STATE OF MISSISSIPPI
TATE REEVES
GOVERNOR
MISSISSIPPI DEPARTMENT OF ENVIRONMENTAL QUALITY
CHRIS WELLS, INTERIM EXECUTIVE DIRECTOR

April 23, 2020

Mary S. Walker
Regional Administrator
U.S. Environmental Protection Agency
61 Forsyth Street
Atlanta, Georgia 30303-8960

Dear ~~Madam Walker~~ Mary:

Re: Mississippi Infrastructure Prong 4 Approval Request

On April 23, the Mississippi Department of Environmental Quality sent to the United States Environmental Protection Agency (EPA) a proposed State Implementation Plan (SIP) package to address Best Available Retrofit Technology (BART) requirements for the seven eligible Electric Generating Units in Mississippi. The Department requested parallel processing of the BART SIP and that EPA change its limited approval and limited disapproval of Mississippi's Regional Haze State Implementation Plan (SIP) to a full approval.

With this letter, if the EPA fully approves Mississippi's final BART SIP and converts the limited approval and limited disapproval of Mississippi's Regional Haze SIP to a full approval, the Department requests that the EPA change its disapprovals of the visibility transport portions (i.e., prong 4) of revisions to Mississippi's infrastructure SIPs addressing the Clean Air Act requirements for the 2008 8-hour ozone, 2010 1-hour nitrogen dioxide (NO_2), 2010 1-hour sulfur dioxide (SO_2), and 2012 annual fine particulate matter ($PM_{2.5}$) National Ambient Air Quality Standards (NAAQS) to approvals. In the past, EPA disapproved the prong 4 portions of Mississippi's May 29, 2012, 2008 8-hour ozone NAAQS infrastructure SIP submission; July 26, 2012, 2008 8-hour ozone NAAQS infrastructure SIP resubmission; February 28, 2013, 2010 1-hour NO_2 NAAQS infrastructure SIP submission; June 20, 2013, 2010 1-hour SO_2 NAAQS infrastructure SIP submission; and December 8, 2015, 2012 annual $PM_{2.5}$ NAAQS infrastructure SIP submission. (*See* 81 FR 33139; May 25, 2016.)

If you have any questions or need further information, please advise.

Sincerely,

Chris Wells
Interim Executive Director

OFFICE OF POLLUTION CONTROL
Post Office Box 2261Jackson, Mississippi 39225-2261·Tel: (601) 961-5171·Fax: (601) 354-6612·www.mdeq.ms.gov
AN EQUAL OPPORTUNITY EMPLOYER

cc: Lynorae Benjamin
U.S. EPA Region 4
Air Planning and Implementation Branch
Atlanta, GA

STATE OF MISSISSIPPI
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CHRIS WELLS, INTERIM EXECUTIVE DIRECTOR

April 23, 2020

Mary S. Walker
Regional Administrator
U.S. Environmental Protection Agency
61 Forsyth Street
Atlanta, Georgia 30303-8960

Dear ~~Madam Walker~~ Mary:

Re: Mississippi EGU BART SIP

Enclosed is the proposed State Implementation Plan (SIP) package to address Best Available Retrofit Technology (BART) requirements for the seven eligible Electric Generating Units (EGUs) in Mississippi.

Mississippi's Regional Haze SIP was submitted on September 22, 2008 to the EPA, and subsequently amended and the amendment was sent on May 9, 2011. The seven EGUs were included in a final rule which EPA issued a limited approval and limited disapproval on Mississippi's Regional Haze SIP because of deficiencies arising from reliance on the Clean Air Interstate Rule to satisfy certain regional haze requirements for those affected EGUs. (77 FR 38191) The Department requests EPA parallel process the proposed BART SIP and find that it corrects the deficiencies which led to the limited approval and limited disapproval of Mississippi's Regional Haze SIP. The Department also requests EPA withdraw the limited disapproval of the Regional Haze SIP and fully approve the Regional Haze SIP as meeting all regional haze requirements of the Clean Air Act for the first implementation period.

The public comment period on this proposed SIP will begin April 23, 2020 and ends on May 23, 2020.

Barring significant adverse comment or a request for public hearing, the Department plans to submit the final BART SIP by July 1, 2020.

If you have any questions or need further information, please advise.

Sincerely,

Chris Wells
Interim Executive Director

cc: Lynorae Benjamin
U.S. EPA Region 4
Air Planning and Implementation Branch
Atlanta, GA

Tim Allen
U.S. Fish and Wildlife Service
Air Quality Branch
Lakewood, CO

Brett Anderson
USDA Forest Service
Roanoke, VA

Melanie Peters
National Park Service
Air Resources Division
Denver, Colorado

MISSISSIPPI
DEPARTMENT OF ENVIRONMENTAL QUALITY
OFFICE OF POLLUTION CONTROL

PROPOSED
STATE IMPLEMENTATION PLAN (SIP) REVISION
REGARDING FEDERAL REGIONAL HAZE PROGRAM BEST AVAILABLE RETROFIT TECHNOLOGY (BART) REQUIREMENTS FOR ELECTRIC GENERATING UNITS (EGU)

Public Notice Start Date: April 23, 2020
Public Comment End Date: May 23, 2020

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1) Introduction: Proposed State Implementation Plan (SIP) Revision Regarding Regional Haze Requirements of the Federal Clean Air Act Addressing Visibility in Federal Class I Areas.

Regional haze is visibility impairment caused by sources and activities emitting fine particles and their precursors, often transported over large regions. Particles affect visibility through the scattering and absorption of light. Reducing fine particles in the atmosphere is an effective method of improving visibility. In the southeast, the most important sources of haze-forming emissions are coal-fired power plants, industrial boilers and other combustion sources, but mobile source emissions, area sources, fires, and wind blown dust also contribute.

In the 1977 Amendments to the Clean Air Act (CAA), Congress set forth a program for protecting the visibility in mandatory Class I Federal areas in order to protect visibility in 156 national parks and wilderness areas. In 1999, the United States Environmental Protection Agency (EPA) promulgated the Regional Haze Rule (RHR) (64 FR 35713), which revised the existing visibility regulations in order to integrate provisions addressing regional haze impairment and establish a comprehensive visibility protection program for Class I Federal areas. States are required to submit state implementation plans (SIPs) to EPA that set out each state's plan for complying with the regional haze rule and to consult with other states and federal land managers, in order to reduce visibility impairment.

Five Regional Planning Organizations (RPOs) assist with the coordination and cooperation needed to address the visibility issue. The states that make up the southeastern portion of the contiguous United States are known as VISTAS (Visibility Improvement – State and Tribal Association of the Southeast) and include: Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, West Virginia, and the Eastern Band of Cherokee Indians. Through the VISTAS program, Mississippi has developed a SIP in order to meet the regional haze requirements set forth by the EPA and to assess the effect of the state's emissions on Class 1 areas in surrounding states.

Section 169A of the CAA directs States to assess certain large, older emission sources for additional controls in order to address visibility impacts. States are directed to conduct BART determinations for such sources in specific source categories, and which contribute to visibility impairment in Class I areas. The 1999 regional haze rule includes the BART requirement, and directs States to include BART in their regional haze SIPs. On July 6, 2005, USEPA published a revised final rule, including Appendix Y to 40 CFR Part 51, the *Guidelines for BART Determinations Under the Regional Haze Rule* (hereinafter referred to as the “BART Guidelines”) that provides direction to states on determining which of these sources should be subject to BART, and how to determine BART for each source.

The purpose of this SIP is to address BART requirements for seven BART eligible electric Generating Units (EGUs) in Mississippi. These facilities were determined to be not subject to BART in Mississippi’s 2008 Regional Haze submittal because they were subject to the Clean Air Interstate Rule (CAIR) that was determined to be better than BART for Sulfur Dioxide and Nitrogen Oxides and the particulate matter impacts were below the BART Threshold. However, the Cross State Air Pollution Rule (CSAPR) replaced CAIR and Mississippi was determined to be only subject the Ozone Season NOx Provisions. Since SO2 is the primary pollutant of concern for Regional Haze in the southeast and the facilities were not subject to the SO2 provisions of CSAPR, these facilities had to be readdressed for BART.

2) Notification of Public Comment period for Proposed Regional Haze SIP Revision.

The notice of public comment is to be published beginning on April 23, 2020 in daily newspapers in the cities of Gulfport, Jackson, and Tupelo in the State of Mississippi. The notice of public hearing and the proposed SIP revision will be made available for public review in the main branches of the public libraries in the above mentioned cities and at the offices of the Mississippi Department of Environmental Quality, 515 E. Amite Street, Jackson, Mississippi. This notice was also posted on the MDEQ website and mailed to persons on the air pollution control regulation mailing list. A public hearing will be held if there is sufficient interest.

The public notice follows this page.

Public Notice
Mississippi Commission on Environmental Quality
P.O. Box 2261
Jackson, MS 39225
Telephone No. (601) 961-5171

Public Notice Start Date: April 23, 2020 MDEQ Contact: Elliott Bickerstaff

Deadline for Comment: May 23, 2020

Please take note that the Mississippi Commission on Environmental Quality ("Commission") is providing draft information for comment regarding Mississippi's Regional Haze State Implementation Plan (SIP) for Federal Class I Areas that may be affected by emissions from within the State of Mississippi as required by 40 CFR 51.308. This SIP revises the previous SIP that was initially adopted by the Commission on August 28, 2008 and revised on May 9, 2011. This revision of the SIP addresses Best Available Retrofit Technology (BART) provisions of the Regional Haze Rule for seven electric generating units in Mississippi.

Pending the approval of the SIP, the Commission is also requesting that the EPA change its disapprovals of the visibility transport portions (i.e., prong 4) of revisions to Mississippi's infrastructure SIPs addressing the Clean Air Act requirements for the 2008 8-hour ozone, 2010 1-hour nitrogen dioxide (NO_2), 2010 1-hour sulfur dioxide (SO_2), and 2012 annual fine particulate matter ($PM_{2.5}$) National Ambient Air Quality Standards (NAAQS) to approvals. In the past, EPA disapproved the prong 4 portions of Mississippi's May 29, 2012, 2008 8-hour ozone NAAQS infrastructure SIP submission; July 26, 2012, 2008 8-hour ozone NAAQS infrastructure SIP resubmission; February 28, 2013, 2010 1-hour NO_2 NAAQS infrastructure SIP submission; June 20, 2013, 2010 1-hour SO_2 NAAQS infrastructure SIP submission; and December 8, 2015, 2012 annual $PM_{2.5}$ NAAQS infrastructure SIP submission.

Additional details about the SIP are available by contacting Elliott Bickerstaff at 601-961-5176. A copy of the draft SIP may be found on the Mississippi Department of Environmental Quality's website at https://www.mdeq.ms.gov/air/.

Persons wishing to comment on this action are invited to submit comments in writing to Elliott Bickerstaff at the Commission's address shown above, no later than 5:00 p.m. on May 23, 2020. All comments received by this date will be considered in preparation of the final submission of the SIP to EPA. A public hearing may be held if the Commission finds a significant degree of public interest in the draft SIP.

Please bring the foregoing to the attention of persons whom you know will be interested.

3) Legal Authority for the Proposed Regional Haze SIP Revision

No legislative actions are needed concerning this proposed SIP revision. The State of Mississippi Air & Water Pollution Control Law, Section 49-17-1 to 49-17-43, Mississippi Code of 1972, gives the Commission on Environmental Quality the necessary legal authority to adopt and implement this proposed SIP revision. State law (as of July 1, 2007) Mississippi Code Annotated, Section 49-17-13(3) designates the Commission as the State air pollution control agency for all purposes of the federal pollution control legislation and programs and to take all actions necessary thereto.

Public participation on the proposed SIP revision will achieved by a public comment period beginning April 23, 2020.

4) Control Strategy for the Proposed Regional Haze SIP Revision

The SIP narrative in Appendix R addresses control strategies for improvement of visibility in Federal Class I areas.

5) Control Regulations for the Proposed Regional Haze SIP Revision

The proposed regional haze SIP Revision does not include any proposed changes to state regulations. The SIP Narrative in Appendix R references Federal requirements addressing visibility in Federal Class I areas.

6) Health Effects of the Proposed Regional Haze SIP Revision

No adverse health effects are expected to be caused by this proposed Regional Haze SIP revision.

7) Economics Effects of the Proposed Regional Haze SIP Revision

No adverse economic effects due to this proposed Regional Haze SIP revision are foreseen.

8) Social Effects of the Proposed Regional Haze SIP Revision

No adverse social effects are foreseen as a result of this proposed Regional Haze SIP revision.

9) Air Quality Effects of the Proposed Regional Haze SIP Revision

This proposed Regional Haze SIP revision will not have any adverse air quality effects.

MISSISSIPPI
DEPARTMENT OF ENVIRONMENTAL QUALITY
OFFICE OF POLLUTION CONTROL

APPENDIX R
SIP NARRATIVE ADDRESSING
EGU BART DETERMINATIONS

Proposed

April 23, 2020

1.0 BACKGROUND

Regional haze is visibility impairment caused by sources and activities emitting fine particles and their precursors, often transported over large regions. Particles affect visibility through the scattering and absorption of light. Reducing fine particles in the atmosphere is an effective method of improving visibility. In the southeast, the most important sources of haze-forming emissions are coal-fired power plants, industrial boilers and other combustion sources, but mobile source emissions, area sources, fires, and wind blown dust also contribute.

In the 1977 Amendments to the Clean Air Act (CAA), Congress set forth a program for protecting the visibility in mandatory Class I Federal areas in order to protect visibility in 156 National Parks and Wilderness Areas. In 1999, the United States Environmental Protection Agency (EPA) promulgated the Regional Haze Rule (RHR) (64 FR 35713), which revised the existing visibility regulations in order to integrate provisions addressing regional haze impairment and establish a comprehensive visibility protection program for Class I Federal areas. States are required to submit state implementation plans (SIPs) to EPA that set out each state's plan for complying with the regional haze rule and to consult with other states and federal land managers, in order to reduce visibility impairment in Class I Areas

Five Regional Planning Organizations (RPOs) assist with the coordination and cooperation needed to address the visibility issue. The states that make up the southeastern portion of the contiguous United States are known as VISTAS (Visibility Improvement – State and Tribal Association of the Southeast) and include: Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, West Virginia, and the Eastern Band of Cherokee Indians. There are no Class I areas in Mississippi. Through the VISTAS RPO, Mississippi has developed a SIP in order to meet the regional haze requirements set forth by the EPA and to assess the effect of the state's emissions on Class 1 areas in surrounding states. The nearest Class I areas in surrounding states are the Breton Wilderness Area in Louisiana, the Sipsey Wilderness Area in Alabama, the Caney Creek Wilderness Area and Upper Buffalo Wilderness Area in Arkansas, and St. Marks Wilderness Area in Florida.

Section 169A of the CAA directs States to assess certain large, older emission sources for additional controls in order to address visibility impacts. States are directed to conduct BART determinations for such sources in specific source categories, and which contribute to visibility impairment in Class I areas. The 1999 regional haze rule includes the BART requirement, and directs States to include BART in their regional haze SIPs. On July 6, 2005, USEPA published a revised final rule, including Appendix Y to 40 CFR Part 51, the *Guidelines for BART Determinations Under the Regional Haze Rule* (hereinafter referred to as the "BART Guidelines") that provides direction to states on determining which of these sources should be subject to BART, and how to determine BART for each source.

The purpose of this SIP is to address BART requirements for seven BART eligible electric Generating Units (EGUs) in Mississippi. These facilities were determined to be not subject to BART in Mississippi's 2008 Regional Haze submittal because they were subject to the Clean Air Interstate Rule (CAIR) that was determined to be better than BART for Sulfur Dioxide and Nitrogen Oxides and the particulate matter impacts were below the BART Threshold. However, the Cross State Air Pollution Rule (CSAPR) replaced CAIR and Mississippi was determined to be only subject the Ozone Season NOx Provisions. Since SO2 is the primary pollutant of concern for Regional Haze in the southeast and the facilities were not subject to the SO2 provisions of CSAPR, these facilities had to be readdressed for BART.

2.0 BART REQUIREMENTS

A BART-eligible source is one which has the potential to emit 250 tons or more of a visibility-impairing air pollutant; was in existence on August 7, 1977 and began operation on or after August 7, 1962; and fits within one or more of 26 specifically listed source categories. Under the CAA, BART is required for any BART-eligible source that a State determines ‘‘emits any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility in any such area.’’

For those sources subject to BART, Section 169A(g)(7) of the CAA requires that States must consider the following factors in making BART determinations: (1) the costs of compliance, (2) the energy and non-air quality environmental impacts of compliance, (3) any existing pollution control technology in use at the source, (4) the remaining useful life of the source, and (5) the degree of improvement in visibility which may reasonably be anticipated to result from the use of such technology.

3.0 BART-ELIGIBLE SOURCE IDENTIFICATION

The BART-eligible sources were identified using the methodology in the BART Guidelines:

- One or more emissions units at the facility fit within one of the 26 categories listed in the BART Guidelines;
- The emission unit(s) were in existence on August 7, 1977 and began operation at some point on or after August 7, 1962; and
- The potential emissions from all emission units that meet the above criteria are greater than 250 tons or more per year of any of these visibility-impairing pollutants: SO_2, NO_x, and PM_{10}.

As discussed in Section 1, this submittal is only addressing seven BART eligible EGUs in the state. Table 1 list these facilities along with the nearest Class 1 Areas.

Facility Name	City, County	Nearest Class I areas
Mississippi Power Company, Plant Jack Watson	Gulfport, Harrison County	Breton WA* – 48 km St. Marks WA – 450 km
Mississippi Power Company, Chevron Cogenerating Plant	Pascagoula, Jackson County	Breton WA – 48 km St. Marks WA – 410 km
Mississippi Power Company, Plant Victor J Daniel	Ecatawpa, Jackson County	Breton WA – 61 km St. Marks WA – 416 km
Cooperative Energy, R D Morrow Plant	Purvis, Lamar County	Breton WA – 139 km Sipsey WA – 380 km
Cooperative Energy, Moselle Plant	Moselle, Jones County	Breton WA – 170 km Sipsey WA – 344 km
Entergy Mississippi Inc, Gerald Andrus Plant	Greenville, Washington County	Caney Creek WA – 290 km Upper Buffalo WA – 360 km
Entergy Mississippi Inc, Baxter Wilson Plant	Vicksburg, Warren County	Breton WA – 310 km Caney Creek WA – 370 km

Table 1. BART-Eligible EGUs in Mississippi *Wilderness Area

The BART Guidelines recommend addressing the visibility-impairing pollutants: SO_2, NO_x, and particulate matter, and suggest that States use their best judgment in determining whether address VOC or ammonia emissions impair visibility in a Federal Class 1 area. MDEQ addressed SO_2 and NO_x, and used particulate matter less than 10 microns in diameter (PM_{10}) as an indicator for particulate matter to identify BART-eligible units, as the BART Guidelines recommend. Per the 2008 Mississippi regional haze plan, VISTAS modeling demonstrated that VOCs are not significant emissions for the first planning period from 2004 to 2018. Point-source impacts from VOC emissions are below a significance level that the emissions will not be evaluated. VISTAS modeled several large ammonia sources whose potential emissions exceeded 250 tons per year and demonstrated an impact on visibility at certain Class I areas in the VISTAS region. However, Mississippi does not have any large point sources of ammonia near Class I areas. For these reasons, MDEQ did not evaluate emissions of VOCs and ammonia in BART determinations.

4.0 SUBJECT-TO-BART MODELING RESULTS OVERVIEW

The CALPUFF model along with the new IMPROVE equation were used in the modeling analysis per the VISTAS modeling protocol. Mississippi selected a subjectivity threshold of 0.5 dv. A discussion and rational for this can be found on page 67 of the September 2008 submittal narrative. Table 2 below summarizes the results. A more complete discussion and the full modeling results can be found in Appendix L. Six of the facilities were determined to be not subject to BART based on the modeling. One facility, Cooperative Energy, Plant R.D. Morrow has removed all eligible units from service, so they are not subject. Mississippi Power, Plant Daniel had SO2 Scrubbers installed since the initial modelling and Mississippi Power, Plant Watson has been converted to natural gas only since the initial modeling. These facilities were remodeled using more current emissions which resulted in a determination that both are below the threshold and not subject to BART. Entergy Mississippi, Baxter Wilson Plant has removed the ability to burn fuel oil and has removed Unit 2, the larger unit, from operation. Entergy Mississippi, Gerald Andrus Plant has also removed the ability to burn fuel oil.

The State reviewed updated emissions rates and annual emissions for SO2, NOx, and PM10 for 2016-2018 to supplement the original BART exemption modeling for Baxter Wilson, Gerald Andrus, Plant Chevron, and Plant Moselle. The purpose for the supplemental emissions analyses for these four sources is to show that the initial CALPUFF modeling (Version 5.8 Level 070623 (Baxter Wilson, Gerald Andrus, Plant Moselle) and Version 5.754 Level 060202 (Plant Chevron))[1] with BART baseline periods of 2001-2003 (Baxter Wilson, Gerald Andrus, Plant Moselle) and 2003-2005 (Plant Chevron)[2] is still representative of more current visibility impacts from each source even though the CALPUFF model has been updated since that time and the emissions rates and annual emissions profiles are different since the BART baseline periods used. The Supplemental analysis found that the modeling and determinations that the facilities were not subject is valid. This analysis can be found in appendix L.

[1] For Plant Chevron, CALPUFF version 5.754 Level 060202 was used, which is consistent with the VISTAS BART Modeling Protocol.
[2] Plant Chevron used a baseline period of 2003-2005.

Facility Name	Eligible Units	Class I Area	Results	Appendix
Mississippi Power Company, Plant Jack Watson	4,5	Breton WA	0.44 dv Not Subject	L.1
Mississippi Power Company, Chevron Cogenerating Plant	1,2,3,4	Breton WA	0.27 dv Not Subject	L.2
Mississippi Power Company, Plant Victor J Daniel	1,2	Breton WA	0.39 dv Not Subject	L.3
Cooperative Energy, R D Morrow Plant	1,2	Breton WA	NA- Eligible Units Removed	L.4
Cooperative Energy, Moselle Plant	3	Breton WA	0.048 Not Subject	L.5
Entergy Mississippi Inc, Gerald Andrus Plant	1	Caney Creek WA	0.15 Not Subject	L.6
Entergy Mississippi Inc, Baxter Wilson Plant	1,2	Breton WA	0.49 Not Subject	L.7

Table 2. Subject to BART modeling results

5.0 BART CONTROL DETERMINATION SUMMARIES

Since all of the facilities were determined to be not subject to BART, no control determinations were necessary.

6.0 FEDERAL LAND MANAGER CONSULTATIONS

The Consultation with the Federal Land Managers that has occurred was addresses in the Section 10 of the original SIP submitted September 22, 2008. For this revision, Mississippi afforded the Federal Land Managers (FLMs) the opportunity to consult on the Mississippi EGU BART SIP with a draft SIP sent on November 22, 2019.

[Section to be completed addressing any FLM comments at final submittal.]

APPENDICES

Appendices A-K – Reserved

Appendix L – Updated BART Modeling Information

Appendix M - Comments

Appendix L
Mississippi BART Determinations

Appendix L – Mississippi BART Determinations

- L.1 – Mississippi Power Company—Plant Watson
- L.2 – Mississippi Power Company—Chevron Cogeneration
- L.3 – Mississippi Power Company—Plant Daniel
- L.4 – Cooperative Energy (Formerly South Mississippi Electric Power Association)—Plant Morrow
- L.5 – Cooperative Energy (Formerly South Mississippi Electric Power Association)—Plant Moselle
- L.6 – Entergy Gerald Andrus Power Plant
- L.7 – Entergy Baxter Wilson Power Plant
- L.8 – VISTAS Protocol

Appendix L.1: Mississippi Power Company—Plant Watson

Appendix L.1 contents:

L.1.1 Appendix Summary

L1.2 BART Modeling Report and Protocol

Appendix L.1.1 – Appendix Summary

Mississippi Power Company—Plant Watson (1280-00055) BART Process Summary

Mississippi Power Plant Watson is an Electricity Generating facility with two Natural Gas fueled units that meet the eligibility criteria. Plant Watson is 48 km from the Breton Wilderness Area, a Class I area, and has a possible visibility impact. As a fossil fuel fired steam electric plant, MS Power—Plant Watson meets the initial BART eligibility requirement of source category code. Therefore, on June 3, 2011, Mississippi Department of Environmental Quality (MDEQ) sent them a letter requesting information to determine BART eligibility. Based on the information received from MS Power—Plant Watson, two units were deemed BART eligible because they met the following criteria:

- Operating or under construction between August 7, 1962 to August 7, 1977
- Having potential emissions that exceed the limit of 250 tons per year for SO_2, NO_X, or PM_{10}

The following are the BART-eligible point sources for MS Power—Plant Watson:

Emission Unit	**Heat Input (MMBtu/hr)**	**Potential Emissions (tons per year)**			**Existing Control Equipment**
		SO_2	NO_X	PM_{10}	
Unit 4—Utility Boiler	2,760	6.92	3,453.37	86.37	n/a
Unit 5—Utility Boiler	5,544	14.94	7,458.92	186.59	n/a
	Totals:	21.86	10,912.29	272.96	

Table L.1.1 – BART eligible units

Because the source meets BART-eligibility requirements, CALPUFF modeling was performed on these units. Both Units 4 and 5 at Plant Watson were converted to natural gas only in 2015. Mississippi Power performed updated CALPUFF modeling using current emissions (2017-2019) and the latest EPA approved model (version 5.8.5 Level 151214). The new IMPROVE equation was used in the modeling analysis per the VISTAS Modeling Protocol. The modeling protocol was submitted to EPA Region 4 and approved in March 2020. The modeling analysis demonstrated a maximum 98^{th} percentile 24-hour average visibility impact of 0.44 dv, and a 22^{nd} highest day's visibility impact over all three years of 0.41 dv. The modeling Protocol and Report are in appendix 1.2. Mississippi agrees with this modeling analysis. The threshold contribution for BART subjectivity selected by Mississippi is 0.5 dv; therefore, MS Power, Plant Watson is not subject to BART and no further analysis is required.

BART Exemption Modeling Report:

Mississippi Power Company
Plant Watson

Prepared by:

Southern Company Services
for Mississippi Power Company

March 2020

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1.0 Introduction

1.1 Background and Objectives

The Regional Haze Rule requires Best Available Retrofit Technology (BART) for any BART-eligible source that ‘‘emits any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility” in any mandatory Class I federal area. Pursuant to federal regulations, states have the option of exempting a BART-eligible source from the BART requirements based on dispersion modeling that demonstrates that the source cannot reasonably be anticipated to cause or contribute to visibility impairment in a Class I area. It is noted that, while Mississippi is not home to any Class I areas, it is subject to the Regional Haze program requirements due to its proximity to Class I areas in other states, namely, the Breton National Wilderness Area (NWA) in Louisiana.

Electric generating units (EGUs) 4 and 5 at Plant Watson, owned and operated by Mississippi Power Company (MPC), were determined to be BART-eligible units. Based on the 2008 State Implementation Plan (SIP) submitted by the Mississippi Department of Environmental Quality (MDEQ), these units were determined to be exempt from BART based upon the CALPUFF visibility modeling analysis performed at that time. EPA did not take action on the 2008 MDEQ SIP submittal for nearly four years. During this time, several actions by EPA and the courts, described below, resulted in a letter dated July 12, 2012, from MDEQ to MPC requesting that MPC submit a new SO_2 and PM BART analysis for Plant Watson. MDEQ explicitly stated that an analysis for NO_x was not required as it was covered under the “better-than-BART” alternative that was CAIR and would also be covered under the better-than-BART alternative of CSAPR. Then, subsequent to the vacatur of CSAPR, MDEQ requested that MPC also include NO_x in the BART analysis (NO_x, SO_2, and PM) for Plant Watson Units 4 and 5. MDEQ required the analysis be completed and submitted to the agency by December 15, 2012.

In 2005, the Environmental Protection Agency (EPA) promulgated a rule (70 FR 39104, July 6, 2005) allowing states subject to the Clean Air Interstate Rule (CAIR) to determine that CAIR satisfies the BART requirements for SO_2 and/or NO_x for electric generating units (EGUs). On December 23, 2008, the U.S. Court of Appeals for the D.C. Circuit found the CAIR rule to be legally flawed and remanded the rule to EPA. On July 6, 2011, in response to remand by the U.S. Court of Appeals for the D.C. Circuit, EPA replaced CAIR with the Cross-State Air Pollution Rule (CSAPR). While the state of Mississippi was included in the annual SO_2 and NO_x programs and the seasonal NO_x program for CAIR, it is only included in the CSAPR seasonal NO_x program.

MPC completed the requested analysis and submitted the BART modeling and determination report to the MDEQ in November 2012. In its analysis, MPC demonstrated with CALPUFF visibility modeling that Watson Units 4 and 5 SO_2, NO_x and PM_{10} emissions for natural gas firing do not cause or contribute to visibility impairment.

On February 5, 2020, MDEQ proposed that MPC update the BART screening analysis based on the most recent emissions for NO_x, SO_2, and PM at Plant Watson Units 4 and 5 and updates to the CALPUFF model version.

The modeling procedures outlined in the source-specific modeling protocol for Plant Watson dated March 2020 were used to determine whether Plant Watson Units 4 and 5 are subject to BART requirements (exemption modeling). The modeling procedures are consistent with those outlined in the updated final VISTAS common BART modeling protocol (dated December 22, 2005, revision 3.2 – August 31, 2006) (hereinafter, “VISTAS protocol”), attached as an appendix in the source-specific Plant Watson Modeling Protocol.

1.2 Location of source vs. relevant Class I Areas

The MDEQ, which is responsible for implementation of the state's Regional Haze program, has determined that Units 4 and 5 at Plant Watson are BART-eligible. Figure 1-1 shows the location of Plant Watson relative to nearby Class I Areas. There is one Class I area within 300 km of the plant: Breton NWA, with the nearest point at a distance of 48.1 km and the farthest point approaching 100 km from Plant Watson. It is noted the next closest Class I areas are the Sipsey Wilderness Area in Alabama and St. Marks Wilderness Area in Florida. These Class I areas are approximately 455 km and 460 km, from Plant Watson. BART exemption modeling will be conducted for this Class I area in accordance with the referenced VISTAS protocol and the procedures described in this source-specific BART modeling protocol.

1.3 Organization of exemption report

Section 2 of this report describes the source emissions that were used as input to the BART exemption modeling. Section 3 describes modeling results. Appendix A is a copy of the approved modeling protocol. Appendix B is a summary of the delta-deciview values for the top 20 days for each year/each Class I Area and for the Top 25 Days Over Three Years.

Figure 1-1 Location of Class I Areas in Relation to Plant Watson

2.0 Source description and emissions data

The stack parameters and emissions data used to assess the visibility impacts at the Class I areas within 300 km of Plant Watson were discussed in detail in the approved Plant Watson BART Modeling Protocol. Table 2-1 provides a summary of the modeling parameters used in the BART CALPUFF exemption modeling.

Table 2-1 Plant Watson modeling emission parameters

Source/ Unit	Actual Stack Ht[1]	Base Elev.	Flue Diameter	Gas Exit Vel.	Stack Gas Exit Temp.	Emissions			Particle Speciation							
						SO_2	NO_X	PM_{10}	Filt. PM_{10}	Coarse Soil	Fine PM	Fine Soil	EC	Cond. PM_{10}	SO_4	Organic
	m	**m**	**m**	**m/s**	**deg K**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**
Unit 4[2]	106.7	5.5	4.9	25.0	397.6	1.33	479.67	18.71	6.67	0.00	6.67	6.22	0.45	12.04	0.41	12.04
Unit 5[2]	121.9	5.5	6.4	28.4	444.5	2.75	1,661.67	48.23	23.14	0.00	23.14	21.59	1.55	25.09	0.84	25.07
Emissions Converted to g/sec >>>						**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**
Unit 4	106.7	5.5	4.9	25.0	397.6	0.17	60.44	2.36	0.84	0.00	0.84	0.78	0.06	1.52	0.05	1.52
Unit 5	121.9	5.5	6.4	28.4	444.5	0.35	209.37	6.08	2.92	0.00	2.92	2.72	0.20	3.16	0.11	3.16

1. Stack height credit is equal to actual height; stack heights are less than GEP.
2. The modeled location for the stacks is 305,854 m UTM East, 3,368,909 m UTM North, Zone 16 using the North America Datum 83 coordinate system.

3.0 Modeling results

The exemption modeling results are provided in Table 3-1. Appendix A lists delta-deciview results for the top 20 days for each year modeled and the top 25 days for the overall three years at each Class I area. The table indicates that both the 8th highest day's impacts for each year and the 22nd highest day's impacts over all three years are below 0.5 delta-dv. These results demonstrate that Plant Watson's SO_2, NO_x and PM_{10} emissions do not cause or contribute to visibility impairment. Therefore, the source is not subject to BART for SO_2, NO_x and PM_{10}, and no further BART analysis is required.

Model inputs and output files related to this BART exemption modeling analysis are provided on the electronic storage media submitted with this report. They include all CALPUFF, CALPOST, and POSTUTIL input and output files.

Table 3-1 Summary of Results – Plant Watson Refined BART Exemption Modeling

		2001			2002			2003			Highest of the 8th Highest delta-dv for the 3-years	22nd Highest delta-dv over 3-year period
Class I Area	Distance from source to Class I area boundary	# of days and receptors beyond 98th percentile with impact > 0.5 delta-dv		8th highest delta-dv	# of days and receptors beyond 98th percentile with impact > 0.5 delta-dv		8th highest delta-dv	# of days and receptors beyond 98th percentile with impact > 0.5 delta-dv		8th Highest delta-dv		
	km	Days	Rec	delta-dv	Days	Rec	delta-dv	Days	Rec	delta-dv	delta-dv	delta-dv
Breton Island	48.1	0	0	0.309	0	0	0.435	0	0	0.436	0.436	0.408

Appendix A

BART Exemption Modeling Protocol: Mississippi Power Company Plant Watson

BART Exemption Modeling Protocol:

Mississippi Power Company
Plant Watson

Prepared by:

Southern Company Services
for Mississippi Power Company

March 2020

Contents

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1.0 Introduction

1.1 Background and Objectives

The Regional Haze Rule requires Best Available Retrofit Technology (BART) for any BART-eligible source that ‘‘emits any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility” in any mandatory Class I federal area. Pursuant to federal regulations, states have the option of exempting a BART-eligible source from the BART requirements based on dispersion modeling that demonstrates that the source cannot reasonably be anticipated to cause or contribute to visibility impairment in a Class I area. It is noted that, while Mississippi is not home to any Class I areas, it is subject to the Regional Haze program requirements due to its proximity to Class I areas in other states, namely, the Breton National Wildlife Area (NWA) in Louisiana.

Electric generating units (EGUs) 4 and 5 at Plant Watson, owned and operated by Mississippi Power Company (MPC), were determined to be BART-eligible units. Based on the 2008 State Implementation Plan (SIP) submitted by the Mississippi Department of Environmental Quality (MDEQ), these units were determined to be exempt from BART based upon the CALPUFF visibility modeling analysis performed at that time. EPA did not take action on the 2008 MDEQ SIP submittal for nearly four years. During this time, several actions by EPA and the courts, described below, resulted in a letter dated July 12, 2012, from MDEQ to MPC requesting that MPC submit a new SO_2 and PM BART analysis for Plant Watson. MDEQ explicitly stated that an analysis for NO_x was not required as it was covered under the “better-than-BART” alternative that was CAIR and would also be covered under the better-than-BART alternative of CSAPR. Then, subsequent to the vacatur of CSAPR, MDEQ requested that MPC also include NO_x in the BART analysis (NO_x, SO_2, and PM) for Plant Watson Units 4 and 5. MDEQ required the analysis be completed and submitted to the agency by December 15, 2012.

In 2005, the Environmental Protection Agency (EPA) promulgated a rule (70 FR 39104, July 6, 2005) allowing states subject to the Clean Air Interstate Rule (CAIR) to determine that CAIR satisfies the BART requirements for SO_2 and/or NO_x for electric generating units (EGUs). On December 23, 2008, the U.S. Court of Appeals for the D.C. Circuit found the CAIR rule to be legally flawed and remanded the rule to EPA. On July 6, 2011, in response to remand by the U.S. Court of Appeals for the D.C. Circuit, EPA replaced CAIR with the Cross-State Air Pollution Rule (CSAPR). While the state of Mississippi was included in the annual SO_2 and NO_x programs and the seasonal NOx program for CAIR, it is only included in the CSAPR seasonal NOx program.

MPC completed the requested analysis and submitted the BART modeling and determination report to the MDEQ in November 2012. In its analysis, MPC demonstrated with CALPUFF visibility modeling that Watson Units 4 and 5 SO_2, NO_x and PM_{10} emissions for natural gas firing do not cause or contribute to visibility impairment.

On February 5, 2020, MDEQ proposed that MPC update the BART screening analysis based on the most recent emissions for NO_x, SO_2, and PM at Plant Watson Units 4 and 5 and updates to the CALPUFF model version.

This modeling protocol discusses the methodology that MPC will apply for performing the updated BART screening modeling analysis for NO_x, SO_2, and PM for Units 4 and 5 at Plant Watson. The modeling procedures outlined will be used to determine whether the source is subject to BART requirements (exemption modeling). The modeling procedures are consistent with those outlined in the updated final VISTAS common BART modeling protocol (dated December 22, 2005, revision 3.2 – August 31, 2006) (hereinafter, “VISTAS protocol”), attached as Appendix A. This source-specific BART modeling protocol references relevant portions of the VISTAS protocol.

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1.2 Location of source vs. relevant Class I Areas

The MDEQ, which is responsible for implementation of the state's Regional Haze program, has determined that Units 4 and 5 at Plant Watson are BART-eligible. Figure 1-1 shows the location of Plant Watson relative to nearby Class I Areas. There is one Class I area within 300 km of the plant: Breton NWA, with the nearest point at a distance of 48.1 km and the farthest point approaching 100 km from Plant Watson. It is noted the next closest Class I areas are the Sipsey Wilderness Area in Alabama and St. Marks Wilderness Area in Florida. These Class I areas are approximately 455 km and 460 km, from Plant Watson. BART exemption modeling will be conducted for this Class I area in accordance with the referenced VISTAS protocol and the procedures described in this source-specific BART modeling protocol.

1.3 Organization of protocol document

Section 2 of this protocol describes the source emissions that will be used as input to the BART exemption modeling. Section 3 describes the input data to be used for the modeling, including the modeling domain, background concentrations, and meteorological data. Section 4 describes the air quality modeling procedures and Section 5 discusses the presentation of modeling results. All references are either cited in footnotes or are included in the VISTAS common protocol (Appendix A, Section 7), so no additional references section is included in this document. Appendices B and C provide additional information on baseline source emissions. Appendix D provides documentation and rationale for using the SEARCH Oak Grove Data for estimating ambient ammonia (NH_3) concentrations over the Gulf of Mexico proposed for this modeling analysis.

Figure 1-1   Location of Class I Areas in Relation to Plant Watson

2.0 Source description and emissions data

2.1 Unit-specific source data

The emissions data used to assess the visibility impacts at the Class I areas within 300 km of Plant Watson are discussed in this section. This protocol addresses SO_2, NO_x, and PM_{10} emissions.

Baseline SO_2 and NO_x emissions are based on the highest measured daily CEMS emission rate during normal operating conditions for the 3-year period from January 1, 2017 through December 31, 2019.[1]

Since various components of PM_{10} emissions have different visibility extinction efficiencies, the PM_{10} emissions are divided, or "speciated," into several components (VISTAS common protocol Sections 4.3.3 and 4.4.2). The VISTAS protocol (Section 5.0) allows for the use of source-specific emissions and speciation factors and/or default values from AP-42. The PM_{10} emissions and speciation approaches that were used for the modeling are indicated below. Where default speciation values are used, the data represent a boiler firing natural gas with no post-combustion control equipment.

- Total PM_{10} is comprised of filterable and condensable emissions.
- The most recent PM stack tests from 2019 from Watson Units 4 and 5, firing natural gas, were used to calculate baseline filterable PM_{10} emissions with the highest 24-hour heat input for the 3-year baseline period (2017-2019). This results in the "maximum 24-hour average emission rate" as required by the VISTAS protocol.
- All of the filterable PM_{10} is assumed to be fine (less than 2.5 microns in size). Of the fine portion, 6.7%[2] is elemental carbon (EC) and the remainder is inorganic fine particles (soil). Fine soil is the difference between fine PM and EC.
- Condensable PM_{10} consists of inorganic and organic compounds. The inorganic portion is assumed to be sulfate (SO_4), although other non-sulfate inorganic condensables could be present. Sulfate is calculated as 20% of SO_2 times the ratio of the molecular weights (98/64). The organic portion is modeled as organic aerosols. Total condensable PM_{10} emissions are based on the emission factor in AP-42, Table 1.4-2.
- Baseline emissions of secondary organic aerosols (the remaining portion of condensable PM_{10}) are derived as the difference between the total condensable emissions and the SO_4 emissions.

In practice, CALPUFF allows for the user to input certain components of PM_{10} as separate species and separate sizes, which will result in more accurate estimates of wet and dry deposition velocity and more accurate impacts on light scattering. As noted above, the particle size distribution information is provided in AP-42 Table 1-1.6 and will be used for the BART exemption modeling as well as the BART determination modeling, if needed.

Table 2-1 provides a summary of the modeling emission parameters to be used in the BART CALPUFF modeling, consistent with the source emissions data presented in Appendices B and C for the baseline. All of the emissions in Table 2-1 were derived from CEMS data for the January 1, 2017 through December 31, 2019 period and represent the maximum 24-hour average lb/hr rates (excluding startup, shutdown, malfunctions, or

[1] The period of January 1, 2017 through December 31, 2019 was selected because it was the most recent available quality controlled reviewed data at the time the modeling protocol was developed.

[2] Table 6, "Catalog of Global Emissions Inventory Tools for Black Carbon", William Battye and Kathy Boyer, EPA Contract No. 68-D-98-046, January 2002, MDEQ letter dated June 3, 2011

other nonrepresentative operations, etc.).[3] For NO_x and SO_2, the values are directly from CEMS data. Filterable PM_{10} emissions were calculated using the most recent stack test results (2019) for each unit and multiplying these values with the maximum 24-hour heat input derived from CEMS for each unit. PM_{10} speciation was then performed as indicated above, such that total Filterable PM_{10} is made up of Coarse Soil plus total Fine PM and total Fine PM is made up of Fine Soil plus Elemental Carbon (EC).

2.2 Stack Height

The actual stack heights for the stacks serving Units 4 and 5 at Plant Watson are 350 and 400 feet, respectively, above plant grade. The calculated GEP height for these stacks is 455.5 and 440.2 feet, respectively, above plant grade (see MPC submittals to MDEQ associated with Construction Permit Number 1020-00055). The dominant structure producing this GEP height is the Boiler 5 building. Because the GEP height for the stack exceeds its actual height, the actual stack height will be modeled.

[3] See Appendix C of the Plant Watson Modeling Protocol for emissions discussion.

Table 2-1 Plant Watson modeling emission parameters

Source / Unit	Actual Stack Ht[1]	Base Elev.	Flue Diameter	Gas Exit Vel.	Stack Gas Exit Temp.	Emissions			Particle Speciation							
						SO_2	NO_X	PM_{10}	Filt. PM_{10}	Coarse Soil	Fine PM	Fine Soil	EC	Cond. PM_{10}	SO_4	Organic
	m	m	m	m/s	deg K	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr
Unit 4[2]	106.7	5.5	4.9	25.0	397.6	1.33	479.67	18.71	6.67	0.00	6.67	6.22	0.45	12.04	0.41	12.04
Unit 5[2]	121.9	5.5	6.4	28.4	444.5	2.75	1,661.67	48.23	23.14	0.00	23.14	21.59	1.55	25.09	0.84	25.07
Emissions Converted to g/sec >>>						g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
Unit 4	106.7	5.5	4.9	25.0	397.6	0.17	60.44	2.36	0.84	0.00	0.84	0.78	0.06	1.52	0.05	1.52
Unit 5	121.9	5.5	6.4	28.4	444.5	0.35	209.37	6.08	2.92	0.00	2.92	2.72	0.20	3.16	0.11	3.16

1. Stack height credit is equal to actual height; stack heights are less than GEP.
2. The modeled location for the stacks is 305,854 m UTM East, 3,368,909 m UTM North, Zone 16 using the North America Datum 83 coordinate system.

3.0 Air quality modeling procedures

Modeling analyses to assess visibility impacts in accordance with BART requirements will generally follow the VISTAS protocol, except for case-specific updates and refinements. This section provides a summary of the modeling procedures that will be used for the refined CALPUFF analysis to be conducted for Plant Watson.

3.1 Model selection and features

EPA has recommended use of the CALPUFF model for estimation of visibility impacts for BART analyses. The major features of the CALPUFF modeling system, including those of CALMET and the post processors (CALPOST and POSTUTIL), are referenced in Section 3 of the VISTAS protocol. BART modeling for Plant Watson will use the following versions of the CALPUFF modeling system components:

CALPUFF: Version 5.8.5, Level 151214
CALMET: Version 5.8, Level 070623
POSTUTIL: Version 1.56, Level 070627
CALPOST: Version 6.221, Level 080724

3.2 Modeling domain and receptors

The Plant Watson BART exemption modeling will use the sub-domain 4, 4-km CALMET data supplied by Mr. Tim Allen of the U.S. Fish and Wildlife Service. This domain includes all Class I areas within 300 km of the source, plus a 50-km buffer.

