ENVIRON

Best Available Retrofit Technology Modeling Analysis

Valero Bill Greehey Refinery (Corpus Christi) East Plant
TCEQ Account No. NE0043A

Prepared for:

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Corpus Christi, Texas

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C O N T E N T S

T A B L E S

F I G U R E S

A T T A C H M E N T S

TEXAS PROFESSIONAL ENGINEER'S STATEMENT

30 TAC 116.1510(b) requires that modeling demonstrations used to show that a BART-eligible source does not contribute to visibility impairment at any Class I area must be submitted under seal of a Texas licensed professional engineer to the Texas Commission on Environmental Quality Air Permits Division. By this statement, I hereby certify that the dispersion modeling analysis described and documented within this report was performed by me or under my direct supervision and that the model inputs used and results presented are true and correct to the best of my knowledge. Any limitations with respect to sources or availability of information and assumptions used in the analysis are noted within the report.

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May 31, 2007

Date

Texas Licensed Professional Engineer
Number 69070

1. INTRODUCTION

1.1 Background information

In 1999, the EPA promulgated rules to address visibility impairment – often referred to as "regional haze" – at designated federal Class I areas. These include areas such as national parks and wilderness areas where visibility is considered to be an important part of the visitor experience.[1] There are two Class I areas in Texas – Big Bend and Guadalupe National Parks – as well as a number in surrounding states in close proximity to Texas. Guidelines providing direction to the states for implementing the regional haze rules were issued by EPA in July 2005. Affected states, including Texas, are required to develop plans for addressing visibility impairment. This includes a requirement that certain existing sources be equipped with Best Available Retrofit Technology, or BART. Texas is required to submit a regional haze plan to EPA no later than December 17, 2007.

1.2 Potentially Affected Sources

The Texas Commission on Environmental Quality (TCEQ) regional haze rule adopted on January 10, 2007 (presented in Attachment A), identifies potentially affected sources as those:[2]

- Belonging to one of 26 industry source categories;[3]
- Having the potential to emit (PTE) 250 tons per year or more of any visibility-impairing pollutant;[4] and
- Not in operation prior to August 7, 1962, and in existence on August 7, 1977.

Based on results of a survey completed by potential BART-eligible sources and submitted to the TCEQ in 2005, 126 accounts were identified as potentially BART-eligible. This includes the Valero Bill Greehey Refinery (Corpus Christi) East Plant (hereafter referred to as the Valero Bill Greehey Refinery).

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[1] 40 CFR 51, Subpart P

[2] 30 TAC Chapter 116, Subchapter M, effective February 7, 2007.

[3] (1) fossil fuel-fired steam electric plants of more than 250 MMBtu/hour heat input; (2) coal-cleaning plants (thermal dryers); (3) Kraft pulp mills; (4) Portland cement plants; (5) primary zinc smelters; (6) iron and steel mill plants; (7) primary aluminum ore reduction plants; (8) primary copper smelters; (9) municipal incinerators capable of charging more than 250 tons of refuse per day; (10) hydrofluoric, sulfuric, and nitric acid plants; (11) petroleum refineries; (12) lime plants; (13) phosphate rock processing plants; (14) coke oven batteries; (15) sulfur recovery plants; (16) carbon black plants (furnace process); (17) primary lead smelters; (18) fuel conversion plants; (19) sintering plants; (20) secondary metal production facilities; (21) chemical process plants; (22) fossil fuel-fired boilers of more than 250 MMBtu/hour heat input; (23) petroleum storage and transfer facilities with capacity exceeding 300,000 barrels; (24) taconite ore processing facilities; (25) glass fiber processing plants; and (26) charcoal production facilities.

[4] *Visibility-impairing air pollutant* is defined in 30 TAC 116.1500((2) as "Any of the following: nitrogen oxides, sulfur dioxide, or particulate matter."

1.3 Exemptions

In 30 TAC 116.1510, the regulations identify four methods of exempting a BART-eligible source from the engineering analysis (described in 30 TAC 116.1520) and control requirements (described in 30 TAC 116.1530) of BART. These exemptions are as follows:

- Exempt by rule based on potential emissions and distance to the nearest Class I area.
- Electric Generating units (EGUs) participating in the Clean Air Interstate Rule (for NO_x and SO_2 only).
- Screening exemption modeling conducted by the TCEQ.
- Source-specific exemption modeling.

Following is a brief discussion of each exemption.

1.3.1 Exempt by Rule

Following EPA guidance, the TCEQ has established exemptions based on potential emissions and distance to the nearest Class I area.

- Sources with the potential-to-emit (PTE) less than 500 tons per year of combined NO_X and SO_2 and located more than 50 kilometers (km) from any Class I area are not subject to BART for NO_X and SO_2.
- Sources with the PTE less than 1,000 tons per year of combined NO_X and SO_2 and located more than 100 km from any Class I area are not subject to BART for NO_X and SO_2.
- Sources with the PTE of less than 40 tons per year of NO_X or SO_2 are not subject to BART for that pollutant, regardless of distance to a Class I area.
- Sources with the PTE less than 15 tons per year of PM_{10} are not subject to BART for PM_{10}, regardless of distance to a Class I area.

PTE is defined in 30 TAC 116.10 (27) as “The maximum capacity of a stationary source to emit a pollutant under its physical and operational design. Any physical or enforceable operational limitation on the capacity of the stationary source to emit a pollutant, including air pollution control equipment and restrictions on hours of operation or on the type or amount of material combusted, stored, or processed, may be treated as part of its design only if the limitation or the effect it would have on emissions is federally enforceable.” To take advantage of a model plant exemption, the PTE must be federally enforceable no later than April 30, 2007.

PTE for BART-eligible emission units at the Valero Bill Greehey Refinery is greater than the listed thresholds. Therefore, the facility is not exempt by rule.

1.3.2 EGU Exemption

BART-eligible EGUs that participate in the Clean Air Interstate Rule trading program for NO_X and SO_2 are not subject to the engineering analysis and control requirements of BART. The Valero Bill Greehey Refinery is not an EGU and does not qualify for this exemption.

1.3.3 TCEQ Screening Exemption Modeling

The TCEQ performed cumulative group BART screening exemption modeling using the Comprehensive Air Quality Model with extensions (CAMx). The 126 potentially BART-eligible sources were included in the screening exemption modeling.

Three types of BART screening exemption modeling were conducted:

- BART sources volatile organic compound (VOC) zero-out modeling to ascertain whether or not Texas BART VOC emissions cause or contribute to visibility impairment at any Class I area;
- BART sources primary particulate matter (PM) zero-out and chemically inert modeling to ascertain whether or not BART primary PM emissions cause or contribute to visibility impairment at any Class I area; and
- BART sources SO_2 and NO_X modeling using the PM Source Apportionment Technology (PSAT) and the Plume-in-Grid (PiG) subgrid-scale point source model.

Findings were as follows:

- The VOC zero-out modeling analysis indicated that visibility impacts at Class I areas due to VOC emissions from all Texas BART sources were well below the 0.5 delta-deciview (del-dv) significance threshold.[5] As a result of this finding, the TCEQ decided to exclude VOC from the definition of visibility-impairing pollutant.
- Visibility impacts due to PM emissions were greater than the 0.5 dv significance threshold for two EGU and one non-EGU accounts. The EGUs are TXU's Monticello Steam Electric Station and AEP's Welsh Power Plant. The non-EGU is International Paper's Texarkana Mill.
- Visibility impacts due to SO_2 and NO_X emissions were greater than the 0.5 dv significance threshold for source groupings that included 48 accounts.

For a more detailed description of the BART screening exemption modeling and the results of the modeling, the reader is referred to the following documents (included in Appendices B and C, respectively):

- *Final Report, Screening Analysis of Potential BART-Eligible Sources in Texas*, September 27, 2006, prepared by ENVIRON International Corporation;[6] and
- *ADDENDUM I, BART Exemption Screening Analysis, DRAFT*, December 6, 2006, prepared by ENVIRON International Corporation.[7]

30 TAC 116.1510(e) specifies that:

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[5] A *deciview* is a measure of visibility impairment. *Delta-deciview*, or *del-dv* is a measure of visibility impairment relative to natural conditions.

[6] http://www.tceq.state.tx.us/assets/public/implementation/air/sip/bart/BART_FinalReport.pdf.

[7] http://www.tceq.state.tx.us/assets/public/implementation/air/sip/bart/addendum-screening.pdf.

"Any BART-eligible source that has been screened out by the Texas Commission on Environmental Quality-conducted screening modeling is not subject to the requirements of [BART] if the owner or operator has reviewed that modeling inputs for that source and the executive director receives written certification that the inputs are correct no later than February 28, 2007."

The Valero Bill Greehey Refinery passed the screening analysis for PM but did not pass for NO_X and SO_2.

1.3.4 Source-Specific Exemption Modeling

TCEQ regulations state that:

> "The owner or operator of a BART-eligible source may demonstrate, using a model and modeling guidelines approved by the executive director, that the source does not contribute to visibility impairment at a Class I area. A BART-eligible source that does not contribute to visibility impairment at any Class I area is not subject to the requirements of [BART]. A source is considered to not contribute to visibility impairment if, as demonstrated by modeling performed by the executive director or performed in accordance with the guidelines approved by the executive director, it causes a visibility impairment of less than 0.5 deciviews at all Class I areas."

Exemption modeling is to be submitted to the TCEQ under the seal of a Texas professional engineer.

TCEQ guidance, presented in Appendix D, identifies the following exemption modeling options for potentially BART-affected sources: [8]

- CALPUFF for Class I areas located within 300 km of the source;
- CALPUFF for Class I areas located beyond 300 km of the source for a conservative screening analysis; and
- CAMx for Class I areas located beyond 300 km of the source in a refined analysis.

The Valero Bill Greehey Refinery is located 554 km from the nearest Class I area. Therefore, per TCEQ guidance, CAMx may be used in a refined analysis to determine if visibility impacts due to emissions of visibility-impairing pollutants from BART-eligible emission are significant or insignificant.

[8] *Best Available Retrofit Technology (BART) Modeling Protocol to Determine Sources Subject to BART in the State of Texas*, January 2007, prepared by the TCEQ.

2. CAMx MODELING

2.1 General Approach

CAMx modeling was performed according to TCEQ executive director-approved guidance (included as Appendix E). Except for certain changes appropriate for performing source-specific modeling, the methodology followed that used by ENVIRON in performing the screening analysis detailed in the September 27, 2006, report.

2.2 Model Description

2.2.1 Model Version

CAMx Version 4.41 (V4.41) was used in the source-specific BART modeling. This version includes several updates to the model including implementation of the PSAT within the full-science PiG.

2.2.2 Modeling Database

The source-specific BART modeling was performed using the latest version (Version Typical 2002F) of the 2002 annual regional photochemical modeling database developed as part of the Central Regional Air Planning Association (CENRAP) regional haze work. CENRAP developed the 2002 annual modeling database for CAMx on the 36 km unified national Regional Planning Organization (RPO) grid that covers the continental United States. This database was developed following the procedures outlined in the CENRAP protocol and CENRAP modeling Quality Assurance Program Plan.[9,10] The CENRAP database was enhanced to include a 12 km nested grid that covers Texas and Class I areas in and near Texas including:

- Big Bend National Park, Texas (BIBE1)
- Breton National Wildlife Refuge, Louisiana (BRET1)
- Caney Creek Wilderness Area, Arkansas (CACR1)
- Carlsbad Caverns National Park, New Mexico (CAVE1)
- Guadalupe Mountains National Park, Texas, (GUMO1)
- Salt Creek Wilderness Area, New Mexico (SACR1)
- Wichita Mountains National Wildlife Refuge, Oklahoma (WIMO1)

Figure 2-1 presents the 36 km modeling domain that was used in the CAMx BART exemption modeling and

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[9] Morris, R.E. et al, *Modeling Protocol for the CENRAP 2002 Annual Emissions and Air Quality Modeling (Draft 2.0)*, December 2004.

[10] Morris, R.E. and G. Tonnesen, *Quality Assurance Project Plan (Draft) for Central Regional Air Planning Association (CENRAP) Emissions and Air Quality Modelin*g, Revision 3, March 2006.

the source-specific subject-to-BART analysis. Figure 2-2 shows the location of the Valero Bill Greehey Refinery and Class I areas within the nested12 km modeling domain. Lambert Conformal Projection (LCP) coordinates are shown.

The CAMx flexi-nesting feature was used to incorporate the 12 km Texas Grid within the CENRAP 36 km modeling domain. Full flexi-nesting was invoked in which CAMx internally interpolates all of the meteorological, emission and other inputs from the 36 km grid to the 12 km grid. This option has the desired effect of allowing point source plume chemistry, transport and dispersion to be represented and resolved by the higher resolution 12 km grid after treatment of the near-source plume chemistry and dynamics using the subgrid-scale PiG module when plume size is below 12 km.

Figure 2-1. Texas BART 36 km Modeling Domain and Locations of IMPROVE Monitoring Sites that Include Class I Areas (red circles)

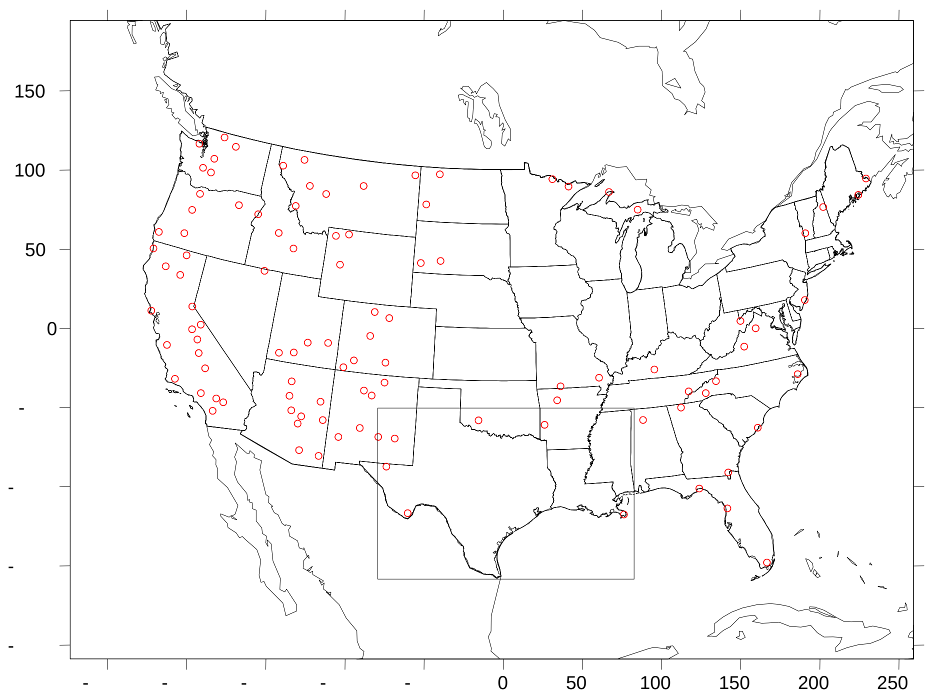
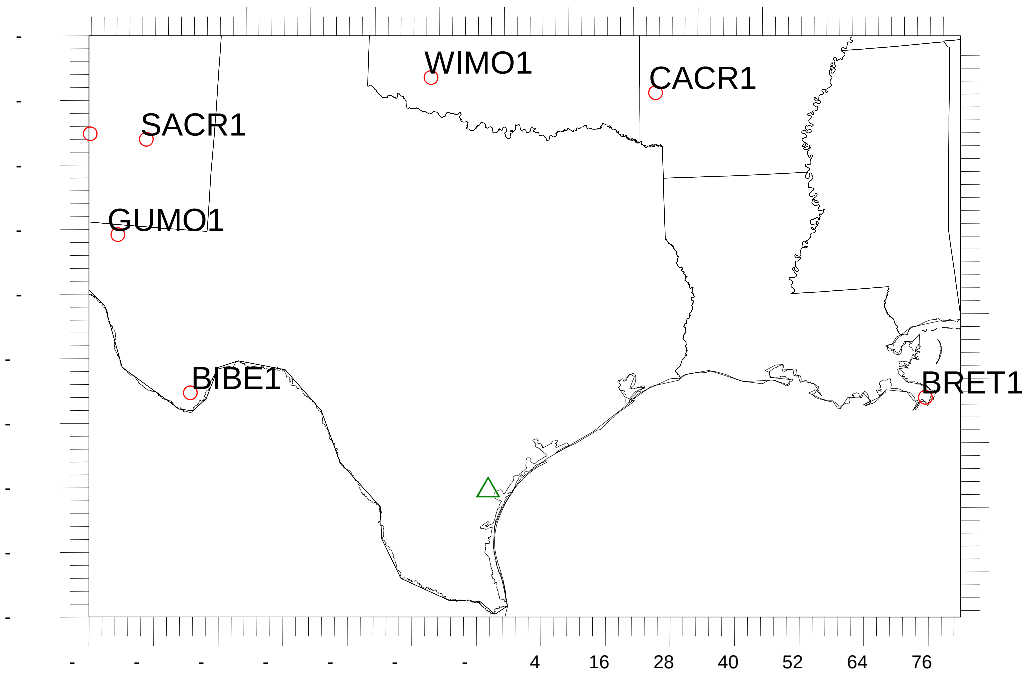


Figure 2-2. Texas BART 12 km Modeling Domain and Locations of IMPROVE Monitoring Sites that Include Class I Areas (red circles) and Location of the Valero Bill Greehey Refinery (green triangle)



2.2.3 Meteorology

CAMx uses the fifth-generation National Center for Atmospheric Research (NCAR) / Penn State Mesoscale Model (MM5) to predict regional-scale atmospheric conditions for calendar year 2002. MM5 is a limited-area, non-hydrostatic, terrain-following sigma-coordinate model designed to simulate or predict meso-scale and regional-scale atmospheric circulation. It has been developed as a community meso-scale model and is continuously being improved by contributions from users at several universities and government laboratories. MM5 is the latest in a series that developed from a meso-scale model originally used at Penn State in the early 1970s. Since that time, it has undergone many changes designed to broaden its usage. These include:

- A multiple-nest capability;
- Non-hydrostatic dynamics which allows the model to be used at a few-kilometer scale (down to 1 to 2 kilometers);
- Multitasking capability on shared- and distributed-memory machines;
- A four-dimensional data-assimilation capability; and
- More physics options.

MM5 is supported by several auxiliary programs which are referred to collectively as the MM5 modeling system.

Terrestrial and isobaric meteorological data are horizontally interpolated from a latitude-longitude mesh to a variable high-resolution domain on either a Mercator, Lambert conformal, or polar stereographic projection. Since the interpolation does not provide meso-scale detail, the interpolated data is enhanced with observations from the standard network of surface and rawinsonde (upper air) stations.

2.2.4 VOC Emissions

Although VOC is not a visibility-impairing pollutant by rule, actual VOC emissions from the CENRAP Typical 2002F database for BART-eligible emission units were included in the source-specific exemption modeling. VOC chemistry affects radical concentrations in the atmosphere. Radical species, particularly the hydroxyl radical, play an important role in sulfate and nitrate formation. Because VOC is not a visibility-impairing pollutant, the impact of VOC emissions on visibility at Class I areas were not tracked.

2.3 Source Specific Inputs

There are 53 BART-eligible emission units at the Valero Bill Greehey Refinery that emit or have the potential to emit under normal operations one or more visibility-impairing pollutants: NO_X, SO_2, and/or PM_{10}. Valero has a flexible permit with short-term and long-term site-wide emission caps. In lieu of determining worst-case emissions on a unit-by-unit basis, the one-hour emission cap for the account was used as a surrogate for worst-case 24-hour actual emissions from BART-eligible sources. This approach is highly conservative considering that the flexible permit cap is a not-to-exceed, one-hour emission limit for all emission units – both BART-eligible and non-BART-eligible – at the site. The 1-hour emission caps are as follows:

NO_X = 350 lbs/hour (8,400 lbs/24-hours)

SO_2 = 389 lbs/hour (9,336 lbs/24-hours)

PM_{10} = 92.3 lbs/hour (2,215.2 lbs/24-hours)

A copy of the current flexible permit (Permit Numbers 2937 and PSD-TX-1023M1) was provided by Valero to ENVIRON.

The entire emissions cap was distributed among the BART-eligible emission units according to the ratio of 2002 actual emissions used in the BART screening analysis. For example, if the 2002 actual emissions for Emission Unit A is 2% of the NO_X, 4% of the PM_{10} and 15% of the SO_2 from all BART-eligible emission units, then 2% of the 1-hour NO_X emission cap, 4% of the 1-hour PM_{10} emission cap and 15% of the 1-hour SO_2 emission cap were assigned to that emission unit for source-specific BART modeling purposes.

Texas facilities typically do not measure or calculate $PM_{2.5}$ emissions for permitting or emissions inventory reporting purposes. For emissions inventory reporting purposes facilities will assume that emissions of total suspended particulate (TSP), PM_{10}, and $PM_{2.5}$ are equal. The Valero Bill Greehey Refinery provided PM_{10} emissions for their maximum 24-hour emissions. Therefore, PM_{10} emissions were distributed between $PM_{2.5}$ and PM_{10} based on the ratio of $PM_{2.5}$ to PM_{10} for BART-eligible facilities reported in the CENRAP Typical 2002F database. Furthermore, PM emissions were speciated based on the BART-eligible unit source classification code (SCC). The PM speciation was performed by the emissions processor, SMOKE.

Modeling parameters for the Valero Bill Greehey Refinery (Corpus Christi) East Plant are presented in Attachment F. Emission source parameters – stack location, height, diameter, temperature, velocity, etc. – were taken from the CAMx screening analysis modeling input files and updated, as appropriate.

2.4 Modeling Methodology

2.4.1 Compiling Emissions

Source-specific BART modeling was conducted for eight accounts using a single CAMx modeling run. BART-eligible sources associated with each account were assigned a unique point index in the point source file. Appropriate emission rates were used for the BART sources and stack diameters for these sources were set negative for PiG treatment. The BART emission sources were appended to the non-BART emission sources to complete PSAT inventory. Once the PSAT emission files were generated, CAMx was then run to obtain separate PM source apportionment modeling results for each of the facilities participating in this evaluation. PSAT was run for the sulfate (SO_4), nitrate (NO_3) and primary particulate families of PSAT tracers.

2.4.2 Running CAMx with PSAT

A fixed-width format ASCII receptor definition input file containing the location of Class I areas in the coordinate system of the CAMx grid was created. The Class I areas considered in the analysis were those where one or more of the source groupings with accounts included in this modeling evaluation had impacts greater than 0.5 dv as determined during the screening analysis. These areas are as follows.

- Bandelier National Monument, New Mexico
- Big Bend National Park, Texas
- Bosque del Apache National Wildlife Refuge, New Mexico
- Breton Wilderness Area, Louisiana
- Caney Creek Wilderness Area, Arkansas
- Carlsbad Caverns National Park, New Mexico
- Great Sand Dunes Wilderness Area, Colorado
- Guadalupe Mountains National Park, Texas
- Hercules-Glade Wilderness Area, Missouri
- Mesa Verde National Park, Colorado
- Mingo Wilderness Area, Missouri
- Pecos Wilderness Area, New Mexico

- Salt Creek Wilderness Area, New Mexico
- Upper Buffalo Wilderness Area, Arkansas
- White Mountain Wilderness Area, New Mexico
- Wheeler Peak Wilderness Area, New Mexico
- Wichita Mountains National Wildlife Refuge, Oklahoma

PSAT apportions PM components among several Source Groups. The BART-eligible emissions units within the same accounts considered in this analysis were grouped and assigned a unique group number defined in the point source emissions input file. The area and non-BART sources were grouped together and assigned a source region number, one that is different from numbers assigned to the BART-eligible groups, defined in a source region map.

PSAT was invoked within the CAMx control file. Full flexi-nesting was invoked in which CAMx internally interpolates all of the meteorological and other inputs from the 36 km grid to the 12 km grid.

2.5 Post Processing

CAMx determined the 24-hour average concentrations of SO_4, NO_3 and particulate matter. These values were used to calculate the mass extinction, b_{source}, at each Class I area.

$$b_{source} = b_{SO4} + b_{NO3} + b_{PM}$$

The Haze Index (HI) and the change in deciview (del-dv) from the source's and natural conditions HI were then calculated for each Class I area considered in the analysis.

$$HI_{source} = 10\ 1n[(b_{source} + b_{natural})/10]$$

$$\text{del-dv} = HI_{source} - HI_{natural}$$

The CAMx guidance document approved by the TCEQ executive director and posted to the TCEQ website (http://www.tceq.state.tx.us/implementation/air/sip/bart/haze.html) as of February 28, 2007, specifies that the 98^{th} percentile del-dv resulting from emissions from BART-eligible emission units at each BART-eligible account are to be compared to the 0.5 dv significance level to determine if the source has a potentially significant impact on visibility. As stated in the approved guidance document, accounts with 98^{th} percentile values below 0.5 dv at all Class I areas are considered to have insignificant impacts on visibility.

EPA Region VI and Federal Land Manager (FLM) modeling personnel expressed to the TCEQ that 98^{th} percentile values may not be sufficiently conservative to ensure adequate protection of visibility resources at the Class I areas.[11] Specific concerns stated by EPA and the FLMs were that:

1. CAMx is run using only one year of meteorological data (vs. three for CALPUFF in a refined modeling analysis);
2. The chemistry used in CAMx is more realistic, yet less conservative than that used in CALPUFF; and
3. Plume spread using CAMx is more realistic, yet less conservative than that typically observed using CALPUFF.

Therefore, EPA and the FLMs stated a desire that the TCEQ use the del-dv for the highest day, not the 98th percentile, in determining significance. As a result, the TCEQ communicated their intentions to revise modeling guidance and require use of the highest value to determine significance.

[11] The term *Federal Land Manager* applies to all agencies that manage federal lands, including the National Park Service, USDA Forest Service and the U.S. Fish & Wildlife Service.

3. MODELING RESULTS

Table 3-1 presents the maximum impacts due to emissions from the Valero Bill Greehey Refinery at all Class I areas included in the CAMx modeling analysis. These results are presented graphically in Figures 3-1 and 3-2.

Table 3-1. Maximum Impacts at All Class I Areas Evaluated

Class I Area	Maximum Impact (dv)
Bandelier	0.008
Big Bend	**0.114**
Bosque del Apache	0.010
Breton	0.009
Caney Creek	**0.112**
Carlsbad Caverns	0.045
Great Sand Dunes	0.004
Guadalupe Mountains	0.046
Hercules-Glade	0.070
La Garita	0.002
Mesa Verde	0.002
Mingo	0.027
Pecos	0.016
Salt Creek	0.032
San Pedro Parks	0.005
Upper Buffalo	**0.091**
Weminuche	0.002
White Mountain	0.013
Wheeler Peak	0.007
Wichita Mountains	0.086

Figure 3-1. CAMx Modeling Results:
Class I Areas Bandelier through La Garita

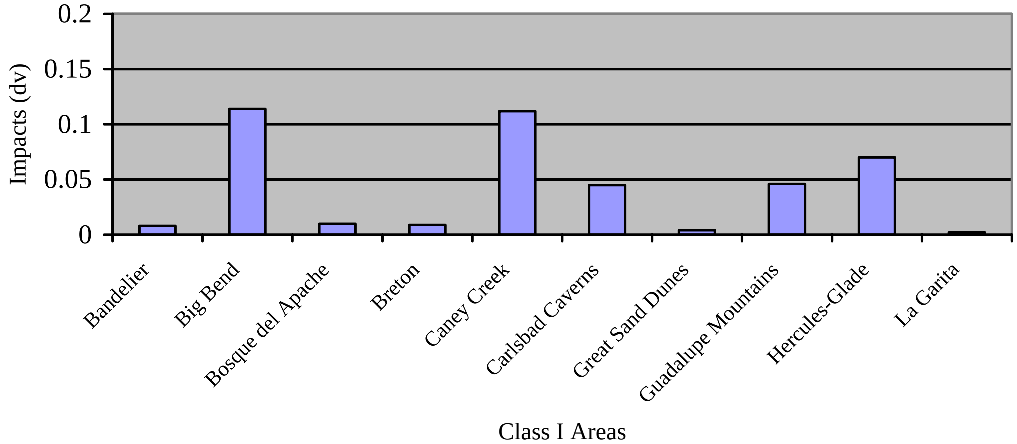
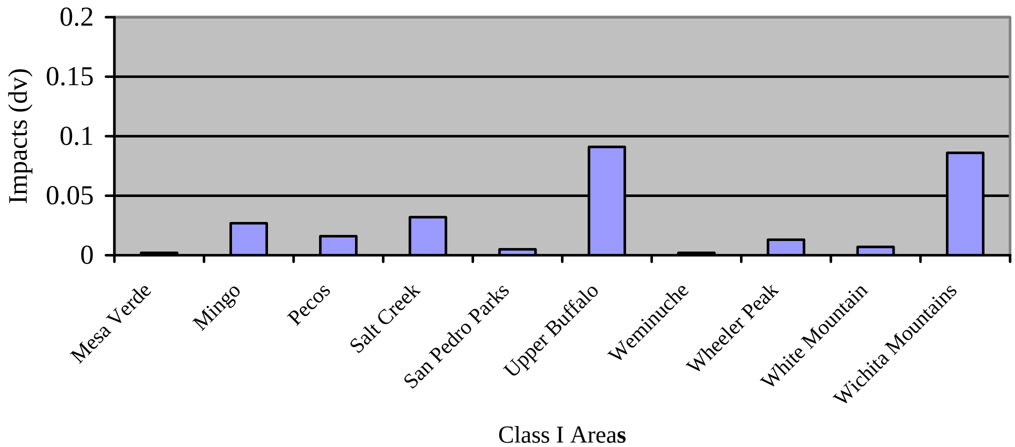


Figure 3-2. CAMx Modeling Results:
Class I Areas Mesa Verde through Wichita Mountains



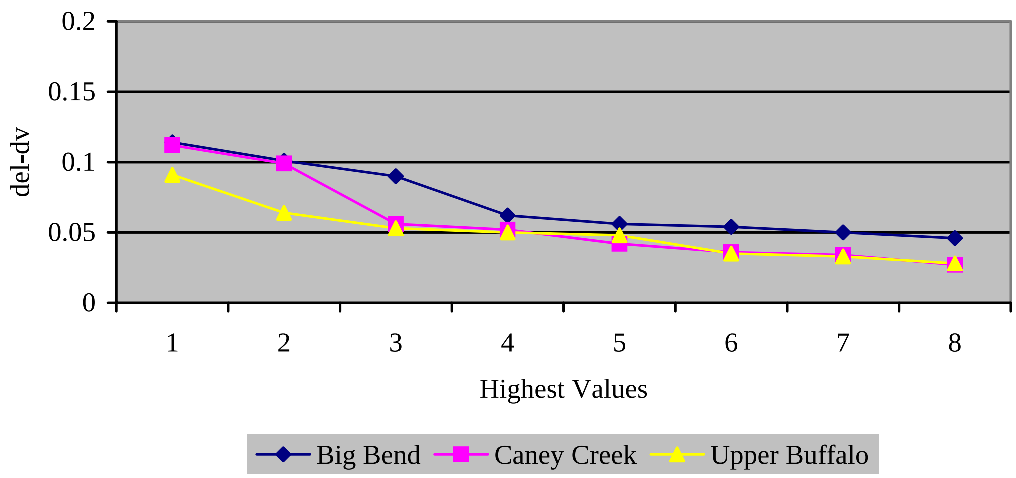
The eight highest impact days at the three Class I areas with the highest maximum impacts due to emissions from the Valero Bill Greehey Refinery are presented in Table 3-2.

Table 3-2. Eight Highest Impact Days

Day	Visibility Impacts (dv)		
	Big Bend National Park, Texas	Caney Creek Wild., Arkansas	Upper Buffalo Wild. Arkansas
Highest	0.114	0.112	0.091
2nd Highest	0.101	0.099	0.064
3rd Highest	0.090	0.056	0.053
4th Highest	0.062	0.052	0.050
5th Highest	0.056	0.042	0.048
6th Highest	0.054	0.036	0.035
7th Highest	0.050	0.034	0.033
8th Highest	0.046	0.027	0.028

These results are presented graphically in Figure 3-3.

Figure 3-3. Eight Highest Impact Days



As shown, all visibility impacts are less than 0.5 dv. Therefore, per regulation, the Valero Bill Greehey Refinery does not significantly contribute to visibility impairment at any Class I area and is exempt from the BART engineering analysis and control requirements.

Modeling input and output files will be retained by ENVIRON and made available to the TCEQ and/or others upon request.

A T T A C H M E N T A

30 TAC 116, Subchapter M: Best Available Retrofit Technology (BART)
Effective February 1, 2007

SUBCHAPTER M: BEST AVAILABLE RETROFIT TECHNOLOGY (BART)
§§116.1500, 116.1510, 116.1520, 116.1530, 116.1540
Effective February 1, 2007

§116.1500. Definitions.

The following terms, when used in this subchapter, have the following meanings unless the context clearly indicates otherwise. For terms not defined in this section, the definitions contained in 40 Code of Federal Regulations (CFR) §51.301, as effective August 30, 1999, are incorporated by reference.

(1) **Best available retrofit technology (BART)-eligible source**--Any emissions units that comprise any of the following stationary sources of air pollutants, including any reconstructed source, that were not in operation prior to August 7, 1962, and were in existence on August 7, 1977, and collectively have the potential to emit 250 tons per year (including fugitive emissions, to the extent quantifiable) of any visibility-impairing air pollutant:

(A) fossil fuel-fired steam electric plants of more than 250 million British thermal units (BTU) per hour heat input;

(B) coal-cleaning plants (thermal dryers);

(C) kraft pulp mills;

(D) portland cement plants;

(E) primary zinc smelters;

(F) iron and steel mill plants;

(G) primary aluminum ore reduction plants;

(H) primary copper smelters;

(I) municipal incinerators capable of charging more than 250 tons of refuse per day;

(J) hydrofluoric, sulfuric, and nitric acid plants;

(K) petroleum refineries;

(L) lime plants;

(M) phosphate rock processing plants;

(N) coke oven batteries;

(O) sulfur recovery plants;

(P) carbon black plants (furnace process);

(Q) primary lead smelters;

(R) fuel conversion plants;

(S) sintering plants;

(T) secondary metal production facilities;

(U) chemical process plants;

(V) fossil fuel-fired boilers of more than 250 million BTUs per hour heat input;

(W) petroleum storage and transfer facilities with capacity exceeding 300,000 barrels;

(X) taconite ore processing facilities;

(Y) glass fiber processing plants; and

(Z) charcoal production facilities.

(2) **Visibility-impairing air pollutant**--Any of the following: nitrogen oxides, sulfur dioxide, or particulate matter.

Adopted January 10, 2007 Effective February 1, 2007

§116.1510. Applicability and Exemption Requirements.

(a) The requirements of this subchapter apply to best available retrofit technology (BART)-eligible sources as defined in §116.1500 of this title (relating to Definitions).

(b) The owner or operator of a BART-eligible source may demonstrate, using a model and modeling guidelines approved by the executive director, that the source does not contribute to visibility impairment at a Class I area. A BART-eligible source that does not contribute to visibility impairment at any Class I area is not subject to the requirements of §116.1520 or §116.1530 of this title (relating to Best Available Retrofit Technology (BART) Analysis and Best Available Retrofit Technology (BART) Control Implementation). A source is considered to not contribute to visibility impairment if, as demonstrated by modeling performed by the executive director or performed in accordance with the guidelines approved by the executive director, it causes a visibility impairment of less than 0.5 deciviews at all Class I areas. The modeling demonstration must be submitted under seal of a Texas licensed professional engineer and must be received by the commission's Air Permits Division no later than April 30, 2007.

(c) The following BART-eligible sources are not subject to the requirements of §116.1520 or §116.1530 of this title for the indicated pollutant(s). Owners or operators claiming exemption under this subsection shall maintain records sufficient to demonstrate compliance with the exemption criteria, and shall make such records available upon request of personnel from the commission or any local air pollution control agency having jurisdiction.

(1) Any BART-eligible source that has the potential to emit less than 500 tons per year of combined nitrogen oxides (NO_x) and sulfur dioxide (SO_2) and that is located more than 50 kilometers from any Class I area is not subject to BART for NO_x and SO_2.

(2) Any BART-eligible source that has the potential to emit less than 1,000 tons per year of combined NO_x and SO_2 and that is located more than 100 kilometers from any Class I area is not subject to BART for NO_x and SO_2.

(3) Any BART-eligible source that has the potential to emit less than 40 tons per year of NO_x or 40 tons per year of SO_2 is not subject to BART for NO_x or SO_2, respectively. Any BART-eligible source that has the potential to emit less than 15 tons per year of particulate matter with an aerodynamic diameter less than or equal to a nominal 10 micrometers (PM_{10}) is not subject to BART for PM_{10}.

(d) BART-eligible electric generating units participating in the Clean Air Interstate Rule Trading Program are not subject to the requirements of §116.1520 or §116.1530 of this title for NO_x and SO_2.

(e) Any BART-eligible source that has been screened out by the Texas Commission on Environmental Quality-conducted screening modeling is not subject to the requirements of §116.1520 or §116.1530 of this title, for the specified pollutant(s), if the owner or operator has reviewed the modeling inputs for that source and the executive director receives written certification that the inputs are correct no later than February 28, 2007.

Adopted January 10, 2007 Effective February 1, 2007

§116.1520. Best Available Retrofit Technology (BART) Analysis.

(a) Except as provided under §116.1510(b), (c), or (d) of this title (relating to Applicability and Exemption Requirements), each best available retrofit technology (BART)-eligible source shall conduct an analysis of emissions control alternatives for all visibility-impairing pollutants. This analysis must include the identification of all available, technically feasible retrofit technologies, and for each technology identified, an analysis of the cost of compliance, the energy and non-air quality environmental impacts, the degree of visibility improvement in affected Class I areas resulting from the use of the control technology, the remaining useful life of the source, and any existing control technology present at the source. Based on this analysis, the owner or operator shall identify an emission control strategy as the prospective BART control strategy for the source. The determination of BART must be made according to 40 Code of Federal Regulations Part 51, Appendix Y, as effective September 6, 2005.

(b) As part of the BART analysis required in subsection (a) of this section, the owner or operator shall include detailed information documenting the projected hourly and annual emission limits for the selected BART control strategy.

(c) The owner or operator of each BART-eligible source shall submit a completed BART analysis to the commission's Air Permits Division under seal of a Texas licensed professional engineer. The completed BART analysis must be received by the commission's Air Permits Division no later than April 30, 2007.

Adopted January 10, 2007 Effective February 1, 2007

§116.1530. Best Available Retrofit Technology (BART) Control Implementation.

(a) Each owner or operator of a best available retrofit technology (BART)-eligible source shall install and operate BART-required control equipment no later than five years after the United States Environmental Protection Agency has approved a Regional Haze State Implementation Plan for the State of Texas. Each owner or operator shall maintain the BART-required control equipment and establish procedures to ensure such equipment is properly and continuously operated and maintained.

(b) Prior to any installation of BART-required control equipment, each owner or operator of a BART-eligible source shall comply with the requirements under Subchapter B of this chapter (relating to New Source Review Permits), Subchapter F of this chapter (relating to Standard Permits) or Subchapter H of this chapter (relating to Permits for Grandfathered Facilities) as applicable to authorize the construction or modification and to establish emission limitations of BART.

Adopted January 10, 2007 Effective February 1, 2007

§116.1540. Exemption from Best Available Retrofit Technology (BART) Control Implementation.

The owner or operator of any best available retrofit technology (BART)-eligible source may apply for an exemption from the requirement to install, operate, and maintain BART-required control equipment, pursuant to the provisions of 40 Code of Federal Regulations §51.303. Any exemption request under this section requires initial approval from the executive director and final approval from the administrator of the United States Environmental Protection Agency (EPA). Exemption requests submitted to the EPA must be accompanied by written concurrence from the executive director.

Adopted January 10, 2007 Effective February 1, 2007

A T T A C H M E N T B

Final Report: Screening Analysis of Potential BART-Eligible Sources in Texas
September 27, 2006

Final Report

Screening Analysis of
Potential BART-Eligible
Sources in Texas

Work Order No. 582-04-65563-06-10

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GLOSSARY OF ACRONYMS

AERMOD	American Meteorological Society/Environmental Protection Agency Regulatory Model Improvement Committee Model
BAND	Bandelier
BART	Best Available Retrofit Technology
BIBE	Big Bend
bnatural	Clean Natural Conditions
BOAP	Bosque del Apache
BRET	Breton
bsource	Total light extinction due to a source
CAA	Clean Air Act
CACR	Caney Creek
CAIR	Clean Air Interstate Rule
CALPUFF	California Puff Model
CAMx	Comprehensive Air Quality Model with extensions
CCRS	Coarse Crustal particulate matter
CENRAP	Central Regional Air Planning Association
CMAQ	Community Multiscale Air Quality Modeling System
CPRM	Coarse other Primary particulate matter
del-dv	change in deciview (delta-deciview)
dv	deciviews
EC	Elemental Carbon
EGU	Electric Generating Units
EPA	Environmental Protection Agency
f(RH)	Relative Humidity adjustment factor
FCRS	Fine Crustal particulate matter
FLAG	Federal Land Managers Air Quality Related Values Workgroup
FLM	Federal Land Manager
FPRM	Fine other Primary particulate matter
FR	Federal Register
GREASD	Greatly Reduced and Simplified Dynamics
GRSA	Great Sand Dunes
GUMO	Guadalupe Mountains
HEGL	Hercules-Glade
Hg	Mercury
HI	Haze Index
IMPROVE	Interagency Monitoring of Protected Visual Environments
IRON	Incremental Reactions for Organics and Nitrogen Oxides
km	Kilometers
MEVE	Mesa Verde
MING	Mingo
Mm^{-1}	Inverse Megameters
MRPO	Midwest Regional Planning Organization
MW	Megawatt
NH_4	Ammonium
NO_3	Particulate Nitrate
non-EGU	Non-Electric Generating Units

NO_x	Nitrogen Oxides
NSR	New Source Review
OC	Organic Carbon
OMC	Organic Matter Carbon
OSAT	Ozone Source Apportionment Technology
PGM	Photochemical Grid Model
PiG	Plume-in-Grid
PLUVUE	Plume Visibility Model
PM	Particulate Matter
PM_{10}	Particulate Matter with aerodynamic diameters less than 10 microns
$PM_{2.5}$	Particulate Matter with aerodynamic diameters less than 2.5 microns
POA	Primary Organic Aerosol
PSAT	Particulate Matter Source Apportionment Technology
PSD	Prevention of Significant Deterioration
QAPP	Quality Assurance Program Plan
Q/D	Emissions of source / distance to nearest Class 1 area
RH	Relative Humidity
RHR	Regional Haze Rule
RPO	Regional Planning Organization
SACR	Salt Creek
SAPE	San Pedro Parks
SIP	State Implementation Plan
SMOKE	Sparse Matrix Operator Kernel Emissions
SO_2	Sulfur Dioxide
SO_4	Sulfate
SOA	Secondary Organic Aerosol
TCEQ	Texas Commission on Environmental Quality
TIP	Tribal Implementation Plan
tpy	tons per year
UARG	Utility Air Regulatory Group
UPBU	Upper Buffalo
VISTAS	Visibility Improvement State and Tribal Association of the Southeast
VOC	Volatile Organic Compounds
WEMI	Weminuche
WHIT	White Mountain
WHPE	Wheeler Peak
WHRI	White River monitor considered a surrogate for Flat Tops, Maroon Bells-Snowmass, West Elk, and Eagles Nest
WIMO	Wichita Mountains
WRAP	Western Regional Air Partnership

1.0 INTRODUCTION

OVERVIEW

The final version of EPA's Regional Haze Regulations was published in the *Federal Register* on July 6, 2005 (70 FR 39104, EPA, 2005). One of the provisions of the program is the requirement that certain existing stationary sources emitting visibility-impairing air pollutants install and operate the Best Available Retrofit Technology (BART). The regulations require case-by-case BART determination to define specific emissions limitations representing BART and schedules for compliance for each source subject to BART. This analysis will be part of the Regional Haze State Implementation Plan (SIP). The SIP must be submitted to EPA by December 17, 2007.

A BART eligible source or existing stationary facility means any stationary source of air pollutants, including any reconstructed source, which: (a) "was not in operation prior to August 7, 1962, and was in existence on August 7, 1977," (b) "has the potential to emit 250 tons per year or more of any air pollutant" and (c) falls within one or more of 26 specifically listed source categories (40 CFR Section 51.301). BART controls are required for any BART-eligible source that can be reasonably expected to cause or contribute to impairment of visibility in any of the 156 federal parks and wilderness (Class I) areas protected under the regional haze rule. Air quality modeling is an important tool available to the states in determining whether a source can be reasonably expected to contribute to visibility impairment at a Class I area.

Texas has over one hundred potential BART-eligible sources that need to be evaluated to determine whether they contribute significantly to visibility impairment of a Class I area. The individual modeling of each of these potential BART-eligible sources would be quite resource intensive. The Texas Commission on Environmental Quality (TCEQ) performed BART screening analysis to determine whether emissions from groups of potential BART-eligible sources contribute significantly to visibility impairment of Class I areas. If the visibility impacts from a group of potential BART-eligible sources does not contribute significantly to the visibility impairment of any Class I area, then it stands to reason that each BART source in the group would not contribute significantly to visibility impairment at any Class I area.

Purpose

The TCEQ compiled a list of potential BART-eligible sources against the three BART-eligible criteria and performed screening analyses to determine which source groups do not cause or contribute significantly to visibility impairment of Class I areas. The screening analyses then tested whether it is appropriate to exclude volatile organic compounds (VOC) and/or particulate matter (PM) emissions from potential BART-eligible sources in Texas from the BART process. The resulting screened potential BART-eligible sources list will be more manageable, allowing the TCEQ to focus their efforts on determining whether BART controls are needed for the remaining BART-eligible sources.

This document presents the results of the Texas BART screening analysis that was aimed at determining the following:

- Whether VOC and/or PM emissions from potential BART-eligible sources in Texas can be shown to contribute insignificantly to visibility impairment at Class I areas, and therefore, may not need perform any further BART analysis; and

- Whether there are groups of non-Electric Generating Utilities (non-EGU) potential BART-eligible sources whose total SO_2 and NO_x emissions can be shown to contribute insignificantly to visibility impairment at Class I areas, and therefore may not need perform any further BART analysis.

Texas BART Screening Analysis Modeling Protocol

Prior to performing the Texas BART screening analysis, a modeling protocol was prepared that provided details on the modeling approach to be used for the Texas group BART screening analysis (ENVIRON, 2005b). The modeling protocol was reviewed by TCEQ and EPA prior to performing the analysis. The Texas BART screening analysis modeling protocol contained a summary of the BART requirements taken from EPA's BART guidelines (EPA, 2005) and BART modeling protocols prepared by Visibility Improvement State and Tribal Association of the Southeast (VISTAS, 2006), Central Regional Air Planning Association (CENRAP), (Alpine and ENVIRON, 2005) and Western Regional Air Partnership (WRAP) (UCR and ENVIRON, 2006).

BART Modeling Guidance

To evaluate the visibility impacts of a potential BART-eligible source at Class I areas beyond 50 kilometers (km) from the source, EPA modeling guidance (EPA, 2003c) recommends the use of the California Puff Model (CALPUFF) model. For modeling the impact of sources closer than 50 km to a Class I area, EPA's BART guidance recommends that expert modeling judgment be used "giving consideration to both CALPUFF and other methods." The Plume Visibility Model-II (PLUVUE) model is mentioned as a possible model to consider in addition to CALPUFF within 50 km of a source. The EPA guidance notes that regional scale photochemical grid models may have merit, but such models are resource intensive relative to CALPUFF. Photochemical grid models are clearly more appropriate for cumulative modeling options such as in the determination of the aggregate contribution of all BART-eligible sources to visibility impairment, but such use should involve consultation with the appropriate EPA Regional Office.

CALPUFF is recommended for ascertaining whether a potential BART-eligible source may need to perform further BART analysis. If a source is determined to be subject to BART, CALPUFF or another appropriate model should be used to evaluate the improvement in visibility resulting from the application of BART controls. Emissions reflecting periods of start-up, shutdown, and malfunction are not to be considered in determining the appropriate emission rates. EPA recommends that states use the highest 24-hour average actual emission rate for the most recent five-year period (excluding periods with start-up, shutdown, and malfunctions). Visibility improvements may be evaluated on a pollutant-specific basis.

EPA's BART guidance allows states to "submit to EPA a demonstration, based on an analysis of overall visibility impacts, that emissions from BART-eligible sources in your state, considered together, are not reasonably anticipated to cause or contribute to any visibility impairment in a Class I area, and thus no source should be subject to BART" (EPA, 2005). This "Option 3" approach that has been pursued in the Texas BART screening analysis discussed in this report. EPA guidance notes that “you may also use a photochemical grid model” and “if you wish to use a grid model, you should consult with the appropriate EPA Regional Office to develop an appropriate modeling protocol” (EPA, 2005). The TCEQ entered into discussions with EPA Region 6 and developed a group screening modeling approach that was agreed to as acceptable.

