
Small Lake Above U-Shaped Lake	Rio Grande	La Garita	CO	37.9436	-106.8639	3932	59.9	0.0001	0.0099	0.927	0.19%	0.1155	<10%	yes	59.8
U-Shaped Lake	Rio Grande	La Garita	CO	37.9422	-106.8606	3566	81.4	0.0001	0.0099	0.927	0.14%	0.1155	<10%	yes	81.2
Avalanche Lake	White River	Maroon Bells	CO	39.1439	-107.0998	3260	158.8	0.0001	0.0040	1.282	0.02%	0.0334	<10%	yes	158.8
Capitol Lake	White River	Maroon Bells	CO	39.1630	-107.0820	3530	154.4	0.0001	0.0038	1.110	0.02%	0.0374	<10%	yes	154.4
Moon Lake (Upper)	White River	Maroon Bells	CO	39.1644	-107.0589	3578	53.0	0.0001	0.0038	1.110	0.07%	0.0374	<10%	yes	52.9
Upper Middle Beartrack Lake	Arapaho and Roosevelt	Mount Evans	CO	39.5711	-105.6067	3542	50.9	0.0000	0.0022	0.869	0.05%	0.0273	<10%	yes	50.9
Abyss Lake	Pike and San Isabel	Mount Evans	CO	39.5858	-105.6592	3856	81.1	0.0000	0.0021	0.896	0.03%	0.0249	<10%	yes	81.1
Frozen Lake	Pike and San Isabel	Mount Evans	CO	39.5775	-105.6583	3944	93.3	0.0000	0.0021	0.896	0.03%	0.0249	<10%	yes	93.2
North Lake	Pike and San Isabel	Mount Evans	CO	39.5914	-105.6733	3420	80.9	0.0000	0.0021	0.896	0.03%	0.0249	<10%	yes	80.9
South Lake	Pike and San Isabel	Mount Evans	CO	39.5903	-105.6714	3432	66.7	0.0000	0.0021	0.896	0.04%	0.0249	<10%	yes	66.7
Lake Elbert	Medicine Bow-Routt	Mount Zirkel	CO	40.6342	-106.7069	3289	56.6	0.0000	0.0023	1.726	0.03%	0.0146	<10%	yes	56.6
Seven Lakes (LG East)	Medicine Bow-Routt	Mount Zirkel	CO	40.8958	-106.6819	3273	36.2	0.0000	0.0020	1.546	0.04%	0.0143	<10%	yes	36.2
Summit Lake	Medicine Bow-Routt	Mount Zirkel	CO	40.5453	-106.6819	3146	48.0	0.0000	0.0021	1.449	0.03%	0.0154	<10%	yes	48.0
Deep Creek Lake	Gunnison	Raggeds	CO	39.0089	-107.2400	3359	20.6	0.0000	0.0030	0.887	0.18%	0.0369	<1(μeq/L)	yes	20.6
Island Lake	Arapaho and Roosevelt	Rawah	CO	40.6272	-105.9411	3392	71.0	0.0000	0.0016	1.079	0.02%	0.0162	<10%	yes	71.0
Kelly Lake	Arapaho and Roosevelt	Rawah	CO	40.6256	-105.9594	3293	179.9	0.0000	0.0016	1.079	0.01%	0.0162	<10%	yes	179.8
Rawah Lake #4	Arapaho and Roosevelt	Rawah	CO	40.6711	-105.9578	3497	41.3	0.0000	0.0017	1.098	0.04%	0.0170	<10%	yes	41.3
Crater Lake (Sangre de Cristo)	Rio Grande	Sangre de Cristo	CO	37.5756	-105.4951	3871	162.9	0.0002	0.0121	0.959	0.08%	0.1366	<10%	yes	162.8
Lower Stout Lake	San Isabel	Sangre de Cristo	CO	38.3528	-105.8892	3585	145.2	0.0001	0.0093	0.671	0.10%	0.1492	<10%	yes	145.1
Upper Little Sand Creek Lake	San Isabel	Sangre de Cristo	CO	37.9039	-105.5356	3773	129.5	0.0002	0.0109	1.064	0.09%	0.1107	<10%	yes	129.4
Upper Stout Lake	San Isabel	Sangre de Cristo	CO	38.3503	-105.8908	3609	76.3	0.0001	0.0093	0.671	0.20%	0.1492	<10%	yes	76.2
Glacier Lake (Colorado)	San Juan-Rio Grande	South San Juan	CO	37.2594	-106.5879	3639	63.4	0.0005	0.0245	1.145	0.37%	0.2318	<10%	yes	63.2
Lake South of Blue Lakes	San Juan-Rio Grande	South San Juan	CO	37.2243	-106.6307	3615	16.9	0.0006	0.0327	1.312	1.60%	0.2698	<1(μeq/L)	yes	16.6
Big Eldorado Lake	San Juan-Rio Grande	Weminuche	CO	37.7133	-107.5433	3811	19.6	0.0002	0.0118	1.128	0.58%	0.1135	<1(μeq/L)	yes	19.5
Four Mile Pothole	San Juan-Rio Grande	Weminuche	CO	37.4684	-107.0525	---	123.4	0.0007	0.0328	1.173	0.25%	0.3040	<10%	yes	123.1
Lake Due South of Ute Lake	San Juan-Rio Grande	Weminuche	CO	37.6361	-107.4428	---	13.2	0.0004	0.0155	1.067	1.20%	0.1583	<1(μeq/L)	yes	13.0
Little Eldorado	San Juan-Rio Grande	Weminuche	CO	37.7133	-107.5458	3812	-3.3	0.0002	0.0118	1.128	3.44%	0.1135	<1(μeq/L)	yes	-3.4
Little Granite Lake	San Juan-Rio Grande	Weminuche	CO	37.6205	-107.3317	3304	80.7	0.0004	0.0199	0.830	0.32%	0.2602	<10%	yes	80.5
Lower Sunlight Lake	San Juan-Rio Grande	Weminuche	CO	37.6331	-107.5830	3668	80.9	0.0004	0.0158	1.177	0.18%	0.1461	<10%	yes	80.7
Middle Ute Lake	San Juan-Rio Grande	Weminuche	CO	37.6483	-107.4752	3644	42.8	0.0003	0.0137	1.052	0.33%	0.1414	<10%	yes	42.6
Small Pond Above Trout Lake	San Juan-Rio Grande	Weminuche	CO	37.6519	-107.1564	3562	25.5	0.0004	0.0205	1.087	0.80%	0.2045	<10%	yes	25.3
Upper Grizzly Lake	San Juan-Rio Grande	Weminuche	CO	37.6200	-107.5836	3993	29.9	0.0005	0.0174	1.177	0.54%	0.1613	<10%	yes	29.7
Upper Sunlight Lake	San Juan-Rio Grande	Weminuche	CO	37.6278	-107.5797	3824	28.0	0.0005	0.0174	1.177	0.58%	0.1613	<10%	yes	27.8
West Snowdon Lake	San Juan-Rio Grande	Weminuche	CO	37.7103	-107.6935	3652	39.4	0.0002	0.0104	0.978	0.29%	0.1151	<10%	yes	39.2
White Dome Lake	San Juan-Rio Grande	Weminuche	CO	37.7089	-107.5525	3822	2.1	0.0002	0.0118	1.128	5.51%	0.1135	<1(μeq/L)	yes	1.9
South Golden Lake	Grand Mesa, Uncompahgre and Gunnison	West Elk	CO	38.7776	-107.1828	3371	111.4	0.0000	0.0034	0.984	0.03%	0.0376	<10%	yes	111.4

5.5.2 ANC Calculations for Combined BLM Planning Areas

The Attachment E-1, E-2 and E-3 spreadsheets also contain ANC calculations for the combined BLM Planning Area Source Groups Q through T of new emission sources. Below we provide results for Source Group R (new Federal O&G and mining within 13 CO BLM Planning Areas) and the Cumulative Emissions Scenario (Source Group T) that also adds new O&G and O&G emissions from the Mancos Shale development in northern New Mexico.

Table 5-36 displays the ANC results at the 58 sensitive lakes for the combined new Federal O&G and mining within the 13 Colorado BLM Planning Areas (Source Group R) and the 2021 High, Low and Medium Development Scenarios. For the lakes that have base ANC values > 25 μeq/l the maximum percent change in ANC is always below the USFS LAC 10% threshold for all three 2021 emission scenarios. However, for the 8 lakes with base ANC < 25 μeq/l, three have changes in ANC greater than the 1 μeq/l USFS LAC threshold for the 2021 High Development Scenario (Table 5-36a): Upper Ned Wilson Lake (1.5 μeq/l); Blue Lake (1.0 μeq/l) and Deep Creek Lake (1.4 μeq/l). The mitigation in the 2021 Medium Development scenario is sufficient to reduce the change in ANC value at Blue Lake (0.9 μeq/l) to below the 1 μeq/l LAC threshold, but the change in ANC values at Upper Ned Wilson (1.3 μeq/l) and Deep Creek (1.2 μeq/l) lakes remain above the LAC threshold. For these same three lakes the change in ANC values are all below the 1 μeq/l USFS LAC threshold for the 2021 Low Development Scenario.

The ANC results for the Cumulative Emissions Scenario (Source Group T) and the 2021 High, Low and Medium Emissions Scenario are shown in Tables 5-37 and 5-38. Since this Source Group contains Source Group R then the same three sensitive lakes with ANC < 25 μeq/l have changes in ANC greater than the 1 μeq/l USFS LAC threshold for the 2021 High Development Scenario (Table 5-37): Upper Ned Wilson Lake (2.7 μeq/l); Blue Lake (2.5 μeq/l) and Deep Creek Lake (2.7 μeq/l). However, in addition there is one sensitive lake with base ANC > 25 μeq/l whose change in ANC exceeds the USFS 10% LAC threshold for the 2021 High Development Scenario and Source Group T: No Name Lake (10.3%). The mitigation in the 2021 Medium Development Scenario is sufficient to reduce the change in ANC at No Name Lake (9.6%) to below the 10% LAC threshold but not to reduce it at the other three lakes with base ANC < 25 μeq/l to below the 1 μeq/l LAC threshold (Table 5-38b). For the 2021 Low Development Scenario and Source Group T, all sensitive lakes have change in ANC below the LAC thresholds (Table 5-38a).

Note that the USFS ANC LAC thresholds were developed for evaluating potential lake acidification for individual Projects, not for quasi-cumulative emission source groups of new O&G development across an entire state as in Source Groups R and T. In addition, the USFS ANC LAC thresholds were developed for evaluating potential lake acidification for individual Projects (i.e. new emissions since baseline lake chemistry data was monitored), not for cumulative emissions scenarios that include all existing O&G since the baseline ANC values that are used in the ANC calculations would already account for impacts from existing emissions sources.

Table 5-36a. ANC calculations at sensitive lakes for new Federal oil and gas development and mining within the 13 Colorado BLM Planning Areas (Source Group R) and 2021 High Development Scenario.

Lake	National Forest	Wilderness Area	State	Latitude (Deg N)	Longitude (Deg W)	Elevation (m)	10th Percentile Lowest ANC Value (µeq/L)	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%)*	Delta ANC (µeq/L)*	USFS LAC Threshold	Below Threshold?	2021 Hi Predicted 10th Percentile Lowest ANC Value (µeq/L)
Brooklyn Lake	White River	Collegiate Peaks	CO	39.0495	-106.6569	3737	101.7	0.0034	0.0783	0.898	0.95%	0.9643	<10%	yes	100.7
Tabor Lake	White River	Collegiate Peaks	CO	39.0628	-106.6564	3746	112.4	0.0034	0.0808	0.860	0.92%	1.0378	<10%	yes	111.4
Booth Lake	White River	Eagles Nest	CO	39.6986	-106.3050	3493	86.8	0.0040	0.1109	0.844	1.67%	1.4451	<10%	yes	85.3
Upper Willow Lake	White River	Eagles Nest	CO	39.6458	-106.1747	3469	134.1	0.0030	0.0783	0.741	0.87%	1.1643	<10%	yes	132.9
Ned Wilson Lake	White River	Flat Tops	CO	39.9614	-107.3239	3385	39.0	0.0102	0.1579	1.158	3.94%	1.5347	<10%	yes	37.5
Upper Ned Wilson Lake	White River	Flat Tops	CO	39.9628	-107.3236	3386	12.9	0.0102	0.1579	1.158	11.92%	1.5347	<1(µeq/L)	no	11.3
Lower NWL Packtrail Pothole	White River	Flat Tops	CO	39.9682	-107.3241	3379	29.7	0.0102	0.1579	1.158	5.18%	1.5347	<10%	yes	28.1
Upper NWL Packtrail Pothole	White River	Flat Tops	CO	39.9656	-107.3238	3380	48.7	0.0102	0.1579	1.158	3.15%	1.5347	<10%	yes	47.2
Walk Up Lake	Ashley	--	UT	40.8110	-110.0383	---	55.2	0.0002	0.0035	0.878	0.08%	0.0445	<10%	yes	55.2
Bluebell Lake	Ashley	High Uintas	UT	40.6970	-110.4822	3322	55.5	0.0001	0.0020	0.883	0.05%	0.0256	<10%	yes	55.5
Dean Lake	Ashley	High Uintas	UT	40.6785	-110.7616	3275	48.9	0.0001	0.0018	1.061	0.04%	0.0186	<10%	yes	48.9
No Name (Utah, Duchesne - 4D2-039)	Ashley	High Uintas	UT	40.6710	-110.2758	3302	67.0	0.0002	0.0043	0.844	0.09%	0.0574	<10%	yes	67.0
Upper Coffin Lake	Ashley	High Uintas	UT	40.8342	-110.2383	3361	64.9	0.0001	0.0024	0.960	0.04%	0.0281	<10%	yes	64.8
Fish Lake	Wasatch-Cache	High Uintas	UT	40.8361	-110.0676	---	105.8	0.0002	0.0034	0.869	0.04%	0.0436	<10%	yes	105.7
Blodgett Lake, Colorado	White River	Holy Cross	CO	39.4062	-106.5352	3558	47.7	0.0045	0.1149	0.928	2.86%	1.3652	<10%	yes	46.3
Upper Turquoise Lake	White River	Holy Cross	CO	39.5098	-106.5332	3450	104.0	0.0052	0.1219	0.809	1.60%	1.6675	<10%	yes	102.3
Upper West Tennessee Lake	San Isabel	Holy Cross	CO	39.3445	-106.4250	3649	114.2	0.0032	0.0911	0.904	0.97%	1.1082	<10%	yes	113.1
Blue Lake (Colorado; Boulder - 4E1-040)	Arapaho and Roosevelt	Indian Peaks	CO	40.0876	-105.6169	3446	19.3	0.0046	0.1069	1.128	5.45%	1.0491	<1(µeq/L)	no	18.2
Crater Lake	Arapaho and Roosevelt	Indian Peaks	CO	40.0755	-105.6639	3141	53.1	0.0045	0.0962	1.071	1.88%	0.9973	<10%	yes	52.1
King Lake (Colorado; Grand - 4E1-049)	Arapaho and Roosevelt	Indian Peaks	CO	39.9441	-105.6858	3486	52.3	0.0045	0.1029	0.959	2.27%	1.1875	<10%	yes	51.1
No Name Lake (Colorado; Boulder - 4E1-055)	Arapaho and Roosevelt	Indian Peaks	CO	40.0375	-105.6269	3422	25.6	0.0049	0.1099	1.126	4.22%	1.0811	<10%	yes	24.5
Upper Lake	Arapaho and Roosevelt	Indian Peaks	CO	40.1545	-105.6805	3271	69.0	0.0054	0.1029	1.139	1.46%	1.0081	<10%	yes	68.0
Small Lake Above U-Shaped Lake	Rio Grande	La Garita	CO	37.9436	-106.8639	3932	59.9	0.0010	0.0295	0.927	0.58%	0.3495	<10%	yes	59.6
U-Shaped Lake	Rio Grande	La Garita	CO	37.9422	-106.8606	3566	81.4	0.0010	0.0295	0.927	0.43%	0.3495	<10%	yes	81.0
Avalanche Lake	White River	Maroon Bells	CO	39.1439	-107.0998	3260	158.8	0.0055	0.1349	1.282	0.73%	1.1619	<10%	yes	157.6
Capitol Lake	White River	Maroon Bells	CO	39.1630	-107.0820	3530	154.4	0.0057	0.1319	1.110	0.85%	1.3144	<10%	yes	153.1
Moon Lake (Upper)	White River	Maroon Bells	CO	39.1644	-107.0589	3578	53.0	0.0057	0.1319	1.110	2.48%	1.3144	<10%	yes	51.7
Upper Middle Beartrack Lake	Arapaho and Roosevelt	Mount Evans	CO	39.5711	-105.6067	3542	50.9	0.0028	0.0593	0.869	1.49%	0.7570	<10%	yes	50.1
Abyss Lake	Pike and San Isabel	Mount Evans	CO	39.5858	-105.6592	3856	81.1	0.0025	0.0611	0.896	0.93%	0.7533	<10%	yes	80.3
Frozen Lake	Pike and San Isabel	Mount Evans	CO	39.5775	-105.6583	3944	93.3	0.0025	0.0611	0.896	0.81%	0.7533	<10%	yes	92.5
North Lake	Pike and San Isabel	Mount Evans	CO	39.5914	-105.6733	3420	80.9	0.0025	0.0611	0.896	0.93%	0.7533	<10%	yes	80.2
South Lake	Pike and San Isabel	Mount Evans	CO	39.5903	-105.6714	3432	66.7	0.0025	0.0611	0.896	1.13%	0.7533	<10%	yes	66.0
Lake Elbert	Medicine Bow-Routt	Mount Zirkel	CO	40.6342	-106.7069	3289	56.6	0.0097	0.1496	1.726	1.73%	0.9766	<10%	yes	55.6
Seven Lakes (LG East)	Medicine Bow-Routt	Mount Zirkel	CO	40.8958	-106.6819	3273	36.2	0.0087	0.1238	1.546	2.50%	0.9064	<10%	yes	35.3
Summit Lake	Medicine Bow-Routt	Mount Zirkel	CO	40.5453	-106.6819	3146	48.0	0.0092	0.1495	1.449	2.41%	1.1586	<10%	yes	46.8
Deep Creek Lake	Gunnison	Raggeds	CO	39.0089	-107.2400	3359	20.6	0.0040	0.1137	0.887	6.84%	1.4087	<1(µeq/L)	no	19.2
Island Lake	Arapaho and Roosevelt	Rawah	CO	40.6272	-105.9411	3392	71.0	0.0057	0.0929	1.079	1.36%	0.9674	<10%	yes	70.1
Kelly Lake	Arapaho and Roosevelt	Rawah	CO	40.6256	-105.9594	3293	179.9	0.0057	0.0929	1.079	0.54%	0.9674	<10%	yes	178.9
Rawah Lake #4	Arapaho and Roosevelt	Rawah	CO	40.6711	-105.9578	3497	41.3	0.0055	0.0949	1.098	2.35%	0.9684	<10%	yes	40.3
Crater Lake (Sangre de Cristo)	Rio Grande	Sangre de Cristo	CO	37.5756	-105.4951	3871	162.9	0.0015	0.0311	0.959	0.22%	0.3599	<10%	yes	162.6
Lower Stout Lake	San Isabel	Sangre de Cristo	CO	38.3528	-105.8892	3585	145.2	0.0018	0.0388	0.671	0.44%	0.6406	<10%	yes	144.6
Upper Little Sand Creek Lake	San Isabel	Sangre de Cristo	CO	37.9039	-105.5356	3773	129.5	0.0015	0.0311	1.064	0.25%	0.3249	<10%	yes	129.2
Upper Stout Lake	San Isabel	Sangre de Cristo	CO	38.3503	-105.8908	3609	76.3	0.0018	0.0388	0.671	0.84%	0.6406	<10%	yes	75.7
Glacier Lake (Colorado)	San Juan-Rio Grande	South San Juan	CO	37.2594	-106.5879	3639	63.4	0.0008	0.0186	1.145	0.28%	0.1798	<10%	yes	63.2
Lake South of Blue Lakes	San Juan-Rio Grande	South San Juan	CO	37.2243	-106.6307	3615	16.9	0.0009	0.0236	1.312	1.17%	0.1979	<1(µeq/L)	yes	16.7
Big Eldorado Lake	San Juan-Rio Grande	Weminuche	CO	37.7133	-107.5433	3811	19.6	0.0010	0.0246	1.128	1.22%	0.2405	<1(µeq/L)	yes	19.4
Four Mile Pothole	San Juan-Rio Grande	Weminuche	CO	37.4684	-107.0525	---	123.4	0.0010	0.0232	1.173	0.18%	0.2187	<10%	yes	123.2
Lake Due South of Ute Lake	San Juan-Rio Grande	Weminuche	CO	37.6361	-107.4428	---	13.2	0.0008	0.0206	1.067	1.62%	0.2132	<1(µeq/L)	yes	12.9
Little Eldorado	San Juan-Rio Grande	Weminuche	CO	37.7133	-107.5458	3812	-3.3	0.0010	0.0246	1.128	7.29%	0.2405	<1(µeq/L)	yes	-3.5
Little Granite Lake	San Juan-Rio Grande	Weminuche	CO	37.6205	-107.3317	3304	80.7	0.0008	0.0229	0.830	0.38%	0.3030	<10%	yes	80.4
Lower Sunlight Lake	San Juan-Rio Grande	Weminuche	CO	37.6331	-107.5830	3668	80.9	0.0012	0.0267	1.177	0.31%	0.2515	<10%	yes	80.6
Middle Ute Lake	San Juan-Rio Grande	Weminuche	CO	37.6483	-107.4752	3644	42.8	0.0009	0.0206	1.052	0.51%	0.2164	<10%	yes	42.6
Small Pond Above Trout Lake	San Juan-Rio Grande	Weminuche	CO	37.6519	-107.1564	3562	25.5	0.0008	0.0231	1.087	0.92%	0.2339	<10%	yes	25.2
Upper Grizzly Lake	San Juan-Rio Grande	Weminuche	CO	37.6200	-107.5836	3993	29.9	0.0014	0.0272	1.177	0.86%	0.2571	<10%	yes	29.6
Upper Sunlight Lake	San Juan-Rio Grande	Weminuche	CO	37.6278	-107.5797	3824	28.0	0.0014	0.0272	1.177	0.92%	0.2571	<10%	yes	27.7
West Snowdon Lake	San Juan-Rio Grande	Weminuche	CO	37.7103	-107.6935	3652	39.4	0.0008	0.0246	0.978	0.70%	0.2754	<10%	yes	39.1
White Dome Lake	San Juan-Rio Grande	Weminuche	CO	37.7089	-107.5525	3822	2.1	0.0010	0.0246	1.128	11.67%	0.2405	<1(µeq/L)	yes	1.8
South Golden Lake	Grand Mesa, Uncompahgre and Gunnison	West Elk	CO	38.7776	-107.1828	3371	111.4	0.0022	0.0870	0.984	0.87%	0.9643	<10%	yes	110.4

Table 5-36b. ANC calculations at sensitive lakes for new Federal oil and gas development and mining within the 13 Colorado BLM Planning Areas (Source Group R) and 2021 Low Development Scenario.

Lake	National Forest	Wilderness Area	State	Latitude (Deg N)	Longitude (Deg W)	Elevation (m)	10th Percentile Lowest ANC Value (μeq/L)	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%)*	Delta ANC (μeq/L)*	USFS LAC Threshold	Below Threshold?	2021 Hi Predicted 10th Percentile Lowest ANC Value (μeq/L)
Brooklyn Lake	White River	Collegiate Peaks	CO	39.0495	-106.6569	3737	101.7	0.0007	0.0157	0.898	0.19%	0.1930	<10%	yes	101.5
Tabor Lake	White River	Collegiate Peaks	CO	39.0628	-106.6564	3746	112.4	0.0007	0.0161	0.860	0.18%	0.2066	<10%	yes	112.2
Booth Lake	White River	Eagles Nest	CO	39.6986	-106.3050	3493	86.8	0.0008	0.0223	0.844	0.33%	0.2901	<10%	yes	86.5
Upper Willow Lake	White River	Eagles Nest	CO	39.6458	-106.1747	3469	134.1	0.0006	0.0157	0.741	0.17%	0.2330	<10%	yes	133.9
Ned Wilson Lake	White River	Flat Tops	CO	39.9614	-107.3239	3385	39.0	0.0020	0.0322	1.158	0.80%	0.3121	<10%	yes	38.7
Upper Ned Wilson Lake	White River	Flat Tops	CO	39.9628	-107.3236	3386	12.9	0.0020	0.0322	1.158	2.42%	0.3121	<1(μeq/L)	yes	12.6
Lower NWL Packtrail Pothole	White River	Flat Tops	CO	39.9682	-107.3241	3379	29.7	0.0020	0.0322	1.158	1.05%	0.3121	<10%	yes	29.3
Upper NWL Packtrail Pothole	White River	Flat Tops	CO	39.9656	-107.3238	3380	48.7	0.0020	0.0322	1.158	0.64%	0.3121	<10%	yes	48.4
Walk Up Lake	Ashley	--	UT	40.8110	-110.0383	---	55.2	0.0000	0.0007	0.878	0.02%	0.0083	<10%	yes	55.2
Bluebell Lake	Ashley	High Uintas	UT	40.6970	-110.4822	3322	55.5	0.0000	0.0004	0.883	0.01%	0.0049	<10%	yes	55.5
Dean Lake	Ashley	High Uintas	UT	40.6785	-110.7616	3275	48.9	0.0000	0.0003	1.061	0.01%	0.0035	<10%	yes	48.9
No Name (Utah, Duchesne - 4D2-039)	Ashley	High Uintas	UT	40.6710	-110.2758	3302	67.0	0.0000	0.0008	0.844	0.02%	0.0106	<10%	yes	67.0
Upper Coffin Lake	Ashley	High Uintas	UT	40.8342	-110.2383	3361	64.9	0.0000	0.0005	0.960	0.01%	0.0055	<10%	yes	64.8
Fish Lake	Wasatch-Cache	High Uintas	UT	40.8361	-110.0676	---	105.8	0.0000	0.0006	0.869	0.01%	0.0083	<10%	yes	105.8
Blodgett Lake, Colorado	White River	Holy Cross	CO	39.4062	-106.5352	3558	47.7	0.0009	0.0223	0.928	0.56%	0.2650	<10%	yes	47.4
Upper Turquoise Lake	White River	Holy Cross	CO	39.5098	-106.5332	3450	104.0	0.0010	0.0244	0.809	0.32%	0.3332	<10%	yes	103.7
Upper West Tennessee Lake	San Isabel	Holy Cross	CO	39.3445	-106.4250	3649	114.2	0.0007	0.0175	0.904	0.19%	0.2128	<10%	yes	114.0
Blue Lake (Colorado; Boulder - 4E1-040)	Arapaho and Roosevelt	Indian Peaks	CO	40.0876	-105.6169	3446	19.3	0.0009	0.0208	1.128	1.06%	0.2040	<1(μeq/L)	yes	19.0
Crater Lake	Arapaho and Roosevelt	Indian Peaks	CO	40.0755	-105.6639	3141	53.1	0.0009	0.0188	1.071	0.37%	0.1948	<10%	yes	52.9
King Lake (Colorado; Grand - 4E1-049)	Arapaho and Roosevelt	Indian Peaks	CO	39.9441	-105.6858	3486	52.3	0.0009	0.0202	0.959	0.45%	0.2328	<10%	yes	52.0
No Name Lake (Colorado; Boulder - 4E1-055)	Arapaho and Roosevelt	Indian Peaks	CO	40.0375	-105.6269	3422	25.6	0.0010	0.0216	1.126	0.83%	0.2122	<10%	yes	25.4
Upper Lake	Arapaho and Roosevelt	Indian Peaks	CO	40.1545	-105.6805	3271	69.0	0.0011	0.0200	1.139	0.28%	0.1956	<10%	yes	68.8
Small Lake Above U-Shaped Lake	Rio Grande	La Garita	CO	37.9436	-106.8639	3932	59.9	0.0002	0.0056	0.927	0.11%	0.0668	<10%	yes	59.8
U-Shaped Lake	Rio Grande	La Garita	CO	37.9422	-106.8606	3566	81.4	0.0002	0.0056	0.927	0.08%	0.0668	<10%	yes	81.3
Avalanche Lake	White River	Maroon Bells	CO	39.1439	-107.0998	3260	158.8	0.0012	0.0261	1.282	0.14%	0.2262	<10%	yes	158.6
Capitol Lake	White River	Maroon Bells	CO	39.1630	-107.0820	3530	154.4	0.0013	0.0257	1.110	0.17%	0.2576	<10%	yes	154.1
Moon Lake (Upper)	White River	Maroon Bells	CO	39.1644	-107.0589	3578	53.0	0.0013	0.0257	1.110	0.49%	0.2576	<10%	yes	52.7
Upper Middle Beartrack Lake	Arapaho and Roosevelt	Mount Evans	CO	39.5711	-105.6067	3542	50.9	0.0005	0.0118	0.869	0.30%	0.1502	<10%	yes	50.7
Abyss Lake	Pike and San Isabel	Mount Evans	CO	39.5858	-105.6592	3856	81.1	0.0005	0.0121	0.896	0.18%	0.1489	<10%	yes	81.0
Frozen Lake	Pike and San Isabel	Mount Evans	CO	39.5775	-105.6583	3944	93.3	0.0005	0.0121	0.896	0.16%	0.1489	<10%	yes	93.1
North Lake	Pike and San Isabel	Mount Evans	CO	39.5914	-105.6733	3420	80.9	0.0005	0.0121	0.896	0.18%	0.1489	<10%	yes	80.8
South Lake	Pike and San Isabel	Mount Evans	CO	39.5903	-105.6714	3432	66.7	0.0005	0.0121	0.896	0.22%	0.1489	<10%	yes	66.6
Lake Elbert	Medicine Bow-Routt	Mount Zirkel	CO	40.6342	-106.7069	3289	56.6	0.0019	0.0317	1.726	0.36%	0.2061	<10%	yes	56.4
Seven Lakes (LG East)	Medicine Bow-Routt	Mount Zirkel	CO	40.8958	-106.6819	3273	36.2	0.0017	0.0248	1.546	0.50%	0.1814	<10%	yes	36.1
Summit Lake	Medicine Bow-Routt	Mount Zirkel	CO	40.5453	-106.6819	3146	48.0	0.0019	0.0325	1.449	0.52%	0.2510	<10%	yes	47.7
Deep Creek Lake	Gunnison	Raggeds	CO	39.0089	-107.2400	3359	20.6	0.0010	0.0239	0.887	1.44%	0.2974	<1(μeq/L)	yes	20.3
Island Lake	Arapaho and Roosevelt	Rawah	CO	40.6272	-105.9411	3392	71.0	0.0011	0.0190	1.079	0.28%	0.1967	<10%	yes	70.8
Kelly Lake	Arapaho and Roosevelt	Rawah	CO	40.6256	-105.9594	3293	179.9	0.0011	0.0190	1.079	0.11%	0.1967	<10%	yes	179.7
Rawah Lake #4	Arapaho and Roosevelt	Rawah	CO	40.6711	-105.9578	3497	41.3	0.0011	0.0193	1.098	0.47%	0.1959	<10%	yes	41.1
Crater Lake (Sangre de Cristo)	Rio Grande	Sangre de Cristo	CO	37.5756	-105.4951	3871	162.9	0.0003	0.0063	0.959	0.04%	0.0727	<10%	yes	162.8
Lower Stout Lake	San Isabel	Sangre de Cristo	CO	38.3528	-105.8892	3585	145.2	0.0003	0.0077	0.671	0.09%	0.1270	<10%	yes	145.1
Upper Little Sand Creek Lake	San Isabel	Sangre de Cristo	CO	37.9039	-105.5356	3773	129.5	0.0003	0.0067	1.064	0.05%	0.0696	<10%	yes	129.4
Upper Stout Lake	San Isabel	Sangre de Cristo	CO	38.3503	-105.8908	3609	76.3	0.0003	0.0077	0.671	0.17%	0.1270	<10%	yes	76.2
Glacier Lake (Colorado)	San Juan-Rio Grande	South San Juan	CO	37.2594	-106.5879	3639	63.4	0.0002	0.0034	1.145	0.05%	0.0329	<10%	yes	63.4
Lake South of Blue Lakes	San Juan-Rio Grande	South San Juan	CO	37.2243	-106.6307	3615	16.9	0.0002	0.0041	1.312	0.21%	0.0348	<1(μeq/L)	yes	16.9
Big Eldorado Lake	San Juan-Rio Grande	Weminuche	CO	37.7133	-107.5433	3811	19.6	0.0002	0.0045	1.128	0.22%	0.0441	<1(μeq/L)	yes	19.6
Four Mile Pothole	San Juan-Rio Grande	Weminuche	CO	37.4684	-107.0525	---	123.4	0.0002	0.0043	1.173	0.03%	0.0403	<10%	yes	123.3
Lake Due South of Ute Lake	San Juan-Rio Grande	Weminuche	CO	37.6361	-107.4428	---	13.2	0.0002	0.0039	1.067	0.30%	0.0399	<1(μeq/L)	yes	13.1
Little Eldorado	San Juan-Rio Grande	Weminuche	CO	37.7133	-107.5458	3812	-3.3	0.0002	0.0045	1.128	1.34%	0.0441	<1(μeq/L)	yes	-3.3
Little Granite Lake	San Juan-Rio Grande	Weminuche	CO	37.6205	-107.3317	3304	80.7	0.0002	0.0043	0.830	0.07%	0.0564	<10%	yes	80.7
Lower Sunlight Lake	San Juan-Rio Grande	Weminuche	CO	37.6331	-107.5830	3668	80.9	0.0002	0.0049	1.177	0.06%	0.0462	<10%	yes	80.8
Middle Ute Lake	San Juan-Rio Grande	Weminuche	CO	37.6483	-107.4752	3644	42.8	0.0002	0.0038	1.052	0.09%	0.0403	<10%	yes	42.7
Small Pond Above Trout Lake	San Juan-Rio Grande	Weminuche	CO	37.6519	-107.1564	3562	25.5	0.0002	0.0043	1.087	0.17%	0.0434	<10%	yes	25.4
Upper Grizzly Lake	San Juan-Rio Grande	Weminuche	CO	37.6200	-107.5836	3993	29.9	0.0003	0.0050	1.177	0.16%	0.0477	<10%	yes	29.8
Upper Sunlight Lake	San Juan-Rio Grande	Weminuche	CO	37.6278	-107.5797	3824	28.0	0.0003	0.0050	1.177	0.17%	0.0477	<10%	yes	28.0
West Snowdon Lake	San Juan-Rio Grande	Weminuche	CO	37.7103	-107.6935	3652	39.4	0.0001	0.0044	0.978	0.13%	0.0495	<10%	yes	39.3
White Dome Lake	San Juan-Rio Grande	Weminuche	CO	37.7089	-107.5525	3822	2.1	0.0002	0.0045	1.128	2.14%	0.0441	<1(μeq/L)	yes	2.0
South Golden Lake	Grand Mesa, Uncompahgre and Gunnison	West Elk	CO	38.7776	-107.1828	3371	111.4	0.0005	0.0169	0.984	0.17%	0.1881	<10%	yes	111.2

Table 5-36c. ANC calculations at sensitive lakes for new Federal oil and gas development and mining within the 13 Colorado BLM Planning Areas (Source Group R) and 2021 Medium Development Scenario.

Lake	National Forest	Wilderness Area	State	Latitude (Deg N)	Longitude (Deg W)	Elevation (m)	10th Percentile Lowest ANC Value (µeq/L)	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%)*	Delta ANC (µeq/L)*	USFS LAC Threshold	Below Threshold?	2021 Hi Predicted 10th Percentile Lowest ANC Value (µeq/L)
Brooklyn Lake	White River	Collegiate Peaks	CO	39.0495	-106.6569	3737	101.7	0.0033	0.0641	0.898	0.78%	0.7944	<10%	yes	100.9
Tabor Lake	White River	Collegiate Peaks	CO	39.0628	-106.6564	3746	112.4	0.0032	0.0661	0.860	0.76%	0.8541	<10%	yes	111.5
Booth Lake	White River	Eagles Nest	CO	39.6986	-106.3050	3493	86.8	0.0039	0.0912	0.844	1.38%	1.1946	<10%	yes	85.6
Upper Willow Lake	White River	Eagles Nest	CO	39.6458	-106.1747	3469	134.1	0.0029	0.0645	0.741	0.72%	0.9645	<10%	yes	133.1
Ned Wilson Lake	White River	Flat Tops	CO	39.9614	-107.3239	3385	39.0	0.0100	0.1309	1.158	3.29%	1.2846	<10%	yes	37.7
Upper Ned Wilson Lake	White River	Flat Tops	CO	39.9628	-107.3236	3386	12.9	0.0100	0.1309	1.158	9.97%	1.2846	<1(µeq/L)	no	11.6
Lower NWL Packtrail Pothole	White River	Flat Tops	CO	39.9682	-107.3241	3379	29.7	0.0100	0.1309	1.158	4.33%	1.2846	<10%	yes	28.4
Upper NWL Packtrail Pothole	White River	Flat Tops	CO	39.9656	-107.3238	3380	48.7	0.0100	0.1309	1.158	2.64%	1.2846	<10%	yes	47.4
Walk Up Lake	Ashley	--	UT	40.8110	-110.0383	---	55.2	0.0002	0.0032	0.878	0.07%	0.0413	<10%	yes	55.2
Bluebell Lake	Ashley	High Uintas	UT	40.6970	-110.4822	3322	55.5	0.0001	0.0019	0.883	0.04%	0.0237	<10%	yes	55.5
Dean Lake	Ashley	High Uintas	UT	40.6785	-110.7616	3275	48.9	0.0001	0.0017	1.061	0.04%	0.0172	<10%	yes	48.9
No Name (Utah, Duchesne - 4D2-039)	Ashley	High Uintas	UT	40.6710	-110.2758	3302	67.0	0.0002	0.0040	0.844	0.08%	0.0536	<10%	yes	67.0
Upper Coffin Lake	Ashley	High Uintas	UT	40.8342	-110.2383	3361	64.9	0.0001	0.0022	0.960	0.04%	0.0260	<10%	yes	64.8
Fish Lake	Wasatch-Cache	High Uintas	UT	40.8361	-110.0676	---	105.8	0.0002	0.0031	0.869	0.04%	0.0404	<10%	yes	105.7
Blodgett Lake, Colorado	White River	Holy Cross	CO	39.4062	-106.5352	3558	47.7	0.0043	0.0938	0.928	2.35%	1.1209	<10%	yes	46.5
Upper Turquoise Lake	White River	Holy Cross	CO	39.5098	-106.5332	3450	104.0	0.0049	0.0999	0.809	1.32%	1.3749	<10%	yes	102.6
Upper West Tennessee Lake	San Isabel	Holy Cross	CO	39.3445	-106.4250	3649	114.2	0.0031	0.0745	0.904	0.80%	0.9110	<10%	yes	113.3
Blue Lake (Colorado; Boulder - 4E1-040)	Arapaho and Roosevelt	Indian Peaks	CO	40.0876	-105.6169	3446	19.3	0.0045	0.0897	1.128	4.60%	0.8857	<1(µeq/L)	yes	18.4
Crater Lake	Arapaho and Roosevelt	Indian Peaks	CO	40.0755	-105.6639	3141	53.1	0.0044	0.0810	1.071	1.59%	0.8452	<10%	yes	52.3
King Lake (Colorado; Grand - 4E1-049)	Arapaho and Roosevelt	Indian Peaks	CO	39.9441	-105.6858	3486	52.3	0.0043	0.0864	0.959	1.92%	1.0021	<10%	yes	51.3
No Name Lake (Colorado; Boulder - 4E1-055)	Arapaho and Roosevelt	Indian Peaks	CO	40.0375	-105.6269	3422	25.6	0.0048	0.0927	1.126	3.58%	0.9175	<10%	yes	24.7
Upper Lake	Arapaho and Roosevelt	Indian Peaks	CO	40.1545	-105.6805	3271	69.0	0.0052	0.0868	1.139	1.24%	0.8557	<10%	yes	68.1
Small Lake Above U-Shaped Lake	Rio Grande	La Garita	CO	37.9436	-106.8639	3932	59.9	0.0010	0.0250	0.927	0.50%	0.2975	<10%	yes	59.6
U-Shaped Lake	Rio Grande	La Garita	CO	37.9422	-106.8606	3566	81.4	0.0010	0.0250	0.927	0.37%	0.2975	<10%	yes	81.1
Avalanche Lake	White River	Maroon Bells	CO	39.1439	-107.0998	3260	158.8	0.0052	0.1099	1.282	0.60%	0.9518	<10%	yes	157.8
Capitol Lake	White River	Maroon Bells	CO	39.1630	-107.0820	3530	154.4	0.0054	0.1089	1.110	0.71%	1.0910	<10%	yes	153.3
Moon Lake (Upper)	White River	Maroon Bells	CO	39.1644	-107.0589	3578	53.0	0.0054	0.1089	1.110	2.06%	1.0910	<10%	yes	51.9
Upper Middle Beartrack Lake	Arapaho and Roosevelt	Mount Evans	CO	39.5711	-105.6067	3542	50.9	0.0027	0.0492	0.869	1.24%	0.6321	<10%	yes	50.3
Abyss Lake	Pike and San Isabel	Mount Evans	CO	39.5858	-105.6592	3856	81.1	0.0025	0.0507	0.896	0.78%	0.6287	<10%	yes	80.5
Frozen Lake	Pike and San Isabel	Mount Evans	CO	39.5775	-105.6583	3944	93.3	0.0025	0.0507	0.896	0.67%	0.6287	<10%	yes	92.6
North Lake	Pike and San Isabel	Mount Evans	CO	39.5914	-105.6733	3420	80.9	0.0025	0.0507	0.896	0.78%	0.6287	<10%	yes	80.3
South Lake	Pike and San Isabel	Mount Evans	CO	39.5903	-105.6714	3432	66.7	0.0025	0.0507	0.896	0.94%	0.6287	<10%	yes	66.1
Lake Elbert	Medicine Bow-Routt	Mount Zirkel	CO	40.6342	-106.7069	3289	56.6	0.0095	0.1296	1.726	1.51%	0.8520	<10%	yes	55.7
Seven Lakes (LG East)	Medicine Bow-Routt	Mount Zirkel	CO	40.8958	-106.6819	3273	36.2	0.0085	0.1068	1.546	2.17%	0.7879	<10%	yes	35.5
Summit Lake	Medicine Bow-Routt	Mount Zirkel	CO	40.5453	-106.6819	3146	48.0	0.0090	0.1295	1.449	2.10%	1.0103	<10%	yes	47.0
Deep Creek Lake	Gunnison	Raggeds	CO	39.0089	-107.2400	3359	20.6	0.0038	0.0924	0.887	5.59%	1.1506	<1(µeq/L)	no	19.4
Island Lake	Arapaho and Roosevelt	Rawah	CO	40.6272	-105.9411	3392	71.0	0.0055	0.0790	1.079	1.17%	0.8283	<10%	yes	70.2
Kelly Lake	Arapaho and Roosevelt	Rawah	CO	40.6256	-105.9594	3293	179.9	0.0055	0.0790	1.079	0.46%	0.8283	<10%	yes	179.0
Rawah Lake #4	Arapaho and Roosevelt	Rawah	CO	40.6711	-105.9578	3497	41.3	0.0054	0.0806	1.098	2.01%	0.8288	<10%	yes	40.5
Crater Lake (Sangre de Cristo)	Rio Grande	Sangre de Cristo	CO	37.5756	-105.4951	3871	162.9	0.0014	0.0258	0.959	0.18%	0.3006	<10%	yes	162.6
Lower Stout Lake	San Isabel	Sangre de Cristo	CO	38.3528	-105.8892	3585	145.2	0.0017	0.0324	0.671	0.37%	0.5383	<10%	yes	144.7
Upper Little Sand Creek Lake	San Isabel	Sangre de Cristo	CO	37.9039	-105.5356	3773	129.5	0.0015	0.0258	1.064	0.21%	0.2714	<10%	yes	129.2
Upper Stout Lake	San Isabel	Sangre de Cristo	CO	38.3503	-105.8908	3609	76.3	0.0017	0.0324	0.671	0.71%	0.5383	<10%	yes	75.8
Glacier Lake (Colorado)	San Juan-Rio Grande	South San Juan	CO	37.2594	-106.5879	3639	63.4	0.0008	0.0158	1.145	0.24%	0.1535	<10%	yes	63.2
Lake South of Blue Lakes	San Juan-Rio Grande	South San Juan	CO	37.2243	-106.6307	3615	16.9	0.0008	0.0200	1.312	1.00%	0.1684	<1(µeq/L)	yes	16.7
Big Eldorado Lake	San Juan-Rio Grande	Weminuche	CO	37.7133	-107.5433	3811	19.6	0.0009	0.0211	1.128	1.05%	0.2072	<1(µeq/L)	yes	19.4
Four Mile Pothole	San Juan-Rio Grande	Weminuche	CO	37.4684	-107.0525	---	123.4	0.0010	0.0198	1.173	0.15%	0.1875	<10%	yes	123.2
Lake Due South of Ute Lake	San Juan-Rio Grande	Weminuche	CO	37.6361	-107.4428	---	13.2	0.0008	0.0178	1.067	1.41%	0.1850	<1(µeq/L)	yes	13.0
Little Eldorado	San Juan-Rio Grande	Weminuche	CO	37.7133	-107.5458	3812	-3.3	0.0009	0.0211	1.128	6.28%	0.2072	<1(µeq/L)	yes	-3.5
Little Granite Lake	San Juan-Rio Grande	Weminuche	CO	37.6205	-107.3317	3304	80.7	0.0008	0.0196	0.830	0.32%	0.2604	<10%	yes	80.5
Lower Sunlight Lake	San Juan-Rio Grande	Weminuche	CO	37.6331	-107.5830	3668	80.9	0.0012	0.0230	1.177	0.27%	0.2176	<10%	yes	80.6
Middle Ute Lake	San Juan-Rio Grande	Weminuche	CO	37.6483	-107.4752	3644	42.8	0.0008	0.0177	1.052	0.44%	0.1868	<10%	yes	42.6
Small Pond Above Trout Lake	San Juan-Rio Grande	Weminuche	CO	37.6519	-107.1564	3562	25.5	0.0008	0.0197	1.087	0.79%	0.2002	<10%	yes	25.3
Upper Grizzly Lake	San Juan-Rio Grande	Weminuche	CO	37.6200	-107.5836	3993	29.9	0.0013	0.0234	1.177	0.74%	0.2223	<10%	yes	29.7
Upper Sunlight Lake	San Juan-Rio Grande	Weminuche	CO	37.6278	-107.5797	3824	28.0	0.0013	0.0234	1.177	0.79%	0.2223	<10%	yes	27.8
West Snowdon Lake	San Juan-Rio Grande	Weminuche	CO	37.7103	-107.6935	3652	39.4	0.0007	0.0212	0.978	0.61%	0.2382	<10%	yes	39.1
White Dome Lake	San Juan-Rio Grande	Weminuche	CO	37.7089	-107.5525	3822	2.1	0.0009	0.0211	1.128	10.06%	0.2072	<1(µeq/L)	yes	1.9
South Golden Lake	Grand Mesa, Uncompahgre and Gunnison	West Elk	CO	38.7776	-107.1828	3371	111.4	0.0021	0.0717	0.984	0.72%	0.7976	<10%	yes	110.6

Table 5-37. ANC calculations at sensitive lakes for new Federal oil and gas development and mining and new non-Federal oil and gas within the 14 Colorado and northern New Mexico BLM Planning Areas (Source Group T) and the 2021 High Development Scenario.

Lake	National Forest	Wilderness Area	State	Latitude (Deg N)	Longitude (Deg W)	Elevation (m)	10th Percentile Lowest ANC Value (μeq/L)	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%)*	Delta ANC (μeq/L)*	USFS LAC Threshold	Below Threshold?	2021 Hi Predicted 10th Percentile Lowest ANC Value (μeq/L)
Brooklyn Lake	White River	Collegiate Peaks	CO	39.0495	-106.6569	3737	101.7	0.0046	0.1530	0.898	1.83%	1.8629	<10%	yes	99.8
Tabor Lake	White River	Collegiate Peaks	CO	39.0628	-106.6564	3746	112.4	0.0045	0.1560	0.860	1.76%	1.9824	<10%	yes	110.4
Booth Lake	White River	Eagles Nest	CO	39.6986	-106.3050	3493	86.8	0.0054	0.2179	0.844	3.24%	2.8117	<10%	yes	84.0
Upper Willow Lake	White River	Eagles Nest	CO	39.6458	-106.1747	3469	134.1	0.0040	0.1590	0.741	1.74%	2.3385	<10%	yes	131.8
Ned Wilson Lake	White River	Flat Tops	CO	39.9614	-107.3239	3385	39.0	0.0127	0.2759	1.158	6.77%	2.6408	<10%	yes	36.4
Upper Ned Wilson Lake	White River	Flat Tops	CO	39.9628	-107.3236	3386	12.9	0.0127	0.2759	1.158	20.50%	2.6408	<1(μeq/L)	no	10.2
Lower NWL Packtrail Pothole	White River	Flat Tops	CO	39.9682	-107.3241	3379	29.7	0.0127	0.2759	1.158	8.91%	2.6408	<10%	yes	27.0
Upper NWL Packtrail Pothole	White River	Flat Tops	CO	39.9656	-107.3238	3380	48.7	0.0127	0.2759	1.158	5.42%	2.6408	<10%	yes	46.1
Walk Up Lake	Ashley	--	UT	40.8110	-110.0383	---	55.2	0.0003	0.0061	0.878	0.14%	0.0773	<10%	yes	55.1
Bluebell Lake	Ashley	High Uintas	UT	40.6970	-110.4822	3322	55.5	0.0001	0.0039	0.883	0.09%	0.0482	<10%	yes	55.5
Dean Lake	Ashley	High Uintas	UT	40.6785	-110.7616	3275	48.9	0.0001	0.0034	1.061	0.07%	0.0345	<10%	yes	48.8
No Name (Utah, Duchesne - 4D2-039)	Ashley	High Uintas	UT	40.6710	-110.2758	3302	67.0	0.0003	0.0075	0.844	0.15%	0.0983	<10%	yes	66.9
Upper Coffin Lake	Ashley	High Uintas	UT	40.8342	-110.2383	3361	64.9	0.0002	0.0044	0.960	0.08%	0.0500	<10%	yes	64.8
Fish Lake	Wasatch-Cache	High Uintas	UT	40.8361	-110.0676	---	105.8	0.0002	0.0059	0.869	0.07%	0.0751	<10%	yes	105.7
Blodgett Lake, Colorado	White River	Holy Cross	CO	39.4062	-106.5352	3558	47.7	0.0061	0.2229	0.928	5.50%	2.6215	<10%	yes	45.0
Upper Turquoise Lake	White River	Holy Cross	CO	39.5098	-106.5332	3450	104.0	0.0069	0.2359	0.809	3.07%	3.1910	<10%	yes	100.8
Upper West Tennessee Lake	San Isabel	Holy Cross	CO	39.3445	-106.4250	3649	114.2	0.0044	0.1799	0.904	1.90%	2.1672	<10%	yes	112.0
Blue Lake (Colorado; Boulder - 4E1-040)	Arapaho and Roosevelt	Indian Peaks	CO	40.0876	-105.6169	3446	19.3	0.0065	0.2489	1.128	12.51%	2.4074	<1(μeq/L)	no	16.8
Crater Lake	Arapaho and Roosevelt	Indian Peaks	CO	40.0755	-105.6639	3141	53.1	0.0062	0.2159	1.071	4.15%	2.2040	<10%	yes	50.9
King Lake (Colorado; Grand - 4E1-049)	Arapaho and Roosevelt	Indian Peaks	CO	39.9441	-105.6858	3486	52.3	0.0061	0.2369	0.959	5.15%	2.6928	<10%	yes	49.6
No Name Lake (Colorado; Boulder - 4E1-055)	Arapaho and Roosevelt	Indian Peaks	CO	40.0375	-105.6269	3422	25.6	0.0073	0.2709	1.126	10.25%	2.6250	<10%	no	23.0
Upper Lake	Arapaho and Roosevelt	Indian Peaks	CO	40.1545	-105.6805	3271	69.0	0.0073	0.2269	1.139	3.17%	2.1848	<10%	yes	66.8
Small Lake Above U-Shaped Lake	Rio Grande	La Garita	CO	37.9436	-106.8639	3932	59.9	0.0016	0.0717	0.927	1.40%	0.8401	<10%	yes	59.1
U-Shaped Lake	Rio Grande	La Garita	CO	37.9422	-106.8606	3566	81.4	0.0016	0.0717	0.927	1.03%	0.8401	<10%	yes	80.5
Avalanche Lake	White River	Maroon Bells	CO	39.1439	-107.0998	3260	158.8	0.0076	0.2629	1.282	1.41%	2.2419	<10%	yes	156.6
Capitol Lake	White River	Maroon Bells	CO	39.1630	-107.0820	3530	154.4	0.0080	0.2579	1.110	1.65%	2.5435	<10%	yes	151.9
Moon Lake (Upper)	White River	Maroon Bells	CO	39.1644	-107.0589	3578	53.0	0.0080	0.2579	1.110	4.80%	2.5435	<10%	yes	50.4
Upper Middle Beartrack Lake	Arapaho and Roosevelt	Mount Evans	CO	39.5711	-105.6067	3542	50.9	0.0044	0.1670	0.869	4.12%	2.0965	<10%	yes	48.8
Abyss Lake	Pike and San Isabel	Mount Evans	CO	39.5858	-105.6592	3856	81.1	0.0039	0.1570	0.896	2.35%	1.9085	<10%	yes	79.2
Frozen Lake	Pike and San Isabel	Mount Evans	CO	39.5775	-105.6583	3944	93.3	0.0039	0.1570	0.896	2.05%	1.9085	<10%	yes	91.4
North Lake	Pike and San Isabel	Mount Evans	CO	39.5914	-105.6733	3420	80.9	0.0039	0.1570	0.896	2.36%	1.9085	<10%	yes	79.0
South Lake	Pike and San Isabel	Mount Evans	CO	39.5903	-105.6714	3432	66.7	0.0039	0.1570	0.896	2.86%	1.9085	<10%	yes	64.8
Lake Elbert	Medicine Bow-Routt	Mount Zirkel	CO	40.6342	-106.7069	3289	56.6	0.0121	0.2506	1.726	2.85%	1.6134	<10%	yes	55.0
Seven Lakes (LG East)	Medicine Bow-Routt	Mount Zirkel	CO	40.8958	-106.6819	3273	36.2	0.0106	0.2068	1.546	4.11%	1.4904	<10%	yes	34.7
Summit Lake	Medicine Bow-Routt	Mount Zirkel	CO	40.5453	-106.6819	3146	48.0	0.0114	0.2505	1.449	3.99%	1.9157	<10%	yes	46.1
Deep Creek Lake	Gunnison	Raggeds	CO	39.0089	-107.2400	3359	20.6	0.0055	0.2207	0.887	13.15%	2.7098	<1(μeq/L)	no	17.9
Island Lake	Arapaho and Roosevelt	Rawah	CO	40.6272	-105.9411	3392	71.0	0.0072	0.1708	1.079	2.46%	1.7504	<10%	yes	69.3
Kelly Lake	Arapaho and Roosevelt	Rawah	CO	40.6256	-105.9594	3293	179.9	0.0072	0.1708	1.079	0.97%	1.7504	<10%	yes	178.1
Rawah Lake #4	Arapaho and Roosevelt	Rawah	CO	40.6711	-105.9578	3497	41.3	0.0071	0.1768	1.098	4.30%	1.7773	<10%	yes	39.5
Crater Lake (Sangre de Cristo)	Rio Grande	Sangre de Cristo	CO	37.5756	-105.4951	3871	162.9	0.0024	0.0932	0.959	0.65%	1.0597	<10%	yes	161.9
Lower Stout Lake	San Isabel	Sangre de Cristo	CO	38.3528	-105.8892	3585	145.2	0.0026	0.1050	0.671	1.17%	1.7042	<10%	yes	143.5
Upper Little Sand Creek Lake	San Isabel	Sangre de Cristo	CO	37.9039	-105.5356	3773	129.5	0.0024	0.0905	1.064	0.72%	0.9271	<10%	yes	128.6
Upper Stout Lake	San Isabel	Sangre de Cristo	CO	38.3503	-105.8908	3609	76.3	0.0026	0.1050	0.671	2.23%	1.7042	<10%	yes	74.6
Glacier Lake (Colorado)	San Juan-Rio Grande	South San Juan	CO	37.2594	-106.5879	3639	63.4	0.0018	0.0741	1.145	1.11%	0.7043	<10%	yes	62.7
Lake South of Blue Lakes	San Juan-Rio Grande	South San Juan	CO	37.2243	-106.6307	3615	16.9	0.0020	0.0965	1.312	4.72%	0.7985	<1(μeq/L)	yes	16.1
Big Eldorado Lake	San Juan-Rio Grande	Weminuche	CO	37.7133	-107.5433	3811	19.6	0.0016	0.0637	1.128	3.13%	0.6151	<1(μeq/L)	yes	19.0
Four Mile Pothole	San Juan-Rio Grande	Weminuche	CO	37.4684	-107.0525	---	123.4	0.0023	0.0926	1.173	0.70%	0.8602	<10%	yes	122.5
Lake Due South of Ute Lake	San Juan-Rio Grande	Weminuche	CO	37.6361	-107.4428	---	13.2	0.0017	0.0617	1.067	4.79%	0.6309	<1(μeq/L)	yes	12.5
Little Eldorado	San Juan-Rio Grande	Weminuche	CO	37.7133	-107.5458	3812	-3.3	0.0016	0.0637	1.128	18.64%	0.6151	<1(μeq/L)	yes	-3.9
Little Granite Lake	San Juan-Rio Grande	Weminuche	CO	37.6205	-107.3317	3304	80.7	0.0016	0.0729	0.830	1.18%	0.9544	<10%	yes	79.8
Lower Sunlight Lake	San Juan-Rio Grande	Weminuche	CO	37.6331	-107.5830	3668	80.9	0.0021	0.0734	1.177	0.84%	0.6816	<10%	yes	80.2
Middle Ute Lake	San Juan-Rio Grande	Weminuche	CO	37.6483	-107.4752	3644	42.8	0.0015	0.0589	1.052	1.43%	0.6104	<10%	yes	42.2
Small Pond Above Trout Lake	San Juan-Rio Grande	Weminuche	CO	37.6519	-107.1564	3562	25.5	0.0017	0.0746	1.087	2.93%	0.7461	<10%	yes	24.7
Upper Grizzly Lake	San Juan-Rio Grande	Weminuche	CO	37.6200	-107.5836	3993	29.9	0.0024	0.0766	1.177	2.39%	0.7131	<10%	yes	29.2
Upper Sunlight Lake	San Juan-Rio Grande	Weminuche	CO	37.6278	-107.5797	3824	28.0	0.0024	0.0766	1.177	2.55%	0.7131	<10%	yes	27.3
West Snowdon Lake	San Juan-Rio Grande	Weminuche	CO	37.7103	-107.6935	3652	39.4	0.0012	0.0616	0.978	1.74%	0.6834	<10%	yes	38.7
White Dome Lake	San Juan-Rio Grande	Weminuche	CO	37.7089	-107.5525	3822	2.1	0.0016	0.0637	1.128	29.86%	0.6151	<1(μeq/L)	yes	1.4
South Golden Lake	Grand Mesa, Uncompahgre and Gunnison	West Elk	CO	38.7776	-107.1828	3371	111.4	0.0030	0.1708	0.984	1.69%	1.8803	<10%	yes	109.5

Table 5-38a. ANC calculations at sensitive lakes for new Federal oil and gas development and mining and new non-Federal oil and gas within the 14 Colorado and northern New Mexico BLM Planning Areas (Source Group T) and the 2021 Low Development Scenario.

Lake	National Forest	Wilderness Area	State	Latitude (Deg N)	Longitude (Deg W)	Elevation (m)	10th Percentile Lowest ANC Value (μeq/L)	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%)*	Delta ANC (μeq/L)*	USFS LAC Threshold	Below Threshold?	2021 Hi Predicted 10th Percentile Lowest ANC Value (μeq/L)
Brooklyn Lake	White River	Collegiate Peaks	CO	39.0495	-106.6569	3737	101.7	0.0012	0.0513	0.898	0.61%	0.6206	<10%	yes	101.1
Tabor Lake	White River	Collegiate Peaks	CO	39.0628	-106.6564	3746	112.4	0.0011	0.0516	0.860	0.58%	0.6525	<10%	yes	111.7
Booth Lake	White River	Eagles Nest	CO	39.6986	-106.3050	3493	86.8	0.0014	0.0734	0.844	1.09%	0.9427	<10%	yes	85.8
Upper Willow Lake	White River	Eagles Nest	CO	39.6458	-106.1747	3469	134.1	0.0010	0.0535	0.741	0.58%	0.7828	<10%	yes	133.3
Ned Wilson Lake	White River	Flat Tops	CO	39.9614	-107.3239	3385	39.0	0.0030	0.0903	1.158	2.19%	0.8545	<10%	yes	38.1
Upper Ned Wilson Lake	White River	Flat Tops	CO	39.9628	-107.3236	3386	12.9	0.0030	0.0903	1.158	6.63%	0.8545	<1(μeq/L)	yes	12.0
Lower NWL Packtrail Pothole	White River	Flat Tops	CO	39.9682	-107.3241	3379	29.7	0.0030	0.0903	1.158	2.88%	0.8545	<10%	yes	28.8
Upper NWL Packtrail Pothole	White River	Flat Tops	CO	39.9656	-107.3238	3380	48.7	0.0030	0.0903	1.158	1.75%	0.8545	<10%	yes	47.8
Walk Up Lake	Ashley	--	UT	40.8110	-110.0383	---	55.2	0.0001	0.0021	0.878	0.05%	0.0259	<10%	yes	55.2
Bluebell Lake	Ashley	High Uintas	UT	40.6970	-110.4822	3322	55.5	0.0000	0.0014	0.883	0.03%	0.0176	<10%	yes	55.5
Dean Lake	Ashley	High Uintas	UT	40.6785	-110.7616	3275	48.9	0.0000	0.0012	1.061	0.03%	0.0122	<10%	yes	48.9
No Name (Utah, Duchesne - 4D2-039)	Ashley	High Uintas	UT	40.6710	-110.2758	3302	67.0	0.0001	0.0026	0.844	0.05%	0.0333	<10%	yes	67.0
Upper Coffin Lake	Ashley	High Uintas	UT	40.8342	-110.2383	3361	64.9	0.0000	0.0016	0.960	0.03%	0.0177	<10%	yes	64.8
Fish Lake	Wasatch-Cache	High Uintas	UT	40.8361	-110.0676	---	105.8	0.0001	0.0020	0.869	0.02%	0.0252	<10%	yes	105.7
Blodgett Lake, Colorado	White River	Holy Cross	CO	39.4062	-106.5352	3558	47.7	0.0016	0.0745	0.928	1.83%	0.8713	<10%	yes	46.8
Upper Turquoise Lake	White River	Holy Cross	CO	39.5098	-106.5332	3450	104.0	0.0018	0.0792	0.809	1.02%	1.0655	<10%	yes	102.9
Upper West Tennessee Lake	San Isabel	Holy Cross	CO	39.3445	-106.4250	3649	114.2	0.0011	0.0595	0.904	0.62%	0.7130	<10%	yes	113.5
Blue Lake (Colorado; Boulder - 4E1-040)	Arapaho and Roosevelt	Indian Peaks	CO	40.0876	-105.6169	3446	19.3	0.0017	0.0822	1.128	4.11%	0.7909	<1(μeq/L)	yes	18.5
Crater Lake	Arapaho and Roosevelt	Indian Peaks	CO	40.0755	-105.6639	3141	53.1	0.0016	0.0704	1.071	1.35%	0.7148	<10%	yes	52.4
King Lake (Colorado; Grand - 4E1-049)	Arapaho and Roosevelt	Indian Peaks	CO	39.9441	-105.6858	3486	52.3	0.0015	0.0782	0.959	1.69%	0.8839	<10%	yes	51.4
No Name Lake (Colorado; Boulder - 4E1-055)	Arapaho and Roosevelt	Indian Peaks	CO	40.0375	-105.6269	3422	25.6	0.0019	0.0910	1.126	3.43%	0.8777	<10%	yes	24.7
Upper Lake	Arapaho and Roosevelt	Indian Peaks	CO	40.1545	-105.6805	3271	69.0	0.0019	0.0741	1.139	1.03%	0.7087	<10%	yes	68.3
Small Lake Above U-Shaped Lake	Rio Grande	La Garita	CO	37.9436	-106.8639	3932	59.9	0.0005	0.0289	0.927	0.56%	0.3373	<10%	yes	59.6
U-Shaped Lake	Rio Grande	La Garita	CO	37.9422	-106.8606	3566	81.4	0.0005	0.0289	0.927	0.41%	0.3373	<10%	yes	81.0
Avalanche Lake	White River	Maroon Bells	CO	39.1439	-107.0998	3260	158.8	0.0021	0.0842	1.282	0.45%	0.7160	<10%	yes	158.1
Capitol Lake	White River	Maroon Bells	CO	39.1630	-107.0820	3530	154.4	0.0022	0.0834	1.110	0.53%	0.8193	<10%	yes	153.6
Moon Lake (Upper)	White River	Maroon Bells	CO	39.1644	-107.0589	3578	53.0	0.0022	0.0834	1.110	1.55%	0.8193	<10%	yes	52.2
Upper Middle Beartrack Lake	Arapaho and Roosevelt	Mount Evans	CO	39.5711	-105.6067	3542	50.9	0.0012	0.0598	0.869	1.47%	0.7474	<10%	yes	50.1
Abyss Lake	Pike and San Isabel	Mount Evans	CO	39.5858	-105.6592	3856	81.1	0.0010	0.0550	0.896	0.82%	0.6655	<10%	yes	80.4
Frozen Lake	Pike and San Isabel	Mount Evans	CO	39.5775	-105.6583	3944	93.3	0.0010	0.0550	0.896	0.71%	0.6655	<10%	yes	92.6
North Lake	Pike and San Isabel	Mount Evans	CO	39.5914	-105.6733	3420	80.9	0.0010	0.0550	0.896	0.82%	0.6655	<10%	yes	80.3
South Lake	Pike and San Isabel	Mount Evans	CO	39.5903	-105.6714	3432	66.7	0.0010	0.0550	0.896	1.00%	0.6655	<10%	yes	66.1
Lake Elbert	Medicine Bow-Routt	Mount Zirkel	CO	40.6342	-106.7069	3289	56.6	0.0028	0.0761	1.726	0.86%	0.4850	<10%	yes	56.1
Seven Lakes (LG East)	Medicine Bow-Routt	Mount Zirkel	CO	40.8958	-106.6819	3273	36.2	0.0024	0.0615	1.546	1.21%	0.4383	<10%	yes	35.8
Summit Lake	Medicine Bow-Routt	Mount Zirkel	CO	40.5453	-106.6819	3146	48.0	0.0026	0.0755	1.449	1.19%	0.5726	<10%	yes	47.4
Deep Creek Lake	Gunnison	Raggeds	CO	39.0089	-107.2400	3359	20.6	0.0016	0.0696	0.887	4.14%	0.8527	<1(μeq/L)	yes	19.7
Island Lake	Arapaho and Roosevelt	Rawah	CO	40.6272	-105.9411	3392	71.0	0.0017	0.0531	1.079	0.76%	0.5395	<10%	yes	70.5
Kelly Lake	Arapaho and Roosevelt	Rawah	CO	40.6256	-105.9594	3293	179.9	0.0017	0.0531	1.079	0.30%	0.5395	<10%	yes	179.3
Rawah Lake #4	Arapaho and Roosevelt	Rawah	CO	40.6711	-105.9578	3497	41.3	0.0017	0.0553	1.098	1.33%	0.5507	<10%	yes	40.7
Crater Lake (Sangre de Cristo)	Rio Grande	Sangre de Cristo	CO	37.5756	-105.4951	3871	162.9	0.0008	0.0397	0.959	0.28%	0.4485	<10%	yes	162.5
Lower Stout Lake	San Isabel	Sangre de Cristo	CO	38.3528	-105.8892	3585	145.2	0.0007	0.0411	0.671	0.46%	0.6623	<10%	yes	144.5
Upper Little Sand Creek Lake	San Isabel	Sangre de Cristo	CO	37.9039	-105.5356	3773	129.5	0.0007	0.0380	1.064	0.30%	0.3868	<10%	yes	129.1
Upper Stout Lake	San Isabel	Sangre de Cristo	CO	38.3503	-105.8908	3609	76.3	0.0007	0.0411	0.671	0.87%	0.6623	<10%	yes	75.7
Glacier Lake (Colorado)	San Juan-Rio Grande	South San Juan	CO	37.2594	-106.5879	3639	63.4	0.0007	0.0396	1.145	0.59%	0.3746	<10%	yes	63.0
Lake South of Blue Lakes	San Juan-Rio Grande	South San Juan	CO	37.2243	-106.6307	3615	16.9	0.0009	0.0525	1.312	2.56%	0.4328	<1(μeq/L)	yes	16.5
Big Eldorado Lake	San Juan-Rio Grande	Weminuche	CO	37.7133	-107.5433	3811	19.6	0.0005	0.0286	1.128	1.40%	0.2751	<1(μeq/L)	yes	19.4
Four Mile Pothole	San Juan-Rio Grande	Weminuche	CO	37.4684	-107.0525	---	123.4	0.0010	0.0476	1.173	0.36%	0.4406	<10%	yes	122.9
Lake Due South of Ute Lake	San Juan-Rio Grande	Weminuche	CO	37.6361	-107.4428	---	13.2	0.0006	0.0294	1.067	2.28%	0.2996	<1(μeq/L)	yes	12.9
Little Eldorado	San Juan-Rio Grande	Weminuche	CO	37.7133	-107.5458	3812	-3.3	0.0005	0.0286	1.128	8.34%	0.2751	<1(μeq/L)	yes	-3.6
Little Granite Lake	San Juan-Rio Grande	Weminuche	CO	37.6205	-107.3317	3304	80.7	0.0006	0.0350	0.830	0.57%	0.4568	<10%	yes	80.3
Lower Sunlight Lake	San Juan-Rio Grande	Weminuche	CO	37.6331	-107.5830	3668	80.9	0.0007	0.0342	1.177	0.39%	0.3154	<10%	yes	80.5
Middle Ute Lake	San Juan-Rio Grande	Weminuche	CO	37.6483	-107.4752	3644	42.8	0.0005	0.0276	1.052	0.67%	0.2848	<10%	yes	42.5
Small Pond Above Trout Lake	San Juan-Rio Grande	Weminuche	CO	37.6519	-107.1564	3562	25.5	0.0006	0.0358	1.087	1.40%	0.3567	<10%	yes	25.1
Upper Grizzly Lake	San Juan-Rio Grande	Weminuche	CO	37.6200	-107.5836	3993	29.9	0.0009	0.0359	1.177	1.11%	0.3323	<10%	yes	29.5
Upper Sunlight Lake	San Juan-Rio Grande	Weminuche	CO	37.6278	-107.5797	3824	28.0	0.0009	0.0359	1.177	1.19%	0.3323	<10%	yes	27.7
West Snowdon Lake	San Juan-Rio Grande	Weminuche	CO	37.7103	-107.6935	3652	39.4	0.0004	0.0276	0.978	0.77%	0.3046	<10%	yes	39.0
White Dome Lake	San Juan-Rio Grande	Weminuche	CO	37.7089	-107.5525	3822	2.1	0.0005	0.0286	1.128	13.35%	0.2751	<1(μeq/L)	yes	1.8
South Golden Lake	Grand Mesa, Uncompahgre and Gunnison	West Elk	CO	38.7776	-107.1828	3371	111.4	0.0008	0.0553	0.984	0.54%	0.6068	<10%	yes	110.8

Table 5-38b. ANC calculations at sensitive lakes for new Federal oil and gas development and mining and new non-Federal oil and gas within the 14 Colorado and northern New Mexico BLM Planning Areas (Source Group T) and the 2021 Medium Development Scenario.

Lake	National Forest	Wilderness Area	State	Latitude (Deg N)	Longitude (Deg W)	Elevation (m)	10th Percentile Lowest ANC Value (μeq/L)	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%)*	Delta ANC (μeq/L)*	USFS LAC Threshold	Below Threshold?	2021 Hi Predicted 10th Percentile Lowest ANC Value (μeq/L)
Brooklyn Lake	White River	Collegiate Peaks	CO	39.0495	-106.6569	3737	101.7	0.0045	0.1350	0.898	1.62%	1.6477	<10%	yes	100.0
Tabor Lake	White River	Collegiate Peaks	CO	39.0628	-106.6564	3746	112.4	0.0043	0.1370	0.860	1.55%	1.7450	<10%	yes	110.7
Booth Lake	White River	Eagles Nest	CO	39.6986	-106.3050	3493	86.8	0.0052	0.1929	0.844	2.87%	2.4938	<10%	yes	84.3
Upper Willow Lake	White River	Eagles Nest	CO	39.6458	-106.1747	3469	134.1	0.0039	0.1410	0.741	1.55%	2.0780	<10%	yes	132.0
Ned Wilson Lake	White River	Flat Tops	CO	39.9614	-107.3239	3385	39.0	0.0124	0.2419	1.158	5.96%	2.3255	<10%	yes	36.7
Upper Ned Wilson Lake	White River	Flat Tops	CO	39.9628	-107.3236	3386	12.9	0.0124	0.2419	1.158	18.06%	2.3255	<1(μeq/L)	no	10.6
Lower NWL Packtrail Pothole	White River	Flat Tops	CO	39.9682	-107.3241	3379	29.7	0.0124	0.2419	1.158	7.84%	2.3255	<10%	yes	27.3
Upper NWL Packtrail Pothole	White River	Flat Tops	CO	39.9656	-107.3238	3380	48.7	0.0124	0.2419	1.158	4.78%	2.3255	<10%	yes	46.4
Walk Up Lake	Ashley	--	UT	40.8110	-110.0383	---	55.2	0.0003	0.0057	0.878	0.13%	0.0721	<10%	yes	55.2
Bluebell Lake	Ashley	High Uintas	UT	40.6970	-110.4822	3322	55.5	0.0001	0.0036	0.883	0.08%	0.0447	<10%	yes	55.5
Dean Lake	Ashley	High Uintas	UT	40.6785	-110.7616	3275	48.9	0.0001	0.0031	1.061	0.07%	0.0321	<10%	yes	48.8
No Name (Utah, Duchesne - 4D2-039)	Ashley	High Uintas	UT	40.6710	-110.2758	3302	67.0	0.0003	0.0070	0.844	0.14%	0.0918	<10%	yes	66.9
Upper Coffin Lake	Ashley	High Uintas	UT	40.8342	-110.2383	3361	64.9	0.0002	0.0041	0.960	0.07%	0.0466	<10%	yes	64.8
Fish Lake	Wasatch-Cache	High Uintas	UT	40.8361	-110.0676	---	105.8	0.0002	0.0055	0.869	0.07%	0.0701	<10%	yes	105.7
Blodgett Lake, Colorado	White River	Holy Cross	CO	39.4062	-106.5352	3558	47.7	0.0059	0.1969	0.928	4.87%	2.3204	<10%	yes	45.3
Upper Turquoise Lake	White River	Holy Cross	CO	39.5098	-106.5332	3450	104.0	0.0066	0.2079	0.809	2.71%	2.8183	<10%	yes	101.2
Upper West Tennessee Lake	San Isabel	Holy Cross	CO	39.3445	-106.4250	3649	114.2	0.0042	0.1589	0.904	1.68%	1.9178	<10%	yes	112.3
Blue Lake (Colorado; Boulder - 4E1-040)	Arapaho and Roosevelt	Indian Peaks	CO	40.0876	-105.6169	3446	19.3	0.0064	0.2269	1.128	11.42%	2.1987	<1(μeq/L)	no	17.1
Crater Lake	Arapaho and Roosevelt	Indian Peaks	CO	40.0755	-105.6639	3141	53.1	0.0060	0.1959	1.071	3.77%	2.0032	<10%	yes	51.1
King Lake (Colorado; Grand - 4E1-049)	Arapaho and Roosevelt	Indian Peaks	CO	39.9441	-105.6858	3486	52.3	0.0060	0.2169	0.959	4.73%	2.4695	<10%	yes	49.8
No Name Lake (Colorado; Boulder - 4E1-055)	Arapaho and Roosevelt	Indian Peaks	CO	40.0375	-105.6269	3422	25.6	0.0071	0.2489	1.126	9.43%	2.4151	<10%	yes	23.2
Upper Lake	Arapaho and Roosevelt	Indian Peaks	CO	40.1545	-105.6805	3271	69.0	0.0072	0.2069	1.139	2.89%	1.9967	<10%	yes	67.0
Small Lake Above U-Shaped Lake	Rio Grande	La Garita	CO	37.9436	-106.8639	3932	59.9	0.0015	0.0636	0.927	1.25%	0.7463	<10%	yes	59.2
U-Shaped Lake	Rio Grande	La Garita	CO	37.9422	-106.8606	3566	81.4	0.0015	0.0636	0.927	0.92%	0.7463	<10%	yes	80.6
Avalanche Lake	White River	Maroon Bells	CO	39.1439	-107.0998	3260	158.8	0.0073	0.2319	1.282	1.25%	1.9819	<10%	yes	156.8
Capitol Lake	White River	Maroon Bells	CO	39.1630	-107.0820	3530	154.4	0.0076	0.2279	1.110	1.46%	2.2521	<10%	yes	152.1
Moon Lake (Upper)	White River	Maroon Bells	CO	39.1644	-107.0589	3578	53.0	0.0076	0.2279	1.110	4.25%	2.2521	<10%	yes	50.7
Upper Middle Beartrack Lake	Arapaho and Roosevelt	Mount Evans	CO	39.5711	-105.6067	3542	50.9	0.0043	0.1540	0.869	3.80%	1.9358	<10%	yes	49.0
Abyss Lake	Pike and San Isabel	Mount Evans	CO	39.5858	-105.6592	3856	81.1	0.0038	0.1430	0.896	2.15%	1.7408	<10%	yes	79.4
Frozen Lake	Pike and San Isabel	Mount Evans	CO	39.5775	-105.6583	3944	93.3	0.0038	0.1430	0.896	1.87%	1.7408	<10%	yes	91.5
North Lake	Pike and San Isabel	Mount Evans	CO	39.5914	-105.6733	3420	80.9	0.0038	0.1430	0.896	2.15%	1.7408	<10%	yes	79.2
South Lake	Pike and San Isabel	Mount Evans	CO	39.5903	-105.6714	3432	66.7	0.0038	0.1430	0.896	2.61%	1.7408	<10%	yes	65.0
Lake Elbert	Medicine Bow-Routt	Mount Zirkel	CO	40.6342	-106.7069	3289	56.6	0.0118	0.2256	1.726	2.58%	1.4574	<10%	yes	55.1
Seven Lakes (LG East)	Medicine Bow-Routt	Mount Zirkel	CO	40.8958	-106.6819	3273	36.2	0.0104	0.1858	1.546	3.71%	1.3443	<10%	yes	34.9
Summit Lake	Medicine Bow-Routt	Mount Zirkel	CO	40.5453	-106.6819	3146	48.0	0.0112	0.2255	1.449	3.61%	1.7306	<10%	yes	46.3
Deep Creek Lake	Gunnison	Raggeds	CO	39.0089	-107.2400	3359	20.6	0.0053	0.1947	0.887	11.63%	2.3953	<1(μeq/L)	no	18.2
Island Lake	Arapaho and Roosevelt	Rawah	CO	40.6272	-105.9411	3392	71.0	0.0070	0.1538	1.079	2.23%	1.5807	<10%	yes	69.4
Kelly Lake	Arapaho and Roosevelt	Rawah	CO	40.6256	-105.9594	3293	179.9	0.0070	0.1538	1.079	0.88%	1.5807	<10%	yes	178.3
Rawah Lake #4	Arapaho and Roosevelt	Rawah	CO	40.6711	-105.9578	3497	41.3	0.0069	0.1588	1.098	3.88%	1.6009	<10%	yes	39.7
Crater Lake (Sangre de Cristo)	Rio Grande	Sangre de Cristo	CO	37.5756	-105.4951	3871	162.9	0.0023	0.0837	0.959	0.59%	0.9532	<10%	yes	162.0
Lower Stout Lake	San Isabel	Sangre de Cristo	CO	38.3528	-105.8892	3585	145.2	0.0026	0.0943	0.671	1.06%	1.5331	<10%	yes	143.7
Upper Little Sand Creek Lake	San Isabel	Sangre de Cristo	CO	37.9039	-105.5356	3773	129.5	0.0023	0.0814	1.064	0.65%	0.8353	<10%	yes	128.7
Upper Stout Lake	San Isabel	Sangre de Cristo	CO	38.3503	-105.8908	3609	76.3	0.0026	0.0943	0.671	2.01%	1.5331	<10%	yes	74.8
Glacier Lake (Colorado)	San Juan-Rio Grande	South San Juan	CO	37.2594	-106.5879	3639	63.4	0.0017	0.0646	1.145	0.97%	0.6148	<10%	yes	62.8
Lake South of Blue Lakes	San Juan-Rio Grande	South San Juan	CO	37.2243	-106.6307	3615	16.9	0.0019	0.0839	1.312	4.11%	0.6950	<1(μeq/L)	yes	16.2
Big Eldorado Lake	San Juan-Rio Grande	Weminuche	CO	37.7133	-107.5433	3811	19.6	0.0015	0.0565	1.128	2.78%	0.5464	<1(μeq/L)	yes	19.1
Four Mile Pothole	San Juan-Rio Grande	Weminuche	CO	37.4684	-107.0525	---	123.4	0.0022	0.0802	1.173	0.60%	0.7461	<10%	yes	122.6
Lake Due South of Ute Lake	San Juan-Rio Grande	Weminuche	CO	37.6361	-107.4428	---	13.2	0.0015	0.0543	1.067	4.22%	0.5560	<1(μeq/L)	yes	12.6
Little Eldorado	San Juan-Rio Grande	Weminuche	CO	37.7133	-107.5458	3812	-3.3	0.0015	0.0565	1.128	16.56%	0.5464	<1(μeq/L)	yes	-3.8
Little Granite Lake	San Juan-Rio Grande	Weminuche	CO	37.6205	-107.3317	3304	80.7	0.0015	0.0639	0.830	1.04%	0.8376	<10%	yes	79.9
Lower Sunlight Lake	San Juan-Rio Grande	Weminuche	CO	37.6331	-107.5830	3668	80.9	0.0020	0.0649	1.177	0.75%	0.6037	<10%	yes	80.3
Middle Ute Lake	San Juan-Rio Grande	Weminuche	CO	37.6483	-107.4752	3644	42.8	0.0014	0.0519	1.052	1.26%	0.5387	<10%	yes	42.2
Small Pond Above Trout Lake	San Juan-Rio Grande	Weminuche	CO	37.6519	-107.1564	3562	25.5	0.0016	0.0653	1.087	2.57%	0.6540	<10%	yes	24.8
Upper Grizzly Lake	San Juan-Rio Grande	Weminuche	CO	37.6200	-107.5836	3993	29.9	0.0023	0.0675	1.177	2.11%	0.6294	<10%	yes	29.3
Upper Sunlight Lake	San Juan-Rio Grande	Weminuche	CO	37.6278	-107.5797	3824	28.0	0.0023	0.0675	1.177	2.25%	0.6294	<10%	yes	27.4
West Snowdon Lake	San Juan-Rio Grande	Weminuche	CO	37.7103	-107.6935	3652	39.4	0.0012	0.0548	0.978	1.55%	0.6087	<10%	yes	38.7
White Dome Lake	San Juan-Rio Grande	Weminuche	CO	37.7089	-107.5525	3822	2.1	0.0015	0.0565	1.128	26.52%	0.5464	<1(μeq/L)	yes	1.5
South Golden Lake	Grand Mesa, Uncompahgre and Gunnison	West Elk	CO	38.7776	-107.1828	3371	111.4	0.0029	0.1508	0.984	1.49%	1.6624	<10%	yes	109.7

5.6 2021 NAAQS Comparisons

In this section we compare the CAMx 2021 High, Low and Medium Development Scenario modeling results with the National Ambient Air Quality Standard (NAAQS). For the ozone NAAQS analysis, the results are analyzed using both the absolute CAMx 2021 modeling results as well as using the CAMx 2008 and 2021 modeling results in a relative fashion to scale the observed DVB to project future year 2021 DVF as recommended by EPA (2007) and described in Section 4.5.

5.6.1 Ozone NAAQS Analysis using Relative Modeling Results

EPA's Model Attainment Test Software (MATS) was used to make future year ozone DVF projections using the CAMx 2008 Base Case and 2021 High and Low Development Scenario modeling results. MATS was also used to make ozone DVF projections for the 2021 High and Low Development Scenario removing the contributions of four of the combined Source Groups R, S, T and U. MATS was used to make 2021 ozone DVF projections at the monitoring sites as well as throughout the CARMMS modeling domain using the MATS Unmonitored Area Analysis (UAA) procedures.

5.6.1.1 Ozone Design Value Projections at Monitoring Sites

The results of the 2021 ozone DVF projections at the monitoring sites are given in Attachments F-1, F-2 and F-3 and shown in Table 5-39. The maximum DVB (based on 2006-2010 observations) is 82.0 ppb at the Rocky Flats North (CO_Jefferson_006) monitor that is projected to be reduced to 79.6, 78.3 and 79.6 ppb for the 2021 High, Low and Medium Development Scenarios, respectively. There are 17 (out of 37) monitoring sites in the CARMMS 4 km domain with DVB above the ozone NAAQS (i.e., DVB ≥ 71 ppb). We note that 71 ppb is used for comparison rather than 70 ppb because EPA recommends rounding 8-hr ozone design values to the tenths digit until the last step in the MATS calculation when the final base or future design value is truncated to the nearest ppb. We also note that the ozone NAAQS is based on a 3-year average while the DVB is based on a 5-year observational period. Because DVBs are available here from the MATS analysis, they are compared to the NAAQS as they provide a measure of the severity of ozone concentrations in the base time period (here 2006-2010). The number of sites with DVB above the NAAQS is reduced to 14 in the 2021 emission scenarios. Removing the contributions due to new O&G and mining on Federal lands within the 13 Colorado BLM Planning Areas (Source Group R) reduces the 2021 DVF at Rocky Flats North to 79.1, 78.2 and 79.1 ppb for the High, Low and Medium Development Scenarios, respectively; all these values are still above the ozone NAAQS (71.0 ppb or higher). When emissions from new non-Federal O&G within the 13 Colorado Planning Areas are also removed (Source Group S), the projected 2021 DVFs are 76.1, 76.8 and 76.1 ppb for the High, Low and Medium Development Scenarios, all still above the NAAQS. The maximum reduction in 2021 DVFs due to the removal of Source Group R at any monitor is 0.9 ppb (at Rocky Flats North and two other sites) in the High Development Scenario. The corresponding maximum reductions by removing Source Group R in the Low and Medium Scenarios are 0.1 and 0.4 ppb. The maximum reduction in 2021 DVF due to the removal of Source Group S, T and U in the High Development Scenario are, respectively, 5.4, 5.4 and 7.8 ppb at the Greely – Weld Tower (CO_Weld_009) monitoring site. Most of the O&G development in Weld County (Royal Gorge FO Area#1; Source Group I) is on non-Federal lands so the monitors in Weld County are less affected by the Federal O&G development (Source Group R).

The impact of the NMFFO (Source Group N) on 2021 DVF is determined by difference between Groups T and S and shown in Tables 5-39a, b and c. The maximum contribution of the FFO to 2021 DVF in the High scenario is 0.21 ppb at the monitoring site near Bloomfield (ID 350450009) in San Juan county in New Mexico. This value drops to 0.16 ppb and 0.09 ppb in the Medium and Low scenarios, respectively.

Table 5-39a. Current year ozone Base Design Values (DVB) and projected 2021 future year ozone Design Values (DVF) for the 2021 High Development Scenario and without Source Group R, S, T, U and N.