The receptors used for each of the Class I areas are based on the NPS database of Class I receptors, as recommended by the VISTAS protocol (Section 4.3.3). Breton NWA has a total of 40 receptors in this database. Figure 3-1 shows the receptor locations.

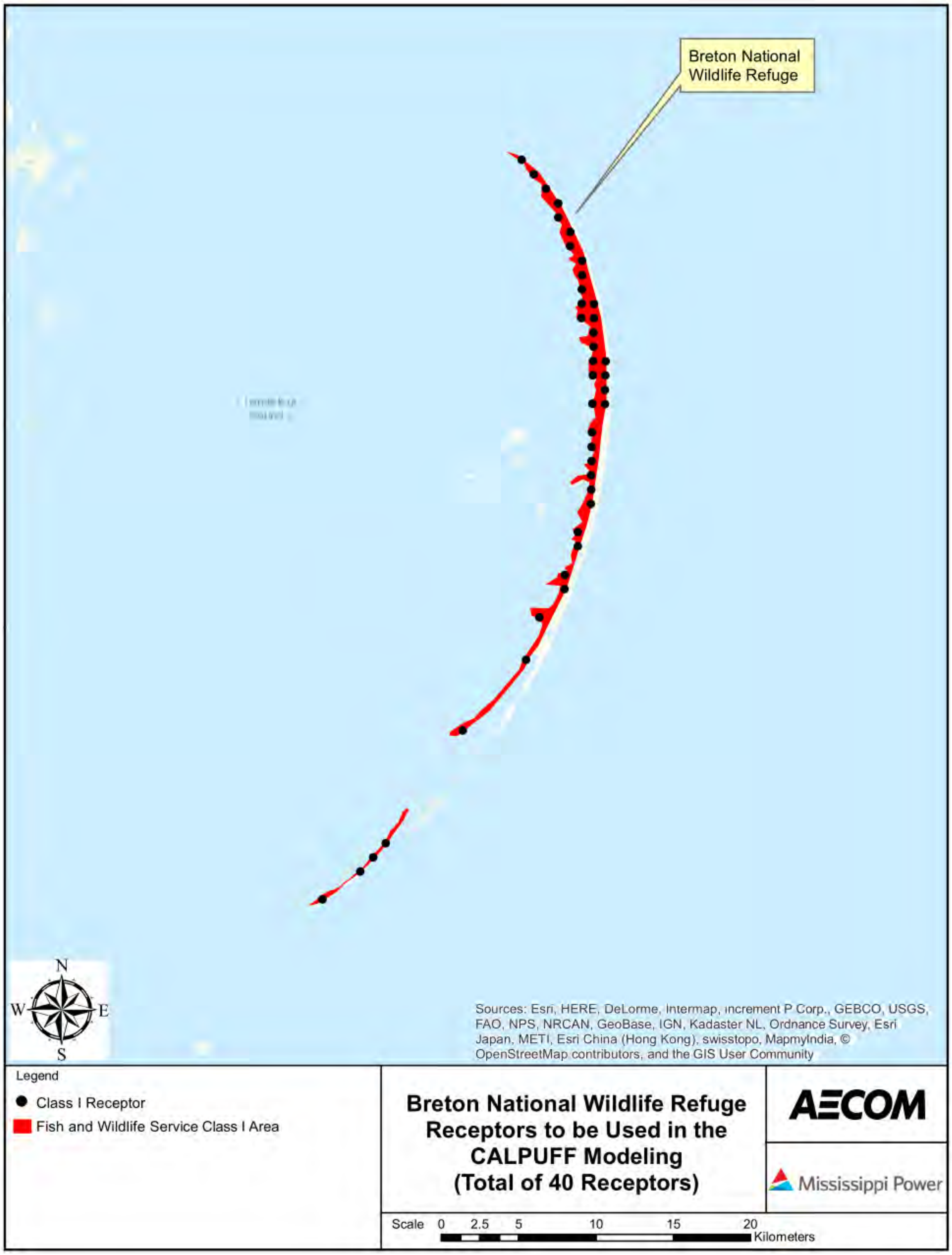
The BART exemption modeling will be conducted for Watson Units 4 and 5 (BART eligible units) for each Class I area within 300 km of the source (specifically, the Breton NWA).

3.3 Technical options used in the modeling

For CALPUFF model options, Plant Watson will follow the VISTAS protocol (Section 4.4.1), which states that IWAQM (EPA, 1998) guidance should be followed. The VISTAS protocol (Section 4.3.3) also notes that building downwash effects are not required to be included unless the state directs the source to include these effects. Since Plant Watson is more than 40 km from the nearest Class I area, building downwash effects will not be included in the CALPUFF modeling.

The POSTUTIL utility program (VISTAS protocol Section 4.4.2) will be used to repartition HNO_3 and NO_3 using monthly median ambient ammonia (NH_3) concentrations obtained from the nearest rural SEARCH air quality monitoring site (OAK). MPC will use ammonia data collected at the OAK SEARCH ambient monitoring site, located near Oak Grove, MS, to determine monthly background ammonia values. See Section 4.2 for additional discussion.

Figure 3-1 Modeling Receptors for Breton Wilderness Area



3.4 Visibility impact calculations

Visibility impacts at Breton will be assessed using the default Method 8 in CALPOST. Inputs to Method 8 will be obtained from the Federal Land Managers' Air Quality Related Values Working Group (FLAG) 2010 report[4] and will be based on the annual average background natural conditions.

The BART rule significance threshold for the contribution to visibility impairment is 0.5 deciviews. The VISTAS protocol (Section 4.3.2) indicates that with the use of the 4-km sub-regional CALMET database, a source does not cause or contribute to visibility impairment if the 98th percentile (or 8th highest) day's change in extinction from natural conditions does not exceed 0.5 deciviews for any of the modeled years (an added check is that the 22nd highest prediction over the three years modeled should also not exceed 0.5 deciviews for a source to be exempted from a BART determination). Both the 98th percentile (or 8th highest) day's change in extinction from natural conditions for any modeled year and the 22nd highest prediction over the three years modeled will be evaluated. The maximum impact from either method should not exceed 0.5 deciviews for the source to be exempted from a BART determination.

Figure 4-1 of the VISTAS protocol presents a flow chart showing the steps of the analysis to determine whether a source is subject to BART. Again, it should be noted that the modeling for Plant Watson will focus on Sub-regional Fine-Scale modeling as depicted in the lower half of the figure.

If the exemption modeling demonstrates that Plant Watson does not cause or contribute to visibility impairment, then the source will not be subject to BART requirements, and no further analysis is needed.

3.5 Background Sea Salt Concentration for Breton National Wildlife Refuge

One of the particulate species that is accounted for in the CALPOST Method 8 visibility calculations is sea salt. Sea salt is present in the natural environment, especially in marine environments, and is hygroscopic in nature.

The background sea salt concentration at the various IMPROVE sites, provided in Table 6 of the 2010 FLAG guidance, comes from direct measurements of the chloride and sodium concentrations. However, the representativeness of the FLAG values for Breton Wilderness Area is questionable because the values in the 2010 FLAG report are based upon older data that has been superseded by more recent measurements.

MPC will use an updated background sea salt value based on more recent monitoring from the newer Breton monitor (BRIS1) rather than the older monitor (BRET1) that was destroyed during Hurricane Katrina in 2005 (BRET1). It is noteworthy that the BRIS1 monitor is located closer to saltwater bodies than the BRET1 monitor, so its measurements are more representative of the conditions at the Breton NWA. In addition, the measurement procedures at BRET1 may have changed after 2003, becoming more consistent with those used at the current BRIS1 monitor.

As shown in the graph below,[5] annual average sea salt concentrations measured at the BRET1 monitor over the first three years of operation (2001-2003) are substantially lower than the value measured in the last full

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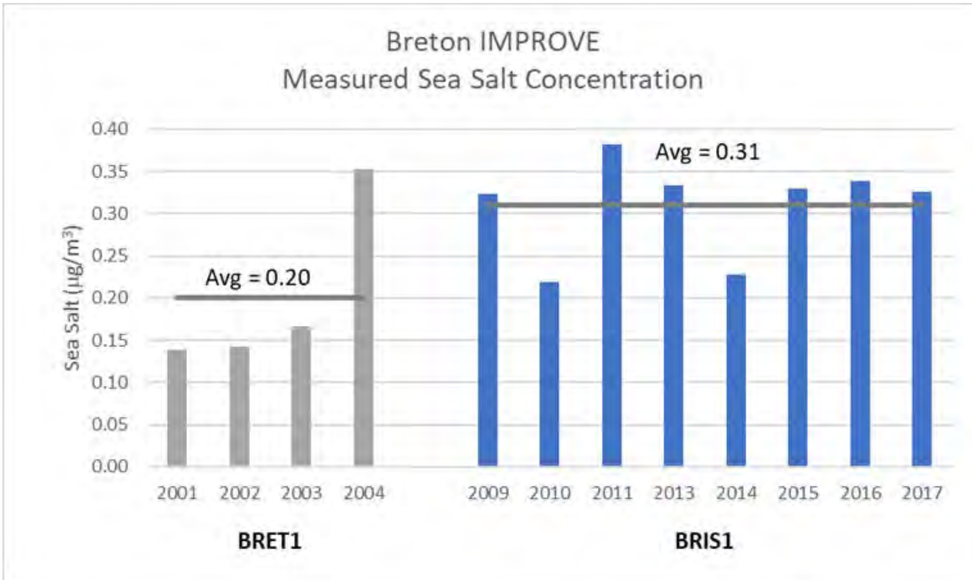
[4] Federal Land Managers' Air Quality Related Values Work Group (FLAG) Phase I Report (revised 2010) (U.S. Department of the Interior, 2010).

[5] Data were obtained from the IMPROVE website at the following link: http://vista.cira.colostate.edu/Improve/rhr-summary-data/. The spreadsheet available at this link titled, "SIA_group_means_10_18.csv", which provides annual average sea salt concentrations over all valid days, was most recently posted to the IMPROVE website in December 2018.

year of operation (2004). The 2004 value from BRET1 (0.35 μg/m³) is consistent with the values that have been measured over more recent years (2009-2017) at the BRIS1 monitor (0.21-0.37 μg/m³).

Figure 3-2 Breton IMPROVE Measured Sea Salt Concentrations



Because the BRIS1 data are more recent and more consistent over time, MPC believes that they are more representative for Breton. Therefore, MPC will use annual sea salt concentration in the calculation of visibility impairment for Breton that is based on the average of the 2009-2017 annual average sea salt concentrations from the BRIS1 monitor (0.31 μg/m³).

3.6 General quality assurance procedures

Chapter 6 of the Final VISTAS Modeling Protocol discusses quality assurance (QA). The purpose of the QA program is to establish procedures for ensuring that products produced by the application of the modeling techniques for BART studies satisfy the regulatory objectives of the BART program.

Staff from Southern Company Services (SCS) developed the emissions inputs and are directing the outside consulting services of AECOM for the BART exemption modeling for MPC's Plant Watson. The team members coordinated to verify that all recommended methods specified in the Final VISTAS Modeling Protocol, the source-specific modeling protocol, and within this protocol are followed and that the modeling will be carefully and professionally conducted. AECOM experts will be provided source-specific stack parameters and emissions data for Plant Watson, which AECOM will use to complete the modeling analysis in accordance with the VISTAS common protocol.

AECOM has substantial experience conducting CALPUFF analyses for assessment of visibility impairment under the Regional Haze Rule in many applications, including those in the VISTAS (SESARM) Regional Planning Organization. Several of their BART application projects have been reviewed and accepted by the state, EPA, and Federal Land Manager agencies. AECOM uses CALDESK animation software as well as

Lakes Environmental CALVIEW software with base maps to visualize the sources, receptors, and meteorology used in the analyses. AECOM also uses the CALPUFF QA output files in conjunction with ArcMap GIS software to plot the locations of the sources and receptors as CALPUFF interprets them from the input data. The output files from CALPUFF and CALPOST are reviewed by AECOM staff to assure accuracy and compliance with approved regulatory procedures.

For this application, the 4-km grid-spaced CALMET and ozone files for sub-domain 4, developed and provided by Mr. Tim Allen of the U.S. Fish & Wildlife Service, will be utilized. CALPUFF input file templates that were developed by VISTAS will be used. AECOM modelers will use the test met file to "benchmark" the use of the CALMET files on their computers as indicated on page 59 of the VISTAS common protocol. All CALPUFF, CALPOST, and POSTUTIL input and output files will be submitted electronically along with the modeling report.

4.0 Input data to the CALPUFF model

4.1 CALMET meteorological files

VISTAS developed five sub-regional 4-km CALMET meteorological databases for three years (2001-2003) (VISTAS protocol Section 4.4.2). The sub-regional modeling domains are strategically designed to cover all potential BART eligible sources within VISTAS states and all PSD Class I areas within 300 km of those sources (to the nearest edge). Mr. Tim Allen of the U.S. Fish and Wildlife Service has updated the meteorological databases for these domains using CALMET Version 5.8. The extents of the 4-km sub-regional domains are shown in Figure 4-4 of the VISTAS protocol. The BART modeling for Plant Watson will be done using the updated meteorological dataset for the 4-km subdomain 4 obtained from Mr. Allen.

4.2 Air quality database (background ozone and ammonia)

Hourly measurements of ozone from all non-urban monitors over the period 2001-2003, as generated by VISTAS, will be used as input to CALPUFF.

For ammonia, five years (2004-2008) of 24-hour ammonia concentrations measured at a nearby SEARCH air quality monitoring site (OAK) will be used to calculate site-specific monthly concentrations based on the geometric mean. OAK is a rural monitoring site in southern Mississippi, approximately 65 km inland from the Gulf Coast. It is reasonable to assume that this site is representative of the regional background, and that the observations from OAK are more appropriate than using the VISTAS default background of 0.5 ppb. The observed monthly background concentrations will be input into POSTUTIL for HNO_3/NO_3 partitioning. See Appendix D for a discussion of the representativeness of the OAK ammonia data for Breton. SEARCH ammonia measurement and quality assurance procedures are described in two peer-reviewed journal articles.[6,7] The quality assurance procedures were adapted from EPA Method IO-4.2.[8] Natural conditions and monthly f(RH) at Class I Areas

For each of the applicable Class I areas, natural background conditions must be established in order to determine a change from natural conditions related to a source's emissions. Inputs to CALPOST Method 8 will be obtained from the FLAG 2010[9] report and will be based on the annual average background natural conditions.

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[6] Edgerton, E.S., R.D. Saylor, B.E. Hartsell, J.J. Jansen, and D.A. Hansen. 2007. Ammonia and ammonium measurements from the southeastern United States. Atmos. Environ. 41:3339–3351. doi:10.1016/j.atmosenv.2006.12.034

[7] Saylor, R., L. Myles, D. Sibble, J. Caldwell, and J. Xing. 2015. Recent trends in gas-phase ammonia and PM2.5 ammonium in the Southeast United States. Journal of the Air & Waste Management Association. 65:3, 347-357. doi:10.1080/10962247.2014.992554

[8] U.S. EPA. 1999. IO Compendium Method IO-4.2: Compendium of Methods for the Determination of Inorganic Compounds in Ambient Air: Determination of Reactive Acidic and Basic Gases and Strong Acidity of Atmospheric Fine Particles. EPA/625/R-96/010a. Cincinnati, OH.

[9] Federal Land Managers' Air Quality Related Values Work Group (FLAG) Phase I Report (revised 2010) (U.S. Department of the Interior, 2010).

5.0 Presentation of modeling results

The BART exemption modeling results for Plant Watson will be provided to the state agency in a manner as described in the VISTAS protocol (Section 4.5). A report will be produced that includes the following elements (as suggested in the VISTAS protocol):

1. A map of the source location and Class I areas within 300 km of the source.

2. For the CALPUFF modeling domain, a table listing all Class I areas in the VISTAS domain and those in neighboring states and impacts from the BART 4-km grid exemption modeling at those Class I areas within 300 km of the source, as illustrated in Table 4-3 of the VISTAS protocol.

3. A discussion of the number of Class I areas with visibility impairment due to source emissions for the 98th percentile days in each year (and the 98th percentile over all three years modeled) greater than 0.5 dv.

4. For the Class I area with the maximum impact, a discussion of the number of days beyond those excluded (e.g., the 98th percentile for refined analyses) that the impact of the source exceeds 0.5 dv, the number of receptors in the Class I area where the impact exceeds 0.5 dv, and the maximum impact.

5. For any finer grid CALPUFF exemption modeling, results for those Class I areas for which impacts of the source exceeded 0.5 dv in the 4-km initial modeling. We would report the same type of results as provided for 4-km exemption modeling.

The electronic files used to conduct the CALPUFF modeling will be submitted along with the modeling report on storage media.

Appendix A

VISTAS Common BART Modeling Protocol

Protocol for the Application of the CALPUFF Model for Analyses of Best Available Retrofit Technology (BART)

December 22, 2005

(Revision 3.2 – 8/31/06)

Visibility Improvement State and Tribal Association of the Southeast (VISTAS)

TABLE OF CONTENTS

SUMMARY

This Protocol for the Application of the CALPUFF Model for Analyses of Best Available Retrofit Technology (BART) for the VISTAS Regional Planning Organization (RPO) describes common procedures for carrying out air quality modeling to support BART determinations that are consistent with guidelines of the U.S. Environmental Protection Agency in 40 CFR Part 51 Appendix W and Appendix Y. The Protocol is intended to serve as the basis for a common understanding among the organizations that will be performing BART analyses or reviewing the BART modeling results in the VISTAS region.

Background

Best Available Retrofit Technology is required for any BART-eligible source that ‘‘emits any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility” in any mandatory Class I federal area. According to 40 CFR Part 51 Appendix Y, “*You can use dispersion modeling to determine that an individual source cannot reasonably be anticipated to cause or contribute to visibility impairment in a Class I area and thus is not subject to BART*.” In the “individual source attribution approach,” a BART-eligible source that is responsible for a 1.0 deciview (dv) change or more is considered to “cause” visibility impairment. A BART-eligible source that is responsible for a 0.5 dv change or more is considered to “contribute” to visibility impairment in a Class I area. Any source determined to cause or contribute to visibility impairment in any Class I area is subject to BART.

The member states of the VISTAS RPO agreed to develop a common BART Modeling Protocol to guide them, their sources, and reviewers in the BART determination and review effort. The Protocol has been in preparation within VISTAS since January 2005. The original authors are Pat Brewer, VISTAS Technical Coordinator, and Ivar Tombach, VISTAS Technical Advisor. The VISTAS state BART contacts, particularly Tom Rogers, FL, Chris Arrington, WV, Leigh Bacon, AL, and Michael Kiss, VA, have directed and extensively reviewed the Protocol. The Protocol was enhanced and completed with the assistance of Joseph Scire, Christelle Escoffier-Czaja and Jelena Popovic of Earth Tech, Inc. and it has received extensive contributions and review from the VISTAS federal partners: Federal Land Managers and US EPA. The VISTAS RPO held a meeting on September 21, 2005 in Research Triangle Park, NC to discuss the Protocol with participants before starting a public comment period. The Protocol underwent formal external review during the period between September 26, 2005 and October 31, 2005. Numerous comments were received. All comments were carefully considered and discussed with VISTAS participants and federal partners. VISTAS gratefully acknowledges the very useful contributions of those that provided comments. On November 1st, 2005 VISTAS held another meeting with its participants in Nashville, TN to present and discuss the comments being considered for inclusion in the Protocol. No formal document will be prepared to address all the comments received on the Protocol.

Objectives

The objectives of the Protocol (discussed in Chapter 1) are to provide:

- A consistent approach to determine if a source is subject to BART
- A consistent model (CALPUFF) and modeling guidelines for BART determinations
- Clearly delineated modeling steps
- A common CALPUFF configuration
- Guidance for site-specific modeling
- Common expectations for reporting model results

The Protocol is not intended to define the engineering analyses required by the US EPA's BART Guidance, nor address model alternatives to the CALPUFF model, nor address emissions trading.

Chapter 2 is intended to provide summary background on EPA's guidance for BART modeling. The CALPUFF model system is reviewed in Chapter 3, while specific recommendations for applying the CALPUFF model for BART purposes appear in Chapter 4. Chapter 5 describes the specific information that should be included in site-specific protocols. Chapter 6 describes the quality assurance requirements for BART analyses in the VISTAS RPO.

Recommendations

The major recommendations for VISTAS BART modeling included in this Protocol are:

I. Process

Follow the BART process steps discussed in Chapter 2:

1. Identify BART eligible sources
2. Identify which pollutants have greater than *de minimis* emission levels
3. Identify sources that are subject to BART
4. Identify baseline visibility impact of each BART source
5. Identify feasible controls and emission changes
6. Identify the change in visibility impact for each candidate BART control option
7. Compare the visibility improvement of BART control options to other statutory factors in the engineering analysis

II. CALPUFF Model Configuration

Use the CALPUFF dispersion modeling system, as described in Chapter 4, to determine if a single source is subject to BART. VISTAS will use CALPUFF Version 5.754 and CALMET Version 5.7. These versions contain enhancements funded by the Minerals Management Service (MMS) and VISTAS. They were developed by Earth Tech, Inc. and are maintained on the CALPUFF website (www.src.com) for public access.

VISTAS is making publicly available 12-km CALMET output files for the entire VISTAS modeling domain (eastern United States) and intends to also provide CALMET output files for five 4-km grid subdomains covering the VISTAS states and VISTAS Class I areas. To create the CALMET input files, Earth Tech used the MM5 databases developed by EPA for 2001, VISTAS for 2002, and Midwest RPO for 2003. For the 12 km grid large domain covering the entire VISTAS region, Earth Tech used the No-Obs setting (i.e., did not include additional surface and upper air observations beyond those incorporated in the MM5 calculations). For finer resolution subdomains (4 km grid or less), available surface and upper air observations will be used in addition to MM5 meteorological model outputs. The specific model settings will be provided with the CALMET files and via the CALPUFF website so that users can review or replicate the work.

For CALPUFF modeling, source emissions should be defined using the maximum 24-hour actual emission rate during normal operation for the most recent 3 or 5 years. If maximum 24-hr actual emissions are not available, continuous emissions data, permit allowable emissions, potential emissions, and emissions factors from AP-42 source profiles may be used as available.

Key points from comments received on the specific CALPUFF, CALPOST, and POSTUTIL configurations are highlighted below.

- After running CALPUFF for an individual facility, repartition NO_3 in POSTUTIL.[1]
- Use ozone data from non-urban monitors as the background ozone input.
- Use the Pasquill-Gifford dispersion method.[2]

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[1] The original intent, as expressed in the Final VISTAS BART Modeling Protocol (22 December 2005) was to use CMAQ-derived background data for SO_2, NO_3 and NH_3 in POSTUTIL. After extensive discussion with the EPA and FLMs in early 2006, EPA did not approve the recommended approach so background gaseous concentrations from CMAQ 2002 modeling will not be provided by VISTAS for use in POSTUTIL. Rather the standard default NH_3 concentrations specified on page 14 of the IWAQM Phase 2 report (IWAQM, 1998) will be used.

[2] The Final VISTAS BART Modeling Protocol (Dec. 22, 2005) recommended using turbulence-based AERMOD dispersion methods, citing EPA's *Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rule.* 70 FR 68218-68261. 9 November 2005. Subsequently, EPA Region IV notified the VISTAS states that using turbulence-

- In CALPOST, use Method 6 with monthly average RH for calculating extinction, as recommended by the EPA.

- Use EPA default calculations of light extinction under current and natural background conditions. In addition to the default assumptions, a source may choose to also calculate visibility using the recently revised IMPROVE algorithm described by Pitchford, et al., (2005).

Provide results in tables as illustrated in Chapter 4 that describe, for each source:

- Number of receptors within a single Class I area with impact > 0.5 dv

- Number of days at all receptors in the Class I area with impact > 0.5 dv

- Number of Class I areas with impacts > 0.5 dv

III. CALPUFF Application for BART

For determining if a BART-eligible source is subject to BART CALPUFF modeling, use a two-tier approach. For the initial exemption modeling use CALPUFF with 12-km grid CALMET. For finer resolution of meteorological fields, use CALPUFF with CALMET of 4-km or smaller grid size.

VISTAS States are accepting EPA guidance that the threshold value to establish that a source contributes to visibility impairment is 0.5 deciview.

VISTAS States are using emissions (tons per year) divided by distance (km) from a Class I area boundary (Q/d) as a presumptive indicator that a BART-eligible source is subject to BART. If Q/d for SO_2 is greater than 10 for 2002 actual annual emissions, then the State presumes that the source is subject to BART and no exemption modeling will be performed using VISTAS funds. If the source agrees with this presumption, then the source can proceed to the BART determination using CALPUFF to evaluate impacts of control options and perform the engineering analyses. If a source disagrees, the source may perform fine grid modeling to determine if its impact is <0.5 dv.

For sources with Q/d less than or equal to 10, VISTAS intends to fund TRC Environmental Corp.[3] to assist States with the initial CALPUFF exemption modeling. Each State will prioritize which sources will be offered modeling by VISTAS. Modeling of these sources will be conducted in priority order to first accommodate States with nearer term timing constraints in their SIP development process. To conserve VISTAS resources, modeling will begin with sources at lower Q/d values and continue with sources with higher Q/d values until a Q/d value

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based dispersion methods would be considered a non-guideline application of CALPUFF. Thus this Protocol has been revised to indicate Pasquill-Gifford dispersion coefficients should be used.

[3] In April 2006, Earth Tech's CALPUFF modeling staff became part of TRC Environmental Corporation. References to Earth Tech and to TRC in this protocol refer to the same technical staff, just at different times.

that consistently results in a greater than 0.5 dv impact is identified. Chapter 4 addresses the number of VISTAS sources eligible for BART based on Q/d analysis.

Note that VISTAS does not propose to use Q/d to exempt BART-eligible sources, but only to prioritize sources for modeling purposes. Thus this application is consistent with EPA guidance not to use Q/d for exemption purposes.

For the 12-km initial modeling exemption test, compare the highest single 24-hour average value across all receptors in the Class I area to the threshold value of 0.5 dv. If the highest 24-hr average value is below 0.5 dv at all Class I areas, then the source is not subject to BART. If the highest 24-hr average value is greater than 0.5 dv, then the source may choose to perform finer grid modeling for exemption purposes or may accept determination that the source is subject to BART and proceed to establish visibility impacts prior to and after BART controls. If using the single highest 24-hr average value proves, after initial 12-km grid CALPUFF modeling, to be too conservative a screening level, VISTAS may allow some exceedances of the threshold value for exemption purposes, up to no more than the 98th percentile value.

The 12-km modeling results can be used to focus finer grid modeling for exemption purposes on only those Class I areas where impacts greater than 0.5 dv were projected in the 12-km modeling.

For finer grid (4 km or less) analyses, use the 98th percentile impact value for the 24-hr average. Use either the 8th highest day in each year or the 22nd highest day in the 3-year period, whichever is more conservative, for comparison to the exemption threshold.

Use the same model assumptions for pre-BART visibility impact and for BART control options modeling: establish baseline visibility from the pre-BART run; change one control at a time; and evaluate the change in visibility impact, i.e. the delta-deciview. Note that "no control" may constitute BART.

Visibility impact is one of the five factors considered in the engineering analysis required under the USEPA BART guideline. If a source accepts to institute the most stringent control, the engineering analyses are not required.

This common VISTAS Protocol consistently recommends conservative assumptions. Individual States ultimately have responsibility to determine which, if any, BART controls are recommended in their State Implementation Plans (SIPs).

1. INTRODUCTION AND PROTOCOL OBJECTIVES

1.1 Background

Under regional haze regulations, the Environmental Protection Agency (EPA) has issued final guidelines dated July 6, 2005 for Best Available Retrofit Technology (BART) determinations (70 FR 39104-39172). The regional haze rule includes a requirement for BART for certain large stationary sources. Sources are BART-eligible if they meet three criteria including potential emissions of at least 250 tons per year of a visibility-impairing pollutant, were put in place between August 7, 1962 and August 7, 1977, and fall within one of the 26 listed source categories in the guidance. A BART engineering evaluation using five statutory factors -- 1) existing controls; 2) cost; 3) energy and non-air environmental impacts; 4) remaining useful life of the source; 5) degree of visibility improvement expected from the application of controls -- is 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. (Note that, depending on the five factors, the evaluation may result in no control.) Air quality modeling is an important tool available to the States to determine whether a source can be reasonably expected to contribute to visibility impairment in a Class I area.

Throughout this document the term "BART-eligible emission unit" is defined as any single emission unit that meets the criteria described above. A "BART-eligible source" is defined as the total of all BART-eligible emission units at a single facility. If a source has several emission units, only those that meet the BART-eligible criteria are included in the definition "BART-eligible source".

One of the listed categories is steam electric plants of more than 250 million BTU/hr heat input. To determine if such a plant has greater than 250 million BTU/hr heat input and is potentially subject to BART, the boiler capacities of all electric generating units (EGUs) should be added together regardless of construction date. In this category, electric generating sources greater than 750 MW have presumptive SO_2 and NO_x emission limits. States may presume the same limits for EGU sources between 250-750 MW. However, units at those sources constructed after the BART-eligibility dates are not subject to a BART engineering evaluation. EPA, in the Clean Air Interstate Rule (CAIR), determined that an EGU participating in the CAIR trading program satisfies the BART requirements for SO_2 and NO_x. VISTAS states are tentatively accepting this guidance. CAIR does not cover PM so EGUs would still need to evaluate impacts of PM if PM emissions are above *de minimis* values.

As illustrated in Table 1-1, as of December 5, 2005, VISTAS States had identified a total of 274 BART-eligible sources that fall into 20 of the 26 BART source categories. Of the 274 sources with BART-eligible units, 84 sources are utility EGUs and 190 are non-EGU industrial sources. (Note that these numbers are not final and are subject to slight adjustments and refinements.) No BART sources are located on Tribal lands.

Table 1-1. VISTAS BART Eligible Sources (not updated since December 2005)

State	Total Number of Sources	EGU Sources	Non-EGU Sources
AL	48	8	40
FL	50	23	27
GA	24	10	14
KY	29	12	17
MS	18	8	10
NC	16	5	11
SC	31	6	25
TN	13	2	11
VA	18	3	15
WV	26	7	19
Total	**273**	**84**	**189**

1.2 Objective of this Protocol

The objective of this VISTAS' BART Modeling Protocol is to describe common procedures for air quality modeling to support BART determinations that are consistent with the EPA guidelines. The protocol will serve as the basis for establishing a common understanding among the organizations who will be performing the BART analyses or reviewing the BART modeling results, including VISTAS State and Local air regulatory agencies, EPA, Federal Land Managers (FLMs), source operators, and contractors for the sources. This final protocol incorporates EPA final guidance and comments that were received on VISTAS' draft protocol[4] and provides additional description of modeling procedures. The original final protocol of 22 December 2005 has been revised since then to clarify items, resolve technical issues, and reflect decisions by the EPA and FLMs. This document is the third revision.

The VISTAS States have accepted EPA's guidance to use the CALPUFF modeling system to comply with the BART modeling requirements of the regional haze rule. A BART-eligible source will be required to submit a site-specific modeling protocol to the State for review and approval prior to performing CALPUFF modeling. States will consult with FLMs and the EPA when evaluating the site-specific BART protocols. The site-specific protocol will include the

[4] *Draft Protocol for the Application of the CALPUFF Model for Analyses of Best Available Retrofit Technology (BART). VISTAS*, March 22, 2005 and September 20, 2005.

source-specific data on source location, stack parameters, and emissions. The methods of the VISTAS common modeling protocol will be followed in the site-specific protocol unless the source proposes to the State, and the State approves, alternative methods or assumptions.

Each VISTAS State or Local agency retains responsibility for the specific procedures and processes it will follow in working with the BART sources under its jurisdiction, the FLMs, EPA, and public to determine BART controls for sources in the State. Nothing in the VISTAS process replaces States' responsibility to determine BART controls.

The remainder of this document describes the CALPUFF modeling system and the application of CALPUFF to two situations:

- Air quality modeling to determine whether a BART-eligible source is "subject to BART" and therefore the BART analysis process must be applied to its operations.
- Air quality modeling of emissions from sources that have been found to be subject to BART, to evaluate regional haze benefits of alternative control options and to document the benefits of the preferred option.

Chapters 2 and 3 of this document are intended to provide background information on EPA's guidance for BART analysis modeling and on the CALPUFF modeling system. Subsequent chapters include more specific recommendations. Chapter 2 of this document reviews EPA's guidance for regional haze BART analysis modeling, as outlined in the 6 July 2005 Federal Register notice. The CALPUFF model is the preferred model recommended by the EPA for BART modeling analyses and its characteristics and limitations are discussed in Chapter 3. The specific steps to determine whether a BART-eligible source is subject to BART and to evaluate BART controls are described in Chapter 4. The procedures include initial modeling of BART-eligible sources using CALPUFF run in a conservative mode with regional meteorological datasets. For sources determined to be subject to BART based on these first modeling analyses, further finer grid CALPUFF analyses would be performed. The model configuration for the common modeling protocol is described in Chapter 4. Details of the source-specific protocol are described in Chapter 5. A quality assurance plan is outlined in Chapter 6.

EPA's guidance allows for the use of appropriate alternative models, however VISTAS will not develop a protocol for alternative models. This protocol focuses on guidance for the application of the preferred CALPUFF modeling approach. If a source wants to use an alternative model in its BART demonstration, the source will need to submit a detailed written justification to the State for review and approval. The State will provide the documentation to the EPA and Federal Land Managers for their review.

Also, this protocol does not address a preferred modeling approach to demonstrate the effectiveness of an optional emissions cap and trade program. Such a cap and trade program is not required, but can be implemented in lieu of BART if desired by the VISTAS States. VISTAS

States are not pursuing a regional trading alternative under the proposed EPA trading guidance (70 FR 44154-44175) that is to be promulgated in 2006.

2. REVIEW OF EPA'S GUIDANCE FOR BART MODELING

The final guidance for regional haze BART determinations was published in the Federal Register on 6 July 2005 (70 FR 39104 to 39172). It prescribes the modeling approaches that are to be used for various stages of the BART analysis process.

This chapter provides a summary of EPA's guidance for BART modeling. It is not intended to provide a comprehensive review of the guidance. Nor does this chapter address specific recommendations for VISTAS' approach to CALPUFF BART modeling. Those recommendations appear in Chapter 4.

2.1 Overview of the Regional Haze BART Process

The process of establishing BART emission limitations consists of four steps:

1) 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 August 7, 1962 and August 7, 1977 in order to be BART-eligible. Finally, a source is eligible for BART if potential emissions of visibility-impairing air pollutants are greater than 250 tons per year. Qualifying pollutants include primary particulate matter (PM_{10}) and gaseous precursors to secondary fine particulate matter, such as SO_2 and NO_x. Whether ammonia or volatile organic compounds (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 be considered as primary $PM_{2.5}$ emissions and not VOCs for BART purposes.

(Note: If the source is subject to BART because one visibility impairing pollutant has potential emissions > 250 TPY, the State may determine that other visibility impairing pollutants are not subject to BART if their potential emissions are less than the *de minimis* levels (40 TPY for SO_2 and NO_x and 15 TPY of PM_{10} or $PM_{2.5}$. This assumes that the other BART-eligibility criteria are met.)

2) Determine 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. The preferred approach is an assessment with an air quality model such as CALPUFF 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.[5] The threshold to determine whether a single source "causes" visibility impairment is set at

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[5] A recent draft settlement agreement with the EPA (to be published in the *Federal Register* for public comment) provides that a State has the discretion to decide whether annual average or 20% best natural conditions are to be used as the reference. This ruling resolves an ambiguity in EPA's BART guidance, where the BART guideline

1.0 deciview change from natural conditions over a 24-hour averaging period in the final BART rule (70 FR 39118). 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. The test against the threshold is "driven" by the contribution level, since if a source "causes", by definition it "contributes".

EPA recommends that the 98th percentile value from the modeling be compared to the contribution threshold of 0.5 deciviews (or a lower level set by a State) to determine if a source does not contribute to visibility impairment and therefore is not subject to BART. Whether or not the 98th percentile value exceeds the threshold must be determined at each Class I area. Over an annual period, this implies the 8th highest 24-hr value at a particular Class I area is compared to the contribution threshold. Over a 3-year modeling period, the 98th percentile value may be interpreted as the highest of the three annual 98th percentile values at a particular Class I area or the 22nd highest value in the combined three year record, whichever is more conservative.

Alternatively, States have the option of considering that all BART-eligible sources within the State are subject to BART and skipping the initial impact analysis. In rare cases, a State might be able to do exactly the opposite, and use regional modeling to conclude that all BART-eligible sources in the State do not cumulatively contribute to "measurable" visibility impairment in any Class I areas. Also, the States have an option to exempt individual sources based on model plant analysis conducted by EPA in finalizing the BART rule. Under this option, sources with potential emissions of SO_2 plus NO_x of less than 500 tons and a distance from any Class I area greater than 50 kilometers or sources with SO_2 plus NO_x potential emissions of less than 1000 tons and a distance from any Class I area greater than 100 kilometers can be exempted. PM emissions are not specifically addressed in the model plant analysis, but subsequent discussions with EPA staff indicate that PM may be considered along with SO_2 and NO_x, so that a plant could be exempted if the combined potential emissions of SO_2, NO_x, plus PM meet the criteria above.

3) Determine BART controls 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

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text says "natural conditions" at 70 FR 39162, col. 3, while the preamble to the BART rule says "natural visibility baseline for the 20% best visibility days" at 70 FR 39125, col. 1.

e) The degree of improvement in visibility that may reasonably be anticipated to result from the use of such technology.

Note that if a source agrees to apply the most stringent controls available to BART-eligible units, the BART analysis is essentially complete and no further analysis is necessary (70 FR 39165).

4) Incorporate the BART determination into the State Implementation Plan for Regional Haze, which is due by December 2007.

Instead of applying BART on a source-by-source basis, a State (or a group of States) has the option of implementing an emissions trading program that is designed to achieve regional haze improvements that are greater than the visibility improvements that could be expected from BART. If the geographic distributions of emissions under the two approaches are similar, determining whether trading is "better than BART" may be possible by simply comparing emissions expected under the trading program against the emissions that could be expected if BART was applied to eligible sources. If the geographic distributions of emissions are likely to be different, however, air quality modeling comparing the expected improvements in visibility from the trading program and from BART would be required. (See the proposed BART Alternative rule, at 70 FR 44160.) EPA suggests that regional modeling using a photochemical grid model may be more appropriate than CALPUFF for this purpose.

Note that EPA has indicated in the BART rule (70 FR 39138-39139) that emissions reductions under the Clean Air Interstate Rule (CAIR) meet the BART requirement for SO_2 and NO_x control for those EGUs subject to BART. However, PM emissions from EGUs are not addressed by CAIR and therefore a BART analysis may still be required for PM.

2.2 Model Recommendations for the BART Analysis

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 as "the best regulatory modeling application currently available for predicting a single source's contribution to visibility impairment" (70 FR 39162). The use of another "appropriate model" is allowed although the EPA prefers the use of CALPUFF. If a source wants to use an alternative model, the source needs to submit a written justification and source-specific modeling protocol to its State for review and approval. As part of the consultation process, the State will provide documentation to EPA and FLM.

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 PLUVUE-II plume visibility model is mentioned as a possible model to consider instead of CALPUFF for a source within less than 50 km of a Class I area.

The EPA guidance notes that "regional scale photochemical grid models may have merit, but such models have been designed to assess cumulative impacts, not impacts from individual sources" and

they are “very resource intensive and time consuming relative to CALPUFF”, but States may consider their use for SIP development in the future as they may be adapted and “demonstrated to be appropriate for single source applications” (70 FR 39123). Photochemical grid models may be 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 (70 FR 39163).

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).

In the BART modeling analyses the EPA recommends that the State use the highest 24-hour average actual emission rate for the most recent three to five-year period of record. Emissions on days influenced by periods of start-up, shutdown and malfunction are not to be considered in determining the appropriate emission rates. (70 FR 39129).

If a source is found 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. Visibility improvements may be evaluated on a pollutant-specific basis in the BART determination (70 FR 39129).

For evaluating the improvement in visibility resulting from the application of BART, the EPA guidelines state that States are “encouraged to account for the magnitude, frequency, and duration of the contributions to visibility impairment caused by the source based on the natural variability of meteorology” (70 FR 39129).

2.3 Performance of a Cap and Trade Program

If a State or States elect to pursue an optional cap and trade program, they are required to demonstrate greater “reasonable progress” in reducing haze than would result if BART were applied to the same sources. In some cases, a State may simply be able to demonstrate that a trading program that achieves greater progress at reducing emissions will also achieve greater progress at reducing haze. Such would be the case if the likely geographic distribution of emissions under the trading program would not be greatly different from the distribution if BART was in place.

If the expected distribution of emissions is different under the two approaches, then “dispersion modeling” of all sources must be used to determine the difference in visibility at each impacted Class I area, in order to establish that the optional trading program will result in visibility improvements aggregated over all Class I areas that are “better than BART” (70 FR 39137-39138). The BART guidance does not specify the method to be used for this modeling. From a technical perspective, either applying CALPUFF to every source or using a regional photochemical model would satisfy the need.

A rulemaking procedure is currently underway to establish final guidance for such alternatives to BART (70 FR 44154-44175). The rule is expected to be finalized in 2006.

3. OVERVIEW OF THE CALPUFF MODELING SYSTEM

This chapter contains a general description of the CALPUFF modeling system and its capabilities and limitations. It does not include specific recommendations regarding the use of the model for BART analysis in the VISTAS region. These specific recommendations can be found in Chapter 4.

3.1 Capabilities and features of CALPUFF

The CALPUFF modeling system (Scire et al., 2000a, b) is recommended as the preferred modeling approach for use in the BART analyses. CALPUFF and its meteorological model, CALMET, are designed to handle the complexities posed by the complex terrain, the large source-receptor distances, chemical transformation and deposition, and other issues related to Class I visibility impacts. The CALPUFF modeling system has been adopted by the EPA as a *Guideline Model* for source-receptor distances greater than 50 km, and for use on a case-by-case basis in complex flow situations for shorter distances (68 FR 18440-18482). CALPUFF is recommended for Class I impact assessments by the Federal Land Managers Workgroup (FLAG 2000) and the Interagency Workgroup on Air Quality Modeling (IWAQM) (EPA 1998). The final BART guidance recommends CALPUFF as "the best modeling application available for predicting a singe source's contribution to visibility impairment" (70 FR 39122). As a result of these recommendations, the VISTAS modeling protocol is based on the use of CALPUFF for its BART determinations.

The main components of the CALPUFF modeling system are shown in Figure 3-1. CALMET is a diagnostic meteorological model that is used to drive the CALPUFF dispersion model. It produces three-dimensional wind and temperature fields and two-dimensional fields of mixing heights and other meteorological fields. It contains slope flow effects, terrain channeling, and kinematic effects of terrain. CALMET includes special algorithms for treating the overwater boundary layer and coastal interaction effects. CALMET can use meteorological observational data and/or three-dimensional output from prognostic numerical meteorological models such as MM5 (Grell et al., 1995) or RUC (Benjamin et al., 2004) in the developments of its fine-scale meteorological fields.

CALPUFF is a non-steady-state Lagrangian puff transport and dispersion model that advects Gaussian puffs of multiple pollutants from modeled sources. CALPUFF's algorithms have been designed to be applicable on spatial scales from a few tens of meters to hundreds of kilometers from a source. It includes algorithms for near-field effects such as building downwash, stack tip downwash and transitional plume rise as well as processes important in the far-field such as chemical transformation, wet deposition, and dry deposition. CALPUFF contains an option to allow puff splitting in the horizontal and vertical directions, which extends the distance range of the model. The primary outputs from CALPUFF are hourly concentrations and hourly deposition fluxes evaluated at user-specified receptor locations.

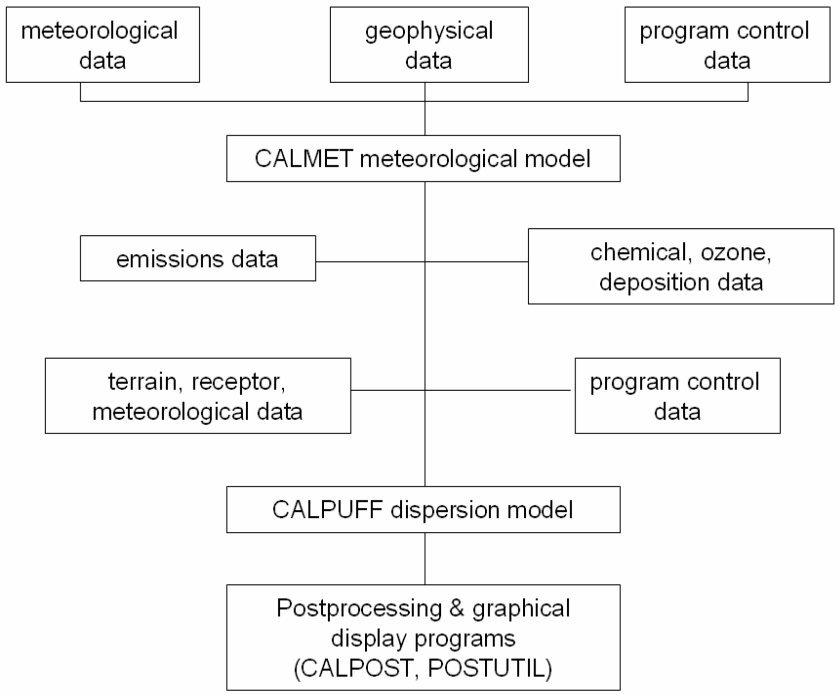

Figure 3-1. CALPUFF modeling system components.

