APPENDIX C

BART Cal-Puff Modeling

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Results of CALMET/CALPUFF BART Modeling for Class I Federal Area Individual Source Attribution Visibility Impairment

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Acknowledgements:

The modeling results presented in this report are based on a modeling protocol (Appendix 1). The protocol is based on the EPA-approved modeling protocol submitted by the Colorado Department of Public Health and Environment (CDPHE) Air Pollution control Division (APCD). The only major exception is that a different approach is taken to determine the natural background.

Table of Contents

1. Introduction

This document presents modeling results based on California Air Resources Board (ARB)'s modeling protocol for the initial phase of the Best Available Retrofit Technology (BART) modeling process, referred to as the "subject-to-BART" analysis, which includes SO_2, NO_x, and direct PM_{10} emissions from all BART-eligible units at a given facility. A copy of the protocol is included in Appendix 1.

Code of Federal Regulations Title 40 Part 51 Appendix Y (hereafter referred to as the BART guideline) requires that the BART control equipment be used for any BART-eligible source that ''emits any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility" in any mandatory Class I federal area. Federal Class I areas are defined in the Clean Air Act as national parks over 6,000 acres and wilderness areas and memorial parks over 5,000 acres, established as of 1977. Pursuant to the BART guideline, states have the option of exempting a BART-eligible source from the BART requirements based on dispersion modeling demonstrating that the source cannot reasonably be anticipated to cause or contribute to visibility impairment in a Class I area.

According to the BART guideline, a BART-eligible source is considered to "contribute" to visibility impairment in a Class I area if the modeled 98^{th} percentile change in deciviews is equal to or greater than the "contribution threshold." Deciview (dv) is defined by and calculated directly from the total light extinction coefficient (b_{ext} expressed in inverse mega meters, Mm^{-1}):

$$dv = 10\ln(b_{ext} / 10Mm^{-1})$$

The deciview scale is nearly zero for a pristine atmosphere, and each deciview change corresponds to a small but perceptible scenic change that is observed under either clean or polluted conditions. Any BART-eligible source determined to cause or contribute to visibility impairment in any Class I area is subject to BART. Federal regulations implementing the BART requirement afford states some latitude in the criteria for determining whether a BART-eligible source is subject to BART. The ARB uses the "contribution threshold" of 0.5 deciviews for the 98^{th} percentile 24-hour change in visibility (delta-deciview) because the BART guideline requires that the threshold is not higher than 0.5 deciviews.

Pursuant to the BART guideline and to prepare the submittal of a state implementation plan for regional haze, ARB staff performed air quality modeling with the CALPUFF modeling system to assess which BART-eligible sources in California are likely to be subject to BART. ARB staff applied CALPUFF with three years of meteorological data to determine if the 98th percentile 24-hour change in visibility (delta-deciview) from a BART-eligible source is equal to or greater than a contribution threshold of 0.5 deciviews (dv) at any Class I area.

The results presented in this initial subject-to-BART modeling cover eight BART-eligible sources. As such, additional modeling performed by ARB staff or source operators (with ARB's approval) may supersede these results. Subsequent modeling should use modeling techniques consistent with the recommendations in ARB's protocol and the BART guideline. ARB may approve deviations from this protocol for a specific source if the changes are acceptable to U.S. EPA and improve model performance while retaining consistency with the BART guideline. All modeling will be subject to ARB review and approval.

2. Short Description of Modeling Procedures

The modeling protocol was followed during the entire modeling process. The following is a short description of the steps involved in the modeling.

The modeling domain is shown in Figure 1. Also shown are locations of emission sources and receptors placed in Class I areas. The Lambert Conformal Conic projection modeling domain covers all Class I areas in California and the locations of California's BART-eligible sources that are required to do detailed modeling and analysis. The domain also includes Class I areas in nearby states that are potentially impacted by California BART-eligible sources. The modeling domain is extended by 50-km beyond all sources and Class I areas to capture potential recirculation of pollutants. The CALMET/CALPUFF domain is 1332 km x 1332 km in the longitudinal and meridional directions, respectively, with 4-kilometer grid resolution.

CALMET meteorological modeling has been conducted with three years of meteorological data. In the CALMET modeling, surface observational data collected at 279 stations and MM5 data generated by the prognostic meteorological model, MM5, along with geophysical data, are used.

CALPUFF uses CALMET output data and hourly ozone observational data as its input. CALPUFF generates hourly concentration data for visibility impact analysis.

The visibility impact analysis is performed with CALPOST. CALPOST processes the hourly, model-simulated concentration data. CALPOST calculates the visibility impact taking into account background concentrations of visibility-impairing pollutants and a relative humidity adjustment factor published by the U.S. EPA (1993).

3. Emission Data and Modeling Results

This section is organized by subject-to-BART facilities: each subsection describes emission data for an individual facility along with the corresponding visibility impairment modeling results. Visibility impairment pollutants included in the modeling are SO_2, NO_x and PM_{10}. Emission rates of sulfate, nitrate, elemental carbon, organic carbon, coarse particulates and soil are all set to zero but the background concentrations of these pollutants are considered in the post-processing stage so that their effects on visibility are taken into account to characterize natural conditions in Class I areas. Figure 1 gives an overview of the eight source locations and Class I areas.

The BART guideline requires that the 98^{th} percentile daily (24-hour) average of visibility impact be lower than 0.5 dv. Because there are 365 or 366 days in a year, 2 percent of total number of days in a year is 7 days plus a fraction of a day. Therefore the 98^{th} percentile of daily average will be the 8^{th} highest in a year.

Table 3.0.1 summarizes the maximum visibility impact on Class I areas from the BART-eligible sources, during the baseline years (2000-2002.)

Table 3.0.1. Summary of Visibility Impact

Facility	Maximum Impact (in deciviews)	Outcome (exceeds the 0.500 dv threshold?)
Conoco-Phillips Refinery and Carbon Plant in Bay Area	0.366	Does not exceed
Reliant Alta Boilers in Mojave Desert	0.489	Does not exceed
Searles Valley Minerals in Mojave Desert	0.208	Does not exceed
Rhodia Sulfuric Acid Plant in Bay Area	0.092	Does not exceed
Valero Refining Company in Bay Area	0.758*	Exceeds
Shell Refining Company in Bay Area	0.169	Does not exceed
Tesoro Marketing and Refining in Bay Area	0.069	Does not exceed
Chevron USA Inc in Bay Area	0.393	Does not exceed

* does not reflect proposed emission controls

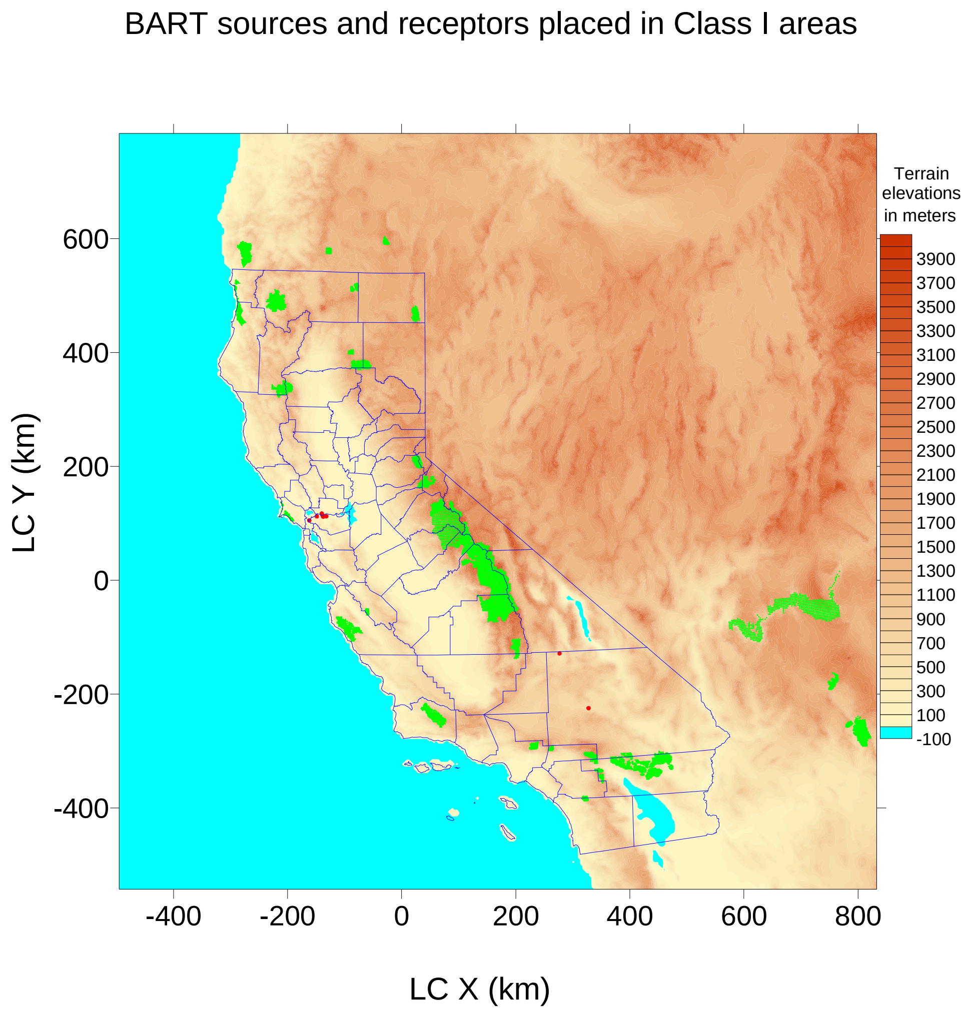

Figure 1. Class I areas and subject-to-BART sources for which initial visibility impairment analysis has been conducted.

3.1. Conoco-Phillips Refinery and Carbon Plant in Bay Area

3.1.1. Description of Emission Sources

The Conoco-Phillips Refinery and Carbon Plant is located at 2101 Franklin Canyon Road in Rodeo, California. There are 17 emission units that are considered as BART-eligible, of which the most significant emission source is a kiln that releases SO_2, NO_x and PM_{10}. The latitude and longitude of the kiln are 38°01'11.04" and 122°14'14.7'', respectively. Specifications of the major unit needed in the modeling are listed in Table 3.1.1. Units with emission totals less than 1 ton per day are included in the modeling but not shown in the table.

Table 3.1.1. Source and Emission Parameters of Conoco-Phillips Refinery and Carbon Plant

Source Description	Base Ev. (m)	Stack Height (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temp. (K)	SO_2 (g/s)	NO_x (g/s)	PM_{10} (g/s)
Kiln	42.98	45.72	4.17	4.35	505.3	31.528	11.035	5.044

3.1.2. Visibility Impact Analysis

With three years worth of meteorological data, the modeling analysis shows that the visibility impact by the Conoco Phillips Refinery and Carbon Plant does not exceed 0.5 dv. Table 3.1.2 lists the 8^{th} highest visibility impact, name of the Class I area that is impacted the most and number of Class I areas on which the BART-eligible source exerts an impact greater than or equal to 0.500 dv.

Table 3.1.2. Visibility Impact Calculated with Three Years Worth of Meteorological Data

Modeling Year	The 8^{th} highest visibility impact (in deciview)	Names of Class I areas with impact greater than 0.500 dv
2000	0.366	None
2001	0.343	None
2002	0.307	None

Because the 8^{th} highest visibility impact does not exceed the 0.5 dv threshold, there is no need for a BART determination

3.2. Reliant Alta (Coolwater) Boilers in Mojave Desert

3.2.1. Description of Emission Sources

The Reliant Alta (Coolwater) Boilers are located at 37072 East Sante Fe Road in Daggett, California. Five emission units are considered as BART-eligible: a group of one boilers and turbines with five stacks that release SO2, NOx and PM10. The latitude and longitude of the units are 34°50’17.88” and 116°47’53.52’’, respectively. Specifications of the units needed in the modeling are listed in Table 3.2.1.

Table 3.2.1. Source and Emission Parameters of Alta (Coolwater) Boiler

Source Description	Base Ev. (m)	Stack Height (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temp. (K)	SO_2 (g/s)	NO_x (g/s)	PM_{10} (g/s)
Boiler 1078	597.4	44.50	3.2	12.8	394.3	0.0657	12.698	0.214
Turbine 1079	597.4	21.64	5.49	10.61	449.8	0.102	19.65	0.315
Turbine 1080	597.4	21.64	5.49	10.61	449.8	0.0883	16.87	0.315
Turbine 1081	597.4	21.64	5.49	10.61	449.8	0.105	19.2	0.315
Turbine 1082	597.4	21.64	5.49	10.61	449.8	0.106	19.7	0.315

3.2.2. Visibility Impact Analysis

With three years worth of meteorological data, the modeling analysis shows that the visibility impact by the Reliant Alta (Coolwater) Units does not exceed 0.5 dv. Table 3.2.2 lists the 8th highest visibility impact, name of the Class I area that is mostly impacted and number of Class I areas on which the BART-eligible source exerts an impact greater than or equal to 0.5 dv.