Overview of Approach

For the specific BART screening analysis undertaken in this study, a photochemical grid model is more appropriate than the single-source CALPUFF model for the following reasons:

- There are a large number of potential BART-eligible sources in Texas, and use of a photochemical grid model will allow the efficient screening of many sources in a scientifically defensible manner;
- For most potential BART-eligible sources in Texas, the Class I areas where visibility impacts will be estimated are far away from the source;
- TCEQ has identified which of the many potential BART-eligible sources satisfy the three criteria for being BART-eligible. If sources can be determined to make an insignificant contribution to visibility impairment at Class I areas as a group, resources can then be focused on those sources determined most likely to impact visibility in Class I areas;
- Use of a photochemical grid model allows the quantitative assessment of the visibility impacts due to potential BART-eligible sources’ VOC and PM emissions;
- Use of a photochemical grid model with full chemistry alleviates concerns raised about the inadequacy of the CALPUFF sulfate and nitrate chemistry (Morris, Tana and Yarwood, 2003; Morris, Lau and Koo, 2005; Morris et al., 2006); and
- Use of a photochemical grid model provides an evaluation of the cumulative impact of BART-eligible sources on visibility in Class I areas.

The Texas BART screening analysis was built upon the regional photochemical modeling (Morris et al., 2005d) being conducted by CENRAP. In particular, the CENRAP 2002 36 km modeling database for the Comprehensive Air Quality Model with extensions (CAMx) (ENVIRON, 2005a) was enhanced to include a 12 km grid over Texas and nearby Class I areas. CAMx zero-out VOC and PM emissions from BART sources and inert primary PM BART sources emissions modeling was conducted to determine whether potential BART-eligible sources’ VOC and PM emissions could be shown to contribute insignificantly to visibility impairment at any Class I area. The CAMx PM Source Apportionment Technology (PSAT) modeling was also conducted for groups of potential BART-eligible sources’ SO_2 and NO_x emissions. A potential BART-eligible source in a group that is shown not to contribute significantly to visibility impairment at any Class I area may be excluded from further steps in the BART process. Several features and recent enhancements to the CAMx modeling system that make it more suitable for performing BART screening modeling include:

- **Flexi-nesting:** Finer grids can be specified (12 km in this case) without necessarily needing to provide finer grid meteorological and emission inputs. The flexi-nesting allows for better simulation of transport, dispersion, and chemistry of point sources.
- **PSAT:** PSAT allows tracking of the impacts of BART sources or groups of BART sources within a single run. A single run is more efficient than performing many separate zero-out modeling runs for each BART source or group of BART sources.

- **Implementation of PSAT and the full chemistry Plume-in-Grid (PiG):** The PSAT and full chemistry PiG provide more accurate treatment of the near-source transport, plume dispersion, and plume chemistry of the BART sources.

A new version of CAMx was used in this work that incorporates all of these features (CAMx V4.4). This version of CAMx is currently undergoing final testing and evaluation and will be posted on the CAMx website (www.camx.com) along with an updated user's guide and test problem in 2006. This version of the model is currently available on request from ENVIRON (contact camx@environ.org).

2.0 MODELING APPROACH

This section describes the modeling approach and databases that were used to perform the BART screening analysis of potential BART-eligible sources. The analyses consisted of two basic elements:

- **VOC and PM Modeling Analyses:** An analysis of the VOC and PM emissions from all potential BART-eligible sources was performed. Followed by analysis of VOC from all potential BART-eligible sources. Finally, analyses of the PM emissions from the BART-eligible sources was performed using grouped sources.

- **PSAT Modeling Analyses for SO_2 and NO_x emissions:** Screening analyses for groups of potential BART-eligible non-EGU sources' SO_2 and NO_x emissions were performed to determine whether the group's visibility impacts at Class I areas were insignificant.

Both elements of the BART screening analyses used the same 36/12 km 2002 annual database for CAMx (ENVIRON, 2005a) based on the database developed by CENRAP (www.cenrap.org). The VOC and PM emission screening analyses were performed using emissions zero-out modeling and, for primary PM only, inert simulations. The group of sources' SO_2 and NO_x emissions screening analyses were performed using an updated version of the CAMx PSAT.

2002 ANNUAL 36/12 KM MODELING DATABASE

The BART screening modeling was performed using the CAMx Version 4.4 model and the 2002 annual regional photochemical modeling database developed as part of the CENRAP (Morris, 2005d). CENRAP developed a 2002 annual modeling database for CAMx on the 36 km unified national Regional Planning Organization (RPO) grid that covers the continental United States. This database was developed following the procedures outlined in the CENRAP Modeling Protocol (Morris et al., 2004c) and CENRAP modeling Quality Assurance Program Plan (QAPP) (Morris and Tonnesen, 2004b). The CENRAP preliminary base case model performance evaluation results for the CAMx model on the national 36 km grid using the CENRAP base A emissions is given in Morris et al., (2005d). The CENRAP modeling protocol, QAPP, and preliminary base A evaluation reports provide details on the development of the CENRAP 2002 36 km annual modeling database. Provided below is a summary of the enhancements made to the CENRAP database for use in this BART screening analysis. Additional details can be found in the modeling protocol (ENVIRON, 2005b).

Enhancements to the CENRAP 2002 Modeling Database

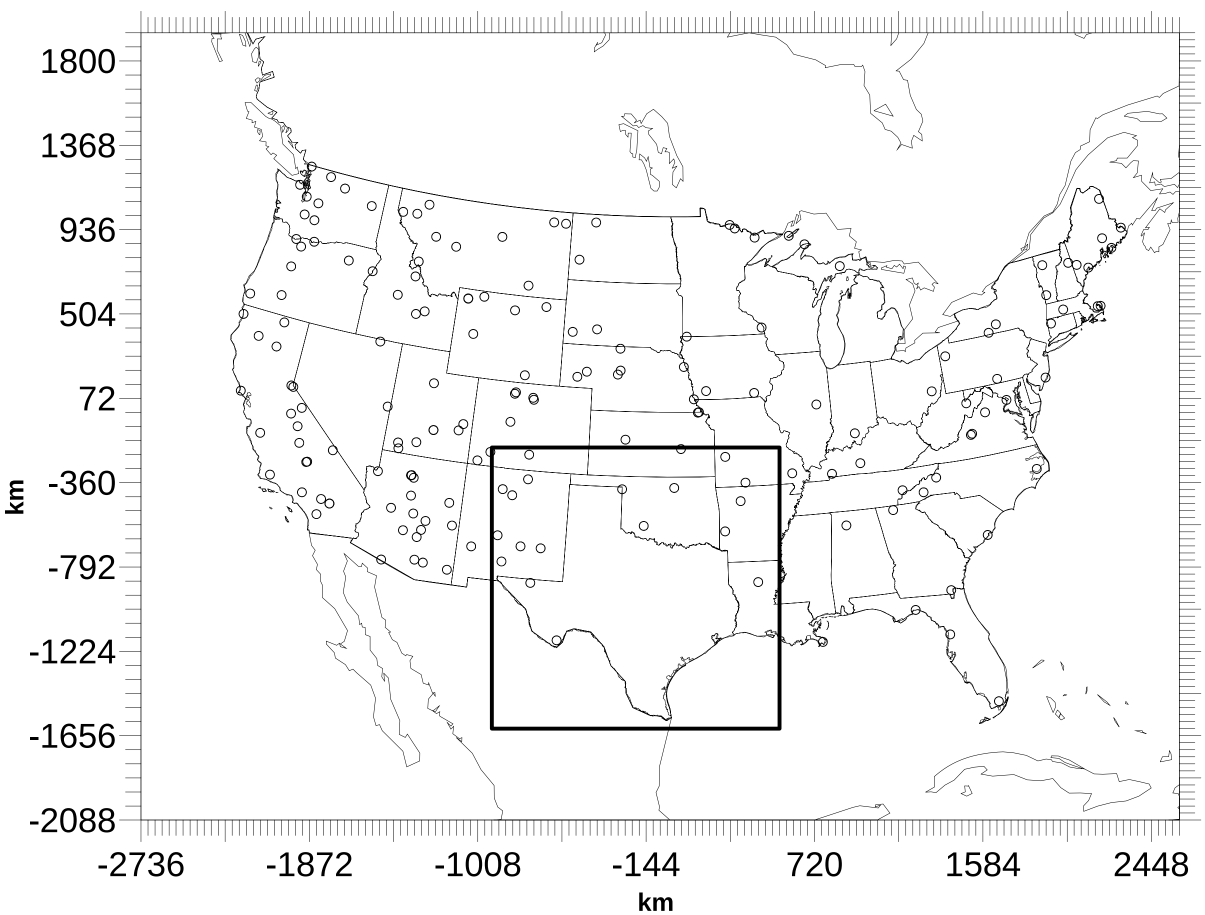
The CENRAP 2002 36 km annual CAMx evaluation using the base A emissions and CAMx Version 4.20 is reported in Morris and co-workers (2005d). Additional model performance evaluation displays for more recent base cases are available on the CENRAP modeling Website (http://pah.cert.ucr.edu/aqm/cenrap/cmaq.shtml#camx). CENRAP is currently updating the 2002 base case emissions and updated CMAQ and CAMx simulations are forthcoming. For the Texas

BART screening modeling, the base B base case database was used (the most current available at the time).

The CENRAP Base B 2002 36 km annual CAMx photochemical modeling database was updated to include a 12 km nested-grid that covers Texas and Class I areas in and near Texas including:

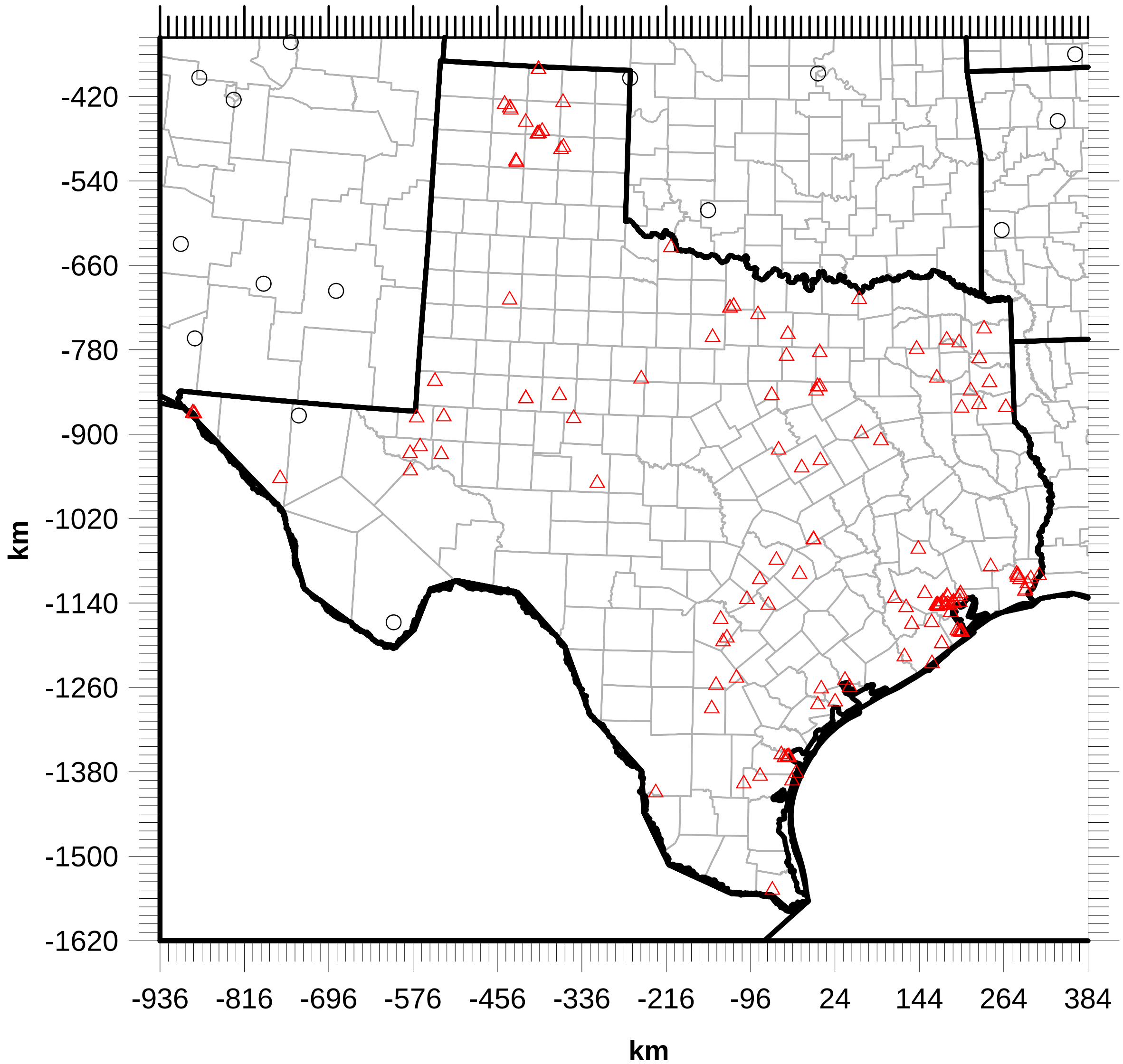
- National Parks: Big Bend (BIBE), Guadalupe Mountains (GUMO), and Carlsbad Caverns
- Wildlife Refuges: Salt Creek (SACR) and Wichita Mountains (WIMO)
- Wilderness Areas: White Mountain (WHIT), Caney Creek (CACR), Upper Buffalo (UPBU), and Hercules-Glade (HEGL).

Figure 2-1 displays the 36/12 km nested grid structure used for the CAMx BART screening modeling analysis. The locations of the potential BART-eligible sources and Interagency Monitoring of Protected Visual Environments (IMPROVE) sites that includes Class I areas within the 12 km modeling domain are shown in Figure 2-2. The CAMx flexi-nesting feature was used to specify a 12 km Texas fine grid within the CENRAP 36 km modeling domain. Full flexi-nesting was invoked in which CAMx internally interpolates meteorological data, emissions and other inputs from the 36 km grid to the 12 km grid.



36km Domain: South West Corner = (-2736 km, -2088 km) NX, NY = (148x112)
LCP Definition: (-97.0, 40.0, 45.0, 33.0)

Figure 2-1. Texas BART modeling 36/12 km modeling domain and the locations of the IMPROVE monitoring sites that include Class I areas, indicated by circles.



12km Domain: South West Corner = (-936 km, -1620 km) NX, NY = (111x108)
LCP Definition: (-97.0, 40.0, 45.0, 33.0)

Figure 2-2. Texas BART modeling 12 km modeling domain and the locations of the IMPROVE monitoring sites (circles) that include Class I areas and locations of potential BART-eligible sources in Texas (triangles).

ENHANCEMENTS TO THE PM SOURCE APPORTIONMENT TECHNOLOGY

PSAT was used to conduct the SO_2 and NO_x potential BART-eligible screening analysis. In Version 4.4 of CAMx, the PSAT was updated to be compatible with the CAMx full chemistry Plume-in-Grid (PiG) module. The next section briefly describes the PSAT technique and the enhancements that were made to the CAMx PiG and PSAT to make them compatible with each other. More details are provided in the modeling protocol (ENVIRON, 2005b).

PSAT Formulation

PSAT is designed to source apportion the following PM species modeled in CAMx:

- Sulfate (SO_4)
- Particulate nitrate (NO_3)
- Ammonium (NH_4)
- Particulate mercury (Hg(p))
- Secondary organic aerosol (SOA)
- Six categories of primary particulate matter (PM)
    - Elemental carbon (EC)
    - Primary organic aerosol (POA)
    - Fine crustal PM (FCRS)
    - Fine other primary PM (FPRM)
    - Coarse crustal PM (CCRS)
    - Coarse other primary PM (CPRM)

PSAT performs PM source apportionment for each user defined source group. A source group consists of a combination of a geographic regions and emissions source categories. Examples of source regions include: countries, states, nonattainment areas, or counties. Examples of source categories include: area sources, mobile sources, biogenic sources, elevated point sources or individual point sources. The user defines a map to specify the source regions. The user then defines each source category. For example, separate gridded low-level emissions and/or elevated point source emissions. The model then determines each source group by joining the source categories with the source region map.

The PSAT "reactive tracers" that are added for each source category/region combination (*i*) are described below. In general, a single tracer can track primary PM species, whereas secondary PM species require several tracers to track the relationship between gaseous precursors and the resulting PM. Particulate nitrate and secondary organics are the most complex species to apportion because the emitted precursor gases (NO_x and VOCs) are several steps removed from the resulting PM species (NO_3 and SOA). There is a PSAT convention that tracer names for particulate species begin with the letter "P."

<u>**Sulfur (SO_4 Tracers)**</u>

$SO2_i$ Primary SO_2 emissions
$PS4_i$ Particulate sulfate ion from primary emissions plus secondarily formed sulfate

<u>**Nitrogen (NO_3 Tracers)**</u>

RGN_i Reactive gaseous nitrogen including primary NO_x ($NO + NO_2$) emissions plus nitrate radical (NO_3), nitrous acid (HONO) and dinitrogen pentoxide (N_2O_5).
TPN_i Gaseous peroxyl acetyl nitrate (PAN) plus peroxy nitric acid (PNA)
NTR_i Organic nitrates (RNO_3)
$HN3_i$ Gaseous nitric acid (HNO_3)
$PN3_i$ Particulate nitrate ion from primary emissions plus secondarily formed nitrate
$NH3_i$ Gaseous ammonia (NH_3)
$PN4_i$ Particulate ammonium (NH_4)

Secondary Organic Aerosol (SOA Tracers)

ALK_i Alkane/Paraffin secondary organic aerosol precursors
ARO_i Aromatic (toluene and xylene) secondary organic aerosol precursors
CRE_i Cresol secondary organic aerosol precursors
TRP_i Biogenic olefin (terpene) secondary organic aerosol precursors
$CG1_i$ Condensable gases from toluene and xylene reactions (low volatility)
$CG2_i$ Condensable gases from toluene and xylene reactions (high volatility)
$CG3_i$ Condensable gases from alkane reactions
$CG4_i$ Condensable gases from terpene reactions
$CG5_i$ Condensable gases from cresol reactions
$PO1_i$ Particulate organic aerosol associated with CG1
$PO2_i$ Particulate organic aerosol associated with CG2
$PO3_i$ Particulate organic aerosol associated with CG3
$PO4_i$ Particulate organic aerosol associated with CG4
$PO5_i$ Particulate organic aerosol associated with CG5

Mercury (Hg Tracers)

$HG0_i$ Elemental Mercury vapor
$HG2_i$ Reactive gaseous Mercury vapor
PHG_i Particulate Mercury

Primary Particulate Matter (PM Tracers)

PEC_i Primary Elemental Carbon
POA_i Primary Organic Aerosol
PFC_i Fine Crustal PM
PFN_i Other Fine Particulate
PCC_i Coarse Crustal PM
PCS_i Other Coarse Particulate

PSAT includes a total of 32 tracers for each source group (*i*) if source apportionment is applied to all types of PM. Since source apportionment may not always be needed for all species, the PSAT implementation is flexible and allows source apportionment for any or all of the chemical classes in each CAMx simulation (i.e. the SO_4, NO_3, SOA, Hg and primary PM classes listed above). For example, source apportionment for sulfate/nitrate/ammonium requires just nine tracers per source group.

One fundamental assumption in PSAT is that PM is apportioned back to the primary precursor for each type of PM. For example, SO_4 is apportioned to SO_x emissions, NO_3 is apportioned to NO_x emissions, NH_4 is apportioned to NH_3 emissions, etc.

Updates to the PSAT Formulation

The CAMx PSAT and PiG algorithms were updated to treat the near-source dispersion and chemistry of secondary PM formation in the PM source apportionment calculations. A new full-chemistry PiG module was developed that has been extended to PSAT and Ozone Source Apportionment Technology (OSAT). The full-chemistry PiG treats the gas-phase and aqueous-phase reactions associated with ozone, sulfate and nitrate formation.

PROCEDURES FOR VOC AND PM EMISSIONS BART SCREENING ANALYSIS

Two types of screening analyses were performed to assess the visibility impacts of VOC and PM emissions from potential BART-eligible sources:

(1) zero-out VOC and PM emissions modeling; and
(2) inert PM emissions modeling.

The results from the VOC and PM BART screening analyses are provided in Chapter 3.

Zero-Out VOC and PM Emissions Screening Analyses

The first BART screening analysis evaluated the cumulative visibility impacts at Class I areas of VOC and PM emissions from all potential BART-eligible sources in Texas using two 2002 annual CAMx 36/12 km simulations:

- 2002 BART base case emissions scenario (with estimated 24-hour maximum VOC and PM emissions for BART-eligible sources); and

- 2002 BART VOC and PM emissions zero-out scenario.

The 2002 BART base case emissions scenario was based on the CENRAP 2002 typical base B base case emissions scenario. The BART guidelines require that BART modeling use the maximum actual 24-hour emissions for each BART-eligible source (EPA, 2005). The CENRAP 2002 typical scenario includes average actual emissions for all sources. The maximum 24-hour actual emission rates are not readily available for most sources. To account for the differences between maximum 24-hour actual and average typical actual, the average typical actual emissions for potential BART-eligible sources in the CENRAP 2002 typical base B base case emissions scenario were doubled at the suggestion of EPA Region 6. EPA noted that this assumption provides a conservative (overstatement) estimate of maximum actual 24-hour emissions for most sources.

Visibility impacts were calculated at each Class I area using the differences in 24-hour PM concentrations between the 2002 BART base case and 2002 BART zero-out case following the procedures given in EPA's BART modeling guidance (EPA, 2005). The BART procedures were outlined in the Federal Land Managers Air Quality Related Values Workgroup report (FLAG, 2000) and EPA regional haze guidance documents (EPA, 2003a, b). The FLAG (2000) procedures were developed to estimate visibility impacts at Class I areas from proposed new sources as part of the Prevention of Significant Deterioration (PSD) and New Source Review (NSR) process and were adapted to BART. These procedures use the IMPROVE reconstructed mass extinction equation (Malm et al., 2000). Instead of using measured PM concentrations from an IMPROVE monitor, incremental PM concentrations from the differences in the CAMx 2002 BART base case and 2002 BART VOC/PM zero-out runs were used in the equation.

The IMPROVE reconstructed mass extinction equation is used to estimate visibility at Class I areas using IMPROVE monitoring data and has also been used for evaluating visibility impacts at Class I areas due to new sources using modeling output of a single source or group of sources.

The total light extinction due to a source (b_{source}), in units of inverse Megameters (Mm^{-1}), is assumed to be the sum of the light extinction due to the source's individual PM species concentration impacts times an extinction efficiency coefficient:

$$\mathbf{b_{source} = b_{SO4} + b_{NO3} + b_{OC} + b_{EC} + b_{soil} + b_{coarse}}$$

$$b_{SO4} = 3\,[(NH_4)_2SO_4]f(RH)$$
$$b_{NO3} = 3\,[NH_4NO_3]f(RH)$$
$$b_{OC} = 4\,[OMC]$$
$$b_{EC} = 10\,[EC]$$
$$b_{Soil} = 1\,[Soil]$$
$$b_{coarse} = 0.6\,[Coarse\ Mass]$$

Here f(RH) are relative humidity adjustment factors. As recommended by EPA BART modeling guidance, Class I area specific monthly average f(RH) values were used (EPA, 2005; 2003a). The concentrations in the square brackets are in $\mu g/m^3$ and are based on the differences in concentrations between the 2002 BART base case and 2002 BART VOC/PM zero-out case. Although CAMx explicitly models ammonia and ammonium, the IMPROVE extinction equation assumes that SO_4 and NO_3 are completely neutralized by ammonium. The OMC in the above equation is Organic Matter Carbon, and OC is Organic Carbon. When using IMPROVE measurements, the current IMPROVE extinction equation assumed an OMC/OC ratio of 1.4 (i.e., the IMPROVE OC measurement is multiplied by 1.4 to obtain OMC). Since CAMx directly models OMC, the 1.4 factor is not needed. The following species mappings were used to map the CAMx species to those used in the IMPROVE reconstructed mass extinction equation given above:

$$[(NH_4)_2SO_4] = 1.375 \times PSO4$$
$$[NH_4NO_3] = 1.290 \times PNO3$$
$$[OMC] = POA + SOA1 + SOA2 + SOA3 + SOA4 + SOA5$$
$$[EC] = PEC$$
$$[Soil] = FPRM + FCRS$$
$$[Coarse\ Mass] = CPRM + CCRS$$

Here PSO4 and PNO3 are the CAMx particulate sulfate and nitrate species. POA is the CAMx primary Particulate Organic Aerosol species, whereas SOA1 through 5 are the five Secondary Organic Aerosol species carried in CAMx. Primary Elemental Carbon is represented by PEC in CAMx. CAMx carries two species that represent the other $PM_{2.5}$ components (i.e., fine particles that are not SO_4, NO_3, EC or OC), one for the crustal (FCRS), and the other for the remainder of the primary emitted $PM_{2.5}$ species (FPRM). Similarly, CAMx carries two species to represent Coarse Mass ($PM_{10-2.5}$), one for crustal (CCRS), and one for other (CPRM).

The Haze Index (HI) for the source is calculated in deciviews from the source's extinction plus natural background using the following formula:

$$HI_{source} = 10 \ln[(b_{source} + b_{natural})/10]$$

Here, $b_{natural}$ is the Class I area specific clean natural visibility background (natural conditions); EPA's default values are used in this analysis (EPA, 2003b).

The source's HI is compared against natural conditions to assess the significance of the source's visibility impact. EPA guidance lists natural conditions ($b_{natural}$) by Class I areas in terms of Mm^{-1} (EPA, 2003b) and assumes clean conditions with no man-made or weather interference. The visibility significance metric for evaluating BART sources is the change in deciview (del-dv) from the source's and natural conditions Haze Indices:

$$\text{del-dv} = HI_{source} - HI_{natural} = 10 \ln[(b_{source} + b_{natural})/10] - 10 \ln[b_{natural}/10]$$
$$= 10 \ln[(b_{source} + b_{natural})/b_{natural}]$$

The visibility impacts from the CAMx BART VOC/PM zero-out run was first calculated using all PM species (i.e., those associated with both VOC and PM precursors). We then made separate visibility calculations using just those PM species associated with the elimination of the BART VOC emissions (i.e., SOA1, SOA2, SOA3, SOA4, and SOA5) and then just those species associated with the elimination of the primary PM emissions (i.e., PSO4, PNO3, POA, PEC, FCRS, FPRM, FCRS and CCRS).

VOC: $b_{source} = 4\,[SOA1+SOA2+SOA3+SOA4+SOA5]$

PM: $b_{source} = 3\,f(RH)([1.375PSO4]+[1.290PNO3]) + 4[POA] + 10[PEC] + 1[FPRM+FCRS] + 0.6[CPRM+CCRS])$

The del-dv impacts were calculated at each Class I area within the CENRAP southern BART modeling region that contains Texas, as specified in the CENRAP BART Modeling Protocol (Alpine and ENVIRON, 2005). Table 2-1 lists the Class I areas included in the BART screening analysis. Table 2-1 also includes the deciviews and the extinctions associated with the Annual Average Natural Conditions and Best 20% Natural Conditions of these Class I areas (EPA, 2003b). Since the PSAT runs are computationally resource intensive, not all of the Class I sites analyzed were included in the 12 km domain. Sites analyzed, which were in the 36 km domain, are noted is Table 2-1.

Table 2–1. Class I areas included in the analysis.

IMPROVE sites	Longitude	Latitude	Class I Area	Domain	Best 20% dv	Best 20% $b_{natural}$ (Mm-1)	Annual average dv	Annual average $b_{natural}$ (Mm-1)
BAND1	-106.27	35.78	Bandelier	12km	1.90	12.1	4.46	15.6
BIBE1	-103.18	29.30	Big Bend	12km	1.81	12.0	4.37	15.5
BOAP1	-106.85	33.87	Bosque del Apache	12km	1.85	12.0	4.41	15.5
CACR1	-94.14	34.45	Caney Creek	12km	3.65	14.4	7.49	21.1
GUMO1	-104.81	31.83	Guadalupe Mountains, Carlsbad Caverns	12km	1.91	12.1	4.47	15.6
HEGL1	-92.92	36.61	Hercules-Glade	12km	3.59	14.3	7.43	21.0
SACR1	-104.40	33.46	Salt Creek	12km	1.87	12.1	4.43	15.6
SAPE1	-106.85	36.01	San Pedro Parks	12km	1.91	12.1	4.47	15.6
UPBU1	-93.20	35.83	Upper Buffalo	12km	3.60	14.3	7.44	21.0
WHIT1	-105.54	33.47	White Mountain	12km	1.86	12.0	4.42	15.6
WHPE1	-105.45	36.59	Wheeler Peak, Pecos	12km	1.95	12.2	4.51	15.7
WIMO1	-98.71	34.73	Wichita Mountains	12km	3.39	14.0	7.23	20.6
WHRI1	-106.82	39.15	Flat Tops, Maroon Bells-Snowmass, West Elk, Eagles Nest	36km	1.96	12.2	4.52	15.7
BRET1	-89.21	29.12	Breton	36km	3.85	14.7	7.69	21.6
GRSA1	-105.52	37.72	Great Sand Dunes	36km	1.98	12.2	4.54	15.7
WEMI1	-107.80	37.66	La Garita, Black Canyon of the Gunnison, Weminuche	36km	1.94	12.1	4.50	15.7
MEVE1	-108.49	37.20	Mesa Verde	36km	1.97	12.2	4.53	15.7
MING1	-90.14	36.97	Mingo	36km	3.59	14.3	7.43	21.0

EPA's BART guidance suggests that a significance threshold to determine whether a source contributes significantly to visibility impairment at a Class I area should be no greater than 0.5 dv. Thus, if the del-dv due to all potential BART-eligible sources VOC and/or PM emissions at every Class I area and for all days from 2002 are < 0.5 dv, then VOC and PM emissions from all potential BART-eligible sources may be determined to contribute insignificantly to visibility impairment. Therefore, the VOC and/or PM emissions from each potential BART source would not be significant. Under these conditions, VOC and/or PM emissions would no longer need to be considered.

Since there were days in 2002 for which the del-dv is > 0.5 dv in the BART VOC/PM zero-out screening analysis, the results were examined in more detail, including the analysis of the frequency, magnitude and duration of the visibility impacts. The BART guidance suggests comparing the 98th percentile del-dv at any Class I area with the 0.5 dv significant threshold to determine whether a significant visibility impact would reasonably be expected to occur. Using one year of modeling results (2002) the 98th percentile would correspond to the eighth highest 24-hour average visibility impact at each Class I area. PM and VOC were also analyzed separately to determine if one of these pollutants could be determined to impact insignificantly to visibility impairment at the Class I areas.

Inert Primary PM Screening Analysis

The preliminary zero-out modeling indicated that the visibility impacts at one or more Class I areas due to PM emissions from all potential BART-eligible sources in Texas exceeded the 0.5 del-dv threshold, therefore the group of all Texas BART PM sources were analyzed further. However, the visibility impacts due to all Texas BART sources' VOC emissions were not significant because they were < 0.5 del-dv threshold at all Class I areas. Therefore, each Texas BART source's VOC emissions are < 0.5 del-dv.

Further analyses of the BART PM emissions were made by grouping the sources for screening modeling. Since only primary PM emissions were being considered in these runs, chemistry was not needed. Primary PM emissions were analyzed using inert CAMx 2002 36/12 km simulations of the grouped BART sources. The procedures for evaluating the visibility impacts from the inert CAMx simulations are the same as described for the PM impacts from the zero-out runs. However, instead of using concentrations differences from the 2002 BART base case and 2002 zero-out case, the total concentrations due to all BART sources in each BART group from the CAMx inert simulation were used.

PROCEDURES FOR SCREENING MODELING OF BART SOURCES SO_2 AND NO_x EMISSIONS

The screening analysis for potential BART-eligible non-EGU SO_2 and NO_x emissions used the updated PSAT in CAMx V4.4 and the 2002 36/12 km modeling database described above. The non-EGU potential BART-eligible sources were initially divided up into 10 source groups for the PSAT screening analysis. CAMx/PSAT was run for the 2002 annual year on the 36/12 km grid with each potential BART-eligible source flagged to use the new PSAT PiG feature. As suggested by EPA Region 6, the CENRAP average non-EGU BART SO_2 and NO_x emissions were doubled to provide a conservative estimate of maximum 24-hour actual emissions.

As described for the zero-out run, if the del-dv due to all sources in a source group at every Class I area and for all days from 2002 is < 0.5 dv, then each potential BART-eligible source in the source group would be < 0.5 dv. Thus, each source would contribute insignificantly to visibility impairment.

PSAT Modeling for SO_2 and NO_x emissions was performed for non-EGUs. The $PM_{2.5}$ provisions of the Clean Air Interstate Rule (CAIR) apply to Texas. EPA BART guidance (EPA, 2005) states that CAIR satisfies the BART SO_2 and NO_x requirements for CAIR $PM_{2.5}$ States.

PSAT Visibility Impacts

The sulfate and nitrate families of PSAT tracers were invoked for the PSAT BART screening analysis. The visibility impacts at each Class I area were calculated in a similar manner as described above for the zero-out modeling, only the PSO4 and PNO3 concentrations from each PSAT BART source group were used in the extinction equation. The IMPROVE reconstructed mass extinction equation for each potential BART-eligible source group included the sulfate and nitrate components:

$$\mathbf{b_{group} = b_{SO4} + b_{NO3}}$$

$$b_{SO4} = 3\,[(NH_4)_2SO_4]f(RH)$$
$$b_{NO3} = 3\,[NH_4NO_3]f(RH)$$

The f(RH) are the monthly average relative humidity adjustment factors, as recommended by EPA's guidance (EPA, 2003a). The concentrations in the square brackets are in $\mu g/m^3$ and are the sulfate and nitrate from the PSAT output for each potential BART-eligible PSAT source group (i). Sulfate and nitrate are assumed to be fully neutralized by ammonium:

$$[(NH_4)_2SO_4] = 1.375 \times PS4_i$$
$$[NH_4NO_3] = 1.290 \times PN3_i$$

The Haze Index (HI) for the source group is calculated in deciview from the source group's extinction plus natural background using the following formula:

$$HI_{group} = 10 \ln[(b_{group} + b_{natural})/10]$$

The source's HI is compared to natural conditions to assess the significance of the source's visibility impact. EPA guidance lists natural conditions ($b_{natural}$) by Class I area in terms of Mm^{-1} (EPA, 2003b) and assumes clean conditions with no anthropogenic or weather interference. The visibility significance metric for evaluating BART sources is the change in deciview (del-dv) from the source's and natural conditions haze indices:

$$\text{del-dv} = HI_{group} - HI_{natural} = 10 \ln[(b_{group} + b_{natural})/10] - 10 \ln[b_{natural}/10]$$

VISIBILITY SIGNIFICANCE THRESHOLDS

EPA's BART guidance lists a significance threshold for contributing to visibility impairment at a Class I area as a 0.5 change in deciview (del-dv) over natural conditions (EPA, 2005). The guidance also states that the 98th percentile (e.g., eighth highest in a year) change in deciview value should be compared against the 0.5 del-dv significance threshold. EPA's visibility natural conditions guidance document lists three default natural condition values corresponding to best 20% days, worst 20% days, and annual average (EPA, 2003b). The guidance recommends that natural conditions corresponding to the best 20% days be used when calculating the BART visibility significance metric. However, the use of the best 20% natural conditions in the BART significance test was challenged by the Utility Air Regulatory Group (UARG). As part of the settlement to this challenge, EPA now allows the use of annual average natural conditions in the calculation of the BART visibility significance metrics (Paise, 2006 a, b). This analysis presents the change in deciview (del-dv) due to each group of BART sources in Class I areas using both the maximum and 98th percentile values, and both the best 20% and annual average natural conditions. The final recommendation on the significance determination is based on the 98th percentile change in deciview over annual average natural conditions.

3. BART VOC AND PM SCREENING ANALYSIS

The first part of the BART screening analysis estimated the visibility impacts at Class I areas from VOC and PM emissions from all potential BART-eligible sources in Texas. The visibility impacts at Class I areas are expressed as the change in deciview (del-dv) compared to natural conditions. If the estimated 98th percentile del-dv compared to the annual average natural conditions due to VOC and PM emissions from all potential BART-eligible sources is < 0.5 at all Class I areas, then VOC and PM emissions from each BART source would be < 0.5 del-dv and therefore may require no further BART analyses. The BART VOC and PM emissions screening analysis was conducted using CAMx zero-out modeling as described in Section 2. Details of the screening VOC and PM screening analyses are given below.

BART-Eligible Sources' VOC and PM_{10} emissions

The zero-out modeling initially grouped all potential BART sources together. The initial screening analysis demonstrated that the visibility impacts of PM, and VOC emissions from all potential BART-eligible sources was > 0.5 del-dv as some Class I areas.

Because the VOC and PM impacts from all sources were shown to be > 0.5 del-dv, further screening modeling was conducted. The VOC emission impacts were shown to be < 0.5 del-dv (see Figure 3-1, below). The primary PM emissions impacts, however, were shown to be > 0.5 del-dv. Therefore, additional CAMx analyses of the BART PM emission were conducted.

BART EGU and non-EGU sources were separated and then further divided into subgroups. A list of BART-eligible EGU and non-EGU sources' VOC and PM_{10} emissions and their associated groups are shown in Tables 3-1 and 3-2, respectively.

The VOC and PM_{10} emissions in Tables 3-1 and 3-2 are the annual average emission estimates from the CENRAP 2002 database. To estimate the highest 24-hour actual emissions to be used in the BART analysis, the modeling used doubled annual average emissions. The VOC and PM_{10} emissions are processed by the Sparse Matrix Operator Kernel Emissions (SMOKE) emissions model that speciates the VOC and PM_{10} emissions into the individual VOC and PM species used in CAMx. The Carbon Bond IV (CB4) chemistry option was used in the CAMx runs.

Table 3-1. Potential BART-eligible EGU sources and their VOC/PM_{10} emissions.

ID	Account	Company	Plant	VOC (tpy)	PM_{10} (tpy)	VOC Zero-Out	PM Zero-Out group	Needs Further Analysis for PM
1	BC0015L	LOWER COLORADO RIVER AUTHORITY	LOWER COLORADO RIVE	32	52	pass	3A	
2	BG0057U	CITY PUBLIC SERVICE	SOMMERS DEELY SPRUC	147	1473	pass	1A	
3	BG0186I	CITY PUBLIC SERVICE	V.H. BRAUNIG PLANT	43	58	pass	3A	
4	CD0013K	AEP TEXAS CENTRAL COMPANY	LA PALMA POWER STAT	13	30	pass	2	
5	CI0012D	TEXAS GENCO LP	CEDAR BAYOU STATION	113	157	pass	pass	
6	DB0251U	TXU ELECTRIC COMPANY	NORTH LAKE STEAM EL	22	27	pass	2	
7	EE0029T	EL PASO ELECTRIC CO	NEWMAN STATION	31	54	pass	2	
8	FB0025U	TXU GENERATION COMPANY LP	VALLEY STEAM ELEC.	44	58	pass	3A	
9	FC0018G	LOWER COLORADO RIVER AUTHORITY	FAYETTE POWER PROJE	167	1255	pass	2	
10	FG0020V	TEXAS GENCO LP	W A PARISH STATION	89	281	pass	2	
11	FI0020W	TXU BIG BROWN COMPANY LP	BIG BROWN	134	933	pass	3A	
12	GB0037T	TEXAS GENCO LP	P H ROBINSON STATIO	43	62	pass	1A	
13	GJ0043K	SOUTHWESTERN ELECTRIC POWER		17	24	pass	2	
14	HQ0012T	TXU GENERATION COMPANY LP	DECORDOVA STEAM ELE	85	113	pass	2	
15	JI0030K	AEP TEXAS NORTH COMPANY	W.T.U.-FT. PHANTOM	26	36	pass	1A	
16	LN0081B	XCEL ENERGY	JONES STATION	43	85	pass	3A	
17	MB0116C	TXU GENERATION COMPANY LP	TRADINGHOUSE STM EL	89	116	pass	3A	
18	ME0006A	SOUTHWESTERN ELECTRIC POWER WILKES	WILKES POWER PLT	41	56	pass	2	
19	MM0023J	TXU GENERATION COMPANY LP	SANDOW STEAM ELECTR	67	735	pass	1A	
20	MO0014L	TXU GENERATION COMPANY LP	MORGAN CREEK STEAM	25	32	pass	1A	
21	MQ0009F	ENTERGY GULF STATES INC	LEWIS CREEK PLANT	65	89	pass	2	
22	NE0024E	AEP TEXAS CENTRAL COMPANY	BARNEY M DAVIS POWE	46	66	pass	2	
23	NE0025C	LON C HILL POWER	LON C HILL	7	10	pass	1A	
24	NE0026A	AEP TEXAS CENTRAL COMPANY	NUECES BAY POWER ST	28	39	pass	3A	
25	OC0013O	ENTERGY GULF STATES INC	SABINE PLANT	168	234	pass	3A	
26	PG0040T	SOUTHWESTERN PUBLIC SERVICE	NICHOLS STATION	10	19	pass	1A	
27	PG0041R	SOUTHWESTERN PUBLIC SERVICE	HARRINGTON STATION	97	1546	pass	2	
28	RL0020K	TXU GENERATION COMPANY LP	MARTIN LAKE ELECTRI	257	881	pass	1A	
29	TA0352I	TXU GENERATION COMPANY LP	EAGLE MOUNTAIN STAT	19	27	pass	1A	
30	TF0012D	SOUTHWESTERN ELECTRIC POWER	WELSH POWER PLANT	89	1755	pass	3B	X
31	TF0013B	TXU GENERATION COMPANY LP	MONTICELLO STM ELE	245	3297	pass	1B	X
32	TG0044C	AEP TEXAS		12	23	pass	3A	
33	TH0004D	ELECTRIC UTILITY DEPT	DECKER CREEK POWER	5	69	pass	1A	
34	VC0003D	VICTORIA POWER		5	8	pass	1A	
35	WC0028Q	TXU GENERATION COMPANY LP	PERMIAN BSN STM ELE	60	82	pass	3A	
36	WE0005G	LAREDO POWER		11	19	pass	2	
37	YB0017V	TXU GENERATION COMPANY LP	GRAHAM STEAM ELECTR	19	27	pass	2	

Table 3-2. Potential BART-eligible non-EGU sources and their VOC/PM_{10} emissions.

ID	Account	Company	Plant	VOC (tpy)	PM_{10} (tpy)	VOC Zero-Out	PM Zero-Out	Needs Further Analysis for PM	Note
1	AB0012W	DUKE ENERGY FIELD SERVICES	FULLERTON GAS PLANT	317	20	Pass	3		
2	AC0017B	ABITIBI CONSOLIDATED CORP		81	3	Pass	see note		Excluded (PM_{10}<10tpy)
3	AC0019U	EXAS FOUNDRIES		180	226	Pass	see note		No longer BART-eligible
4	AG0024G	PUEBLO MIDSTREAM GAS CORP	FASHING PLANT	39	1	Pass	see note		Excluded (PM_{10}<10tpy)
5	BG0045E	CAPITOL CEMENT DIV CAPITOL	PORTLAND CEMENT	95	40	Pass	2C		
6	BJ0001T	CHEMICAL LIME LTD	CHEMICAL LIME--CLIF	4	224	Pass	3		
7	BL0002S	AMOCO CHEMICAL CO	CHOCOLATE BAYOU PLN	417	130	Pass	1A		
8	BL0021O	BASF CORPORATION	FREEPORT SITE	38	4	Pass	see note		Excluded (PM_{10}<10tpy)
9	BL0038U	SOLUTIA INC		264	23	Pass	2AC		
10	BL0082R	THE DOW CHEMICAL CO	PLANT B	517	78	Pass	2C		
11	BL0113I	EQUISTAR		282	65	Pass	1A		
12	BL0268B	EQUISTAR CHEMICALS LP		397	13	Pass	3		
13	BL0758C	CHEVRON PHILLIPS CHEMICAL	SWEENY COMPLEX	109	103	Pass	1A		
14	CA0011B	J.L. DAVIS GAS PROCESSING	LULING GAS PLANT	9	1	Pass	see note		Excluded (PM_{10}<10tpy)
15	CB0003M	ALCOA ALUMINA & CHEMICALS	POINT COMFORT PLANT	176	296	Pass	1A		
16	CB0028T	UNION CARBIDE CORPORATION	SEADRIFT PLANT	492	60	Pass	1A		
17	CG0010G	INTERNATIONAL PAPER CO		1322	578	Pass	2AA	X	
18	CG0012C	ENBRIDGE PIPELINES	BRYANS MILL PLANT	2	1	Pass	see note		Excluded (PM_{10}<10tpy)
19	CI0022A	DYNEGY MIDSTREAM SERVICES		553	21	Pass	3		
20	CR0020C	COPANO PROCESSING LP		551	10	pass	1A		
21	CY0019H	DYNEGY MIDSTREAM SERVICES	WADDELL COMPRESSOR	35	1	pass	see note		Excluded (PM_{10}<10tpy)
22	EB0057B	HUNTSMAN POLYMERS		878	107	pass	1A		
23	EB0197H	DUKE ENERGY FIELD SERVICES		245	7	pass	see note		No longer BART-eligible
24	ED0011D	CHAPARRAL STEEL MIDLOTHIAN		340	157	pass	3		
25	ED0034O	NORTH TEXAS CEMENT COMPANY	NORTH TEXAS CEMENT	15	448	pass	1B		
26	ED0051O	OWENS CORNING		100	298	pass	3		
27	ED0066B	TXI OPERATIONS, L.P.	MIDLOTHIAN PLANT	18	85	pass	1A		
28	FG0036G	TXI OPERATION LP	CLODINE EXPANDED SH	5	77	pass	1A		
29	GB0001R	BP AMOCO CHEMICAL COMPANY	BP AMOCO CHEMICAL T	500	93	pass	3		
30	GB0004L	BP PRODUCTS NORTH AMERICA IN TEXAS	TEXAS CITY REFINERY	1180	737	pass	2B		
31	GB0055R	MARATHON ASHLAND PETROLEUM	TEXAS CITY REFINERY	478	272	pass	3		

ID	Account	Company	Plant	VOC (tpy)	PM_{10} (tpy)	VOC Zero-Out	PM Zero-Out	Needs Further Analysis for PM	Note
32	GB0073P	VALERO REFINING CO TEXAS	TEXAS CITY REFINERY	153	150	pass	3		
33	GB0076J	UNION CARBIDE CORP	VINYL ACETATE FACIL	154	0	pass	see note		Excluded (PM_{10}<10tpy)
34	GH0003Q	CABOT CORPORATION	PAMPA PLANT	1025	55	pass	3		
35	GH0004O	CELANESE CHEMICAL	CHEMICAL MANUFACTUR	644	194	pass	1A		
36	HD0029C	A.N.R. PIPELINE COMPANY	E.G. HILL COMPRESSO	82	33	pass	2B		
37	HG0033B	EQUISTAR CHEMICALS LP	CHANNELVIEW COMPLEX	29	0	pass	see note		Excluded (PM_{10}<10tpy)
38	HG0048L	LYONDELL CITGO REFINING L P	LYONDELL-CITGO REFI	888	284	pass	1A		
39	HG0126Q	HOECHST CELANESE CHEMICAL	CLEAR LAKE PLANT	334	601	pass	3		
40	HG0130C	VALERO REFINING TEXAS LP	HOUSTON REFINERY	252	188	pass	2C		
41	HG0175D	CROWN CENTRAL PETROLEUM	PASADENA PLANT	570	687	pass	1B		
42	HG0218K	EI DUPONT		306	35	pass	3		
43	HG0228H	EXXON CHEMICAL CO	BAYTOWN OLEFINS PLA	209	50	pass	2C		
44	HG0229F	EXXONMOBIL CHEMICAL CO	BAYTOWN CHEMICAL PL	746	75	pass	3		
45	HG0232Q	EXXONMOBIL CORP	EXXONMOBIL REF & SU	3983	761	pass	1B		
46	HG0310V	CHEVRON PHILLIPS CHEMICAL	CHEVRON CHEMICAL CO	364	211	pass	1A		
47	HG0558G	ATOFINA CHEMICALS INC	ATOFINA INC	11	1	pass	see note		Excluded (PM_{10}<10tpy)
48	HG0562P	TEXAS PETROCHEMICALS LP	TX PETROCHEMICALS L	48	51	pass	3		
49	HG0632T	ROHM & HAAS TEXAS	DEER PARK PLANT	578	234	pass	3		
50	HG0659W	SHELL OIL CO	DEER PARK PLANT	2219	359	pass	2AB		
51	HG0697O	RHODIA, INC.	HOUSTON PLANT	3	28	pass	1A		
52	HG1451S	OSYVINYLSLP		245	36	pass	2C		
53	HH0019H	NORIT AMERICAS INC	NORIT AMERICAS INC	163	168	pass	3		
54	HH0042M	EASTMAN CHEMICAL COMPANY	TEXAS OPERATIONS	4257	273	pass	1B		
55	HK0014M	TEXAS LEHIGH CEMENT CO	TEXAS LEHIGH CEMENT	153	272	pass	2AC		
56	HR0018T	VALENCE MIDSTREAM LTD	COMO PLT	7	6	pass	see note		Excluded (PM_{10}<10tpy)
57	HT0011Q	ALON USA LP	BIG SPRING REFINERY	517	91	pass	2B		
58	HT0027B	SID RICHARDSON CARBON CO	BIG SPRING CARBON B	17	19	pass	2C		
59	HW0008S	DEGUSSA ENGINEERED CARBONS BORGER	BORGER CARBON BLACK	100	71	pass	2AC		
60	HW0013C	CHEVRON PHILLIPS CHEMICAL CO		407	9	pass	see note		Excluded (PM_{10}<10tpy)
61	HW0017R	SID RICHARDSON CARBON	BORGER CARBON BLACK	2	111	pass	1A		
62	HW0018P	PHILLIPS 66 CO	BORGER REFINERY	145	21	pass	3		
63	HX2897U	BP AMOCO POLYMERS INC		249	8	pass	see note		No longer BART-eligible
64	JB0016M	VINTAGE PETROLEUM, INC.	W RANCH COMP STA VA	53	13	pass	2C		
65	JC0003K	WESTVACO		103	236	pass	2B		
66	JE0005H	ATOFINA PETROCHEMICALS INC	PORT ARTHUR REFINER	632	529	pass	2C		

ID	Account	Company	Plant	VOC (tpy)	PM_{10} (tpy)	VOC Zero-Out	PM Zero-Out	Needs Further Analysis for PM	Note
67	JE0039N	THE GOODYEAR TIRE AND RUBBER CO		1528	33	pass	1A		
68	JE0042B	PREMCOR REFINING GROUP	PORT ARTHUR REFINER	135	3	pass	see note		Excluded (PM_{10}<10tpy)
69	JE0052V	HUNTSMAN CORPORATION	PORT NECHES PLANT	304	58	pass	3		
70	JE0065M	EXXON MOBIL CHEMICAL CO		104	2	pass	see note		Excluded (PM_{10}<10tpy)
71	JE0067I	EXXONMOBIL OIL CORP	BEAUMONT REFINERY	462	574	pass	3		
72	JE0091L	SUN MARINE TERMINAL		40	0	pass	see note		Excluded (PM_{10}<10tpy)
73	JE0135Q	HUNTSMAN PETROCHEMICAL CORP		520	68	pass	2B		
74	JE0343H	BMC HOLDINGS INC	BMC HOLDINGS INC	24	63	pass	1A		
75	JH0025O	JOHNS MANVILLE INTERNATIONAL		75	141	pass	2AC		
76	MB0123F	LEHIGH CEMENT COMPANY	LEHIGH PORTLAND CEM	10	225	pass	2B		
77	MC0002H	ENBRIDGE PIPELINE	TILDEN GAS PLANT	36	0	pass	see note		Excluded (PM_{10}<10tpy)
78	MH0009H	CELANESE LIMITED		127	496	pass	1B		
79	MM0001T	ALCOA INC	ALCOA SANDOW PLANT	152	254	pass	1A		
80	MR0008T	DIAMOND SHAMROCK REFINING	MCKEE PLANTS	818	128	pass	2C		
81	NB0037F	TXI OPERATIONS, L.P.	STREETMAN PLANT	284	181	pass	3		
82	NE0022I	TICONA POLYMERS INC	BISHOP FACILITY	309	31	pass	3		
83	NE0027V	CITGO REFINING & CHEMICALS	CORPUS CHRISTI REFI	666	622	pass	1A		
84	NE0043A	VALERO REFINING COMPANY	COMPLEX 6B 7 8	823	175	pass	3		
85	NE0120H	KOCH PETROLEUM GROUP LP	CORPUS CHRISTI EAST	183	288	pass	3		
86	NE0122D	FLINT HILLS RESOURCES LP	WEST REFINERY	240	13	pass	1A		
87	OA0024I	NORTHERN NATURAL GAS CO	SPEARMAN PLANT	38	13	pass	see note		No longer BART-eligible
88	OC0007J	EI DUPONT DENEMOURS & CO	SABINE RIVER WORKS	1040	87	pass	2AC		
89	PE0024Q	DUKE ENERGY FIELD SERVICES	WAHA GAS PLANT	116	4	pass	see note		Excluded (PM_{10}<10tpy)
90	TH0010I	AUSTIN WHITE LIME CO		4	367	pass	see note		No longer BART-eligible
91	VC0008Q	EI DU PONT DE NEMOURS & CO	EI DU PONT DE NEMOU	230	187	pass	2B		
92	WH0014S	WICHITA FALLS PLANT		191	81	pass	2C		
93	WN0021G	DEVON GAS SERVICES, L.P.	BRIDGEPORT	226	28	pass	see note		No longer BART-eligible
94	WN0042V	DYNEGY MIDSTREAM SERVICES		3	0	pass	see note		Excluded (PM_{10}<10tpy)

BART VOC Zero-Out Results

Figure 3-1 displays the visibility impacts due to all Texas BART-eligible sources' VOC emissions. VOC produces secondary organic aerosol species (SOA) that degrade visibility (see Section 2). The results indicated that the del-dv for all of the metrics (the maximum and 98th percentile using both the best 20% and annual average natural conditions) were all below 0.2 del-dv and so did not exceed the 0.5 significance threshold at the Class I areas analyzed. Therefore, each Texas BART source's VOC emissions would also be below the 0.5 del-dv significance threshold and therefore does not require further BART analysis.