CID	Name	Lat	Long	State	County	DVB	DVF					Contribution from				
							2021 High	2021 High w/o R	2021 High w/o S	2021 High w/o T	2021 High w/o U	Group R	Group S	Group T	Group U	Group N
080013001	CO_Adams_3001	39.8381	-104.9498	Colorado	Adams	71.5	71.0	70.6	68.3	68.3	66.6	0.5	2.7	2.8	4.5	0.014
080130011	CO_Boulder_0011	39.9572	-105.2385	Colorado	Boulder	77.3	74.4	73.9	70.5	70.5	68.4	0.5	3.9	3.9	5.9	0.008
080310014	CO_Denver_0014	39.7518	-105.0307	Colorado	Denver	70.3	69.0	68.5	66.7	66.7	65.3	0.4	2.3	2.3	3.7	0.014
080350004	CO_Douglas_0004	39.5345	-105.0704	Colorado	Douglas	78.3	75.1	74.6	72.9	72.9	71.6	0.4	2.1	2.1	3.5	0.008
080410013	CO_El Paso_0013	38.9583	-104.8172	Colorado	El Paso	68.0	66.2	65.9	65.0	65.0	64.0	0.3	1.1	1.2	2.1	0.014
080410016	CO_El Paso_0016	38.8531	-104.9013	Colorado	El Paso	70.3	69.0	68.7	68.0	68.0	67.0	0.2	0.9	1.0	2.0	0.021
080590002	CO_Jefferson_0002	39.8003	-105.1000	Colorado	Jefferson	75.0	73.4	72.9	70.8	70.7	69.1	0.5	2.7	2.7	4.3	0.007
080590005	CO_Jefferson_0005	39.6388	-105.1395	Colorado	Jefferson	74.3	72.0	71.7	70.3	70.3	69.1	0.4	1.8	1.8	3.0	0.000
080590006	CO_Jefferson_0006	39.9128	-105.1886	Colorado	Jefferson	82.0	79.6	79.1	76.1	76.0	73.9	0.5	3.6	3.6	5.7	0.008
080590011	CO_Jefferson_0011	39.7437	-105.1780	Colorado	Jefferson	76.3	73.9	73.6	71.6	71.6	70.1	0.4	2.4	2.4	3.8	0.015
080671004	CO_La Plata_1004	37.3039	-107.4842	Colorado	La Plata	70.0	69.1	68.9	68.8	68.8	68.5	0.2	0.3	0.3	0.6	0.000
080677001	CO_La Plata_7001	37.1368	-107.6286	Colorado	La Plata	66.0	65.8	65.6	65.3	65.1	62.9	0.2	0.5	0.6	2.8	0.179
080677003	CO_La Plata_7003	37.1026	-107.8702	Colorado	La Plata	67.0	66.9	66.6	66.4	66.2	64.2	0.2	0.5	0.6	2.6	0.148
080690007	CO_Larimer_0007	40.2772	-105.5450	Colorado	Larimer	74.3	72.6	72.4	70.6	70.6	69.5	0.2	1.9	1.9	3.1	0.008
080690011	CO_Larimer_0011	40.5925	-105.1411	Colorado	Larimer	78.0	79.0	78.8	73.8	73.8	71.3	0.2	5.2	5.2	7.7	0.008
080691004	CO_Larimer_1004	40.5775	-105.0789	Colorado	Larimer	67.3	67.4	67.3	63.5	63.5	61.6	0.1	3.9	3.9	5.8	0.007
080830101	CO_Montezuma_0101	37.1983	-108.4903	Colorado	Montezuma	69.3	69.1	68.9	68.8	68.7	67.7	0.2	0.3	0.4	1.4	0.062
081230009	CO_Weld_0009	40.3864	-104.7374	Colorado	Weld	72.7	72.3	72.0	67.0	66.9	64.5	0.4	5.4	5.4	7.8	0.014
350010023	NM_Bernalillo_0023	35.1343	-106.5852	New Mexico	Bernalillo	66.0	63.4	63.3	63.2	63.2	62.5	0.1	0.2	0.2	0.9	0.033
350010024	NM_Bernalillo_0024	35.0631	-106.5788	New Mexico	Bernalillo	67.3	64.3	64.2	64.1	64.1	63.5	0.1	0.2	0.2	0.8	0.027
350010027	NM_Bernalillo_0027	35.1539	-106.6972	New Mexico	Bernalillo	68.3	64.4	64.4	64.3	64.3	63.9	0.0	0.1	0.1	0.5	0.013
350010029	NM_Bernalillo_0029	35.0171	-106.6574	New Mexico	Bernalillo	67.0	64.0	63.9	63.8	63.8	63.3	0.1	0.1	0.2	0.7	0.014
350011012	NM_Bernalillo_1012	35.1852	-106.5082	New Mexico	Bernalillo	69.0	66.6	66.6	66.5	66.4	65.7	0.1	0.2	0.2	0.9	0.041
350011013	NM_Bernalillo_1013	35.1932	-106.6138	New Mexico	Bernalillo	68.7	65.2	65.1	65.0	65.0	64.3	0.1	0.2	0.2	0.8	0.028
350431001	NM_Sandoval_1001	35.2994	-106.5483	New Mexico	Sandoval	60.3	58.4	58.3	58.2	58.2	57.6	0.1	0.2	0.2	0.8	0.036
350431003	NM_Sandoval_1003	35.2381	-106.6494	New Mexico	Sandoval	70.0	66.4	66.3	66.2	66.2	65.6	0.1	0.2	0.2	0.8	0.028
350439004	NM_Sandoval_9004	35.6153	-106.7244	New Mexico	Sandoval	68.0	67.3	67.1	66.9	66.8	65.7	0.2	0.4	0.4	1.6	0.068
350450009	NM_San Juan_0009	36.7422	-107.9769	New Mexico	San Juan	62.0	60.9	60.7	60.6	60.4	57.2	0.1	0.3	0.5	3.6	0.211
350451005	NM_San Juan_1005	36.7967	-108.4725	New Mexico	San Juan	67.0	65.4	65.2	64.9	64.8	62.7	0.2	0.5	0.7	2.8	0.147
490110004	UT_Davis_0004	40.9030	-111.8845	Utah	Davis	77.0	74.7	74.6	74.6	74.6	74.5	0.0	0.0	0.0	0.2	0.000
490350003	UT_Salt Lake_0003	40.6467	-111.8497	Utah	Salt Lake	78.0	75.0	75.0	75.0	75.0	74.8	0.0	0.0	0.0	0.2	0.000
490352004	UT_Salt Lake_2004	40.7364	-112.2103	Utah	Salt Lake	75.7	72.5	72.5	72.5	72.5	72.4	0.0	0.0	0.0	0.1	0.007
490353006	UT_Salt Lake_3006	40.7364	-111.8722	Utah	Salt Lake	77.0	73.8	73.8	73.8	73.8	73.7	0.0	0.0	0.0	0.2	0.000
490370101	UT_San Juan_0101	38.4500	-109.8167	Utah	San Juan	70.0	69.2	69.2	69.1	69.1	68.8	0.0	0.1	0.1	0.4	0.007
490490002	UT_Utah_0002	40.2536	-111.6631	Utah	Utah	72.0	70.1	70.1	70.1	70.1	70.0	0.0	0.0	0.0	0.1	0.000
490495008	UT_Utah_5008	40.4303	-111.8039	Utah	Utah	72.3	69.9	69.9	69.9	69.9	69.9	0.0	0.0	0.0	0.1	0.000
490495010	UT_Utah_5010	40.1364	-111.6597	Utah	Utah	72.3	70.3	70.3	70.3	70.3	70.3	0.0	0.0	0.0	0.0	0.000

Table 5-39b. Current year ozone Base Design Values (DVB) and projected 2021 future year ozone Design Values (DVF) for the 2021 Low Development Scenario and without Source Group R, S, T, U and N.

CID	Name	Lat	Long	State	County	DVB	DVF					Contribution from				
							2021 Low	2021 Low w/o R	2021 Low w/o S	2021 Low w/o T	2021 Low w/o U	Group R	Group S	Group T	Group U	Group N
080013001	CO_Adams_3001	39.8381	-104.9498	Colorado	Adams	71.5	70.1	70.0	69.0	69.0	67.2	0.1	1.2	1.2	3.0	0.007
080130011	CO_Boulder_0011	39.9572	-105.2385	Colorado	Boulder	77.3	72.8	72.7	71.2	71.2	69.1	0.1	1.7	1.7	3.8	0.000
080310014	CO_Denver_0014	39.7518	-105.0307	Colorado	Denver	70.3	68.2	68.1	67.2	67.2	65.8	0.1	1.0	1.0	2.4	0.007
080350004	CO_Douglas_0004	39.5345	-105.0704	Colorado	Douglas	78.3	74.2	74.1	73.3	73.3	71.9	0.1	0.9	0.9	2.3	0.000
080410013	CO_El Paso_0013	38.9583	-104.8172	Colorado	El Paso	68.0	65.8	65.7	65.3	65.3	64.3	0.1	0.5	0.5	1.5	0.007
080410016	CO_El Paso_0016	38.8531	-104.9013	Colorado	El Paso	70.3	68.7	68.6	68.3	68.3	67.2	0.1	0.4	0.4	1.4	0.014
080590002	CO_Jefferson_0002	39.8003	-105.1000	Colorado	Jefferson	75.0	72.5	72.4	71.4	71.4	69.7	0.1	1.2	1.2	2.9	0.000
080590005	CO_Jefferson_0005	39.6388	-105.1395	Colorado	Jefferson	74.3	71.3	71.2	70.6	70.6	69.4	0.1	0.7	0.7	2.0	0.007
080590006	CO_Jefferson_0006	39.9128	-105.1886	Colorado	Jefferson	82.0	78.3	78.2	76.8	76.8	74.6	0.1	1.5	1.5	3.7	0.008
080590011	CO_Jefferson_0011	39.7437	-105.1780	Colorado	Jefferson	76.3	73.2	73.1	72.1	72.1	70.6	0.1	1.0	1.0	2.5	0.008
080671004	CO_La Plata_1004	37.3039	-107.4842	Colorado	La Plata	70.0	69.0	69.0	68.9	68.8	68.6	0.0	0.1	0.1	0.4	0.008
080677001	CO_La Plata_7001	37.1368	-107.6286	Colorado	La Plata	66.0	65.6	65.6	65.4	65.3	63.0	0.0	0.3	0.3	2.6	0.086
080677003	CO_La Plata_7003	37.1026	-107.8702	Colorado	La Plata	67.0	66.7	66.6	66.4	66.3	64.3	0.0	0.3	0.3	2.4	0.067
080690007	CO_Larimer_0007	40.2772	-105.5450	Colorado	Larimer	74.3	71.8	71.7	71.0	71.0	69.8	0.0	0.8	0.8	2.0	0.000
080690011	CO_Larimer_0011	40.5925	-105.1411	Colorado	Larimer	78.0	77.3	77.3	74.7	74.7	72.1	0.0	2.6	2.6	5.2	0.008
080691004	CO_Larimer_1004	40.5775	-105.0789	Colorado	Larimer	67.3	66.1	66.0	64.2	64.2	62.2	0.0	1.9	1.9	3.8	0.000
080830101	CO_Montezuma_0101	37.1983	-108.4903	Colorado	Montezuma	69.3	69.0	68.9	68.8	68.8	67.7	0.0	0.2	0.2	1.2	0.028
081230009	CO_Weld_0009	40.3864	-104.7374	Colorado	Weld	72.7	70.5	70.4	67.9	67.9	65.4	0.1	2.6	2.6	5.1	0.007
350010023	NM_Bernalillo_0023	35.1343	-106.5852	New Mexico	Bernalillo	66.0	63.3	63.3	63.2	63.2	62.5	0.0	0.1	0.1	0.8	0.020
350010024	NM_Bernalillo_0024	35.0631	-106.5788	New Mexico	Bernalillo	67.3	64.2	64.2	64.2	64.1	63.5	0.0	0.1	0.1	0.7	0.014
350010027	NM_Bernalillo_0027	35.1539	-106.6972	New Mexico	Bernalillo	68.3	64.4	64.4	64.4	64.4	63.9	0.0	0.1	0.1	0.5	0.007
350010029	NM_Bernalillo_0029	35.0171	-106.6574	New Mexico	Bernalillo	67.0	64.0	63.9	63.9	63.9	63.4	0.0	0.1	0.1	0.6	0.006
350011012	NM_Bernalillo_1012	35.1852	-106.5082	New Mexico	Bernalillo	69.0	66.6	66.6	66.5	66.5	65.8	0.0	0.1	0.1	0.8	0.014
350011013	NM_Bernalillo_1013	35.1932	-106.6138	New Mexico	Bernalillo	68.7	65.1	65.1	65.0	65.0	64.4	0.0	0.1	0.1	0.7	0.014
350431001	NM_Sandoval_1001	35.2994	-106.5483	New Mexico	Sandoval	60.3	58.4	58.3	58.3	58.3	57.6	0.0	0.1	0.1	0.7	0.012
350431003	NM_Sandoval_1003	35.2381	-106.6494	New Mexico	Sandoval	70.0	66.4	66.3	66.3	66.2	65.6	0.0	0.1	0.1	0.7	0.014
350439004	NM_Sandoval_9004	35.6153	-106.7244	New Mexico	Sandoval	68.0	67.1	67.1	66.9	66.9	65.8	0.0	0.2	0.2	1.4	0.033
350450009	NM_San Juan_0009	36.7422	-107.9769	New Mexico	San Juan	62.0	60.7	60.7	60.6	60.5	57.3	0.0	0.2	0.3	3.4	0.093
350451005	NM_San Juan_1005	36.7967	-108.4725	New Mexico	San Juan	67.0	65.2	65.2	64.9	64.9	62.8	0.1	0.3	0.3	2.5	0.060
490110004	UT_Davis_0004	40.9030	-111.8845	Utah	Davis	77.0	74.7	74.6	74.6	74.6	74.5	0.0	0.0	0.0	0.2	0.000
490350003	UT_Salt Lake_0003	40.6467	-111.8497	Utah	Salt Lake	78.0	75.0	75.0	75.0	75.0	74.8	0.0	0.0	0.0	0.2	0.000
490352004	UT_Salt Lake_2004	40.7364	-112.2103	Utah	Salt Lake	75.7	72.5	72.5	72.5	72.5	72.4	0.0	0.0	0.0	0.1	0.000
490353006	UT_Salt Lake_3006	40.7364	-111.8722	Utah	Salt Lake	77.0	73.8	73.8	73.8	73.8	73.7	0.0	0.0	0.0	0.1	0.000
490370101	UT_San Juan_0101	38.4500	-109.8167	Utah	San Juan	70.0	69.2	69.2	69.2	69.2	68.8	0.0	0.0	0.0	0.4	0.006
490490002	UT_Utah_0002	40.2536	-111.6631	Utah	Utah	72.0	70.1	70.1	70.1	70.1	70.0	0.0	0.0	0.0	0.0	0.000
490495008	UT_Utah_5008	40.4303	-111.8039	Utah	Utah	72.3	69.9	69.9	69.9	69.9	69.9	0.0	0.0	0.0	0.1	0.000
490495010	UT_Utah_5010	40.1364	-111.6597	Utah	Utah	72.3	70.3	70.3	70.3	70.3	70.3	0.0	0.0	0.0	0.0	0.000

Table 5-39c. Current year ozone Base Design Values (DVB) and projected 2021 future year ozone Design Values (DVF) for the 2021 Medium Development Scenario and without Source Group R, S, T, U and N.

CID	Name	Lat	Long	State	County	DVB	DVF					Contribution from				
							2021 Med	2021 Med w/o R	2021 Med w/o S	2021 Med w/o T	2021 Med w/o U	Group R	Group S	Group T	Group U	Group N
080013001	CO_Adams_3001	39.8381	-104.9498	Colorado	Adams	71.5	71.0	70.6	68.3	68.3	66.6	0.4	2.7	2.7	4.4	0.007
080130011	CO_Boulder_0011	39.9572	-105.2385	Colorado	Boulder	77.3	74.3	73.9	70.5	70.5	68.4	0.4	3.8	3.8	5.9	0.008
080310014	CO_Denver_0014	39.7518	-105.0307	Colorado	Denver	70.3	68.9	68.6	66.7	66.7	65.3	0.4	2.2	2.2	3.6	0.007
080350004	CO_Douglas_0004	39.5345	-105.0704	Colorado	Douglas	78.3	75.0	74.7	72.9	72.9	71.6	0.4	2.1	2.1	3.4	0.000
080410013	CO_El Paso_0013	38.9583	-104.8172	Colorado	El Paso	68.0	66.1	65.9	65.0	65.0	64.0	0.3	1.1	1.1	2.1	0.013
080410016	CO_El Paso_0016	38.8531	-104.9013	Colorado	El Paso	70.3	68.9	68.7	68.0	68.0	67.0	0.2	0.9	0.9	1.9	0.014
080590002	CO_Jefferson_0002	39.8003	-105.1000	Colorado	Jefferson	75.0	73.4	73.0	70.8	70.8	69.1	0.4	2.6	2.6	4.3	0.015
080590005	CO_Jefferson_0005	39.6388	-105.1395	Colorado	Jefferson	74.3	72.0	71.7	70.3	70.3	69.1	0.3	1.7	1.7	2.9	0.000
080590006	CO_Jefferson_0006	39.9128	-105.1886	Colorado	Jefferson	82.0	79.6	79.1	76.1	76.1	73.9	0.4	3.5	3.5	5.7	0.008
080590011	CO_Jefferson_0011	39.7437	-105.1780	Colorado	Jefferson	76.3	73.9	73.6	71.6	71.6	70.2	0.3	2.3	2.3	3.8	0.007
080671004	CO_La Plata_1004	37.3039	-107.4842	Colorado	La Plata	70.0	69.1	69.0	68.8	68.8	68.6	0.2	0.3	0.3	0.6	0.000
080677001	CO_La Plata_7001	37.1368	-107.6286	Colorado	La Plata	66.0	65.7	65.6	65.3	65.2	63.0	0.2	0.4	0.6	2.8	0.139
080677003	CO_La Plata_7003	37.1026	-107.8702	Colorado	La Plata	67.0	66.8	66.6	66.4	66.3	64.2	0.2	0.4	0.5	2.6	0.121
080690007	CO_Larimer_0007	40.2772	-105.5450	Colorado	Larimer	74.3	72.5	72.4	70.6	70.6	69.5	0.2	1.9	1.9	3.0	0.007
080690011	CO_Larimer_0011	40.5925	-105.1411	Colorado	Larimer	78.0	79.0	78.8	73.8	73.8	71.3	0.1	5.2	5.2	7.7	0.000
080691004	CO_Larimer_1004	40.5775	-105.0789	Colorado	Larimer	67.3	67.4	67.3	63.5	63.5	61.6	0.1	3.9	3.9	5.8	0.000
080830101	CO_Montezuma_0101	37.1983	-108.4903	Colorado	Montezuma	69.3	69.0	68.9	68.8	68.7	67.7	0.1	0.3	0.3	1.4	0.049
081230009	CO_Weld_0009	40.3864	-104.7374	Colorado	Weld	72.7	72.3	72.0	67.0	67.0	64.6	0.3	5.3	5.3	7.7	0.015
350010023	NM_Bernalillo_0023	35.1343	-106.5852	New Mexico	Bernalillo	66.0	63.4	63.3	63.2	63.2	62.5	0.1	0.2	0.2	0.8	0.027
350010024	NM_Bernalillo_0024	35.0631	-106.5788	New Mexico	Bernalillo	67.3	64.3	64.2	64.1	64.1	63.5	0.1	0.1	0.2	0.8	0.027
350010027	NM_Bernalillo_0027	35.1539	-106.6972	New Mexico	Bernalillo	68.3	64.4	64.4	64.3	64.3	63.9	0.0	0.1	0.1	0.5	0.007
350010029	NM_Bernalillo_0029	35.0171	-106.6574	New Mexico	Bernalillo	67.0	64.0	63.9	63.8	63.8	63.3	0.1	0.1	0.1	0.7	0.014
350011012	NM_Bernalillo_1012	35.1852	-106.5082	New Mexico	Bernalillo	69.0	66.6	66.6	66.5	66.4	65.7	0.1	0.2	0.2	0.9	0.027
350011013	NM_Bernalillo_1013	35.1932	-106.6138	New Mexico	Bernalillo	68.7	65.1	65.1	65.0	65.0	64.3	0.1	0.2	0.2	0.8	0.021
350431001	NM_Sandoval_1001	35.2994	-106.5483	New Mexico	Sandoval	60.3	58.4	58.3	58.2	58.2	57.6	0.1	0.1	0.2	0.8	0.030
350431003	NM_Sandoval_1003	35.2381	-106.6494	New Mexico	Sandoval	70.0	66.4	66.3	66.2	66.2	65.6	0.1	0.2	0.2	0.8	0.021
350439004	NM_Sandoval_9004	35.6153	-106.7244	New Mexico	Sandoval	68.0	67.2	67.1	66.9	66.8	65.7	0.2	0.3	0.4	1.5	0.055
350450009	NM_San Juan_0009	36.7422	-107.9769	New Mexico	San Juan	62.0	60.8	60.7	60.6	60.4	57.3	0.1	0.3	0.5	3.6	0.161
350451005	NM_San Juan_1005	36.7967	-108.4725	New Mexico	San Juan	67.0	65.4	65.2	64.9	64.8	62.7	0.2	0.5	0.6	2.7	0.120
490110004	UT_Davis_0004	40.9030	-111.8845	Utah	Davis	77.0	74.7	74.6	74.6	74.6	74.5	0.0	0.0	0.0	0.2	0.000
490350003	UT_Salt Lake_0003	40.6467	-111.8497	Utah	Salt Lake	78.0	75.0	75.0	75.0	75.0	74.8	0.0	0.0	0.0	0.2	0.000
490352004	UT_Salt Lake_2004	40.7364	-112.2103	Utah	Salt Lake	75.7	72.5	72.5	72.5	72.5	72.4	0.0	0.0	0.0	0.1	0.000
490353006	UT_Salt Lake_3006	40.7364	-111.8722	Utah	Salt Lake	77.0	73.8	73.8	73.8	73.8	73.7	0.0	0.0	0.0	0.2	0.000
490370101	UT_San Juan_0101	38.4500	-109.8167	Utah	San Juan	70.0	69.2	69.2	69.1	69.1	68.8	0.0	0.1	0.1	0.4	0.000
490490002	UT_Utah_0002	40.2536	-111.6631	Utah	Utah	72.0	70.1	70.1	70.1	70.1	70.0	0.0	0.0	0.0	0.1	0.000
490495008	UT_Utah_5008	40.4303	-111.8039	Utah	Utah	72.3	69.9	69.9	69.9	69.9	69.9	0.0	0.0	0.0	0.1	0.000
490495010	UT_Utah_5010	40.1364	-111.6597	Utah	Utah	72.3	70.3	70.3	70.3	70.3	70.3	0.0	0.0	0.0	0.0	0.000

5.6.1.2 Ozone Design Value Projection Unmonitored Area Analysis

MATS was used to perform an unmonitored area analysis (UAA) of the 2021 ozone DVF projections for the 2021 High, Low and Medium Development Scenarios and the 2021 results without the contributions from the combined Source Groups R, S, T and U. The MATS UAA interpolates the current year observed ozone DVBs across the CARMMS 4 km domain and then makes 2021 ozone DVF projections throughout the domain using the relative change in the CAMx 2008 and 2021 modeling results in each 4 km grid cell. Figure 5-1 displays the spatial distribution of the MATS UAA derived 2008 ozone DVBs and 2021 ozone DVFs and their differences for the three 2021 emission scenarios. The color scheme for the spatial plots has a cut-point at 71.0 ppb so tiles that are greenish-yellow or warmer indicate exceedances of the 0.070 ppm ozone NAAQS. The current year DVBs indicate areas of ozone exceedances in Denver, Salt Lake City and large parts of Colorado and northeastern Utah with a maximum DVB of 81.5 ppb just northwest of Denver (Figure 5-1, top left). For the 2021 High, Low and Medium Development Scenarios the areas of 2021 ozone DVF exceedances are reduced but still prevalent over large parts of Colorado, Utah and northeastern New Mexico with a peak DVF of 78.5, 78.2 and 78.5 ppb for the 2021 High, Low and Medium Development Scenarios, respectively, just northwest of Denver near Rocky Flats North (top right in Figures 5-1a, 5-1b and 5-1c). The 2021 DVF – 2008 DVB difference plots (Figure 5-1, bottom) shows mainly ozone reductions with the largest reduction in the Denver and SLC areas but also ozone increases in the Piceance Basin (Garfield County) for the 2021 High Scenario (Figure 5-1a) that is not seen for the Low Scenario (Figure 5-1b), but is seen in the Medium Development Scenario (Figure 5-1c). The largest ozone increase in both 2021 scenarios occurs near downtown Denver and is due to less fresh NO_X emissions that suppress urban ozone concentrations.

The 2021 High Development Scenario UAA ozone DVF without Source Group R (Federal O&G and mining in 13 CO BLM Planning Areas) results in reduction in the DVFs with the highest reduction of 3.9 ppb in the Piceance Basin and the peak DVF being reduced from 79.3 to 78.5 ppb that occurs just northwest of Denver (Figure 5-2a, top panels). In contrast, the removal of Source Group R from the 2021 Low Development Scenario results in smaller ozone reductions again mainly in the Piceance Basin with a maximum reduction of 1.3 ppb (Figure 5-3a, top panels). The removal of Source Group R from the 2021 Medium Development Scenario reduces the maximum 2021 DVF to 78.2 ppb with a maximum DVF reduction of 3.2 ppb that occurs in the Piceance Basin (Figure 5-4a). There are still areas in Denver and SLC and other parts of Colorado and Utah with 2021 DVFs exceeding the NAAQS with Source Group R removed.

Removing both Federal O&G and mining and non-Federal O&G (Source Group S) results in more reductions in the 2021 DVFs, especially in Weld County in the greater Denver area (Figures 5-2a, 5-3a and 5-4a, bottom panels). There are large reductions in 2021 DVFs in the Piceance and D-J Basins (Weld County) with the largest reduction being 8.8 ppb (High Scenario), 4.1 ppb (Low Scenario) and 8.0 ppb (Medium Scenario) in the Piceance Basin.

Source Group T adds the new O&G within the Mancos Shale development area to Source Group S (Figures 5-2b, 5-3b and 5-4b, top panels) and results in nearly identical 2021 DVFs as Source Group S in Colorado only with more ozone reductions in northwestern New Mexico.

When all O&G and mining emissions in the 4 km domain are removed from the 2021 High and Low Development Scenarios in Source Group U, there are widespread reductions in the 2021 ozone DVFs throughout Colorado and spreading into Utah, New Mexico, Oklahoma and Texas. Large ozone reductions occur in the D-J Basin (Weld County), Piceance Basin, Uinta Basin and South San Juan Basin; the single grid cell with the highest ozone reduction in the High (-13.2 ppb), Low (-9.5 ppb) and Medium (-12.5 ppb) occurs in the Piceance Basin (Figures 5-2b, 5-3b and 5-3c, bottom panels).

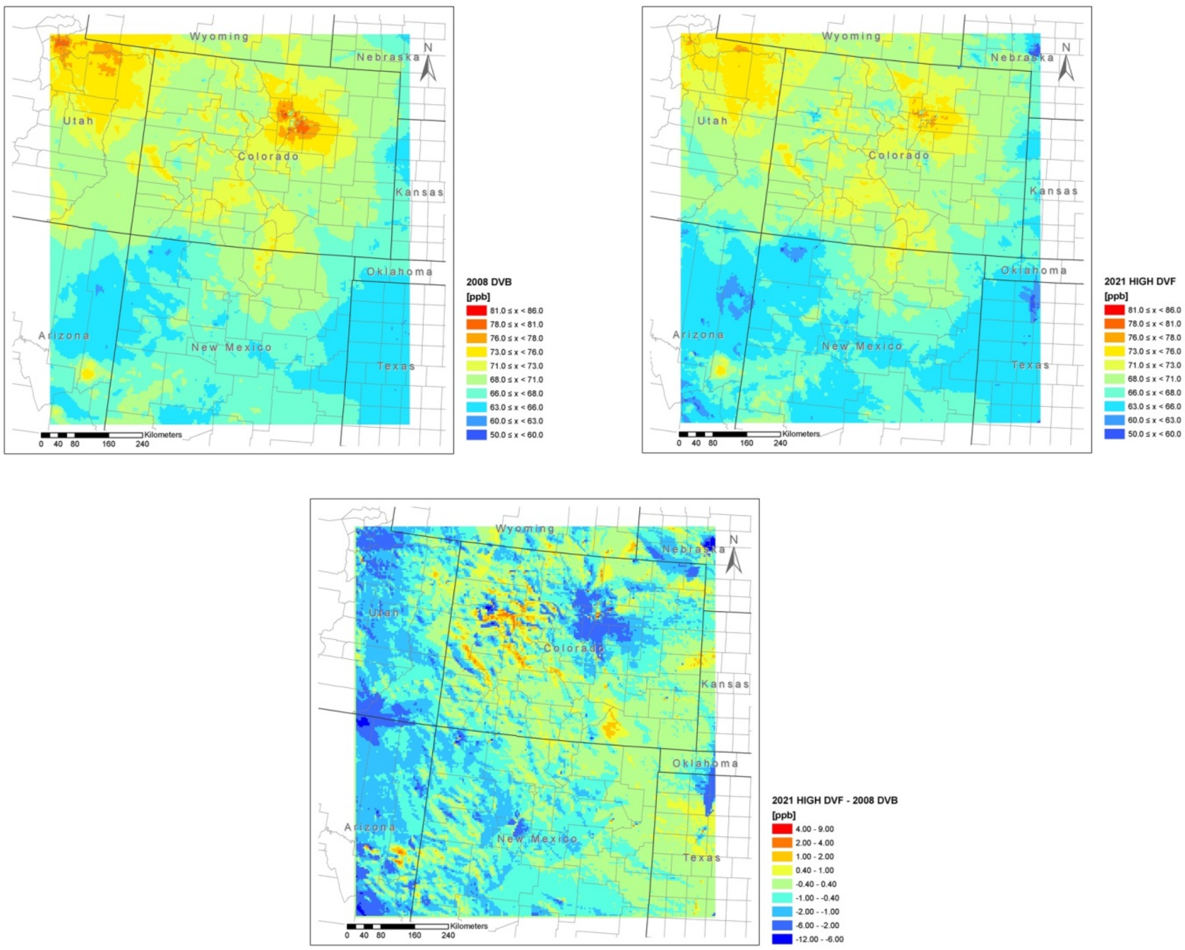


Figure 5-1a. 2008-centered ozone DVB (top left), 2021 High Development Scenario ozone DVF (top right) and their differences (2021 High – 2008) (bottom) calculated using MATS.

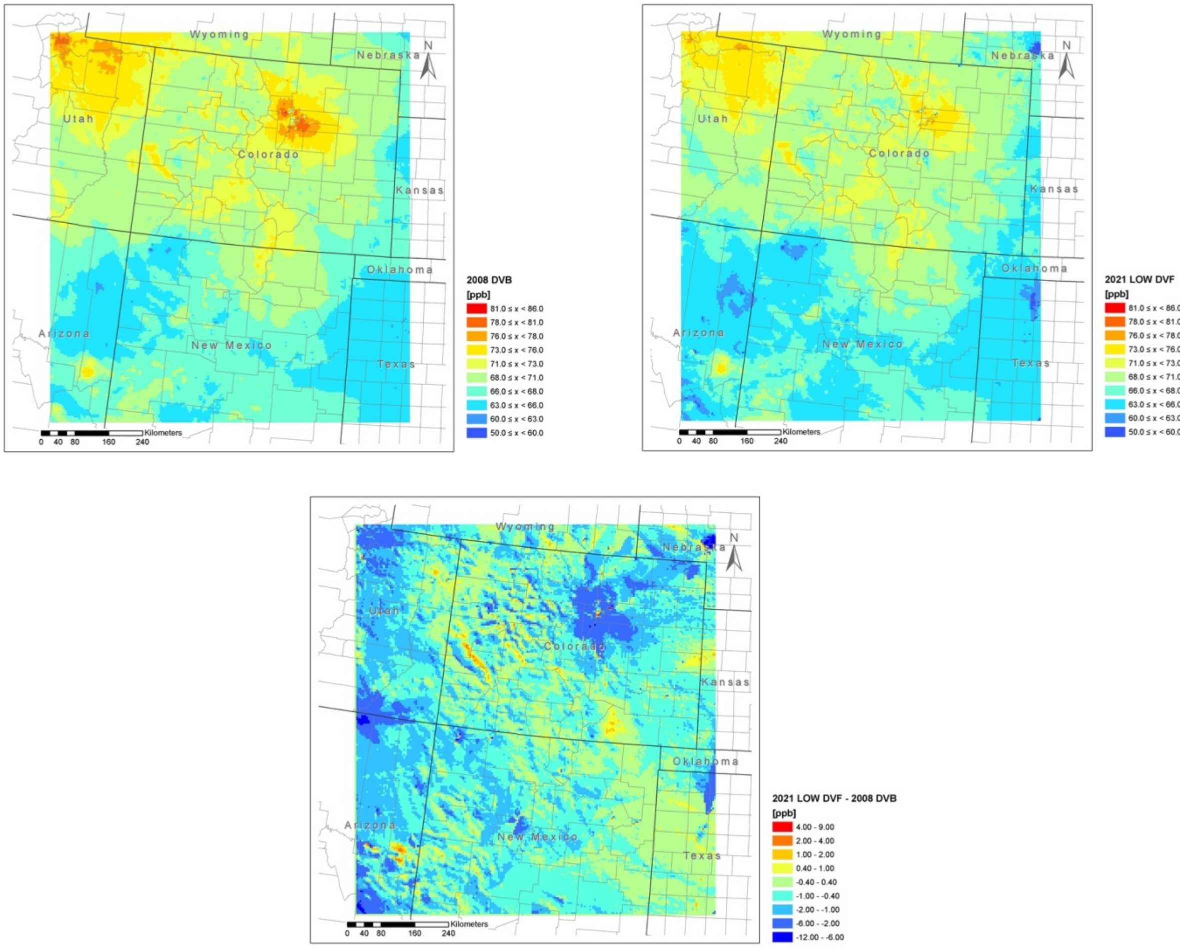


Figure 5-1b. 2008-centered ozone DVB (top left), 2021 Low Development Scenario ozone DVF (top right) and their differences (2021 Low – 2008) (bottom) calculated using MATS.

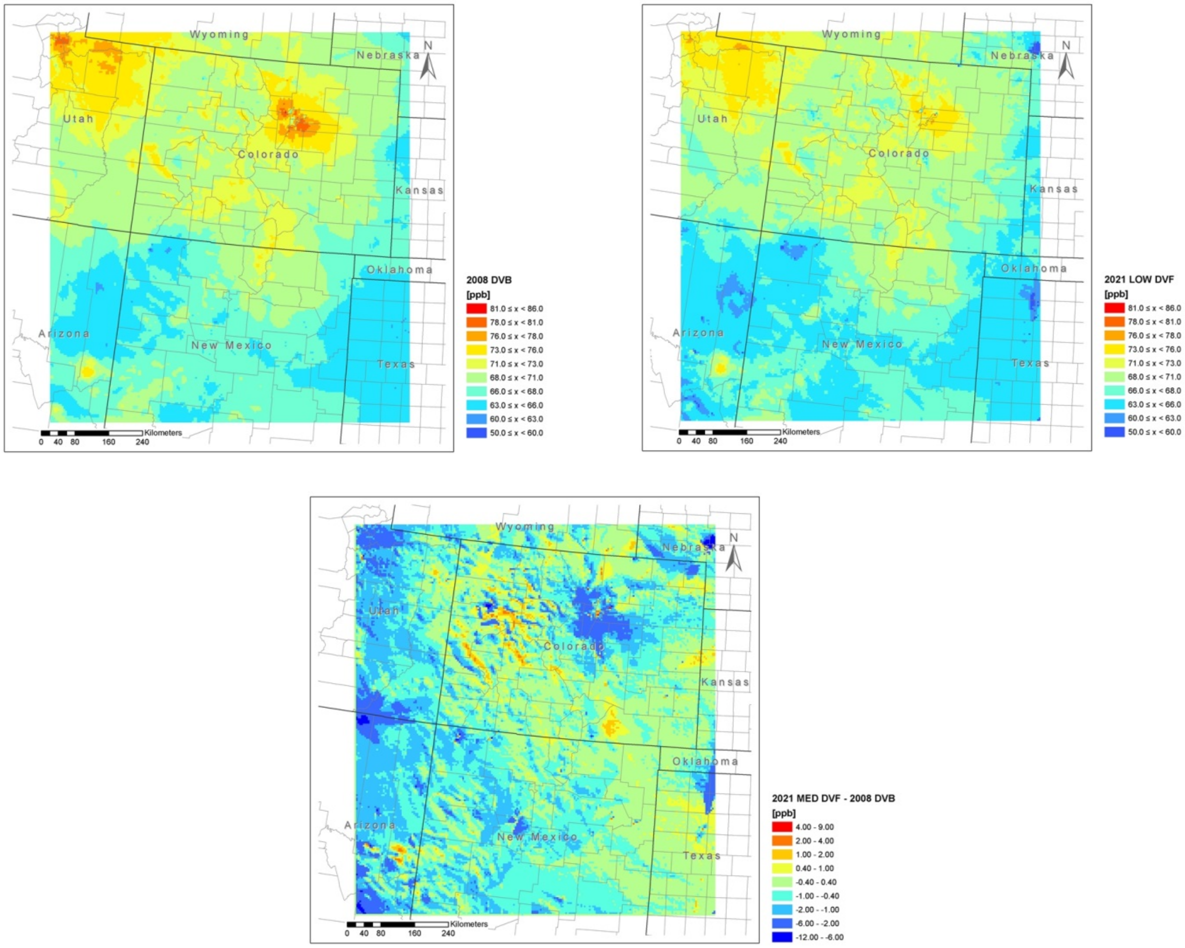


Figure 5-1c. 2008-centered ozone DVB (top left), 2021 Medium Development Scenario ozone DVF (top right) and their differences (2021 Medium – 2008) (bottom) calculated using MATS.

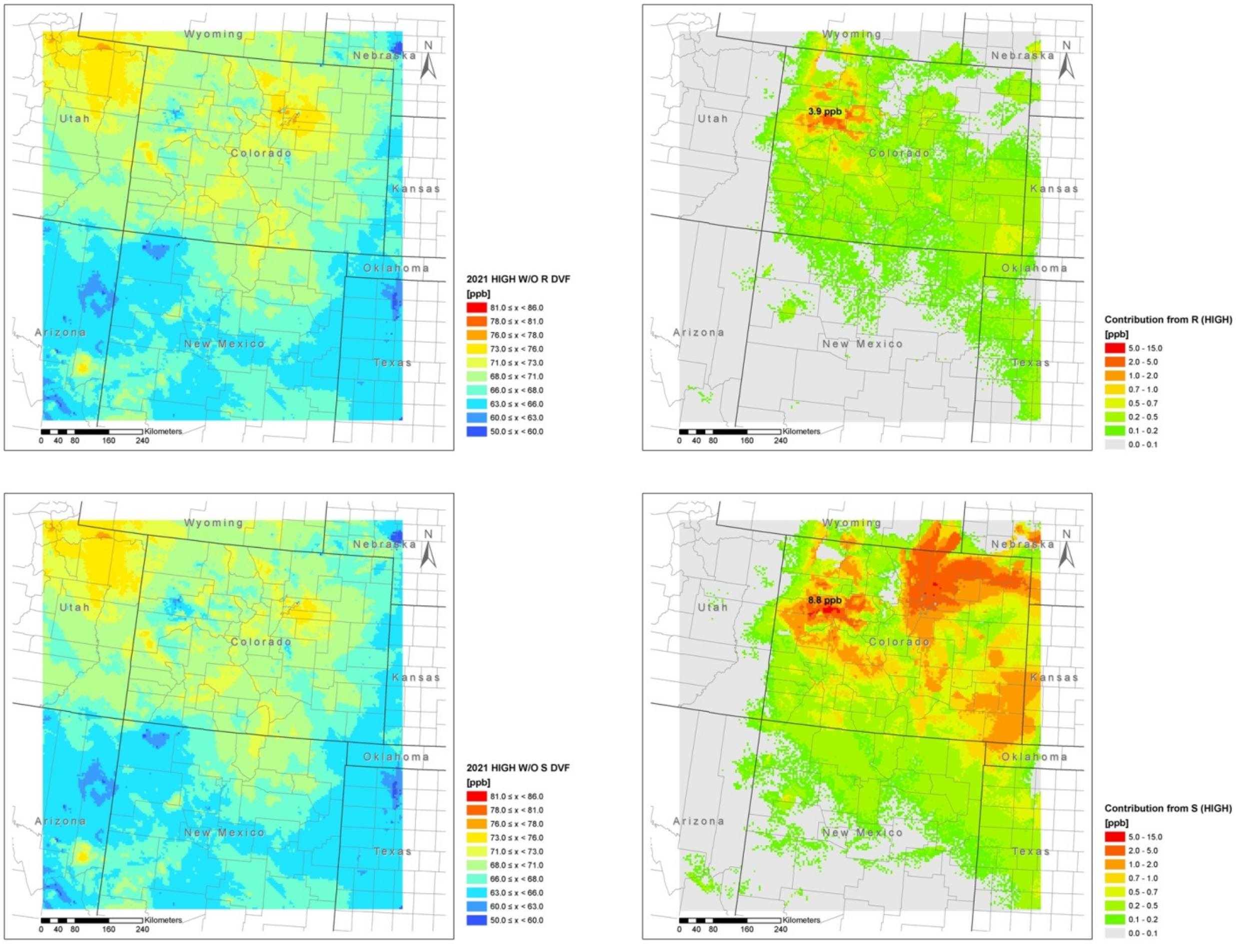


Figure 5-2a. 2021 projected ozone DVF 2021 Unmonitored Area Analysis for Source Group R (top) and S (bottom) showing 2021 DVF without each Source Group (left) and difference in DVFs with 2021 High Development Scenario (right).

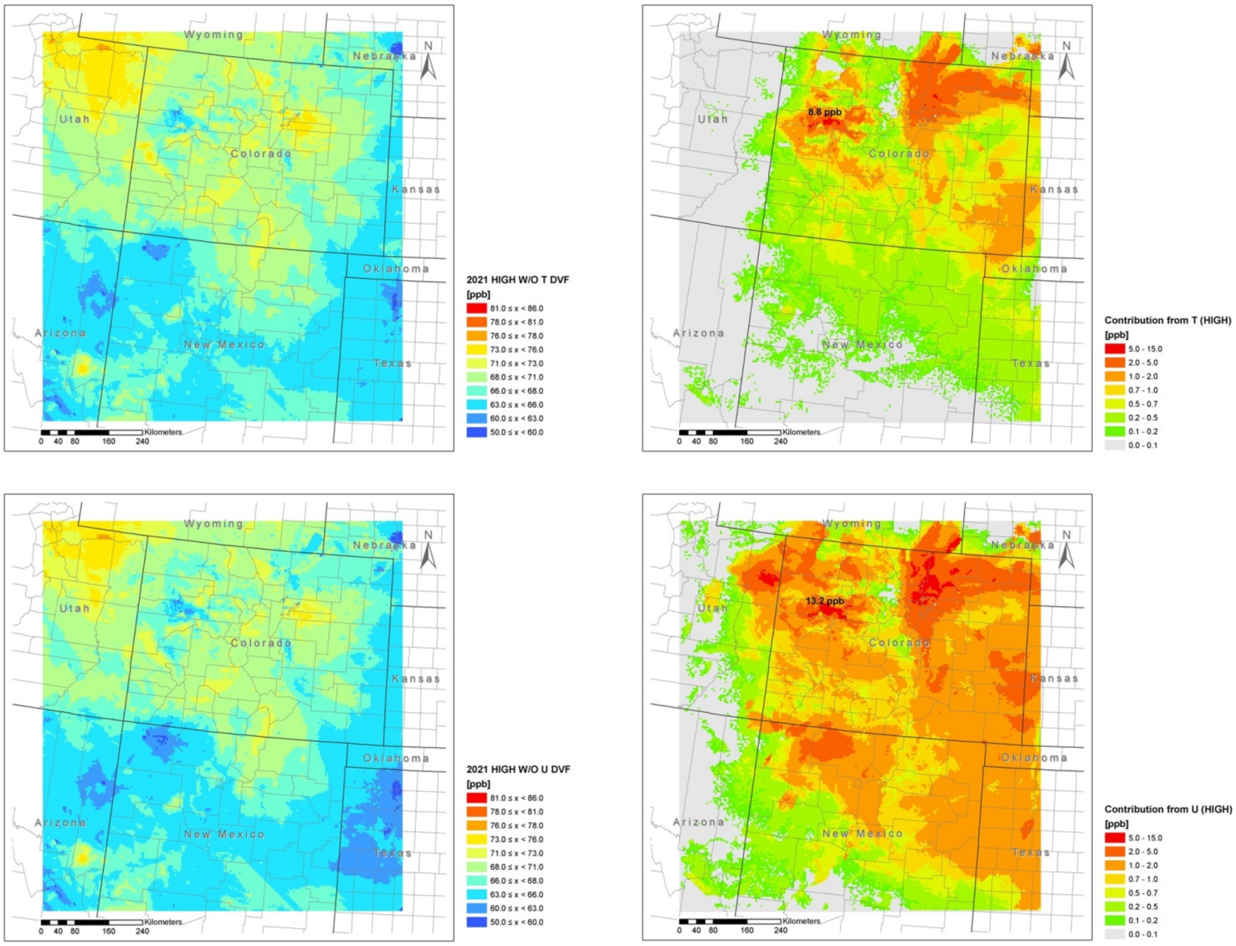


Figure 5-2b. 2021 projected ozone DVF 2021 Unmonitored Area Analysis for Source Group T (top) and U (bottom) showing 2021 DVF without each Source Group (left) and difference in DVFs with 2021 High Development Scenario (right).

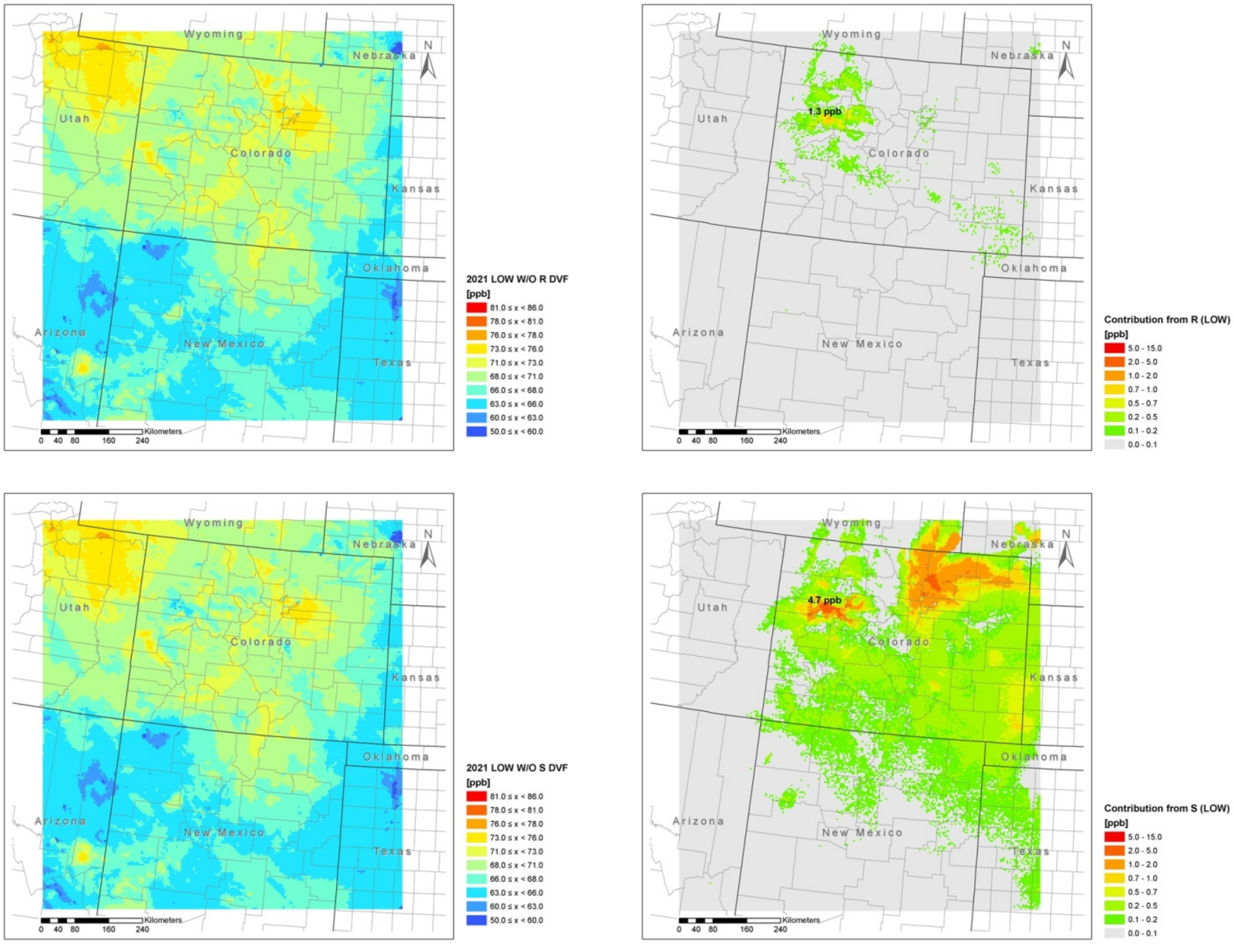


Figure 5-3a. 2021 projected ozone DVF 2021 Unmonitored Area Analysis for Source Group R (top) and S (bottom) showing 2021 DVF without each Source Group (left) and difference in DVFs with 2021 Low Development Scenario (right).

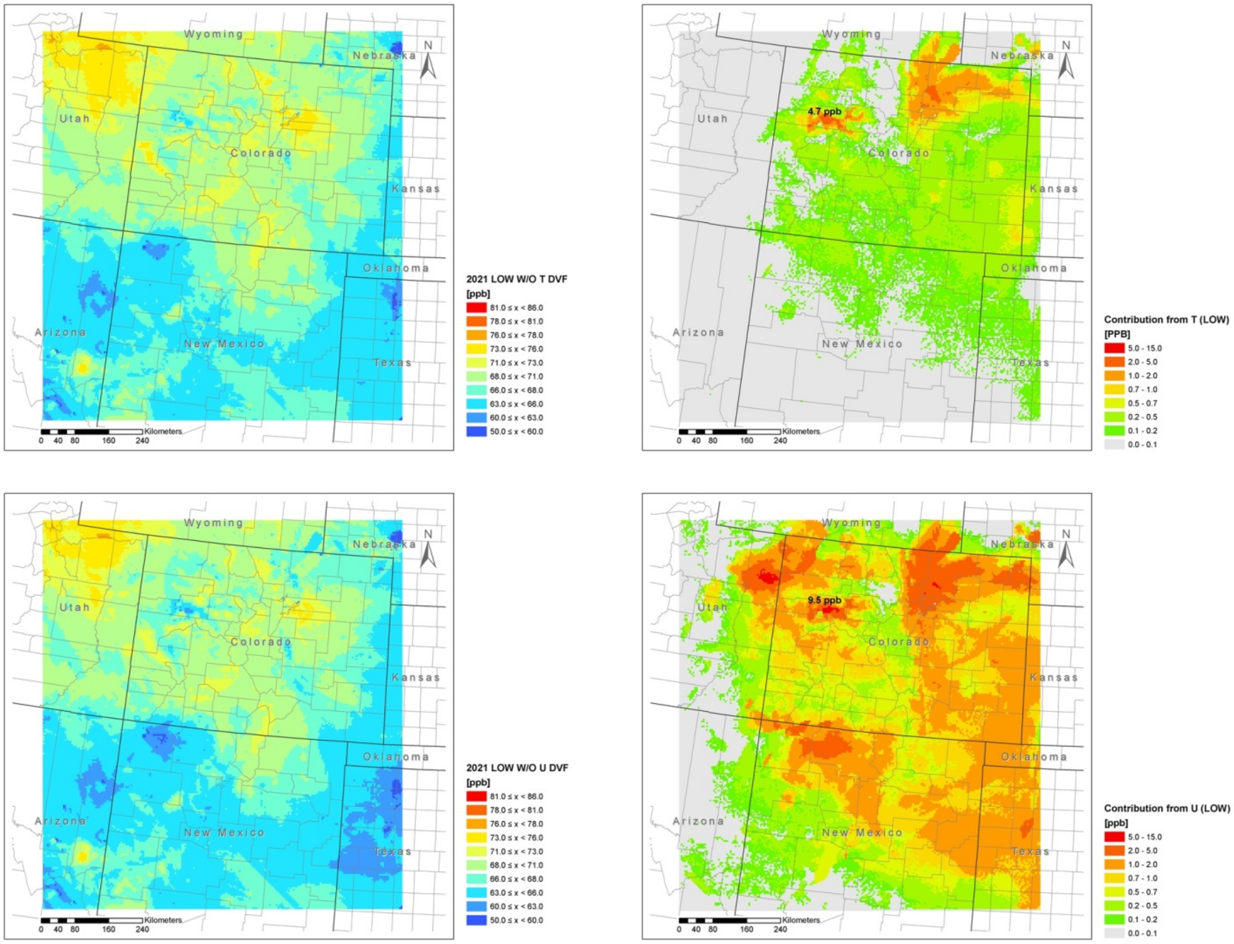


Figure 5-3b. 2021 projected ozone DVF 2021 Unmonitored Area Analysis for Source Group T (top) and U (bottom) showing 2021 DVF without each Source Group (left) and difference in DVFs with 2021 Low Development Scenario (right).

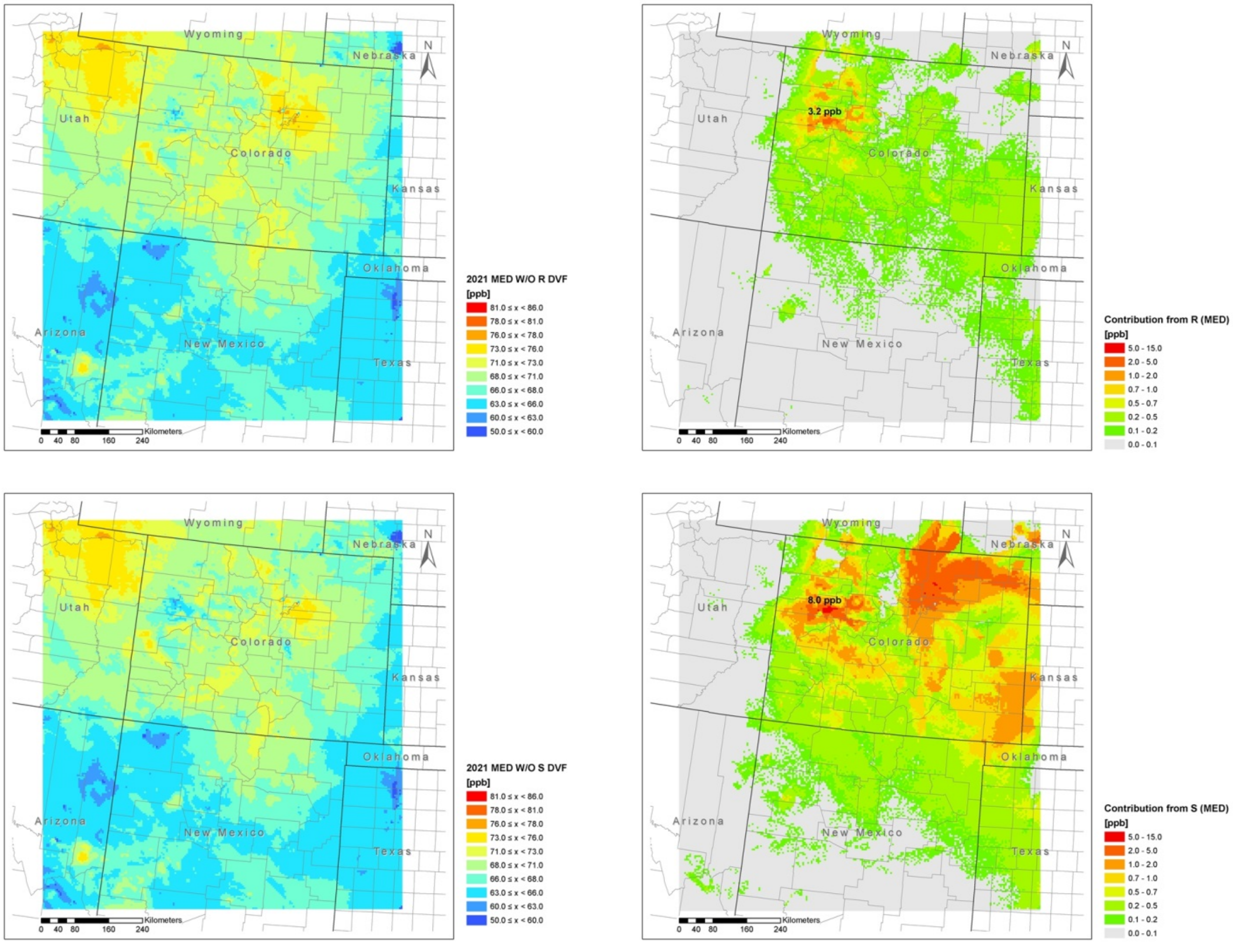


Figure 5-4a. 2021 projected ozone DVF 2021 Unmonitored Area Analysis for Source Group R (top) and S (bottom) showing 2021 DVF without each Source Group (left) and difference in DVFs with 2021 Medium Development Scenario (right).

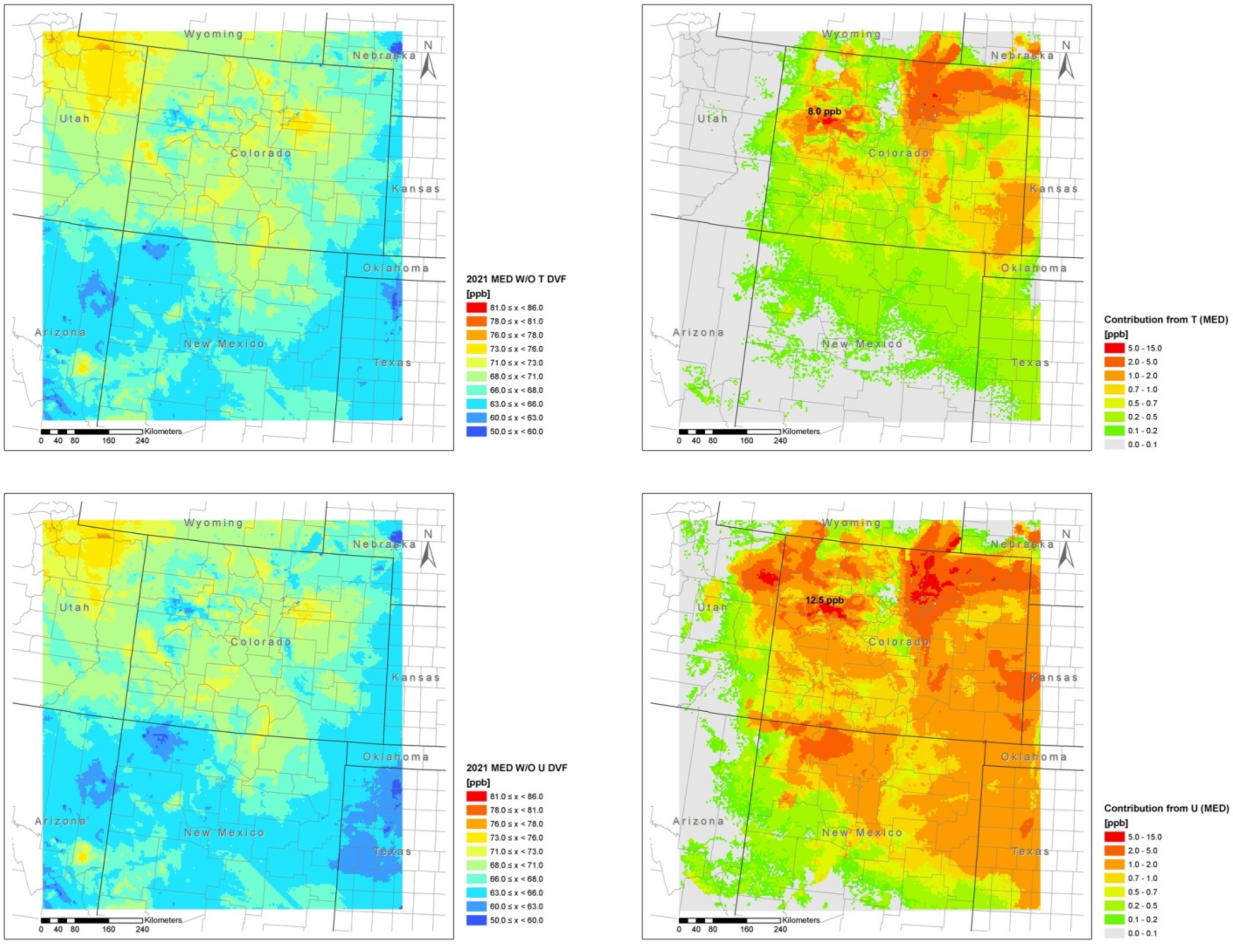


Figure 5-4b. 2021 projected ozone DVF 2021 Unmonitored Area Analysis for Source Group T (top) and U (bottom) showing 2021 DVF without each Source Group (left) and difference in DVFs with 2021 Medium Development Scenario (right).

5.6.2 Ozone NAAQS Analysis using the Absolute Modeling Results

The CAMx source apportionment absolute modeling results in the 2021 High, Low and Medium Development Scenarios are analyzed and compared to the NAAQS in this section. The ozone NAAQS is defined as the three-year average of the 4th highest daily maximum 8-hour (DMAX8) ozone concentration. Since CARMMS only uses one year of modeling results (2008 meteorological year), the 2021 4th highest DMAX8 ozone concentration is used as a pseudo-NAAQS comparison metric. The contributions of each Source Group to ozone is examined as the difference between the 4th highest DMAX8 ozone concentration for the 2021 emissions scenario minus the 4th highest DMAX8 ozone for the 2021 scenario with the Source Group contributions removed. In addition, the contributions of each Source Group to modeled 2021 4th high DMAX8 ozone greater than the NAAQS (i.e., 71.0 ppb or greater) is also analyzed.

5.6.2.1 Contributions of Source Groups to 4th High DMAX8 Ozone

Figure 5-5 displays the 4th highest DMAX8 ozone for the 2008 Base Case and the 2021 High, Low and Medium Development Scenarios and their differences and the 4th highest DMAX8 ozone for the 2021 scenario with the ozone contributions from natural emissions removed (Source Group V). This last display was generated to determine whether exceedances of the NAAQS could have been primarily due to natural emissions. The color scale in Figure 5-5 has a sharp contrast from green to yellow when an exceedances of the ozone NAAQS occurs (i.e., 71.0 ppb or higher). For the 2008 Base Case, there are several regions where the modeled 2021 4th high DMAX8 ozone exceeds the NAAQS (Figure 5-5, top left): the Denver area, Uinta Basin and Salt Lake City (SLC) and other large parts of Colorado, New Mexico and Utah.

In the 2021 High, Low and Medium Development Scenarios, the areas of ozone exceedances mostly still remain with the new ozone NAAQS of 0.070 ppm. There are also ozone increases in the Uinta Basin in the three 2021 scenarios (Figure 5-5, top right), with the predicted 4th highest DMAX8 ozone concentration in 2021 in this basin. The 2021 – 2008 ozone differences (Figure 5-5, bottom left) show more decreases than increases and the areas of ozone increases tend to occur in O&G development areas, such as the D-J, Piceance and Uinta Basins. The contribution of natural emissions to the modeled 4th highest daily maximum 8-hour ozone concentrations (Figure 5-5, bottom right) show that there are large contributions to peak ozone from natural sources in northern New Mexico, northern Utah and parts of Colorado.

Attachment I is a zipped file that contains spatial maps of concentrations including total concentrations and the contributions of each of the Source Groups to the 4th highest DMAX8 ozone and other pollutants from the 2021 High, Low and Medium Development Scenarios CAMx source apportionment modeling. Figure 5-6 displays example spatial maps of contributions to the 4th highest DMAX8 ozone concentrations for Source Groups E (GJFO), F (UFO), J (USFS-PG), R (Federal O&G/mining in CO) T (Cumulative Emissions Scenario) and U (all O&G in 4 km CARMMS domain) and the 2021 High, Low and Medium Development Scenarios that were extracted out of Attachment I. The maximum ozone contributions to the 4th highest DMAX8 ozone for each of the Source Groups are given in Table 5-40. Note that these are maximum Source Group contributions to the 4th highest DMAX8 ozone and could occur when the total ozone is less or greater than the ozone NAAQS. Section 5.6.2.2 discusses the Source Group contributions only when the total 4th high DMAX8 ozone exceeds the ozone NAAQS.

Ozone contributions due to Federal O&G development in the GJFO Planning Area are centered on the GJFO area where a maximum ozone contribution of 6.2 ppb occurs for the 2021 High Development Scenario (Table 5-40 and Figure 5-6a, top left). The mitigation in the 2021 Medium Development Scenario reduces this maximum GJFO ozone contribution by -18% to 5.1 ppb. There are much lower 4th high DMAX8 ozone contributions due to GJFO in the 2021 Low Development Scenario (Figure 5-6a, top right) with a maximum contribution of only 0.5 ppb.

Lower 4th high DMAX8 ozone contributions are seen for UFO new Federal O&G with highest ozone contributions of 0.4, 0.1 and 0.3, ppb respectively, for the 2021 High, Low and Medium Development Scenarios occurring in the northeast corner of the UFO Planning Area (Figure 5-6b). Even smaller ozone contributions still are seen due to new Federal O&G within the USFS-PG area with maximum values of 0.3, 0.1 and 0.2 ppb in the 2021 High, Low and Medium Development Scenarios, respectively (Figure 5-6c).

Contributions to fourth highest daily maximum 8-hour ozone from new Federal O&G emissions in the NMFFO Planning Area are generally between those due to the GJFO and UFO Planning Areas with peak contributions of 1.0, 0.5 and 0.8 ppb respectively, in the 2021 High, Low and Medium Development Scenarios with the peak occurring near the NM/CO stateline.

The maximum ozone contribution due to Federal O&G and mining throughout the 13 CO Planning areas (Source Group R) for the 2021 High, Low and Medium Development Scenarios are, respectively, 8.4, 2.9 and 7.0 ppb and occur in the Piceance Basin (Table 5-40 and Figure 5-6e). There are several areas with ozone contributions of 2 ppb or more for the 2021 High and Medium Development Scenarios and the Cumulative Emissions Source Group T (new Federal and non-Federal O&G and mining in the 14 BLM Planning Areas), including the Piceance and D-J Basins but also in southeastern Colorado (RGFO area No. 2) as shown in the top left and bottom panels of Figure 5-6f. Substantial ozone reductions are seen in the 2021 Low Development Scenario (Figure 5-6f, top right) with the highest ozone being reduced from 17.6 and 16.2 ppb in the High and Medium scenarios to 8.7 ppb in the Low Development Scenario.

Figure 5-6g displays the reduction in 4th highest DMAX8 ozone concentrations due to the elimination of all O&G and Colorado mining (Source Group U) in the 4 km CARMMS domain. All of the major O&G Basins exhibit reductions in ozone in excess of 3 ppb in the 2021 High and Medium Development Scenarios with the highest ozone reduction occurring in the Uinta Basin of 28.3 ppb for the High, Low and Medium Development scenarios. Note that the same O&G emissions were used in the Uinta Basin for the three CARMMS 2021 scenarios that came from the BLM UTSO ARMS study, which explains why there is little difference in the peak ozone contribution for the three scenarios.

Table 5-40. Maximum contribution to the 4th highest DMAX8 ozone (ppb) for each of the Source Groups and the 2021 High, Low and Medium Development Scenarios.

Source Group	High	Low	Medium
A. Little Snake FO	0.5	0.1	0.5
B. White River FO	5	1	4
C. Colorado River Valley FO (w/o Roan Plateau)	1.6	1.2	1.4
D. Roan Plateau	2	1.1	1.9
E. Grand Junction FO	6.2	0.5	5.1
F. Uncompahgre FO	0.4	0.1	0.3
G. Tres Rios FO	1	0.2	0.9
H. Kremmling FO	0.8	0.1	0.6
I. Royal Gorge FO No. 1 (North)	0.1	0	0
J. Pawnee Grasslands	0.3	0.1	0.2
K. Royal Gorge FO No. 2	0.4	0	0.3
L. Royal Gorge FO No. 3	0.1	0.1	0.1
M. Royal Gorge FO No. 4	0.1	0	0
N. New Mexico Farmington FO (Mancos)	1	0.5	0.8
O. Colorado River Valley FO (w/ Roan Plateau)	3.5	2.1	2.9
P. Royal Gorge FO (total)	0.5	0.1	0.3
Q. Federal Mining in Colorado	0.5	0.5	0.5
R. New Federal O&G and Mining In Colorado	8.4	2.9	7
S. New Federal/Non-Federal O&G/Mining in CO	17.5	8.7	16.2
T. New Federal/Non-Federal O&G/Mining in CO/NM	17.6	8.7	16.2
U. Existing and New Fed/Non-Fed O&G in 4 km Domain	28.3	28.3	28.3
V. Natural Emissions	25	6.1	25
Y. Coal EGU NM	13.5	13.5	13.5
Z. Coal EGU CO	11.8	11.8	11.8
AA. Oil/Gas EGU NM	0.5	0.5	0.5
AB. Oil/Gas EGU CO	1.3	1	1.3
AC. All EGUs in 4 km Domain	13.6	13.6	13.6
AD. CO Mining + Coal EGUs CO	11.8	11.8	11.8
AE. CO O&G + Oil/Gas EGUs CO	17.5	8.7	16.2
AF. NM O&G + Oil/Gas EGU NM	1.2	0.6	0.9

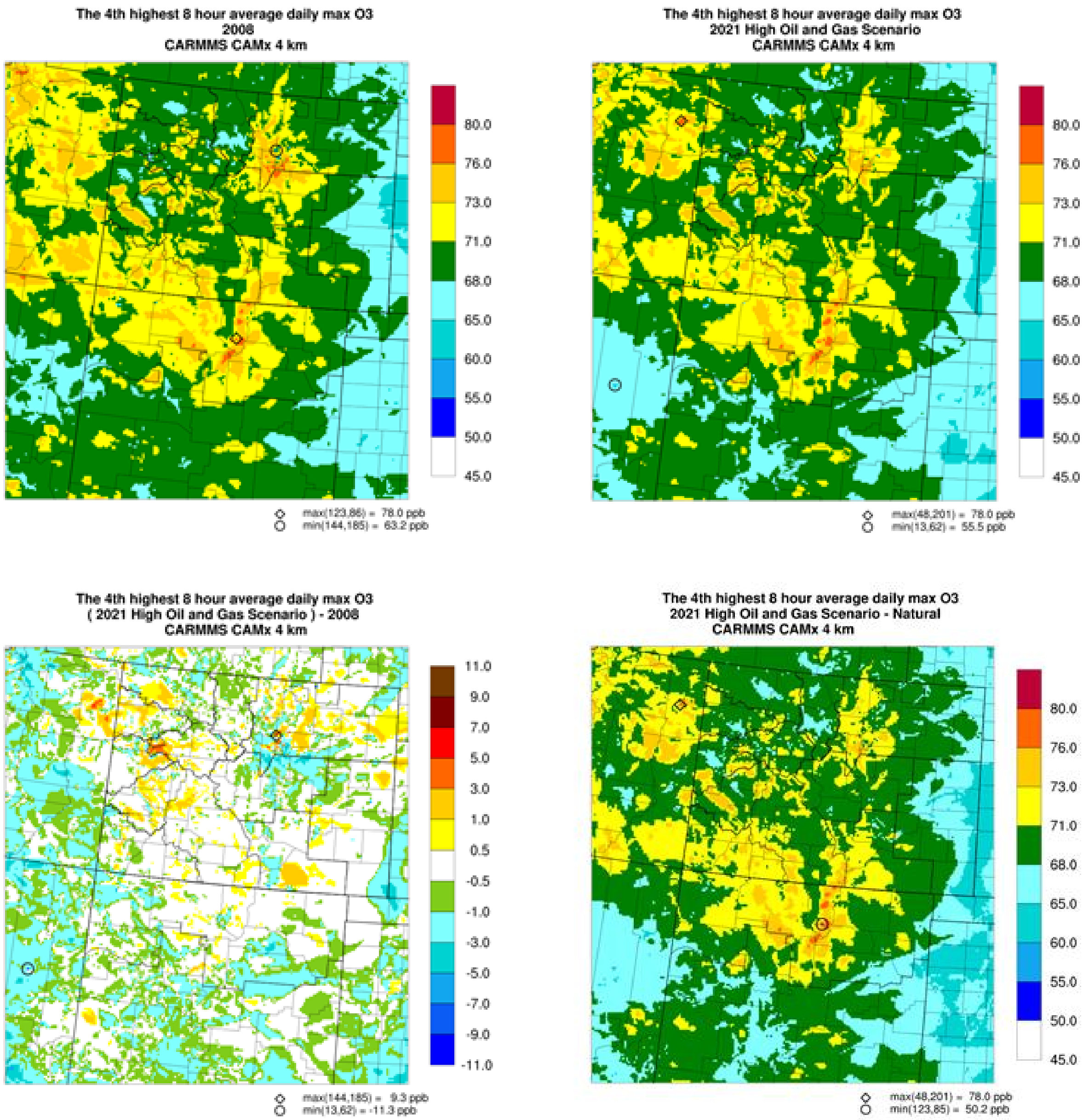


Figure 5-5a. Fourth highest daily maximum 8-hour ozone concentrations for the 2008 Base Case (top left), 2021 High Development Scenario (top right), 2021 High minus 2008 differences (bottom left) and Natural Emissions (bottom right).

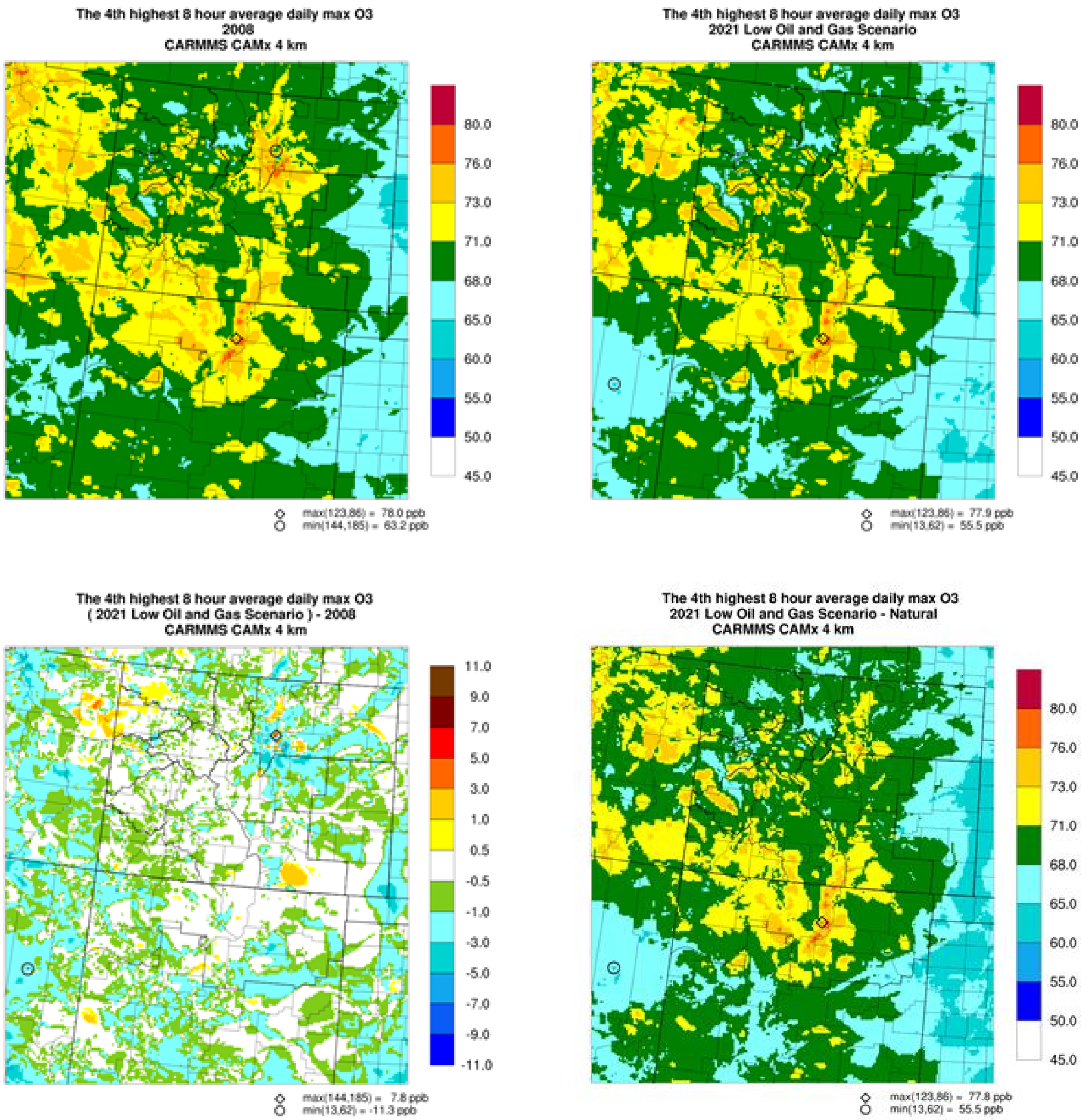


Figure 5-5b. Fourth highest daily maximum 8-hour ozone concentrations for the 2008 Base Case (top left), 2021 Low Development Scenario (top right), 2021 Low minus 2008 differences (bottom left) and Natural Emissions (bottom right).

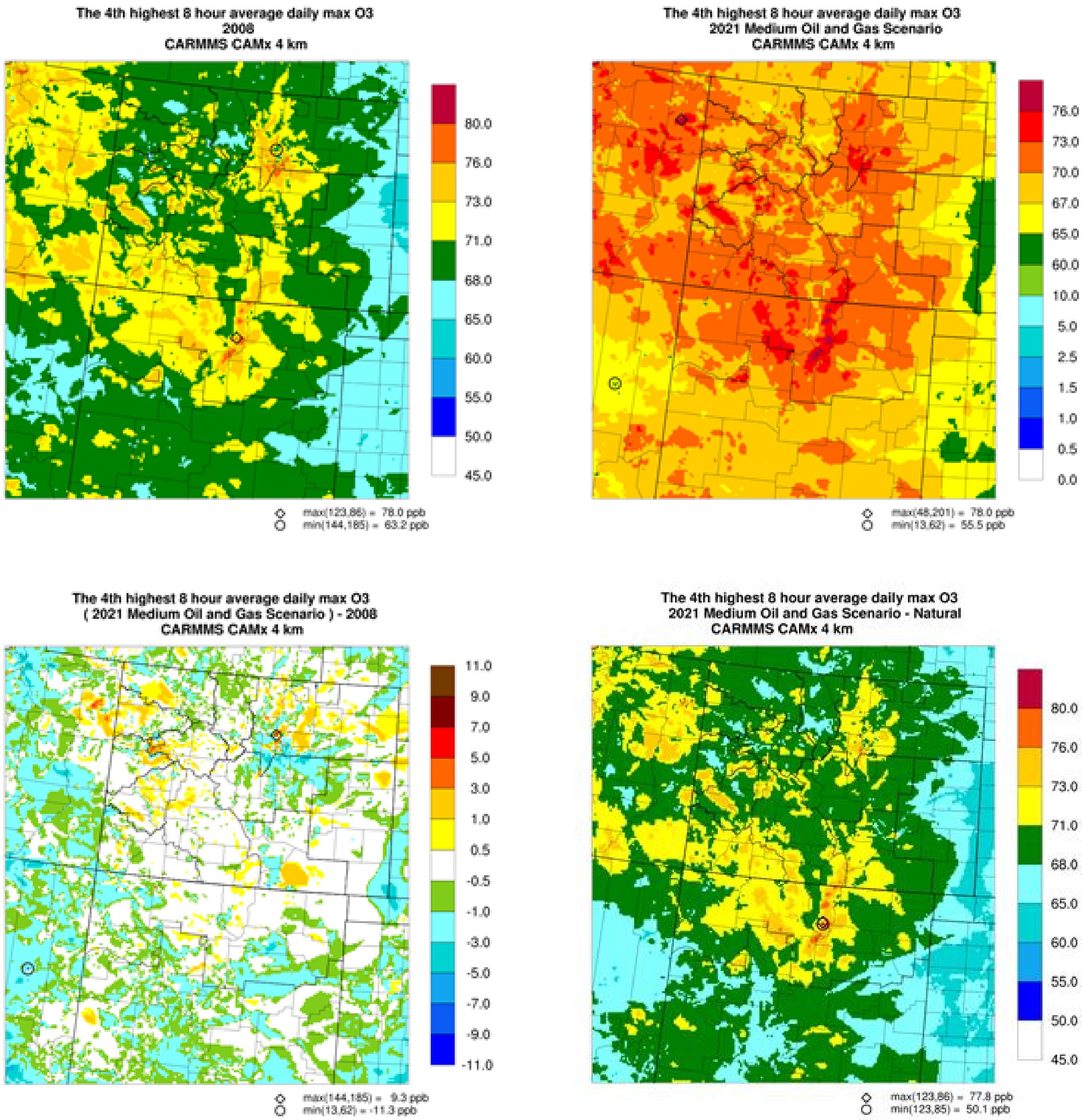


Figure 5-5c. Fourth highest daily maximum 8-hour ozone concentrations for the 2008 Base Case (top left), 2021 Medium Development Scenario (top right), 2021 Medium minus 2008 differences (bottom left) and Natural Emissions (bottom right).

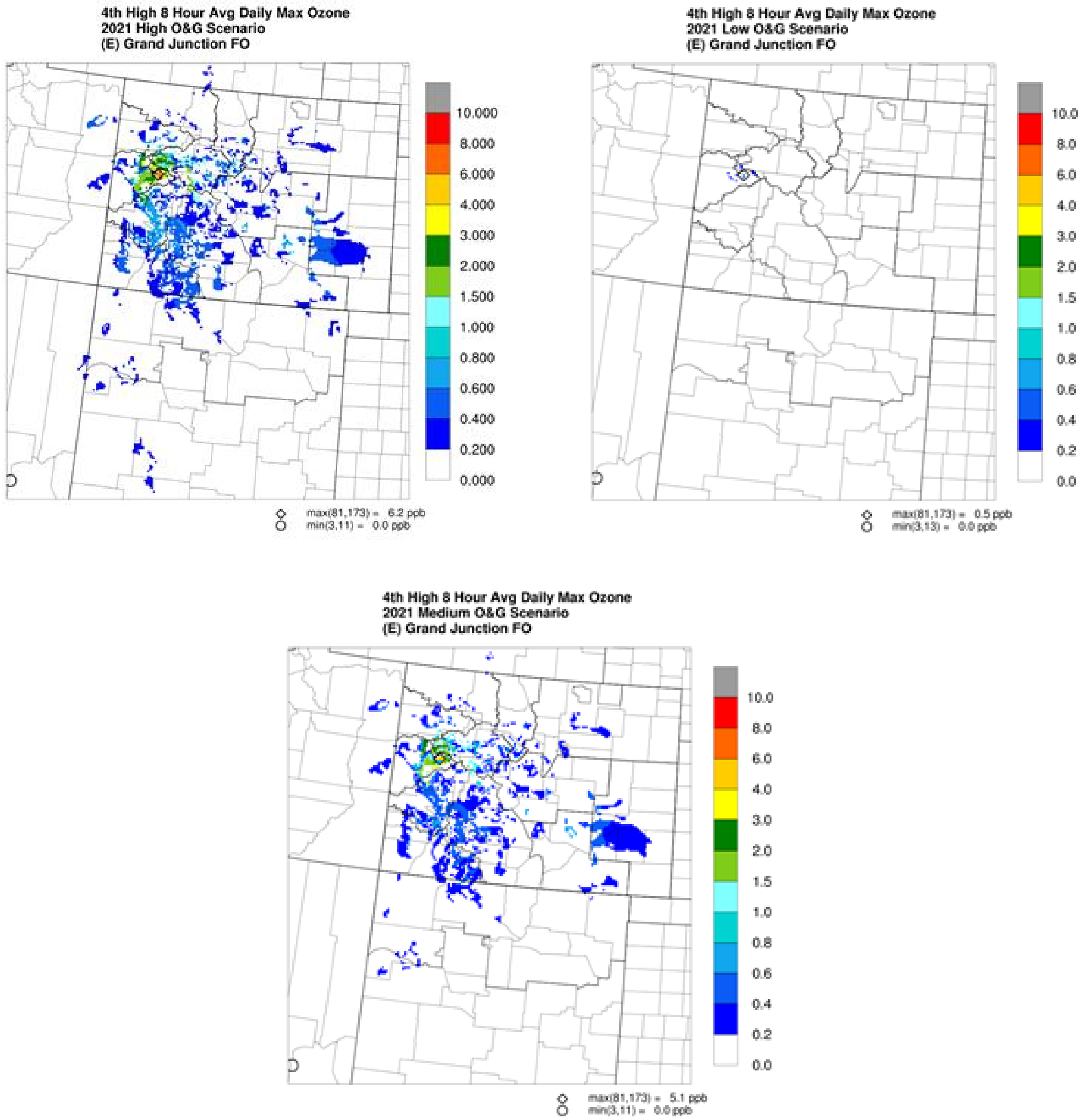


Figure 5-6a. Contributions to fourth highest daily maximum 8-hour ozone due to emissions from new Federal O&G within the GJFO (Source Group E) for the 2021 High (top left), Low (top right) and Medium (bottom) Development Scenarios.

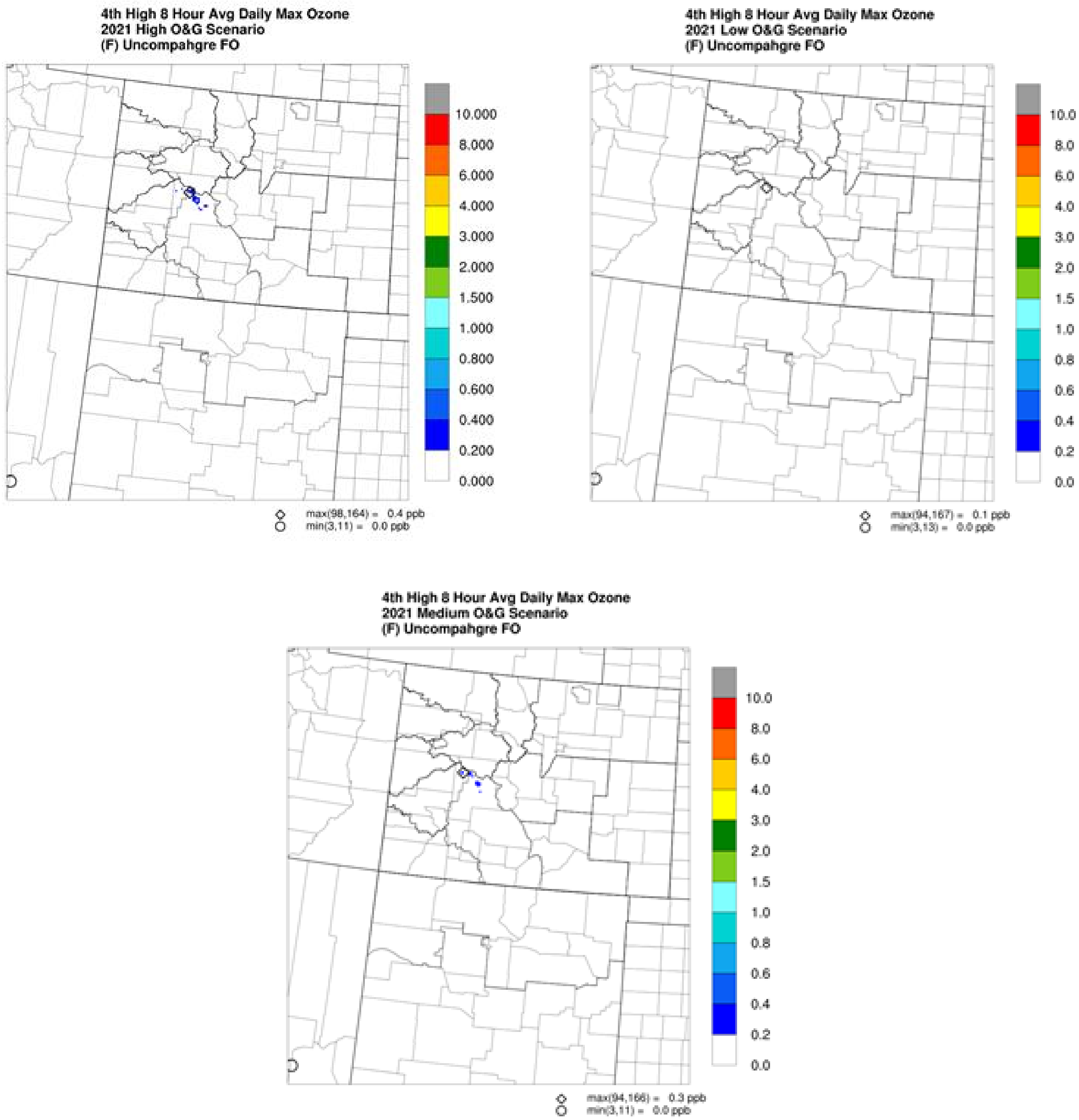


Figure 5-6b. Contributions to fourth highest daily maximum 8-hour ozone due to emissions from new Federal O&G within the UFO (Source Group F) for the 2021 High (top left), Low (top right) and Medium (bottom) Development Scenarios.