Table 3.2.2. Visibility Impact Calculated with Three Years Worth of Meteorological Data

Modeling Year	The 8th highest visibility impact (in deciview)	Names of Class I areas with impact greater than 0.500 dv
2000	0.489	None
2001	0.406	None
2002	0.288	None

Because the 8th highest visibility impact does not exceed the 0.5 dv threshold, there is no need for a BART determination.

3.3. Searles Valley Minerals in Mojave Desert

3.3.1. Description of Emission Sources

The Searles Valley Minerals facility is located at 12801 Maripose Street in Trona, California. Two emission units are considered BART-eligible: two boilers with two stacks that release SO_2, NO_x and PM_{10}. The latitude and longitude of the boilers are 35°46'8.04" and 117°22'53.76'', respectively. Specifications of the units needed in the modeling are listed in Table 3.3.1.

Table 3.3.1. Source and Emission Parameters of Searles Valley Minerals

Source Description	Base Ev. (m)	Stack Height (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temp. (K)	SO_2 (g/s)	NO_x (g/s)	PM_{10} (g/s)
Argus 554	510.5	64.01	3.505	13.589	325.9	2.748	23.262	0.930
Argus 555	510.8	64.31	3.505	13.594	326.5	3.195	23.252	0.967

3.3.2. Visibility Impact Analysis

With three years worth of meteorological data, the modeling analysis shows that the visibility impact by the Searles Valley Minerals' boilers does not exceed 0.5 dv. Table 3.3.2 lists the 8th highest visibility impact, name of the Class I area that is mostly impacted and number of Class I areas on which the BART-eligible source exerts an impact greater than or equal to 0.5 dv.

Table 3.3.2. Visibility Impact Calculated with Three Years Worth of Meteorological Data

Modeling Year	The 8th highest visibility impact (in deciview)	Names of Class I areas with impact greater than 0.500 dv
2000	0.192	None
2001	0.103	None
2002	0.208	None

Because the 8th highest visibility impact does not exceed the 0.5 dv threshold, there is no need for a BART determination.

3.4. Rhodia Sulfuric Acid Plant in Bay Area

3.4.1. Description of Emission Sources

The Rhodia Sulfuric Acid Plant is located at 100 Macoco Road in Martinez, California. Two emission units are considered as BART-eligible, one of which is a sulfuric acid plant stack that releases SO_2, NO_x and PM_{10}. The other emission unit, a combination of cooling towers, is included in the modeling but not shown in the following table because of its low emissions. The latitude and longitude of the plant are 38°01’59.8” and 122°06’59.8’’, respectively. Specifications of the major unit needed in the modeling are listed in Table 3.4.1.

Table 3.4.1. Source and Emission Parameters of Rhodia Sulfuric Acid Plant

Source Description	Base Ev. (m)	Stack Height (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temp. (K)	SO_2 (g/s)	NO_x (g/s)	PM_{10} (g/s)
Sulfuric acid plant	19.81	28.96	2.13	9.75	308.15	18.29	0.513	0.397

3.4.2. Visibility Impact Analysis

With three years worth of meteorological data, the modeling analysis shows that the visibility impact by the Rhodia Acid Plant does not exceed 0.5 dv. Table 3.4.2 lists the 8th highest visibility impact, name of the Class I area that is impacted the most and number of Class I areas on which the BART-eligible source exerts an impact greater than or equal to 0.5 dv.

Because the 8th highest visibility impact does not exceed the 0.5 dv threshold, there is no need for a BART determination.

Table 3.4.2. Visibility Impact Calculated with Three Years Worth of Meteorological Data

Modeling Year	The 8th highest visibility impact (in deciview)	Names of Class I areas with impact greater than 0.500 dv
2000	0.092	None
2001	0.069	None
2002	0.081	None

3.5. Valero Refining Company in Bay Area

3.5.1. Description of Emission Sources

The Valero Refining Company is located at 3400 East 2nd Street in Benicia, California. There are 12 stacks collecting emissions from 17 units that are considered BART-eligible, of which the most significant emission source is a single stack, which is referred to as p1 main stack, collecting emissions from a crude preheat process furnace, a reduced crude preheat process furnace, a FCCU regenerator, and a coker. The latitude and longitude of the plant are 38°04'25.83" and 122°07'57.43'', respectively. Specifications of the major unit needed in the modeling are listed in Table 3.5.1. Units with emission totals less than 1 ton per day are included in the modeling but not shown in the table. In the table the source 'P1 main stack' received the SO_2, NO_x, and PM_{10} emissions from several units including the coker, crude preheat F-101, reduced preheat F-102, and FCCU regenerator R702.

Table 3.5.1. Source and Emission Parameters of Valero Refining Company

Source Description	Base Ev. (m)	Stack Height (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temp. (K)	SO_2 (g/s)	NO_x (g/s)	PM_{10} (g/s)
P1 main stack	28.96	141.73	4.57	22.31	607.6	179.18	21.754	5.15

3.5.2. Visibility Impact Analysis

With three years worth of meteorological data, the modeling analysis shows that the visibility impact by the Valero Refining Company exceeds 0.5 dv. Table 3.5.2 lists the 8th highest visibility impact, name of the Class I area that is impacted the most, and number of Class I areas on which the BART-eligible source exerts an impact greater than or equal to 0.500 dv.

Because of the exceedance of the 0.5 dv threshold, control options must be evaluated for the source. A visibility impact analysis must be conducted for each proposed emission control measure. This analysis is part of the BART determination.

Table 3.5.2. Visibility Impact Calculated with Three Years Worth of Meteorological Data

Modeling Year	The 8th highest visibility impact (in deciview)	Names of Class I areas with impact greater than 0.500 dv
2000	0.758	Point Reyes National Seashore
2001	0.547	Point Reyes National Seashore
2002	0.524	Point Reyes National Seashore

Two emission reduction strategies were proposed for evaluation of their visibility impact. The maximum 24-hour emissions for normal operations were provided by the Bay Area Air Quality Management District. One emission reduction strategy (g1) was to reduce SO2, NOx and PM10 emissions from the coker, crude preheat F-101, reduced preheat F-102, and FCCU regenerator R702 that would be routed to a new main stack, and NO_x control on units that would be routed to the p30 west stack and the p31 stack. The other emission reduction strategy (g2) would, beyond g1, further reduce NO_x emissions from units that would be routed to the p19 west stack, p20 west stack, p17 west stack, p18 east stack, p24 stack and p25 stack. After the controls are placed, the emission unit with highest emissions is the new main stack, but the SO_2 emission rate is significantly reduced. For both g1 and g2, a new main stack will replace the existing p1 main stack. Therefore, some of the emission parameters will be different from what are shown in Table 3.5.1. Emission parameters for the new main stack are shown in Table 3.5.3.

Table 3.5.3. Emission Parameters of the New p1 Main Stack

Source Description	Base Ev. (m)	Stack Height (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temp. (K)
New main stack	17.53	65.53	4.57	25.07	378.98

Table 3.5.4 provides emission changes in grams/second while Table 3.5.5 provides percentage changes from baseline. Blank cells under the g1 or g2 columns denote that emissions are the same as baseline. The highlighted areas of the tables show that the g1 and g2 scenarios differ only in the treatment of NO_x from stacks P17-P20 and P24-P25.

Modeling analyses were conducted with the two emission reduction strategies. For g1 and g2, Tables 3.5.6 and 3.5.7 list, respectively, the 8th highest visibility impact, name of the Class I area that is impacted the most and number of Class I areas on which the BART-eligible source exerts an impact greater than or equal to 0.500 dv.

Table 3.5.4. Existing Emission Rates with Corresponding G1 and G2 **Rate (g/s)** Changes* from Existing

Source Description	SO2 (g/s)		PM10 (g/s)		NOx (g/s)		
	Existing	g1 & g2	Existing	g1 & g2	Existing	g1	g2
Cooling Tower	0.00		1.16		0.00		
New Main Stack	179.18	-167.20	5.15	-0.32	21.75	-4.52	
P30	0.21	0.11	0.21		1.37	-0.95	
P31	0.21	0.11	0.21	-0.11	1.37	-1.05	
P47	0.21		0.42		1.16		
P50	0.00		0.00		0.02		
P17	0.05		0.11		2.42		-2.10
P18	0.05		0.11		2.42		-2.10
P19	0.11		0.11		2.83		-2.41
P20	0.11		0.11		2.83		-2.41
P24	0.05		0.11		2.10		-1.79
P25	0.05		0.11		2.10		-1.79

* Blank cells have no change from baseline.

Table 3.5.5. Existing Emission Rates with Corresponding g1 and g2 **Percentage (%)** Changes* from Existing

Source Description	SO2 (g/s)		PM10 (g/s)		NOx (g/s)		
	Existing	g1 & g2	Existing	g1 & g2	Existing	g1	g2
Cooling Tower	0.00		1.16		0.00		
New Main Stack	179.18	-93%	5.15	-6%	21.75	-21%	
P30	0.21	+50%	0.21		1.37	-69%	
P31	0.21	+50%	0.21	-50%	1.37	-77%	
P47	0.21		0.42		1.16		
P50	0.00		0.00		0.02		
P17	0.05		0.11		2.42		-87%
P18	0.05		0.11		2.42		-87%
P19	0.11		0.11		2.83		-85%
P20	0.11		0.11		2.83		-85%
P24	0.05		0.11		2.10		-85%
P25	0.05		0.11		2.10		-85%

* Blank cells have no change from baseline.

Table 3.5.6. Visibility Impact Calculated with Three Years Worth of Meteorological Data (with emission reduction strategy g1)

Modeling Year	The 8th highest visibility impact (in deciview)	Names of Class I areas with impact greater than 0.500 dv
2000	0.225	None
2001	0.291	None
2002	0.259	None

Table 3.5.7 shows that g2 provides an additional reduction of 0.091 dv over g1 for modeling year 2001.

Table 3.5.7. Visibility Impact Calculated with Three Years Worth of Meteorological Data (with emission reduction strategy g2)

Modeling Year	The 8th highest visibility impact (in deciview)	Names of Class I areas with impact greater than 0.500 dv
2000	0.189	None
2001	0.200	None
2002	0.160	None

3.6. Shell Refining Company in Bay Area

3.6.1. Description of Emission Sources

The Shell Refining Company is located at 3485 Pacheco Blvd in Martinez, California. Four emission units are considered BART-eligible, of which the most significant emission source is a boiler that releases SO_2, NO_x and PM_{10}. The latitude and longitude of the boiler are 38°00'49.93" and 122°06'46.48'', respectively. Specifications of the major unit needed in the modeling are listed in Table 3.6.1. Units with emission totals less than 1 ton per day are included in the modeling but not shown in the table.

Table 3.6.1. Source and Emission Parameters of Shell Refining Company

Source Description	Base Ev. (m)	Stack Height (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temp. (K)	SO_2 (g/s)	NO_x (g/s)	PM_{10} (g/s)
Boiler	17.00	49.00	2.40	15.44	550.2	18.843	9.784	0.546

3.6.2. Visibility Impact Analysis

With three years worth of meteorological data, the modeling analysis shows that the visibility impact by the Shell Refining Company does not exceed 0.5 dv. Table 3.6.2 lists the 8th highest visibility impact, name of the Class I area that is impacted the most and number of Class I areas on which the BART-eligible source exerts an impact greater than or equal to 0.500 dv.

Table 3.6.2. Visibility Impact Calculated with Three Years Worth of Meteorological Data

Modeling Year	The 8th highest visibility impact (in deciview)	Names of Class I areas with impact greater than 0.500 dv
2000	0.126	None
2001	0.169	None
2002	0.139	None

Because the 8th highest visibility impact does not exceed the 0.5 dv threshold, there is no need for a BART determination.

3.7. Tesoro Marketing and Refining in Bay Area

3.7.1. Description of Emission Sources

The Tesoro Marketing and Refining is located at 150 Solano Way in Martinez, California. There are four emission units that are considered as BART-eligible, of which the most significant emission source is a sulfur recovery unit with one stack that releases SO_2, NO_x and PM_{10}. The latitude and longitude of the sulfur recovery unit are 38°01'39.07" and 122°03'25.20'', respectively. Specifications of the major unit needed in the modeling are listed in Table 3.7.1. Units with emission totals less than 1 ton per day are included in the modeling but not shown in the table.