A set of postprocessing programs associated with CALPUFF computes visibility effects and allows cumulative source impacts to be assessed, including potential non-linear effects of ammonia limitation on nitrate formation. The CALPOST postprocessor contains several options for computing change in extinction and deciviews for visibility assessments. The POSTUTIL postprocessor includes options for summing contributions of individual sources or groups of sources to assess cumulative impacts. POSTUTIL also contains CALPUFF's nitric acid-nitrate chemical equilibrium module, which allows the cumulative effects of ammonia consumption by background sources to be assessed in the postprocessor. In addition, the combination of CALPUFF and POSTUTIL allows the effects of source emissions of ammonia to be incrementally added to background ammonia levels when determining nitrate formation.

The rest of this chapter summarizes the capabilities and features of the CALPUFF modeling components in more detail.

3.1.1 Major Features of CALMET

The CALMET meteorological model consists of a diagnostic wind field module and micrometeorological modules for overwater and overland boundary layers. When modeling a large geographical area, as would be necessary for the regional VISTAS domain, the user has the option to use a Lambert Conformal Projection coordinate system to account for Earth's curvature.

The major features and options of the meteorological model are summarized in Table 3-1. The techniques used in the CALMET model are briefly described below.

Table 3-1. Major Features of the CALMET Meteorological Model

- **Boundary Layer Modules of CALMET**
  - Overland Boundary Layer - Energy Balance Method
  - Overwater Boundary Layer - Profile Method
    - -- COARE algorithm
    - -- OCD-based method
  - Produces Gridded Fields of:
    - -- Surface Friction Velocity
    - -- Convective Velocity Scale
    - -- Monin-Obukhov Length
    - -- Mixing Height
    - -- PGT Stability Class
    - -- Air Temperature (3-D)
    - -- Precipitation Rate

- **Diagnostic Wind Field Module of CALMET**
  - Slope Flows
  - Kinematic Terrain Effects
  - Terrain Blocking Effects
  - Divergence Minimization
  - Produces Gridded Fields of U, V, W Wind Components
  - Inputs Include Domain-Scale Winds, Observations, and (optionally) Coarse-Grid Prognostic Model Winds
  - Lambert Conformal Projection Capability

CALMET Boundary Layer Models

The CALMET model contains two boundary layer models for application to overland and overwater grid cells.

Overland Boundary Layer Model: Over land surfaces, the energy balance method of Holtslag and van Ulden (1983) is used to compute hourly gridded fields of the sensible heat flux, surface

friction velocity, Monin-Obukhov length, and convective velocity scale. Mixing heights are determined from the computed hourly surface heat fluxes and observed temperature soundings using a modified Carson (1973) method based on Maul (1980). The model also determines gridded fields of Pasquill-Gifford-Turner (PGT) stability class and hourly precipitation rates.

Overwater Boundary Layer Model: The aerodynamic and thermal properties of water surfaces suggest that a different method is best suited for calculating the boundary layer parameters in the marine environment. A profile technique, using air-sea temperature differences, is used in CALMET to compute the micro-meteorological parameters in the marine boundary layer. The version of CALMET being used by VISTAS contains improvements in the overwater boundary layer parameterizations (Fairall et al., 2003) based on the Coupled Ocean Atmosphere Response Experiment (COARE) and enhancements in the calculation of overwater mixed layer heights (Batchvarova and Gryning, 1991, 1994). Further details and the results of an evaluation of the model containing these enhancements are described in Scire et al. (2005). An upwind-looking spatial averaging scheme is optionally applied to the mixing heights and three-dimensional temperature fields in order to account for important advective effects.

Diagnostic Wind Field Module

The diagnostic wind field module uses a two-step approach to the computation of the wind fields (Douglas and Kessler, 1988). In the first step, an initial-guess wind field is adjusted for kinematic effects of terrain, slope flows, and terrain blocking effects to produce a Step 1 wind field. Gridded MM5 can be used to define the initial guess field. The second step consists of an objective analysis procedure to introduce observational data into the Step 1 wind field to produce a final wind field.

Step 1 Wind Field. Development of the Step 1 wind field begins with the initial guess field defined by the MM5 prognostic meteorological model. Normally, the CALMET computational domain is specified to be at finer grid resolution than the MM5 dataset used to initialize the initial guess field. For example, 36-km MM5 data available for VISTAS modeling may be used to develop the initial guess field on a 12-km or even a 1-km CALMET grid. The Step 1 algorithms in CALMET described below apply terrain adjustments to the initial guess field on the fine-scale CALMET grid. Thus, the CALMET winds are adjusted to respond to fine-scale terrain features not necessarily seen by the coarser scale MM5 model.

Kinematic Effects of Terrain: The approach of Liu and Yocke (1980) is used to evaluate the effects of the terrain on the wind field. The initial guess field winds are used to compute a terrain-forced vertical velocity, subject to an exponential, stability-dependent decay function. The effects of terrain on the horizontal wind components are evaluated by applying a divergence-minimization scheme to the initial guess wind field. The divergence minimization scheme is applied iteratively until the three-dimensional divergence is less than a threshold value.

Slope Flows: The original slope flow algorithm in CALMET has been upgraded (Scire and Robe, 1997) based on the shooting flow algorithm of Mahrt (1982). This scheme includes both

advective-gravity and equilibrium flow regimes. At night, the slope flow model parameterizes the flow down the sides of the valley walls into the floor of the valley, and during the day, upslope flows are parameterized. The magnitude of the slope flow depends on the local surface sensible heat flux and local terrain gradients. The slope flow wind components are added to the wind field adjusted for kinematic effects.

Blocking Effects: The thermodynamic blocking effects of terrain on the wind flow are parameterized in terms of the local Froude number (Allwine and Whiteman, 1985). If the Froude number at a particular grid point is less than a critical value and the wind has an uphill component, the wind direction is adjusted to be tangent to the terrain.

Step 2 Wind Field. The wind field resulting from the above adjustments of the initial-guess wind is the Step 1 wind field. The second step of the procedure may involve introduction of observational data into the Step 1 wind field through an objective analysis procedure. An inverse-distance squared interpolation scheme is used which weights observational data heavily in the vicinity of the observational station, while the Step 1 wind field dominates the interpolated wind field in regions with no observational data. The resulting wind field is subject to smoothing, an optional adjustment of vertical velocities based on the O'Brien (1970) method, and divergence minimization to produce a final Step 2 wind field.

The introduction of observational data in the Step 2 calculation is an option. It is also possible to run the model in "no observations" (No-Obs) mode, which involves the use only of MM5 gridded data for the initial guess field followed by fine-scale terrain adjustments by CALMET. In No-Obs mode, observational data are not used in the Step 2 calculations. The No-Obs mode is appropriate when the MM5 simulations adequately characterize the regional wind patterns and when local observations, especially surface observations, reflect local conditions on a scale smaller than that of the CALMET domain and hence their spatial representativeness may be limited. Such situations are most likely to occur when the CALMET grid scale is relatively large i.e., coarser than the scale of variation of the true wind field, which is particularly likely to occur in complex terrain or along the seashore,

3.1.2 Major Features of CALPUFF

By its puff-based formulation and through the use of three-dimensional meteorological data developed by the CALMET meteorological model, CALPUFF can simulate the effects of time- and space-varying meteorological conditions on pollutant transport from sources in complex terrain. The major features and options of the CALPUFF model are summarized in Table 3-2 at the end of this subsection. Some of the technical algorithms are briefly described below.

Complex Terrain: The effects of complex terrain on puff transport are derived from the CALMET winds. In addition, puff-terrain interactions at gridded and discrete receptor locations are simulated using one of two algorithms that modify the puff-height (either that of ISCST3 or a general "plume path coefficient" adjustment), or an algorithm that simulates enhanced vertical dispersion derived from the weakly-stratified flow and dispersion module of the Complex Terrain

Dispersion Model (CTDMPLUS) (Perry et al., 1989). The puff-height adjustment algorithms rely on the receptor elevation (relative to the elevation at the source) and the height of the puff above the surface. The enhanced dispersion adjustment relies on the slope of the gridded terrain in the direction of transport during the time step.

Subgrid Scale Complex Terrain (CTSG): An optional module in CALPUFF, CTSG treats terrain features that are not resolved by the gridded terrain field, and is based on the CTDMPLUS (Perry et al., 1989). Plume impingement on subgrid-scale hills is evaluated at the CTSG subgroup of receptors using a dividing streamline height (H_d) to determine which pollutant material is deflected around the sides of a hill (below H_d) and which material is advected over the hill (above H_d). The local flow (near the feature) used to define H_d is taken from the gridded CALMET fields. As in CTDMPLUS, each feature is modeled in isolation with its own set of receptors.

Puff Sampling Functions: A set of accurate and computationally efficient puff sampling routines is included in CALPUFF, which solve many of the computational difficulties encountered when applying a puff model to near-field releases. For near-field applications during rapidly-varying meteorological conditions, an elongated puff (slug) sampling function may be used. An integrated puff approach may be used during less demanding conditions. Both techniques reproduce continuous plume results under the appropriate steady state conditions.

Building Downwash: The Huber-Snyder and Schulman-Scire downwash models are both incorporated into CALPUFF. An option is provided to use either model for all stacks, or make the choice on a stack-by-stack and wind sector-by-wind sector basis. Both algorithms have been implemented in such a way as to allow the use of wind direction specific building dimensions. The PRIME building downwash model (Schulman et al., 2000) is also included in CALPUFF as an option.

Dispersion Coefficients: Several options are provided in CALPUFF for the computation of dispersion coefficients, including the use of turbulence measurements (σ_v and σ_w), the use of similarity theory to estimate σ_v and σ_w from modeled surface heat and momentum fluxes, or the use of Pasquill-Gifford (PG) or McElroy-Pooler (MP) dispersion coefficients, or dispersion equations based on the CTDM. Options are provided to apply an averaging time correction or surface roughness length adjustments to the PG coefficients. In version 5.754 of CALPUFF being used by VISTAS, an option is provided to use the AERMOD turbulence profiles for determining dispersion rates, which is the most recent approach to dispersion in EPA-approved regulatory modeling. In addition, turbulence advection is included. For additional details on these features, see Scire et al. (2005).

Overwater and Coastal Interaction Effects: Because the CALMET meteorological model contains both overwater and overland boundary layer algorithms, the effects of water bodies on plume transport, dispersion, and deposition can be simulated with CALPUFF. The puff formulation of CALPUFF is designed to handle spatial changes in meteorological and dispersion conditions, including the abrupt changes that occur at the coastline of a major body of water.

Dry Deposition: A resistance model is provided in CALPUFF for the computation of dry deposition rates of gases and particulate matter as a function of geophysical parameters, meteorological conditions, and pollutant species. For particles, source-specific mass distributions may be provided for use in the resistance model. Of particular interest for BART analyses is the ability to separately model the deposition of fine particulate matter (< 2.5 μm diameter) from coarse particulate matter (2.5-10 μm diameter).

Wind Shear Effects: CALPUFF contains an optional puff splitting algorithm that allows vertical wind shear effects across individual puffs to be simulated. Differential rates of dispersion and transport among the "new" puffs generated from the original, well-mixed puff can substantially increase the effective rate of horizontal spread of the material. Puffs may also be split in the horizontal when the puff size becomes large relative to the grid size, to account for wind shear across the puffs.

Wet Deposition: An empirical scavenging coefficient approach is used in CALPUFF to compute the depletion and wet deposition fluxes due to precipitation scavenging. The scavenging coefficients are specified as a function of the pollutant and precipitation type (i.e., frozen vs. liquid precipitation).

Chemical Transformation: CALPUFF includes options for parameterizing chemical transformation effects using the five species scheme (SO_2, $SO_4^=$, NO_x, HNO_3, and NO_3^-) employed in the MESOPUFF II model or a set of user-specified, diurnally-varying transformation rates. The MESOPUFF II scheme is recommended by IWAQM. It produces secondary fine particulate matter (sulfate and nitrate) from emissions of SO_2 and NO_x and thus allows analyses of visibility impacts. Ambient ozone concentrations are used in the parameterized chemical transformation module as a surrogate for OH radicals during daylight hours. Ambient ammonia concentrations are used together with a temperature and relative humidity-dependent equilibrium relationship to partition nitric acid and nitrate on an hour-by-hour and receptor-by-receptor basis.

Table 3-2. Major Features of the CALPUFF Dispersion Model

- **Source types**
  - Point sources (constant or variable emissions)
  - Line sources (constant or variable emissions)
  - Volume sources (constant or variable emissions)
  - Area sources (constant or variable emissions)

- **Non-steady-state emissions and meteorological conditions**
  - Gridded 3-D fields of meteorological variables (winds, temperature)
  - Spatially-variable fields of mixing height, friction velocity, convective velocity scale, Monin-Obukhov length, precipitation rate
  - Vertically and horizontally-varying turbulence and dispersion rates
  - Time-dependent source and emissions data for point, area, and volume sources
  - Temporal or wind-dependent scaling factors for emission rates, for all source types

- **Interface to the Emissions Production Model (EPM)**
  - Time-varying heat flux and emissions from controlled burns and wildfires

- **Efficient sampling functions**
  - Integrated puff formulation
  - Elongated puff (slug) formulation

- **Dispersion coefficient (σ_y, σ_z) options**
  - Direct measurements of σ_v and σ_w
  - Estimated values of σ_v and σ_w based on similarity theory
    - -- AERMOD turbulence profiles
    - -- Original turbulence profiles
  - Pasquill-Gifford (PG) dispersion coefficients (rural areas)
  - McElroy-Pooler (MP) dispersion coefficients (urban areas)
  - CTDM dispersion coefficients (neutral/stable)

- **Vertical wind shear**
  - Puff splitting
  - Differential advection and dispersion

- **Plume rise**
  - Buoyant and momentum rise
  - Stack tip effects
  - Building downwash effects
  - Partial penetration
  - Vertical wind shear

- **Building downwash**
  - Huber-Snyder method
  - Schulman-Scire method
  - PRIME method

- **Complex terrain**
  - Steering effects in CALMET wind field
  - Optional puff height adjustment: ISC3 or "plume path coefficient"
  - Optional enhanced vertical dispersion (neutral/weakly stable flow in CTDMPLUS)

Table 3-2. Major Features of the CALPUFF Dispersion Model (Cont'd)

- **Subgrid scale complex terrain (CTSG option)**
  - Dividing streamline, H_d, as in CTDMPLUS:
    - Above H_d, material flows over the hill and experiences altered diffusion rates
    - Below H_d, material deflects around the hill, splits, and wraps around the hill

- **Dry Deposition**
  - Gases and particulate matter
  - Three options:
    - Full treatment of space and time variations of deposition with a resistance model
    - User-specified diurnal cycles for each pollutant
    - No dry deposition

- **Overwater and coastal interaction effects**
  - Overwater boundary layer parameters (COARE algorithm or OCD-based method)
  - Abrupt change in meteorological conditions, plume dispersion at coastal boundary
  - Plume fumigation

- **Chemical transformation options**
  - Pseudo-first-order chemical mechanism for SO_2, $SO_4^{=}$, NO_x, HNO_3, and NO_3^- (MESOPUFF II method)
  - Pseudo-first-order chemical mechanism for SO_2, $SO_4^{=}$, NO, NO_2, HNO_3, and NO_3^- (RIVAD/ARM3 method)
  - User-specified diurnal cycles of transformation rates
  - No chemical conversion

- **Wet Removal**
  - Scavenging coefficient approach
  - Removal rate a function of precipitation intensity and precipitation type

3.1.3 Major Features of Postprocessors (CALPOST and POSTUTIL)

The two main postprocessors of interest for BART applications are the CALPOST and POSTUTIL programs. CALPOST is used to process the CALPUFF outputs, producing tabulations that summarize the results of the simulations, identifying, for example, the highest and second-highest hourly-average concentrations at each receptor. When performing visibility-related modeling, CALPOST uses concentrations from CALPUFF to compute light extinction and related measures of visibility (haze index in deciviews), reporting these for a 24-hour averaging time.

The CALPOST processor contains several options for evaluating visibility impacts, including the method described in the BART guidance, which uses monthly average relative humidity values. CALPOST contains implementations of the IWAQM-recommended and FLAG-recommended visibility techniques and additional options to evaluate the impact of natural weather events (fog, rain and snow) on background visibility and visibility impacts from modeled sources.

The POSTUTIL processor is a program that allows the cumulative impacts of multiple sources from different simulations to be summed, can compute the difference between two sets of

predicted impacts (useful for evaluating the benefits of BART controls), and contains a chemistry module to evaluate the equilibrium relationship between nitric acid and nitrate aerosols. This capability allows the potential non-linear effects of ammonia scavenging by sulfate and nitrate sources to be evaluated in the formation of nitrate from an individual source. CALPUFF makes the full ambient ammonia concentration available to each puff without regard for any scavenging by other puffs. POSTUTIL corrects for such scavenging when the puffs generated by the CALPUFF model overlap, as could be the case for a single source when the wind speed is low, or when nitrate formation is to be attributed to each of several sources that are in a cluster and whose plumes overlap,

POSTUTIL will also compute the impacts of individual sources or groups of sources on sulfur and nitrogen deposition into aquatic, forest and coastal ecosystems. The postprocessor allows the changes in deposition fluxes resulting from changes in emissions to be quantified. For example the output of POSTUTIL and CALPOST can be used as input into an Acid Neutralizing Capacity (ANC) analysis, or for comparison to Deposition Analysis Thresholds (DATs).

3.2 Discussion of CALPUFF Applicability and Limitations

3.2.1 Transport and Diffusion

According to the IWAQM Phase 2 report (page 18), "CALPUFF is recommended for transport distances of 200 km or less. Use of CALPUFF for characterizing transport beyond 200 to 300 km should be done cautiously with an awareness of the likely problems involved."[6]

IWAQM's 200-km limitation derives from the observation that, when compared to the data of the Cross Appalachian Tracer Experiment (CAPTEX), the basic configuration of CALPUFF overestimated inert tracer concentrations by factors of 3 to 4 at receptors that were 300 to 1000 km from the source. The apparent reason was insufficient horizontal dispersion of the simulated plume, presumably because an actual large plume does not remain coherent in the presence of vertical wind shears that typically occur, especially during the night, and of horizontal wind shears over the large puffs that arise over long transport distances.

To better represent such situations, an optional puff splitting algorithm has since been added to CALPUFF to simulate wind shear effects across a well-mixed individual puff by dividing the puff horizontally and vertically into two or more pieces. Differential rates of transport among the new puffs thus generated can increase the horizontal spread of the material in the plume due to vertical wind speed shear and wind direction shear. The horizontal puff splitting algorithm is

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[6] The IWAQM presentation at EPA's 6th Modeling Conference provides the background for this recommendation: "The IWAQM concludes that CALPUFF be recommended as providing unbiased estimates of concentration impacts for transport distances of order 200 km and less, and for transport times of order 12 hours or less. For larger transport times and distances, our experience thus far is that CALPUFF tends to underestimate the horizontal extent of the dispersion and hence tends to overestimate the surface-level concentration maxima. This does not preclude the use of CALPUFF for transport beyond 300 km, but it does suggest that results in such instances be used cautiously and with some understanding." (From page D-12 of the IWAQM Phase 2 report.)

designed to allow large puffs that may grow to be several grid cells or more in size to split into smaller puffs that can then more accurately respond to variations in the local wind field across the original large puff. This will also tend to increase horizontal dispersion of the plume. Since the creation of additional puffs via puff splitting will increase the computational requirements of the model, possibly substantially, puff splitting is not enabled by default, but can be turned on at the option of the user. Puff splitting may be appropriate for transport distances over 200 to 300 km, or possibly over shorter distances in complex terrain.

Turning to the shorter distance end of the transport range, the CALPUFF section of Appendix A of the *Guideline on Air Quality Models* (40 CFR 51, Appendix W) states, "CALPUFF is intended for use on scales from tens of meters from a source to hundreds of kilometers." This is supported by the IWAQM Phase 2 report, which indicates that the diffusion algorithms in CALPUFF were designed to be suitable for both short and long distances. In this regard, CALPUFF does contain algorithms for such near-field effects as plume rise, building downwash, and terrain impingement and includes routines that deal with the computational difficulties encountered when applying a puff model in the field near to a source.

The recommendations for regulatory use in Appendix A of the *Guideline on Air Quality Models* state, "CALPUFF is appropriate for long range transport (source-receptor distance of 50 to several hundred kilometers)", but provisions for using CALPUFF in the near-field in "complex flow" situations are also included in the regulatory guidance. Complex flow situations may include complex terrain, coastal areas, situations where plume fumigation is likely, and areas where stagnation, flow reversals, recirculation or spatial variability in wind fields (e.g., as due to changes in valley orientation) are important.

The tracer studies with which CALPUFF transport and diffusion capabilities were evaluated in the IWAQM Phase 2 report were generally over distances greater than 50 km. More recently, additional studies of model performance have been performed at shorter distances, including at a power plant in New York state in complex terrain (at source-receptor distances of 2 to 8.5 km) and a second power plant in Illinois in simple terrain (at source-receptor distances in arcs ranging from 0.5 km to 50 km from the stack) (Strimaitis et al., 1998). Other CALPUFF evaluation studies over short-distances include ones by Chang et al. (2001) and Morrison et al. (2003). These studies demonstrate good model performance over source-receptor distances from a few hundred meters to 50 km.

An important factor in the performance of CALPUFF is the choice of dispersion coefficients. The EPA has defined the "regulatory default" option in CALPUFF to allow either Pasquill-Gifford (PG) or turbulence-based dispersion coefficients. CALPUFF has been evaluated and shown to perform better using turbulence-based dispersion for tall stacks (Strimaitis et al, 1998). CALPUFF with turbulence-based dispersion has also been evaluated for overwater transport and coastal situations (Scire et al., 2005). In many other studies, including AERMOD evaluation studies conducted by EPA, the use of PG-dispersion, or more specifically the lack of a convective probability density function (pdf) module, has been demonstrated to result in underprediction of peak concentrations.

In November 2005, EPA approved the AERMOD model, which relies on turbulence-based dispersion, as a regulatory Guideline Model[7]. The ISCST3 model and its PG dispersion coefficients are being phased out as an acceptable regulatory approach. However, EPA Region IV has indicated that the application of turbulence-based dispersion coefficients in CALPUFF needs to be further demonstrated before they are approved for BART application. They will consider accepting the use of turbulence dispersion coefficients on a case-by-case basis for sources that are close to Class I areas.

For regional haze light extinction calculations, use of a plume-simulating model such as CALPUFF is appropriate only when the plume is sufficiently diffuse that it is not visually discernible as a plume *per se*, but nevertheless its presence could alter the visibility through the background haze. The IWAQM Phase 2 report states that such conditions occur starting 30 to 50 km from a source. In this light, the BART guidance strongly recommends using CALPUFF for source-receptor distances greater than 50 km but also presents CALPUFF as an option that can be considered for shorter transport distances.

As discussed above, there do not appear to be any scientific reasons why CALPUFF cannot be used for even shorter transport distances than 30 km, though, as long as the scale of the plume is larger than the scale of the output grid so that the maximum concentrations and the width of the plume are adequately represented and so that the sub-grid details of plume structure can be ignored when estimating effects on light extinction. The standard 1-km output grid that has been established for Class I area analyses should serve down to source-receptor distances somewhat under 30 km; how much closer than 30 km will depend on the topography and meteorology of the area and should be evaluated on a case-by-case basis. For extremely short transport distances, depiction of the concentration distribution will require a grid that is finer than 1 km. (For reference, the width of a Gaussian plume, $2\sigma_y$, is roughly 1 km after 10 km of travel distance, assuming Pasquill-Gifford dispersion rates under neutral conditions.)

As an additional consideration, if the plume width is small compared to the visual range, the atmospheric extinction along a typical sight path of tens of kilometers through the plume will be inhomogeneous and the simple CALPOST point estimate of regional light extinction at a receptor point will not be correct. However, the effect of averaging light extinction estimates for 24 hours, during which the plume location shifts over various receptor points, is likely to mitigate this problem to some degree and suggests that using CALPUFF at distances under 30 km will often be appropriate. For the narrow plumes that result from short transport distances, though, the modeled peak 24-hr average extinction at a receptor will tend to overstate the effect of the source on regional haze.

[7] *Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rule.* 70 FR 68218-68261. 9 November 2005.

The U.S. EPA has suggested that the plume visibility model, PLUVUE-II, could be used in lieu of CALPUFF for simulating visibility effects at such short distances.[8] PLUVUE-II is a Gaussian model that simulates the dispersion, chemical conversion, and optical effects of emissions of particles, SO_2, and NO_x from a single source. Its outputs include the discoloration of the sky by the plume (so called "plume blight") and the effect of the plume on visibility along user-selected sight paths that pass through the plume. The impacts of the plume on visibility depend not only on the plume composition, but also on the sight path chosen and its direction relative to the axis of the plume and the location of the sun. It isn't clear how such sight-path dependent results could be compared to the 0.5 and 1.0 deciview thresholds in the BART guidance. Since CALPUFF is designed to be useful for short transport distances (with features such as the simulation of plume downwash caused by structures at the source), CALPUFF seems more appropriate than PLUVUE-II for evaluating source impact at short distances for BART assessment purposes.

3.2.2 Aerosol Constituents

Primary $PM_{2.5}$

Appendix A of the *Guideline on Air Quality Models* (40 CFR 51, Appendix W) states that CALPUFF can treat primary pollutants such as PM_{10}. In actuality, CALPUFF can simulate PM_{10} or $PM_{2.5}$ or some other size range, because the assumed size distribution of the particles is a user input. The smaller the particles, the more they disperse like an inert gas. In most cases, the dispersion of inert $PM_{2.5}$ particles will be only minutely different from that of an inert gas, but the behavior of larger particles will differ.

A particularly important contributor to PM concentrations is the rate of deposition to the surface. $PM_{2.5}$ particles, which have a mass median diameter around 0.5 µm, have an average net deposition velocity of about 1 cm/min (or about 14 m/day) and thus the deposition of fine particles is usually not significant except for ground-level emissions. On the other hand, coarse particles (those PM_{10} particles larger than $PM_{2.5}$) have an average deposition velocity of more than 1 m/min (or 1440 m/day), which is significant, even for emissions from elevated stacks.

CALPUFF includes parametric representations of particle and gas deposition in terms of atmospheric, deposition layer, and vegetation layer "resistances" and, for particles, the gravitational settling speed. Gravitational settling, which is of particular importance for the coarse fraction of PM_{10}, is accounted for in the calculation of the deposition velocity. Effects of inertial impaction (important for the upper part of the PM_{10} distribution) and Brownian motion (important for small, sub-micron particles) and wet scavenging are also addressed. The BART guidance recommends that fine particulate matter (less than 2.5 µm diameter), which has higher light extinction efficiency than coarse particulate matter (2.5-10 µm diameters), should be treated separately in the model. CALPUFF allows for user-specified size categories to be treated as

[8] However, for the reasons given in this paragraph, VISTAS does not recommend PLUVUE-II for BART application

separate species, which includes calculating size-specific dry deposition velocities for each size category.

A primary $PM_{2.5}$ emission from coal-fired electric generating units (EGUs) that is of relevance to visibility calculations is that of primary sulfate. Although primary sulfate emissions account for only a small fraction of the total sulfur emissions from such sources, it may be important to simulate their effect with CALPUFF, especially at shorter distances before significant formation of secondary sulfate conversion from SO_2 has taken place.

Sulfur Dioxide and Secondary Particulate Sulfate

The MESOPUFF-II chemistry algorithm used in CALPUFF[9] simulates the gas phase oxidation of sulfur dioxide to sulfate by a linear transformation rate that was developed using regression relationships derived from the analysis of chemical conversion rates produced by a complex photochemical box model (see Scire et al., 1984, for a description of the development of the chemical module). As in all empirically-derived models, the relationships are based on easily-computed or observed parameters that are used as surrogates for the factors that control SO_2 oxidation.

The surrogate factors included in the parameterized chemistry during the daytime hours include solar radiation intensity, ambient ozone concentration, and atmospheric stability class. For example, gas phase SO_2 oxidation is a function of OH radical concentrations. Ozone concentrations are correlated with OH radical concentrations during daytime hours, and their use in the daytime SO_2 conversion rate in CALPUFF is based on this correlation relationship. The philosophy is that OH radical measurements are not available and cannot easily be computed within a model like CALPUFF, but ozone is commonly measured throughout the country, so the use of the well-known surrogate variable (ozone) is more useful in the empirical relationship than factors that are unknown or have a high degree of uncertainty. The same logic applies to the other variables in the relationship. They are surrogates for factors that the regression analysis has shown to be important in SO_2 oxidation rates. At night, the SO_2 conversion is set to a constant low value (default is 0.2%/hr). Aqueous phase oxidation of SO_2 is represented by an additive term that varies with relative humidity and peaks at 3%/hr at 100% relative humidity. CALPUFF represents the chemical conversion as a linear process because it requires linear independence between puffs, although as explained below, non-linear behavior in nitrate formation can be modeled.

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[9] CALPUFF offers two options for parameterizing chemical transformations: the 5 species (SO_2, $SO_4^{=}$, NO_x, HNO_3, and NO_3^-) MESOPUFF-II system and the 6 species RIVAD system (which treats NO and NO_2 separately). IWAQM recommends using the MESOPUFF-II system with CALPUFF. The RIVAD system is believed to be more appropriate for clean environments, however, and therefore was used in the Southwest Wyoming Regional CALPUFF Air Quality Modeling Study in 2001. For the VISTAS region, the IWAQM- and FLM-recommended MESOPUFF-II chemistry is most appropriate.

The IWAQM Phase 2 report concludes that this chemistry algorithm is adequate for representing the gas phase sulfate formation but that it does not adequately account for the aqueous phase oxidation of SO_2. Actual aqueous phase oxidation in clouds or fog can proceed at rates much greater than 3% per hour, leading IWAQM to suggest that sulfate might be underestimated in such situations. However, aqueous phase oxidation depends on liquid water content, not relative humidity. In reality, liquid water does not exist in the atmosphere at relative humidity much below 100%, while the CALPUFF aqueous reaction term produces sulfate at lower relative humidity. This can lead CALPUFF to overestimate sulfate concentrations when the humidity is high but the cloud water that enables aqueous conversion is not present. Therefore, the direction of the bias in the aqueous chemistry simulation of sulfate formation can vary.

Other potential sources of error in the sulfate formation mechanism of CALPUFF include (1) overestimation of sulfate formation when NO_x concentrations in the plume are high and in actuality they deplete the local availability of ozone and hydrogen peroxide for oxidizing the SO_2; and (2) lack of direct consideration of the effect of temperature on the conversion rates, which may cause the model to overstate sulfate formation on cold days (below 10C or 50°F) (Morris et al., 2003). However, in CALPUFF, the effects of temperature are, to some degree, compensated for indirectly by the use of the solar radiation surrogate variable in the empirical conversion equations.

Whether these potential errors are important will depend on the setting. For example, Figure 3-2 shows a comparison of predicted and observed 24-hour sulfate concentrations, due to a large number of SO_2 sources, at the Pinedale IMPROVE site in Wyoming for the 1995 period (Scire et al., 2001). Overall, in this case there was very little bias in the sulfate predictions. Whether CALPUFF predictions would compare as well with measurements in the Southeast remains to be seen.

CALPUFF does not identify the chemical form of the sulfate compound that results from its reactions, which will generally be some form of ammoniated sulfate whose degree of neutralization will depend on the availability of ammonia in the atmosphere. This consideration, which has been found to be relevant for calculating light extinction in the VISTAS region, is not addressed by CALPUFF or CALPOST.

In most applications, the ozone concentrations required for the sulfate formation calculations are derived from ambient measurements, although concentrations simulated by regional models can be used.

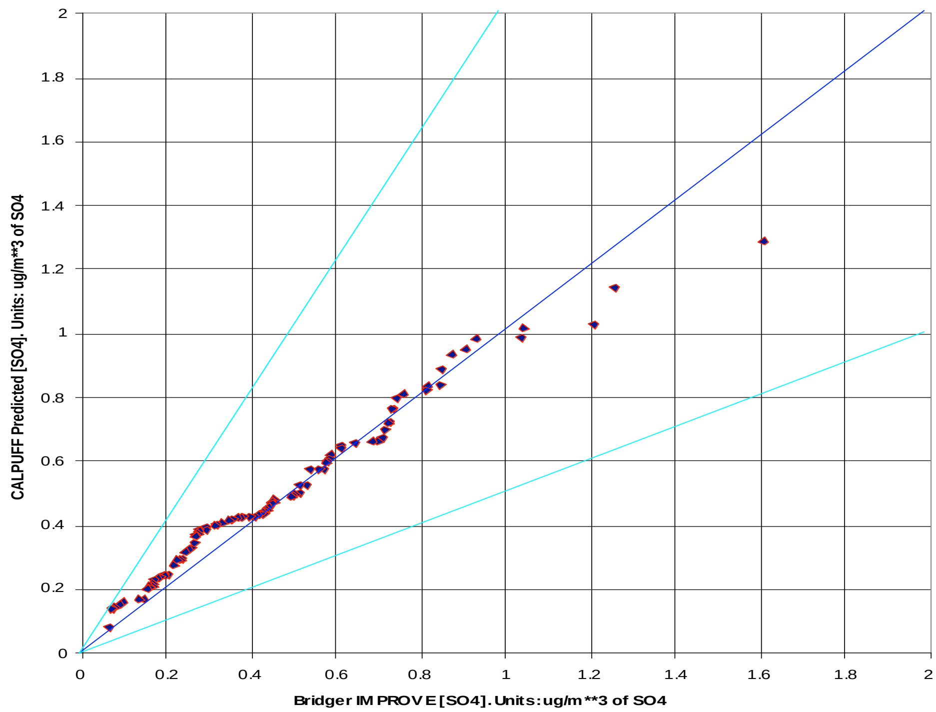

Figure 3-2. Observed vs. CALPUFF-predicted 24-hour sulfate concentrations at the IMPROVE monitoring site in Pinedale, Wyoming for 1995.

NO_x and Secondary Ammonium Nitrate

The MESOPUFF-II chemistry algorithm used in CALPUFF simulates the oxidation of NO_x to nitric acid and organic nitrates (both gases) by transformation rates that depend on NO_x concentration, ambient ozone concentration, and atmospheric stability class during the day. The conversion rate at night is set at to a constant value (default is 2.0 %/hr). The temperature- and humidity-dependent equilibrium between nitric acid gas and ammonium nitrate particles is taken into account when estimating the ammonium nitrate particle concentration, an equilibrium that depends on the ambient concentration of ammonia. The user supplies the value of the ambient concentration of ammonia. CALPUFF assumes that the sulfate reacts preferentially with that ammonia to form ammonium sulfate and the left over ammonia is available to form ammonium nitrate.

The IWAQM Phase 2 report considers that this mechanism is adequate for representing nitrate chemistry. Potential situations where this assumption may not be correct, however, include (1) plumes with high concentrations of NO_x that deplete the ambient ozone and thus limit the

transformation of NO_x to nitric acid in the plume; and (2) when ambient temperature is below 10 C, and thus the transformation rate is much slower and the nitrate concentration may be lower than that simulated by CALPUFF (Morris et al., 2003). In both cases, CALPUFF may overestimate the amount of nitrate that is produced. In particular, the impact of ammonium nitrate concentrations on visibility at Class I areas in the VISTAS region is greatest in the winter, when temperatures are lowest, the nitrate concentrations are the greatest, and the sulfate concentrations tend to be the least. CALPUFF may overstate the impacts of NO_x emissions at those times, especially in the colder northern states**.** This potential overestimate of nitrate was not evident, however, in an evaluation of CALPUFF-modeled nitrate against actual observational data in the Wyoming study, as shown in Figure 3-3a (Scire et al., 2001),

Another factor in the calculation of nitrate is that CALPUFF makes the full amount of the background concentration of ammonia available to each puff, and that amount is scavenged by the sulfate in the puff. If puffs overlap, then that approach could overstate the amount of ammonium nitrate that is formed in total if, in reality, the combined scavenging by the overlapping puffs at a location would deplete the available ammonia enough that the combined nitrate formation was limited by the availability of ammonia. This effect of such ammonia limiting can be large in summer; for a source 75 km west of Mammoth Cave National Park, one modeling analysis found the maximum light extinction impact of the source to be 7.4% (roughly 0.74 deciviews) at the park when CALPUFF was used without consideration of ammonia limiting and about 30% less, between 5.5 and 5.8% (roughly 0.55 to 0.58 dv), when the effect of ammonia limiting was considered (Escoffier-Czaja and Scire, 2002).

To address the issue, since 1999 (i.e., after the IWAQM Phase 2 report) the CALPUFF system has included the optional POSTUTIL postprocessing program, which repartitions the ammonia and nitric acid concentrations estimated by CALPUFF to reflect potential ammonia-limiting effects on the development of nitrate**.** This allows non-linearity associated with ammonia limiting effects to be included in the CALPUFF model estimates. POSTUTIL computes the total sulfate concentrations from all sources (modeled sources plus inflow boundary conditions) and estimates the amount of ammonia available for total nitrate formation after the preferential scavenging of ammonia by sulfate. That is, as new sulfate, nitrate or ammonia from the source of interest is added to an existing mix of pollutants, POSTUTIL will estimate both the nitrate formed from the new source and the change in background nitrate as a result of the incremental depletion of ammonia (due to the new sulfate and nitrate) or addition of ammonia (from a new source of ammonia).

Reliable estimates of the ambient concentrations of ammonia, especially with the temporal and spatial resolution that would be optimal for use with CALPUFF, are needed to take full advantage of the increased accuracy provided by POSTUTIL. The processor requires estimated concentrations of ammonia throughout the modeling domain and period. Such estimates can be inferred from CASTNet measurements, which are integrated over a week, from 24-hr SEARCH measurements, or from the output of a regional photochemical model such as CMAQ or CAMx. The CASTNet network is fairly sparse and the uncertainty in the ammonia measurements is large,

so defining the ammonia concentration throughout the Southeast would require extensive interpolation or extrapolation from the measured values. The quality of the SEARCH measurements is much better, but there are only 8 sites and they do not cover the entire VISTAS domain. Modeled concentrations have the advantage of being resolved in space and time, but their accuracy should be evaluated by comparison with measurements wherever possible.

Benefit is obtained by considering seasonal trends of ammonia and using POSTUTIL to determine the diurnal variability in available ammonia due to the daily cycle of nitrate formation associated with temperature and relative humidity effects. For example, results of the Wyoming study (see Figure 3-3a) show that POSTUTIL adjustments produced daily average nitrate concentrations well within the factor of two lines and with very little mean bias. On the other hand, analysis of the same results with use of constant ammonia of 0.5 ppb or 1.0 ppb produced consistent overpredictions of nitrate by factors of 2-3 and 3-4, respectively, as shown in Figure 3-3b (Scire et al., 2003).

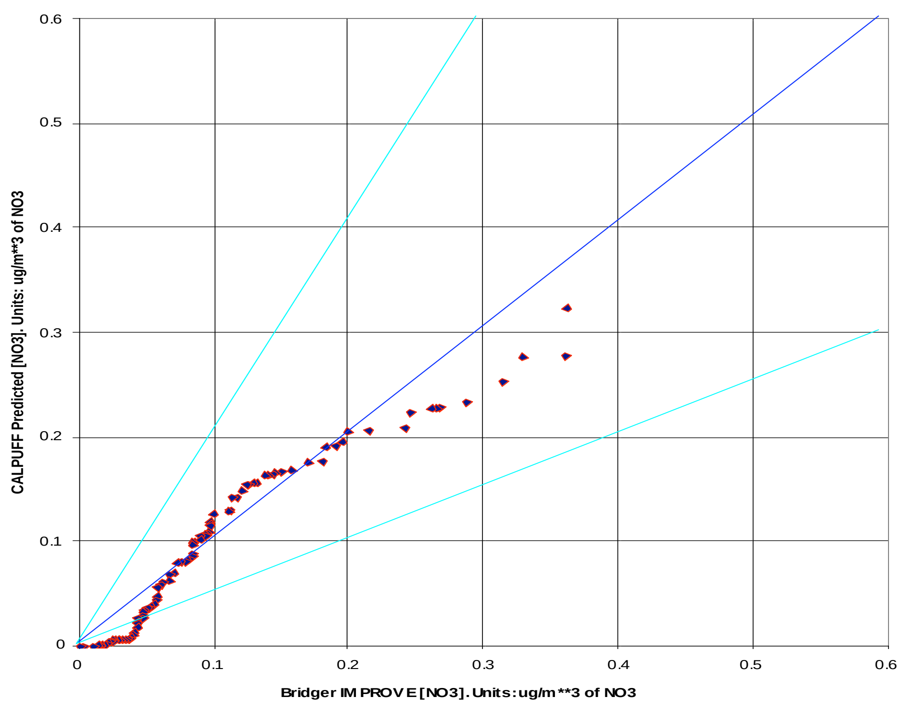

Figure 3-3a. Observed vs. CALPUFF-predicted 24-hour nitrate concentrations at the IMPROVE monitoring site in Pinedale, Wyoming for 1995 using the ammonia limiting method. (Scire et al., 2001)

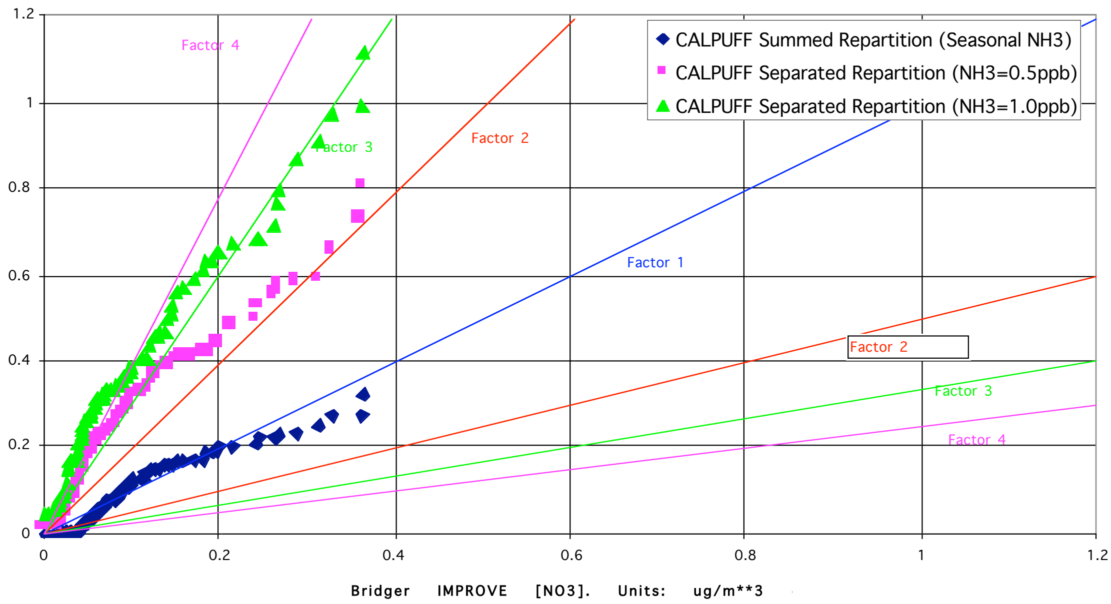

Figure 3-3b. Observed vs. CALPUFF-predicted 24-hour nitrate concentrations at the IMPROVE monitoring site in Pinedale, Wyoming for 1995 using the ammonia limiting method (blue), constant ammonia at 0.5 ppb (pink) and constant ammonia at 1.0 ppb (green). (Scire et al., 2003)

Secondary Organic Aerosol

Ongoing research studies at several Class I areas throughout the country (Fallon and Bench, 2004) and at SEARCH sites in the Southeast (Edgerton et al., 2004) are finding that, typically, 90 to 95% of the rural organic carbon fine particle concentration consists of modern carbon (e.g., that from the burning of vegetation and deriving from VOC emissions from vegetation) and only 5 to 10% is attributable to man's burning of fossil fuels. In addition, a field study at Great Smoky Mountains National Park in August 2002 (Tanner, et al., 2005) found that an average of 83% of the fine carbon was modern carbon

According to IMPROVE measurements, organics account for roughly 10% of the particle-caused light extinction in Class I areas in the Southeast. We can thus conclude that, in general, secondary organic carbon particles derived from anthropogenic fossil fuel burning emissions are unlikely to have a large impact (around 1%) on current visibility. (Man-caused burning of vegetation can have significant localized, short-term impacts, however.)

Current organic fine particle concentrations in the Southeast are typically within a factor of 2 of the 1.4 $\mu g/m^3$ concentration assumed for natural conditions by the EPA, which means that current fossil fuel burning would contribute less than 2% to visibility in an atmosphere that represents natural conditions. Thus, it is unlikely that VOC and organic particle contributions from BART

sources will cause a large impact to visibility at Class I areas, but a 5% (0.5 dv) localized impact from a particularly large VOC source cannot be dismissed out of hand.