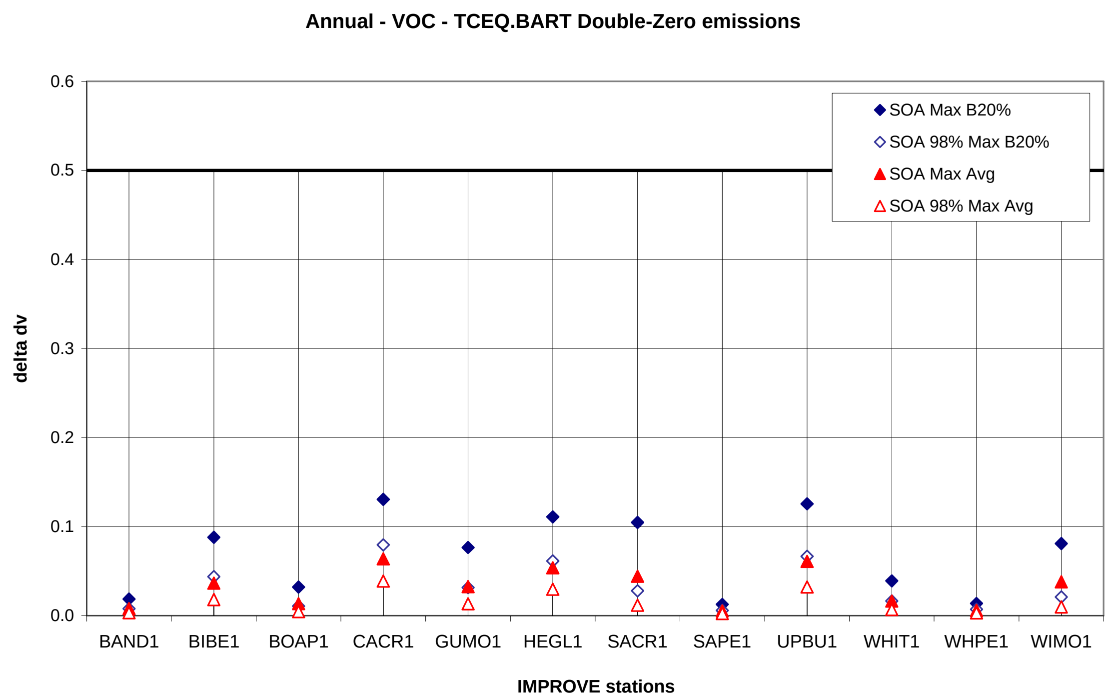


Figure 3-1. The visibility impacts (del-dv) at Class I areas from all eligible Texas BART sources' VOC emissions.

BART PM Zero-Out Results

The preliminary BART PM emissions zero-out modeling indicated that the visibility impacts due to PM emissions from all BART sources exceeded the 0.5 del-dv threshold at several Class I areas as shown in Figure 3-2 (unfilled triangle represents 98th percentile del-dv over annual average natural conditions. The larger visibility impacts occurred at the Class I areas near sources in northeast Texas (Caney Creek/CACR, Hercules-Glade/HEGL, and Upper Buffalo/UPBU), while smaller impacts appeared near sources in west Texas (Big Bend/BIBE and Guadalupe Mountains/GUMO) and north Texas (Wichita Mountains/WIMO). Given this information, further analyses were carried out by dividing the BART PM sources into subgroups, with consideration of their proximity to Class I areas and the magnitude of their PM emissions.

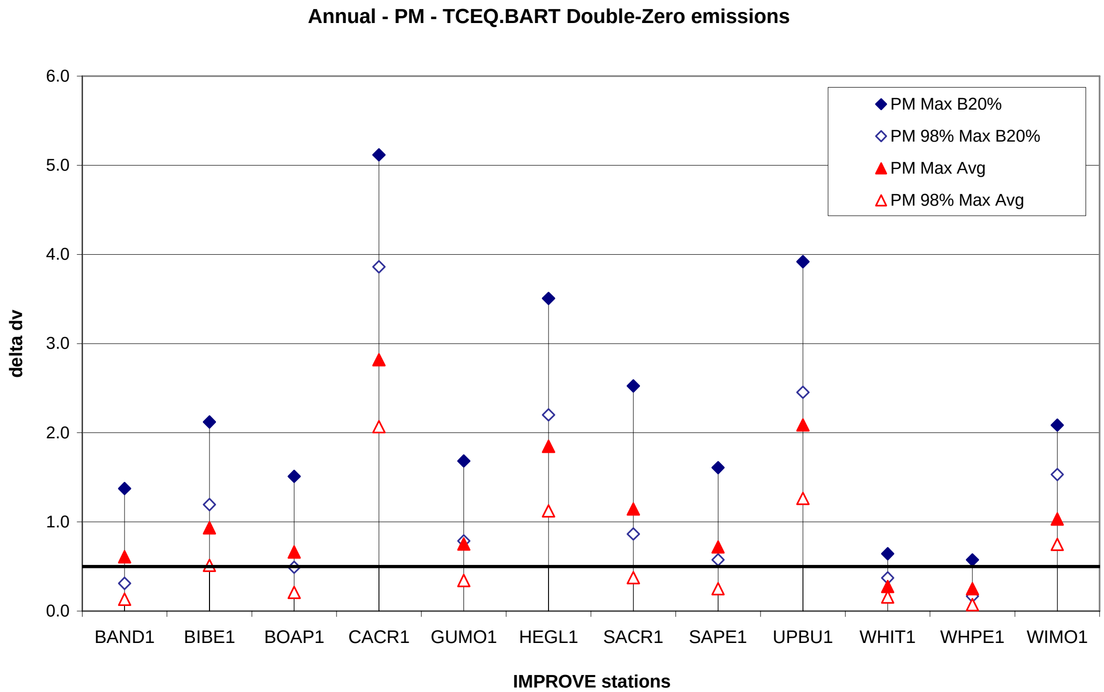


Figure 3-2. The visibility impacts (del-dv) at Class I areas from all Texas potentially BART-eligible sources' PM emissions.

Prior to conducting further PM modeling analyses, some BART sources were removed from the screening process. Six non-EGU accounts (WN0021G, EB0197H, OA0024I, TH0010I, HX2897U, and AC0019U) were dropped from the potential BART-eligible list based on information supplied by the sources to the TCEQ. Additionally, TCEQ eliminated 15 sources with PM emissions under 10 tons per year (tpy) based on the establishment of a de minimis threshold as suggested in EPA's BART Guidance (EPA, 2005). The remaining sources were divided into EGU and non-EGU categories. These source groups were then further divided into subgroups. Inert model runs were conducted with these groups, and if any source groups failed the 0.5 del-dv threshold, the sources in that group were broken down even further and re-analyzed.

The subgroup analyses for primary PM emissions were made for each of these BART source groups using CAMx inert simulations. The results for potential BART EGU sources are shown in Figures 3-3a-e. The potential BART-eligible EGU sources, except EGU source group #1B and 3B (account TF0013B and TF0012D, respectively), passed the BART PM group screening test. Accounts TF0013B and TF0012D impacted visibility impairment at CACR by approximately 0.61 del-dv and 0.72 del-dv, respectively. Further modeling analyses using better estimates of the highest actual 24-hour emissions may produce values < 0.5 del-dv for these two sources.

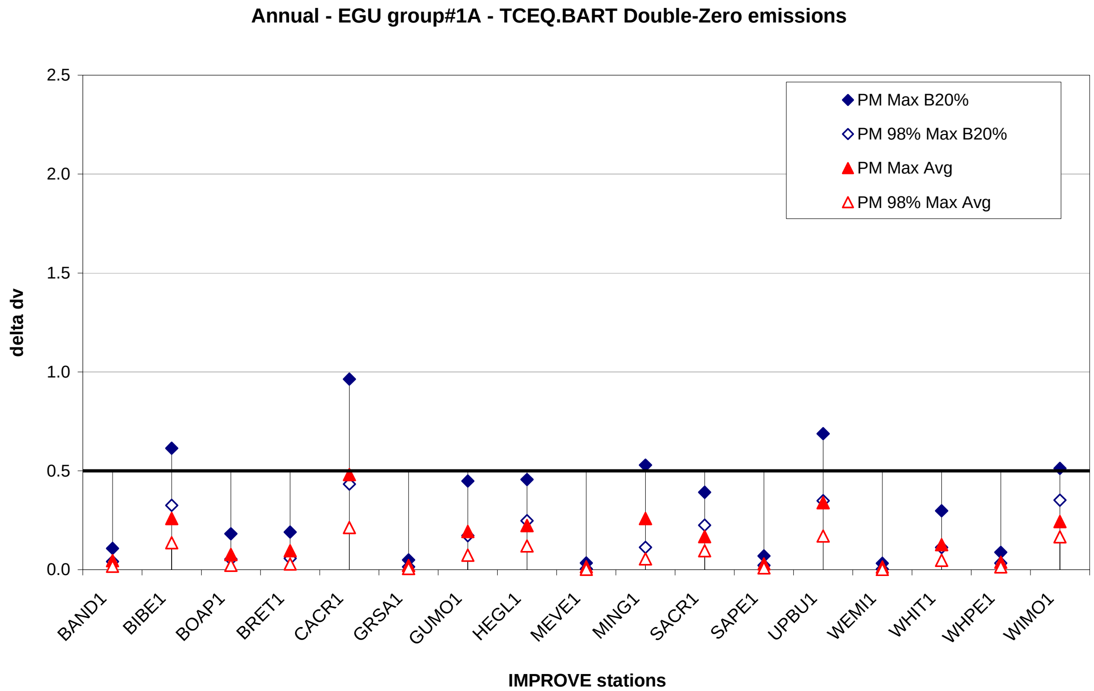


Figure 3-3a. Visibility impacts (del-dv) at Class I areas due to PM emissions from EGU Source Group 1A.

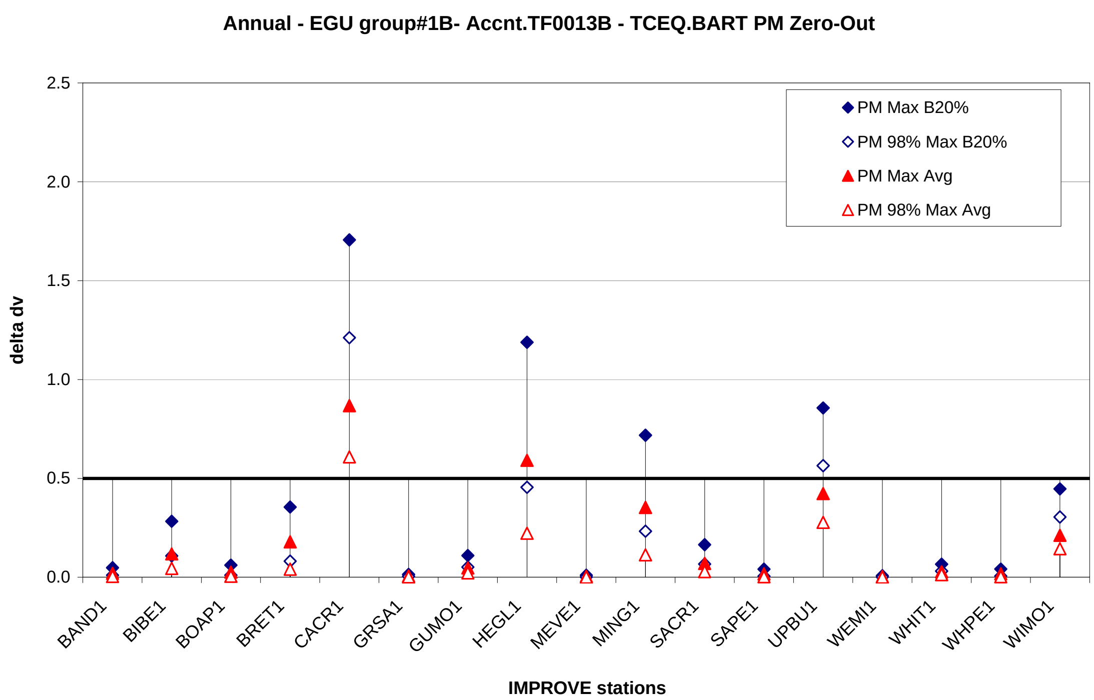


Figure 3-3b. Visibility impacts (del-dv) at Class I areas due to PM emissions from EGU Source Group 1B, account TF0013B. Del-dv > 0.5 at CACR for all metrics and HEGL/UPBU for 2 of 4 metrics.

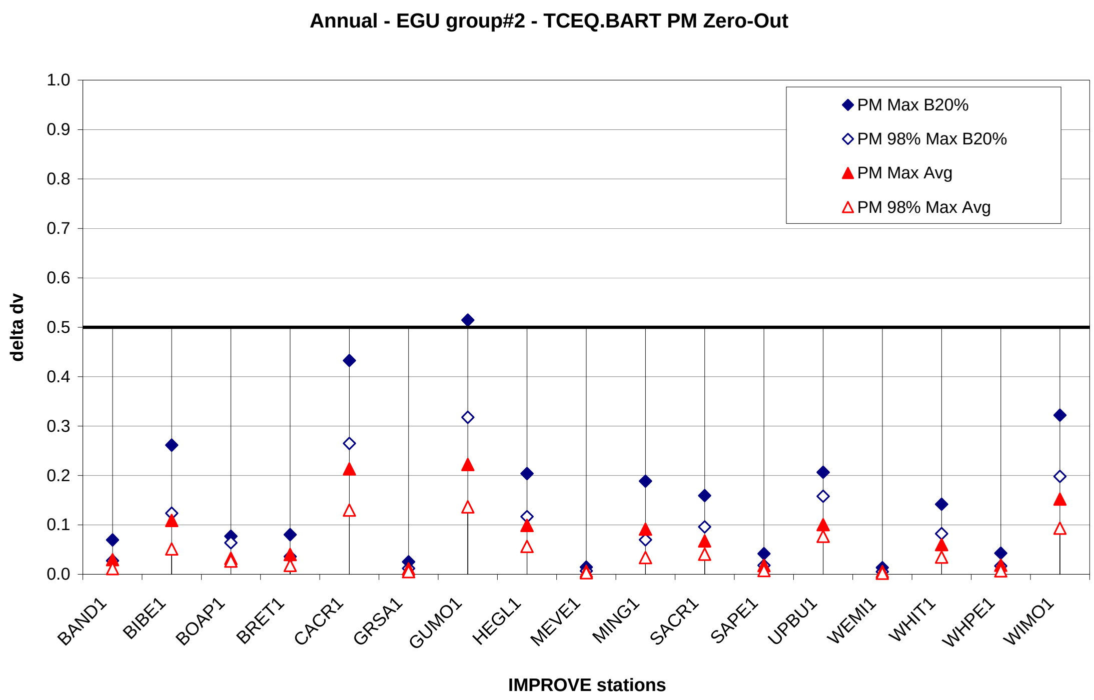


Figure 3-3c. Visibility impacts (del-dv) at Class I areas due to PM emissions from EGU Source Group 2.

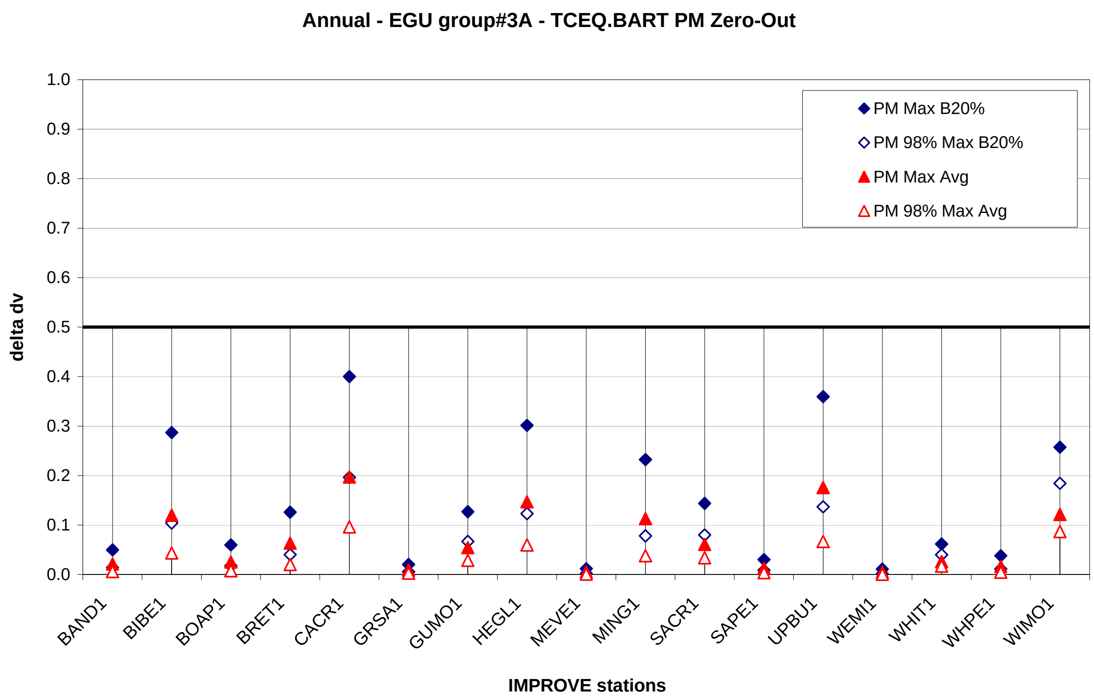


Figure 3-3d. Visibility impacts (del-dv) at Class I areas due to PM emissions from EGU Source Group 3A.

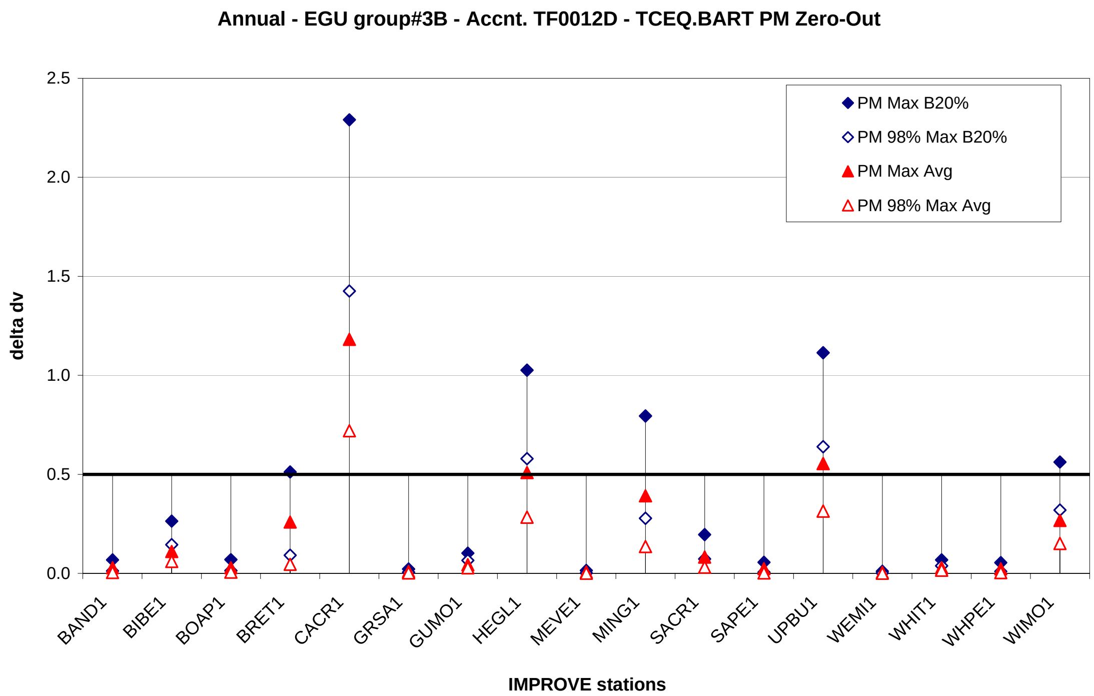


Figure 3-3e. Visibility impacts (del-dv) at Class I areas due to PM emissions from EGU Source Group 3B, account TF0012D. Del-dv > 0.5 at CACR for all metrics and HEGL/UPBU for 3 of 4 metrics.

The results for potential BART-eligible non-EGU sources are shown in Figure 3-4a-f. The potential BART non-EGU sources, except non-EGU group 2AA (account CG0010G), are under the 05. del-dv threshold and therefore may require no further BART analyses. Account CG0010G estimated 98th percentile visibility impairment at CACR was 0.92 del-dv and therefore must perform further analyses.

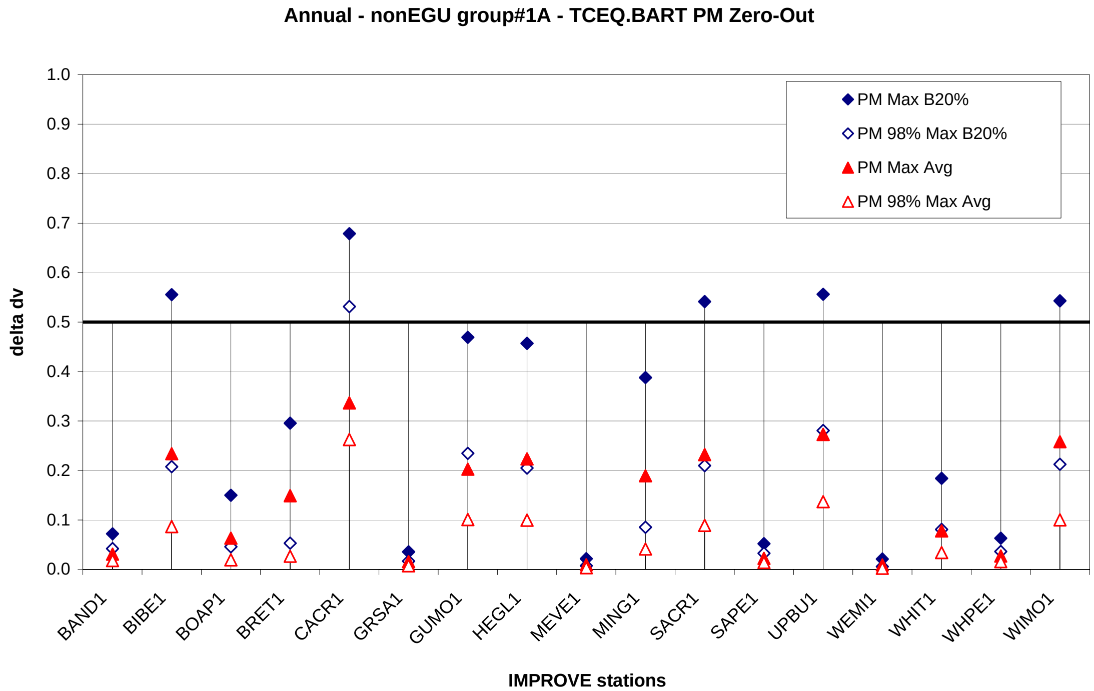


Figure 3-4a. Visibility impacts (del-dv) at Class I areas due to PM emissions from non-EGU Source Group 1A.

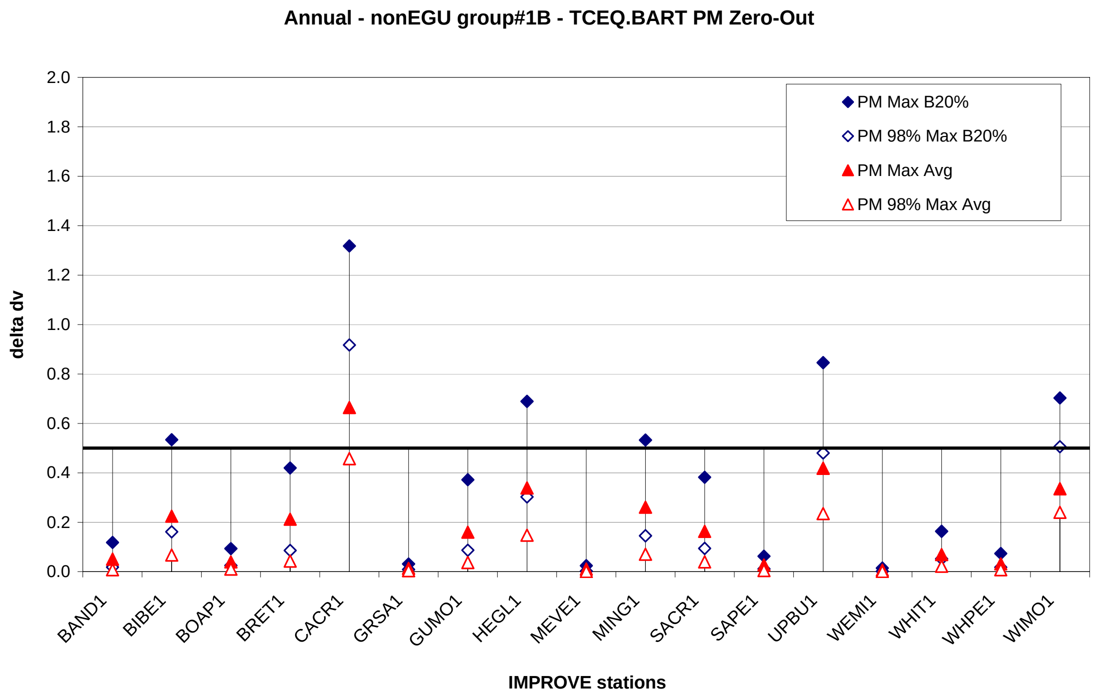


Figure 3-4b. Visibility impacts (del-dv) at Class I areas due to PM emissions from non-EGU Source Group 1B.

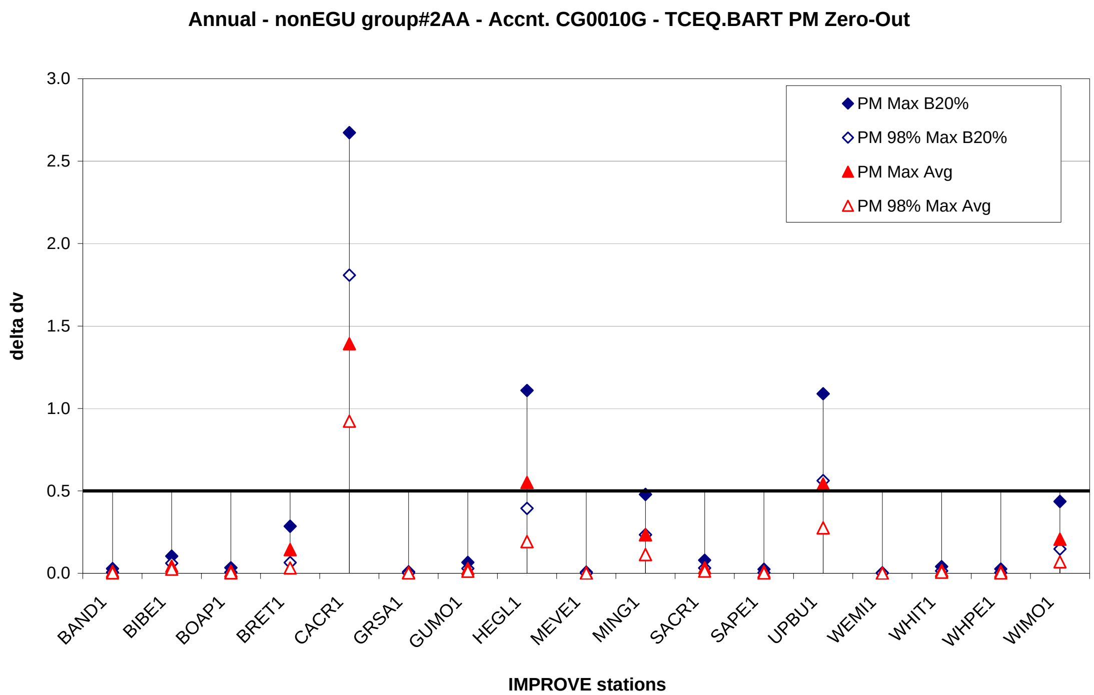


Figure 3-4c. Visibility impacts (del-dv) at Class I areas due to PM emissions from non-EGU Group Source 2AA, account CG0010G. Del-dv > 0.5 at CACR for all metrics and HEGL/UPBU for 2 and 3 of 4 metrics, respectively.

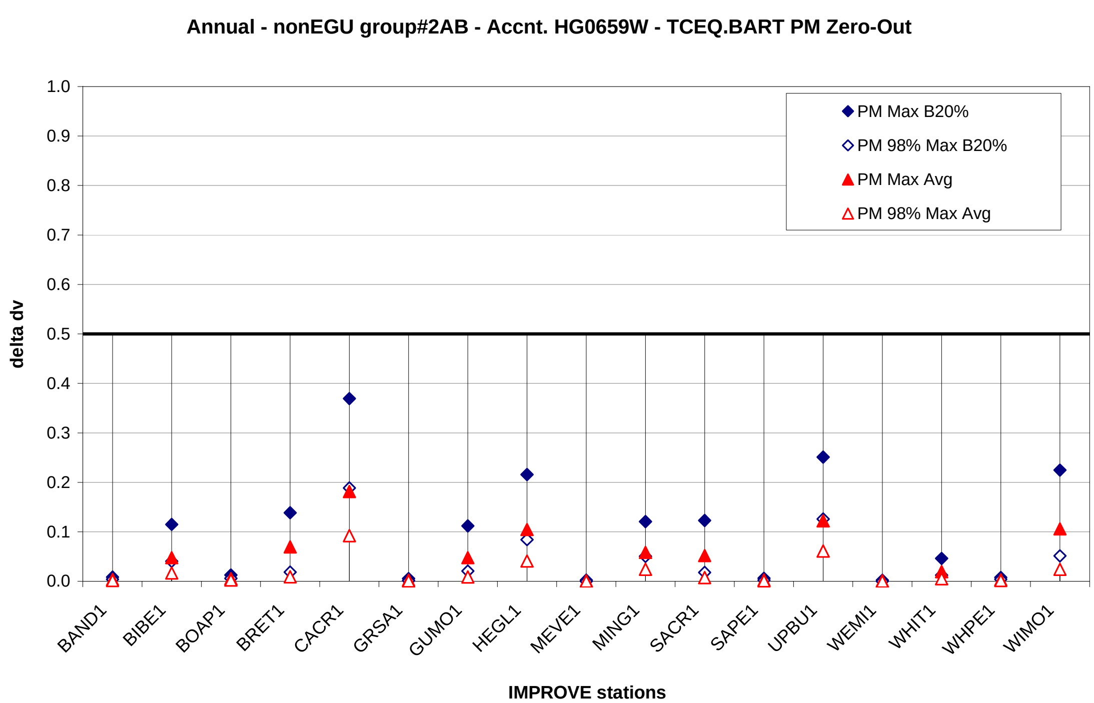


Figure 3-4d. Visibility impacts (del-dv) at Class I areas due to PM emissions from non-EGU Source Group 2AB.

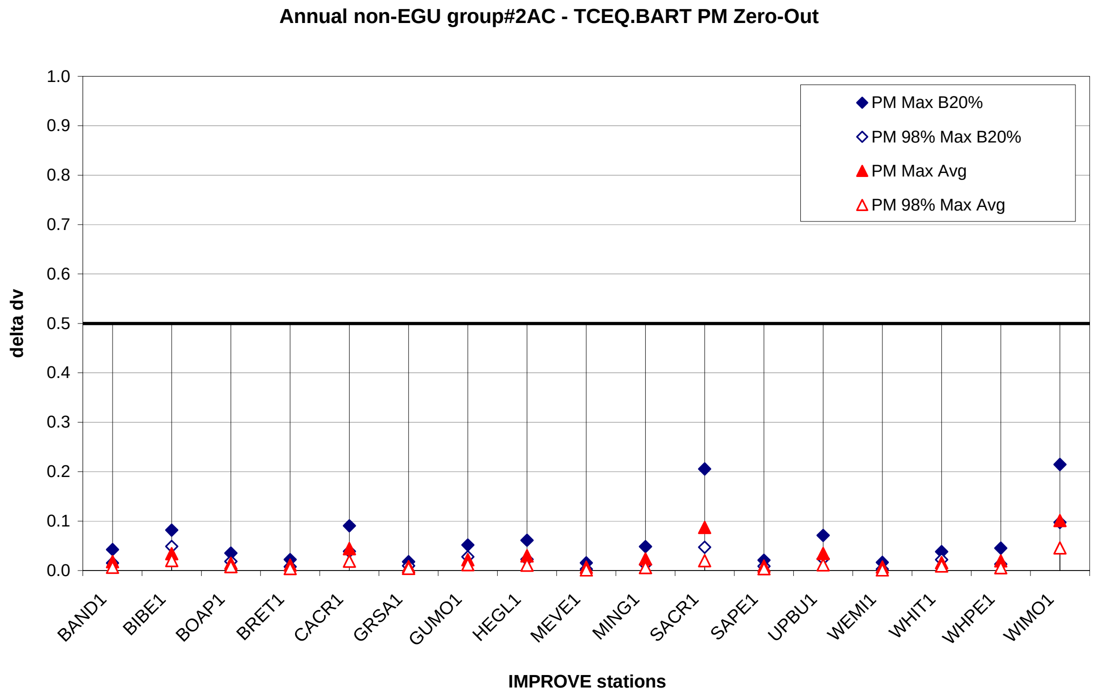


Figure 3-4e. Visibility impacts (del-dv) at Class I areas due to PM emissions from non-EGU Source Group 2AC.

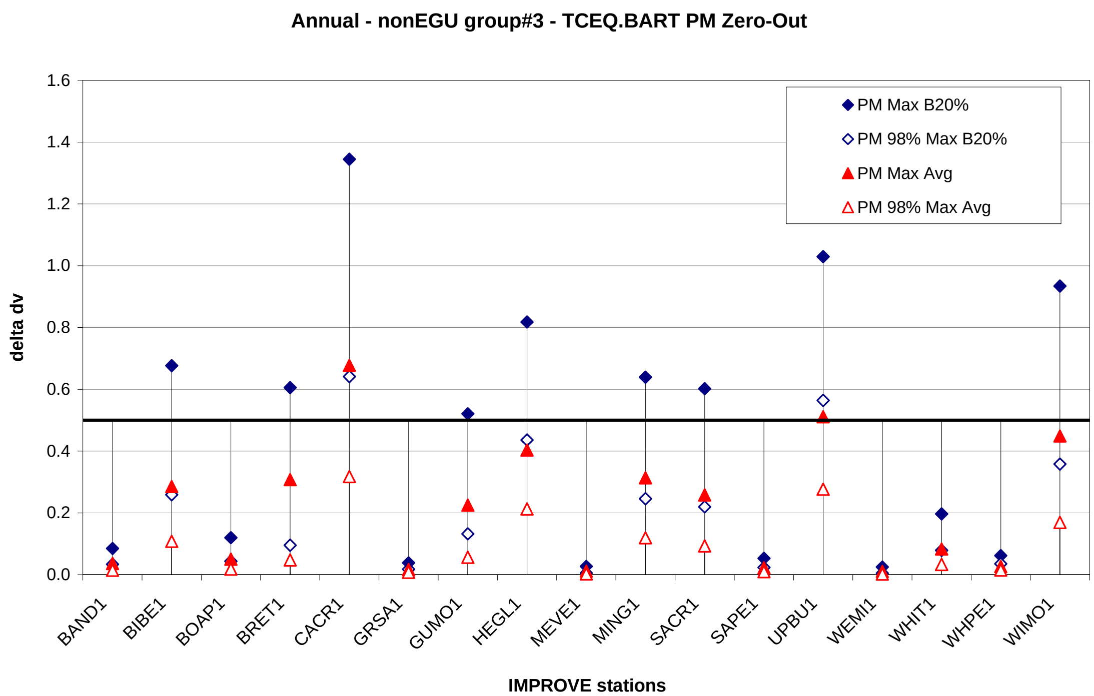


Figure 3-4f. Visibility impacts (del-dv) at Class I areas due to PM emissions from non-EGU Source Group 3.

One of the BART-eligible EGU sources, account CI0012D, was not included in the PM zero-out modeling runs. This account has a relatively small PM Q/D of 0.25 tpy/km and the nearest Class I area is BIBE. Other accounts in the same areas (shown in Figure 3-5), which have PM Q/D ranging from 0.02 - 4.7, were all screened out. Thus, account CI0012D can be reasonably assumed to pass the screening analysis as well.

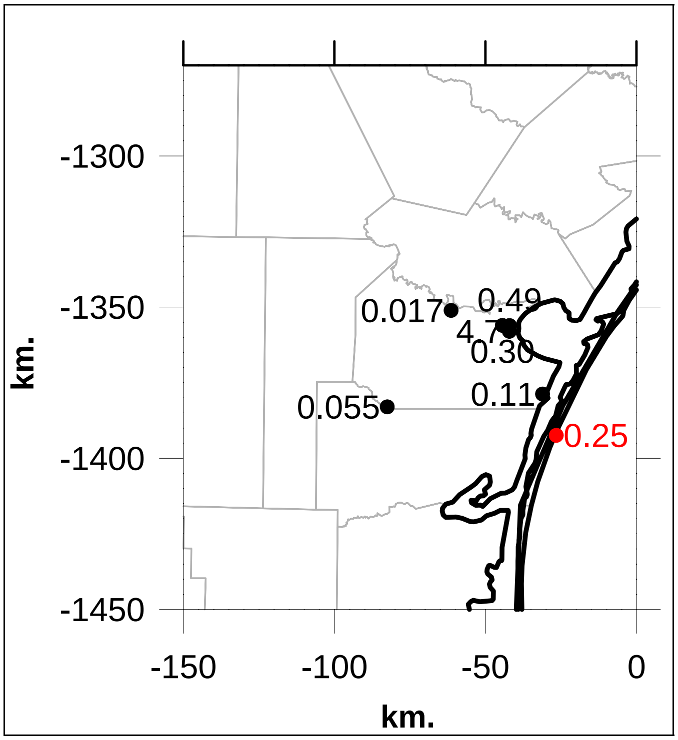


Figure 3-5. PM Q/D (tpy/km) of the facilities close to account CI0012D; account CI0012D shown in red.

Summary VOC and PM BART Analyses

The VOC zero-out analyses indicated that the visibility impacts at Class I areas, due to all Texas BART sources' VOC emissions, are well below the 0.5 del-dv significance threshold. However, the visibility impacts due to PM emissions from two EGU accounts (TF0013B, TF0012D) and one non-EGU account (CG0010G) exceeded the 0.5 del-dv threshold at Caney Creek (CACR). These three facilities' PM emissions will require further analysis under BART.

4. BART SO_2 AND NO_x SCREENING ANALYSES

The second part of the BART screening analysis estimated the visibility impacts at Class I areas due to SO_2 and NO_x emissions from non-EGU potential BART-eligible sources. Since Texas is part of the $PM_{2.5}$ provisions of the Clean Air Interstate Rule (CAIR), EPA guidance indicates that controls for potential BART-eligible EGU sources are covered under the CAIR program for $PM_{2.5}$, NO_x and SO_2. As described for the zero-out simulations, if a source group's 98th percentile del-dv over annual average natural conditions impact is < 0.5 at all Class I areas, each BART source in the group may be assumed to be insignificant and the source may require no further analysis under the BART rule.

Non-EGU Potential BART-Eligible Sources' SO_2 and NO_x Emissions

Table 4-1 lists potential BART-eligible non-EGU sources' SO_2 and NO_x emissions and their associated source groups that were used to perform screening modeling. Unlike the zero-out CAMx modeling for VOC and PM emissions and inert CAMx modeling for PM emissions, the group screening modeling for SO_2 and NO_x emissions used the CAMx PSAT to track the SO_4 and NO_3 contributions due to each BART source group. As described in Section 2, with more details in the modeling protocol (ENVIRON, 2005a), PSAT is an efficient method for looking at the contributions of many groups of sources to PM concentrations. With the implementation of PSAT within the full-chemistry PiG, as used in CAMx Version 4.4 in this study, this approach has all the advantages of a source-oriented plume model, like CALPUFF (near source plume dispersion), and a photochemical grid model (full-science chemistry, more accurate treatment of wind shear, transport, and dispersion at longer downwind distances). The PSAT screening analysis initially divided up the potential BART-eligible non-EGU sources into 10 source groups (referred to as the Round 1 groupings in Table 4-1). The assignment of potential BART-eligible non-EGU sources to the Round 1 source groups was made by ranking each source in terms of their total SO_2 and NO_x emissions divided by distance to the closest Class I area (i.e., Q/D). The top ten percent of the sources with the highest Q/D values were assigned to Group 1 and so on, so that the lower the source group number the more likely the group would have a potential visibility impact at a Class I areas due to higher emissions and/or closeness to a Class I area. Each BART source group in the preliminary run consisted of approximately 9 to 11 separate accounts (i.e., potential BART-eligible non-EGU sources).

Table 4-1. Classification of potential BART-eligible non-EGU sources into Source Groups for BART group screening modeling using CAMx/PSAT/PiG.