Table 3.7.1. Source and Emission Parameters of Tesoro Marketing and Refining

Source Description	Base Ev. (m)	Stack Height (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temp. (K)	SO_2 (g/s)	NO_x (g/s)	PM_{10} (g/s)
Sulfur Recovery	7.01	106.68	1.83	0.82	535.9	10.648	0.016	0.00

3.7.2. Visibility Impact Analysis

With three years worth of meteorological data, the modeling analysis shows that the visibility impact by the Tesoro Marketing and Refining does not exceed 0.5 dv. Table 3.7.2 lists the 8th highest visibility impact, name of the Class I area that is impacted the most and number of Class I areas on which the BART-eligible source exerts an impact greater than or equal to 0.500 dv.

Because the 8th highest visibility impact does not exceed the 0.5 dv threshold, there is no need for a BART determination.

Table 3.7.2. Visibility Impact Calculated with Three Years Worth of Meteorological Data

Modeling Year	The 8th highest visibility impact (in deciview)	Names of Class I areas with impact greater than 0.500 dv
2000	0.068	None
2001	0.055	None
2002	0.069	None

3.8. Chevron USA Inc. in Bay Area

3.8.1. Description of Emission Sources

The Chevron USA Inc. is located at 841 Chevron Way in Richmond, California. There are 38 emission units emitting to 31 stacks that are considered BART-eligible, of which the most significant emission source is a H2 reforming furnace that releases SO_2, NO_x and PM_{10}. The latitude and longitude of the H2 reforming furnace are 37°56'49.87" and 122°23'43.19'', respectively. Specifications of the major unit needed in the modeling are listed in Table 3.8.1. Units with emission totals less than 1 ton per day are included in the modeling but not shown in the table.

Table 3.8.1. Source and Emission Parameters of Chevron USA Inc.

Source Description	Base Ev. (m)	Stack Height (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temp. (K)	SO_2 (g/s)	NO_x (g/s)	PM_{10} (g/s)
H2 Reforming Furnace	2.70	49.38	2.80	16.20	644.3	0.339	20.494	0.722

3.8.2. Visibility Impact Analysis

With three years worth of meteorological data, the modeling analysis shows that the visibility impact by the Chevron USA Inc. does not exceed 0.5 dv.
Table 3.8.2 lists the 8th highest visibility impact, name of the Class I area that is impacted the most and number of Class I areas on which the BART-eligible source exerts an impact greater than or equal to 0.500 dv.

Because the 8th highest visibility impact does not exceed the 0.5 dv threshold, there is no need for a BART determination. Also, controls will be placed on the reforming furnace reducing the baseline emissions from what was modeled. A consent decree imposes a limit on the H2 Reforming Furnace of 0.021 lb NOx/MMbtu.

Table 3.8.2. Visibility Impact Calculated with Three Years Worth of Meteorological Data

Modeling Year	The 8th highest visibility impact (in deciview)	Names of Class I areas with impact greater than 0.500 dv
2000	0.385	None
2001	0.393	None
2002	0.371	None

Reference:

"Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule." U.S. EPA, EPA-454/B-03-005. September 2003.

Appendix 1. Modeling Protocol: CALMET/CALPUFF BART Protocol for Class I Federal Area Individual Source Attribution Visibility Impairment Modeling Analysis

CALMET/CALPUFF BART Protocol for Class I Federal Area Individual Source Attribution Visibility Impairment Modeling Analysis

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August 2007

Acknowledgements:

This modeling protocol is based on the EPA-approved modeling protocol submitted by the Colorado Department of Public Health and Environment (CDPHE) Air Pollution control Division (APCD). The only major exception is that a different approach is taken to determine the natural background.

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4. Introduction

Federal law requires Best Available Retrofit Technology (BART) for any BART-eligible source that ‘‘emits any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility” in any mandatory Class I federal area. Pursuant to federal regulations, states have the option of exempting a BART-eligible source from the BART requirements based on dispersion modeling demonstrating that the source cannot reasonably be anticipated to cause or contribute to visibility impairment in a Class I area.

According to 40 CFR Part 51, Appendix Y (BART guideline), a BART-eligible source is considered to “contribute” to visibility impairment in a Class I area if the modeled 98th percentile change in deciviews is equal to or greater than the “contribution threshold.” Deciview (dv) is defined by and calculated directly from the total light extinction coefficient (b_{ext} expressed in Mm^{-1}):

$$dv = 10\ln(b_{ext} / 10Mm^{-1})$$

The deciview scale is nearly zero for a pristine atmosphere, and each deciview change corresponds to a small but perceptible scenic change that is observed under either clean or polluted conditions. Any BART-eligible source determined to cause or contribute to visibility impairment in any Class I area is subject to BART. Federal regulations implementing the BART requirement afford states some latitude in the criteria in determining whether a BART-eligible source is subject to BART. The ARB sets a “contribution threshold” of 0.5 deciviews for the 98th percentile 24-hour change in visibility (delta-deciview) because the BART guideline requires that the threshold not be higher than 0.5 deciviews.

This document serves as ARB’s modeling protocol for the initial phase of the BART modeling process, referred to as the “subject-to-BART” analysis, which includes SO_2, NO_x, and direct PM_{10} emissions from all BART-eligible units at a given facility.

Pursuant to the BART guideline and to prepare the submittal of a state implementation plan for regional haze, ARB staff will perform air quality modeling with the CALPUFF modeling system to assess which BART-eligible sources in California are likely to be subject to BART. ARB staff will apply CALPUFF with three years of meteorological data to determine if the 98th percentile 24-hour change in visibility (delta-deciview) from a BART-eligible source is equal to or greater than a contribution threshold of 0.5 deciviews at any Class I area.

ARB staff will use this protocol for the initial subject-to-BART modeling. However, additional modeling performed by ARB staff or source operators may supersede the results. Subsequent modeling should use modeling techniques consistent with the recommendations in this protocol and the BART guideline. ARB may approve deviations from this protocol for a specific source if the changes are acceptable to U.S. EPA and improve model performance while retaining consistency with the BART guideline. All modeling will be subject to ARB review and approval.

Relevant language from the BART guideline is included to show the modeling recommendations in context. Other sections of this protocol explain how the ARB proposes to implement the recommendations. The BART guidelines set out in 40 CFR Part 51, Appendix Y, are provided in part in Appendix _.

4.1. Visibility Calculations

The general theory for performing visibility calculations with the CALPUFF modeling system is described in several documents, including:

- "Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report and Recommendations for Modeling Long Range Transport Impacts" (IWAQM, 1998)
- "Federal Land Manager's Air Quality Related Values Workgroup (FLAG): Phase I Report" (FLAG, 2000)
- "A User's Guide for the CALPUFF Dispersion Model" (Scire, 2000)

In general, visibility is characterized either by visual range (the greatest distance that a large object can be seen) or by the light extinction coefficient, which is a measure of the light attenuation per unit distance due to scattering and absorption by gases and particles.

Visibility is impaired when light is scattered in and out of the line of sight and by light absorbed along the line of sight. The light extinction coefficient (b_{ext}) considers light extinction by scattering (b_{scat}) and light extinction by absorption (b_{abs}):

$$b_{ext} = b_{scat} + b_{abs}$$

The scattering components of extinction (b_{scat}) can be represented by these components:

- light scattering due to air molecules = Rayleigh scattering = $b_{rayleigh}$
- light scattering due to particles = b_{sp}

Additionally, particle scattering, b_{sp}, can be expressed by its components:

$$b_{sp} = b_{SO4} + b_{NO3} + b_{OC} + b_{SOIL} + b_{Coarse}$$

where:

b_{SO4} = scattering coefficient due to sulfates = $3[(NH_4)_2SO_4]f(RH)$
b_{NO3} = scattering coefficient due to nitrates = $3[NH_4NO_3]f(RH)$
b_{OC} = scattering coefficient due to organic aerosols = 4[OC]
b_{SOIL}= scattering coefficient due to fine particles = 1[Soil]
b_{Coarse}= scattering coefficient due to coarse particles = 0.6[Coarse Mass]

The f(RH) term is the relative humidity adjustment factor. The Federal Land Manager's Air Quality Related Values Workgroup (FLAG) (1999) recommends using historic averages of f(RH) for the Class I area(s) of concern. There exist several tabulations of monthly f(RH) values. In this modeling protocol we recommend using the US EPA 2003 tabulation (U.S. EPA, 2003, EPA-454/B-03-005) of f(RH).

The absorption components of extinction (b_{abs}) can be represented by these components:

- light absorption due to gaseous absorption = b_{ag}
- light absorption due to particle absorption = b_{ap}

According to FLAG (2000), nitrogen dioxide is the only major light-absorbing gas in the lower atmosphere; it generally does not affect hazes. Therefore only particle absorption is considered in the visibility analysis. Particle absorption from soot is defined as:

- b_{ap} = absorption due to elemental carbon (soot) = 10[EC]

The concentration values (in brackets) are expressed in micrograms per cubic meter. The numeric coefficient at the beginning of each equation is the dry scattering or absorption efficiency in meters-squared per gram.

Based on the discussion of scattering and absorption components above, the simple total atmospheric extinction equation provided on the prior page can be expanded and expressed as:

$$b_{ext} = (b_{SO4} + b_{NO3} + b_{OC} + b_{SOIL} + b_{Coarse}) + 10[EC] + b_{rayleigh}$$

In this equation, the sulfate (SO_4) and nitrate (NO_3) components are referred to as hygroscopic components because the extinction coefficient depends upon relative humidity. The other components are non-hygroscopic.

The CALPUFF modeling will provide ground level concentrations of visibility impairing pollutants such as sulfate and nitrate. These ground level concentrations will be used to calculate the extinction coefficient, b_{ext}, with the equations described above. Similarly, an extinction coefficient can be calculated for background concentrations of visibility impairing pollutants. If the extinction coefficient due to pollutants emitted from the BART source of concern is denoted as b_{source}, and the extinction coefficient due to background concentrations is denoted as $b_{background}$, then the delta-deciview, Δdv, value can be calculated as follows:

$$\Delta dv = 10\ ln((b_{background} + b_{source}) / b_{background}).$$

The delta-deciview is the change in visibility caused by the visibility impairing pollutants from the BART source of concern.

5. Emission Estimates

According to the BART guideline,

> "*The emissions estimates used in the models are intended to reflect steady-state operating conditions during periods of high capacity utilization. We do not generally recommend that emissions reflecting periods of start-up, shutdown, and malfunction be used, as such emission rates could produce higher than normal effects than would be typical of most facilities. We recommend that States use the 24 hour average actual emission rate from the highest emitting day of the meteorological period modeled, unless this rate reflects periods start-up, shutdown, or malfunction*."

Short-term emission rates (≤ 24-hours) should be modeled since visibility impacts are calculated for a 24-hour averaging period. SO_2, NO_x, and PM_{10} (including condensable and filterable direct PM_{10}[1]) should be modeled from all BART-eligible units at the facility. ARB staff will initially use allowable emission rates or federally enforceable emission limits. If 24-hour emissions limits do not exist, limits of a different averaging period may be used. Specifically, if limits do not exist, maximum hourly emissions based on emission factors and design capacity may be used.

If the source operator elects to develop emission rates for subject-to-BART modeling, case-by-case procedures should be developed in consultation with ARB staff. In general, the following emission rates are acceptable:

[1] Common speciated PM species for CALPUFF include fine particulate matter (PMF), coarse particulate matter (PMC), soot or elemental carbon (EC), organic aerosols (SOA), and sulfate (SO_4). H_2SO_4, for example, is a PM_{10} species emitted from coal-fired units that is typically modeled as SO_4 in CALPUFF.

- Short-term (≤ 24-hours) allowable emission rates (e.g., emission rates calculated using the maximum rated capacity of the source).
- Federally enforceable short-term limits (≤ 24-hours).
- Peak 24-hour actual emission rates (or calculated emission rates) from the most recent 3 to 5 years of operation that account for "high capacity utilization" during normal operating conditions and fuel/material flexibility allowed under the source's permit. In situations where a unit is allowed to use more than one fuel, the fuel resulting in the highest emission rates should be used for the modeling, even if that fuel has not been used in the last 3 to 5 years.

If short-term rates are not available, emissions rates based on averaging periods longer than 24-hours are acceptable only in cases where the modeling shows that the source has impacts equal to or greater than the contribution threshold.