CALPUFF has only rudimentary capabilities for addressing formation of visibility-impairing organic particles from some forms of volatile organic carbon (VOC). The capabilities that do exist include the following.

First, PM_{10} emissions (such as from power plants) are often divided into filterable and condensable components, with the condensable mass being 100-200% of the filterable mass. For purposes of visibility analyses with CALPUFF, a fraction of the condensable part is typically treated as organic particles, i.e., it is assumed that a fraction of the condensable components in the PM_{10} emissions condense into organic $PM_{2.5}$ particles. The size of this organic fraction varies with process and process equipment, and can range from 20 to 100% of the condensable mass. These fine organic particles can be readily modeled by CALPUFF. (The remaining condensable material may be sulfuric, hydrochloric, or hydrofluoric acid.)

Second, a module that treats the formation of secondary organic particles from organic emissions was recently developed and is now part of the CALPUFF system. (Scire et al., 2001). This simplified secondary organic aerosol (SOA) module is a linear, parameterized representation that is currently considered best suited for biogenic organics. It relies on the conventional wisdom that only hydrocarbons with more than six carbon atoms can form significant SOA (Grosjean and Seinfeld, 1989). For example, according to this rule, isoprene (C_5H_8) does not make SOA but terpenes do, making pine trees more important biogenic contributors to SOA than oak trees.[10]

Limited evaluation of the performance of CALPUFF at simulating SOA with its biogenic SOA module at one IMPROVE site in a regional modeling study in Wyoming found that 95% of 101 estimated 24-hr SOA concentrations were within 2% of the measured values (Scire et al., 2001). This performance seems promising, although the developers view the SOA module as needing more testing and evaluation.

Thus, CALPUFF includes approaches for dealing with condensable VOC emissions that are characterized as condensable PM_{10} and with biogenic VOCs, although the soundness of concentration estimates by these approaches when modeling a plume from a single source is largely untested.[11] The CALPUFF simulation of VOC emissions from sources whose VOC emissions are predominantly anthropogenic is problematic, however. Perhaps the approach used for the simplified biogenic SOA module may be extended to anthropogenic VOCs when speciated VOC emissions information is available. If only those VOCs with more than six carbon atoms are presumed to be of importance, this eliminates many anthropogenic sources of VOC emissions. For example, the fugitive emissions of butane and ethane during petroleum processing

[10] Recent research suggests that isoprene may be a SOA precursor, however.

[11] Note that neither of these VOC-related simulation approaches is described in the current (Version 5) CALPUFF User's Guide dated January 2001. See the Wyoming report referenced above for a description of this module.

are not important, while aromatic emissions (such as of toluene and xylene) are considered by the SOA module's mechanism. Development, testing, and evaluation would be needed before one could rely on such a module for estimating SOA from anthropogenic SOA emissions, though.

Therefore, to demonstrate the visibility impacts of VOC emissions from BART-eligible sources, means other than CALPUFF will be needed. A technical approach using a regional photochemical model to evaluate visibility impacts of VOC emissions is presented in Section 4.1.3. CALPUFF can be used to estimate the contribution from the primary condensable fraction of PM_{10} emissions, though.

3.2.3 Regional Haze

Calculation of the impact of the simulated plume particulate matter component concentrations on light extinction is carried out in the CALPOST postprocessor. The formula used is the usual IMPROVE/EPA formula, which is applied to determine a change in light extinction due to changes in component concentrations. Using the notation of CALPOST, the formula is the following:

$$b_{ext} = 3\, f(RH)\, [(NH_4)_2SO_4] + 3\, f(RH)\, [NH_4NO_3] + 4[OC] + 1[Soil] + \\ + 0.6[Coarse\ Mass] + 10[EC] + b_{Ray} \qquad (3\text{-}1)$$

The concentrations, in square brackets, are in $\mu g/m^3$ and b_{ext} is in units of Mm^{-1}. The Rayleigh scattering term (b_{Ray}) has a default value of 10 Mm^{-1}, as recommended in EPA guidance for tracking reasonable progress (EPA, 2003a).

There are a few important differences in detail and in notation between the CALPOST formula for estimating light extinction (i.e., Equation 3-1) and that of IMPROVE and EPA. First, the *OC* in the formula above represents organic carbonaceous matter (OMC in IMPROVE's notation), which is 1.4 times the *OC* (i.e., organic carbon alone) in the IMPROVE formula. The *EC* above is synonymous with *LAC* in the IMPROVE formula. CALPOST now offers the option of using the old IMPROVE *f(RH)* curve, whose values are documented in the December 2000 FLAG report, or the *f(RH)* now used by IMPROVE and EPA (as documented in EPA's regional haze guidance documents). Also, CALPOST sets the maximum *RH* at 98% by default (although the user can change it), while the EPA's guidance now caps it at 95%.

The haze index (HI) is calculated from the extinction coefficient via the following formula:

$$HI = 10 \ln (b_{ext}/10) \qquad (3\text{-}2)$$

where *HI* is in units of deciviews (dv) and b_{ext} is in Mm^{-1}. The impact of a source is determined by comparing HI for estimated natural background conditions with the impact of the source and without the impact of the source.

CALPOST Methods

CALPOST uses Equation 3-1 to calculate the extinction increment due to the source of interest and provides various methods for estimating the background extinction against which the increment is compared in terms of percent or deciviews.

For background extinction, the CALPOST processor contains seven techniques for computing the change in light extinction due to a source or group of sources (called Methods 1-7). These are usually reported as 24-hour average values, consistent with EPA and FLM guidance. In addition, there are two techniques for computing the 24-hour average change in extinction (i.e., as the ratio of 24-hour average extinctions, or as the average of 24-hour ratios). A brief summary of the techniques is provided below. Method 2 is the current default, recommended by both IWAQM (EPA, 1998) and FLAG (2000) for refined analyses. Method 6 is recommended by EPA's BART guidance (70 FR 39162).

Methods 4 and 5 use optically measured hourly background extinctions, which represent current actual levels of extinction and thus are not consistent with the "natural conditions" the BART proposal says should be used as a baseline. Methods 1 through 3 and 6 and 7 allow for user inputs of estimated (e.g., natural conditions) background extinction or component concentrations, and thus are consistent with the BART proposal.

Method 1 allows the user to specify a single value of a "dry" background extinction coefficient for each receptor, specify that a certain fraction of that coefficient is due to hygroscopic species, and use relative humidity measurements to vary the extinction hourly via a 1993 IWAQM *f(RH)* curve or, optionally, the EPA regional haze f(RH) curve (EPA, 2003b). The *RH* is capped at 98% or a user-selected value (95% for the EPA curve). The same *f(RH)* is applied to both the modeled sulfate and nitrate.

For an example of the use of Method 1, one could use the dry particle extinction coefficient of 9.09 Mm^{-1} that results from EPA's default natural conditions concentrations, together with an assumption that for natural conditions, say, 0.9 Mm^{-1} (or 10%) of this amount results from hygroscopic ammonium sulfate and ammonium nitrate, and then apply *f(RH)* to this 10%.

In Method 2, user-specified, speciated monthly concentration values are used to describe the background. When applied to natural conditions, for which EPA's default natural conditions concentrations are annual averages, the same component concentrations would have to be used throughout the year (unless potential refinements to those default values resulted in concentrations that vary during the year). Hourly background extinction is then calculated using these concentrations and hourly, site-specific *f(RH)* from a 1993 IWAQM curve (a different one

than that in Method 1) or, optionally, the EPA regional haze f(RH) curve.[12] Again the *RH* is capped at either 98% (default) or a user-selected value (most commonly at 95%).

Method 3 is the same as Method 2, except that any hour in which the RH exceeds 98% (or the selected maximum) is dropped from the analysis. When 24-hr extinction is computed, no fewer than 6 valid hours are accepted at each receptor; otherwise the value for the day is tabulated as "missing".

Method 6 is similar to Method 2, except monthly f(RH) values (e.g., EPA's monthly climatologically representative values in EPA (2003a, b)) are used in place of hourly values for calculating both the extinction impact of the source emissions and the background conditions extinction. Hourly source impacts, with the effect on extinction due to sulfates and nitrates calculated using the monthly-average relative humidity in f(RH), are compared against the monthly default natural background concentrations. Thus the monthly-averaged relative humidity is applied to the hygroscopic components (i.e., sulfate and nitrate) of both the source impact and the background extinction with Method 6**.**

Method 7 is a new variant of Method 2 that was developed as a result of a ruling by the Assistant Secretary of the Interior for Fish and Wildlife and Parks, in response to a New Source Review case in Montana, that "natural conditions" should reflect the visibility impairment caused by significant meteorological events such as fog, precipitation, or naturally occurring haze (DOI, 2003).[13] Under Method 7, during hours when visibility is obscured by meteorological conditions, the actual measured visibility is used to represent natural conditions instead of the value that is calculated from EPA's default natural conditions concentrations under Method 2. A recent modification developed in response to FLM comments on Method 7, in which the daily average natural extinction is calculated somewhat differently, is called Method 7', i.e., "7 prime".

Refined Estimates of Extinction and Natural Background Visibility

Separate from the BART discussions, IMPROVE, EPA, and the Regional Planning Organizations are evaluating whether refinements are warranted to the methods recommended in EPA's guidance to calculate default estimates of natural background visibility. In particular, IMPROVE has recently approved an alternative to the formula (Eq. 3-1) it uses to estimate extinction from particle concentration measurements (Pitchford et al., 2005).

Refinements in the revised IMPROVE formula include the following:

- Adding a sea salt term, including a growth factor due to relative humidity

[12] Note that the hourly-varying natural background extinction in this method is not consistent with that prescribed by the EPA's natural conditions guidance (EPA, 2003b), for which a "climatologically-representative" f(RH) that only varies monthly is to be used. Method 6 uses these monthly average humidity values.

[13] The Secretary's guidance applies only to Federal Land Managers. EPA's position on this interpretation of natural conditions is unknown.

- Increasing the factor used to calculate the mass of particulate organic matter (OC in Eq. 3-1) from organic carbon measurements

- Modifying the relative humidity growth formula, f(RH), for sulfates and nitrates

- Revising the extinction efficiencies (the numerical constants in Equation 3-1) for sulfates, nitrates, and organic carbon so that they vary with concentration

- Adding a site-specific Rayleigh scattering term to the formula. Values will be calculated by IMPROVE for all Class I areas.

For the purposes of calculating current, future, and natural background visibility at VISTAS Class I areas as part of the reasonable progress analyses, VISTAS intends to present regional air quality modeling results using both the current EPA recommended assumptions and the newly revised aerosol extinction formula. If a BART-eligible source chooses to consider its projected impacts using the newly revised formula as well as the current formula, then modifications would need to be made to CALPOST to carry out calculations with the new algorithm.

4. VISTAS' COMMON MODELING PROTOCOL

4.1 Overview of Common Modeling Approach

In this section, guidance is provided on the use of the CALPUFF modeling system for two purposes:

1) Evaluating whether a BART-eligible source is exempt from BART controls because it is not reasonably expected to cause or contribute to impairment of visibility in Class I areas, and

2) Quantifying the visibility benefits of BART control options.

For purpose 1), States must determine whether a source emits any air pollutant (SO_2, NO_x, PM, and in certain cases VOC and NH_3) that "may reasonably be anticipated to cause or contribute to any impairment of visibility" in a Class I area. The States have 3 options to accomplish this:

A) Conclude that all BART-eligible sources in State are subject to BART.

B) Demonstrate that all BART-eligible sources in the State together do not cause or contribute to any visibility impairment

C) Determine if the impact from each individual BART-eligible source is greater than a threshold value.

VISTAS States intend to follow Option C (determine if the visibility impact from individual sources exceeds a contribution threshold) for SO_2 and NO_x emissions. The methods for Option C are described in Section 4.1.1. In early 2006, VISTAS pursued Option B (demonstrate that all BART eligible sources in a State do not impact visibility) for VOC, NH_3 and PM emissions. The approach and results for Option B are described in Section 4.1.3. As a result of this exercise, the VISTAS States have determined that the Option C exemption analyses should also include PM emissions and, for sources with large NH_3 emissions, NH_3. The States determined that anthropogenic VOC emissions do not cause or contribute to visibility impairment at VISTAS Class I areas and that VOC emissions do not need to be considered in BART analyses.

4.1.1 BART Exemption Analysis

As illustrated in Figure 4-1, three steps will evaluate whether a BART-eligible source of SO_2, NO_x, or PM is subject to BART:

1) VISTAS plans to use Q/d as a presumptive indicator that a source is subject to BART. If Q/d for SO_2 > 10 for 2002 actual emissions, then the State presumes that the source is subject to BART. If the source agrees with this presumption, then no exemption modeling is required and the source can proceed to the BART determination using CALPUFF to evaluate impacts of control options and can perform the engineering analyses. If a source disagrees, the source

may perform fine grid modeling as described in Section 4.4 to determine if its impact is < 0.5 dv.

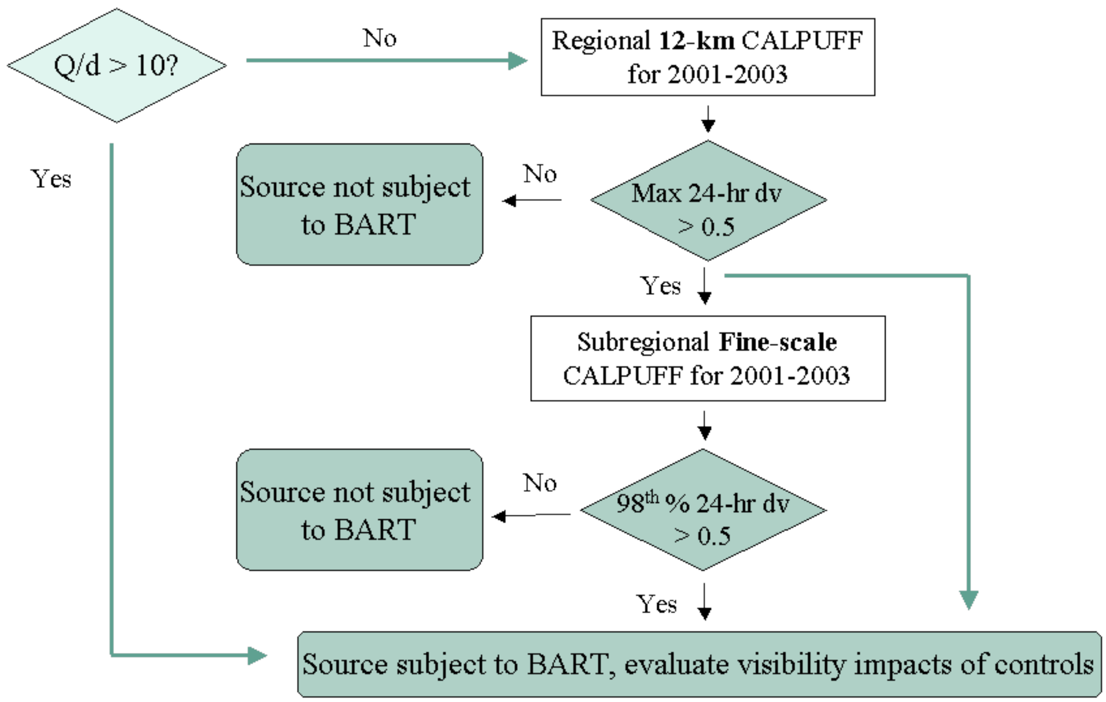

Figure 4-1. Flow chart showing the components of the VISTAS common modeling protocol. Assessment should be made for each Class I Area. (If a source agrees to install the most stringent controls then the modeling steps indicated above and engineering analyses and visibility impact modeling would not be required.)

2) An optional initial modeling assessment using the CALPUFF model with the coarse scale 12-km regional VISTAS domain can be used to answer questions whether (a) a particular source may be exempted from further BART analyses and (b) if finer grid CALPUFF analysis were to be undertaken, which Class I areas should be included. Assumptions for the initial modeling assessment are conservative so that a source that contributes to visibility impairment is not exempted in error. If a source is shown not to contribute to visibility impairment using the initial modeling assessment, the source would not be subject to BART and would be exempted from further BART analyses. If a source is shown to contribute to visibility impairment using the initial modeling assessment, the source has the option to undertake finer grid CALPUFF modeling to evaluate further whether it is subject to BART.

3) A finer grid CALPUFF modeling analysis using a subregional CALMET domain will be the definitive test as to whether a source is subject to BART.

For large sources that will clearly exceed the initial screening thresholds, this step can be skipped and the analysis may proceed directly to the finer grid modeling analysis, which is described in Section 4.4.

4.1.2 BART Control Evaluation

For sources that are determined to be subject to BART controls, part of the BART review process involves evaluating the visibility benefits of different BART control measures. These benefits will be determined by making additional CALPUFF simulations using the same CALMET and CALPUFF configuration as those used in the finer grid analysis of Step 2. The only exception is that the source and emissions data used in the CALPUFF control evaluation simulations will reflect the BART control measures being evaluated. Using the same model configuration will produce an "apples-to-apples" comparison, where differences in impacts are due to the effectiveness of the controls rather than model configuration differences. For example, a control scenario evaluation that uses more conservative assumptions than the base case simulation may produce results showing no or little improvement in visibility impacts. That control scenario run with the same model configuration as the base case may show significant visibility improvement. Therefore, in order to not obscure the response to predicted visibility improvements by differences in the modeling approach, the same model configuration should be used in the BART control evaluation simulation as in the base case simulation.

The base case to which the effectiveness of BART controls is to be compared is the "current emissions" scenario for which the finer grid Step 2 modeling was performed. The postprocessing steps and procedures are the same as in the BART eligibility simulation. Side-by-side comparison of the visibility impacts will be tabulated to quantify the effectiveness of each control scenario relative to the base case.

The modeling evaluation is a unit-by-unit evaluation and can be conducted on a pollutant specific basis. Modeling results are used with the other four statutory factors mentioned in Section 2.1 to decide which control technology, if any, is appropriate. Finally, if a source decides to use the most stringent control technology available, the BART control analysis, including modeling, is not necessary.

4.1.3 VISTAS' Treatment of VOC, NH_3, and PM

Volatile Organic Compounds

CALPUFF is currently not recommended for addressing visibility impacts from VOC because its capability to simulate secondary organic aerosol formation from VOC emissions is not adequately tested, especially for anthropogenic emissions. (Separately, condensable organic carbon can be calculated from PM_{10}.)

VISTAS has performed a weight of evidence analysis to demonstrate, using the CMAQ regional air quality model, that the combined VOC emissions from all point sources (BART-eligible and non-BART) in each State do not contribute to visibility impairment. Emissions sensitivity

simulations run for VISTAS by Georgia Institute of Technology using VISTAS' 12 x 12 km grid and CMAQ v 4.3 for episodes in July 2001 and January 2002 demonstrated very low to no response of organic carbon levels and light extinction at Class I areas to changing VOC emissions from all anthropogenic sources in the VISTAS 12-km modeling domain (eastern US). Georgia Tech repeated the sensitivity analyses using the VISTAS 12-km domain and CMAQ v 4.4 with a refined SOA module for summer (Jun 1-Jul 10) and winter (Nov 19-Dec 19) periods in 2002. VOC emissions from all anthropogenic point sources in every VISTAS State were reduced by 100% (i.e., eliminated). The maximum 24-hr impact of all VOC emissions from all point sources throughout the VISTAS domain was thus determined to be less than 0.5 dv (compared to annual average natural background) at every Class I area in the VISTAS domain and in adjacent States. It follows that the impact of any one BART-eligible source would be much less than 0.5 dv. Based on these analyses, the VISTAS States have concluded that VOC emissions from BART sources do not cause or contribute to visibility impairment and do not need to be included in BART analyses.

Ammonia

EPA has given states the option to address ammonia (NH_3) emissions from BART-eligible sources. VISTAS also contracted with Georgia Tech to calculate NH_3 emissions sensitivities using CMAQ v 4.4 with a refined SOA module and the same Jun-Jul and Nov-Dec periods in 2002 that were used for the VOC sensitivity evaluation. The NH_3 emissions from all point sources (BART-eligible and not-BART) in every State were reduced by 100% for these analyses. This sensitivity evaluation showed that the collective impact of all VISTAS region point NH_3 emissions is greater than 0.5 dv (compared to annual average natural background) at several Class I areas. When the NH_3 emissions were scaled to represent 100% reduction from only the BART-eligible sources in each State, then the maximum impact of those sources was under 0.5 dv at most, but not all Class I areas. The high values appear to result primarily from emissions from 13 large NH_3 sources. In the absence of those 13 facilities, the scaled NH_3 emissions peak impacts at Class I areas were 0.3 dv or less. Based on these analyses, the VISTAS States recommended that, except for these 13 facilities, NH_3 emissions not be included in BART modeling. States will provide instructions to those 13 sources as to how to evaluate contributions of their NH_3 emissions to visibility impairment. For documentation purposes, in summer 2006 VISTAS is repeating the NH_3 emissions sensitivity calculations, using CMAQ v4.5 with Base F emissions and reducing 100% of NH_3 emissions from only the BART-eligible sources in the VISTAS states.

Primary Particulate Matter

Primary particulate matter is considered a visibility impairing pollutant. However, the extent to which primary PM from BART-eligible sources contributes to impairment at Class I areas in the southeastern US is not clear. For EGUs, the EPA has determined that emissions reductions of SO_2 and NO_x under the CAIR rule meet the BART requirements, but these EGUs may still be subject to BART for primary PM. To determine the potential impacts of PM from EGU and non-EGU sources in the VISTAS states, two CMAQ sensitivity runs for the first and third quarters of 2002 were carried out by VISTAS' CMAQ modeling team of ENVIRON, UCR, and Alpine

Geophysics In one run, all primary PM from EGUs was removed while in the other run all primary PM from non-EGU sources was removed. All other CMAQ modeling components were held constant. At almost all Class I areas in the VISTAS region, primary PM emissions contribute to regional haze, with the collective impact of all EGU and non-EGU point primary PM emissions being greater than 0.5 dv compared to annual average natural background. In fact, the impacts of EGU PM emissions alone or of non-EGU PM emissions alone were each mostly greater than 0.5 dv. Although the impacts of BART sources alone would be smaller, the VISTAS States have concluded that all BART-eligible sources need to consider the impacts of their PM emissions.

4.2 Optional Source-Specific Modeling

In some circumstances, a source may want to apply techniques designed to evaluate the impacts in a more detailed way than the standard VISTAS common protocol. A source may propose source-specific modeling procedures to address special issues to the State for State review. For example, sources very close to Class I areas may be better treated by a finer grid resolution that the generic Step 2 "fine" grid resolution meteorological fields provided by VISTAS. In some situations, higher resolution MM5 or other prognostic meteorological datasets may be available than the standard 12-km or 36-km MM5 datasets provided by VISTAS. Because it is not possible to anticipate all of the situations where there would be a benefit to conducting more detailed source-specific analyses, the option to pursue this option is left as an open issue, to be resolved and justified based on specific factors relevant for the source in question.

A source-specific modeling protocol is required for each source. This document should describe the data sources and model configuration, and provide rationale for any changes in the model approach from the common protocol. This source-specific protocol must be provided for review and approval by the State. The State will share the protocol with EPA and the Federal Land Managers for their review. Discussion of approaches to source-specific modeling and an outline of the typical contents of the source-specific protocol are presented in Chapter 5. Discussions with the regulatory authorities should be conducted prior to development of a source-specific protocol to ensure all of the relevant issues are included in the protocol.

4.3 Initial Procedure for BART Exemption

4.3.1 Overview of Initial Approach

The first step in the common protocol, the initial assessment in Figure 4-1, is a simple procedure to evaluate whether a source can be exempted from BART controls using a consistent set of meteorological and dispersion options. A pre-computed set of meteorological files and a pre-defined CALPUFF input option configuration, based on guidance in the final BART rule (70 FR 39104-39172) and other EPA and FLAG model guidance, will allow relatively simple initial simulations. The regional initial domain is designed to allow any Class I areas within the VISTAS area to be evaluated with a single meteorological database and consistent CALPUFF modeling options. The second important question that this first screening step will answer is, if

initial modeling indicates a source may impact visibility significantly, what Class I areas should be included in a finer grid analysis? Due to the multitude of factors affecting the contribution of a source to visibility in a Class I area, simple screens or rules of thumb alone (such as that the closest Class I area will produce the controlling visibility impacts) are not likely to be universally reliable.

4.3.2 Discussion of 12-km Initial Exemption Modeling

Meteorological Fields

A regional initial domain and a set of pre-computed regional CALMET meteorological files will be prepared for VISTAS, to allow any Class I areas within the VISTAS area to be evaluated with a consistent meteorological database and consistent CALPUFF modeling options.

The following three years of MM5 meteorological data have been assembled by VISTAS for use in the regional CALPUFF modeling effort:

- 2001 MM5 dataset at 12 km and 36 km grid (developed for EPA)
- 2002 MM5 dataset at 12 km and 36 km grid (developed by VISTAS)
- 2003 MM5 dataset at 36 km grid (developed by the Midwest Regional Planning Organization).

These data sets have been provided to Earth Tech by VISTAS, and from them Earth Tech has produced annual CALMET meteorological files at 12-km grid resolution for the domain shown in Figure 4-2. The CALMET modeling output files in the form of CALPUFF-ready three-dimensional meteorological files will be available on external hard drives to the States and other parties.

The initial procedure to determine if a BART-eligible source is subject to BART uses the pre-computed CALMET meteorological fields for the years 2001-2003 on the 12-km CALMET domain in Figure 4-2 and simulates with CALPUFF any BART-eligible source to be screened. The CALMET simulations will be developed using the highest resolution MM5 data available for each year (i.e., 36-km MM5 data for 2003, 12-km MM5 data for 2001 and 2002).

The development of the regional CALMET meteorological fields from MM5 data will be conducted in No-Observations ("No-Obs") mode. The MM5 data already reflect assimilation of observational data and are likely to adequately characterize regional wind patterns that are consistent with the 12-km grid scale. Blending of MM5 data with local observations (which are mainly at the surface) could lead to wind structures that may not be realistic under some conditions and may result in poorer characterization of the regional winds. Thus, the effort required to prepare observational data sets for CALMET for the large regional domain involves considerable effort that may not provide corresponding improvement of the wind field.

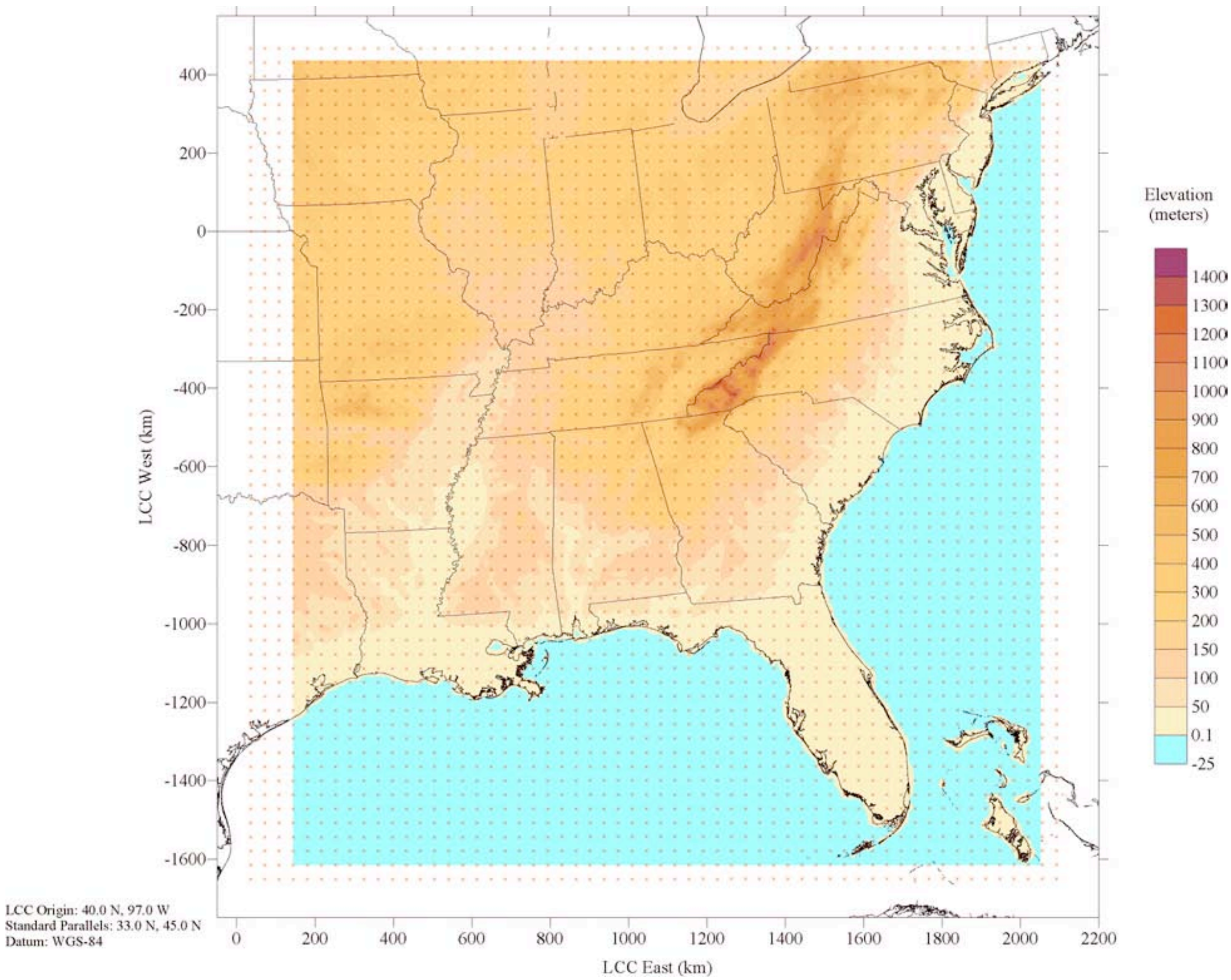

Figure 4-2. VISTAS Regional 12-km Resolution CALMET Modeling Domain (color area with terrain contours). The locations of the 36-km resolution MM5 grid points are shown on the plot.

For 2003, the 36-km MM5 data will be used as CALMET's initial guess field and then the CALMET diagnostic terrain adjustments (see Section 3.1.1) will be applied to reflect terrain on the scale of the CALMET grid (i.e., 12-km). When the 12-km MM5 (2001 and 2002) data are used, the diagnostic CALMET terrain adjustments will be turned off since the grid resolution of the MM5 data is the same as the CALMET grid and the terrain adjustments on the 12-km grid scale will already be reflected in the MM5 dataset. In this case, the MM5 winds will be interpolated by CALMET to the CALMET layers and CALMET's boundary layer modules will compute mixing heights, turbulence parameters and other meteorological parameters that are required by CALPUFF.

Impact Threshold

The final BART guidance recommends that the threshold value to define whether a source "contributes" to visibility impairment is 0.5 dv change from natural conditions[14] (although States may set a lower threshold). The 98th percentile (8th highest annual) 24-hr average predicted impact at the Class I area, as calculated using CALPOST Method 6 (monthly average relative humidity values), is to be compared to this contribution threshold value. For this comparison, the predicted impact at the Class I area on any day is taken to be the highest 24-hr average impact at any receptor in the Class I area on that day. (Note that the receptor where the highest impact occurs can change from day to day.) According to clarification of the BART guidance received from EPA, for a three-year simulation the modeling values to be compared with the threshold are the greatest of the three annual 8th highest values or the 22nd highest value over all three years combined, whichever is greater.

For the purposes of the initial analysis, however, the *highest value* over the three-year period (not the 98th percentile value) is to be compared to the contribution threshold. This ensures a significant measure of conservatism in the initial approach. VISTAS will evaluate the initial CALPUFF results to determine if using the single highest value provides too conservative a screen for exemption purposes. If so, VISTAS may increase the number of exceedances of the contribution threshold that would be allowed and still qualify to exempt a source.

4.3.3 Model Configuration and Settings for Initial Analysis

VISTAS will use CALPUFF Version 5.754 and CALMET Version 5.7. These versions contain enhancements funded by the Minerals Management Service (MMS) and VISTAS. They were developed by Earth Tech, Inc. and they are maintained on the CALPUFF website (www.src.com) for public access. This version includes CALMET, CALPUFF, CALPOST, CALSUM, and POSTUTIL as well as CALVIEW.

The initial analysis uses a CALPUFF computational domain that includes all Class I areas within 300 km of a source. These Class I areas are specified in the CALPUFF control file for analysis. States could decide to require a different value for the maximum distance threshold for the CALPUFF domain, depending on the locations of the Class I areas in their states and other factors such as meteorological conditions and the magnitudes of the emissions from BART-eligible sources. The regional CALMET domain will be unchanged by these adjustments.

Also, the initial approach is designed to significantly reduce the CALPUFF simulation time by restricting the CALPUFF computational domain size to include only areas where significant impacts are feasible rather than the entire regional domain. CALPUFF allows its computational domain to be specified as a subset of the CALMET meteorological domain by settings within the

[14] As described in Footnote 5 on page 6, States have the option of defining natural conditions as either the annual average default conditions or the average of the 20% best natural condition days.

CALPUFF input file. The advantage of selecting a smaller CALPUFF computational domain in the regional CALPUFF simulations is that CALPUFF run time is proportional to the number and residence time of the puffs on the domain (and other factors such as the number of receptors and the internal time step computed by the model). A CALPUFF domain covering an area 300 km from a source in all directions would involve only 50 x 50 12-km grid cells, which will require modest computational resources.

CALMET output files for the VISTAS regional domain shown in Figure 4-2 will be provided to VISTAS by Earth Tech. These files will be in CALPUFF-ready format, and as such, no CALMET user inputs will be required. An option in CALMET allows finer grid CALMET input files to be calculated from the 12-km CALMET files.

The basic characteristics of the CALMET, CALPUFF and CALPOST configurations for the initial analyses are listed below.

CALMET Modeling Configuration (12-km initial exemption modeling)

The CALMET model configuration for the regional CALMET simulations will be defined by Earth Tech in collaboration with the VISTAS States. The basic model configuration will follow the recommended IWAQM guidance (EPA, 1998; Pages A-1 through A-6), except as noted below.

The basic features of the modeling simulation are the following:

- Modeling period: 3 years (2001-2003)

- Meteorological inputs: MM5 data provide initial guess fields in CALMET

- CALMET grid resolution: 12-km (same Lambert Conformal coordinate system and grid cells as the 12-km 2001/2002 MM5 simulations)

- CALMET vertical layers: 10 layers. Cell face heights (meters): 0, 20, 40, 80, 160, 320, 640, 1200, 2000, 3000, 4000.

- CALMET mode: No-Observations mode including option to read overwater data directly from MM5.

- Diagnostic options: IWAQM default values, except as follows: diagnostic terrain blocking and slope flow algorithms used for 2003 simulations (using 36-km MM5 data), but no diagnostic terrain adjustments in 2001 and 2002 simulation (using 12-km MM5 data)

- CALMET options dealing with radius of influence parameters (R1, R2, RMAX1, RMAX2, RMAX3), BIAS, ICALM parameters are <u>not used</u> in No-Observations mode.

- TERRAD (terrain scale) is required for runs with diagnostic terrain adjustments (i.e., the 2003 simulations). Values of ~10-20 km will be tested, and an appropriate value determined.

- Land use defining water: JWAT1 = 55, JWAT2 = 55 (large bodies of water). This feature allows the temperature field over large bodies of water such as the Atlantic Ocean and the Great lakes to be properly characterized by buoy observations.

- Mixing height averaging parameter (MNMDAV) will be determined by Earth Tech for the regional simulations based on sensitivity tests. The purpose of the testing is to optimize the variable to allow spatial variability in the mixing height field, but without excessive noise.

- Geophysical data for regional runs: SRTM-GTOPO30 30-arcsec terrain data, Composite Theme Grid (CTG) USGS 200m land use dataset. References for these and other CALMET datasets can be found on the CALPUFF data page of the official CALPUFF site (www.src.com).

CALPUFF Modeling Configuration (Initial exemption modeling)

The CALPUFF model configuration for the regional CALPUFF initial simulations will follow the recommended IWAQM guidance (EPA, 1998; Pages B-1 through B-8), except as noted below:

- CALPUFF domain configured to include the source and all Class I areas within 300km of the source plus 50km buffer zone in each direction. CALPUFF is recommended for all source-receptor distances to be considered in the BART analyses.

- Chemical mechanism: MESOPUFF II module

- Species modeled: SO_2, SO_4, NO_x, HNO_3, NO_3 and particulate matter in size categories of <0.625 µm, 0.625-1.0 µm, 1.0-1.25 µm, 1.25-2.5 µm, 2.5-6.0 µm and 6-10 µm aerodynamic diameters. As noted below, the particulate matter emissions by size category will be combined into the appropriate species for the visibility analysis (i.e., elemental carbon (EC), fine PM or "soil" (< 2.5 µm in diameter), coarse PM (between 2.5-10 µm in diameter) and organics (called secondary organic aerosols (SOA) in the CALPOST postprocessor).

- Emission rates for modeling based on EPA BART guidance, i.e., maximum 24-hour actual emission rate with normal operations from the highest emitting day of the meteorological period modeled (excluding days where start-up, shutdown or malfunctions occurred sometime during the day.) Note that potential emissions are used to determine if a source is BART-eligible, but 24-hour average maximum emissions are used for modeling purposes (70 FR 39162). Pollutants considered include SO_2, H_2SO_4, NO_x and PM_{10}.

Condensable emissions are considered as primary fine particulate matter and allocated equally to the two submicrometer-particle size classes. If actual source emissions data are not available, the modeling should be based on permit limits. If source-specific size

categories are not available, then AP-42 factors may be used for sources where AP-42 factors are available. For sources where AP-42 factors are not available, alternative approaches to speciation are given below.

Excluded from the modeling are pollutants with plant-wide emissions less than *de minimis* levels (40 tons per year for SO_2 and NO_x and 15 tons per year for PM_{10}). *De minimis* levels are plant wide for each visibility-impairing pollutant, so individual units may be modeled even if they have emissions below *de minimis* if the plant total is greater than *de minimis*.

- Particulate emissions speciation: Break down, as appropriate, filterable and condensable particulate matter into the following species categories: elemental carbon (soot), "soil" (fine PM < 2.5 µm diameter), coarse particulate matter (2.5-10 µm diameter) and organics. The process is illustrated in Figure 4-3. If source-specific speciated emissions factors are not available, AP-42 factors or speciation information developed by the National Park Service (http://www2.nature.nps.gov/air/permits/ect/index.cfm) can be used to estimate the PM speciation for many source sectors.

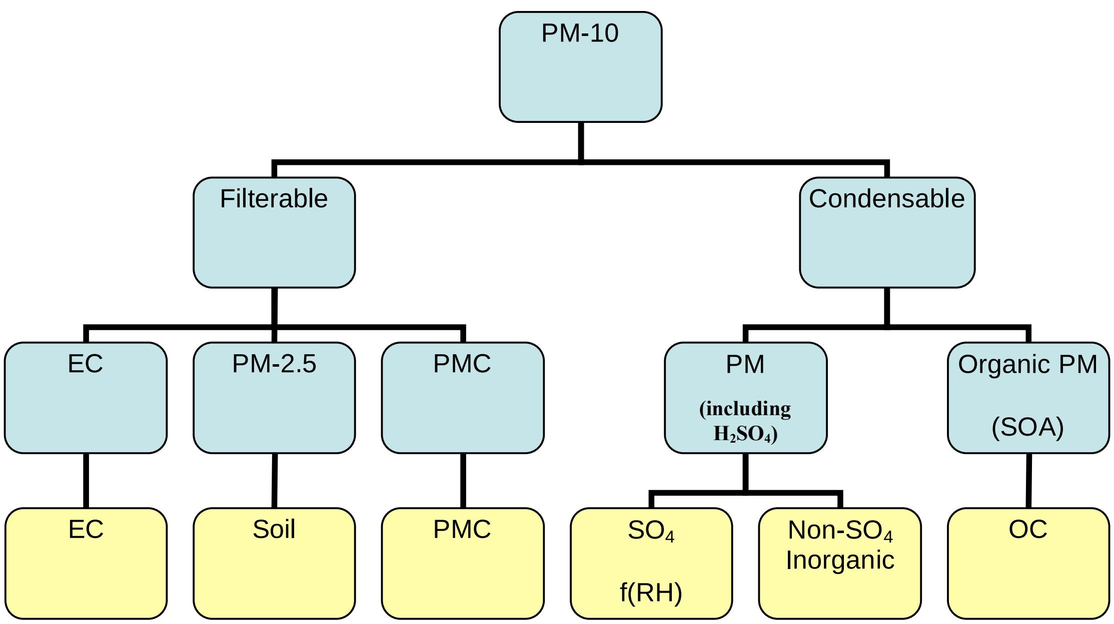

Figure 4-3. Speciation of PM-10 Emissions. (PMC is coarse particulate matter -- 2.5 to 10 µm diameter.)

Otherwise, assumptions will need to be proposed by the source, and reviewed and approved by the State. Possible acceptable alternative approaches to estimating speciation include the following:

- Speciation profiles developed by the SMOKE emissions model for use in VISTAS' CMAQ regional air quality modeling (available at http://www.vistas-sesarm.org/BART/calpuff.asp).
- The approach described in a memo available at http://www.vistas-sesarm.org/BART/calpuff.asp, which provides reasonably conservative estimates in situations where data are incomplete.

- Class I receptors: Use FLM Class I receptor list with receptor elevations provided (available from the NPS).

- CALPUFF model options: Use IWAQM (EPA, 1998) default guidance, including Pasquill-Gifford dispersion coefficients.

- Ozone dataset – use observed ozone data for 2001-2003 from CASTNet and AIRS stations. Only non-urban ozone stations should be used in the OZONE.DAT file. Monthly average ozone (backup) background values are to be computed based on daytime average ozone concentrations from the OZONE.DAT file (6am-6pm average ozone concentrations computed by month).

- Background ammonia concentration: In CALPUFF, use constant (0.5 ppb) value for ammonia.

- Puff representation: integrated puff sampling methodology.

- Building downwash: Ignore building downwash unless source is within 50-km of a Class I area and the State instructs the source to specifically consider building downwash.

CALPOST and POSTUTIL Configuration (Initial exemption modeling)

- Use Visibility Method 6 in CALPOST

- Species considered in visibility analysis: SO_4, NO_3, EC, SOA (i.e., condensable organic emissions), soil, coarse PM

- Natural background light extinction: Several options are acceptable at the discretion of the State: (1) A single annual average natural background extinction for each Class I area, as presented in Appendix B of EPA's natural conditions guidance (EPA, 2003b); (2) A single value that represents the average haze index on the 20% best natural conditions days, again as presented in the same Appendix B; or (3) A monthly average natural background as calculated by CALPOST under Method 6, based on annual average default natural

conditions component concentrations and monthly average f(RH) values for the centroid of the Class I area, from Table A-3 in the natural conditions guidance document,.

A special procedure is needed for options 1 and 2, since CALPOST requires input of natural background concentrations of PM components while the backgrounds for options 1 and 2 are expressed in EPA's guidance document as extinction coefficients or haze indices (in deciviews). In order to produce the appropriate natural background in CALPOST for these options, use Equation 3-2 to calculate the extinction coefficient that corresponds to EPA's haze index value for the Class I area (if necessary), subtract the Rayleigh scattering value of 10 Mm^{-1}, and enter a soil concentration (in $\mu g/m^3$) into CALPOST that is numerically equal to this result. (Since the extinction efficiency of soil is 1 m^2/g, Equation 3-1 shows that this process produces a background extinction that equals the EPA's value.) Leave the concentrations of all other species blank, since the number that is entered represents extinction by all components.

- Light extinction efficiencies: Use EPA (2003a) values. If a source chooses, the new IMPROVE algorithm for calculating light extinction (see Section 3.2.3) may be used in addition to the default IMPROVE algorithm. (Calculations would need to be performed outside CALPOST or CALPOST would need to be modified to accommodate the new algorithm.)

- Nitrate repartitioning in POSTUTIL: Do not use for the initial modeling.

The initial run results will be based on the highest change in light extinction (deciviews) from natural conditions over the three-year modeling period for each Class I area considered. Predicted changes exceeding the "contribution" threshold (0.5 deciviews) will trigger a finer grid CALPUFF modeling analysis.

4.4 Finer Grid Modeling Procedures

4.4.1 Rationale for and Overview of Finer Grid Modeling Approach

There are two potential applications for finer grid CALPUFF modeling:

BART Exclusion Modeling. First, finer grid CALPUFF modeling can be used to demonstrate that a source does not cause or contribute to visibility impairment in any Class I areas, and thus can be excluded from BART controls. As shown in Figure 4-1, if the initial regional modeling results are not below the threshold for visibility impacts, the next step is to conduct modeling using a finer grid resolution for the meteorological fields and the treatment of terrain effects and land use variability. In the finer grid modeling the predicted visibility impairment that is compared to the threshold is based on the BART guidance of the 98^{th} percentile change in deciviews value rather than the more conservative highest value used in the initial analysis.