ID	Account	Company	Plant	NO_x* (tpy)	SO_2* (tpy)	Round 1 Group	Round 2 Group	Needs Further Analysis for SO_x and NO_x	Note
1	AB0012W	DUKE ENERGY FIELD SERVICES	FULLERTON GAS PLANT	1256	2374	1		X	
2	CG0010G	INTERNATIONAL PAPER CO		1619	374	1		X	
3	ED0034O	NORTH TEXAS CEMENT COMPANY	NORTH TEXAS CEMENT	2572	4434	1		X	
4	GB0004L	BP PRODUCTS NORTH AMERICA IN TEXAS	TEXAS CITY REFINERY	6320	4084	1		X	
5	GH0004O	CELANESE CHEMICAL	CHEMICAL MANUFACTUR	2609	4015	1		X	
6	HG0659W	SHELL OIL CO	DEER PARK PLANT	5811	6968	1		X	
7	HW0008S	DEGUSSA ENGINEERED CARBONS BORGER	BORGER CARBON BLACK	445	3604	1		X	
8	HW0017R	SID RICHARDSON CARBON	BORGER CARBON BLACK	638	3535	1		X	
9	JE0067I	EXXONMOBIL OIL CORP	BEAUMONT REFINERY	3871	9747	1		X	
10	HD0029C	A.N.R. PIPELINE COMPANY	E.G. HILL COMPRESSO	4028	0.4	2		X	
11	HG0232Q	EXXONMOBIL CORP	EXXONMOBIL REF & SU	4372	1301	2		X	
12	HH0042M	EASTMAN CHEMICAL COMPANY	TEXAS OPERATIONS	2612	105	2		X	
13	HR0018T	VALENCE MIDSTREAM LTD	COMO PLT	247	2743	2		X	
14	HT0011Q	ALON USA LP	BIG SPRING REFINERY	344	3311	2		X	
15	HT0027B	SID RICHARDSON CARBON CO	BIG SPRING CARBON B	185	3149	2		X	
16	MR0008T	DIAMOND SHAMROCK REFINING	MCKEE PLANTS	1549	2245	2		X	
17	NB0037F	TXI OPERATIONS, L.P.	STREETMAN PLANT	691	3468	2		X	
18	NE0027V	CITGO REFINING & CHEMICALS	CORPUS CHRISTI REFI	1201	5103	2		X	
19	ED0066B	TXI OPERATIONS, L.P.	MIDLOTHIAN PLANT	1388	893	3		X	
20	GB0055R	MARATHON ASHLAND PETROLEUM	TEXAS CITY REFINERY	1134	2329	3		X	
21	GH0003Q	CABOT CORPORATION	PAMPA PLANT	1335	342	3		X	

ID	Account	Company	Plant	NO_x* (tpy)	SO_2* (tpy)	Round 1 Group	Round 2 Group	**Needs Further Analysis for SO_x and NO_x**	Note
22	HG0048L	LYONDELL CITGO REFINING L P	LYONDELL-CITGO REFI	2288	789	3		X	
23	HG0697O	RHODIA, INC.	HOUSTON PLANT	6.8	5099	3		X	
24	HH0019H	NORIT AMERICAS INC	NORIT AMERICAS INC	489	784	3		X	
25	NE0043A	VALERO REFINING COMPANY	COMPLEX 6B 7 8	1318	3233	3		X	
26	OC0007J	EI DUPONT DENEMOURS & CO	SABINE RIVER WORKS	3125	7.3	3		X	
27	PE0024Q	DUKE ENERGY FIELD SERVICES	WAHA GAS PLANT	131	1571	3		X	
28	HG0126Q	HOECHST CELANESE CHEMICAL	CLEAR LAKE PLANT	946	1202	4		X	
29	HG0130C	VALERO REFINING TEXAS LP	HOUSTON REFINERY	461	2243	4		X	
30	HG0175D	CROWN CENTRAL PETROLEUM	PASADENA PLANT	566	1291	4		X	
31	HK0014M	TEXAS LEHIGH CEMENT CO	TEXAS LEHIGH CEMENT	1156	805	4		X	
32	JE0005H	ATOFINA PETROCHEMICALS INC	PORT ARTHUR REFINER	796	1007	4		X	
33	MC0002H	ENBRIDGE PIPELINE	TILDEN GAS PLANT	1.9	2276	4		X	
34	VC0008Q	EI DU PONT DE NEMOURS & CO	EI DU PONT DE NEMOU	2723	18	4		X	
35	EB0197H	DUKE ENERGY FIELD SERVICES		709	0	4		see note	No longer BART-eligible
36	WN0021G	DEVON GAS SERVICES, L.P.	BRIDGEPORT	936	0.8	4		see note	No longer BART-eligible
37	BG0045E	CAPITOL CEMENT DIV CAPITOL	PORTLAND CEMENT	718	850	5	2	X	
38	BJ0001T	CHEMICAL LIME LTD	CHEMICAL LIME--CLIF	700	509	5	1		
39	BL0002S	AMOCO CHEMICAL CO	CHOCOLATE BAYOU PLN	2006	12	5	1		
40	BL0082R	THE DOW CHEMICAL CO	PLANT B	1895	1.7	5	2	X	
41	HG0632T	ROHM & HAAS TEXAS	DEER PARK PLANT	748	1076	5	1		
42	JC0003K	WESTVACO		1489	72	5	2	X	
43	MB0123F	LEHIGH CEMENT COMPANY	LEHIGH PORTLAND CEM	531	576	5	3	X	

ID	Account	Company	Plant	NO_x* (tpy)	SO_2* (tpy)	Round 1 Group	Round 2 Group	**Needs Further Analysis for SO_x and NO_x**	Note
44	MM0001T	ALCOA INC	ALCOA SANDOW PLANT	36	1458	5	3	X	
45	OA0024I	NORTHERN NATURAL GAS CO	SPEARMAN PLANT	868	0	5	see note	see note	No longer BART-eligible
46	AG0024G	PUEBLO MIDSTREAM GAS CORP	FASHING PLANT	20	1005	6	4	X	
47	CA0011B	J.L. DAVIS GAS PROCESSING	LULING GAS PLANT	90	1021	6	4	X	
48	CY0019H	DYNEGY MIDSTREAM SERVICES	WADDELL COMPRESSOR	537	0.7	6	3	X	
49	ED0011D	CHAPARRAL STEEL MIDLOTHIAN		490	122	6	see note		Excluded (VOC modeled out)
50	HG0310V	CHEVRON PHILLIPS CHEMICAL	CHEVRON CHEMICAL CO	1013	44	6	5		
51	HW0018P	PHILLIPS 66 CO	BORGER REFINERY	590	59	6	4	X	
52	JE0039N	THE GOODYEAR TIRE AND RUBBER CO		1137	3.8	6	4	X	
53	JE0052V	HUNTSMAN CORPORATION	PORT NECHES PLANT	942	8.8	6	5		
54	JE0343H	BMC HOLDINGS INC	BMC HOLDINGS INC	1192	4.3	6	3	X	
55	EB0057B	HUNTSMAN POLYMERS		432	2.1	7	see note		Excluded (VOC modeled out)
56	GB0073P	VALERO REFINING CO TEXAS	TEXAS CITY REFINERY	637	264	7	6	X	
57	HG0228H	EXXON CHEMICAL CO	BAYTOWN OLEFINS PLA	1005	5.7	7	5		
58	HG0229F	EXXONMOBIL CHEMICAL CO	BAYTOWN CHEMICAL PL	701	104	7	7	X	
59	HG0558G	ATOFINA CHEMICALS INC	ATOFINA INC	18	920	7	6	X	
60	JB0016M	VINTAGE PETROLEUM, INC.	W RANCH COMP STA VA	1036	0.0	7	6	X	
61	JE0135Q	HUNTSMAN PETROCHEMICAL CORP		735	1.8	7	see note		Excluded (VOC modeled out)
62	NE0022I	TICONA POLYMERS INC	BISHOP FACILITY	1129	4.8	7	5		
63	NE0120H	KOCH PETROLEUM GROUP LP	CORPUS CHRISTI EAST	915	65	7	6	X	
64	BL0113I	EQUISTAR		636	1.4	8	see note		Excluded (VOC modeled out)

ID	Account	Company	Plant	NO_x* (tpy)	SO_2* (tpy)	Round 1 Group	Round 2 Group	Needs Further Analysis for SO_x and NO_x	Note
65	CB0003M	ALCOA ALUMINA & CHEMICALS	POINT COMFORT PLANT	951	20	8	7	X	
66	ED0051O	OWENS CORNING		329	26	8	8	X	
67	FG0036G	TXI OPERATION LP	CLODINE EXPANDED SH	194	635	8	7	X	
68	GB0001R	BP AMOCO CHEMICAL COMPANY	BP AMOCO CHEMICAL T	813	5	8	7	X	
69	HW0013C	CHEVRON PHILLIPS CHEMICAL CO		48	280	8	see note		Excluded (VOC modeled out)
70	MH0009H	CELANESE LIMITED		612	43	8	8	X	
71	WH0014S	WICHITA FALLS PLANT		107	28	8	8	X	
72	TH0010I	AUSTIN WHITE LIME CO		375	253	8	see note		No longer BART-eligible
73	BL0038U	SOLUTIA INC		502	10	9	see note		Excluded (VOC modeled out)
74	BL0758C	CHEVRON PHILLIPS CHEMICAL	SWEENY COMPLEX	356	15	9	9	X	
75	CB0028T	UNION CARBIDE CORPORATION	SEADRIFT PLANT	463	0.1	9	8	X	
76	CG0012C	ENBRIDGE PIPELINES	BRYANS MILL PLANT	84	0.3	9	9	X	
77	CI0022A	DYNEGY MIDSTREAM SERVICES		406	1.6	9	see note		Excluded (VOC modeled out)
78	CR0020C	COPANO PROCESSING LP		454	1.6	9	see note		Excluded (VOC modeled out)
79	HG0218K	EI DUPONT		160	175	9	see note		Excluded (VOC modeled out)
80	HG0562P	TEXAS PETROCHEMICALS LP	TX PETROCHEMICALS L	334	1.9	9	9	X	
81	NE0122D	FLINT HILLS RESOURCES LP	WEST REFINERY	284	27	9	9	X	
82	AC0017B	ABITIBI CONSOLIDATED CORP		28	0.3	10	10	X	
83	BL0021O	BASF CORPORATION	FREEPORT SITE	323	0.1	10	10	X	
84	BL0268B	EQUISTAR CHEMICALS LP		6.2	0.8	10	see note		Excluded (VOC modeled out)
85	HG0033B	EQUISTAR CHEMICALS LP	CHANNELVIEW COMPLEX	11	0.0	10	see note		Excluded (VOC modeled out)

ID	Account	Company	Plant	NO_x* (tpy)	SO_2* (tpy)	Round 1 Group	Round 2 Group	Needs Further Analysis for SO_x and NO_x	Note
86	HG1451S	OSYVINYLSLP		89	0.7	10	see note		Excluded (VOC modeled out)
87	JE0042B	PREMCOR REFINING GROUP	PORT ARTHUR REFINER	96	0.4	10	10	X	
88	JE0065M	EXXON MOBIL CHEMICAL CO		29	0.0	10	see note		Excluded (VOC modeled out)
89	JE0091L	SUN MARINE TERMINAL		0.9	0.1	10	see note		Excluded (VOC modeled out)
90	JH0025O	JOHNS MANVILLE INTERNATIONALJOHNS MANVILLE		97	19	10	10	X	
91	AC0019U	TEXAS FOUNDRIES		3	2	10	see note		No longer BART-eligible
92	HX2897U	BP AMOCO POLYMERS INC		31	0.3	10	see note		No longer BART-eligible
93	GB0076J	UNION CARBIDE CORP	VINYL ACETATE FACIL	0	0	see note	see note		Excluded (NO_x <20tpy and Sox<20tpy)
94	WN0042V	DYNEGY MIDSTREAM SERVICES		0	0	see note	see note		Excluded (NO_x <20tpy and SO_x<20tpy)

* SO_2 and NO_x average actual emissions from 2002 CENRAP database, modeling used doubled values as an estimate of 24-hour maximum emission rate.

SO_2 and NO_x Visibility Impacts from PSAT

The preliminary Round 1 PSAT results indicated that all 10 BART source groups exceeded the 0.5 del-dv threshold of the key significance metric (98th percentile change in deciview over annual average natural conditions) in at least one Class I area as shown. Therefore, the BART group failed the screening test. As shown in Figure 4-1, the first four BART source groups (i.e., ones with the highest Q/D values) contributed 2 to 3.5 del-dv at a Class I area using the key metric (98th percentile/annual average, unfilled triangle in Figure 4-1), whereas source groups 5 through 10 contributed < 2 del-dv. The largest estimated visibility impairments occurred at the Class I areas near northeast Texas, in Arkansas and southern Missouri (CACR, HEGL, and UPBU), while the next highest estimated visibility impacts occurred near western Texas (BIBE and GUMO) and northern Texas (WIMO in Oklahoma).

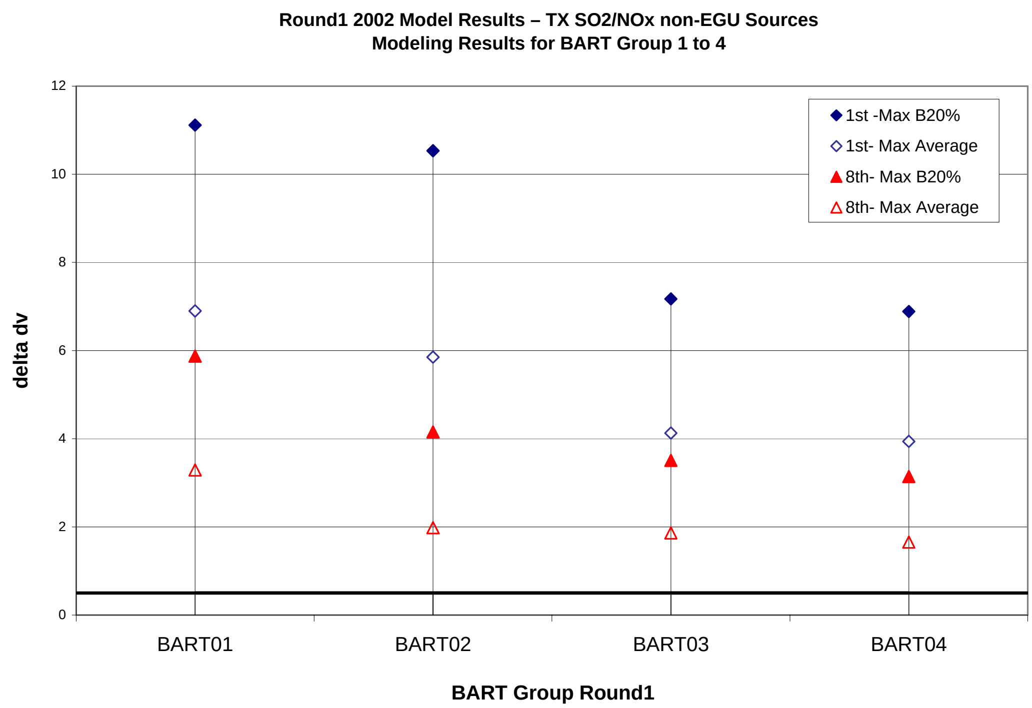


Figure 4-1. Preliminary Round 1 visibility impacts (del-dv) at Class I areas from potential BART- eligible non-EGU source groups 1 to 4 (highest Q/D).

TCEQ decided that SO_2 and NO_x emissions for sources in the first four groups from Round 1 would be unlikely to screen out. The SO_2/ NO_x BART screening modeling effort then concentrated on lower contributing BART source groups (source groups 5 to 10), which are composed of 56 accounts. Some of these accounts were removed from Round 2 PSAT analyses for two reasons: based on continuing analysis by the TCEQ on BART eligibility, some of the non-EGU accounts were found to not be BART-eligible as mentioned in the zero-out modeling in Section 3; and 13 sources that were classified as potential BART-eligible sources because their VOC emissions exceeded the emissions significance threshold (> 250 tpy). Since VOC emissions from all BART sources were shown to contribute insignificantly to visibility impairment at any Class I area (see Section 3) and the SO_2 and/or NO_x emissions from these sources are typically under 20 tpy, the TCEQ determined that the emissions from these 13 sources were not significant so they were removed from the PSAT list. The remaining sources from the preliminary Round 1 modeling source groups 5 through 10 were then divided into 10 source groups for Round 2 screening modeling.

Round 2 of PSAT modeling indicated that only BART source Group 1 and Group 5 did not exceed the 0.5 dv threshold for the key visibility metric, as shown in Figure 4-2 (unfilled triangle); therefore, sources in these two groups may be determined to need no further BART analysis. The other Round 2 BART source groups estimated changes in deciview ranging from 0.7-1.2 del-dv, and therefore failed the group screening test. The largest visibility impairments occurred at the Class I areas near northeast Texas (CACR, HEGL, and UPBU), while second highest visibility impairments were estimated near north Texas (WIMO).

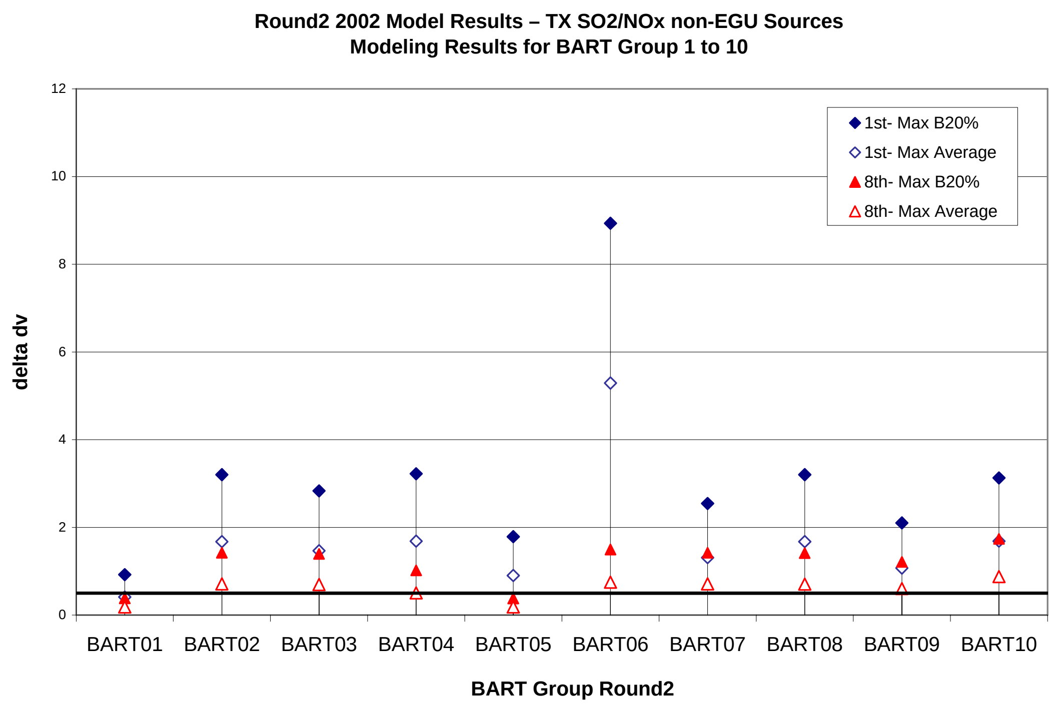


Figure 4-2. Round 2 visibility impacts (del-dv) at Class I areas from potential BART-eligible non-EGU Source Groups 1 to 10 SO_2 and NO_x emissions.

5. SUMMARY AND CONCLUSIONS

The TCEQ has evaluated a list of potential BART-eligible sources in Texas as part of the requirement in the EPA's Regional Haze Regulations. There are over one hundred such sources in Texas. The TCEQ performed group BART screening analyses to determine whether emissions from groups of potential BART-eligible sources contribute significantly to visibility impairment at Class I areas. This report presents a summary of the group BART screening analysis conducted for TCEQ. Two modeling approaches were used in the BART screening analysis: (1) BART VOC and PM emissions zero-out modeling; and (2) BART SO_2 and NO_x PSAT modeling. The visibility impacts at Class I areas are presented in terms of the percent change in deciview (del-dv) over natural conditions due to emissions from BART sources. The 0.5 del-dv significance threshold was used to assess whether a potential BART-eligible source group does not contribute significantly to visibility impairment. Both the estimated maximum and 98^{th} percentile change in deciview over natural conditions at Class I areas were presented and two natural conditions were used: best 20% days and annual average. Based on EPA's BART Guidance (EPA, 2005) and recent updates (Paise, 2006a, b), the key visibility metric used to compare against the 0.5 del-dv significance threshold was the 98^{th} percentile change in deciview over annual average natural conditions.

The following section summarizes which BART sources were in source groups that were below or above the 0.5 del-dv significance threshold. TCEQ will make the determination of whether a source is subject to BART or not.

Texas BART VOC Emissions Zero-Out Screening Analysis

The visibility impacts due to all Texas potential BART-eligible sources' VOC emissions did not exceed the 0.5 del-dv threshold at all Class I areas. Each Texas BART source's VOC emissions are below the 0.5 del-dv visibility significance threshold, therefore TCEQ is justified in stating that all VOC emissions from Texas BART sources require not further analysis under the BART rule.

Texas BART PM Emissions Zero-Out and Inert Screening Analysis

The visibility impacts due to all Texas potential BART-eligible sources' primary PM emissions from the CAMx zero-out modeling were > 0.5 del-dv at some Class I areas, so the sources failed the group BART. Further PM analyses were performed for potential BART-eligible source groups using CAMx inert PM simulations. Non-EGU and EGU sources were analyzed in separate source groups. Three accounts, TF0013B, TF0012D, and CG0010, exceeded the 0.5 threshold (see Table 5-1). These three accounts were located in northeast Texas and all three of these facilities exceeded the 0.5 del-dv visibility significance threshold by themselves at Caney Creek (CACR). The visibility impacts due to PM emissions from the remaining source groups of potential BART-eligible sources were below the 0.5 del-dv at all Class I areas so passed the group screening test for PM emissions.

Table 5–1. List of potential BART-eligible sources that failed the PM emissions screening analyses.

Account	Company	Plant	PM10 (tpy)	EGU/ NON-EGU	98 % del-dv
CG0010G	INTERNATIONAL PAPER CO		578	non-EGU	0.92
TF0012D	SOUTHWESTERN ELECTRIC POWER	WELSH POWER PLANT	1755	EGU	0.72
TF0013B	TXU GENERATION COMPANY LP	MONTICELLO STM ELE	3297	EGU	0.61

SO_2 and NO_x PSAT

The screening analysis for SO_2 and NO_x emissions was performed using the updated PSAT in CAMx. The analysis was only performed for potential BART-eligible non-EGU sources, as EPA has stated that the BART requirements for Texas EGU sources are covered under the CAIR $PM_{2.5}$ program. Due to the computational resource requirement, only two rounds of simulations were conducted, and thus, the results were reported as a group rather than an individual account. Source Groups with 65 accounts were estimated to exceed the 0.5 del-dv threshold so the group BART screening test was not passed. The highest visibility impairments occurred at the Class I areas near northeast Texas (CACR, HEGL, and UPBU), while some minor impairments that still exceeded the 0.5 del-dv threshold also were estimated near west Texas (BIBE and GUMO) and north Texas (WIMO). Table 5-2 lists the potential BART-eligible non-EGU sources that were in source groups that did not pass the group BART screening test for SO_2 and NO_x emissions.

Table 5–2. List of potential BART-eligible non-EGU sources that were in Source Groups whose SO_2 and NO_x emissions did not pass the group BART screening analysis test using the CAMx PSAT simulations.

Account	Company	Plant	NO_x (tpy)	SO_2 (tpy)
AB0012W	DUKE ENERGY FIELD SERVICES	FULLERTON GAS PLANT	1256	2374
AC0017B	ABITIBI CONSOLIDATED CORP		28	0.3
AG0024G	PUEBLO MIDSTREAM GAS CORP	FASHING PLANT	20	1005
BG0045E	CAPITOL CEMENT DIV CAPITOL	PORTLAND CEMENT	718	850
BL0021O	BASF CORPORATION	FREEPORT SITE	323	0.1
BL0082R	THE DOW CHEMICAL CO	PLANT B	1895	1.7
BL0758C	CHEVRON PHILLIPS CHEMICAL	SWEENY COMPLEX	356	15
CA0011B	J.L. DAVIS GAS PROCESSING	LULING GAS PLANT	90	1021
CB0003M	ALCOA ALUMINA & CHEMICALS	POINT COMFORT PLANT	951	20
CB0028T	UNION CARBIDE CORPORATION	SEADRIFT PLANT	463	0.1
CG0010G	INTERNATIONAL PAPER CO		1619	374
CG0012C	ENBRIDGE PIPELINES	BRYANS MILL PLANT	84	0.3
CY0019H	DYNEGY MIDSTREAM SERVICES	WADDELL COMPRESSOR	537	0.7
ED0034O	NORTH TEXAS CEMENT COMPANY	NORTH TEXAS CEMENT	2572	4434
ED0051O	OWENS CORNING		329	26
ED0066B	TXI OPERATIONS, L.P.	MIDLOTHIAN PLANT	1388	893
FG0036G	TXI OPERATION LP	CLODINE EXPANDED SH	194	635
GB0001R	BP AMOCO CHEMICAL COMPANY	BP AMOCO CHEMICAL T	813	5
GB0004L	BP PRODUCTS NORTH AMERICA IN TEXAS	TEXAS CITY REFINERY	6320	4084
GB0055R	MARATHON ASHLAND PETROLEUM	TEXAS CITY REFINERY	1134	2329
GB0073P	VALERO REFINING CO TEXAS	TEXAS CITY REFINERY	637	264

Account	Company	Plant	NO_x (tpy)	SO_2 (tpy)
GH0003Q	CABOT CORPORATION	PAMPA PLANT	1335	342
GH0004O	CELANESE CHEMICAL	CHEMICAL MANUFACTUR	2609	4015
HD0029C	A.N.R. PIPELINE COMPANY	E.G. HILL COMPRESSO	4028	0.4
HG0048L	LYONDELL CITGO REFINING L P	LYONDELL-CITGO REFI	2288	789
HG0126Q	HOECHST CELANESE CHEMICAL	CLEAR LAKE PLANT	946	1202
HG0130C	VALERO REFINING TEXAS LP	HOUSTON REFINERY	461	2243
HG0175D	CROWN CENTRAL PETROLEUM	PASADENA PLANT	566	1291
HG0229F	EXXONMOBIL CHEMICAL CO	BAYTOWN CHEMICAL PL	701	104
HG0232Q	EXXONMOBIL CORP	EXXONMOBIL REF & SU	4372	1301
HG0558G	ATOFINA CHEMICALS INC	ATOFINA INC	18	920
HG0562P	TEXAS PETROCHEMICALS LP	TX PETROCHEMICALS L	334	1.9
HG0659W	SHELL OIL CO	DEER PARK PLANT	5811	6968
HG0697O	RHODIA, INC.	HOUSTON PLANT	6.8	5099
HH0019H	NORIT AMERICAS INC	NORIT AMERICAS INC	489	784
HH0042M	EASTMAN CHEMICAL COMPANY	TEXAS OPERATIONS	2612	105
HK0014M	TEXAS LEHIGH CEMENT CO	TEXAS LEHIGH CEMENT	1156	805
HR0018T	VALENCE MIDSTREAM LTD	COMO PLT	247	2743
HT0011Q	ALON USA LP	BIG SPRING REFINERY	344	3311
HT0027B	SID RICHARDSON CARBON CO	BIG SPRING CARBON B	185	3149
HW0008S	DEGUSSA ENGINEERED CARBONS BORGER	BORGER CARBON BLACK	445	3604
HW0017R	SID RICHARDSON CARBON	BORGER CARBON BLACK	638	3535
HW0018P	PHILLIPS 66 CO	BORGER REFINERY	590	59
JB0016M	VINTAGE PETROLEUM, INC.	W RANCH COMP STA VA	1036	0.0
JC0003K	WESTVACO		1489	72
JE0005H	ATOFINA PETROCHEMICALS INC	PORT ARTHUR REFINER	796	1007
JE0039N	THE GOODYEAR TIRE AND RUBBER CO		1137	3.8
JE0042B	PREMCOR REFINING GROUP	PORT ARTHUR REFINER	96	0.4
JE0067I	EXXONMOBIL OIL CORP	BEAUMONT REFINERY	3871	9747
JE0343H	BMC HOLDINGS INC	BMC HOLDINGS INC	1192	4.3
JH0025O	JOHNS MANVILLE INTERNATIONAL	JOHNS MANVILLE	97	19
MB0123F	LEHIGH CEMENT COMPANY	LEHIGH PORTLAND CEM	531	576
MC0002H	ENBRIDGE PIPELINE	TILDEN GAS PLANT	1.9	2276
MH0009H	CELANESE LIMITED		612	43
MM0001T	ALCOA INC	ALCOA SANDOW PLANT	36	1458
MR0008T	DIAMOND SHAMROCK REFINING	MCKEE PLANTS	1549	2245
NB0037F	TXI OPERATIONS, L.P.	STREETMAN PLANT	691	3468
NE0027V	CITGO REFINING & CHEMICALS	CORPUS CHRISTI REFI	1201	5103
NE0043A	VALERO REFINING COMPANY	COMPLEX 6B 7 8	1318	3233
NE0120H	KOCH PETROLEUM GROUP LP	CORPUS CHRISTI EAST	915	65
NE0122D	FLINT HILLS RESOURCES LP	WEST REFINERY	284	27
OC0007J	EI DUPONT DENEMOURS & CO	SABINE RIVER WORKS	3125	7.3
PE0024Q	DUKE ENERGY FIELD SERVICES	WAHA GAS PLANT	131	1571
VC0008Q	EI DU PONT DE NEMOURS & CO	EI DU PONT DE NEMOU	2723	18
WH0014S	WICHITA FALLS PLANT		107	28

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A T T A C H M E N T C

ADDENDUM I: BART Exemption Screening Analysis
Draft December 6, 2006

ADDENDUM I

BART Exemption Screening Analysis
Draft December 6, 2006

SO_2 and NO_x Texas Model Plants (TMP)

This Addendum presents a subsequent assessment of the BART exemption screening analysis documented in *Screening Analysis of Potential BART-Eligible Sources in Texas* (Morris and Nopmongcol, 2006). PSAT modeling was conducted that followed Option 3 in EPA's BART guidance which allows group exemption modeling of potential BART-eligible sources' SO_2 and NO_x emissions. Because the Clean Air Interstate Rule (CAIR) addresses the SO_2 and NO_x BART requirements for Texas Electrical Generating Units (EGUs), the SO_2 and NO_x emissions BART group exemption screening analysis was conducted for just non-EGU (NEGU) potential BART-eligible sources. Two rounds of PSAT modeling were conducted. None of the source groups screened out during the first round. TCEQ decided to set aside the largest sources and to attempt a second round of PSAT modeling on the BART groups 5 through 10. These groups were split into deciles and modeled. During the second round two source groups were screened out; source groups #1 and #5. This left 65 NEGU sources that did not screen out for SO_2 and NO_x. For further information on the PSAT screening see chapter 4 of the report. This cumulative group exemption approach is a very efficient screening method, in that if the visibility impact at all Class I areas due to a group of BART sources is not significant, then each BART source in the group is also not significant. However, if the source group failed the screening analysis, the approach cannot exempt small sources in the group that may not be anticipated to cause visibility impairment. In that case, a model plant approach can be useful, and thus has been used for this subsequent summary analysis of the PSAT modeling output described in this Addendum.

A PM Screening Reanalysis of Account BG0057U

In addition to this model plant analysis, a PM screening reanalysis of account BG0057U EGU is presented. An incorrect stack diameter had been used in the previous analysis. Based on information provided by the company the modeling analysis was rerun for this source.

List of Class I Areas at Which Sources Failed

At the end of this addendum is a list of sources that did not pass the screening analyses along with the Class I areas at which they failed.

TMPs of the SO_2 and NO_x Screening Analysis

Option 2 in EPA's BART guidance (EPA, 2005) described an approach that the state may use in the BART exemption analysis using model plants based on representative sources sharing certain characteristics. A model plant analysis may illustrate that plants with certain characteristics do not contribute to visibility impairment in the Class I areas. For this analysis, TCEQ used the modeling results for sources that successfully passed the threshold test and used these Texas Model Plants (TMPs) to establish distance and emission rate thresholds that would indicate that a source would not have an impact on a given Class I area. Based on the modeling results, BART sources that emit less than a certain amount per year and are located a certain distance from the nearest Class I area can be exempted.

In carrying out this approach, first the TMPs were identified. In the PSAT screening analysis for non-EGU sources, 7 potential BART-eligible sources were shown to not contribute significantly to visibility impairment and therefore were declared exempt from BART. These seven sources (listed in Table A-1) can be used as model plants to exempt certain other potential BART-eligible sources that share specific characteristics. To account for regional factors, potential BART-eligible sources were only compared to the TMP that shares the same nearest Class I area. BART sources that emit combined SO_2 and NO_x emissions less than the TMPs and are located further from the nearest Class I area than the TMPs may be declared exempt from BART.

Table A-1. List of TMPs that passed the SO_2 and NO_x emissions exemption screening analysis

Model Plant	Account	Company	Site	NO_x + SO_2 (tpy)	Closest Class I Area	Closest Distance from Class I Area (km)	Q/D (tpy /km)
1	BL0002S	AMOCO CHEMICAL CO	CHOCOLATE BAYOU PLN	2018	BRET	587	3.44
2	JE0052V	HUNTSMAN CORPORATION	PORT NECHES PLANT	951	BRET	471	2.02
3	BJ0001T	CHEMICAL LIME LTD	CHEMICAL LIME—CLIF	1209	WIMO	352	3.43
4	NE0022I	TICONA POLYMERS INC	BISHOP FACILITY	1134	BIBE	564	2.01
5	HG0228H	EXXON CHEMICAL CO	BAYTOWN OLEFINS PLA	1011	CACR	530	1.91
6	HG0310V	CHEVRON PHILLIPS CHEMICAL	CHEVRON CHEMICAL CO	1057	CACR	521	2.03
7	HG0632T	ROHM & HAAS TEXAS	DEER PARK PLANT	1824	CACR	534	3.41

All of the potential BART-eligible sources in the PSAT Round 1 groups have Q/D values higher than the TMPs. None of the sources from round 1 passed this TMP analysis. In addition, BART-eligible sources can only be compared with TMPs that share the same nearest Class I area, limiting the comparison to those sources with closest Class I areas of BIBE, BRET, CACR and WIMO. Therefore, account CY0019H, nearest to GUMO, was not eligible and continued to fail the BART exemption analysis.

Table A-2 shows the potential BART-eligible sources in PSAT Round 2 grouped by nearest Class I area. Sources in each group were compared to the TMP that shares the same nearest Class I area. If the source can pass the two criteria, emissions and a distance from Class I area of one of the TMPs, then it may be exempt from BART. For example, account NE0120H is closest to BIBE and so was compared to the TMP 4 in Table A-1. The combined SO_2 and NO_x emissions of this account (979 TPY) are less than the emissions from TMP 4 (1134 TPY) and the source is located further from the nearest Class I area (592 km) than the TMP 4 (564 km). For these reasons, account NE0120H is exempt from BART using the TMP criteria. If there are more than one representative TMP in a group, potential BART-eligible sources are only required to pass the criteria of one of the TMPs in that group. For instance, there are two TMPs representing BRET, TMP 1 and 2, account JE0042B passed the criteria of TMP 2 and therefore can be exempt from BART. Figures A-(1-4) show the locations of the potential BART-eligible sources, their associated TMPs and Q/D ratios.

Seventeen (17) sources passed the TMP analysis. Note that the results summary in Table A-2 does not take into account the direction the source is located from the Class I area. However, because Class I areas near Texas tend to be on the borders or in other states, the general direction from the sources to the Class I areas are consistent (e.g., direction to BIBE is generally to the west, direction to CACR is generally to the northeast, etc.). Thus, the sources have similar source-receptor relationships.

Table A-2. List of potential BART-eligible non-EGU sources included in the NO_x and SO_2 TMP analysis

Nearest Class I Area	Account	Company	Site	NO_x + SO_2 (tpy)	Closest Distance from Class I Area (km)	TMP	Passed	Distance from a Model Plant
BIBE	AG0024G	PUEBLO MIDSTREAM GAS CORP	FASHING PLANT	1025	494	4		143
	BG0045E	CAPITOL CEMENT DIV CAPITOL	PORTLAND CEMENT	1568	482	4		230
	CA0011B	J.L. DAVIS GAS PROCESSING	LULING GAS PLANT	1111	534	4		243
	CB0003M	ALCOA ALUMINA & CHEMICALS	POINT COMFORT PLANT	971	654	4	YES	175
	CB0028T	UNION CARBIDE CORPORATION	SEADRIFT PLANT	464	636	4	YES	149
	JB0016M	VINTAGE PETROLEUM, INC.	W RANCH COMP STA VA	1036	646	4	YES	182
	NE0120H	KOCH PETROLEUM GROUP LP	CORPUS CHRISTI EAST	979	592	4	YES	49
	NE0122D	FLINT HILLS RESOURCES LP	WEST REFINERY	311	582	4	YES	42
BRET	BL0021O	BASF CORPORATION	FREEPORT SITE	323	607	1	YES	32
						2	YES	179
	BL0082R	THE DOW CHEMICAL CO	PLANT B	1897	605	1	YES	33
						2		179
	GB0001R	BP AMOCO CHEMICAL COMPANY	BP AMOCO CHEMICAL T	818	560	1		31
						2	YES	118
	GB0073P	VALERO REFINING CO TEXAS	TEXAS CITY REFINERY	901	559	1		33
						2	YES	116
	JE0039N	THE GOODYEAR TIRE AND RUBBER CO		1141	497	1		127
						2		27
	JE0042B	PREMCOR REFINING GROUP	PORT ARTHUR REFINER	97	472	1		139
						2	YES	13
	JE0343H	BMC HOLDINGS INC	BMC HOLDINGS INC	1196	481	1		144
						2		11
CACR	AC0017B	ABITIBI CONSOLIDATED CORP		28	348	5		182
						6		173
						7		186
	BL0758C	CHEVRON PHILLIPS CHEMICAL	SWEENY COMPLEX	370	619	5	YES	105
						6	YES	117
						7	YES	97
	CG0012C	ENBRIDGE PIPELINES	BRYANS MILL PLANT	84	140	5		391
						6		382
						7		395
	FG0036G	TXI OPERATION LP	CLODINE EXPANDED SH	829	551	5	YES	68
						6	YES	78
						7	YES	59

Nearest Class I Area	Account	Company	Site	NO_x + SO_2 (tpy)	Closest Distance from Class I Area (km)	TMP	Passed	Distance from a Model Plant
	HG0229F	EXXONMOBIL CHEMICAL CO	BAYTOWN CHEMICAL PL	805	531	5	YES	1
						6	YES	13
						7		8
	HG0558G	ATOFINA CHEMICALS INC	ATOFINA INC	939	532	5	YES	16
						6	YES	26
						7		8
	HG0562P	TEXAS PETROCHEMICALS LP	TX PETROCHEMICALS L	336	540	5	YES	24
						6	YES	35
						7	YES	15
	JC0003K	WESTVACO		1560	458	5		113
						6		101
						7		122
	MH0009H	CELANESE LIMITED		655	649	5	YES	141
						6	YES	152
						7	YES	132
WIMO	ED0051O	OWENS CORNING		356	308	3		107
	HW0018P	PHILLIPS 66 CO	BORGER REFINERY	649	263	3		564
	JH0025O	JOHNS MANVILLE INTERNATIONALJOHNS MANVILLE		116	293	3		75
	MB0123F	LEHIGH CEMENT COMPANY	LEHIGH PORTLAND CEM	1107	387	3	YES	42
	MM0001T	ALCOA INC	ALCOA SANDOW PLANT	1493	488	3		137
	WH0014S	WICHITA FALLS PLANT		135	97	3		257

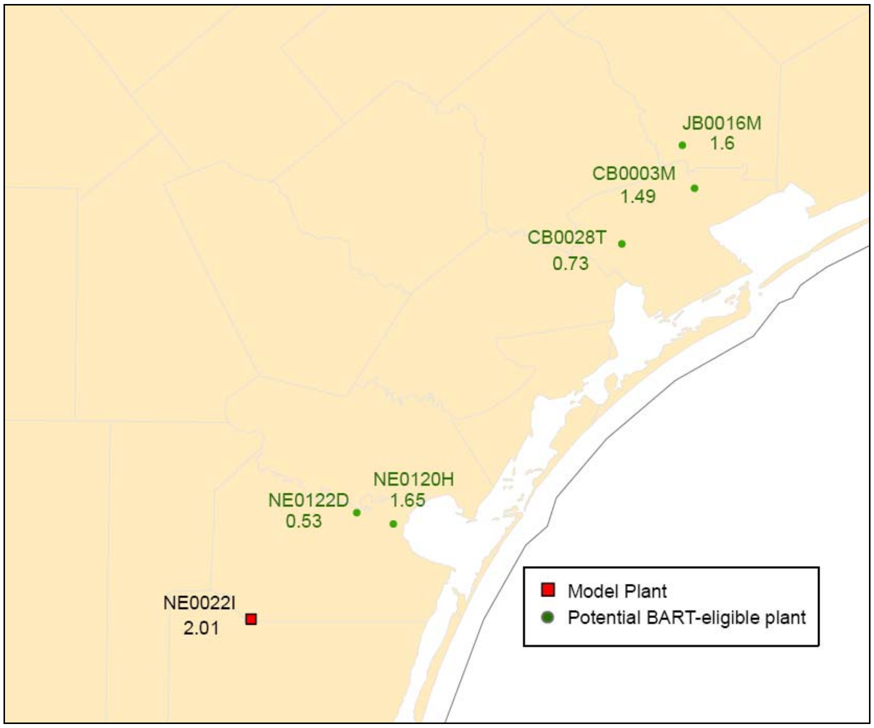

Figure A-1 Potential BART-eligible non-EGU sources nearest to BIBE that passed the TMP analysis; numbers shown are Q/D of the sources (only model plants associated with BIBE are labeled).

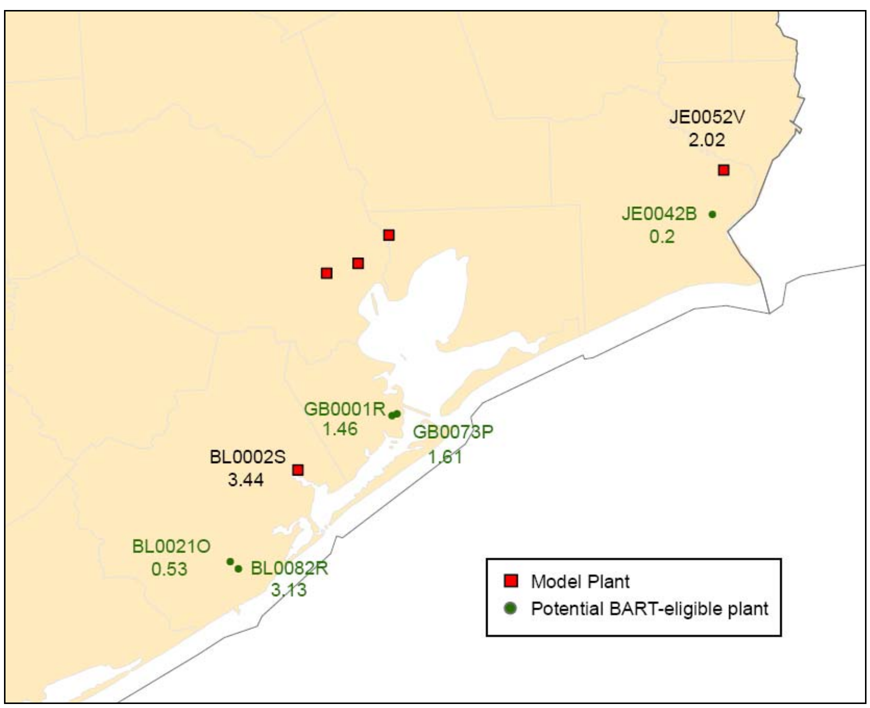

Figure A-2 Potential BART-eligible non-EGU sources nearest to BRET that passed the TMP analysis; numbers shown are Q/D of the sources (only model plants associated with BRET are labeled).

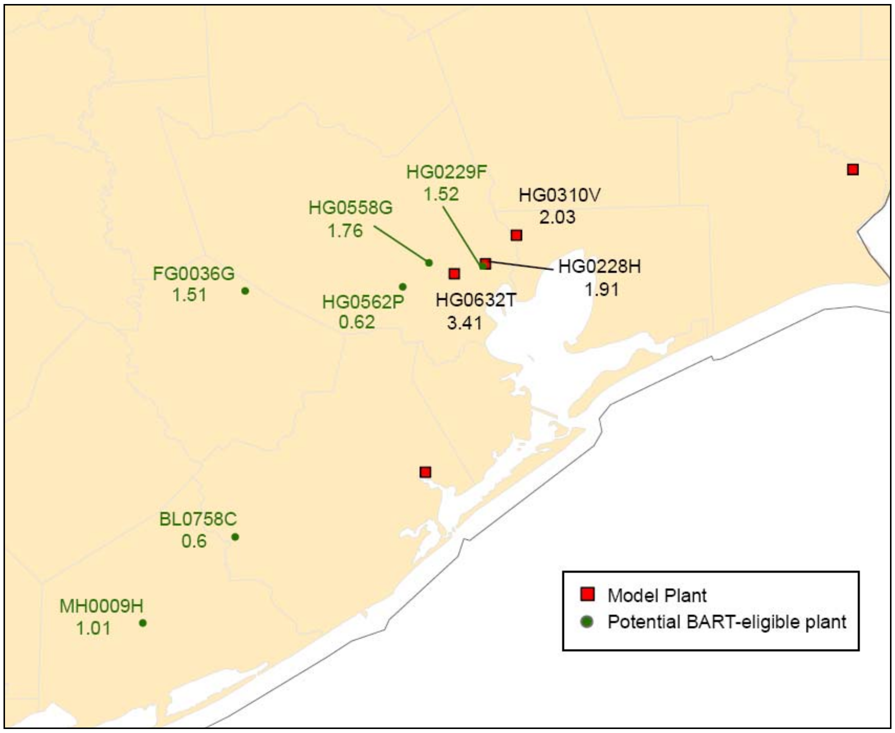

Figure A-3 Potential BART-eligible non-EGU sources nearest to CACR that passed the TMP analysis; numbers shown are Q/D of the sources (only model plants associated with CACR are labeled).

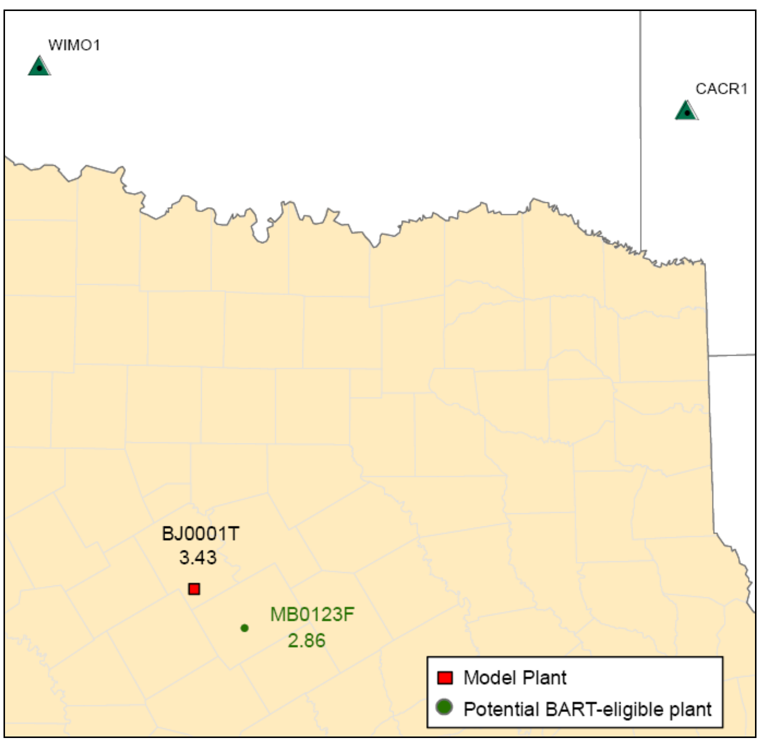

Figure A-4 Potential BART-eligible non-EGU sources nearest to WIMO that passed the TMP analysis; numbers shown are Q/D of the sources (only model plants associated with WIMO are labeled).

A PM Screening Reanalysis of Account BG0057U

Account BG0057U, City Public Service (Sommer Deely Spruce Power Plant), noticed that the diameters of the stacks for two facilities, plant ID 2 boiler-unit 1 and plant ID 4 boiler-unit 2, used in the PM source group modeling analysis were not correct. The diameters used in the previous modeling analysis were 1 foot whereas the corrected diameters are 26 feet. Using the incorrect stack diameter could lead to miscalculated plume rise and thus vertically misplaced the emissions. Therefore, an additional PM emissions zero-out modeling analysis of this source was rerun with the corrected stack parameters.

Figure A-5 displays the visibility impacts due to the PM emissions from account BG0057U using the corrected stack diameters. The visibility impacts from this source are less than 0.5 del-dv at all Class I areas, and it can therefore be considered exempt from BART.

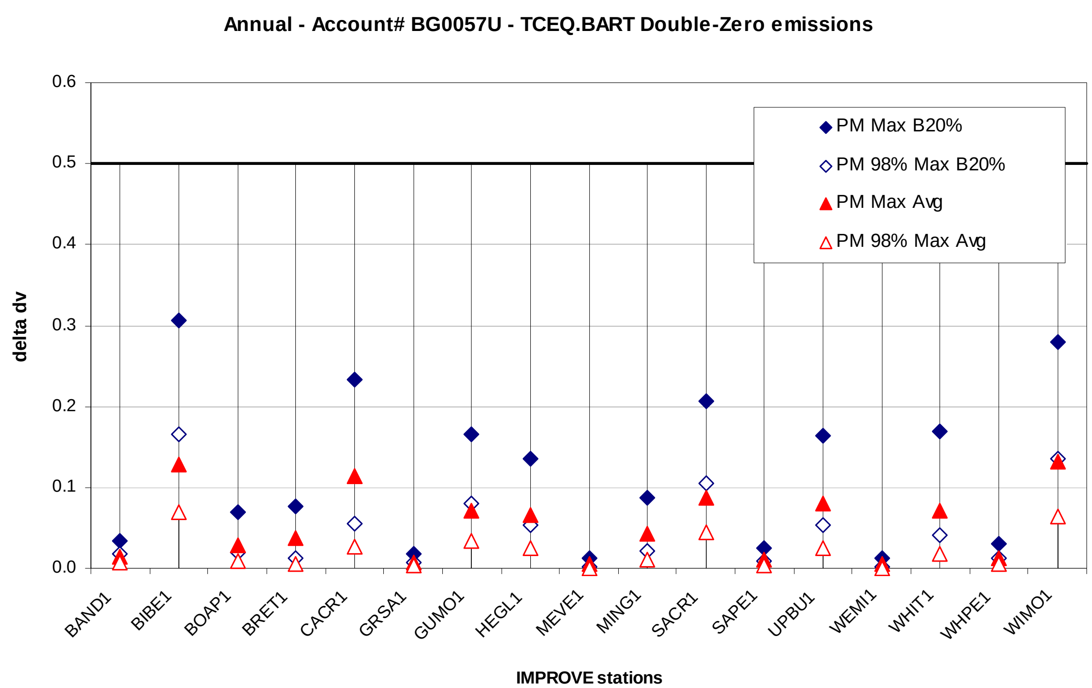

Figure A-5. Visibility impacts (del-dv) at Class I areas from account BG0057U.

Table A-3 lists the potential BART-eligible EGU and non-EGU sources that did not pass the PM emissions exemption analysis described in chapter 3 of the report. Table A-4 summarizes the potential BART-eligible non-EGU sources that did not pass the SO_2 and NO_x emissions exemption analyses using both the PSAT and model plant approach. In both tables, the Class I areas that each source failed are shown. Sources will have to conduct further analysis including the listed Class I areas.

Table A-3. List of potential BART-eligible EGU and non-EGU sources that failed the PM emissions exemption CAMx screening analysis.

Account	Company	Site	PM_{10} (tpy)	EGU/NON-EGU	Failed at Class I Areas
CG0010G	INTERNATIONAL PAPER CO		578	Non-EGU	CACR
TF0012D	SOUTHWESTERN ELECTRIC POWER	WELSH POWER PLANT	1755	EGU	CACR
TF0013B	TXU GENERATION COMPANY LP	MONTICELLO STM ELE	3297	EGU	CACR

Table A-4. List of potential BART-eligible non-EGU sources included in round 1 and round 2 PSAT groupings whose SO_2 and NO_x emissions did not pass the "PSAT" nor the "TMP" analysis.