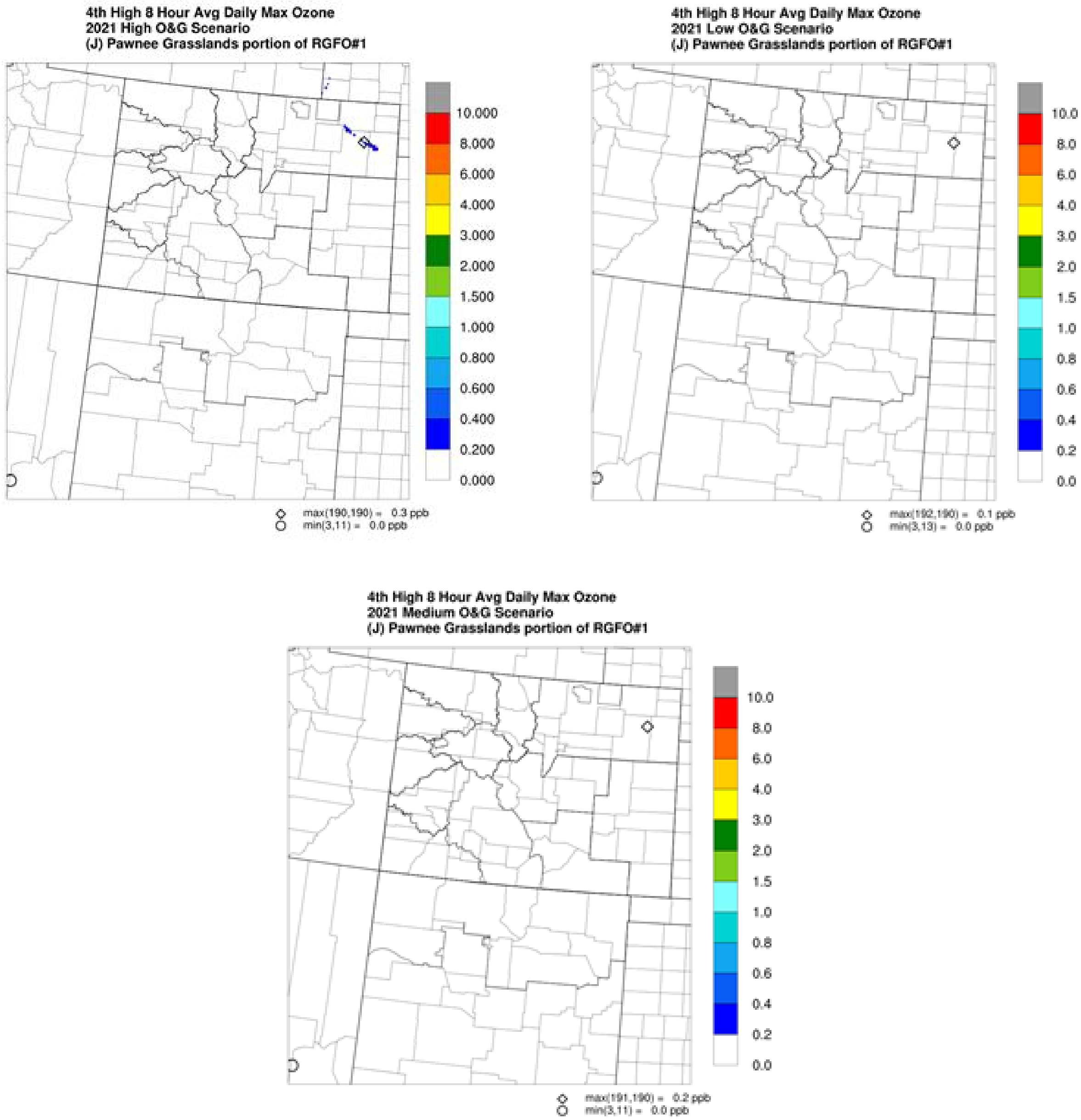


Figure 5-6c. Contributions to fourth highest daily maximum 8-hour ozone due to emissions from new Federal O&G within the USFS Pawnee Grasslands (Source Group J) for the 2021 High (top left), Low (top right) and Medium (bottom) Development Scenarios.

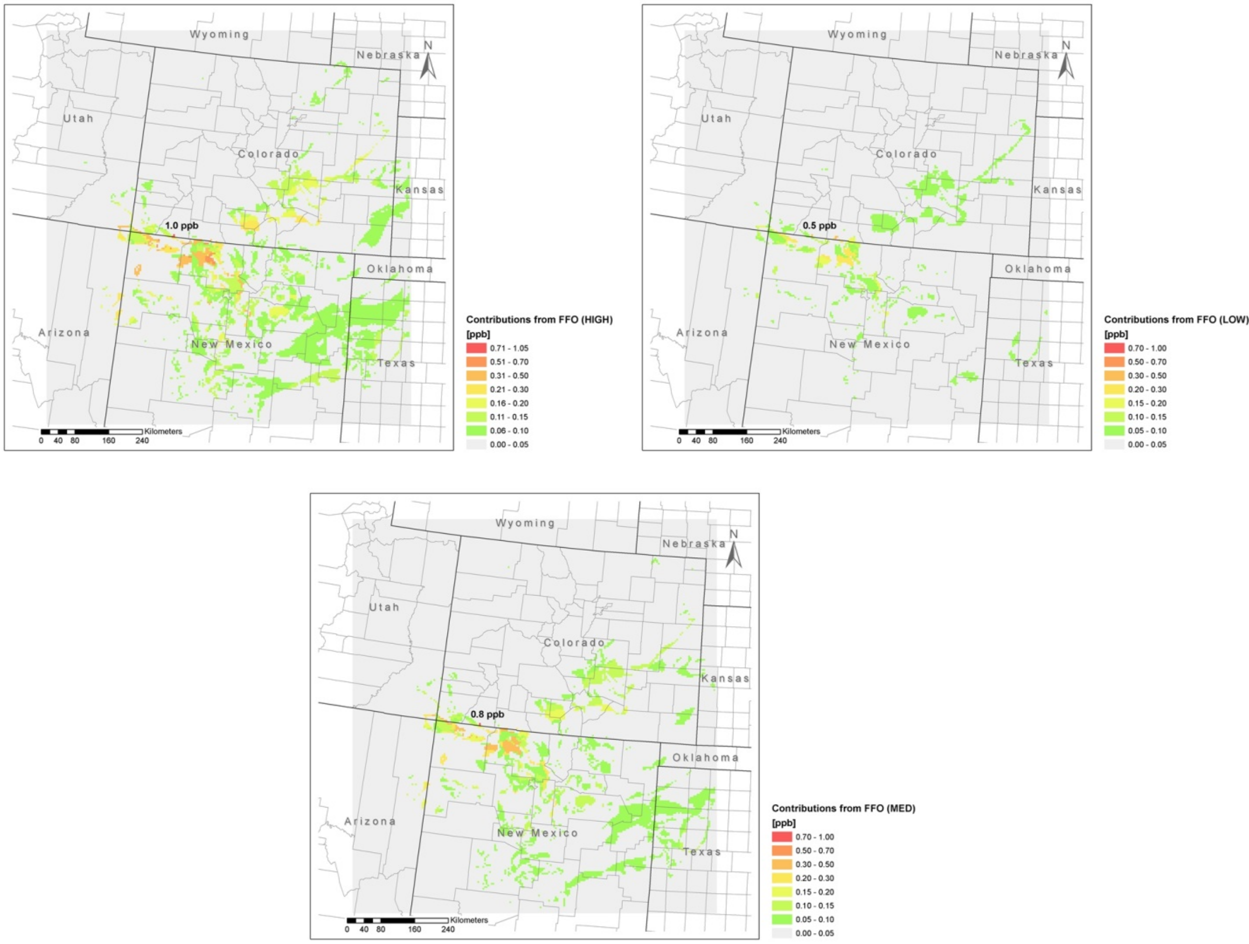


Figure 5-6d. Contributions to fourth highest daily maximum 8-hour ozone due to emissions from NM Farmington FO (Source Group N) for the 2021 High (top left), Low (top right) and Medium (bottom) Development Scenarios.

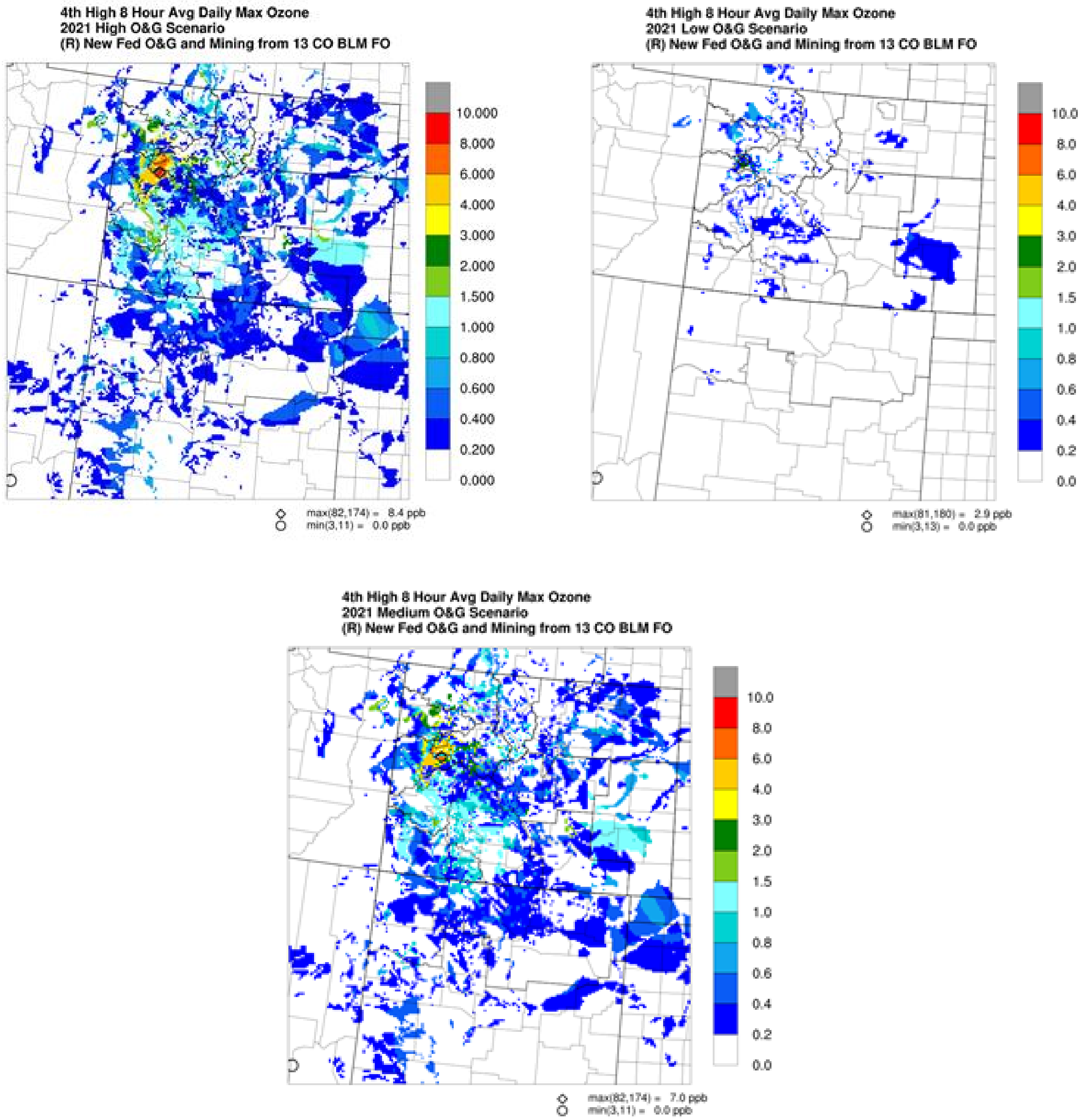


Figure 5-6e. Contributions to fourth highest daily maximum 8-hour ozone due to emissions from new Federal O&G and mining within the 13 Colorado BLM Planning Areas (Source Group R) for the 2021 High (top left), Low (top right) and Medium (bottom) Development Scenarios.

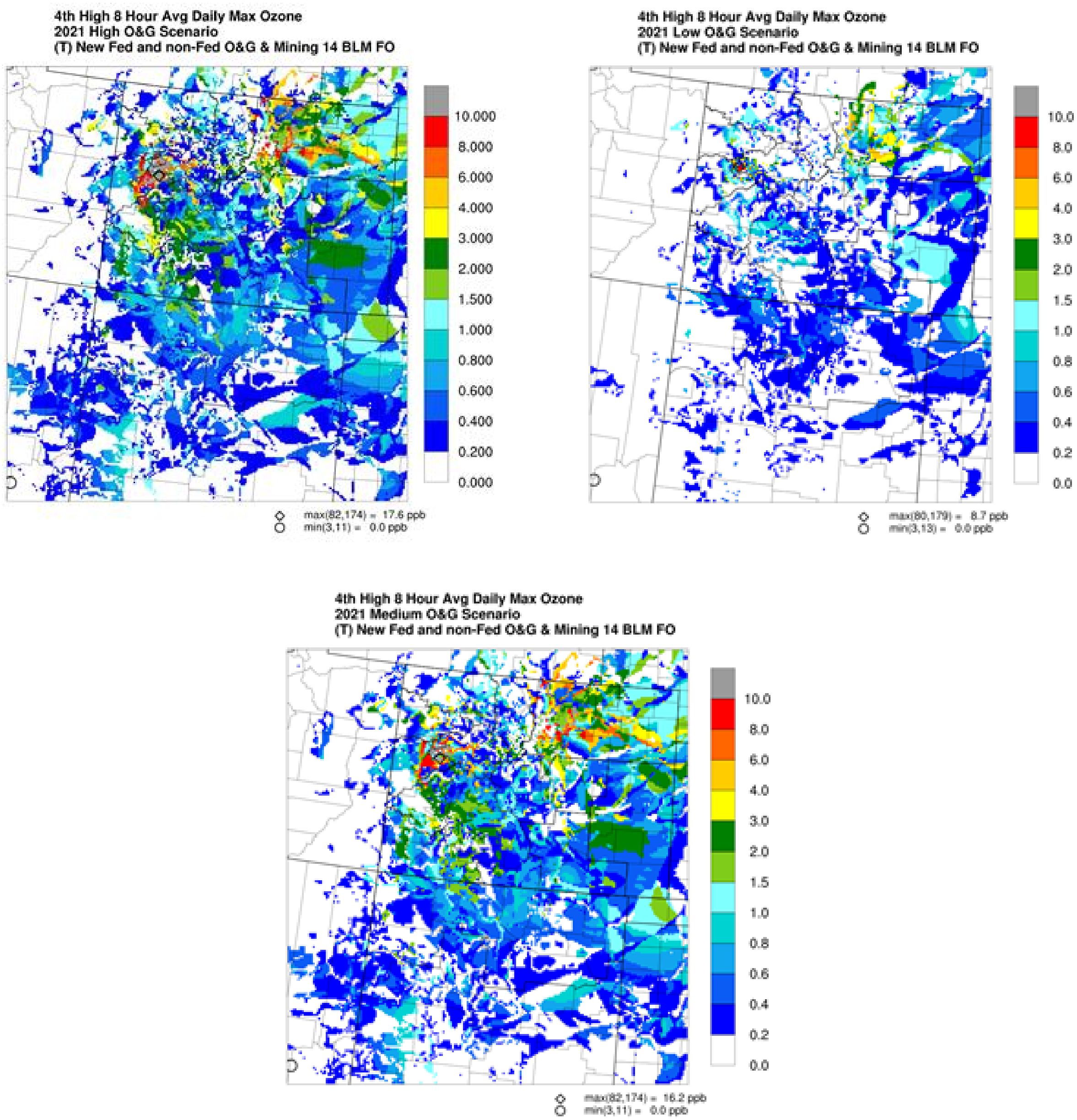


Figure 5-6f. Contributions to fourth highest daily maximum 8-hour ozone due to emissions from new Federal and non-Federal O&G and mining within the 14 CO/NM BLM Planning Areas (Source Group T) for the 2021 High (top left), Low (top right) and Medium (bottom) Development Scenarios.

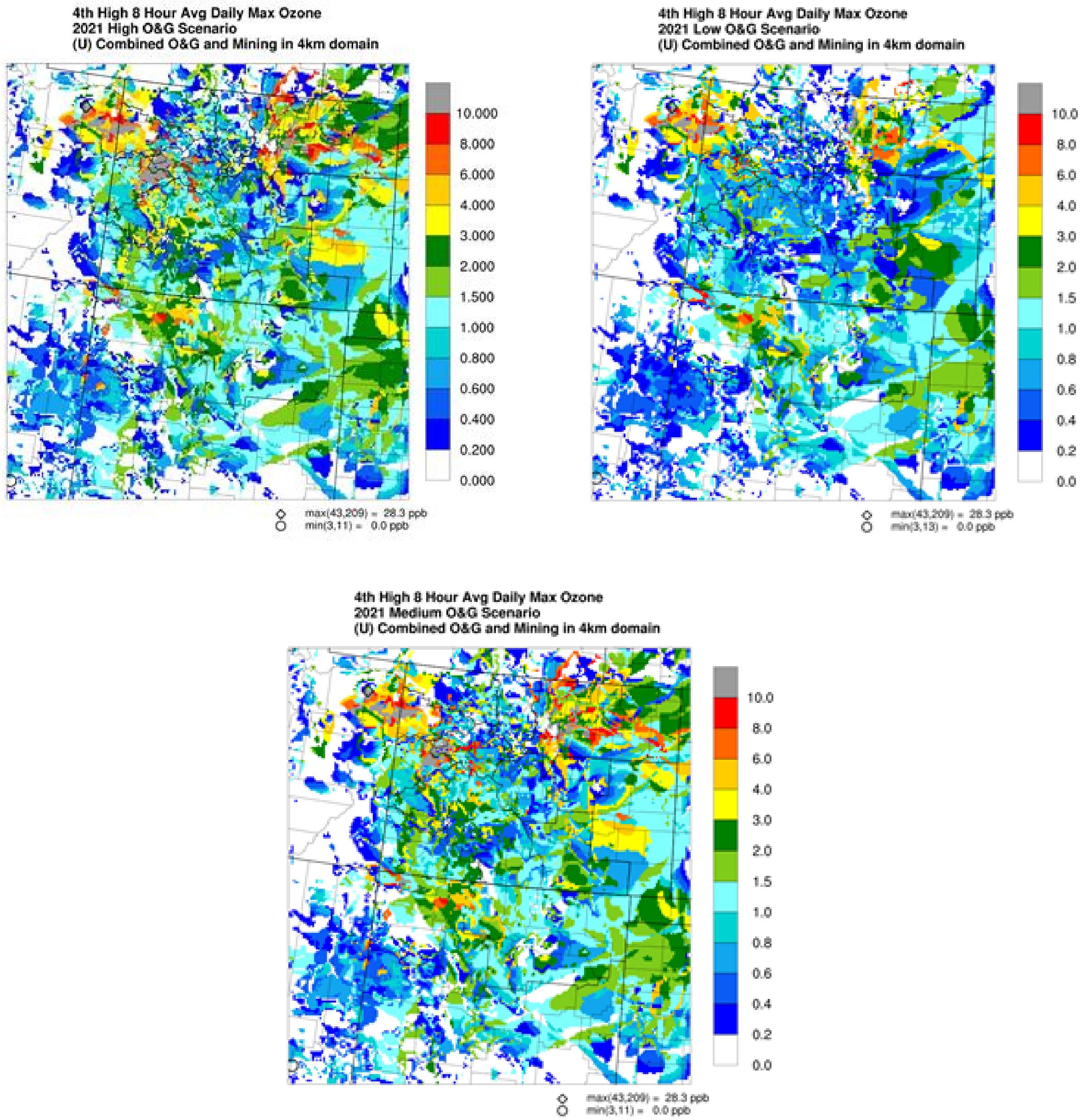


Figure 5-6g. Contributions to fourth highest daily maximum 8-hour ozone due to emissions from existing, new Federal and non-Federal O&G within the entire CARMMS 4 km domain and Federal mining in Colorado (Source Group U) for the 2021 High (top left), Low (top right) and Medium (bottom) Development Scenarios.

5.6.2.2 Source Group Absolute Contributions to Ozone Exceedances

The contributions of each Source Group to 4th highest DMAX8 ozone above the current ozone NAAQS (71.0 ppb and higher) for the 2021 High, Low and Medium Development Scenarios are contained in Attachments G-1, G-2 and G-3, respectively. The Attachment G interactive Excel spreadsheet contains two sheets: "StatTable" that displays the maximum ozone contribution for each Source Group to modeled 2021 DMAX8 ozone greater than the NAAQS; and "Scatter_by_exceedance_region" that shows the ozone contribution of a Source Group, controlled by cell C1, to all grid cells with modeled 2021 4th high DMAX8 ozone greater than the NAAQS by region. Table 5-41 from StatTable in Attachment G lists the maximum ozone contribution to any modeled 2021 4th high DMAX8 ozone greater than the NAAQS. The Grand Junction FO is the individual BLM Planning Area with the largest contribution to 2021 modeled exceedances of the ozone NAAQS of 6.1 ppb for the High, 0.1 ppb for the Low and 5.0 ppb for the Medium Development Scenarios when the 2021 total ozone was 72.3, 71.5 and 71.2 ppb, respectively. The NM FFO has a maximum ozone contribution of about 1 ppb to modeled 2021 DMAX8 ozone in excess of the ozone NAAQS in the 2021 High scenario and reduced by about half in the Low Development scenario.

The highest contribution to 2021 DMAX8 ozone for all Federal O&G and mining within the 13 Colorado BLM Planning Areas (Source Group R) is 8.4, 0.6 and 7.0 ppb for the 2021 High, Low and Medium Development Scenarios, respectively. The contribution of new Federal and non-Federal O&G and Federal mining within the 14 BLM Planning Areas (Source Group T) to 2021 DMAX8 ozone exceedances are 17.6, 6.2 and 16.2 ppb for the High, Low and Medium Development Scenarios, respectively. The highest contribution of all O&G in the CARMMS domain and Colorado mining sources to modeled 2021 DMAX8 ozone exceedances is 26.5, 24.7 and 26.3 ppb (Table 5-41) for the 2021 High, Low and Medium Development Scenarios; these values are primarily due to O&G emissions in the Uinta Basin.

Figure 5-7a shows the contribution of Federal O&G emissions from the FFO BLM Planning Area to the 2021 4th high DMAX8 ozone at all grid cells in the domain that came from the "Scatter_by_exceedance_region" sheet in Attachments G-1, G-2 and G-3. Apart from an isolated contribution of 1.0 ppb, FFO area contributions are all less than 0.6 ppb in the 2021 High Development Scenario and less than 0.35 and 0.42, respectively, Low and Medium Development Scenarios, respectively (Figure 5-7a, left). The contributions of new Federal O&G and mining within the 13 Colorado BLM Planning Areas (Source Group R) to exceedances of the ozone NAAQS is shown in the right panels in Figure 5-7a with the highest contributions of approximately 8.5 ppb, 0.6 and 7.0 ppb for the High, Low and Medium Scenarios, respectively. Addition of new non-Federal O&G that is contained in Source Group T greatly increases the O&G contribution to exceedances in the Denver area with contributions of approximately 18 ppb, 6 ppb and 16 ppb for the High, Low and Medium Development Scenarios, respectively (Figure 5-7b, left). Inclusion of the O&G emissions from outside CO and NM as well (Source Group U) results in contributions between 25 ppb and 30 ppb to ozone exceedances, primarily in the Uinta Basin (Figure 5-7b, right).

Table 5-41a. Maximum ozone contribution by Source Group to total modeled 2021 4th high DMAX8 ozone greater than the NAAQS for the 2021 High Development Scenario.

Group	Name	Max		
		Max Contribution (ppb)	Corresponding 4th MDA8	% Max Contribution
A	Little Snake FO	0.2667	72.7	0.37%
B	White River FO	3.7600	72.8	5.16%
C	Colorado River Valley FO (CRVFO)	1.6144	71.5	2.26%
D	Roan Plateau Planning area portion of CRVFO	2.0462	72.9	2.81%
E	Grand Junction FO	6.1446	72.3	8.50%
F	Uncompahgre FO	0.4271	71.3	0.60%
G	Tres Rios FO	0.3814	71.7	0.53%
H	Kremmling FO	0.0760	71.3	0.11%
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0.0292	71.2	0.04%
J	Pawnee Grasslands portion of RGFO#1	0.1018	71.1	0.14%
K	RGFO#2 – West-Central/South	0.0256	71.2	0.04%
L	RGFO#3 – South	0.0521	71.0	0.07%
M	RGFO#4 – East-Central	0.0278	71.1	0.04%
N	New Mexico Farmington FO	1.0051	71.1	1.41%
O	Total Colorado River Field Office	3.4472	71.5	4.82%
P	Total Royal Gorge Field Office	0.1253	71.1	0.18%
Q	Mining from 13 Colorado BLM Planning Areas	0.4741	71.3	0.66%
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	8.4315	72.3	11.67%
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	17.5408	72.3	24.27%
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	17.5722	72.3	24.31%
U	Combined O&G and Mining in 4 km domain	26.5235	77.3	34.33%
V	Natural Emissions	24.9659	75.1	33.23%
Y	Coal EGU NM	13.4862	73.6	18.33%
Z	Coal EGU CO	11.8342	73.5	16.10%
AA	Oil/Gas EGU NM	0.1313	71.1	0.18%
AB	Oil/Gas EGU CO	1.3495	73.4	1.84%
AC	All EGUs in 4km Domain	13.6008	73.6	18.48%
AD	CO Mining + Coal EGUs CO	11.8387	73.5	16.11%
AE	CO O&G + Oil/Gas EGUs CO	17.5198	72.3	24.24%
AF	NM O&G + Oil/Gas EGU NM	1.1364	71.1	1.60%

Table 5-41b. Maximum ozone contribution by Source Group to total modeled 2021 4th high DMAX8 ozone greater than the NAAQS for the 2021 Low Development Scenario.

Group	Name	Max		
		Max Contribution (ppb)	Corresponding 4th MDA8	% Max Contribution
A	Little Snake FO	0.0509	71.5	0.07%
B	White River FO	0.3628	71.7	0.51%
C	Colorado River Valley FO (CRVFO)	0.1029	71.0	0.14%
D	Roan Plateau Planning area portion of CRVFO	0.0976	71.8	0.14%
E	Grand Junction FO	0.1028	71.5	0.14%
F	Uncompahgre FO	0.0433	71.0	0.06%
G	Tres Rios FO	0.0536	71.2	0.08%
H	Kremmling FO	0.0106	71.2	0.01%
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0.0053	71.5	0.01%
J	Pawnee Grasslands portion of RGFO#1	0.0194	71.5	0.03%
K	RGFO#2 – West-Central/South	0.0021	71.3	0.00%
L	RGFO#3 – South	0.0321	71.0	0.05%
M	RGFO#4 – East-Central	0.0035	71.0	0.00%
N	New Mexico Farmington FO	0.3359	71.5	0.47%
O	Total Colorado River Field Office	0.1978	71.8	0.28%
P	Total Royal Gorge Field Office	0.0321	71.0	0.05%
Q	Mining from 13 Colorado BLM Planning Areas	0.2042	72.5	0.28%
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	0.6207	73.5	0.84%
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	6.2129	71.7	8.66%
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	6.2171	71.7	8.67%
U	Combined O&G and Mining in 4 km domain	24.7389	76.1	32.53%
V	Natural Emissions	6.1439	71.5	8.59%
Y	Coal EGU NM	13.4862	73.5	18.34%
Z	Coal EGU CO	11.8342	73.4	16.13%
AA	Oil/Gas EGU NM	0.1184	71.6	0.17%
AB	Oil/Gas EGU CO	1.0016	72.7	1.38%
AC	All EGUs in 4km Domain	13.6008	73.5	18.50%
AD	CO Mining + Coal EGUs CO	11.8387	73.4	16.14%
AE	CO O&G + Oil/Gas EGUs CO	6.7264	71.1	9.45%
AF	NM O&G + Oil/Gas EGU NM	0.4243	71.5	0.59%

Table 5-41c. Maximum ozone contribution by Source Group to total modeled 2021 4th high DMAX8 ozone greater than the NAAQS for the 2021 Medium Development Scenario.

Group	Name	Max		
		Max Contribution (ppb)	Corresponding 4th MDA8	% Max Contribution
A	Little Snake FO	0.2412	72.7	0.33%
B	White River FO	2.5776	71.2	3.62%
C	Colorado River Valley FO (CRVFO)	1.3502	71.0	1.90%
D	Roan Plateau Planning area portion of CRVFO	1.8582	71.7	2.59%
E	Grand Junction FO	4.9609	71.2	6.97%
F	Uncompahgre FO	0.3327	71.5	0.47%
G	Tres Rios FO	0.3298	71.7	0.46%
H	Kremmling FO	0.0646	71.8	0.09%
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0.0197	71.2	0.03%
J	Pawnee Grasslands portion of RGFO#1	0.0591	71.2	0.08%
K	RGFO#2 – West-Central/South	0.0205	71.1	0.03%
L	RGFO#3 – South	0.0368	71.0	0.05%
M	RGFO#4 – East-Central	0.0176	71.0	0.02%
N	New Mexico Farmington FO	0.4071	72.4	0.56%
O	Total Colorado River Field Office	2.9149	71.7	4.06%
P	Total Royal Gorge Field Office	0.0806	71.9	0.11%
Q	Mining from 13 Colorado BLM Planning Areas	0.4741	71.2	0.67%
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	6.9959	71.2	9.82%
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	16.2105	71.2	22.76%
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	16.2347	71.2	22.80%
U	Combined O&G and Mining in 4 km domain	26.2502	78.0	33.64%
V	Natural Emissions	24.9712	75.1	33.24%
Y	Coal EGU NM	13.4862	73.6	18.33%
Z	Coal EGU CO	11.8342	73.5	16.11%
AA	Oil/Gas EGU NM	0.1184	72.1	0.16%
AB	Oil/Gas EGU CO	1.3495	73.3	1.84%
AC	All EGUs in 4km Domain	13.6008	73.6	18.49%
AD	CO Mining + Coal EGUs CO	11.8387	73.5	16.11%
AE	CO O&G + Oil/Gas EGUs CO	16.1895	71.2	22.74%
AF	NM O&G + Oil/Gas EGU NM	0.4804	72.4	0.66%

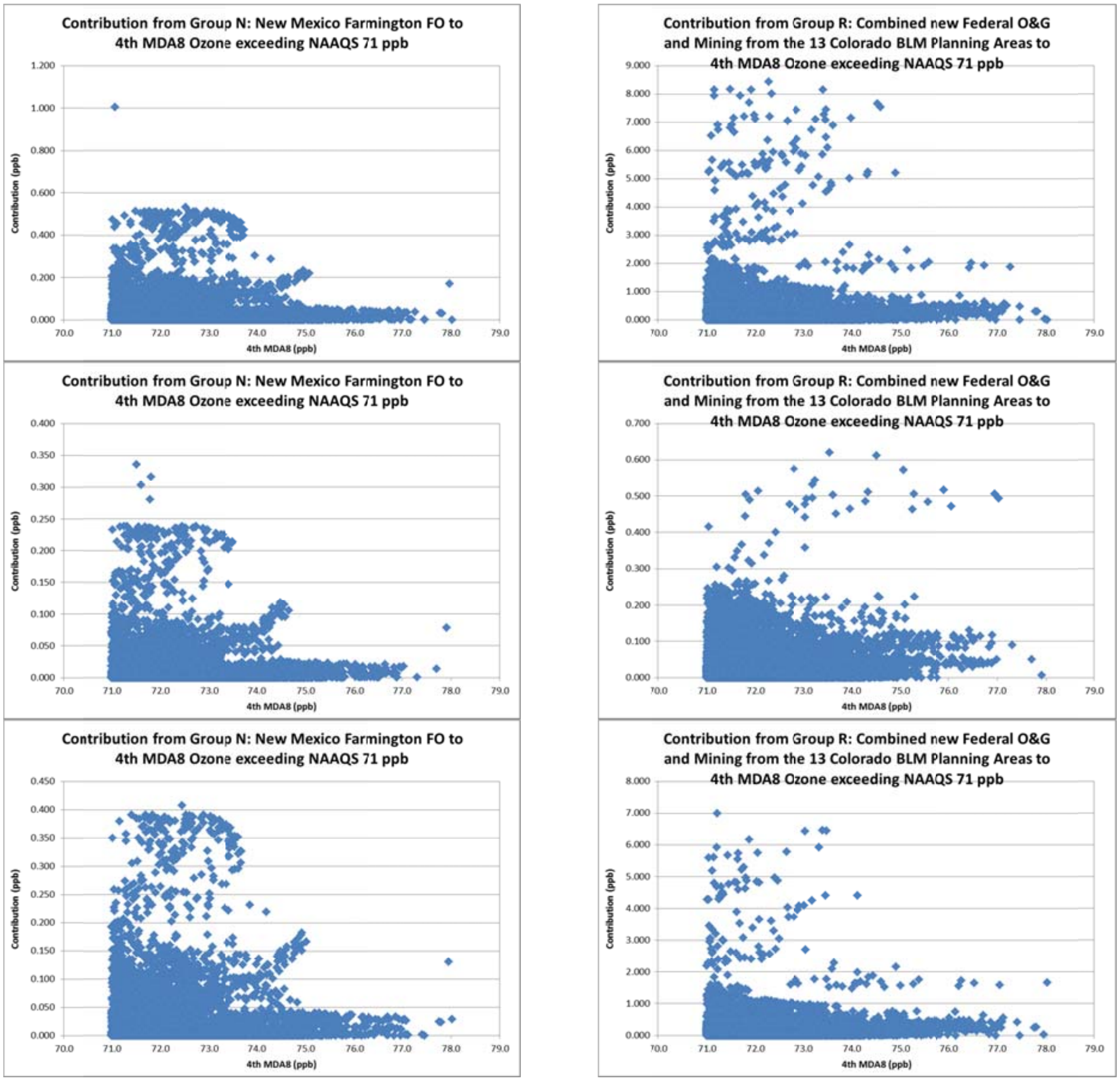


Figure 5-7a. Contributions of Federal O&G from the NMFFO (Source Group N; left) and new Federal O&G and mining in the 13 Colorado Planning Areas (Source Group R; right) to modeled fourth highest daily maximum 8-hour ozone concentrations greater than the NAAQS for the 2021 High (top), Low (middle) and Medium (bottom) Development Scenarios.

Figure 5-7b. Contributions of new Federal and non-Federal O&G and mining from the 14 BLM Planning Areas (Source Group T; left) and all O&G within the 4 km CARMMS domain plus Colorado Federal mining (Source Group U; right) to modeled fourth highest daily maximum 8-hour ozone concentrations greater than the NAAQS for the 2021 High (top), Low (middle) and Medium (bottom) Development Scenarios.

5.6.3 $PM_{2.5}$ NAAQS Analysis

There are two $PM_{2.5}$ NAAQS, one for a 24-hour averaging time that is expressed as a three-year average of the 98th percentile value in a year with a threshold of 35 µg/m^3 and an annual average over three-years with a threshold of 12 µg/m^3. With a complete year of modeling results, the 98th percentile corresponds to the 8th highest daily $PM_{2.5}$ concentration in a year.

5.6.3.1 24-Hour $PM_{2.5}$ NAAQS Analyses

Figure 5-8 displays the 8th highest 24-hour $PM_{2.5}$ concentrations for the 2008 Base Case and 2021 emission scenarios and their differences and the contributions of Natural Emissions to the 8th highest 24-hour $PM_{2.5}$ concentration. The maximum 8th high 24-hour $PM_{2.5}$ in 2008 (671 µg/m^3) and 2021 High, Low and Medium Development Scenarios (670 µg/m^3) far exceeds the 35 µg/m^3 NAAQS (Figure 5-8, top panels). This high value occurs on the southern border of the CARMMS 4 km domain and is due to emissions from wildfires, as shown by its absence when Natural Emissions are removed (Figure 5-8, bottom right). Even without Natural Emissions, there are several areas where the model-estimated 8th highest 24-hour $PM_{2.5}$ concentration exceeds the NAAQS in the 2021 emissions scenarios as shown in Figure 5-9 for the 2021 High Development Scenario. These 24-hour $PM_{2.5}$ exceedance areas are identified in Figure 5-9 with numbered labels. In the analysis below we group several exceedance grid cells together: North NM (Areas 13-18); Arizona (Areas 7-9); and Central NM (Areas 11-12).

Attachments H-1, H-2 and H-3 display Source Group's contribution to 8th highest 24-hour $PM_{2.5}$ concentrations when the total concentration is above the NAAQS for the 2021 High, Low and Medium Development Scenarios, respectively. Figure 5-10 from Attachment H-1 displays the contributions of Natural Emissions (Source Group V) and Federal mining in Colorado (Source Group Q) to the 8th highest 24-hour $PM_{2.5}$ concentration in the 2021 High Development Scenario when it exceeds the 24-hour $PM_{2.5}$ NAAQS. The exceedances in Ruidoso NM (Area 10) and North NM (Areas 13-18) appear to be due to wildfires (Natural Emissions) based on the top panel in Figure 5-10. Mining on Federal lands (Source Group Q) is causing the exceedance in South Moffat County (Area 3) based on the bottom panel in Figure 5-10.

The contributions to the 8th highest daily $PM_{2.5}$ concentrations that exceed the NAAQS from Source Groups R and S and the 2021 High Development Scenario are shown in Figure 5-11. For Source Group R, the scale has been set at a maximum of 0.25 µg/m^3 (Figure 5-11, top) so the 45.8 µg/m^3 contribution from mining in South Moffat County that was seen in Figure 5-10 (bottom) is not shown. This figure indicates that new Federal O&G within the 13 CO BLM Planning Areas contribute less than 0.25 µg/m^3 when the modeled 2021 8th highest 24-hour $PM_{2.5}$ concentration exceeds the NAAQS (Figure 5-11, top). Adding in the non-Federal O&G emissions (Source Group S; Figure 5-11, bottom) we see contributions due to non-Federal O&G to modeled exceedances of the NAAQS as high as 15 µg/m^3 that is due to non-Federal O&G emissions in the RGFO Planning Area north of Denver (Weld County).

Figure 5-12 displays the contributions of Federal O&G from the GRFO, UFO and USFS-PG Planning Areas and combined Source Group R (new Federal O&G and mining in 13 Colorado Planning Areas) to the 8th highest 24-hour $PM_{2.5}$ concentrations for the 2021 High Development Scenario. Results for the 2021 Low and Medium Development Scenario are lower and can be found in Attachment I. The maximum contribution to 8th highest 24-hour $PM_{2.5}$ concentration due to emissions from new Federal O&G in these four Source Groups in the High Development Scenario are 1.8 µg/m^3 (GJFO), 0.4 µg/m^3 (UFO), 0.7 µg/m^3 (USFS-PG) and 45.7 µg/m^3 (Source Group R) (Table 5-42). The maximum contribution due to new Federal O&G and mining from all of the Colorado BLM Planning areas (45.7 µg/m^3) is due to a coal mine in the LSFO Planning Area.

Figure 5-13a shows the contributions of new Federal O&G emissions in the NMFFO Planning Area (Mancos Shale; Source Group N) to $PM_{2.5}$ concentrations in the three 2021 scenarios. The peak 8th highest daily $PM_{2.5}$ concentrations are 0.8, 0.3 and 0.4 µg/m^3 in the 2021 High, Low and Medium Development Scenarios, respectively.

Figure 5-13b presents the contributions of new Federal and non-Federal O&G and mining in the 14 BLM Planning Areas (Source Group T) and all O&G emissions in the 4 km CARMMS domain (Source Group U) for the 2021 High, Low and Medium Development Scenarios. The maximum 24-hour $PM_{2.5}$ contribution in all four panels in Figure 5-12 is essentially identical (45.7 µg/m^3) and is due to a coal mine in the LSFO Planning Area. 24-hour $PM_{2.5}$ contributions in excess of 3 µg/m^3 can be seen in the D-J and Piceance Basins and the Uinta Basin for Source Group U.

Table 5-42 summarizes the maximum contribution to the 8th highest 24-hour $PM_{2.5}$ concentrations for all of the Source Groups and the 2021 High, Low and Medium Development Scenarios. For most BLM Planning Areas, the contribution of Federal O&G to the 8th highest 24-hour $PM_{2.5}$ concentrations is small, less than 1 µg/m^3. The exception to this is new Federal O&G emissions from the WRFO Planning Area (6.8, 0.6 and 5.1 µg/m^3) and GJFO Planning Area (1.8, 0.1 and 1.4 µg/m^3) in the High, Low and Medium scenarios, respectively. FFO contributions are small: 0.8, 0.3 and 0.4 µg/m^3 in the High, Low and Medium scenarios, respectively. As noted previously, mining on Federal lands in the LSFO contributes a maximum of 45.7 µg/m^3 to the 8th highest 24-hour $PM_{2.5}$ concentration; the mining contribution drives the maximum contribution for all of the combination Source Groups (Q through U).

The year 2021 minus year 2008 impacts difference plots (bottom left of Figures 5-8a, 5-8b and 5-8c) while comparing plots for Source Groups R and T indicates relatively large increases in 24-hour $PM_{2.5}$ concentrations primarily due to new non-Federal oil and gas in the RGFO. It should be noted that unpaved road traffic and construction fugitive dust emissions were calculated by the BLM COSO for all new RGFO Federal and non-Federal oil and gas development and the year 2008 emissions inventory did not account for total oil and gas related traffic / construction fugitive dust and therefore, the difference plots concentration changes (year 2021 minus year 2008) are overestimates.

Table 5-42a. Maximum contribution to the 8th high 24-hour $PM_{2.5}$ concentrations (µg/m^3) for each of the Source Groups and the 2021 High, Low and Medium Development Scenarios.

Source Group	High	Low	Medium
A. Little Snake FO	0.51	0.11	0.57
B. White River FO	6.81	0.64	5.10
C. Colorado River Valley FO (w/o Roan Plateau)	0.42	0.23	0.29
D. Roan Plateau	0.28	0.12	0.20
E. Grand Junction FO	1.76	0.10	1.40
F. Uncompahgre FO	0.37	0.06	0.17
G. Tres Rios FO	0.42	0.04	0.26
H. Kremmling FO	0.06	0.01	0.03
I. Royal Gorge FO No. 1 (North)	0.16	0.02	0.05
J. Pawnee Grasslands	0.66	0.11	0.23
K. Royal Gorge FO No. 2	0.07	0.01	0.05
L. Royal Gorge FO No. 3	0.02	0.01	0.01
M. Royal Gorge FO No. 4	0.11	0.01	0.04
N. New Mexico Farmington FO (Mancos)	0.82	0.30	0.37
O. Colorado River Valley FO (w/ Roan Plateau)	0.70	0.32	0.49
P. Royal Gorge FO (total)	0.82	0.14	0.28
Q. Federal Mining in Colorado	45.62	45.62	45.62
R. New Federal O&G and Mining In Colorado	45.74	45.65	45.72
S. New Federal/Non-Federal O&G/Mining in CO	45.76	45.66	45.75
T. New Federal/Non-Federal O&G/Mining in CO/NM	45.76	45.66	45.75
U. Existing and New Fed/Non-Fed O&G in 4 km Domain	45.84	45.75	45.83
V. Natural Emissions	659.84	659.84	659.84
Y. Coal EGU NM	21.19	27.91	21.19
Z. Coal EGU CO	3.85	3.53	3.85
AA. Oil/Gas EGU NM	0.04	0.04	0.04
AB. Oil/Gas EGU CO	0.15	0.15	0.15
AC. All EGUs in 4 km Domain	21.21	27.92	21.21
AD. CO Mining + Coal EGUs CO	45.67	45.67	45.67
AE. CO O&G + Oil/Gas EGUs CO	14.16	7.80	14.14
AF. NM O&G + Oil/Gas EGU NM	0.82	0.30	0.37

Table 5-42b. Maximum contribution to the annual $PM_{2.5}$ concentrations ($\mu g/m^3$) for each of the Source Groups and the 2021 High, Low and Medium Development Scenarios.

Source Group	Annual $PM_{2.5}$ ($\mu g/m^3$)		
	High	Low	Medium
A. Little Snake FO	0.65	0.09	0.47
B. White River FO	4.44	0.74	2.65
C. CRVFO (No Roan)	0.29	0.19	0.19
D. Roan Plateau	0.23	0.12	0.18
E. Grand Junction FO	0.97	0.07	0.56
F. Uncompahgre FO	0.22	0.07	0.13
G. Tres Rios FO	0.39	0.05	0.21
H. Kremmling FO	0.03	0.00	0.02
I. Royal Gorge FO No. 1	0.05	0.01	0.02
J. Pawnee Grasslands	0.23	0.05	0.08
K. Royal Gorge FO No. 2	0.04	0.00	0.03
L. Royal Gorge FO No. 3	0.01	0.01	0.01
M. Royal Gorge FO No. 4	0.07	0.01	0.02
N. NMFFO (Mancos)	0.31	0.15	0.19
O. CRVFO (w/ Roan)	0.46	0.27	0.33
P. Royal Gorge FO (total)	0.28	0.06	0.10
Q. Federal Mining in CO	20.69	20.69	20.69
R. New Federal O&G/Mining in CO	20.74	20.70	20.74
S. New O&G/Mining in CO	20.77	20.72	20.76
T. New O&G/Mining in CO/NM	20.77	20.72	20.76
U. All O&G in 4 km Domain	20.81	20.76	20.81
V. Natural Emissions	26.45	26.45	26.45
Y. Coal EGU NM	11.42	11.42	11.42
Z. Coal EGU CO	1.06	1.06	1.06
AA. Oil/Gas EGU NM	0.02	0.02	0.02
AB. Oil/Gas EGU CO	0.02	0.02	0.02
AC. All EGUs in 4 km Domain	11.43	11.43	11.43
AD. CO Mining + Coal EGUs CO	20.76	20.76	20.76
AE. CO O&G + Oil/Gas EGUs CO	4.87	1.81	4.13
AF. NM O&G + Oil/Gas EGU NM	0.31	0.15	0.19

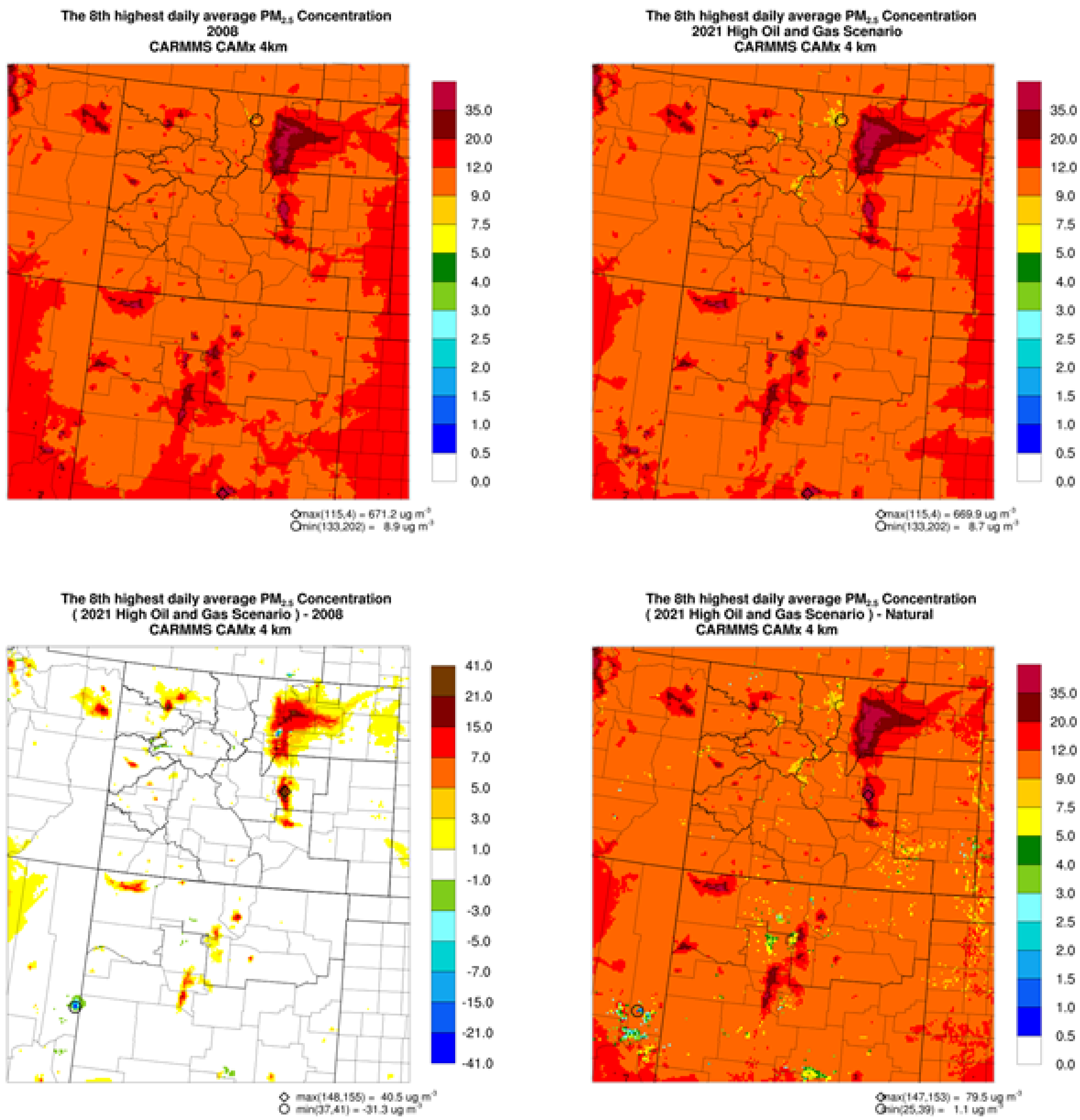


Figure 5-8a. Eighth highest 24-hour $PM_{2.5}$ concentrations for the 2008 Base Case (top left), 2021 High Development Scenario (top right), 2021 High minus 2008 differences (bottom left) and Natural Emissions (bottom right).

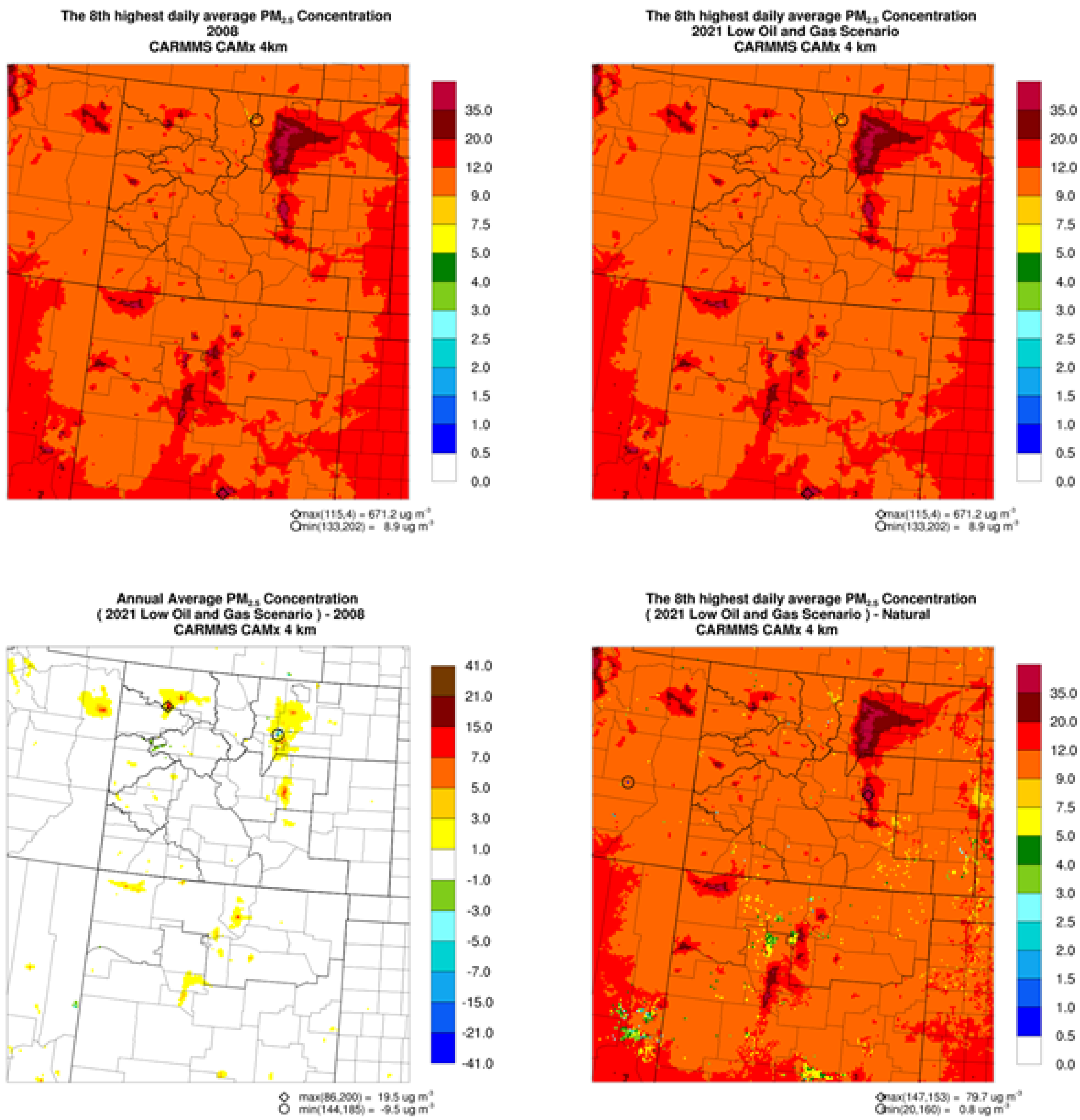


Figure 5-8b. Eighth highest 24-hour $PM_{2.5}$ concentrations for the 2008 Base Case (top left), 2021 Low Development Scenario (top right), 2021 Low minus 2008 differences (bottom left) and Natural Emissions (bottom right).

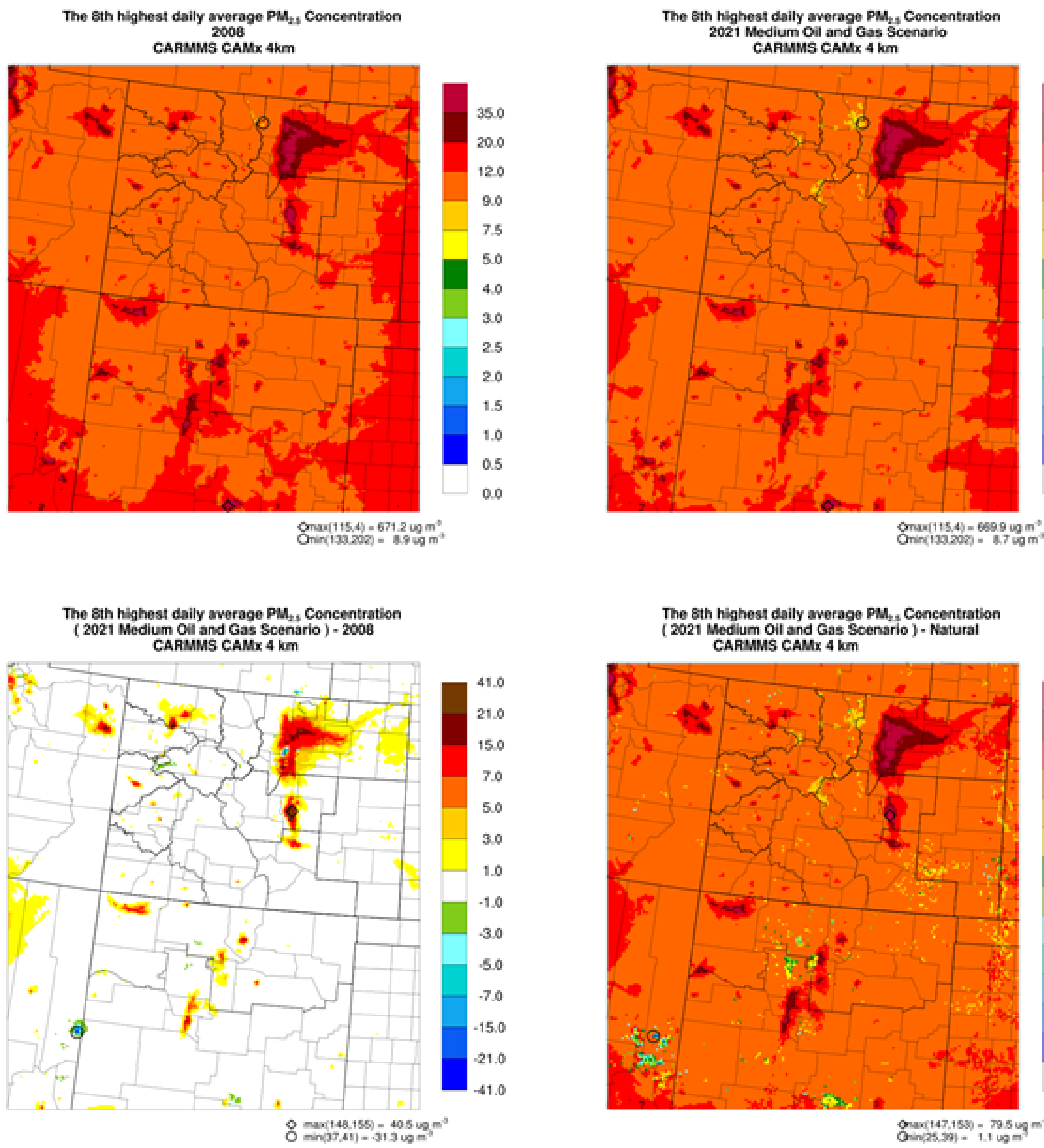


Figure 5-8c. Eighth highest 24-hour $PM_{2.5}$ concentrations for the 2008 Base Case (top left), 2021 Medium Development Scenario (top right), 2021 Medium minus 2008 differences (bottom left) and Natural Emissions (bottom right).

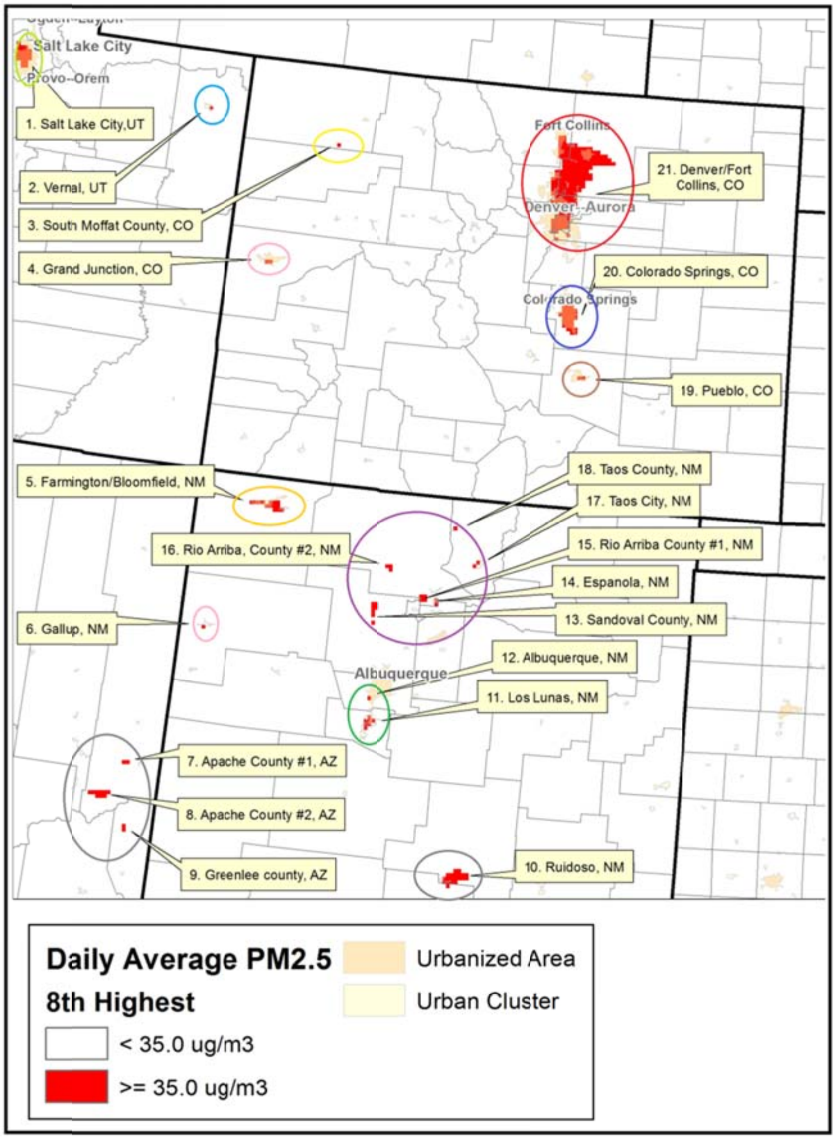


Figure 5-9. Locations of grid cells with modeled 2021 High Development Scenario 8th highest 24-hour $PM_{2.5}$ concentrations above the 35 $\mu g/m^3$ NAAQS.

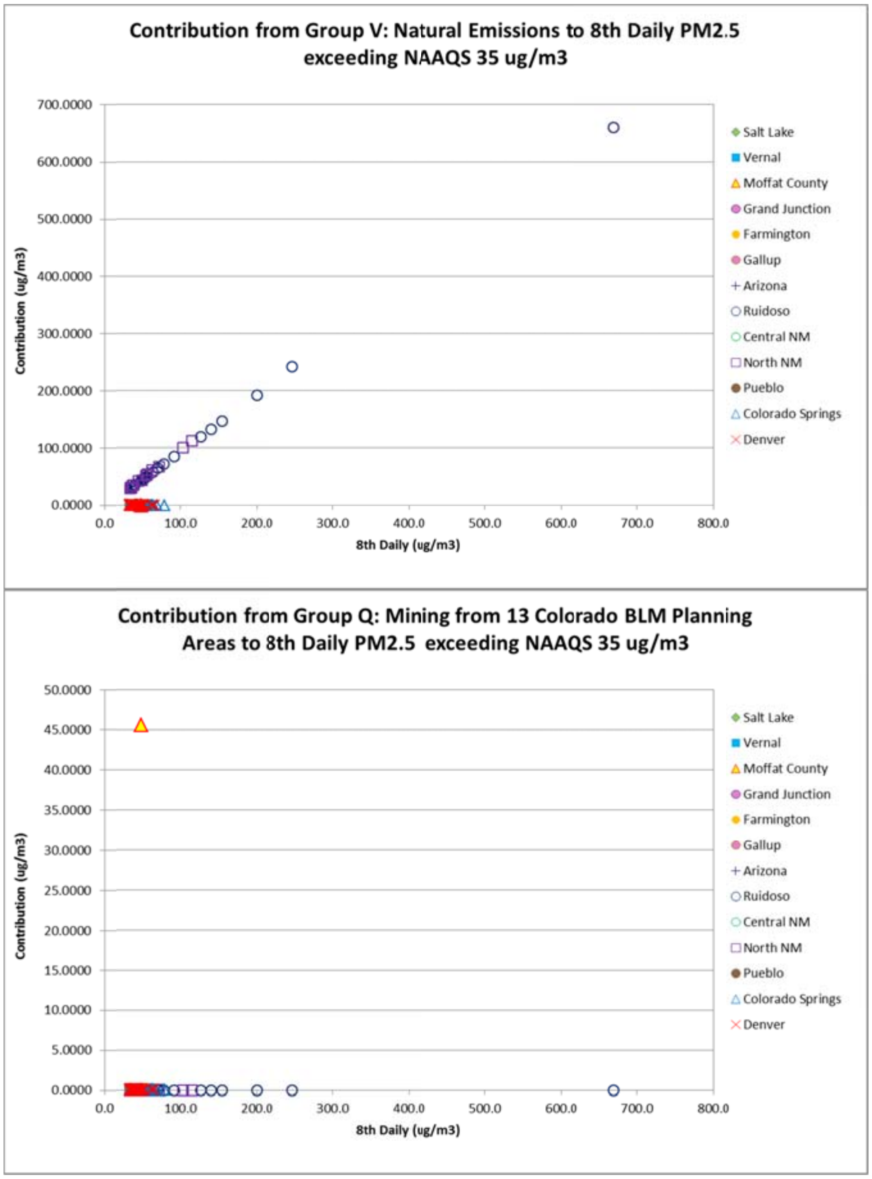


Figure 5-10. Natural Emissions (Source Group V, top) and Mining of Federal land in Colorado (Source Group Q, bottom) contributions to the modeled 8th highest 24-hour $PM_{2.5}$ concentration from the 2021 High Development Scenario.

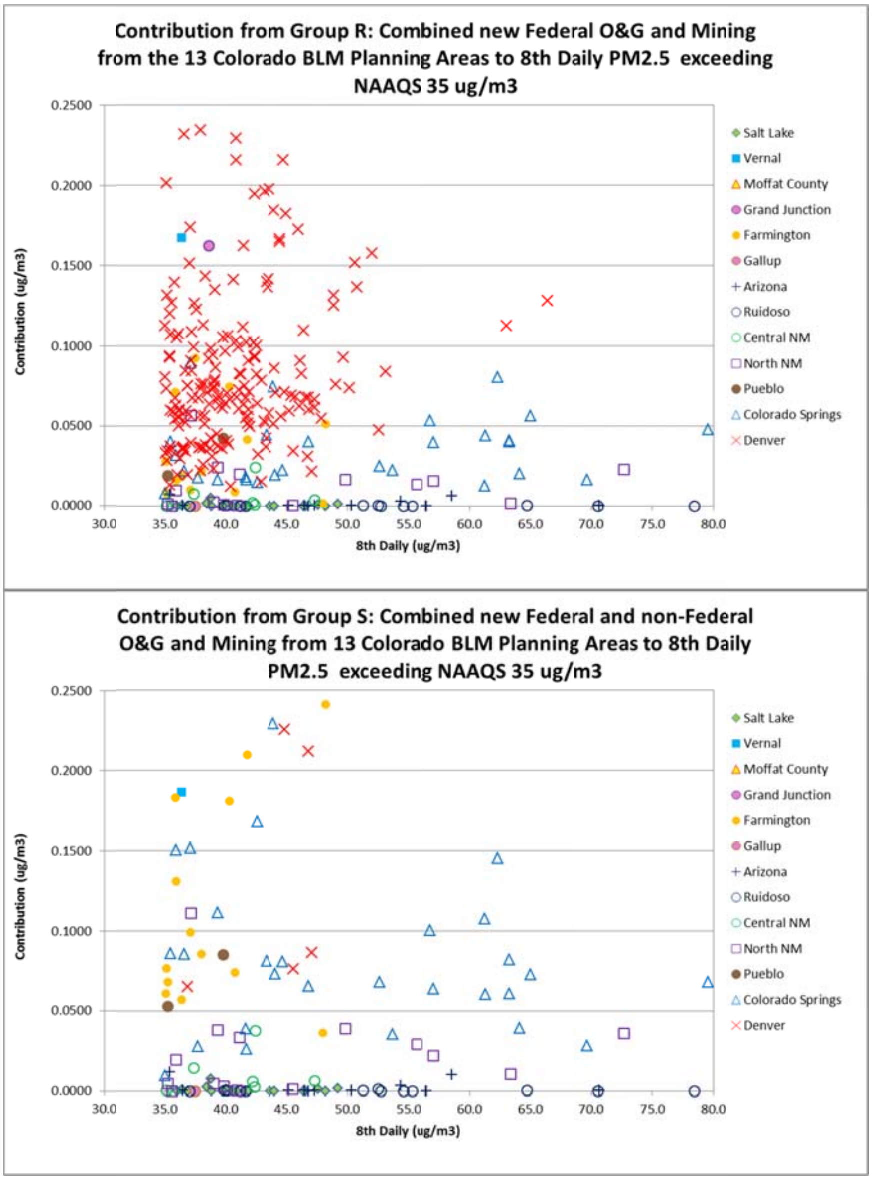


Figure 5-11. Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas (Source Group R, top) and Mining of Federal land in Colorado (Source Group S, bottom) contributions to the modeled 8th highest 24-hour $PM_{2.5}$ concentration from the 2021 High Development Scenario.

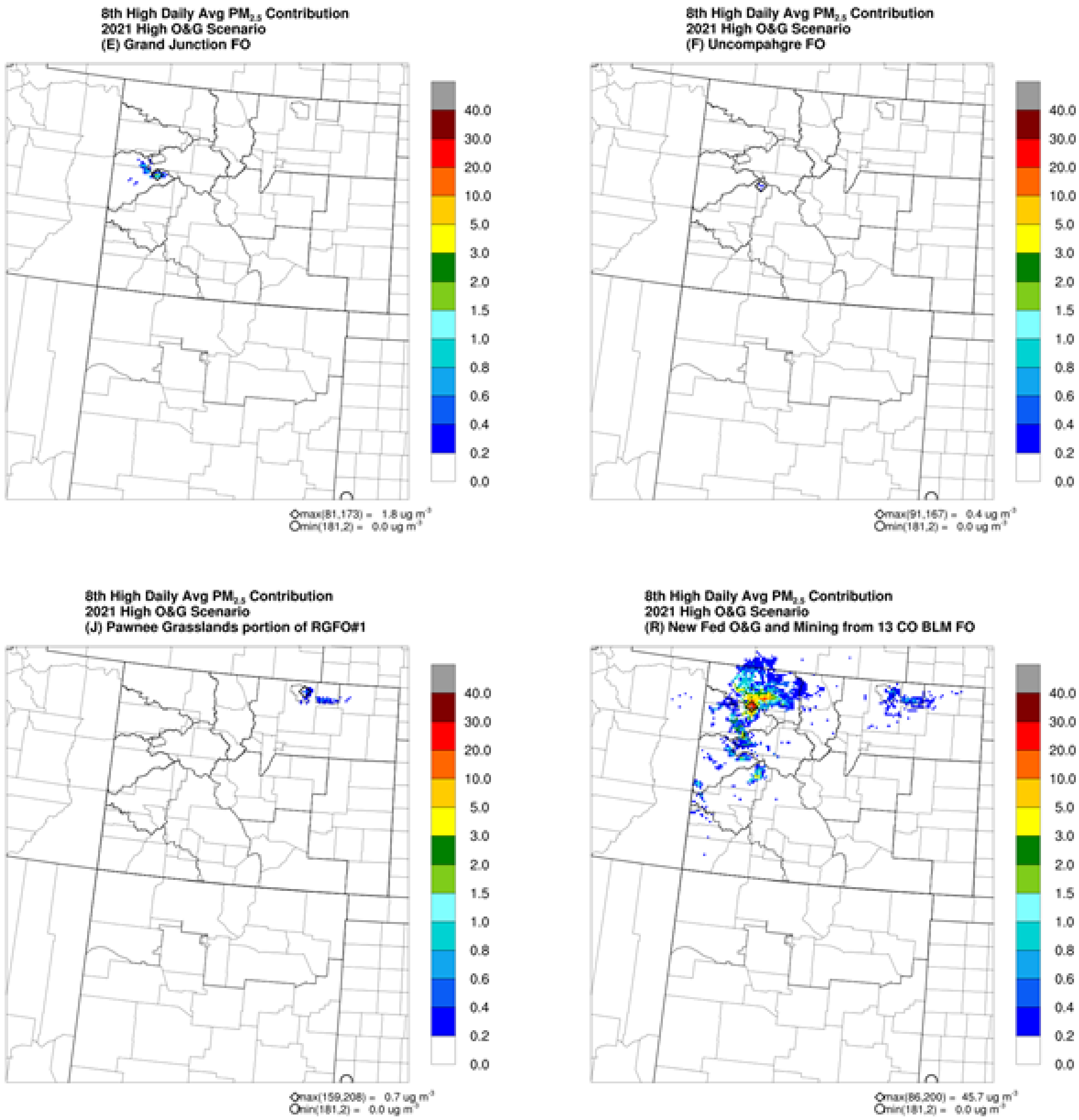


Figure 5-12. Contribution to 8th highest daily $PM_{2.5}$ concentrations due to emissions from new Federal O&G within the GJFO (top left), UFO (top right) and USFS-PG (bottom left) Planning Areas and new Federal O&G and mining within the 13 Colorado BLM Planning Areas (bottom right) for the 2021 High Development Scenario.

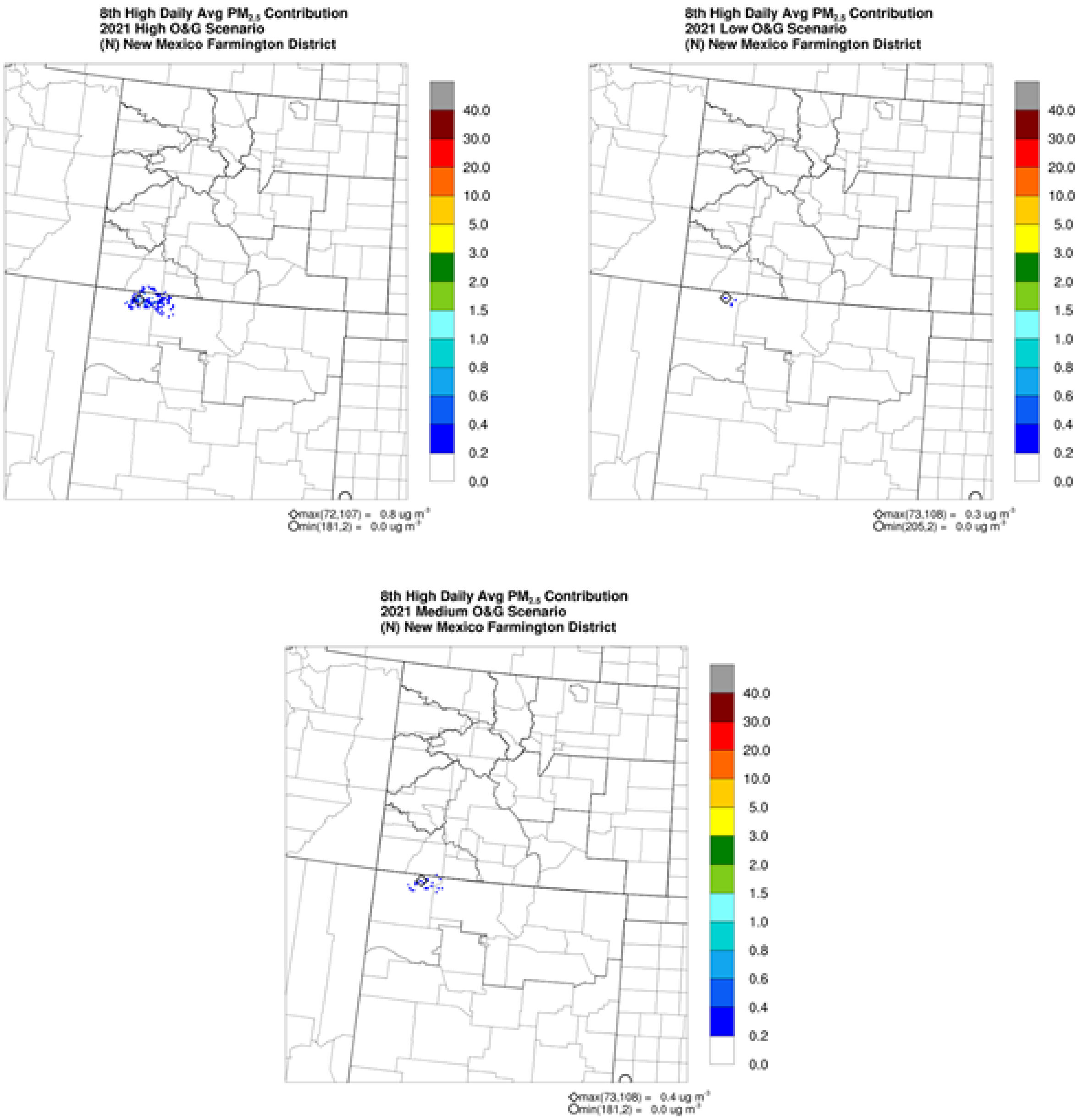


Figure 5-13a. Contribution to 8th highest daily $PM_{2.5}$ concentration from NM Farmington FO (source group N) for the 2021 High (top left), Low (top right) and Medium (bottom) Development Scenarios.

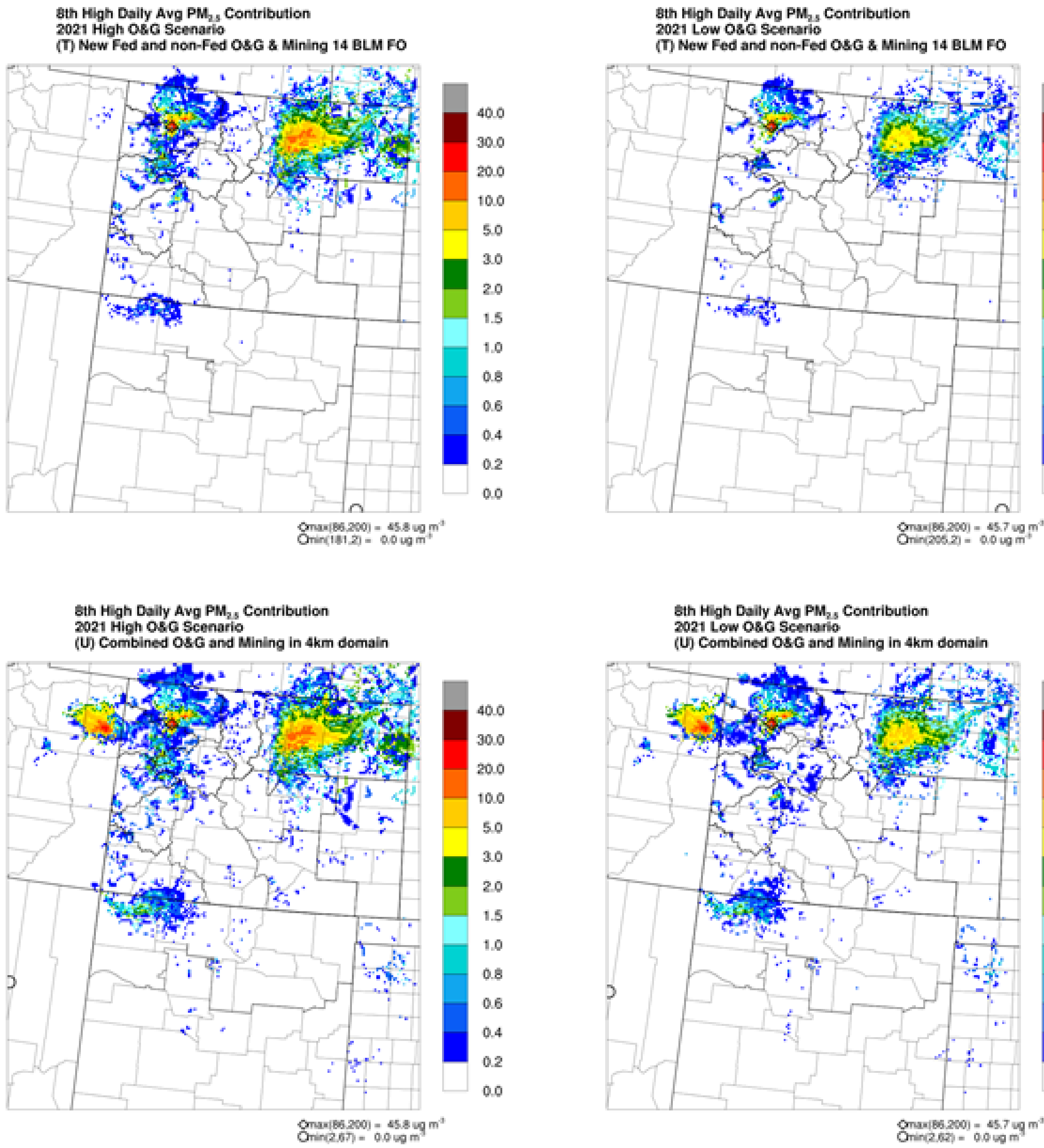


Figure 5-13b. Contribution to 8th highest daily $PM_{2.5}$ concentrations due to emissions from new Federal and non-Federal O&G and mining within the 14 BLM Planning Areas (top) and all O&G emissions within the 4 km CARMMS domain (bottom) for the 2021 High (left) and Low (right) Development Scenarios.

5.6.3.2 Annual $PM_{2.5}$ NAAQS Analysis

Figure 5-14 displays the annual average $PM_{2.5}$ concentrations for the 2008 Base Case and 2021 emissions scenarios and their differences and the annual average $PM_{2.5}$ concentrations without Natural Emissions. The highest annual average $PM_{2.5}$ concentration is about 33 µg/m^3 in the 2008 and 2021 emission scenarios and occurs in the southern most portion of the CARMMS 4 km domain near Ruidoso, NM and is due to wildfires since it is gone when the natural emissions are removed. However, even without Natural Emissions there are several areas where the modeled annual $PM_{2.5}$ concentrations exceed the 12 µg/m^3 annual $PM_{2.5}$ NAAQS (red areas in Figure 5-14) in the 2008 Base case and 2021 High and Low Development Scenarios. There are noticeable increases in $PM_{2.5}$ concentrations in Moffat County in the BLM LSFO Planning Area for the 2021 emission scenarios compared to the 2008 base case that are due to higher emissions from mines (Figure 5-14, top two panels). For example, the Colowyo mine $PM_{2.5}$ emissions are 325 TPY in the 2008 base case and 3,400 TPY in the 2021 emission scenarios.

The maximum contribution of each Source Group to annual $PM_{2.5}$ concentrations for the 2021 High and Low Development Scenarios are shown in Table 5-42b. With two exceptions, new Federal O&G within each of the 14 BLM Planning Areas have contributions of less than 1 µg/m^3 to annual average $PM_{2.5}$ concentrations. The two exceptions are the WRFO (4.4, 0.7 and 2.7 µg/m^3) and GJFO (1.0, 0.1 and 0.6 µg/m^3) Planning Areas, and even for those two areas the contributions of the 2021 Low Development Scenario are below 1 µg/m^3. Mining on Federal lands in Colorado contributes a maximum of 20.7 µg/m^3 due to the coal mine in the LSFO Planning Area. The maximum annual $PM_{2.5}$ due to mining drives the maximum annual $PM_{2.5}$ contributions for all of the combined Source Groups Q through U. Natural emissions (wildfires) contribute a maximum annual $PM_{2.5}$ contribution of 26.4 µg/m^3.

Figure 5-15a shows the contributions of new Federal O&G emissions in the NMFFO Planning Area (Mancos Shale; Source Group N) to $PM_{2.5}$ concentrations in the three 2021 scenarios. The spatial peaks of the annual average $PM_{2.5}$ concentrations are 0.3, 0.1 and 0.2 µg/m^3 in the 2021 High, Low and Medium Development Scenarios, respectively.

Figure 5-15b displays the differences in annual average $PM_{2.5}$ concentrations between the 2021 High Development Scenario and 2021 with the contributions from Source Groups F (UFO), J (USFS-PG), R and T removed; results for the 2021 Low and Medium Development Scenarios are similar but lower and can be found in Attachment I. Very small contributions to annual $PM_{2.5}$ are seen for new Federal O&G from the UFO and USFS-PG Planning Areas (maximum of 0.2 µg/m^3). The high contribution of the LSFO coal mine (20.7 µg/m^3) is seen in the Source Group R plot (Figure 5-15b, bottom left). Relatively high (> 3 µg/m^3) contributions to annual average $PM_{2.5}$ are seen in the Source Group T contributions in Weld County (Figure 5-15b, bottom right). These higher Weld County $PM_{2.5}$ contributions in Source Group T compared to Source Group R are due to $PM_{2.5}$ emissions from new non-Federal O&G emissions, which is confirmed by the spatial emission plots in Figure 3-10. As noted for $PM_{2.5}$ 24-hour average impacts discussion, unpaved road traffic and construction fugitive dust emissions were calculated by the BLM COSO for all new RGFO Federal and non-Federal oil and gas development and the year 2008 emissions inventory did not account for total oil and gas related traffic / construction fugitive dust and therefore, the difference plots concentration changes (year 2021 minus year 2008) are overestimates.

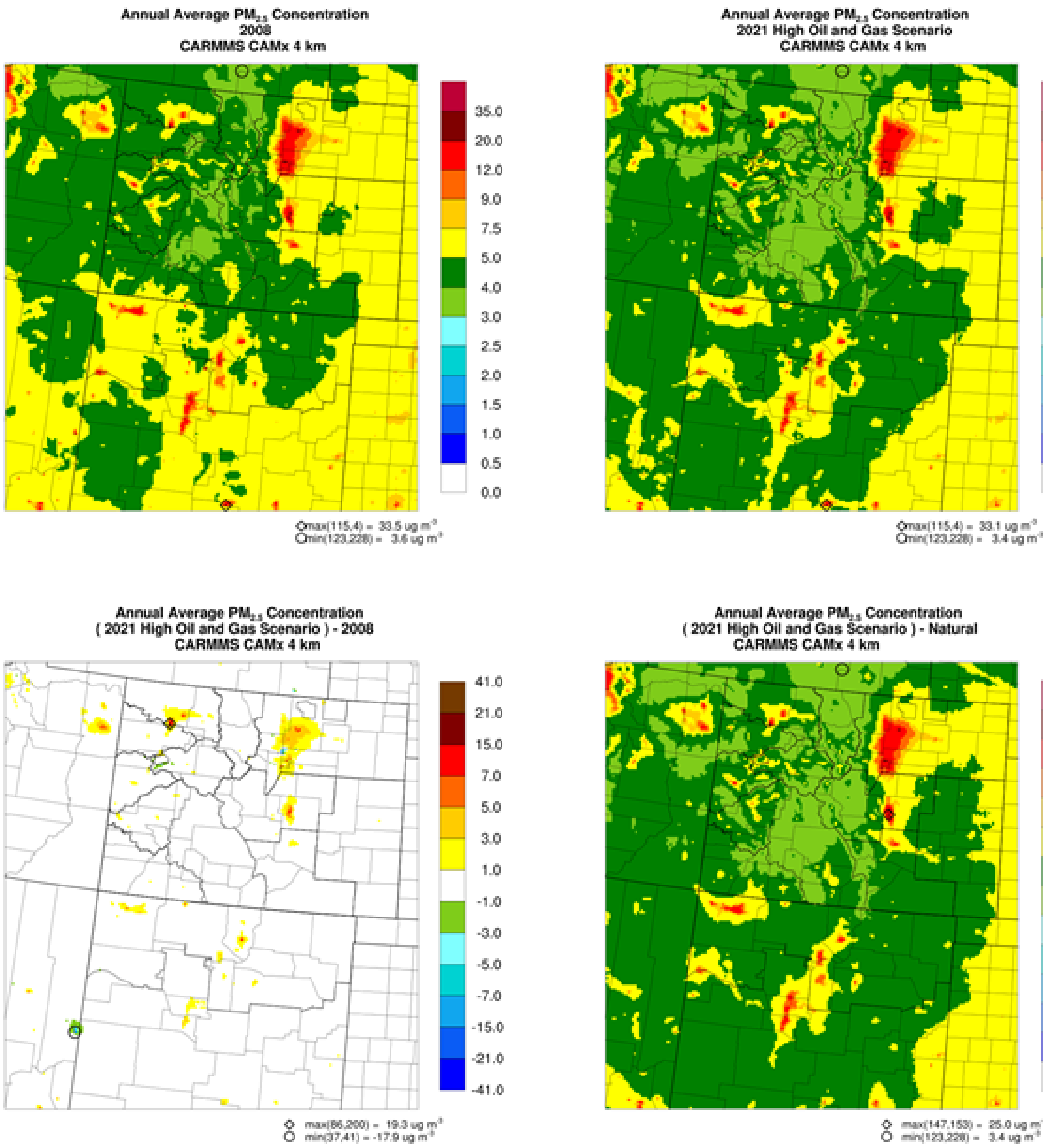


Figure 5-14a. Annual average $PM_{2.5}$ concentrations for the 2008 Base Case (top left), 2021 High Development Scenario (top right), 2021 High minus 2008 differences (bottom left) and Natural Emissions (bottom right).

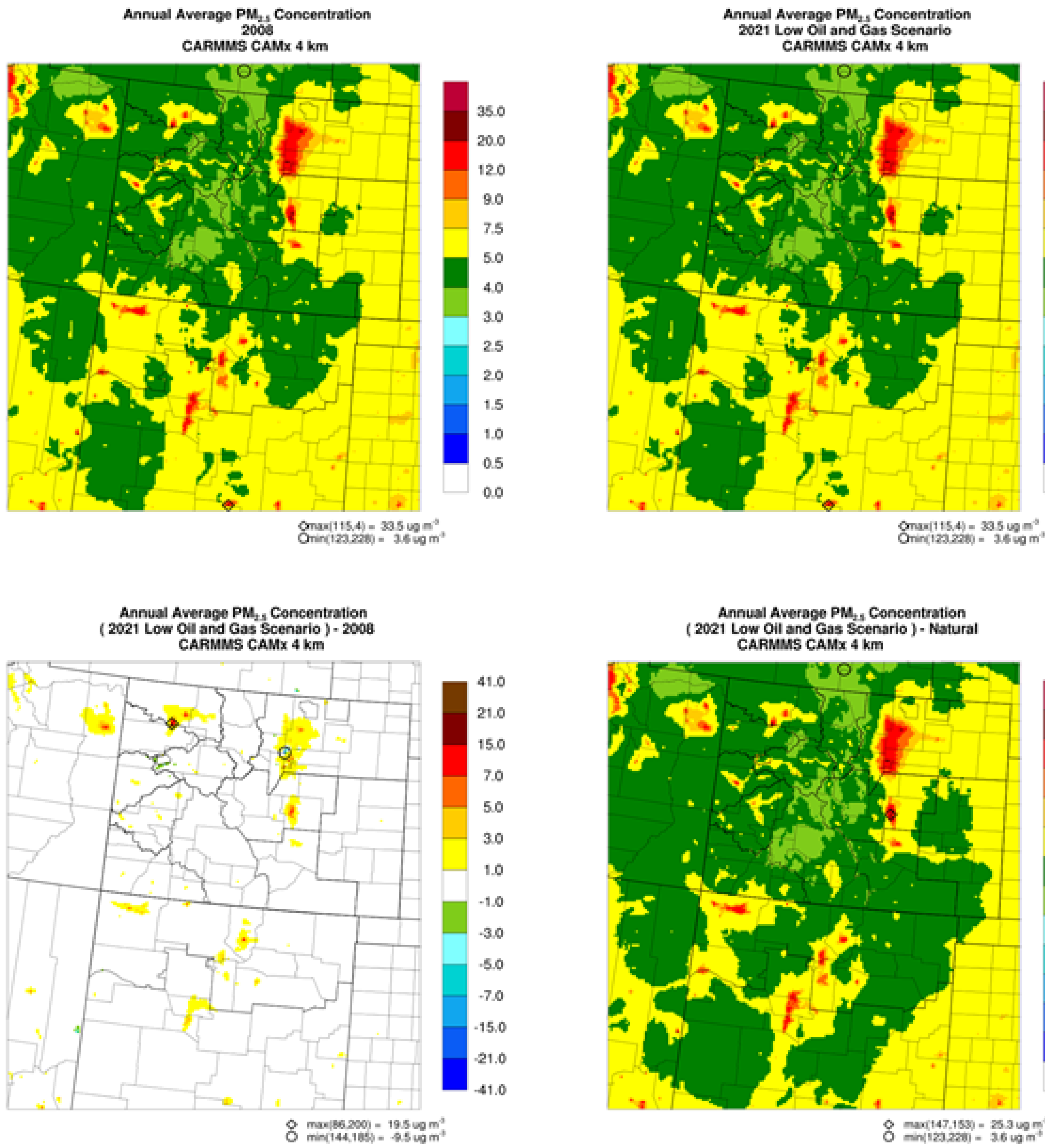


Figure 5-14b. Annual average $PM_{2.5}$ concentrations for the 2008 Base Case (top left), 2021 Low Development Scenario (top right), 2021 Low minus 2008 differences (bottom left) and Natural Emissions (bottom right).