The BART guidance indicates that the emissions rate to be used for such modeling is the highest 24-hr rate during the modeling period. Depending on the availability of source data, the following

emissions information (listed in order of priority) should be used with CALPUFF for BART exclusion modeling:

- 24 hr maximum value emissions for the period 2001-2003 (Continuous Emission Monitor, CEM data)
- 24 hr maximum value from continuous emissions monitoring data
- facility stack test emissions
- potential to emit
- permit allowable emissions, if available
- emissions factors from AP-42 source profiles

Quantify Benefits of BART. The second application of refined modeling is to quantify the visibility benefits from the BART control options. This is accomplished by running CALPUFF with the baseline emissions rates and again with emissions after BART controls. It is important that emission reductions be evaluated in the postprocessing step rather than by using "negative" emission rates in the CALPUFF model. The chemical scheme requires that emission rates always be positive.

For any of these applications, a source-specific modeling protocol that defines source properties and the specific model configuration is required. As discussed in Section 5, the source specific protocol should include source-specific emissions data and can refer to this document for all methods and assumptions that follow this common protocol.

4.4.2 Model Configuration and Settings for Finer Grid Modeling

Grid resolution substantially better than 12-km is needed for a finer grid CALPUFF assessment of visibility impacts in most cases involving Class I areas in complex terrain or coastal areas. Thus, the CALMET fine grid resolution in the subregional modeling domains used for finer grid modeling will depend on the terrain, land use (especially coastal boundaries), location of the source, distance of the source from Class I areas, and total size of the subregional modeling domain.

VISTAS States have 2001-2003 CALMET files for five 4-km sub-regional domains as illustrated in Figure 4-4. The subdomains are designed to address all BART eligible sources within each VISTAS states and all Class I areas within 300 km of the BART-eligible sources. For application for a single source, a smaller domain of roughly 200-300 km by 200-300 km is recommended. Requests to obtain the 4-km CALMET files should be made to the State BART representatives.

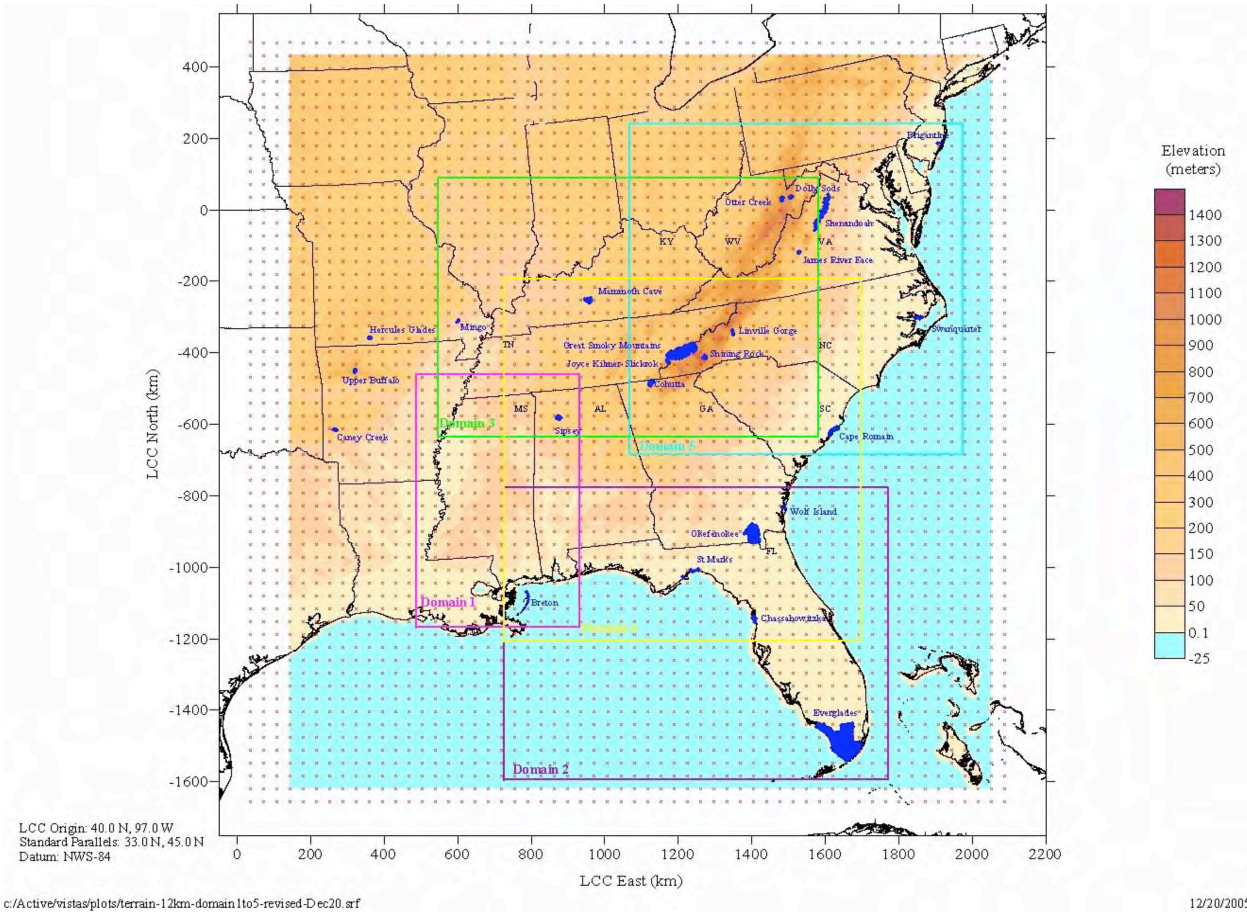

Figure 4-4. The five subregional domains for 4-km CALMET modeling.

In some instances, as part of the source-specific protocol, a source may propose to the State to use an even finer grid simulation to properly characterize the flow fields and land use changes that affect dispersion. An application for source-receptor distances within about 50 km may require a grid resolution less than 1 km if complex terrain effects are likely to be important. This determination should be made on a case-by-case basis. There is not a single distance at which a particular grid size is appropriate. It depends on factors such as the complexity of the terrain, the source-receptor distances involved, the location of the source relative to the terrain features, the physical stack parameters (e.g., a tall stack in complex terrain may be unaffected by the terrain-forced flow), proximity of the source and Class I area to a coastline, and other factors including availability of representative observational data.

The finer grid CALMET simulations were run in hybrid mode, using both MM5 data to define the initial guess fields and meteorological observational data in the Step 2 calculations. Overwater (buoy) data will be provided in addition to the hourly surface meteorological observations, precipitation observations and twice-daily upper air sounding data.

A domain-specific set of modeling parameters will be defined for each subregional domain. The proper selection of the CALMET diagnostic wind field parameters that are used to blend observations with the Step 1 wind field depends on factors such as the locations of the meteorological stations relative to terrain and coastal features (which affects the representativeness of the observational data), the terrain length scale, and the quality (resolution) of the MM5 data used to define the initial guess field and its ability to properly resolve wind flows on the fine-scale CALMET domain. The definition of the proper CALMET parameters is done as part of sensitivity testing where model performance is evaluated against available observations and expected terrain effects, such as channeling of flows within a valley.

In addition to the better grid resolution and the introduction of observational data in the finer grid simulations, several other modeling refinements can enhance the accuracy of the finer grid modeling. These include use of the higher resolution terrain DEM data (~3 arc sec USGS data) in defining the gridded terrain fields and application of the ammonia limiting method in the POSTUTIL post-processor. Otherwise, the source configuration, emissions, pollutant speciation, Class I receptors, ozone datasets and CALPUFF model options will be the same as in the initial runs. Similarly, CALPOST will be used in the same manner as for the initial analyses. However, POSTUTIL can be used to repartition nitrate in the finer grid modeling, using background ammonia concentrations according to the IWAQM Phase 2 report (IWAQM, 1998).

For the finer grid BART exclusion analysis, the test for evaluating whether a source is contributing to visibility impairment is based on the 98th percentile modeled value (rather than the highest predicted value used for the initial evaluation), which is consistent with EPA's BART guidance.

4.5 Presentation of Modeling Results

The CALPOST processing computes the daily maximum change in deciviews. A sample of the summary table produced by CALPOST is shown in Table 4-1. For evaluating compliance with the VISTAS screening threshold, the highest change in extinction value, located at the bottom of the CALPOST list file is compared to the threshold value (e.g., 0.5 dv). For example, in the sample shown in Table 4-1, the summary at the bottom shows that the highest visibility impact is 1.219 dv, with 9 days over the year showing values greater than 0.5 dv. Therefore this source would not pass the initial analysis, and finer grid modeling would be required.

In addition to the highest change in deciview value on each day over all the receptors in a particular Class I area, the CALPOST summary table in Table 4-1 contains the coordinates of the receptor, receptor type (D indicates discrete receptors), the total haze level (background + source, in dv), the background haze in deciviews, the change in haziness (delta dv), the humidity term applied to hygroscopic aerosols (f(RH)), and the contribution of each species to light extinction (in percent of the total source contribution) for SO_4, NO_3, organics, elemental carbon, coarse and fine particulate matter.

Table 4-1. Example of CALPOST Output, Showing Maximum Daily Impacts of Source and Locations of Those Impacts.

YEAR	DAY	HR	RECEPTOR	COORDINATES (km)		TYPE	DV(Total)	DV(BKG)	DELTA DV	F(RH)	%_SO4	%_NO3	%_OC	%_EC	%_PMC	%_PMF
2001	2	0	3	20.540	79.782	D	5.397	5.358	0.039	4.314	44.33	47.22	3.07	1.07	0.00	4.30
2001	3	0	9	31.680	79.822	D	4.566	4.421	0.145	1.767	40.75	33.89	9.19	3.24	0.00	12.94
2001	4	0	1	24.723	77.951	D	4.540	4.540	0.000	2.076	0.00	0.00	0.00	0.00	0.00	0.00
2001	5	0	77	30.228	94.571	D	4.950	4.939	0.011	3.144	43.13	44.74	4.64	1.45	0.00	6.05
2001	6	0	1	24.723	77.951	D	5.181	5.166	0.015	3.772	38.58	56.05	1.90	0.70	0.00	2.76
2001	7	0	3	20.540	79.782	D	6.366	5.745	0.620	5.439	44.98	44.99	3.69	1.26	0.00	5.08
.																
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2001	363	0	113	27.414	103.782	D	5.725	5.652	0.073	5.164	53.49	35.51	4.03	1.39	0.00	5.58
2001	364	0	113	27.414	103.782	D	6.554	6.521	0.033	7.826	48.12	47.09	1.67	0.64	0.00	2.48
2001	365	0	1	24.723	77.951	D	6.499	6.499	0.000	7.757	0.00	0.00	0.00	0.00	0.00	0.00

```
--- Number of days with Delta-Deciview  =>   0.50:         9
--- Number of days with Delta-Deciview  =>   1.00:         2
---             Largest Delta-Deciview  =             1.219
```

For the finer grid analysis, the data in the table can be imported into a spreadsheet and sorted on the delta dv column. Table 4-2 shows an example of the ranked visibility impacts (change in dv) for each of three years at six different Class I areas. The 98th percentile (8th highest value) in the sorted table would be compared to the contribution threshold (e.g., 0.5 dv). In the example shown in this table, the source passes the finer grid analysis because the highest 98th percentile visibility impact is below the contribution threshold of 0.5 dv.

The Results section of the CALPUFF modeling report should contain the following information:

1. Map of source location and Class I areas within 300 km of the source

2. For the VISTAS 12-km CALPUFF initial exemption modeling domain, a table listing all Class I areas in the VISTAS domain and those in neighboring states and impacts at those Class I areas within 300 km of the source, as illustrated in Table 4-3.

3. A discussion of the number of Class I areas with visibility impairment from the source on 98th percentile days in each year greater than 0.5 dv (total visibility impairment minus impairment on 20% best days for natural background visibility equals delta-dv, the visibility impact attributed to the source).

4. For the Class I area with the maximum impact, discussion of the number of days below the 98th percentile that the impact of the source exceeds 0.5 dv, the number of receptors in the Class I area where the impact exceeds 0.5 dv, and the maximum impact.

5. For finer grid CALPUFF exemption modeling, results for those Class I areas for which impacts of the source exceeded 0.5 dv in the 12-km initial exemption modeling. Report same results as provided for 12-km initial exemption modeling.

6. For control option modeling, each control option tested should be listed in tabular format. For each control option and for each Class I area where the impact of the source exceeded 0.5 dv, report the change in pollutant emissions and the change in visibility impact from the source as a result of the control option. The effectiveness of candidate control options are to be compared to each other, not to a specific target improvement.

   States will provide further guidance on graphic presentation of results to simplify evaluation of effectiveness of control measures. For example, a temporal plot of the change in deciviews between the controlled and uncontrolled cases could be developed for the receptor with the maximum modeled impact in each Class I area.

7. Copies of all input files and input data in electronic format for the CALMET, CALPUFF, CALPOST and POSTUTIL runs should be archived and provided to the State.

Table 4-2. Example of Visibility Impact Rankings at Six Class I Areas

Class I Area	2001	2002	2003
	Delta-Deciview Ranks 1-8	Delta-Deciview Ranks 1-8	Delta-Deciview Ranks 1-8
Great Smoky NP	0.99	0.95	1.20
	0.88	0.63	0.90
	0.62	0.51	0.73
	0.59	0.50	0.72
	0.55	0.46	0.59
	0.52	0.42	0.47
	0.48	0.37	0.45
	0.47	0.36	0.42
Linville Gorge	0.67	0.81	0.76
	0.45	0.69	0.47
	0.43	0.65	0.37
	0.33	0.50	0.35
	0.29	0.45	0.31
	0.27	0.33	0.30
	0.25	0.31	0.28
	0.23	0.29	0.28
Shining Rock	0.66	0.73	0.75
	0.43	0.69	0.45
	0.41	0.63	0.36
	0.35	0.52	0.34
	0.26	0.46	0.28
	0.24	0.34	0.27
	0.23	0.29	0.26
	0.22	0.26	0.25
Cohutta	0.26	0.54	0.61
	0.23	0.47	0.42
	0.22	0.43	0.30
	0.21	0.37	0.29
	0.20	0.37	0.28
	0.19	0.31	0.28
	0.18	0.31	0.25
	0.16	0.30	0.25
Joyce Kilmer-Slickrock	0.34	0.52	0.27
	0.33	0.43	0.24
	0.31	0.32	0.23
	0.26	0.31	0.20
	0.24	0.30	0.14
	0.20	0.28	0.13
	0.18	0.24	0.11
	0.17	0.24	0.10
Mammoth Cave NP	0.56	0.57	0.50
	0.44	0.56	0.37
	0.38	0.53	0.36
	0.29	0.35	0.35
	0.25	0.33	0.31
	0.24	0.33	0.24
	0.22	0.30	0.21
	0.21	0.29	0.19

Table 4-3. Format of Summary of Results for CALPUFF Modeling in VISTAS' 12-km Modeling Domain to Determine if a BART Eligible Source is Subject to BART.

Class I area	Distance (km) from source to Class I area boundary	# of days[1] and # of receptors with impact > 0.5 dv in Class I area: 2001		# of days[1] and # of receptors with impact > 0.5 dv in Class I area: 2002		# of days[1] and # of receptors with impact > 0.5 dv in Class I area: 2003		# of days[1] and # of receptors with impact > 1.0 dv in Class I area for 3-yr period		Max. 24-hr impact over 3-yr period
Dolly Sods, WV										
Shenandoah, VA										
James River Face, VA										
Mammoth Cave, KY										
Sipsey, AL										
Great Smoky Mtns, TN										
Cohutta, GA										
Shining Rock, NC										
Linville Gorge, NC										
Swanquarter, NC										
Cape Romain, SC										
Okefenokee, GA										
Saint Marks, FL										
Chassahowitzka, FL										
Everglades, FL										
Brigantine, NJ										
Breton Island, LA										
Caney Creek, AR										
Upper Buffalo, AR										
Mingo, MO										
Hercules Glade, MO										

[1]Days below the 98^{th} percentile of days in each year or the three-year modeling period, as appropriate

4.6 VISTAS Contribution to CALPUFF Modeling of BART Eligible Sources

VISTAS will provide updates and supporting information concerning the Common Modeling Protocol (this document) on the VISTAS website. In addition, VISTAS will make publicly available the following data bases developed by Earth Tech:

- VISTAS version of the CALPUFF modeling system, maintained on the CALPUFF website. Version 5.754 includes CALMET, CALPUFF, CALPOST, and POSTUTIL files, updated in December 2005. The last update in this VISTAS version is a CALMET update that addresses over water dispersion, which was developed for the Minerals Management Service (MMS) in fall 2005. This VISTAS version of CALPUFF will not be updated further unless errors are found in the code, except that a new one-step POSTUTIL procedure will be incorporated. BART-eligible sources in the VISTAS states will be able to use this VISTAS version throughout the BART modeling exercise.

- 12-km CALMET output files for 2001, 2002, and 2003 produced as described in previous sections. Further detail on model configuration and settings will be provided with the output files and will be made available on the CALPUFF website.

- CALMET will include a software modification to allow the meteorological data inputs into CALMET to be used to generate finer grid CALMET files without having to go back to the original MM5 output files

- Five 4-km CALMET subdomains for 2001, 2002, and 2003, produced as described in previous sections. Further detail on model configuration and settings will be provided with the output files and will be made available on the website.

- File with CALPUFF model configuration and settings sufficient to replicate CALPUFF modeling done for VISTAS using 12 km CALMET, including

    - Ozone data used to run CALPUFF

    - Ammonia concentrations used to run CALPUFF.

    - All other set up files used in VISTAS 12-km CALPUFF run

Samples of these data files and examples of their application with CALPUFF for BART screening analyses can be found on the CALPUFF web site at (http://www.src.com/verio/download/sample_files.htm).

5. SOURCE-SPECIFIC MODELING PROTOCOL

Sources are required to submit a source-specific protocol to the State for review and approval prior to source-specific modeling. States will provide the documentation to EPA and FLM for their review. An outline of the typical contents of the site-specific protocol is provided in Table 5-1.

If a source-specific modeling approach is proposed that differs from the common approach in Chapter 4, a more-detailed modeling protocol than that required under the common procedures is required. This protocol must explain the data sources, model configuration, and rationale for changes in the model approach from the common protocol and must be approved by the State.

Unit-specific source data include the following parameters:

- Location (e.g., UTM coordinates, UTM zone and datum)
- Stack height above the ground
- Stack diameter
- Exit velocity
- Exit temperature
- Emission rates (SO_2, H_2SO_4, NO_x and PM_{10}).

Additional building dimension information (building width, length, height and corner locations) is needed for short stacks that are less than Good Engineering Practice (GEP) height. This information is used in providing effective structure dimensions for building downwash calculations. (The requirement to conduct building downwash modeling may be waived by individual States or if the transport distance is greater than 50 km.)

The source coordinates must be expressed in the coordinate system used to define the CALMET and CALPUFF modeling domains. For the regional screening simulations, a Lambert Conformal Conic (LCC) coordinate system will be used. The required parameters to define an LCC coordinate include two matching parallels, latitude/longitude of the projection origin, coordinate datum, and false Easting and Northing (if used) of the projection origin. Subregional and source-specific domains may be using either an LCC or UTM projection.

The CALPUFF Graphical User Interface (GUI) system provides software (called COORDS) to compute to/from latitude/longitude, LCC and UTM coordinates for a large number of datums. In addition, the CALVIEW graphics feature allows the use of georeferenced satellite or aerial photographs to be used as base maps to confirm source locations. Links to sources of suitable base maps can be found on the CALPUFF data site (www.src.com) in the section on “Aerial Photos”.

Table 5-1. Sample Table of Contents of a Source-Specific Fine-Scale Modeling Protocol.

1. INTRODUCTION
   - 1.1 Objectives
   - 1.2 Location of Source vs. Relevant Class I Areas
   - 1.3 Source Impact Evaluation Criteria
2. SOURCE DESCRIPTION
   - 2.1 Unit-specific Source Data
   - 2.2 Boundary Conditions
3. GEOPHYSICAL AND METEOROLOGICAL DATA
   - 3.1 Modeling Domain and Terrain
   - 3.2 Land Use
   - 3.3 Meteorological Data Base
     - 3.3.1 MM5 Simulations
     - 3.3.2 Measurements and Observations
   - 3.4 Air Quality Data Base
     - 3.4.1 Ozone Concentrations – Measured or Modeled
     - 3.4.2 Ammonia Concentrations – Measured or Modeled
     - 3.4.3 Concentrations of Other Pollutants – Measured or Modeled
   - 3.5 Natural Conditions at Class I Areas
4. AIR QUALITY MODELING METHODOLOGY
   - 4.1 Plume Model Selection
     - 4.1.1 Major Relevant Features of CALMET
     - 4.2.2 Major Relevant Features of CALPUFF
   - 4.2 Modeling Domain Configuration
   - 4.3 CALMET Meteorological Modeling
   - 4.4 CALPUFF Computational Domain and Receptors
   - 4.5 CALPUFF Modeling Option Selections
   - 4.6 Light Extinction and Haze Impact Calculations
   - 4.7 Modeling Products
5. REVIEW PROCESS
   - 6.1 CALMET Fields
   - 6.2 CALPUFF, CALPOST, and POSTUTIL Results
6. REFERENCES

APPENDICES

A.1 VISTAS BART MODELING PROTOCOL

A.2 … other appendices as needed

An example of the data that need to be reported is provided in Table 5-2. More detail on the stack data, emissions species, and particulate size fractions to be reported will be made available on the CALPUFF website, www.src.com, Check with your State for the more detailed format of Table 5-2 that is to be used.

Discussions with the regulatory authorities should be conducted prior to development of a protocol to ensure all of the relevant issues are included in the protocol.

Table 5-2. Example of Source Documentation for BART Eligible Source.

Unit name and/or description	**Start-up dates**	**SO_2 potential emissions (tpy)**	**NO_x potential emissions (tpy)**	**Total PM potential emissions (tpy)**
Emissions source name				
…				
Total emissions				
Potential BART-eligible emissions				

6. QUALITY ASSURANCE

6.1 Scope and Purpose of the QA program

Air quality modeling covered under this protocol is an important tool for use in determining whether a BART-eligible source can be reasonable expected to cause or contribute to visibility impairment in a Class I area, and therefore whether this source should be subject to BART controls, and if so, to determine the relative benefits of various BART controls. The purpose of the quality assurance (QA) program is to establish procedures for ensuring that products produced by the application of the modeling techniques for BART studies satisfy the regulatory objectives of the BART program.

The scope of the QA program affects different users differently. Common features of most applications will be the setup and execution of the CALPUFF air quality model and processing of modeling results to determine if a source contributes to visibility impairment at a Class I area. In many cases, users will be provided meteorological datasets that have been developed with VISTAS funding under a suitable QA program for use in the BART modeling. Other users will be involved in site-specific or source-specific analyses that will use additional datasets and potentially different modeling options and/or tools. More extensive quality assurance will be required in these latter types of applications. It is the responsibility of the modeler to ensure that an adequate QA protocol is in place for a particular application.

The CALPUFF modeling system contains built-in features to facilitate quality assurance of the modeling results. These include the automatic production of "QA" files for various datasets, including geophysical fields, sources and receptors, and imbedded tracking of model options and switches within the output files from the major modeling units of the modeling system. The Graphical User Interface system (GUI) provided as part of the latest CALPUFF modeling system allows these QA files to be displayed graphically.

In addition, a detailed software management system is in place to track version and level numbers associated each program and utility within the CALPUFF modeling system. This information is carried forward in all of the output files to create an audit trail of software versions and major model options used that can be retrieved and displayed from the model output files.

Because the required QA procedures will depend heavily on the exact application, there will be differences among different users and different applications.

In addition, the BART modeling process involves multiple organizations. The States have overall responsibility for the process and may also execute some or all of the modeling. VISTAS is contributing general guidance via this protocol and is preparing meteorological fields and performing modeling under the guidance of the States. The sources that are BART-eligible need to provide process information and emissions data for use in the analyses. In addition, those sources that are involved in BART assessments will need to be actively involved in control

technology decisions and assessments. Finally, some of the modeling steps may be carried out by contractors on behalf of VISTAS, a State, or a source.

Each of these organizations has a responsibility to ensure that it is providing correct information to others and to evaluate the quality of any analyses it is performing, whether with data of its own or from others. This chapter provides general guidance and information on those aspects of quality assurance that are specific to the CALPUFF modeling effort, irrespective of which organization is carrying out the effort. The focus is on the common protocol efforts described in Chapter 4. As described in Section 6.3, more comprehensive QA may be needed for the unique aspects of the source-specific modeling described in Chapter 5.

6.2 QA Procedures for Common Protocol Modeling

The VISTAS common protocol (Section 4) describes the methods and procedures for use in conducting regional scale screening modeling to determine the whether a particular source or group of sources is subject to BART controls. In the initial application, the regional CALPUFF-ready meteorological data files will be provided by VISTAS. The amount of effort for end-users performing QA of these pre-defined meteorological fields will be reduced from what is required in developing source-specific meteorological fields, as described below. Also, VISTAS is planning to provide five subregional CALMET meteorological datasets in a CALPUFF-ready format. The development of these CALMET datasets will be subject to a QA program as part of their development, so the necessary quality assurance activity of end-users is again reduced from what would be required in the development of the dataset. It is not expected that the quality assurance steps in the development will be repeated in each application. The VISTAS-provided regional and subregional meteorological fields will include a test case simulation for demonstrating that expected modeling results are obtained on the user's computer platform. This test should be repeated by every user.

Although the CALPUFF modeling system is recommended by the U.S. Environmental Protection Agency for application to BART analyses, a considerable amount of expertise and modeling judgment is needed at certain stages of the analysis. The modeling is not a "cookbook" exercise, a fact that was recognized by the U.S. EPA in describing the expertise needed for CALMET modeling (EPA, 1998; pp. 9-10,). Current methods for performing refined chemistry calculation also require an understanding of the chemical and meteorological processing affecting ammonium nitrate formation. VISTAS has committed to provide appropriate CALPUFF training to assist States in obtaining the necessary expertise with the latest CALPUFF modeling tools and techniques. An appropriate level of knowledge of the model formulation, technical approach and assumptions is essential for successful BART modeling.

6.2.1 Quality Control of Input Data

The input data required by the model depends on the application. At a minimum, source data is required by CALPUFF (see Section 6.2.3) along with a list of choices made about model options and switches. Most of the modeling option choices are specified or recommended by regulatory

guidance and default values (see references in Section 4.3.3). However, remodeling of the boundary conditions is not required for VISTAS-provided finer grid domains so the expertise level is not as high as it would be for development of the boundary conditions files from scratch.

To the extent that modeling applications are using pre-defined CALMET files and CALPUFF templates, the quality assurance will be straightforward. More detailed steps are needed for the setup of modeling files for source-specific applications of subregional domains finer than 4 km.

The basic procedures that will apply to all CALPUFF model applications will include a confirmation of the source data, including units, verification of the correct source and receptor locations, including datum and projection, confirmation of the switch selections relative to modeling guidance, checks of the program switches and file names for the various processing steps, and confirmation of the use of the proper version and level of each model program. It is a common and recommended procedure for an independent modeler not involved in the setup of the modeling files to independently confirm the model switches and data entry in the actual model input files and to conduct an independent run of the worst case event as a confirmation check.

In addition, common practice requires that a model project CD (or DVD or set of DVDs) be created that contains all of the data and program files needed to reproduce the model results presented in a report. The model list files from each step are included on the project CD. This information allows independent checking and confirmation of the modeling process.

6.2.2 Quality Control of Application of CALMET

For users of the VISTAS CALPUFF-ready CALMET meteorological files, a number of large datafiles will be provided by VISTAS on external USB2 or Firewire hard drives in a format ready for use with the CALPUFF model. The QA steps associated with the development of the VISTAS common datasets will be provided separately as part of the modeling documentation. It is not expected that the QA steps conducted in the development of the meteorological datasets will be repeated in each application, although tests to confirm that the dataset is suitable for the application for which it is being used should be performed as part of the QA. This is discussed in more detail below.

The regional screening CALMET grid is defined in Chapter 4 on a 12-km Lambert Conformal Conic (LCC) grid system. The subregional and source-specific domains may be defined in either LCC or Universal Transverse Mercator (UTM) coordinates. In the case of the LCC projection, two matching parallels, latitude/longitude of the projection origin, coordinate datum, and false Easting and Northing (if used) of the projection origin must also be defined. For any domains in UTM coordinates, the UTM zone (see Appendix D of the CALMET User's Guide) and datum must be defined. The appropriate projection and map factors are provided as part of the definition of the VISTAS regional grid system. For a source-specific domain, the grid parameters will be provided as part of the source-specific protocol.

Appendix A of the IWAQM report (EPA, 1998) contains a list of recommended CALMET switch settings. Except as modified in Chapter 4 of this protocol or in a source-specific protocol, the IWAQM guidance should be used in setting up the CALMET simulations. The CALMET model obtains the switch settings from an ASCII "control file" with a default name of CALMET.INP. Whether the model is run using a GUI or from the control line in a DOS, Linux, or Unix window, it is essential that the control file be reviewed as part of the CALMET QA analysis. The CALMET GUI retains all of the input descriptive information that is part of the standard CALPUFF.INP file structure. This includes the default value for each variable, a text description of the variable, the meaning of each variable option, the units of the variable and inter-relationships among variables indicating if/when the variable is used. Some third-party commercial GUIs strip out this descriptive information, which makes the QA step more difficult, although it is essential for perform nonetheless using the variable names as references for the variables in the file.

Part of the CALPUFF modeling system's built-in QA capabilities is a variable tracking system that retains the control file inputs for CALMET and CALPUFF in the output files create by the models. This information includes the Version and Level numbers of the processor codes and main model codes used in the simulations as well as the control files from the main models (CALMET and CALPUFF). The information from the preprocessing steps and the CALMET and CALPUFF model simulations is all carried forward and saved in the CALPUFF/postprocessor output files so that the final concentration/flux files contain a history of the model options and switch settings. This allows a user or reviewing agency to confirm the switch settings provided in a control file with that actually used in the model simulations. An optional switch in the CALPOST processor creates a complete listing of the QA data. This step requires access to the output CALPUFF concentration and/or flux files, which are normally practical to store on CDs or DVDs and to provide a part of the Project CD/DVD set.

6.2.3 Quality Control of Application of CALPUFF

The quality assurance of the source and emissions data is a major component of the CALPUFF modeling. Also, many errors are found in source coordinates and related projection/datum parameters, so confirmation of the source location is an important part of the modeling QA.

The locations of the Class I area receptors are another important CALPUFF input. The use of pre-defined receptors as provided by the National Park Service (NPS) receptor dataset is recommended in the VISTAS common protocol. However, although the latitude and longitude of each receptor point is provided, it is necessary to ensure that the proper UTM or LCC coordinates have been computed for computational domain selected. In particular, the datum of the NPS conversion software is not specified, so it is recommended that coordinates be checked using the CALPUFF GUI's COORDS software or another comparable coordinate translation software package that recognizes various datums.

Most of the CALPUFF input variables contain default values. Appendix B of the IWAQM report contains a list of recommended CALPUFF switch settings. Except as modified in Chapter 4 of

this protocol or in a source-specific protocol, the IWAQM guidance should be used in setting up the CALPUFF simulations. The CALPUFF model obtains the switch settings from an ASCII "control file" with a default name called the CALPUFF.INP file. As is the case with the comparable CALMET file, it is essential that the control file be reviewed manually as part of the CALPUFF QA analysis. To facilitate this process, as was the case with the CALMET GUI, the CALPUFF GUI retains all of the input descriptive information that is part of the standard CALPUFF.INP file structure. Some third-party commercial GUIs strip out this descriptive information, which makes the QA step more difficult, although it is essential for perform nonetheless using the variable names as references for the variables in the file.

6.2.4 Quality Control of Application of CALPOST and POSTUTIL

CALPOST is run separately for each Class I area in order to obtain the necessary visibility statistics for evaluating compliance with the BART screening and finer grid modeling thresholds. The inputs to CALPOST involve selection of the visibility method (Method 6 in the standard EPA BART guidance), entry of Class I area-specific data for computing background extinction (either average or best 20% natural conditions, as prescribed by the State) and monthly relative humidity factors for hygroscopic aerosols. CALPOST contains a receptor screening that allow subsets of a receptor network modeling in CALPUFF to be selected for processing in a given CALPOST run. This is how receptors within a single Class I area are selected for processing from a CALPUFF output file that may contain receptors from several Class I areas. CALPOST contains options for creating plot files that will help in the confirmation that the proper receptor subset is extracted.

The CALPOST output file contains a listing of the highest visibility impact each day of the model simulation over all receptors included in CALPOST analysis. Receptors will normally be selected in each CALPOST run so that each CALPOST run represents the impacts at a single Class I area. The table includes the data shown in the example in Table 4-1. For a screening assessment, the peak value of the change in extinction is shown at the bottom of the visibility table (see Table 4-1). For a finer grid simulation, the 98th percentile value (8th highest day) is used for comparison against the BART threshold of 0.5 deciviews. It is necessary to import the results of the CALPOST table into a sorting program such as a spreadsheet to rank the daily change in extinction values such as is presented in Table 4-2.

The CALPOST inputs that need to be carefully checked as part of the CALPOST quality assurance are:

- Visibility technique (Method 6 in the common VISTAS protocol)

- Monthly Class I-specific relative humidity factors for Method 6

- Background light extinction values

- Inclusion of all appropriate species from modeled sources (e.g., sulfate, nitrate, organics, (as SOA), coarse and fine particulate matter and elemental carbon.

- Appropriate species names for coarse PM used

- Extinction efficiencies for each species

- Appropriate Rayleigh scattering term (10 Mm^{-1} for screening modeling but Class I area specific value for finer grid modeling)

- Screen to select appropriate Class I receptors for each CALPOST simulation.

The CALPOST program produces plot files compatible with CALVIEW that allow confirmation of receptor locations that is useful in evaluating the receptor screening step.

POSTUTIL allows the user to sum the contributions of sources from different CALPUFF simulations into a total concentration file. In addition, it contains options to scale the concentrations from different modeled species (e.g., different particle sizes) into species-dependent size distributions for the particulate matter. For example, PM is often simulated with unit emission rates for each particle size category and, in the POSTUTIL stage, the contributions of each size category based on the species being considered (e.g., elemental carbon, coarse particulate matter, etc.) are combined to form the species concentrations for input into CALPOST. This process, although simple, requires a careful review of the weighting factors for each source. POSTUTIL also allows a repartitioning of nitric acid and nitrate to account for the effects of ammonia limiting conditions.

If source-specific modeling is performed using different sources of data or different techniques, the source-specific modeling protocol should provide justification for deviations from the VISTAS common protocol, and a QA plan specific for the application provided to address the quality assurance of the data used.

6.3 Additional QA Issues for Alternative Source-Specific Modeling

The level of QA required for application of source-specific protocols will be substantially higher than for the use of datasets that have already been subject to a QA procedure. For example, source-specific protocols may include the use of on-site meteorological datasets, the use of higher resolution prognostic meteorological (e.g., MM5) datasets, alternative visibility calculations, different extinction coefficients, or other changes to the common protocol. In addition to providing a source-specific modeling protocol describing and justifying the changes to the modeling approach from the VISTAS common protocol, the site-specific applications should include the development of a QA plan to properly evaluate the data used in the site-specific modeling.

The critical CALMET input parameters depend on the mode in which the model is run (observations mode, hybrid mode or no-observations mode), and the location and spatial

representativeness of any observational data. In a site specific protocol involving the development of a meteorological dataset, the elements of the QA process include preparation of wind rose (using observed, MM5 and CALMET-derived data), including examination of the data as a function of season and time of day (e.g., 4am, 10am, 4pm wind roses), time series analyses, and presentation of 2-D vector plots illustrating terrain effects/sea breeze circulation or other features of the flow expected to occur within the domain. For example, 2-D vector plots produced during light wind speed stable conditions (e.g., early morning such as 4 am) are good for assessing the performance of the CALMET model configuration and switches in reproducing terrain effects because these conditions are likely to maximize the terrain impacts in the model. Season wind roses at 4 am, 10 am and 4 pm would be expected to show the development of sea breeze circulations that may be important for certain applications. Customization of the QA process for the individual site-specific domain based on the availability of data and the physical processes expected to be important at that location should be conducted as part of the site-specific QA plan development.

If site-specific CALPUFF simulations involving the Ammonia Limiting Method are conducted, performance of the model in reproducing observed CASTNet or IMPROVE sulfate and nitrate concentrations at measurement sites within the site-specific modeling domain should be evaluated. The use of alternative ammonia concentration data (e.g., CMAQ output rather than derived ammonia based on aerosol measurements) will require an evaluation of the model performance relative to the techniques in the VISTAS common protocol.

In any site-specific protocol a site-specific QA plan should be prepared.

6.4 Assessment of Uncertainty in Modeling Results

Chapter 3 discussed the uncertainties and known limitations in CALPUFF. The source specific modeling report does not need to repeat the uncertainties listed in Chapter 3, but the reviewer should interpret results in light of these limitations. It is expected that the performance of the model will be better in predicting changes in visibility impacts due to BART controls than in predicting absolute visibility values. This is because uncertainties in meteorological conditions transport and dispersion are expected to be less important in evaluating a change in impact, since a comparable effect will be included in both the base and sensitivity simulations.

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Appendix B

Source-Specific Sulfuric Acid Emissions for BART Baseline Case

Sulfuric Acid (H_2SO_4) Emissions

During the combustion of sulfur-containing fuels, a percentage of the SO_2 formed is further oxidized to SO_3. As the flue gas cools across the air heater, this SO_3 combines with flue gas moisture to form vapor-phase and/or condensed sulfuric acid (H_2SO_4). The baseline H_2SO_4 emissions were calculated consistent with the method used by Southern Company to derive emissions for Toxics Release Inventory (TRI) purposes. This method is documented in a report titled “Estimating Total Sulfuric Acid Emissions from Stationary Power Plants,” published by the Electric Power Research Institute and updated in 2018. The approach described in this report assumes that H_2SO_4 emissions released from the stack are proportional to SO_2 emissions from combustion and are dependent on the fuel type and the removal of H_2SO_4 by downstream equipment (i.e., ESP and air heater).

The calculations below show baseline sulfuric acid emissions. The baseline sulfuric acid emissions estimate accounts for the manufacture of H_2SO_4 through combustion. Calculated sulfuric acid releases then account for loss or removal within the system.

Sulfuric Acid Manufactured from Combustion (EMComb):
EMComb = K x F1 x E2

where,
EMComb = total sulfuric acid manufactured from combustion, lbs/yr
K = Molecular weight constant = 98.07 / 64.04 = 1.53
(98.07 = Molecular weight of sulfuric acid; 64.04 = Molecular weight of SO2.)
F1 = Fuel Impact Factor (from EPRI “Estimating Total Sulfuric Acid Emissions from Stationary Power Plants” Table 4-1) = 0.01
E2 = Sulfur dioxide emissions, lb/hr (from CEMS heat input and fuel data)

Sulfuric Acid Manufactured from Combustion is:
Unit 4:
EMComb = 1.53 x 0.01 x 1.33 lb/hr SO2= 0.02 lbs/hr

Unit 5:
EMComb = 1.53 x 0.01 x 2.75 lb/hr SO2= 0.042 lbs/hr

Total Sulfuric Acid Released from Combustion (TSAR)
TSAR = EMComb x F2

where
F2 = technology impact factors from downstream equipment (for Watson 4 and 5: air heater and ESP)
F2 = 0.5 air heater
F2 = 0.63 ESP

TSAR = EMComb x (0.5) x (0.63) =
Unit 4
TSAR = 0.02 lbs/hr x (0.5) x (0.63) = 0.0064 lbs/hr

Unit 5
TSAR = 0.042 lbs/hr x (0.5) x (0.63) = 0.013 lbs/hr

Appendix C

Summary of Days with Nonrepresentative Emissions

Summary

Following guidance outlined in 40 CFR 51 Appendix Y, MPC has reviewed the actual emission rates from January 1, 2017 to December 31,2019 to identify days with periods of nonrepresentative operations. Per EPA guidance, days that include hours of nonrepresentative operation should not be included in determination of the highest actual daily emission rate used for BART exemption modeling. The table below provides a summary of days with such operation that were not included in this determination. It is noted, for NO_X, MPC excluded 20 out of 834 (2.3%) operating days for unit 5. MPC's review of the 20 days indicated that the emissions recorded in CEMs did not represent normal operation due to equipment malfunctions and data substituted according to the Part 75 data substitution protocol.

Table 3. Summary of Days with Nonrepresentative Emissions

Date	(tons)	(lbs/hr)	Description
4/18/2019	41.48	3457.00	CEMs software issue. NOx concentrations substituted at 200% of the full-scale setting. OFA dampers settings.
4/24/2019	35.56	2963.17	CEMs software issue. NOx concentrations substituted at 200% of the full-scale setting. OFA dampers settings.
4/17/2019	31.69	2641.08	CEMs software issue. NOx concentrations substituted at 200% of the full-scale setting. OFA dampers settings.
4/13/2019	29.85	2487.08	CEMs software issue. NOx concentrations substituted at 200% of the full-scale setting. OFA dampers settings.
4/14/2019	29.22	2435.00	CEMs software issue. NOx concentrations substituted at 200% of the full-scale setting. OFA dampers settings.
4/22/2019	28.91	2409.33	CEMs software issue. NOx concentrations substituted at 200% of the full-scale setting. OFA dampers settings.
6/4/2018	27.47	2289.17	CEMs software issue. NOx concentrations substituted at 200% of the full-scale setting.
4/12/2019	27.47	2288.75	CEMs software issue. NOx concentrations substituted at 200% of the full-scale setting. OFA dampers settings.
4/23/2019	27.01	2250.67	CEMs software issue. NOx concentrations substituted at 200% of the full-scale setting. OFA dampers settings.
4/10/2019	26.62	2217.92	CEMs software issue. NOx concentrations substituted at 200% of the full-scale setting. OFA dampers settings.
10/15/2018	26.57	2213.83	CEMs software issue. NOx concentrations substituted at 200% of the full-scale setting.
4/9/2019	26.50	2208.08	CEMs software issue. NOx concentrations substituted at 200% of the full-scale setting. OFA dampers settings.
10/14/2018	25.31	2108.75	CEMs software issue. NOx concentrations substituted at 200% of the full-scale setting.
4/8/2019	24.00	2000.17	CEMs software issue. NOx concentrations substituted at 200% of the full-scale setting. OFA dampers settings.
4/11/2019	23.34	1945.25	CEMs software issue. NOx concentrations substituted at 200% of the full-scale setting. OFA dampers settings.
6/26/2018	22.98	1915.17	CEMs software issue. NOx concentrations substituted at 200% of the full-scale setting.
4/1/2019	22.60	1883.00	CEMs software issue. NOx concentrations substituted at 200% of the full-scale setting. OFA dampers settings.

4/25/2018	22.55	1879.50	CEMs software issue. NOx concentrations substituted at 200% of the full-scale setting.
10/13/2018	20.98	1748.17	CEMs software issue. NOx concentrations substituted at 200% of the full-scale setting.
6/27/2018	20.85	1737.58	CEMs software issue. NOx concentrations substituted at 200% of the full-scale setting.

Appendix D
Use of Oak Grove Data for Estimating Ambient Ammonia Concentrations over the Gulf of Mexico

Submitted to

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December 20, 2011

Introduction

Gaseous ammonia (NH_3) is the predominant alkaline compound in the atmosphere and, as such, plays important roles in particle nucleation, aerosol neutralization and $PM_{2.5}$ accumulation. NH_3 is also of interest in regulatory circles as an input variable for Best Available Retrofit Technology (BART) modeling of aerosol concentrations in Class I areas. Most Class I areas are located on land, but some (including the Breton Island NWA) are located in marine environments. Hence, there is a regulatory requirement to specify NH_3 concentrations over the open waters of the Gulf of Mexico for model calculations. Unfortunately, there are no systematic measurements of NH_3 over the Gulf of Mexico. Therefore, it is necessary to estimate NH_3 concentrations based on other considerations. This report uses a weight of evidence approach to estimate NH_3 concentrations over the Gulf of Mexico and to recommend use of data from the Oak Grove, MS SEARCH site for BART calculations.

The SEARCH network is shown in Figure 1. SEARCH includes eight sites arranged in four rural-urban pairs in and around the cities of Atlanta, GA; Birmingham, AL; Pensacola, FL and Gulfport, MS. Four of the eight SEARCH sites that were operational between 2004 and 2008 are within 80 kilometers of the Gulf of Mexico. Of these, two are urban (GFP and PNS) one is suburban (OLF) and one is rural (OAK).