Account	Company	Site	NO_x (tpy)	SO_2 (tpy)	Failed at Class I Areas
AB0012W	DUKE ENERGY FIELD SERVICES	FULLERTON GAS PLANT	1256	2374	BAND, BIBE, BOAP, BRET, CACR, GRSA, GUMO, HEGL, MING, SACR, UPBU, WHIT, WHPE, WIMO
AC0017B	ABITIBI CONSOLIDATED CORP		28	0.3	CACR, HEGL, MING, UPBU, WIMO
AG0024G	PUEBLO MIDSTREAM GAS CORP	FASHING PLANT	20	1005	CACR, HEGL, MING, UPBU, WIMO
BG0045E	CAPITOL CEMENT DIV CAPITOL	PORTLAND CEMENT	718	850	CACR, HEGL, MING, UPBU, WIMO
CA0011B	J.L. DAVIS GAS PROCESSING	LULING GAS PLANT	90	1021	CACR, HEGL, MING, UPBU, WIMO
CG0010G	INTERNATIONAL PAPER CO		1619	374	BAND, BIBE, BOAP, BRET, CACR, GRSA, GUMO, HEGL, MING, SACR, UPBU, WHIT, WHPE, WIMO
CG0012C	ENBRIDGE PIPELINES	BRYANS MILL PLANT	84	0.3	CACR, HEGL, MING, UPBU, WIMO
CY0019H	DYNEGY MIDSTREAM SERVICES	WADDELL COMPRESSOR	537	0.7	BIBE, CACR, HEGL, MING, UPBU, WIMO
ED0034O	NORTH TEXAS CEMENT COMPANY	NORTH TEXAS CEMENT	2572	4434	BAND, BIBE, BOAP, BRET, CACR, GRSA, GUMO, HEGL, MING, SACR, UPBU, WHIT, WHPE, WIMO
ED0051O	OWENS CORNING		329	26	CACR, HEGL, MING, UPBU, WIMO
ED0066B	TXI OPERATIONS, L.P.	MIDLOTHIAN PLANT	1388	893	BIBE, CACR, GUMO, HEGL, MING, SACR, UPBU, WIMO
GB0004L	BP PRODUCTS NORTH AMERICA IN TEXAS	TEXAS CITY REFINERY	6320	4084	BAND, BIBE, BOAP, BRET, CACR, GRSA, GUMO, HEGL, MING, SACR, UPBU, WHIT, WHPE, WIMO
GB0055R	MARATHON ASHLAND PETROLEUM	TEXAS CITY REFINERY	1134	2329	BIBE, CACR, GUMO, HEGL, MING, SACR, UPBU, WIMO
GH0003Q	CABOT CORPORATION	PAMPA PLANT	1335	342	BIBE, CACR, GUMO, HEGL, MING, SACR, UPBU, WIMO
GH0004O	CELANESE CHEMICAL	CHEMICAL MANUFACTUR	2609	4015	BAND, BIBE, BOAP, BRET, CACR, GRSA, GUMO, HEGL, MING, SACR, UPBU, WHIT, WHPE, WIMO
HD0029C	A.N.R. PIPELINE COMPANY	E.G. HILL COMPRESSO	4028	0.4	BIBE, CACR, GUMO, HEGL, MING, SACR, UPBU, WHIT, WIMO
HG0048L	LYONDELL CITGO REFINING L P	LYONDELL-CITGO REFI	2288	789	BIBE, CACR, GUMO, HEGL, MING, SACR, UPBU, WIMO
HG0126Q	HOECHST CELANESE CHEMICAL	CLEAR LAKE PLANT	946	1202	BIBE, CACR, HEGL, MING, UPBU, WIMO
HG0130C	VALERO REFINING TEXAS LP	HOUSTON REFINERY	461	2243	BIBE, CACR, HEGL, MING, UPBU, WIMO
HG0175D	CROWN CENTRAL PETROLEUM	PASADENA PLANT	566	1291	BIBE, CACR, HEGL, MING, UPBU, WIMO
HG0232Q	EXXONMOBIL CORP	EXXONMOBIL REF & SU	4372	1301	BIBE, CACR, GUMO, HEGL, MING, SACR, UPBU, WHIT, WIMO
HG0659W	SHELL OIL CO	DEER PARK PLANT	5811	6968	BAND, BIBE, BOAP, BRET, CACR, GRSA, GUMO, HEGL, MING, SACR, UPBU, WHIT, WHPE, WIMO
HG0697O	RHODIA, INC.	HOUSTON PLANT	6.8	5099	BIBE, CACR, GUMO, HEGL, MING, SACR, UPBU, WIMO
HH0019H	NORIT AMERICAS INC	NORIT AMERICAS INC	489	784	BIBE, CACR, GUMO, HEGL, MING, SACR, UPBU, WIMO
HH0042M	EASTMAN CHEMICAL COMPANY	TEXAS OPERATIONS	2612	105	BIBE, CACR, GUMO, HEGL, MING, SACR, UPBU, WHIT, WIMO
HK0014M	TEXAS LEHIGH CEMENT CO	TEXAS LEHIGH CEMENT	1156	805	BIBE, CACR, HEGL, MING, UPBU, WIMO

Account	Company	Site	NO_x (tpy)	SO_2 (tpy)	Failed at Class I Areas
HR0018T	VALENCE MIDSTREAM LTD	COMO PLT	247	2743	BIBE, CACR, GUMO, HEGL, MING, SACR, UPBU, WHIT, WIMO
HT0011Q	ALON USA LP	BIG SPRING REFINERY	344	3311	BIBE, CACR, GUMO, HEGL, MING, SACR, UPBU, WHIT, WIMO
HT0027B	SID RICHARDSON CARBON CO	BIG SPRING CARBON B	185	3149	BIBE, CACR, GUMO, HEGL, MING, SACR, UPBU, WHIT, WIMO
HW0008S	DEGUSSA ENGINEERED CARBONS BORGER	BORGER CARBON BLACK	445	3604	BAND, BIBE, BOAP, BRET, CACR, GRSA, GUMO, HEGL, MING, SACR, UPBU, WHIT, WHPE, WIMO
HW0017R	SID RICHARDSON CARBON	BORGER CARBON BLACK	638	3535	BAND, BIBE, BOAP, BRET, CACR, GRSA, GUMO, HEGL, MING, SACR, UPBU, WHIT, WHPE, WIMO
HW0018P	PHILLIPS 66 CO	BORGER REFINERY	590	59	CACR, HEGL, MING, UPBU, WIMO
JC0003K	WESTVACO		1489	72	CACR, HEGL, MING, UPBU, WIMO
JE0005H	ATOFINA PETROCHEMICALS INC	PORT ARTHUR REFINER	796	1007	BIBE, CACR, HEGL, MING, UPBU, WIMO
JE0039N	THE GOODYEAR TIRE AND RUBBER CO		1137	3.8	CACR, HEGL, MING, UPBU, WIMO
JE0067I	EXXONMOBIL OIL CORP	BEAUMONT REFINERY	3871	9747	BAND, BIBE, BOAP, BRET, CACR, GRSA, GUMO, HEGL, MING, SACR, UPBU, WHIT, WHPE, WIMO
JE0343H	BMC HOLDINGS INC	BMC HOLDINGS INC	1192	4.3	BIBE, CACR, HEGL, MING, UPBU, WIMO
JH0025O	JOHNS MANVILLE INTERNATIONALJOHNS MANVILLE		97	19	CACR, HEGL, MING, UPBU, WIMO
MC0002H	ENBRIDGE PIPELINE	TILDEN GAS PLANT	1.9	2276	BIBE, CACR, HEGL, MING, UPBU, WIMO
MM0001T	ALCOA INC	ALCOA SANDOW PLANT	36	1458	BIBE, CACR, HEGL, MING, UPBU, WIMO
MR0008T	DIAMOND SHAMROCK REFINING	MCKEE PLANTS	1549	2245	BIBE, CACR, GUMO, HEGL, MING, SACR, UPBU, WHIT, WIMO
NB0037F	TXI OPERATIONS, L.P.	STREETMAN PLANT	691	3468	BIBE, CACR, GUMO, HEGL, MING, SACR, UPBU, WHIT, WIMO
NE0027V	CITGO REFINING & CHEMICALS	CORPUS CHRISTI REFI	1201	5103	BIBE, CACR, GUMO, HEGL, MING, SACR, UPBU, WHIT, WIMO
NE0043A	VALERO REFINING COMPANY	COMPLEX 6B 7 8	1318	3233	BIBE, CACR, GUMO, HEGL, MING, SACR, UPBU, WIMO
OC0007J	EI DUPONT DENEMOURS & CO	SABINE RIVER WORKS	3125	7.3	BIBE, CACR, GUMO, HEGL, MING, SACR, UPBU, WIMO
PE0024Q	DUKE ENERGY FIELD SERVICES	WAHA GAS PLANT	131	1571	BIBE, CACR, GUMO, HEGL, MING, SACR, UPBU, WIMO
VC0008Q	EI DU PONT DE NEMOURS & CO	EI DU PONT DE NEMOU	2723	18	BIBE, CACR, HEGL, MING, UPBU, WIMO
WH0014S	WICHITA FALLS PLANT		107	28	CACR, HEGL, MING, UPBU, WIMO

A T T A C H M E N T D

Best Available Retrofit Technology (BART) Modeling Protocol to Determine Sources Subject to BART in the State of Texas
January 2007

January 2007

Best Available Retrofit Technology (BART) Modeling Protocol to Determine Sources Subject to BART in the State of Texas

Air Permits Division
Texas Commission on Environmental Quality

Print on
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Table of Contents

Summary of Significant Changes

General - Removed “draft” wording and made other minor editorial changes throughout the document.

Section V.B - Changed the version of CALPUFF to the EPA approved version.

Section V.B - Changed the version of POSTUTIL to the EPA approved version.

Section V.B - Changed the version of CALPOST to the EPA approved version.

Section V.C - Added information about re-compiling the code when using the CENRAP-developed CALMET dataset.

Section V.E - Clarified that sources performing the source-specific subject-to-BART screening analysis should consider all visibility impairing species.

Section VIII - Added information for including files associated with re-compiling the code with the electronic archive.

I. Introduction

On July 6, 2005, the U.S. Environmental Protection Agency (EPA) published final amendments to its 1999 Regional Haze Rule in the Federal Register, including Appendix Y, the final guidance for Best Available Retrofit Technology (BART) determinations (70 FR 39104-39172). The BART rule requires the installation of BART on emission sources that fit specific criteria and "may reasonably be anticipated to cause or contribute" to visibility impairment in any Class I area. Air quality modeling is a means for determining which sources cause or contribute to visibility impairment. Texas' proposed protocol for conducting this modeling for BART is provided herein.

The Texas Commission on Environmental Quality (TCEQ) foresees two purposes for this protocol. First, sources may use the protocol to determine if BART-eligible units are subject to BART and must perform a BART analysis. Second, sources that are subject to BART will have this protocol to use as a starting point to conduct modeling required when making a BART analysis.

New BART guidance, both formal and informal, continues to become available from EPA and the Federal Land Managers (FLMs) that oversee visibility in Class I areas. Texas has developed a schedule for completing BART analyses and implementing the BART strategy in order to meet State Implementation Plan (SIP) deadlines. If the state is to meet those deadlines, modeling to determine sources subject to BART and modeling to make BART analyses may need to be done before all final BART guidance from EPA and the FLMs becomes available.

II. Background

Generally, Class I areas are national parks and wilderness areas in which visibility is more stringently protected under the Clean Air Act than any other areas in the United States. The Class I areas are shown in Appendix A.

The BART requirements are a part of the SIP that will be submitted to EPA in late 2007. The SIP is a comprehensive plan of action to increase visibility in the Class I areas and includes reasonable progress goals in addition to the goals established by sources subject to BART.

The BART provisions are a part of the overall plan that focuses on reducing emissions from large sources that, due to age, were exempted from other control requirements in the Clean Air Act. An emissions source is considered eligible for BART if it:

- Falls into one of 26 listed categories;
- Has the potential to emit at least 250 tons per year of any visibility-impairing pollutant (primarily NO_x, SO_2, or PM); and
- Existed on August 7, 1977, yet was not in operation before August 7, 1962.

Thus, the BART provisions do not cover all sources that may cause or contribute to visibility impairment in any Class I area.

According to the BART guidance, an individual source is considered to cause visibility impairment if it has a least a 1.0 deciview (dv) impact on the visibility in a Class I area. A source is considered to contribute to visibility impairment if it has at least a 0.5 dv impact.

The BART guidance allows a state to exempt individual sources from the BART requirements if they do not cause or contribute to any impairment of visibility in a Class I area. Exemption is done through air quality modeling. Although the BART guidance does not dictate how such an analysis must be done, it provides direction, which was used to develop this modeling protocol.

The BART analysis process includes several other steps in addition to the modeling described in this protocol. These steps, none of which are addressed in this document, include detailed analysis of:

- Costs of compliance;
- Energy and non-air quality impacts;
- Existing pollution control technologies in use at the BART-eligible unit;
- Remaining useful life of the units and/or facility; and
- Improvements in visibility expected from the use of BART controls.

III. BART Air Quality Modeling Approach

One of the air quality modeling approaches suggested by EPA in the BART guidance is an individual source attribution approach. Specifically, this entails modeling source-specific BART-eligible units and comparing modeled impacts to a particular deciview threshold (described above).

The modeling approach discussed here is specifically designed for conducting a source-specific subject-to-BART screening analysis. There may be differences between modeling for conducting BART analyses and that for conducting a visibility analysis for a New Source Review permit, which may involve similar emission sources and the same air dispersion model used here.

In preparing this modeling protocol, the TCEQ consulted BART modeling protocols drafted by other organizations to maintain an appropriately consistent approach within the Central States Regional Air Planning Association (CENRAP). The three available BART modeling protocols consulted were:

1. "Best Available Retrofit Technology (BART) Modeling Protocol to Determine Sources Subject to BART in the State of Minnesota," final version March 2006;
2. "Best Available Retrofit Technology (BART) Modeling Protocol to Determine Sources Subject to BART in the State of Kansas," final version June 2006;
3. "Screening Analysis of Potentially BART-Eligible Sources in Texas," developed by ENVIRON International Corporation, December 2005.

This protocol is most similar to the Kansas and Minnesota final protocols. Texas is in EPA Region VI, and they will be reviewing Texas' Regional Haze SIP, of which BART will be a part.

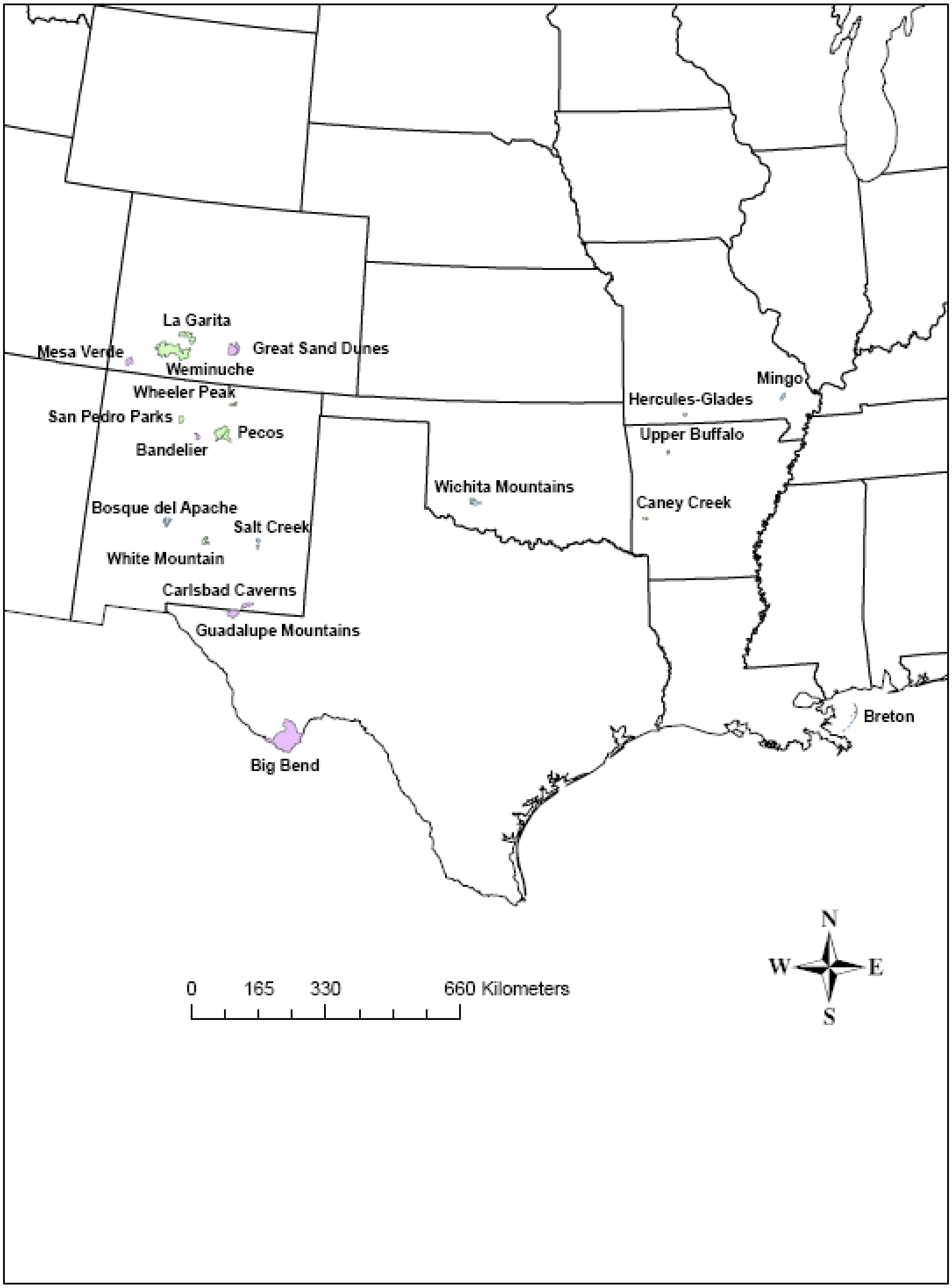
IV. Class I Areas to Assess

Table 1, *Class I Areas Evaluated for BART*, contains the list of Class I areas to be included in the modeling analysis. The list was developed for the subject-to-BART screening evaluation conducted by ENVIRON for the TCEQ. Figure 1, *Location of Class I Areas*, shows the location of each Class I area to be evaluated. Sources conducting the source-specific subject-to-BART screening analysis should include all Class I areas that the ENVIRON screening evaluation showed their source group to have impacts greater than 0.5 dv on visibility.

Table 1 - Class I Areas Evaluated for BART

Class I Area	State	Visibility Monitoring Site Name
Bandelier Wilderness Area	NM	BAND1
Big Bend National Park	TX	BIBE1
Bosque del Apache Wilderness Area	NM	BOAP1
Breton Wilderness Area	LA	BRET1
Caney Creek Wilderness Area	AR	CACR1
Carlsbad Caverns National Park	NM	GUMO1
Great Sand Dunes Wilderness Area	CO	GRSA1
Guadalupe Mountains National Park	TX	GUMO1
Hercules-Glades Wilderness Area	MO	HEGL1
La Garita Wilderness Area	CO	WEMI1
Mesa Verde National Park	CO	MEVE1
Mingo Wilderness Area	MO	MING1
Pecos Wilderness Area	NM	WHPE1
Salt Creek Wildlife Refuges	NM	SACR1
San Pedro Parks Wilderness Area	NM	SAPE1
Upper Buffalo Wilderness Area	AR	UPBU1
Weminuche Wilderness Area	CO	WEMI1
Wheeler Peak Wilderness Area	NM	WHPE1
White Mountain Wilderness Area	NM	WHIT1
Wichita Mountains Wildlife Refuges	OK	WIMO1

Figure 1 - Location of Class I Areas



V. Air Quality Model and Inputs

According to the final Regional Haze Rule's BART guidance, a source "can use CALPUFF or other appropriate model to predict the visibility impacts from a single source at a Class I area." For purposes of the source-specific subject-to-BART screening analysis, the TCEQ recommends the use of CALPUFF. The TCEQ recognizes that CALPUFF has limited ability to simulate the complex atmospheric chemistry involved in the estimation of secondary particulate formation. However, for purposes of this source-specific subject-to-BART screening analysis, the TCEQ recommends the use of CALPUFF for the following reasons:

1. The increased level of effort required for conducting particulate apportionment in the regional scale, full-chemistry Eulerian model (CAMx or CMAQ) to acquire individual source contributions to Class I areas, relative to the simplicity of the CALPUFF model;
2. The limited scope of what this modeling is to determine; and
3. The additional modeling of BART controls that will be conducted as part of the Regional Haze SIP with the CAMx or CMAQ models.

EPA's BART guidance recommends following the EPA's Interagency Workgroup on Air Quality Modeling (IWAQM) guidance, Phase 2 recommendations for long-range transport. The IWAQM guidance was developed to address air quality impacts as assessed through the Prevention of Significant Deterioration (PSD) program at Class I areas, where the source generally is located beyond 50 kilometer (km) of the Class I area. The IWAQM guidance does not specifically address the type of assessment that will occur with the BART analysis.

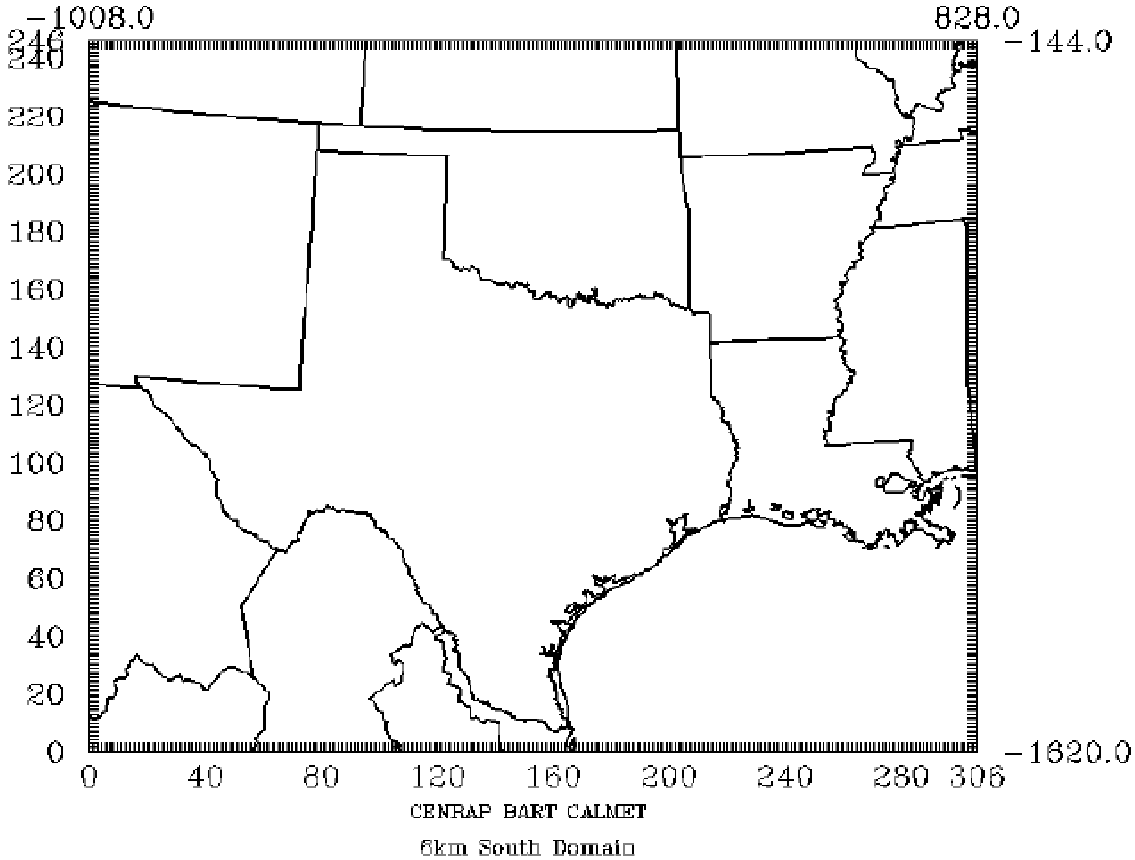
Given the uncertainties of transport and dispersion processes in CALPUFF for distances greater than 300 km, consideration may be given to the CAMx model for determining visibility impacts at Class I areas located 300 km beyond the source in a refined modeling analysis. Below is a list of options for selecting a model to use. The first two apply to the source-specific subject-to-BART screening analysis, and the third is an option for a refined modeling analysis:

1. CALPUFF for Class I areas located within 300 km of the source;
2. CALPUFF for Class I areas located beyond 300 km of the source for a conservative screening analysis; and
3. CAMx for Class I areas located beyond 300 km of the source in a refined analysis.

A. Modeling Domain

The CALPUFF source-specific subject-to-BART screening modeling should be conducted with the CENRAP south 6 km grid. The extent of the proposed CALPUFF domain is shown in Figure 2, *6 km CENRAP South CALPUFF Domain*.

Figure 2 - 6 km CENRAP South CALPUFF Domain



CALPUFF should be applied for three annual simulations spanning the years 2001 through 2003. The IWAQM guidance allows the use of fewer than five years of meteorological data if a meteorological model using four-dimensional data assimilation is used to supply data. See the section on meteorology for more information.

B. CALPUFF System Implementation

There are three main components to the CALPUFF model:

1. Meteorological Data Modeling (CALMET);
2. Dispersion Modeling (CALPUFF); and
3. Post processing (CALPOST).

Versions of the modeling components that may be used in the source-specific subject-to-BART screening analysis are shown in Table 2, *CALPUFF Modeling Components*.

Table 2 - CALPUFF Modeling Components

Processor	Version	Level
TERREL	3.311	030709
CTGCOMP	2.42	030709
CTGPROC	2.42	030709
MAKEGEO	2.22	030709
CALMM5	2.4	050413
CALMET	5.53a	040716
CALPUFF	5.711a	040716
POSTUTIL	1.3	030402
CALPOST	5.51	030709

C. Meteorological data modeling (CALMET)

The 2001-2003 CENRAP-developed CALMET dataset should be used in the source-specific subject-to-BART screening analysis. For additional information on the settings used to develop this dataset, refer to the CENRAP BART Modeling Guidelines document at www.cenrap.org/modeling_document.asp.

Since no observational data were used in the CALMET outputs developed by CENRAP, the prognostic meteorological dataset from MM5 is not supplemented with surface or upper air observations during the CALMET processing. The use of observations is thought to counterbalance smoothing that may occur when using the coarse grid scale of the MM5 data. Both the EPA and FLMs commented on the draft CENRAP guidelines that observations should be used in refined CALPUFF modeling. However, the TCEQ considers this screening modeling to be conservative. Therefore, the TCEQ will not require the use of observational data. Sources may use observational data if they wish to conduct a more refined modeling analysis.

In order to use the CENRAP-developed CALMET dataset, the parameter files for CALPUFF, POSTUTIL, and CALPOST may have to be edited to accommodate the size of the CENRAP-developed CALMET dataset modeling domain. Once the parameter files have been edited, the CALPUFF, POSTUTIL, and CALPOST model code will need to be re-compiled.

D. Stack parameters

Stack parameters required for modeling BART-eligible units are: height of the stack opening from ground, inside stack diameter, exit gas flow rate, exit gas temperature, base elevation above sea level, and location coordinates of the stack. Because the modeling conducted for BART is concerned with long-range transport, not localized impacts, including the effects of building downwash in the source-specific subject-to-BART screening analysis are not necessary. Sources may include the effects of building downwash if they wish to conduct a more refined modeling analysis.

E. Emissions

Emission rates for the BART analyses follow EPA's BART guidance. Specifically, the 24-hour average actual emission rate with normal operations from the highest emitting day of the year should be modeled. Identification of the maximum 24-hour actual emission rates should be made for the most recent four years (2002-2005), according to the following prioritization:

1. Continuous Emissions Monitoring (CEM) data;
2. Facility emissions tests;
3. Emissions factors;
4. Permit limits; or lastly,
5. Potential to emit.

The species that should be modeled and/or emitted in the source-specific subject-to-BART screening analysis are listed in Table 3, *Species Modeled in BART Screening Analysis*. Sources should include all species if the ENVIRON screening evaluation showed any of their source groups to have impacts greater than 0.5 dv on visibility.

Table 3 - Species Modeled in BART Screening Analysis

Species	Modeled	Emitted	Dry Deposited
SO_2	Yes	Yes	Computed-gas
SO_4	Yes	No	Computed-particle
NO_x	Yes	Yes	Computed-gas
HNO_3	Yes	No	Computed-gas
NO_3	Yes	No	Computed-particle
PM-fine	Yes	Yes	Computed-particle
PM-coarse	Yes	Yes	Computed-particle

Note: *In the case of a source where the PM profile for sulfate (SO_4), elemental carbon (EC), and secondary organic aerosols (SOA) are known, SO_4 should be modeled as a separate species in CALPUFF.*

Particle size parameters are entered in the CALPUFF input file for dry deposition of particles. There are default values for “aerosol” species (i.e., SO_4, NO_3, and $PM_{2.5}$). The default value for each of these species is 0.48 µm geometric mass mean diameter and 2.0 µm geometric standard deviation. Where the source is able to supply emissions of $PM_{2.5}$, the default values may be appropriate. However, many sources may not be able to supply $PM_{2.5}$ emissions and will supply what is available, PM_{10} emissions data. In this case, using the default values may underestimate deposition of particulates and overestimate the particulate contribution to visibility. For sources that are not able to supply $PM_{2.5}$ emissions, the source should speciate PM_{10} emissions to $PM_{2.5}$ and PM course by using $PM_{2.5}$/ PM_{10} emission factors, if they are available. If there are no emission factors available, either use the worst-case assumption that all particulate is $PM_{2.5}$ or the source could provide a suggested emissions factor with full scientific documentation.

F. Dispersion modeling (CALPUFF)

The CALMET output is used as input to the CALPUFF model, which simulates the effects of the meteorological conditions on the transport and dispersion of pollutants from an individual source. In general, the default options are used in the CALPUFF model. The CALPUFF model has a puff-splitting option that splits puffs that become large over greater transport distances. The TCEQ recommends that the puff-splitting option not be used in the source-specific subject-to-BART screening analysis.

Detailed information on all CALPUFF settings to be used in the source-specific subject-to-BART screening analysis can be found in Appendix B.

Ozone and ammonia concentrations: Ozone (O_3) and ammonia (NH_3) can be input to CALPUFF as hourly or monthly background values. Background ozone and ammonia concentrations are assumed to be temporally and spatially invariant and will be fixed at 40 and 3 ppb, respectively, across the entire domain for all months. NH_3 concentrations may be derived from regional modeling outputs that CENRAP is currently developing. However, at this time these NH_3 values are not available in a model ready form.

Receptors: Receptors are locations where model results are calculated and provided in the CALPUFF output files. Receptor locations should be derived from the National Park Service (NPS) Class I area receptor database at www2.nature.nps.gov/air/maps/receptors/index.cfm. The discrete receptors are necessary for calculating visibility impacts in the selected Class I areas. The NPS provides receptors in all the Class I areas on a 1 km basis. These receptors should be kept at the 1 km spacing for the BART modeling.

Outputs: The CALPUFF modeling results will be displayed in units of micrograms per cubic meter ($\mu g/m^3$). In order to determine visibility impacts, the CALPUFF outputs must be post-processed.

G. Post-processing (CALPOST)

Hourly concentration outputs from CALPUFF are processed through POSTUTIL and CALPOST to determine visibility conditions. Specifically, POSTUTIL takes the concentration file output from CALPUFF and recalculates the nitric acid and nitrate partition based on total available sulfate and ammonia. CALPOST uses the concentration file processed through POSTUTIL, along with relative humidity data, to perform visibility calculations. For the source-specific subject-to-BART screening analysis, the only modeling results out of the CALPUFF modeling system of interest are the visibility impacts. Please see Appendix C and D for detailed settings for POSTUTIL and CALPOST.

Light extinction: Light extinction must be computed in order to calculate visibility. CALPOST has seven methods for computing light extinction. The BART screening analysis should use Method 6, which computes extinction from speciated particulate matter with monthly Class I area-specific relative humidity adjustment factors. Relative humidity is an important factor in determining light extinction (and therefore visibility) because sulfate and nitrate aerosols, which absorb moisture from the air, have greater extinction efficiencies with greater relative humidity. The BART screening analysis should apply relative humidity correction factors (*f*(RH)s) to sulfate and nitrate concentration outputs from CALPUFF, which can be obtained from EPA's "Guidance for Estimating Natural Visibility Conditions under the Regional Haze Rule (EPA, 2003). The *f*(RH) values for the Class I areas that should be assessed are provided in Table 4, *Monthly Averaged f(RH) Based on Centroid of the Class I Area*.

Table 4 - Monthly Averaged *f*(RH) Based on Centroid of the Class I Area

Class I Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bandelier	2.2	2.1	1.8	1.6	1.6	1.4	1.7	2.1	1.9	1.7	2.0	2.2
Big Bend	2.0	1.9	1.6	1.5	1.6	1.6	1.7	2.0	2.1	1.9	1.8	1.9
Bosque del Apache	2.1	1.9	1.6	1.4	1.4	1.3	1.8	2.0	1.9	1.6	1.8	2.2
Breton	3.7	3.5	3.7	3.6	3.8	4.0	4.3	4.3	4.2	3.7	3.7	3.7
Caney Creek	3.4	3.1	2.9	3.0	3.6	3.6	3.4	3.4	3.6	3.5	3.4	3.5
Carlsbad Caverns	2.1	2.0	1.6	1.5	1.6	1.6	1.8	2.1	2.2	1.8	1.9	2.1
Great Sand Dunes	2.4	2.3	2.0	1.9	1.9	1.8	1.9	2.3	2.2	1.9	2.4	2.4
Guadalupe Mountains	2.0	2.0	1.6	1.5	1.6	1.5	1.9	2.2	2.2	1.8	1.9	2.2
Hercules-Glades	3.2	2.9	2.7	2.7	3.3	3.3	3.3	3.3	3.4	3.1	3.1	3.3
La Garita	2.3	2.2	1.9	1.8	1.8	1.6	1.7	2.1	2.0	1.8	2.2	2.3
Mesa Verde	2.5	2.3	1.9	1.5	1.5	1.3	1.6	2.0	1.9	1.7	2.1	2.3
Mingo	3.3	3.0	2.8	2.6	3.0	3.2	3.3	3.5	3.5	3.1	3.1	3.3
Pecos	2.3	2.1	1.8	1.7	1.7	1.5	1.8	2.1	2.0	1.7	2.0	2.2
Salt Creek	2.1	1.9	1.5	1.5	1.7	1.6	1.8	2.0	2.1	1.8	1.8	2.1
San Pedro Parks	2.3	2.1	1.8	1.6	1.6	1.4	1.7	2.0	1.9	1.7	2.1	2.2
Upper Buffalo	3.3	3.0	2.7	2.8	3.4	3.4	3.4	3.4	3.6	3.3	3.2	3.3
Weminuche	2.4	2.2	1.9	1.7	1.7	1.5	1.6	2.0	1.9	1.7	2.1	2.3
Wheeler Park	2.3	2.2	1.9	1.8	1.8	1.6	1.8	2.2	2.1	1.8	2.2	2.3
White Mountain	2.1	1.9	1.6	1.5	1.5	1.4	1.8	2.0	2.0	1.7	1.8	2.1
Wichita Mountains	2.7	2.6	2.4	2.4	3.0	2.7	2.3	2.5	2.9	2.6	2.7	2.8

The $PM_{2.5}$ concentrations are considered part of the dry light extinction equation and do not have a humidity adjustment factor. The light extinction equation is the sum of the wet sulfate and nitrate and dry components $PM_{2.5}$ plus Rayleigh scattering, which is 10 inverse megameters (Mm^{-1}).

VI. Visibility Impacts

Perceived visibility in deciviews is derived from the light extinction coefficient. The visibility change related to background is calculated using the modeled and established natural visibility conditions. For the BART screening analysis, daily visibility will be expressed as a change in deciviews compared to natural visibility conditions.

The annual average natural levels of aerosol components at each Class I area are shown in Table 5, *Average Annual Natural Levels of Aerosol Components (µg/m³)*. Natural conditions by component in this table are based on whether the Class I area is in the eastern or the western part of the United States. These data are in EPA's "Guidance for Estimating Natural Visibility Conditions under the Regional Haze Rule" (EPA, 2003).

Table 5 - Average Annual Natural Levels of Aerosol Components ($\mu g/m^3$)

Class I Area	Region	SO_4	NO_3	OC	EC	Soil	Coarse Mass
Bandelier	WEST	0.12	0.10	0.47	0.02	0.50	3.00
Big Bend	WEST	0.12	0.10	0.47	0.02	0.50	3.00
Bosque del Apache	WEST	0.12	0.10	0.47	0.02	0.50	3.00
Breton	EAST	0.23	0.10	1.40	0.02	0.50	3.00
Caney Creek	EAST	0.23	0.10	1.40	0.02	0.50	3.00
Carlsbad Caverns	WEST	0.12	0.10	0.47	0.02	0.50	3.00
Great Sand Dunes	WEST	0.12	0.10	0.47	0.02	0.50	3.00
Guadalupe Mountains	WEST	0.12	0.10	0.47	0.02	0.50	3.00
Hercules-Glades	EAST	0.23	0.10	1.40	0.02	0.50	3.00
La Garita	WEST	0.12	0.10	0.47	0.02	0.50	3.00
Mesa Verde	WEST	0.12	0.10	0.47	0.02	0.50	3.00
Mingo	EAST	0.23	0.10	1.40	0.02	0.50	3.00
Pecos	WEST	0.12	0.10	0.47	0.02	0.50	3.00
Salt Creek	WEST	0.12	0.10	0.47	0.02	0.50	3.00
San Pedro Parks	WEST	0.12	0.10	0.47	0.02	0.50	3.00
Upper Buffalo	EAST	0.23	0.10	1.40	0.02	0.50	3.00
Weminuche	WEST	0.12	0.10	0.47	0.02	0.50	3.00
Wheeler Peak	WEST	0.12	0.10	0.47	0.02	0.50	3.00
White Mountain	WEST	0.12	0.10	0.47	0.02	0.50	3.00
Wichita Mountains	WEST	0.12	0.10	0.47	0.02	0.50	3.00

In a cooperative agreement with EPA Regions VI and VII and FLMs, CENRAP guidance deviates from use of the 98th percentile impact. The CALMET datasets as described in this protocol were processed with the "No-Obs" options (i.e., surface and upper air observations were not used in the CALMET wind field interpolation). Aware that exercising CALMET with No-Obs may lead in some applications to potentially less conservatism in the CALPUFF visibility results compared with the use of CALMET with observations, CENRAP has agreed to EPA's recommendation that the maximum visibility impact, rather than the 98th percentile value, should be used for screening analyses using the CENRAP-developed CALMET datasets. This approach should be used in the source-specific subject-to-BART screening analysis.

Sources with modeled maximum impacts below the 0.5 dv threshold are exempt from the remainder of the BART process. Sources with impacts at or above 0.5 dv can either perform refined CALPUFF modeling to show their visibility impact is in fact below the 0.5 dv threshold or continue with the BART process and perform a BART analysis. This analysis will likely include more refined CALPUFF modeling, using observations coupled with the 98th percent impact, finer grid resolution, puff splitting, focused domain, etc.

VII. Change in Visibility Due to BART Controls

Once sources perform their BART analysis and BART emission limits are established, additional CALPUFF modeling should be conducted in order to establish visibility improvement at Class I areas with BART applied. The post-control CALPUFF simulation should be compared to the pre-control CALPUFF simulation by calculating the change in visibility over natural conditions between the pre-control and post-control simulations.

VIII. Reporting

Sources performing refined modeling will be required to submit a modeling protocol to the TCEQ for approval. Protocols must also be made available concurrently to EPA and FLMs for their review. Sources using TCEQ's source-specific subject-to-BART screening modeling protocol will not be required to provide a modeling protocol to the TCEQ. However, sources using the TCEQ's source-specific subject-to-BART screening modeling protocol must provide a modeling protocol to the EPA and FLMs for their review.

The report accompanying the source-specific subject-to-BART screening analysis should provide a clear description of the modeling procedures and the results of the analysis. An electronic archive that includes the full set of CALPUFF inputs and model output fields should also be included with the report. If the model code is re-compiled, the electronic archive should include all of the edited parameter files and a summary of the steps taken to re-compile the code, including the compiler used.

References

Minnesota Pollution Control Agency (March 2006). *Best Available Retrofit Technology (BART) Modeling Protocol to Determine Sources Subject to BART in the State of Minnesota*.

Kansas Department of Health and Environment (June 2006). *Best Available Retrofit Technology (BART) Modeling Protocol to Determine Sources Subject to BART in the State of Minnesota*.

Iowa Department of Natural Resources (May 2006). *Variegated Protocol in Support of Best Available Retrofit Technology Determinations*.

Scire, J.S., D.G. Strimaitis, and R.J. Yamartino. (January 2000). *A User's Guide for the CALPUFF Dispersion Model (Version 5).* Earth Tech, Inc., Concord, Massachusetts.

Scire, J.S., D.G. Strimaitis, and R.J. Yamartino. (January 2000). *A User's Guide for the CALMET Dispersion Model (Version 5).* Earth Tech, Inc., Concord, Massachusetts.

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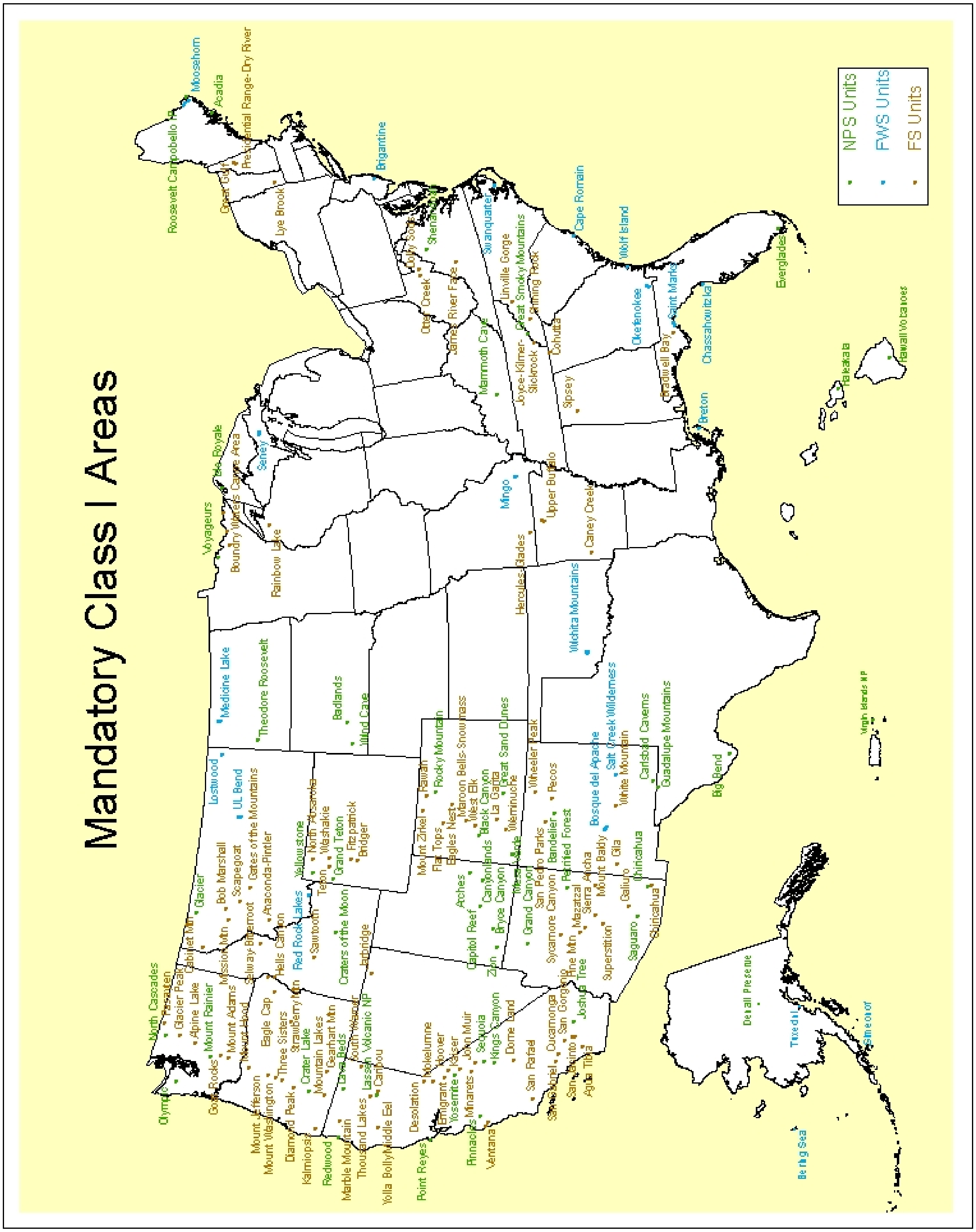
U.S. EPA (September 2003). *Regional Haze: Estimating Natural Visibility Conditions Under the Regional Haze Rule*. EPA-454/B-03-005.

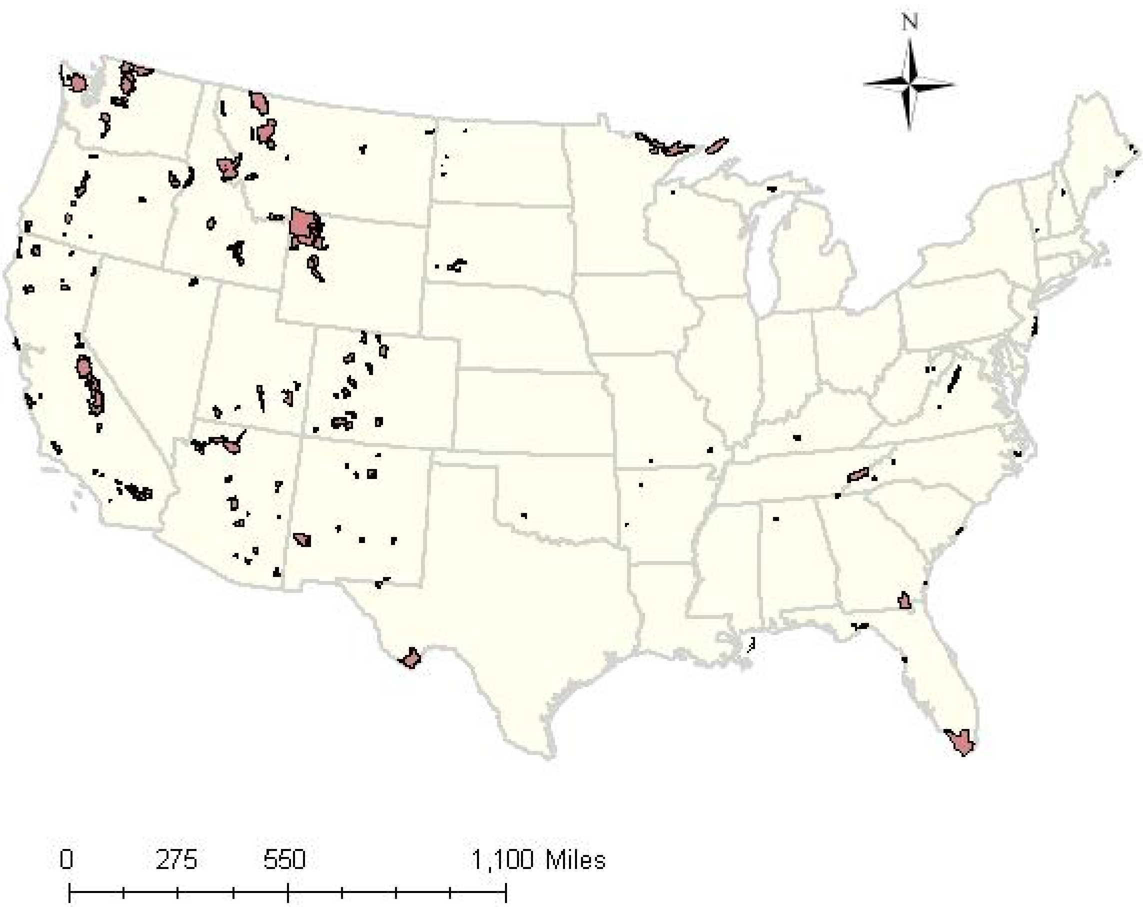
U.S. EPA. (July 2005). *Regional Haze Regulations and Guidelines for Best Available Retrofit Technology (BART) Determinations.* Federal Register Vol. 70, No. 128.