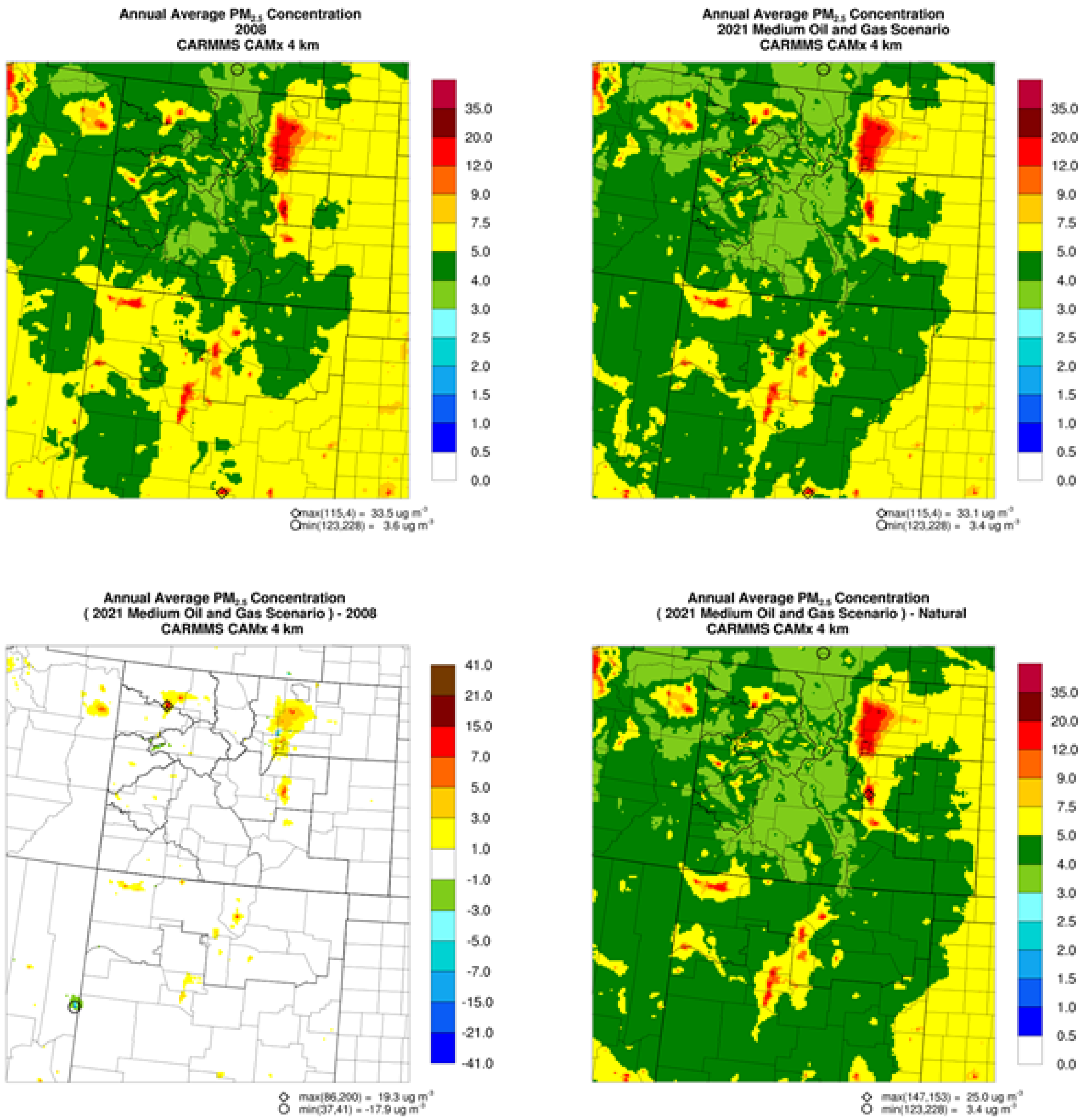


Figure 5-14c. Annual average $PM_{2.5}$ concentrations for the 2008 Base Case (top left), 2021 Medium Development Scenario (top right), 2021 Medium minus 2008 differences (bottom left) and Natural Emissions (bottom right).

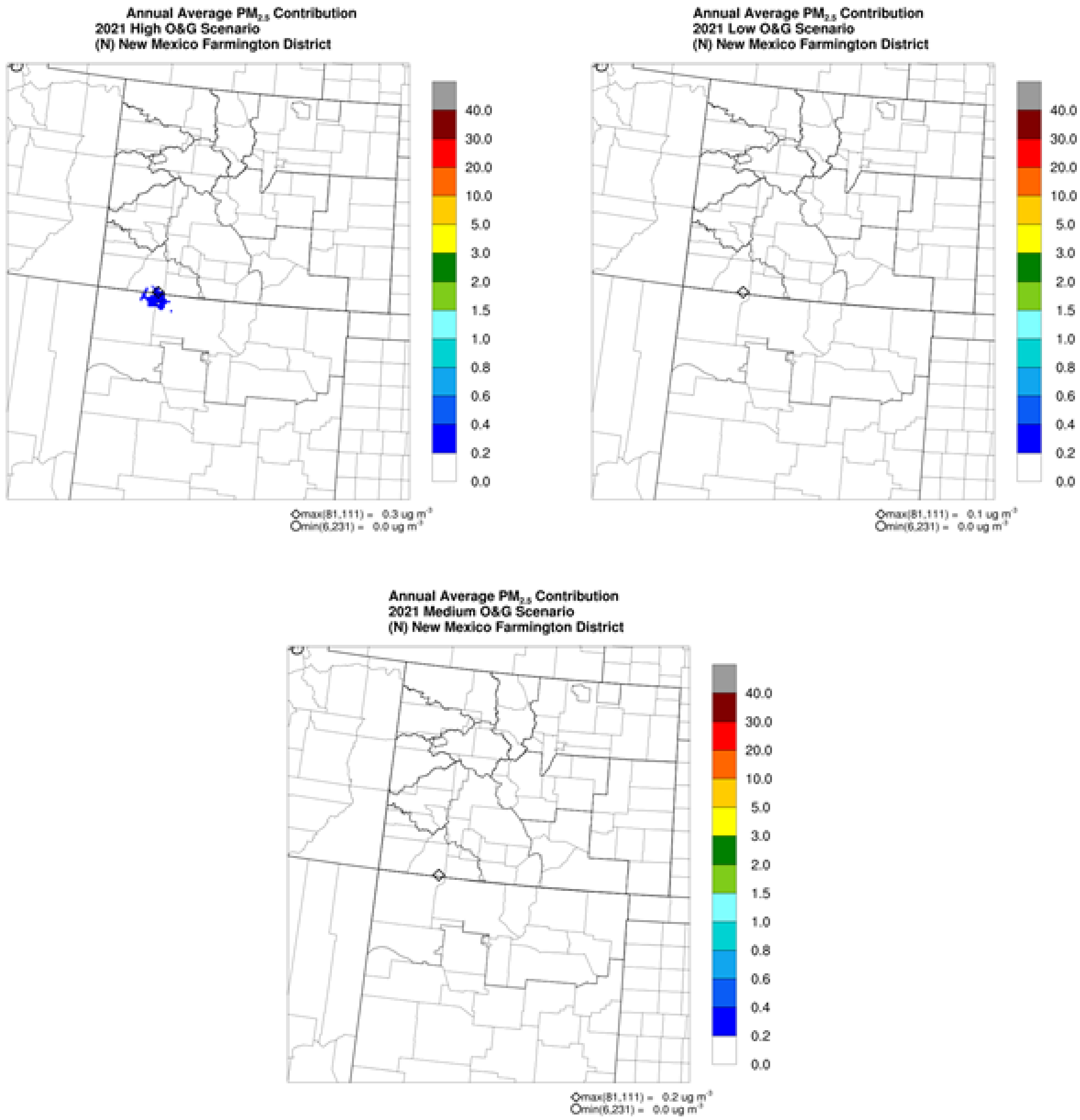


Figure 5-15a. Contribution to annual average $PM_{2.5}$ from NM Farmington FO (source group N) for the 2021 High (top left), Low (top right) and Medium (bottom) Development Scenarios.

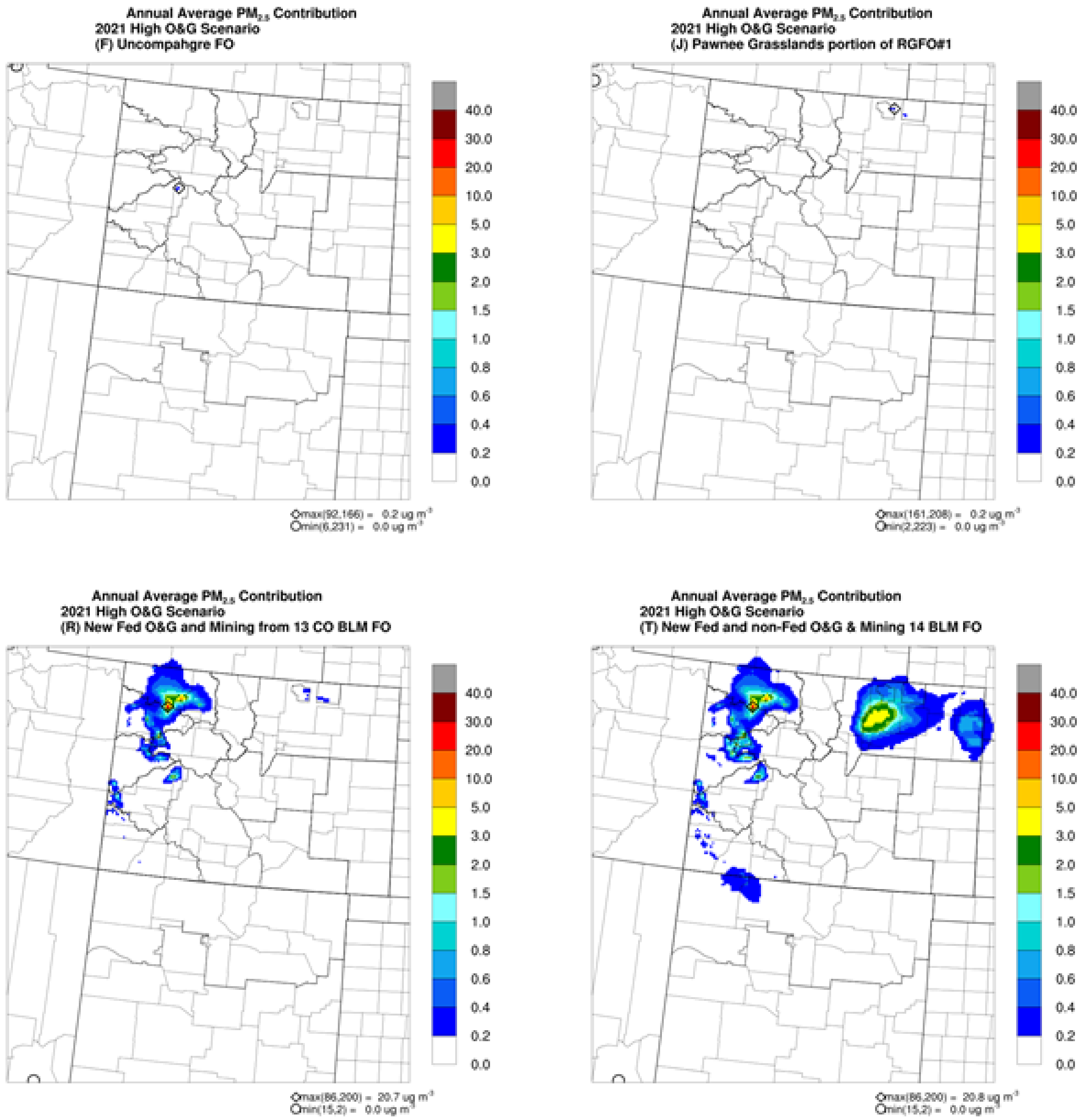


Figure 5-15b. Contribution to annual average $PM_{2.5}$ concentrations due to emissions from new Federal O&G within the UFO (top left) and USGS-PG (top right) Planning Areas and new O&G and mining from the 13 Colorado BLM Planning Areas (bottom left) and new Federal O&G and mining and non-Federal O&G from the 14 CO/NM BLM Planning Areas for the 2021 High Development Scenario.

5.6.4 PM_{10} NAAQS Analysis

Figures 5-16, 5-17a and 5-17b display the 2021 High Development Scenario modeling results for 24-hour PM_{10} that can be compared to the 150 $\mu g/m^3$ 24-hour PM_{10} NAAQS. Much of the discussion on 24-hour $PM_{2.5}$ also holds for 24-hour PM_{10}, although there are less exceedances of the 24-hour PM_{10} NAAQS since the threshold is higher. Extremely high highest second high PM_{10} concentrations occur in the 2008 and 2021 emissions scenarios that exceed 1,000 $\mu g/m^3$ (Figure 5-16, top panels). However, when natural emissions are removed the highest PM_{10} concentration drops to approximately 400 $\mu g/m^3$, which is much lower but still above the 24-hour PM_{10} NAAQS. With two exceptions, the maximum contribution of new Federal O&G emissions to the 2nd highest 24-hour PM_{10} concentrations from each of the BLM Planning Areas individually is less than 3 $\mu g/m^3$. The two exceptions and the maximum contributions due to the 2021 High, Low and Medium Development Scenarios are the WRFO (32, 3 and 12 $\mu g/m^3$) and GJFO (8, 0.2 and 4 $\mu g/m^3$) Planning Areas.

Figure 5-17a shows the contributions of new Federal O&G emissions in the NMFFO Planning Area (Mancos Shale; Source Group N) to PM_{10} concentrations in the three 2021 scenarios. The spatial peaks of the 2^{nd} highest 24-hour PM_{10} concentrations are 2.5, 1.1 and 1.1 $\mu g/m^3$ in the 2021 High, Low and Medium Development Scenarios, respectively.

The contributions due to new Federal O&G to 2^{nd} high 24-hour PM_{10} for the UFO and USFS-PG and the 2021 High Development Scenario are shown in the top two panels of Figure 5-17b with very small contributions seen. The bottom two panels in Figure 5-17b show the contributions of Source Groups R and T to the 2nd high 24-hour PM_{10} concentration for the 2021 High Development Scenario that display the mining contribution in South Moffat County and new non-Federal O&G contribution in Weld County. The contributions of all of the Source Groups and all three 2021 emission scenarios to 24-hour PM_{10} concentrations can be found in Attachment I.

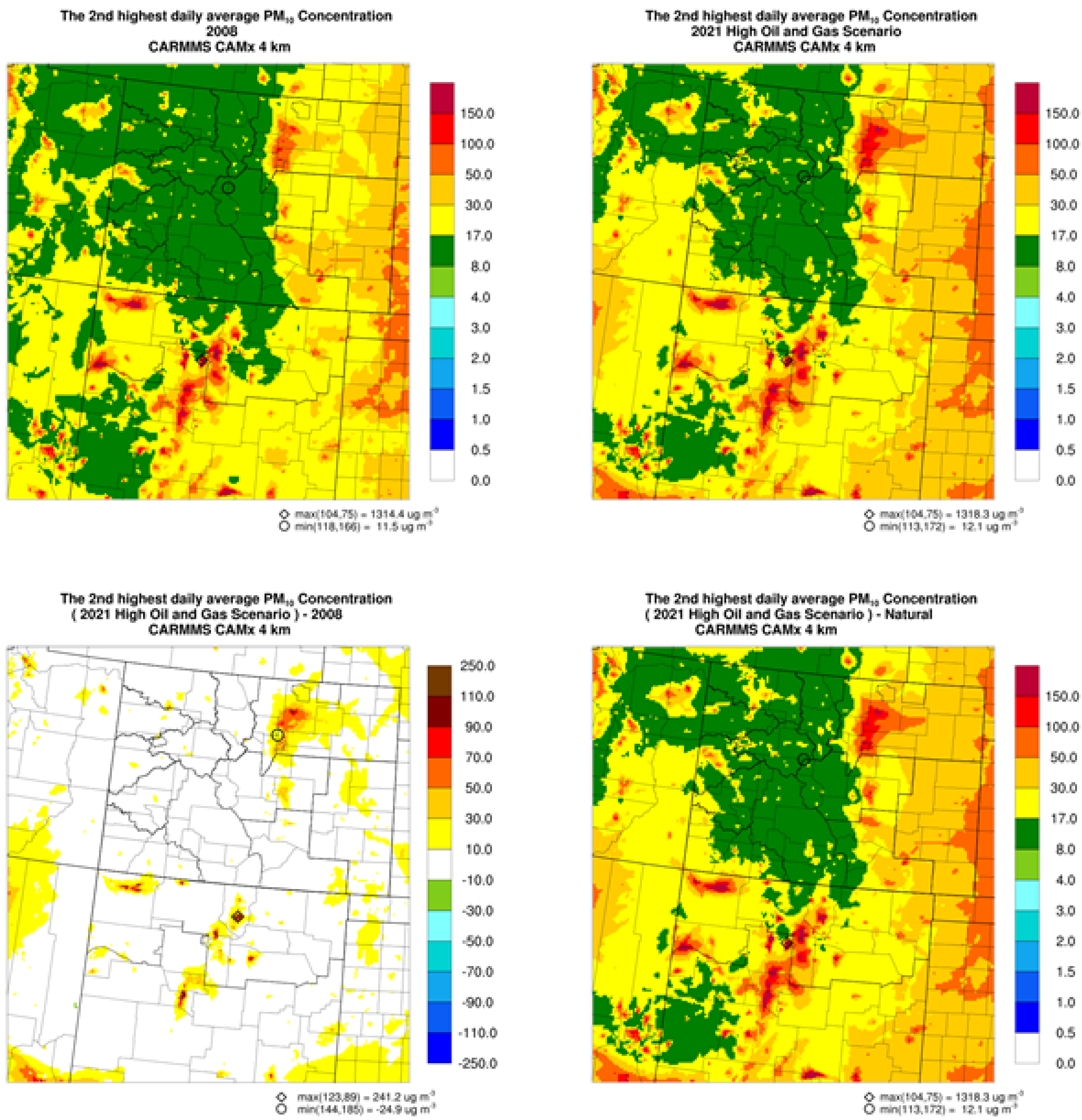


Figure 5-16. Second highest 24-hour average PM_{10} concentrations for the 2008 Base Case (top left), 2021 High Development Scenario (top right), 2021 minus 2008 differences (bottom left) and Natural Emissions (bottom right).

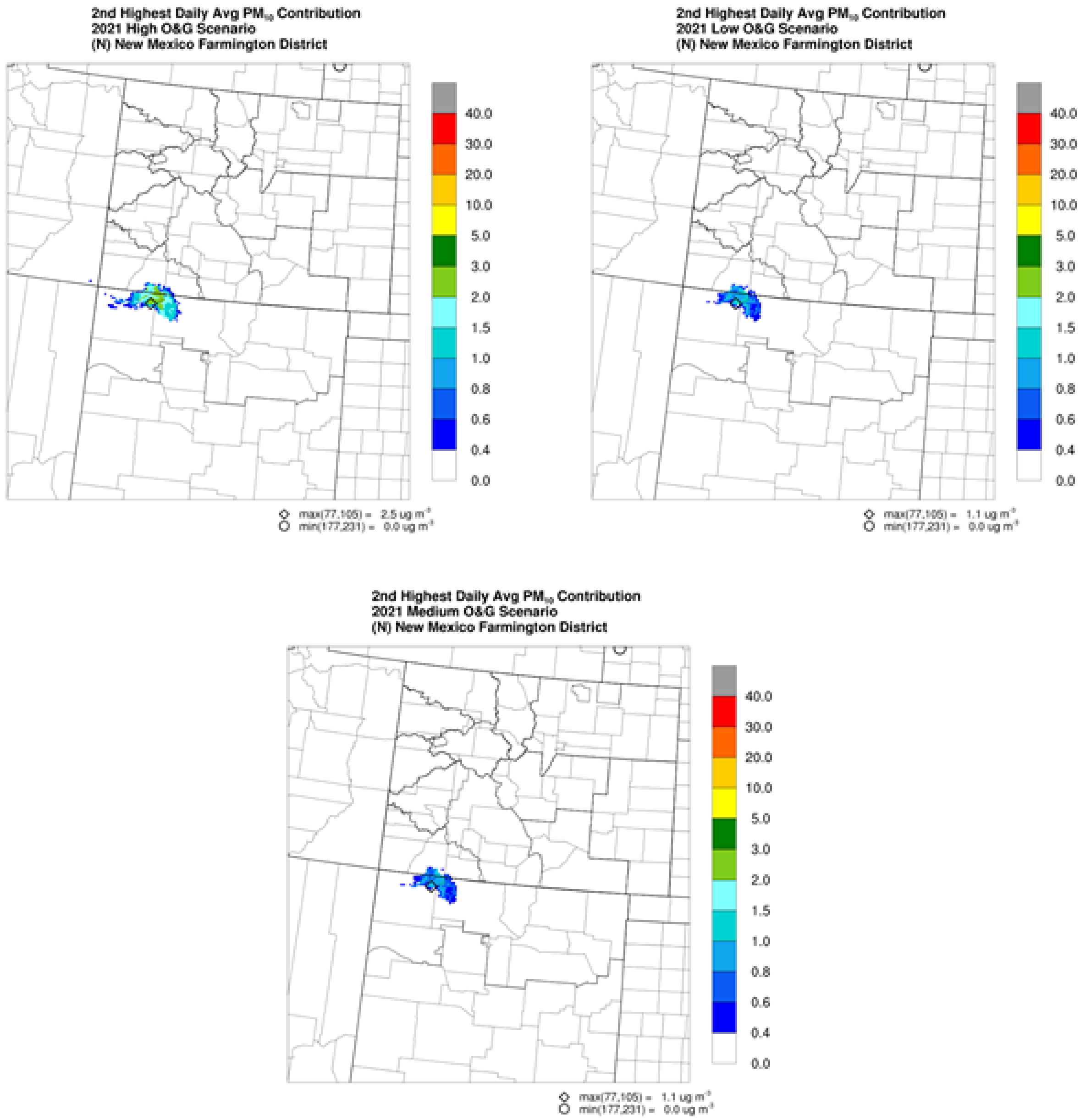


Figure 5-17a. Contribution to second highest 24-hour average PM_{10} concentrations from NM Farmington FO (source group N) for the 2021 High (top left), Low (top right) and Medium (bottom) Development Scenarios.

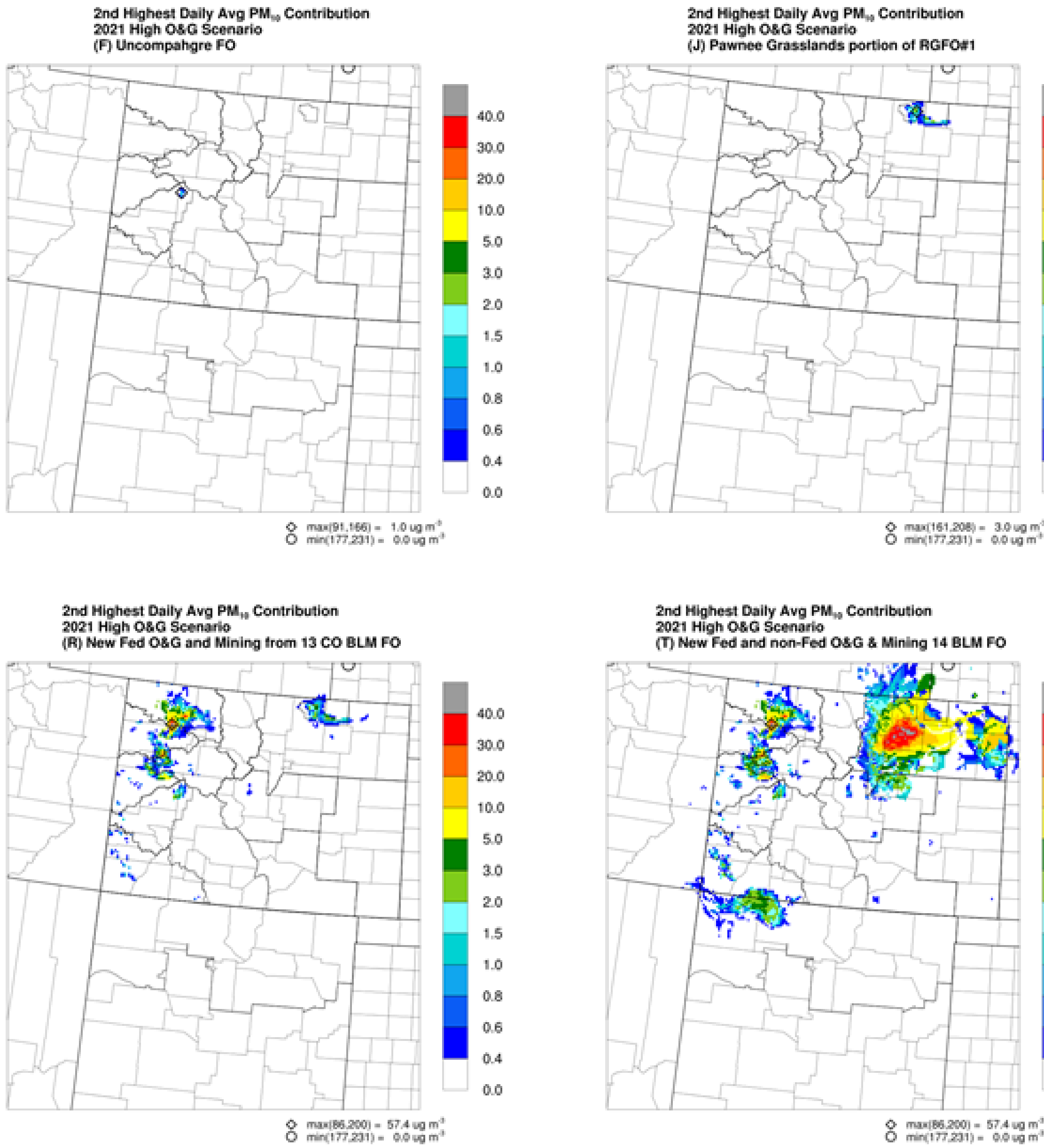


Figure 5-17b. Contribution to second highest 24-hour average PM_{10} concentrations due to emissions from new Federal O&G within the UFO (top left) and USGS-PG (top right) Planning Areas and new O&G and mining from the 13 Colorado BLM Planning Areas (bottom left) and new Federal O&G and mining and non-Federal O&G from the 14 CO/NM BLM Planning Areas for the 2021 High Development Scenario.

5.6.5 SO_2 NAAQS Analysis

The 2008 Base Case and 2021 High Development Scenario, their differences and contributions of Natural Emissions to 1-hour, 3-hour and annual SO_2 concentrations are shown in Figures 5-18 through 5-21, respectively. The 1-hour SO_2 NAAQS is 196 µg/m^3 and it is exceeded when the colors in Figure 5-18 are yellow or hotter. With one exception, the 4th highest daily maximum 1-hour SO_2 concentrations are below the NAAQS throughout the 4 km CARMMS domain for the 2021 High Development Scenario. The exception is an isolated point in northeast Arizona where a value of 452 µg/m^3; this high value is due to what appears to be an error in the EPA PM NAAQS 2020 emissions database which was the source of the inventory for the current study. This database has a stack at Tucson Electric in Springerville with a stack height of 12 m (which is unrealistic for an EGU stack) and a high SO_2 emissions rate (2500 tpy). With one exception, new Federal O&G emissions in the 14 BLM Planning Areas have very small contributions to 1-hour, 3-hour, 24-hour and annual SO_2 concentrations with contributions being less than 1 µg/m^3. The exception is for the WRFO Planning Area (Source Group B) that contributes 78.4, 75.2, 42.7 and 18.0 µg/m^3 to the 1-hour, 3-hour, 24-hour and annual average SO_2 concentrations for the 2021 High and Medium Development Scenarios and 12.8, 12.4, 7.0 and 3.0 µg/m^3 for the 2021 Low Development Scenario. As noted in Section 3.7, a majority of the SO_2 emissions in the WRFO Planning Area are due to the Meeker and Willow Creek gas plants whose emissions were based on the CDPHE 2008 APEN data grown to 2021 based on the change in gas production within the Piceance Basin between 2008 and 2021. For the 2021 High Development Scenario the 2021 growth factor from 2008 was a factor of 3.4.

Example spatial maps showing the SO_2 contributions for Source Groups R and T and the 2021 High Development Scenario are given in Figure 5-22 with other Source Groups and 2021 emission scenarios given in Attachment I. In particular, new Federal O&G emissions in the NMFFO (Mancos Shale) have a negligible (close to zero) contribution to SO_2 concentrations (see Figures showing contribution of group N in Attachment I) because of relatively low SO_2 emissions from this Planning Area. The same is also true of the cumulative contribution of NMFFO O&G plus oil/gas-fired EGUs in the "ANTO" area (source group AF). The contributions of other oil/gas-fired and coal-fired EGUs as well as other sources in the modelling domain are presented in maps in Attachment I.

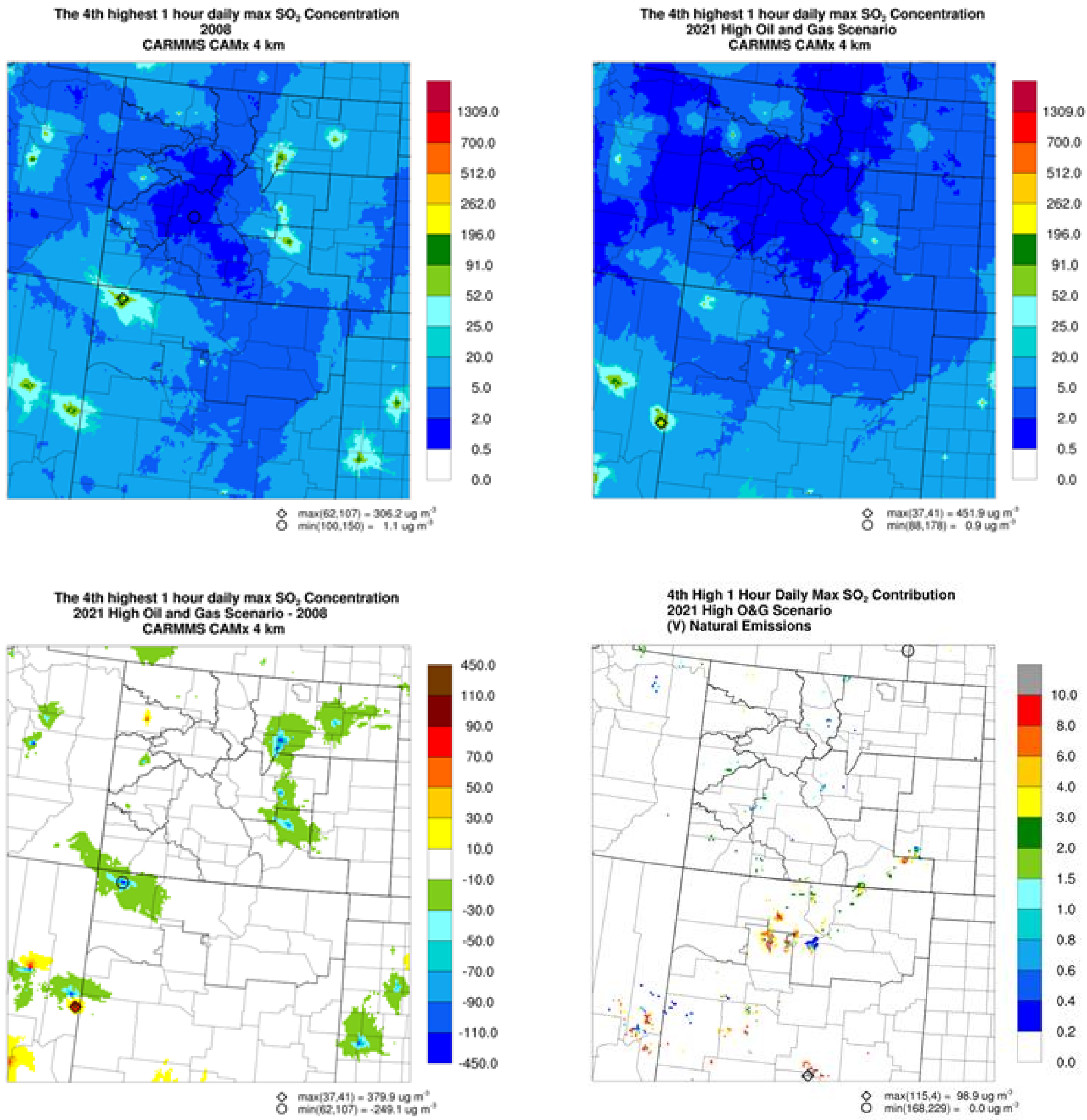


Figure 5-18. Fourth highest (99th percentile) daily maximum 1-hour average SO_2 concentrations for the 2008 Base Case (top left), 2021 High Development Scenario (top right), 2021 minus 2008 differences (bottom left) and Natural Emissions (bottom right).

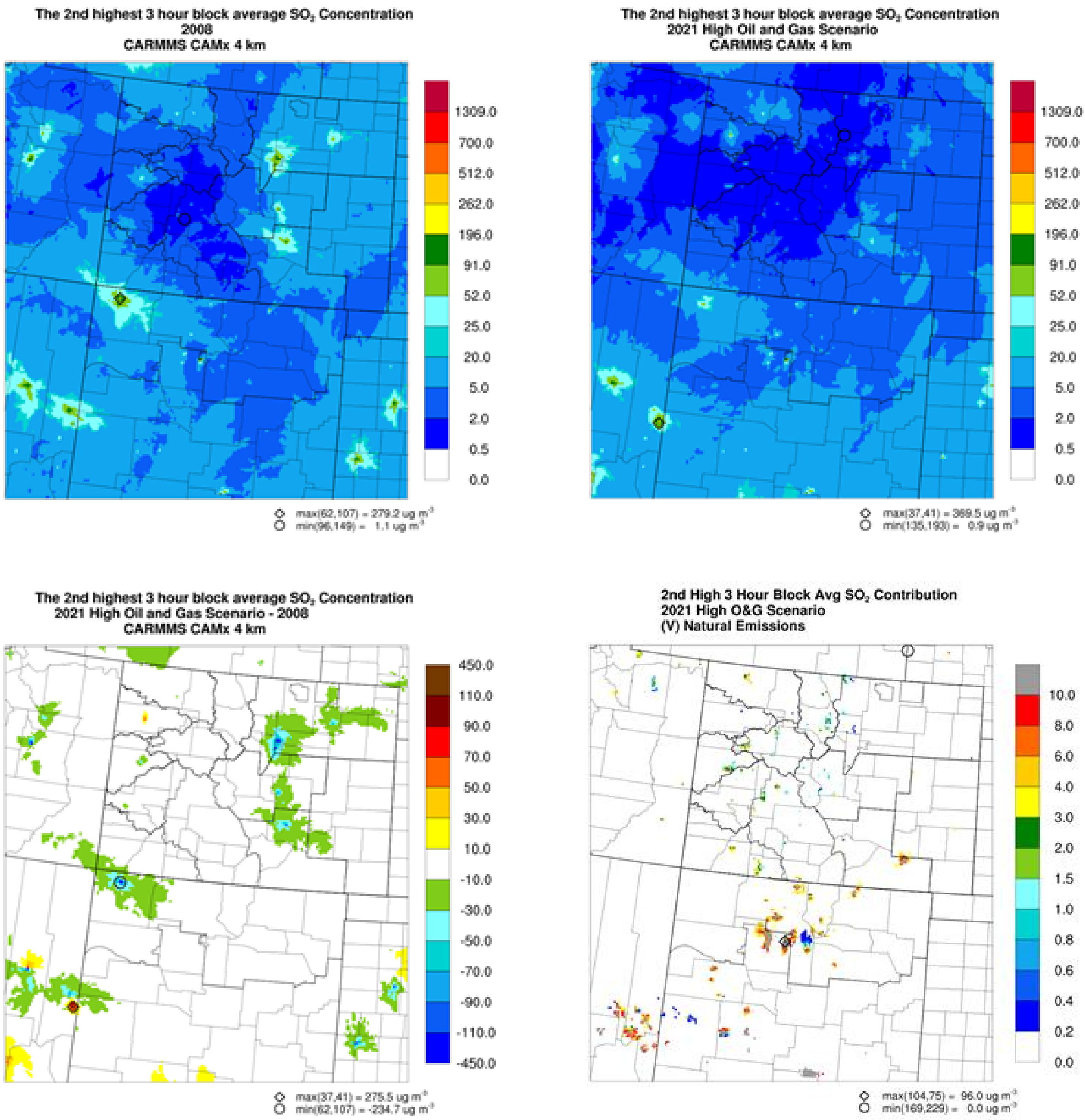


Figure 5-19. Second highest 3-hour average SO_2 concentrations for the 2008 Base Case (top left), 2021 High Development Scenario (top right), 2021 minus 2008 differences (bottom left) and Natural Emissions (bottom right).

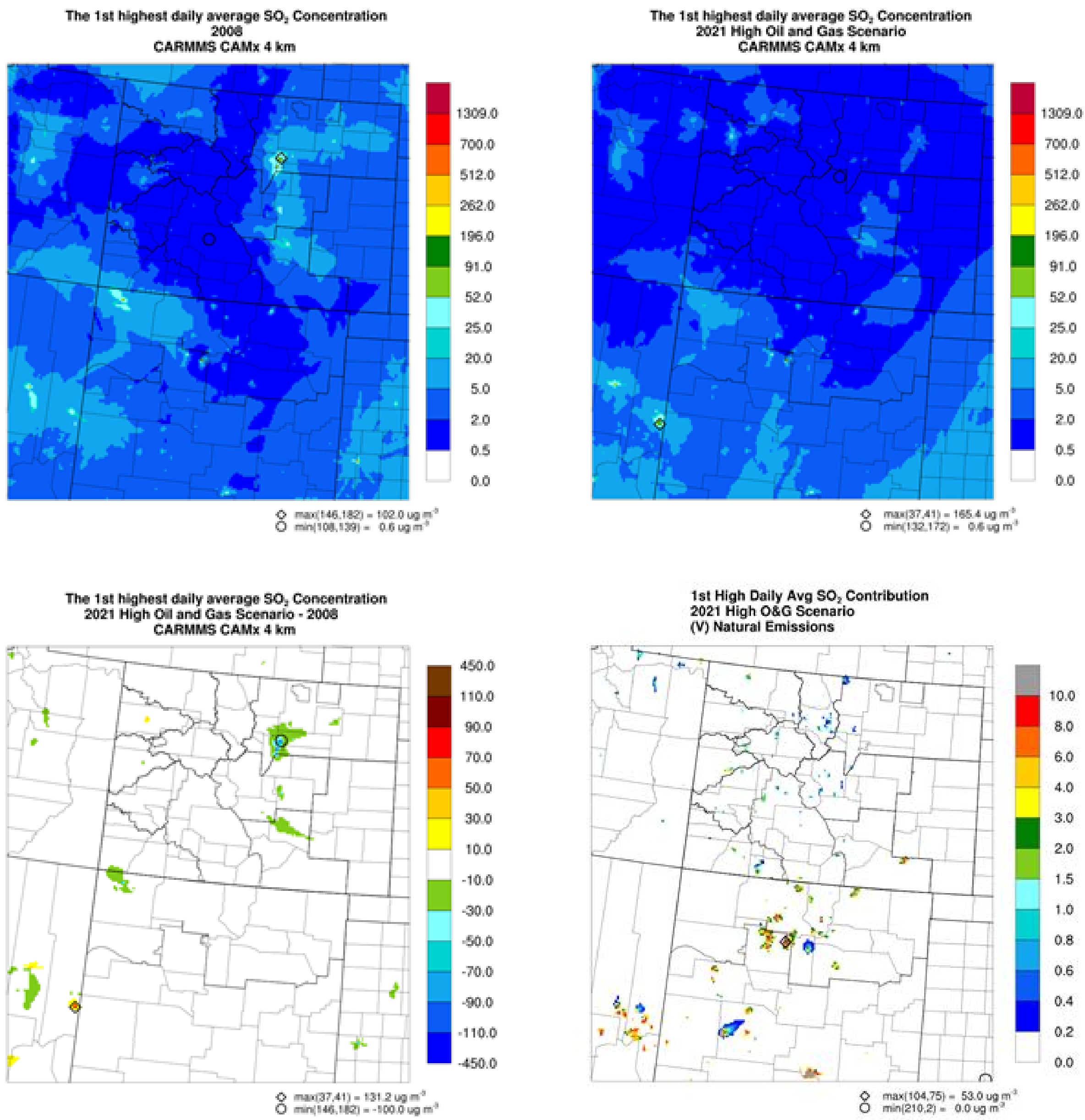


Figure 5-20. 24-hour average SO_2 concentrations for the 2008 Base Case (top left), 2021 High Development Scenario (top right), 2021 minus 2008 differences (bottom left) and Natural Emissions (bottom right).

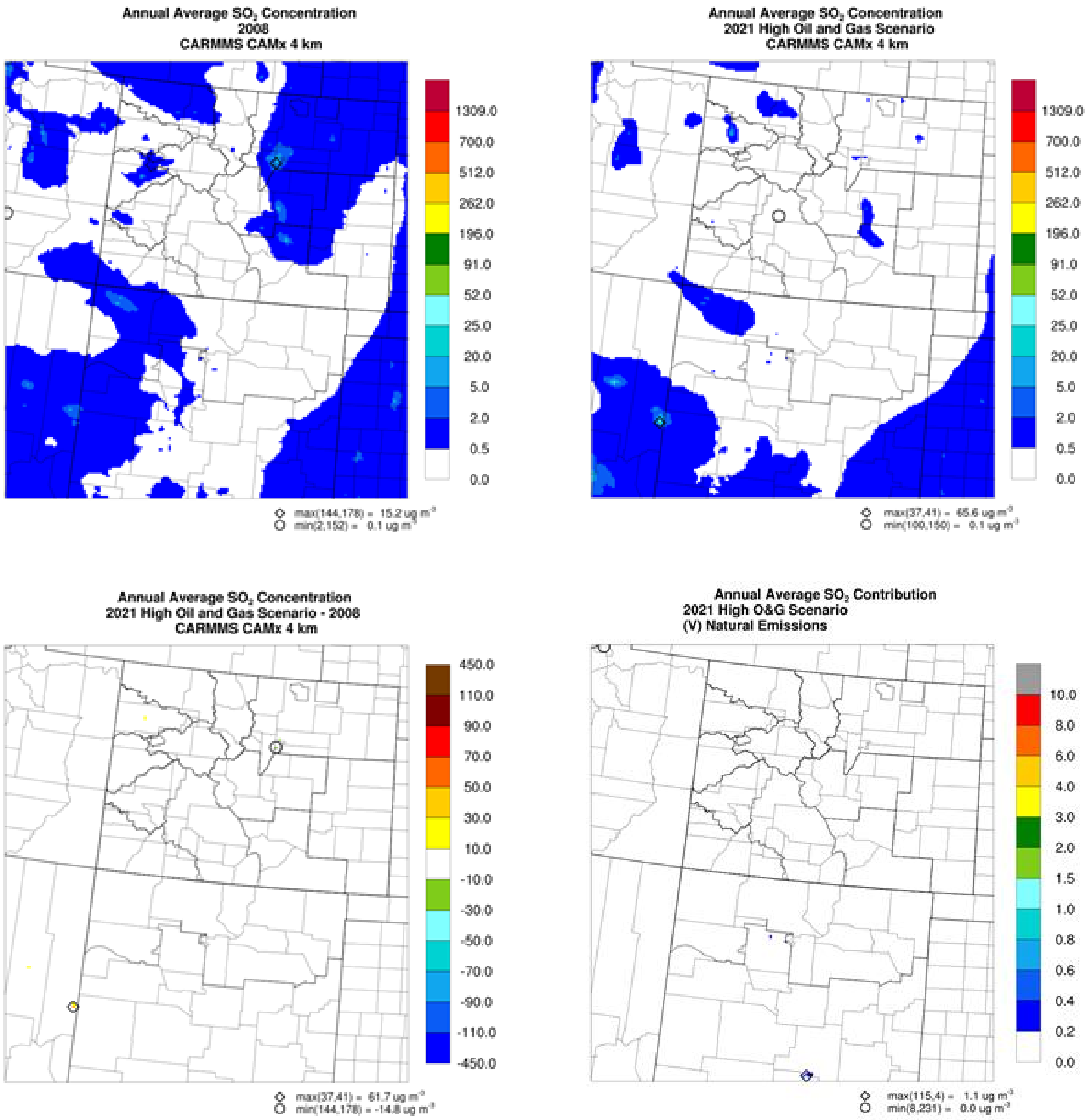


Figure 5-21. Annual average SO_2 concentrations for the 2008 Base Case (top left), 2021 High Development Scenario (top right), 2021 minus 2008 differences (bottom left) and Natural Emissions (bottom right).

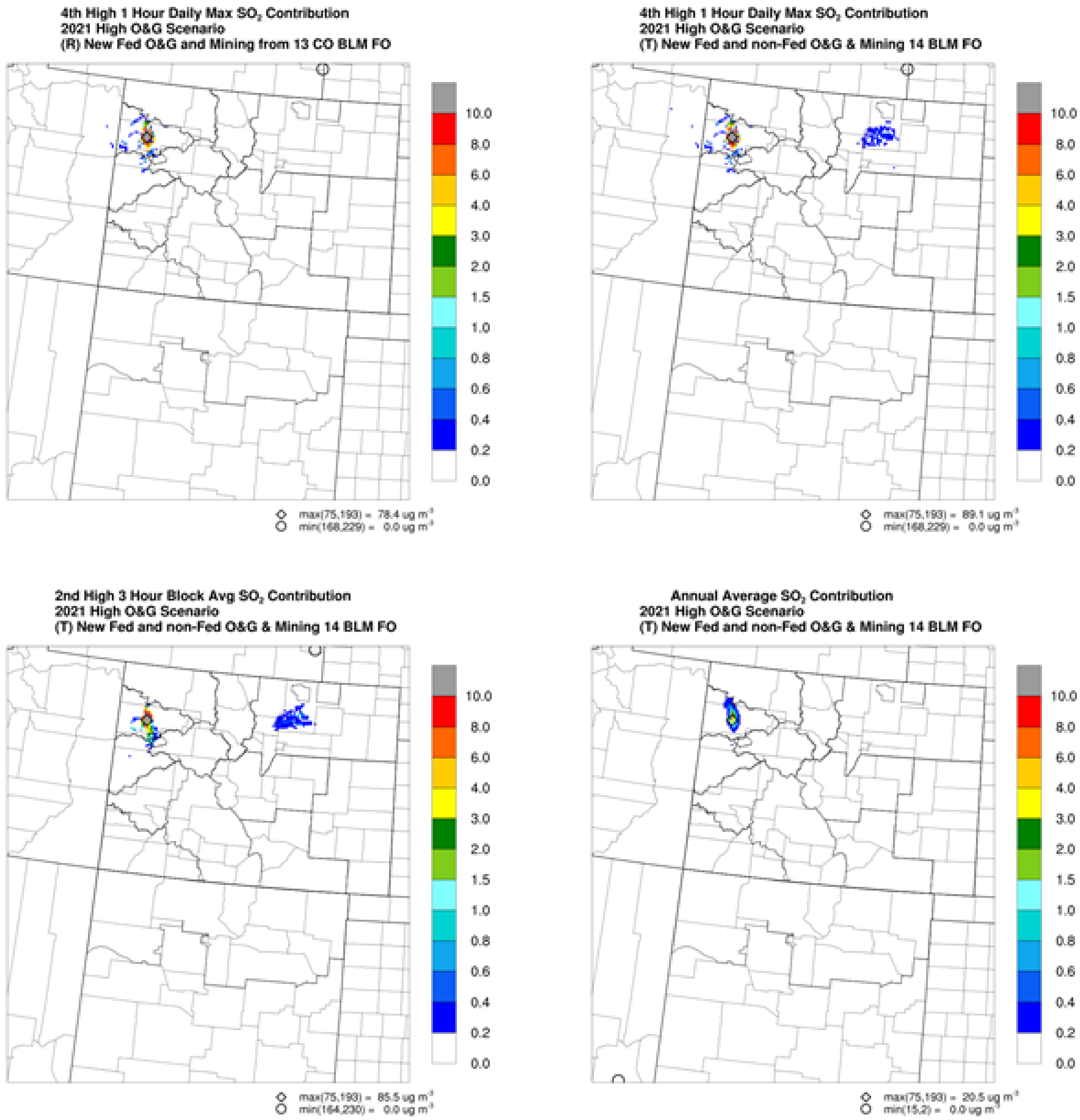


Figure 5-22. Contribution to fourth highest daily maximum hourly SO_2 concentrations due to emissions from new Federal O&G and mining within the 13 CO BLM Planning Areas (top left) and new Federal O&G and mining and non-Federal O&G within the 14 CO/NM BLM Planning Areas (top right). New Federal O&G and mining and new non-Federal O&G from 14 CO/NM BLM Planning Areas contributions to second highest 3-hour SO_2 (bottom left) and annual average SO_2 (bottom right) concentrations for the 2021 High Development Scenario.

5.6.6 NO_2 NAAQS Analysis

Figure 5-23a displays spatial maps of the 98th percentile daily maximum 1-hour NO_2 concentrations for the 2008 Base Case and 2021 High, Low and Medium Development Scenarios with the differences in NO_2 concentrations between the 2021 emissions scenarios and the 2008 Base Case shown in Figure 5-23b. The 1-hour NO_2 NAAQS is 188 $\mu g/m^3$ (100 ppb) and the tile plots in Figure 5-23a have a cut-point at 188 $\mu g/m^3$. For example, an exceedance of the 1-hour NO_2 NAAQS can be seen in the Denver area in the 2008 Base Case that goes away in the 2021 emission scenarios. In all four scenarios, the highest 1-hour NO_2 concentration occurs on the southern border of the 4 km CARMMS domain that is above the NAAQS. This NO_2 exceedance is due to wildfires and is present in the 2008 Base Case and 2021 scenarios since wildfires were assumed to be unchanged. The fact that the peak 1-hour NO_2 value at this wildfire location is identical for all three 2021 emission scenarios indicates that the 2021 O&G emissions have minimal contributions to it. Excluding this isolated wildfire location in the southern part of the 4 km CARMMS domain, the 8th highest daily maximum 1-hour NO_2 concentrations only exceeds the 1-hour NO_2 NAAQS at one other location in the 2021 emission scenarios that is the northeastern corner of Weld County. Although there are Federal O&G emissions increases nearby to this location, they do not occur at this high NO_2 concentration location (Figure 3-10). The fact that there is little reduction in this 1-hour NO_2 peak between the 2021 High and Low Development Scenarios (Figure 5-23b) suggests that the high NO_2 concentration in Weld County is due to other new sources in the 2021 emission scenario and could be attributed to increases in non-Federal oil and gas emissions. As indicated from the plots shown in Section 3.2.1, RGFO area 1 (Weld County is located in RGFO area 1) non-Federal oil and gas emissions for the Low Scenario are actually higher than projected year 2021 non-Federal oil and gas emissions for the High / RFD Scenario. There are projected increases in NO_2 concentrations from 2008 to 2021 of 10 to 30 $\mu g/m^3$ in San Juan County and Rio Arriba County in the FFO Planning Area in the High, Low and Medium scenarios.

The differences in 1-hour NO_2 concentrations between the 2008 and 2021 emission scenarios (Figure 5-23b) indicate reductions in the Denver area, slight increases in the O&G development areas (e.g., Uinta, Piceance and D-J Basins) and several isolated occurrences of large increases in northern, eastern and southern Colorado as well as eastern Arizona and New Mexico. As noted above, the cause of the large NO_2 concentration increase at the point in northeast corner of Weld County is not clear but doesn’t appear to be due to new Federal O&G emissions. As shown in Figure 3-10, there are some increases in non-Federal oil and gas emissions projected to occur in the vicinity of the predicted Weld County concentrations and are likely contributing to the modeled impacts. The NO_2 increase in Cheyenne County in eastern Colorado does not appear to be due to new O&G emissions since there are no new O&G emissions at that location in the 2021 emission scenarios (Figure 3-10). Upon further review of the year 2011 oil and gas APENs database that was used to define existing O&G emissions inventory, there is a large (> 1,200 TPY) NO2 emissions source located in the vicinity of the predicted concentrations in Cheyenne County. The increase in 2021 NO_2 concentrations in the southwest corner of Las Anima County in southern Colorado is at the location of new O&G emissions (primarily non-Federal) for the Raton Basin and likely due to O&G emissions, but the resultant total NO_2 concentrations are below the NAAQS. The two locations of NO_2 concentration increases in eastern Arizona and New Mexico are away from any O&G emissions (Figure 3-10). Since the same increases are seen for the 2021 High, Low and Medium Development Scenarios (Figure 5-23b) then they are not due to Colorado based O&G emissions. They are likely due to EPA's 2020 emission projections used for non-O&G anthropogenic emissions in the 2021 emission scenarios, possibly the deployment of new electrical generating units.

The maximum contribution to the 98th percentile daily maximum 1-hour NO_2 concentrations from the NM Farmington FO Planning Area (Figure 5-23c) for each of the High, Low and Medium Development scenarios are 11.7 µg/m^3, 6.1 µg/m^3 and 8.6 µg/m^3, respectively.

The maximum contributions of source group AD (Figure 5-23d), mining and coal EGUs in Colorado, is 91.7 µg/m^3 across all three development scenarios. Source group AE, comprising O&G emissions and oil/gas EGUs in Colorado (Figure 5-23e), has maximum contributions for the high, medium and low development scenarios of 130.7, 58.7 and 106.1 µg/m^3 respectively. Lastly, the maximum contributions to the 1-hour NO_2 concentrations from source group AF (O&G sources and oil/gas EGUs in New Mexico) for each of the high, medium and low development scenarios (Figure 5-23f) are 11.7, 6.1, 8.6 µg/m^3, respectively.

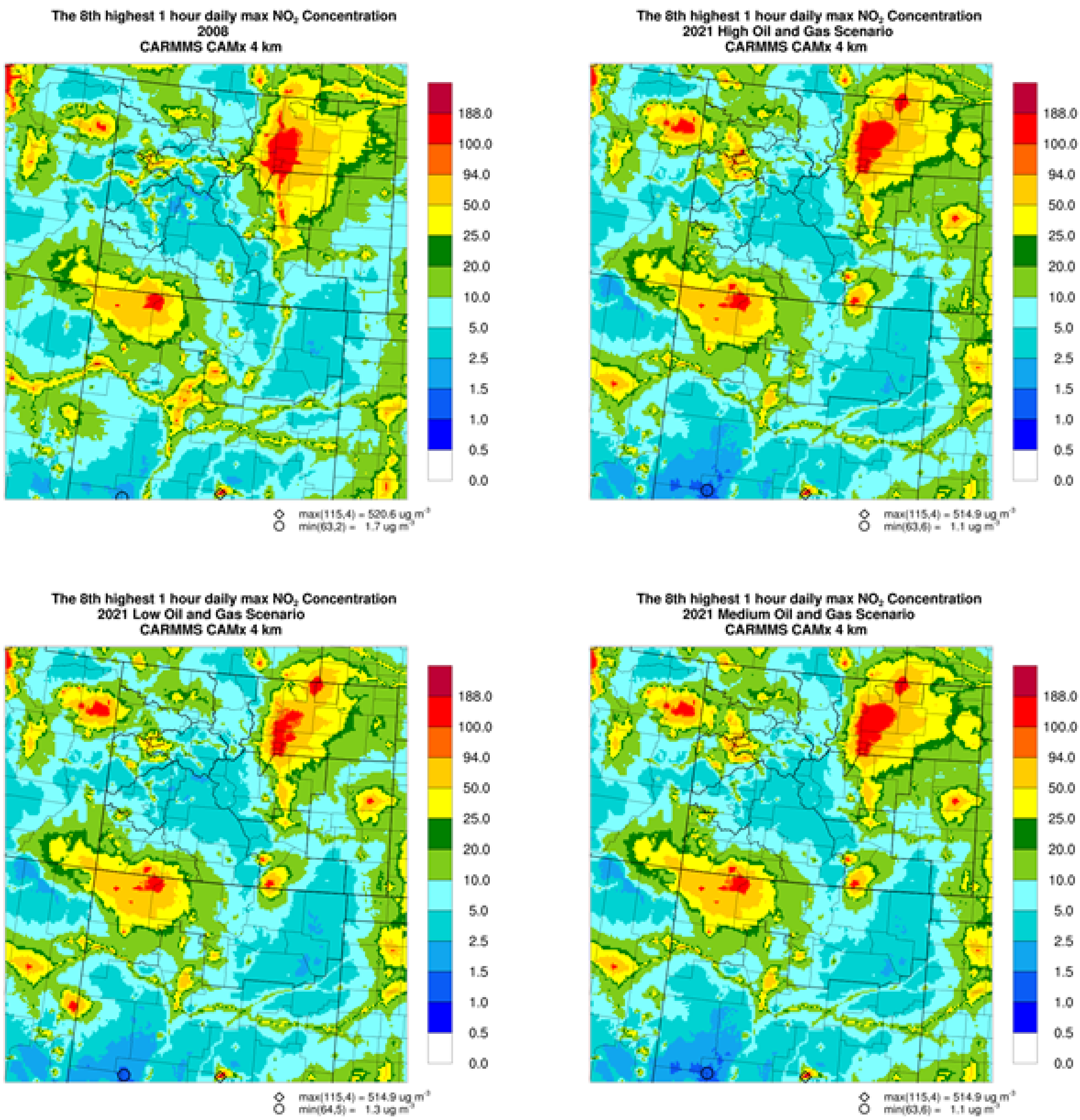


Figure 5-23a. Eighth highest (98th percentile) daily maximum 1-hour average NO_2 concentrations for the 2008 Base Case (top left), 2021 High Development Scenario (top right), 2021 Low Development Scenario (bottom left) and 2021 Medium Development Scenario (bottom right).

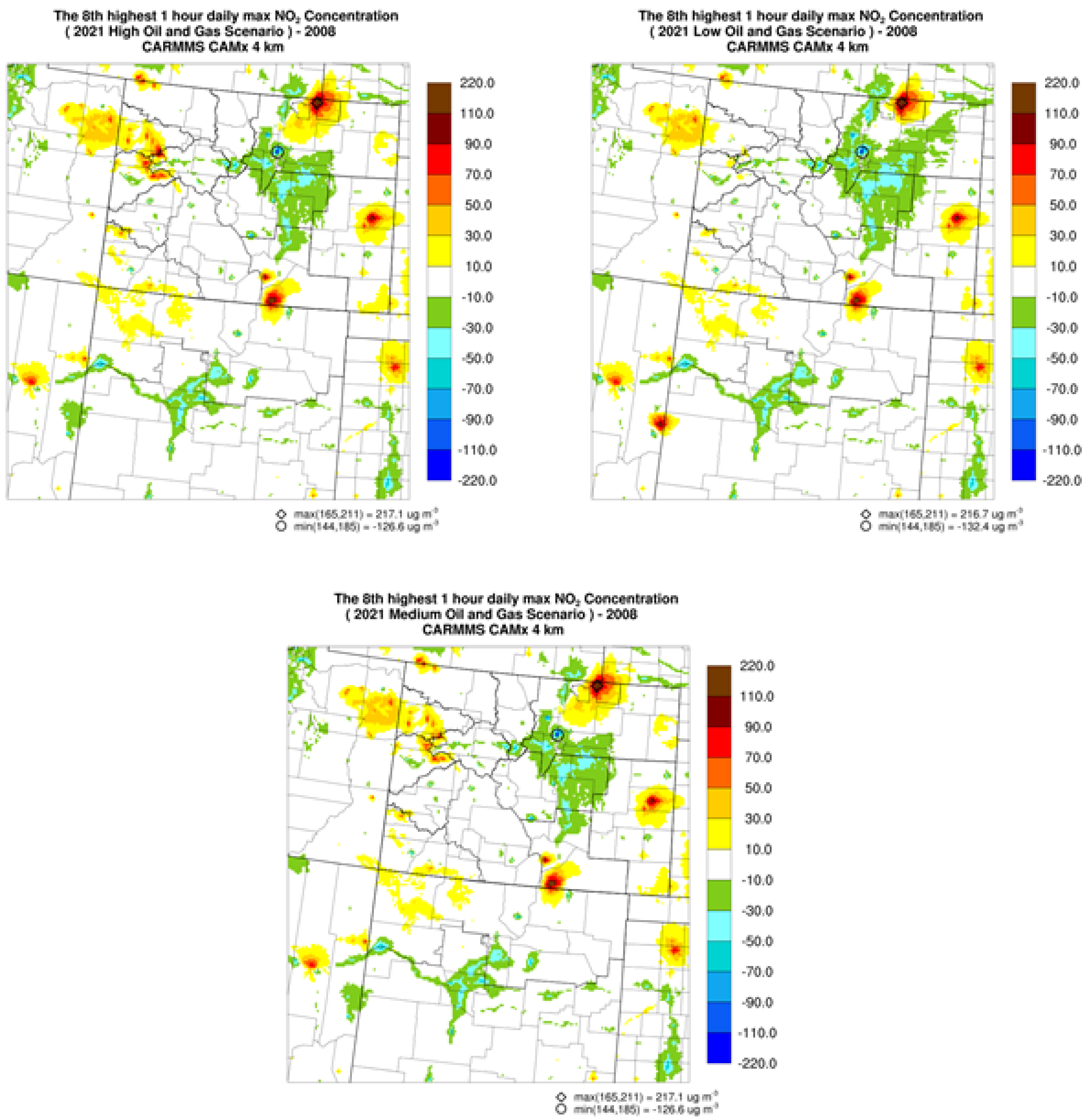


Figure 5-23b. Differences in eighth highest (98th percentile) daily maximum 1-hour average NO_2 concentrations between the 2021 emission scenarios and the 2008 Base Case for the 2021 High (top left), Low (top right) and Medium (bottom) Development Scenarios.

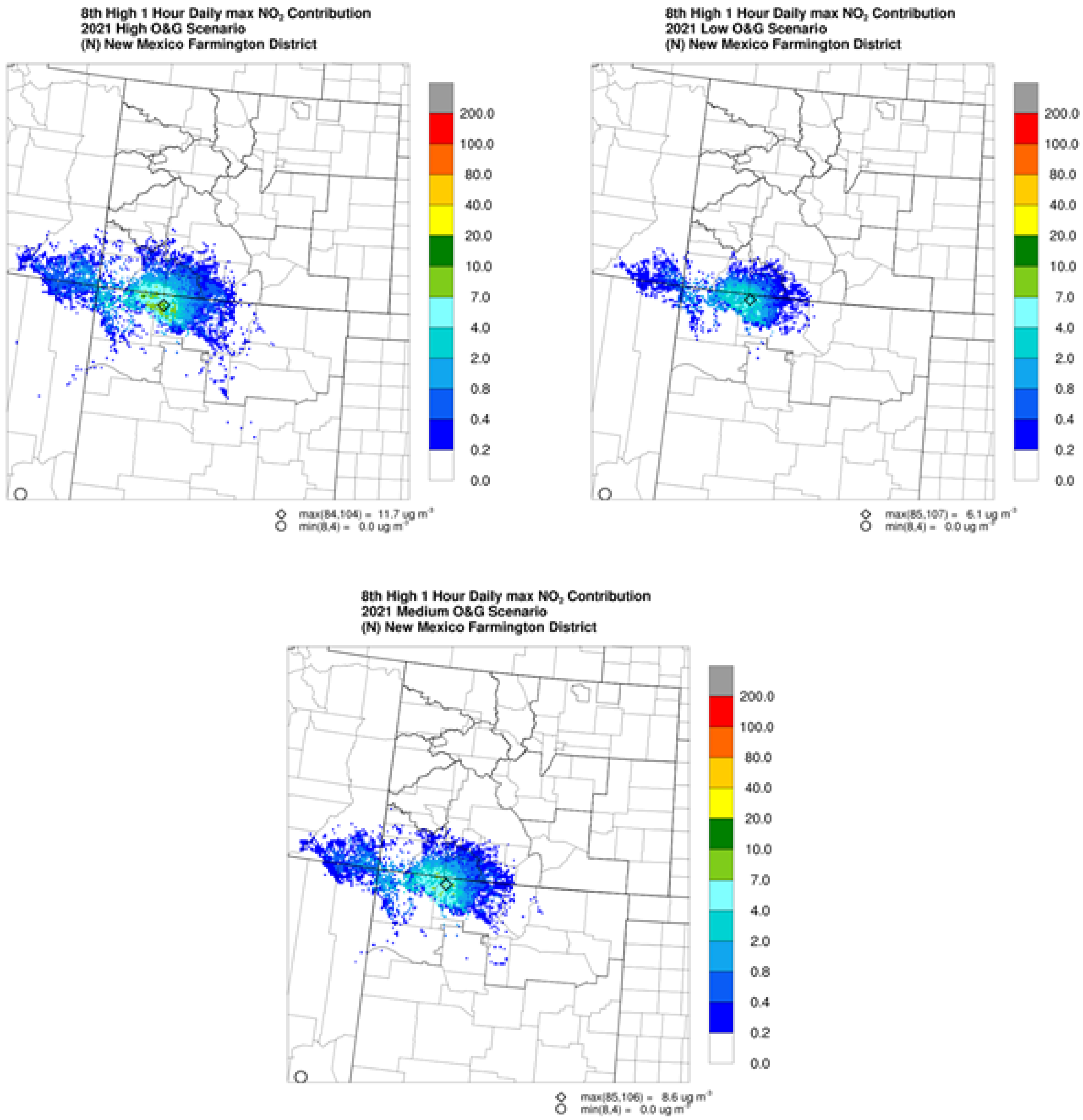


Figure 5-23c. Contributions from NM Farmington FO (source group N) to the eighth highest (98th percentile) daily maximum 1-hour average NO_2 concentrations in the 2021 High (top left), Low (top right) and Medium (bottom) Development Scenarios.

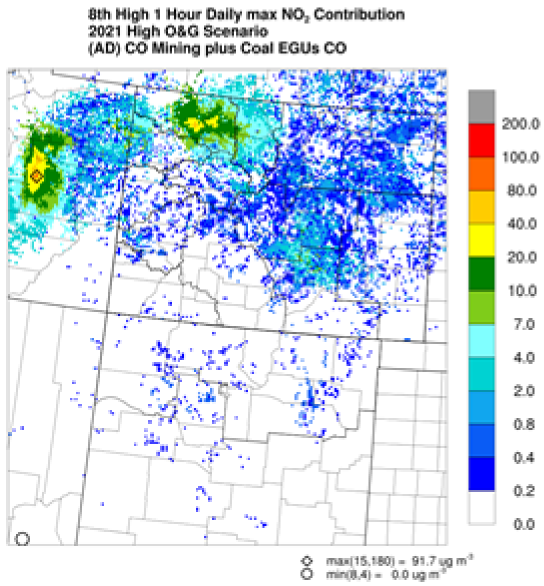


Figure 5-23d. Contributions from CO mining plus coal EGUs CO (source group AD) to the eighth highest (98th percentile) daily maximum 1-hour average NO_2 concentrations in the 2021 High Development Scenario.

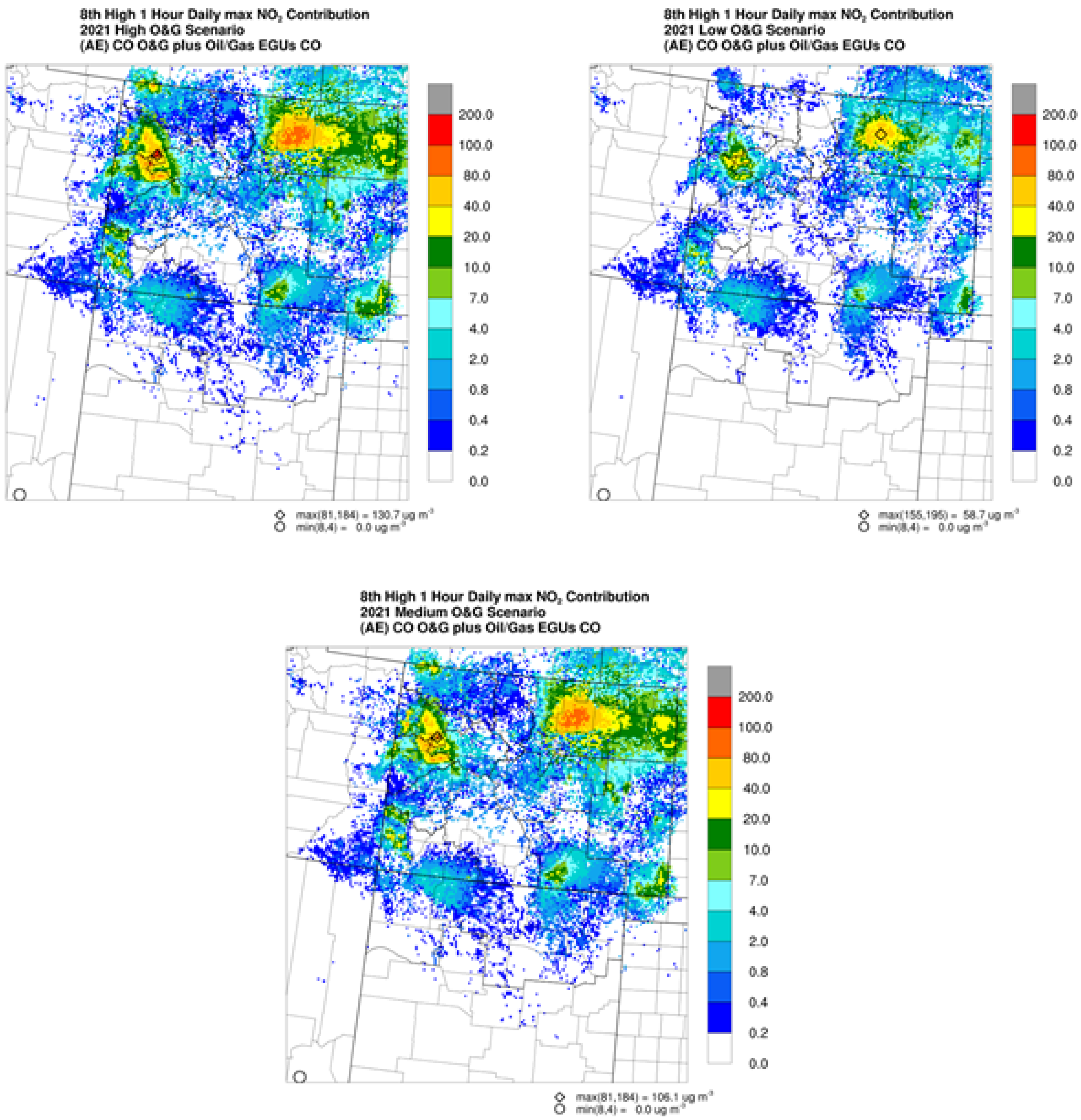


Figure 5-23e. Contributions from CO O&G plus oil/gas EGUs CO (source group AE) to the eighth highest (98th percentile) daily maximum 1-hour average NO_2 concentrations in the 2021 High (top left), Low (top right) and Medium (bottom) Development Scenarios.

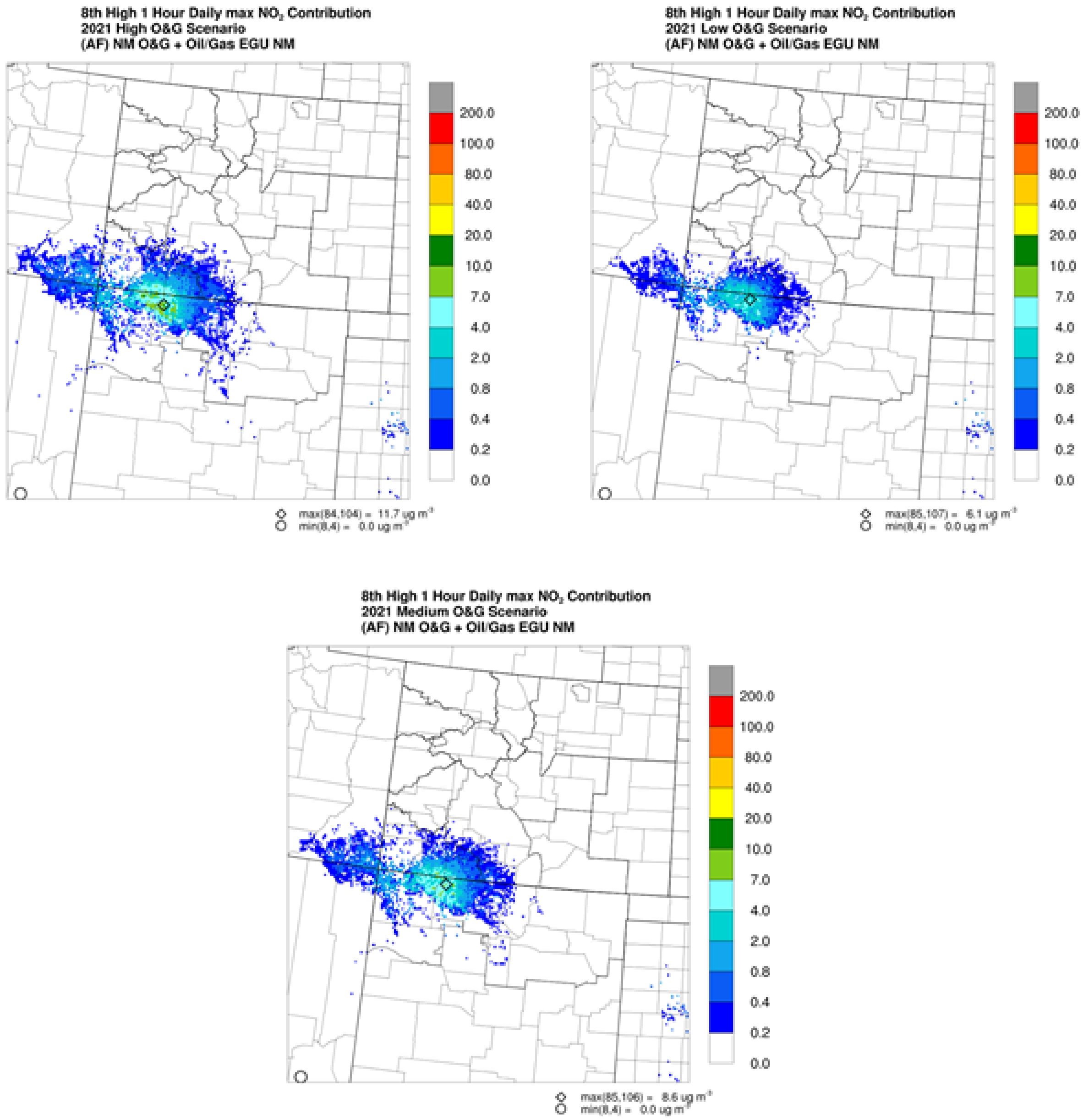


Figure 5-23f.Contributions from NM O&G plus oil/gas EGUs NM (source group AF) to the eighth highest (98th percentile) daily maximum 1-hour average NO_2 concentrations in the 2021 High (top left), Low (top right) and Medium (bottom) Development Scenarios.

5.7 Source-Receptor Issues

The following section is reproduced from the CARMMS 1.0 report and is provided here only as an explanation of why results of impacts at Class I/II areas are often conservative.

Grid cells were assumed to represent receptors for Class I and sensitive Class I areas if there was any overlap between the grid cell and Class I/II area. Thus, there was the potential for emissions from oil and gas and other sources to be located in the same grid cell/receptor as a Class I/II area. However, in reality new oil and gas sources would not be located in a Class I area so such situations would likely overstate the oil and gas air quality impacts in a Class I area. This section identifies several instances when Class I/II areas are defined very close to new oil and gas emissions resulting air quality impacts that are likely higher than would actually occur.

New Federal O&G development on some of the BLM Planning Areas had relatively higher concentrations impacts at specific Class I areas. For example, new Federal O&G within the TRFO had Maximum annual NO_2 impacts at Mesa Verde Class I area of 1.97 μg/m^3 that was 79% of the annual NO_2 PSD Class I increment for the 2021 High Development Scenario. In addition, the visibility impacts at Mesa Verde due to new Federal O&G within TRFO Planning Area for the 2021 High Development Scenario had 35 days with $\Delta dv > 0.5$ and 4 days with $\Delta dv > 1.0$. Recall that grid cells used to represent receptors for Class I and sensitive Class II areas were defined if any portion of the Class I/II area intersected with the grid cell no matter how small the overlap is in order to be conservative (see Section 4.3.2). Figure 5-24 displays the grid cells used to represent the Mesa Verde Class I area along with new Federal O&G emissions from the TRFO Planning Area. The most northern Mesa Verde 4 km grid cell receptor is surrounded by emissions from the TRFO Planning Area with the Class I area covering approximately 20% of the 4 km grid cell so using this 4 km grid cell as a receptor for the Mesa Verde Class I area is probably appropriate. However, there have been other cases when the Class I/II area cover a very small portion of a grid cell that is used as a receptor for a Class I/II area. Perhaps a Class I/II area should be required to have a minimal overlap with a grid cell (e.g., 5%) in order for the grid cell to be considered as a receptor for the Class I/II area.

Another example of relatively larger impacts was seen for TRFO at the South San Juan Class II area (16 days with $\Delta dv > 0.5$). Figure 5-25 compares the grid cells used to represent the South San Juan Wilderness and compares them to new Federal O&G emissions from the TRFO Planning Area. In this case the emissions from the TRFO Planning Area occur in one of the grid cells being used to represent the South San Juan area and the grid cell contains a large portion of the Class II area. It might be beneficial to examine the TRFO O&G emissions to determine whether they are spatially located correctly.

A final example of relatively larger impacts is for new Federal O&G emissions from the NMFFO that had relatively large visibility impacts (210 days with $\Delta dv > 0.5$ and 50 days with $\Delta dv > 1.0$) at the Aztec Ruins Class II area. Aztec Ruins is a small area that is represented by two 4 km grid cells and sits in the middle of the NMFFO Mancos Shale development area. This is shown in Figure 5-26 with the two cells representing Aztec Ruins unlabelled but seen in the middle of the NMFFO O&G emissions.

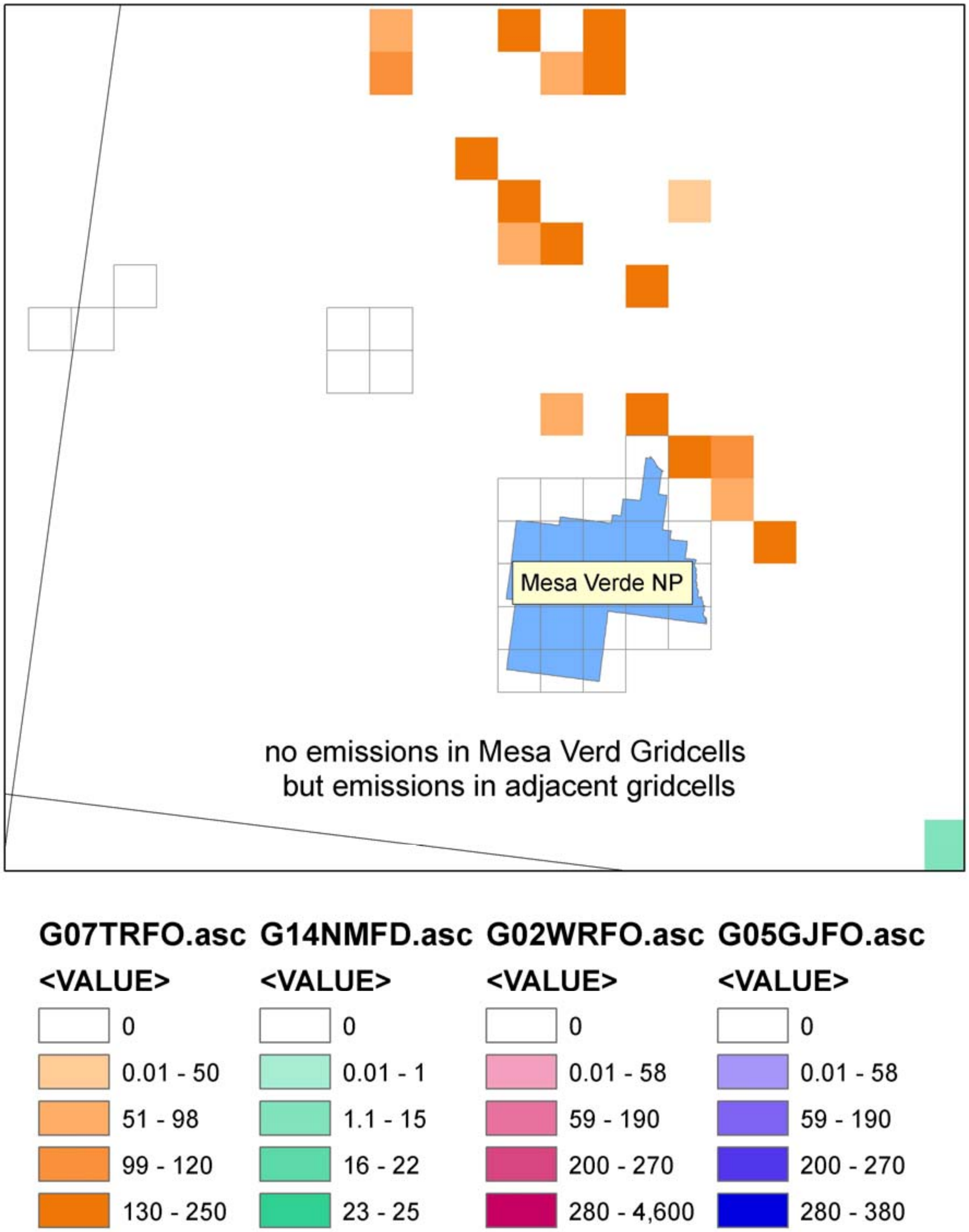


Figure 5-24. Grid cells used to represent the Mesa Verde Class I area with new Federal O&G emissions from the TRFO Planning Area.

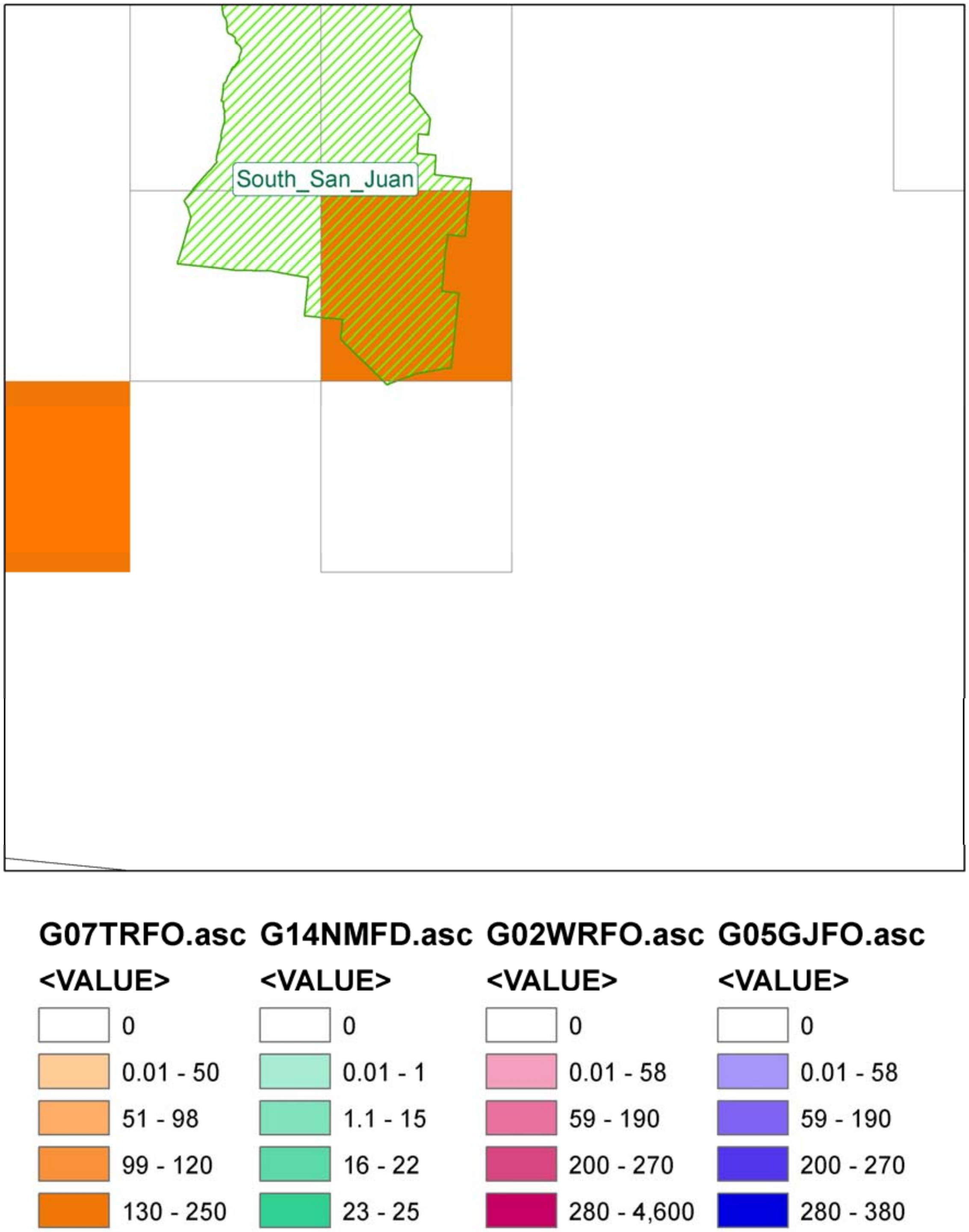


Figure 5-25. Grid cells used to represent the South San Juan Class II area with new Federal O&G emissions from the TRFO Planning Area.

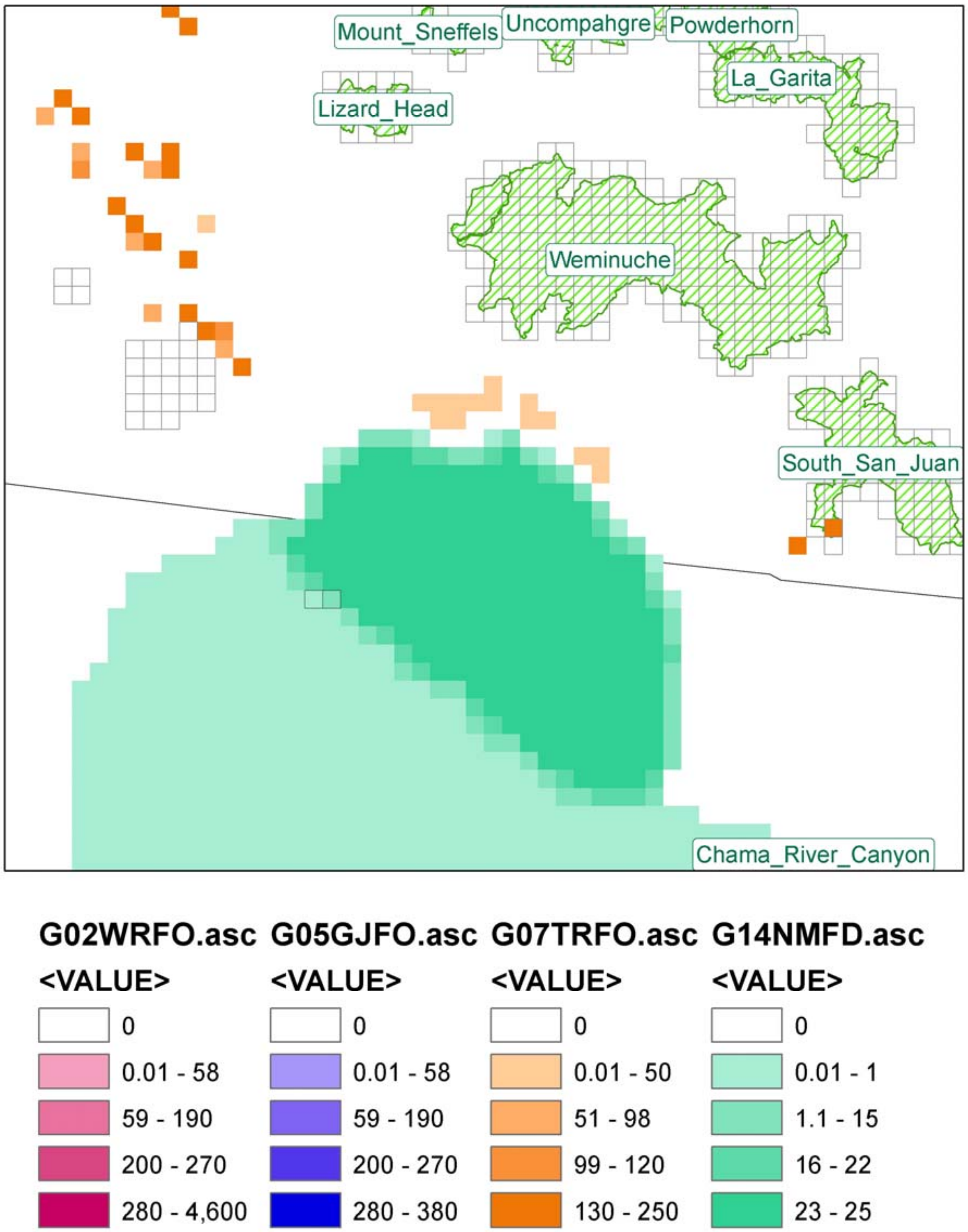


Figure 5-26. Grid cells used to represent the Class I and sensitive Class II areas with new Federal O&G emissions from the NMFFO (Mancos Shale) Planning Area.