6. CALMET/CALPUFF Modeling Methodology

For the subject-to-BART modeling, ARB staff will follow recommendations made by the CALPUFF developer to set model parameters and adjust some default settings to be more representative of terrain features in California.

ARB staff will use this protocol in the initial subject-to-BART modeling. However, the initial modeling may be superseded by additional modeling performed by ARB staff or the source operator. Subsequent modeling should use modeling techniques consistent with the recommendations in this protocol and the BART guideline. All modeling will be subject to review and approval by the ARB. The ARB may approve deviations from this protocol for a specific source if the changes are acceptable to U.S. EPA and improve model performance while retaining consistency with the BART guideline. This protocol is intended to provide sufficient technical documentation to support the application of CALPUFF at distances up to 300 kilometers. Impacts at Class I areas greater than 300 km may be used, but it should be recognized that the use of puff splitting in CALPUFF would provide more accurate results for Class I areas beyond 300km.

According to the "*Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report and Recommendations for Modeling Long Range Transport Impacts*" (IWAQM Phase 2 Report):

In the context of the Phase 2 recommendation, the focus of the visibility analysis is on haze. These techniques are applicable in the range of thirty to fifty kilometers and beyond from a source. At source-receptor distances less than thirty to fifty kilometers, the techniques for analyzing visual plumes (sometimes referred to as 'plume blight') should be applied.

6.1. CALMET/CALPUFF Model Selection

The following versions will be used:

CALPUFF: version 5.754, level 060202,
CALMET: version 5.724, level 060414,
CALPOST: version 5.6393, level 060202.

This version of the CALPUFF modeling system is recommended by the Visibility Improvement State and Tribal Association of the Southeast (VISTAS) for BART analyses. The use of CALPUFF is recommended in 40 CFR 51 Appendix Y (BART guideline). The primary niche for CALPUFF is as a long-range transport model. It is a multi-layer, non-steady-state puff dispersion model that can simulate the effects of time- and space-varying meteorological conditions on pollutant transport, chemical transformations, vertical wind shear, and deposition (Scire, 2000).

6.1.1. CALMET

CALMET is a diagnostic meteorological model. It has been under constant update and improvement by the developer (Scire, 2000). For this particular study, the model uses a Lambert Conformal Projection coordinate system to account for the Earth's curvature.

CALMET uses a two-step approach to calculate wind fields. In the first step, an initial-guess wind field is adjusted for slope flows and terrain blocking effects, for example, to produce a Step 1 wind field. In the second step, an objective analysis is performed to introduce observational data into the Step 1 wind field.

In this application, the initial guess wind fields are based on 12-km resolution MM5 meteorological fields for 2000 and 2002 and 36-km MM5 data for 2001 (i.e., in CALMET IPROG is set to 14). The MM5 files for 2000 were generated by ARB staff and the MM5 files for 2001 and 2002 were provided by WRAP. Because the 2000 MM5 data were generated specifically for applications in California, the data may be more reliable and more representative of the meteorological conditions of California. If modeling results for visibility impairment are substantially different for different years, more weight should be given to the year 2000 result.

The BART guideline does not specify the exact number of years of mesoscale meteorological data to be used in CALPUFF for subject-to-BART determination, but according to 40 CFR 51 Appendix W, at least three years of meteorological data should be used. Five years of meteorological data is preferable. At the time of developing this protocol and during the process of carrying out CALPUFF modeling and analysis, five years of mesoscale meteorological data will not be readily available at reasonable grid resolutions for California; therefore this protocol proposes to use three years of meteorological data for the CALMET/CALPUFF modeling.

6.1.1.1. CALMET Modeling Domain

The modeling domain is shown in Figure 1. Also shown are locations of receptors to be placed in Class I areas. It is based on a Lambert Conformal Conic projection. The domain covers all Class I areas in California and the locations of Californa's BART-eligible sources that are required to do detailed modeling and analysis. The domain also includes Class I areas in nearby states that are potentially impacted by California BART-eligible sources. The modeling domain is extended by 50-km beyond all sources and Class I areas to capture potential recirculation of pollutants. The CALMET domain is 1332 km x 1332 km in the longitudinal and meridional directions, respectively, with 4-kilometer grid resolution. This modeling domain will be used to generate a unified meteorological data set so that it can be used in CALPUFF modeling for all BART-eligible sources.

If a source operator elects to perform additional subject-to-BART modeling beyond ARB's initial modeling using a different CALMET/CALPUFF setup, the ARB may approve a smaller modeling domain on a case-by-case basis.
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BART sources and receptors placed in Class I areas

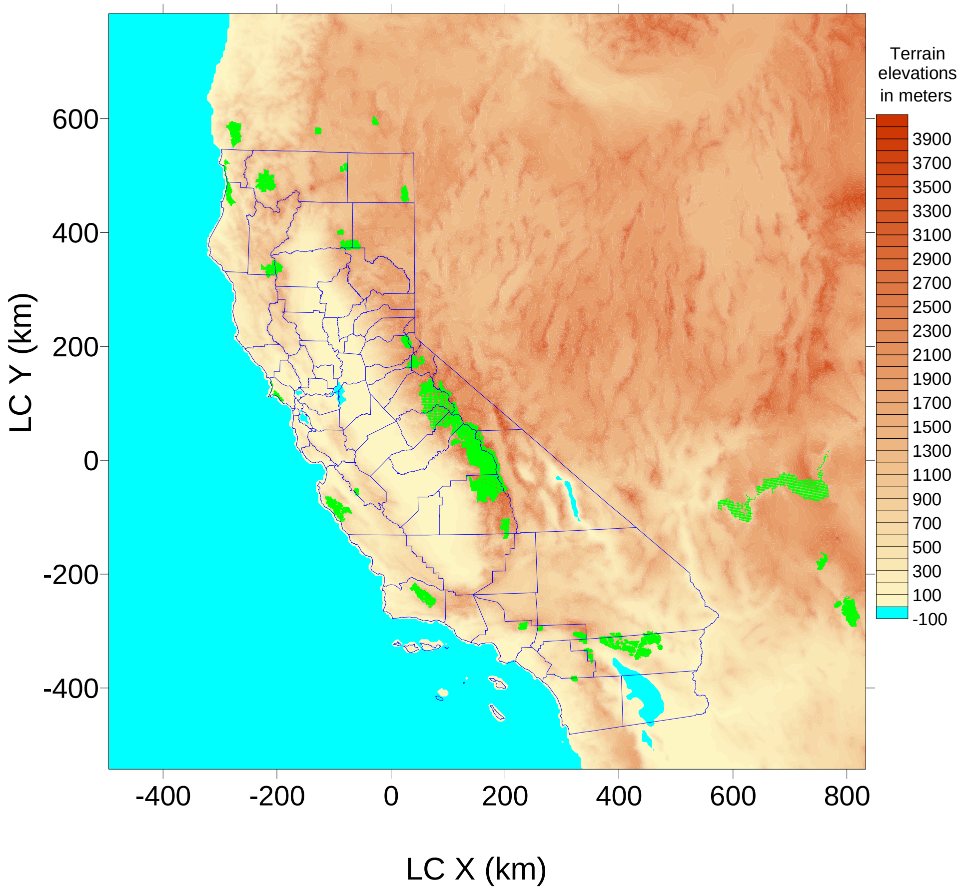

Figure 1. CALMET/CALPUFF modeling domain.

6.1.1.2. CALMET Performance Evaluation

The meteorological fields developed by the MM5/CALMET modeling system will be checked selectively as well as randomly for reasonableness using visualization tools. The reasonableness includes consistency of wind fields with terrain forcing, and diurnal variations of both wind and temperature fields. A comprehensive evaluation will not be conducted because of the lack of model performance evaluation guidelines

6.1.1.3. Terrain

Gridded terrain elevations for the modeling domain are derived from 3 arc-second digital elevation models (DEMs) produced by the United States Geological Survey (USGS). The files cover 1-degree by 1-degree blocks of latitude and longitude. USGS 1:250,000 scale DEMs were used. These DEM data have a resolution of about 90 meters. Terrain elevations are shown in Figure 1.

6.1.1.4. Land Use

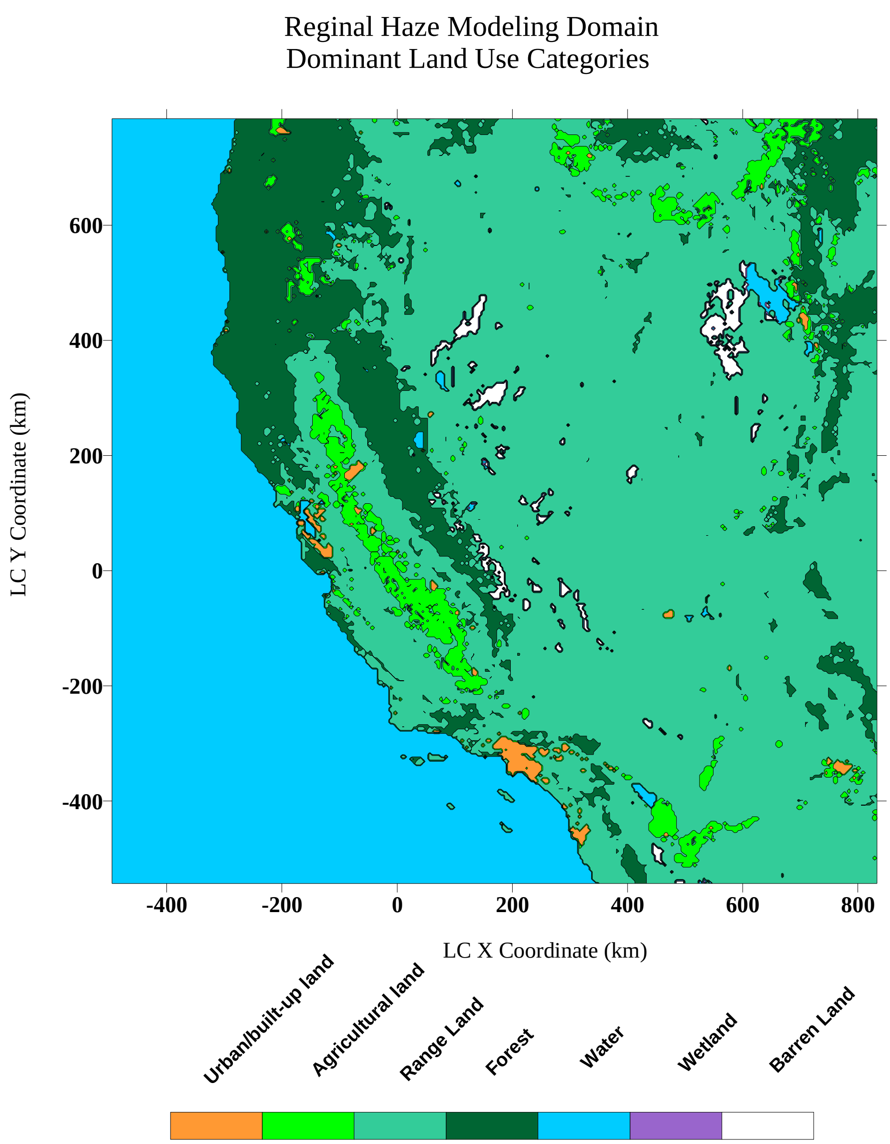

Figure 2. CALMET land use categories.

The land use data are based on the Composite Theme Grid format (CTG) using Level I USGS land use categories. The USGS land use categories will be mapped into 14 CALMET land use categories. Land use categories in the modeling domain are shown in Figure 2. The land use categories are described in Table 1.

Default CALMET Land Use Categories and Associated Geophysical Parameters
Based on the U.S. Geological Survey Land Use Classification System
(14-Category System)

Land Use Type	Description	Surface Roughness (m)	Albedo	Bowen Ratio	Soil Heat Flux Parameter	Anthropogenic Heat Flux (W/m²)	Leaf Area Index
10	Urban or Built-up Land	1.0	0.18	1.5	.25	0.0	0.2
20	Agricultural Land - Unirrigated	0.25	0.15	1.0	.15	0.0	3.0
-20*	Agricultural Land - Irrigated	0.25	0.15	0.5	.15	0.0	3.0
30	Rangeland	0.05	0.25	1.0	.15	0.0	0.5
40	Forest Land	1.0	0.10	1.0	.15	0.0	7.0
51	Small Water Body	0.001	0.10	0.0	1.0	0.0	0.0
54	Bays and Estuaries	0.001	0.10	0.0	1.0	0.0	0.0
55	Large Water Body	0.001	0.10	0.0	1.0	0.0	0.0
60	Wetland	1.0	0.10	0.5	.25	0.0	2.0
61	Forested Wetland	1.0	0.1	0.5	0.25	0.0	2.0
62	Nonforested Wetland	0.2	0.1	0.1	0.25	0.0	1.0
70	Barren Land	0.05	0.30	1.0	.15	0.0	0.05
80	Tundra	.20	0.30	0.5	.15	0.0	0.0
90	Perennial Snow or Ice	.20	0.70	0.5	.15	0.0	0.0

* Negative values indicate "irrigated" land use

Table 1. Land use categories table from CALMET User's Guide.