Appendix A – Federal Class I Areas
Map showing locations and names of areas



Appendix A – Federal Class I Areas
Map showing extent of areas

Mandatory Federal Class I Areas



Appendix B – CALPUFF Control File Inputs

Variable	Description	Value	Default	Comments
INPUT GROUP 1: General run control parameters				
METRUN	Control parameter for running all periods in met. File (0=no; 1=yes)	0	Y	
IBYR	Starting year of the CALPUFF run	2002	n/a	2001 and 2003 are the other years modeled
IBMO	Starting month	1	n/a	
IBDY	Starting day	1	n/a	
IBHR	Starting hour	1	n/a	
XBTZ	Base time zone	6.0	n/a	Central Standard Time
IRLG	Length of the run (hours)	8760	n/a	2001=8760hrs, 2003=8748hrs only 12 hrs on 12/31
NSPEC	Total number of species modeled	7	5	
NSE	Number of species emitted	4	3	
METFM	Meteorological data format	1	Y	CALMET unformatted file
AVET	Averaging time (minutes)	60.0	Y	
PGTIME	Averaging time (minutes) for PG - σ_y	60.0	Y	
INPUT GROUP 2: Technical options				
MGAUSS	Control variable determining the vertical distribution used in the near field	1	Y	Gaussian
MCTADJ	Terrain adjustment method	3	Y	Partial plume path adjustment
MCTSG	CALPUFF sub-grid scale complex terrain module (CTSG) flag	0	Y	CTSG not modeled
MSLUG	Near-field puffs are modeled as elongated “slugs”?	0	Y	No
MTRANS	Transitional plume rise modeled?	1	Y	Transitional plume rise computed
MTIP	Stack tip downwash modeled?	1	Y	Yes
MBDW	Method used to simulate building downwash?	1	Y	ISC method
MSHEAR	Vertical wind shear above stack top modeled in plume rise?	0	Y	No
MSPLIT	Puff splitting allowed?	0	Y	No
MCHEM	Chemical mechanism flag	1	Y	Transformation rates computed internally (MESOPUFF II scheme)
MAQCHEM	Aqueous phase transformation flag	0	Y	Aqueous phase not modeled
MWET	Wet removal modeled?	1	Y	Yes
MDRY	Dry deposition modeled?	1	Y	Yes
MDISP	Method used to compute dispersion coefficients	3	Y	PG dispersion coefficients in RURAL & MP coefficients in urban areas
MTURBVW	Sigma-v/sigma-theta, sigma-w measurements used?	3	Y	Use both sigma-(v/theta) and sigma-w from PROFILE.DAT Note: not provided

Variable	Description	Value	Default	Comments
MDISP2	Backup method used to compute dispersion when measured turbulence data are missing	3	Y	PG dispersion coefficients in RURAL & MP coefficients in urban areas
MROUGH	PG sigma-y,z adj. for roughness?	0	Y	No
MPARTL	Partial plume penetration of elevated inversion?	1	Y	Yes
MTINV	Strength of temperature inversion	0	Y	No
MPDF	PDF used for dispersion under convective conditions?	0	Y	No
MSGTIBL	Sub-Grid TIBL module used for shoreline?	0	Y	No
MBCON	Boundary conditions (concentration) modeled?	0	Y	No
MFOG	Configure for FOG model output	0	Y	No
MREG	TEST options specified to see if they conform to regulatory values?	1	Y	Checks made
INPUT GROUP 3: Species list				
CSPEC	Species modeled	SO2 SO4 NOX HNO3 NO3 PM25 PM10	n/a	Modeled: All Emitted: SO2, NOx, PM25, PM10 Dry deposited: SO2(gas), SO4(particle), NOx(gas), HNO3(gas), NO3(particle), PM25(particle), PM10(particle)
INPUT GROUP 4: Map projection and grid control parameters				
PMAP	Map projection	LCC	N	Lambert conformal conic
FEAST	False Easting	0.0	Y	
FNORT	False Northing	0.0	Y	
RLATO	Latitude	40N	n/a	
RLONG	Longitude	97W	n/a	
XLAT1 XLAT2	Matching parallel(s) of latitude for projection	33N 45N	n/a n/a	
DATUM	Datum region for the coordinates	WGS-G	N	WGS-84 GRS 80 spheroid, global coverage (WGS84)
 NX NY NZ	Meteorological grid: No. X grid cells in meteorological grid No. Y grid cells in meteorological grid No. vertical layers in meteorological grid	 306 246 10	n/a	
DGRIDKM	Grid spacing (km)	6	n/a	
ZFACE	Cell face heights (m)	0, 20, 40,80, 160, 320, 640, 1200,	n/a	

Variable	Description	Value	Default	Comments
		2000, 3000, 4000		
XORIGKM YORIGKM	Reference coordinates of SW corner of grid cell (1,1) (km)	-1008 -1620	n/a	
 IBCOMP JBCOMP IECOMP JECOMP	<u>Computational grid:</u> X index of LL corner Y index of LL corner X index of UR corner Y index of UR corner	 1 1 306 246	n/a	
LSAMP IBSAMP JBSAMP IESAMP JESAMP MESHDN	Logical flag indicating if gridded receptors are used X index of LL corner Y index of LL corner X index of UR corner Y index of UR corner Nesting factor of the sampling grid	F 1	- Y	Receptors are only in the Class I areas assessed
INPUT GROUP 5: Output options				
SPECIES	Species (or group) list for output options	1	n/a	Concentrations saved for SO2, SO4, NOx, HNO3, NO3, PM25, PM10
INPUT GROUP 6: Subgrid scale complex terrain (CTSG) inputs				
NHILL	Number of terrain features	0	Y	
NCTREC	Number of special complex terrain receptors	0	Y	
MHILL	Terrain and CTSG receptor data for CTSG hills input in CTDM format?	2	n/a	Hill data created by OPTHILL & input below in subgroup (6b); receptor data in subgroup (6c) note: no data provided
XHILL2M	Factor to convert horizontal dimensions to meters	1	Y	
ZHILL2M	Factor to convert vertical dimensions to meters	1	Y	
XCTDMKM	X-origin of CTDM system relative to CALPUFF coordinate system, in Km	0	n/a	
YCTDMKM	Y-origin of CTDM system relative to CALPUFF coordinate system, in Km	0	n/a	
INPUT GROUP 7: Chemical parameters for dry deposition of gases				
SPECIES DIFFUSVTY ALPHA STR REACTVTY MESO RES HENRYS C	Chemical parameters for dry deposition of gases	-	Y Y Y Y Y Y	SO2; NOx; HNO3 0.1509 0.1656 0.1628 1000 1 1 8 8 18 0 5 0 0.04 3.5 8.0*E-8
INPUT GROUP 8: Size parameters for dry deposition of particles				
SPECIES GEO. MASS MEAN DIA.	Single species: mean and standard deviation used to compute deposition velocity for	-	n/a	SO4 NO3 PM25 PM10 0.48 0.48 0.48 0.48

Variable	Description	Value	Default	Comments
GEO.STAND DEV.	NINT size-ranges; averaged to obtain mean deposition velocity. Grouped species: size distribution specified, standard deviation as "0". Model uses deposition velocity for stated mean diameter.			2 2 2 2
INPUT GROUP 9: Miscellaneous dry deposition parameters				
RCUTR	Reference cuticle resistance	30	Y	
RGR	Reference ground resistance	10	Y	
REACTR	Reference pollutant reactivity	8	Y	
NINT	Number of particle-size intervals to evaluate effective particle deposition velocity	9	Y	
IVEG	Vegetation state in unirrigated areas	1	Y	
INPUT GROUP 10: Wet deposition parameters				
POLL LIQ PRECIP FRZ PRECIP	Scavenging coefficients	-	Y Y Y	SO2 SO4 NOx HNO3 NO3 3E-5 1E-4 0 6E-5 1E-4 0 3E-5 0 0 3E-5
INPUT GROUP 11: Chemistry parameters				
MOZ	Ozone data input option	0	N	
BCKO3	Monthly ozone concentrations	-	N	12*40
BCKNH3	Monthly ammonia concentrations	-	N	12*3
RNITE1	Nighttime SO2 loss rate	0.2	Y	
RNITE2	Nighttime NOx loss rate	2.0	Y	
RNITE3	Nighttime HNO3 formation rate	2.0	Y	
MH2O2	H2O2 data input option	1	Y	
BCKH2O2	Monthly H2O2 concentrations	-	Y	MQACHEM = 0; not used
BCKPMF OFRAC VCNX	Secondary Organic Aerosol options	-	-	MCHEM = 1; thus, not used
INPUT GROUP 12: Misc. Dispersion and computational parameters				
SYTDEP	Horizontal size of puff beyond which time-dependent dispersion equations (Heffter) are used.	550	Y	
MHFTSZ	Switch for using Heffter equation for sigma z as above	0	Y	
JSUP	Stability class used to determine plume growth rates for puffs above boundary layer	5	Y	
CONK1	Vertical dispersion constant for stable conditions	0.01	Y	
CONK2	Vertical dispersion constant for neutral/unstable conditions	0.1	Y	
TBD	Factor determining transition-point from Schulman-Scire to Huber-Snyder building	0.5	Y	No building downwash used

Variable	Description	Value	Default	Comments
	downwash scheme			
IURB1 IURB2	Range of land use categories for which urban dispersion is assumed	10 19	Y Y	METFM=1; not used
ILANDUIN	Land use category for modeling domain	-	-	METFM=1; not used
ZOIN	Roughness length (m) for modeling domain	-	-	METFM=1; not used
XLAIIN	Leaf area index for modeling domain	-	-	METFM=1; not used
ELEVIN	Elevation above sea level	-	-	METFM=1; not used
XLATIN	Latitude (degrees) for met location	-	-	METFM=1; not used
XLONIN	Longitude (degrees) for met location	-	-	METFM=1; not used
ANEMHT	Anemometer height (m)	-	-	METFM=1; not used
ISIGMAV	Form of lateral turbulence data in PROFILE.DAT	1	Y	Read sigma-v
IMIXCTDM	Choice of mixing heights	-	-	METFM=1; not used
XMXLEN	Maximum length of a slug	1	Y	
XSAMLEN	Maximum travel distance of a puff/slug during one sampling step	1	Y	
MXNEW	Maximum number of slugs/puffs released from one source during one time step	99	Y	
MXSAM	Maximum number of sampling steps for one puff/slug during one time step	99	Y	
NCOUNT	Number of iterations used when computing the transport wind for a sampling step that includes gradual rise	2	Y	
SYMIN	Minimum sigma y for a new puff/slug	1	Y	
SZMIN	Minimum sigma z for a new puff/slug	1	Y	
 SVMIN SWMIN	Default minimum turbulence velocities sigma-v and sigma-w for each stability class	-	Y	A B C D E F .5 .5 .5 .5 .5 .5 .2 .12 .08 .06 .03 .016
CDIV	Divergence criterion for dw/dz across puff used to initiate adjustment for horizontal convergence	0, 0	Y	
WSCALM	Minimum wind speed allowed for non-calm conditions. Used as minimum speed returned when using power-law extrapolation toward surface	0.5	Y	
XMAXZI	Maximum mixing height (m)	4000	N	Top interface in CALMET simulation
XMINZI	Minimum mixing height (m)	20	N	
 WSCAT	Default wind speed classes	-	Y	1 2 3 4 5 1.54 3.09 5.14 8.23 10.80

Variable	Description	Value	Default	Comments
PLXO	Default wind speed profile power-law exponents for stabilities 1-6	-	Y ISC RURAL	A B C D E F .07 .07 .10 .15 .35 .55
PTGO	Default potential temperature gradient for stable classes E, F (deg K/m)	-	Y	0.020; 0.035
PPC	Default plume path coefficients for each stability class	-	Y	A B C D E F .5 .5 .5 .5 .35 .35
SL2PF	Slug-to-puff transitions criterion factor equal to sigma-y/length of slug	10	Y	
NSPLIT	Number of puffs that result every time a puff is split	3	Y	
IRESPLIT	Time of day when split puffs are eligible to be split once again; this is typically set once per day, around sunset before nocturnal shear develops	-	N	Hour 18 = 1
ZISPLIT	Split is allowed only if last hour's mixing height (m) exceeds a minimum value	100	Y	
ROLDMAX	Split is allowed only if ratio of last hour's mixing ht to the maximum mixing ht experienced by the puff is less than a maximum value	0.25	Y	
NSPLITH	Number of puffs that result every time a puff is split	5	Y	
SYSPLITH	Minimum sigma-y of puff before it may be split	1	Y	
SHSPLITH	Minimum puff elongation rate due to wind shear, before it may be split	2	Y	
CNSPLITH	Minimum concentration of each species in puff before it may be split	1E-7	Y	
EPSSLUG	Fractional convergence criterion for numerical SLUG sampling integration	1E-4	Y	
EPSAREA	Fractional convergence criterion for numerical AREA source integration	1E-6	Y	
DSRISE	Trajectory step-length (m) used for numerical rise integration	1	Y	
HTMINBC	Minimum height (m) to which BC puffs are mixed as they are emitted. Actual height is reset to the current mixing height at the release point if greater than this minimum	500	Y	
RSAMPBC	Search radius (in BC segment lengths) about a receptor for sampling nearest BC puff. BC puffs are emitted with a spacing	10	N	

Variable	Description	Value	Default	Comments
	of one segment length, so the search radius should be greater than 1			
MDEPBC	Near-surface depletion adjustment to concentration profile used when sampling BC puffs?	1	Y	Adjust concentration for depletion
INPUT GROUP 13: Point source parameters				
NPT1	Number of point sources with parameters	-	n/a	
IPTU	Units used for point source emissions	1	Y	
NSPT1	Number of source-species combinations with variable emissions scaling factors	0	Y	
NPT2	Number of point sources with variable emission parameters provided in external file	0	n/a	
INPUT GROUP 14: Area source parameters – Not used				
INPUT GROUP 15: Line source parameters – Not used				
INPUT GROUP 16: Volume source parameters – Not used				
INPUT GROUP 17: Non-gridded (discrete) receptor information				
NREC	Number of non-gridded receptors	0 3996	n/a	147 Bandelier 480 Big Bend 168 Bosque del Apache 40 Breton 80 Caney Creek 256 Carlsbad Caverns 195 Great Sand Dunes 127 Guadalupe Mountains 80 Hercules-Glades 187 La Garita 312 Mesa Verde 47 Mingo 321 Pecos 55 Salt Creek 247 San Pedro Parks 72 Upper Buffalo 744 Weminuche 109 Wheeler Peak 270 White Mountain 59 Wichita Mountains

Appendix C – POSTUTIL Control File Inputs

Variable	Description	Value	Default	Comments
INPUT GROUP 1: General run control parameters				
ISYR	Starting Year	2002	n/a	2001 and 2003 also modeled
ISMO	Starting month	1	n/a	
IDY	Starting day	1	n/a	
ISHR	Starting hour	1	n/a	
NPER	Number of periods to process	8760	n/a	2001=8760 hrs, 2003=8748hrs only 12 hrs on 12/31
NSPECINP	Number of species to process from CALPUFF runs	7	n/a	
NSPECOUT	Number of species to write to output file	7	n/a	
NSPECCMP	Number of species to compute from those modeled	0	n/a	
MDUPLCT	Stop run if duplicate species names found?	0	Y	
NSCALED	Number of CALPUFF data files that will be scaled	0	Y	
MNITRATE	Re-compute the HNO3/NO3 partition for concentrations?	1	N	Yes, for all sources combined
BCKNH3	Default ammonia concentrations used for HNO3/NO3 partition	-	N	12*3
INPUT GROUP 2: Species processing information				
ASPECI	NSPECINP species will be processed	-	n/a	SO2, SO4, NOx, HNO3, NO3, PM25, PM10
ASPECO	NSPECOUT species will be written	-	n/a	SO2, SO4, NOx, HNO3, NO3, PM25, PM10

Appendix D – CALPOST Control File Inputs

Variable	Description	Value	Default	Comments
INPUT GROUP 1: General run control parameters				
METRUN	Option to run all periods found in met files	0	Y	Run period explicitly defined
ISYR	Starting Year	2002	n/a	2001 and 2003 also modeled
ISMO	Starting month	1	n/a	
IDY	Starting day	1	n/a	
ISHR	Starting hour	1	n/a	
NHRS	Number of hours to process	8760	n/a	2001=8760hrs, 2003=8748hrs only 12 hrs on 12/31
NREP	Process every hour of data?	1	Y	Every hour processed
ASPEC	Species to process	VISIB	n/a	Visibility processing
ILAYER	Layer/deposition code	1	Y	CALPUFF concentrations
A, B	Scaling factors X(new) = X(old) *A + B	0, 0	Y	
LBACK	Add hourly background concentrations/fluxes?	F	Y	
MSOURCE	Option to process source contributions	0	Y	
LG LD	Gridded receptors processed? Discrete receptors processed?	F T	N/Y	Receptors located only in the Class I areas assessed
LCT	CTSG Complex terrain receptors processed?	F	Y	
LDRING	Report results by DISCRETE receptor RING?	F	Y	
NDRECP	Flag for all receptors after the last one assigned is set to “0”	-1	Y	
IBGRID JBGRID IEGRID JEGRID	Range of gridded receptors	-1 -1 -1 -1	Y	When LG = T Entire grid processed if all =-1
NGONOFF	Number of gridded receptor rows provided to identify specific gridded receptors to process	0	Y	
BTZONE	Base time zone for the CALPUFF simulation	6	n/a	
MFRH	Particle growth curve f(RH) for hygroscopic species	2	Y	FLAG (2000) f(RH) tabulation. Note: not used
RHMAX	Maximum relative humidity (%) used in particle growth curve	-	N	Not used
LVSO4 LVNO3 LVOC LVPMC LVPMF LVEC	Modeled species to be included in computing light extinction	T T F T T F	Y Y N Y Y N	
LVBK	Include BACKGROUND when ranking for TOP-N, TOP-50, and exceedence tables?	T	Y	
SPECPMC	Species name used for particulates in	PM10	N	

Variable	Description	Value	Default	Comments
SPECPMF	MODEL.DAT file	PM25	N	
EEPMC EEPMF	Modeled particulate species	0.6 1.0	Y Y	
EEPMCBK	Background particulate species	0.6	Y	
EESO4 EENO3 EEOC EESOIL EEEC	Other species	3.0 3.0 4.0 1.0 10	Y Y Y Y Y	
LAVER	Background extinction computation	F	Y	
MVISBK	Method used for background light extinction	6	N	Compute extinction from speciated PM measurements. FLAG RH adjustment factor applied to observed and modeled sulfate and nitrate
RHFAC	Extinction coefficients for hygroscopic species (modeled and background). Monthly RH adjustment factors	-	n/a	See Table 4 in main protocol document
BKSO4 BKNO3 BKPMC BKOC BKSOIL BKEC	Monthly concentrations of ammonium sulfate, ammonium nitrate, coarse particulates, organic carbon, soil and elemental carbon to compute background extinction coefficients	-	n/a	See Table 5 in main protocol document
BEXTRAY	Extinction due to Rayleigh scattering (1/Mm)	10	Y	
IPRTU	Units for all output	3	N	micrograms/cubic meter
L24HR	Averaging time reported	T	n/a	
LTOPN	Visibility: Top “N” table for each averaging time selected.	F	Y	
NTOP	Number of ‘Top-N’ values at each receptor selected (NTOP must be <=4)	4	Y	
MDVIS	Output file with visibility change at each receptor?	0	Y	Create file of DAILY (24 hour) delta-deciview. Grid model run.

A T T A C H M E N T E

Guidance for Application of the CAMx Hybrid Photochemical Grid Model to Assess Visibility Impacts of Texas BART Sources at Class I Areas
September 27, 2006

Modeling Guidance

Guidance for the Application of the CAMx Hybrid Photochemical Grid Model to Assess Visibility Impacts of Texas BART Sources at Class I Areas

Work Order No. 582-04-65563-06-10
Amendment No. 02

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September 27, 2006

Disclaimer: This document is provided for informational purposes only and is not yet final guidance of the Texas Commission on Environmental Quality (TCEQ.) It is offered to assist BART-eligible sources prepare for the requirements of the new BART rule in Chapter 116, if ultimately adopted by TCEQ. This guidance may change as a result of the adoption of the rules BART engineering analyses will not be accepted prior to adoption of the rule.

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GLOSSARY OF ACRONYMS

AERMOD	American Meteorological Society/Environmental Protection Agency Regulatory Model Improvement Committee Model
AQRVs	Air Quality Related Values
BART	Best Available Retrofit Technology
$b_{natural}$	Clean Natural Conditions
b_{source}	Total light extinction due to a source
CAA	Clean Air Act
CAIR	Clean Air Interstate Rule
CALPUFF	California Puff Model
CAMx	Comprehensive Air Quality Model with extensions
CCRS	Coarse Crustal particulate matter
CENRAP	Central Regional Air Planning Association
CMAQ	Community Multiscale Air Quality Modeling System
CPRM	Coarse other Primary particulate matter
del-dv	change in deciview (delta-deciview)
dv	deciviews
EC	Elemental Carbon
EGU	Electrical Generating Units
EPA	United States Environmental Protection Agency
f(RH)	Relative Humidity adjustment factor
FCRS	Fine Crustal particulate matter
FIPS	Federal Information Processing Standard
FLAG	Federal Land Managers Air Quality Related Values Workgroup
FLM	Federal Land Manager
FPRM	Fine other Primary particulate matter
FR	Federal Register
GREASD	Greatly Reduced and Simplified Dynamics
Hg	Mercury
HI	Haze Index
IMPROVE	Interagency Monitoring of Protected Visual Environments
IRON	Incremental Reactions for Organics and Nitrogen Oxides
ISC	Industrial Source Complex Model
km	kilometers
LSODE	Livermore Solver for Ordinary differential Equations
Mm^{-1}	Inverse Megameters
MRPO	Midwest Regional Planning Organization
MW	Megawatt
NH_4	Ammonium
NO_3	Particulate Nitrate
non-EGU	Non-Electrical Generating Units
NO_x	Nitrogen Oxides
NSR	New Source Review
OC	Organic Carbon
OMC	Organic Matter Carbon
OSAT	Ozone Source Apportionment Technology
PEC	Primary Elemental Carbon
PGM	Photochemical Grid Model
PiG	Plume-in-Grid

PLUVUE	Plume Visibility Model
PM	Particulate Matter
PM_{10}	Particulate Matter with aerodynamic diameters less than 10 microns
$PM_{2.5}$	Particulate Matter with aerodynamic diameters less than 2.5 microns
POA	Primary Organic Aerosol
PPM	Piecewise-Parabolic Method
PSAT	Particulate Matter Source Apportionment Technology
PSD	Prevention of Significant Deterioration
QAPP	Quality Assurance Program Plan
RH	Relative Humidity
RHR	Regional Haze Rule
RPO	Regional Planning Organization
SCICHEM	Second-order Closure Integrated Puff model with CHEMistry
SCIPUFF	Second-order Closure Integrated Puff model
SIP	State Implementation Plan
SMOKE	Sparse Matrix Operator Kernel Emissions
SO_2	Sulfur Dioxide
SO_4	Sulfate
SOA	Secondary Organic Aerosol
TCEQ	Texas Commission on Environmental Quality
TIP	Tribal Implementation Plan
tpy	ton per year
VISTAS	Visibility Improvement State and Tribal Association of the Southeast
VOC	Volatile Organic Compounds
WRAP	Western Regional Air Partnership

INTRODUCTION

OVERVIEW

The final version of United States Environmental Protection Agency's (EPA) Regional Haze Regulations that include the Best Available Retrofit Technology (BART) Guidelines was published in the Federal Register on 6 July 2005 (70 FR 39104; EPA, 2005). One of the provisions of the program is the requirement that certain existing stationary sources emitting visibility-impairing air pollutants install and operate BART. The regulations require case-by-case BART determinations to define specific emissions limits representing BART. The regulations also establish schedules for compliance for each source subject to BART. These requirements will be part of the State Implementation Plan (SIP) revisions that Texas must submit to EPA by 17 December 2007. Sources are subject to BART if they can be reasonably anticipated to cause or contribute to visibility impairment at a Class I area. Once a source is determined to be subject to BART, an engineering analysis and determination of the degree of visibility improvement due to BART controls must be performed. The EPA BART Guidelines suggest several potential methods for determining whether a source is subject to BART and the methods for determining what the expected visibility benefits of the BART controls will be, including dispersion modeling.

For the subject to BART assessment, EPA BART Guidelines state that "You can use CALPUFF, or another EPA approved model, to predict the visibility impacts from a single source at a Class I area" (EPA, 2005). For the visibility improvement determination, EPA BART Guidelines state "Use CALPUFF, or other appropriate dispersion model to determine the visibility improvement expected at a Class I area from the potential BART control technology applied to the source" (EPA, 2005). For the subject to BART modeling, cumulative modeling may also be conducted to show that no source in a State is subject to BART. This cumulative BART exemption modeling may be done "on a pollutant by pollutant basis or for all visibility-impairing pollutants to determine if emissions from these sources contribute to visibility impairment" (EPA, 2005). BART Guidelines suggest using California Puff Model (CALPUFF) or a photochemical grid model to perform the cumulative group exemption modeling, but notes "if you wish to use a grid model, you should consult with the appropriate EPA Regional Office to develop an appropriate modeling protocol" (EPA, 2005).

The purpose of this document is to provide sources in Texas with guidelines for preparing a modeling protocol and modeling analysis using the Comprehensive Air Quality Model with extensions (CAMx) grid model. Sources also have the option to use CALPUFF. See TCEQ's BART webpage for information on the Texas CALPUFF Modeling Guidelines (http://www.tceq.state.tx.us/implementation/air/sip/bart/haze.html).

Sources performing modeling will be required to submit a modeling protocol to the TCEQ for approval. Protocols must also be made available concurrently to EPA and Federal Land Managers (FLM) for their review.

The report accompanying the source-specific subject-to-BART screening analysis should provide a clear description of the modeling procedures and the results of the analysis. An electronic archive that includes the full set of inputs and model output fields should also be included with the report.

TCEQ BART Screening Exemption Modeling

TCEQ has performed cumulative group BART screening exemption modeling (Morris and Nopmongcol, 2006) using the Comprehensive Air Quality Model with extensions (CAMx). CAMx is a photochemical grid model (PGM) that incorporates the latest scientific advances including current state of science treatment of transport, dispersion deposition and chemical transformation (gas-phase and aqueous-phase chemistry and aerosol chemistry and dynamics). As required in the EPA BART Guidelines, a modeling protocol was prepared (ENVIRON, 2005) and distributed to EPA and the FLMs prior to the BART cumulative exemptions screening analysis for their review. Three types of BART screening exemption modeling were conducted (Morris and Nopmongcol, 2006):

- BART sources Volatile Organic Compounds (VOC) zero-out modeling to ascertain whether or not Texas BART VOC emissions cause or contribute to visibility impairment on any Class I areas;
- BART sources primary particulate matter (PM) zero-out and chemically inert modeling to ascertain whether or not BART primary PM emissions cause or contribute to visibility impairment on any Class I areas; and
- BART sources SO_2 and NO_x modeling using the PM Source Apportionment Technology (PSAT) and the Plume-in-Grid (PiG) subgrid-scale point source model.

Concerns have been raised regarding the use of PGMs for single source assessments, such as a BART visibility assessment. These concerns revolve around:

(1) PGMs can only resolve the dynamics and chemistry of a point source plume to the grid resolution specified and use of a high resolution grid (e.g., 100 m to 1 km) to resolve a plume would require extensive model inputs and model run times; and

(2) to assess the impacts of a source two runs have to be performed, a base case with the source and a zero-out case where the emissions of the source are eliminated. As PGM runs are already more costly than a source-oriented plume model, like CALPUFF, the need to do multiple zero-out runs to assess the individual impacts of multiple sources is quite costly. Recent advances in the CAMx model development have alleviated these concerns regarding the use of PGMs for single source assessments as follows (Morris, Emery and Yarwood, 2006):

- Implementation of the PM Source Apportionment Technology (PSAT) that allows the separate tracking of individual source PM impacts so that the individual impacts from many different sources can be obtained cost-effectively in one run;
- The threading of the PSAT PM source apportionment through the full-chemistry PiG module so that the early plume chemistry and plume dynamics can be tracked by the subgrid-scale PiG module until the plume size is commensurate with the grid resolution when the plume can be adequately simulated by the grid model; and

- Implementation of flexi-nesting whereby finer nests can be specified inside of a coarser grid and the model can interpolate some or all of the model inputs from the coarse grid, which allows better resolution of point source plume chemistry and dispersion.

Purpose

Although CAMx now has the capability to cost-effectively estimate the air quality and visibility impacts of individual sources, being that it is a relatively new technology, the procedures for performing such a single source assessment using CAMx/PSAT/PiG are not fully documented. Thus, this document will provide guidance in the application of CAMx for single source assessments as needed for BART, New Source Review (NSR) and Prevention of Significant Determination (PSD) assessments. The TCEQ BART screening exemption modeling is used as an example approach for these types of assessments.

BACKGROUND

Regional Haze Rule and BART Guidelines

Section 169A of the Federal Clean Air Act (CAA) sets forth a national goal for visibility which is the "prevention of any future, and the remedying of any existing, impairment of visibility in Class I areas which impairment results from manmade air pollution." In 1999, EPA published a final rule to address a type of visibility impairment known as regional haze (64 FR 35714). The Regional Haze Rule (RHR) requires states to submit SIPs to address regional haze visibility impairment in 156 federally protected parks and wilderness areas (i.e., the Class I scenic areas identified in the CAA). The 1999 rule was issued to fulfill a long-standing EPA commitment to address regional haze under the authority and requirements of sections 169A and 169B of the CAA. As required by the CAA, the final RHR included a requirement for BART for certain large stationary sources that were put in place between 1962 and 1977. The regional haze rule addresses visibility impairment resulting from emissions from a multitude of sources located across a wide geographic area. Because the problem of regional haze is believed to be caused in large measure by long-range transport of emissions from multiple sources, initially EPA adopted an approach that required states to look at the contribution of all BART sources to the problem of regional haze in determining both applicability and the appropriate level of control. If a source potentially subject to BART is located in an area from which pollutants may be transported to a Class I area, that source ''may reasonably be anticipated to cause or contribute'' to visibility impairment in the Class I area. EPA's BART guidelines include procedures for single source assessments of their visibility contributions.

The BART guidelines were written primarily for the benefit of state, local and Tribal agencies, and describe a process for making the BART determinations and establishing the emission limitations that must be included in their SIPs or Tribal implementation plans (TIPs). The guidelines provide a process for making BART determinations that states can use in implementing the regional haze BART requirements on a source-by-source basis. States must follow the guidelines in making BART determinations on a source-by-source basis for 750 megawatt (MW) power plants but are not required to use the process in the guidelines when making BART determinations for other types of sources, i.e., states retain the discretion to adopt approaches that differ from the guidelines.

A BART eligible source or existing stationary facility means any stationary source of air pollutants, including any reconstructed source, which: (a) “was not in operation prior to August 7, 1962, and was in existence on August 7, 1977," (b) "has the potential to emit 250 tons per year or more of any air pollutant" and (c) falls within one or more of 26 specifically listed source categories (40 CFR Section 51.301). BART controls are required for any BART-eligible source which can be reasonably expected to cause or contribute to impairment of visibility in any of the 156 federal parks and wilderness (Class I) areas protected under the regional haze rule. Air quality modeling is an important tool available to the states in determining whether a source can be reasonably expected to contribute to visibility impairment in a Class I area.

In EPA’s 1 August 2005 proposed rulemaking (70 FR 44154) entitled “Revisions to Provisions Governing Alternative to Source-Specific Best Available Retrofit Technology Determinations,” the agency provided states with a process to show that an emissions trading program may be used as an alternative to applying BART. Texas, however, will not be participating in this program.

Role of Air Quality Models

The EPA guidelines present several options for assessing whether or not a BART-eligible source is subject to BART control requirements. The options, relying on different modeling and/or emissions analysis approaches, are provided as guidance and the states are entitled to use other reasonable approaches for analyzing the visibility impacts of an individual source or group of sources. The options are:

> **Option 1: Individual Source Attribution.** States 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, states can analyze an individual source’s impact on visibility as a result of its emissions of SO_2, NO_x, and direct PM emissions. Because some dispersion models cannot currently be used to estimate the predicted impacts on visibility from an individual source’s emissions of VOC or ammonia, states may elect to 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. EPA-approved models should be used to predict the visibility impacts from a single source at a Class I area.
>
> **Option 2: Use of ‘Model’ Plants.** Under this option, analysis of model (or prototypical) plants could be used to exempt certain BART-eligible sources that share specific characteristics. This type of analysis may be most useful in identifying the types of small sources that do not cause or contribute to visibility impairment for purposes of BART and thus should not be subject to a BART review. Different Class I areas may have different characteristics, however, so care should be used to ensure that the criteria developed are appropriate for the applicable cases. The guidance (EPA, 2005) suggests that states could use modeling analyses of representative plants to reflect groupings of specific sources with important common characteristics and based on these analyses, states may determine that certain types of sources may clearly be anticipated to cause or contribute to visibility impairment whereas others do not.

EPA's 'Model' plant example in their BART guidance pertains to exempting sources whose SO_2, NO_x, or SO_2 plus NO_x emissions are less than 500 tons per year (tpy) and are greater than 50 km from any Class I area, or for sources whose emissions are less than 1,000 tpy and are greater than 100 kilometers (km) from any Class I area. EPA directed that states may (if they so choose) use the example cited in the Guidelines to exempt sources with no further analysis. In other words, states that establish 0.5 deciviews as a contribution threshold may exempt sources that emit less than 500 tons per year of NO_x or SO_2 (or combined NO_x and SO_2) with no further analysis, as long as these sources are located more than 50 km from any Class I area. Also, states that establish 0.5 deciviews as a contribution threshold may exempt sources that emit less than 1000 tons per year of NO_x or SO_2 (or combined NO_x and SO_2) with no further analysis, as long as these sources are located more than 100 km from any Class I area. Texas used the model plant option as an initial screening method of its BART sources.

Option 3: Cumulative Modeling. States may also submit to EPA a demonstration, based on an analysis of overall visibility impacts, that emissions from BART-eligible sources in your state, considered together, are not reasonably anticipated to cause or contribute to any visibility impairment in a Class I area and thus no source should be subject to BART. You may do this on a pollutant by pollutant basis or for all visibility-impairing pollutants to determine if emissions from these sources contribute to visibility impairment.

While EPA identifies several options for determining whether or not a source is "subject to BART," the most credible method is the use of dispersion modeling. Air quality modeling allows a state or source operator to analyze an individual source's impact on visibility as a result of its emissions of SO_2, NO_x, and direct PM emissions.

EPA assumes in the BART guidance that dispersion modeling cannot currently be used to estimate the predicted impacts on visibility from an individual source's emissions of VOC or ammonia. Instead, EPA suggests 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. The primary difficulty in using CALPUFF for VOCs is that the CALPUFF modeling system, recommended as the BART modeling platform, does not adequately treat PM formation from VOCs. Use of photochemical grid models to assess the visibility impacts of VOC emissions provides a quantitative and more scientifically defensible approach than a qualitative assessment.

A primary difficulty in estimating visibility impairment resulting from ammonia is uncertainties in the ammonia emissions inventories. These uncertainties result in modeled impacts on PM levels that are not as reliable as the results of modeling other PM components. While ammonia emissions from industrial facilities are relatively well-characterized, livestock operations and soil are major sources of ammonia emissions, and their quantification is highly uncertain. In 70 FR 39104, EPA concluded that the decision whether to consider ammonia as a visibility-impairing pollutant in a specific case where a potential BART source actually emits more than 250 tpy of ammonia is best left to the state.

EPA Guidance on Air Quality Models

The BART determination under the Regional Haze Rule seeks to quantify the impact of source emissions of SO_2, NO_x, and direct PM ($PM_{2.5}$ and/or PM_{10}) on hourly and daily visibility impairment at receptors located within downwind Class I areas. Since visibility is defined in the context of light extinction, which itself is determined by atmospheric concentrations of specific fine particulate species – sulfate, nitrate, organic carbonaceous matter, elemental carbon, other fine particles and coarse mass – the modeling method(s) used must be capable of simulating these components reliably.

EPA's position on recommended models for fine particulate and visibility estimation ***from single point sources*** is clearly set out in the Final BART Rule and in the BART Modeling guidance document. The Final BART Rule states, "Because the air quality model CALPUFF is currently the best application available to predict the impact of a single source on visibility in a Class I area, we proposed that a CALPUFF assessment be used as the preferred approach first, for determining whether an individual source is subject to BART, and second, in the BART determination process. CALPUFF can be used to estimate not only the effects of directly emitted $PM_{2.5}$ emissions from a source, but also to predict the visibility impacts from the transport and chemical transformation of fine particle precursors." The Rule goes on to state that "regional scale modeling typically involves use of a photochemical grid model that is capable of simulating aerosol chemistry, transport, and deposition of airborne pollutants, including particulate matter and ozone. Regional scale air quality models are generally applied for geographic scales ranging from a multi-state to the continental scale. Because of the design and intended applications of grid models, they may not be appropriate for BART assessments, so states should consult with the appropriate EPA Regional Office prior to carrying out any such modeling."

In contrast, EPA's "Guidance for Demonstrating Attainment of the Air Quality Goals for $PM_{2.5}$ and Regional Haze" (EPA, 2001) sets forth the types of models that should be used for simulating secondary fine particulate and visibility for SIPs. EPA states, "States should use a regional scale photochemical grid model to estimate the effects of a control strategy on secondary components of PM. Changes in primary components may be estimated using a numerical grid model (with no chemistry), a Lagrangian model, or in some cases a receptor model." Thus, in its Regional Haze and $PM_{2.5}$ SIP modeling guidance, EPA indicates that CALPUFF (a Lagrangian non-steady-state Gaussian puff model) should not be used for secondary PM and visibility impacts at Class I areas, but rather is relegated to the category of estimating primary species.

So, on the one hand, EPA maintains that CALPUFF is the "best regulatory modeling application currently available for predicting a single source's contribution to visibility impairment" and notes, "it is the only EPA-approved model for use in estimating single source pollutant concentrations resulting from the long range transport of primary pollutants." On the other hand, only regional grid models with appropriate chemistry are to be used in developing $PM_{2.5}$ and Regional Haze SIPs. EPA has attempted to reconcile these two positions in the Final BART Rule by asserting that (a) regional models were not developed to treat individual point sources and (b) CALPUFF's secondary aerosol chemistry is adequate for estimating relative benefits of controls on BART sources.

More recent developments in photochemical grid modeling should alleviate some of the concerns related to using them for single-source visibility assessment. In particular, the use of finer grid spacing and new PM PiG modeling techniques can extend the grid model's applicability to assess the visibility impacts of a single source and groups of sources. As photochemical grid models include state-of-science representation of chemistry, this allows for the quantitative assessment of the visibility impacts of VOC emissions, as well as, more accurate and scientifically correct treatment of secondary PM formation (e.g., sulfates and nitrates) and regional transport and dispersion.

Steps in the BART Modeling Process

The BART guidelines identify three steps required to determine emission limitations for affected sources.

> **Identify BART-Eligible Sources.** The first step is to identify whether a source is BART-eligible based on its source category, when it was put in service, and the magnitude of its emissions of one or more "visibility-impairing" air pollutants. The BART guidelines list 26 source categories of stationary sources that are BART-eligible. Sources must have been put in service between 7 August 1962 and 7 August 1977 in order to be BART-eligible. Potential emissions of 250 tpy or more of a visibility-impairing air pollutant are required to make a source eligible for BART. Qualifying pollutants include primary PM_{10} and gaseous precursors to secondary fine particulate matter such as SO_2 and NO_x. Whether ammonia and VOCs should be included as visibility-impairing pollutants for BART eligibility is left for the states to determine on a case-by-case basis. The guidance states that high molecular weight VOCs with 25 or more carbon atoms and low vapor pressure should to be considered as primary $PM_{2.5}$ emissions and not VOCs for BART purposes.
>
> **Determine Sources Subject to BART.** Next, one determines whether a BART-eligible source can be excluded from BART controls by demonstrating that the source cannot be reasonably expected to cause or contribute to visibility impairment in a Class I area. EPA's preferred approach is an assessment with the CALPUFF modeling system (or other appropriate model) followed by comparison of the estimated 24-hr visibility impacts against a threshold above estimated natural conditions to be determined by the States. The threshold to determine whether a single source "causes" visibility impairment is set at 1.0 deciview change from natural conditions over a 24-hour averaging period in the final BART rule (70 FR 39118). Any exceedance of this threshold would trigger a BART determination. The guidance also states that the proposed threshold at which a source may "contribute" to visibility impairment should not be higher than 0.5 deciviews, although depending on factors affecting a specific Class I area, it may be set lower than 0.5 deciviews.
>
> EPA's guidance builds upon the 1990 National Acid Precipitation Assessment Program (NAPAP) that found that a 5% change in light extinction will evoke a just noticeable change in most landscapes. Converting the 5% change in light extinction to a change in

deciviews yields a change of approximately 0.5 deciviews. EPA believes that this is a natural breakpoint at which to set the BART exemption levels. Since visibility degradation may begin to be recognized by a human observer at this extinction level, the guidance uses a 0.5 deciview change on a 24-hour average basis for determining that an individual source is contributing to visibility impairment at a Class I area. This level would be calculated by comparing the air quality model's results for an individual source against "natural visibility" conditions. To assess a source's impact one compares the 98^{th} percentile modeled value (8^{th} highest day annually at a receptor or 22^{nd} highest over 3-years) with the 0.5 deciview threshold to determine if the source contributes to visibility impairment and is therefore subject to BART.

Determine Appropriate Types and Levels of Control. The third step is to determine BART for the source by considering various control options and selecting the "best" alternative, taking into consideration: (a) any pollution control equipment in use at the source (which affects the availability of options and their impacts), (b) the costs of compliance with control options, (c) the remaining useful life of the facility, (d) the energy and non air-quality environmental impacts of compliance, and (e) the degree of improvement in visibility that may reasonably be anticipated to result from the use of such technology.

For states under the $PM_{2.5}$ provisions of the Clean Air Interstate Rule (CAIR), EPA has noted that CAIR satisfies the BART requirements for Electrical Generating Units' (EGU) SO_2 and NO_x emissions. However, since CAIR does not address VOC and PM emissions, a state still needs to determine whether an EGU's VOC and/or PM emissions contribute significantly to visibility impairment at any Class I area and, if so, address the rest of the BART requirements.

According to the BART guidance, a modeling protocol should be submitted for all modeling demonstrations regardless of the distance from the BART-eligible source to the Class I area. EPA's role in the development of the protocol is only advisory as the "states better understand the BART-eligible source configurations" and factors affecting their particular Class I areas (70 FR 39126).

CALPUFF Modeling Recommendations

To evaluate the visibility impacts of a BART-eligible source at Class I areas beyond 50 km from the source, the EPA guidance recommends the use of the CALPUFF model (EPA, 2003c). For modeling the impact of a source closer than 50 km to a Class I area, EPA's BART guidance recommends that expert modeling judgment be used "giving consideration to both CALPUFF and other methods." The Plume Visibility Model (PLUVUE)-II model is mentioned as a possible model to consider in addition to CALPUFF within 50 km of a source. The EPA guidance notes that regional scale photochemical grid models may have merit, but such models are resource intensive relative to CALPUFF. Photochemical grid models are clearly more appropriate for cumulative modeling options such as in the determination of the aggregate contribution of all-BART-eligible sources to visibility impairment, but such use should involve consultation with the appropriate EPA Regional Office.

CALPUFF is recommended for ascertaining whether a source may be exempted from BART. If a source is determined to be subject to BART, CALPUFF or another appropriate model should be used to evaluate the improvement in visibility resulting from the application of BART controls. Emissions reflecting periods of start-up, shutdown, and malfunction are not to be considered in determining the appropriate emission rates. The EPA recommends that the state use the highest 24-hour average actual emission rate for the most recent five-year period (excluding periods with start-up, shutdown, and malfunctions). Visibility improvements may be evaluated on a pollutant-specific basis. States are encouraged to account for the magnitude, frequency, and duration of the contributions to visibility impairment caused by the source when assessing whether the source is reasonably anticipated to cause or contribute to visibility impairment at a Class I area.

Alternative Models for BART Analyses

All air quality models potentially suited to BART analysis share a common foundation: the species-conservation (or atmospheric diffusion) equation. Source-oriented air quality models, including CALPUFF, derive from this equation. The atmospheric diffusion equation applies equally to many sources. The distinction lies in how the various terms are treated (CAMx, CMAQ) or neglected (CALPUFF) in the governing equations and the choice of coordinate system (Lagrangian or Eulerian). Much of the simplicity of the CALPUFF model derives from the fact that many chemical and physical processes known to influence visibility are simply ignored. In contrast, comprehensive regional models treat these processes in detail, albeit at the expense of greater computer resources and data needs. EPA's BART guidance allows for the use of alternative models on a case-by-case basis.

EPA's dismissal of regional scale modeling ignores a substantial body of research and model development carried out at the agency and elsewhere in the U.S. over the past 20 years. Although grid models have generally been applied at geographic scales ranging from a multi-state to the continental scale and were not initially designed to simulate individual point sources, modern one-atmospheric regional photochemical grid models, employing nested grid (Kumar and Russell, 1996) and Plume-in-Grid techniques (Karamanchandani et al., 2002; ENVIRON, 2005), are fully applicable to the analysis of point source plumes, most especially when reactive atmospheric chemistry occurs. If they were not, then they would not be reliable in simulating the combined effects of the wide array of anthropogenic and biogenic emissions that cause gas phase, particulate, secondary aerosol, and visibility air pollution problems. Furthermore, the convergence of fast commodity-based LINUX computer clusters and recently-developed regional modeling emissions, meteorological, and air quality databases make application of these modeling platforms no longer a research or academic exercise. While regional scale modeling clearly requires expertise to perform properly, the actual program costs to conduct a CMAQ or CAMx regional modeling study are, today, quite comparable with and often less than a traditional PSD modeling study using plume models, such as Industrial Source Complex Model (ISC), CALPUFF, or The American Meteorological Society/Environmental Protection Agency Regulatory Model Improvement Committee Model (AERMOD). Given grid nesting and Plume-in-Grid technology, modern regional models are applicable to a broad range of scales from 10-20 km to continental scale. In fact, regional photochemical grid models have been applied with grid spacing down to hundreds of meters on occasion (Kemball-Cook, Emery and Yarwood, 2005). Regional photochemical grid models are clearly more appropriate than CALPUFF for cumulative modeling requirements such as in the determination of the aggregate contribution of all-BART-eligible sources to visibility impairment. As confirmed in EPA's fine particulate and regional haze modeling guidance discussed previously (EPA, 2001) and clearly shown by Morris and co-workers (2003; 2005; 2006), regional photochemical grid models, such as CMAQ and

CAMx, provide a much more accurate and technically correct representation of the formation of secondary PM species, such as sulfate (SO_4), nitrate (NO_3), and secondary organic aerosols (SOA), than CALPUFF.

Still, for the vast majority of potential BART-eligible sources the application of the CALPUFF modeling system will in all likelihood be sufficient to address the needs of the source owner, the state, and the approving agency (EPA and the FLM.) However, for the BART modeling in Texas, a photochemical grid model (PGM) is more appropriate than the single-source CALPUFF model for the following reasons:

- There are a large number of potential BART-eligible sources in Texas, and the CAMx screening BART exemption runs allow the efficient screening of many sources in a scientifically defensible manner;
- For most potential BART-eligible sources in Texas, the Class I areas where visibility impacts are estimated are a great distance from the source. The sources that have not yet screened out of BART, based on the CAMx runs already performed on behalf of TCEQ, are between 97 and 654 km from the nearest Class I area. Of the 67 sources remaining, 50 are more than 300 km from the nearest Class I area;
- TCEQ has conducted analyses to identify which of the many potential BART-eligible sources satisfy the three criteria for being BART-eligible. Some of these sources have been determined to make an insignificant contribution to visibility impairment at Class I areas as a group, resources can now be focused on those sources determined most likely to impact visibility in Class I areas (Morris and Nopmongcol, 2006);
- Use of a PGM allows for the quantitative assessment of the visibility impacts due to potential BART-eligible sources' VOC and PM emissions;
- Use of a PGM provides an evaluation of the cumulative impact of BART-eligible sources on visibility in Class I areas; and
- Use of a hybrid PGM that uses a full-chemistry PiG module for near-source plume chemistry and dynamics and a three-dimensional grid model for plume chemistry, transport and dispersion at farther downwind distances contains all of the scientific advantages of both CALPUFF and a PGM while treating secondary PM formation using full-science algorithms at all scales.

2.0 CAMx BART MODELING APPROACH

This section describes the general modeling approach used to perform the BART screening analysis of potential BART-eligible sources in the state of Texas using the CAMx PGM. This modeling approach is used as an example for how the CAMx, with its PSAT and PiG features, can be used to perform single source or groups of sources visibility assessments as part of the BART exemption and visibility improvement steps. The approach could also be used for air quality and Air Quality Related Values (AQRVs) assessments from proposed new or modified sources as part of the NSR and PSD process (Morris, Emery and Yarwood, 2006). There are two elements that were performed in the Texas BART screening exemption modeling using CAMx:

- Screening analysis of the potential visibility impacts at Class I areas due to all potential BART-eligible sources VOC and PM emissions; and

- Screening analysis for groups of potential BART-eligible non-EGU sources' SO_2 and NO_x emissions to determine whether the group's visibility impacts at Class I areas are significant or not.

Both elements of the screening analysis used the same 36/12 km 2002 annual database. The VOC and PM emission screening analysis was performed using emissions zero-out modeling and inert primary PM modeling, whereas the group of sources' SO_2 and NO_x emissions screening analysis was performed using the PSAT that has been implemented in the full-chemistry PiG. The SO_2 and NO_x emissions analysis could also include the PM PSAT family of source apportionment tracers (and SOA/VOC family as well) and could also be applied for EGU sources.

VERSION OF CAMx

CAMx Version 4.4β (V4.4β) was used in the Texas BART screening exemption modeling analysis. CAMx V4.4β is an updated version to CAMx V4.31 (ENVIRON, 2005) that is currently (August 2006) publicly available on the CAMx website for no cost (www.camx.com). CAMx V4.4β includes several updates to CAMx V4.31, including the implementation of the PSAT within the full-science PiG. CAMx V4.4β is available on request, but is undergoing final testing and will be posted to the CAMx website with an updated user's guide and test case shortly (late summer or early fall 2006).