6.0 ACRONYMS

ACHD	Allegheny County Health Department
AES	Applied Envirosolutions
AMET	Atmospheric Model Evaluation Tool
APCA	Anthropogenic Precursor Culpability Assessment
APU	Auxiliary Power Units
ARMS	Air Resource Management Study
AQ	Air Quality
AQRV	Air Quality Related Value
AQS	Air Quality System
BC	Boundary Condition
BLM	Bureau of Land Management
CAFOS	Concentrated Animal Feeding Operations
CAMD	Clean Air Markets Division
CAMx	Comprehensive Air-quality Model with extensions
CAPS	Criteria Air Pollutants
CARMMS	Colorado Air Resource Management Modeling Study
CASTNet	Clean Air Status and Trends Network
CAVR	Clean Air Visibility Rule
CB05	Carbon Bond mechanism version 5
CD-C	Continental Divide-Creston
CDPHE	Colorado Department of Health and Environment
CEM	Continuous Emissions Monitor
CENRAP	Central Regional Air Planning Association
CMAQ	Community Multiscale Air Quality modeling system
CMU	Carnegie Mellon University
ConCEPT	Consolidated Community Emissions Processing Tool
CONUS	Continental United States
COSO	BLM Colorado State Office
CRVFO	Colorado River Valley Field Office
CPC	Center for Prediction of Climate
CSAPR	Cross State Air Pollution Rule
CSN	Chemical Speciation Network
DDM	Decoupled Direct Method
DEASCO3	Deterministic and Empirical Assessment of Smoke's Contribution to Ozone
Dv	deciview
ECA	Emissions Control Area
EGU	Electrical Generating Units
EIS	Environmental Impact Statement
EM	Emissions Model
EMS	Emissions Modeling System
EPA	Environmental Protection Agency
EPS	Emissions Processing System
ERG	Eastern Research Group
ESRL	Earth Systems Research Laboratory
FB	Fractional Bias
FE	Fractional Error

FFO	New Mexico BLM Farmington Field Office
FINN	Fire Inventory from NCAR
FLM	Federal Land Manager
FRM	Federal Reference Method
FWS	Fish and Wildlife Service
GCM	Global Chemistry Model
GEOS-Chem	Goddard Earth Observing System (GEOS) global chemistry model
GJFO	Grand Junction Field Office
GSE	Ground Support Equipment
IAD	Impact Assessment Domain
IMPROVE	Interagency Monitoring of Protected Visual Environments
IMWD	Inter-Mountains West Processing Domain
IPAMS	Independent Petroleum Association of the Mountain States
JSFP	Joint Science Fire Program
FO	Kremmling Field Office
LCP	Lambert Conformal Projection
LTO	Landing and Takeoff Operations
LSFO	Little Snake Field Office
LSM	Land Surface Model
MADIS	Meteorological Assimilation Data Ingest System
MATS	Modeled Attainment Test Software
MEGAN	Model of Emissions of Gases and Aerosols in Nature
MM	Meteorological Model
MM5	Version 5 of the Mesoscale Model
MNGE	Mean Normalized Gross Error
MNB	Mean Normalized Bias
MOVES	Motor Vehicle Emissions Simulator
MOZART	Model for Ozone And Related chemical Tracers
NAAQS	National Ambient Air Quality Standard
NADP	National Acid Deposition Program
NCAR	National Center for Atmospheric Research
NCDC	National Climatic Data Center
NDBC	National Data Buoy Center
NEI	National Emissions Inventory
NEPA	National Environmental Policy Act
NMB	Normalized Mean Bias
NME	Normalized Mean Error
NMED	New Mexico Environmental Department
NMFFO	New Mexico Farmington Field Office
NMIM	National Mobile Inventory Model
NMSO	BLM New Mexico State Office
NOAA	National Oceanic and Atmospheric Administration
NPRI	National Pollutant Release Inventory
NPS	National Park Service
NSPS	New Source Performance Standard
NSR	New Source Review
O&G	Oil and Gas
OA	Organic Aerosol
OSAT	Ozone Source Apportionment Technology

PAVE	Package for Analysis and Visualization
PBL	Planetary Boundary Layer
PGM	Photochemical Grid Model
PiG	Plume-in-Grid
PM	Particulate Matter
PPM	Piecewise Parabolic Method
PSAT	Particulate Source Apportionment Technology
PSD	Prevention of Significant Deterioration
QA	Quality Assurance
QC	Quality Control
RAQC	Regional Air Quality Council
RGFO	Royal Gorge Field Office
RMC	Regional Modeling Center
RMNP	Rocky Mountain National Park
RMP	Resource Management Plan
ROMANS	Rocky Mountain Atmospheric Nitrogen and Sulfur Study
SCC	Source Classification Code
SIP	State Implementation Plan
SMOKE	Sparse Matrix Kernel Emissions modeling system
SOA	Secondary Organic Aerosol
TCEQ	Texas Commission on Environmental Quality
TRFO	Tres Rios Field Office
UAM	Urban Airshed Model
UCR	University of California at Riverside
UFO	Uncompahgre Field Office
UNC	University of North Carolina
UPA	Unpaired Peak Accuracy
USFS	United States Forest Service
USFS-PG	United State Forest Service Pawnee Grasslands
UTSO	BLM Utah State Office
VERDI	Visualization Environment for Rich Data Interpretation
VISTAS	Visibility Improvements for States and Tribal Associations in the Southeast
VMT	Vehicle Miles Traveled
WBD	Wind Blown Dust model
WEA	Western Energy Alliance
WESTUS	Western United States
WRAP	Western Regional Air Partnership
WRFO	White River Field Office
WGA	Western Governors' Association
WRF	Weather Research Forecasting model

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APPENDIX A

2008 WRF Meteorological Modeling for CARMMS

A.1 Introduction

The WRF model performance evaluation was conducted as part of WestJumpAQMS and is documented in a "WRF Application/Evaluation" report (ENVIRON and Alpine, 2012[1]). The WestJumpAQMS 2008 WRF model performance evaluation was based on a combination of qualitative and quantitative analyses. The qualitative approach was to compare the spatial distribution of the model estimated monthly total precipitation with the monthly Center for Prediction of Climate (CPC) precipitation analysis using graphical outputs. The quantitative approach was to examine tabulations and graphical displays of the model bias and error for surface wind speed, wind direction, temperature, and mixing ratio (humidity) and compare the performance statistics to benchmarks developed based on a history of meteorological modeling as well as past meteorological model performance evaluations. The statistics were calculated using the publicly available METSTAT evaluation tool, which calculates the statistical performance metrics and can produce time series of predicted and observed meteorological variable and performance statistics. The observed database for winds, temperature, and water mixing ratio that were used in this analysis is from the National Oceanic and Atmospheric Administration (NOAA), Earth System Research Laboratory (ESRL) Meteorological Assimilation Data Ingest System (MADIS). The locations of the MADIS monitoring sites within the 36 and 12 km WRF modeling domains are shown in Figures A-1 and A-2. The rain observations were taken from the NOAA CPC[2] retrospective rainfall archives.

The WestJumpAQMS 2008 WRF Application/Evaluation report evaluated the WRF surface meteorological parameters using METSTAT across the 36 km CONUS, 12 km WESTUS and 4 km IMWD modeling domains and compared them against meteorological model performance benchmarks. Provided with the WestJumpAQMS WRF Application/Evaluation report was the evaluation of the WRF model performance at each individual surface monitoring site in the inter-mountains western states. The results for all sites in Colorado are available on the WestJumpAQMS website[3] with a few examples of the WRF Colorado model performance given below.

[1] http://www.wrapair2.org/pdf/WestJumpAQMS_2008_Annual_WRF_Final_Report_February29_2012.pdf
[2] http://www.cpc.ncep.noaa.gov/products/precip/realtime/retro.shtml
[3] http://www.wrapair2.org/pdf/westjump.wrf.site.co.2012-04-04.pdf

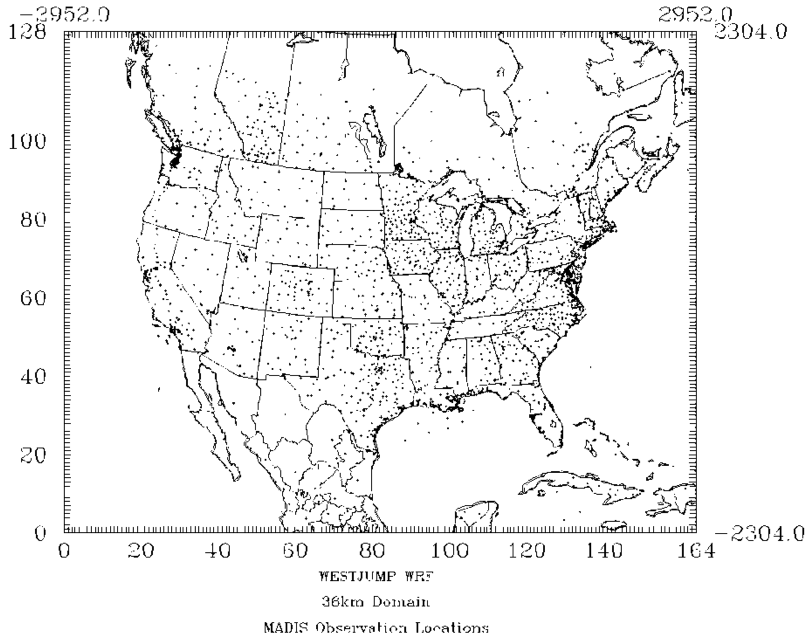

Figure A-1. Locations of MADIS surface meteorological modeling sites within the WestJumpAQMS WRF 36 km modeling domain.

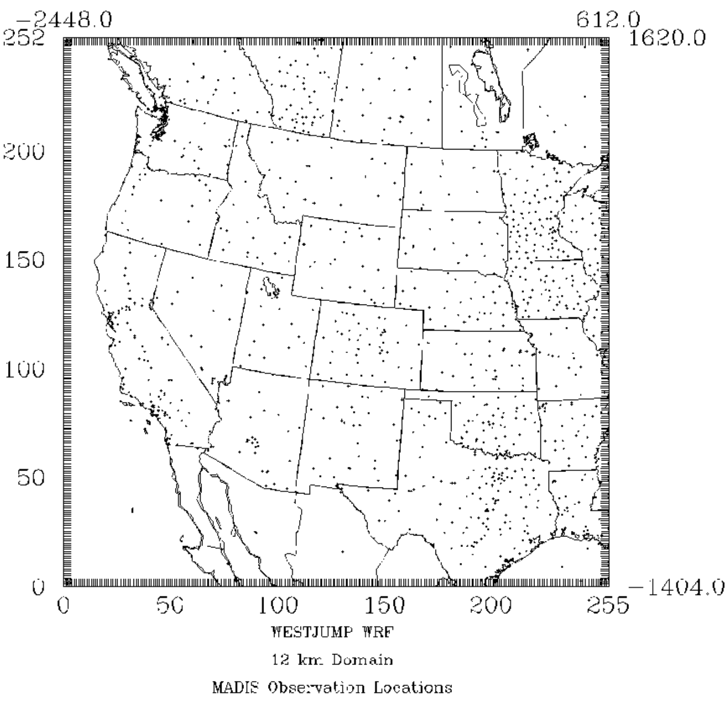

Figure A-2. Locations of MADIS surface meteorological modeling sites within the WestJumpAQMS WRF 12 km modeling domain.

A.2 Meteorological Model Performance Benchmarks

Meteorological model performance evaluation benchmarks have been developed after examining the model performance of ~30 meteorological model simulations that produced "good" air quality model performance, primarily to support ozone SIPs (Emery et al., 2001). The key to the benchmarks is to understand how good or poor the results are relative to other model applications run for the U.S. These meteorological model performance benchmarks include measures of bias and error in surface temperature, wind speed and direction and water vapor mixing ratio. Because the benchmarks were developed primarily for meteorological model simulations to support urban ozone planning they represent model performance under fairly "simple" conditions. That is, usually fairly flat terrain (although sometimes with coastal conditions) with simple meteorological conditions (e.g., stationary high pressure). Meteorological model performance within the complex terrain of the Inter-Mountain West would be expected to be not as good as in these simple conditions. Thus, for some of the meteorological model performance metrics (i.e., temperature) more "complex" performance benchmarks have been developed (Kemball-Cook et al., 2005; McNally, 2009).

The equations for bias, error and Root Mean Squared Error (RMSE) are given below. Table A-1 list the simple and complex meteorological model performance benchmarks that the WRF 2008 simulation model performance was compared against. It is important to emphasize that the benchmarks are not passing/failing grades, rather they are metrics that allow the intercomparison of meteorological model performance.

$$\text{Bias} = \frac{1}{N}\sum_{i=1}^{N}(P_i - O_i)$$

$$\text{Error} = \frac{1}{N}\sum_{i=1}^{N}|P_i - O_i|$$

$$\text{RMSE} = \left[\frac{1}{N}\sum_{i=1}^{N}(P_i - O_i)^2\right]^{1/2}$$

Table A-1. Simple and complex meteorological model performance benchmarks for surface meteorological model performance evaluation.

Meteorological	Benchmark		
Variable	Simple (Emery et al., 2001)	Complex (McNally, 2009)	Complex (Kemball-Cook et al., 2005)
Temperature Bias	≤±0.5°K	≤±1.0 K	≤±2.0 K
Temperature Error	≤2.0°K	≤3.0 K	≤3.5 K
Mixing Ratio Bias	≤±1.0 g/kg	--	NA
Mixing Ratio Error	≤2.0 g/kg	--	NA
Wind Speed Bias	≤±0.5 m/s	--	≤±1.5 m/s
Wind Speed RMSE	≤2.0 m/s	--	≤2.5 m/s
Wind Direction Bias	≤±10 degrees	--	NA
Wind Direction Error	≤30 degrees	--	≤±55 degrees

A.3 Summary of 2008 WRF Model Performance Evaluation for the CARMMS Region

The WestJumpAQMS WRF Application/Evaluation report evaluated WRF across several preliminary Impact Assessment Domains as shown in Figure A-3. The CO_UT 4 km IAD most closely resembles the CARMMS 4 km modeling domain so those results are discussed below. WestJumpAQMS also evaluated WRF's surface meteorological model performance separately for each site in Colorado that is discussed at the end of this section.

A.3.1 Surface Meteorological Model Performance

Figure A-4 display soccer plots of monthly humidity (mixing ratio) and temperature model performance within the CO_UT 4 km IAD domain (see Figure A-3) for the WestJumpAQMS 2008 4 km WRF simulation. Soccer plots plot a model's bias versus error and compares them with the model performance benchmark, where in these figures from the WestJumpAQMS WRF Application/Evaluation report (ENVIRON and Alpine, 2012) the Simple and McNally (2009) Complex benchmarks are used (see Table A-1). The WRF 36, 12 and 4 km humidity model performance achieves the Simple Performance Benchmark within the CO_UT 4 km IAD domain (Figure A-4, left). The monthly humidity performance for the WRF 4 km simulation is exhibiting near zero bias and very low error that achieves the Performance Benchmarks.

The WRF 36 km temperature performance has a bias that achieves the ≤±1.0 K McNally and ≤±2.0 K Kemball-Cook Complex Benchmarks (Figure A-4, right). However, the WRF 12 and 4 km simulation temperature exhibits a positive bias ranging from 0.0 to 1.3 K so that some months fall outside of the McNally but are within the Kemball-Cook Complex Benchmarks. The last four months of the year have a positive bias that is greater than 1.0 K. The WRF 12 and 4 km simulation temperature error falls between the Simple (2.0 K) and Complex 3.0/3.5 K) Benchmarks.

The WRF wind speed bias and error falls between the Simple and Complex benchmarks (Figure A-5, left). WRF exhibits a low wind speed bias across the CO-UT 4 km IAD domain with the negative bias greater for the warm than the cool months. The WRF 12 and 4 km wind direction has a near zero bias that is always within ±5 degrees that achieves the Simple Benchmark (≤±10 degrees). However, the wind direction error falls between the Simple (≤30 degrees) and Complex ≤55 degree benchmarks

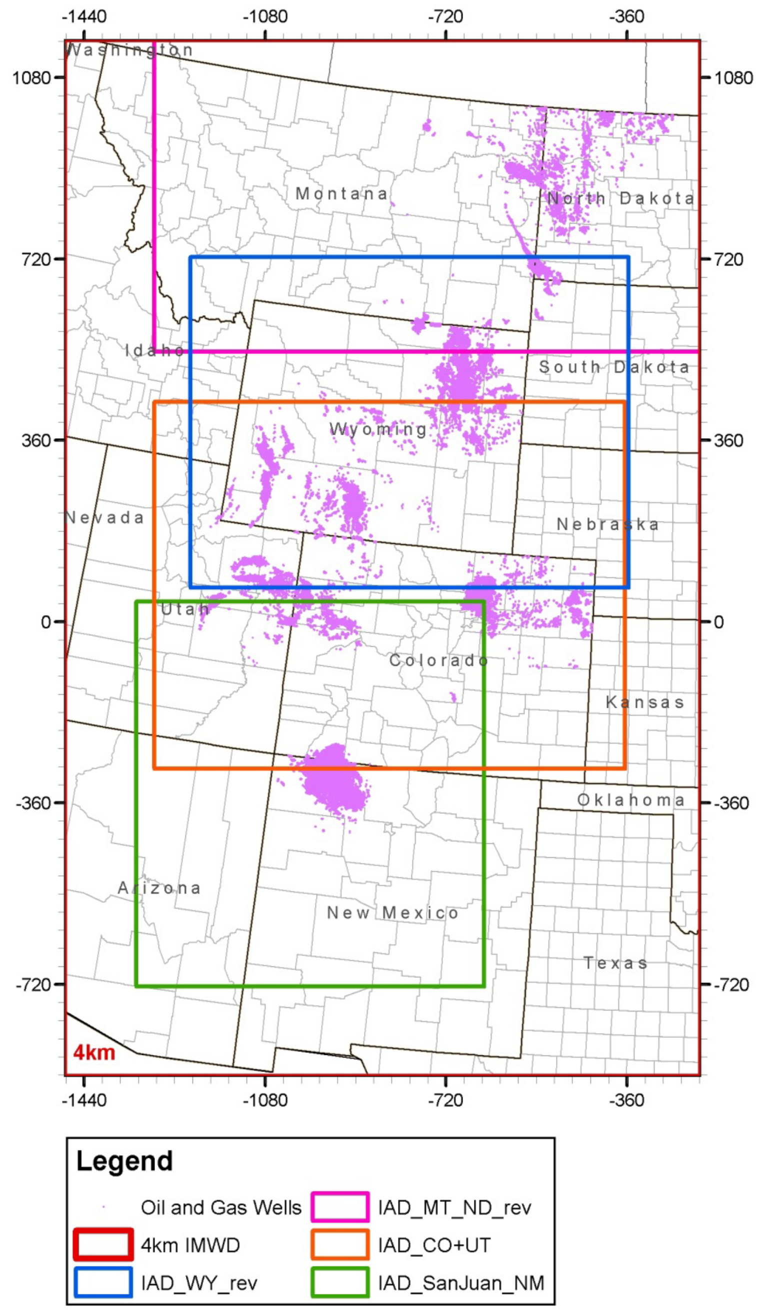

Figure A-3. Locations of the preliminary 4 km Impact Assessment Domains (IADs) used in the WestJumpAQMS 2008 WRF evaluation.

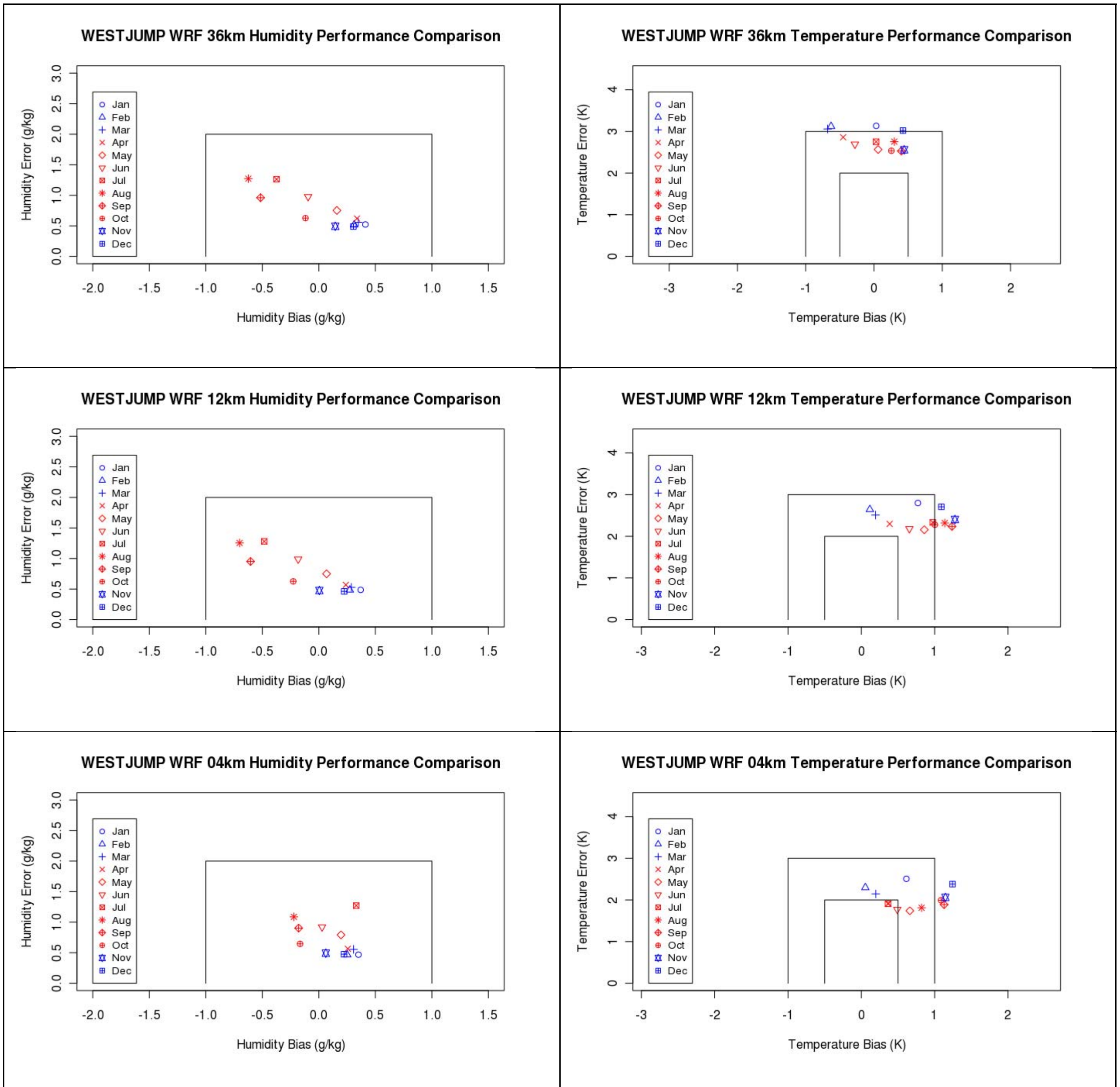

Figure A-4. Monthly Humidity (left) and Temperature (right) performance for all sites in the preliminary CO_UT 4 km Impact Assessment Domain for the 36 km (top), 12 km (middle) and 4 km (bottom) WestJumpAQMS WRF simulations.

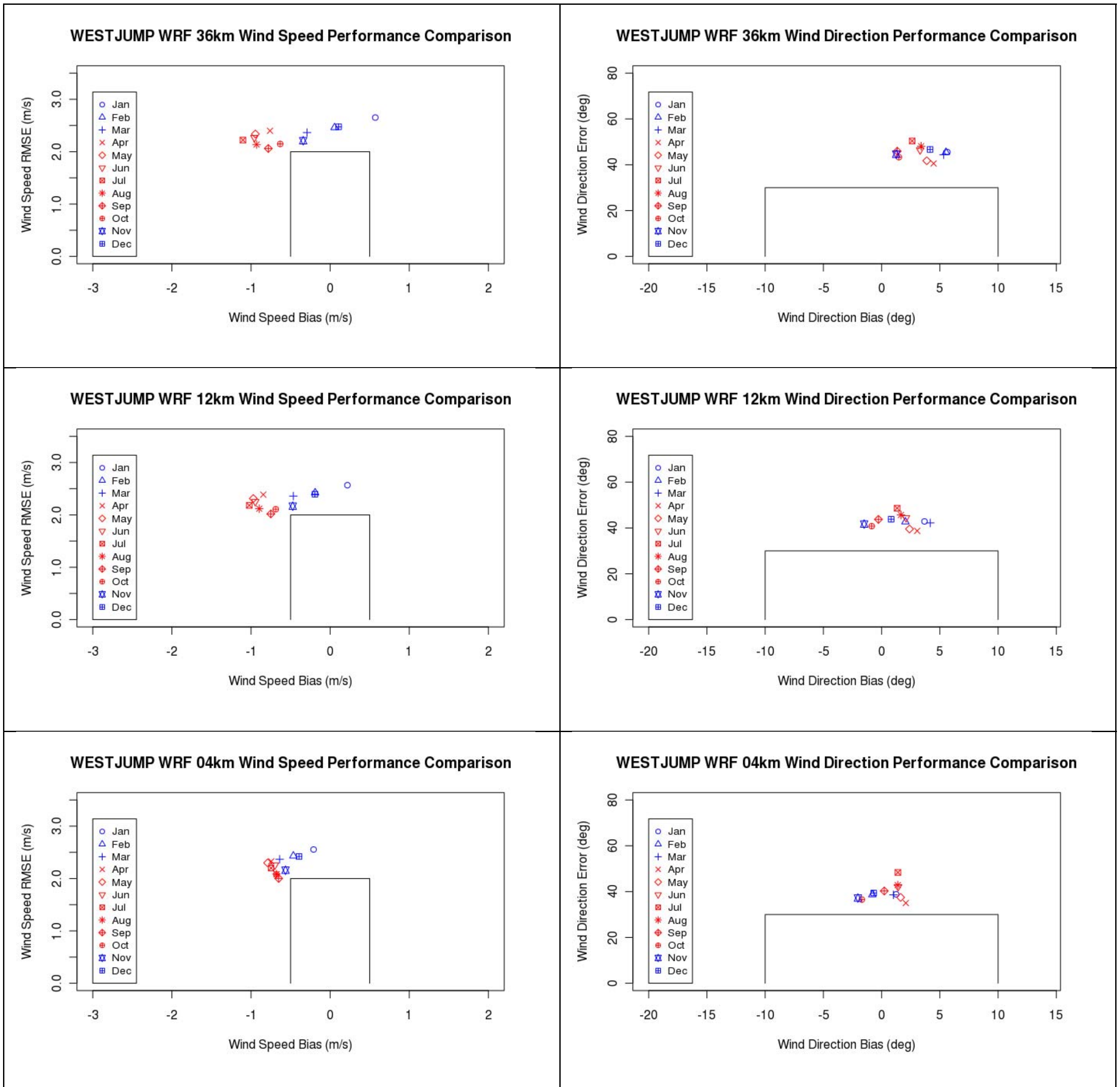

Figure A-5. Wind Speed (left) and Wind Direction (right) performance for all sites in the preliminary CO_UT 4 km Impact Assessment Domain for the 36 km (top), 12 km (middle) and 4 km (bottom) WestJumpAQMS WRF simulations.

A.3.2 Precipitation Evaluation

Figure A-6 compares monthly total precipitation across the 4 km IMWD for the CPC analysis fields based on observations, the WRF 4 km estimates and the four months of January, April, July and October (see WestJumpAQMS WRF report for remainder of months, ENVIRON and Alpine, 2012). The much higher resolution in the WRF 4 km precipitation fields is readily apparent compared to the coarser CPC fields and must be accounted for in the interpretation of precipitation model performance. In January 2008, the spatial distribution of the CPC and WRF monthly precipitation fields are very similar with most of it occurring in the western half of the domain and much dryer conditions east of the Front Range. The CPC and WRF estimate similar areas of higher precipitation intensity, although the WRF has smaller areas of higher intensity than the CPC analysis fields due to the higher resolution (Figure A-6a, top).

In April 2008, both the CPC analysis and WRF monthly precipitation exhibit a diagonal northwest to southeast orientation in the precipitation pattern with areas of higher intensity occurring over the Bitterroot Range on the ID-MT border, stretching down along the continental divide and in NB, KS and OK (Figure A-6a, bottom).

In July 2008, the desert southwest summer monsoon is clearly evident in the CPC and WRF precipitation fields with the highest intensity occurring in Arizona and New Mexico (Figure A-6b, top). Higher precipitation amounts are also seen in the high plains in the eastern part of the 4 km IMWD, with the Rocky Mountains in the western part of the 4 km IMWD being much dryer.

In October 2008, both the CPC and WRF have very similar spatial patterns of monthly precipitation with the highest intensity precipitation occurring in Kansas stretching down to OK and TX, with WRF estimating higher intensity in OK/TX than seen in the CPC fields (Figure A-6b, bottom).

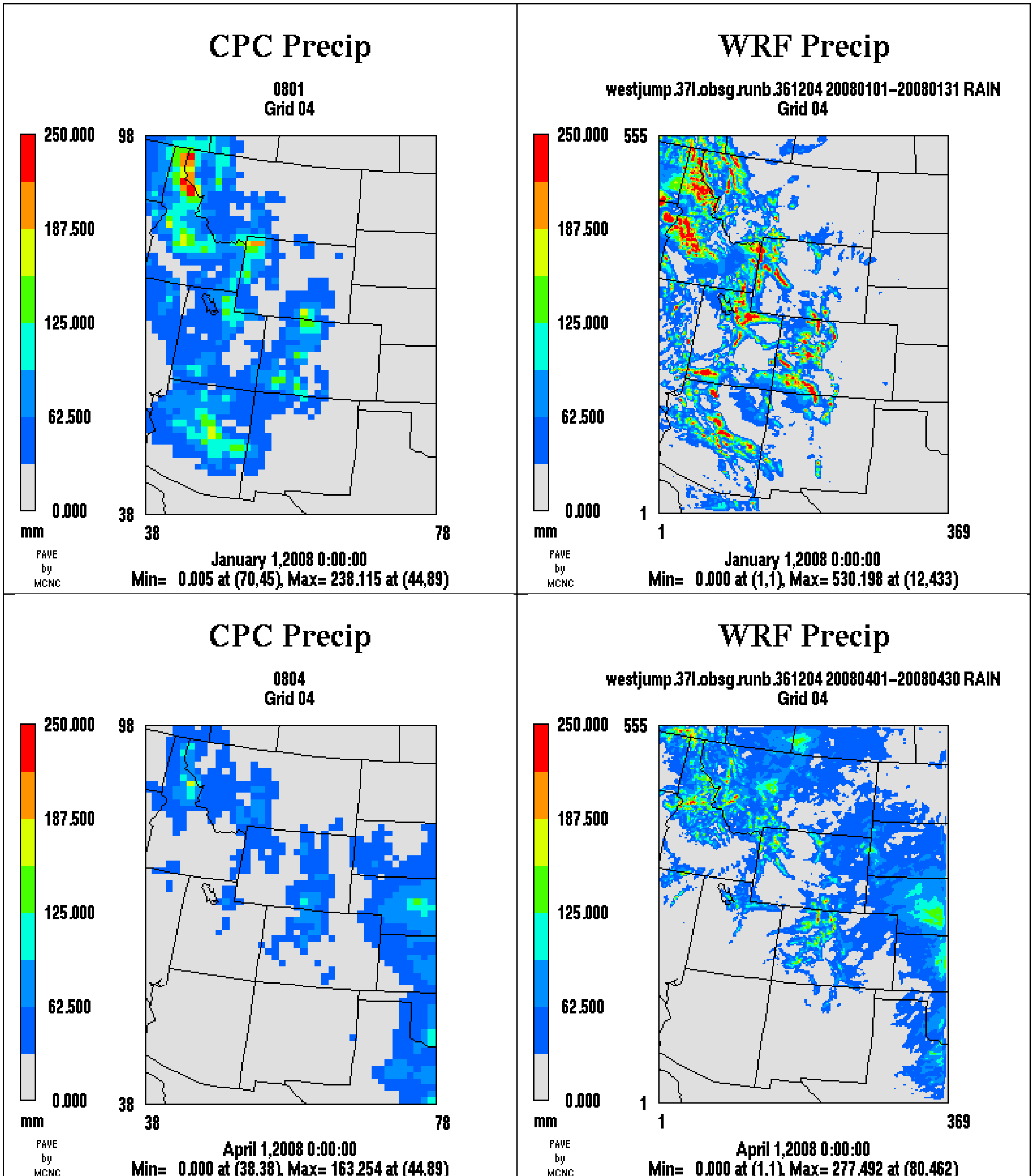

Figure A-6a. Comparison of January (top) and April (bottom) 2008 monthly precipitation amounts (mm) over the 4 km Inter-Mountain West Domain (IMWD) from the CPC analysis of observations (left) and estimated by the WestJumpAQMS 4 km WRF simulation.

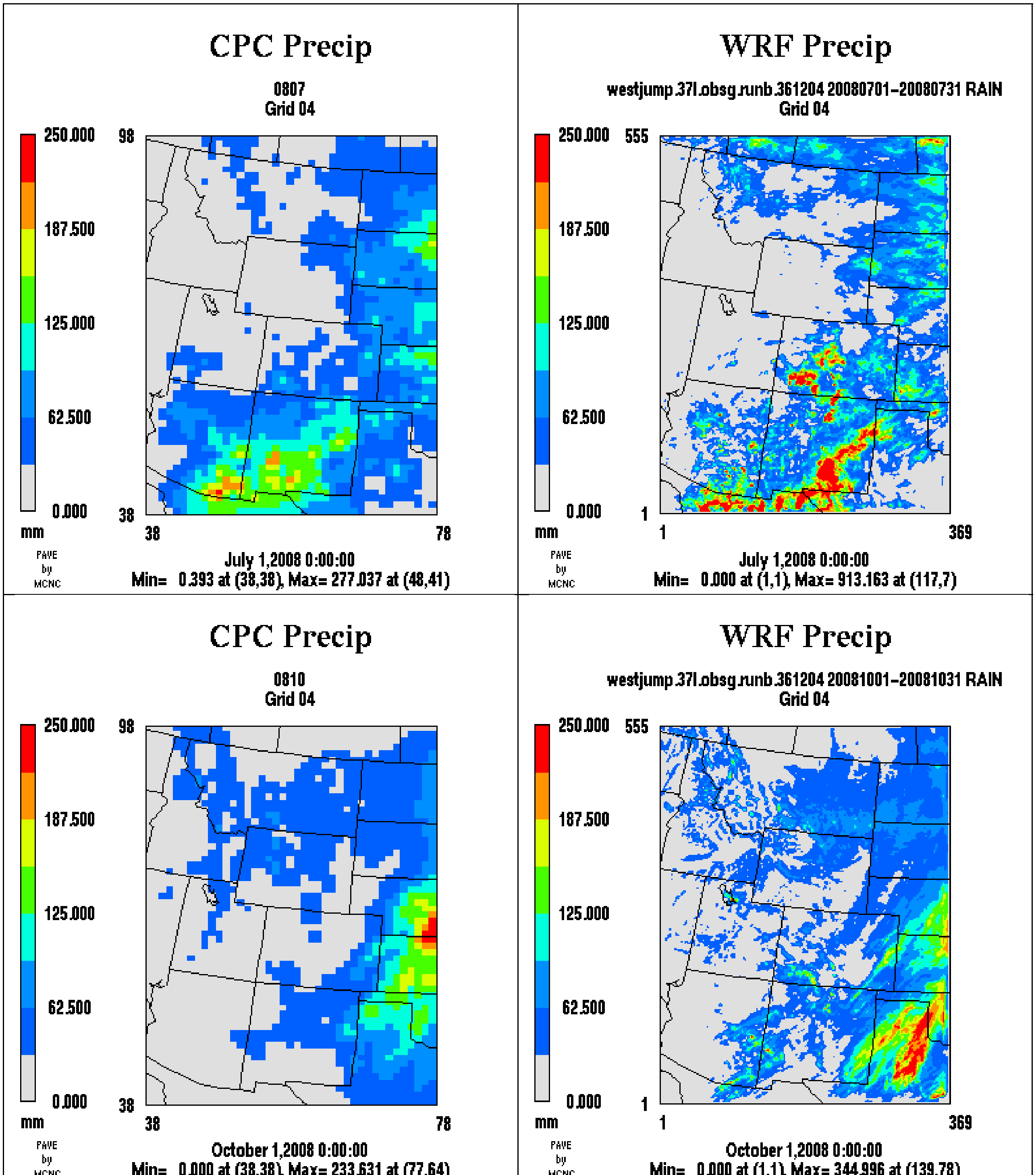

Figure A-6b. Comparison of July (top) and October (bottom) 2008 monthly precipitation amounts (mm) over the 4 km Inter-Mountain West Domain (IMWD) from the CPC analysis of observations (left) and estimated by the WestJumpAQMS 4 km WRF simulation.

A.3.3 Performance at Individual Monitoring Sites

WestJumpAQMS performed WRF 4 km surface meteorological model performance at individual monitoring sites in Colorado that is posted to its website[4]. The WRF performance varies greatly by site, which may be due in part to each site having its own local influences that cannot be captured by the 4 km WRF average meteorological conditions. For example, Figures A-7 and A-8 displays the WRF 4 km model performance at the Grand Junction (KGJT) and Gunnison (KGUC) Colorado monitoring sites that lie within the BLM Grand Junction and Uncompahgre Field Offices planning areas, respectively. KGJT has a negative wind direction bias that mostly falls within the ±10 degree performance benchmark and error that falls between the 30 and 55 degree simple and complex benchmarks. KGUC, on the other hand, has much worse wind direction performance with a positive bias that ranges from 0 to 30 degrees and errors of 50 to 80 degrees that fall outside of the benchmark ranges. Similar wind speed performance is seen with mostly an underestimation bias right at the -0.5 m/s simple benchmark but always achieving the complex benchmarks. The humidity benchmarks are almost always achieved at both sites with only July at KGJT falling outside of the benchmark due to being too moist. Different temperature model performance characteristics are seen at the two sites with KGJT achieving the complex benchmark (≤±1.0 K) except for the cold winter months that are too warm by from 1.5 to 3.0 K. Whereas KGUC always achieves the complex benchmark with monthly temperature bias and error clustered around the -0.5 K and 2.0 K simple benchmark bias and error point, except for January that has an overestimation bias of ~0.75 K.

[4] http://www.wrapair2.org/pdf/westjump.wrf.site.co.2012-04-04.pdf

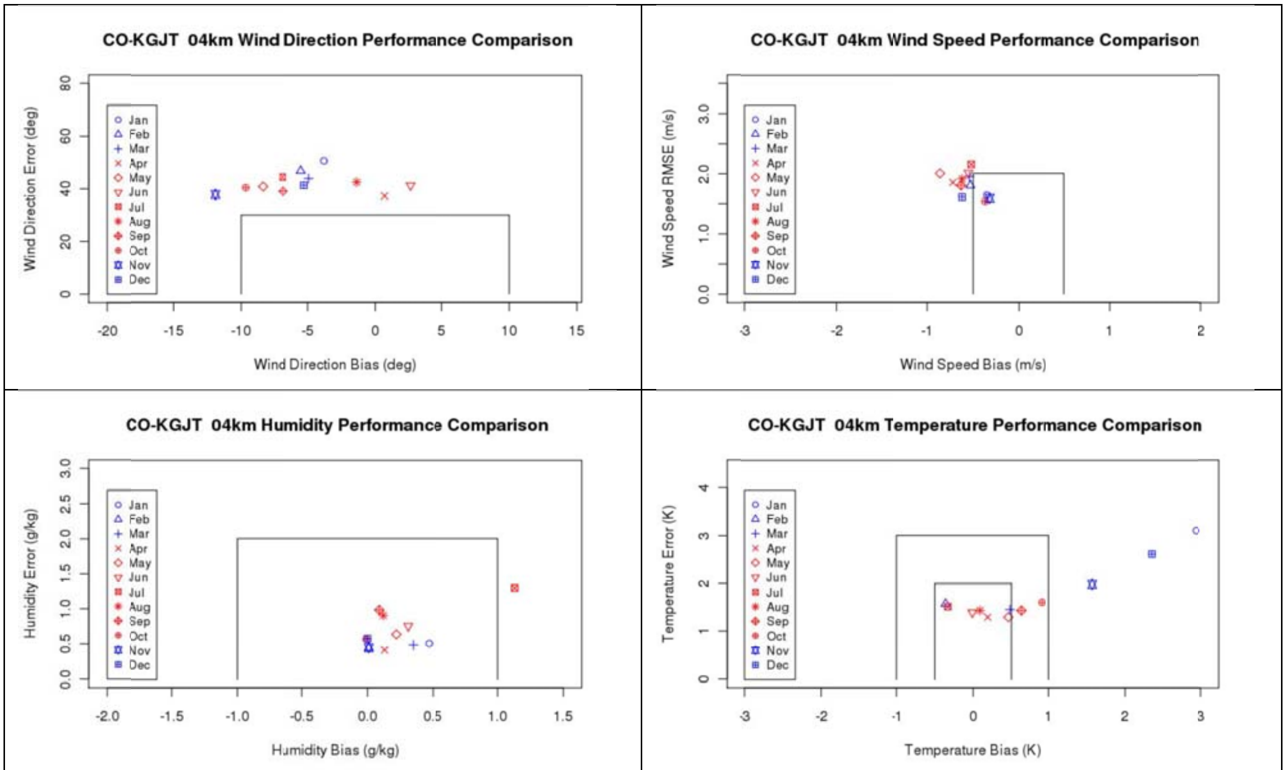

Figure A-7. Monthly WRF 4 km surface meteorological model performance at the Grand Junction (KGJT), Colorado monitoring site.

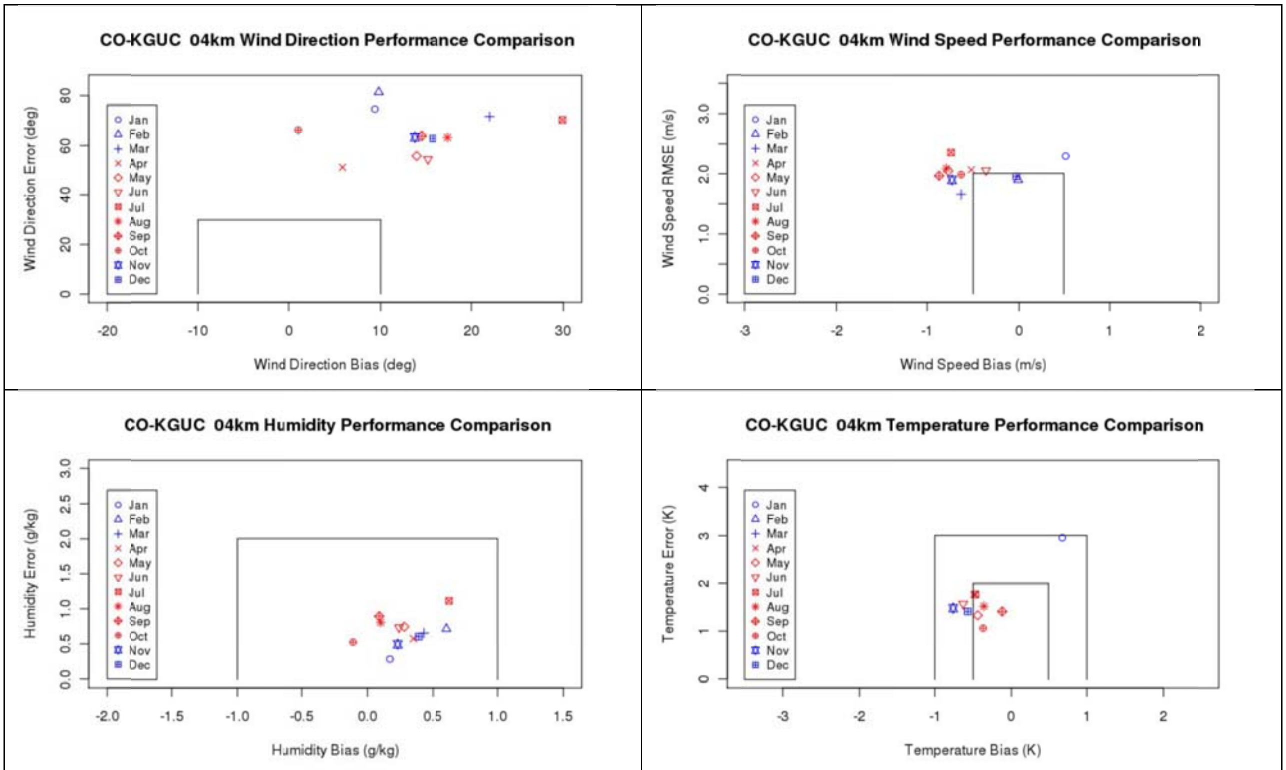

Figure A-8. Monthly WRF 4 km surface meteorological model performance at the Gunnison (KGUT), Colorado monitoring site.

APPENDIX B

2008 CAMX Base Case Model Performance Evaluation

B.1 Introduction

The CAMx PGM was selected for modeling air quality and AQRV impacts due to oil and gas and other activity within the Colorado and northern New Mexico BLM-planning areas. CAMx was selected over CMAQ due to the availability of the CAMx source apportionment tool and the need to obtain separate air quality and air quality related value (AQRV) contributions due to emissions of BLM authorized oil and gas sources in numerous Colorado and northern New Mexico BLM planning areas. CAMx Version 6.1 (V6.1, released April, 2014) was used in the CARMMS future year modeling analysis. However, CAMx V6.0 (September 2013 release) was used for the 2008 Base Case modeling. The CAMx V6.1 future year and CAMx V6.0 2008 Base Case models were configured to obtain identical results, although the CAMx V6.1 future year source apportionment took advantage of a new point source emissions "compact format" feature that greatly reduces the disk space requirements and consequently computational resources for the future year source apportionment modeling.

B.2 CAMx Model Configuration

The CAMx PGM 2008 Base Case modeling was configured as shown in Table B-1 and described below.

Advection and Diffusion Methods: The piecewise parabolic method (PPM) advection solver was used for horizontal transport (Colella and Woodward, 1984) along with the spatially varying (Smagorinsky) horizontal diffusion approach. CAMx will use K-theory for vertical diffusion using the CMAQ-like vertical diffusivities from WRFCAMx.

Chemical Mechanism: The CB05 gas-phase chemical mechanism was selected for the CAMx 2008 Base Case modeling to be consistent with WestJumpAQMS.

Spin-Up Initialization: A minimum of ten days of model spin up (i.e., using meteorological and emission conditions for December 21-31, 2007) was used to initialize the PGM.

Model Run Strategy: CAMx includes two approaches for using multiple central processing units (CPUs) for multi-processing: (1) Message Passing Interface (MPI) that performs modeling domain decomposition, passes the model solution for each subdomain to different CPUs at each time step, and then reassembles the solution across the whole domain at the end of the time step; and (2) Open Multiprocessing (OpenMP) that uses compiler directives to use multiple CPUs in the model simulation. An optimal configuration of MPI and OpenMP will be determined for the Linux Cluster being used to minimize the model throughput time. After benchmarking several different configurations, the CAMx CARMMS current and future year model simulations were run separately for four quarters using ~10 days of spin-up and using 24 CPUs for each quarter (i.e., using 96 CPUs at once) with 6 MPI domain decomposition and each MPI subdomain was run with 4 OpenMP multi-processing CPUs (24 = 6 x 4).

Boundary Conditions: Boundary conditions (BCs) for the 36 km CONUS domain CAMx simulation were based on output from the Model for OZone And Related chemical Tracers

(MOZART,[1]) global chemistry model. BCs for the CARMMS CAMx 2008 4 km based case simulation were based on the WestJumpAQMS CAMx 2008 36/12 km Base Case simulation.

Photolysis Rates: For photolysis rates, CAMx requires a lookup table of photolysis rates as well as gridded albedo/haze/ozone/snow as input. Day-specific ozone column data are based on the Total Ozone Mapping Spectrometer (TOMS) data measured using the satellite-based Ozone Monitoring Instrument (OMI[2]). Albedo is based on land use data, which includes enhanced albedo values when snow cover is present. For CAMx there is an ancillary snow cover input that is based on WRF output that overrides the land use based albedo input to use an enhanced snow cover albedo value. The Tropospheric Ultraviolet and Visible (TUV) Radiation Model[3] photolysis rate processor was used. CAMx is configured to use the in-line TUV to adjust for cloud cover and account for the effects aerosol loadings have on photolysis rates; this latter effect on photolysis may be especially important in adjusting the photolysis rates due to the occurrence of PM concentrations associated with emissions from fires. Note that the same photolysis rates are used in the 2008 Base Case and 2021 future year modeling.

Landuse: Landuse fields were generated based on U.S. Geological Survey (USGS) Geographic Information Retrieval and Analysis System (GIRAS) data[4]. The WRF estimate snow cover data is used to override the USGS land cover categories when snow cover is present.

Meteorological Inputs: The WestJumpAQMS 2008 WRF-derived meteorological fields were processed to generate CAMx meteorological inputs for the CARMMS 4 km domain and 2008 using the WRFCAMx processor.

Plume in Grid: The subgrid-scale Plum-in-Grid module was not used in the CARMMS modeling.

Other Model configuration options are detailed in Table B-1.

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[1] http://www.acd.ucar.edu/wrf-chem/mozart.shtml
[2] http://ozoneaq.gsfc.nasa.gov/
[3] http://cprm.acd.ucar.edu/Models/TUV/
[4] http://pubs.usgs.gov/ds/2006/240/

Table B-1. CAMx model configurations for BLM CARMMS 2008 4 km Base Case simulation.

Science Options	Configuration	Details
Model Codes	CAMx V6.0 – May 2013 Release	CAMx V6.1 (April 2014) used in 2021 future year modeling
Horizontal Grid Mesh- Regional Run to generate Boundary Conditions (BC) for the 4 km impact assessment domain	36/12 km	36/12 km run to generate BC for CARMMS 4 km impact assessment domain. 36/12 km run with 2 way grid nesting
36 km grid	148 x 112 cells	36 km CONUS RPO domain
12 km grid	239 x 206 cells	12 km WESTUS domain from WestJumpAQMS domain
Horizontal Grid Mesh- CARMMS Impact Assessment Runs	4 km	216 x 234
Vertical Grid Mesh	25 vertical layers, defined by WRF	Layer 1 thickness ~24- m. Model top at ~19-km above MSL
Grid Interaction	36/12 km two way nesting provide one-way grid nesting to 4 km CARMMS domain	CARMMS 4 km stand-alone domain
Initial Conditions	10 day spin-up	
Boundary Conditions	36 km CONUS domain from MOZART global chemistry model	4 km domain BCs from 36/12 km regional run
Emissions		
Baseline Emissions Processing	SMOKE, MOVES and MEGAN	
Sub-grid-scale Plumes	No Plume-in-Grid for major NO_X sources	
Chemistry		
Gas Phase Chemistry	CB05	
Meteorological Processor	WRFCAMx	
Horizontal Diffusion	Spatially varying	Smagorinsky
Vertical Diffusion	CMAQ-like in WRFCAMx	
Diffusivity Lower Limit	Kz_min = 0.1 to 1.0 m^2/s or 2.0 m_2/s	
Deposition Schemes		
Dry Deposition	Zhang dry deposition scheme	Zhang et al., 2001; 2003
Wet Deposition	CAMx -specific formulation	rain/snow/graupel/virga
Numerics		
Gas Phase Chemistry Solver	Euler Backward Iterative (EBI) -- Fast Solver	
Vertical Advection Scheme	Implicit scheme w/ vertical velocity update (CAMx)	
Horizontal Advection Scheme	Piecewise Parabolic Method (PPM) scheme	Colella and Woodward, 1984
Integration Time Step	Wind speed dependent	~0.1-1 min for 4 km domain

B.3 2008 CAMx Base Case Modeling

WestJumpAQMS performed CAMx modeling using two-way grid nesting on the regional 36 km CONUS and 12 km WESTUS domains using the 2008 Base Case emission scenario to develop boundary conditions (BCs) for the smaller 4 km CARMMS domain. WestJumpAQMS then ran CAMx for the 4 km CARMMS impact assessment domain using 2008 Base Case emissions and BCs from the CAMx 2008 Base Case 36/12 km run.

B.4 Photochemical Model Performance Evaluation

The CAMx 2008 Base Case modeling and model performance evaluation was conducted under the WestJumpAQMS. Originally CARMMS was going to completely rely on the WestJumpAQMS model evaluation of the CARMMS 2008 Base Case simulation and CARMMS did not intend to perform any additional 2008 Base Case modeling or model performance evaluation. WestJumpAQMS conducted a comprehensive detailed model performance of the CAMx 2008 36/12 km Base Case simulation across the 36 km CONUS and 12 km WESTUS domains, and within each western State for ozone, total $PM_{2.5}$ mass, speciated $PM_{2.5}$, sulfur and nitrogen wet deposition and for several ozone and $PM_{2.5}$ precursor (e.g., SO_2 and NO_X) and related (e.g., HNO3) species. Section 4.5.3 of the WestJumpAQMS final report (ENVIRON, Alpine and UNC[5]) presented the evaluation the CARMMS 2008 4 km Base Case simulation across the CARMMS 4 km domain.

B.4.1 February 28, 2014 IAQRT Meeting

The WestJumpAQMS model evaluation results for the CARMMS CAMx 4 km Base Case simulation were presented to the Interagency Air Quality Review Team (IAQRT) on February 28, 2014 at the BLM Colorado State Office (COSO). EPA expressed several concerns regarding the adequacy of the model performance evaluation of the CARMMS 2008 4 km Base Case. In particular they believed that the ozone model performance evaluation should be performed using a 60 ppb observed ozone cut-off instead of the 40 ppb cut-off used by WestJumpAQMS. In addition, they expressed concerns about just calculating monthly model performance statistics across the entire 4 km CARMMS modeling domain.

The evaluation of the CAMx model for the CARMMS 2008 base case simulation produced many more evaluation products than provided in the WestJumpAQMS final report. However, it did not calculate ozone model performed statistics using a 60 ppb observed ozone cut-off threshold as desired by EPA. So we calculated additional ozone model performance statistics using the 60 ppb ozone cut-off threshold. The spreadsheet of monthly ozone bias and error model performance statistics and their comparison with the ozone bias (≤±15%) and error (≤35%) performance goals was updated as follows:

[5] http://www.wrapair2.org/pdf/WestJumpAQMS_FinRpt_Finalv2.pdf

Ozone Averaging Times

- Hourly
- Daily maximum 8-Hour Ozone Concentrations

Ozone Monitoring Networks

- AQS
- CASTNet

Bias and Error Statistical Metrics

- Fractional Bias and Error
- Normalized Mean Bias and Error
- Mean Normalized Bias and Error

As discussed below, with the exception of some winter months, the monthly ozone statistical performance metrics across the CARMMS 4 km domain still achieved EPA's performance goals even using the 60 ppb cut-off threshold for both averaging times and monitoring networks and three types of bias/error performance metrics.

Regarding more details on the CARMMS CAMx 4 km base case MPE, we packaged up the model performance products in a zipped file that includes many differences types of monthly model performance metrics and species for sites in the CARMMS 4 km modeling domain. Model performance displays include scatter plots and time series plots of predicted and observed concentrations, in addition to a full suite of model performance evaluation statistical metrics, and are provided for each month of 2008 as follows:

- All sites in the CARMMS 4 km domain and all hours/days in a month.
- At each individual site in the CARMMS 4 km domain and all hours/days in a month.
- For each day in 2008 across all sites in the CARMMS 4 km domain.

Model performance displays and statistics are provided for numerous gas-phase (e.g., ozone and NO_X) and particulate matter (PM) species (e.g., SO4, NO3, NH4, EC, OA). EPA specifically requested model performance for ammonia (NH3) and ammonium (NH4). However, there were no routine NH3 measurements available in 2008 and NH4 was just measured at the CSN network. Although we also evaluated CAMx against derived ammonium (NH4d) at IMPROVE sites that is obtained using the IMPROVE SO4 and NO3 measurements and assuming they are completely neutralized by NH4; note this will overstate actual NH4 values because SO4 is not always neutralized and both SO4 and NO3 can be neutralized by other cations besides NH4.

The detailed model performance displays and metrics for the CARMMS CAMx 2008 base case simulation is contained in the zipped file "CARMMS_2008_4km_MPE_Details.zip" that contains over 4,500 separate model performance displays and is larger than 70 Mb.

Below we present the WestJumpAQMS evaluation of the CARMMS 2008 Base Case simulation across the 4 km CARMMS domain with the addition of the ozone metrics using the 60 ppb cut-off concentrations discussed above. However, we do not present the evaluation down to the individual site as the amount of information is too overwhelming.

B.4.2 Observed Monitoring Networks

The following routine air quality measurement data networks were used in the CAMx model performance evaluation:

EPA AQS Surface Air Quality Data: Data files containing hourly-averaged concentration measurements at a wide variety of state and EPA monitoring networks are available in the Air Quality System (AQS[6]) database throughout the U.S. These data sets will be reformatted for use in the model evaluation software tools. There are several types of networks within the AQS that measure different species. The standard hourly AQS AIRS monitoring stations typically measure hourly ozone, NO_2, NO_X and CO concentration and there are thousands of sites across the U.S. The Federal Reference Method (FRM) network measures 24-hour total $PM_{2.5}$ mass concentrations using a 1:3 day sampling frequency, with some sites operating on an everyday frequency. The Chemical Speciation Network (CSN) measures speciated $PM_{2.5}$ concentrations including SO_4, NO_3, NH_4, EC, OC and elements at 24-hour averaging time period using a 1:3 or 1:6 day sampling frequency.

IMPROVE Monitoring Network: The Interagency Monitoring of Protected Visual Environments (IMPROVE[7]) network collects 24-hour average $PM_{2.5}$ and PM_{10} mass and speciated $PM_{2.5}$ concentrations (with the exception of ammonium) using a 1:3 day sampling frequency. IMPROVE monitoring sites are mainly located at more rural Class I area sites that correspond to specific National Parks and Wilderness Areas across the U.S., with most of the sites located in the western U.S. Although there are also some IMPROVE protocol sites that can be more urban-oriented.

CASTNet Monitoring Network: The Clean Air Status and Trends Network (CASTNet[8]) operates approximately 80 monitoring sites in mainly rural areas across the U.S. CASTNet sites typically collected hourly ozone, temperature, wind speed and direction, sigma theta, solar radiation, relative humidity, precipitation and surface wetness. CASTNet also collects weekly (Tuesday to Tuesday) samples of speciated $PM_{2.5}$ sulfate, nitrate, ammonium and other relevant ions and weekly gaseous SO_2 and nitric acid (HNO_3).

NADP Network: The National Acid Deposition Program (NADP[9]) collects weekly samples of SO_4, NO_3 and NH_4 in precipitation (wet deposition) in their National Trends Network (NTN) at over a 100 sites across the U.S. that are mainly located in rural areas away from big cities and major point sources. Seven NADP sites also collect daily wet deposition measurements (AIRMON) when precipitation occurs. Over 20 of the NADP sites also collect weekly mercury (MDN)

[6] http://www.epa.gov/ttn/airs/airsaqs/aqsweb/
[7] http://vista.cira.colostate.edu/IMPROVE/
[8] http://java.epa.gov/castnet/
[9] http://nadp.sws.uiuc.edu/NADP/

samples. Note that observed sulfate and nitrate dry deposition can be estimated at CASTNet sites using concentrations and a micro-meteorological model that produces a deposition velocity. But these are not true observations, but model estimates of dry deposition flux using observed atmospheric concentrations and meteorological variables and a micro-meteorological deposition model.

B.4.3 Model Performance Goals

Over two decades ago EPA developed PGM ozone model performance goals that are listed in Table B-2 (EPA, 1991). During the regional haze RPO process, additional model performance goals and criteria were developed for PM species (Boylan, 2004; Morris et al., 2009c,d) that are listed in Table B-3. Note that the EPA 1991 ozone model performance goals were applied to the mean normalized bias (MNB) and mean normalized gross error (MNGE) model performance statistics that are calculated for all predicted and observed hourly ozone pairs matched by time and location for which the observed hourly ozone is above a threshold, with a 60 ppb threshold recommended. However, the 60 ppb ozone cut-off was selected for urban ozone modeling of areas with high ozone concentrations addressing the 1-hour ozone NAAQS of 124 ppb. Ozone is much lower these days so an observed ozone cut-off threshold concentration of 40 ppb was used for calculating the MNB and MNGE ozone statistics in addition to the 60 ppb cut-off value. For PM performance statistics, the Fractional Bias (FB) and Fractional Error (FE) bias/error performance metrics are compared against goals and criteria developed during the Regional Planning Organizations (RPOs) modeling to support the Regional Haze Rule (Boylan, 2004; Morris et al., 2009c,d). Table B-4 lists the definitions of the model performance statistical metrics.

More recently, EPA compiled and interpreted the model performance from 69 PGM modeling studies in the peer-reviewed literature between 2006 and March 2012 and developed recommendations on what should be reported in a model performance evaluation (Simon, Baker and Phillips, 2012). Although these recommendations are not official EPA guidance, they are useful for consideration in the BLM CARMMS model performance evaluation:

- PGM MPE studies should at a minimum report the Mean Bias (MB) and Mean Error (ME or RMSE), and Normalized Mean Bias (NMB) and Normalized Mean Error (NME) and/or Fractional Bias (FB) and Fractional Error (FE). Both the MNB and FB are symmetric around zero with the FB bounded by -200% to +200%.
- Use of the Mean Normalized Bias (MNB) and Gross Error (MNGE) is not encouraged because they are skewed toward low observed concentrations and can be misinterpreted due to the lack of symmetry around zero.
- The model evaluation statistics should be calculated for the highest resolution temporal resolution available and for important regulatory averaging times (e.g., daily maximum 8-hour ozone).
- It is important to report processing steps in the model evaluation and how the predicted and observed data were paired and whether data are spatially/temporally averaged before the statistics are calculated.

- Predicted values should be taken from the grid cell that contains the monitoring site, although bilinear interpolation to the monitoring site point can be used for higher resolution modeling (< 12 km).
- $PM_{2.5}$ should also be evaluated separately for each major component species (e.g., SO_4, NO_3, NH_4, EC, OA and OPM2.5).
- Evaluation should be performed for subsets of the data including, high observed concentrations (e.g., ozone > 60 ppb[10]), by subregions and by season or month.
- Evaluation should include more than just ozone and $PM_{2.5}$, such as SO_2, NO_2 and CO.
- Spatial displays should be used in the model evaluation to evaluate model predictions away from the monitoring sites. Time series of predicted and observed concentrations at a monitoring site should also be used.
- It is necessary to understand measurement artifacts in order to make meaningful interpretation of the model performance evaluation.

Given these recommendations we will stress the FB and FE and NMB and NME measures of bias and error over the MNB and MNGE.

Table B-2. Hourly ozone model performance goals from EPA's 1991 PGM modeling guidance.

Goal	Metric	Definition	Comment
≤±20%	Unpaired Peak Accuracy (UPA)	$\frac{P - O_{peak}}{O_{peak}}$	Compare highest predicted and observed daily maximum hourly ozone concentrations unmatched by location and hour but matched by day.
≤±15%	Mean Normalized Bias (MNB)	$\frac{1}{N}\sum_{i=1}^{N}\frac{(P_i - O_i)}{O_i}$	Predicted and observed hourly ozone concentrations matched by time and location when observed ozone is 60 ppb or greater. Use a 40 ppb cut-off in CARMMS.
≤35%	Mean Normalized Gross Error (MNGE)	$\frac{1}{N}\sum_{i=1}^{N}\frac{\lvert P_i - O_i \rvert}{O_i}$	Predicted and observed hourly ozone concentrations matched by time and location when observed ozone is 60 ppb or greater. Use a 40 ppb cut-off in CARMMS.

Table B-3. Ozone and PM model performance goals and criteria for bias and error (Boylan, 2004; Morris et al., 2009c,d).

Bias	Error	Comment
≤±15%	≤35%	Ozone model performance Goal from the 1991 guidance that would be considered very good model performance for PM species (EPA, 1991).
≤±30%	≤50%	PM model performance Goal, considered good PM performance (Boylan, 2004).
≤±60%	≤75%	PM model performance Criteria, considered average PM performance. Exceeding this level of performance for PM species with significant mass may be cause for concern (Boylan, 2004).

[10] Note that because of the low ozone concentrations in the Montana/Dakotas the Simon, Baker and Phillips (2012) 60 ppb threshold recommendation should be lowered to 40 ppb.

Table B-4. Definition of model performance evaluation statistical measures used to evaluate PGMs in the past.

Statistical Measure	Mathematical Expression	Notes
Accuracy of paired peak (AP)	$\frac{P - O_{peak}}{O_{peak}}$	Comparison of the peak observed value (O_{peak}) with the predicted value at same time and location
Coefficient of determination (r2)	$\frac{\left[\sum_{i=1}^{N}(P_i - \overline{P})(O_i - \overline{O})\right]^2}{\sum_{i=1}^{N}(P_i - \overline{P})^2 \sum_{i=1}^{N}(O_i - \overline{O})^2}$	Pi = prediction at time and location i; Oi = observation at time and location i; $\overline{P}$ = arithmetic average of Pi, i=1,2,…, N; $\overline{O}$ = arithmetic average of Oi, i=1,2,…,N
Normalized Mean Error (NME)	$\frac{\sum_{i=1}^{N}\lvert P_i - O_i \rvert}{\sum_{i=1}^{N} O_i}$	Reported as %
Root Mean Squared Error (RMSE)	$\left[\frac{1}{N}\sum_{i=1}^{N}(P_i - O_i)^2\right]^{1/2}$	Reported as %
Fractional Gross Error (FE)	$\frac{2}{N}\sum_{i=1}^{N}\left\lvert\frac{P_i - O_i}{P_i + O_i}\right\rvert$	Reported as % and bounded by 0% to 200%
Mean Absolute Gross Error (MAGE)	$\frac{1}{N}\sum_{i=1}^{N}\lvert P_i - O_i \rvert$	Reported as concentration (e.g., $\mu g/m^3$)
Mean Normalized Gross Error (MNGE)	$\frac{1}{N}\sum_{i=1}^{N}\frac{\lvert P_i - O_i \rvert}{O_i}$	Reported as %
Mean Bias (MB)	$\frac{1}{N}\sum_{i=1}^{N}(P_i - O_i)$	Reported as concentration (e.g., $\mu g/m^3$)
Mean Normalized Bias (MNB)	$\frac{1}{N}\sum_{i=1}^{N}\frac{(P_i - O_i)}{O_i}$	Reported as %
Mean Fractionalized Bias (Fractional Bias, FB)	$\frac{2}{N}\sum_{i=1}^{N}\left(\frac{P_i - O_i}{P_i + O_i}\right)$	Reported as %, bounded by -200% to +200%
Normalized Mean Bias (NMB)	$\frac{\sum_{i=1}^{N}(P_i - O_i)}{\sum_{i=1}^{N} O_i}$	Reported as %
Bias Factor (BF)	$\frac{1}{N}\sum_{i=1}^{N}\left(\frac{P_i}{O_i}\right)$	Reported as BF:1 or 1: BF or in fractional notation (BF/1 or 1/BF).

B.4.4 Model Performance Evaluation Approach

The WestJumpAQMS CAMx 2008 base case model performance evaluation focused on evaluating the model for its primary intended purpose, estimating the air quality and AQRV impacts within the 4 km CARMMS modeling domain. Based on EPA modeling guidance (EPA, 1991; 2007), the recommendations of Simon, Baker and Philips (2012) and previous studies, the WestJumpAQMS CAMx model performance evaluation included the following:

- The PGM should be evaluated across all relevant species for which observations are available, including ozone, NO, NO_2, NO_X, HNO_3, SO_2, $PM_{2.5}$, PM_{10}, speciated $PM_{2.5}$ (SO_4, NO_3, NH_4, EC, OA and OPM2.5) and wet sulfur and nitrogen deposition.
- Numerous statistical performance measures should be calculated (Table B-4) and reported following the recommendations of Simon, Baker and Phillips (2012)
- The native sampling frequency of the observations will be used in the evaluation, along with important regulatory averaging times (e.g., daily maximum 8-hour ozone, annual $PM_{2.5}$ and annual wet deposition).
- The PGM evaluation should also include geographic, temporal and concentration stratifications.
- The PGM results should be more thoroughly evaluated for the 4 km CARMMS domain.
- Seasonal and monthly evaluation should be included.
- Evaluation for high observed concentrations should be made.
- Several graphical displays of model performance may be used, including, but not limited to:
    - Scatter Plots of predicted and observed concentrations/depositions.
    - Spatial Maps of performance, including spatial maps of model predictions with superimposed observations and interpolated spatial maps of bias and error.
    - Time Series Plots of predicted and observed concentrations using native observation averaging time.
    - Soccer Plots that compare model performance statistics with model performance goals (Table B-3).

Details on the CAMx 2008 model performance evaluation are provided in the WestJumpAQMS final report and supporting material. Below we summarized the CAMx model performance evaluation statistical metrics for just within the CARMMS 4 km modeling domain that is the subject of this study.

B.5 Model Evaluation within the 4 km CARMMS Domain

WestJumpAQMS developed a separate CAMx 4 km modeling database for the 2008 annual period and the 4 km CARMMS modeling domain (see Figure 2-1) that covers all of Colorado, the northern two-thirds of New Mexico as well as eastern Utah and northeastern Arizona. WestJumpAQMS conducted a separate model performance evaluation of the CAMx 2008 base case simulation for the CARMMS 4 km domain that is summarized from the WestJumpAQMS final report (ENVIRON, Alpine and UNC, 2013) in this section. Also presented below are some supplemental ozone evaluation results as suggested by the IAQRT in their February 28, 2014 meeting.

Figures B-1 through B-4 displays the monthly and annual daily maximum 8-hour (DMAX8) and hourly ozone model performance statistics across all CASTNet (top) and AQS (bottom) sites in the 4 km CARMMS domain using observed ozone cut-off concentrations of 40 and 60 ppb. The Fractional Bias and Error (FB and FE) and Normalized Mean Bias and Error (NMB and NME) performance statistics are used in these Figures. The Mean Normalized Bias and Error (MNB and MNE) statistics are not presented following the recommendations of Simon, Baker and Philips (2012). The CARMMS ozone model performance statistics are compared against EPA's 1991 bias (≤±15%) and error (≤35%) ozone model performance goals (Table B-2). The CAMx 4 km model pDMAX8 ozone performance evaluation across CASTNet and AQS monitors within the CARMMS 4 km domain using the FB 40 ppb cut-off are ≤±6% with an annual FB of less than 2%, which achieves the ozone bias ≤±15% performance goal by a wide margin (Figure B-1a). Similarly, the monthly DMAX8 ozone FE tends to be between 5% and 12%, so achieves the ozone performance goal of ≤35% by over a factor of 2 (Figure B-1a). Some of the underestimation of the DMAX8 ozone at the Colorado CASTNet sites (e.g., in May) may be due in part to the model's inability to fully simulate stratospheric ozone intrusion events (e.g., at Gothic). Figure B-1b presents similar DMAX8 ozone modeling results for the NMB and NME performance statistics using a 40 ppb cut-off that also exhibit very good model performance statistics that achieves the ozone model performance goals.

Figure B-2 presents similar DMAX8 ozone performance statistics as Figure B-1 only using a 60 ppb ozone cut-off value instead of 40 ppb. With a focus on higher observed ozone concentrations then it is not surprising that the model exhibits an underestimation bias. The maximum underestimation bias occurs in the late winter and spring when stratospheric ozone and winter ozone events occur that the model has difficulty in reproducing. The DMAX8 ozone with 60 ppb cut-off performance statistics still achieve the ozone error performance goal for all months and bias goal for all months except February 2008.

Figure B-3 and B-4 are like Figure B-1 and B-2 only for hourly ozone model performance instead of DMAX8 ozone. The hourly ozone model performance using a 40 ppb cut-off value achieves the ozone goals for all months of the year (Figure B-3); it is encouraging that much better ozone performance is seen during the summer ozone season. Using a 60 ppb ozone cut-off, the hourly ozone underestimation bias is so great during the winter months that it exceeds the ozone model performance goal (Figure B-4). However, during the summer when the observed and model ozone is higher and is the primary ozone period of concern, CAMx achieves the ozone model performance goals.

The CAMx 4 km total $PM_{2.5}$ mass performance across the FRM, IMPROVE and CSN sites in the 4 km CARMMS domain is shown in Figure B-5. The model tends to overestimate $PM_{2.5}$ in the winter falling to a near zero bias in the summer. However, the overestimation bias is usually within the PM Performance Criteria with only 5 of the 36 monthly FBs (14% of the time) failing to achieve the PM Performance Criteria. 14 months achieve the PM Performance goal (~40% of the time), which occur in the summer and months adjacent to the summer.

Figures B-6 and B-7 display the CAMx 4 km model performance related to sulfur species that includes SO4 at IMPROVE, CSN and CASTNet monitoring networks, SO2 at CASTNet and wet SO4 deposition at NADP. SO4 tends to be overestimated in the winter and underestimated in the spring, summer and early fall. SO2 is also overestimated in the winter and fall with near zero bias to underestimating in the spring and summer, which indicates that the summer SO4 underestimation is not due to insufficient oxidation of available SO2 concentrations. The wet SO4 deposition also is overestimated in the winter and underestimated in the summer suggesting that too rapid wet depositions is not the cause of the summer SO4 underestimation tendency. The summer underestimation of wet SO4 deposition also suggests that the overstated WRF convective precipitation is not overly washing out the atmospheric pollutants.

Figures B-8 and B-9 displays CAMx 4 km model performance statistics related to nitrogen species including NO3, HNO3 and combined NO3 plus HNO3. Monthly NO3 performance at the IMPROVE sites almost always achieves the PM Performance Goal, whereas it is generally underestimated across the CSN and CASTNet networks with the largest underestimation bias occurring in the summer. On the other hand, HNO3 tends to be overestimated by the CAMx 4 km CARMMS base case and the performance of total nitrate (HNO3+NO3) exhibits much better performance with near zero bias in the spring and summer that achieves the PM Performance Goals. These results suggest that some of the NO3 underestimation bias may be due to not enough conversion of the gaseous HNO3 to particulate NO3. This could be due to insufficient ammonia present to buffer the nitric acid or not fully accounting for other basic compounds that can neutralize nitric acid (e.g., Calcium, Sodium, etc.). Thermodynamic variables could also partly account for this if the temperatures were too hot or the atmosphere not moist enough.

NH4 model performance across he IMPROVE, CSN and NADP networks in the CARMMS 4 km domain is shown in Figure B-10. NH4 is underestimated, which is consistent with the SO4 and NO3 underestimation bias, with the performance being better across the CSN network that always achieves the PM Performance Criteria and sometimes achieves the PM Performance Goal. The underestimation bias is greater across the IMPROVE network due to the use of derived NH4d in the evaluation that overestimates actual ambient NH4 concentrations. The NH4 wet deposition exhibits near zero or an underestimation bias indicating that the NH4 underestimation tendency is not due to overstated wet scavenging.

The CAMx 4 km model performance for gaseous NO_X and NO_Y across AQS and nonmethane organic compounds (NMOC) across PAMS monitoring sites are shown in Figure B-11. NO_X is underestimated in the winter with near zero bias in the summer, whereas NO_Y is overestimated in the summer, underestimated in the winter and has near zero bias in the spring. Given that these measurements may have artifacts and picking up other reactive nitrogen species, it is hard to interpret the evaluation. NMOC is underestimated throughout the year, which may be due in part to the fact they tend to be sited in urban areas.

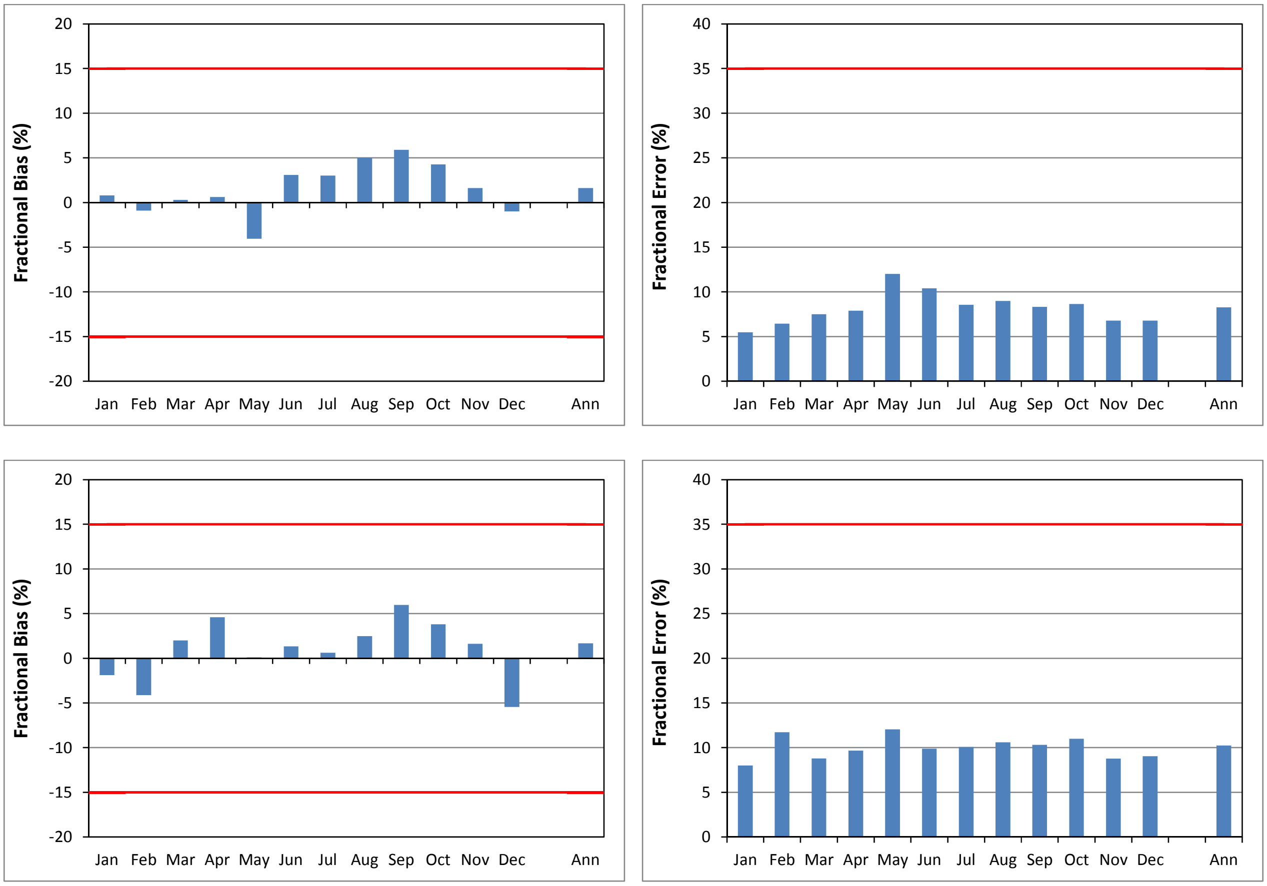

Figure B-1a. CAMx 4 km daily maximum 8-hour ozone model performance for Fractional Bias (left) and Fractional Error (right) across CASTNet (top) and AQS (bottom) monitors within the CARMMS 4 km domain using a 40 ppb observed ozone cut-off value.

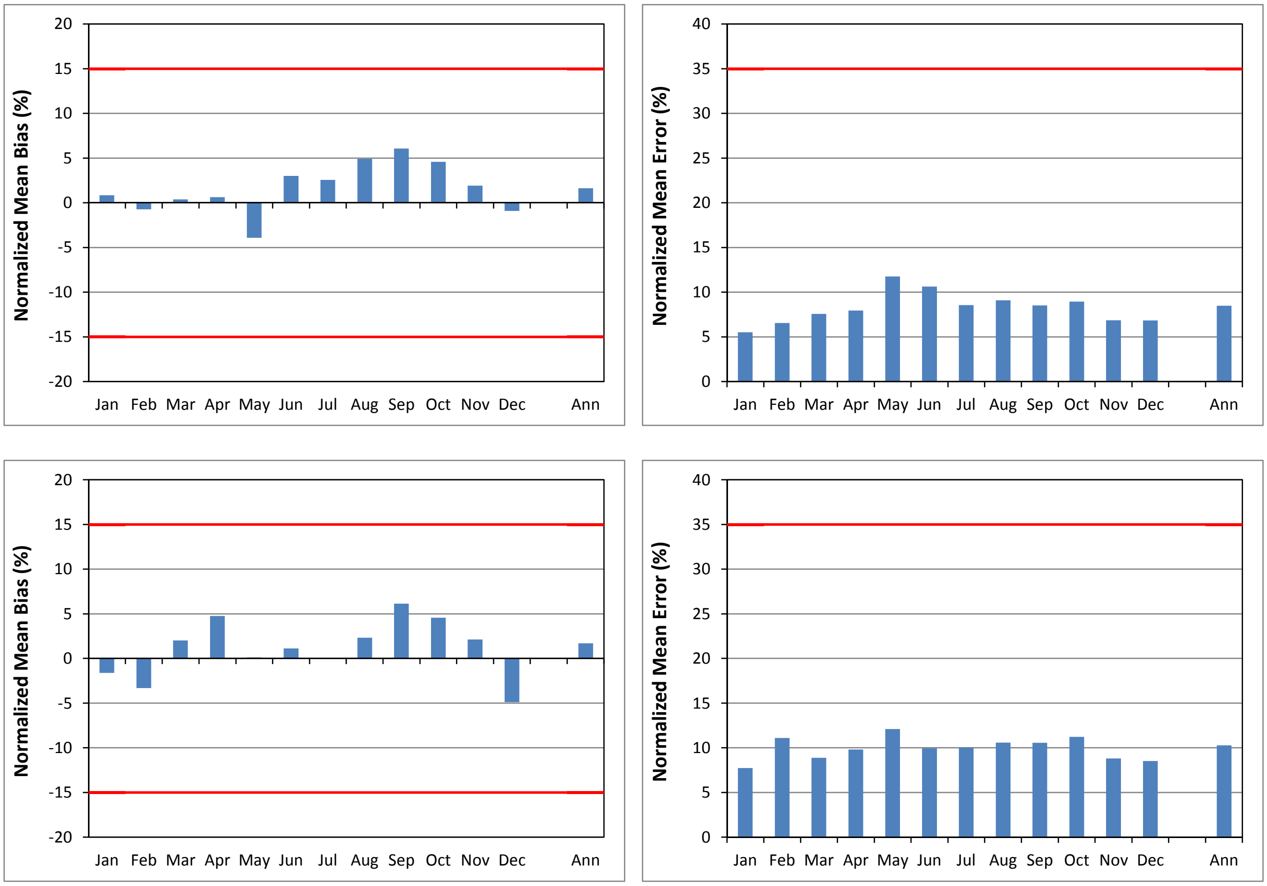

Figure B-1b. CAMx 4 km daily maximum 8-hour ozone model performance for Normalized Mean Bias (left) and Normalized Mean Error (right) across CASTNet (top) and AQS (bottom) monitors within the CARMMS 4 km domain using a 40 ppb observed ozone cut-off value.

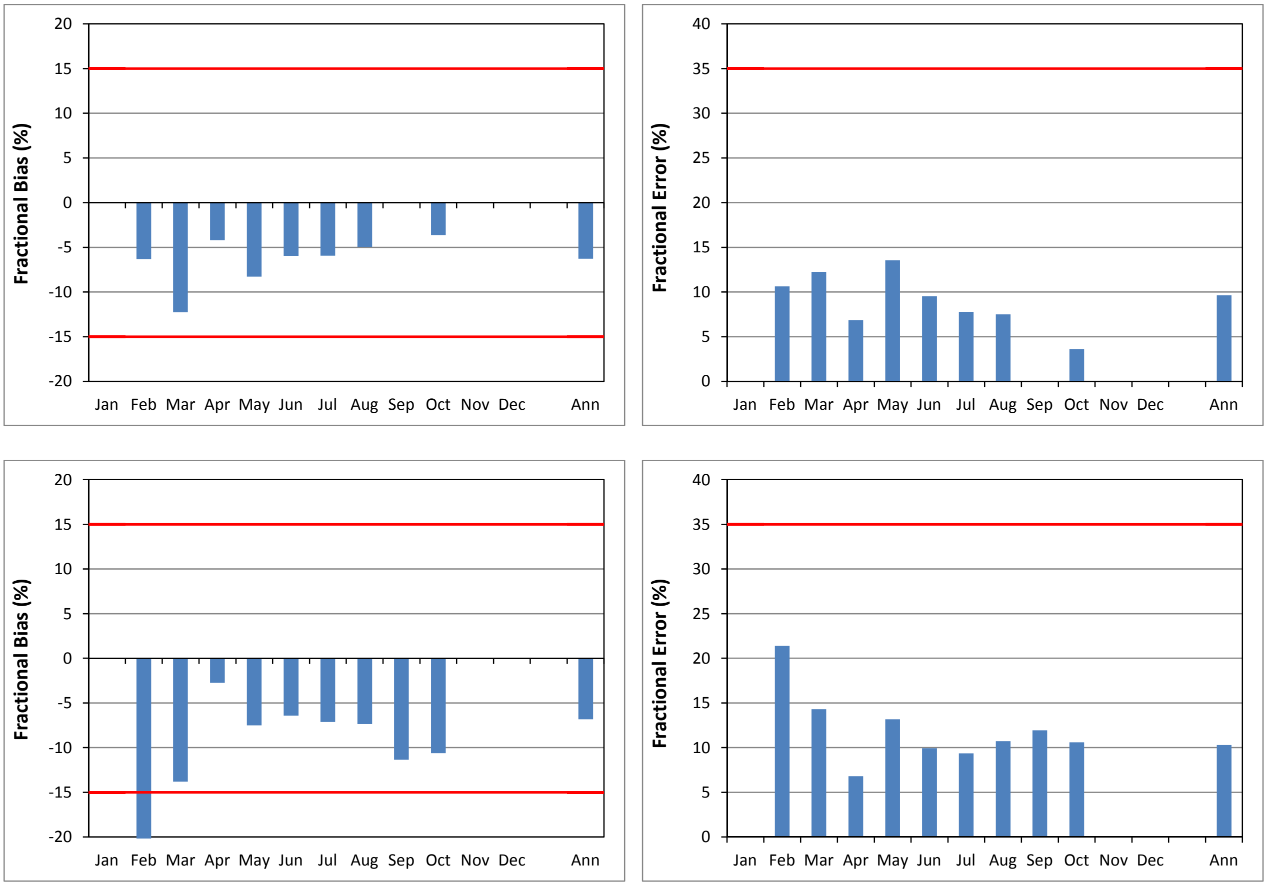

Figure B-2a. CAMx 4 km daily maximum 8-hour ozone model performance for Fractional Bias (left) and Fractional Error (right) across CASTNet (top) and AQS (bottom) monitors within the CARMMS 4 km domain using a 60 ppb observed ozone cut-off value.

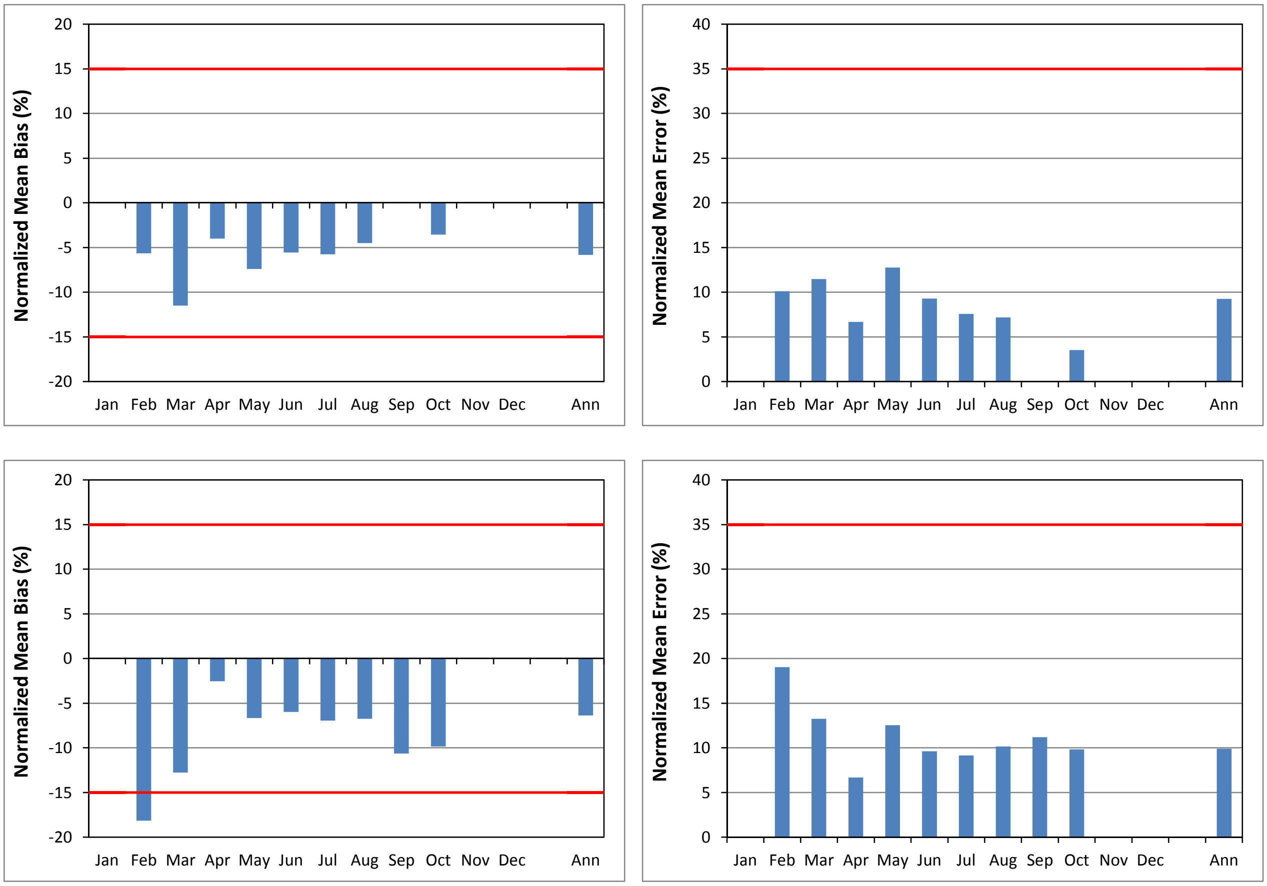

Figure B-2b. CAMx 4 km daily maximum 8-hour ozone model performance for Normalized Mean Bias (left) and Normalized Mean Error (right) across CASTNet (top) and AQS (bottom) monitors within the CARMMS 4 km domain using a 60 ppb observed ozone cut-off value.