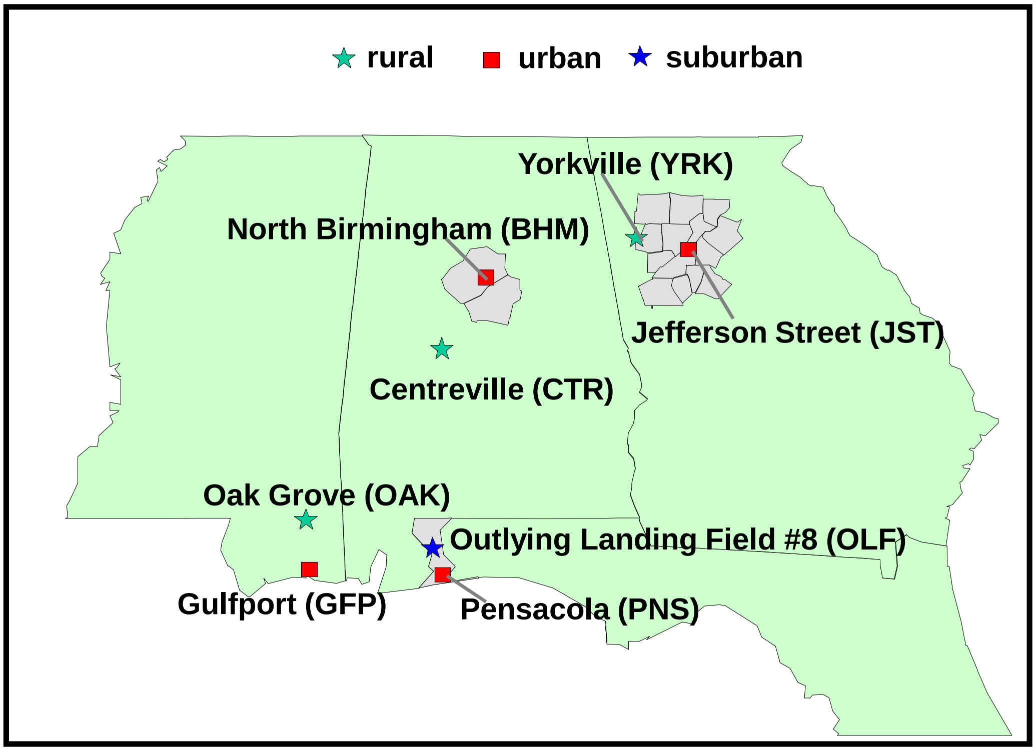

Figure 1. SEARCH air quality sites.

Figure 2 shows average NH3 concentrations for the SEARCH network for the 5-year period 2004-2008. Details of the sampling method are described in Edgerton et al. (2007). Briefly, 24-hour samples were collected on citric acid impregnated annular denuders following the USEPA 1 in 3 day national $PM_{2.5}$ sampling schedule. Denuder samples were extracted in 20 mL of deionized water then analyzed for dissolved NH_4^+ via ion chromatography. Field blanks were collected at each site and used to blank-correct data and to calculate the method detection limit (24 ppt). Measurement precision was 60 parts per trillion (ppt), based on collocated samplers at one site. SEARCH observations show roughly a 10-fold range of concentrations across the southeastern U.S. Lowest concentrations (c. 300 ppt) occur at rural-forested sites, while the highest concentrations (>2000 ppt) are observed at an urban-industrial site (BHM) or rural sites influenced by nearby animal husbandry (YRK). Average concentration for the four sites in proximity to the Gulf of Mexico range from 300 ppt at OAK to 700-800 ppt at GFP and PNS. If we take the regional signal to be on the order of 300 ppt, then the medium sized cities along the Gulf of Mexico are enhanced by about 500 ppt and the largest city (Atlanta) is enhanced by about 1000 ppt. NH_3 concentrations for the only suburban site in the network (OLF) are 50% (150 ppt) above the regional signal.

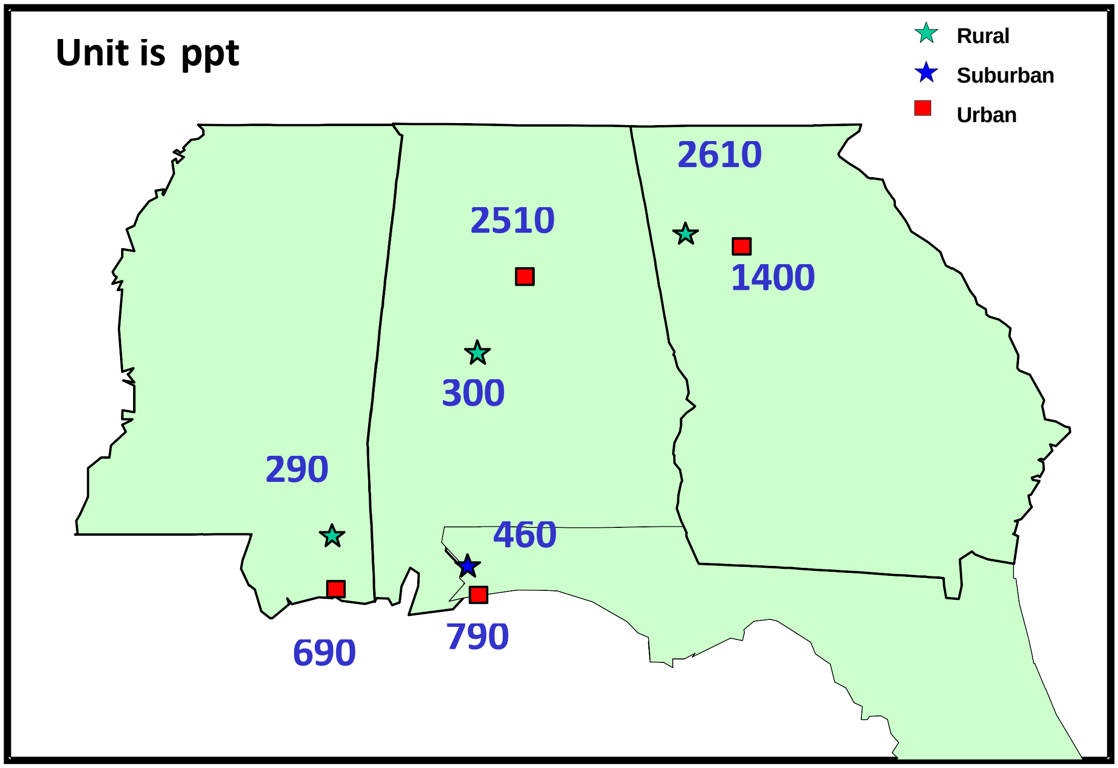

Figure 2. Average NH_3 concentrations at SEARCH sites, 2004-2008.

As a point of comparison, it is instructive to review NH_3 data from the major oceans of the world (see Table 1). These data are quite limited, but they show that NH_3 concentrations removed from terrestrial sources are uniformly <250 ppt. Data also suggest hemispheric differences, with values of approximately 100-250 ppt in the northern hemisphere and <100 ppt in the southern hemisphere. Broadly speaking, then, we would expect Gulf of Mexico NH_3 to fall somewhere in the range of northern hemispheric concentrations (i.e., 100-250 ppt).

Table 1. Mean atmospheric NH_3 concentrations from cruises in various oceanic regions.

Oceanic Region	Year	$NH_{3(g)}$ ppt	Reference
North Atlantic	2005	105	Johnson et al., 2008
Central Atlantic	2003	238	Norman and Leck, 2005
South Atlantic	2003	51	Norman and Leck, 2005
North Sea	2002	71	Johnson et al., 2008
Norwegian Sea	2001	184	Johnson et al., 2008
Indian Ocean	2003	27	Norman and Leck, 2005
Central pacific	1998	16	Quinn et al., 1990
Southern Ocean	1978	86	Ayers and Gras, 1980

NH_3 Emission Rates from Terrestrial and Marine Areas

Emission rate information can also shed light on concentrations because gradients in primary pollutants inevitably occur between areas with high emission density and those with low emission density. Figure 3 shows county-level NH_3 emission rates (kg-N/ha/yr) for the lower 48 states. These data are from the 2002 national emissions inventory compiled by the USEPA. Clearly, there is a broad range of emissions across the country as a whole as well as the southeast. The highest emission rates (>20 kg-N/ha/yr) are associated with agricultural areas (e.g., Iowa) and large urban centers (e.g., Atlanta, New York, Dallas); the lowest emission rates ($\leq$1 kg-N/ha/yr) are associated with sparsely populated areas of the west, southeast, upper midwest and upper northeast. Not surprisingly, the pattern of emission rates across the southeast closely matches that of NH_3 concentrations observed in SEARCH. The overall ranges suggest a ratio of concentration to emission of roughly 100:1 to 200:1; that is, an emission rate of 1 kg-N/ha/yr equates to an ambient concentration of roughly 100-200 ppt.

Similar emissions data for the Gulf of Mexico would allow us to extrapolate NH_3 concentrations to the region of interest. Unfortunately, emissions data specific to the Gulf of Mexico are unavailable; however, Johnson et al. (2007) recently reviewed oceanic emission rates based on a series of research cruises that were conducted between 1995 and 2005. In general, results showed that that NH3 fluxes were higher in equatorial oceans (i.e., 20 degrees S latitude to 20 degrees N latitude) and lower in the more northern regions (i.e., $\geq$40 degrees N or S latitude), and that surface water temperature largely determined whether the ocean was a source or sink for NH_3 (Johnson et al. 2007). Maximum emission rates of about 0.75 kg-N/ha/yr were observed in the equatorial Atlantic and minimum emission rates of about 0.25 kg-N/ha/yr were observed in the north Atlantic. Intermediate emission rates were observed for latitudes bracketing the Gulf of Mexico. Combining these findings with the emission-concentration ratio from above suggests that average NH_3 concentrations in the Gulf of Mexico are likely to be $\leq$200 ppt.

Air Mass Trajectories

As noted above, average NH_3 concentrations at GFP, 1.6 kilometers from the Gulf of Mexico, are about 400 ppt higher than those at OAK, 70 kilometers from the Gulf which can be explained largely by emissions density as discussed above. This is the case on average, but there are many occasions when concentrations at GFP and OAK are much closer than 400 ppt. This feature of the data can be exploited to gain insight into concentrations over the Gulf of Mexico. Figure 4 shows individual 24-hour measurements for GFP and OAK for 2008 and 2009. GFP concentrations are usually higher, but concentrations converge to within +/- 100 ppt about 20% of the time. Air mass back trajectories were calculated to determine whether days with similar NH_3 concentrations at GFP and OAK were dominated by marine or terrestrial air masses. Twenty-four hour back trajectories were calculated for GFP with the NOAA-HY-SPLIT model using 40km resolution meteorological data as input and three starting elevations (200, 500 and 1000 meters above mean sea level). Results of these calculations show three general transport conditions for convergent

NH_3 concentrations. The first and by far most common condition involves advection of air from the Gulf of Mexico (left panel). Advection from the Gulf of Mexico prevails on about 81% of the convergent days and is associated with an average NH_3 concentration of 260 ppt at GFP. The two other conditions (middle and right panels) involve rapid transport from Texas and the southwest (12%, 330 ppt) and transport from the north and northwest (8%, 220 ppt). These results show that NH_3 concentrations over the Gulf must be lower than average concentrations in GFP and are very likely on par with those at OAK.

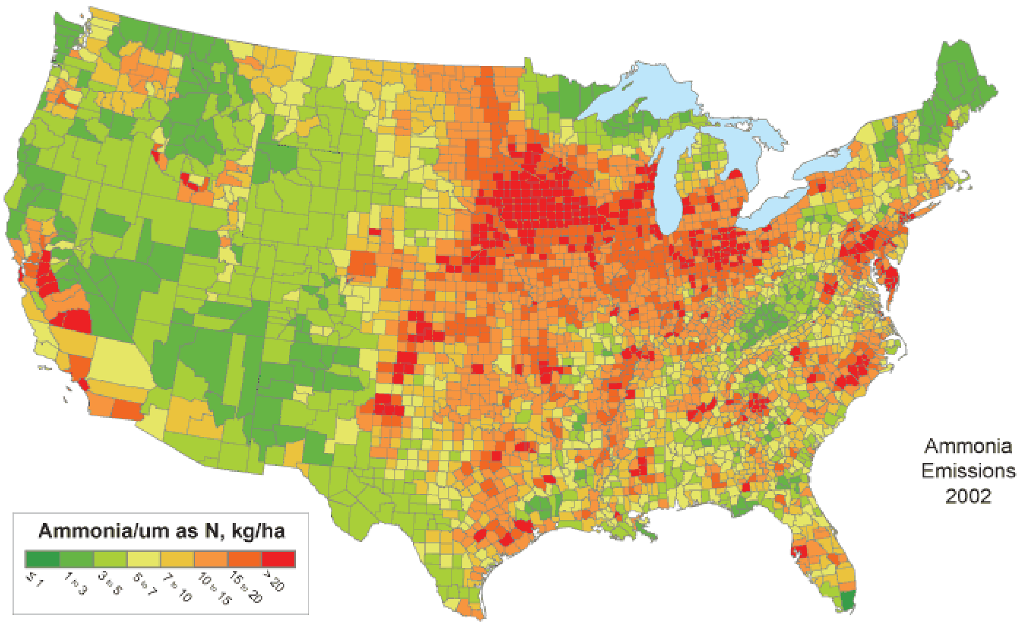

Figure 3. County-level NH_3 emission rates for CY2002 (NEI, 2002).

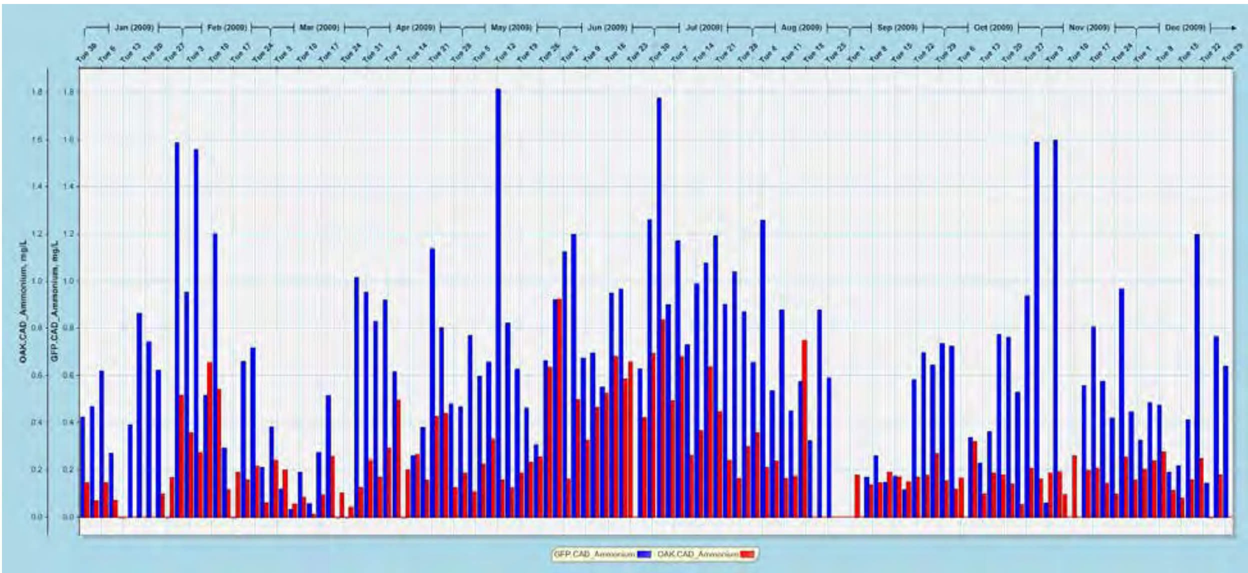

Figure 4. Daily NH_3 concentrations for GFP (blue) and OAK (red).

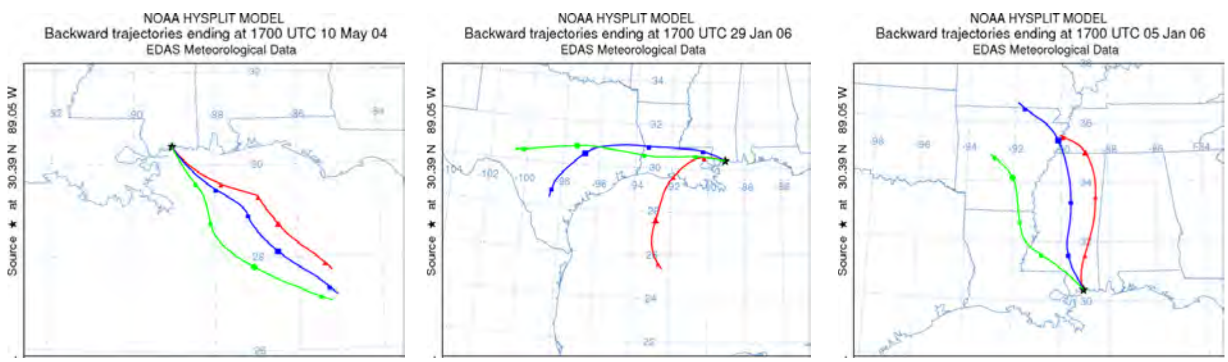

Figure 5. 1-day back trajectories for GFP illustrating transport on days when GFP NH_3 = OAK NH_3 ±100 ppt (200 m trajectory in green, 500 m blue, 1000 m red). Advection from Gulf (left), TX and SW (middle), N and NW (right).

Near-Coastal Monitoring Data from AMON

In addition to SEARCH, the National Acid Deposition Program operates the atmospheric ammonia monitoring network (AMON) to establish spatial patterns and temporal trends of NH_3 across the US and Canada. AMON has approximately 24 sites, some of which date back to 2007, but most were established in 2010. AMON uses a passive sampler (Radiello, Inc.) exposed continuously for 2-week periods to measure NH_3. The advantages of this approach include low cost and complete temporal coverage. Disadvantages of this approach include inability to quantify effects of short-term events (e.g., forest fires) and the assumption of a constant diffusion velocity to the passive collection surface. Despite the latter, long-term average concentrations from passive samplers are generally considered to be to comparable to those from active sampling techniques such as denuders.

One of the original AMON sites is located at Cape Romain, SC (see Figure 6). Cape Romain is a coastal-forested site located within a few kilometers of the Atlantic Ocean and has a complete data record for three calendar years (2008-2010).

Figure 6. Google-Earth image showing SEARCH network and Cape Romain AMON site.

Table 2 shows ranked averages of NH_3 concentrations for the SEARCH network, plus Cape Romain. As can be seen, average NH_3 for Cape Romain (280 ppt) is virtually identical to OAK and CTR and appreciably lower than any other SEARCH site. Given the proximity of Cape Romain to the Atlantic, these data confirm low concentrations for marine air masses. de Kluizenaar and Farrell (2000) reported similarly low NH_3 concentrations for several coastal sites in western Ireland. For example, data from Connemara National Park in west central Ireland showed an annual average NH_3 concentration of 260 ppt. The authors noted that concentrations were well below average when transport was from the Atlantic, but did not attempt to stratify concentrations based on marine versus terrestrial provenance.

Table. 2. Ranked NH_3 concentrations for Cape Romain and SEARCH sites, 2008-2010.

Site	Environment	Mean NH3, ppt	95% CI, ppt
Yorkville, GA	Rural-Agricultural	2600	200
Birmingham, AL	Urban-Industrial	2460	160
Jefferson Street, GA	Urban	1270	70
Gulfport, MS	Urban	700	50
OLF, FL	Suburban	450	40
Centreville, AL	Inland-Forested	310	30
Oak Grove, MS	Inland-Forested	300	30
Cape Romain, SC	*Coastal-Forested*	*280*	*40*

Atmosphere-Seawater Equilibrium Calculations

Absent direct measurements, NH_3 concentrations can be estimated based on equilibrium partitioning between seawater and the atmosphere. This calculation requires seawater measurements of total dissolved ammonium, pH, temperature and salinity as shown below (Johnson et al, 2008):

$$NH_{3(g)eq} = 24.5x10^3 K_H[NH_x]K_a^* \qquad \text{(eq. 1)}$$

where,

$NH_{3(g)eq}$ = equilibrium NH_3 concentration in air, parts per trillion
K_H = Henry's Law constant for NH_3 solubility in seawater, unitless
= 1/[17.93x(T/273.15)exp((4092/T-9.70)]
T = seawater temperature, K
$[NH_x]$ = total dissolved ammonium (NH_4^+ and NH_3) in seawater, nmol/L
$K_a^* = K_a/(K_a+[H^+])$, unitless
$[H^+]$ = seawater H^+ concentration = $10^{(-pH)}$
K_a = acidity constant for NH_3 = $10^{(-pKa)}$
pK_a = -0.467 + 0.00113xS +2887.9/T
S = seawater salinity, parts per thousand

$NH_{3(g)eq}$ is weakly dependent on salinity, but highly dependent on both temperature and pH. As temperature increases, the Henry's Law constant increases, shifting NH_3 from the dissolved phase to the gas phase. As pH increases, K_a* increases, also shifting NH_3 to the gas phase.

There is an abundance of temperature, pH and salinity data for the Gulf of Mexico, but a paucity of good quality $[NH_x]$ data . One of the most extensive NH_x data sets was collected from July to August 2007 during the NOAA-Sponsored Gulf of Mexico East Coast Carbon (GOMECC) project (R/V Ronald H. Brown Cruise Report RB-07-05). The cruise started in Galveston, TX, traversed the Gulf of Mexico and eastern seaboard of the U.S. and ended in Boston, MA. The cruise track is shown in Figure 7. Semi-continuous surface water measurements of NH_x, salinity, temperature and pH were made at all stations (circles) in Figure 7 and along much of the path in between stations. The data set for the Gulf of Mexico includes 479 valid data points for $[NH_x]$ with an average value of 110 ± 60 nmol/L. Seawater temperature, salinity and pH during the Gulf of Mexico portion of the cruise were 29-31 degrees C, 35-36 and 8.0-8.1, respectively.

Table 3 shows estimated $NH_{3(g)eq}$ for the GoM based on GOMECC data. Bold values in Table 1 indicate the range of expected $NH_{3(g)eq}$ under observed conditions of pH and temperature, while other values are for lower temperatures outside the range of cruise observations, but encountered at other times of the year. For $[NH_x]$ = 110 nmol/L, expected $NH_{3(g)eq}$ is in the range of 197 ppt (29C, pH 8.0) and 303 ppt (31C, pH 8.1). These results are very consistent with observed concentrations from the SEARCH Oak Grove site (inland-forested) and the AMON Cape Romain site (coastal-forested). Calculations also show much lower $NH_{3(g)eq}$ (50-150 ppt) for temperatures in the range of 15-25 C. In other words, if water chemistry is assumed to be more or less constant, then water temperature will drive expected $NH_{3(g)eq}$ even lower during cooler periods of the year.

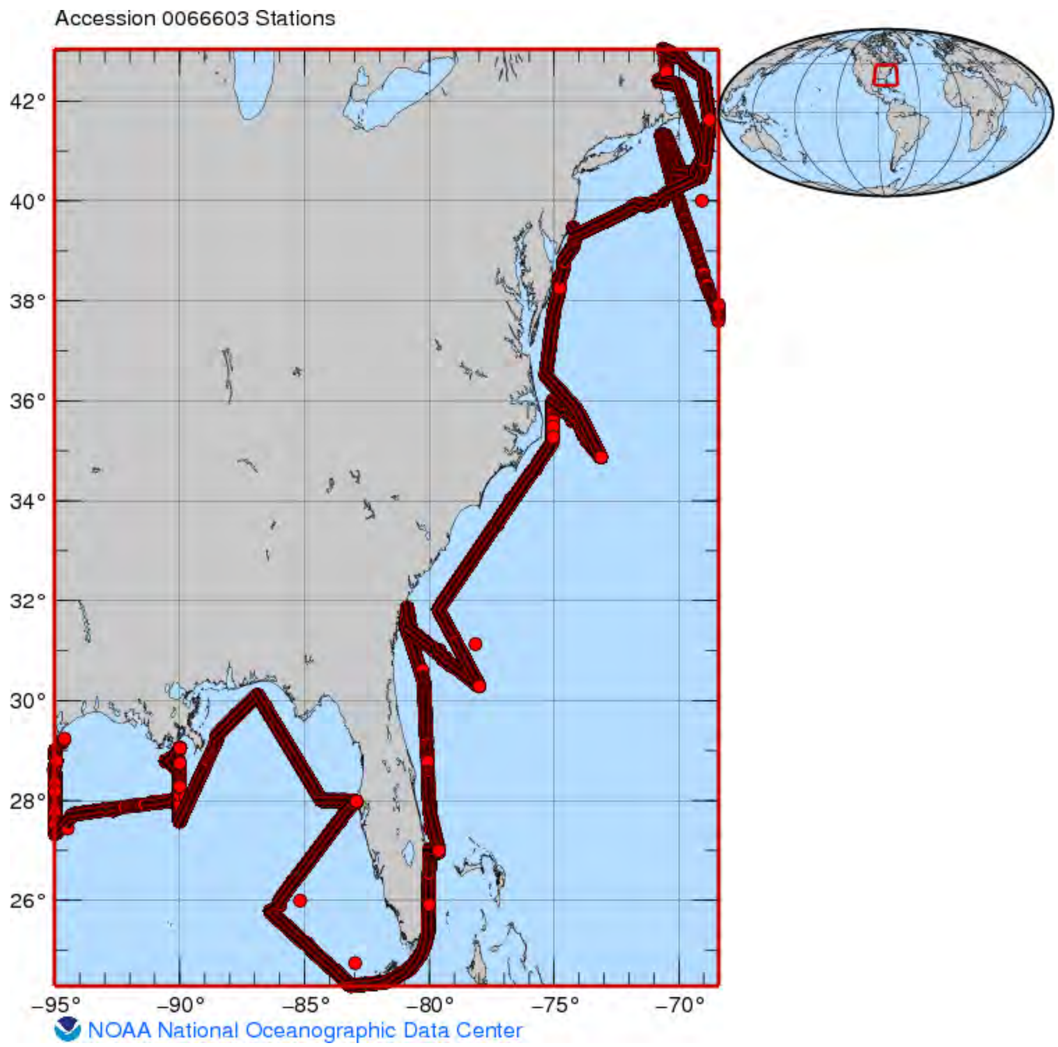

Figure 7. Cruise track for RV Brown GOMECC Project, July 11, 2007-August 4, 2007 (from R/V Ronald H. Brown Cruise Report RB-07-05).

Table 3. Calculated $NH_{3(g)eq}$ based on GOMECC observations (mean $[NH_x]$=110 nmol/L).

T, C	pH	pKa	K_H	[H+]	K_a	K_a*	$NH_{3(g)eq}$, ppt
29	**8.00**	**9.136**	**0.0011**	**1.00E-08**	**7.31E-10**	**0.068**	**197**
29	**8.05**	**9.136**	**0.0011**	**8.91E-09**	**7.31E-10**	**0.076**	**220**
29	**8.10**	**9.136**	**0.0011**	**7.94E-09**	**7.31E-10**	**0.084**	**244**
30	**8.00**	**9.105**	**0.0011**	**1.00E-08**	**7.86E-10**	**0.073**	**220**
30	**8.05**	**9.105**	**0.0011**	**8.91E-09**	**7.86E-10**	**0.081**	**245**
30	**8.10**	**9.105**	**0.0011**	**7.94E-09**	**7.86E-10**	**0.090**	**272**
31	**8.00**	**9.073**	**0.0012**	**1.00E-08**	**8.45E-10**	**0.078**	**245**
31	**8.05**	**9.073**	**0.0012**	**8.91E-09**	**8.45E-10**	**0.087**	**273**
31	**8.10**	**9.073**	**0.0012**	**7.94E-09**	**8.45E-10**	**0.096**	**303**
25	8.10	9.265	0.0009	7.94E-09	5.44E-10	0.064	157
20	8.10	9.430	0.0007	7.94E-09	3.72E-10	0.045	88
15	8.10	9.601	0.0006	7.94E-09	2.51E-10	0.031	48

Conclusions

Systematic measurements of atmospheric NH_3 concentrations over the Gulf of Mexico are non-existent and therefore it is necessary to use measurements from land-based stations or to estimate concentrations from other sources of information for the purpose of input into BART calculations. In this analysis, four convergent lines of evidence show that NH_3 concentrations at the Oak Grove, MS SEARCH site represent a realistic upper limit estimate for those over the Gulf of Mexico. These lines of evidence are as follows: 1) NH_3 emission rates imply lower NH_3 concentrations over the Gulf of Mexico than adjoining near-coastal areas; 2) NH_3 concentrations at the SEARCH site in Gulfport, MS average 260 ppt when air mass transport is on-shore from the Gulf of Mexico; 3) data from the near-coastal NADP AMON site at Cape Romain, SC exhibit long-term (2008-2010) average NH_3 concentrations of 280 ppt; and 4) equilibrium calculations based on Gulf of Mexico surface water chemistry suggest summertime NH_3 concentrations of roughly 200-300 ppt and much lower concentrations (<100 ppt) when water temperature is lower.

Table 4 contains monthly median concentration from OAK for the period 2004-2008. Given the large n for each month, it is suggested that these data comprise the most representative estimate of monthly variation over the Gulf of Mexico. It should be noted that the OAK data show peak NH3 concentrations in the spring, whereas seawater temperatures would suggest peak concentrations over the Gulf of Mexico during the summer (assuming constant seawater chemistry). Considering that fine particulate nitrate formation (i.e., NH_4NO_3) is promoted at lower temperatures (Seinfeld and Pandis, 1998), this implies that model calculations using OAK NH_3 data will tend to overestimate fine particulate nitrate concentrations over the Gulf of Mexico.

Table 4. Monthly median NH_3 concentrations at Oak Grove, MS SEARCH site, 2004-2008 (n ~ 50/month).

Month	Median NH3, ppt
1	205
2	190
3	290
4	395
5	380
6	220
7	190
8	150
9	180
10	190
11	180
12	200

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Appendix B

Delta-Deciview Values for the Top 25 Days Over Three Years and for the Top 20 Days for Each Year

Table B-1 Ranked Daily Visibility Change for Breton (Top 25 Days Over Three Years)

YEAR	DAY	RCPTR	DV (Total)	DV (BKG)	DELTA DV	%SO4	%NO3	%OC	%EC	%PMC	%PMF	%NO2	Rank
2002	63	37	9.817	8.702	1.115	0.83	75.37	6.79	1.06	0	1.48	14.46	1
2002	43	15	9.598	8.716	0.882	0.69	84.75	5.06	0.76	0	1.05	7.69	2
2002	362	37	9.666	8.839	0.827	0.5	89.34	3.34	0.48	0	0.67	5.68	3
2003	142	9	9.32	8.782	0.538	0.92	83.14	5.66	0.82	0	1.15	8.31	4
2001	33	5	9.224	8.716	0.508	1.15	61.44	9.39	1.42	0	1.98	24.61	5
2002	72	40	9.198	8.702	0.495	1.29	70.86	9.25	1.34	0	1.87	15.38	6
2003	90	7	9.194	8.702	0.492	0.59	84.39	4.41	0.69	0	0.96	8.96	7
2003	17	40	9.332	8.843	0.489	1.24	59.85	9.7	1.52	0	2.13	25.57	8
2003	18	4	9.327	8.843	0.484	0.73	78.12	5.62	0.84	0	1.17	13.53	9
2003	353	40	9.321	8.839	0.482	1.81	36.51	14.52	2.31	0	3.23	41.62	10
2002	8	24	9.31	8.843	0.467	0.47	87.84	3.44	0.5	0	0.7	7.05	11
2003	345	6	9.304	8.839	0.465	1.13	75.47	7.99	1.24	0	1.74	12.43	12
2001	358	5	9.3	8.839	0.461	1.19	70.44	8.87	1.36	0	1.9	16.24	13
2003	49	24	9.177	8.716	0.46	0.47	86.69	3.63	0.53	0	0.74	7.95	14
2002	38	40	9.169	8.716	0.453	0.95	72.18	7.3	1.15	0	1.6	16.83	15
2001	9	4	9.293	8.843	0.45	0.94	70.24	7.23	1.14	0	1.59	18.85	16
2002	238	35	9.43	8.992	0.438	1.32	69.46	8.76	1.26	0	1.76	17.45	17
2003	300	1	9.205	8.769	0.436	1.46	65.15	10.05	1.54	0	2.15	19.65	18
2002	361	40	9.274	8.839	0.435	0.66	81.21	4.61	0.8	0	1.12	11.59	19
2001	12	40	9.256	8.843	0.413	1.35	52.89	10.8	1.69	0	2.36	30.91	20
2003	348	37	9.251	8.839	0.412	1.53	54.82	11.53	1.81	0	2.53	27.77	21
2003	358	8	9.247	8.839	0.408	1.31	58.48	10.13	1.58	0	2.21	26.29	**22**
2003	14	1	9.251	8.843	0.408	0.87	82.05	5.91	0.89	0	1.25	9.03	23
2001	6	5	9.246	8.843	0.403	0.63	85.96	4.35	0.65	0	0.91	7.5	24
2002	58	37	9.114	8.716	0.397	0.88	75	7.07	1.12	0	1.56	14.38	25

Table B-2 Ranked Daily Visibility Change for Breton (Top 20 Days for 2001)

YEAR	DAY	RCPTR	DV (Total)	DV (BKG)	DELTA DV	%SO4	%NO3	%OC	%EC	%PMC	%PMF	%NO2	Rank
2001	33	5	9.224	8.716	0.508	1.15	61.44	9.39	1.42	0	1.98	24.61	1
2001	358	5	9.3	8.839	0.461	1.19	70.44	8.87	1.36	0	1.9	16.24	2
2001	9	4	9.293	8.843	0.45	0.94	70.24	7.23	1.14	0	1.59	18.85	3
2001	12	40	9.256	8.843	0.413	1.35	52.89	10.8	1.69	0	2.36	30.91	4
2001	6	5	9.246	8.843	0.403	0.63	85.96	4.35	0.65	0	0.91	7.5	5
2001	36	16	9.065	8.716	0.349	1.08	68.14	8.59	1.3	0	1.81	19.08	6
2001	8	39	9.162	8.843	0.319	2.1	28.03	16.63	2.6	0	3.63	47.01	7
2001	109	40	8.991	8.682	0.309	0.54	89.92	3.92	0.58	0	0.81	4.22	8
2001	314	6	9.081	8.777	0.304	0.85	85.73	5.9	0.92	0	1.28	5.32	9
2001	359	37	9.115	8.839	0.276	1.03	74.57	7.95	1	0	1.4	14.05	10
2001	24	24	9.117	8.843	0.274	1.2	69.73	8.73	1.23	0	1.71	17.4	11
2001	60	16	8.966	8.702	0.264	0.29	94.26	1.44	0.22	0	0.31	3.48	12
2001	335	37	9.097	8.839	0.258	0.56	85.08	4.06	0.59	0	0.82	8.89	13
2001	352	40	9.096	8.839	0.257	1.3	55.06	10.39	1.62	0	2.26	29.36	14
2001	84	1	8.956	8.702	0.254	0.75	82.95	5.77	0.9	0	1.26	8.36	15
2001	19	38	9.074	8.843	0.231	1.6	42.26	12.47	1.97	0	2.75	38.94	16
2001	25	1	9.073	8.843	0.23	0.85	75.78	6.34	1.01	0	1.4	14.61	17
2001	194	40	9.236	9.017	0.219	2.46	45.37	15.77	2.47	0	3.45	30.48	18
2001	65	40	8.908	8.702	0.206	1.86	36.76	15.68	2.42	0	3.37	39.91	19
2001	345	17	9.038	8.839	0.199	0.29	91.99	1.92	0.27	0	0.38	5.15	20

Table B-3 Ranked Daily Visibility Change for Breton (Top 20 Days for 2002)

YEAR	DAY	RCPTR	DV (Total)	DV (BKG)	DELTA DV	%SO4	%NO3	%OC	%EC	%PMC	%PMF	%NO2	Rank
2002	63	37	9.817	8.702	1.115	0.83	75.37	6.79	1.06	0	1.48	14.46	1
2002	43	15	9.598	8.716	0.882	0.69	84.75	5.06	0.76	0	1.05	7.69	2
2002	362	37	9.666	8.839	0.827	0.5	89.34	3.34	0.48	0	0.67	5.68	3
2002	72	40	9.198	8.702	0.495	1.29	70.86	9.25	1.34	0	1.87	15.38	4
2002	8	24	9.31	8.843	0.467	0.47	87.84	3.44	0.5	0	0.7	7.05	5
2002	38	40	9.169	8.716	0.453	0.95	72.18	7.3	1.15	0	1.6	16.83	6
2002	238	35	9.43	8.992	0.438	1.32	69.46	8.76	1.26	0	1.76	17.45	7
2002	361	40	9.274	8.839	0.435	0.66	81.21	4.61	0.8	0	1.12	11.59	8
2002	58	37	9.114	8.716	0.397	0.88	75	7.07	1.12	0	1.56	14.38	9
2002	62	7	9.086	8.702	0.384	0.92	69.14	7.72	1.22	0	1.7	19.29	10
2002	48	40	9.064	8.716	0.348	1.2	62.01	9.89	1.46	0	2.05	23.39	11
2002	321	40	9.114	8.777	0.337	1.49	47.12	12.22	1.92	0	2.67	34.57	12
2002	186	40	9.323	9.017	0.305	1.33	76.47	7.8	1.2	0	1.67	11.53	13
2002	44	2	9.008	8.716	0.292	0.84	80.96	6.15	0.88	0	1.23	9.93	14
2002	344	37	9.113	8.839	0.274	1.57	52	11.9	1.79	0	2.5	30.25	15
2002	239	40	9.261	8.992	0.269	2.39	60.08	13.95	2.16	0	3.02	18.4	16
2002	363	13	9.103	8.839	0.264	0.37	97.38	1.64	0.24	0	0.34	0.03	17
2002	359	37	9.084	8.839	0.245	1.45	58.09	11.21	1.7	0	2.37	25.19	18
2002	3	37	9.073	8.843	0.23	1.35	55.35	10.7	1.68	0	2.35	28.57	19
2002	348	37	9.062	8.839	0.223	1.87	43.92	14.2	2.19	0	3.06	34.77	20

Table B-4 Ranked Daily Visibility Change for Breton (Top 20 Days for 2003)

YEAR	DAY	RCPTR	DV (Total)	DV (BKG)	DELTA DV	%SO4	%NO3	%OC	%EC	%PMC	%PMF	%NO2	Rank
2003	142	9	9.32	8.782	0.538	0.92	83.14	5.66	0.82	0	1.15	8.31	1
2003	90	7	9.194	8.702	0.492	0.59	84.39	4.41	0.69	0	0.96	8.96	2
2003	17	40	9.332	8.843	0.489	1.24	59.85	9.7	1.52	0	2.13	25.57	3
2003	18	4	9.327	8.843	0.484	0.73	78.12	5.62	0.84	0	1.17	13.53	4
2003	353	40	9.321	8.839	0.482	1.81	36.51	14.52	2.31	0	3.23	41.62	5
2003	345	6	9.304	8.839	0.465	1.13	75.47	7.99	1.24	0	1.74	12.43	6
2003	49	24	9.177	8.716	0.46	0.47	86.69	3.63	0.53	0	0.74	7.95	7
2003	300	1	9.205	8.769	0.436	1.46	65.15	10.05	1.54	0	2.15	19.65	8
2003	348	37	9.251	8.839	0.412	1.53	54.82	11.53	1.81	0	2.53	27.77	9
2003	358	8	9.247	8.839	0.408	1.31	58.48	10.13	1.58	0	2.21	26.29	10
2003	14	1	9.251	8.843	0.408	0.87	82.05	5.91	0.89	0	1.25	9.03	11
2003	118	1	9.017	8.682	0.335	0.28	97.35	1.58	0.25	0	0.35	0.18	12
2003	81	7	9.014	8.702	0.311	0.69	84.14	5.08	0.77	0	1.08	8.24	13
2003	104	40	8.992	8.682	0.31	1.36	84.09	8.14	1.29	0	1.8	3.32	14
2003	340	5	9.145	8.839	0.306	1.39	56.81	10.76	1.67	0	2.33	27.03	15
2003	4	1	9.142	8.843	0.299	0.69	85.11	4.65	0.7	0	0.97	7.88	16
2003	44	6	9.011	8.716	0.295	0.28	96.28	1.69	0.26	0	0.37	1.12	17
2003	61	7	8.987	8.702	0.285	1.62	55.69	12.13	1.91	0	2.67	25.98	18
2003	332	37	9.048	8.777	0.271	2.09	28.3	17.14	2.72	0	3.8	45.94	19
2003	89	40	8.963	8.702	0.261	1.69	40.62	14.33	2.2	0	3.08	38.08	20

Appendix L.2: Mississippi Power Company—Chevron Cogeneration

Appendix L.2 contents:

Mississippi Power Company—Chevron Cogeneration (1280-00048) BART Process Summary

Mississippi, Chevron Cogeneration facility is electricity generating facility with four gas fired Combined cycle combustion turbines that meets the eligibility criteria. Chevron Cogeneration is 48 km from Breton National Wildlife Refuge, a Class 1 area, and has a possible visibility impact. As a fossil fuel steam electric plant, MS Power—Chevron Cogeneration meets the initial BART eligibility requirements of source category code. Therefore, on June 3, 2011, Mississippi Department of Environmental Quality (MDEQ) sent them a letter requesting information to determine BART eligibility. Based on the information received from MS Power—Chevron Cogeneration, several units were deemed BART eligible because they met the following criteria:

- Operating or under construction between August 7, 1962 to August 7, 1977
- Having potential emissions that exceed the limit of 250 tons per year for SO_2, NO_X, or PM_{10}

The following are the BART-eligible point sources for MS Power—Chevron Cogeneration:

Emission Unit	**Heat Input (MMBtu/hr)**	**Potential Emissions (tons per year)**			**Existing Control Equipment**
		SO_2	NO_X	PM_{10}	n/a
Unit 1—Combustion Turbine w/HRSG	305.9	3.29	523.77	8.34	n/a
Unit 2—Combustion Turbine w/HRSG	305.9	3.39	537.14	8.56	n/a
Unit 3—Combustion Turbine w/HRSG	455.9	4.38	697.41	11.15	n/a
Unit 4—Combustion Turbine w/HRSG	455.9	4.31	686.97	10.96	n/a
	Totals:	15.37	2,445.29	39.01	

Table L.2.1 BART Eligible Sources at MS Power, Chevron Cogeneration plant

Because the source meets BART-eligibility requirements, Chevron Cogeneration performed CALPUFF modeling on these units to determine subjectivity. CALPUFF model version 5.754 Level 060202, along with the new IMPROVE equation were used in the modeling analysis per the VISTAS modeling protocol. The modeling analysis demonstrated a maximum 98th percentile 24-hour average visibility impact over the three years modeled of 0.27 dv, and a 22nd highest day's visibility impact over all three years of 0.24 dv. These values are well within the State's selected subjectivity threshold of 0.5 dv indicating that the facility is not Subject to BART. Because the CALPUFF model has been updated since the modeling was conducted in 2012, more current (2016-2018) emissions values, called from annual emissions reports from Plant Chevron, were compared with the baseline values to give greater assurance of the determination.

Table L.2.2 compares the modeled emissions with updated 24 hr average emissions. The evaluation finds that the maximum SO2 emissions were slightly higher, but still quite low, in the updated compared to the baseline period (3.51 lb/hr vs 8.10 lb/hr), that the maximum NOx emissions were significantly lower in the updated compared to baseline period (558.29 vs 419.96 lb/hr), and that the maximum PM_{10} emissions were slightly lesser (8.66 lb/hr vs. 8.90 lb/hr). The modeling found that most of the visibility impact from this facility was from nitrates so the decrease in NOx would indicate a decreased visibility impact on the Breton Class 1 area.

Emission Unit	Maximum 24 hour average emissions (2001-2003)			Maximum 24 hour average emissions (2016-2018)		
	SO2 (lb/hr)	NOx (lb/hr)	PM10 (lb/hr)	SO2 (lb/hr)	NOx (lb/hr)	PM10 (lb/hr)
Unit 1	0.75	119.58	1.903	0.17	90.91	1.88
Unit 2	0.775	122.64	1.954	0.17	88.84	1.83
Unit 3	1.00	159.23	2.545	4.11	119.64	2.47
Unit 4	0.983	156.84	2.502	3.66	120.56	2.49
Total all	3.508	558.285	8.904	8.10	419.96	8.66

Table L.2.2 *Plant Chevron Modeled and 2016 through 2018 emissions*

Table L.2.3 compares the annual baseline emissions of 2001 through 2003 to 2016 through 2018 annual emissions. The table shows that the annual emissions are slightly (less than 10 %) higher in the 2016-2018 period, excepting the significant decrease in PM emissions.

Year	**Combined Annual Emissions (tons) Units 1-4**		
	SO_2	NO_X	PM_{10}
2001	1.61	1238.26	66.14
2002	1.55	1181.77	62.59
2003	1.44	1264.50	67.65
2016	8.01	1430.36	29.50
2017	7.77	1274.89	26.30
2018	2.50	1295.82	7.94

Table L.2.3 - *baseline and current period annual emissions comparison*

Since Plant Chevron's modeling found that their impact was significantly less than the .5 deciview impact threshold and a review of their current emissions finds that there are no significant increases and the Average Daily NOx emissions are significantly lower than the emissions during the modeled period, Mississippi agrees with the modeling and finds that they are not subject to BART.

BART Modeling Protocol:

Mississippi Power Company
Plant Chevron

Prepared by:

Southern Company Services
for Mississippi Power Company

July 2011

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1.0 Introduction

1.1 Objectives

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

In 2005, the Environmental Protection Agency (EPA) promulgated a rule allowing states subject to the Clean Air Interstate Rule (CAIR) to determine that CAIR satisfies the BART requirements for SO_2 and NO_x for electric generating units (EGUs). On December 23, 2008, the U.S. Court of Appeals for the D.C. Circuit remanded the CAIR rule to EPA, and on July 6, 2011, EPA promulgated the Cross State Air Pollution Rule (CSAPR) as a replacement to CAIR. However, while the state of Mississippi was included in CAIR, it is not included in CSAPR for $PM_{2.5}$. In anticipation of development, MS DEQ, in a letter dated June 3, 2011, requested that Mississippi Power Company (MPC) conduct BART analyses for SO_2, NO_x and PM for the BART-eligible units at Plant Chevron. This modeling protocol discusses the methodology that MPC will apply for performing the BART modeling analysis for SO_2, NO_x and PM.