2002 ANNUAL 36/12 KM MODELING DATABASE

The Texas BART screening analysis exemption modeling was performed using a 2002 annual regional photochemical modeling database that was developed as part of the Central Regional Air Planning Association (CENRAP) regional haze work. CENRAP has developed a 2002 annual modeling database for CAMx on the 36 km unified national Regional Planning Organization (RPO) grid that covers the continental US. This database was developed following the procedures outlined in the CENRAP Modeling Protocol (Morris et al., 2004) and CENRAP modeling Quality Assurance Program Plan (QAPP) (Morris and Tonnesen, 2004). The CENRAP preliminary base case model performance evaluation results for the CAMx model on the national 36 km grid using the CENRAP Base A emissions is given in Morris et al., (2005d). The CENRAP Modeling Protocol, QAPP and preliminary Base A evaluation reports provide details on the development of the CENRAP 2002 36 km annual modeling database. Additional information is provided below related to enhancements to the CENRAP database for use in the Texas BART exemption screening analysis.

Enhancements to the CENRAP 2002 Modeling Database

The CENRAP 2002 36 km annual CAMx evaluation using the Base A emissions and CAMx Version 4.20 is reported in Morris and co-workers (2005d) with additional model performance evaluation displays available on the CENRAP modeling Website (http://pah.cert.ucr.edu/aqm/cenrap/cmaq.shtml#camx). CENRAP has updated the CAMx 2002 36 km Base A emissions to Base B and CAMx version 4.30. The Base B base case database was the starting point for the Texas BART exemption modeling screening analysis.

The CENRAP Base B 2002 36 km annual CAMx photochemical modeling database was enhanced to include a 12 km nested-grid that covers Texas and Class I areas in and near Texas including:

- Big Bend, Guadalupe Mountains, Carlsbad Caverns National Parks;
- Salt Creek Wichita Mountains Wildlife Refuges and White Mountain; and
- Caney Creek, Upper Buffalo and Hercules Glade Wilderness Areas.

Figure 2-1 displays the 36/12 km nested grid structure that was used in the Texas CAMx BART exemption modeling analysis. The locations of the potential BART-eligible sources and Class I areas within the 12 km modeling domain are shown in Figure 2-2. The CAMx flexi-nesting feature was used to incorporate the 12 km Texas grid within the CENRAP 36 km modeling domain. Full flexi-nesting was invoked in which CAMx internally interpolates all of the meteorological, emissions and other inputs from the 36 km grid to the 12 km grid. This option has the desired effect of allowing the BART point source plumes' chemistry, transport and dispersion to be represented and resolved by the higher resolution 12 km grid after treatment of their near-source plume chemistry and dynamics using the subgrid-scale PiG module when plume size is below 12 km.

If BART or similar assessments using CAMx are desired, a new 12 km grid flexi-nest could be defined focused on the selected states and nearby Class I areas.

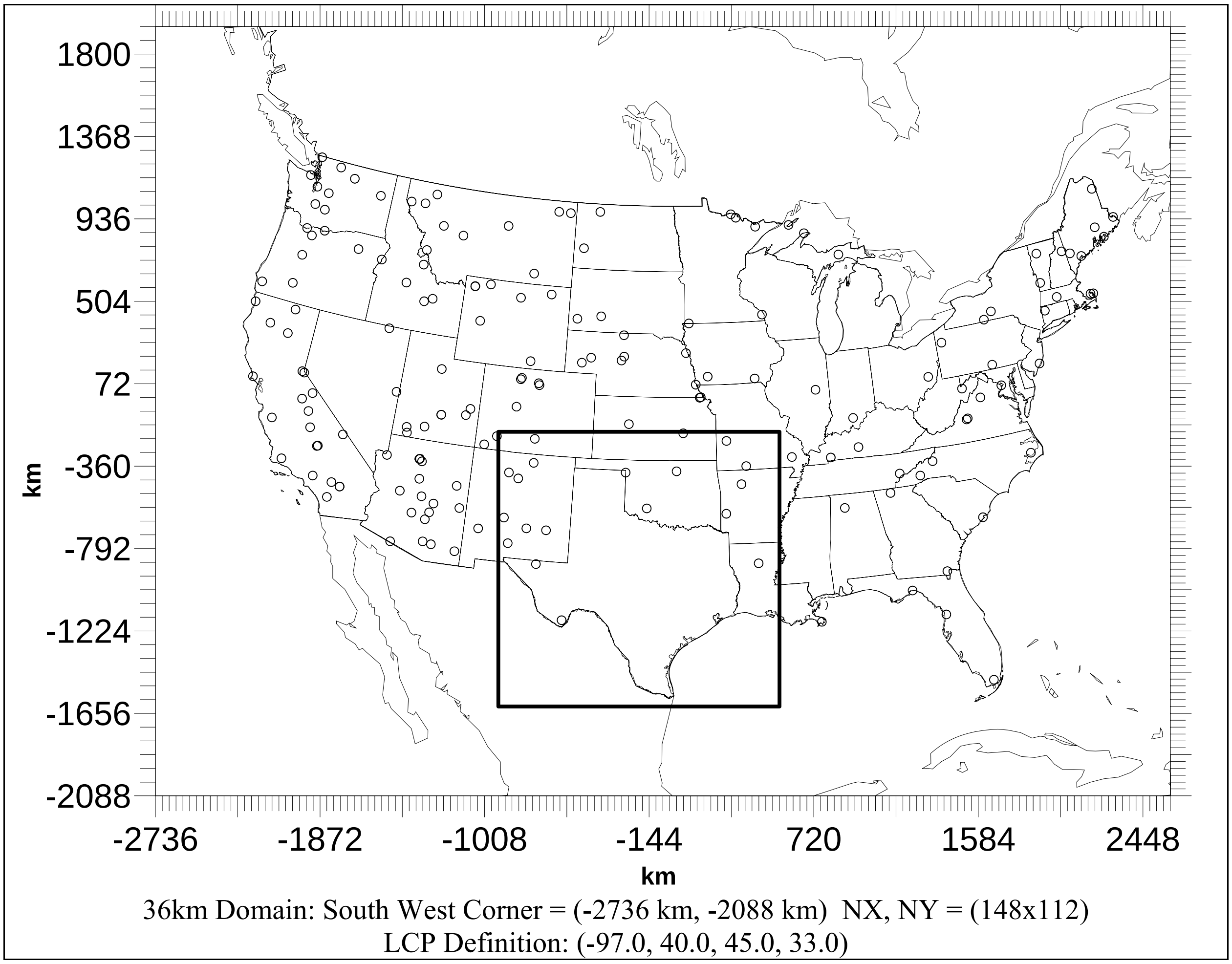
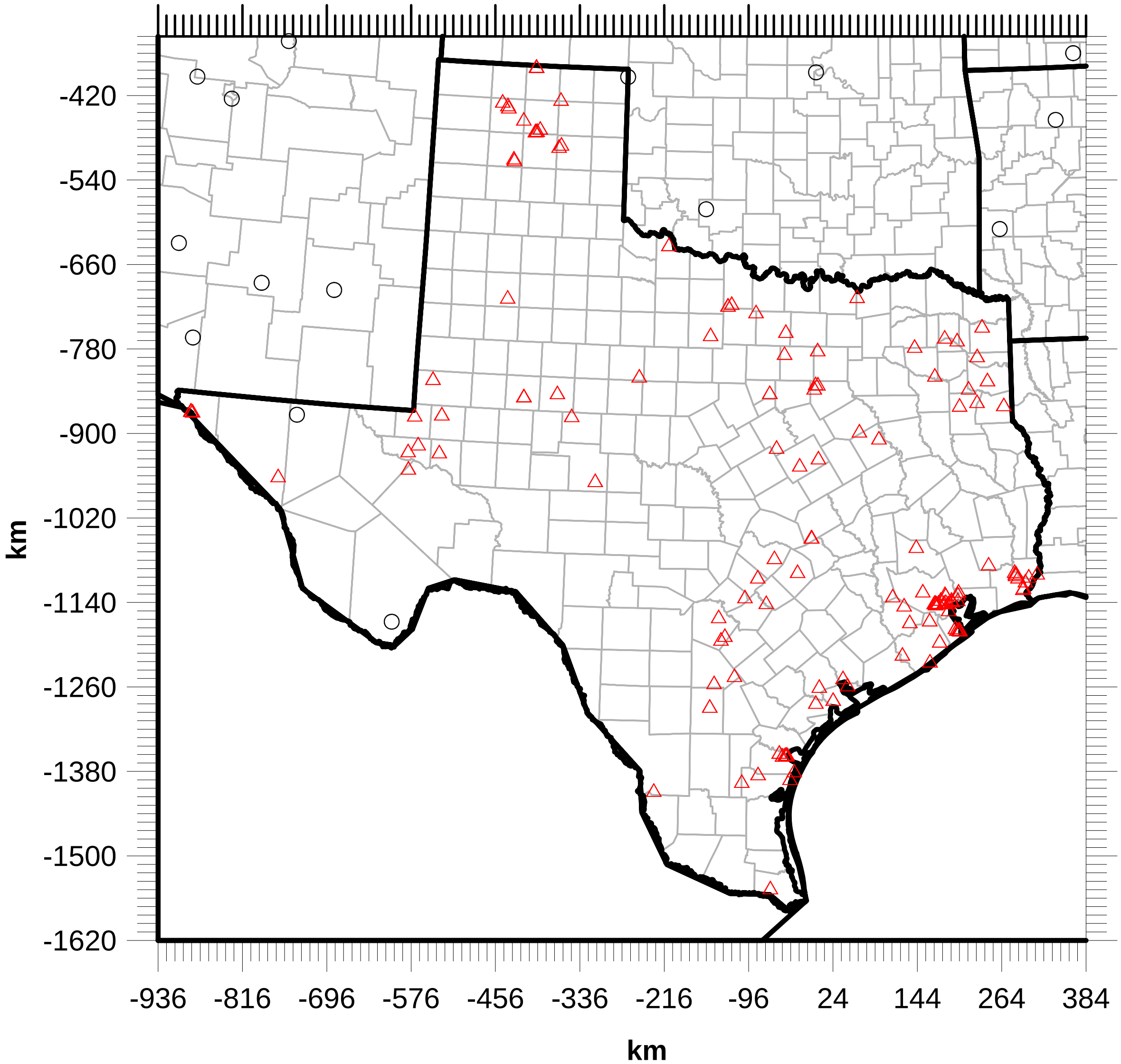


Figure 2-1. Texas BART modeling 36/12 km modeling domain and locations of the IMPROVE monitoring sites that include Class I areas (indicated by circles).



12km Domain: South West Corner = (-936 km, -1620 km) NX, NY = (111x108)
LCP Definition: (-97.0, 40.0, 45.0, 33.0)

Figure 2-2. Texas BART modeling 12 km modeling domain and locations of the IMPROVE monitoring sites (indicated by circles) that include Class I areas and locations of potential BART-eligible sources in Texas (indicated by triangles).

ENHANCEMENTS TO THE PM SOURCE APPORTIONMENT TECHNOLOGY

To estimate the air quality and/or visibility impacts from a single source or group of sources, the CAMx model PSAT is used. PSAT was updated to be compatible with the CAMx PiG module (CAMx V4.4β). Described below is the technical formulation of the PSAT source apportionment technique and the enhancements to the CAMx PiG and PSAT to make them compatible with each other.

PSAT Formulation

PSAT is designed to source apportion the following PM species modeled in CAMx:

- Sulfate (SO_4)
- Particulate nitrate (NO_3)
- Ammonium (NH_4)
- Particulate mercury (Hg(p))
- Secondary organic aerosol (SOA)
- Six categories of primary PM
    - Elemental carbon (EC)
    - Primary organic aerosol (POA)
    - Fine crustal PM (FCRS)
    - Fine other primary PM (FPRM)
    - Coarse crustal PM (CCRS)
    - Coarse other primary PM (CPRM)

PSAT performs PM source apportionment for each user defined source group. A source group consists of a combination of a geographic region and emissions source category. Examples of source regions include states, nonattainment areas and counties, whereas examples of source categories include mobile sources, biogenic sources, elevated point sources or even an individual source. The user defines a geographic source region map to specify the source regions. The user then inputs each separate source category as separate gridded low-level emission and/or elevated point source emission inputs. The model then determines each source group by overlaying the source categories on top of the source region map.

The PSAT "reactive tracers" that are added for each source category/region (*i*) are described below. In general, a single tracer can track primary PM species whereas secondary PM species require several tracers to track the relationship between gaseous precursors and the resulting PM. Particulate nitrate and secondary organics are the most complex species to apportion because the emitted precursor gases (NO_x, VOCs) are several steps removed from the resulting PM species (NO_3, SOA). The PSAT tracers for each type of PM are listed below. PSAT convention is that tracer names for particulate species begin with the letter "P."

<u>Sulfur</u>

$SO2_i$ Primary SO_2 emissions
$PS4_i$ Particulate sulfate ion from primary emissions plus secondarily formed sulfate

Nitrogen

- RGN_i Reactive gaseous nitrogen including primary NO_x (NO + NO_2) emissions plus nitrate radical (NO_3), nitrous acid (HONO) and dinitrogen pentoxide (N_2O_5).
- TPN_i Gaseous peroxyl acetyl nitrate (PAN) plus peroxy nitric acid (PNA)
- NTR_i Organic nitrates (RNO_3)
- $HN3_i$ Gaseous nitric acid (HNO_3)
- $PN3_i$ Particulate nitrate ion from primary emissions plus secondarily formed nitrate
- $NH3_i$ Gaseous ammonia (NH_3)
- $PN4_i$ Particulate ammonium (NH_4)

Secondary Organic Aerosol

- ALK_i Alkane/Paraffin secondary organic aerosol precursors
- ARO_i Aromatic (toluene and xylene) secondary organic aerosol precursors
- CRE_i Cresol secondary organic aerosol precursors
- TRP_i Biogenic olefin (terpene) secondary organic aerosol precursors
- $CG1_i$ Condensable gases from toluene and xylene reactions (low volatility)
- $CG2_i$ Condensable gases from toluene and xylene reactions (high volatility)
- $CG3_i$ Condensable gases from alkane reactions
- $CG4_i$ Condensable gases from terpene reactions
- $CG5_i$ Condensable gases from cresol reactions
- $PO1_i$ Particulate organic aerosol associated with CG1
- $PO2_i$ Particulate organic aerosol associated with CG2
- $PO3_i$ Particulate organic aerosol associated with CG3
- $PO4_i$ Particulate organic aerosol associated with CG4
- $PO5_i$ Particulate organic aerosol associated with CG5

Mercury

- $HG0_i$ Elemental Mercury vapor
- $HG2_i$ Reactive gaseous Mercury vapor
- PHG_i Particulate Mercury

Primary Particulate Matter

- PEC_i Primary Elemental Carbon
- POA_i Primary Organic Aerosol
- PFC_i Fine Crustal PM
- PFN_i Other Fine Particulate
- PCC_i Coarse Crustal PM
- PCS_i Other Coarse Particulate

PSAT includes a total of 32 tracers for each source group (*i*) if source apportionment is applied to all types of PM. Since source apportionment may not always be needed for all species, the PSAT implementation is flexible and allows source apportionment for any or all of the chemical classes in each CAMx simulation (i.e. the SO_4, NO_3, NH_4, SOA, Hg and primary PM classes listed above). For example, source apportionment for sulfate/nitrate/ammonium requires 9 tracers per source group.

One fundamental assumption in PSAT is that PM should be apportioned to the primary precursor for each type of PM. For example, SO_4 is apportioned to SO_x emissions, NO_3 is apportioned to NO_x emissions, NH_4 is apportioned to NH_3 emissions, etc. As a source apportionment method, PSAT must account for all modeled sources of a PM species. Consider two model species A and B that are apportioned by reactive tracers a_i and b_i, respectively. Reactive tracers must be included for all sources of *A* and *B* including emissions, initial conditions and boundary conditions so that complete source apportionment is obtained, i.e., $A = \Sigma a_i$ and $B = \Sigma b_i$.

In PSAT, the general approach to modeling change over a model time step Δt is illustrated for a chemical reaction $A \rightarrow B$. The general equation for species destruction is:

$$a_i(t + \Delta t) \quad = \quad a_i(t) + \Delta A \frac{a_i}{\sum a_i}$$

Here, the relative apportionment of *A* is preserved as the total amount changes. This equation applies to chemical removal of *A* and also to physical removal of *A* by processes such as deposition or transport out of a specific grid cell.

The general equation for species production (e.g, chemical production by the chemical reaction $A \rightarrow B$) is:

$$b_i(t + \Delta t) \quad = \quad b_i(t) + \Delta B \frac{a_i}{\sum a_i}$$

Here, production of *B* inherits the apportionment of the precursor *A*. The same equation applies for "production" of *B* in a specific grid cell due to emissions or transport. For the case where *B* increases due to emissions, a_i is the apportionment of the emissions inventory. For the case where *B* increases due to transport, a_i is the apportionment of the upwind grid cell.

In some cases, source category specific weighting factors (w_i) must be added to the equation for species destruction:

$$a_i(t + \Delta t) \quad = \quad a_i(t) + \Delta A \frac{w_i a_i}{\sum w_i a_i}$$

An example is chemical decay of the aromatic VOC tracers (ARO,) which must be weighted by the average hydroxyl radical (OH) rate constant of each ARO_i. ARO tracers for different source groups have different average VOC reactivities because the relative amounts of toluenes and xylenes differ between source categories.

In some cases, source category specific weighting factors (w_i) must be added to the equation for species production:

$$b_i(t + \Delta t) \quad = \quad b_i(t) + \Delta B \frac{w_i a_i}{\sum w_i a_i}$$

An example is chemical production of condensable gases (CG1 or CG2) from ARO tracers, which must be weighted by aerosol yield weighting factors. The aerosol yield weighting factors depend upon the relative amounts of toluenes and xylenes in each source group.

Several aerosol reactions are treated as equilibria, $A \leftrightarrow B$. If *A* and *B* reach equilibrium at each time step, it follows that their source apportionments also reach equilibrium:

$$a_i(t+\Delta t) = [a_i(t)+b_i(t)]\left(\frac{A}{A+B}\right)$$

$$b_i(t+\Delta t) = [a_i(t)+b_i(t)]\left(\frac{B}{A+B}\right)$$

Examples are the equilibrium between gas phase nitric acid and aerosol nitrate, gas phase ammonium and aerosol ammonium, and condensable organic gases (CG) and secondary organic aerosols (SOA).

The PSAT source apportionment technique has been extensively tested and evaluated against other source apportionment techniques (e.g., ENVIRON, 2005; Morris et al., 2005; Yarwood et al., 2004).

UPDATES TO THE PSAT FORMULATION AND NEW FULL-SCIENCE CHEMISTRY PiG

The CAMx PSAT and PiG algorithms were updated to treat the near-source chemistry of secondary PM formation and to be compatible with each other. The PiG module now treats full-science aerosol chemistry and dynamics in addition to gas-phase chemistry and has been extended to PSAT and Ozone Source Apportionment Technology (OSAT.) The formulation of the full-science PiG is described below.

Modeling photochemistry is a highly non-linear problem because chemical rates for most compounds depend upon their ambient concentrations. Ambient concentrations in turn depend on how well the modeling grid resolves emissions, transport, and chemical history. Thus, grid resolution plays a vital role in the ability of the model to properly characterize photochemical conditions. Increasing resolution should, in theory, lead to a better model as the time/space discretization tends toward a continuum. However, practical and theoretical considerations suggest that the lower limit on horizontal grid spacing is about 1000 meters for Eulerian air quality models such as CAMx. Nevertheless, even higher resolution is often necessary to adequately simulate chemistry within concentrated point source plumes.

As a result, many modern Eulerian models contain a Plume-in-Grid sub-model that tracks individual plume segments (or puffs) in a Lagrangian sense, accounting for plume-scale dispersion and chemical evolution, until such time as puff mass can be adequately represented within the larger grid model framework. It is important to understand that the inclusion of a Lagrangian puff model within an Eulerian grid model is a forced construct. The formulations of the two modeling approaches are fundamentally different and there is no theoretically “correct” methodology. This explains the variety of Plume-in-Grid methodologies that are in use today. The CAMx PiG module was recently updated in Version 4.4 of the model.

The new PiG approach in CAMx treats the full suite of gas-phase photochemistry, aqueous-phase chemistry and aerosol phase chemistry and dynamics. Chemical processes are simulated within each plume segment using an “incremental chemistry” approach, whereby puffs carry the incremental contributions of the puff relative to the grid concentrations. Incremental puff concentrations can be positive or negative, depending upon the species and stage of plume evolution. A similar chemistry approach is used in the Second-order Closure Integrated puff model (SCIPUFF) with CHEMistry (SCICHEM) Lagrangian model (EPRI, 2000). The approach lends itself to incorporating chemistry for particulates as well.

Basic Puff Structure and Diffusive Growth

The CAMx PiG releases a stream of plume segments (puffs) from a point source specified in the CAMx input file by setting the point source stack diameter to a negative value. Each puff possesses a longitudinal length and directional orientation defined by the separation of a leading and a trailing point. Initial separation of these points is determined by the wind vector at final plume rise. Each point is then subsequently and independently transported through the gridded wind fields, which directly accounts for puff stretching and changes to centerline orientation due to deforming shears. The official "position" of each puff is defined by the center point of each puff between the endpoints. This position defines the grid cell in which the puff resides for the calculation of diffusion and chemistry.

Like other puff models, the shape of each puff is characterized by a spread tensor, which is defined from a set of Gaussian standard deviations (so-called "sigmas") along the three spatial axes (σ_x, σ_y, σ_z). Diffusive growth is defined by the growth in these sigma values. The total cross-sectional width extends $\pm 1.5\sigma$ from puff centerline. The limits of $\pm 1.5\sigma$ result in an average concentration across the Gaussian distribution that nearly equals a uniformly mixed concentration across that distance. The total longitudinal length is the distance between the puff endpoints $\pm 1.5\sigma_y$. Horizontal area is calculated using the formula for an ellipse. Different vertical constructs are employed for Greatly Reduced and Simplified Dynamics (GREASD) and Incremental Reactions for Organics and NO_x (IRON) PiG, as described later in this section. Figure 2-3 presents a schematic representation of each puff in horizontal cross-section.

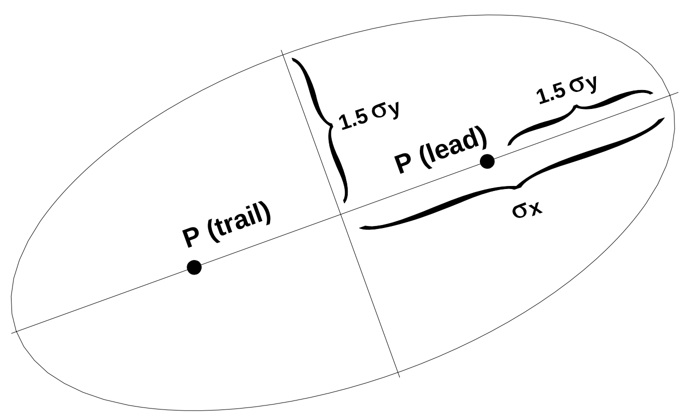


Figure 2-3. Schematic representation of CAMx PiG puff shape in the horizontal. Directional orientation of the puff is arbitrary, and evolves during the aging of the puff according to wind direction, shears and diffusive growth along its trajectory.

An explicit solution approach was developed for puff growth that shares SCICHEM theory and concepts (EPRI, 2000), but includes some simplifications. SCICHEM solves predictive spatial moment equations with second-order closure that relate the evolution of the puff spread tensor ($\sigma_{ij}=\sigma_i \times \sigma_j$) to resolved mean shears and turbulent velocity statistics. The Reynolds-averaged second-moment transport equation is given as:

$$\frac{d\sigma_{ij}}{dt} = \sigma_{ik}\frac{\partial \overline{u}_j}{\partial x_k} + \sigma_{jk}\frac{\partial \overline{u}_i}{\partial x_k} + \frac{\left\langle x_i' \overline{u_j' c'} \right\rangle}{Q} + \frac{\left\langle x_j' \overline{u_i' c'} \right\rangle}{Q}$$

where $\overline{u}$ is the mean wind vector component, the primed values represent turbulent fluctuations from the mean, and the angle brackets denote integrals over space. The Reynolds averaging process always introduces higher-order fluctuation correlations, and this is given by the turbulent flux moments $\left\langle x' \overline{u' c'} \right\rangle$, where $\overline{u' c'}$ represents the turbulent flux of concentration. It is these last two diffusion terms that SCICHEM solves in its second-order closer scheme.

For sub-puff scale turbulence, SCICHEM employs the restriction that the only off-diagonal component of $\left\langle x' \overline{u' c'} \right\rangle$ to be considered is the symmetric horizontal term ($i=x$, $j=y$), and then only for the large-scale (meso to synoptic) contribution to puff deformation when puff scale reaches such dimensions. In CAMx, we ignore this off-diagonal flux moment term altogether since puff mass is ultimately introduced to the grid when puff size is at the grid scale (1-50 km in practically all applications), and thus puffs never reach spatial scales at which this term becomes important. SCICHEM also makes the assumption that the horizontal turbulence is isotropic, $\left\langle x' \overline{u' c'} \right\rangle = \left\langle y' \overline{v' c'} \right\rangle$. This results in a single diffusivity equation for both *x* and *y* directions, and a single diffusivity for the *z* direction:

$$K_x = K_y = \frac{\left\langle y' \overline{v' c'} \right\rangle}{Q}$$

$$K_z = \frac{\left\langle z' \overline{w' c'} \right\rangle}{Q}$$

This approach for CAMx adopted the SCICHEM second-order tendency equations to model the time-evolution of puff turbulent flux moments (represented by diffusivities $K_x=K_y$ and K_z) and their contribution to the evolution of puff spread (represented by the diagonal components of the puff spread tensor, $\sigma_x^2 = \sigma_y^2$ and σ_z^2). The off-diagonal contributions to puff spread was ignored, since they were unnecessary in the context of the CAMx PiG. Puff spread was defined for puff depth (σ_z) and puff width (σ_y); the latter was also added to the longitudinal length to allow for diffusive growth along the puff centerline. The effects of wind shears were accounted for in the evolution of lateral spread, but assumed that the evolution of vertical spread was solely the result of turbulent fluxes.

The resulting two Reynolds-averaged second-moment transport equations for CAMx PiG are:

$$\frac{d\sigma_z^2}{dt} = 2K_z$$

$$\frac{d\sigma_y^2}{dt} = 2\sigma_y^2 D + 2\sigma_y\sigma_z\left(\frac{du}{dz}^2 + \frac{dv}{dz}^2\right)^{1/2} + 2K_y$$

where D is deformation of horizontal wind (see Section 2).

The SCICHEM tendency equation for the horizontal turbulent flux moment is:

$$\frac{d}{dt}\left\langle y'\overline{v'c'}\right\rangle = Qq^2 - A\frac{q}{\Lambda}\left\langle y'\overline{v'c'}\right\rangle$$

where $A = 0.75$, $q^2 = \overline{v'v'}$, and Λ is the horizontal turbulent length scale. Separate equations are given for two different boundary layer turbulence scales (shear- and buoyancy-produced), such that:

$$\left\langle y'\overline{v'c'}\right\rangle = \left\langle y'\overline{v'c'}\right\rangle_{shear} + \left\langle y'\overline{v'c'}\right\rangle_{buoyancy}$$

Within the surface-based boundary layer, the horizontal velocity variance is given by:

$$q_{buoyancy}^2 = 0.13\,w_*^2\left[1 + 1.5\exp(z/z_i)\right]$$

$$q_{shear}^2 = 2.5u_*^2(1 - z/z_i)$$

where u_* is the friction velocity, w_* is the convective velocity scale, z is height above the surface, and z_i is the height of the surface-based boundary layer. The horizontal turbulent length scale is given by:

$$\frac{1}{\Lambda_{shear}^2} = \frac{1}{(0.3\,z_i)^2} + \frac{1}{(0.65\,z)^2}$$

$$\Lambda_{buoyancy} = 0.3\,z_i$$

In the stable boundary layer, only the shear components of q^2 and Λ are applied. Above the boundary layer, SCICHEM applies rough approximations for the velocity variance and turbulent length scale: $q^2 = 0.25$ m^2/s^2, and $\Lambda = 1000$ m.

The SCICHEM tendency equation for the vertical turbulent flux moment is

$$\frac{d}{dt}\left\langle z'\overline{w'c'}\right\rangle = A\frac{q_v}{\Lambda_v}\left(QK_z^{eq} - \left\langle z'\overline{w'c'}\right\rangle\right)$$

where $q_v^2 = \overline{w'w'}$, Λ_v is the vertical turbulent length scale, and K_z^{eq} is the equilibrium diffusivity. Whereas a specific equation for K_z^{eq} is formulated for SCICHEM, we have chosen to specify the value of this parameter from the gridded fields of vertical diffusivity in CAMx. Again SCICHEM gives separate equations for shear- and buoyancy-produced turbulence scales.

Within the surface-based boundary layer, the vertical velocity variance is given by

$$q_v^2\Big|_{shear} = 1.5\,u_*^2\left(1 - z/z_i\right)$$

$$q_v^2\Big|_{buoyancy} = 1.1\,w_*^2\left(z/z_i\right)^{2/3}\left(1.05 - z/z_i\right)$$

The vertical turbulent length scale for both shear and buoyancy is equal to Λ_{shear} given above for horizontal length scale. Above the boundary layer, SCICHEM again applies rough approximations for the velocity variance and turbulent length scale:

$$q_v^2 = 0.01\ \text{m}^2/\text{s}^2\text{, and } \Lambda_v = 10\ \text{m}.$$

The external variables needed by IRON PiG to complete the dispersion calculations include z_i, u_* and w_*. All of these are available from an internal module in CAMx that calculates these boundary layer similarity theory parameters. Thus, no additional parameters are needed to be input to the model.

Puff Transport

A fresh set of new puffs are released from all PiG point sources within the modeling domain for the duration of the smallest time step among the master and all nested grids. The length of each puff is determined by the combination of the mean total wind speed at the height of final plume rise and time step. Limits are placed on maximum extruded length based on half the finest resolution in the given simulation. If winds and time-steps are such that the maximum allowed length is violated, then several puffs are extruded from a given stack per time step. The orientation of the puff length is along the total wind vector. Total puff volume is determined by stack volumetric flow rate in conjunction with growth due to turbulent entrainment following the SCICHEM approach. Initial σ_y and σ_z are explicitly calculated from this entrainment calculation.

Effects of wind divergence on plume deformation are treated in an explicit manner within the CAMx PiG using a "chained puff" approach (Figure 2-4). Points at the leading and trailing edges of the puff centerline are individually transported through the gridded wind fields, which directly accounts for puff stretching and changes to centerline orientation due to deforming shears. Since PiG puffs can extend over multiple layers, layer density-weighted average wind components are determined for each endpoint based on the vertical coverage of the puff, and these are used for advection of those points. GREASD PiG puffs are not allowed to expand beyond the depth of the layer in which the centerpoint resides, so only the single layer wind components are used to advect the endpoints.

The "chain" aspect means that at least initially (as puffs are extruded from the stack) the trailing point of a puff emitted at time *t* will be the leading point of a puff emitted at time *t+dt*. However, as the puffs are advected downstream, the leading point of one puff will deviate from the trailing point the puff behind it due to evolving puff depth and wind fields. Puff volume is conserved in convergent/divergent wind fields. Puff endpoints may move closer together or further apart, in wind fields that are slowing or accelerating downstream. We compute puff end-point separation changes and then adjust puff widths and depths to maintain constant puff volume. The change in computed puff endpoint spacing defines puff length tendencies, then puff depth tendencies are computed from grid-resolved vertical wind shear (*dw/dz*), and finally we determine the puff width tendencies required to conserve puff volume.

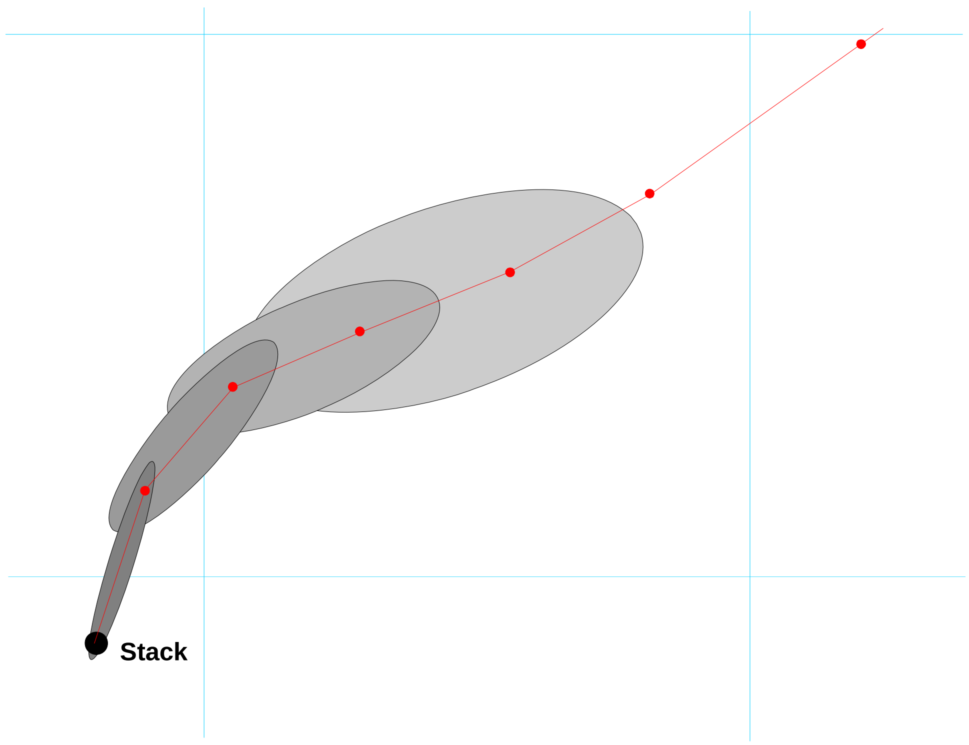


Figure 2-4. Schematic representation of a chain of PiG puffs emitted from a point source into an evolving gridded wind field. The red line connected by dots represents puff centerlines, with dots representing leading and trailing points of each puff. The CAMx computational grid is denoted by the blue lines.

The official "position" of each puff is defined by the center point of each puff between the endpoints. This position defines which grid domain and grid cell the puff resides for the calculation of diffusion and chemistry. This definition holds even if the puff is sufficiently long that the endpoints are in different grid cells (or even different grid domains if near a domain boundary). With our definition for termination when horizontal area approaches grid cell area, the extents of the puff length should not extend across more than two grid cells.

PiG Chemistry

The primary goal of the new PiG formulation in CAMx Version 4.4 was to include a more complete treatment of chemistry in point source pollutant plumes, while secondarily improving puff-grid mass exchange and adding additional features central for treating toxic pollutants not normally carried by the standard CAMx chemical mechanisms. Several approaches have been developed to treat photochemistry within point source plume models. One of the more elegant methodologies is the incremental chemistry idea embodied in the SCICHEM model (EPRI, 2000). However, the implementation of incremental chemistry in SCICHEM is very complex, especially in its handling of the chemistry of overlapping puffs. In adopting this innovative approach for the new PiG, it was necessary to reformulate the physical and chemical configuration of the PiG puffs and to utilize an accurate numerical solution approach based on the Livermore Solver for ordinary differential equations (LSODE) chemical solver.

The Concept of Incremental Chemistry

For a second-order reaction between puff species *A* and *B*, the total reaction rate is the following:

$$R_T = k(P_A)(P_B) \tag{1}$$

where P_A and P_B are the total puff concentrations of each species. The total puff concentrations can be expressed as the sum of the background and puff perturbation concentrations:

$$P_A = (c_A + C_A)$$

$$P_B = (c_B + C_B)$$

where C is the ambient concentration and c is the puff increment concentration. Thus the reaction rate is found to be:

$$R_T = k(c_A + C_A)(c_B + C_B)$$

or

$$R_T = k(c_A c_B + C_A c_B + c_A C_B + C_A C_B)$$

If we subtract the rate of change of the background,

$$R_{Ambient} = kC_A C_B \tag{2}$$

by assuming that it is explicitly and separately treated by the grid model, we obtain the reaction rate for the puff increments:

$$R_P = k(c_A c_B + C_A c_B + c_A C_B) \tag{3}$$

Equation 3 is the basis of SCICHEM incremental chemical kinetic solver. One problem with this approach is the mixed terms, $C_A c_B$ and $c_A C_B$. Most chemical solver packages are designed to solve rate equations for total concentration, as in Equation 1. Thus, for the new PiG an alternative numerical solution scheme was developed for puff perturbation chemistry. The CAMx chemical solver can be independently applied to the rate equation for total puff concentrations, Equation 1, and to the rate equation for ambient concentrations, Equation 2. By subtraction of the two solutions, we obtain the solution to rate Equation 3. This requires no modification to, and is obviously completely self-consistent with, the CAMx chemical solvers. Once the incremental puff reaction rates are obtained they are applied to the incremental puff mass to calculate the new (adjusted for chemistry) incremental concentrations. These new puff increments are subsequently advected and dispersed by the transport portions of the PiG code.

Puff Constructs for Incremental Chemistry

The new PiG sub-model includes three new constructs designed specifically to facilitate the incremental chemistry approach:

- Treatments to handle puff-grid information exchange for puffs spanning multiple model layers;
- The concept of "virtual dumping" to handle the chemical impacts of large puffs that can overlap other puffs within a given grid column; and
- The concept of multiple puff "reactor" cells to account for the chemical effects of concentration distributions within each puff.

Each of these are described below.

Puff Layer Spanning

The new PiG is designed to chemically process point source plume mass within streams of puffs until such time that each puff can be adequately resolved on the *horizontal* grid. Unlike the previous versions of the PiG approach, where the vertical layer structure dictates puff leaking and ultimately termination, the approach in new PiG leads to the necessity that puffs be allowed to vertically span multiple grid model layers before they reach horizontal grid scales. This introduces technical implications for defining "background" concentrations and ambient conditions for puff chemistry, as well as for transferring plume incremental mass to the grid. The solution employed in the new PiG is to:

1) Assume that the vertical distribution of puff concentration is always uniform;
2) Distribute puff mass transfer (via "leaking" and "dumping") to the grid according to the puff fractional coverage across each model layer and by density-weighting; and
3) Determine mean background concentrations and other ambient conditions (e.g., temperature, humidity, etc.) over the puff vertical span via similar fractional layer-density weighting.

PiG puffs are considered to be elliptical in the horizontal, with the minor axis spanning the cross-wind puff width (defined as $\pm 1.5\sigma_y$), and the major axis spanning the along-wind puff length (defined as length $\pm 1.5\sigma_y$ on each end). This is similar to GREASD PiG. However, given the complications associated with multiple layer spanning and mass-weighting of ambient inputs and dumped mass, puffs are rectangular and uniform in the vertical, with total puff depth defined as $\pm 1.5\sigma_z$.

Horizontally, the mean background concentration and ambient conditions are taken from the single host grid column containing each puff center point, even if the puff is large and/or spans a horizontal cell interface.

Chemistry Solution

In summary, chemistry is solved for each PiG puff "reactor" in three steps:

1) The layer-mean background (grid + overlapping puff) concentrations and environmental conditions over the volume occupied by the puff are stored and then chemically updated via the LSODE gas-phase chemistry mechanism;
2) The pre-updated mean background concentrations are added to the puff increments and the total concentrations are chemically updated; and
3) The updated results from step 1 are subtracted from the updated results of step 2 to provide the updated incremental concentrations.

An important consequence of this approach is that the incremental puff mass may be positive or negative. For example, a high- NO_x puff that is destroying ambient ozone will have negative ozone increments. The puff increments are subsequently advected and dispersed by the transport portions of the IRON PiG code. The updated background concentrations, which include "virtual dumps" of mass from large puffs, are used for reference only in the puff incremental chemistry algorithm; the actual grid concentrations are updated in the grid chemistry routine.

Puff Dumping and PiG Rendering

Mass transfer from puff to grid can happen in two ways: slowly, termed "leaking," or suddenly, termed "dumping." As described earlier, all mass is transferred from the PiG to the vertical grid structure in a density-weighted fashion according to each puff's fractional layer coverage. The process of leaking ensures that puff mass is transferred to the grid continuously, rather than in discrete lumps of pollutants with very different concentrations than those in the grid. The idea behind puff leakage is to account for turbulent shearing of mass from the main plume and its subsequent dispersion to the grid scale. This rate of transfer should be directly proportional to the puff size relative to the grid scale. The user can control whether a puff is leaked or not, and for Texas BART screening modeling, we have assumed the default mode in which puffs are not leaked to the grid. This will allow the full-science PiG plume model to treat the chemistry of the BART point source plumes as plume chemistry until the plume size is commensurate to the grid cell size, rather than the early dilution of the plume emissions across the grid when the puff is leaked.

Puff leakage is controlled by comparing the horizontal area of a puff to a specified leakage parameter, defined as a fraction of horizontal grid cell area. When a puff is first emitted, there is no leakage. As the puff grows in volume, the concentrations within the reactors are reduced accordingly by dilution. When the puff area exceeds the leakage onset parameter, a fraction of the mass in each puff reactor is transferred to the grid. This fraction is determined by the relative exceedance of the leakage parameter; initial leakage is slow as the exceedance is relatively small, but leakage rates grow as the puff continues to grow beyond the leakage parameter.
The reduced mass from leakage is compensated by a reduced effective volume, so that concentrations are not artificially diluted by leakage (an essential chemical imperative). Thus, two distinct volumes are tracked: the actual volume (defined by the puff spread sigmas) and the effective volume. While these are identical before leakage, they obviously deviate after leakage is initiated, and thereafter the relative deformation of the actual puff volume (via diffusion, shearing, etc.) is used to scale the deformation of effective puff volume.

Eventually the horizontal span of the puff will exceed the grid cell area, and the remaining mass is then dumped all at once to the grid. However, because of the combination of photochemical processing and leakage, by the time a puff dumps the potential for producing numerical shocks is much reduced. Furthermore, if the puff exceeds a user-defined maximum age, puff mass is transferred to the grid. Also, puff mass is dumped to the grid model when the chemical maturity of the puff is such that plume-scale chemistry is no longer appropriate.

While the mass confined to the puffs at any given time has not yet affected the grid concentrations, it will eventually, so it can be somewhat misleading to sequester this mass from visualizations of a model simulation. The puff mass can be optionally incorporated into the model average output files for visualization purposes (referred to as "PiG rendering"). Rendering employs a "virtual dump" of the puff masses into the average concentration array each time step. As described for chemistry, virtual puff mass is added as an increment over the entire grid column according to fractional layer-density weighting over puff depth, thus diluting its concentrations relative to that within the puff. The actual puff mass remains within the puffs over the course of their lifetimes. This visualization is available for 3-D average output files, and can produce some rather startling effects in output displays, including very narrow virtual plumes, or streaks, representing mass moving through the grid in sub-grid puffs, but not subject to grid-scale eddy diffusion.

High Resolution Puff Sampling

PiG optionally employs surface-layer puff sampling of concentration species on a user-defined grid of arbitrary horizontal resolution, similarly to the way nested grids are defined. Sampling grids are entirely passive, and intended to provide a display of the plume concentrations at scales much smaller than typically used for the finest computational grids (i.e., <1 km), primarily around and downwind of a source complex. Sampled PiG concentrations are time-averaged like the output concentrations provided on the computational grids, and are written to files with similar format so that they may be readily viewed and manipulated with CAMx post-processing software. Additional information on configuring and using PiG sampling grids is provided in Section 5.

Given that the puffs constantly evolve via diffusive growth and reshaping due to deforming shears, the sampling procedure includes trigonometric calculations to define which sampling points are influenced by each puff. This influence is determined according to the puffs' two-dimensional horizontal Gaussian shape shown in Figure 2-3. To include a sufficiently large percentage of mass across each puff for sampling, limits of $\pm 3\sigma_y$ in both horizontal dimensions are used to define the puffs' total elliptical area coverage. Puffs are only sampled if they extend vertically into the model's surface layer.

3.0 PROCEDURES FOR VOC AND PM EMISSIONS BART SCREENING ANALYSIS USING ZERO-OUT AND INERT MODELING

This section presents the procedures that can be used to perform cumulative BART screening exemption modeling for combined VOC and PM emissions and for PM emissions alone. Details on the steps needed to perform this analysis, selection of the recommended CAMx options and scripts and computer operation notes are provided in Chapter 5.

OVERVIEW OF APPROACH

One type of BART screening analysis using CAMx would be to estimate the cumulative visibility impacts at Class I areas due to VOC and PM emissions from all potential BART-eligible sources. To address impacts due to both VOC and NO_x emissions two CAMx 36/12 km simulations will be conducted for the 2002 annual period:

- 2002 BART Base Case Emissions Scenario; and
- 2002 BART VOC and PM Emissions Zero-Out Scenario.

For the Texas screening analysis, the 2002 BART Base Case Emissions Scenario was based on the CENRAP 2002 Typical Base Case emissions scenario, although other base case scenarios could also be used (e.g., 2002 Western Regional Air Partnership/WRAP, Visibility Improvement State and Tribal Association of the Southeast/VISTAS, Midwest RPO base cases, CAIR 2001 base case, etc.). The EPA BART guidelines require that BART modeling use the maximum actual 24-hour emissions for each BART-eligible source (excluding start up and shut down). The 2002 base case scenarios typically contain average actual emissions for all sources. The maximum 24-hour actual emission rates are not readily available for most sources. Thus, to account for the differences between maximum 24-hour actual and average typical actual, the average typical actual emissions for potential BART-eligible sources in the 2002 Base Case emissions scenario were doubled as recommended by EPA Region 6. Doubling the average emissions provides a conservative estimate of maximum 24-hour emissions for most sources.

Visibility Calculations

Visibility impacts are calculated at each Class I area using the differences in 24-hour PM concentrations between the 2002 Base Case and 2002 BART Sources VOC and PM Emissions Zero-Out Case scenarios following the procedures given in EPA's BART modeling guidance (EPA, 2005) that are based on the Federal Land Managers Air Quality Related Values Workgroup report (FLAG, 2000). The FLAG (2000) procedures were developed to estimate visibility impacts at Class I areas from proposed new sources as part of the Prevention of Significant Deterioration (PSD) and New Source Review (NSR) process and were adapted to BART. These procedures use the Interagency Monitoring of Protected Visual Environments (IMPROVE) reconstructed mass extinction equation (Malm et al., 2000), only instead of using measured PM concentrations from an IMPROVE monitor, incremental PM concentrations from the differences in the CAMx 2002 Base Case and 2002 BART VOC/PM Zero-Out runs will be utilized in the equation.

The IMPROVE reconstructed mass extinction equation is used to estimate visibility at Class I areas using IMPROVE monitoring data and has also been used for evaluating visibility impacts at Class I areas due to new sources using modeling output of a single source or group of sources. The total light extinction due to a source (b_{source}), in units of inverse Megameters (Mm^{-1}), is assumed to be the sum of the light extinction due to the source's individual PM species concentration impacts times an extinction efficiency coefficient:

$$\mathbf{b_{source} = b_{SO4} + b_{NO3} + b_{OC} + b_{EC} + b_{soil} + b_{coarse}}$$

$$b_{SO4} = 3\,[(NH_4)_2SO_4]f(RH)$$
$$b_{NO3} = 3\,[NH_4NO_3]f(RH)$$
$$b_{OC} = 4\,[OMC]$$
$$b_{EC} = 10\,[EC]$$
$$b_{Soil} = 1\,[Soil]$$
$$b_{coarse} = 0.6\,[Coarse\ Mass]$$

Here f(RH) are relative humidity adjustment factors. EPA BART modeling guidance recommends that Class I area specific monthly average f(RH) values be used (EPA, 2005; 2003a). The concentrations in the square brackets are in $\mu g/m^3$ and are based on the differences in concentrations between the 2002 BART Base Case and 2002 BART VOC/PM Zero-Out Case. Although CAMx explicitly models ammonia and ammonium, the IMPROVE extinction equation assumes that SO_4 and NO_3 are completely neutralized by ammonium. The OMC in the above equation is Organic Matter Carbon (OMC). When using IMPROVE measurements, the current IMPROVE extinction equation assumed an OMC/OC ratio of 1.4 (i.e., the IMPROVE Organic Carbon or OC measurement is multiplied by 1.4 to obtain OMC). Since CAMx directly models OMC, the 1.4 factor is not needed. The following species mappings are used to map the CAMx species to those used in the IMPROVE reconstructed mass extinction equation given above:

$$[(NH_4)_2SO_4] = 1.375 \times PSO4$$
$$[NH_4NO_3] = 1.290 \times PNO3$$
$$[OMC] = POA + SOA1 + SOA2 + SOA3 + SOA4 + SOA5$$
$$[EC] = PEC$$
$$[Soil] = FPRM + FCRS$$
$$[Coarse\ Mass] = CPRM + CCRS$$

Here PSO4 and PNO3 are the CAMx particulate sulfate and nitrate species. POA is the CAMx primary Particulate Organic Aerosol species, whereas SOA1-5 are the five Secondary Organic Aerosol species carried in CAMx. Primary Elemental Carbon is represented by PEC in CAMx. CAMx carries two species that represent the other $PM_{2.5}$ components (i.e., fine particles that are not SO_4, NO_3, EC or OC), one for the crustal (FCRS) and the other for the remainder of the primary emitted $PM_{2.5}$ species (FPRM). Similarly, CAMx carries two species to represent Coarse Mass ($PM_{2.5\text{-}10}$), one for crustal (CCRS) and one for other coarse PM (CPRM).