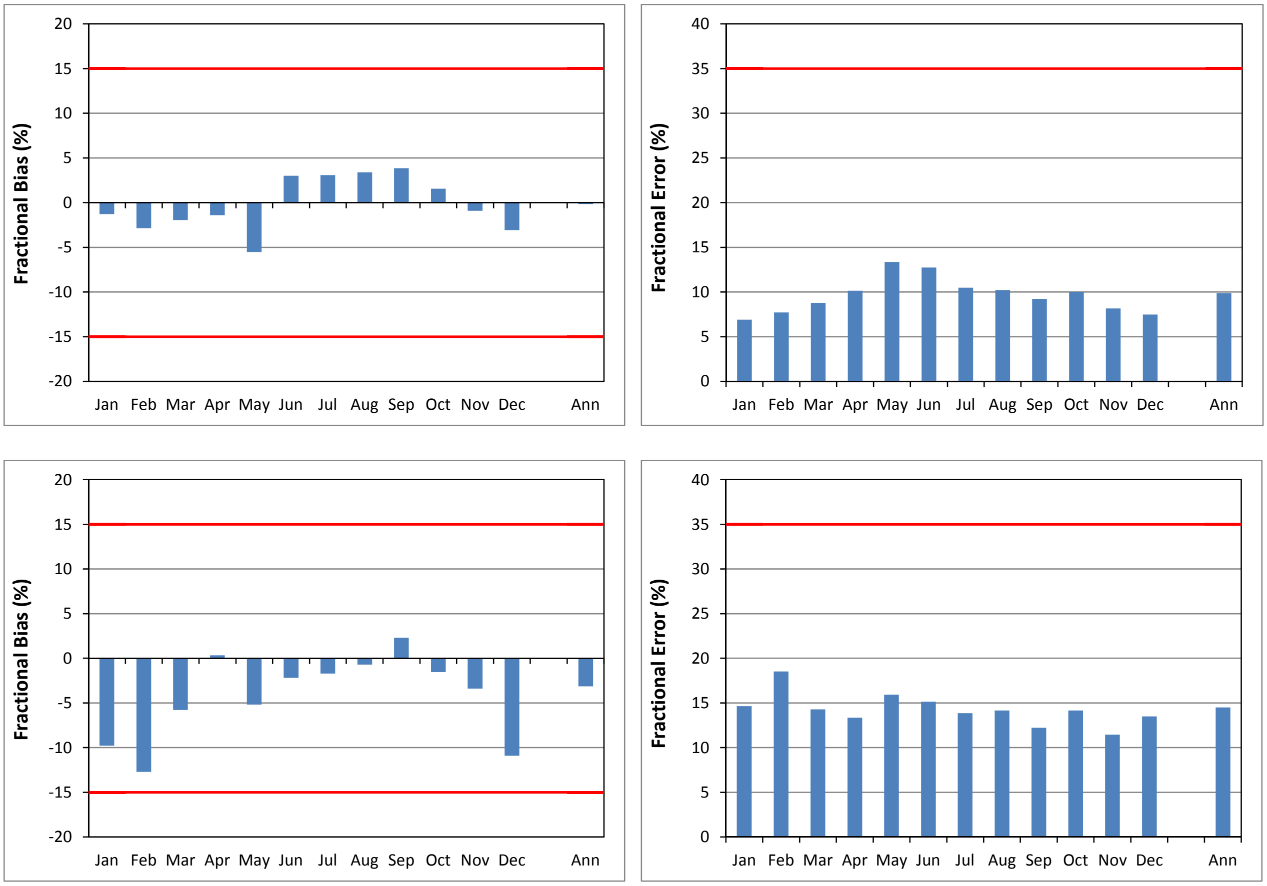

Figure B-3a. CAMx 4 km hourly ozone model performance for Fractional Bias (left) and Fractional Error (right) across CASTNet (top) and AQS (bottom) monitors within the CARMMS 4 km domain using a 40 ppb observed ozone cut-off value.

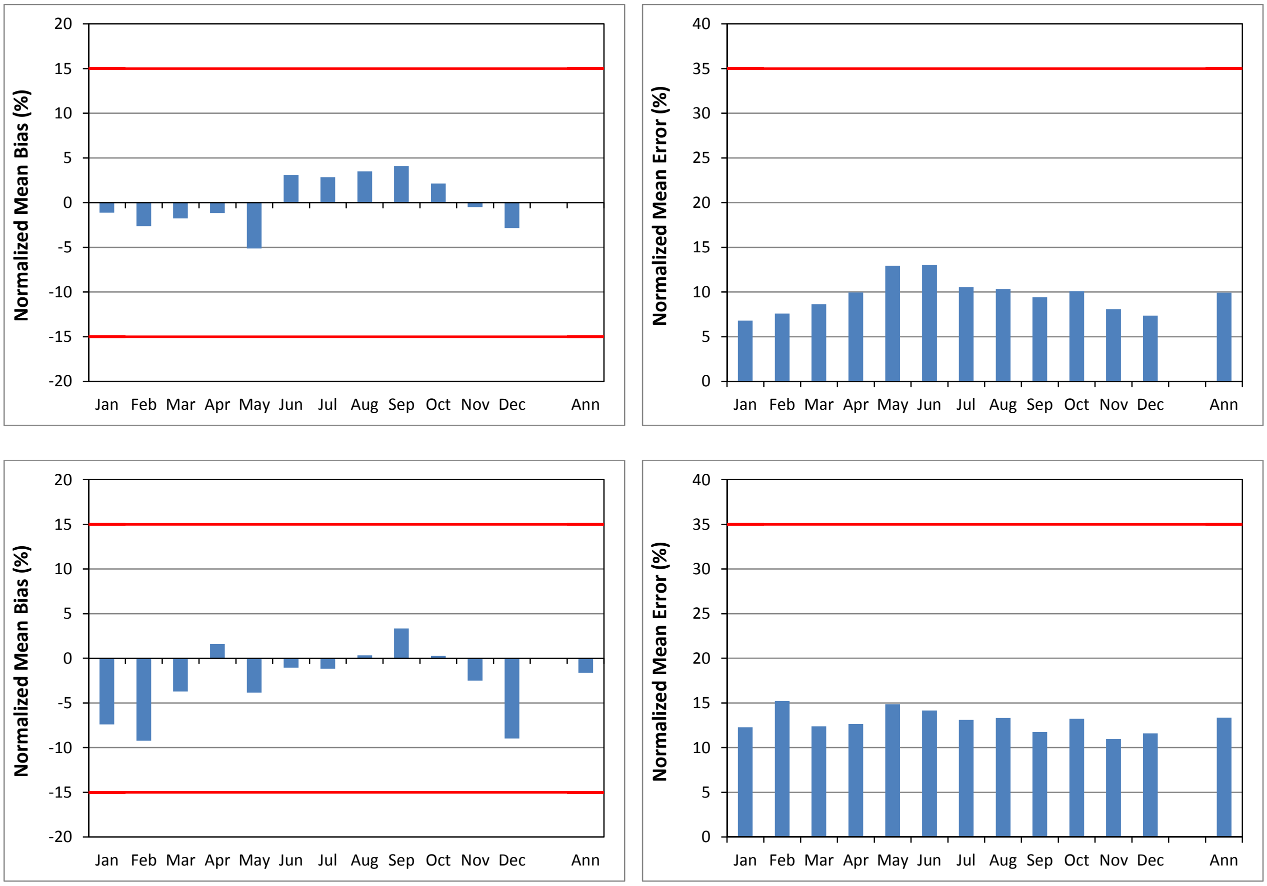

Figure B-3b. CAMx 4 km hourly ozone model performance for Normalized Mean Bias (left) and Normalized Mean Error (right) across CASTNet (top) and AQS (bottom) monitors within the CARMMS 4 km domain using a 40 ppb observed ozone cut-off value.

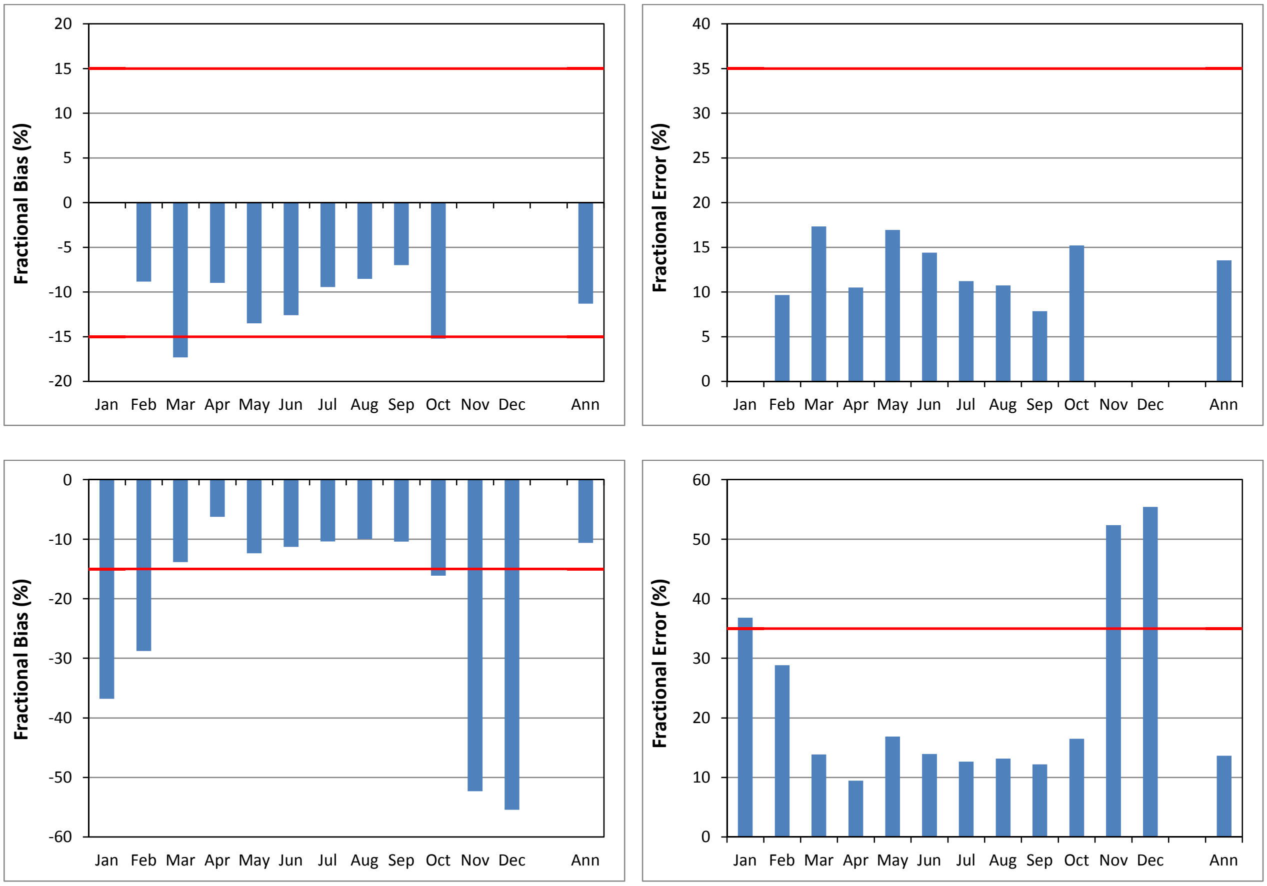

Figure B-4a. CAMx 4 km hourly ozone model performance for Fractional Bias (left) and Fractional Error (right) across CASTNet (top) and AQS (bottom) monitors within the CARMMS 4 km domain using a 60 ppb observed ozone cut-off value.

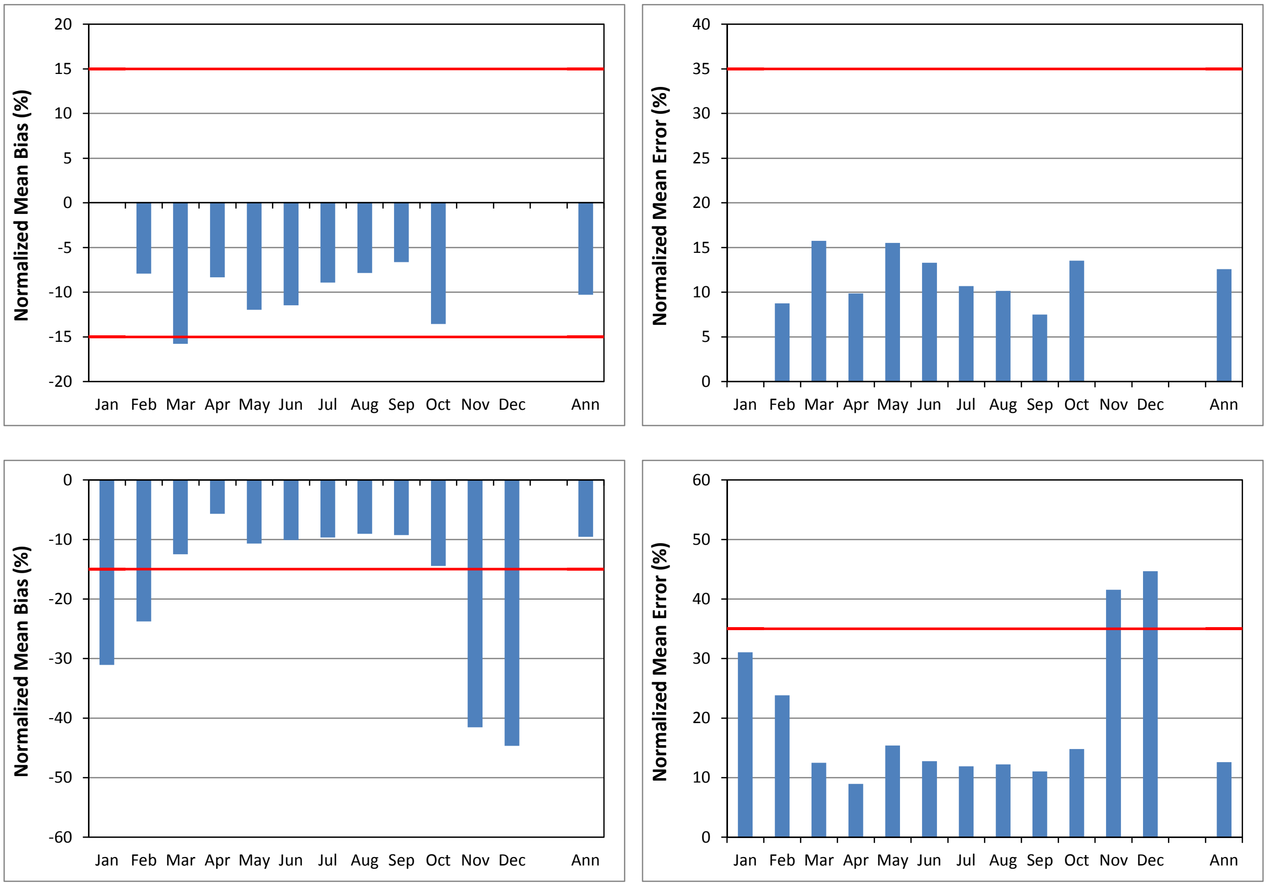

Figure B-4b. CAMx 4 km hourly ozone model performance for Normalized Mean Bias (left) and Normalized Mean Error (right) across CASTNet (top) and AQS (bottom) monitors within the CARMMS 4 km domain using a 60 ppb observed ozone cut-off value.

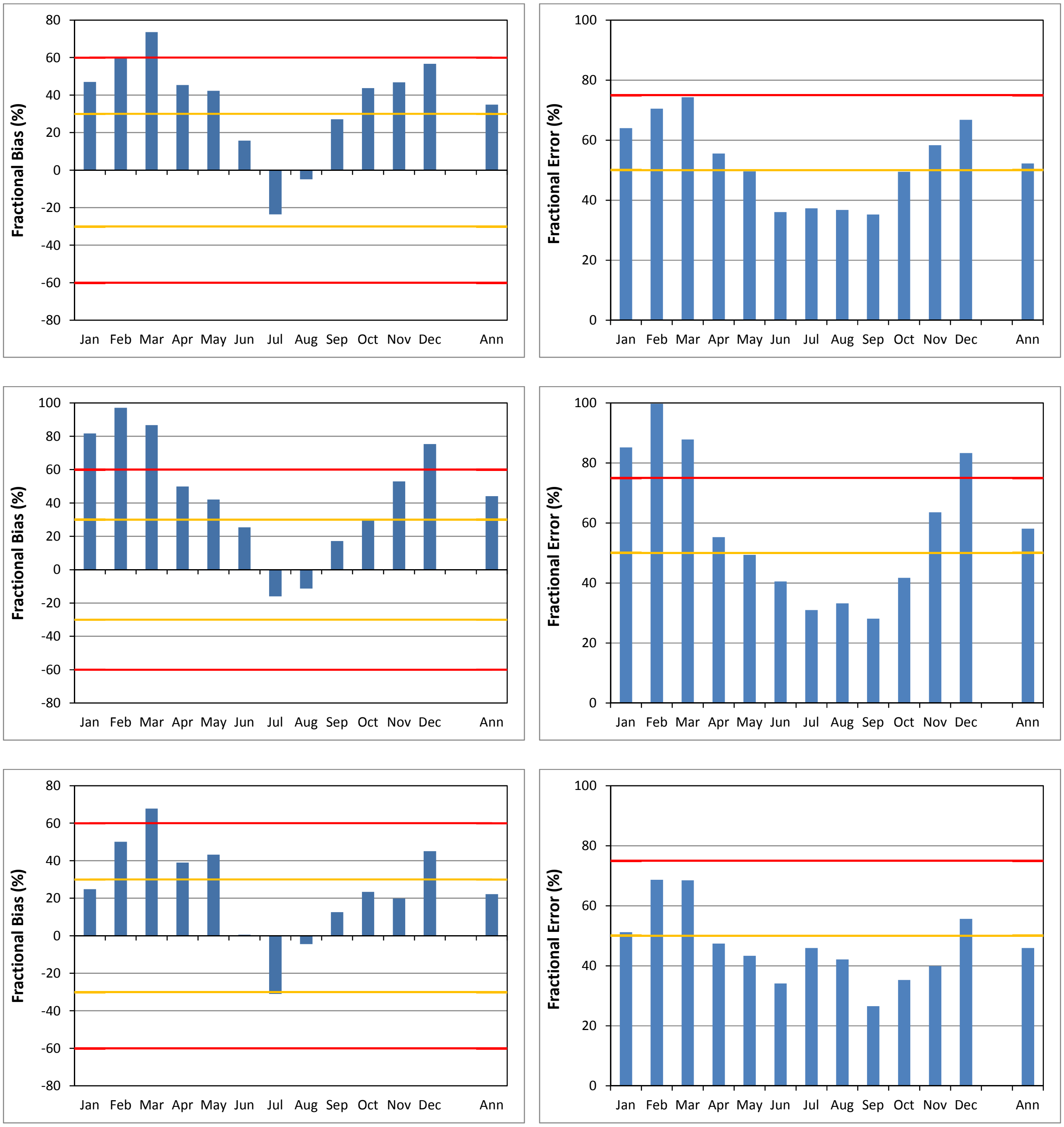

Figure B-5. CAMx 4 km $PM_{2.5}$ model performance for FB (left) and FE (right) across FRM (top), IMPROVE (middle) and CSN (bottom) monitors within the CARMMS 4 km Impact Assessment Domain (IAD).

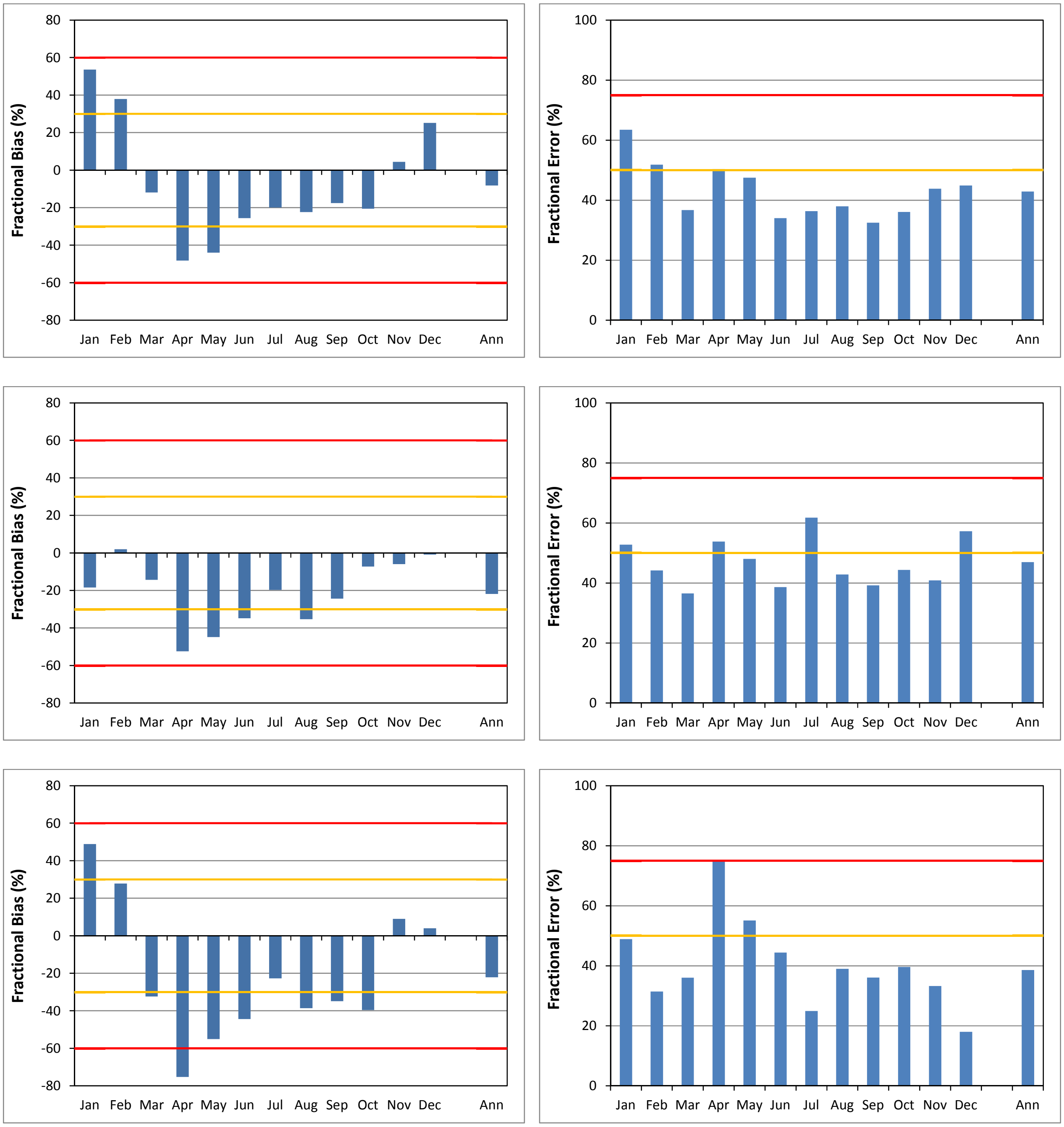

Figure B-6. CAMx 4 km Sulfate (SO4) model performance for FB (left) and FE (right) across IMPROVE (top), CSN (middle) and CASTNet (bottom) monitors within the CARMMS 4 km Impact Assessment Domain (IAD).

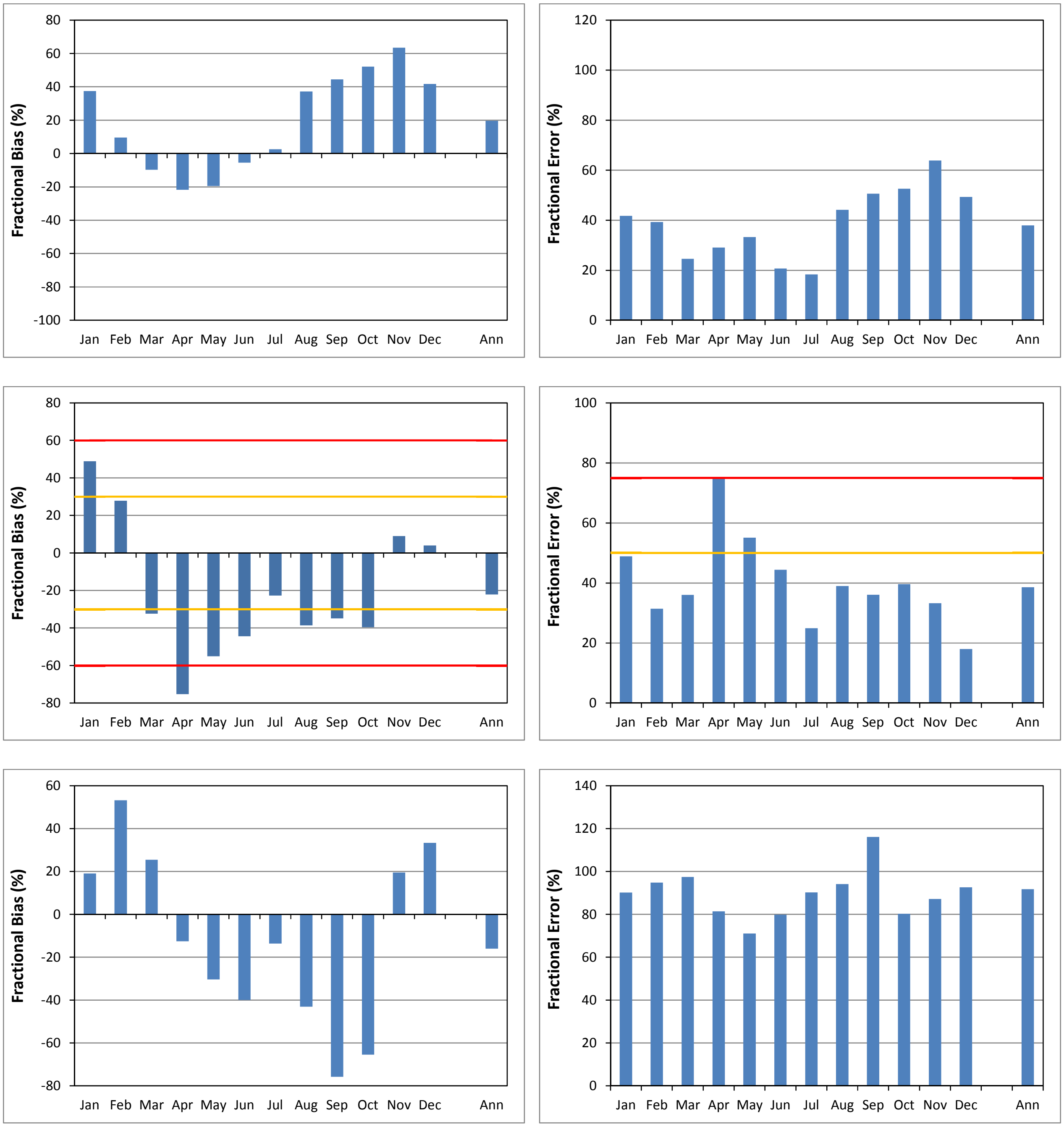

Figure B-7. CAMx 4 km SO2 (top) and SO4 (middle) at CASTNet and SO4 Wet Deposition (bottom) at NADP model performance for FB (left) and FE (right) monitors within the CARMMS 4 km Impact Assessment Domain (IAD).

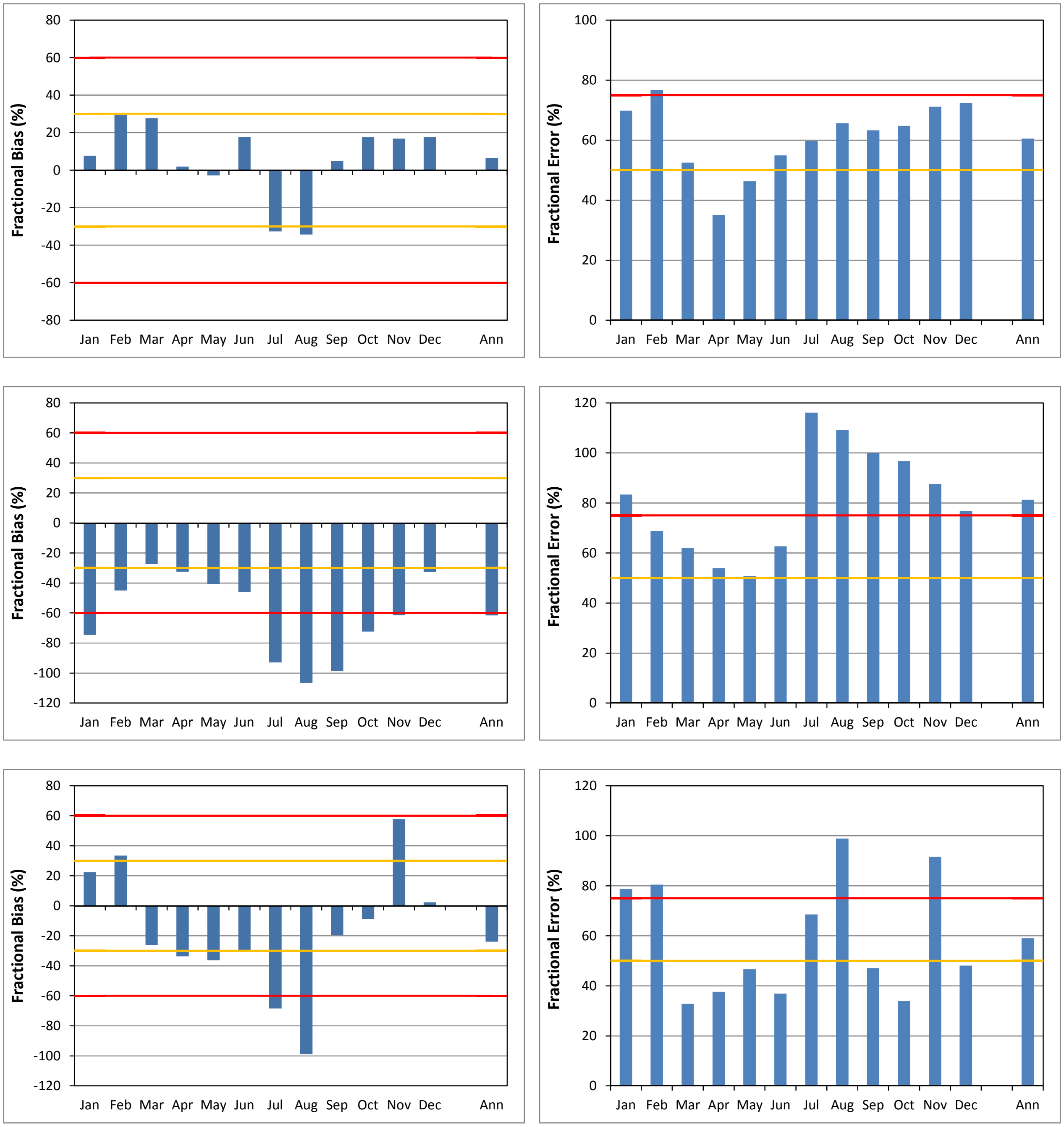

Figure B-8. CAMx 4 km NO3 model performance for FB (left) and FE (right) across IMPROVE (top), CSN (middle) and CASTNet (bottom) monitors within the CARMMS 4 km Impact Assessment Domain (IAD).

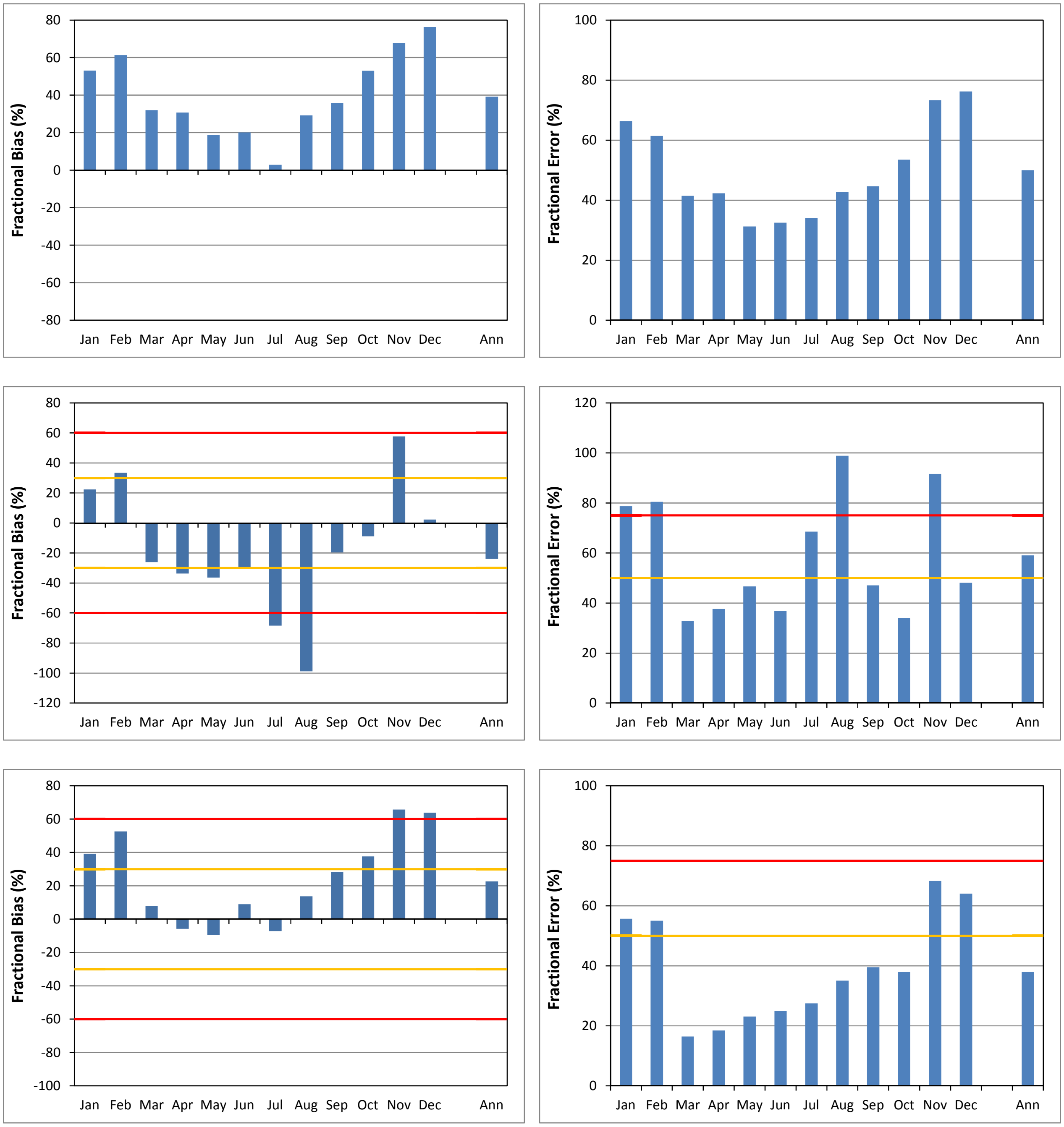

Figure B-9. CAMx 4 km HNO3 (top), NO3 (middle) and tHNO3+NO3 (bottom) model performance for FB (left) and FE (right) across CASTNet monitors within the CARMMS 4 km Impact Assessment Domain (IAD).

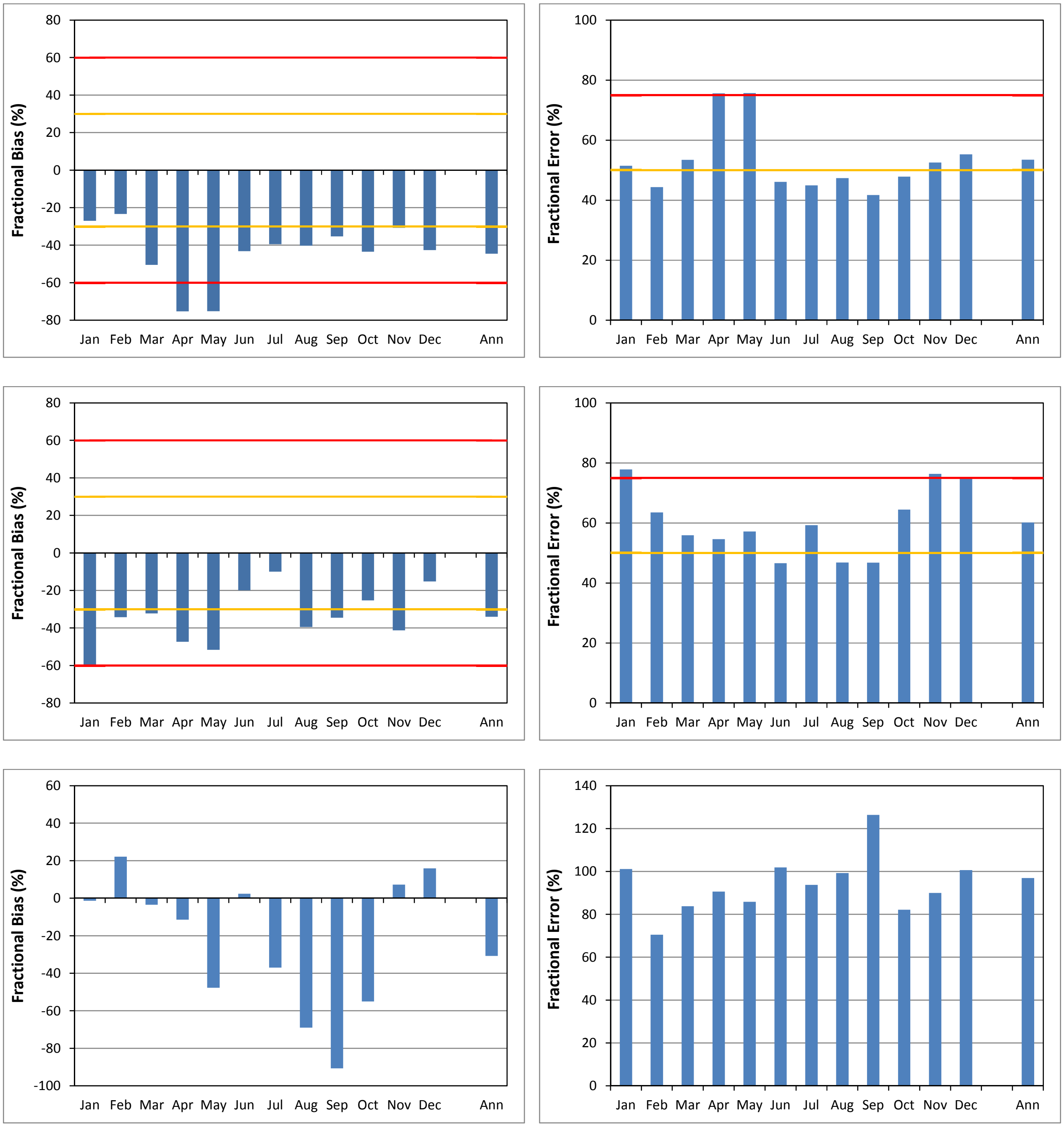

Figure B-10. CAMx 4 km NH4 concentration and wet deposition model performance for FB (left) and FE (right) across IMPROVE (top), CSN (middle) and NADP (bottom) monitors within the CARMMS 4 km Impact Assessment Domain (IAD).

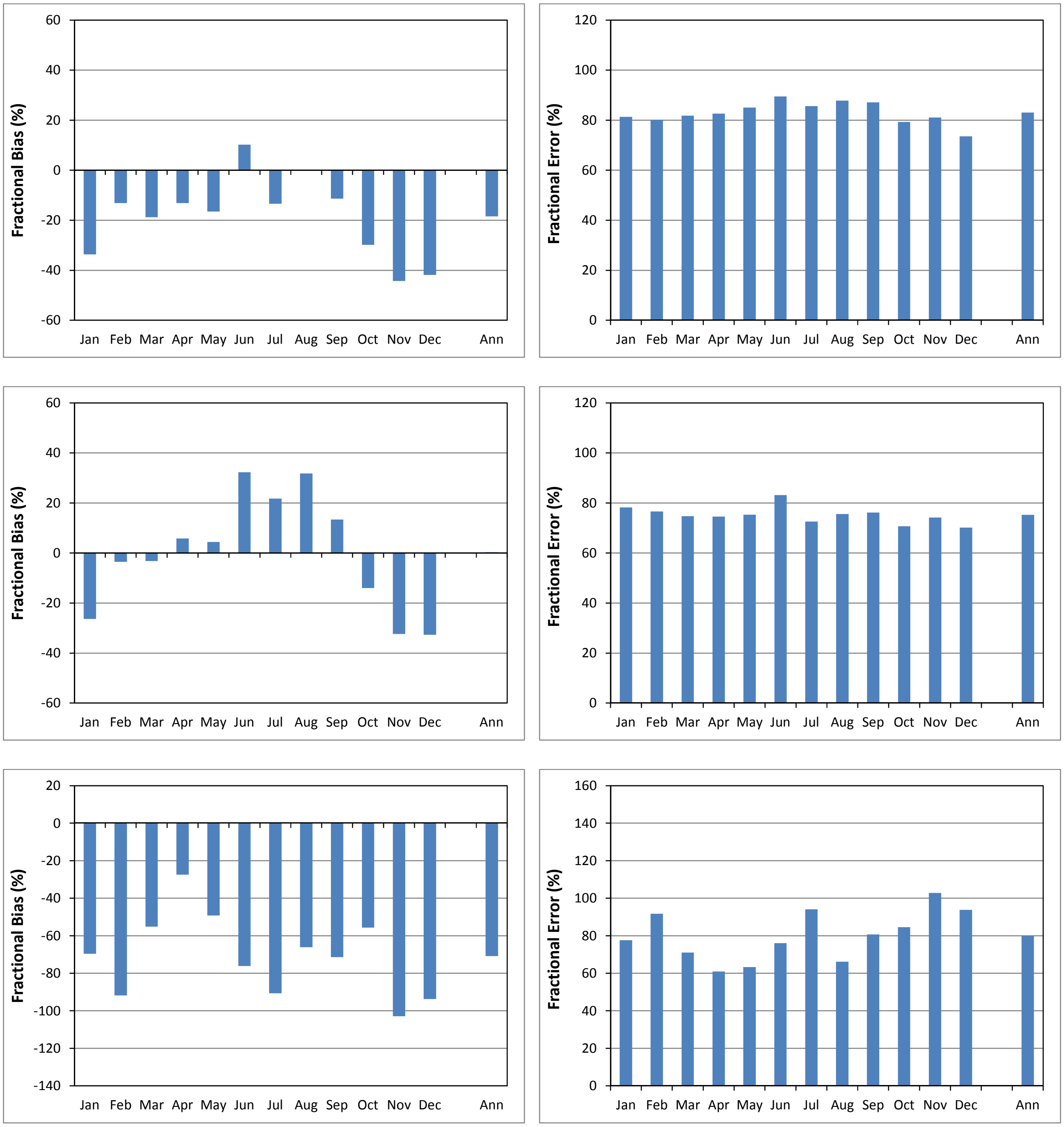

Figure B-11. CAMx 4 km NO_X (top), NO_Y (middle) and NMOC (bottom) model performance for FB (left) and FE (right) across AQS and PAMS) monitors within the CARMMS 4 km Impact Assessment Domain (IAD).

APPENDIX C

CARMMS Technical Memorandum
Draft Final CARMMS Oil and Gas Emission Calculator Documentation
August 15, 2013

August 15, 2013

MEMORANDUM

To: Chad Meister and Forrest Cook, BLM Colorado State Office
From: John Grant, Jim Zapert, and Ralph Morris
Subject: Draft Final CARMMS Oil and Gas Emission Calculator Documentation

1.0 INTRODUCTION

1.1 Scope and Goals

The purpose of this document is to explain the emissions calculation procedures used in the oil and gas emission calculators that have been developed for the Western Colorado Air Resource Management Modeling Study (West-CARMMS). We have improved existing emissions calculators and develop representative calculators for "typical" crude oil, conventional gas (with condensate), coal bed natural gas (CBNG), and shale gas within the region. New information has been incorporated for drilling times; engine configurations; condensate and produced water production; well pad versus offsite gas treatment and storage; well-head, infield, and pipeline compression; and gas/oil production. The ability to readily modify input assumptions such as production parameters, emission control assumptions, and wellhead equipment configurations has also been incorporated into the calculator.

The refined emission calculators will be used to develop the baseline and future-year emissions inventories under Task 2 for the Western Colorado Bureau of Land Management (BLM) planning areas (see Figure 1-1).

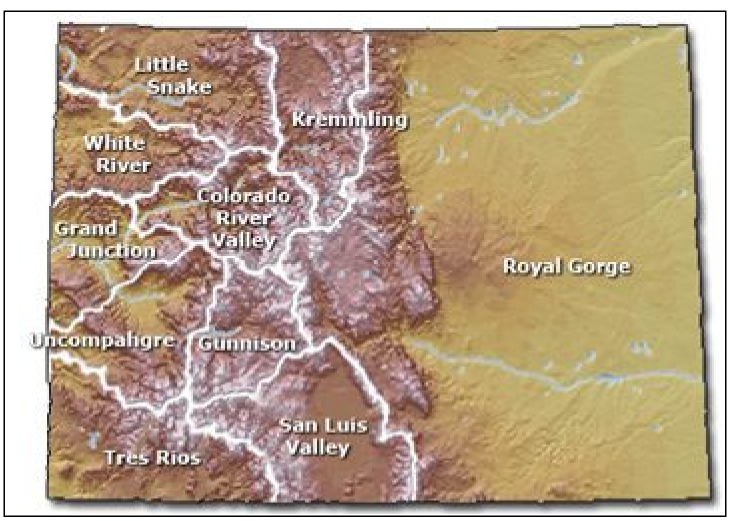

Figure 1-1. Colorado Field Office Planning Areas.

1.2 Overview of Calculators

Emission calculators have been developed for each of the following well types.

- Conventional gas
- Conventional oil
- Shale gas
- Coalbed natural gas (CBNG)

For each well type a separate, a self-contained emission calculator spreadsheet contains all of the inputs and calculations need to generate wellsite emissions.

Additionally, a calculator has been developed to estimate midstream emissions for each area. The midstream emission calculator draws upon Colorado Department of Public Health (CDPHE) Air Pollutant Emission Notice (APEN) emissions for base year emission estimates. Future year midstream emission projections are dependent on the change in oil and gas production in a given planning area which can be updated based on linkages to the by well type emission calculators.

1.2.1 Pollutants

The emission calculators include estimates of emissions of criteria air pollutants (CAPs), greenhouse gases (GHGs), and hazardous air pollutants (HAPs) as follows:

- Criteria Pollutants
  - Carbon monoxide (CO)
  - Nitrogen oxides (NO_X)
  - Particulate matter less than or equal to 10 microns in diameter (PM_{10})
  - Particulate matter less than or equal to 2.5 microns in diameter ($PM_{2.5}$)
  - Sulfur dioxide (SO_2)
  - Volatile Organic Compounds (VOCs)
- Greenhouse Gases
  - Carbon dioxide (CO_2)
  - Methane (CH_4)
  - Nitrous oxide (N_2O)
- Hazardous Air Pollutants (HAPs)

While lead (pb) is a criteria pollutant, emissions of lead in the BLM western Colorado planning areas are expected to be extremely low and are therefore not included in this analysis.

HAP emissions were estimated for each emissions source. For oil and gas emissions sources, HAP emissions from venting and combustion source categories were estimated for formaldehyde, n-hexane, benzene, toluene, ethylbenzene, and xylenes (BTEX).

Anthropogenic greenhouse gas emission inventories typically include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases. Fluorinated gases are not expected to be emitted in appreciable quantities by any category considered in this emission inventory and were therefore not included in this analysis.

1.2.2 Temporal

The calculators estimate annual emissions associated with oil and gas exploration. Per the West-CARMMS scope of work, base year emissions are estimated for 2011 with annual emission forecasts to 2021.

2.0 CALCULATOR DEVELOPMENT

2.1 Calculator Inputs

The emission calculator for each well type allows for specification of the following inputs.

- Base year oil and gas activity (gas production, oil production, spud counts, active well counts)
- Well decline estimates
- Level of control by source category
- Gas composition
- Equipment configurations (e.g. drill rigs, fracing rigs)
- Gas venting activity (e.g. completions, blowdowns)

The inputs are implemented to estimate by source category emissions as described below. Appendices A, B, C, and D show the by source category inputs for each well type.

The midstream emission calculator includes estimates of base year 2011 gas plant and compressor station emissions taken from CDPHE APEN data. Base year midstream emissions are projected to future years based upon the gas production in each planning area. Appendix C5 shows base year 2011 midstream emissions by field office and facility as reported in APENS data.

2.2 Emission Calculations

Emission calculations for all emission-generating activities were developed based on typical emission inventory methodology. Methods used to estimate emissions from each source category are explained in Section 2.2.1. For each source category, emissions for the base year were estimated. Emissions were then forecasted to future years, accounting for activity growth and for applicable sources emissions controls.

The methodologies described here are used consistently in all four calculators by well type; however the input data of each calculator was selected to best reflect the operational characteristics of each well type (oil, gas, CBNG, and shale gas) and thus obtained from literature sources including the following Air Quality Technical Support Documents (AQTSD) from Colorado field office planning areas and BLM emission calculators listed below; shale gas calculator inputs were taken from a recent shale gas project (Bull Mountain, Zapert, 2013) in the Uncompahgre field office:

- White River AQTSD (URS, 2012a)
- Colorado River Valley AQTSD (URS, 2012b)
- Grand Junction AQTSD (ENVIRON, 2012a)
- Uncompahgre AQTSD (ENVIRON, 2012b)
- BLM Crude Oil Well Gas Emission Calculator (BLM, 2013a)
- BLM Coalbed Natural Gas Well Emission Calculator (BLM, 2013b)

Emissions are generated in three main phases of oil and gas systems:

- Emissions from Well Construction and Development
- Emissions from the Production Phase (occurring at-or-nearby the well pad)
- Emissions from Midstream Sources (Central Gas Compression and Processing)

The methodologies implemented to estimate base year and future year emissions from oil and gas sources are explained in this section.

2.2.1 Emissions from Well pad Construction and Development

Emissions from Well pad Construction and Development include those generated by equipment, vehicles and activities related to well pad construction, access roads construction, pipeline construction, wellbore drilling and well completions. Table 2-1 includes the emission sources identified for the well pad construction and development phase. Pollutant emissions are initially estimated on a per surrogate basis and later scaled with the projected surrogate estimate to obtain area-wide annual emissions from each source.

Table 2-1. Construction source categories and scaling surrogates.

Equipment Source Category	Emissions units per event	Scaling Surrogate
Well Pad, Access Road, and Pipeline Construction Equipment	tons/new pad	New pads per year
Well Pad, Access Road and Pipeline Construction Traffic	tons/new pad	New pads per year
Drilling Equipment and Completion Equipment	tons/spud	Spuds per year
Fracing Equipment	tons/spud	Spuds per year
Refracing Equipment	tons/well	Active wells per year
Drilling and Well Completion Traffic	tons/spud	Spuds per year
Rig Hauling and Rig Moving Traffic	tons/pad	New pads per year
Well Pad, Access Road and Pipeline Construction Wind Erosion	tons/new pad	New pads per year
Well Completion Venting	tons/spud	Spuds per year

2.2.1.1 Well Pad, Access Road, and Pipeline Construction Equipment

This category refers to emissions associated with off-road engines used during construction of well pads, access roads and pipelines and is also inclusive of well pad reclamation activity. Detailed data for each engine type such as horsepower rating, hours of operation, fuel type, engine technology and load factors were derived from the literature. The EPA NONROAD2008a model (USEPA, 2009b) was used to compile emission factors for each equipment type. The N_2O emissions factor was obtained from the 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17 (API, 2009). Engines were classified in three types as activity data and emissions factors vary by utility: well pad construction equipment, access road construction equipment and pipeline construction equipment.

Emissions on a per event (new well pads) basis for an engine type for which data was provided were estimated according to Equation 1:

$$E_{engine\ k,i} = \frac{EF_i \times HP \times LF \times t_{event} \times n}{907{,}185} \qquad \text{Equation (1)}$$

where:

E_{engine} are emissions of pollutant *i* from an engine type k [ton/pad]
EF_i is the emissions factor of pollutant *i* [g/hp-hr]
HP is the horsepower of the engine k [hp]
LF is the load factor of the engine k
t_{event} is the number of hours the engine is used [hr/pad]
907,185 is the mass unit conversion [g/ton]
n is the number of type-k engines

2.2.1.1.1 Area-Wide Annual Emissions from Source Category

Annual emissions from well pad construction equipment by pollutant were estimated from the sum of engine emissions from each of the construction engine types ($E_{engineTOTAL,i} = \sum E_{engine\ k,i}$) according to Equation 2:

$$E_{well\ pad\ equip,\ i} = E_{engineTOTAL,i} \times S_{well\ pad} \qquad \text{Equation (2)}$$

where:

$E_{well\ pad\ equip}$ are annual emissions of pollutant i from well pad construction and development equipment [ton/yr]
$E_{engineTOTAL,i}$ is sum of all engine emissions per event [ton/pad]
$S_{well\ pad}$ is the scaling surrogate for well pad construction [new pads/yr]

2.2.1.2 Well Pad, Access Road and Pipeline Construction Traffic

This category refers to the exhaust emissions from light-duty and heavy-duty vehicle traffic during well pad, access road and pipeline construction. Emission factors were developed using the MOVES2010a model (USEPA, 2010). For each field office, by project year representative county emissions factors were developed. The emission factors were prepared for two vehicle classes, heavy duty trucks (source type combination short-haul truck) and pick-up trucks (source type light commercial truck). MOVES2010a emissions factors were modeled to include exhaust running, idle and start, brake wear, tire wear, and evaporative processes. The N_2O emission factor was obtained from 2012 Climate Registry Default Emission Factors (TCR, 2012). The representative county for each field office and annual average per mile emission factors by county, year and vehicle type are summarized in Appendix C-6.

Emissions from two distinct fleet types were estimated in this source category dependent on the vehicle destination/use: (1) well pad and access road construction vehicles and (2) pipeline construction vehicles. Annual vehicle miles traveled (VMT) to well site were available for each vehicle class (light duty and heavy duty) within each fleet type (well pad and access road, and pipeline construction), thus exhaust emissions for each of four vehicle groups were calculated using the MOVES2010a emission factors on a grams per mile basis, as shown in Equation 3.

$$E_{traffic,\ i} = \frac{EF_i \times N_{trips} \times D}{907185} \qquad \text{Equation (3)}$$

where:

$E_{traffic,\ i}$ is traffic exhaust emissions for pollutant i per well pad [ton/pad]
EF_i is the average emission factor of pollutant i [g/mile]
N_{trips} is the annual number of round trips per activity [trips/pad]
D is the round trip distance [miles/trip]
907185 is the mass conversion [g/ton]

2.2.1.2.1 Area-Wide Annual Emissions from Source Category

Annual emissions for well pad, pipeline and access road construction traffic by pollutant were propagated with the appropriate scaling surrogate according to Equation 4:

$$E_{well\ pad\ traffic,\ i} = E_{traffic,\ i} \times S_{well\ pad} \qquad \text{Equation (4)}$$

where:

$E_{well\ pad\ traffic,\ i}$ is the annual exhaust emissions of pollutant i from well pad, pipeline and access road construction traffic [ton/yr]
$E_{traffic,\ i}$ are the emissions of pollutant i per new well pad [ton/wellpad]
$S_{well\ pad}$ is the scaling surrogate for well pad and access road construction traffic [new pads/yr]

2.2.1.3 <u>Drilling, Completion and Hydraulic Fracturing Equipment</u>

This section refers to emissions associated with off-road engines used during drilling and completion activities. Detailed data for each engine type per source category such as horsepower rating, hours of operation, fuel type, engine technology and load factors was derived from the literature. Emissions for four distinct engine groups were estimated: (1) drilling equipment, (2) completion equipment, (3) fracing equipment, and (4) refracing equipment. Emissions were estimated separately by engine type as inputs and surrogates (see

Table 2-1) varied by type; however the same methodology delineated by Equations 5 and 6 was used in all calculations.

For drilling, completion and hydraulic fracturing equipment, the EPA Tier 2 Federal Diesel Engine Standard emission rates were applied for NO_X, VOC, CO, PM_{10} and $PM_{2.5}$ emissions. The N_2O emissions factor was obtained from the 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17 (API, 2009). Emissions on a per event (spuds or active wells) basis for an engine type were estimated according to Equation 5:

$$E_{engine\ k,i} = \frac{EF_i \times HP \times LF \times t_{event} \times n}{907{,}185} \qquad \text{Equation (5)}$$

where:

E_{engine} are exhaust emissions of pollutant *i* from an engine type k [ton/event]
EF_i is the emissions factor of pollutant *i* [g/hp-hr]
HP is the horsepower of the engine k [hp]
LF is the load factor of the engine k
t_{event} is the number of hours engine k is used [hr/event]
907,185 is the mass unit conversion [g/ton]
n is the number of type-k engines

2.2.1.3.1 Area-Wide Annual Emissions from Source Category

Annual equipment emissions by pollutant were estimated separately for each of the four engine groups and scaled with the appropriate scaling surrogate according to Equation 6:

$$E_{D\&C\ equipment,\ i} = E_{engineTOTAL,i} \times S_{event} \qquad \text{Equation (6)}$$

where:

$E_{D\&C\ equipment,i}$ is annual emissions of pollutant i from completion/drilling equipment [ton/yr]
$E_{engineTOTAL,i}$ is sum of all engine emissions per event [ton/event]
S_{event} is the scaling surrogate for completion/drilling operations [event/yr] according to Table 2-1.

2.2.1.4 Drilling and Well Completion Traffic

This section refers to on-road emissions from light-duty and heavy-duty vehicle traffic during drilling and completion operations. Methodology to estimate traffic emissions from these source categories was similar to that of source category *Well Pad, Access Road and Pipeline Construction Traffic.* However, emissions for *Drilling Traffic* and *Completion Traffic* were calculated separately since activity inputs and surrogates varied by source category. Input data to estimate the annual vehicle miles traveled (VMT) per activity was derived from the literature for each vehicle class (light duty and heavy duty) within each fleet. Fleets were defined by the vehicle destination or utility, which vary by the type of oil and gas development (conventional and CBNG versus shale). These are shown in Table 2-2 below. Annual average emission factors from EPA's MOVES2010a model as described in Section 2.2.1.2 were applied.

Table 2-2. Vehicle fleets used during drilling and completion.

Vehicle Use/Destination	Vehicle Class		Fleet group ID
	Type	Class	
Drilling Traffic	Semi Trucks	Heavy Duty Truck	1
	Pickup Trucks	Light Duty Truck	2
Rig Move Drilling Traffic	Semi Trucks	Heavy Duty Truck	3
Rig Hauling	Semi Trucks	Heavy Duty Truck	4
Well Completion & Testing	Semi Trucks	Heavy Duty Truck	5
	Pickup Trucks	Light Duty Truck	6

Exhaust emissions for each of the fleet groups were calculated using the appropriate MOVES2010a emission factors on a grams per mile basis, as shown in Equation 7:

$$E_{traffic,\ i} = \frac{EF_i \times N_{trips} \times D}{907185} \quad \text{Equation (7)}$$

where:

$E_{traffic,\ i}$ is the traffic emissions for pollutant i per spud [tons/spud]
EF_i is the average emission factor of pollutant i [g/mile]
N_{trips} is the annual number of round trips per activity [trips/spud]
D is the round trip distance [miles/trip]
907185 is the mass unit conversion [g/ton]

Given that emissions from the vehicle fleets are based on the same surrogate (spuds), total emissions from drilling and completion traffic will be the sum of emissions per spud from each fleet (calculated with Equation 7), as shown in Equation 8:

$$E_{traffic,D\&C,\ i} = \sum_{fleet=1}^{7} \left(E_{traffic,\ i}\right)_{fleet} \quad \text{Equation (8)}$$

where

$E_{traffic,D\&C,\ i}$ is the total drilling and completions emissions of pollutant i per spud [ton/spud]
$E_{traffic,\ i}$ is the traffic emissions for pollutant i per spud for a vehicle fleet [tons/spud]

2.2.1.4.1 Area-Wide Annual Emissions from Source Category

Annual emissions for drilling/completion traffic by pollutant were propagated with the appropriate scaling surrogate (spuds per year) according to Equation 9:

$$E_{traffic,\ i} = E_{traffic,D\&C,\ i} \times S_{spud} \quad \text{Equation (9)}$$

where:

$E_{category\ traffic,\ i}$ are annual emissions of pollutant i from drilling/completion traffic [ton/yr]

$E_{traffic,D\&C,\ i}$ is the total drilling and completions emissions of pollutant i per spud [ton/spud]
S_{spud} is the scaling surrogate for drilling/completion traffic [spuds/yr]

2.2.1.5 Construction Equipment Fugitive Dust

Fugitive dust emissions from disturbed land by well pad construction and reclamation equipment were estimated based on AP-42 Chapter 13 Section 13.2.3 guidance for estimating emissions from Heavy Construction Operations (USEPA, 1995). A construction fugitive dust emission factor for total suspended particles (TSP) is available in the AP-42 guidance (1.2 tons-TSP/acre/month of activity).

Total suspended particle emissions from wellpad construction equipment on a per wellpad basis are estimated based on Equation 10:

$$E_{equip.dust,TSP} = EF \times A \times t \times \frac{(1-C)}{30} \qquad \text{Equation (10)}$$

where:
$E_{equip,dust,TSP}$ is the TSP emissions from construction equipment fugitive dust [tons/wellpad]
A is the average number of acres disturbed per wellpad [acres/wellpad]
t is the number of construction days per wellpad [days]
C is the control efficiency
30 is the conversion factor for days/month

Conversion factors for TSP to particulate matter PM_{10} (EPA, 2006b) and from PM_{10} to $PM_{2.5}$ (Midwest Research Institute, 2006) were used to estimate other fugitive dust pollutant emissions (PM_{10} and $PM_{2.5}$). A control efficiency of 50% was assumed for well pad construction watering control.

2.2.1.5.1 Area-Wide Annual Emissions from Source Category

Annual emissions for construction equipment fugitive dust, by pollutant i, were propagated with the appropriate scaling surrogate (wellpads per year) according to Equation 11:

$$E_{equip,dust,i_{TOTAL}} = E_{equip.dust,i} \times S_{new\ pads} \qquad \text{Equation (11)}$$

where:
$E_{equip,dust,i_{TOTAL}}$ is the annual dust emissions of pollutant i from construction equipment [ton/yr]
$E_{equip.dust,i}$ is the fugitive dust emissions of pollutant i from construction equipment per pad [tons/wellpad]
$S_{new\ pads}$ is the scaling surrogate for construction equipment fugitive dust [new pads/yr]

2.2.1.6 Fugitive Dust Emissions from Construction, Drilling and Completion Support Vehicles

Fugitive dust emissions from vehicle travel on unpaved roads were estimated based on the AP-42 technical guidance in Section 13.2.2.1 Unpaved Roads (USEPA, 2006a). Road dust emission factors for vehicles traveling on unpaved surfaces at industrial sites can be estimated with Equation 12.

$$EF_i = k\left(\frac{s}{12}\right)^a \left(\frac{W}{3}\right)^b \qquad \text{Equation (12)}$$

where:

EF is the size-specific particulate emissions factor for pollutant i (lb/mile)
s is the surface material silt content (%)
W is the mean vehicle weight (tons)
k, a, b are empirical constants according to Table 2-3.

Table 2-3. Empirical constants by pollutant to estimate road dust emissions factor.

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

Because the emissions factor is a function of vehicle weight, individual emissions factor for heavy duty vehicles and light duty vehicles were derived with Equation 12. To account for natural mitigation of road dust emissions due to annual precipitation and from watering control, Equation 13 was applied:

$$EF_{mitigated} = EF_i \times \frac{365-P}{365} \times \frac{100-CE}{100} \qquad \text{Equation (13)}$$

where:

$EF_{mitigated}$ is the annual average emission factor for uncontrolled conditions including natural mitigation [lb/mile]
EF_i is the size-specific emission factor [lb/mile]
P is number of precipitation days (>0.01" rainfall) at the site
CE is the control efficiency for watering in unpaved roads; CE =50%

Emissions were estimated for all types of vehicles involved in construction, drilling and completion activities. The vehicle groups were classified according to their vehicle class and utility, and literature data was collected to estimate annual vehicle miles traveled per activity (or event), which varied by vehicle groups and by the type of oil and gas development (conventional oil, conventional gas, CBNG, and shale). The vehicle fleets used in each type of development are shown in Table 2-4.

Table 2-4. Vehicles groups related to fugitive road dust emissions in well construction and development.

Vehicle group ID	Utility/destination	Vehicle Class	Event (surrogate)
1	Well Pad Access Road	Heavy Duty Truck	New pads

Vehicle group ID	Utility/destination	Vehicle Class	Event (surrogate)
2	Construction	Light Duty Truck	
3	Pipeline Construction	Heavy Duty Truck	
4		Light Duty Truck	
5	Drilling Traffic	Heavy Duty Truck	Spuds
6		Light Duty Truck	
7	Rig Move Drilling Traffic	Heavy Duty Truck	New pads
8		Light Duty Truck	
9	Rig Hauling	Heavy Duty Truck	
10	Well Completion & Testing	Heavy Duty Truck	Spuds
11		Light Duty Truck	
12	Fuel Haul Truck	Heavy Duty Truck	Spuds

Fugitive dust road emissions were calculated using the mitigated emissions factor ($EF_{mitigated}$) from Equation 13, along with the vehicle miles traveled for each vehicle group as shown in Equation 14.

$$E_{traffic,\ i} = \frac{EF_{mitigated} \times N_{trips} \times D}{2000} \qquad \text{Equation (14)}$$

where:

$E_{traffic,\ i}$ is the traffic fugitive dust emissions for pollutant i per event [ton/event]

$EF_{mitigated}$ is the average emission factor of pollutant i for fugitive dust emissions [lb/mile]

N_{trips} is the annual number of round trips per activity [trips/event]
D is the round trip distance [miles/trip]
2000 is the mass conversion [lb/ton]

2.2.1.6.1 Area-Wide Annual Emissions from Source Category

Annual emissions for road fugitive dust from construction/drilling/completion traffic were propagated with the appropriate scaling surrogate according to Equation 15:

$$E_{dust,traffic,\ i} = E_{traffic,\ i} \times S_{event} \qquad \text{Equation (15)}$$

where:

$E_{dust,traffic,\ i}$ are annual emissions of pollutant i for road fugitive dust from construction/drilling/completion traffic [ton/yr]
$E_{traffic,\ i}$ are the emissions of pollutant i per event (spuds or new pads) [ton/event]
S_{event} is the scaling surrogate for the vehicle group [event/yr]

2.2.1.7 Construction Wind Erosion

Wind erosion dust emissions associated with well pad construction, and road, pipeline construction operations, and well pad reclamation activity were estimated based on AP-42 guidance for the estimation of emissions from industrial wind erosion (USEPA, 2006b). Wind erosion emissions per well pad were estimated based on Equation 16:

$$E_{dust,i} = \frac{P \times A \times r}{907{,}185} \qquad \text{Equation (16)}$$

where:

$E_{dust,\ i}$ are dust emissions for pollutant i from construction wind erosion [ton/pad]
P is the erosion potential [g/m^2]
A is the well pad construction area [m^2/pad]
r is the particle size multiplier for PM_{10} or $PM_{2.5}$
907,185 is a mass unit conversion [g/ton]

The erosions potential is a function of the wind friction velocity, as shown in equation 17 and 18:

$$P = 58 \times (u^* - u_t)^2 + 25(u^* - u_t) \qquad \text{Equation (17)}$$

where:

u^* is the friction velocity (m/s)
u_t is the threshold friction velocity (m/s)

$$P = 0 \quad \text{for} \quad (u^* \leq u_t) \qquad \text{Equation (18)}$$

Friction velocity estimates (u*) were made by multiplying the average annual fastest wind speed by 0.053 per AP-42 guidance (USEPA, 2006b). Particle size multipliers of 0.5 and 0.075 were assumed for PM_{10} and $PM_{2.5}$ respectively per AP-42 guidance.

2.2.1.7.1 Area-Wide Annual Emissions from Source Category

The annual construction dust wind erosion emissions were scaled by multiplying per well pad emissions by the scaling surrogate (new pads) according to Equation 19:

$$E_{wind\ erosion\ total,\ i} = E_{dust,\ i} \times S_{well\ pad} \qquad \text{Equation (19)}$$

where:

$E_{.dust\ erosion\ total,i}$ are the annual emissions of pollutant *i* from construction dust wind erosion [ton/yr]
$E_{dust,\ i}$ are the dust emissions of pollutant i per well pad [ton/pad]
$S_{well\ pad}$ is the scaling surrogate for construction dust wind erosion [pad/yr]

2.2.1.8 Well Completion Venting

This section describes emissions from well completion venting. The calculation methodology for estimating venting emissions from a single completion event is shown below in Equation 20:

$$E_{completion,i} = \left[\frac{P \times Q_{completion}}{\frac{R}{MW_{gas}} \times T \times 3.5 \times 10^{-5}} \right] \times \frac{f_i}{907185} \times (1 - 0.95F_{flare} - F_{green}) \qquad \text{Equation (20)}$$

where:

$E_{completion,i}$ is the uncontrolled emissions of pollutant *i* from a single completion event [ton/event]
P is atmospheric pressure [1 atm]
$Q_{completion}$ is the volume of gas generated per completion [MCF/event]
R is the universal gas constant [0.082 L-atm/mol-K]
MW_{gas} is the molecular weight of the gas [g/mol]
T is the atmospheric temperature [298 K]
f_i is the mass fraction of pollutant *i* in the completion venting gas
F_{green} is the fraction of completions that were controlled by green completion techniques
F_{flare} is the fraction of completions controlled by flare
0.95 is the control efficiency of the flare

2.2.1.8.1 Extrapolation to Area-Wide Annual Emissions

Annual emissions are obtained by scaling-up emissions per event by the number of spuds for a particular year. The total emissions from completion venting are estimated following Equation 21:

$$E_{completion,TOTAL,i} = E_{completion,i} \times S_{spuds} \qquad \text{Equation (21)}$$

where:

$E_{completion,TOTAL}$ are the annual emissions for pollutant i from completion venting [tons/year]
$E_{completion,i}$ are the completion emissions from a single completion event [tons/event], event=spuds
S_{spuds} is the scaling surrogate for completion venting in a particular year [spuds/year]

2.2.1.9 Well Completion Flaring

This section describes the methodology for estimating flaring emissions from completion venting as described in Equation 22. It was assumed the efficiency of the flare was 95 percent.

$$E_{flare,completion} = \left(\frac{EF_i \times Q_{completion} \times F_{flared} \times HV}{1000} \right) \Big/ 2000 \qquad \text{Equation (22)}$$

where:

$E_{flare,completion}$ is the area-wide flaring emissions of pollutant i for well completions [ton/event]
EF_i is the flaring emissions factor for pollutant *i* [lb/MMBtu]
$Q_{completion}$ is the volume of gas generated per completion [MCF/event]
HV is the local heating value of the gas [BTU/SCF]
F_{flared} is the fraction of well completions with flares

2.2.1.9.1 Extrapolation to Area-Wide Annual Emissions

Annual area-wide flaring emissions for well completions are scaled-up using the total number of spuds per year as shown in Equation 23:

$$E_{heater,TOTAL,i} = E_{heater,i} \times S_{TOTAL}$$ Equation (23)

where:

$E_{heater,TOTAL}$ is the annual emissions from well completion flaring for pollutant i [[ton/yr]
E_{heater} is the emissions from well completion flaring for pollutant i per event [ton/event]
S_{TOTAL} is the total number of spuds for a particular year [spuds]. The number of well completions is assumed equal to the spuds count for the year.

2.2.2 Emissions from the Production Phase

Emissions from the Production phase include those generated by equipment, vehicles and activities related to oil and gas production at well sites after a well has been completed. Pollutant emissions are initially estimated on a per event basis and later scaled with the projected number of events per year (scaling surrogate) to obtain Area-wide annual emissions from each source.

2.2.2.1 Well Workovers Equipment

This category refers to emissions associated with off-road engines used during well workovers. Detailed data for a typical workover engine such as horsepower rating, hours of operation, fuel type, engine technology and load factor was derived from the literature. The EPA NONROAD2008a model (EPA, 2009b) was used to compile emission factors for 'other oil field equipment' representative of workover engines. The N_2O emissions factor was obtained from the 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17 (API, 2009).

Emissions on a per well basis for a workover engine were estimated according to Equation 24:

$$E_{engine,\ i} = f \times \frac{EF_i \times HP \times LF \times t \times n}{907{,}185}$$ Equation (24)

where:

E_{engine} are emissions of pollutant *i* from a workover engine [ton/well]
EF_i is the emissions factor of pollutant *i* [g/hp-hr]
HP is the horsepower of the engine [hp]
LF is the load factor of the engine
t is the number of hours of use per day [hr/day]
907,185 is the mass unit conversion [g/ton]
n is the number of operating days per well [days/well]
f is the well workover frequency per year

2.2.2.1.1 Area-Wide Annual Emissions from Source Category

Annual emissions from well workover equipment by pollutant were estimated according to Equation 25:

$$E_{WO-equip,\ i} = E_{engine\ i} \times S_{wells} \qquad \text{Equation (25)}$$

where:

$E_{WO-equip,\ i}$ are annual emissions of pollutant i from workover equipment [ton/yr]
$E_{engine,\ i}$ is emissions of pollutant i from workover equipment per well [ton/well]
$S_{well\ pad}$ is the scaling surrogate for workovers [active wells/yr]

2.2.2.2 Production Traffic (Well workovers, Road Maintenance, Well Pad Reclamation and Production)

This section describes the estimation of exhaust emissions from light-duty and heavy-duty vehicle traffic used for Well Workovers, Maintenance, Well Pad Reclamation and Production. This excludes traffic from tank loading and compressor stations maintenance. Vehicle classes within the four source categories are shown in Table 2-5. Emissions from these vehicle fleets were first estimated on a per well basis and later on scaled to annual Area-wide emissions with the scaling surrogate, active wells per year.

Table 2-5. Vehicle fleets comprising production traffic.

Vehicle fleets ID	Utility (source category)	Vehicle Class	Event (surrogate)
1	Well Workover Commuting Vehicles	Light Duty Truck	Active Wells
2		Heavy Duty Truck	
3	Road Maintenance	Light Duty Truck	
4	Road and Well Pad Reclamation	Light Duty Truck	

Emission factors were developed using the MOVES2010a model as described in Section 2.2.1.2 above.

Exhaust emissions for the five vehicle groups were estimated as shown in Equation 26.

$$E_{fleet,traffic,\ i} = \frac{EF_i \times N_{trips} \times D}{907185} \qquad \text{Equation (26)}$$

where:

$E_{fleet,traffic,\ i}$ is the fleet's traffic emissions for pollutant i per well [tons/well]
EF_i is the average emission factor of pollutant i [g/mile]
N_{trips} is the annual number of round trips per activity [trips/well]
D is the round trip distance [miles/trip]
907185 is the mass unit conversion [g/ton]

2.2.2.2.1 Area-Wide Annual Emissions from Source Category

Annual emissions for each category (fleet) of production traffic were propagated with the appropriate scaling surrogate (active wells per year) according to Equation 27:

$$E_{fleet,TOTAL,i} = E_{fleet,traffic,,\ i} \times S_{wells} \qquad \text{Equation (27)}$$

where:

$E_{fleet,TOTAL,\ i}$ are annual emissions of pollutant i from a production fleet [ton/yr]
$E_{fleet,traffic,\ i}$ is the emissions of pollutant i per well for a production traffic fleet [ton/well]
S_{wells} is the scaling surrogate for the source category [active wells/yr]

2.2.2.3 Fugitive Dust Emissions from Production Traffic (Well Workovers, Road Maintenance, Well Pad Reclamation and Other Production)

Fugitive dust emissions from vehicle travel on unpaved roads were estimated based on the AP-42 technical guidance Section 13.2.2.1 Unpaved Roads (EPA, 2006a). Road dust emission factors for vehicles traveling on unpaved surfaces at industrial sites can be estimated with Equation 28.

$$EF_i = k\left(\frac{s}{12}\right)^a\left(\frac{W}{3}\right)^b \qquad \text{Equation (28)}$$

Where:

EF is the size-specific particulate emissions factor for pollutant i (lb/mile)
s is the surface material silt content (%)
W is the mean vehicle weight (tons)
k, a, b are empirical constants according to Table 2-6.

Table 2-6. Empirical constants by pollutant to estimate road dust emissions factor.

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

Because the emissions factor is a function of vehicle weight, individual emissions factor for heavy duty vehicles and light duty vehicles were calculated with Equation 28. To account for natural mitigation of road dust emissions due to annual precipitation and from watering control, Equation 29 was applied:

$$EF_{mitigated} = EF_i \times \frac{365-P}{365} \times \frac{100-CE}{100} \qquad \text{Equation (29)}$$

Where:

$EF_{mitigated}$ is the annual average emission factor for uncontrolled conditions including natural mitigation [lb/mile]
EF_i is the size-specific emission factor [lb/mile]
P is number of precipitation days (>0.01" rainfall) at the site
CE is the control efficiency for watering in unpaved roads

Vehicle fleets comprising production traffic are shown in Table 2-5. Fugitive dust emissions from these vehicle fleets were first estimated on a per well basis and later scaled to annual Area-wide emissions with the scaling surrogate, active wells per year.

Fugitive dust road emissions per well were calculated using the mitigated emissions factor ($EF_{mitigated}$) from Equation 29, along with the vehicle miles traveled for each vehicle group. This is shown in Equation 30

$$E_{fleet,traffic,\ i} = \frac{EF_{mitigated} \times N_{trips} \times D}{2000} \qquad \text{Equation (30)}$$

where:

$E_{fleet,traffic,\ i}$ is the traffic fugitive dust emissions for pollutant i per well [ton/well]
$EF_{mitigated}$ is the average emission factor of pollutant i for fugitive dust emissions [lb/mile]
N_{trips} is the annual number of round trips per activity [trips/well]
D is the round trip distance [miles/trip]
2000 is the mass conversion [lb/ton]

2.2.2.3.1 Area-Wide Annual Emissions from Source Category

Annual fugitive dust emissions for each category (fleet) of Production traffic were propagated with the appropriate scaling surrogate (active wells per year) according to Equation 31:

$$E_{fleet,TOTAL,i} = E_{fleet,traffic,,\ i} \times S_{wells} \qquad \text{Equation (31)}$$

where:

$E_{fleet,TOTAL,\ i}$ are annual fugitive dust emissions of pollutant i from a production fleet [ton/yr]
$E_{fleet,traffic,\ i}$ is the fugitive dust emissions of pollutant i per well for a production traffic fleet [ton/well]
S_{wells} is the scaling surrogate for the source category [active wells/yr]

2.2.2.4 Blowdown venting

This section refers to the estimation of emissions from venting during well blowdowns. The calculation methodology for estimating emissions from a single blowdown event is shown below in Equation 32:

$$E_{blowdown,i} = \left(\frac{P \times (V_{vented})}{\left(R / MW_{gas} \right) \times T \times 3.5 \times 10^{-5}} \right) \times \frac{f_i}{907185}$$

Equation (32)

where:

$E_{blowdown,i}$ is the emissions of pollutant *i* from a single blowdown event [ton/event]
P is atmospheric pressure [1 atm]
V_{vented} is the volume of vented gas per blowdown (uncontrolled) [MCF/event]
R is the universal gas constant [0.082 L-atm/mol-K]
MW_{gas} is the molecular weight of the gas [g/mol]
T is the atmospheric temperature [298 K]
f_i is the mass fraction of pollutant *i* in the vented gas

2.2.2.4.1 Area-Wide Annual Emissions from Source Category

The total emissions from all annual blowdowns events occurring are estimated with Equation 33:

$$E_{blowdown,TOTAL} = E_{blowdown,i} \times N_{blowdown} \times S_{wells}$$

Equation (33)

where:

$E_{blowdown,TOTAL}$ are the total annual emissions from blowdowns [tons/yr]
$E_{blowdown,i}$ are the blowdown emissions from a single blowdown event [tons/event]
$N_{blowdown}$ is the frequency of blowdowns per well per year [events/yr-well]
S_{wells} is the total number of active wells for a particular year [wells]

2.2.2.5 Well Recompletion Venting

This section describes emissions from well recompletion venting. The calculation methodology for estimating venting emissions from a single recompletion event is shown below in Equation 34:

$$E_{recompletion,i} = \left[\frac{P \times Q_{recompletion}}{\frac{R}{MW_{gas}} \times T \times 3.5 \times 10^{-5}} \right] \times \frac{f_i}{907185}$$

Equation (34)

where:

$E_{recompletion,i}$ is the uncontrolled emissions of pollutant *i* from a single recompletion event [ton/event]
P is atmospheric pressure [1 atm]
$Q_{recompletion}$ is the volume of gas generated per recompletion [MCF/event]
R is the universal gas constant [0.082 L-atm/mol-K]
MW_{gas} is the molecular weight of the gas [g/mol]

T is the atmospheric temperature [298 K]
f_i is the mass fraction of pollutant *i* in the recompletion venting gas

2.2.2.5.1 Extrapolation to Annual Area-Wide Emissions

Annual emissions are obtained by scaling-up emissions per event with the total number of recompletion events in a particular year. The total emissions from recompletion venting are estimated following Equation 35:

$$E_{recompletion,TOTAL,i} = E_{recompletion,i} \times f \times S_{well\ count} \qquad \text{Equation (35)}$$

where:

$E_{completion,TOTAL}$ are the annual emissions for pollutant i from recompletion venting [tons/year]
$E_{completion,i}$ are the venting emissions from a single recompletion event [tons/event]
f is the frequency of recompletion events per well per year [events/yr-well]
$S_{well\ count}$ is the scaling surrogate for recompletion venting in a particular year [active wells]

2.2.2.6 Wellhead Fugitives

This source category refers to fugitive emissions or *leaks* from well equipment such as pump seals, valves, connectors, flanges, etc. Fugitive emissions were estimated for three main streams identified: gas service stream, liquids service stream and high oil stream. VOC, CO_2 and CH_4 emissions per stream were estimated using device-specific TOC emission factors for oil and gas production (USEPA, 1995b) and equipment counts. Input data was obtained from the literature on total device counts per well by type of equipment and by the type of service to which the equipment applies – gas, liquids and high oil.

Fugitive VOC emissions for an individual device in a given stream (gas, liquids, and high oil) were estimated according to Equation 36:

$$E_{fugitiveVOC,k} = EF_{TOC} \times N \times t_{annual} \times Y \qquad \text{Equation (36)}$$

where:

$E_{fugitive\ VOC,\ k}$ is the fugitive VOC emissions for a given device k [ton/yr-well]
EF_{TOC} is the emission factor of TOC [kg/hr/device]
N is the total number of devices type-k for a given stream per well [devices/well]
Y is the ratio of VOC to TOC in the vented gas

Total VOC fugitive emissions for a given stream are equal to the sum of all fugitive emissions from devices in that stream per Equation 37:

$$E_{fugitiveVOC,stream} = \sum E_{fugitiveVOC,\ k} \qquad \text{Equation (37)}$$

where:

$E_{fugitive\ VOC,stream}$ is the total fugitive VOC emissions in a given stream per well [ton/yr-well]

CO_2 and CH_4 fugitive emissions per stream were estimated according to Equations 38 and 39:

$$E_{fugitiveCH4,stream} = E_{fugitiveVOC,stream} \times \frac{weight\ fraction_{CH4}}{weight\ fraction_{VOC}}$$ Equation (38)

$$E_{fugitiveCO2,stream} = E_{fugitiveVOC,stream} \times \frac{weight\ fraction_{CO2}}{weight\ fraction_{VOC}}$$ Equation (39)

where:

$E_{fugitive\ CO2,stream}$ is the total fugitive CO_2 emissions in a given stream per well [ton/yr-well]
$E_{fugitive\ CH4,stream}$ is the total fugitive CH_4 emissions in a given stream per well [ton/yr-well]
Weight fractions per pollutant were based on gas compositions. For gas and well streams, sales gas composition was used. For condensate stream, fugitive-post flash compositions were used.

2.2.2.6.1 Area-Wide Annual Emissions from Source Category

Fugitive emissions were propagated annually according to Equation 40 using the scaling surrogate, active well counts:

$$E_{fugitive,\ i} = E_{fugitive\ i,stream} \times S_{well\ count}$$ Equation (40)

where:

$E_{fugitive,\ i}$ are the annual fugitive emissions for pollutant i in a given stream [ton/yr]
$E_{fugitive\ I,\ stream}$ are fugitive emissions of pollutant i in a stream per well [ton/yr-well]
$S_{well\ count}$ is the number of active wells for a particular year [active wells]

2.2.2.7 Pneumatic Devices

Emissions for pneumatic devices will vary by the bleed rate of the device. The methodology for estimating the emissions from a mix of pneumatic devices i (liquid level controllers, pressure controllers, etc.) for a single typical well is shown in Equation 41:

$$E_{pneumatic,j} = \frac{f_j}{907185}\left(\sum_i \dot{V}_i \times N_i \times t_{annual}\right) \times \frac{P}{\left(\left(R/MW_{gas}\right) \times T \times 3.5 \times 10^{-5}\right)}$$ Equation (41)

where:

$E_{pneumatic,j}$ is the total emissions of pollutant *j* from all pneumatic devices for a typical well [ton/year/well]
$\dot{V}_i$ is the volumetric bleed rate from device *i* [MCF/hr/device]
N_i is the average number of devices *i* found in a well [devices/well]
t_{annual} is the number of hours per year that devices were operating [8760 hr/yr]
P is the atmospheric pressure [1 atm]

R is the universal gas constant [0.082 L-atm/mol-K]
MW_{gas} is the molecular weight of the gas [g/mol]
T is the atmospheric temperature [298 K]
f_j is the mass fraction of pollutant j in the vented gas

2.2.2.7.1 Extrapolation to Area-Wide Annual Emissions

Annual emissions from pneumatic devices were estimated according to Equation 42:

$$E_{pneumatic,TOTAL,j} = E_{pneumatic,j} \times N_{well} \qquad \text{Equation (42)}$$

where:

$E_{pneumatic,TOTAL,j}$ is the total annual emissions of pollutant j from pneumatic devices [ton/yr]
$E_{pneumatic,j}$ is the pneumatic device emissions of pollutant j for a single typical well [ton/yr/well]
N_{well} is the total number of active wells in the basin [wells]

2.2.2.8 <u>Pneumatic Pumps</u>

To estimate emissions from pneumatic pumps, literature data indicating the average rate of gas consumption per gallon of chemical injected and the annual chemical throughput for a single pump was applied. Emissions per well from pneumatic pumps were estimated as shown in Equation 43:

$$E_{pump,i} = \frac{N_{CIP} \times V_{vented,gas} \times t_{pump} \times MW_i \times R \times Y_i}{2000} \qquad \text{Equation (43)}$$

where:

$E_{pump,\,i}$ is the pneumatic pump emissions for pollutant i per well [ton/yr-well]
$V_{vented,TOTAL}$ is the average gas venting rate per pump [SCF/pump/hr]
N_{CIP} is the number of gas-actuated pneumatic pumps per well [pump/well]
t_{pump} is the annual hours of operation of a pump [hrs/yr]
MW_i is the molecular weight of pollutant i [lb/lb-mol]
R is the universal gas constant [lb-mol/391.9scf]
Y_i is the molar fraction of pollutant i in pneumatic pump vented gas
2000 is the mass unit conversion [lb/ton]

2.2.2.8.1 Area-Wide Annual Emissions from Source Category

To estimate area-wide annual emissions from pneumatic pumps the scaling surrogate, active wells, was used according to Equation 44

$$E_{pneumaticpumps,\ i} = E_{pump,\ i} \times S_{well\ count} \qquad \text{Equation (44)}$$

where:

$E_{pneumaticpumps,\ i}$ are the annual emissions for pollutant i from pneumatic pumps [ton/yr]
$E_{pump,\ i}$ is the emissions from all pneumatic pumps per well [ton/yr-well]
$S_{well\ count}$ is the number of active wells for a particular year [wells]

2.2.2.9 Water Injection Pumps

This category refers to exhaust emissions associated with diesel combustion in water injection pump engines. Detailed data for each engine type such as horsepower rating, hours of operation, fuel type, engine technology and load factors was derived from the literature. The EPA NONROAD2008a model (USEPA, 2009b) was used to compile emission factors. The N_2O emissions factor was obtained from the 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17 (API, 2009).