6.1.1.5. CALMET ZFACE and ZIMAX Settings

Eleven vertical layers will be used with vertical cell face (ZFACE) heights at: 0, 20, 100, 200, 350, 500, 750, 1000, 2000, 3000, 4000, and 5000 meters. The minimum mixing height will be set to 50 m, and the maximum mixing height will be set to 3000 m.

6.1.1.6. CALMET BIAS Setting

The BIAS settings for each vertical cell determine the relative weight given to the vertically extrapolated surface meteorological observations and upper air soundings. The initial guess field is computed with an inverse distance weighting of the surface and upper air data. It can be modified by the layer-dependent bias factor (BIAS). The values for BIAS can range from –1.0 to 1.0. For example, if BIAS is set to +0.25, the weight of the surface wind observation is reduced by 25%. If BIAS is set to –0.25, the weight of the upper air wind observation is reduced by 25%. If BIAS is set to zero, there is no change in the weighting from the normal inverse distance squared weighting. As recommended by the National Park Service (NPS), the default values of 0.0 will be used for all 11 vertical layers in this analysis.

6.1.1.7. CALMET RMIN2 and IXTERP Settings

Vertical extrapolation of data from a surface station is skipped if the surface station is close to the upper air station. The variable RMIN2 sets the distance between an upper air station and a surface station that must be exceeded in order for the extrapolation to take place. RMIN2 will be set to the default value of 4, as recommended by the NPS. The default value of –4 for IEXTRP is used. By setting IEXTRP to –4 (as opposed to +4), layer 1 data at upper air stations is ignored. When IEXTRP=±4, the van Ulden and Holtslag wind extrapolation method is used. The method uses similarity theory and observed data to extend the influence of the surface wind speed and direction aloft.

6.1.1.8. CALMET Settings: R1, R2, RMAX1, RMAX2, RMAX3

An inverse-distance method is used to determine the influence of observations in the Step 1 wind field. R1 controls weighting of the surface layer and R2 controls weighting of the layers aloft. For example, R1 is the distance from an observational station at which the observation and first guess field are equally weighted. In addition, RMAX1, RMAX2, and RMAX3 determine the radius of influence over land in the surface layer, over land in layers aloft, and over water, respectively. That is, an observation is excluded if the distance from the observational site to a given grid point exceeds the maximum radius of influence. As recommended by the NPS, R1 and RMAX1 will be set to 30 km so that the initial guess field does not overwhelm the surface observations. R2 is set to 50 km and RMAX2 is set to 100 km. For over water surface observation both R3 and RMAX3 are set to 30 km, the same as the parameters for over land stations.

6.1.1.9. CALMET Surface Stations

The National Climatology Data Center (NCDC) surface observational data at 279 stations will be used in this initial analysis. The locations of these surface meteorological stations are shown in Figure 3.

6.1.1.10. CALMET Upper Air Stations

The initial analysis will not consider upper air observational data for mainly two reasons. The first reason is that a substantial amount of data are missing, and there exists no rigorous method to fill in missing data. Filling in missing data arbitrarily will likely alter the meteorological field generated by the CALMET model. The other reason is that, since the output of the MM5 mesoscale meteorological model provides an adequate coverage of upper air meteorology, neglecting upper air observational data will have an insignificant effect on the CALMET meteorological field. Future analyses may consider upper air observational data.

6.1.1.11. CALMET Precipitation Stations

The initial analysis will not consider precipitation data. Future analyses may consider observational precipitation data.

Locations of surface meteorological stations

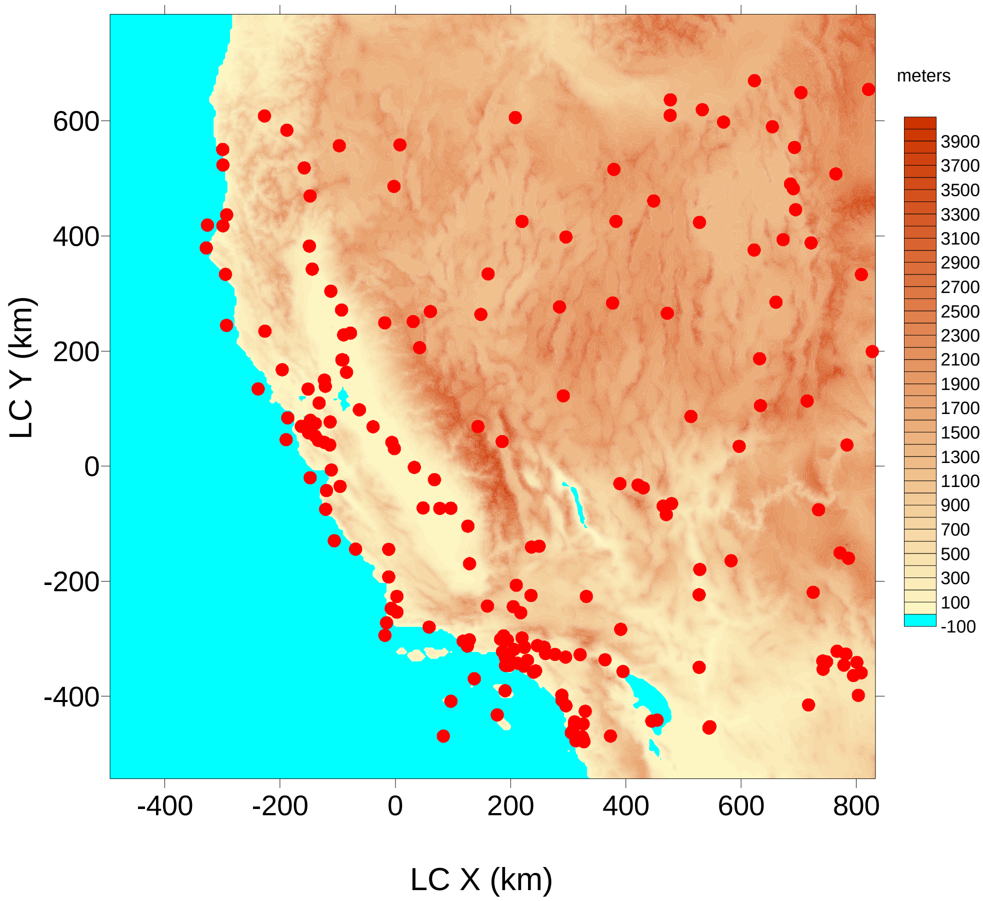

Figure 3. Locations of surface meteorological stations.

6.1.1.12. CALMET Parameter Summary

Table 2 summarizes some of the key CALMET parameters.

Variable	Description	EPA Default	Our Values
GEO.DAT	Name of Geophysical data file	GEO.DAT	GEO.DAT
SURF.DAT	Name of Surface data file	SURF.DAT	SURF.DAT
PRECIP.DAT	Name of Precipitation data file	PRECIP.DAT	NA
NUSTA	Number of upper air data sites	User Defined	0
UPn.DAT	Names of NUSTA upper air data files	UPn.DAT	NA
IBYR	Beginning year	User Defines	User Defines
IBMO	Beginning month	User Defines	User Defines

Variable	Description	EPA Default	Our Values
IBDY	Beginning day	User Defines	User Defines
IBHR	Beginning hour	User Defines	User Defines
IBTZ	Base time zone	User Defines	8
IRLG	Number of hours to simulate	User Defines	User Defines
IRTYPE	Output file type to create (must be 1 for CALPUFF)	1	1
LCALGRD	Are w-components and temperature needed?	T	T
NX	Number of east-west grid cells	User Defines	333
NY	Number of north-south grid cells	User Defines	333
DGRIDKM	Grid spacing	User Defines	4
XORIGKM	Southwest grid cell X coordinate	User Defines	-497.152
YORIGKM	Southwest grid cell Y coordinate	User Defines	-544.910
XLATO	Southwest grid cell latitude	User Defines	31.856
YLONO	Southwest grid cell longitude	User Defines	125.797
IUTMZN	UTM Zone	User Defines	NA
XLAT1	Latitude of 1st standard parallel	30	30
XLAT2	Latitude of 2nd standard parallel	60	60
RLON0	Longitude used if LLCONF = T	90	120.5
RLAT0	Latitude used if LLCONF = T	40	37
NZ	Number of vertical Layers	User Defines	12
ZFACE	Vertical cell face heights (NZ+1 values)	User Defines	0,20,40,80,160,300,600,1000,1500,2000,3000,4000, and 5000
LSAVE	Save met. Data fields in an unformatted file?	T	T
IFORMO	Format of unformatted file (1 for CALPUFF)	1	1
NSSTA	Number of stations in SURF.DAT file	User Defines	279
NPSTA	Number of stations in PRECIP.DAT	User Defines	0
ICLOUD	Is cloud data to be input as gridded fields? 0=No)	0	0
IFORMS	Format of surface data (2 = formatted)	2	2
IFORMP	Format of precipitation data (2= formatted)	2	2
IFORMC	Format of cloud data (2= formatted)	2	2
IWFCOD	Generate winds by diagnostic wind module? (1 = Yes)	1	1
IFRADJ	Adjust winds using Froude number effects? (1= Yes)	1	1
IKINE	Adjust winds using Kinematic effects? (1 = Yes)	0	0
IOBR	Use O’Brien procedure for vertical winds? (0 = No)	0	0
ISLOPE	Compute slope flows? (1 = Yes)	1	1
IEXTRP	Extrapolate surface winds to upper layers? (-4 = use similarity theory and ignore layer 1 of upper air station data)	-4	-4

Variable	Description	EPA Default	Our Values
ICALM	Extrapolate surface calms to upper layers? (0 = No)	0	0
BIAS	Surface/upper-air weighting factors (NZ values)	NZ*0	NZ*0
IPROG	Using prognostic or MM-FDDA data? (0 = No)	0	14
LVARY	Use varying radius to develop surface winds?	F	F
RMAX1	Max surface over-land extrapolation radius (km)	User Defines	30
RMAX2	Max aloft over-land extrapolations radius (km)	User Defines	30
RMAX3	Maximum over-water extrapolation radius (km)	User Defines	50
RMIN	Minimum extrapolation radius (km)	0.1	0.1
RMIN2	Distance (km) around an upper air site where vertical extrapolation is excluded (Set to –1 if IEXTRP = ±4)	4	4
TERRAD	Radius of influence of terrain features (km)	User Defines	50
R1	Relative weight at surface of Step 1 field and obs	User Defines	1.0
R2	Relative weight aloft of Step 1 field and obs	User Defines	1.0
DIVLIM	Maximum acceptable divergence	5.E-6	5.E-6
NITER	Max number of passes in divergence minimization	50	50
NSMTH	Number of passes in smoothing (NZ values)	2,4*(NZ-1)	2,4*(NZ-1)
NINTR2	Max number of stations for interpolations (NA values)	99	99
CRITFN	Critical Froude number	1	1
ALPHA	Empirical factor triggering kinematic effects	0.1	0.1
IDIOPT1	Compute temperatures from observations (0 = True)	0	0
ISURFT	Surface station to use for surface temperature (between 1 and NSSTA)	User Defines	1
IDIOPT2	Compute domain-average lapse rates? (0 = True)	0	0
IUPT	Station for lapse rates (between 1 and NUSTA)	User Defines	NA
ZUPT	Depth of domain-average lapse rate (m)	200	200
IDIOPT3	Compute internally initial guess winds? (0 = True)	0	0
IUPWND	Upper air station for domain winds (-1 = 1/r**2 interpolation of all stations)	-1	-1
ZUPWND	Bottom and top of layer for 1st guess winds (m)	1,1000	1,1000