Units 1, 2, 3, and 4 at Plant Chevron, located near Pascagoula, which are owned and operated by Mississippi Power Company, have been identified as a BART-eligible source. The purpose of this document is to summarize the procedures by which a modeling analysis will be conducted for this source. The modeling procedures outlined will be used to determine whether the source is subject to BART requirements (exemption modeling). If it is determined that the source is subject to BART, this protocol will be updated (e.g., adding data to Table 2-1) and then the procedures below will be used to evaluate the visibility improvement factor in the BART determination step (determination modeling). The modeling procedures are consistent with those outlined in the updated final VISTAS common BART modeling protocol (dated December 22, 2005, revision 3.2 – August 31, 2006), available at http://www.vistas-sesarm.org/BART/index.asp. This source-specific BART modeling protocol references relevant portions of the common VISTAS modeling protocol.

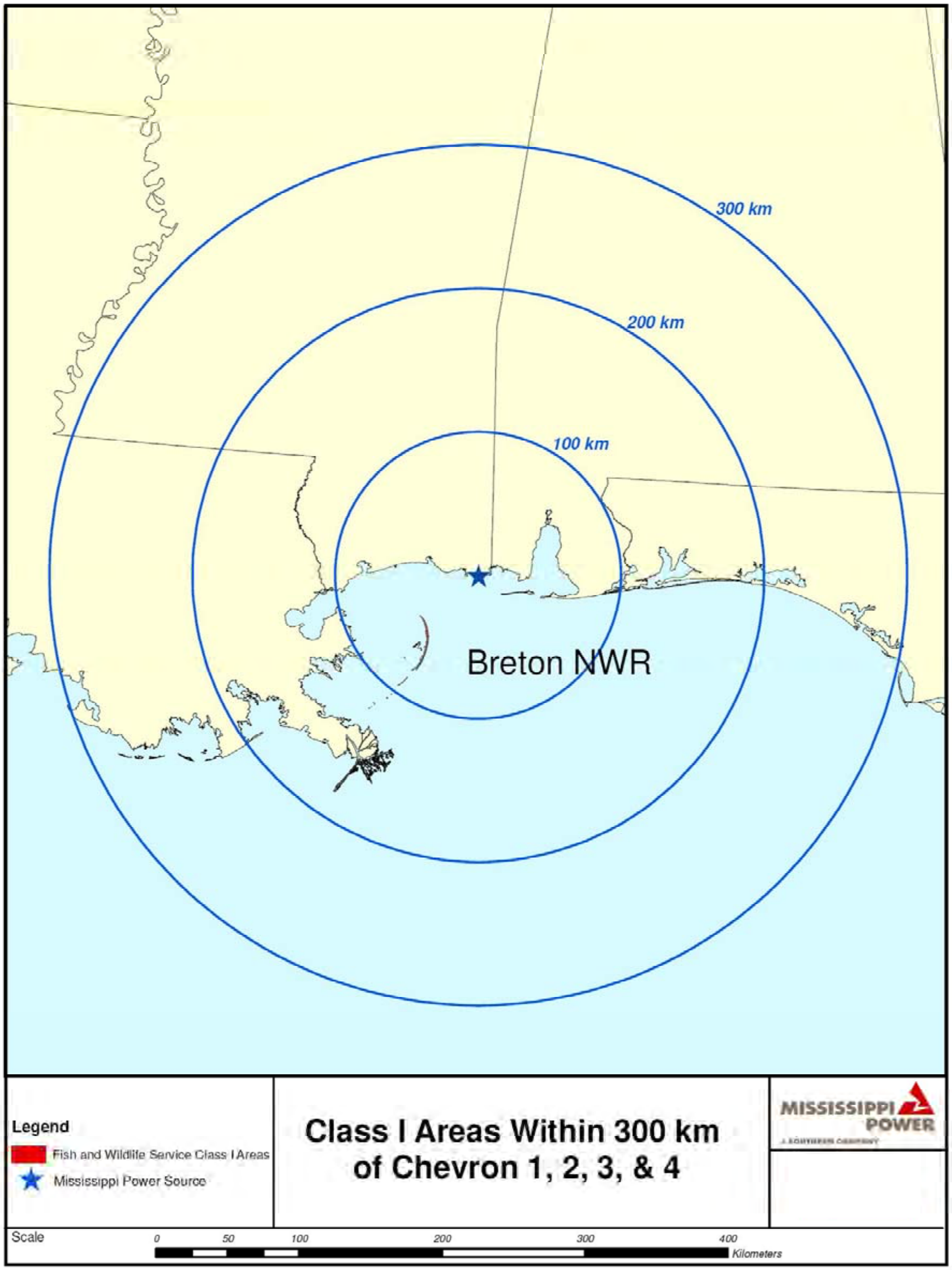
1.2 Location of source vs. relevant Class I Areas

The Mississippi Department of Environmental Quality, which is in charge of the state’s BART program, has determined that Units 1, 2, 3, and 4 at Plant Chevron are BART-eligible for PM. Figure 1-1 shows a plot of Plant Chevron relative to nearby Class I Areas. There is one Class I area within 300 km of the plant: Breton Island (48.1 km). The BART exemption modeling will be conducted for this Class I area in accordance with the referenced VISTAS common BART modeling protocol and the procedures described in this source-specific BART modeling protocol. If necessary, visibility improvement modeling for the BART determination step will be performed for this Class I area if the exemption modeling shows a greater than 0.5 deciview impact.

1.3 Organization of protocol document

Section 2 of this protocol describes the source emissions that will be used as input to the BART exemption modeling and, if necessary, the BART determination modeling. Section 3 describes the input data to be used for the modeling including the modeling domain, terrain and land use, and meteorological data. Section 4 describes the air quality modeling procedures and Section 5 discusses the presentation of modeling results. Since all of the references cited are also included in the VISTAS common BART modeling protocol (Section 7.), no additional references section is included in this document. Appendices A and B provide additional information on the baseline source emissions.

Figure 1-1 Location of Class I Areas in Relation to Plant Chevron



2.0 Source description and emissions data

2.1 Unit-specific source data

The emissions data used to assess the visibility impacts at the Class I areas within 300 km of Plant Chevron are discussed in this section. This protocol addresses SO_2, NO_x and PM_{10} emissions.

Baseline SO2 and NOx emissions are based on the highest measured 24-hour CEMS emission rate for the 3-year period of 2003-2005.

Since various components of PM_{10} emissions have different visibility extinction efficiencies, the PM_{10} emissions are divided, or "speciated," into several components (VISTAS common protocol Sections 4.3.3 and 4.4.2). The VISTAS protocol (Section 5.) allows for the use of source-specific emissions and speciation factors and/or default values from AP-42. The PM_{10} emissions and speciation approach to be used for the modeling described in this protocol is indicated in the bullets below. Where default speciation values are used, the data represents a unit where baseline emission controls include electrostatic precipitators (ESPs), but no post-combustion NO_x or SO_2 control equipment exists.

- Total PM_{10} is comprised of filterable and condensable emissions.
- Since stack tests are not performed for the Chevron Units, baseline filterable PM_{10} emissions are based on AP-42 emissions factors and the highest 24 hour fuel burn for the most recent 3-year period (2003-2005). This results in the "maximum 24-hour average emission rate" as required by the VISTAS protocol.
- All of the filterable PM_{10} is assumed to be fine (less than 2.5 microns in size). Of the fine portion, 6.7% is elemental carbon and the remainder is inorganic fine particulates (soil).
- Condensable PM_{10} consists of inorganic and organic compounds. The inorganic portion is by default assumed to be H_2SO_4, although other non-sulfate inorganic condensables could be present. The organic portion is modeled as organic aerosols. Total condensable PM_{10} emissions are based on the emissions factor in AP-42, Table 3.1-2a.
- Baseline H_2SO_4 emissions are calculated consistent with the method used by Mississippi Power to derive these emissions for TRI purposes. This approach assumes that the H_2SO_4 emissions released from the stack are proportional to SO_2 emissions from combustion and are dependent on the fuel type and the removal of H_2SO_4 by downstream equipment (i.e., heat recovery steam generator). Appendix A provides the basis for the site-specific value used.
- Baseline emissions of secondary organic aerosols (the remaining portion of condensable PM_{10}) are derived as the difference between the total condensable emissions and the H_2SO_4 emissions.

Table 2-1 provides a summary of the modeling emission parameters to be used in the BART CALPUFF modeling, consistent with the source emissions data presented in Appendix A for the baseline. All of the emissions in Table 2-1 were derived from fuel burn data for the 2003 to 2005 period and represent the maximum 24-hour average lb/hr rates (excluding days where startup, shutdown, or malfunctions occurred). For NO_x, SO_2, and filterable PM_{10} the values are calculated using daily fuel burn data and emission factors from AP-42, Tables 3.1-1 and 3.1-2a. PM_{10} speciation was then performed as indicated above such that total Filterable PM_{10} is all assumed to be Fine PM (i.e., total of Fine Soil plus Elemental Carbon).

If the BART exemption modeling indicates that a BART determination is required, then one or more SO_2, NO_x and particulate matter control options will be considered for the modeling to determine the incremental visibility improvement from the baseline case. The BART engineering analysis will provide the justifications for the selected, technically feasible options and the species-specific control efficiencies. Table 2-1 will be updated to provide the modeling parameters for these feasible options and resubmitted to the Mississippi Department of Environmental Quality for review. Any site-specific deviations from the default particulate matter speciation guidance would be outlined at that time.

Table 2-1 Plant Chevron modeling emission parameters

Case	Source / Unit	Location UTM (Zone 16 NAD-83)		Actual Stack Ht	Base Elev.	Flue Dia-meter	Gas Exit Vel.	Stack Gas Exit Temp.	Emissions			Particle Speciation[1]							
		UTM East	UTM North						SO_2	NO_X	PM_{10}	Filt. PM_{10}	Coarse Soil	Fine PM	Fine Soil	EC	Cond. PM_{10}	H_2SO_4	Organic
		m	m	m	m	m	m/s	deg K	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr
Baseline Data - Current Configuration (Unit Basis)																			
Baseline	Unit 1	356,694	3,357,386	11.9	2.6	3.1	8.9	491.3	0.750	119.583	1.903	0.542	0.000	0.542	0.505	0.036	1.361	0.032	1.329
Baseline	Unit 2	356,662	3,357,383	11.9	2.6	3.1	8.9	498.6	0.775	122.635	1.954	0.558	0.000	0.558	0.521	0.037	1.396	0.033	1.363
Baseline	Unit 3	356,652	3,357,370	18.0	2.6	3.0	9.1	506.9	1.000	159.225	2.545	0.733	0.000	0.733	0.684	0.049	1.812	0.042	1.769
Baseline	Unit 4	356,633	3,357,391	18.0	2.6	3.0	9.1	514.7	0.983	156.842	2.502	0.717	0.000	0.717	0.669	0.048	1.785	0.042	1.743
Baseline Data - Current Configuration (Stack Basis)																			
				Modeled Stk Ht[2]															
		m	m	M	m	m	m/s	deg K	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr
Stack 1	Unit 1	356,694	3,357,386	11.9	2.6	3.1	8.9	491.3	0.750	119.583	1.903	0.542	0.000	0.542	0.505	0.036	1.361	0.032	1.329
Stack 2	Unit 2	356,662	3,357,383	11.9	2.6	3.1	8.9	498.6	0.775	122.635	1.954	0.558	0.000	0.558	0.521	0.037	1.396	0.033	1.363
Stack 3	Unit 3	356,652	3,357,370	18.0	2.6	3.0	9.1	506.9	1.000	159.225	2.545	0.733	0.000	0.733	0.684	0.049	1.812	0.042	1.769
Stack 4	Unit 4	356,633	3,357,391	18.0	2.6	3.0	9.1	514.7	0.983	156.842	2.502	0.717	0.000	0.717	0.669	0.048	1.785	0.042	1.743
Stack Basis Emissions Converted to g/sec									g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
Stack 1	Unit 1	356,694	3,357,386	11.9	2.6	3.1	8.9	491.3	0.095	15.068	0.240	0.068	0.000	0.068	0.064	0.005	0.172	0.004	0.167
Stack 2	Unit 2	356,662	3,357,383	11.9	2.6	3.1	8.9	498.6	0.098	15.452	0.246	0.070	0.000	0.070	0.066	0.005	0.176	0.004	0.172
Stack 3	Unit 3	356,652	3,357,370	18.0	2.6	3.0	9.1	506.9	0.126	20.062	0.321	0.092	0.000	0.092	0.086	0.006	0.230	0.005	0.223
Stack 4	Unit 4	356,633	3,357,391	18.0	2.6	3.0	9.1	514.7	0.124	19.762	0.315	0.090	0.000	0.090	0.084	0.006	0.225	0.005	0.220
Retrofit Control Options (if BART analysis is required)[3]																			
SO2 Control 1	Unit 1																		
↓																			
SO2 Control n	Unit 1																		
	↓																		
SO2 Control 1	Unit 4																		
↓																			
SO2 Control n	Unit 4																		

NOX Control 1	Unit 1																		
↓																			
NOX Control n	Unit 1																		
	↓																		
NOX Control 1	Unit 4																		
↓																			
NOX Control n	Unit 4																		
PM Control 1	Unit 1																		
↓																			
PM Control n	Unit 1																		
	↓																		
PM Control 1	Unit 4																		
↓																			
PM Control n	Unit 4																		

[1] Elemental carbon (EC) and Fine PM are a part of Filterable PM_{10} and H_2SO_4 and Organics are a part of Condensable PM_{10}. Note that H_2SO_4 is input to CALPUFF as SO_4. The molecular weights of H_2SO_4 and SO_4 are 98 and 96 respectively, therefore the conversion factor from H_2SO_4 to SO_4 is 96/98.

[2] Stack height credit is equal to actual stack height; stack height is less than 65 m de minimis GEP height.

[3] This data will be provided later if a BART determination analysis is required.

3.0 Input data to the CALPUFF model

3.1 General modeling procedures:

VISTAS has developed five sub-regional 4-km CALMET meteorological databases for three years (2001-2003) (VISTAS common protocol Section 4.4.2). The sub-regional modeling domains are strategically designed to cover all potential BART eligible sources within VISTAS states and all PSD Class I areas within 300 km of those sources (to the nearest edge). The extents of the 4-km sub-regional domains are shown in Figure 4-4 of the VISTAS common BART modeling protocol. The BART modeling for Plant Chevron will be done using the 4-km subdomain 4.

USGS 90-meter Digital Elevation Model (DEM) files were used by VISTAS to generate the terrain data at 4-km resolution for input to the 4-km sub-regional CALMET run. Likewise, USGS 90-meter Composite Theme Grid (CTG) files were used by VISTAS to generate the land use data at 4-km resolution for input to the 4-km sub-regional CALMET run.

Three years of MM5 data (2001-2003) were used by VISTAS to generate the 4-km sub-regional meteorological datasets. See Sections 4.3.2 and 4.4.2 in the VISTAS common BART modeling protocol for more detail on these issues.

It is intended that all of the modeling for Plant Chevron will use the 4-km subdomain 4. However, if the results indicate that the modeling could be improved with a CALPUFF run using a finer grid, then refinements in the modeling procedures will be considered and the Mississippi Department of Environmental Quality will be asked to approve these refinements.

In the event that a finer grid resolution is used, CALMET must be rerun. Other modifications to inputs of CALMET would include the extent of the modeling domain, the resolution of the terrain and land use data, and other relevant settings. The same MM5 data and observations as used for the 4-km sub-regional CALMET simulations would be used. The extent of the modeling domain may need to be changed because of disk space restrictions. The size of the CALMET output is directly proportional to the grid resolution of the run. The domain would be limited to the source and the exclusive Class I area(s) being assessed with a higher grid resolution, including a 50-km buffer in all directions.

If CALMET needs to be run at even a finer grid resolution, then the appropriate model setting/files (specifically the GEO.DAT file) will be modified. A summary of these modifications would be provided to the Mississippi Department of Environmental Quality for review and approval.

3.2 Air quality database (background ozone and ammonia)

Hourly measurements of ozone from all non-urban monitors, as generated by VISTAS, will be used as input to CALPUFF. For ammonia, five years (2004-2008) of 24-hour ammonia concentrations measured at a nearby SEARCH air quality monitoring site (OAK) will be used to calculate monthly median concentrations. OAK is a rural monitoring site in southern Mississippi, approximately 65 km inland from the Gulf Coast. It is reasonable to assume that this site is representative of the regional background, and that the observations from OAK are more appropriate than using the VISTAS default background of 0.5 ppb. The observed monthly background concentrations will be input into Postutil for HNO_3/NO_3 partitioning. The OAK SEARCH NH3 data for 2003-2005 are available from the SEARCH ftp site (ftp://mail.atmospheric-research.com/24-hr%20NH3%20Data/).

3.3 Natural conditions and monthly f(RH) at Class I Areas

For each of the applicable Class I areas, natural background conditions must be established in order to determine a change from natural conditions related to a source's emissions. The modeling described by this protocol document intends to use annual average natural background light extinction (EPA 2003 values).

To determine the input to CALPUFF, it is first necessary to convert the deciviews to extinction using the equation:

$$Extinction\ (Mm^{-1}) = 10\ \exp\ \left[\frac{deciviews}{10}\right]$$

For example, the EPA guidance document indicates for Great Smoky Mountains National Park that the deciview value for the average of the days is 7.60. This is equivalent to an extinction of 21.38 inverse megameters (Mm^{-1}).

This extinction includes the default 10 Mm^{-1} for Rayleigh scattering. The remaining extinction is due to naturally occurring particles, and should be held constant for the entire year's simulation. Therefore, the data provided to CALPOST for Great Smoky Mountains would be the total natural background extinction minus 10 (expressed in Mm^{-1}), or 11.38. This is most easily input as fine soil concentrations (11.38 $\mu g/m^3$) in CALPOST, since the extinction efficiency of soil (PM-fine) is 1.0 and there is no f(RH) component. The concentration entries for all other particle constituents would be set to zero, and the fine soil concentration would be kept the same for each month of the year. The monthly values of f(RH) for input to CALPOST will be taken from "Guidance for Tracking Progress Under the Regional Haze Rule" (EPA, 2003) Appendix A, Table A-3. The f(RH) values that will be used in the revised IMPROVE equation spreadsheet are from the "Revised IMPROVE Algorithm for Estimating Light Extinction from Particle Speciation Data" (November 30, 2005) (see section 4.4).

4.0 Air quality modeling procedures

This section provides a summary of the modeling procedures outlined in the VISTAS protocol that will be used for the refined CALPUFF analysis to be conducted for Plant Chevron.

4.1 Model selection and features

As noted in the VISTAS protocol (Summary, Recommendations Section II.), VISTAS recommended use of CALPUFF Version 5.754 and CALMET Version 5.7. These versions contain enhancements funded by the Minerals Management Service (MMS) and VISTAS. This release includes CALMET, CALPUFF, CALPOST, CALSUM, and POSTUTIL as well as CALVIEW.

The major features of the CALPUFF modeling system, including those of CALMET and the post processors (CALPOST and POSTUTIL), are referenced in Section 3 of the VISTAS protocol.

4.2 Modeling domain and receptors

The initial Plant Chevron BART runs will use the sub-domain 4, 4-km CALMET data supplied by VISTAS, as discussed above. This domain includes all Class I areas within 300 km of the source, plus a 50-km buffer. If there is the need for a refined analysis with a finer grid, a supplement to this modeling protocol will be provided describing the proposed procedures.

The receptors used for each of the Class I areas are based on the NPS database of Class I receptors, as recommended by the VISTAS common protocol (Section 4.3.3).

The BART exemption modeling will be conducted for Chevron Units 1, 2, 3 and 4 (BART eligible units) for each Class I area within 300 km of the source (Breton Island). If the exemption modeling shows an impact greater than 0.5 deciview at Breton Island, the BART determination modeling for visibility improvement will be conducted separately for each of units 1, 2, 3 and 4 and separately for each pollutant-specific control option. For Breton, Mississippi Power will include in the modeling analysis all of the receptors that the US F&WS has identified. However, Mississippi Power does not believe that all of the receptors are still valid receptors. As a result of hurricane and wave activity, several of the receptors identified by the US F&WS for Breton are now located over water, rather than over land. Pursuant to the Wilderness Act of 1964, which defines wilderness as "land," and because Congress made clear when it created the Breton wilderness area that only the land mass was designated as wilderness, receptors that are now over water are not relevant for assessing visibility impacts at Breton. Nevertheless, Mississippi Power will include both the valid and invalid receptors for purposes of this analysis. Appendix C provides more detailed support for the identification and elimination of invalid receptors at Breton. Inspection of more recent aerial imagery from Google Earth suggests that even more receptors may be over water, and further analysis to consider the validity of additional receptors may be warranted.

4.3 Technical options used in the modeling

CALMET modeling for the VISTAS-provided 4-km subdomains will be performed per the procedures specified in the VISTAS common BART modeling protocol. If it is decided to conduct additional modeling with a finer grid than 4 km, this modeling protocol will be updated to specify the technical options to be used in the CALMET run, in order to allow for state agency review and approval.

For CALPUFF model options, Plant Chevron will follow the VISTAS common BART modeling protocol (Section 4.4.1), which states that IWAQM (EPA, 1998) guidance should be followed. The VISTAS protocol (Section 4.3.3) also notes that building downwash effects are not required to be included unless the state directs the source to include these effects. Since Plant Chevron is more than 40 km from the nearest Class I area, building downwash effects will not be included in the CALPUFF modeling.

The POSTUTIL utility program (VISTAS common protocol Section 4.4.2) will be used to repartition HNO_3 and NO_3 using monthly median ambient ammonia (NH_3) concentrations obtained from the nearest rural SEARCH air quality monitoring site (OAK).

4.4 Light extinction and haze impact calculations

The new IMPROVE equation will be used to analyze the visibility impacts from the CALPUFF model results. The new IMPROVE equation is appropriate for this analysis because of the following rationale:

1) The new equation is the result of an extensive evaluation of the most recent scientific data, undertaken by an ad hoc group of scientists including representatives from the National Park Service, the National Oceanic and Atmospheric Administration, academia, and industry. The old equation was based on data and information that was over a decade old, whereas the new equation is based on the most recent data and information gleaned from scientific studies done over the past decade. The new equation adds more accurate terms for estimating light extinction due to sulfate and nitrate, through the incorporation of size differentiation and revisions to the extinction coefficients. Organic matter estimates are improved through a refinement to the organic compound mass to organic mass ratio

2) The new equation corrects several errors and omissions in the old equation. For example, sea salt, which affects light extinction, was not part of the old equation, but has been added to the new equation. Moreover, the old equation's constant Rayleigh scattering term (corresponding to scattering at 10,000 feet elevation) has been revised to reflect the actual elevation of the specific Class I area.

The ad hoc group of scientists who recommended the changes to the equation drafted a technical support document entitled "Revised IMPROVE Algorithm for Estimating Light Extinction from Particle Speciation Data" (November 30, 2005). That document demonstrates that, for 21 Class I areas with nephelometer data, the new equation produces more accurate results than the old equation. The IMPROVE Steering Committee reviewed the work of the ad hoc group and its technical support document, and approved the new equation in December 2005.

The revisions to the IMPROVE equation are particularly important for coastal sites (such as Breton). Sea salt is an important component of extinction at coastal sites, and thus should be included in the equation for estimating visibility impacts. In addition, the site-specific Rayleigh scattering term is important for coastal sites because the default value in the old equation (10 Mm-1) was based on an elevation of 10,000 feet. At near-zero sea level, the new equation uses a more accurate coefficient of 11 Mm-1.

The new formula is shown below.

$$
\begin{aligned}
b_{ext} \approx\ & 2.2 \times f_S(RH) \times [\mathit{Small\ Sulfate}] + 4.8 \times f_L(RH) \times [\mathit{Large\ Sulfate}] \\
& + 2.4 \times f_S(RH) \times [\mathit{Small\ Nitrate}] + 5.1 \times f_L(RH) \times [\mathit{Large\ Nitrate}] \\
& + 2.8 \times [\mathit{Small\ Organic\ Mass}] + 6.1 \times [\mathit{Large\ Organic\ Mass}] \\
& + 10 \times [\mathit{Elemental\ Carbon}] \\
& + 1 \times [\mathit{Fine\ Soil}] \\
& + 1.7 \times f_{SS}(RH) \times [\mathit{Sea\ Salt}] \\
& + 0.6 \times [\mathit{Course\ Mass}] \\
& + \mathit{Rayleigh\ Scattering}\ (\mathit{Site\ Specific}) \\
& + 0.33 \times [NO_2\ (ppb)]
\end{aligned}
$$

The apportionment of the total concentration of sulfate compounds into the concentrations of the small and large size fractions is accomplished using the following equations.

$$[Large\ Sulfate] = \frac{[Total\ Sulfate]}{20\mu g/m^3} \times [Total\ Sulfate], \quad [Total\ Sulfate] < 20\mu g/m^3$$

$$[Large\ Sulfate] = [Total\ Sulfate], \quad [Total\ Sulfate] \geq 20\mu g/m^3$$

$$[Small\ Sulfate] = [Total\ Sulfate] - [Large\ Sulfate]$$

The new formula has separate f(RH) values for large (f_L) and small (f_s) sulfate and nitrate size fractions, and for sea salt (f_{ss})

Dr. Ivar Tombach (VISTAS consultant) has produced a spreadsheet tool (September 29, 2006) to allow the new IMPROVE formula results to be derived from the basic CALPOST outputs. The new IMPROVE spreadsheet and instructions for its use are available on the VISTAS website (http://www.vistas-sesarm.org/BART/calpuff.asp).

For additional justification for use of the new IMPROVE equation, please see the Mississippi DEQ's Proposed State Implementation Plan (SIP) Revision Regarding Federal Regional Haze Program Requirements.

The BART rule significance threshold for the contribution to visibility impairment is 0.5 deciviews. The VISTAS protocol (Section 4.3.2) indicates that with the use of the 4-km sub-regional CALMET database, a source does not cause or contribute to visibility impairment if the 98th percentile (or 8th highest) day's change in extinction from natural conditions does not exceed 0.5 deciviews for any of the modeled years (an added check is: the 22nd highest prediction over the three years modeled should also not exceed 0.5 deciviews for a source to be exempted from a BART determination). Both the 98th percentile (or 8th highest) day's change in extinction from natural conditions for any modeled year and the 22nd highest prediction over the three years modeled will be evaluated. The maximum impact from each method should not exceed 0.5 deciviews for the source to be exempted from a BART determination.

Figure 4-1 of the VISTAS common BART modeling protocol presents a flow chart showing the components of that protocol for the analysis to determine whether a source is subject to BART. Again, it should be noted that the modeling for Plant Chevron will focus on Subregional Fine-Scale modeling as depicted in the lower half of the figure.

If the exemption modeling demonstrates that Plant Chevron does not cause or contribute to visibility impairment, then the source will not be subject to BART requirements, and no further analysis is needed. Otherwise, the source will proceed to perform BART determination modeling for each unit for the baseline and each control option in a similar manner as has been described in this document. This protocol will be supplemented with a revised Table 2-1 and any other source specific adjustments if the source is determined to be subject-to-BART.

5.0 Presentation of modeling results

The BART exemption and, if necessary, the BART determination modeling results for Plant Chevron will be provided to the state agency in a manner as described in the VISTAS protocol (Section 4.5). A report will be produced that includes the following elements (as suggested in the VISTAS protocol):

1. A map of the source location and Class I areas within 300 km of the source.

2. For the CALPUFF modeling domain, a table listing all Class I areas in the VISTAS domain and those in neighboring states and impacts from the BART 4-km grid exemption modeling at those Class I areas within 300 km of the source, as illustrated in Table 4-3 of the VISTAS protocol.

3. A discussion of the number of Class I areas with visibility impairment due to source emissions for the 98th percentile days in each year (and the 98th percentile over all three years modeled) greater than 0.5 dv.

4. For the Class I area with the maximum impact, a discussion of the number of days beyond those excluded (e.g., the 98th percentile for refined analyses) that the impact of the source exceeds 0.5 dv, the number of receptors in the Class I area where the impact exceeds 0.5 dv, and the maximum impact.

5. For any finer grid CALPUFF exemption modeling, results for those Class I areas for which impacts of the source exceeded 0.5 dv in the 4-km initial modeling. We would report the same type of results as provided for 4-km exemption modeling.

The BART determination modeling will be performed for those Class I areas shown in the exemption modeling to exceed 0.5 dv impact. The extent of the BART determination modeling results will depend on the number of technically viable controls identified in the engineering analysis phase of the BART assessment. The results presented will be a comparison of the 98^{th} percentile value for the baseline and each control strategy derived as is outlined above for the exemption modeling. The same statistics as those mentioned above in Steps 3 and 4 would be provided, and a summary of the relative results among all emission scenarios run would be produced.

Additionally, the appropriate electronic files used to conduct the CALPUFF modeling will be submitted on CD-ROM or DVD media.

Appendix A

Basis for Source-Specific Sulfuric Acid Emissions for BART Baseline Case

Sulfuric Acid (H2SO4) Emissions

During the combustion of sulfur-containing fuels, a percentage of the SO_2 formed is further oxidized to SO_3. As the flue gas cools across the air heater, this SO_3 combines with flue gas moisture to form vapor-phase and/or condensed sulfuric acid (H_2SO_4). The baseline H_2SO_4 emissions shown in Table 2-1 of this BART modeling protocol were calculated consistent with the method used by Southern Company to derive these emissions for Toxics Release Inventory (TRI) purposes. This method is documented in a report titled Estimating Total Sulfuric Acid Emissions from Stationary Power Plants: Revision 3 (2005) prepared by Keith Harrison and Dr. Larry Monroe (Southern Company Services) and Edward Cichanowicz (Consultant). The approach described in this report assumes that H_2SO_4 emissions released from the stack are proportional to SO_2 emissions from combustion and are dependent on the fuel type and the removal of H_2SO_4 by downstream equipment (i.e., heat recovery steam generator).

The calculations below show baseline sulfuric acid emissions that are expected. Since this facility does not contain post combustion NO_x controls, the baseline sulfuric acid emissions estimate accounts for the manufacture of H_2SO_4 through combustion. Calculated sulfuric acid releases then account for loss or removal within the system.

Sulfuric Acid Manufactured from Combustion (EMComb):
EMComb = K x F1 x E2
where,
EMComb = total sulfuric acid manufactured from combustion, lbs/yr
K = Molecular weight and units conversion constant = 98.07 / 64.04 * 2000 = 3,063
(98.07 = Molecular weight of sulfuric acid; 64.04 = Molecular weight of SO2; Conversion from tons per year to pounds per year – multiply by 2000.)
F1 = Fuel Impact Factor (from the emissions estimating report)
E2 = Sulfur dioxide emissions, tons (from CEMS data).

Sulfuric Acid Manufactured from Combustion is:
Chevron 1:
EMComb = 3,063 x 0.0555 x 0.750 lbs/hr / 2000 = 0.064 lbs/hr
Chevron 2
EMComb = 3,063 x 0.0555 x 0.775 lbs/hr / 2000 = 0.066 lbs/hr
Chevron 3:
EMComb = 3,063 x 0.0555 x 1.000 lbs/hr / 2000 = 0.085 lbs/hr
Chevron 4
EMComb = 3,063 x 0.0555 x 0.983 lbs/hr / 2000 = 0.084 lbs/hr

Sulfuric Acid Released from Combustion (ERComb)
ERComb = EMComb x F2 (technology impact factor for HRSG)
ERComb = EMComb x (0.5)
Chevron 1
ERComb = 0.064 lbs/hr x (0.5) = 0.032 lbs/hr
Chevron 2
ERComb = 0.066 lbs/hr x (0.5) = 0.033 lbs/hr
Chevron 3
ERComb = 0.085 lbs/hr x (0.5) = 0.043 lbs/hr
Chevron 4
ERComb = 0.084 lbs/hr x (0.5) = 0.042 lbs/hr

Appendix B

Estimated Emissions of Primary Total Carbon and Primary Sulfate From Coal-Fired Power Plants

[The above titled paper is included as a separate document along with this site specific BART modeling protocol. This paper was prepared for Southern Company by Eric S. Edgerton of Atmospheric Research & Analysis, Inc.]

Estimated Emissions of Condensable Carbon and Condensable SO_3 From Coal-Fired Power Plants

Prepared for

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June 11, 2006

ABSTRACT

Data from the SEARCH network were used to estimate condensable carbon and condensable SO_3 emissions from coal-fired power plants (CFPPs). Continuous trace gas and $PM_{2.5}$ measurements were used to identify CFPP plumes and to quantify incremental fine particulate total carbon (TC) and fine particulate total sulfate (SO_4) during the period October 2005-May 2006. As measured in the field, incremental TC includes emitted particulate OC, particulate EC and condensable carbon as well as secondary organic aerosol (SOA). Incremental SO_4 includes emitted particulate SO_4, condensable SO_3, and secondary SO_4. As such, TC and SO_4 provide upper bounds for CFPP emissions of condensable carbon and condensable SO_3. Plume events were selected so as to avoid confounding of TC and SO_4 signals by other sources, and to minimize in-plume production of secondary SO_4 and SOA. Results are presented as ratios relative to SO_2, for example, pounds TC per pound SO_2 (lb TC/lb SO_2,). Plume increments can be interpreted as emission ratios for TC and primary SO_4. For TC, 14 plume events from 4 sites and 7 CFPPs exhibited sufficiently stable data for analysis. Of these, 11 events yielded an average TC/SO_2 emission ratio of 3.2×10^{-3} lb/lb (range 1.1×10^{-3} to 6.6×10^{-3}). In other words, TC emissions represented about 0.32 percent of SO_2 emissions, on a mass basis. The 3 remaining events yielded negative emission ratios using the default approach, and an average emission ratio of 1.5×10^{-3} using an alternate approach. For SO_4, a total of 20 events from 4 sites and 8 CFPPs were analyzed. Results showed an average SO_4/SO_2 emission ratio of 6.4×10^{-3} lb/lb (range 2.1×10^{-3} to 15.0×10^{-3}). On average, SO_4 was found to represent about 0.64 percent of SO_2 emissions during the study period. Inferred emission ratios should be considered upper bound estimates because: 1) the measurements include, in addition to the condensable

carbon and condensable SO_3 emissions of interest, primary particulate carbon (EC and OC) and primary particulate sulfate emitted by the CFPP; 2) may include secondary carbon and secondary sulfate produced in the atmosphere; and 3) could be inflated due to preferential loss of SO_2 from the plume (due to conversion and/or dry deposition) in transit from the CFPP to the research site.

INTRODUCTION

The Southeastern Aerosol Research and Characterization Study (SEARCH) was designed to provide extensive, long-term data on the sources and chemical characteristics of $PM_{2.5}$ and PM_{coarse} for the southeastern U. S. SEARCH is unique in that continuous $PM_{2.5}$ measurements of all major components are made at urban/rural pairs of sites in and around four southeastern U. S. cities. In conjunction with co-measured meteorological and trace gas data, continuous $PM_{2.5}$ measurements provide opportunities for: (1) investigating sources and physico-chemical dynamics of $PM_{2.5}$; (2) evaluating chemical transport and transformation models; (3) assessing the effectiveness of emissions reduction programs; and (4) examining relationships between PM mass and composition and various health end points.

CFPPs emit three forms of primary particulate carbon to the atmosphere: filterable organic carbon (OC), filterable elemental carbon (EC) and condensable carbon. OC and EC are emitted as particles, while condensable carbon is emitted in the vapor phase and is presumed to condense rapidly onto pre-existing particles. These three forms of carbon, plus secondary organic aerosol

(SOA), are measured collectively in the SEARCH network, as total carbon (TC), using continuous measurement techniques. CFPPs also emit two forms of primary particulate sulfate: filterable sulfate and condensable sulfur trioxide (SO_3). In the atmosphere, condensable SO_3 reacts more or less instantaneously with water vapor to produce particulate sulfate. These forms of sulfate, plus secondary sulfate from oxidation of SO_2, are also measured in the SEARCH network using continuous techniques.

This report uses SEARCH data to: (1) identify CFPP plumes observed at numerous sites during the fall of 2005 through spring of 2006; and, (2) calculate total carbon (TC) and total sulfate (SO_4) associated with such plumes. Results are used to estimate CFPP emission ratios of TC and SO_4, relative to SO_2. Given that the measurement techniques do not discriminate between the various form of particulate carbon and particulate sulfate present in the plume, results can be used as upper bound estimates of emission ratios for condensable carbon and condensable SO_3.

EXPERIMENTAL

Continuous measurements of trace gases fine particulate TC and fine particulate SO_4 were made at the Southeastern Aerosol Research and Characterization (SEARCH) sites shown in Figure 1. Analyzable plume events were observed at 5 of the 8 SEARCH sites between early October 2005 and early May 2006: Yorkville, GA; Jefferson Street, GA; Centreville, AL; OLF, FL; and Gulfport, MS. Brief descriptions for these 5 sites are provided below.

<u>Yorkville, GA</u> - Yorkville (lat. 33.9283 N, long. 85.0456 W) is a rural/agricultural site 55 km WNW and 40 km SSW of Atlanta, GA and Rome, GA, respectively. The site is on a broad ridge (elev. 395 m) in a large (>150 ha) clearing devoted largely to pasture. CFPPs in the vicinity of Yorkville are shown in Figure 2.

<u>Centreville, AL</u> – Centreville (lat. 32.9029 N, long. 87.2497 W) is located on private property in rural Bibb County, approximately 85 km SSW of Birmingham, AL. The surrounding area includes the Talladega National Forest and is heavily wooded with mixed deciduous (oak-hickory) and loblolly pine. CFPPs in the vicinity of Centreville are shown in Figure 2.

<u>Jefferson Street (Atlanta), GA</u> - Jefferson Street (lat. 33.7775 N, long. 84.4167 W) is an urban/industrial-residential site 4.5 kilometers NW of downtown Atlanta, GA. The site is located at 829 Jefferson Street NW, on Georgia Power Company property in a 70m by 125m grass-covered clearing on a knoll 15 meters above street level. CFPPs in the vicinity of Jefferson Street are shown in Figure 3.

<u>Outlying Landing Field #8 (OLF), FL</u> - OLF (lat. 30.5496 N, long. 87.3734 W) is a suburban site 21 km NW of downtown Pensacola, FL and 20 km N of the Gulf of Mexico. The site is adjacent to a paved, lightly traveled (< 200 vehicles/day) road on the northern edge of a large (>500 ha) grass-covered field. CFPPs in the vicinity of OLF are shown in Figure 3.

<u>Gulfport, MS</u> – Gulfport (lat. 30.3901 N, long. 89.0498 W) is located 1.5 km from the Gulf of Mexico on the premises of the Harrison County Youth Court at 47 Maples Ave. The area is covered with sparse forest and grass, with single family homes to the east, an elementary school to the north and athletic fields to the south. CFPPs in the vicinity of OLF are shown in Figure 3.

Continuous Trace Gas and Particle Measurements

SO_2, NO_y and CO are measured at each site and used to: 1) screen for periods of influence from point sources (specifically CFPPs) and non-point sources; 2) identify specific CFPPs based on SO_2:NO_y ratios; and 3) calculate TC/SO_2 and SO_4/SO_2 ratios. Continuous (1-minute average) measurements were made at a reference height of 10 m above ground level. Sample air is pulled through a weather-proof inlet box and then into the equipment shelter via ¼" o.d. heavy wall PFA Teflon tubing. The inlet box contains catalytic converters (for NOy), solenoids and plumbing for introduction of zero air and calibrant gases. Calibration gases (+/- 1% for CO and NO and +/- 2% for SO_2) were supplied by Scott-Marrin, Inc. (Riverside, CA).

SO_2 is measured via pulsed UV fluorescence with a TEI Model 43ctl analyzer operated on a 0-200 ppb scale. The instrument is calibrated every third day by gas replacement and zeroed 10 out of every 90 minutes by diverting sample air through a sodium carbonate impregnated annular denuder (URG, Carrboro, NC). The analyzer is also subjected to weekly multipoint gas replacement calibrations (GRC).

CO is measured via gas filter correlation with non-dispersive infrared detection using a TEI Model 48ctl analyzer operated on a 0-3000 ppb scale (0-10,000 ppb at JST). The analyzer is calibrated and zeroed on the same schedule as the SO2 analyzer. Zeroing is performed by diverting the sample stream through a heated (50-100C) trap containing approximately 200 grams of 1% Pt on alumina (DeGussa, Seviersville, TN).

NO_y is measured via ozone-NO chemiluminescence following reduction to NO on a 350 °C Mo catalytic converter, using a dual-channel TEI Model ctl NO-NO_x analyzer operated on a 0-200 ppb scale. The analyzer is zeroed four times per day and calibrated every third day via gas replacement. Converter efficiency is checked once a week with n-propyl nitrate.

SO_4 is measured continuously using a variation of the Harvard School of Public Health (HSPH) approach. This method uses a 1000 °C inconel steel tube to reduce particulate SO4 to sulfur dioxide (SO_2). The SO_2 is then detected using a Thermo-Environmental Instruments (TEI, Franklin, MA) Model 43S or 43Ctl high sensitivity, pulsed ultra-violet fluorescence SO_2 analyzer. Sample air is pulled through a 2.5 µm sharp-cut cyclone inlet (BGI, Atlanta, GA), then through two 30 mm o.d., 254 mm long sodium carbonate and citric acid coated annular denuders (URG, Carrboro, NC) followed by a 30 mm o.d., 100 mm long carbon honeycomb denuder (MAST Carbon Ltd., Surrey, UK). The denuders effectively remove a wide range of interferents, including SO_2, reduced sulfur gases, nitrogen oxides and volatile organic compounds. Sample air then passes through a 300 mm section of inconel tubing heated to 1000 °C in a Lindberg/Blue M horizontal tube furnace. Every 90 minutes, the system is zeroed for 10 minutes by diverting sample air through an inline filter upstream of the converter. The SO_2 analyzer is subjected to manual and automated gas replacement audits on a weekly schedule.

Total carbon (TC) is measured continuously with a Sunset Laboratory Model RT-OCEC Aerosol Carbon Analyzer. This device operates on an hourly cycle, with 47 minutes devoted to sample collection and 13 minutes devoted to sample analysis. In sample mode, ambient air is pulled through an activated carbon monolith denuder (Novacarb™, Mast Carbon Ltd., UK) at a flow rate of 8.5 lpm, then through dual quartz fiber filters. In analysis mode, the filters are heated through several temperature plateaus to a final temperature of 900 °C. CO_2 produced during the heating cycle is quantified with a non-dispersive infra-red (NDIR) detector and TC is calculated based on CO_2 produced and sample volume. The TC analyzer is automatically calibrated with 5% methane in helium after every analysis cycle.

Trajectory Calculations

Twenty-four hour back trajectories are generated using the interactive version of the NOAA HYSPLIT4 model on the NOAA-ARL web site (*12*). Back trajectories use EDAS 40 km meteorological data and default vertical motion, with starting heights of 1000 m, 500 m and 250 m, for the time (hour) of peak SO_2 concentration during each event. The 250 m trajectory is used to determine which CFPP affected the site, as well as time of emission at the CFPP.

Event Selection and Data Reduction

Event selection attempted to identify episodes with minimal contamination from non-CFPP sources. In general, this means that different episodes are used for TC and SO_4 analyses. For TC, we look for clean, well-ventilated conditions during the middle of the day, with low and stable CO concentrations. This avoids rush hour emissions and near-surface sources that tend to accumulate under the nocturnal boundary layer. While some VOC to SOA conversion is possible, the effect should be small during fall and winter because of: 1) low biogenic precursor emissions; and 2) low temperatures; and 3) low solar insolation. For SO_4, in contrast, we are less concerned with contamination from non-CFPP sources, but want to avoid strong sunlight and consequent photochemical production of secondary SO_4 within the plume. Thus, the majority of SO_4 events selected for this analysis occurred either at night or during the early morning hours.

TC emission ratios are calculated using the "ratio of deltas" method, as shown below,

$$ER_{TC} = (TC_{Plume} - TC_{Base})/(SO2_{Plume} - SO2_{Base}) = \Delta TC/\Delta SO_2, \quad \text{(Eq. 1)}$$

where subscripts Plume and Base refer to concentrations measured during the plume event and before or after the event, respectively. The technique is illustrated in Figure 4, which shows an event that occurred at Yorkville on April 9, 2006. The upper panel shows SO_2 and CO during the course of the day. Note that the regular gaps in the time series reflect zeroing cycles. SO_2 concentrations were <5 ppb until about 1430 local standard time (LST), when they increased sharply and remained above 40 ppb until about 1630, then fell below 5 ppb for the remainder of the day. CO concentrations were between 80 and 100 ppb for the entire day, indicating no evidence of plumes from biomass burning, transportation and other activities.

The lower panel shows time series for SO_2 (red symbols) and TC (black bars), also for April 9, 2006. In this case, SO_2 concentrations have been averaged to coincide exactly with the 47-minute Sunset collection period. The plume event is shown in the red box and the downward facing arrows indicate the two values used (i.e., averaged) to calculate Base concentration. The symbols and bars at 1500 LST and 1600 LST are averaged to calculate Plume concentration. Base and Plume concentrations are then used to calculate the ratio of deltas, as shown in Equation 1. Note that ΔTC during this event (0.22 $\mu g/m^3$) is quite small compared to the overall range of TC observed during the day, despite the fact that average SO_2 concentrations exceeded 75 ppb for the 47-minute period beginning at 1600 LST. This is typical of CFPP plume events and underscores the fact that CFPPs are minor sources of particulate carbon. In other words, large plumes are needed in order to even "see" an increase in TC. The small increment of TC associated with CFPP events places a high premium on stable TC measurements.