The Haze Index (HI) for the source is calculated in deciviews (dv) from the source's extinction plus natural background using the following formula:

$$HI_{source} = 10\ \ln[(b_{source} + b_{natural})/10]$$

Here, $b_{natural}$ is the Class I area specific clean natural visibility background where EPA's default values will be used in this analysis (EPA, 2003b).

The source's HI is compared against natural conditions to assess the significance of the source's visibility impact. EPA guidance lists natural conditions ($b_{natural}$) by Class I area in terms of Mm^{-1} (EPA, 2003b) and assumes clean conditions with no man-made or weather interference. The visibility significance metric for evaluating BART sources is the change in deciview (del-dv) from the source's and natural conditions haze indices:

$$\text{del-dv} = HI_{source} – HI_{natural} = 10 \ln[(b_{source} + b_{natural})/10] - 10 \ln[b_{natural}/10]$$
$$= 10\ln[(b_{source} + b_{natural})/b_{natural}]$$

The visibility impacts from the CAMx BART VOC/PM zero-out run can be calculated using all PM species to assess the visibility impacts due to the elimination of both VOC and PM emissions. Separate visibility calculations may be made using those PM species that may be associated with the elimination of the BART VOC emissions (i.e., SOA1, SOA2, SOA3, SOA4 and SOA5) and then those species associated with the elimination of the primary PM emissions (i.e., PSO4, PNO3, POA, PEC, FCRS, FPRM, FCRS and CCRS).

The del-dv impacts will be calculated at all Class I areas of interest. For each day, the maximum del-dv impact in a Class I area will be used to represent the visibility impact for that day at that Class I area.

Significance Threshold

The EPA BART guidance suggests that a significance threshold to determine whether a source significantly contributes to visibility impairment at a Class I area should be no greater than 0.5 dv. Thus, if the del-dv due to all potential BART-eligible sources VOC and PM emissions at every Class I area and for all days from 2002 are < 0.5 dv, then VOC and PM emissions from all potential BART-eligible sources would not contribute significantly to visibility impairment, and therefore, the VOC and PM emissions from each individual potential BART source would not be significant.

If there are any days in 2002 for which the del-dv is greater than 0.5 dv in the BART VOC/PM zero-out screening analysis, the results should be examined in more detail, including the analysis of the frequency, magnitude and duration of the visibility impacts. The BART guidance suggests comparing the 98th percentile del-dv at any Class I area with the 0.5 dv significant threshold to determine whether a significant visibility impact would reasonably be expected to occur. Using one year of modeling results (2002), the 98th percentile would correspond to the eighth highest 24-hour average visibility impact at each Class I area.

The separate assessment of the contribution of VOC (SOA1-5) versus primary PM related PM species should be examined to determine whether one precursor pollutant or the other is the cause of the del-dv exceeding the 0.5 dv significance threshold.

BART Screening Analysis for PM Emissions Only

If BART screening analysis is desired for primary PM emissions by themselves, then it is much simpler and more computationally efficient to run an inert CAMx simulation with the potential BART-eligible primary PM emissions as input. Gas-phase species and gas-, aqueous- and aerosol-phase chemistry do not affect the primary PM species so these species and chemistry do not need to be simulated when looking at the primary PM impacts. In this case, the BART PM emissions are processed and simulated by the model and only one inert simulation needs to be conducted. Chemistry is turned off in CAMx by setting the "Chemistry" option in the CAMx input file to ".false." (see Appendix A or B for example CAMx run control input files).

4.0 PROCEDURES FOR SCREENING BART SOURCES USING PSAT AND PiG

This section discusses the procedures for using CAMx with the PSAT and full-chemistry PiG subgrid-scale plume module for single source or multiple source BART or similar (e.g., NSR/PSD) modeling. Although the Texas PSAT/PiG BART screening analysis addressed impacts of SO_2 and NO_x emissions from BART non-EGU sources, the general approach can be used for all visibility impairing pollutants (i.e., NO_x, SO_2, PM, VOC and NH_3) as well as for both EGU and non-EGU sources. However, the PSAT computational requirements for simulating Secondary Organic Aerosol (SOA) formation from VOCs are more extensive than for the other PSAT families (see Chapter 2). In addition, the contributions of SOA due to BART type source VOC emissions to visibility impairment at Class I areas is extremely small. Thus, if VOC emissions are an issue, it is recommended that they first be addressed through a zero-out run as described in Chapter 3.

Specifics on the steps and options to be specified for running CAMx/PSAT/PiG for BART and similar assessments are provided in Chapter 5.

SUMMARY OF APPROACH

The updated PSAT that includes the new PiG module in CAMx Version 4.4 (and later versions) is used in the single source or multiple source BART analysis. For the Texas application, the 2002 36/12 km modeling database described in Section 2 was used. The Texas CAMx/PSAT/PiG source apportionment divided the non-EGU potential BART-eligible sources into several source groups for the screening analysis. CAMx/PSAT was run for the 2002 annual year on the 36/12 km grid with each potential BART-eligible source flagged to use the new PSAT PiG feature.

As described in Chapter 3, if the del-dv due to all sources in a source group at every Class I area and for all days from 2002 is < 0.5 dv, then each individual potential BART-eligible source in the source group would not contribute significantly to visibility impairment.

Visibility Impacts from PSAT

In the Texas CAMx/PSAT/PiG BART modeling, the sulfate (SO_4) and nitrate (NO_3) families of PSAT source apportionment tracers were invoked for the PSAT BART screening analysis. However, in the discussion below we try to be more general and include a discussion of how you would use the PSAT tracers for the primary PM and SOA PSAT families of PM source apportionment. However, as noted above, it is highly desirable to screen out the VOC emissions (and primary PM if possible) as a significant visibility contributor as the computational requirements of the PSAT SOA family of tracers is greater than the other PSAT families.

The visibility impacts at each Class I area will be calculated in a similar manner as described in Section 3 that uses the IMPROVE reconstructed mass extinction equation. Only concentrations from each PSAT BART source group will be used to calculate the Haze Index (HI) and change in deciview (del-dv) from natural conditions.

$$\mathbf{b_{source} = b_{SO4} + b_{NO3} + b_{OC} + b_{EC} + b_{soil} + b_{coarse}}$$

$$
\begin{aligned}
b_{SO4} &= 3\,[(NH_4)_2SO_4]f(RH) \\
b_{NO3} &= 3\,[NH_4NO_3]f(RH) \\
b_{OC} &= 4\,[OMC] \\
b_{EC} &= 10\,[EC] \\
b_{Soil} &= 1\,[Soil] \\
b_{coarse} &= 0.6\,[Coarse\ Mass]
\end{aligned}
$$

Here f(RH) are the monthly average relative humidity adjustment factors from EPA's guidance (EPA, 2003a). The concentrations in the square brackets are in $\mu g/m^3$ and are the concentrations from the PSAT output for each potential BART-eligible PSAT source group (i) with sulfate and nitrate assumed to be fully neutralized by ammonium. Using the PSAT species naming convention (see Chapter 2) these concentrations are as follows:

$$
\begin{aligned}
[(NH_4)_2SO_4] &= 1.375 \times PS4_i \\
[NH_4NO_3] &= 1.290 \times PN3_i \\
[OMC] &= POA_i + PO1_i + PO2_i + PO3_i + PO4_i + PO5_i \\
[EC] &= PEC_i \\
[Soil] &= PFC_i + PFN_i
\end{aligned}
$$

The Haze Index (HI) for the source group is calculated in deciview from the source group's extinction plus natural background using the following formula:

$$HI_{group} = 10\ \ln[(b_{group} + b_{natural})/10]$$

The source's HI is compared against natural conditions to assess the significance of the source's visibility impact. EPA guidance lists natural conditions ($b_{natural}$) by Class I areas in terms of Mm^{-1} (EPA, 2003b) and assumes clean conditions with no man-made or weather interference. The visibility significance metric for evaluating BART sources is the change in deciview (del-dv) from the source's and natural conditions haze indices:

$$\text{del-dv} = HI_{group} - HI_{natural} = 10\ \ln[(b_{group} + b_{natural})/10] - 10\ \ln(b_{natural}/10)$$

The 0.5 dv significance threshold is used to assess whether a potential BART-eligible source or source group contributes significantly to visibility impairment. If the del-dv for each day of 2002 and every 12 km grid cell that intersects with any Class I area is less than 0.5 dv, then the source groups SO_2 and NO_x emissions do not contribute significantly to visibility impairment at any Class I area. EPA's BART guidance suggests using the 98th percentile visibility impact at a Class I area in the visibility significance determination using this approach, then a source group would not have a significant contribution to visibility if the 8th highest 24-hour average del-dv at each Class I area is less than 0.5 dv.

5.0 DETAILS ON MODELING PROCEDURES

This section provides the details on the modeling procedures discussed in Chapters 4 and 5 for a single BART source or a group of BART sources, or a similar type of modeling analysis using CAMx. Example CAMx run scripts for a base case run as used in the Texas VOC and PM zero-out run is provided in Appendix A, and an example CAMx run script for a Texas BART PSAT/PiG modeling analysis is provided in Appendix B.

VOC AND PM ZERO-OUT MODELING

The CAMx VOC and PM zero-out modeling of BART emissions is conceptually straight forward and involves two runs: a base case simulation and a simulation with all VOC and PM emissions from the BART sources eliminated. For the Texas BART screening analysis, the CENRAP 2002 36 km Base B base case was the starting point for the analysis. The EPA BART Guidelines require the use of maximum actual 24-hour emission rates. Sources will need to determine their actual 24-hour maximum emission rate for use in their modeling analyses. The first step in the analysis is the Sparse Matrix Operator Kernel Emissions (SMOKE) emissions processing of the BART sources 24-hour maximum emission rates.

Compiling Emissions

1. Process the base case emissions with all emissions using SMOKE.

2. Separate BART sources 24-hour maximum actual VOC and PM emissions from 2002 base case emissions.

3. Separately process VOC and PM emissions from BART sources alone using SMOKE.

4. Zero-Out BART VOC and PM emissions inputs are obtained by subtracting the BART VOC and PM emissions (Step 3) from the base case emissions (Step 1).

Once the base case with the 24-hour maximum actual BART VOC and PM emissions and zero-out BART VOC and PM emissions model-ready emission inputs have been prepared, CAMx modeling and post-processing is performed in the following steps:

Running and Post-Processing CAMx

1. Perform CAMx runs for both zero-out and 24-hour maximum actual BART VOC and PM emissions scenarios.

2. Post-process the CAMx BART modeling results. This step involves extracting concentration data from the hourly average concentrations output files (*avrg and *favrg) which have a binary format (refer to the CAMx user's guide) and calculating 24-hour average concentrations from the hourly concentrations.

3. For each Class I area, calculate the change in 24-hour average concentrations of SOA (SOA1-4) from 24-hour maximum actual scenario and the zero-out scenario. Repeat the same steps to obtain two 24-hour average PM (non-SOA species) concentrations.

4. Calculate the mass extinction (b_{source}) and the difference in deciview (del-dv) from the source's and natural conditions haze indices. The formulation is described in Chapter 4.

5. Compare the 98th percentile del-dv at any Class I area with the 0.5 dv significance threshold. The delta deciview at the 98th percentile would correspond to the eighth highest 24-hour average visibility impact at each Class I area during the modeled year.

Appendix A lists an example CAMx script for the 2002 base case with 24-hour maximum actual Texas BART VOC and PM emissions. The script for the 2002 zero-out BART VOC and PM emissions would be similar, with the file names changed for the output files and the point source emission inputs. Changes from the standard CENRAP 2002 Base Case CAMx modeling script are:

- File names and locations to conform with current modeling;

- Addition of a second grid nest centered over Texas using a 12 km resolution grid (e.g., Number_of_Grids = 2,); and

- Specifying no input files for the second grid so that full flexi-nesting of the 12 km grid inputs from the 36 km grid will be used.

The differences in concentrations at each Class I receptor area will be extracted from the binary output files from the two CAMx runs. The visibility calculations described in Chapter 4 can then performed using an Excel spreadsheet.

PSAT MODELING

PSAT apportions PM components among several source groups as specified by the user. Source groups consist of a source region, defined by a source region map provided as input, and source categories, that are defined by the low-level and point source emission inputs that can be input for each of the PSAT source category. For example, the source region map could divide the domain into 10 different geographic areas (e.g., states) and separate emissions files could be provided for 4 source categories (e.g., biogenic, mobile, area or point) resulting in 42 source groups to be tracked (initial and boundary conditions are always tracked as two source groups).

For the PSAT BART modeling, each BART source or group of BART sources for which separate PM source apportionment is desired needs to be separately identified as a unique source group in the PSAT run. One way of doing this is to have multiple sets of the point source emission inputs with the first one being all point sources with their full emissions, the second one would be all point sources but with all emissions set to zero except those for the first BART source group, the third one would have all point source emissions zeroed-out except the second BART source group, etc. The CAMx PSAT could then be run using these different point source emissions source groups as inputs for each PSAT source group and with a source region map that included one region for the whole modeling domain.

However, for the Texas BART PSAT screening modeling we used an alternative approach using the PSAT/OSAT "point source override" feature. This was done by having a source region map with one source region for the entire domain and assigning a separate source region value in the point source input file that will override the source region that the point source resides in. In addition, a negative flag has to be set for source stack diameters in order for the BART point source to receive the PiG treatment. PSAT outputs require significant disk space. An annual run can take up to 450 gigabytes (GB) (excluding the deposition and the restart (*.depn and *.inst.1,) files. The steps for setting up the BART PSAT emissions are as follows:

<u>Compiling Emissions</u>

1. Process emissions from BART sources separately from non-BART sources. If there is more than one source group, the BART emission file must carry facility information including Federal Information Processing Standard (FIPS) codes, plant ID and stack ID to cross reference each point source to a point index list. In SMOKE, users have an option to create an elevated-point source input file in an ASCII format that contains all of this necessary information.
2. Assign the point index for each source group in the (unused) kcell[1] value on the point source file to a unique value for that source group.
3. Use maximum 24-hour actual NO_x and SO_2 emissions for the BART sources.
4. Set the stack diameters negative for the BART sources for PiG treatment.
5. Steps 2-4 can be accomplished by using "PIGSET_BART" program which outputs a binary CAMx-ready point source file.
6. Append BART emissions to non-BART emissions. This step can be achieved by using "PTSMRG" program.
7. Make a duplicate of the emission file and rename the copy. This step is necessary because the PSAT source apportionment tool needs to read the same emission file as the CAMx host model and once the CAMx main module is accessing it you can not open the file again for reading by PSAT.

Once the PSAT emission files have been generated, then CAMx can be run to obtain separate PM source apportionment modeling results for each individual BART source or group of BART sources as desired. Appendix B lists an example CAMx script for one of the Texas PSAT source apportionment model simulations. The screening analysis demonstrated that Texas BART sources' VOC emissions are insignificant to the visibility impairments at Class I areas (Morris and Nopmongcol, 2006). In addition, this screening analysis indicated that only some facilities contribute significantly to the visibility impairments. Consequently, for the Texas BART screening modeling, PSAT was run only for the SO_4 and NO_3 families of PSAT tracers. This approach, however, could be extended to the PM and SOA families as well.

<u>Running CAMx with PSAT</u>

8. Create a fixed-width format ASCII receptor definition input file. This file contains the location of Class I areas in the coordinate system of the CAMx grid. For example:

[1] The kcell value for each stack is contained in the time-variant portion of the elevated point source file. The value is typically ignored, except as flag for OSAT/PSAT point source override.

POINT BAND1 -831.124 -424.425

9. Generate source area region maps for a master grid and nested grids. The sources area mapping file assigns each grid cell to a specific geographic source region. The format of this file is an array of integer numbers (3i) corresponding to the CAMx domain (refer to the CAMx's user guide). For PSAT run, assign the same unique number, which is different from BART source groups, to every grid cell. For example, if BART source groups range from 1-10, assign number 11 to every grid cell in the source region map file. This unique number represents a group number of area and non-BART sources. Point source override in CAMx will discard this number and replace it with a user-specified BART source groups.
10. PSAT is invoked within the CAMx control file. In the &CAMx_Control namelist module, the variable Probing_Tool must be set to "PSAT" and Pig_Submodel must be set to "GREASD".
11. In the &SA_Control namelist, provide the name of SA_Receptor_Definitions and SA_Source_Area_Map files. For Texas application set PSAT_Treat_SULFATE_Class and PSAT_Treat_NITRATE_Class to "true" for SO_4 and NO_3 PSAT families.
12. Emission and meteorological inputs are optionally provided for the nested grid. If these files are not supplied, the Flexi-Nest algorithm within CAMx will interpolate the missing fields from the parent grid. In the Texas screening analysis case, 12 km Flexi-Nest was turned on.
13. Perform CAMx 36/12km run. 15 spin-up days is recommended.
14. PSAT output is in the receptor concentration file (*.sa.receptor) which contains information for all receptors and all 24 hours for each simulation day. This is a text format that users can use any scripting language to extract the data.
15. Post processing of BART results to estimate visibility for each Class I area is conducted as follows. First, use 24-hour average concentrations of sulfate and nitrate to calculate the mass extinction (b_{source}). Second, calculate the Haze Index (HI) and the change in deciview (del-dv) from the source's and natural conditions HI. The formulations of these two steps are described in Chapter 4. Finally, compare the 98th percentile del-dv at any Class I area with the 0.5 dv significant threshold. The deciview that the 98th percentile would correspond to is the eighth highest 24-hour average visibility impact at each Class I area.

The example CAMx script in Appendix B for a Texas PSAT SO_4 and NO_3 run is similar to the standard CENRAP CAMx 2002 base case script with the following changes:

- File names and locations were changed to be consistent with current applications;
- Number of grids changes to 2 with a 12 km grid added over Texas and surrounding regions;
- No input files specified for 12 km grid so that full flexi-nesting can be used;
- The "Probing Tool" option is set to PSAT; and
- The BOTT advection solver (BOTT, A. 1989) is specified rather than Piecewise-Parabolic Method (PPM).

The PPM solver was used in the zero-out runs. However, the BOTT advection solver was used in the PSAT run because it is more computationally efficient.

COMPUTATIONAL REQUIREMENTS

This section provides some example CAMx configurations for 36/12 km domain with flexi-nesting and associated system requirements when run on a dual-processor LINUX Power Management (PM) (with Operations and Management Platform-OMP).

Table 5-1. Example of computer requirements on a dual-processor Athlon 2800+ (2.1 Ghz) PC.

Run	Configuration	Memory	Disk Usage (excluding *inst.1 and *depn)	CPUs	Execution Time
VOC and PM zero-out	Chemistry turned on (Mechanism 4 CF)	356mB	255 MB/episode day	2	4 hrs/episode day
PM zero-out	Chemistry turned off	245mB	46.5 MB/ episode day	2	20 mins/ episode day
PSAT	10 Point Source Groups	1278mB	1.25 GB/ episode day	2	6.5 hrs/ episode day

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Appendix A

Example CAMx Run Script for a
Base Case or Zero-Out Run

```
#!/bin/csh
#
# CAMx 4.4beta OMP
#
setenv NCPUS 2
setenv MPSTKZ 128M
limit stacksize unlimited
#
set EXEC      =
"/disk52/tceq.bart/camx/src.v4.30.bart2/CAMx.tceq.bart.pg_linux"
#
set RUN     = "v4.30.tceq.bart.12FE"
set CHEM    = "/disk52/cenrap/camx/inputs/others"
set LUSE    = "/disk52/cenrap/camx/inputs/landuse"
set AHOMAP  = "/disk52/cenrap/camx/inputs/ahomap"
set PHOT    = "/disk52/cenrap/camx/inputs/tuv"
set ICBC    = "/disk52/cenrap/camx/inputs/icbctc"
set MET     = "/disk52/cenrap/camx/inputs/met"
set EMIS    = "/disk52/tceq.bart/camx/input/emis"
set OUTPUT  = "/swamp4/tceq.bart/camx/outputs/cen02b/Q1_double"
#
mkdir -p $OUTPUT
#
#  --- set the dates and times ----
#
set STARTDATE = 2002001
set ENDDATE   = 2002090

set JDATE = $STARTDATE

while ( $JDATE <= $ENDDATE )

set RESTART = "true"
if ( $JDATE == $STARTDATE ) set RESTART = "true"

@ YESTERDAY = $JDATE - 1
if ( $YESTERDAY == 2002000 ) set YESTERDAY = 2001365
set YYYY = `j2g $JDATE | awk '{print $1}'`
set MM = `j2g $JDATE | awk '{print $2}'`
set DD = `j2g $JDATE | awk '{print $3}'`

#
#  --- Create the input file (always called CAMx.in)
#
cat << ieof > CAMx.in

 &CAMx_Control

 Run_Message      = 'CAMx 4.30 Mech 4 CF - TCEQ.BART 36-12kmFE'

!--- Model clock control ---

 Time_Zone        = 0,                 ! (0=UTC,5=EST,6=CST,7=MST,8=PST)
 Restart          = .${RESTART}.,
 Start_Date_Hour  = ${YYYY},${MM},${DD},0000,   ! (YYYY,MM,DD,HHHH)
 End_Date_Hour    = ${YYYY},${MM},${DD},2400,   ! (YYYY,MM,DD,HHHH)

 Maximum_Timestep    = 20.,            ! minutes
 Met_Input_Frequency = 60.,            ! minutes
 Ems_Input_Frequency = 60.,            ! minutes
```

```
 Output_Frequency    = 60.,            ! minutes

!--- Map projection parameters ---

 Map_Projection           = 'LAMBERT'  ! (LAMBERT,POLAR,UTM,LATLON)
 UTM_Zone                 = 0,
 POLAR_Longitude_Pole     = 0.,        ! deg (west<0,south<0)
 POLAR_Latitude_Pole      = 0.,        ! deg (west<0,south<0)
 LAMBERT_Central_Meridian = -97.,      ! deg (west<0,south<0)
 LAMBERT_Center_Longitude = -97.,      ! deg (west<0,south<0)
 LAMBERT_Center_Latitude  =  40.,      ! deg (west<0,south<0)
 LAMBERT_True_Latitude1   =  45.,      ! deg (west<0,south<0)
 LAMBERT_True_Latitude2   =  33.,      ! deg (west<0,south<0)

!--- Parameters for the master (first) grid ---

 Number_of_Grids      = 2,
 Master_Origin_XCoord = -2736.,        ! km or deg, SW corner of cell(1,1)
 Master_Origin_YCoord = -2088.,        ! km or deg, SW corner of cell (1,1)
 Master_Cell_XSize    = 36.,           ! km or deg
 Master_Cell_YSize    = 36.,           ! km or deg
 Master_Grid_Columns  = 148,
 Master_Grid_Rows     = 112,
 Number_of_Layers(1)  = 19,

!--- Parameters for the second grid ---

 Nest_Meshing_Factor(2) = 3,           ! Relative to master grid
 Nest_Beg_I_Index(2)    = 51,           ! Relative to master grid
 Nest_End_I_Index(2)    = 87,          ! Relative to master grid
 Nest_Beg_J_Index(2)    = 14,           ! Relative to master grid
 Nest_End_J_Index(2)    = 49,          ! Relative to master grid
 Number_of_Layers(2)    = 19,

!--- Model options ---

 Diagnostic_Error_Check = .false.,      ! True = will stop after 1st timestep
 Advection_Solver       = 'PPM',        ! (PPM,BOTT)
 Chemistry_Solver       = 'CMC',        ! (CMC,IEH)
 PiG_Submodel           = 'GREASD',     ! (None,GREASD,IRON)
 Probing_Tool           = 'None',       ! (None,OSAT,GOAT,APCA,DDM,PA,RTRAC)
 Chemistry              = .true.,
 Dry_Deposition         = .true.,
 Wet_Deposition         = .true.,
 Staggered_Winds        = .true.,
 Gridded_Emissions      = .true.,
 Point_Emissions        = .true.,
 Ignore_Emission_Dates  = .true.,

!--- Output specifications ---

 Root_Output_Name         = '$OUTPUT/camx.$RUN.$JDATE',
 Average_Output_3D        = .false.,
 HDF_Format_Output        = .false.,
 Number_of_Output_Species = 35,
 Output_Species_Names(1)  = 'NO',
 Output_Species_Names(2)  = 'NO2',
 Output_Species_Names(3)  = 'O3',
 Output_Species_Names(4)  = 'PAN',
 Output_Species_Names(5)  = 'NXOY',
```

```
 Output_Species_Names(6)  = 'CO',
 Output_Species_Names(7)  = 'HONO',
 Output_Species_Names(8)  = 'HNO3',
 Output_Species_Names(9)  = 'NTR',
 Output_Species_Names(10)  = 'SO2',
 Output_Species_Names(11)  = 'SULF',
 Output_Species_Names(12)  = 'NH3',
 Output_Species_Names(13)  = 'HCL',
 Output_Species_Names(14)  = 'CG1',
 Output_Species_Names(15)  = 'CG2',
 Output_Species_Names(16)  = 'CG3',
 Output_Species_Names(17)  = 'CG4',
 Output_Species_Names(18)  = 'CG5',
 Output_Species_Names(19)  = 'PNO3',
 Output_Species_Names(20)  = 'PSO4',
 Output_Species_Names(21)  = 'PNH4',
 Output_Species_Names(22)  = 'POA',
 Output_Species_Names(23)  = 'SOA1',
 Output_Species_Names(24)  = 'SOA2',
 Output_Species_Names(25)  = 'SOA3',
 Output_Species_Names(26)  = 'SOA4',
 Output_Species_Names(27)  = 'SOA5',
 Output_Species_Names(28)  = 'PEC',
 Output_Species_Names(29)  = 'FPRM',
 Output_Species_Names(30)  = 'FCRS',
 Output_Species_Names(31)  = 'CPRM',
 Output_Species_Names(32)  = 'CCRS',
 Output_Species_Names(33)  = 'NA',
 Output_Species_Names(34)  = 'PCL',
 Output_Species_Names(35)  = 'PH2O',

!--- Input files ---

 Chemistry_Parameters = '$CHEM/CAMx4.3.chemparam.4_CF',
 Photolyis_Rates      = '$PHOT/tuv.cenrap36km.${YYYY}${MM}.20051013.txt',
 Initial_Conditions   = '$ICBC/ic.cenrap36km.CAMx',
 Boundary_Conditions  = '$ICBC/bc.cenrap36km.CAMx.$JDATE',
 Top_Concentrations   = '$ICBC/topc.cenrap36km.CAMx',
 Albedo_Haze_Ozone    = '$AHOMAP/ahomap.${YYYY}${MM}.20051013.txt',
 Point_Sources        =
'$EMIS/double/CAMx.pt.tceq_double.RPO_US36.cen02b.$JDATE',
 Master_Grid_Restart  = '$OUTPUT/camx.$RUN.$YESTERDAY.inst.2',
 Nested_Grid_Restart  = '$OUTPUT/camx.$RUN.$YESTERDAY.finst.2',
 PiG_Restart          = '$OUTPUT/camx.$RUN.$YESTERDAY.pig',

 Emiss_Grid(1)   = '$EMIS/CAMx.ar.tceq_zero.RPO_US36.cen02b.$JDATE',
 Landuse_Grid(1) = '$LUSE/CAMx.cenrap36km.luse.bin',
 ZP_Grid(1)      = '$MET/camx.zp.${YYYY}${MM}${DD}.OB70.bin',
 Wind_Grid(1)    = '$MET/camx.uv.${YYYY}${MM}${DD}.OB70.bin',
 Temp_Grid(1)    = '$MET/camx.tp.${YYYY}${MM}${DD}.OB70.bin',
 Vapor_Grid(1)   = '$MET/camx.qa.${YYYY}${MM}${DD}.OB70.bin',
 Cloud_Grid(1)   = '$MET/camx.cr.${YYYY}${MM}${DD}.OB70.bin',
 Kv_Grid(1)      = '$MET/camx.kv.${YYYY}${MM}${DD}.CMAQ.kvmin1.0.bin',
 Emiss_Grid(2)   = ' ',
 Landuse_Grid(2) = ' ',
 ZP_Grid(2)      = ' ',
 Wind_Grid(2)    = ' ',
 Temp_Grid(2)    = ' ',
 Vapor_Grid(2)   = ' ',
 Cloud_Grid(2)   = ' ',
```

```
 Kv_Grid(2)      = ' ',

 &
!-----------------------------------------------------------------------------
---
ieof
#
#  --- Execute the model ---
#
/usr/bin/time $EXEC >& $OUTPUT/camx.$RUN.$JDATE.stdout

@ JDATE++
if ( $JDATE == 2001366 ) set JDATE = 2002001

end
```

Appendix B

Example CAMx Run Script for a
PSAT BART Analysis using the
SO_4 and NO_3 PSAT Tracers

```
#!/bin/csh
#
# CAMx 4.40beta OMP
#
setenv NCPUS 2
setenv MPSTKZ 128M
limit stacksize unlimited
#
set EXEC      =
"/disk52/tceq.bart/camx/src.v4.40.Mar29/CAMx.tceq.bart.pg_linuxomp"
#
set run = Q1.tceq.psat.oldmet
set RUN     = "v4.40.tceq.bart.12FE"
set CHEM    = "/disk52/cenrap/camx/inputs/others"
set LUSE    = "/disk52/cenrap/camx/inputs/landuse"
set AHOMAP  = "/disk52/cenrap/camx/inputs/ahomap"
set PHOT    = "/disk52/cenrap/camx/inputs/tuv"
set ICBC    = "/disk52/cenrap/camx/inputs/icbctc"
set MET     = "/disk50/tceq_bart/met"
set MAP     = "/disk52/tceq.bart/camx/input/sa"
set EMIS    = "/disk52/tceq.bart/camx/input/emis/psat"
set OUTPUT  = "/swamp6/tceq.bart2/camx/outputs/Q1.psat.tceqbart.12FE.oldmet"
#
mkdir -p $OUTPUT $run
#
#  --- set the dates and times ----
#
set STARTDATE = 2001353
set ENDDATE   = 2002364

set JDATE = 2002021

while ( $JDATE <= $ENDDATE )

set RESTART = "true"
if ( $JDATE == $STARTDATE ) set RESTART = "false"

@ YESTERDAY = $JDATE - 1
if ( $YESTERDAY == 2002000 ) set YESTERDAY = 2001365
set YYYY = `j2g $JDATE | awk '{print $1}'`
set Y2 = `echo $YYYY | awk '{printf("%2.2d",$1-2000)}'`
set MM = `j2g $JDATE | awk '{print $2}'`
set DD = `j2g $JDATE | awk '{print $3}'`


#  --- Create the input file (always called CAMx.in)
#
cat << ieof > CAMx.in

 &CAMx_Control

 Run_Message      = 'CAMx 4.40 Mech 4 CF - TCEQ.BART 36-12kmFE'

!--- Model clock control ---

 Time_Zone        = 0,                 ! (0=UTC,5=EST,6=CST,7=MST,8=PST)
 Restart          = .${RESTART}.,
 Start_Date_Hour  = ${YYYY},${MM},${DD},0000,   ! (YYYY,MM,DD,HHHH)
 End_Date_Hour    = ${YYYY},${MM},${DD},2400,   ! (YYYY,MM,DD,HHHH)
```

```
 Maximum_Timestep    = 20.,             ! minutes
 Met_Input_Frequency = 60.,             ! minutes
 Ems_Input_Frequency = 60.,             ! minutes
 Output_Frequency    = 60.,             ! minutes

!--- Map projection parameters ---

 Map_Projection            = 'LAMBERT'  ! (LAMBERT,POLAR,UTM,LATLON)
 UTM_Zone                  = 0,
 POLAR_Longitude_Pole      = 0.,        ! deg (west<0,south<0)
 POLAR_Latitude_Pole       = 0.,        ! deg (west<0,south<0)
 LAMBERT_Central_Meridian = -97.,       ! deg (west<0,south<0)
 LAMBERT_Center_Longitude = -97.,       ! deg (west<0,south<0)
 LAMBERT_Center_Latitude  =  40.,       ! deg (west<0,south<0)
 LAMBERT_True_Latitude1   =  45.,       ! deg (west<0,south<0)
 LAMBERT_True_Latitude2   =  33.,       ! deg (west<0,south<0)

!--- Parameters for the master (first) grid ---

 Number_of_Grids      = 2,
 Master_Origin_XCoord = -2736.,         ! km or deg, SW corner of cell(1,1)
 Master_Origin_YCoord = -2088.,         ! km or deg, SW corner of cell (1,1)
 Master_Cell_XSize    = 36.,            ! km or deg
 Master_Cell_YSize    = 36.,            ! km or deg
 Master_Grid_Columns  = 148,
 Master_Grid_Rows     = 112,
 Number_of_Layers(1)  = 19,

!--- Parameters for the second grid ---

 Nest_Meshing_Factor(2) = 3,            ! Relative to master grid
 Nest_Beg_I_Index(2)    = 51,            ! Relative to master grid
 Nest_End_I_Index(2)    = 87,           ! Relative to master grid
 Nest_Beg_J_Index(2)    = 14,            ! Relative to master grid
 Nest_End_J_Index(2)    = 49,           ! Relative to master grid
 Number_of_Layers(2)    = 19,

!--- Model options ---

 Diagnostic_Error_Check = .false.,      ! True = will stop after 1st timestep
 Advection_Solver       = 'BOTT',        ! (PPM,BOTT)
 Chemistry_Solver       = 'CMC',        ! (CMC,IEH)
 Aerosol_Solver         = 'ISOROPIA',  ! (ISOROPIA,EQSAM)
 PiG_Submodel           = 'GREASD',       ! (None,GREASD,IRON)
 Probing_Tool           = 'PSAT',       ! (None,OSAT,GOAT,APCA,DDM,PA,RTRAC)
 Chemistry              = .true.,
 Dry_Deposition         = .true.,
 Wet_Deposition         = .true.,
 Staggered_Winds        = .true.,
 Gridded_Emissions      = .true.,
 Point_Emissions        = .true.,
 Ignore_Emission_Dates  = .true.,

!--- Output specifications ---

 Root_Output_Name          = '$OUTPUT/camx.$RUN.$JDATE',
 Average_Output_3D         = .false.,
 HDF_Format_Output         = .false.,
 Number_of_Output_Species = 35,
 Output_Species_Names(1)  = 'NO',
```

```
 Output_Species_Names(2)  = 'NO2',
 Output_Species_Names(3)  = 'O3',
 Output_Species_Names(4)  = 'PAN',
 Output_Species_Names(5)  = 'NXOY',
 Output_Species_Names(6)  = 'CO',
 Output_Species_Names(7)  = 'HONO',
 Output_Species_Names(8)  = 'HNO3',
 Output_Species_Names(9)  = 'NTR',
 Output_Species_Names(10)  = 'SO2',
 Output_Species_Names(11)  = 'SULF',
 Output_Species_Names(12)  = 'NH3',
 Output_Species_Names(13)  = 'HCL',
 Output_Species_Names(14)  = 'CG1',
 Output_Species_Names(15)  = 'CG2',
 Output_Species_Names(16)  = 'CG3',
 Output_Species_Names(17)  = 'CG4',
 Output_Species_Names(18)  = 'CG5',
 Output_Species_Names(19)  = 'PNO3',
 Output_Species_Names(20)  = 'PSO4',
 Output_Species_Names(21)  = 'PNH4',
 Output_Species_Names(22)  = 'POA',
 Output_Species_Names(23)  = 'SOA1',
 Output_Species_Names(24)  = 'SOA2',
 Output_Species_Names(25)  = 'SOA3',
 Output_Species_Names(26)  = 'SOA4',
 Output_Species_Names(27)  = 'SOA5',
 Output_Species_Names(28)  = 'PEC',
 Output_Species_Names(29)  = 'FPRM',
 Output_Species_Names(30)  = 'FCRS',
 Output_Species_Names(31)  = 'CPRM',
 Output_Species_Names(32)  = 'CCRS',
 Output_Species_Names(33)  = 'NA',
 Output_Species_Names(34)  = 'PCL',
 Output_Species_Names(35)  = 'PH2O',

!--- Input files ---

 Chemistry_Parameters = '$CHEM/CAMx4.3.chemparam.4_CF',
 Photolyis_Rates      = '$PHOT/tuv.cenrap36km.${YYYY}${MM}.20051013.txt',
 Initial_Conditions   = '$ICBC/ic.cenrap36km.CAMx',
 Boundary_Conditions  = '$ICBC/bc.cenrap36km.CAMx.$JDATE',
 Top_Concentrations   = '$ICBC/topc.cenrap36km.CAMx',
 Albedo_Haze_Ozone    = '$AHOMAP/ahomap.${YYYY}${MM}.20051013.txt',
 Point_Sources        = '$EMIS/CAMx.FE.pt.tceq_psat.RPO_US36.cen02b.$JDATE',
 Master_Grid_Restart  = '$OUTPUT/camx.$RUN.$YESTERDAY.inst.2',
 Nested_Grid_Restart  = '$OUTPUT/camx.$RUN.$YESTERDAY.finst.2',
 PiG_Restart          = '$OUTPUT/camx.$RUN.$YESTERDAY.pig',

 Emiss_Grid(1)   = '$EMIS/CAMx.ar.cenrapzero.RPO_US36.cen02b.$JDATE',
 Landuse_Grid(1) = '$LUSE/CAMx.cenrap36km.luse.bin',
 ZP_Grid(1)      = '$MET/camx.zp.${YYYY}${MM}${DD}.OB70.bin',
 Wind_Grid(1)    = '$MET/camx.uv.${YYYY}${MM}${DD}.OB70.bin',
 Temp_Grid(1)    = '$MET/camx.tp.${YYYY}${MM}${DD}.OB70.bin',
 Vapor_Grid(1)   = '$MET/camx.qa.${YYYY}${MM}${DD}.OB70.bin',
 Cloud_Grid(1)   = '$MET/camx.cr.${YYYY}${MM}${DD}.OB70.bin',
 Kv_Grid(1)      = '$MET/camx.kv.${YYYY}${MM}${DD}.CMAQ.kvmin1.0.bin',
 Emiss_Grid(2)   = '$EMIS/CAMx.ar.cenrapzero.RPO_US12.cen02b.$JDATE',
 Landuse_Grid(2) = ' ',
 ZP_Grid(2)      = ' ',
 Wind_Grid(2)    = ' ',
```

```
 Temp_Grid(2)     = ' ',
 Vapor_Grid(2)    = ' ',
 Cloud_Grid(2)    = ' ',
 Kv_Grid(2)       = ' ',

 &
!-----------------------------------------------------------------------------
---

&SA_Control

 SA_File_Root                  = '$OUTPUT/camx.$RUN.$JDATE',
 SA_Summary_Output             = .false.
 SA_Master_Sfc_Output          = .true.,
 SA_Nested_Sfc_Output          = .true.,
 SA_Stratify_Boundary          = .false.,
 SA_Number_of_Source_Regions =  11,
 SA_Number_of_Source_Groups  =  2,
 Use_Leftover_Group            = .false.,
 Number_of_Timing_Releases   =  0,
 SA_Receptor_Definitions     = '$MAP/receptor.tceqbart.txt'
 SA_Source_Area_Map(1)       = '$MAP/BART_psat_regn_36km.txt'
 SA_Source_Area_Map(2)       = '$MAP/BART_psat_regn_12km.txt'
 SA_Points_Group(1)          =
'$EMIS/CAMx.FE.pt.tceq_psat.RPO_US36.cen02b.$JDATE.copy',
 SA_Emiss_Group_Grid(1,1)    = ' ',
 SA_Emiss_Group_Grid(1,2)    = ' ',
 SA_Points_Group(2)          = ' ',
 SA_Emiss_Group_Grid(2,1)    =
'$EMIS/CAMx.ar.cenrapzero.RPO_US36.cen02b.$JDATE.copy',
 SA_Emiss_Group_Grid(2,2)    =
'$EMIS/CAMx.ar.cenrapzero.RPO_US12.cen02b.$JDATE.copy',
 SA_Master_Restart           = '$OUTPUT/camx.$RUN.$YESTERDAY.sa.inst.2',
 SA_Nested_Restart           = '$OUTPUT/camx.$RUN.$YESTERDAY.sa.finst.2',
 PSAT_Treat_SULFATE_Class    = .true.
 PSAT_Treat_NITRATE_Class    = .true.
 PSAT_Treat_SOA_Class        = .false.
 PSAT_Treat_PRIMARY_Class    = .false.
 PSAT_Treat_MERCURY_Class    = .false.
 PSAT_Treat_OZONE_Class      = .false.

&

ieof
#
#  --- Execute the model ---
#
cp CAMx.in $run/camx.$RUN.$JDATE.in
/usr/bin/time $EXEC |& tee $run/camx.$RUN.$JDATE.stdout

@ JDATE++
if ( $JDATE == 2001366 ) set JDATE = 2002001

end
```

ATTACHMENT F

Facility Emission Source Data

FIN	EPN	Stack Height (ft)	Stack Diameter (ft)	Temperature (°F)	Velocity (ft/sec)	Lattitude	Longitude	Cap Allocations (lbs/24 hours)			2002 Actual Emissions (tons/year)		
								NO_X	SO_2	PM_{10}	NO_X	SO_2	PM_{10}
REG + CO	12-CO STK	185	10	400	25.319999	27.810555	-97.43805	990.0	1,924.7	204.6	155.3	666.5	16.1
PPBBMER-V1	EP-FLARE1	100	2.3557	1000	65.599998	27.815277	-97.43694	26.0	0.0	0.0	4.1	0.0	0.0
H-1ALKY1	17-H-1	62	4	600	12.159999	27.811388	-97.43694	45.5	0.6	6.9	7.1	0.2	0.5
PPBBMER-V2	17-H-1	62	4	600	12.159999	27.811388	-97.43694	4.9	0.0	0.0	0.8	0.0	0.0
H-1FCCU1	12-H-1	86	7.5	605	12.85	27.810833	-97.43833	75.0	1.1	11.3	11.8	0.4	0.9
H-1KERO1	37-H-1	100	3.5	728	15.51	27.810277	-97.44527	34.6	0.5	5.2	5.4	0.2	0.4
H-1DIST1	38-H-1	100	3.5	659	15.1	27.810277	-97.445	6.5	0.1	1.0	1.0	0.0	0.1
H-1REF4	39-H-1	91	4.5	704	23.19	27.809722	-97.44611	8.5	0.1	1.3	1.3	0.0	0.1
H-2KERO1	37-H-2	100	3.5	609	9.6400003	27.810277	-97.445	18.7	0.3	2.8	2.9	0.1	0.2
H-2DIST1	38-H-2	100	3.5	500	13.89	27.810277	-97.445	10.9	0.2	1.7	1.7	0.1	0.1
H-2REF4	39-H-2	86	4.5	575	14.1	27.809722	-97.44611	73.3	1.1	11.0	11.5	0.4	0.9
H-3VAC4	8-H-3	100	6	717	11.02	27.809722	-97.445	7.1	0.5	4.8	1.1	0.2	0.4
H-3REF4	39-H-3	152	7.8	538	12.189999	27.809444	-97.44611	1,271.1	6.7	68.7	199.4	2.3	5.4
H-7REF4	39-H-7	86	4.5	575	16.159999	27.809722	-97.44611	62.9	0.9	9.5	9.9	0.3	0.8
H-1BTX1	27-H-1	74	3.25	500	12.6	27.811388	-97.43888	61.5	0.9	9.3	9.7	0.3	0.7
H-2GOT1	44-H-2	122	2	682	15.6	27.809722	-97.44861	96.8	1.4	14.6	15.2	0.5	1.2
SRU1-INCIN	SRU1-INCIN	255	4	682	33.069999	27.810277	-97.44666	8.0	60.1	6.9	1.3	20.8	0.5
CT2	84-CT2	3	0.003	72	0.0003	27.812222	-97.43722	0.0	0.0	536.8	0.0	0.0	42.3
H-6CRU4	8-H-6	142	10.5	581	14.25	27.81	-97.44472	102.5	8.2	84.5	16.1	2.8	6.7
H-2COKE1	7-H-2	170	8.5	345	12.96	27.810555	-97.44611	180.9	3.8	14.1	28.4	1.3	1.1
E. COGEN	COGEN-1	50	10	400	73.699996	27.81	-97.44361	2,117.5	4.4	88.5	332.1	1.5	7.0
HCU-FLARE	HCU-FL1	213	1.3131	1000	65.599998	27.808888	-97.45527	0.3	0.0	0.0	0.0	0.0	0.0
HCU-V3	HCU-FL1	213	1.3131	1000	65.599998	27.808888	-97.45527	0.0	0.0	0.0	0.0	0.0	0.0
REF2-FLARE	REF2-FL1	213	1.408	1000	65.599998	27.809166	-97.45583	0.3	0.0	0.0	0.0	0.0	0.0
QBTX-V1	REF2-FL1	213	1.408	1000	65.599998	27.809166	-97.45583	0.0	0.0	0.0	0.0	0.0	0.0
NHDS-V1	REF2-FL1	213	1.408	1000	65.599998	27.809166	-97.45583	6.3	0.0	0.0	1.0	0.0	0.0
QPSULF-V1	REF2-FL1	213	1.408	1000	65.599998	27.809166	-97.45583	2.8	0.0	0.0	0.4	0.0	0.0
H-1SMR	Q10-H-1	71	5.3299	425	55.639999	27.808055	-97.45555	1,023.3	3.6	55.3	160.5	1.2	4.4
H-4CRU4	8-H-4	100	8.5	760	17.139999	27.81	-97.445	639.1	3.3	34.5	100.2	1.2	2.7
H-5VAC4	8-H-5	100	5	798	20.799999	27.809722	-97.445	38.5	1.0	9.9	6.0	0.3	0.8
QREF2-C1	16-COMP1	31	0.8299	674	70	27.808333	-97.45611	157.5	0.0	0.0	24.7	0.0	0.0
QREF2-C2	16-COMP2	31	0.8299	674	70	27.808333	-97.45611	157.5	0.0	0.0	24.7	0.0	0.0
QREF2-C3	16-COMP3	31	1.1799	674	70	27.808333	-97.45611	196.8	0.0	0.0	30.9	0.0	0.0
QREF2-C4	16-COMP4	31	1.1799	674	70	27.808333	-97.45611	196.8	0.0	0.0	30.9	0.0	0.0
H-125QREF2	QH-125	178	9.5	524	10.119999	27.808333	-97.45638	74.0	0.3	12.4	11.6	0.1	1.0
WP-FLARE	WP-FLARE1	186	5.5958	1000	65.599998	27.809722	-97.44861	0.3	0.0	0.0	0.0	0.0	0.0
ARU1-V1	WP-FLARE1	186	5.5958	1000	65.599998	27.809722	-97.44861	3.3	75.4	0.0	0.5	26.1	0.0
GOT1-V1	WP-FLARE1	186	5.5958	1000	65.599998	27.809722	-97.44861	16.9	0.1	0.0	2.7	0.0	0.0
SWS2-V1	WP-FLARE1	186	5.5958	1000	65.599998	27.809722	-97.44861	59.8	5,685.2	0.0	9.4	1,968.8	0.0
ARU2-V1	WP-FLARE1	186	5.5958	1000	65.599998	27.809722	-97.44861	3.3	75.4	0.0	0.5	26.1	0.0
SWS1-V2	WP-FLARE1	186	5.5958	1000	65.599998	27.809722	-97.44861	7.8	1,472.5	0.0	1.2	509.9	0.0
LEUMER-V1	WP-FLARE1	186	5.5958	1000	65.599998	27.809722	-97.44861	0.1	0.0	0.0	0.0	0.0	0.0
H-1GOT1	44-H-1	120	7.5	430	16.28	27.808888	-97.445	563.7	2.9	30.5	88.4	1.0	2.4
CT1	83-CT1	3	0.003	72	0.0003	27.812777	-97.43833	0.0	0.0	823.7	0.0	0.0	64.9
SRU1-FLARE	SRU1-FLARE	122	5.4258	993	23.849196	27.810277	-97.44666	0.8	0.0	0.0	0.1	0.0	0.0
SWS-FLARE	SWS-FLARE	139	5.3889	911	26.420311	27.810277	-97.44722	1.6	0.0	0.0	0.2	0.0	0.0
CT8	QTBABTX-CT	3	0.003	72	0.0003	27.813055	-97.43638	0.0	0.0	155.9	0.0	0.0	12.3
H-TK-47	H-TK-47	33	1	600	27.29	27.809166	-97.44416	8.0	0.1	1.1	1.3	0.0	0.1
H-TK-48	H-TK-48	33	1	600	27.29	27.809166	-97.44388	8.0	0.1	1.1	1.3	0.0	0.1
H-TK-54	H-TK-54	43	1	600	16.93	27.81	-97.44027	4.9	0.1	0.8	0.8	0.0	0.1
H-TK-83	H-TK-83	49	1	600	16.93	27.809722	-97.44138	4.9	0.1	0.8	0.8	0.0	0.1
H-3GOT1	44-H-3	76	3.5	520	16.5	27.808888	-97.44527	16.5	0.5	5.0	2.6	0.2	0.4
H-TK-70	H-TK-70	50	1	600	16.93	27.810277	-97.44111	4.9	0.1	0.8	0.8	0.0	0.1
							TOTAL:	**8,400.0**	**9,336.0**	**2,215.2**	**1,317.5**	**3,233.1**	**174.5**