Variable	Description	EPA Default	Our Values
IDIOPT4	Read surface winds from SURF.DAT? (0 = True)	0	0
IDIOPT5	Read aloft winds from UPn.DAT? (0 = True)	0	0
CONSTB	Neutral mixing height B constant	1.41	1.41
CONSTE	Convective mixing height E constant	0.15	0.15
CONSTN	Stable mixing height N constant	2400	2400
CONSTW	Over-water mixing height W constant	0.16	0.16
FCORIOL	Absolute value of Carioles parameter	1.E-4	1.E-4
IAVEXZI	Spatial averaging of mixing heights? (1 = True)	1	1
MNMDAV	Max averaging radius (number of grid cells)	1	1
HAFANG	Half-angle for looking upwind (degrees)	30	30
ILEVZI	Layer to use in upwind averaging (between 1 and NZ)	1	1
DPTMIN	Minimum capping potential temperature lapse rate	0.001	0.001
DZZI	Depth for computing capping lapse rate (m)	200	200
ZIMIN	Minimum over-land mixing height (m)	50	50
ZIMAX	Maximum over-land mixing height (m)	3000	3000
ZIMINW	Minimum over-water mixing height (m)	50	50
ZIMAXW	Maximum over-water mixing height (m)	3000	3000
IRAD	Form of temperature interpolation (1 = 1/r)	1	1
TRADKM	Radius of temperature interpolation (km)	500	500
NUMTS	Max number of stations in temperature interpolations	5	5
IAVET	Conduct spatial averaging of temperature? (1 = True)	1	0
TGDEFB	Default over-water mixed layer lapse rate (K/m)	-0.0098	-0.0098
TGDEFA	Default over-water capping lapse rate (K/m)	-0.0045	-0.0045
JWAT1	Beginning landuse type defining water	999	999
JWAT2	Ending landuse type defining water	999	999
NFLAGP	Method for precipitation interpolation (2= 1/r**2)	2	2
SIGMAP	Precip radius for interpolations (km)	100	100
CUTP	Minimum cut off precip rate (mm/hr)	0.01	0.01

Variable	Description	EPA Default	Our Values
SSn	NSSTA input records for surface stations	User Defines	NA
Usn	NUSTA input records for upper-air stations	User Defines	NA
PSn	NPSTA input records for precipitations stations	User Defines	NA

NA = Not Applicable

Table 2. CALMET parameter summary.

6.1.2. CALPUFF

CALPUFF is a multi-layer, multi-species non-steady-state Gaussian puff dispersion which can simulate the effects of time- and space-varying meteorological conditions on pollutant transport, transformation, and removal. CALPUFF contains algorithms for near-source effects such as building downwash, transitional plume rise, subgrid scale terrain interactions as well as longer range effects such as pollutant removal (wet scavenging and dry deposition), chemical transformation, vertical wind shear, overwater transport and coastal interaction effects.

The default technical options in CALPUFF should be used, unless specified otherwise in this protocol. If non-default options or values are used, the reason should be explained and justified in the modeling report.

6.1.2.1. Receptor Network and Class I Federal Areas

The modeling domain should contain all Class I federal areas in California within 300 kilometers of the BART-eligible source. Class I areas outside California within 300 kilometers of any California BART-eligible sources should be included. The setup will include 29 Class I federal areas in California:

Agua Tibia Wilderness Area	Ansel Adams Wilderness Area
Caribou Wilderness Area	Cucamonga Wilderness Area
Desolation Wilderness Area	Domeland Wilderness Area
Emigrant Wilderness Area	Hoover Wilderness Area
John Muir Wilderness Area	Joshua Tree National Park
Kaiser Wilderness Area	Kings Canyon National Park
Lassen Volcanic National Park	Lava Beds National Monument
Marble Mountain Wilderness Area	Mokelumne Wilderness Area
Pinnacles National Monument	Point Reyes National Seashore
Redwood National Park	San Gabriel Wilderness Area
San Gorgonio Wilderness Area	San Jacinto Wilderness Area
San Rafael Wilderness Area	Sequoia National Park

South Warner Wilderness Area	Thousand Lakes Wilderness Area
Ventana Wilderness Area	Yolla Bolly-Middle Eel Wilderness Area
Yosemite National Park	

Another seven Class I areas outside of California will also be included in the modeling because they are potentially affected by California BART-eligible sources. These Class I areas are:

Kalmiopsis Wilderness Area	Grand Canyon National Park
Mountain Lakes Wilderness Area	Sycamore Canyon Wilderness Area
Gearhart Mountain Wilderness Area	Mazatzal Wilderness Area
Pine Mountain Wilderness Area	

The receptors for all of the Class I federal areas were generated by the National Park Service (NPS) using the *NPS Convert Class I Areas* (NCC) computer program. All receptor locations and the computer program are available for download at http://www2.nature.nps.gov/air/maps/Receptors/index.cfm#top. Receptor elevations provided by the NPS conversion program will be used in the modeling.

All receptors will be included in a single CALPUFF simulation. To calculate the visibility impacts in CALPOST for each Class I area, the NCRECP parameter can be used. It specifies the receptor range to be processed in CALPOST.

6.1.2.2. CALPUFF Meteorology

Refer to the CALMET section of the report for details.

6.1.2.3. CALPUFF Modeling Domain

The CALPUFF modeling domain is identical to the CALMET modeling domain.

6.1.2.4. CALPUFF Parameter Summary

Table 3 summarizes some of the key CALPUFF settings.

Variable	Description	EPA Default	Our Values
METDAT	CALMET input data filename	CALMET.DAT	CALMET.DAT
PUFLST	Filename for general output from CALPUFF	CALPUFF.LST	CALPUFF.LST
CONDAT	Filename for output concentration data	CONC.DAT	CONC.DAT
DFDAT	Filename for output dry deposition fluxes	DFLX.DAT	DFLX.DAT
WFDAT	Filename for output wet deposition fluxes	WFLX.DAT	WFLX.DAT
VISDAT	Filename for output relative humidities (for	VISB.DAT	VISB.DAT

Variable	Description	EPA Default	Our Values
	visibility)		
METRUN	Do we run all periods (1) or a subset (0)?	0	0
IBYR	Beginning year	User Defined	User Defined
IBMO	Beginning month	User Defined	User Defined
IBDY	Beginning day	User Defined	User Defined
IBHR	Beginning hour	User Defined	User Defined
IRLG	Length of runs (hours)	User Defined	User Defined
NSPEC	Number of species modeled (for MESOPUFF II chemistry)	5	6
NSE	Number of species emitted	3	3
MRESTART	Restart options (0 = no restart), allows splitting runs into smaller segments	0	1
METFM	Format of input meteorology (1 = CALMET)	1	1
AVET	Averaging time lateral dispersion parameters (minutes)	60	60
MGAUSS	Near-field vertical distribution (1 = Gaussian)	1	1
MCTADJ	Terrain adjustments to plume path (3 = Plume path)	3	3
MCTSG	Do we have subgrid hills? (0 = No), allows CTDM-like treatment for subgrid scale hills	0	0
MSLUG	Near-field puff treatment (0 = No slugs)	0	0
MTRANS	Model transitional plume rise? (1 = Yes)	1	1
MTIP	Treat stack tip downwash? (1 = Yes)	1	1
MSHEAR	Treat vertical wind shear? (0 = No)	0	0
MSPLIT	Allow puffs to split? (0 = No)	0	0
MCHEM	MESOPUFF-II Chemistry? (1 = Yes)	1	1
MWET	Model wet deposition? (1 = Yes)	1	1
MDRY	Model dry deposition? (1 = Yes)	1	1
MDISP	Method for dispersion coefficients (3 = PG & MP)	3	3
MTURBVW	Turbulence characterization? (Only if MDISP = 1 or 5)	3	3
MDISP2	Backup coefficients (Only if MDISP = 1 or 5)	3	3
MROUGH	Adjust PG for surface roughness? (0 = No)	0	0
MPARTL	Model partial plume penetration? (0 = No)	1	1
MTINV	Elevated inversion strength (0 = compute from data)	0	0
MPDF	Use PDF for convective dispersion? (0 = No)	0	0
MSGTIBL	Use TIBL module? (0 = No) allows treatment of subgrid scale coastal areas	0	0
MREG	Regulatory default checks? (1 = Yes)	1	1
CSPECn	Names of species modeled (for MESOPUFF II, must be SO2, SO4, NOx, HNO3, NO3)	User Defined	SO2, SO4, NOX, HNO3, NO3 and PM10
NX	Number of east-west grids of input meteorology	User Defined	333

Variable	Description	EPA Default	Our Values
NY	Number of north-south grids of input meteorology	User Defined	333
NZ	Number of vertical layers of input meteorology	User Defined	12
DGRIDKM	Meteorology grid spacing (km)	User Defined	4
ZFACE	Vertical cell face heights of input meteorology	User Defined	Same as Table 2
XORIGKM	Southwest corner (east-west) of input meteorology	User Defined	-497.152
YORIGIM	Southwest corner (north-south) of input meteorology	User Defined	-544.910
IUTMZN	UTM zone	User Defined	NA
XLAT	Latitude of center of meteorology domain	User Defined	37
XLONG	Longitude of center of meteorology domain	User Defined	120.50
XTZ	Base time zone of input meteorology	User Defined	PST
IBCOMP	Southwest of Xindex of computational domain	User Defined	1
JBCOMP	Southwest of Y-index of computational domain	User Defined	1
IECOMP	Northeast of Xindex of computational domain	User Defined	333
JECOMP	Northeast of Y- index of computational domain	User Defined	333
LSAMP	Use gridded receptors (T -= Yes)	F	F
IBSAMP	Southwest of Xindex of receptor grid	User Defined	1
JBSAMP	Southwest of Y-index of receptor grid	User Defined	1
IESAMP	Northeast of Xindex of receptor grid	User Defined	333
JESAMP	Northeast of Y-index of receptor grid	User Defined	333
MESHDN	Gridded receptor spacing = DGRIDKM/MESHDN	1	1
ICON	Output concentrations? (1 = Yes)	1	1
IDRY	Output dry deposition flux? (1 = Yes)	1	1
IWET	Output wet deposition flux? (1 = Yes)	1	1
IVIS	Output RH for visibility calculations (1 = Yes)	1	1
LCOMPRS	Use compression option in output? (T = Yes)	T	T
ICPRT	Print concentrations? (0 = No)	0	0
IDPRT	Print dry deposition fluxes (0 = No)	0	0
IWPRT	Print wet deposition fluxes (0 = No)	0	0
ICFRQ	Concentration print interval (1 = hourly)	1	1
IDFRQ	Dry deposition flux print interval (1 = hourly)	1	1
IWFRQ	Wet deposition flux print interval (1 = hourly)	1	1
IPRTU	Print output units (1 = g/m**3; g/m**2/s)	1	1
IMESG	Status messages to screen? (1 = Yes)	1	1
Output Species	Where to output various species	User Defined	All modeled species
LDEBUG	Turn on debug tracking? (F = No)	F	F
Dry Gas Dep	Chemical parameters of gaseous deposition species	User Defined	SO2,NOx,HNO3

Variable	Description	EPA Default	Our Values
Dry Part. Dep	Chemical parameters of particulate deposition species	User Defined	SO4,NO3,PM10
RCUTR	Reference cuticle resistance (s/cm)	30.	30.
RGR	Reference ground resistance (s/cm)	10.	10.
REACTR	Reference reactivity	8	8
NINT	Number of particle-size intervals	9	9
IVEG	Vegetative state (1 = active and unstressed)	1	1
Wet Dep	Wet deposition parameters	User Defined	HNO3,SO4,NO3, PM10
MOZ	Ozone background? (1 = read from ozone.dat)	1	1
BCKO3	Ozone default (ppb) (Use only for missing data)	80	80
BCKNH3	Ammonia background (ppb)	10	10
RNITE1	Nighttime SO2 loss rate (%/hr)	0.2	0.2
RNITE2	Nighttime NOx loss rate (%/hr)	2	2
RNITE3	Nighttime HNO3 loss rate (%/hr)	2	2
SYTDEP	Horizontal size (m) to switch to time dependence	550.	550.
MHFTSE	Use Heffter for vertical dispersion? (0 = No)	1	1
JSUP	PG Stability class above mixed layer	5	5
CONK1	Stable dispersion constant (Eq. 2.7-3)	0.01	0.01
CONK2	Neutral dispersion constant (Eq. 2.7-4)	0.1	0.1
TBD	Transition for downwash algorithms (0.5 = ISC)	0.5	0.5
IURB1	Beginning urban landuse type	10	10
IURB2	Ending urban landuse type	19	19

Table 3. CALPUFF parameter summary.

6.1.2.5. Chemical Mechanism

The MESOPUFF II pseudo-first-order chemical reaction mechanism (MCHEM=1) is used for the conversion of SO_2 to sulfate (SO_4) and NO_x to nitrate (NO_3). Refer to the CALPUFF User's Guide for a description of the mechanism (Scire, 2000). Further discussion about the chemical mechanism is presented in Appendix _.