Emissions on a per well basis for a water injection pump were estimated according to Equation 45:

$$E_{engine\ ,i} = \frac{EF_i \times HP \times LF \times t_{event} \times n}{907{,}185} \qquad \text{Equation (45)}$$

where:

E_{engine} are per-well emissions of pollutant *i* from water injection pumps [ton/well]
EF_i is the emissions factor of pollutant *i* [g/hp-hr]
HP is the horsepower of the pump [hp]
LF is the load factor of the pump
t_{event} is the number of hours the engine is used annually [hrs/unit]
907,185 is the mass unit conversion [g/ton]
n is the number of water injection pumps per well [units/well]

2.2.2.9.1 Area-Wide Annual Emissions from Source Category

Annual emissions from water injection pumps for pollutant i were estimated according to Equation 46:

$$E_{water\ pumps,\ i} = E_{engine,\ i} \times S_{well} \qquad \text{Equation (46)}$$

where:

$E_{well\ pad\ equip}$ are annual emissions of pollutant i from water injection pumps [ton/yr]
$E_{engine,\ i}$ is engine emissions per well [ton/well]
S_{well} is the scaling surrogate for water injection pumps [active wells/yr]

2.2.2.10 Miscellaneous Engines

This category refers to exhaust emissions associated with miscellaneous engines at well sites. Detailed data for miscellaneous engines such as horsepower rating, hours of operation, fuel type, engine technology and load factors was derived from the literature. The EPA NONROAD2008a model (USEPA, 2009b) was used to compile emission factors. The N_2O

emissions factor was obtained from the 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17 (API, 2009).

Emissions on a per well basis for miscellaneous engines were estimated according to Equation 47:

$$E_{engine\,,i} = \frac{EF_i \times HP \times LF \times t_{event} \times n}{907{,}185} \times f \qquad \text{Equation (47)}$$

where:

E_{engine} are per-well emissions of pollutant *i* from miscellaneous engines [ton/well]
EF_i is the emissions factor of pollutant *i* [g/hp-hr]
HP is the horsepower of the pump [hp]
LF is the load factor of the pump
t_{event} is the number of hours the engine is used [hrs/unit]
f is the fraction of wells served by a miscellaneous engine
907,185 is the mass unit conversion [g/ton]
n is the number of engines per well [units/well]

2.2.2.10.1 Area-Wide Annual Emissions from Source Category

Annual emissions from miscellaneous engines for pollutant i were estimated according to Equation 48:

$$E_{water\,pumps,\ i} = E_{engine,\ \ i} \times S_{well} \qquad \text{Equation (48)}$$

where:

$E_{well\,pad\,equip}$ are annual emissions of pollutant i from miscellaneous engines [ton/yr]
$E_{engine,\ i}$ is engine emissions per well [ton/well]
S_{well} is the scaling surrogate for miscellaneous engines [active wells/yr]

2.2.2.11 Compressor Station Maintenance Traffic Exhaust

This section describes the estimation of exhaust emissions from light-duty vehicles (pickup trucks) used for compressor maintenance at compressor stations. Emission factors were developed using the MOVES2010a model (USEPA, 2010) as described in Section 2.2.1.2. The total vehicle miles travelled annually from maintenance visits to a single compressor station were obtained from the literature.

Exhaust emissions for this fleet were estimated as shown in Equation 49.

$$E_{fleet,traffic,\ i} = \frac{EF_i \times VMT_{CS}}{907185} \qquad \text{Equation (49)}$$

where:

$E_{fleet,traffic,\ i}$ is the fleet's traffic emissions for pollutant i per well [tons/station]
EF_i is the average emission factor for light duty vehicles of pollutant i [g/mile]
VMT_{CS} is the annual miles travelled for maintenance compressor station [miles/station]

907185 is the mass unit conversion [g/ton]

2.2.2.11.1 Area-Wide Annual Emissions from Source Category

Annual emissions for the compressor maintenance fleet were propagated with the scaling surrogate "total count of active compressor stations" according to Equation 50:

$$E_{fleet,TOTAL,i} = E_{fleet,traffic,,\ i} \times S_{CS} \qquad \text{Equation (50)}$$

where:

$E_{fleet,TOTAL,\ i}$ are annual emissions of pollutant i from compressor station maintenance traffic [ton/yr]

$E_{fleet,traffic,\ i}$ is the emissions of pollutant i per station for the fleet [ton/station]

S_{CS} is the scaling surrogate for the source category [number of active compressor stations per year]

2.2.2.12 Fugitive Dust Emissions from Compressor Station Maintenance Traffic

Road dust emission factors for light duty vehicles traveling on unpaved surfaces to and from compressor stations were estimated with the same methodology as in Section 2.2.1.2.6 using Equations 28 and 29. Fugitive dust road emissions per station (visited) were calculated using the mitigated emissions factor ($EF_{mitigated}$) from Equation 29, along with the annual vehicle miles traveled per compressor station. This is shown in Equation 51.

$$E_{fleet,traffic,\ i} = \frac{EF_{mitigated} \times VMT}{2000} \qquad \text{Equation (51)}$$

where:

$E_{fleet,traffic,\ i}$ is the traffic fugitive dust emissions for pollutant i per station [ton/station]

$EF_{mitigated}$ is the average emission factor of pollutant i for fugitive dust emissions [lb/mile]

VMT is the annual miles travelled for maintenance compressor station [miles/station]

2000 is the mass conversion [lb/ton]

2.2.2.12.1 Area-Wide Annual Emissions from Source Category

Annual fugitive dust emissions for compressor station maintenance traffic were propagated with the "total number of compressor stations" according to Equation 52:

$$E_{fleet,TOTAL,i} = E_{fleet,traffic,,\ i} \times S_{CS} \qquad \text{Equation (52)}$$

where:

$E_{fleet,TOTAL,\ i}$ are annual fugitive dust emissions of pollutant i from compressor station maintenance traffic [ton/yr]

$E_{fleet,traffic,\ i}$ is the emissions of pollutant i per station for the fleet [ton/station]

S_{CS} is the scaling surrogate for the source category [number of active compressor stations per year]

2.2.2.13 Condensate Tanks Flashing

Condensate tank emissions were calculated differently for conventional oil and gas developments and for shale gas developments.

An uncontrolled VOC emissions factor applicable to Garfield, Mesa, Rio Blanco, and Moffat Counties (CDPHE, 2011) was used to estimate emissions for condensate tanks in conventional gas, shale gas and coalbed natural gas developments on a per barrel basis. The published emissions factor was 10 lbs VOC/bbl [0.005 tons/bbl]; for planning areas outside of those counties the emission factor of 11.3 lbs VOC/bbl [0.008 tons/bbl] can be used (CDPHE, 2011). For conventional oil developments, the emissions factor of 1.6 lbs VOC/bbl was used based on BLM (2013). The VOC emissions factor was multiplied by the annual condensate production from each type of well to propagate VOC emissions to the Planning Area level for each year. Similar to the methodology for conventional oil and gas sources, CO_2 and CH_4 total emissions were then calculated using the weight fraction ratios from local flash gas composition analyses using Equations 53 and 54.

$$E_{tanks,CH4} = E_{tanks,VOC} \times \frac{weight\ fraction_{CH4}}{weight\ fraction_{VOC}} \qquad \text{Equation (53)}$$

$$E_{tanks,CO2} = E_{tanks,VOC} \times \frac{weight\ fraction_{CO2}}{weight\ fraction_{VOC}} \qquad \text{Equation (54)}$$

where:

$E_{tanks,VOC}$ is the total annual condensate tanks emissions from APENS database [tons/yr]
$E_{tanks,CO2}$ is the total condensate tank CO_2 emissions [tons/yr]
$E_{tanks,CH4}$ is the total condensate CH_4 emissions [tons/yr]
Weight fractions of each pollutant in flash gas

2.2.2.14 Loading Emissions from Condensate or Oil Tanks

This section describes emissions from truck loading of condensate or crude oil from tanks. The loading loss rate is estimated following Equation 55:

$$L = 12.46 \times \left(\frac{S \times V \times M}{T} \right) \qquad \text{Equation (55)}$$

where:

L is the loading loss rate [lb/1000gal]
S is the saturation factor taken from AP-42 default values based on operating mode. The operating mode for loading assumed was submerged loading: dedicated normal service.
V is the true vapor pressure of the liquid loaded [psia]
M is the molecular weight of the vapor [lb/lb-mole]
T is the temperature of the bulk liquid [^{o}R], T=540 R

VOC tank loading emissions are then estimated by Equation 56:

$$E_{loading,\ VOC} = L \times Y_{voc} \times \frac{42}{2000} \qquad \text{Equation (56)}$$

where:

$E_{loading}$ are the VOC tank loading emissions [ton/bbl]
L is the loading loss rate [lb/1000gal]
Y_{VOC} is the weight fraction of VOC in the vapor in the liquid loaded
42 is a unit conversion [gal/bbl]
2000 is a unit conversion [lbs/ton]

CO_2 and CH_4 emissions are calculated based on Equations 57-58:

$$E_{loading,CH4} = E_{loading,VOC} \times \frac{weight\ fraction_{CH4}}{weight\ fraction_{VOC}} \qquad \text{Equation (57)}$$

$$E_{loading,CO2} = E_{loading,VOC} \times \frac{weight\ fraction_{CO2}}{weight\ fraction_{VOC}} \qquad \text{Equation (58)}$$

where:

$E_{loading,CO2}$ is the total loading CO_2 emissions per barrel of liquid [ton/bbl]
$E_{loadingCH4}$ is the total loading CH_4 emissions per barrel of liquid [ton/bbl]
Weight fractions of each pollutant in the vapor losses from the liquid loaded

2.2.2.14.1 Area-Wide Annual Emissions from Source Category

Annual emissions per pollutant i from condensate loading were scaled by annual condensate production per Equation 59:

$$E_{tank\ loadout,\ i} = E_{loading,\ i} \times S_{bbl\ condensate} \qquad \text{Equation (59)}$$

where:

$E_{tank\ loadout,\ i}$ is the total condensate loading emissions for pollutant i from tank load-out [ton/yr]
$E_{loading,\ i}$ is the condensate loading emissions for pollutant i from per barrel [ton/bbl]
$S_{bbl\ condensate}$ is the total annual of barrels condensate [bbl/yr]

2.2.2.15 <u>Condensate, Crude Oil and Produced Water Hauling Traffic Exhaust</u>

This section describes the estimation of exhaust emissions from heavy-duty vehicles (haul trucks) used for produced condensate hauling from the well site. Emission factors were developed using the MOVES2010a model (EPA, 2010) as described in Section 2.2.1.2. The total round trip distance for each hauling trip was derived from the literature. A hauling volume of per truck of 200 barrels of condensate or crude oil, hence the number of round trips per barrel was estimated (1/200).

Exhaust emissions for condensate and crude oil hauling fleet were estimated as shown in Equation 60a.

$$E_{fleet,traffic,\ i} = \frac{EF_i \times N_{trips} \times D}{907185} \qquad \text{Equation (60a)}$$

where:

$E_{fleet,traffic,\ i}$ is the hauling traffic exhaust emissions for pollutant i per barrel [ton/bbl]
EF_i is the average emission factor of pollutant i for heavy duty vehicles [g/mile]
N_{trips} is the annual number of round trips per barrel [trips/bbl]. N=1/200
D is the round trip distance [miles/trip]
907185 is the mass conversion [g/ton]

2.2.2.15.1 Area-Wide Annual Emissions from Condensate or Crude Oil Hauling

Annual emissions for the condensate and crude oil hauling fleet were propagated with the annual condensate or crude oil production according to Equation 61a:

$$E_{fleet,TOTAL,i} = E_{fleet,traffic,,\ i} \times S_{bbl,condensate} \qquad \text{Equation (61a)}$$

where:

$E_{fleet,TOTAL,\ i}$ are annual emissions of pollutant i from condensate hauling traffic [ton/yr]
$E_{fleet,traffic,\ i}$ is the emissions of pollutant i per barrel for the hauling fleet [ton/bbl]
$S_{bbl,condensate}$ is the scaling surrogate for the source category [barrels of condensate produced per year]

2.2.2.15.2 Produced water hauling exhaust emissions

Produced water refers to the water produced with the gas once the well has been completed and is under operation. This water is typically hauled from the well site storage tanks with water trucks or sent via pipeline to injection wells. Annual produced water rates will vary by the type of well. It was assumed that the annual rate of water production for conventional oil, conventional gas and shale gas wells was 18,250 bbl/well (URS, 2012a); this value can be updated for a given area based on Colorado Oil and Gas Conservation Commission water production data. It was assumed that produced water truck capacity is 130 bbl and that 50 percent of the water is hauled out.

The annual water production per CBNG well was assumed to be 97,900 bbl/well (BLM, 2012); this value can be updated for a given area based on Colorado Oil and Gas Conservation Commission water production data.

Exhaust emissions for produced water hauling fleet were estimated as shown in Equation 60b:

$$E_{fleet,traffic,\ i} = \frac{EF_i \times N_{trips} \times D}{907185} \qquad \text{Equation (60b)}$$

where:

$E_{fleet,traffic,\ i}$ is the produced water hauling exhaust emissions for pollutant i per well [ton/well]
EF_i is the average emission factor of pollutant i for heavy duty vehicles [g/mile]
N_{trips} is the annual number of round trips per well [trips/well]
D is the round trip distance [miles/trip]
907185 is the mass conversion [g/ton]

2.2.2.15.2.1 Area-Wide Annual Emissions from Produced Water Hauling

Annual emissions for the produced water hauling fleet were propagated to the planning area according to Equation 61b:

$$E_{fleet,TOTAL,i} = E_{fleet,traffic,,\ i} \times S_{active\ wells} \qquad \text{Equation (61b)}$$

where:

$E_{fleet,TOTAL,\ i}$ are annual emissions of pollutant i from produced water hauling traffic [ton/yr]
$E_{fleet,traffic,\ i}$ is the emissions of pollutant i per well for the hauling fleet [ton/well]
$S_{active\ wells}$ is the scaling surrogate for the source category, active wells per year [wells/yr]

2.2.2.15.3 Fugitive Dust Emissions from Condensate and Produced Water Hauling Traffic

Road dust emission factors for heavy duty vehicles traveling on unpaved surfaces for condensate hauling and produced water hauling were estimated with the same methodology as in Section 2.2.1.2.6 using Equations 28 and 29. Because the number of trips for both of these activities is based on different surrogates - per barrel for condensate hauling and per well for produced water hauling - as shown in Section 2.2.1.2.15, fugitive dust road emissions of each fleet were calculated using the mitigated emissions factor ($EF_{mitigated}$) from Equation 29. This is shown in Equation 62.

$$E_{fleet,traffic,\ i} = \frac{EF_{mitigated} \times D \times N_{trips}}{2000} \qquad \text{Equation (62)}$$

where:

$E_{fleet,traffic,\ i}$ is the traffic fugitive dust emissions for pollutant i per (1) barrel of condensate [ton/bbl] for condensate hauling or (2) well [ton/well] for produced water hauling
$EF_{mitigated}$ is the average emission factor of pollutant i for fugitive dust emissions [lb/mile]
N_{trips} is the annual number of round trips per (1) barrel of condensate hauled [trips/bbl] for condensate hauling or (2) well [trips/well] for produced water hauling
D is the round trip distance per hauling trip [miles/trip]
2000 is the mass conversion [lb/ton]

2.2.2.15.3.1 Area-Wide Annual Emissions from Condensate and Produced Water Hauling Traffic

Annual fugitive dust emissions for condensate hauling were propagated with the annual condensate production according to Equation 63:

$$E_{fleet,TOTAL,i} = E_{fleet,traffic,,\ i} \times S_{bbl,condensate\ or\ active\ wells} \quad \text{Equation (63)}$$

where:

$E_{fleet,TOTAL,\ i}$ are annual fugitive dust emissions of pollutant i from condensate hauling traffic [ton/yr]

$E_{fleet,traffic,\ i}$ is the dust emissions of pollutant i per barrel for the hauling fleet [ton/surrogate]

$S_{bbl,condensate\ or\ active\ wells}$ is the scaling surrogate for the source category: (1) [barrels of condensate produced per year] for condensate hauling or (2) [active wells per year] for produced water hauling

2.2.2.16 Heaters

This section describes the methodology for estimating emissions from heaters and reboilers. Heater emissions are a function of the properties of the local produced gas used as a fuel. Emissions factors for external combustion of natural gas were obtained from AP-42 Section 1.4 Natural Gas Combustion (USEPA, 1995a). Emissions per well from heaters and reboilers can be estimated individually using Equation 64.

$$E_{heater,i} = N_{heaters} \times \frac{EF_i \times Q_{heater} \times t_{annual}}{(HV_{local} \times 2000)} \quad \text{Equation (64)}$$

where:

$E_{heater,i}$ is the per well emissions for pollutant from a given heater [ton/well-yr]

EF_i is the heater emission factor for a given pollutant i [lb/MM SCF]

Q_{heater} is the heater MMBTU/hr rating [$MMBTU_{rated}$/hr]

HV_{local} is the local natural gas heating value [BTU_{local}/SCF]

t_{annual} is the annual hours of operation [hr/yr]

$N_{heaters}$ is the number of heaters per well

2.2.2.16.1 Area-Wide Annual Emissions from heaters

Annual emissions for heaters and reboilers are estimated with Equation 65 using the scaling surrogate active wells.

$$E_{heater,TOTAL,i} = E_{heater,i} \times W_{TOTAL} \quad \text{Equation (65)}$$

where:

$E_{heater,TOTAL}$ is the total emissions of pollutant i for a given heater type in the Project [ton/yr]

E_{heater} is the per well annual emissions from a given heater type for pollutant i [ton/well-yr]

W_{TOTAL} is the total number of wells for a particular year [wells]

2.2.2.17 Dehydrator Emissions

This section describes the methodology to estimate emissions from dehydrator still vents. Uncontrolled emission factors per unit of gas production for emissions of VOC, CH_4 and CO_2

were derived from the literature for the various well types. Total emissions were propagated using the gas production by well type, assuming 100 percent of the gas undergoes well site dehydration. This was done applying Equation 66.

$$E_{dehyTOTAL,i,j} = EF_{dehy,i} \times S_{gas\ production,j} \qquad \text{Equation (66)}$$

where:

$E_{dehy,TOTAL,\ ,I,j}$ are the total area-wide emissions from dehydrators still vents for pollutant i in year j [tons/yr]

$EF_{dehy,i}$ is the dehydrator still vent emissions rate [tons/MCF]

$S_{gas\ production}$ is the annual gas production in year j [MCF/yr]

2.2.3 Midstream sources

Midstream sources include gathering and treating emissions associated with facilities such as compressor stations and gas plants. Midstream emissions are taken from the 2011 APEN (Air Pollutant Emission Notice) emissions database provided by CDPHE (CDPHE, 2013). CDPHE provided APEN emissions for all oil and gas related emission sources covered by the following SCC and SIC codes:

- All of the SCCs 202002*, 310*, 404003* (where * indicates all sub-SCCs for the SCC)
- And only those with the following SICs: 13*, 492*, 4612

BLM field office planning area designation was assigned according to the latitude and longitude of each source. The APEN oil and gas emissions database includes both well site and midstream sources. Midstream sources were identified for inclusion in the calculator based on the facility name and the suite of equipment included at a given facility. Appendix C-2 includes a table of emissions by facility for each field office area.

Emissions were available in the APEN emissions database for the pollutants VOCs, CO, NO_X, PM_{10} and SO_2 in tons per year. Emissions for CH_4 and CO_2 were calculated using the vented gas speciation according to Equations 67 and 68 for the following sources.

- Glycol Dehydrator
- Natural Gas Processing Facilities, Gas Sweeting: Amine Process
- Condensate Tanks
- Natural Gas Processing Facilities, Flanges and Connections

$$E_{source,CH4} = E_{tanks,VOC} \times \frac{weight\ fraction_{CH4}}{weight\ fraction_{VOC}} \qquad \text{Equation (67)}$$

$$E_{sourceCO2} = E_{tanks,VOC} \times \frac{weight\ fraction_{CO2}}{weight\ fraction_{VOC}} \qquad \text{Equation (68)}$$

where:

$E_{source,VOC}$ is the total annual emissions from APENS database *a source* [tons/yr]
$E_{source,CO2}$ is the total CO_2 emissions from *a source* [tons/yr]
$E_{source,CH4}$ is the total CH_4 emissions from *a source* [tons/yr]
Weight fractions of each pollutant in the vented gas

For combustion sources such as compressor engines, process heaters and flares, emissions for CH_4, N_2O and CO_2 were estimated using the ratios of each greenhouse gas to NOx of emissions factors from AP-42.

Emissions in future years were estimated by multiplying 2011 emissions by the ratio of gas production in a given future year to gas production in 2011.

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APPENDIX C-1

Conventional Gas Well
Calculator Inputs by Source Category

Note: Yellow highlights indicate that inputs were obtained from the Uncompahgre Field Office Air Quality Technical Support Document, ENVIRON, 2012. All inputs taken from other sources are noted.

Gas Analysis & Venting	Speciated Sales Gas Analysis
Gas Component	**Mole Fraction (%)**
Methane C1	81.012
Ethane C2	4.334
Nitrogen	6.718
Water	0.000
Carbon Dioxide	5.380
Nitrous Oxide	0.000
Hydrogen Sulfide	0.000
Propane C3	1.437
i-Butane i-C4	0.288
n-Butane n-C4	0.329
i-Pentane iC5	0.154
n-Pentane nC5	0.104
Hexanes C6	0.111
Heptanes C7	0.037
Octanes+	0.017
Benzene	0.004
Ethylbenzene	0.000
n-Hexane n-C6	0.068
Toluene	0.003
2,2,4-Trimethylpentane	0.001
Xylenes	0.002

Cn_HEq_Exh Construction/Drilling/Completion Equipment

Construction Equipment

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/Well Pad	Equipment Category	HP Range
Well Pad	Construction Equipment	250	4	42	10	13	Other Construction Equipment	300
Well Pad Access Road	Construction Equipment	250	4	42	10	10	Other Construction Equipment	300
Pipeline	Construction Equipment	250	2	42	10	2	Other Construction Equipment	300

Construction Site	Equipment Type	2011 Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O[a]
Well Pad	Construction Equipment	0.18	0.78	2.32	0.15	0.15	0.01	316.19	0.00	0.00
Well Pad Access Road	Construction Equipment	0.18	0.78	2.32	0.15	0.15	0.01	316.19	0.00	0.00
Pipeline	Construction Equipment	0.18	0.78	2.32	0.15	0.15	0.01	316.19	0.00	0.00

Source: EPA NONROADS 2008a

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Drilling

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/activity	NONROAD SCC	Tier Level	HP Range for Efs
Rig-up, Drilling, and Rig-down	Drilling Equipment - Avg	2469	2	40	24	17	2270010010	Tier 2	>1200

Construction Site	Equipment Type	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N2O[a]
Rig-up, Drilling, and Rig-down	Drilling Equipment - Avg	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002

Source: EPA Federal Tier Standards

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Completion/Fracing

Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/activity	NONROAD SCC	Tier Level	HP Range
Completion Equipment	1230	1	40	7	1	2270010010	Tier 2	>1200
Fracing Equipment	12000	1	85	24	1	2270010010	Tier 2	>1200
Refracing Equipment	1500	4	97	1	3	2270010010	Tier 2	>1200

Grand Junction Field Office Air Quality Technical Support Document, ENVIRON, 2012

Data updated from White River Air Quality Technical Support Document, URS, 2012 (Fracing Equipment), and from Uncompahgre Field Office Air Quality Technical Support Document, ENVIRON, 2012 (Completion)

Equipment Type	Capacity (hp)	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O^a
Completion Equipment	1230	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Fracing Equipment	12000	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Refracing Equipment	1500	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002

Source: EPA Federal Tier Standards

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Fracing frequency per spud	1
Refracing Frequency per Year per Well	0.05

Cn_CV_Exh Construction Traffic Exhaust

Well Pad and Access Road Construction Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well Pad/ Year
	Type	Class		
Well Pad and Access Road Construction Traffic	Semi Trucks	HDDV	4	80
	Pickup Trucks	LDDT	4	30
Pipeline Construction	Semi Trucks	HDDV	5	16
	Pickup Trucks	LDDT	5	18

Drilling/Completion/Fracing Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/activity/ Year
	Type	Class		
Drilling Traffic	Semi Trucks	HDDV	4	136
	Pickup Trucks	LDDT	5	136
Rig Hauling	Semi Trucks	HDDV	5	1
Rig Move Drilling Traffic	Semi Trucks	HDDV	5	90
	Pickup Trucks	LDDT	5	42
Well Completion & Testing	Semi Trucks	HDDV	5	84
	Pickup Trucks	LDDT	5	74

Ops_Well WO Workovers

Construction Equipment

Activity	Equipment Type	Capacity (hp)	# of Operating Hours/Day	# of Operating Days/Well	Load Factor	Well Workover Frequency per Year	NONROAD SCC
Well Workover	Workover Equipment	638	9	6	43	0.08	2270010010

Tier Level	HP Range for Efs	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N2O[a]
Tier 2	600-750	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002

Traffic

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year
	Type	Class		
Well Workover	WO Rig	HDDV	4	4
	Haul Truck	HDDV	4	12
	Pickup Truck	LDDT	4	20

blowdown	Blowdown Venting		
Type	Control Efficiency (%)	Volume of gas vented per blowdown Uncontrolled (MCF)	Frequency of Blowdown per well per year
Blowdown	0%	0.75	3.0

Data updated from White River Air Quality Technical Support Document, URS, 2012

well completion	Completion Venting
Type	Total volume of gas during completion (mcf)
All completions	1,000

Data updated from White River Air Quality Technical Support Document, URS, 2012

Recompletion	Recompletion Venting		
Type	Control Efficiency (%)	Volume of gas vented per well per recompletion Uncontrolled (MCF)	No. of recompletion per well per year
Recompletion	0%	1000	1%

Data updated from White River Air Quality Technical Support Document, URS, 2012

Compressor_Venting	Compressor Venting			
Type	**Control Efficiency (%)**	**Volume of gas vented per start-up or shutdown Uncontrolled (MCF)**	**Frequency of Start-up per well per year**	**Frequency of Shutdown per well per year**
Compressor Shutdown	0%	10	1	1

Wellhead Fugitives — Wellhead Fugitive Devices, Pneumatic Devices, and Pneumatic Pumps

Fugitive Devices

component	Ave. # in Gas Service	Ave. # in Liquid service	Ave. # in High Oil service	Ave. # in Water/Oil Service
valves	49	14	0	3
pump seals	2	1	0	0
others	46	0	0	0
connectors	0	0	0	0
flanges	13	8	0	1
open-ended lines	6	2	0	0

Pneumatic Pumps

Type	Gallons/yr/pump	SCF/Gallon	Number of Pump
Pneumatic Pumps	91	118	1

Pneumatic Devices

Device	Number of Devices / well	Lo-Bleed Rate (cfh)
Liquid level controller	2	6
Pressure controller	1	6
Valve controllers	2.0	6
Liquid level controller	0.1	6

Data updated from Colorado River Valley Air Quality Technical Support Document, URS, 2012

WaterInjection_Pumps_Exh	Water Injection Pumps

Type	Capacity (hp)	# of Units per well	Avg. Load Factor (%)	# of Operating Hours	Equipment Category	2011 Emission Factors (g/hp-hr)								
						VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O[a]
Water Injection Pumps	347	0.06	47	2920	Pumps	0.13	0.59	2.14	0.10	0.10	0.00	227.95	0.00	0.00

Source: EPA NONROADS 2008a

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Misc_Engines_Exh	Miscellaneous Engines

Construction Site	Capacity (hp)	# of Units per Well	Fraction of wells to be served by Miscellaneous engine	Avg. Load Factor (%)	# of Operating Hours/Well	Equipment Category
Misc. Engines	118	1	1	50	4380	Misc. Engines

HP Range	2011 Emission Factors (g/hp-hr)								
	VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O[a]
175	0.12	0.41	1.59	0.10	0.10	0.00	227.98	0.00	0.00

Source: EPA NONROADS 2008a

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Condensate Tanks & Traffic	Condensate Tanks
Type	***Base Year Assumptions***
Condensate	1. All Condensate Throughput Sent Tanks
	2. Average Condensate Truck Haulout of 200 bbl/load
Produced Water	3. All Water Throughput Sent Tanks
	4. Average Water Truck Haulout of 100 bbl/load
	5. Based on COGCC data from 2008 to 2011, assumed that about 16 times as much produced water from active wells relative to condensate

Uncontrolled VOC Emission Factors for Condensate Tanks

Applicable to Garfield, Mesa, Rio Blanco, Moffat Counties*	10	lb/bbl

**The uncontrolled VOC emissions factor from Oil and Gas Exploration and Regulation Requirement Fact Sheet, Colorado Department of Public Health and Environment, Air Pollution Control Division, January, 2009.*
http://www.cdphe.state.co.us/ap/sbap/SBAPoilgastankguidance.pdf

Flash Gas Weight Fractions

CO2 Fraction in Flash Gas	%wt	2
CH4 Fraction in Flash Gas	%wt	9
VOC Fraction in Flash Gas	%wt	58
VOC Molecular weight in Flash gas	lb/lb-mol	36

Condensate Truck Load-out

True vapor pressure of liquid loaded, pounds per square inch absolute (psia)	5.2
Mode of Operation	submerged loading: dedicated normal service

Produced Water and Condensate Truck Traffic

Construction Site Destination	Vehicle		Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/BBL OR Round Trips/Year/well
	Type	Class			
Produced Condensate Hauling	Haul Truck (200 bbl)	HDDV	15	4	0.005
Water Hauling	Haul Truck (130 bbl)	HDDV	35	20	70.19

Based on 50% of the water production being hauled. BLM Coalbed Methane Emissions Calculator. Received from BLM March 2012

Ops_RoadMaint Maintenance Traffic

Activity	Vehicle		Total Miles Traveled Per Well	Avg. Vehicle Speed (mph)
	Type	Class		
Road Maintenance	Pickup Truck	LDDV	18	15

Compressor_Engines Compressor Engines

Type of Compressors / Pumps	Rate (Hp)	# Units per Well	Annual Compression (Hp)	Operating Hours/Year
Wellhead Compressor Engines	45	0.1	4	6,778
Lateral Compressor Engines	212	0.02	5	8,760

comp_main_Traffic — Compressor Station Traffic

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Total Miles Traveled per Compressor Station
Compressor Maintenance	Pickup Truck	13	855

Reclaim-RdsWells — Well Pad Reclamation

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Total Miles Traveled per Well
Road and Well Pad Reclamation	Pickup Truck	13	1,110

Others Traffic — Other Traffic

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Year/well
Fuel Hauling	HDDV	15	7	0.6

Heaters and Flaring — Heaters

Wellsite Heaters	Heater Rating (MMBtu/hr)	Fraction of the year heating	hr/yr	No.of Units per Well
Heaters	0.83	0.57	4964	1
Reboilers	0.67	0.53	4599	1

Ops Dehy Dehydrators

Uncontrolled VOC Emissions (tons/mscf)	Uncontrolled CH4 Emissions (tons/mscf)	Uncontrolled CO2 Emissions (tons/mscf)
2.51E-06	4.03E-06	3.15E-07

Data updated from White River Air Quality Technical Support Document, URS, 2012

APPENDIX C-2

Shale Gas Well
Calculator Inputs by Source Category

Note: Yellow highlights indicate that inputs were obtained from the Uncompahgre Field Office Air Quality Technical Support Document, ENVIRON, 2012. All inputs except those from the Bull Mountain Emission Inventory are noted.
Green highlights indicate that inputs were obtained from the data from Bull Mountain Emission Inventory Aug, 2013

Gas Analysis & Venting	Speciated Sales Gas Analysis
Gas Component	**Mole Fraction (%)**
Methane C1	90.150
Ethane C2	1.960
Nitrogen	0.160
Water	0.000
Carbon Dioxide	6.660
Nitrous Oxide	0.000
Hydrogen Sulfide	0.000
Propane C3	0.520
i-Butane i-C4	0.120
n-Butane n-C4	0.100
i-Pentane iC5	0.060
n-Pentane nC5	0.030
Hexanes+ C6+	0.128
Heptanes C7	0.000
Octanes+	0.000
Benzene	0.036
Ethylbenzene	0.002
n-Hexane n-C6	0.000
Toluene	0.047
2,2,4-Trimethylpentane	0.000
Xylenes	0.017
Helium	0.010
O2	0.000

*The full gas composition did not include BTEX and n-hexane components. These were included by adding separately provided BTEX and n-hexane mole fractions to the composition above and subtracting the corresponding mole fractions from the hexanes+ component.

Cn_HEq_Exh	Construction/Drilling/Completion Equipment

Construction Equipment

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/Well Pad**	HP Range
Well Pad	Haul Truck	250	3	40	8	13	300
	Trackhoe	250	1	40	8	13	300
	Dozer	250	2	40	8	13	300
	Grader	250	1	40	8	13	300
	Compactor	250	1	40	8	13	300
	Water Truck	250	1	40	8	13	300
Well Pad Access Road	Dozer	250	2	40	8	10	300
	Grader	250	1	40	8	10	300
	Trackhoe	250	1	40	8	10	300
	Haul Truck	250	3	40	8	10	300
Pipeline	Dozer	250	1	40	10	10	300
	Grader	250	1	40	10	10	300
	Trackhoe	250	1	40	10	10	300
	Bending Mach	250	1	40	10	10	300
	Sideboom	250	1	40	10	10	300
	Utility Tractor	250	1	40	10	10	300

**Includes pad reclamation associated activity

Construction Site	Equipment Type	2011 Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O[a]
Well Pad	For all Construction Equipment	0.18	0.78	2.32	0.15	0.15	0.01	316.19	0.00	0.00
Well Pad Access Road	For all Construction Equipment	0.18	0.78	2.32	0.15	0.15	0.01	316.19	0.00	0.00
Pipeline	For all Construction Equipment	0.18	0.78	2.32	0.15	0.15	0.01	316.19	0.00	0.00

Source: EPA NONROADS 2008a
[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Drilling

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/activity	NONROAD SCC	Tier Level	HP Range for Efs
Rig-up, Drilling, and Rig-down	Drilling Equipment - Avg	1200	1	40	24	35	2270010010	Tier 2	>1200

Construction Site	Equipment Type	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N2O
Rig-up, Drilling, and Rig-down	Drilling Equipment - Avg	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002

Source: EPA Federal Tier Standards
[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Completion/Fracing

Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/activity	NONROAD SCC	Tier Level	HP Range
Completion Equipment	1230	1	40	7	1	2270010010	Tier 2	>1200
Fracing Equipment	12000	1	85	24	1	2270010010	Tier 2	>1200
Refracing Equipment	1500	4	97	1	3	2270010010	Tier 2	>1200

Grand Junction Field Office Air Quality Technical Support Document, ENVIRON, 2012

Data updated from White River Air Quality Technical Support Document, URS, 2012 (Fracing Equipment), and from Uncompahgre Field Office Air Quality Technical Support Document, ENVIRON, 2012 (Completion)

Equipment Type	Capacity (hp)	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O^a
Completion Equipment	1230	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Fracing Equipment	12000	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Refracing Equipment	1500	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002

Source: EPA Federal Tier Standards
[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Fracing frequency per spud	1
Refracing Frequency per Year per Well	0.25

Cn_CV_Exh Construction Traffic Exhaust

Well Pad and Access Road Construction Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well Pad/ Year
	Type	Class		
Well Pad and Access Road Construction Traffic	Semi Trucks	HDDV	16	164
	Pickup Trucks	LDDT	16	40
Pipeline Construction	Semi Trucks	HDDV	16	35
	Pickup Trucks	LDDT	16	48

Drilling/Completion/Fracing Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/activity/ Year
	Type	Class		
Drilling Traffic	Semi Trucks	HDDV	16	917
	Pickup Trucks	LDDT	16	274
Rig Hauling	Semi Trucks	HDDV	16	1
Rig Move Drilling Traffic	Semi Trucks	HDDV	16	90
	Pickup Trucks	LDDT	16	42
Well Completion & Testing	Semi Trucks	HDDV	16	84
	Pickup Trucks	LDDT	16	74

Cn_HEq_FDust Construction Traffic Dust

Area Disturbed for Oil Wells	Avg. Disturbed Acres per wellpad	Construction Days
Well Pad	3.75	15
Well Pad Access Road and Pipeline Construction	1.8	8

Road and Pipeline Construction, (Pipeline Percentage of Acreage)	6%

Ops_Well WO Workovers

Construction Equipment

Activity	Equipment Type	Capacity (hp)	# of Operating Hours/Day	# of Operating Days/Well	Load Factor	Well Workover Frequency per Year	NONROAD SCC
Well Workover	Workover Equipment	500	10	7	43	0.5	2270010010

Tier Level	HP Range for Efs	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N2O[a]
Tier 2	600-750	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002

Traffic

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year
	Type	Class		
Well Workover	WO Rig	HDDV	4.1	0.6
	Haul Truck	HDDV	4.1	1.3
	Pickup Truck	LDDT	4.1	6.4

blowdown — Blowdown Venting

Type	Control Efficiency (%)	Volume of gas vented per blowdown Uncontrolled (MCF)	Frequency of Blowdown per well per year
Blowdown	0%	0.81	3.4

Data updated from White River Air Quality Technical Support Document, URS, 2012

well completion — Completion Venting

Type	Total volume of gas during completion (mcf)
All completions	1,000

Recompletion — Recompletion Venting

Type	Control Efficiency (%)	Volume of gas vented per well per recompletion Uncontrolled (MCF)	No. of recompletion per well per year
Recompletion	0%	30	50%

Compressor_Venting	Compressor Venting			
Type	**Control Efficiency (%)**	**Volume of gas vented per start-up or shutdown Uncontrolled (MCF)**	**Frequency of Start-up per well per year**	**Frequency of Shutdown per well per year**
Compressor Shutdown	0%	10	1	1

Wellhead Fugitives — Wellhead Fugitive Devices, Pneumatic Devices, and Pneumatic Pumps

Fugitive Devices

component	Ave. # in Gas Service	Ave. # in Liquid service	Ave. # in High Oil service	Ave. # in Water/Oil Service
valves	49	14	0	3
pump seals	2	1	0	0
others	46	0	0	0
connectors	0	0	0	0
flanges	13	8	0	1
open-ended lines	6	2	0	0

Pneumatic Pumps

Type	Gallons/yr/pump	SCF/Gallon	Number of Pump
Pneumatic Pumps	91	118	1

Pneumatic Devices

Device	Number of Devices / well	Lo-Bleed Rate (cfh)
Liquid level controller	2	6
Pressure controller	1	6
Valve controllers	2.0	6
Liquid level controller	0.1	6

Data updated from Colorado River Valley Air Quality Technical Support Document, URS, 2012

WaterInjection_Pumps_Exh	Water Injection Pumps

Type	Capacity (hp)	# of Units per well	Avg. Load Factor (%)	# of Operating Hours	Equipment Category	2011 Emission Factors (g/hp-hr)								
						VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O[a]
Water Injection Pumps	347	0.09	47	2920	Pumps	0.13	0.59	2.14	0.10	0.10	0.00	227.95	0.00	0.00

Source: EPA NONROADS 2008a

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Misc_Engines_Exh	Miscellaneous Engines

Construction Site	Capacity (hp)	# of Units per Well	Fraction of wells to be served by Miscellaneous engine	Avg. Load Factor (%)	# of Operating Hours/Well	Equipment Category
Misc. Engines (wellsite water pumps)	19	1	1	47%	8760	Misc. Engines

HP Range	2011 Emission Factors (g/hp-hr)								
	VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O[a]
25	0.27	1.68	8.16	0.04	0.04	0.00	557.28	0.01	0.00

Source: Emission factors for NOx and VOC from EPA Nonroad Spark-Ignition Engines 19 kW and Below - Exhaust Emission Standards, Phase 2, Class II Engine. Emission factors for CO, PM10 and PM2.5 and HAPs from AP-42, Volume I, Fifth Edition, Table 3.2-1.

Emission factors for CO2, CH4, and N2O from Tables C-1 and C-2 of 40 CFR Part 98, Mandatory Reporting of Greenhouse Gases; Final Rule.

Condensate Tanks & Traffic	Condensate Tanks
Type	***Base Year Assumptions***
Condensate	1. All Condensate Throughput Sent Tanks
	2. Average Condensate Truck Haulout of 200 bbl/load
Produced Water	3. All Water Throughput Sent Tanks
	4. Average Water Truck Haulout of 100 bbl/load
	5. Based on COGCC data from 2008 to 2011, assumed that about 16 times as much produced water from active wells relative to condensate

Uncontrolled VOC Emission Factors for Condensate Tanks

Applicable to Garfield, Mesa, Rio Blanco, Moffat Counties*	10	lb/bbl

**The uncontrolled VOC emissions factor from Oil and Gas Exploration and Regulation Requirement Fact Sheet, Colorado Department of Public Health and Environment, Air Pollution Control Division, January, 2009.*
http://www.cdphe.state.co.us/ap/sbap/SBAPoilgastankguidance.pdf

Flash Gas Weight Fractions

CO2 Fraction in Flash Gas	%wt	2
CH4 Fraction in Flash Gas	%wt	9
VOC Fraction in Flash Gas	%wt	58
VOC Molecular weight in Flash gas	lb/lb-mol	36

Condensate Truck Load-out

True vapor pressure of liquid loaded, pounds per square inch absolute (psia)	5.2
Mode of Operation	submerged loading: dedicated normal service

Produced Water and Condensate Truck Traffic

Construction Site Destination	Vehicle		Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/BBL OR Round Trips/Year/well
	Type	Class			
Produced Condensate Hauling	Haul Truck (200 bbl)	HDDV	15	4	0.005
Water Hauling	Haul Truck (130 bbl)	HDDV	15	4	70.19

Based on 50% of the water production being hauled. BLM Coalbed Methane Emissions Calculator. Received from BLM March 2012

Ops_RoadMaint Maintenance Traffic

Activity	Vehicle		Total Miles Traveled Per Well	Avg. Vehicle Speed (mph)
	Type	Class		
Road Maintenance	Pickup Truck	LDDV	18	15

Compressor_Engines Compressor Engines

Type of Compressors / Pumps	Rate (Hp)	# Units per Well	Annual Compression (Hp)	Operating Hours/Year
Wellhead Compressor Engines	45	0.1	4	6,778
Lateral Compressor Engines	212	0.02	5	8,760

comp_main_ Traffic	Compressor Station Traffic		
Activity	**Vehicle Type**	**Avg. Vehicle Speed (mph)**	**Total Miles Traveled per Compressor Station**
Compressor Maintenance	Pickup Truck	13	107

Reclaim-RdsWells	Well Pad Reclamation		
Activity	**Vehicle Type**	**Avg. Vehicle Speed (mph)**	**Total Miles Traveled per Well**
Road and Well Pad Reclamation	Pickup Truck	15	416

Others Traffic	Other Traffic			
Activity	**Vehicle Type**	**Avg. Vehicle Speed (mph)**	**Round Trip Distance (miles)**	**# of Round Trips/Year/well**
Fuel Hauling	HDDV	15	7	7

Heaters and Flaring	Heaters			
Wellsite Heaters	**Heater Rating (MMBtu/hr)**	**Fraction of the year heating**	**hr/yr**	**No.of Units per Well**
Heaters	0.23	0.17	1460	3
Reboilers	0.25	0.50	4380	1

The Bull Mountain Emission Inventory estimated emissions from one separator heater with 0.125 mmbtu/hr heater rating,4380 hours /year and 4 tank heaters with 0.25 mmbtu/hr heater rating and 730 hours/year. For this project, weighted average of separator heater and tank heaters data were used to estimate heater emissions.

Ops Dehy	Dehydrators

Uncontrolled VOC Emissions (tons/mscf)	Uncontrolled CH4 Emissions (tons/mscf)	Uncontrolled CO2 Emissions (tons/mscf)
1.72E-06	2.24E-06	2.91E-06

APPENDIX C-3

Coalbed Natural Gas Well
Calculator Inputs by Source Category

Note: Yellow highlights indicate that inputs were obtained from theBLM Coalbed Methane Emissions Calculator. Received from BLM March 2012. All inputs taken from other sources are noted.

Gas Analysis & Venting	**Speciated Sales Gas Analysis**
Gas Component	**Mole Fraction (%)**
Methane C1	97.913
Ethane C2	0.000
Nitrogen	1.173
Water	0.000
Carbon Dioxide	0.851
Nitrous Oxide	0.000
Hydrogen Sulfide	0.000
Propane C3	0.063
i-Butane i-C4	0.000
n-Butane n-C4	0.000
i-Pentane iC5	0.000
n-Pentane nC5	0.000
Hexanes C6	0.000
Heptanes C7	0.000
Octanes+	0.000
Benzene	0.000
Ethylbenzene	0.000
n-Hexane n-C6	0.000
Toluene	0.000
2,2,4-Trimethylpentane	0.000
Xylenes	0.000

Cn_HEq_Exh Construction/Drilling/Completion Equipment

Construction Equipment

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/Well Pad	Equipment Category	HP Range
Well Pad	Construction Equipment	200	2	80	12	3	Other Construction Equipment	300
Well Pad Access Road	Construction Equipment	200	1	80	4	1	Other Construction Equipment	300
Pipeline	Construction Equipment	200	2	80	10	2	Other Construction Equipment	300

Construction Site	Equipment Type	2011 Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O[a]
Well Pad	Construction Equipment	0.18	0.78	2.32	0.15	0.15	0.01	316.19	0.00	0.00
Well Pad Access Road	Construction Equipment	0.18	0.78	2.32	0.15	0.15	0.01	316.19	0.00	0.00
Pipeline	Construction Equipment	0.18	0.78	2.32	0.15	0.15	0.01	316.19	0.00	0.00

Source: EPA NONROADS 2008a

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Drilling

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/activity	NONROAD SCC	Tier Level	HP Range for Efs
Rig-up, Drilling, and Rig-down	Drilling Equipment - Avg	400	3	77	24	3	2270010010	Tier 2	300-600

Construction Site	Equipment Type	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N2O[a]
Rig-up, Drilling, and Rig-down	Drilling Equipment - Avg	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002

Source: EPA Federal Tier Standards

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Completion/Fracing

Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/activity	NONROAD SCC	Tier Level	HP Range
Completion Equipment	400	1	50	10	5	2270010010	Tier 2	300-600
Fracing Equipment	-	-	-	-	-	-	-	-
Refracing Equipment	-	-	-	-	-	-	-	-

Equipment Type	Capacity (hp)	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O[a]
Completion Equipment	400	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Fracing Equipment	-	-	-	-	-	-	-	-	-	-
Refracing Equipment	-	-	-	-	-	-	-	-	-	-

Source: EPA Federal Tier Standards
[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Fracing frequency per spud	-
Refracing Frequency per Year per Well	-

Cn_CV_Exh Construction Traffic Exhaust

Well Pad and Access Road Construction Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well Pad/ Year
	Type	Class		
Well Pad and Access Road Construction Traffic	Semi Trucks	HDDV	20	3
	Pickup Trucks	LDDT	20	3
Pipeline Construction	Semi Trucks	HDDV	20	8
	Pickup Trucks	LDDT	20	8

Drilling/Completion/Fracing Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/activity/ Year
	Type	Class		
Drilling Traffic	Semi Trucks	HDDV	20	2
	Pickup Trucks	LDDT	20	20
Rig Hauling	Semi Trucks	HDDV	20	12
Rig Move Drilling Traffic	Semi Trucks	HDDV	20	1
	Pickup Trucks	LDDT	20	16
Well Completion & Testing	Semi Trucks	HDDV	20	36
	Pickup Trucks	LDDT	20	12

Cn_HEq_FDust Construction Traffic Dust

Area Disturbed for Oil Wells	Avg. Disturbed Acres per wellpad	Construction Days
Well Pad	6.00	2.50
Well Pad Access Road and Pipeline Construction	4.9	2.17

Road and Pipeline Construction, (Pipeline Percentage of Acreage)	6%

Data from Uncompahgre Field Office Air Quality Technical Support Document, ENVIRON, 2012

Ops_Well WO Workovers

Construction Equipment

Activity	Equipment Type	Capacity (hp)	# of Operating Hours/Day	# of Operating Days/Well	Load Factor	Well Workover Frequency per Year	NONROAD SCC
Well Workover	Workover Equipment	400	10	2	43	0.08	2270010010

Data from Uncompahgre Field Office Air Quality Technical Support Document, ENVIRON, 2012

Tier Level	HP Range for Efs	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N2O[a]
Tier 2	600-750	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002

Traffic

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year
	Type	Class		
Well Workover	WO Rig	HDDV	20	1
	Haul Truck	HDDV	20	1
	Pickup Truck	LDDT	20	2

blowdown Blowdown Venting

Type	Control Efficiency (%)	Volume of gas vented per blowdown Uncontrolled (MCF)	Frequency of Blowdown per well per year
Blowdown	0%	200	2.0

Data updated from White River Air Quality Technical Support Document, URS, 2012

well completion Completion Venting

Type	Total volume of gas during completion (mcf)

All completions	1,000

Data updated from White River Air Quality Technical Support Document, URS, 2012

Recompletion — Recompletion Venting

Type	Control Efficiency (%)	Volume of gas vented per well per recompletion Uncontrolled (MCF)	No. of recompletion per well per year
Recompletion	0%	1000	1%

Data updated from White River Air Quality Technical Support Document, URS, 2012

Compressor_Venting — Compressor Venting

Type	Control Efficiency (%)	Volume of gas vented per start-up or shutdown Uncontrolled (MCF)	Frequency of Start-up per well per year	Frequency of Shutdown per well per year
Compressor Shutdown	0%	10	1	1

Data from Uncompahgre Field Office Air Quality Technical Support Document, ENVIRON, 2012

Wellhead Fugitives — Wellhead Fugitive Devices, Pneumatic Devices, and Pneumatic Pumps

Fugitive Devices

component	Ave. # in Gas Service	Ave. # in Liquid service	Ave. # in High Oil service	Ave. # in Water/Oil Service
valves	49	14	0	3
pump seals	2	1	0	0
others	46	0	0	0
connectors	0	0	0	0
flanges	13	8	0	1
open-ended lines	6	2	0	0

Pneumatic Pumps

Type	Gallons/yr/pump	SCF/Gallon	Number of Pump
Pneumatic Pumps	-	-	-

Pneumatic Devices

Device	Number of Devices / well	Lo-Bleed Rate (cfh)
Liquid level controller	5	6
Transducer	5	6

WaterInjection_ Pumps_Exh Water Injection Pumps

Type	Capacity (hp)	# of Units per well	Avg. Load Factor (%)	# of Operating Hours	Equipment Category	2011 Emission Factors (g/hp-hr)								
						NOxa	PM10b	SO2b	COa	VOCa	PM2.5b	CO2c	CH4c	N2Oc
Water Injection Pumps	34	1	47	8760	Pumps	2.14	0.10	0.0045	0.59	0.13	0.10	227.95	0.002	0.002

a Source: assume compressors will comply with NSPS 40 CFR part 60 subpart JJJJ (same rates as Colorado Regulation 7)
b Source: EPA, AP-42 Section 3.2 Natural Gas Fired Reciprocating Engines
c EPA Mandatory GHG Reporting, Part 98, Subpart C, Tables C-1 and C-2.

Condensate Tanks & Traffic Condensate Tanks

Type	***Base Year Assumptions***
Condensate	1. All Condensate Throughput Sent Tanks
	2. Average Condensate Truck Haulout of 200 bbl/load
Produced Water	3. All Water Throughput Sent Tanks
	4. Average Water Truck Haulout of 100 bbl/load
	5. Based on COGCC data from 2008 to 2011, assumed that about 16 times as much produced water from active wells relative to condensate

Uncontrolled VOC Emission Factors for Condensate Tanks

Applicable to Garfield, Mesa, Rio Blanco, Moffat Counties*	10	lb/bbl

**The uncontrolled VOC emissions factor from Oil and Gas Exploration and Regulation Requirement Fact Sheet, Colorado Department of Public Health and Environment, Air Pollution Control Division, January, 2009.*
http://www.cdphe.state.co.us/ap/sbap/SBAPoilgastankguidance.pdf

Flash Gas Weight Fractions

CO2 Fraction in Flash Gas	%wt	2
CH4 Fraction in Flash Gas	%wt	9
VOC Fraction in Flash Gas	%wt	58
VOC Molecular weight in Flash gas	lb/lb-mol	36

Condensate Truck Load-out

True vapor pressure of liquid loaded, pounds per square inch absolute (psia)	5.2
Mode of Operation	submerged loading: dedicated normal service

Produced Water and Condensate Truck Traffic

Construction Site Destination	Vehicle		Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/BBL OR Round Trips/Year/well
	Type	Class			
Produced Condensate Hauling	Haul Truck (200 bbl)	HDDV	30	20	0.0
Water Hauling	Haul Truck (130 bbl)	HDDV	35	20	70

Assumed 50% of the water production is hauled.

Ops_RoadMaint   Maintenance Traffic

Activity	Vehicle		Total Miles Traveled Per Well	Avg. Vehicle Speed (mph)
	Type	Class		
Road Maintenance	Pickup Truck	LDDV	1	15

comp_main_ Traffic   Compressor Station Traffic

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Total Miles Traveled per Compressor Station
Compressor Maintenance	Pickup Truck	35	2,920

Reclaim-RdsWells   Well Pad Reclamation

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Total Miles Traveled per Well
Road and Well Pad Reclamation	Pickup Truck	30	28

Others Traffic Other Traffic

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Year/well
Fuel Hauling	HDDV	15	14	1.0

Heaters and Flaring Heaters

Wellsite Heaters	Heater Rating (MMBtu/hr)	Fraction of the year heating	hr/yr	No.of Units per Well
Heaters	0.50	0.30	8760	1
Reboilers	3.00	0.30	8760	0.002

Data from Uncompahgre Field Office Air Quality Technical Support Document, ENVIRON, 2012

Ops Dehy Dehydrators

Uncontrolled VOC Emissions (tons/mscf)	Uncontrolled CH4 Emissions (tons/mscf)	Uncontrolled CO2 Emissions (tons/mscf)
1.26E-07	1.60E-05	0.00E+00

APPENDIX C-4

Conventional Oil Well
Calculator Inputs by Source Category

Note: Yellow highlights indicate that inputs were obtained from the Uncompahgre Field Office Air Quality Technical Support Document, ENVIRON, 2012. All inputs taken from other sources are noted.

Gas Analysis & Venting	Speciated Sales Gas Analysis
Gas Component	Mole Fraction (%)
Methane C1	81.012
Ethane C2	4.334
Nitrogen	6.718
Water	0.000
Carbon Dioxide	5.380
Nitrous Oxide	0.000
Hydrogen Sulfide	0.000
Propane C3	1.437
i-Butane i-C4	0.288
n-Butane n-C4	0.329
i-Pentane iC5	0.154
n-Pentane nC5	0.104
Hexanes C6	0.111
Heptanes C7	0.037
Octanes+	0.017
Benzene	0.004
Ethylbenzene	0.000
n-Hexane n-C6	0.068
Toluene	0.003
2,2,4-Trimethylpentane	0.001
Xylenes	0.002

Cn_HEq_Exh Construction/Drilling/Completion Equipment

Construction Equipment

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/Well Pad	Equipment Category	HP Range
Well Pad	Construction Equipment	250	4	42	10	13	Other Construction Equipment	300
Well Pad Access Road	Construction Equipment	250	4	42	10	10	Other Construction Equipment	300
Pipeline	Construction Equipment	250	2	42	10	2	Other Construction Equipment	300

Construction Site	Equipment Type	2011 Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O[a]
Well Pad	Construction Equipment	0.18	0.78	2.32	0.15	0.15	0.01	316.19	0.00	0.00
Well Pad Access Road	Construction Equipment	0.18	0.78	2.32	0.15	0.15	0.01	316.19	0.00	0.00
Pipeline	Construction Equipment	0.18	0.78	2.32	0.15	0.15	0.01	316.19	0.00	0.00

Source: EPA NONROADS 2008a

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Drilling

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/activity	NONROAD SCC	Tier Level	HP Range for Efs
Rig-up, Drilling, and Rig-down	Drilling Equipment - Avg	2469	2	40	24	17	2270010010	Tier 2	>1200

Construction Site	Equipment Type	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N2O[a]
Rig-up, Drilling, and Rig-down	Drilling Equipment - Avg	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002

Source: EPA Federal Tier Standards

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Completion/Fracing

Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/activity	NONROAD SCC	Tier Level	HP Range
Completion Equipment	1230	1	40	7	1	2270010010	Tier 2	>1200
Fracing Equipment	12000	1	85	24	1	2270010010	Tier 2	>1200
Refracing Equipment	1500	4	97	1	3	2270010010	Tier 2	>1200

Grand Junction Field Office Air Quality Technical Support Document, ENVIRON, 2012

Data updated from White River Air Quality Technical Support Document, URS, 2012 (Fracing Equipment), and from Uncompahgre Field Office Air Quality Technical Support Document, ENVIRON, 2012 (Completion)

Equipment Type	Capacity (hp)	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O[a]
Completion Equipment	1230	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Fracing Equipment	12000	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Refracing Equipment	1500	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002

Source: EPA Federal Tier Standards

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Fracing frequency per spud	1
Refracing Frequency per Year per Well	0.05

Cn_CV_Exh Construction Traffic Exhaust

Well Pad and Access Road Construction Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well Pad/ Year
	Type	Class		
Well Pad and Access Road Construction Traffic	Semi Trucks	HDDV	4	80
	Pickup Trucks	LDDT	4	30
Pipeline Construction	Semi Trucks	HDDV	5	16
	Pickup Trucks	LDDT	5	18

Drilling/Completion/Fracing Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/activity/ Year
	Type	Class		
Drilling Traffic	Semi Trucks	HDDV	4	136
	Pickup Trucks	LDDT	5	136
Rig Hauling	Semi Trucks	HDDV	5	1
Rig Move Drilling Traffic	Semi Trucks	HDDV	5	90
	Pickup Trucks	LDDT	5	42
Well Completion & Testing	Semi Trucks	HDDV	5	84
	Pickup Trucks	LDDT	5	74

Cn_HEq_FDust Construction Traffic Dust

Area Disturbed for Oil Wells	Avg. Disturbed Acres per wellpad	Construction Days
Well Pad	4.88	13
Well Pad Access Road and Pipeline Construction	9	10

Road and Pipeline Construction, (Pipeline Percentage of Acreage)	6%

Ops_Well WO Workovers

Construction Equipment

Activity	Equipment Type	Capacity (hp)	# of Operating Hours/Day	# of Operating Days/Well	Load Factor	Well Workover Frequency per Year	NONROAD SCC
Well Workover	Workover Equipment	638	9	6	43	0.08	2270010010

Tier Level	HP Range for Efs	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N2O[a]
Tier 2	600-750	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002

Traffic

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year
	Type	Class		
Well Workover	WO Rig	HDDV	4	4
	Haul Truck	HDDV	4	12
	Pickup Truck	LDDT	4	20

blowdown Blowdown Venting

Type	Control Efficiency (%)	Volume of gas vented per blowdown Uncontrolled (MCF)	Frequency of Blowdown per well per year
Blowdown	0%	0.75	3.0

Data updated from White River Air Quality Technical Support Document, URS, 2012

well completion Completion Venting

Type	Total volume of gas during completion (mcf)
All completions	1,000

Data updated from White River Air Quality Technical Support Document, URS, 2012

Recompletion — Recompletion Venting

Type	Control Efficiency (%)	Volume of gas vented per well per recompletion Uncontrolled (MCF)	No. of recompletion per well per year
Recompletion	0%	1000	1%

Data updated from White River Air Quality Technical Support Document, URS, 2012

Compressor_Venting — Compressor Venting

Type	Control Efficiency (%)	Volume of gas vented per start-up or shutdown Uncontrolled (MCF)	Frequency of Start-up per well per year	Frequency of Shutdown per well per year
Compressor Shutdown	0%	10	1	1

Wellhead Fugitives — Wellhead Fugitive Devices, Pneumatic Devices, and Pneumatic Pumps

Fugitive Devices

component	Ave. # in Gas Service	Ave. # in Liquid service	Ave. # in High Oil service	Ave. # in Water/Oil Service
valves	49	14	0	3
pump seals	2	1	0	0
others	46	0	0	0
connectors	0	0	0	0
flanges	13	8	0	1
open-ended lines	6	2	0	0

Pneumatic Pumps

Type	Gallons/yr/pump	SCF/Gallon	Number of Pump
Pneumatic Pumps	91	118	1

Pneumatic Devices

Device	Number of Devices / well	Lo-Bleed Rate (cfh)

Liquid level controller	2	6
Pressure controller	1	6
Valve controllers	2.0	6
Liquid level controller	0.1	6
	Data updated from Colorado River Valley Air Quality Technical Support Document, URS, 2012	

WaterInjection_Pumps_Exh   Water Injection Pumps

Type	Capacity (hp)	# of Units per well	Avg. Load Factor (%)	# of Operating Hours	Equipment Category	2011 Emission Factors (g/hp-hr)								
						VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O^a
Water Injection Pumps	347	0.06	47	2920	Pumps	0.13	0.59	2.14	0.10	0.10	0.00	227.95	0.00	0.00

Source: EPA NONROADS 2008a

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Misc_Engines_Exh   Miscellaneous Engines

Construction Site	Capacity (hp)	# of Units per Well	Fraction of wells to be served by Miscellaneous engine	Avg. Load Factor (%)	# of Operating Hours/Well	Equipment Category
Misc. Engines	118	1	1	50	4380	Misc. Engines

HP Range	2011 Emission Factors (g/hp-hr)								
	VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O^a
175	0.12	0.41	1.59	0.10	0.10	0.00	227.98	0.00	0.00

Source: EPA NONROADS 2008a
[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Condensate Tanks & Traffic	Condensate Tanks
Type	***Base Year Assumptions***
Condensate	1. All Condensate Throughput Sent Tanks
	2. Average Condensate Truck Haulout of 200 bbl/load
Produced Water	3. All Water Throughput Sent Tanks
	4. Average Water Truck Haulout of 100 bbl/load
	5. Based on COGCC data from 2008 to 2011, assumed that about 16 times as much produced water from active wells relative to condensate

Uncontrolled VOC Emission Factors for Condensate Tanks

Applicable to Garfield, Mesa, Rio Blanco, Moffat Counties*	1.6	lb/bbl

**The uncontrolled VOC emissions factor from the BLM crude oil emission calculator*

Flash Gas Weight Fractions

CO2 Fraction in Flash Gas	%wt	2
CH4 Fraction in Flash Gas	%wt	9
VOC Fraction in Flash Gas	%wt	58
VOC Molecular weight in Flash gas	lb/lb-mol	36

Condensate Truck Load-out

True vapor pressure of liquid loaded, pounds per square inch absolute (psia)	5.2
Mode of Operation	submerged loading: dedicated normal service

Produced Water and Condensate Truck Traffic

Construction Site	Vehicle	Avg. Vehicle Speed	Round Trip Distance	# of Round Trips/BBL

Destination	Vehicle Type	Vehicle Class	(mph)	(miles)	OR Round Trips/Year/well
Produced Condensate Hauling	Haul Truck (200 bbl)	HDDV	15	4	0.005
Water Hauling	Haul Truck (130 bbl)	HDDV	35	20	70.19

Based on 50% of the water production being hauled. BLM Coalbed Methane Emissions Calculator. Received from BLM March 2012

Ops_RoadMaint Maintenance Traffic

Activity	Vehicle		Total Miles Traveled Per Well	Avg. Vehicle Speed (mph)
	Type	Class		
Road Maintenance	Pickup Truck	LDDV	18	15

Compressor_Engines Compressor Engines

Type of Compressors / Pumps	Rate (Hp)	# Units per Well	Annual Compression (Hp)	Operating Hours/Year
Wellhead Compressor Engines	45	0.1	4	6,778
Lateral Compressor Engines	212	0.02	5	8,760

comp_main_ Traffic Compressor Station Traffic

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Total Miles Traveled per Compressor Station
Compressor Maintenance	Pickup Truck	13	855

Reclaim-RdsWells	Well Pad Reclamation		
Activity	**Vehicle Type**	**Avg. Vehicle Speed (mph)**	**Total Miles Traveled per Well**
Road and Well Pad Reclamation	Pickup Truck	13	1,110

Others Traffic	Other Traffic			
Activity	**Vehicle Type**	**Avg. Vehicle Speed (mph)**	**Round Trip Distance (miles)**	**# of Round Trips/Year/well**
Fuel Hauling	HDDV	15	7	0.6

Heaters and Flaring	Heaters			
Wellsite Heaters	**Heater Rating (MMBtu/hr)**	**Fraction of the year heating**	**hr/yr**	**No.of Units per Well**
Heaters	0.83	0.57	4964	1
Reboilers	0.67	0.53	4599	1

Ops Dehy	Dehydrators	
Uncontrolled VOC Emissions (tons/mscf)	**Uncontrolled CH4 Emissions (tons/mscf)**	**Uncontrolled CO2 Emissions (tons/mscf)**
2.51E-06	4.03E-06	3.15E-07

Data updated from White River Air Quality Technical Support Document, URS, 2012

APPENDIX C-5

Midstream Emissions by Field Office and Facility

Field Office	County	Facility Name	2011 Emissions (tons/year)					
			NOx	VOC	CO	PM10	PM2.5	SO2
Grand Junction	Garfield	BARGATH LLC - CRAWFORD TRAIL	208.02	71.50	80.14	6.262	6.262	0.430
Grand Junction	Garfield	CHEVRON USA INC - PICEANCE BASIN CENTRAL	91.80	58.22	52.00	1.938	1.938	0.174
Grand Junction	Garfield	ENCANA (WEST) - HAY CANYON	0.00	23.74	0.00	0.000	0.000	0.000
Grand Junction	Garfield	NATIONAL FUEL CORP. - BAXTER FACILITY	18.50	2.90	4.40	0.081	0.081	0.005
Grand Junction	Garfield	OXY USA WTP LP - CONN CREEK GAS	132.80	35.28	19.13	0.010	0.010	1.760
Grand Junction	Garfield	PUBLIC SERVICE CO BAXTER STATION	58.04	7.56	67.23	0.230	0.230	0.028
Grand Junction	Garfield	SOURCEGAS DBA ROCKY MTN -DEBEQUE C S	28.48	7.97	65.49	0.591	0.591	0.013
Grand Junction	Garfield	TRANSCOLORADO GAS - CONN CREEK	2.10	0.32	0.28	0.040	0.040	0.000
Grand Junction	Garfield	WPX ENERGY RKY MTN, LLC - TRAIL RIDGE CS	31.70	8.00	5.85	0.073	0.073	0.004
Grand Junction	Mesa	ASPEN OPERATING, LLC - SINK CREEK C.S.	49.15	2.81	2.72	0.052	0.000	0.003
Grand Junction	Mesa	AXIA ENERGY - TAYLOR COMPRESSOR STATION	32.75	54.32	72.48	0.000	0.000	0.000
Grand Junction	Mesa	BADGER MIDSTREAM SERVICES - BADGER WGP	50.02	31.39	54.43	1.074	1.074	0.075
Grand Junction	Mesa	BLACK HILLS MIDSTREAM - HORSESHOE CANYON	35.30	66.14	26.50	0.570	0.570	0.035
Grand Junction	Mesa	COLLBRAN VALLEY GAS - ANDERSON GULCH	127.63	68.11	60.97	4.369	4.366	0.120
Grand Junction	Mesa	COLLBRAN VALLEY GAS GATHERING- CVG #2	192.66	112.89	49.33	0.000	0.000	0.000
Grand Junction	Mesa	COLORADO FUEL MANUFACTURERS, INC.	33.20	87.51	21.75	0.975	0.975	1.077
Grand Junction	Mesa	DELTA PETROLEUM CORP - MVS CS AND HCPWRF	4.70	61.90	22.10	0.000	0.000	0.000
Grand Junction	Mesa	ENCANA - PLATEAU CREEK	19.74	11.24	12.78	0.800	0.800	0.008
Grand Junction	Mesa	ETC CANYON PIPELINE - BAR X C.S.	12.20	20.48	14.20	0.376	0.376	0.023
Grand Junction	Mesa	ETC CANYON PIPELINE - PREMIER BAR X	73.32	7.82	5.09	1.340	1.340	0.020
Grand Junction	Mesa	ETC CANYON PIPELINE -PREMIER DEBEQUE	76.04	43.37	55.85	0.998	0.998	0.060
Grand Junction	Mesa	FRAM OPERATING - REEDER MESA CS	74.46	48.70	100.70	0.011	0.011	0.081
Grand Junction	Mesa	NATL FUEL CORP	22.07	7.55	8.85	0.307	0.307	0.015
Grand Junction	Mesa	OXY USA - BRUSH CREEK COMPRESSOR	86.20	61.31	57.57	0.443	0.443	0.027

Field Office	County	Facility Name	2011 Emissions (tons/year)					
			NOx	VOC	CO	PM10	PM2.5	SO2
		STATION						
Grand Junction	Mesa	OXY USA INC. - East Plateau CS	77.67	32.42	48.93	1.772	1.772	0.106
Grand Junction	Mesa	PICEANCE ENERGY - BRUTON C.S.	12.13	11.03	17.19	0.640	0.640	0.000
Grand Junction	Mesa	PICEANCE ENERGY LLC - HAWXHURST RANCH	8.64	23.32	17.26	0.000	0.000	0.000
Grand Junction	Mesa	PUBLIC SERVICE CO ASBURY STATION	26.78	10.67	43.32	0.110	0.110	0.007
Grand Junction	Mesa	PUBLIC SERVICE CO HUNTER CANYON STA	16.37	0.62	1.99	0.200	0.200	0.003
Grand Junction	Mesa	SOURCEGAS DBA ROCKY MTN NG - COLLBRAN	22.82	12.50	19.72	0.460	0.260	0.010
Grand Junction	Mesa	TRANSCOLORADO GAS TR CO - WHITEWATER CS	12.37	5.73	4.65	0.360	0.360	0.020
Kremmling	Grand	PUBLIC SERVICE CO WILLIAMS FORK STATION	12.40	0.40	0.75	0.006	0.006	0.001
Little Snake	Moffat	AGAVE ENERGY - BIL HOL GULCH TREATING	8.58	32.79	17.16	0.040	0.040	0.000
Little Snake	Moffat	ARGALI EXPLORATION COMPANY	45.59	0.98	3.27	0.080	0.080	0.005
Little Snake	Moffat	CUSTOM ENERGY CONSTRUCTION INC BUCK PEAK	4.73	3.47	1.92	0.008	0.008	0.001
Little Snake	Moffat	J W OPERATING CO - GREAT DIVIDE C.S.	10.80	7.79	4.84	0.000	0.000	0.000
Little Snake	Moffat	J-W OPERATING COMPANY -SAND HILLS	28.40	13.25	2.10	0.000	0.000	0.000
Little Snake	Moffat	MERIT ENERGY - SANDWASH C.S.	19.34	7.96	12.90	0.000	0.000	0.000
Little Snake	Moffat	MERRION OIL & GAS - BLUE GRAVEL	34.41	0.11	35.37	0.070	0.070	0.000
Little Snake	Moffat	OVERLAND PASS - MIDPOINT STATION	0.00	8.60	0.00	0.000	0.000	0.000
Little Snake	Moffat	QEP FIELD SERVICES - EAST HIAWATHA CS	58.72	31.42	51.98	0.602	0.592	0.036
Little Snake	Moffat	QEP FIELD SERVICES - LION C.S.	14.30	7.63	14.30	0.475	0.475	0.029
Little Snake	Moffat	QEP FIELD SERVICES - W HIAWATHA C. S.	32.76	31.87	15.09	0.380	0.380	0.000
Little Snake	Moffat	QUESTAR - SKULL CREEK DEW POINT PLANT	56.46	87.10	41.61	0.364	0.359	0.022
Little Snake	Moffat	QUESTAR PIPELINE CO STATE LINE COMP STA	13.41	0.10	1.69	0.320	0.320	0.012
Little Snake	Moffat	QUESTAR PIPELINE PWFC SOUTHSIDE 2/MUSSER	38.54	2.15	1.91	0.070	0.070	0.004
Little Snake	Moffat	ROCKIES EXPRESS PIPELINE - BIG HOLE CS	12.60	4.01	9.96	0.690	0.690	1.290
Little Snake	Moffat	SAMSON RESOURCES - SHELL CREEK GAS COND	31.29	1.03	12.70	0.227	0.170	0.003

Field Office	County	Facility Name	2011 Emissions (tons/year)					
			NOx	VOC	CO	PM10	PM2.5	SO2
Little Snake	Moffat	WYOMING INTERSTATE - SNAKE RIVER C.S.	64.97	7.58	77.43	4.489	4.489	2.177
Little Snake	Rio Blanco	CHEVRON USA - WILSON CREEK GAS PLT	4.94	90.10	10.32	0.008	0.007	1.000
Tres Rios	Archuleta	PUBLIC SERVICE CO - PAGOSA SPRINGS STA	0.10	0.03	0.10	0.000	0.000	0.000
Tres Rios	Dolores	MID-AMERICA PIPELINE CO DOVE CR STA	28.22	2.46	34.37	0.460	0.460	0.010
Tres Rios	Dolores	QEP ENERGY CO - SPARGO NO 2	36.60	0.30	32.70	0.049	0.049	0.003
Tres Rios	Dolores	TRANSCOLORADO GAS TRANS - DOLORES C.S.	17.49	17.58	10.71	0.580	0.580	0.030
Tres Rios	Dolores	WILLIAMS FIELD SERV- JOHNSON AC #1 FACIL	21.20	30.90	13.48	0.413	0.413	0.025
Tres Rios	La Plata	BP AMERICA - PINON COMPRESSOR FACILITY	85.00	24.40	79.60	1.460	1.460	0.088
Tres Rios	Montezuma	KINDER MORGAN CO2 CO. -YELLOW JACKET H10	9.00	2.13	1.96	0.422	0.162	17.000
Tres Rios	Montezuma	MID-AMERICA PIPELINE CO DOLORES STA	25.27	2.20	30.77	0.460	0.460	0.010
Tres Rios	Montezuma	NORTHWEST PIPELINE CORP PLEASANT VIEW	94.73	0.51	7.52	1.142	1.142	1.535
Tres Rios	Montezuma	TRANSCOLORADO GAS TRANS - MANCOS CS	5.97	1.50	2.88	0.150	0.150	0.000
Tres Rios	Montezuma	WILLIAMS FIELD SERVICES- KOSKIE-BRUMLEY	19.41	21.95	6.47	0.443	0.443	0.027
Tres Rios	San Miguel	PATARA MIDSTREAM - ANDY'S MESA	117.46	68.20	43.64	1.963	1.963	0.118
Tres Rios	San Miguel	PATARA MIDSTREAM - HAMILTON CREEK CS	50.86	24.21	27.75	0.426	0.415	0.036
Tres Rios	San Miguel	PATARA OIL & GAS - DOUBLE EAGLE PLANT	57.03	10.35	18.44	0.081	0.081	0.005
Uncompahgre	Gunnison	GUNNISON ENERGY-RAGGED MOUNTAIN C.S.	64.44	55.32	135.60	0.689	0.687	0.053
Uncompahgre	Montrose	TRANSCOLORADO GAS - OLATHE C.S.	12.37	0.51	12.37	0.320	0.320	0.150
Uncompahgre	Montrose	TRANSCOLORADO GAS TRANS - REDVALE CS	17.23	9.42	5.78	0.680	0.680	0.030
Uncompahgre	San Miguel	ROCKY MOUNTAIN NATURAL GAS - NORWOOD C.S	12.20	7.30	25.20	0.213	0.213	0.013
CRV (in Roan Plt.)	Garfield	BARGATH - RABBIT BRUSH C.S.	177.82	64.32	35.31	5.53	5.53	0.30
CRV (in Roan Plt.)	Garfield	BARGATH LLC - ANVIL POINTS CS	131.00	52.60	40.00	2.77	2.77	0.17
CRV (in Roan Plt.)	Garfield	BARGATH LLC - CLOUGH CS	100.80	82.90	40.80	1.98	1.98	0.12
CRV (in Roan Plt.)	Garfield	BARGATH LLC - COTTONWOOD POINT CS	132.60	86.40	132.60	2.27	2.27	0.14
CRV (in Roan Plt.)	Garfield	BARGATH LLC - HAYBARN	54.80	20.30	33.92	2.12	2.12	0.09
CRV (in Roan Plt.)	Garfield	BARGATH LLC - HAYES GULCH	115.80	58.05	34.20	2.35	2.35	0.14

Field Office	County	Facility Name	2011 Emissions (tons/year)					
			NOx	VOC	CO	PM10	PM2.5	SO2
CRV (in Roan Plt.)	Garfield	BARGATH LLC - HEATH CS	220.13	83.88	64.88	4.51	4.51	0.28
CRV (in Roan Plt.)	Garfield	BARGATH LLC - PARACHUTE	299.21	146.32	161.67	9.68	9.68	0.39
CRV (in Roan Plt.)	Garfield	BARGATH LLC - RIFLE STATION	2.80	33.90	2.40	0.00	0.00	0.00
CRV (in Roan Plt.)	Garfield	BARGATH LLC - RILEY CS	115.80	62.40	34.05	2.35	2.35	0.14
CRV (in Roan Plt.)	Garfield	BARGATH LLC - ROAN CLIFFS GAS PLANT	94.60	47.60	66.70	1.80	1.80	0.10
CRV (in Roan Plt.)	Garfield	BARGATH LLC - RULISON CS	116.72	63.71	34.91	0.00	0.00	0.00
CRV (in Roan Plt.)	Garfield	BARGATH LLC - SHARRARD CS	131.84	60.94	64.95	2.98	2.98	0.16
CRV (in Roan Plt.)	Garfield	BARGATH LLC - WEBSTER HILL	172.95	82.59	61.67	5.29	5.29	0.29
CRV (in Roan Plt.)	Garfield	BARGATH LLC - WHEELER GULCH CS	96.50	49.20	28.50	1.90	1.90	0.07
CRV (in Roan Plt.)	Garfield	BARGATH, LLC - WASATCH COMPRESSOR YARD	86.00	82.19	35.60	1.56	1.56	0.09
CRV (in Roan Plt.)	Garfield	ENCANA - RIFLE BOOSTER STATION	43.52	41.73	48.75	1.33	1.32	0.00
CRV (in Roan Plt.)	Garfield	ENCANA (WEST) - MIDDLE FORK C.S.	0.00	422.07	20.10	0.00	0.00	0.00
CRV (in Roan Plt.)	Garfield	ETC CANYON PIPELINE - RIFLE C.S.	238.88	92.78	137.93	4.73	4.73	0.26
CRV (in Roan Plt.)	Garfield	HALLIBURTON ENERGY SVCS	2.66	0.21	0.57	0.18	0.18	0.18
CRV (in Roan Plt.)	Garfield	PUBLIC SERVICE CO - RIFLE GAS PLANT	16.99	18.29	3.33	0.55	0.55	0.01
CRV (in Roan Plt.)	Garfield	WILLIAMS PRODUCTION RMT CO - WEBSTER CS	10.46	2.10	10.46	0.00	0.00	0.00
CRV (in Roan Plt.)	Garfield	WILLIAMS RMT CO - DOE COMPRESSOR STATION	33.10	12.90	3.70	0.09	0.09	0.01
CRV (not in Roan Plt.)	Garfield	ANTERO RES - CASTLE SPRINGS CENTRAL	18.30	6.11	18.30	0.25	0.25	0.02
CRV (not in Roan Plt.)	Garfield	ANTERO RESOURCES - HUNTER MESA COMP STAT	26.14	38.03	31.97	0.00	0.00	0.00
CRV (not in Roan Plt.)	Garfield	BARGATH LLC - CALLAHAN C.S.	102.00	64.45	34.20	2.35	2.35	0.14
CRV (not in Roan Plt.)	Garfield	BARGATH LLC - GRAND VALLEY	94.61	68.70	92.70	1.48	1.41	0.56
CRV (not in Roan Plt.)	Garfield	BARGATH LLC - HOOVER EXPRESS	132.00	71.69	39.00	2.70	2.28	0.18
CRV (not in Roan Plt.)	Garfield	BARGATH LLC - JANGLES	68.00	43.55	22.80	1.55	1.55	0.09
CRV (not in Roan Plt.)	Garfield	BARGATH LLC - STARKEY GULCH CS	132.00	50.95	39.00	2.69	2.69	0.16
CRV (not in Roan Plt.)	Garfield	BARGATH LLC - UNA COMPRESSOR STATION	155.05	65.53	51.83	3.60	3.18	0.45

Field Office	County	Facility Name	2011 Emissions (tons/year)					
			NOx	VOC	CO	PM10	PM2.5	SO2
CRV (not in Roan Plt.)	Garfield	BARGATH, LLC - HYRUP PROD FACILITY	237.62	124.37	82.05	5.77	5.69	0.92
CRV (not in Roan Plt.)	Garfield	BILL BARRETT - BAILEY COMPRESSOR STATION	166.37	193.20	69.30	7.77	7.77	0.44
CRV (not in Roan Plt.)	Garfield	BILL BARRETT CORP - MAMM CREEK CS	292.06	78.37	227.95	15.53	4.44	0.71
CRV (not in Roan Plt.)	Garfield	ENCANA OIL & GAS - HIGH MESA COMP STATIO	99.45	262.57	16.69	1.99	1.99	0.12
CRV (not in Roan Plt.)	Garfield	ENTERPRISE PRODUCTS OP- JACKRABBIT CS	194.08	141.91	134.34	0.01	0.01	0.00
CRV (not in Roan Plt.)	Garfield	ETC CANYON PIPELINE - HOLMES MESA CS	123.73	101.83	82.67	0.00	0.00	0.00
CRV (not in Roan Plt.)	Garfield	ETC CANYON PIPELINE - WALLACE CREEK CS	0.00	18.00	0.00	0.00	0.00	0.00
CRV (not in Roan Plt.)	Garfield	GRAND RIVER GATH - EAST MAMM CREEK CS	138.21	162.64	80.27	3.86	3.86	0.23
CRV (not in Roan Plt.)	Garfield	GRAND RIVER GATHERING - HUNTER MESA CS	148.32	181.24	87.43	0.00	0.00	0.00
CRV (not in Roan Plt.)	Garfield	GRAND RIVER GATHERING - ORCHARD CS	63.20	34.61	20.90	1.07	1.07	0.06
CRV (not in Roan Plt.)	Garfield	GRAND RIVER GATHERING - PUMBA CS	98.35	122.76	140.49	3.56	3.56	0.21
CRV (not in Roan Plt.)	Garfield	NOBLE ENERGY - RULISON STATION	38.84	4.01	14.68	0.84	0.84	0.05
CRV (not in Roan Plt.)	Garfield	PETROLEUM DEVELOPMENT - GARDEN GULCH	26.20	42.03	39.14	1.49	1.49	0.09
CRV (not in Roan Plt.)	Mesa	OXY USA - ALKALI CREEK C.S.	71.56	64.13	56.49	0.04	0.04	0.00
CRV (not in Roan Plt.)	Mesa	SG INTERESTS I - DIVIDE CREEK TREATMENT	39.91	24.14	33.43	1.48	1.48	0.11
White River Valley	Garfield	HUNTER RIDGE - CDP K22 496	29.57	31.78	56.86	0.00	0.00	0.00
White River Valley	Garfield	HUNTER RIDGE ENERGY - STORY GULCH C.S.	155.07	236.41	96.81	0.00	0.00	0.01
White River Valley	Rio Blanco	BARGATH LLC - BLACK SULPHUR CREEK	31.90	0.35	52.20	0.13	0.13	0.01
White River Valley	Rio Blanco	BARGATH LLC - GREASEWOOD CS	96.28	45.82	28.38	1.96	1.96	0.12
White River Valley	Rio Blanco	BARGATH LLC - RYAN GULCH GAS	192.00	127.15	27.30	5.64	5.64	0.34
White River Valley	Rio Blanco	BARGATH LLC - SAGEBRUSH GAS PROCESSING	157.28	44.81	117.04	3.46	3.04	0.20
White River Valley	Rio Blanco	CCES PICEANCE - BUCKSKIN MESA CFS-2	84.70	30.80	21.80	2.70	2.40	0.00
White River Valley	Rio Blanco	ENCANA OIL - EAST DRAGON TRAIL CS	34.66	22.93	41.55	0.53	0.53	0.03
White River Valley	Rio Blanco	ENCANA OIL & GAS - DRAGON TRAIL	431.04	99.33	174.57	13.91	13.89	0.23
White River Valley	Rio Blanco	ENCANA OIL & GAS - PARK CANYON WEST	48.83	40.99	31.73	0.43	0.43	0.03
White River Valley	Rio Blanco	ENCANA OIL & GAS (USA) INC - BULL FORK	39.53	56.80	12.12	0.00	0.00	0.00
White River Valley	Rio Blanco	ENCANA OIL & GAS (USA), INC. - CR 109 CS	2.81	1.03	2.53	0.04	0.04	0.00

Field Office	County	Facility Name	2011 Emissions (tons/year)					
			NOx	VOC	CO	PM10	PM2.5	SO2
White River Valley	Rio Blanco	ENCANA OIL & GAS (USA), INC. - HORSE DRA	10.23	5.93	5.73	0.22	0.22	0.01
White River Valley	Rio Blanco	ENCANA OIL & GAS (USA), INC.- W DRAGON T	60.19	37.96	48.30	0.54	0.54	0.03
White River Valley	Rio Blanco	ENCANA OIL & GAS (USA), INC-W DOUGLAS CR	32.20	97.11	32.20	3.34	3.34	0.07
White River Valley	Rio Blanco	ENTERPRISE GAS PROC - MEEKER GAS PLANT	138.73	317.66	254.06	26.40	26.40	205.27
White River Valley	Rio Blanco	ENTERPRISE GAS-PICEANCE DEV. PROJECT	93.18	208.64	112.70	4.54	4.54	21.83
White River Valley	Rio Blanco	ETC CANYON PIPELINE - N. DOUGLAS CREEK	72.17	54.12	83.19	1.82	0.45	0.10
White River Valley	Rio Blanco	ETC CANYON PIPELINE- CATHEDRAL C.S.	10.77	0.63	1.04	0.02	0.02	0.00
White River Valley	Rio Blanco	ETC CANYON PIPELINE-FOUNDATION CREEK	73.05	69.47	49.87	0.58	0.58	0.03
White River Valley	Rio Blanco	KINDER MORGAN TREATING - MEEKER PLANT	44.96	26.30	43.77	1.56	1.40	0.13
White River Valley	Rio Blanco	NORTHWEST PIPELINE CORP RANGELY STA	382.05	11.61	53.51	2.67	2.67	0.04
White River Valley	Rio Blanco	PICEANCE BASIN GAS GATH - FLETCHER PLANT	45.56	60.67	75.59	1.15	1.15	0.07
White River Valley	Rio Blanco	PUBLIC SERVICE CO GREASEWOOD STATION	24.41	0.17	21.51	0.05	0.05	0.00
White River Valley	Rio Blanco	QUESTAR PIPELINE CO - GREASEWOOD GULCH	51.56	22.50	9.20	2.32	2.32	0.13
White River Valley	Rio Blanco	ROCKY MOUNTAIN NAT GAS - PICEANCE	28.29	31.86	36.01	0.92	0.29	0.02
White River Valley	Rio Blanco	SOUTH-TEX - BASS YELLOW CREEK	14.59	54.91	12.26	0.00	0.00	0.00
White River Valley	Rio Blanco	WEST TEXAS - PICEANCE CREEK GP	61.67	52.39	52.63	1.04	1.03	0.06
White River Valley	Rio Blanco	WHITING OIL & GAS CORP-BOIES RANCH	32.04	37.48	23.06	1.47	1.47	0.09
White River Valley	Rio Blanco	WHITING OIL & GAS -JIMMY GULCH STATION	23.28	19.25	10.03	0.52	0.52	0.03
White River Valley	Rio Blanco	WILLIAMS FIELD - WILLOW CREEK GAS PLANT	199.84	109.89	218.90	37.61	36.90	71.75
White River Valley	Rio Blanco	XTO ENERGY, INC. - PICEANCE CREEK	89.96	91.71	90.02	7.12	6.79	7.85
White River Valley	Mesa	PIONEER NATURAL RES - CSP-3	24.40	5.50	23.09	0.42	0.42	0.02
Canyon Of The Ancients Nm	Montezuma	KINDER MORGAN CO2 CO. -HOVENWEEP CENTRAL	8.60	2.13	1.96	0.422	0.325	16.844

APPENDIX C-6

EPA MOVES Emissions Factor by Field Office, County, and Year

Table F1. Field Office to Representative County On-road Emission Factor Cross-reference.

Field Office	County
Colorado River Valley	Garfield County
Kremmling Field Office	Grand County
Tres Rios Field Office	La Plata County
Grand Junction Field Office	Mesa County
Little Snake Field Office	Moffat County
Uncompahgre Field Office	Montrose County
White River Field Offices	Rio Blanco County

Table F2. On-road Light Duty and Heavy Duty Truck Emisison Factors by Representative County and by Project Year.