Ammonia-limiting methods will be used for repartitioning nitric acid and nitrate on a receptor-by-receptor and hour-by-hour basis to account for over prediction due to overlapping puffs in CALPUFF. Specifically, the use of the MNIRATE=1 option in POSTUTIL is recommended. At this time, other ammonia-limiting methods, including iterative techniques that use observational data to resolve backward the thermodynamic equilibrium equation between NO_3/HNO_3 for each hour to minimize available ammonia, are not acceptable. Generally, for regulatory CALPUFF modeling in California, techniques that assume the atmosphere is always ammonia poor are not acceptable.

6.1.2.6. Chemical Mechanism – Ammonia Sensitivity Tests

A sensitivity test of the effect of background ammonia was conducted by the Air Pollution Control Division of the Colorado Department of Public Health & Environment. Details are presented in Appendix _.

6.1.2.7. Ammonia Assumptions - Discussion

In CALPUFF, as used in this application, the background ammonia concentration is temporally and spatially uniform. It is likely that some portions of the modeling domain are ammonia poor and some are ammonia rich. Thus, setting a domain-wide background is problematic. As discussed in the previous section, when modeling a single large source with high SO_2 emission rates relative to NO_x, the assumed background ammonia concentration is not a critical parameter for determining visibility impacts.

According to the IWAQM Phase 2 Report,

> *A further complication is that the formation of particulate nitrate is dependent on the ambient concentration of ammonia, which preferentially reacts with sulfate. The ambient ammonia concentration is an input to the model. Accurate specification of this parameter is critical to the accurate estimation of particulate nitrate concentrations. Based on a review of available data, Langford et al. (1992) suggest that typical (within a factor of 2) background values of ammonia are: 10 ppb for grasslands, 0.5 ppb for forest, and 1 ppb for arid lands at 20 C. Langford et al. (1992) provide strong evidence that background levels of ammonia show strong dependence with ambient temperature (variations of a factor of 3 or 4) and a strong dependence on the soil pH. However, given all the uncertainties in ammonia data, IWAQM recommends use of the background levels provided above, unless specific data are available for the modeling domain that would discredit the values cited. It should be noted, however, that in areas where there are high ambient levels of sulfate, values such as 10 ppb might overestimate the formation of particulate nitrate from a given source, for these polluted conditions. Furthermore, areas in the vicinity of strong point sources of ammonia, such as feedlots or other agricultural areas, may experience locally high levels of background ammonia.*

Ideally a background ammonia input to CALPUFF needs to characterize spatial and temporal variations. However ammonia data obtained from the existing air quality monitoring network are not adequate to develop a characterization of those variations. Ammonia concentrations collected in special studies are not adequate either to fulfill the need.

6.1.2.8. Ammonia Assumptions

Because of the lack of a comprehensive ammonia data set, it is impossible in this study to develop a background ammonia input to CALPUFF that can reliably represent the temporal and spatial variations in the modeling domain. Domain-wide ammonia background concentrations will be set to 10 ppb which is recommended by the CALPUFF developer as the default value.

6.1.2.9. Ozone Assumptions

According to the IWAQM Phase 2 Report,

> *CALPUFF provides two options for providing the ozone background data: (1) a single, typical background value appropriate for the modeling region, or (2) hourly ozone data from one or more ozone monitoring stations. The second and preferred option requires the creation of the OZONE.DAT file containing the necessary data. For the Demonstration Assessment, the domain was large (700 km by 1000 km) such that the second option was necessary. The IWAQM does not anticipate such large domains as being the typical application. Rather, it is anticipated that the more typical application will involve domains of order 400 km by 400 km or smaller. But even for smaller domains, the ability to provide at least monthly background values of ozone is deemed desirable. The problem in developing time (and perhaps spatial) varying background ozone values is having access to representative background ozone data. Ozone data are available from EPA's Aerometric Information Retrieval System (AIRS); however, AIRS data must be used with caution. Many ozone sites are located in urban and suburban centers and are not representative of oxidant levels experienced by plumes undergoing long range transport.*

Hourly ozone values from ARB's ozone monitoring network will be used as input to CALPUFF.

6.1.3. CALPOST Settings and Visibility Post-Processing

The CALPUFF results will be post-processed with a version of CALPOST (version 5.6393 level 060202) that contains a postprocessor for visibility impairment calculations. POSTUTIL or its functional equivalents may also be used. These programs may be modified to output the correct values needed for BART analysis.

For the initial modeling analysis, all PM_{10} may be assumed to have a extinction efficiency of 1.0 since the contribution of direct PM_{10} emissions is expected to be relatively small compared to visibility impairment caused by SO_2 and NO_x emissions. However, if modeled impacts are below the contribution threshold, condensable and filterable PM_{10} emissions should be quantified and speciated. Alternatively, a sensitivity test could be performed to determine if speciation would change the outcome of the subject-to-BART demonstration. For example, if all PM_{10} is modeled as PMF in CALPOST, the extinction efficiency for PMF could be changed from 1.0 to 10.0 to simulate a worst-case speciation scenario. If this type of sensitivity test or another analysis suggests that PM_{10} speciation could change the outcome of the analysis, then speciation should be performed. If speciated PM_{10} emissions are modeled, the following species should be considered: fine particulates (PMF), coarse particulates (PMC), elemental carbon (EC), organic carbon (SOA), and sulfate (SO_4).

To calculate background light extinction, MVISBK should be set to 6. That is, monthly RH adjustment factors are applied directly to the background and modeled sulfate and nitrate concentrations, as recommended by the BART guideline. The RHMAX parameter, which is the maximum relative humidity factor used in the particle growth equation for visibility processing, is not used when method 6 is selected. Similarly, the relative humidity adjustment factor (f(RH)) curves in CALPOST (e.g., IWAQM growth curve and the 1996 IMPROVE curve) are not used when MVISBK is equal to 6.

f(RH) values listed in Table A-2 of US EPA's 'Guidance for Tracking Progress Under the Regional Haze Rule (EPA, 2003a)' will be used in the modeling. These values are site-specific for each Federal Class I area.

EPA lists three types of Natural Conditions (natural background) in their guidance document, annual average, Best 20% Days and Worst 20% Days (EPA, 2003a). The EPA BART Guidance recommends that the Natural Conditions corresponding to the Best 20% Days be used. However, this issue was challenged by the Utility Air Regulatory Group (UARG) and in a settlement EPA agreed that States could use Annual Average Natural Conditions (Paise, 2006a,b). In BART modeling analyses, the visibility impacts will be calculated using annual average of Natural Conditions and provided to the ARB to make the subject to BART determinations. The Natural Conditions are available on website (http://vista.cira.colostate.edu/improve/Data/IMPROVE/summary_data.htm).

Based on the latest three years' (2001, 2002 and 2003) background concentration measurements, domain wide averaged background concentrations have been calculated from data collected at all Class I areas located in California and will be used in the post-processing for visibility impairment analysis. The background concentrations to be used are listed as follows: BKSO4 = 1.168235 $\mu g/m^3$, BKNO3 = 1.05942 $\mu g/m^3$, BKPMC = 5.713125 $\mu g/m^3$, BKOC = 1.846471 $\mu g/m^3$, BKSOIL = 0.664706 $\mu g/m^3$, BKEC = 0.216471 $\mu g/m^3$.

6.1.3.1. 98th Percentile Methods

According to the BART guideline:

> ...*you should compare your "contribution" threshold against the 98th percentile of values. If the 98th percentile value from your modeling is less than your contribution threshold, then you may conclude that the source does not contribute to visibility impairment and is not subject to BART.* (70 FR 39162)

The U.S.EPA recommends using the 98th percentile value from the distribution of values containing the highest modeled delta-deciview value for each day of the simulation from all modeled receptors at a given Class I area. The 98th percentile delta-deciview value should be determined as the highest of the 8th highest values for each year modeled among all three modeled years.

The 98th percentile value at each Class I area should be compared to the contribution threshold. The contribution threshold has an implied level of precision equal to the level of precision reported from CALPOST. Specifically, the 98th percentile results should be reported to three decimal places.

The U.S. EPA recommended method is referred to as the "day-specific method" or "method 1." The first step in the method is to find the highest modeled delta-deciview value for each day of the simulation from all modeled receptors for the selected time period. Next, daily delta-deciview maxima are ranked in descending order for the number of days processed in CALPOST. Then, the 98th percentile value is determined from the distribution of ranked modeled daily maximum values, irrespective of receptor location. For both a 365-day and a 366-day simulations, the 98th percentile value would be the 8th highest modeled delta-deciview value from the list of ranked delta-deciview values. That is, the top 7 days are ignored, even though the values being ignored may be at different receptors.

A different method, referred to as "receptor-specific method" or "method 2" can also be used to calculate 98th percentile values. The 8th high (for one year) and 22nd high (for 3 years) values recommended by U.S. EPA are consistent with the values that would be generated from the equations in 40 CFR 50 Appendix N - "Interpretation of the National Ambient Air Quality Standards for $PM_{2.5}$" – for determining 98th percentile values for $PM_{2.5}$ monitoring.

7. Results

The CALPUFF modeling results will be reported in a separate document. The results will include 29 Class I federal areas in California and 7 Class I federal areas outside California.

The results for source-to-receptor distances beyond 300 kilometers may be used, but they may overestimate impacts because puff splitting is not used. The model setup used here should provide reasonable estimates for source-to-receptor distances up to 300 kilometers.

8. References

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Appendix – The BART Guidelines From 40 CFR Part 51, Appendix Y

III. HOW TO IDENTIFY SOURCES "SUBJECT TO BART"

Once you have compiled your list of BART-eligible sources, you need to determine whether (1) to make BART determinations for all of them or (2) to consider exempting some of them from BART because they may not reasonably be anticipated to cause or contribute to any visibility impairment in a Class I area. If you decide to make BART determinations for all the BART-eligible sources on your list, you should work with your regional planning organization (RPO) to show that, collectively, they cause or contribute to visibility impairment in at least one Class I area. You should then make individual BART determinations by applying the five statutory factors discussed in Section IV below.

On the other hand, you also may choose to perform an initial examination to determine whether a particular BART-eligible source or group of sources causes or contributes to visibility impairment in nearby Class I areas. If your analysis, or information submitted by the source, shows that an individual source or group of sources (or certain pollutants from those sources) is not reasonably anticipated to cause or contribute to any visibility impairment in a Class I area, then you do not need to make BART determinations for that source or group of sources (or for certain pollutants from those sources). In such a case, the source is not "subject to BART" and you do not need to apply the five statutory factors to make a BART determination. This section of the Guideline discusses several approaches that you can use to exempt sources from the BART determination process.

A. What Steps Do I Follow to Determine Whether A Source or Group of Sources Cause or Contribute to Visibility Impairment for Purposes of BART?

1. How Do I Establish a Threshold?

One of the first steps in determining whether sources cause or contribute to visibility impairment for purposes of BART is to establish a threshold (measured in deciviews) against which to measure the visibility impact of one or more sources. A single source that is responsible for a 1.0 deciview change or more should be considered to "cause" visibility impairment; a source that causes less than a 1.0 deciview change may still contribute to visibility impairment and thus be subject to BART.

Because of varying circumstances affecting different Class I areas, the appropriate threshold for determining whether a source "contributes to any *visibility impairment" for the purposes of BART may reasonably differ across States. As a general matter, any threshold that you use for determining whether a source "contributes" to visibility impairment should not be higher than 0.5 deciviews.*

In setting a threshold for "contribution," you should consider the number of emissions sources affecting the Class I areas at issue and the magnitude of the individual sources' impacts[2] In general, a larger number of sources causing impacts in a Class I area may warrant a lower contribution threshold. States remain free to use a threshold lower than 0.5 deciviews if they conclude that the location of a large number of BART eligible sources within the State and in proximity to a Class I area justify this approach.[3]

2. What Pollutants Do I Need to Consider?

You must look at SO_2, NO_x, and direct particulate matter (PM) emissions in determining whether sources cause or contribute to visibility impairment, including both PM_{10} and $PM_{2.5}$. Consistent with the approach for identifying your BART-eligible sources, you do not need to consider less than de minimis emissions of these pollutants from a source.

As explained in section II, you must use your best judgement to determine whether VOC or ammonia emissions are likely to have an impact on visibility in an area. In addition, although as explained in Section II, you may use PM_{10} an indicator for particulate matter in determining whether a source is BART eligible, in determining whether a source contributes to visibility impairment, you should distinguish between the fine and coarse particle components of direct particulate emissions. Although both fine and coarse particulate matter contribute to visibility impairment, the long-range transport of fine particles is of particular concern in the formation of regional haze. Air quality modeling results used in the BART determination will provide a more accurate prediction of a source's impact on visibility if the inputs into the model account for the relative particle size of any directly emitted particulate matter (i.e. PM_{10} vs. $PM_{2.5}$).

3. What Kind of Modeling Should I Use to Determine Which Sources and Pollutants Need Not Be Subject to BART?

This section presents several options for determining that certain sources need not be subject to BART. These options rely on different modeling and/or emissions analysis approaches. They are provided for your guidance. You may

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2 *We expect that regional planning organizations will have modeling information that identifies sources affecting visibility in individual class I areas.*

3 *Note that the contribution threshold should be used to determine whether an individual source is reasonably anticipated to contribute to visibility impairment. You should not aggregate the visibility effects of multiple sources and compare their collective effects against your contribution threshold because this would inappropriately create a "contribute to contribution" test.*

also use other reasonable approaches for analyzing the visibility impacts of an individual source or group of sources.

Option 1: Individual Source Attribution Approach (Dispersion Modeling)

You can use dispersion modeling to determine that an individual source cannot reasonably be anticipated to cause or contribute to visibility impairment in a Class I area and thus is not subject to BART. Under this option, you can analyze an individual source's impact on visibility as a result of its emissions of SO_2, NO_x and direct PM emissions. Dispersion modeling cannot currently be used to estimate the predicted impacts on visibility from an individual source's emissions of VOC or ammonia. You may use a more qualitative assessment to determine on a case-by-case basis which sources of VOC or ammonia emissions may be likely to impair visibility and should therefore be subject to BART review, as explained in section II.A.3. above.

You can use CALPUFF[4] or other appropriate model to predict the visibility impacts from a single source at a Class I area. CALPUFF is the best regulatory modeling application currently available for predicting a single source's contribution to visibility impairment and is currently the only EPA-approved model for use in estimating single source pollutant concentrations resulting from the long range transport of primary pollutants.[5].[8] It can also be used for some other purposes, such as the visibility assessments addressed in today's rule, to account for the chemical transformation of SO_2 and NO_x.

There are several steps for making an individual source attribution using a dispersion model:

1. Develop a modeling protocol.

Some critical items to include in the protocol are the meteorological and terrain data that will be used, as well as the source-specific information (stack height, temperature, exit velocity, elevation, and emission rates of applicable pollutants) and receptor data from appropriate Class I areas. We recommend following EPA's Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report and Recommendations for Modeling Long Range Transport Impacts[6] for parameter settings and meteorological data inputs. You may use

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[4] *The model code and its documentation are available at no cost for download from http://www.epa.gov/scram001/tt22.htm#calpuff .*

[5] *The Guideline on Air Quality Models, 40 CFR part 51, appendix W, addresses the regulatory application of air quality models for assessing criteria pollutants under the CAA, and describes further the procedures for using the CALPUFF model, as well as for obtaining approval for the use of other, nonguideline models.*

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

other settings from those in IWAQM, but you should identify these settings and explain your selection of these settings.

One important element of the protocol is in establishing the receptors that will be used in the model. The receptors that you use should be located in the nearest Class I area with sufficient density to identify the likely visibility effects of the source. For other Class I areas in relatively close proximity to a BART-eligible source, you may model a few strategic receptors to determine whether effects at those areas may be greater than at the nearest Class I area. For example, you might chose to locate receptors at these areas at the closest point to the source, at the highest and lowest elevation in the Class I area, at the IMPROVE monitor, and at the approximate expected plume release height. If the highest modeled effects are observed at the nearest Class I area, you may choose not to analyze the other Class I areas any further as additional analyses might be unwarranted.

You should bear in mind that some receptors within the relevant Class I area may be less than 50 km from the source while other receptors within that same Class I area may be greater than 50 km from the same source. As indicated by the Guideline on Air Quality Models, 40 CFR part 51, appendix W, this situation may call for the use of two different modeling approaches for the same Class I area and source, depending upon the State's chosen method for modeling sources less than 50 km. In situations where you are assessing visibility impacts for source-receptor distances less than 50 km, you should use expert modeling judgment in determining visibility impacts, giving consideration to both CALPUFF and other appropriate methods.

In developing your modeling protocol, you may want to consult with EPA and your regional planning organization (RPO). Up-front consultation will ensure that key technical issues are addressed before you conduct your modeling.

2. [Run model in accordance] with the accepted protocol and compare the predicted visibility impacts with your threshold for "contribution."

You should calculate daily visibility values for each receptor as the change in deciviews compared against natural visibility conditions. You can use EPA's "Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule," EPA-454/B-03-005 (September 2003) in making this calculation. To determine whether a source may reasonably be anticipated to cause or contribute to visibility impairment at Class I area, you then compare the impacts predicted by the model against the threshold that you have selected.

The emissions estimates used in the models are intended to reflect steady-state operating conditions during periods of high capacity utilization. We do not generally recommend that emissions reflecting periods of start-up, shutdown, and malfunction be used, as such emission rates could produce higher than normal effects than would be typical of most facilities. We recommend that States *use the 24 hour average actual emission rate from the highest emitting day of the meteorological period modeled, unless this rate reflects periods start-up, shutdown, or malfunction. In addition, the monthly average relative humidity is used, rather than the daily average humidity – an approach that effectively lowers the peak values in daily model averages.*

For these reasons, if you use the modeling approach we recommend, you should compare your "contribution" threshold against the 98th percentile of values. If the 98th percentile value from your modeling is less than your contribution threshold, then you may conclude that the source does not contribute to visibility impairment and is not subject to BART.

Appendix - The MESOPUFF II Mechanism

In the MESOPUFF II mechanism, the ammonia background concentration affects the equilibrium between nitric acid, ammonia, and ammonium nitrate. The equilibrium constant for the reaction is a non-linear function of temperature and relative humidity (Scire, 2000). Unlike sulfate, the calculated nitrate concentration is limited by the amount of available ammonia, which is preferentially scavenged by sulfate (Scire, 2000). In particular, the amount of ammonia available for the nitric acid, ammonium nitrate, and ammonia reactions is determined by subtracting sulfate from total ammonia.

While the chemical mechanism simulates both the gas phase and aqueous phase conversion of SO_2 to sulfate, the aqueous phase method, which is important when the plume interacts with clouds and fog, can significantly underestimate sulfate formation. In this report, as recommended by the IWAQM Phase 2 report, the “nighttime SO_2 loss rate (RNITE1)” is set to 0.2 percent per hour. The “nighttime NOx loss rate (RNITE2)” is set to 2.0 percent per hour and the “nighttime HNO_3 formation rate (RNITE3)” is set to 2.0 percent per hour.

According to the 1996 “Mt. Zirkel Wilderness Area Reasonable Attribution Study of Visibility Impairment. Volume II: Results of Data Analysis and Modeling - Final Report,”

The CALPUFF chemical module is formulated around linear transformation rates for SO_2 to sulfate and NO_x to total nitrate. There are two options for specifying these transformation rates:

Option 1: An internal calculation of rates based on local values for several controlling variables (e.g., solar radiation, background ozone, relative humidity, and plume NO_x) as used in MESOPUFF-II. The parametric transformation rate relationships employed were derived from box model calculations using the mechanism of Atkinson et al. (1982).

Option 2: A user-specified input file of diurnally varying but spatially uniform conversion rates.

Morris et al. (1987) reviewed the MESOPUFF-II mechanism as part of the U.S. EPA Rocky Mountain Acid Deposition Model Assessment study. They found that it provided physically plausible responses to many of the controlling environmental parameters. However, the mechanism had no temperature dependence, which is an important factor in the Rocky Mountain region where there are wide variations in temperature. Furthermore, the

MESOPUFF-II transformation scheme was based on box model simulations for conditions more representative of the Eastern U.S. than of the Rocky Mountains.

The largest deficiency in the MESOPUFF-II chemical transformation algorithm is the lack of explicit treatment for in-cloud (aqueous-phase) enhanced oxidation of SO_2 to sulfate. The MESOPUFF-II chemical transformation algorithm includes a surrogate reaction rate to account for aqueous-phase oxidation of SO_2 to sulfate as follows:

$$K_{aq} = 3 \times 10^{-8} \times RH^{4} \text{ (\%/hr) (B.2-1)}$$

Thus, at 100% relative humidity (RH), the MESOPUFF-II aqueous-phase surrogate SO_2 oxidation rate will be 3% per hour. Measurements in generating station plumes suggest spatially- and temporally-integrated SO_2 oxidation rates due to oxidants in clouds to be 10 times this value.

Another issue is the amount of ammonia available for nitrate chemistry. According to a paper by Escoffier-Czaja and Scire (2002),

"In the CALPUFF model, total nitrate ($TNO_3 = HNO_3 + NO_3$) is partitioned into each species according to the equilibrium relationship between HNO_3 and NO_3. This equilibrium varies as a function of time and space, in response to both the ambient temperature and relative humidity. In addition, the formation of nitrate is subject to the availability of NH_3 to form ammonium nitrate (NH_4NO_3), the assumed form of nitrate in the model. In CALPUFF, a continuous plume is simulated as a series of puffs, or discrete plume elements. The total concentration at any point in the model is the sum of the contribution of all nearby puffs from each source. Because CALPUFF allows the full amount of the specified background concentration of ammonia to be available to each puff for forming nitrate, the same ammonia may be used multiple times in forming nitrate, resulting in an overestimate of nitrate formation. In order to properly account for ammonia consumption, a program called POSTUTIL was introduced into the CALPUFF modeling system in 1999. POSTUTIL allows total nitrate to be repartitioned in a post-processing step to account for the total amount of sulfate scavenging ammonia from all sources (both project and background sources) and the total amount of TNO_3 competing for the remaining ammonia. In POSTUTIL, ammonia availability is computed based on receptor concentrations of total sulfate and TNO_3, not on a puff-by-puff basis."

Appendix. Sensitivity test of the effect of ammonia background

To better understand the response of the modeling system to background ammonia when a single point source with significant emissions of SO_2 and NO_x is modeled, the Air Pollution Control Division of the Colorado Department of Public Health & Environment (hereafter in this appendix referred to as the Division) performed sensitivity tests for a source in northeast Colorado and a source in northwest Colorado using the 2002 MM5/CALMET meteorology. In the test case, SO_2, NO_x, and filterable PM_{10} emissions were modeled. The ammonia background value was varied from 0 to 100 ppb. In the northeast Colorado test case, the SO_2 emission rate is about 3 times higher than the NO_x emission rate. In the northwest Colorado test case, the modeled NO_x emission rate is about 4.4 times higher than the SO_2 rate.

In both cases, when the background ammonia concentration is zero, the model produces no nitrate, as expected; however, it produces sulfate.

For the northeast Colorado sensitivity test, where the modeled SO_2 emission rate is significantly higher than the NO_x emission rate, the change in visibility (delta-deciview) is not very sensitive to the background ammonia concentration across the range from 1.0 ppb to 100.0 ppb because of the high SO_2 emission rates relative to NO_x and the way sulfate is produced in the MESOPUFF II chemical mechanism. Visibility impacts drop significantly when the ammonia background is less than 1.0 ppb, but even at 0.0 ppb of ammonia, sulfate impacts remain relative high.

For the northeast Colorado case, on days with the highest visibility impacts, the relative contribution of nitrate and sulfate vary, but most of the modeled visibility impairment is due to sulfate.

For the northwest Colorado sensitivity test, where the modeled NO_x emission rate is significantly higher than the SO_2 emission rate, the change in visibility (delta-deciview) is not sensitive to the background ammonia concentration across the range from 10 ppb to 100 ppb. While there is a moderate drop in impacts when ammonia is dropped from 10 ppb to 1.0 ppb, the model is very sensitive to ammonia when the background ammonia level is less than 1.0 ppb.

For the northwest Colorado test case, according to CALPUFF implemented by the Division, impairment is primarily due to nitrate, but the contribution due to nitrate varies significantly depending on the assumed ammonia background level. For the 100 ppb background case, the nitrate contribution is greater than

90% for the top 20 days. However, for the 0.1 ppb case, the nitrate contribution varies from 43% to 81% for the top 20 days.

Caution should be used when extrapolating the results of these tests to other CALPUFF applications.

Since the MESOPUFF II chemical mechanism used in this analysis depends on several parameters, including ozone and ammonia background concentrations, the methods for determining the background ozone and ammonia concentration fields are discussed in more detail in sections 3.1.2.7 and 3.1.2.8