County	Year	Vehicle Type	Emission Rates (grams/mile)								
			VOC	CO	NOx	PM10	PM2.5	SO2	CO2	CH4	N2O
Garfield County	2011	Light Duty	1.02	12.80	1.49	0.05	0.03	0.01	491	0.05	0.03
Garfield County	2011	Heavy Duty	0.71	3.94	14.41	1.09	0.93	0.02	2403	0.03	0.00
Grand County	2011	Light Duty	1.04	13.58	1.50	0.06	0.04	0.01	495	0.06	0.03
Grand County	2011	Heavy Duty	0.73	4.04	14.69	1.09	0.93	0.02	2404	0.04	0.00
La Plata County	2011	Light Duty	0.99	12.58	1.48	0.05	0.03	0.01	490	0.05	0.03
La Plata County	2011	Heavy Duty	0.72	4.07	14.57	1.09	0.93	0.02	2404	0.04	0.00
Mesa County	2011	Light Duty	0.98	11.99	1.45	0.05	0.02	0.01	488	0.05	0.03
Mesa County	2011	Heavy Duty	0.71	3.99	14.28	1.09	0.93	0.02	2403	0.03	0.00
Moffat County	2011	Light Duty	1.00	12.78	1.47	0.05	0.03	0.01	492	0.05	0.03
Moffat County	2011	Heavy Duty	0.73	4.06	14.54	1.09	0.93	0.02	2404	0.04	0.00
Montrose County	2011	Light Duty	0.97	12.22	1.46	0.05	0.03	0.01	489	0.05	0.03
Montrose County	2011	Heavy Duty	0.72	4.07	14.44	1.09	0.93	0.02	2404	0.04	0.00
Rio Blanco County	2011	Light Duty	1.00	12.68	1.47	0.05	0.03	0.01	491	0.05	0.03
Rio Blanco County	2011	Heavy Duty	0.72	4.03	14.51	1.09	0.93	0.02	2404	0.04	0.00
Garfield County	2012	Light Duty	0.95	12.06	1.39	0.05	0.03	0.01	485	0.05	0.03
Garfield County	2012	Heavy Duty	0.64	3.54	12.74	0.98	0.83	0.02	2402	0.04	0.00
Grand County	2012	Light Duty	0.97	12.83	1.40	0.06	0.03	0.01	489	0.06	0.03
Grand County	2012	Heavy Duty	0.65	3.63	13.00	0.98	0.83	0.02	2404	0.04	0.00
La Plata County	2012	Light Duty	0.92	11.86	1.38	0.05	0.03	0.01	484	0.05	0.03
La Plata County	2012	Heavy Duty	0.65	3.65	12.89	0.98	0.83	0.02	2404	0.04	0.00
Mesa County	2012	Light Duty	0.91	11.28	1.35	0.05	0.02	0.01	481	0.04	0.03
Mesa County	2012	Heavy Duty	0.64	3.58	12.63	0.98	0.83	0.02	2403	0.04	0.00
Moffat County	2012	Light Duty	0.93	12.05	1.37	0.05	0.03	0.01	485	0.05	0.034

County	Year	Vehicle Type	Emission Rates (grams/mile)								
			VOC	CO	NOx	PM10	PM2.5	SO2	CO2	CH4	N2O
Moffat County	2012	Heavy Duty	0.65	3.65	12.86	0.98	0.83	0.02	2404	0.04	0.003
Montrose County	2012	Light Duty	0.91	11.51	1.36	0.05	0.03	0.01	482	0.05	0.033
Montrose County	2012	Heavy Duty	0.65	3.66	12.77	0.98	0.83	0.02	2404	0.04	0.003
Rio Blanco County	2012	Light Duty	0.93	11.95	1.37	0.05	0.03	0.01	484	0.05	0.033
Rio Blanco County	2012	Heavy Duty	0.64	3.62	12.84	0.98	0.83	0.02	2404	0.04	0.004
Garfield County	2013	Light Duty	0.89	11.40	1.29	0.05	0.03	0.01	477	0.05	0.033
Garfield County	2013	Heavy Duty	0.56	3.15	11.19	0.87	0.72	0.02	2402	0.05	0.003
Grand County	2013	Light Duty	0.91	12.18	1.30	0.06	0.03	0.01	481	0.05	0.032
Grand County	2013	Heavy Duty	0.57	3.24	11.41	0.87	0.72	0.02	2404	0.05	0.004
La Plata County	2013	Light Duty	0.86	11.22	1.28	0.05	0.03	0.01	476	0.05	0.033
La Plata County	2013	Heavy Duty	0.57	3.26	11.32	0.87	0.72	0.02	2404	0.05	0.004
Mesa County	2013	Light Duty	0.85	10.66	1.26	0.05	0.02	0.01	473	0.04	0.033
Mesa County	2013	Heavy Duty	0.56	3.19	11.09	0.87	0.72	0.02	2403	0.05	0.003
Moffat County	2013	Light Duty	0.87	11.41	1.27	0.05	0.03	0.01	477	0.05	0.032
Moffat County	2013	Heavy Duty	0.57	3.25	11.30	0.87	0.72	0.02	2404	0.05	0.003
Montrose County	2013	Light Duty	0.84	10.88	1.26	0.05	0.03	0.01	474	0.04	0.030
Montrose County	2013	Heavy Duty	0.57	3.27	11.22	0.87	0.72	0.02	2404	0.05	0.003
Rio Blanco County	2013	Light Duty	0.87	11.31	1.27	0.05	0.03	0.01	477	0.05	0.030
Rio Blanco County	2013	Heavy Duty	0.57	3.23	11.27	0.87	0.72	0.02	2404	0.05	0.004
Garfield County	2014	Light Duty	0.83	10.78	1.19	0.05	0.03	0.01	468	0.05	0.031
Garfield County	2014	Heavy Duty	0.49	2.78	9.83	0.78	0.63	0.02	2402	0.05	0.003
Grand County	2014	Light Duty	0.85	11.55	1.20	0.06	0.03	0.01	472	0.05	0.030
Grand County	2014	Heavy Duty	0.50	2.86	10.03	0.78	0.63	0.02	2404	0.06	0.004
La Plata County	2014	Light Duty	0.80	10.61	1.18	0.05	0.03	0.01	468	0.04	0.030
La Plata County	2014	Heavy Duty	0.50	2.89	9.95	0.78	0.63	0.02	2404	0.06	0.004
Mesa County	2014	Light Duty	0.79	10.06	1.16	0.05	0.02	0.01	465	0.04	0.030
Mesa County	2014	Heavy Duty	0.49	2.82	9.75	0.78	0.63	0.02	2403	0.05	0.003
Moffat County	2014	Light Duty	0.81	10.80	1.18	0.05	0.03	0.01	469	0.05	0.029
Moffat County	2014	Heavy Duty	0.50	2.88	9.93	0.78	0.63	0.02	2404	0.06	0.003
Montrose County	2014	Light Duty	0.79	10.28	1.17	0.05	0.02	0.01	466	0.04	0.028
Montrose County	2014	Heavy Duty	0.50	2.89	9.86	0.78	0.63	0.02	2404	0.05	0.003
Rio Blanco County	2014	Light Duty	0.81	10.70	1.18	0.05	0.03	0.01	468	0.05	0.028
Rio Blanco County	2014	Heavy Duty	0.50	2.86	9.91	0.78	0.63	0.02	2404	0.05	0.004
Garfield County	2015	Light Duty	0.77	10.17	1.10	0.05	0.03	0.01	460	0.04	0.028
Garfield County	2015	Heavy Duty	0.43	2.44	8.61	0.69	0.55	0.02	2402	0.06	0.003
Grand County	2015	Light Duty	0.79	10.95	1.11	0.06	0.03	0.01	463	0.05	0.027
Grand County	2015	Heavy Duty	0.44	2.53	8.79	0.69	0.55	0.02	2404	0.06	0.004
La Plata County	2015	Light Duty	0.75	10.02	1.09	0.05	0.03	0.01	459	0.04	0.027

County	Year	Vehicle Type	Emission Rates (grams/mile)								
			VOC	CO	NOx	PM10	PM2.5	SO2	CO2	CH4	N2O
La Plata County	2015	Heavy Duty	0.44	2.55	8.72	0.69	0.55	0.02	2404	0.06	0.004
Mesa County	2015	Light Duty	0.74	9.49	1.07	0.05	0.02	0.01	456	0.04	0.027
Mesa County	2015	Heavy Duty	0.43	2.48	8.54	0.69	0.55	0.02	2403	0.06	0.003
Moffat County	2015	Light Duty	0.76	10.21	1.09	0.05	0.03	0.01	460	0.04	0.026
Moffat County	2015	Heavy Duty	0.44	2.54	8.70	0.69	0.55	0.02	2404	0.06	0.003
Montrose County	2015	Light Duty	0.74	9.70	1.07	0.05	0.02	0.01	457	0.04	0.025
Montrose County	2015	Heavy Duty	0.44	2.55	8.64	0.69	0.55	0.02	2404	0.06	0.003
Rio Blanco County	2015	Light Duty	0.76	10.11	1.08	0.05	0.03	0.01	459	0.04	0.025
Rio Blanco County	2015	Heavy Duty	0.44	2.52	8.68	0.69	0.55	0.02	2404	0.06	0.004
Garfield County	2016	Light Duty	0.71	9.52	1.01	0.05	0.02	0.01	450	0.04	0.026
Garfield County	2016	Heavy Duty	0.37	2.14	7.54	0.62	0.47	0.02	2402	0.06	0.003
Grand County	2016	Light Duty	0.73	10.29	1.02	0.06	0.03	0.01	453	0.05	0.025
Grand County	2016	Heavy Duty	0.38	2.22	7.70	0.62	0.47	0.02	2404	0.06	0.003
La Plata County	2016	Light Duty	0.69	9.38	1.00	0.05	0.03	0.01	449	0.04	0.025
La Plata County	2016	Heavy Duty	0.38	2.24	7.63	0.62	0.47	0.02	2404	0.06	0.004
Mesa County	2016	Light Duty	0.68	8.86	0.98	0.05	0.02	0.01	446	0.04	0.025
Mesa County	2016	Heavy Duty	0.37	2.18	7.47	0.62	0.47	0.02	2403	0.06	0.003
Moffat County	2016	Light Duty	0.70	9.57	1.00	0.05	0.03	0.01	450	0.04	0.024
Moffat County	2016	Heavy Duty	0.38	2.24	7.62	0.62	0.47	0.02	2404	0.06	0.003
Montrose County	2016	Light Duty	0.68	9.08	0.99	0.05	0.02	0.01	448	0.04	0.023
Montrose County	2016	Heavy Duty	0.38	2.25	7.56	0.62	0.47	0.02	2404	0.06	0.003
Rio Blanco County	2016	Light Duty	0.70	9.47	1.00	0.05	0.03	0.01	450	0.04	0.023
Rio Blanco County	2016	Heavy Duty	0.38	2.21	7.60	0.62	0.47	0.02	2404	0.06	0.004
Garfield County	2017	Light Duty	0.67	9.10	0.93	0.05	0.02	0.01	441	0.04	0.024
Garfield County	2017	Heavy Duty	0.32	1.87	6.58	0.55	0.41	0.02	2402	0.06	0.003
Grand County	2017	Light Duty	0.68	9.87	0.94	0.06	0.03	0.01	444	0.04	0.023
Grand County	2017	Heavy Duty	0.33	1.96	6.72	0.55	0.41	0.02	2404	0.06	0.003
La Plata County	2017	Light Duty	0.64	8.97	0.92	0.05	0.03	0.01	440	0.04	0.023
La Plata County	2017	Heavy Duty	0.33	1.98	6.67	0.55	0.41	0.02	2404	0.06	0.004
Mesa County	2017	Light Duty	0.64	8.46	0.90	0.04	0.02	0.01	437	0.04	0.023
Mesa County	2017	Heavy Duty	0.32	1.92	6.52	0.55	0.41	0.02	2403	0.06	0.003
Moffat County	2017	Light Duty	0.65	9.16	0.92	0.05	0.03	0.01	441	0.04	0.022
Moffat County	2017	Heavy Duty	0.33	1.97	6.65	0.55	0.41	0.02	2404	0.06	0.003
Montrose County	2017	Light Duty	0.63	8.67	0.91	0.05	0.02	0.01	438	0.04	0.021
Montrose County	2017	Heavy Duty	0.33	1.98	6.60	0.55	0.41	0.02	2404	0.06	0.003
Rio Blanco County	2017	Light Duty	0.65	9.06	0.92	0.05	0.03	0.01	440	0.04	0.021
Rio Blanco County	2017	Heavy Duty	0.33	1.95	6.64	0.55	0.41	0.02	2403	0.06	0.003
Garfield County	2018	Light Duty	0.62	8.72	0.86	0.05	0.02	0.01	432	0.04	0.022

County	Year	Vehicle Type	Emission Rates (grams/mile)								
			VOC	CO	NOx	PM10	PM2.5	SO2	CO2	CH4	N2O
Garfield County	2018	Heavy Duty	0.28	1.64	5.75	0.49	0.35	0.02	2402	0.06	0.003
Grand County	2018	Light Duty	0.64	9.49	0.87	0.05	0.03	0.01	436	0.04	0.021
Grand County	2018	Heavy Duty	0.28	1.72	5.88	0.49	0.35	0.02	2404	0.07	0.003
La Plata County	2018	Light Duty	0.60	8.60	0.85	0.05	0.02	0.01	431	0.04	0.021
La Plata County	2018	Heavy Duty	0.28	1.74	5.83	0.49	0.35	0.02	2404	0.07	0.004
Mesa County	2018	Light Duty	0.60	8.09	0.83	0.04	0.02	0.01	429	0.04	0.021
Mesa County	2018	Heavy Duty	0.28	1.68	5.70	0.49	0.35	0.02	2403	0.06	0.003
Moffat County	2018	Light Duty	0.61	8.79	0.85	0.05	0.03	0.01	432	0.04	0.021
Moffat County	2018	Heavy Duty	0.28	1.73	5.82	0.49	0.35	0.02	2404	0.07	0.003
Montrose County	2018	Light Duty	0.59	8.30	0.84	0.05	0.02	0.01	430	0.04	0.020
Montrose County	2018	Heavy Duty	0.28	1.74	5.77	0.49	0.35	0.02	2404	0.07	0.003
Rio Blanco County	2018	Light Duty	0.61	8.69	0.85	0.05	0.03	0.01	432	0.04	0.020
Rio Blanco County	2018	Heavy Duty	0.28	1.71	5.80	0.49	0.35	0.02	2403	0.07	0.003
Garfield County	2019	Light Duty	0.58	8.37	0.79	0.05	0.02	0.01	424	0.04	0.020
Garfield County	2019	Heavy Duty	0.24	1.43	5.04	0.44	0.30	0.02	2402	0.06	0.003
Grand County	2019	Light Duty	0.59	9.14	0.80	0.05	0.03	0.01	427	0.04	0.019
Grand County	2019	Heavy Duty	0.24	1.51	5.15	0.44	0.30	0.02	2404	0.07	0.003
La Plata County	2019	Light Duty	0.56	8.26	0.78	0.05	0.02	0.01	423	0.04	0.020
La Plata County	2019	Heavy Duty	0.24	1.53	5.11	0.44	0.30	0.02	2404	0.07	0.004
Mesa County	2019	Light Duty	0.56	7.76	0.77	0.04	0.02	0.01	421	0.03	0.020
Mesa County	2019	Heavy Duty	0.24	1.47	5.00	0.44	0.30	0.02	2403	0.07	0.003
Moffat County	2019	Light Duty	0.57	8.45	0.78	0.05	0.03	0.01	424	0.04	0.019
Moffat County	2019	Heavy Duty	0.24	1.52	5.10	0.44	0.30	0.02	2404	0.07	0.003
Montrose County	2019	Light Duty	0.56	7.97	0.77	0.05	0.02	0.01	422	0.03	0.018
Montrose County	2019	Heavy Duty	0.24	1.53	5.06	0.44	0.30	0.02	2404	0.07	0.003
Rio Blanco County	2019	Light Duty	0.57	8.35	0.78	0.05	0.03	0.01	424	0.04	0.018
Rio Blanco County	2019	Heavy Duty	0.24	1.50	5.09	0.44	0.30	0.02	2403	0.07	0.003
Garfield County	2020	Light Duty	0.55	8.06	0.73	0.05	0.02	0.01	416	0.04	0.018
Garfield County	2020	Heavy Duty	0.20	1.26	4.43	0.40	0.26	0.02	2402	0.07	0.003
Grand County	2020	Light Duty	0.56	8.84	0.74	0.05	0.03	0.01	420	0.04	0.018
Grand County	2020	Heavy Duty	0.21	1.34	4.54	0.40	0.26	0.02	2403	0.07	0.003
La Plata County	2020	Light Duty	0.53	7.96	0.73	0.05	0.02	0.01	416	0.04	0.018
La Plata County	2020	Heavy Duty	0.21	1.36	4.50	0.40	0.26	0.02	2404	0.07	0.003
Mesa County	2020	Light Duty	0.53	7.47	0.71	0.04	0.02	0.01	413	0.03	0.018
Mesa County	2020	Heavy Duty	0.20	1.30	4.40	0.40	0.26	0.02	2403	0.07	0.003
Moffat County	2020	Light Duty	0.54	8.15	0.73	0.05	0.03	0.01	417	0.04	0.018
Moffat County	2020	Heavy Duty	0.21	1.35	4.49	0.40	0.26	0.02	2404	0.07	0.003
Montrose County	2020	Light Duty	0.52	7.67	0.72	0.05	0.02	0.01	414	0.03	0.017

County	Year	Vehicle Type	Emission Rates (grams/mile)								
			VOC	CO	NOx	PM10	PM2.5	SO2	CO2	CH4	N2O
Montrose County	2020	Heavy Duty	0.21	1.36	4.46	0.40	0.26	0.02	2404	0.07	0.003
Rio Blanco County	2020	Light Duty	0.54	8.05	0.72	0.05	0.03	0.01	416	0.04	0.017
Rio Blanco County	2020	Heavy Duty	0.21	1.33	4.48	0.40	0.26	0.02	2403	0.07	0.003
Garfield County	2021	Light Duty	0.52	7.80	0.68	0.05	0.02	0.01	409	0.04	0.017
Garfield County	2021	Heavy Duty	0.17	1.12	3.94	0.36	0.23	0.02	2402	0.07	0.003
Grand County	2021	Light Duty	0.53	8.57	0.69	0.05	0.03	0.01	413	0.04	0.017
Grand County	2021	Heavy Duty	0.18	1.19	4.04	0.36	0.23	0.02	2403	0.07	0.003
La Plata County	2021	Light Duty	0.50	7.70	0.67	0.05	0.02	0.01	409	0.03	0.017
La Plata County	2021	Heavy Duty	0.18	1.21	4.00	0.36	0.23	0.02	2404	0.07	0.003
Mesa County	2021	Light Duty	0.50	7.22	0.66	0.04	0.02	0.01	406	0.03	0.017
Mesa County	2021	Heavy Duty	0.18	1.16	3.91	0.36	0.23	0.02	2403	0.07	0.003
Moffat County	2021	Light Duty	0.51	7.89	0.67	0.05	0.03	0.01	410	0.03	0.016
Moffat County	2021	Heavy Duty	0.18	1.21	3.99	0.36	0.23	0.02	2404	0.07	0.003
Montrose County	2021	Light Duty	0.49	7.42	0.66	0.05	0.02	0.01	407	0.03	0.016
Montrose County	2021	Heavy Duty	0.18	1.21	3.96	0.36	0.23	0.02	2404	0.07	0.003
Rio Blanco County	2021	Light Duty	0.51	7.79	0.67	0.05	0.02	0.01	409	0.03	0.016
Rio Blanco County	2021	Heavy Duty	0.18	1.19	3.98	0.36	0.23	0.02	2403	0.07	0.003

APPENDIX D

CARMMS Technical Memorandum
Draft CARMMS Coal and Uranium/Vanadium Mining Emissions
June 21, 2013

June 21, 2013

MEMORANDUM

To: Chad Meister and Forrest Cook, BLM Colorado State Office
From: John Grant ENVIRON, Jim Zapert Carter Lake Consulting, Ralph Morris ENVIRON
Subject: Draft CARMMS Coal and Uranium/Vanadium Mining Emissions

INTRODUCTION

The purpose of this document is to explain the sources of emissions and methodology used to compile Western Colorado coal and uranium/vanadium mining emissions. Emissions from coal and uranium/vanadium mines under federal jurisdiction have been developed for the Western Colorado Air Resource Management Modeling Study (West-CARMMS). The primary sources used to compile these emissions are Environmental Assessments and Environmental Impact Statements developed for individual mines as well as 2011 reported emissions from Colorado Department of Public Health (CDPHE) Air Pollutant Emission Notices (APENs).

These mining emissions will be used in baseline and future-year emissions inventories as estimates of coal and uranium mining emissions under Task 2 for the Western Colorado Bureau of Land Management (BLM) planning areas (see Figure 1-1).

Emissions were not estimated for mines not under federal jurisdiction; emissions from these mines in the West-CARMMS will be taken from existing inventory estimates. To avoid double counting in air quality modeling, emissions were not estimated for on-road or off-road mobile sources.

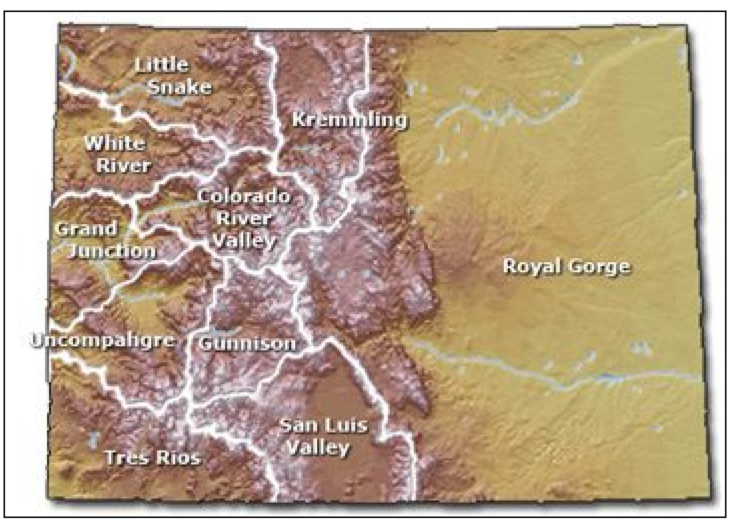

Figure 1-1. Colorado Field Office Planning Areas.

Pollutants

The emissions include estimates of criteria air pollutants (CAPs), greenhouse gases (GHGs), and hazardous air pollutants (HAPs) as follows:

- Criteria Pollutants
  - Carbon monoxide (CO)
  - Nitrogen oxides (NO_X)
  - Particulate matter less than or equal to 10 microns in diameter (PM_{10})
  - Particulate matter less than or equal to 2.5 microns in diameter ($PM_{2.5}$)
  - Sulfur dioxide (SO_2)
  - Volatile Organic Compounds (VOCs)
- Greenhouse Gases
  - Carbon dioxide (CO_2)
  - Methane (CH_4)
  - Nitrous oxide (N_2O)
- Hazardous Air Pollutants (HAPs)

While lead (pb) is a criteria pollutant, emissions of lead in the BLM western Colorado planning areas are expected to be extremely low and are therefore not included in this analysis.

HAP emissions were estimated for each emissions source.

Anthropogenic greenhouse gas emission inventories typically include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases. Fluorinated gases are not expected to be emitted in appreciable quantities by any category considered in this emission inventory and were therefore not included in this analysis.

Temporal

The calculators estimate annual emissions associated coal and uranium/vanadium mining. Per the West-CARMMS scope of work, base year emissions are estimated for 2011 with annual emission forecasts to 2021.

EMISSIONS ESTIMATION

Coal Mining

Annual base year emissions from coal mining were estimated for the coal mines in Western Colorado under federal jurisdiction. As mentioned above, the mining emission estimates are not inclusive of mobile sources to avoid double counting with the mobile sources emissions in the air quality modeling inventory. Additionally, lacking any data upon which to base emission estimates, we have not accounted for potential growth in Kremmling Field Office surface coal mining in Jackson County where the U.S..Geological Survey (USGS) has defined the McCallum area as a known recoverable coal resource area. Table 1 provides a listing of the Western

Colorado mines under BLM jurisdiction and the sources upon which emissions were estimated for those mines. Appendix D-1 provides emission estimates by year and mine.

Table 1. Coal mine emissions estimation methodology.

Mine Name (Field Office)	Emission Estimation Methodology
Book Cliffs Area (Grand Junction)	**Base Year 2011:** Non-operational, zero emissions. **Future Years 2012-2021:** Per the Grand Junction Field Office Draft Regional Management Plant Air Quality Technical Support document (ENVIRON, 2012a), the Book Cliffs area is assumed to have three additional new mines with estimated annual production of 2,000,000 tons/year in the future. Mines are assumed to come online in 2017, 2019, and 2021. Emissions for each mine are assumed to be similar to the Red Cliff Mine Environmental Impact Statement estimates (BLM, 2009) with a scalar of 25% to account for smaller production.
McClane (Grand Junction)	**Base Year 2011:** Non-operational, zero emissions. **Future Years 2012-2021:** Per the Grand Junction Field Office Draft Regional Management Plant Air Quality Technical Support document (ENVIRON, 2012a), the McClane mine is assumed operational from 2015 to 2021. Emissions are assumed to be at pre-December 2010 levels (BLM, 2012a).
Oak Mesa Area (Uncompahgre)	**Base Year 2011:** CDPHE APEN emissions (CDPHE, 2013). **Future Years 2012-2021:** Assume emissions are at levels estimated in the following Environmental Assessment documents: Bowie #2 (BLM, 2012c), West Elk (BLM, 2012d), and Elk Creek (BLM, 2012f) and that emissions remain constant in the 2012-2021 period. The Uncompahgre Coal Resource and Development Potential Report (BLM, 2010), indicated that Somerset Coal Field production is likely to remain stable at recent levels into the future (ENVIRON, 2012b).
King (Tres Rios)	**Base Year 2011:** CDPHE APEN emissions (CDPHE, 2013). **Future Years 2012-2021:** Assume emissions at permitted levels in future years (CDPHE, 2011).
Foidel (Kremmling)	**Base Year 2011, Future Year 2012:** CDPHE APEN emissions (CDPHE, 2013). **Future Years 2013-2021:** Assume emissions are at levels estimated in the draft Environment Assessment (BLM 2013a).
Deserado (White River)	**Base Year 2011:** CDPHE APEN emissions (CDPHE, 2013). **Future Years 2012-2021:** Assume emissions are at levels estimated in the draft Environment Assessment (BLM 2013b).
Trapper (Little Snake)	**Base Year 2011:** CDPHE APEN emissions (CDPHE, 2013). **Future Years 2012-2021:** Assume emissions remain constant at CDPHE 2011 APEN levels.
Colowyo (Little Snake)	**Base Year 2011:** CDPHE APEN emissions (CDPHE, 2013). **Future Years 2012-2021:** Assume emissions remain constant at CDPHE 2011 APEN levels.
Sage Creek (Little Snake)	**Base Year 2011:** Non-operational, zero emissions. **Future Years 2012-2021:** Assume mining begins in 2013 with constant emissions to 2021 at levels estimated in the draft Environment Assessment (BLM 2013c).

Uranium/Vanadium Mining

Annual emissions from uranium/vanadium mining were estimated according to the number of mines constructed and producing in a given year combined with estimates of emissions per mine from discrete emission producing activities: wind erosion, fugitive dust, and stationary engines. Activity inputs such as the equipment operation, tons of material processed, and disturbed area were taken primarily from the Whirlwind Mine EA (BLM, 2008). The estimated number of future uranium mines in operation in the Grand Junction Field Office and Uncompahgre Field Office were taken from ENVIRON (2012a) and ENVIRON (2012b) and are shown in Table 2. Emissions results are presented in Appendix D-2.

Table 2. Schedule of uranium/vanadium mines in production.

Year	Uranium Mining Facilities, GJFO (source: ENVIRON, 2012a)	Uranium Mining Facilities, UFO (source: ENVIRON, 2012b)
2011-2012	0	0
2013	1	1
2014	3	3
2015	5	5
2016	7	7
2017	9	9
2018	10	10
2019	11	11
2020	12	12
2021	13	13
2022	14	14
2023	15	15
2024	16	16
2025	17	17
2026	18	18
2027	19	19
2028	20	20
2029	20	20
2030	20	20

Wind Erosion

Wind erosion dust emissions were estimated based on AP-42 guidance for the estimation of emissions from industrial wind erosion (USEPA, 2006b) based on Equation 1:

$$E_{dust,i} = \frac{k \times P \times M \times N}{907{,}185} \qquad \text{Equation (1)}$$

where:

$E_{dust,\,i}$ are dust emissions for pollutant i from construction wind erosion [ton/mine]
k is the particle size multiplies [0.5 for PM_{10} and 0.075 from $PM_{2.5}$]
P is the erosion potential [g/m^2]
M is the number of disturbed acres [m^2/pad]
N is the number of disturbances
907,185 is a mass unit conversion [g/ton]

The erosions potential is a function of the wind friction velocity, as shown in Equation 2 and 3:

$$P = 58 \times (u* - u_t)^2 + 25(u* - u_t) \quad \text{Equation (2)}$$

where:

*u** is the friction velocity (m/s)

u_t is the threshold friction velocity (m/s)

$$P = 0 \quad for \quad (u* \leq u_t) \quad \text{Equation (3)}$$

Friction velocity estimates (u*) were made by multiplying the average annual fastest wind speed from Uncompahgre, Colorado from 1947 to 1979 by 0.053 per AP-42 guidance (USEPA, 2006b).

Fugitive Dust

Fugitive dust emissions from ventilation and surface facilities were taken from Whirlwind Mine Environmental Assessment (BLM, 2008) permit not-to-exceed values.

Stationary Engines

This category refers to emissions associated with stationary internal combustion engines used in uranium mining. Emission estimates for NOx were taken from the Whirlwind Mine Environmental Assessment permit not-to-exceed values (BLM, 2008). Emission estimates were not available in the Whirlwind Mine Environmental Assessment (BLM, 2008) for other pollutants. Emissions of other pollutants were estimated based on the EPA NONROAD2008a model (USEPA, 2009b) except for N_2O which was estimated based on the 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17 (API, 2009).

Emissions on per piece of equipment were estimated according to Equation 74:

$$E_{engine,i} = \frac{EF_i \times HP \times LF \times t_{event} \times n}{907{,}185} \quad \text{Equation (4)}$$

where:

E_{engine} are emissions of pollutant *i* [ton/equipment]

EF_i is the emissions factor of pollutant *i* [g/hp-hr]

HP is the horsepower [hp]

LF is the load factor

t_{event} is the number of hours the engine is used [hr/pad]

907,185 is the mass unit conversion [g/ton]

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APPENDIX D-1

Coal Mining Emissions

Table A1. 2011 to 2021 Coal Mine Emissions for mines in Western Colorado under federal jurisdiction (tons/year).

Year	VOC (short tons/year)	CO (short tons/year)	NOx (short tons/year)	PM10 (short tons/year)	PM2.5 (short tons/year)	SO2 (short tons/year)	CO2 (short tons/year)	CH4 (short tons/year)	N2O (short tons/year)	HAPs (short tons/year)	CO2eq (short tons/year)	CO2eq (metric tonnes/year)
Book Cliffs (Grand Junction Field Office)												
2011	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0	0	0	0	0	0
2017	1	3	20	6	2	0	2,616	21,278	0	0	449,496	407,891
2018	1	3	20	6	2	0	2,616	21,278	0	0	449,496	407,891
2019	2	5	40	12	4	0	5,231	42,556	0	0	898,992	815,783
2020	2	5	40	12	4	0	5,231	42,556	0	0	898,992	815,783
2021	3	8	60	18	5	0	7,847	63,833	0	0	1,348,489	1,223,674
McClane (Grand Junction Field Office)												
2011	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	13	0.3	0	0	3,818	0	0	80,178	72,757
2016	0	0	0	13	0.3	0	0	3,818	0	0	80,178	72,757
2017	0	0	0	13	0.3	0	0	3,818	0	0	80,178	72,757
2018	0	0	0	13	0.3	0	0	3,818	0	0	80,178	72,757
2019	0	0	0	13	0.3	0	0	3,818	0	0	80,178	72,757
2020	0	0	0	13	0.3	0	0	3,818	0	0	80,178	72,757
2021	0	0	0	13	0.3	0	0	3,818	0	0	80,178	72,757

Year	VOC (short tons/year)	CO (short tons/year)	NOx (short tons/year)	PM10 (short tons/year)	PM2.5 (short tons/year)	SO2 (short tons/year)	CO2 (short tons/year)	CH4 (short tons/year)	N2O (short tons/year)	HAPs (short tons/year)	CO2eq (short tons/year)	CO2eq (metric tonnes/year)
Oak Mesa Area (Uncompahgre Field Office)												
2011	2	15	14	291	81	0.2	44,671	80,619	0.8	0.2	1,737,918	1,577,058
2012	13	41	55	513	190	0.8	53,176	140,290	0.9	1.3	2,999,549	2,721,914
2013	13	41	55	513	190	0.8	53,176	140,290	0.9	1.3	2,999,549	2,721,914
2014	13	41	55	513	190	0.8	53,176	140,290	0.9	1.3	2,999,549	2,721,914
2015	13	41	55	513	190	0.8	53,176	140,290	0.9	1.3	2,999,549	2,721,914
2016	13	41	55	513	190	0.8	53,176	140,290	0.9	1.3	2,999,549	2,721,914
2017	13	41	55	513	190	0.8	53,176	140,290	0.9	1.3	2,999,549	2,721,914
2018	13	41	55	513	190	0.8	53,176	140,290	0.9	1.3	2,999,549	2,721,914
2019	13	41	55	513	190	0.8	53,176	140,290	0.9	1.3	2,999,549	2,721,914
2020	13	41	55	513	190	0.8	53,176	140,290	0.9	1.3	2,999,549	2,721,914
2021	13	41	55	513	190	0.8	53,176	140,290	0.9	1.3	2,999,549	2,721,914
King (Tres Rios Field Office)												
2011	0	0	0	15	14	0	0	0	0	0	0	0
2012	0	0	0	25	24	0	0	0	0	0	0	0
2013	0	0	0	25	24	0	0	0	0	0	0	0
2014	0	0	0	25	24	0	0	0	0	0	0	0
2015	0	0	0	25	24	0	0	0	0	0	0	0
2016	0	0	0	25	24	0	0	0	0	0	0	0
2017	0	0	0	25	24	0	0	0	0	0	0	0
2018	0	0	0	25	24	0	0	0	0	0	0	0
2019	0	0	0	25	24	0	0	0	0	0	0	0
2020	0	0	0	25	24	0	0	0	0	0	0	0
2021	0	0	0	25	24	0	0	0	0	0	0	0

Year	VOC (short tons/year)	CO (short tons/year)	NOx (short tons/year)	PM10 (short tons/year)	PM2.5 (short tons/year)	SO2 (short tons/year)	CO2 (short tons/year)	CH4 (short tons/year)	N2O (short tons/year)	HAPs (short tons/year)	CO2eq (short tons/year)	CO2eq (metric tonnes/year)
Foidel (Kremmling Field Office)												
2011	0	1	4	259	54	0	*	*	*	0	*	*
2012	0	1	4	259	54	0	*	*	*	0	*	*
2013	5	6	11	161	33	0	36,878	1,257	0	0	63,298	57,439
2014	5	6	11	161	33	0	36,878	1,257	0	0	63,298	57,439
2015	5	6	11	161	33	0	36,878	1,257	0	0	63,298	57,439
2016	5	6	11	161	33	0	36,878	1,257	0	0	63,298	57,439
2017	5	6	11	161	33	0	36,878	1,257	0	0	63,298	57,439
2018	0	0	0	0	0	0	0	0	0	0	0	0
2019	0	0	0	0	0	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0	0	0	0	0	0
2021	0	0	0	0	0	0	0	0	0	0	0	0
Deserado (White River Field Office)												
2011	0	0	0	119	13	0	*	*	*	0	*	*
2012	5	6	11	126	15	0	29,498	923	0	0	48,910	44,383
2013	5	6	11	126	15	0	29,498	923	0	0	48,910	44,383
2014	5	6	11	126	15	0	29,498	923	0	0	48,910	44,383
2015	5	6	11	126	15	0	29,498	923	0	0	48,910	44,383
2016	5	6	11	126	15	0	29,498	923	0	0	48,910	44,383
2017	5	6	11	126	15	0	29,498	923	0	0	48,910	44,383
2018	5	6	11	126	15	0	29,498	923	0	0	48,910	44,383
2019	5	6	11	126	15	0	29,498	923	0	0	48,910	44,383
2020	5	6	11	126	15	0	29,498	923	0	0	48,910	44,383
2021	5	6	11	126	15	0	29,498	923	0	0	48,910	44,383

Year	VOC (short tons/year)	CO (short tons/year)	NOx (short tons/year)	PM10 (short tons/year)	PM2.5 (short tons/year)	SO2 (short tons/year)	CO2 (short tons/year)	CH4 (short tons/year)	N2O (short tons/year)	HAPs (short tons/year)	CO2eq (short tons/year)	CO2eq (metric tonnes/year)
Trapper (Little Snake Field Office)												
2011	0	452	115	852	251	0	*	*	*	0	*	*
2012	0	452	115	852	251	0	*	*	*	0	*	*
2013	0	452	115	852	251	0	*	*	*	0	*	*
2014	0	452	115	852	251	0	*	*	*	0	*	*
2015	0	452	115	852	251	0	*	*	*	0	*	*
2016	0	452	115	852	251	0	*	*	*	0	*	*
2017	0	452	115	852	251	0	*	*	*	0	*	*
2018	0	452	115	852	251	0	*	*	*	0	*	*
2019	0	452	115	852	251	0	*	*	*	0	*	*
2020	0	452	115	852	251	0	*	*	*	0	*	*
2021	0	452	115	852	251	0	*	*	*	0	*	*
Colowyo (Little Snake Field Office)												
2011	0	0	0	1,700	252	0	*	*	*	0	*	*
2012	0	0	0	1,700	252	0	*	*	*	0	*	*
2013	0	0	0	1,700	252	0	*	*	*	0	*	*
2014	0	0	0	1,700	252	0	*	*	*	0	*	*
2015	0	0	0	1,700	252	0	*	*	*	0	*	*
2016	0	0	0	1,700	252	0	*	*	*	0	*	*
2017	0	0	0	1,700	252	0	*	*	*	0	*	*
2018	0	0	0	1,700	252	0	*	*	*	0	*	*
2019	0	0	0	1,700	252	0	*	*	*	0	*	*
2020	0	0	0	1,700	252	0	*	*	*	0	*	*
2021	0	0	0	1,700	252	0	*	*	*	0	*	*

Year	VOC (short tons/year)	CO (short tons/year)	NOx (short tons/year)	PM10 (short tons/year)	PM2.5 (short tons/year)	SO2 (short tons/year)	CO2 (short tons/year)	CH4 (short tons/year)	N2O (short tons/year)	HAPs (short tons/year)	CO2eq (short tons/year)	CO2eq (metric tonnes/year)
Sage Creek (Little Snake Field Office)												
2011	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0
2013	4	3	4	112	15	0	4,178	298	0	0	10,447	9,480
2014	4	3	4	112	15	0	4,178	298	0	0	10,447	9,480
2015	4	3	4	112	15	0	4,178	298	0	0	10,447	9,480
2016	4	3	4	112	15	0	4,178	298	0	0	10,447	9,480
2017	4	3	4	112	15	0	4,178	298	0	0	10,447	9,480
2018	4	3	4	112	15	0	4,178	298	0	0	10,447	9,480
2019	4	3	4	112	15	0	4,178	298	0	0	10,447	9,480
2020	4	3	4	112	15	0	4,178	298	0	0	10,447	9,480
2021	4	3	4	112	15	0	4,178	298	0	0	10,447	9,480

* Greenhouse gas emissions not available for all years for the Trapper and Colowyo mines, in 2011 for the Deserado mine, and in 2011 and 2012 for the Foidel mine.

APPENDIX D-2

Uranium/Vanadium Mining Emissions

Table B1. Grand Junction Field Office Uranium/Vanadium Mine Emissions (tons/year).

Year	Mines	VOC (short tons/year)	CO (short tons/year)	NOx (short tons/year)	PM10 (short tons/year)	PM2.5 (short tons/year)	SO2 (short tons/year)	CO2 (short tons/year)	CH4 (short tons/year)	N2O (short tons/year)	HAPs (short tons/year)	CO2eq (short tons/year)	CO2eq (metric tonnes/ year)
2011	0	0	0	0	0	0	0.0	0	0.0	0.0	0.0	0	0
2012	0	0	0	0	0	0	0.0	0	0.0	0.0	0.0	0	0
2013	1	1	4	12	14	13	0.2	1,077	0.0	0.0	0.1	1,080	980
2014	3	3	13	37	42	39	0.7	3,231	0.0	0.0	0.3	3,240	2,940
2015	5	5	22	62	69	66	1.2	5,386	0.1	0.0	0.5	5,401	4,901
2016	7	7	31	86	97	92	1.6	7,540	0.1	0.1	0.7	7,561	6,861
2017	9	9	40	111	125	118	2.1	9,694	0.1	0.1	0.9	9,721	8,821
2018	10	10	44	123	139	131	2.3	10,771	0.2	0.1	1.0	10,801	9,801
2019	11	11	49	135	153	145	2.6	11,848	0.2	0.1	1.1	11,881	10,782
2020	12	12	53	148	167	158	2.8	12,925	0.2	0.1	1.2	12,961	11,762
2021	13	13	57	160	181	171	3.0	14,003	0.2	0.1	1.3	14,041	12,742
2022	14	14	62	172	194	184	3.3	15,080	0.2	0.1	1.4	15,122	13,722
2023	15	15	66	185	208	197	3.5	16,157	0.2	0.1	1.5	16,202	14,702
2024	16	16	71	197	222	210	3.7	17,234	0.2	0.1	1.6	17,282	15,682
2025	17	17	75	209	236	223	4.0	18,311	0.3	0.1	1.7	18,362	16,662
2026	18	18	79	221	250	236	4.2	19,388	0.3	0.2	1.8	19,442	17,642
2027	19	19	84	234	264	250	4.5	20,465	0.3	0.2	1.9	20,522	18,623
2028	20	20	88	246	278	263	4.7	21,542	0.3	0.2	2.0	21,602	19,603
2029	20	20	88	246	278	263	4.7	21,542	0.3	0.2	2.0	21,602	19,603
2030	20	20	88	246	278	263	4.7	21,542	0.3	0.2	2.0	21,602	19,603

Table B2. Uncompahgre Field Office Uranium/Vanadium Mine Emissions (tons/year).

Year	Mines	VOC (short tons/year)	CO (short tons/year)	NOx (short tons/year)	PM10 (short tons/year)	PM2.5 (short tons/year)	SO2 (short tons/year)	CO2 (short tons/year)	CH4 (short tons/year)	N2O (short tons/year)	HAPs (short tons/year)	CO2eq (short tons/year)	CO2eq (metric tonnes/ year)
2011	0	0	0	0	0	0	0.0	0	0.0	0.0	0.0	0	0
2012	0	0	0	0	0	0	0.0	0	0.0	0.0	0.0	0	0
2013	1	1	4	12	14	13	0.2	1,077	0.0	0.0	0.1	1,080	980
2014	3	3	13	37	42	39	0.7	3,231	0.0	0.0	0.3	3,240	2,940
2015	5	5	22	62	69	66	1.2	5,386	0.1	0.0	0.5	5,401	4,901
2016	7	7	31	86	97	92	1.6	7,540	0.1	0.1	0.7	7,561	6,861
2017	9	9	40	111	125	118	2.1	9,694	0.1	0.1	0.9	9,721	8,821
2018	10	10	44	123	139	131	2.3	10,771	0.2	0.1	1.0	10,801	9,801
2019	11	11	49	135	153	145	2.6	11,848	0.2	0.1	1.1	11,881	10,782
2020	12	12	53	148	167	158	2.8	12,925	0.2	0.1	1.2	12,961	11,762
2021	13	13	57	160	181	171	3.0	14,003	0.2	0.1	1.3	14,041	12,742
2022	14	14	62	172	194	184	3.3	15,080	0.2	0.1	1.4	15,122	13,722
2023	15	15	66	185	208	197	3.5	16,157	0.2	0.1	1.5	16,202	14,702
2024	16	16	71	197	222	210	3.7	17,234	0.2	0.1	1.6	17,282	15,682
2025	17	17	75	209	236	223	4.0	18,311	0.3	0.1	1.7	18,362	16,662
2026	18	18	79	221	250	236	4.2	19,388	0.3	0.2	1.8	19,442	17,642
2027	19	19	84	234	264	250	4.5	20,465	0.3	0.2	1.9	20,522	18,623
2028	20	20	88	246	278	263	4.7	21,542	0.3	0.2	2.0	21,602	19,603
2029	20	20	88	246	278	263	4.7	21,542	0.3	0.2	2.0	21,602	19,603
2030	20	20	88	246	278	263	4.7	21,542	0.3	0.2	2.0	21,602	19,603

APPENDIX E

CARMMS Technical Memorandum
Mancos Shale Oil and Gas Emission Calculator Documentation
September 22, 2014

September 22, 2014

MEMORANDUM

To: Mary Uhl, BLM-New Mexico State Office
From: John Grant and Ralph Morris, ENVIRON; Michele Steyskal, Kleinfelder
Subject: Mancos Shale Oil and Gas Emission Calculator Documentation

Introduction

The purpose of this memorandum is to explain the emissions calculation procedures used in the oil and gas emission calculators that have been developed for the Mancos Shale. Based on the oil and gas emission calculator template developed as part of the Colorado Air Resource Management Modeling Study (CARMMS), we have developed representative calculators for "typical" oil dominant and gas dominant wells in the Mancos Shale. "Typical" well site oil and gas equipment characteristics and usage have been incorporated into each calculator based on Mancos Shale well site information provided by BLM staff[1].

Overview of Calculators

Well characteristics are expected to vary significantly across the Mancos Shale Play. Generally oil dominant wells are expected to be located in the southerly part of the play while gas dominant wells are expected in the northern part of the play. The suite of equipment and production characteristics for Mancos Shale wells is expected to be quite different for oil dominant and gas dominant wells. Therefore, emission calculators have been developed separately for oil dominant and gas dominant well types. For each well type a separate, self-contained emission calculator spreadsheet contains all of the inputs and calculations needed to generate well site emissions.

Additional emissions at midstream sources (i.e. compressor stations and gas plants) were assumed negligible for the Mancos Shale development given existing midstream capacity and recent declines in production from conventional sources in the South San Juan Basin.

Scope

Geographical

The emission calculators were developed for the Mancos Shale development area (see Figure 1).

[1] Email from David Mankiewicz, BLM. January 8, 2014.

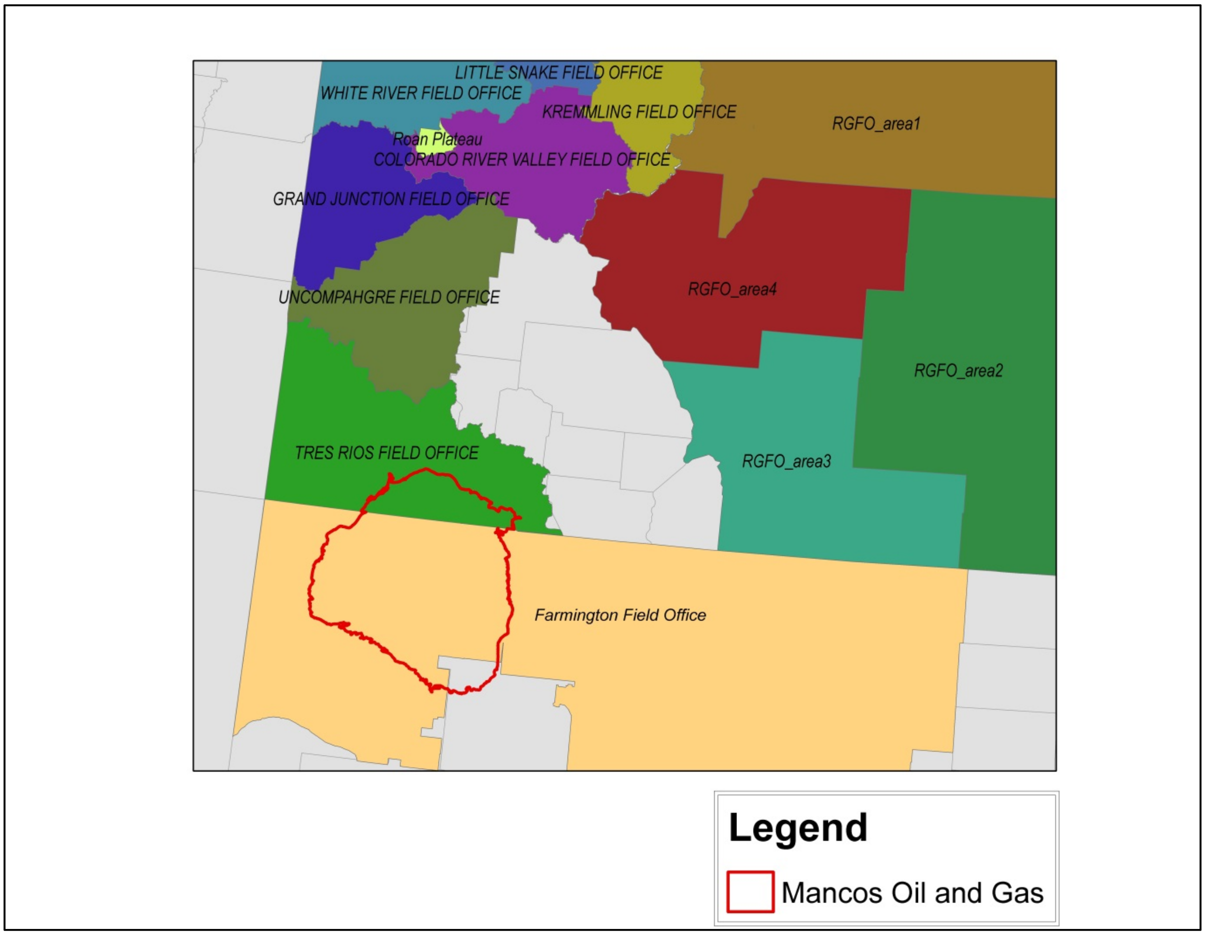

Figure 1. Mancos Shale development area (shown with other oil and gas source areas from CARMMS).

<u>Pollutants</u>

The emission calculators include estimates of emissions of criteria air pollutants (CAPs), greenhouse gases (GHGs), and hazardous air pollutants (HAPs) as follows:

- Criteria Pollutants
  - Carbon monoxide (CO)
  - Nitrogen oxides (NO_X)
  - Particulate matter less than or equal to 10 microns in diameter (PM_{10})
  - Particulate matter less than or equal to 2.5 microns in diameter ($PM_{2.5}$)
  - Sulfur dioxide (SO_2)
  - Volatile Organic Compounds (VOCs)
- Greenhouse Gases
  - Carbon dioxide (CO_2)
  - Methane (CH_4)
  - Nitrous oxide (N_2O)
- Hazardous Air Pollutants (HAPs)

While lead (pb) is a criteria pollutant, emissions of lead are expected to be extremely low and are therefore not included in this analysis.

HAP emissions were estimated for each emissions source. For oil and gas emissions sources, HAP emissions from venting and combustion source categories were estimated for formaldehyde, n-hexane, benzene, toluene, ethylbenzene, and xylenes (BTEX).

Anthropogenic greenhouse gas emission inventories typically include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases. Fluorinated gases are not expected to be emitted in appreciable quantities by any category considered in this emission inventory and were therefore not included in this analysis.

<u>Temporal</u>

The calculators estimate annual emissions associated with oil and gas well-sites for a base year of 2011 with annual emission forecasts to 2021.

<u>Emissions Sources</u>

Emissions are generated in three main phases of oil and gas systems:

- Well construction and development
- Production phase (occurring at-or-nearby the well pad)
- Midstream sources (central gas compression and processing)

Well Construction and Development Phase

Emissions from well pad construction and development are generated by equipment, vehicles and activities related to well pad construction, access roads construction, pipeline construction, wellbore drilling and well completions. Table 1 includes the well pad construction and development phase emission sources. Emissions are initially estimated on a per surrogate basis and later scaled with the projected surrogate estimate to Mancos-wide annual emissions from each source.

Table 1. Construction phase source categories and scaling surrogates.

Equipment Source Category	Scaling Surrogate
Well Pad, Access Road, and Pipeline Construction Equipment	New pads per year
Well Pad, Access Road and Pipeline Construction Traffic	New pads per year
Drilling Equipment and Completion Equipment	Spuds per year
Fracing Equipment	Spuds per year
Refracing Equipment	Active wells per year
Drilling and Well Completion Traffic	Spuds per year
Rig Hauling and Rig Moving Traffic	New pads per year
Well Pad, Access Road and Pipeline Construction Wind Erosion	New pads per year
Well Completion Venting	Spuds per year

Production Phase

Emissions from the production phase (see Table 2) are generated by equipment, vehicles and activities related to oil and gas production at well sites after a well has been completed. Emissions are initially estimated on a per event basis and later scaled with the projected number of events per year (scaling surrogate) to obtain formation-wide annual emissions from each source.

Table 2. Production phase source categories and scaling surrogates.

Equipment Source Category	Scaling Surrogate
Blowdown venting	Active wells per year
Condensate or Crude Oil Hauling Traffic	Oil or condensate production per year
Condensate or Oil Tanks Flashing	Oil or condensate production per year
Dehydrator	Gas production per year
Heaters	Active wells per year
Loading Emissions from Condensate or Oil Tanks	Oil or condensate production per year
Miscellaneous Engines	Active wells per year
Pneumatic Devices	Active wells per year
Pneumatic Pumps	Active wells per year
Produced Water Hauling Traffic, Water tanks	Water production per year
Production Traffic (Well workovers, Road Maintenance, Well Pad Reclamation and Production)	Active wells per year
Water Injection Pumps	Active wells per year
Well Recompletion Venting	Active wells per year
Well Workover Rigs	Active wells per year
Wellhead Fugitives	Active wells per year

Emission Calculation Methods

Emission calculations for all emission-generating activities were developed based on typical emission inventory methodology. The methods used to estimate emissions from each source category are described in detail in Appendix C, Section 2.2 of the CARMMS report[2]. For each source category, emissions for the base year were estimated. Emissions were then forecasted to future years, accounting for activity growth and for applicable sources, emissions controls.

Mancos Shale Calculator Inputs

The emission calculator for each well type allows for specification of various inputs, based upon which the oil and gas emission inventory is estimated.

- Oil and gas activity
  - Well development scenarios
  - Well production decline estimates
- Input factors by source category
  - Equipment configurations (e.g. drill rigs, fracing rigs)
  - Gas venting or losses (e.g. completions, blowdowns)
  - Level of control by source category
  - Gas composition

[2] ENVIRON and Carter Lake Consulting, 2014. Colorado Air Resource Management Modeling Study (CARMMS) Preliminary Results for the High Development Scenario, Draft. Prepared for Bureau of Land Management (BLM), Colorado State Office (COSO). May 2014.

Oil and gas activity

Development Scenarios

The future development of the Mancos Shale for the high scenario was estimated as shown in Table 3 (1) as implemented in CARMMS and (2) as revised for the latest emission inventory estimates. Forecasts of Mancos Shale development are continually evolving as the play becomes better understood. The low scenario will assume that wells are developed at only half the rate of the high scenario and the medium scenario will assume the same rate of development as the high scenario, but with additional emission controls.

Table 3. Well Development for the High Scenario.

Year [a]	Total Wells Drilled [b]		Oil Dominant Wells Drilled		Gas Dominant Wells Drilled	
	Oil Dominant	Gas Dominant	BLM Wells	Non-BLM Wells	BLM Wells	Non-BLM Wells
Revised Estimates						
2015	200	0	140	60	0	0
2016	200	0	140	60	0	0
2017	200	0	140	60	0	0
2018	200	0	140	60	0	0
2019	200	200	140	60	140	60
2020	200	200	140	60	140	60
2021	200	200	140	60	140	60
Estimates included in the CARMMS						
2015	360	40	252	108	28	12
2016	360	40	252	108	28	12
2017	360	40	252	108	28	12
2018	360	40	252	108	28	12
2019	142	258	99	43	181	78
2020	142	258	99	43	181	78
2021	142	258	99	43	181	78

[a] negligible activity prior to 2015
[b] Revised estimates: assume three wells per pad for oil dominant wells and eight wells per pad for gas dominant wells.
Estimates included in the CARMMS: assume eight wells per pads for both oil dominant and gas dominant wells

Well Decline Curves

For the high scenario emissions included in the CARMMS, gas well dominant decline curves were estimated based on very limited data. Lacking better information, a constant annual production rate was assumed for gas production and oil production rates from the Tres Rios Field Office were used (Table 3). The emission calculators were updated based on a complete gas well decline curve and an assumption of no oil production (Table 3) based on more recent data provided by BLM[3].

For the high scenario emissions included in the CARMMS, there was little data available to characterize oil dominant well decline curves. Lacking better information, a constant annual oil production rate was assumed for all scenarios and gas production rates from the Tres Rios Field Office will be used (Table 5). The emission calculators were updated based on oil well decline curve data provided by BLM[4].

[3] Email from David Mankiewicz, BLM. June 2, 2014.
[4] Email from David Mankiewicz, BLM. August 5, 2014.

Table 4. Gas dominant well decline curves.

Well Age	High Scenario (as included in CARMMS)		Updates for Additional Scenarios [c]	
	Gas (MCF/well) [a]	Oil (bbl/well) [b]	Gas (MCF/well)	Oil (bbl/well)
1	36,500	2,511	1,093,254	0
2	36,500	1,589	553,610	0
3	36,500	1,006	378,413	0
4	36,500	636	289,468	0
5	36,500	403	235,246	0
6	36,500	255	198,592	0
7	36,500	161	172,096	0
8	36,500	102	152,021	0
9	36,500	65	136,260	0
10	36,500	41	123,550	0
11	36,500	26	113,074	0
12	36,500	16	104,286	0
13	36,500	10	96,805	0
14	36,500	7	90,357	0
15	36,500	4	84,742	0

[a] No decline given. Source: Email from David Mankiewicz, BLM. January 8, 2014.
[b] Data from TRFO oil well calculator
[c] Source: Email from David Mankiewicz, BLM. June 2, 2014.

Source Categories and Input Factors

Equipment Configurations, Gas Venting Activity, and Gas Composition

Table 6 lists the sources for which Mancos specific data was used versus sources where default data from CARMMS calculators were used.

Appendix E-1 shows the by source category input factors for oil dominant and Appendix E-2 shows the by source category input factors for gas dominant wells including equipment configurations (e.g. drill rigs, fracing rigs), gas venting and loss activity (e.g. completions, blowdowns), and gas compositions. Appendix E-3 shows on-road vehicle emission rates that were used based on MOVES2010a model runs.

Table 5. Oil dominant well decline curves.

Well Age	High Scenario (as included in CARMMS)		Updates for Additional Scenarios [c]	
	Gas (MCF/well) [a]	Oil (bbl/well) [b]	Gas (MCF/well) [d]	Oil (bbl/well) [e]
1	15,108	22,750	213,514	67,938
2	13,610	22,750	107,316	34,147
3	12,262	22,750	82,347	26,202
4	11,047	22,750	69,422	22,089
5	9,952	22,750	61,162	19,461
6	8,966	22,750	55,294	17,594
7	8,077	22,750	50,848	16,179
8	7,277	22,750	47,329	15,059
9	6,556	22,750	44,452	14,144
10	5,906	22,750	42,044	13,378
11	5,321	22,750	39,989	12,724

Well Age	High Scenario (as included in CARMMS)		Updates for Additional Scenarios [c]	
	Gas (MCF/well) [a]	Oil (bbl/well) [b]	Gas (MCF/well) [d]	Oil (bbl/well) [e]
12	4,793	22,750	38,209	12,158
13	4,318	22,750	36,647	11,661
14	3,890	22,750	35,263	11,220
15	3,505	22,750	34,025	10,826

[a] No decline given. 15 year life expectancy. Source: Email from David Mankiewicz, BLM. June 2, 2014.
[b] Data from TRFO oil well calculator
[c] Source: Email from David Mankiewicz, BLM. August 5, 2014.
[d] Based on oil decline curve and gas-to-oil ratio
[e] Average of two available well decline curves

Table 6. Mancos calculator input data.

Mancos Shale Specific Data Inputs	CARMMS Calculator Inputs [a]
Oil Dominant Wells	
• vent gas composition • construction equipment • drill rigs • fracing equipment • completion and recompletion venting • development phase traffic • workover rigs and traffic • wellhead fugitive devices • pumpjack engines • oil tanks • wellhead compressor engines (none expected) • heaters	• well blowdowns • pneumatic devices • pneumatic pumps • water tanks • maintenance traffic • dehydrators
Gas Dominant Wells	
• vent gas composition • construction equipment • drill rigs • fracing equipment • completion venting • development phase traffic • workover rigs and traffic • wellhead fugitive devices • wellhead compressor engines • dehydrators	• well blowdowns • recompletion venting • pneumatic devices • pneumatic pumps • condensate tanks • heaters • maintenance traffic • water tanks

[a] TRFO Conventional Oil calculator inputs for Oil Dominant wells and TRFO Shale Gas calculator inputs for Gas Dominant wells

Recent trends in gas production in the South San Juan Basin show consistent decline since 2006 (Figure 2). Average decline over the 2006 to 2013 period is about 42 billion cubic-feet (BCF) per year, with the largest drop in production occurring from 2012 to 2013 (64 BCF). Over the ten year period from 2011 to 2021, the average annual historical rate of decline would result in a loss of 420 BCF and the most recent, maximum rate of annual decline would result in a loss of 640 BCF. The total gas production estimated to be added to 2021 for the Mancos Shale based on the gas well decline curve and the high development scenario is about 510 BCF per year. Given existing midstream capacity and recent declines in gas production in the South San Juan

Basin, additional emissions at midstream sources (i.e. compressor stations and gas plants) were assumed negligible for the Mancos Shale development.

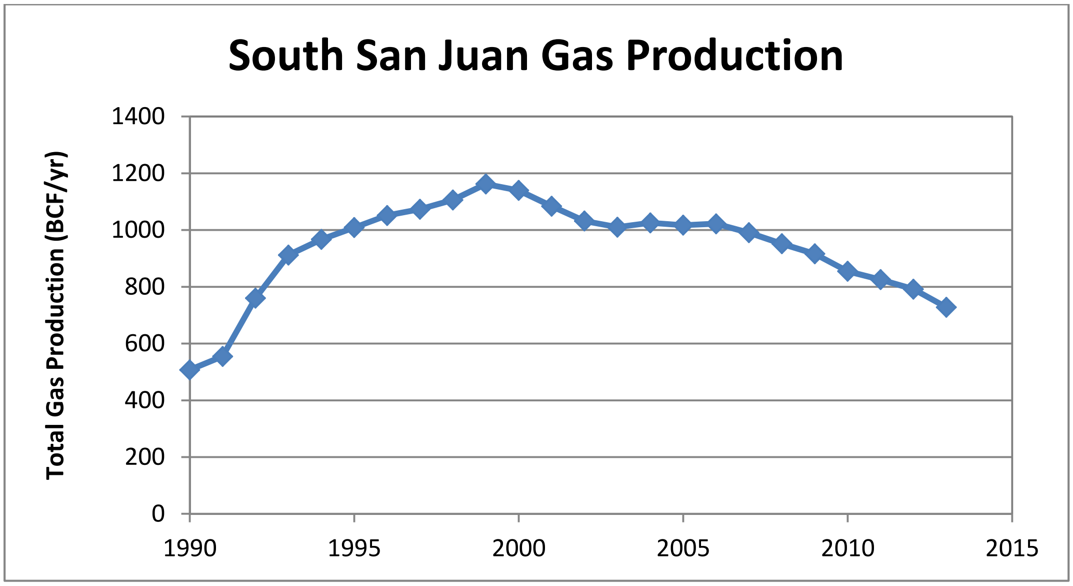

Figure 2. Historical gas production in the South San Juan Basin (including Rio Arriba, San Juan, Sandoval, and McKinley Counties).

Input Factor Revisions

Based on additional peer review of the emissions calculators, the following input factors listed in Table 7 were revised.

Table 7. Emission calculator input factor revisions.

Oil Dominant Wells
Drill rig inputs were revised to assume 24-hours of operation per day for all equipment. This is a superficial change; total hours (and hence emissions) by equipment type remained unchanged from the data provided by BLM[5].
Acres of disturbance were revised as follows: pad- 4.9 acres per well pad, road and pipeline- 9 acres per well pad.
Pumpjacks typically operate close to year-round. Pumpjack operation was revised to 8760 hours per year.
Fugitive components were split among liquid and gas service components based on media type splits in the CARMMS calculators.
The information provided on Mancos Shale well site emissions[5] does not indicate the use of dehydrators and pneumatic pumps. The calculator was revised to assume negligible use of this equipment at oil well sites.
Well pad configuration estimates were revised to assume three wells per pad.
Gas Dominant Wells
Completion emissions were revised to assume control by green completion, consistent with NSPS Subpart OOOO.
Fugitive components were split among liquid and gas service components based on the media type splits in the CARMMS calculators.
Well pad and pipeline construction equipment operation was assumed to be the same as for oil wells

[5] Email from David Mankiewicz, BLM. January 8, 2014.

Controls

Low and High Development Scenarios

The low and the high development scenarios assume that applicable oil and gas emission sources conform to all on-the-books regulations; a summary of controls is presented in Table 8.

Table 8. Mancos calculator controls summary.

Source Category		Control Assumption
Construction	Dust control	50%
Drill Rigs	Tier Level	Tier II
Completion[1]	Tier Level	Tier II
	% of emissions vented/well	0%
	% of Completion Gas Controlled	100%
	% of emissions flared/well	100%
	Control Efficiency - Flare	95%
	% of emissions in closed loop process/well	0%
Dehydrators	Fraction of Dehydrators Controlled	0%
	Control Efficiency	95%
Condensate/ Oil Tanks	Fraction of Condensate Tanks Controlled	100%
	Control Efficiency	95%
Pneumatic Devices	Type of Devices	100%
	Bleed Rate	6 scfh
Pneumatic Pumps	Fraction of Pneumatic Pumps Controlled	0%
	Control Efficiency	95%

[1] As indicated in Table 7, green completions will be assumed for gas wells in any future calculators

Medium Development Scenario

Consistent with the CARMMS, the medium development scenario has the same number of wells as the high development scenario but assumes additional levels of controls. Beyond the application of existing state and federal requirements, additional control of engine and fugitive emission sources is assumed for wells drilled on Federal land as follows:

- Drill rig engines will be assumed to be split equally among the following technology types: Tier 2 diesel, Tier 3 diesel, Tier 4 diesel, and mixed-fuel rigs.
- All completion and fracing engines will be assumed split equally among Tier 2, Tier 3, and Tier 4 diesel engines.
- For completions, no additional control will be assumed. Oil well venting emissions will be controlled by flare and gas well venting emissions will be controlled by green completion.
- All condensate tank and oil tank emissions are controlled by flaring. 95% control efficiency is assumed.
- Dehydrator emissions will be assumed to remain at uncontrolled levels.
- All pneumatic devices are low-bleed devices (6 cfh).
- Assume 80% dust control for unpaved road traffic.

APPENDIX E-1

Mancos Shale Oil Dominant Well Calculator Inputs by Source Category

Note: Yellow highlights indicate that inputs were obtained from the BLM inputs provided for the Mancos Shale.
Note: Green highlights indicate that inputs were obtained from TRFO conventional oil calculator.

Gas Analysis & Venting	**Speciated Sales Gas Analysis**
Gas Component	**Mole Fraction (%)**
Methane C1	88.972
Ethane C2	5.792
Nitrogen	0.094
Carbon Dioxide	2.528
Propane C3	1.365
i-Butane i-C4	0.370
n-Butane n-C4	0.261
i-Pentane iC5	0.155
n-Pentane nC5	0.102
Hexanes+ C6+	0.146
Heptanes C7	0.093
Octanes	0.065
Benzene	0.027
n-Hexane n-C6	0.146
Toluene	0.019
2,2,4-Trimethylpentane	0.000
Xylenes	0.011
Helium	0.000
O2	0.000

Cn_HEq_Exh Construction/Drilling/Completion Equipment

Construction Equipment

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/Well Pad
Well Pad	Trackhoe	100	1	59	10	4
	Dozer	140	1	59	10	4
	Grader	250	1	59	10	4
Well Pad Access Road	Backhoe	100	1	59	10	4
	Dozer	140	1	59	10	4
	Grader	250	1	59	10	3
Pipeline	Backhoe	100	1	59	0	0
	Dozer	140	1	59	0	0
	Grader	250	1	59	10	3

Construction Site	Equipment Type	2011 Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O[a]
All Sites	Construction Equipment	0.18	0.78	2.32	0.15	0.15	0.01	316.19	0.00	0.00

Source: EPA NONROADS 2008a

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Area Disturbed for Oil Wells	Avg. Disturbed Acres per wellpad*	Construction Days
Well Pad	4.9	4
Well Pad Access Road and Pipeline Construction	9	4

Drilling

Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	Average # of Operating Hours/Day	# of Operating Days/activity
Vertical Drill Rig Engine	1000	1	42	24	4
Horizontal Drill Rig Engine	1000	1	59	24	8
Drill Rig Generator	350	1	42	24	12
Trailers Generator	150	1	42	24	12
Air Compressor	550	1	42	24	4
Air Compressor	550	1	42	24	4
Air Compressor Booster	650	1	42	24	4
Forklift	120	1	42	24	4
Aerial Lift	50	1	42	24	0.5
Frontend loader	150	1	42	24	0.5
Dozer	175	1	42	24	0.3

Equipment Type	Tier Level	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N2O[a]
Vertical Drill Rig Engine	Tier 2	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002
Horizontal Drill Rig Engine	Tier 2	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002
Drill Rig Generator	Tier 2	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002
Trailers Generator	Tier 2	0.26	3.73	4.68	0.22	0.22	0.11	530	0.004	0.002
Air Compressor	Tier 2	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002
Air Compressor	Tier 2	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002
Air Compressor Booster	Tier 2	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002
Forklift	Tier 2	0.26	3.73	4.68	0.22	0.22	0.11	530	0.004	0.002
Aerial Lift	Tier 2	0.30	3.73	5.31	0.30	0.30	0.11	530	0.005	0.002
Frontend loader	Tier 2	0.26	3.73	4.68	0.22	0.22	0.11	530	0.004	0.002
Dozer	Tier 2	0.26	2.61	4.68	0.15	0.15	0.11	530	0.004	0.002

Source: EPA Federal Tier Standards

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Completion/Fracing

Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/activity	NONROAD SCC	Tier Level
Frac Pump	1500	1	59	24	3	2270010010	Tier 2
Frac Pump	1500	1	59	24	3	2270010010	Tier 2
Frac Pump	1500	1	59	24	3	2270010010	Tier 2
Frac Pump	1500	1	59	24	3	2270010010	Tier 2
Frac Pump	1500	1	59	24	3	2270010010	Tier 2
Blenders	500	1	42	1	3	2270010010	Tier 2
Auxilary Pump	200	1	42	1	3	2270010010	Tier 2
Sand King	100	1	42	3	3	2270010010	Tier 2
Sand King	100	1	42	3	3	2270010010	Tier 2
Generator	150	1	42	24	3	2270010010	Tier 2

Equipment Type	Capacity (hp)	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O[a]
Frac Pump	1500	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Frac Pump	1500	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Frac Pump	1500	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Frac Pump	1500	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Frac Pump	1500	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Blenders	500	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Auxilary Pump	200	0.26	2.61	4.68	0.15	0.15	0.11	523	0.004	0.002
Sand King	100	0.30	3.73	5.31	0.30	0.30	0.11	520	0.005	0.002
Sand King	100	0.30	3.73	5.31	0.30	0.30	0.11	520	0.005	0.002
Generator	150	0.26	3.73	4.68	0.22	0.22	0.11	520	0.004	0.002

Source: EPA Federal Tier Standards
[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Fracing frequency per spud	1
Refracing Frequency per Year per Well	0

Cn_CV_Exh	Construction Traffic Exhaust

Well Pad and Access Road Construction Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well Pad/ Year
	Type	Class		
Well Pad and Access Road Construction Traffic	Semi Trucks	Heavy Duty Haul Trucks	40.0	15.0
	Pickup Trucks	Passenger Truck	40.0	32.0
Pipeline Construction	Semi Trucks	Heavy Duty Haul Trucks	40.0	6.0
	Pickup Trucks	Passenger Truck	40.0	0.0

Drilling/Completion/Fracing Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/activity/ Year
	Type	Class		
Drilling Traffic	Semi Trucks	Heavy Duty Haul Trucks	40	24
	Pickup Trucks	Passenger Truck	40	52
Conductor Set Traffic	Semi Trucks	Combination Short-haul Truck	40	1
	Pickup Trucks	Passenger Truck	40	5
Well Completion & Testing	Semi Trucks	Combination Short-haul Truck	40	32
	Pickup Trucks	Passenger Truck	40	60

Ops_Well WO	Workovers

Construction Equipment

Activity	Equipment Type	Average Capacity (hp)	# of Operating Hours/Day	No. of Engines	# of Operating Days/Well	Load Factor	Well Workover Frequency per Year
Well Workover	Workover Equipment	504	9	3	2	42	1

Tier Level	HP Range for Efs	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N2O[a]
Tier 2	300-600	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002

Traffic

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year
	Type	Class		
Well Workover	WO Rig	Combination Short-haul Truck	0.0	0.0
	Haul Truck	Combination Short-haul Truck	40.0	6.0
	Pickup Truck	Passenger Truck	40.0	6.0

Blowdowns — Blowdown Venting

Type	Control Efficiency (%)	Volume of gas vented per blowdown Uncontrolled (MCF)	Frequency of Blowdown per well per year
Blowdown	0%	0.75	3.0

Well completions — Completion Venting

Type	Total volume of gas during completion (mcf)
All completions	1,000

Recompletions — Recompletion Venting

Type	Control Efficiency (%)	Volume of gas vented per well per recompletion Uncontrolled (MCF)	No. of recompletion per well per year
Recompletion	0%	5	1

Misc_Engines_Exh — Miscellaneous Engines

Construction Site	Capacity (hp)	# of Units per Well	Fraction of wells to be served by Miscellaneous engine	Avg. Load Factor (%)	# of Operating Hours/Well
Pumpjack Engines	65	1	1.0	54	4368

HP Range	2011 Emission Factors (g/hp-hr)								
	VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O[a]
75	0.44	4.80	2.80	0.18	0.18	0.00	424.16	0.01	0.001

source: NOx and CO from Subpart JJJJ, remaining pollutants from AP-42 rich burn 4-stroke engine emission rates

Wellhead Fugitives — Wellhead Fugitive Devices, Pneumatic Devices, and Pneumatic Pumps

Fugitive Devices

component	Ave. # in Gas Service	Ave. # in Liquid service	Ave. # in High Oil service	Ave. # in Water/Oil Service
valves	9	13	0	3
pump seals	0	0	0	0
others	0	0	0	0
connectors	19	19	0	0
flanges	10	30	0	4
open-ended lines	0	0	0	0

Pneumatic Pumps

Assumed no pneumatic pumps at oil wels

Pneumatic Devices

Device	Number of Devices / well	Lo-Bleed Rate (cfh)
Liquid level controller	2	6
Pressure controller	1	6
Valve controllers	2	6

Ops_RoadMaint Maintenance Traffic

Activity	Vehicle		Total Miles Traveled Per Well	Avg. Vehicle Speed (mph)
	Type	Class		
Road Maintenance	Road Maintenance	Combination Short-haul Truck	80	25

Oil Tanks & Traffic Oil Tanks

Type	***Base Year Assumptions***
Condensate	1. All Oil Throughput Sent Tanks

	2. Average Oil Truck Haul-out of 200 bbl/load
Produced Water	3. All Water Throughput Sent Tanks
	4. Average Water Truck Haul-out of 275 bbl/load
	5. Average estimated production of 11,000 bbl/yr

Uncontrolled VOC Emission Factors for Oil and Water Tanks

Oil Tank VOC Emission rate	2.7	lb/bbl
Water Tank VOC Emission rate*	0.26	lb/bbl

**Regulations. Table 1*

CDPHE Oil and Gas Regulation No. 7 Guidance: An Overview of the Regulations. Table 1

Flash Gas Weight Fractions

CO2 Fraction in Flash Gas	%wt	3
CH4 Fraction in Flash Gas	%wt	10
VOC Fraction in Flash Gas	%wt	62
VOC Molecular weight in Flash gas	lb/lb-mol	54

Oil Truck Load-out

True vapor pressure of liquid loaded, pounds per square inch absolute (psia)	2.3
Temperature of Loaded Liquid (ºR)	510
Mode of Operation	submerged loading: dedicated normal service

Produced Water and Condensate Truck Traffic

Construction Site Destination	Vehicle		Avg. Vehicle Speed (mph)	Round Trip Distance (miles)
	Type	Class		
Produced Condensate Hauling	Haul Truck	Combination Short-haul Truck	25	40
Water Hauling	Haul Truck	Combination Short-haul Truck	25	40

Compressor_Engines	Compressor Engines			
Type of Compressors / Pumps	**Rate (Hp)**	**# Units per Well**	**Annual Compression**	**Operating**

			(Hp)	Hours/Year
Wellhead Compressor Engines	0	0	0	0
Lateral Compressor Engines	0	0	0	0

** no compressor engines are expected to be associated with shale oil wells*

Reclamation Well Pad Reclamation

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Total Miles Traveled per Well
Road and Well Pad Reclamation	Pickup Truck	35	416

Others Traffic Other Traffic

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Year/well
Operations Traffic	Pickup Truck	35	40	50

Heaters and Flaring Heaters

Wellsite Heaters	Heater Rating (MMBtu/hr)	Annual Hours (hr/yr)	No. of Units per Well
Heaters	0.75	4368	1
Reboilers	0.00	0	0

Ops Dehy Dehydrators

Assumed no dehydrators at oil wells

APPENDIX E-2

Shale Gas Well
Calculator Inputs by Source Category

Note: Yellow highlights indicate that inputs were obtained from the BLM inputs provided for the Mancos Shale.
Note: Green highlights indicate that inputs were obtained from TRFO shale gas calculator.

Gas Analysis & Venting	**Speciated Sales Gas Analysis**
Gas Component	**Mole Fraction (%)**
Methane C1	96.028
Ethane C2	0.270
Nitrogen	0.272
Water	0.000
Carbon Dioxide	3.420
Nitrous Oxide	0.000
Hydrogen Sulfide	0.000
Propane C3	0.001
i-Butane i-C4	0.000
n-Butane n-C4	0.000
i-Pentane iC5	0.000
n-Pentane nC5	0.000
Hexanes+ C6+	0.001
Heptanes C7	0.000
Octanes	0.000
Benzene	0.015
Ethylbenzene	0.000
n-Hexane n-C6	0.001
Toluene	0.005
2,2,4-Trimethylpentane	0.000
Xylenes	0.001
Helium	0.000
O2	0.000

Cn_HEq_Exh Construction/Drilling/Completion Equipment

Construction Equipment

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/Well Pad
Well Pad	Trackhoe	100	1	59	10	4
	Dozer	140	1	59	10	4
	Grader	250	1	59	10	4
Well Pad Access Road	Backhoe	100	1	59	10	4
	Dozer	140	1	59	10	4
	Grader	250	1	59	10	3
Pipeline	Backhoe	100	1	59	0	0
	Dozer	140	1	59	0	0
	Grader	250	1	59	10	3

Construction Site	Equipment Type	2011 Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O[a]
All Sites	Construction Equipment	0.18	0.78	2.32	0.15	0.15	0.01	316.19	0.00	0.00

Source: EPA NONROADS 2008a

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Drilling

Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	Average # of Operating Hours/Day	# of Operating Days/activity
Main Deck	1468	4	50	24	24
Generators	150	1	75	24	24

Equipment Type	Tier Level	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N2O[a]
Main Deck	Tier 2	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002
Generators	Tier 2	0.26	3.73	4.68	0.22	0.22	0.11	530	0.004	0.002

Source: EPA Federal Tier Standards

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Completion/Fracing

Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/activity	NONROAD SCC	Tier Level
Main Deck	600	1	80	24	0.3	2270010010	Tier 2
Auxiliary Pump	500	1	80	24	0.3	2270010010	Tier 2
Generators	400	1	75	24	0.3	2270010010	Tier 2
Main Deck	600	1	50	12	7.0	2270010010	Tier 2
Auxiliary Pump	225	1	80	12	3.0	2270010010	Tier 2
Power Swivel	150	1	75	12	3.0	2270010010	Tier 2
Field Generators for Pumps & Lighting	55	3	75	10	25.0	2270010010	Tier 2

Equipment Type	Capacity (hp)	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O^a
Main Deck	600	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Auxiliary Pump	500	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Generators	400	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Main Deck	600	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Auxiliary Pump	225	0.26	2.61	4.68	0.15	0.15	0.11	523	0.004	0.002
Power Swivel	150	0.26	3.73	4.68	0.22	0.22	0.11	520	0.004	0.002
Field Generators for Pumps & Lighting	55	0.30	3.73	5.31	0.30	0.30	0.11	520	0.005	0.002

Source: EPA Federal Tier Standards
[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Fracing frequency per spud	1
Refracing Frequency per Year per Well	0

Area Disturbed for Oil Wells	Avg. Disturbed Acres per wellpad*	Construction Days
Well Pad	6	13
Well Pad Access Road and Pipeline Construction	9	2

**includes frac pond, construction days are a weighted average based on acres disturbed*

Cn_CV_Exh Construction Traffic Exhaust

Well Pad and Access Road Construction Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well Pad/ Year
	Type	Class		
Well Pad and Access Road Construction Traffic	Semi Trucks	Heavy Duty Haul Trucks	144	11
	Pickup Trucks	Passenger Truck	144	48
Pipeline Construction	Semi Trucks	Heavy Duty Haul Trucks	144	1
	Pickup Trucks	Passenger Truck	144	15

Drilling/Completion/Fracing Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/activity/ Year
	Type	Class		
Drilling Traffic	Semi Trucks	Heavy Duty Haul Trucks	175	21
	Pickup Trucks	Passenger Truck	144	6
Rig Hauling	Semi Trucks	Combination Short-haul Truck	144	2
Well Completion & Testing	Semi Trucks	Combination Short-haul Truck	89	175
	Pickup Trucks	Passenger Truck	144	13

Ops_Well WO Workovers

Construction Equipment

Activity	Equipment Type	Average Capacity (hp)	# of Operating Hours/Day	No. of Engines	# of Operating Days/Well	Load Factor	Well Workover Frequency per Year
Well Workover	Workover Equipment	600	10	1	3	43	1

Tier Level	HP Range for Efs	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N2O[a]
Tier 2	600-750	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002

Traffic

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year
	Type	Class		
Well Workover	WO Rig	Combination Short-haul Truck	144	1
	Haul Truck	Combination Short-haul Truck	144	1
	Pickup Truck	Passenger Truck	144	3

Blowdowns Blowdown Venting

Type	Control Efficiency (%)	Volume of gas vented per blowdown Uncontrolled (MCF)	Frequency of Blowdown per well per year
Blowdown	0%	0.81	3.4

Well completions Completion Venting

Type	Total volume of gas during completion (mcf)
All completions	700

Recompletions Recompletion Venting

Type	Control Efficiency (%)	Volume of gas vented per well per recompletion Uncontrolled (MCF)	No. of recompletion per well per year
Recompletion	0%	30	0.5

Misc_Engines_Exh Miscellaneous Engines

Construction Site	Capacity (hp)	# of Units per Well	Fraction of wells to be served by Miscellaneous engine	Avg. Load Factor (%)	# of Operating Hours/Well
Miscellaneous Engines	0	0	0	0	0

Wellhead Fugitives Wellhead Fugitive Devices, Pneumatic Devices, and Pneumatic Pumps

Fugitive Devices

component	Ave. # in Gas Service	Ave. # in Liquid service	Ave. # in High Oil service	Ave. # in Water/Oil Service
valves	22	6	0	1
pump seals	20	10	0	0
others	0	0	0	0
connectors	15	15	0	0
flanges	18	11	0	1
open-ended lines	0	0	0	0

Pneumatic Pumps

Type	Gallons/yr/pump	SCF/Gallon	Number of Pump
Pneumatic Pumps	91	118	1

Pneumatic Devices

Device	Number of Devices / well	Lo-Bleed Rate (cfh)
Liquid level controller	2	6
Pressure controller	1	6
Valve controllers	2	6

Ops_RoadMaint Maintenance Traffic

Activity	Vehicle		Total Miles Traveled Per Well	Avg. Vehicle Speed (mph)
	Type	Class		
Road Maintenance	Road Maintenance	Pickup Truck	18	35

Oil Tanks & Traffic	Oil Tanks
Type	***Base Year Assumptions***
Condensate	1. All Oil Throughput Sent Tanks
	2. Average Oil Truck Haul-out of 200 bbl/load
Produced Water	3. All Water Throughput Sent Tanks
	4. Average Water Truck Haul-out of 260 bbl/load
	5. Average estimated production of 11,000 bbl/yr

Uncontrolled VOC Emission Factors for Oil and Water Tanks

Oil Tank VOC Emission rate	11.8	lb/bbl	Source: Oil and Gas Exploration and Regulation Requirement Fact Sheet, Colorado Department of Public Health and Environment, Air Pollution Control Division, January, 2009. http://www.cdphe.state.co.us/ap/sbap/SBAPoilgastankguidance.pdf
Water Tank VOC Emission rate	0.26	lb/bbl	Source: CDPHE Oil and Gas Regulation No. 7 Guidance: An Overview of the Regulations. Table 1

Flash Gas Weight Fractions

CO2 Fraction in Flash Gas	%wt	2
CH4 Fraction in Flash Gas	%wt	9
VOC Fraction in Flash Gas	%wt	58
VOC Molecular weight in Flash gas	lb/lb-mol	36

Oil Truck Load-out

True vapor pressure of liquid loaded, pounds per square inch absolute (psia)	5
Mode of Operation	submerged loading: dedicated normal service

Produced Water and Condensate Truck Traffic

Construction Site Destination	**Vehicle**		**Avg. Vehicle Speed (mph)**	**Round Trip Distance (miles)**
	Type	**Class**		
Produced Condensate Hauling	Haul Truck	Combination Short-haul Truck	25	4
Water Hauling	Haul Truck	Combination Short-haul Truck	25	4

Compressor_Engines	Compressor Engines			
Type of Compressors / Pumps	**Rate (Hp)**	**# Units per Well**	**Annual Compression (Hp)**	**Operating Hours/Year**
Wellhead Compressor Engines	100	0.2	20	8,760
Lateral Compressor Engines	0	0	0	0

** no compressor engines are expected to be associated with shale oil wells*

Reclamation	Well Pad Reclamation		
Activity	**Vehicle Type**	**Avg. Vehicle Speed (mph)**	**Total Miles Traveled per Well**
Road and Well Pad Reclamation	Pickup Truck	35	416

Others Traffic	Other Traffic			
Activity	**Vehicle Type**	**Avg. Vehicle Speed (mph)**	**Round Trip Distance (miles)**	**# of Round Trips/Year/well**
Fuel Haul Truck	Combination Short-haul Truck	25	7	0.6

Heaters and Flaring	Heaters		
Wellsite Heaters	**Heater Rating (MMBtu/hr)**	**Annual Hours (hr/yr)**	**No. of Units per Well**
Heaters	0.23	1460	1
Reboilers	0.38	4320	0.007

Ops Dehy	Dehydrators	
Uncontrolled VOC Emissions (tons/mscf)	**Uncontrolled CH4 Emissions (tons/mscf)**	**Uncontrolled CO2 Emissions (tons/mscf)**
2.13E-08	1.55E-05	4.35E-07

APPENDIX E-3

On-road Emission Rates

On-road Emission Factors (grams/mile)

Based on MOVES 2010a model run for rural, unrestricted access road

Heavy Duty = Combination Short-haul Truck, diesel @25mph

Light Duty = Passenger Truck, gasoline @35mph

Year	VOC	CO	NOx	PM10	PM2.5	SO2	CO2	CH4	N2O
Heavy Duty									
2011	0.712	3.943	14.407	1.092	0.934	0.018	2403	0.034	0.003
2012	0.636	3.535	12.744	0.980	0.826	0.018	2402	0.042	0.003
2013	0.562	3.147	11.189	0.874	0.724	0.018	2402	0.049	0.003
2014	0.493	2.775	9.831	0.779	0.631	0.018	2402	0.053	0.003
2015	0.429	2.440	8.612	0.693	0.548	0.018	2402	0.056	0.003
2016	0.372	2.138	7.537	0.617	0.474	0.017	2402	0.059	0.003
2017	0.322	1.874	6.580	0.549	0.408	0.017	2402	0.061	0.003
2018	0.275	1.637	5.748	0.489	0.350	0.017	2402	0.063	0.003
2019	0.236	1.433	5.039	0.440	0.303	0.017	2402	0.065	0.003
2020	0.202	1.261	4.435	0.399	0.263	0.017	2402	0.066	0.003
2021	0.174	1.119	3.941	0.364	0.229	0.017	2402	0.067	0.003
Light Duty									
2011	1.023	12.797	1.488	0.051	0.027	0.010	491	0.052	0.034
2012	0.954	12.056	1.389	0.051	0.027	0.009	485	0.049	0.032
2013	0.889	11.402	1.290	0.050	0.026	0.008	477	0.047	0.029
2014	0.829	10.778	1.191	0.049	0.026	0.008	468	0.046	0.026
2015	0.774	10.174	1.098	0.049	0.025	0.008	460	0.044	0.024
2016	0.714	9.518	1.010	0.048	0.025	0.008	450	0.042	0.022
2017	0.666	9.096	0.928	0.048	0.025	0.008	441	0.040	0.021
2018	0.623	8.718	0.857	0.048	0.024	0.008	432	0.038	0.019
2019	0.584	8.368	0.791	0.047	0.024	0.007	424	0.037	0.018
2020	0.551	8.062	0.734	0.047	0.024	0.007	416	0.036	0.016
2021	0.519	7.796	0.680	0.047	0.024	0.007	409	0.035	0.015