For several CFPP events, ΔTC was negative, indicating that Base concentrations were slightly higher than the Plume concentrations. Based on Equation 1, this implies a physically unrealistic negative ER. For these events, we used the detection limit for the Sunset analyzer (0.1 $\mu g/m^3$) in the numerator of Equation 1.

SO_4 emission ratios are calculated by linear least square regression of 1-minute SO_4 concentrations versus 1-minute SO_2 concentrations. The regression slope is equivalent to the primary SO_4/SO_2 emission ratio and the intercept is equivalent to the baseline SO_4 concentration in absence of the plume. Figure 5 illustrates an example SO_4 event which occurred at Yorkville on February 25, 2006. In the upper panel, SO_2 concentration is < 5 ppb until approximately 0400 (LST), increases to nearly 50 ppb just before 0600, then falls below 5 ppb by 0900. SO_4 concentrations (right hand scale) are < 1 ppb (3.9 $\mu g/m^3$) the entire day, but show several minor excursions, some of which are associated with SO_2 excursions and some of which are not. The lower panel shows the scattergram of SO_4 versus SO_2 and associated regression statistics. Data for the regression correspond to the red box in the upper panel. Results show a highly significant relationship between SO_4 and SO_2 ($p<0.01$) with a regression slope of 0.0042 on a ppb/ppb basis. Given that the molecular weight of SO_4 is 1.5 times that of SO_2, the emission ratio for this event is 0.0063 lb/lb or 0.63 %.

It should be noted that both the ratio of deltas approach and the linear regression approach give upper bound estimates of TC and SO_4. The principal reason for this is dry deposition, which removes gaseous SO_2 from the plume much faster than particles. If we assume dry deposition to be a first order loss process, then the effect is to reduce ΔSO_2 in the denominator of equation 1 and thereby inflate the ratio $\Delta TC/\Delta SO_2$. Another reason is photochemical or non-photochemical production of secondary SO_4 and OC, which would increase SO_4 and, at the same time, decrease SO_2 in the plume. Although events have been carefully selected to minimize these effects, we cannot be certain they have been eliminated completely.

RESULTS

Table 1 summarizes results for 14 TC plume events observed at 4 sites. Data include the site which observed the CFPP plume, the likely source of the plume (based on trajectory analyses and SO_2/NO_y ratios) and concentration data for the ratio of deltas calculation. Mean $\Delta TC/\Delta SO_2$ for 11 events is 0.0032 +/- 0.0014 with a range of 0.0011 to 0.0066. OLF and Yorkville both observed 5 events. At OLF, all 5 events were from the Crist CFPP and these gave an emission ratio of 0.0020 +/- 0.0012 lb/lb. At Yorkville, the plume events likely originated from 3 different CFPPs and these gave an average ratio of 0.0033 +/- 0.0021 lb/lb. These events clearly show that TC is a small and difficult to detect component of CFPP emissions.

Table 2 summarizes results for 20 SO_4 plume events observed at 4 sites and likely originating from 8 different CFPPs. Data include the maximum observed 1-minute SO_2 concentration, plus the regression slope and r-squared for SO_4 vs. SO_2. Calculated values for $\Delta SO_4/\Delta SO_2$ range from 0.0030 to 0.0180 lb/lb with an average of 0.0064 lb/lb. In most cases, the regression is highly significant; however, r-square tends to decrease as slope decreases because instrument noise starts to dominate the SO_4 signal. These events clearly show that SO_4 is a small and difficult to detect component of CFPP emissions.

CONCLUSIONS

Continuous field measurements can be used to derive emission estimates for TC and SO_4 from CFPPs which are upper bound estimates of condensable carbon and condensable SO_3. Careful attention must be paid to plume event selection in order to avoid contamination from non-CFPP sources (TC) and photochemical activity in the CFPP plume (SO_4). Optimal conditions for both TC and SO_4 estimates appear to occur during the cooler months when photochemical activity is low and persistent winds advect relatively fresh CFPP plumes to the research sites. Plume analysis results show that primary TC emissions and primary SO_4 emissions from CFPPs are well below 1% of SO2 on a mass basis. For primary TC, analysis of 14 events from 7 different CFPPs gave an overall average emission ratio of 0.0032 lb TC/lb SO_2 (or 0.32% of SO2. For primary SO_4, analysis of 20 events from 8 different CFPPs gave an overall average emission ratio of 0.0064 lb SO_4/lb SO_2 (or 0.64% of SO_2).

Figure 1. The SEARCH Network

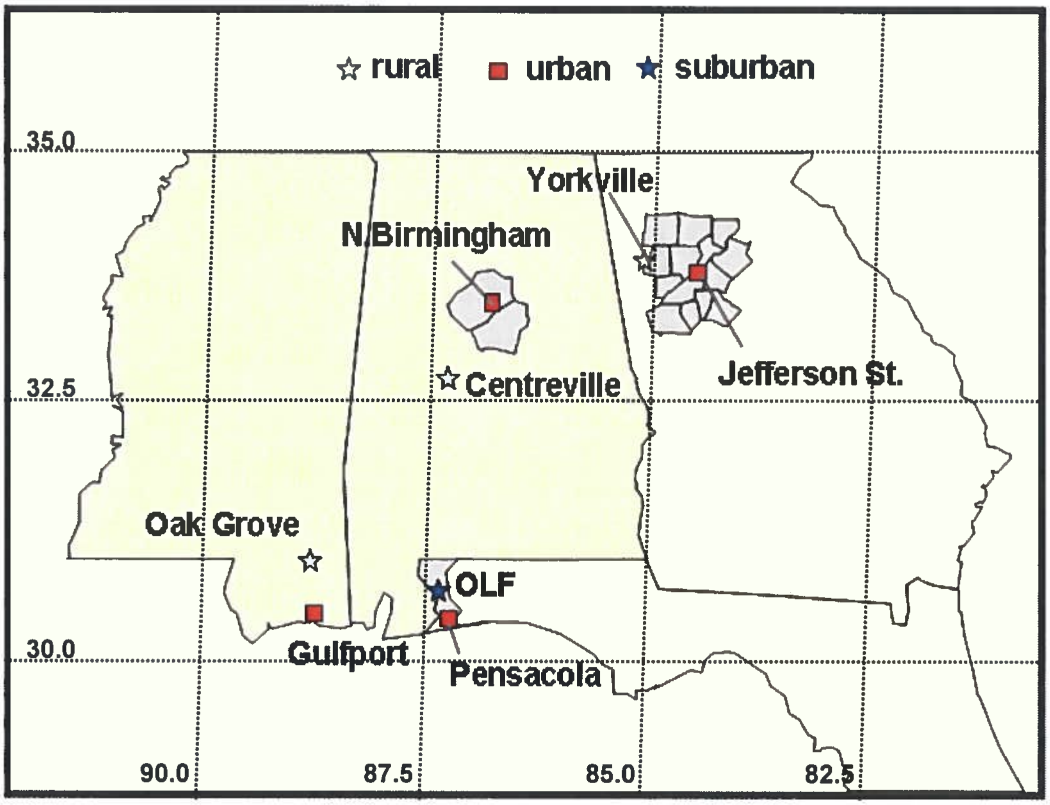


Figure 2. CFPPs observed at YRK (top) and CTR (bottom).

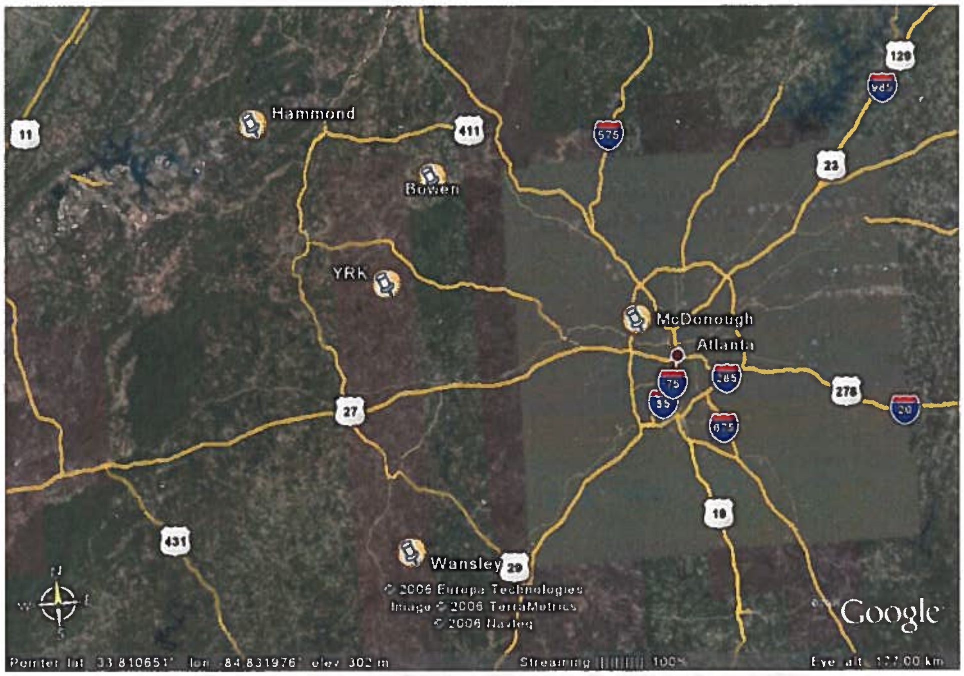


Figure 3. CFPPs observed at JST (top), OLF (middle) and GFP (bottom).

Figure 4. CFPP plume event at YRK showing 1-minute SO_2 and CO (top), 47-minute SO_2 and TC (bottom).

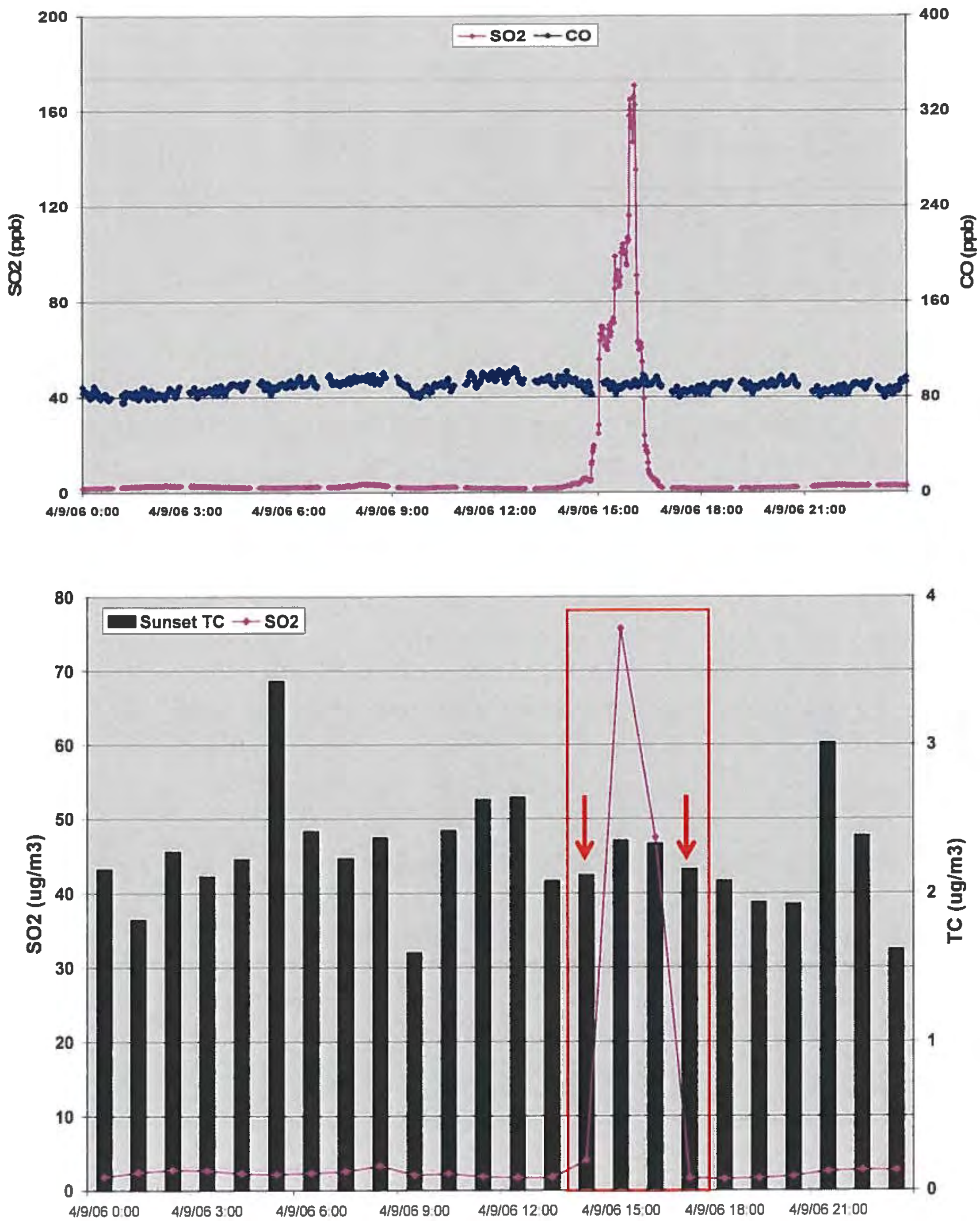
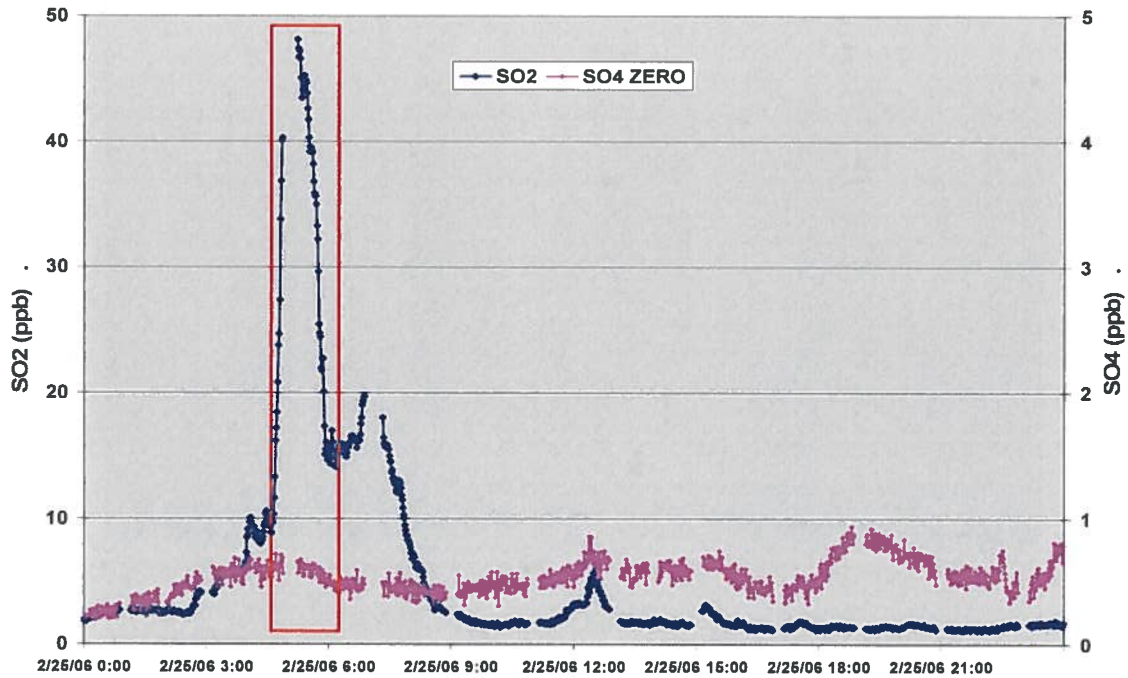


Figure 5. CFPP plume event at YRK showing SO_2 and SO_4 (top) and SO_4 vs. SO_2 (bottom).



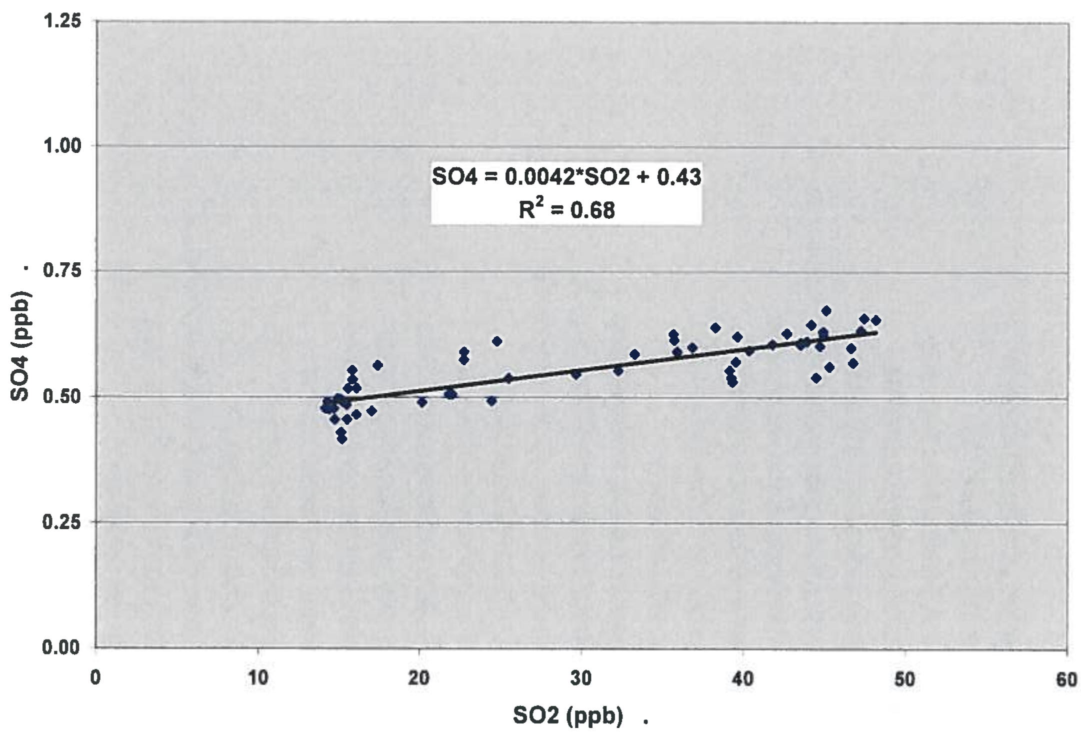


Table 1. Summary of Total Carbon Events.

Site	Date	Probable CFPP	Base SO_2 (ppb)	Plume SO_2 (ppb)	Base TC (µg/m3)	Plume TC (µg/m3)	$\Delta TC/\Delta SO_2$ (lb/lb)	Alternate $\Delta TC/\Delta SO_2$ (lb/lb)
CTR	12/18/05	Gaston	15.6	51.2	2.96	3.30	3.7×10^{-3}	
CTR	12/20/05	Gorgas	15.1	23.1	1.30	1.38	3.8×10^{-3}	
CTR	02/23/06	Miller	5.1	20.6	1.71	1.49	< 0	2.5×10^{-3}
JST	05/06/06	McDonough	3.5	64.5	3.35	3.6	1.6×10^{-3}	
OLF	11/25/05	Crist	11.9	38.9	2.22	2.38	2.3×10^{-3}	
OLF	02/07/06	Crist	4.2	34.6	2.22	2.38	2.0×10^{-3}	
OLF	02/24/06	Crist	11.1	35.0	1.48	1.70	3.5×10^{-3}	
OLF	04/28/06	Crist	4.3	41.2	3.53	3.48	< 0	1.2×10^{-3}
OLF	05/06/06	Crist	3.3	85.3	3.31	3.55	1.1×10^{-3}	
YRK	10/31/05	McDonough	6.3	48.8	2.72	3.45	6.59×10^{-3}	
YRK	02/25/06	Bowen	4.7	39.5	2.24	2.52	3.08×10^{-3}	
YRK	03/04/06	Bowen	5.5	33.4	3.49	3.72	3.15×10^{-3}	
YRK	03/11/06	Wansley	1.8	52.2	4.06	3.87	< 0	7.6×10^{-4}
YRK	04/09/06	Bowen	1.7	61.6	2.12	2.34	3.63×10^{-3}	
Mean (s.d.)							**3.2×10^{-3} (1.4×10^{-3})**	**1.5×10^{-3} (0.9×10^{-3})**

Note: Base and Peak concentrations based on 47-minute averages.

Table 2. Summary of SO_4 Events.

Site	Date	Probable CFPP	1-min Max. SO_2 (ppb)	SO_4 vs. SO_2 Slope	SO_4 vs. SO_2 R^2	$\Delta SO_4/\Delta SO_2$ (lb/lb)
CTR	12/07/05	Gorgas	49.7	5.6×10^{-3}	0.77	8.4×10^{-3}
CTR	12/17/05	Gorgas	21.4	2.0×10^{-3}	0.02	3.0×10^{-3}
CTR	12/17/05	Miller	29.6	2.5×10^{-3}	0.09	3.7×10^{-3}
CTR	12/18/05	Gaston	55.3	4.4×10^{-3}	0.70	6.6×10^{-3}
CTR	12/19/05	Gorgas	30.1	3.6×10^{-3}	0.13	5.4×10^{-3}
CTR	12/20/05	Gorgas	43.3	5.9×10^{-3}	0.81	8.9×10^{-3}
CTR	01/27/06	Miller	20.2	5.1×10^{-3}	0.20	7.7×10^{-3}
GFP	01/26/06	Watson	137.1	3.8 x 10-3	0.95	5.7×10^{-3}
GFP	02/19/06	Watson	49.9	3.6 x 10-3	0.34	5.4×10^{-3}
OLF	11/19/05	Crist	42.8	2.5×10^{-3}	0.08	3.7×10^{-3}
OLF	02/07/06	Crist	52.1	1.4×10^{-3}	0.02	2.1×10^{-3}
OLF	02/24/06	Crist	59.1	4.3×10^{-3}	0.29	6.5×10^{-3}
OLF	4/13/06	Crist	186.	5.4×10^{-3}	0.68	8.1×10^{-3}
YRK	10/09/05	Bowen	33.8	1.2×10^{-3}	0.10	1.8×10^{-3}
YRK	10/31/05	McDonough	73.4	10.0×10^{-3}	0.90	15.0×10^{-3}
YRK	11/11/05	McDonough	48.3	3.3×10^{-3}	0.43	4.9×10^{-3}
YRK	12/18/05	Bowen	202.8	6.6×10^{-3}	0.96	9.9×10^{-3}
YRK	02/08/06	Hammond	31.2	7.6×10^{-3}	0.64	11.4×10^{-3}
YRK	02/25/06	Bowen	47.4	4.4×10^{-3}	0.69	6.6×10^{-3}
YRK	03/04/06	Bowen	60.9	2.4×10^{-3}	0.09	3.6×10^{-3}
Mean (s.d.)						**6.4×10^{-3} (3.3×10^{-3})**

Appendix C

Breton Wilderness Receptors

[The material referenced in Appendix C is included as a separate document along with this site specific BART modeling report.]

Appendix C
Breton Wilderness Receptors

Section 2(c) of the Wilderness Act of 1964 defines "wilderness" as "an area of undeveloped Federal land...." The Wilderness Act called for the Secretary of the Interior to provide recommendations to the President, no later than 1974, concerning the identification of possible wilderness areas, including "a map" and "a definition of boundaries." These recommendations were to be used by Congress to create wilderness areas, through passage of one or more separate laws.

In 1974, the Secretary of the Interior recommended the inclusion of Breton National Wildlife Refuge in the wilderness system. A map was drawn that showed which islands would be included (Figure 1) and, consistent with the definition of wilderness as "land," specified on the map that "all lands within the dashed line have wilderness and refuge status (water not included)." Congress designated Breton as a wilderness area in Public Law 93-632, on January 3, 1975.

Section 162(a) of the Clean Air Act specifies that all national wilderness areas greater than 5,000 acres in size, which were in existence on August 7, 1977, are Class I areas by operation of law. One of these areas was the Breton wilderness area. The 1990 Amendments to the Clean Air Act added language that clarifies that "[t]he extent of the areas designated as Class I under this section shall conform to any changes in the boundaries of such areas which ... may occur subsequent to the date of the enactment of the Clean Air Act Amendments of 1990."

During 2003, the Fish and Wildlife Service published grids of receptor locations for a number of Class I areas, including Breton Wilderness, for the purpose of implementing the new source review and visibility provisions of the Clean Air Act (Figure 2). Consistent with the map referenced by Congress in designating the Breton wilderness area, and the definition of wilderness as "land," all of the specified receptors were over land (Figure 3).

In the years since the boundaries were established, tropical cyclones have passed over the Breton Wilderness and have eroded away much of the land. As a result, a substantial portion of the land constituting the Breton Wilderness no longer exists, having been replaced by water. Several of the receptors identified by the Fish and Wildlife Service for Breton are, therefore, no longer over land.

Although Congress has not yet acted to revise Breton's boundaries to reflect the reality of its current land mass, the fact that the land mass has changed cannot be ignored in implementing the Class I area provisions of the Regional Haze Rule. As discussed above, the definition of wilderness is "land," and the map establishing the boundaries of the Breton Wilderness made clear that the area contains only "lands ... (water not included)." Thus, because a portion of the original land area has been washed away and is under water, the original receptor grid specified by the Fish and Wildlife Service for air quality evaluation is no longer appropriate. Rather, only those receptors that are still located on land are appropriate for evaluating air quality impacts at the Breton Class I area. The receptors that are no longer over land are identified in Figures 4 through 9 and include receptors 1-6, 8, 10, 13, 18, 19, 32 and 36-40.

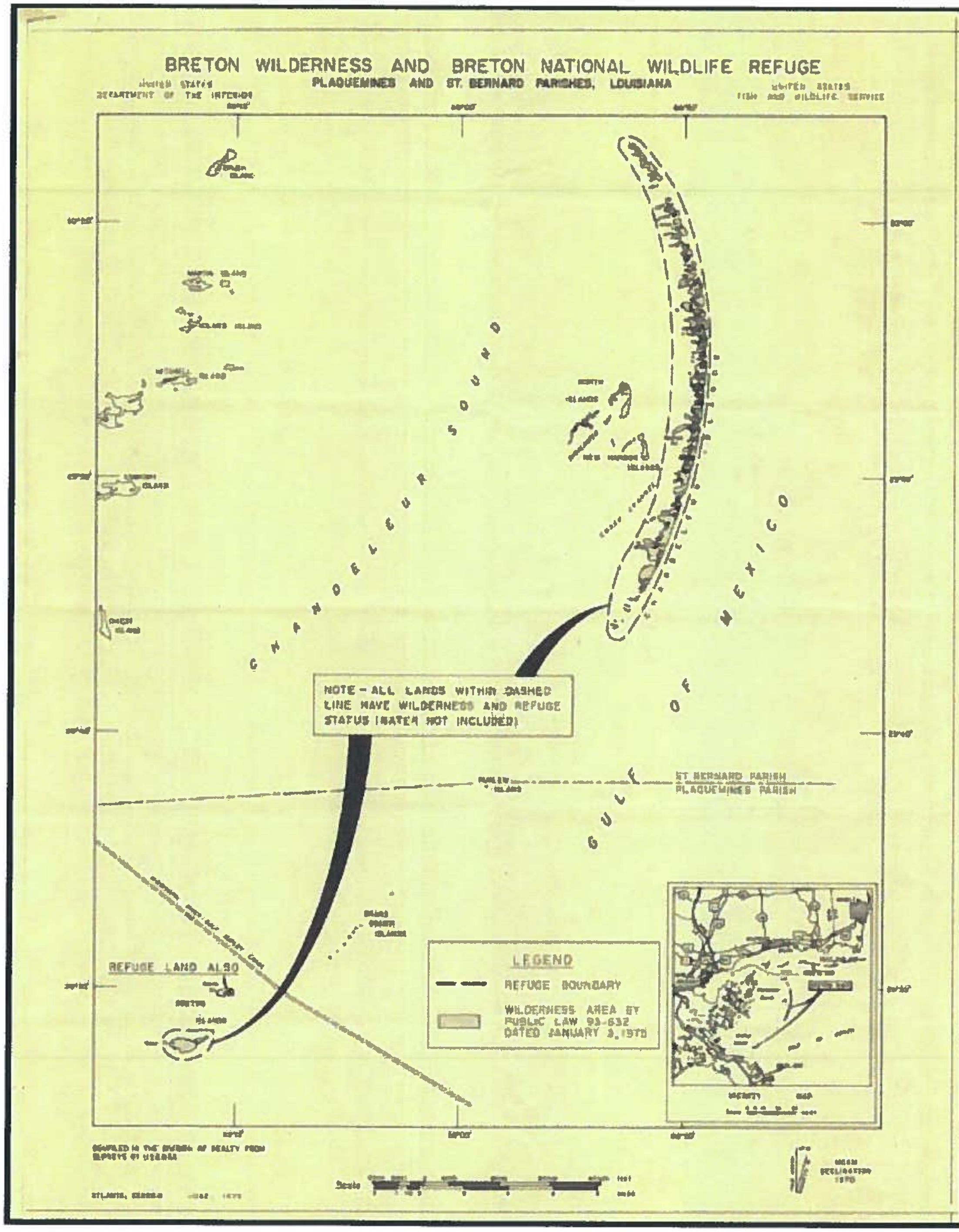


Figure 1. Map of Breton National Wildlife Refuge and Breton Wilderness as established by Public Law 93-632, on January 3, 1975.

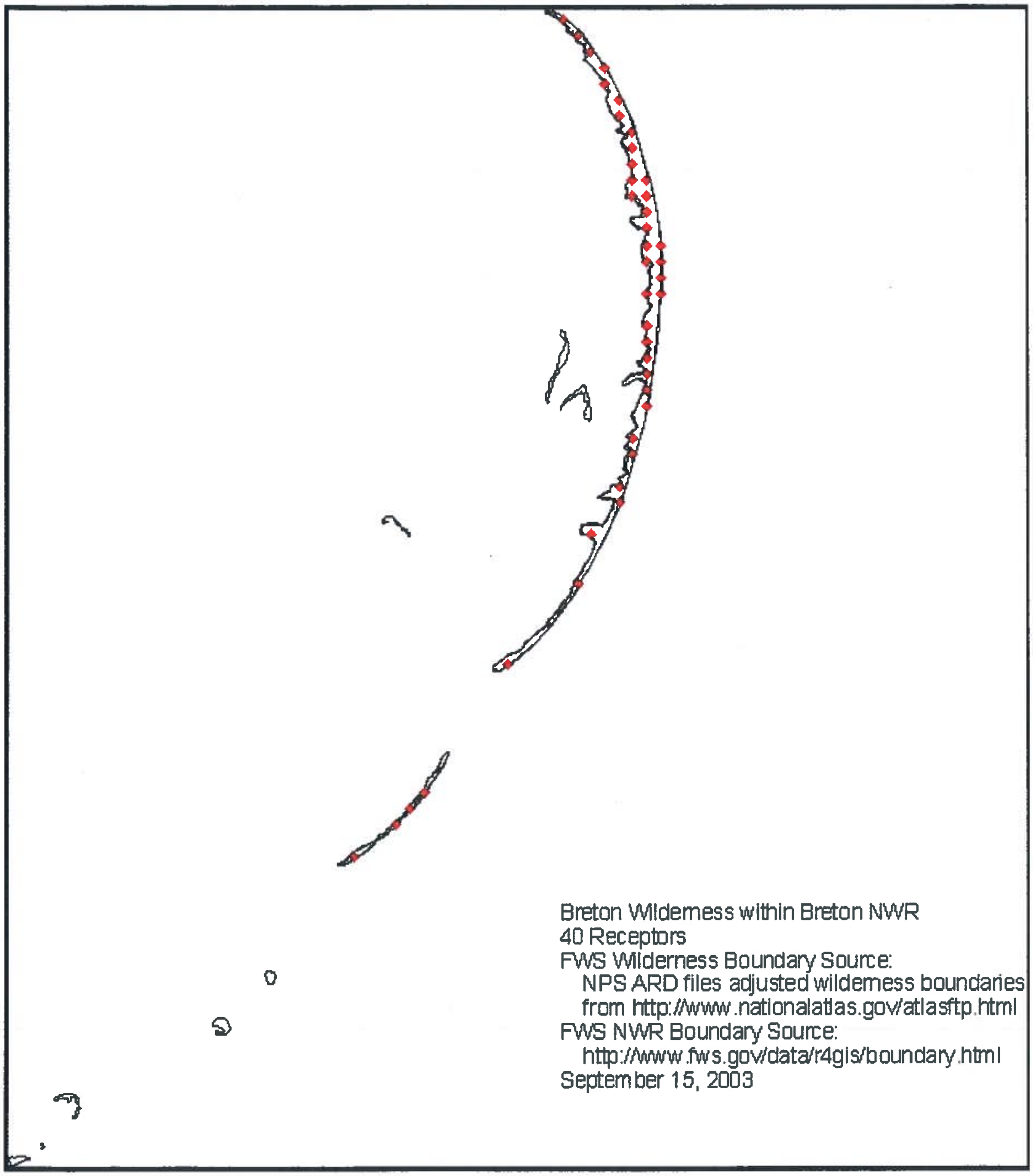


Figure 2. Map of Breton receptors within Breton Wilderness.
(Source: http://www2.nature.nps.gov/air/maps/Receptors/download/ClassIData.zip)

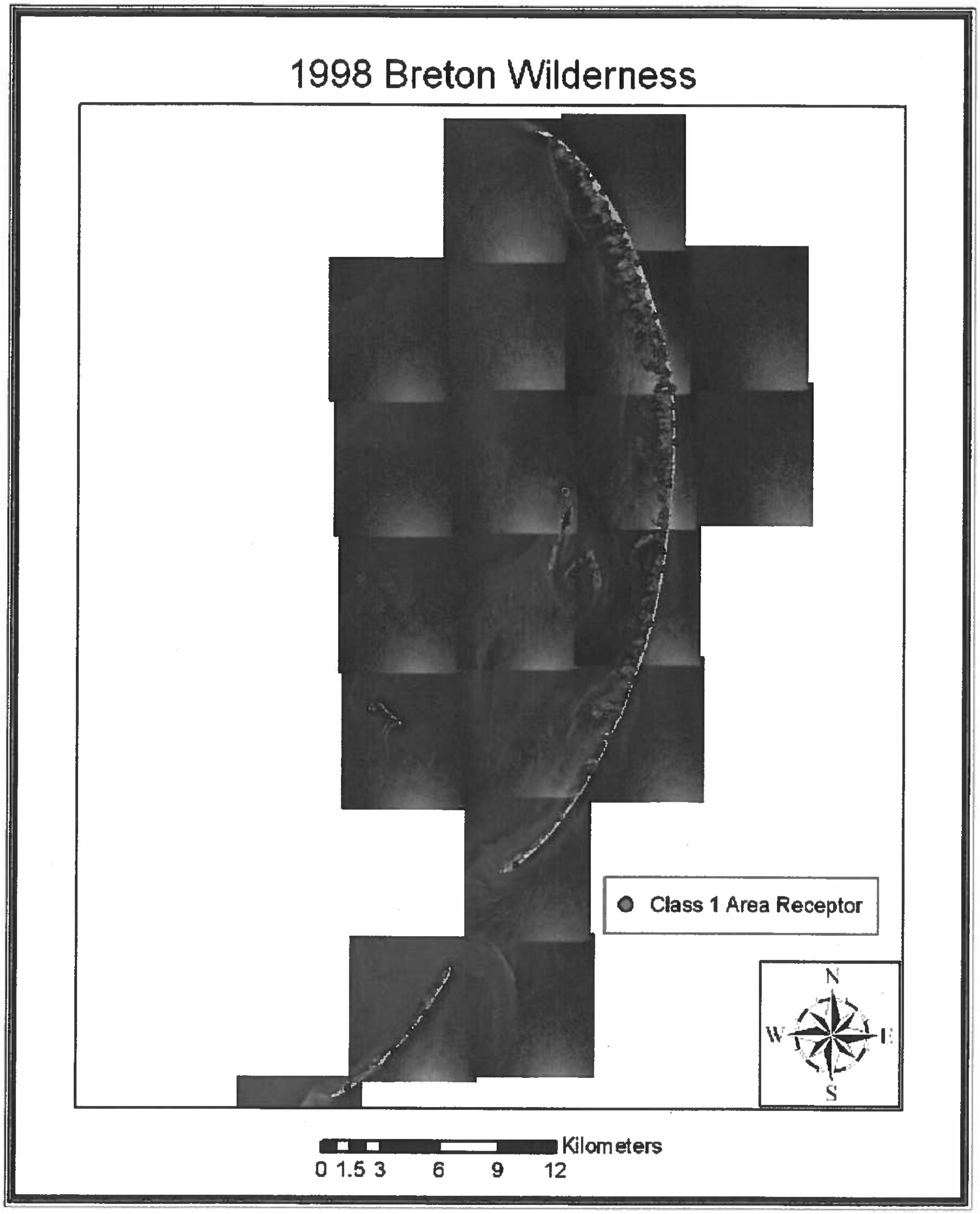


Figure 3. Aerial imagery of Breton Wilderness taken in 1998, showing all receptors were over land at that time.

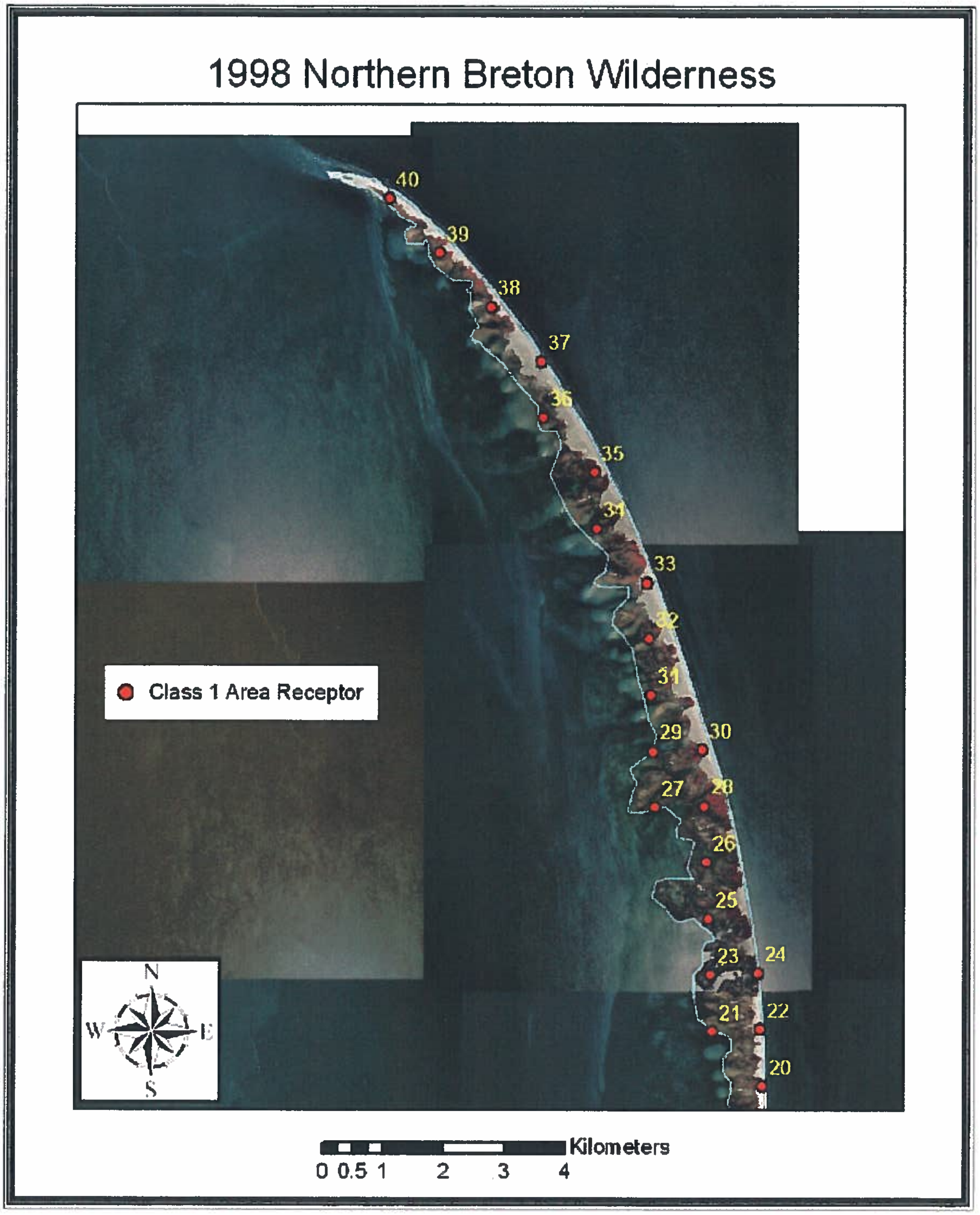


Figure 4. This image shows the northern extent of Breton Wilderness as it existed in 1998, including the receptor locations. In this image, all receptors are over land.

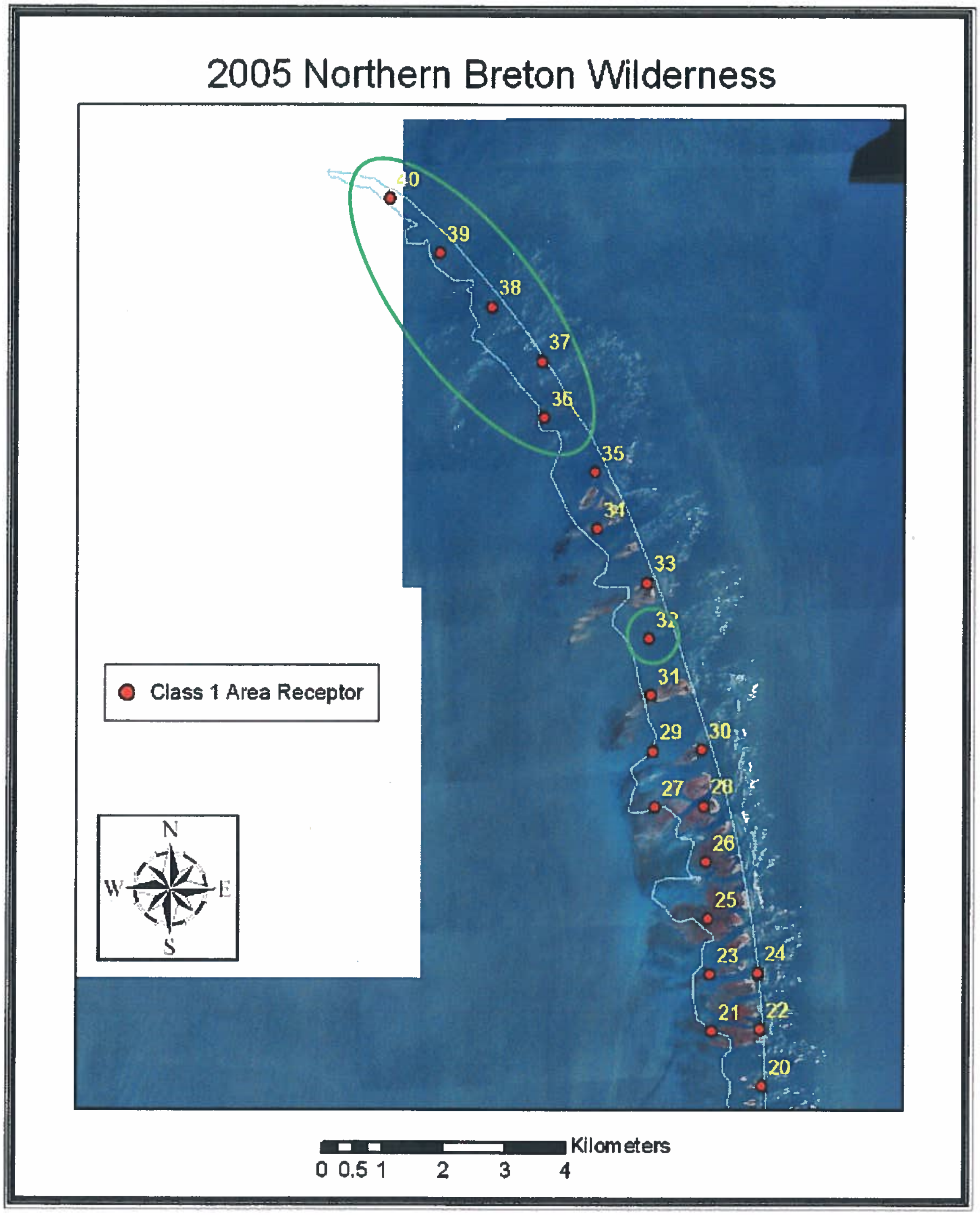


Figure 5. This image shows the northern extent of Breton Wilderness as it existed in 2005, including the receptor locations. Note that receptors 29, 32, 36, 37, 38, 39 and 40 are no longer over land.

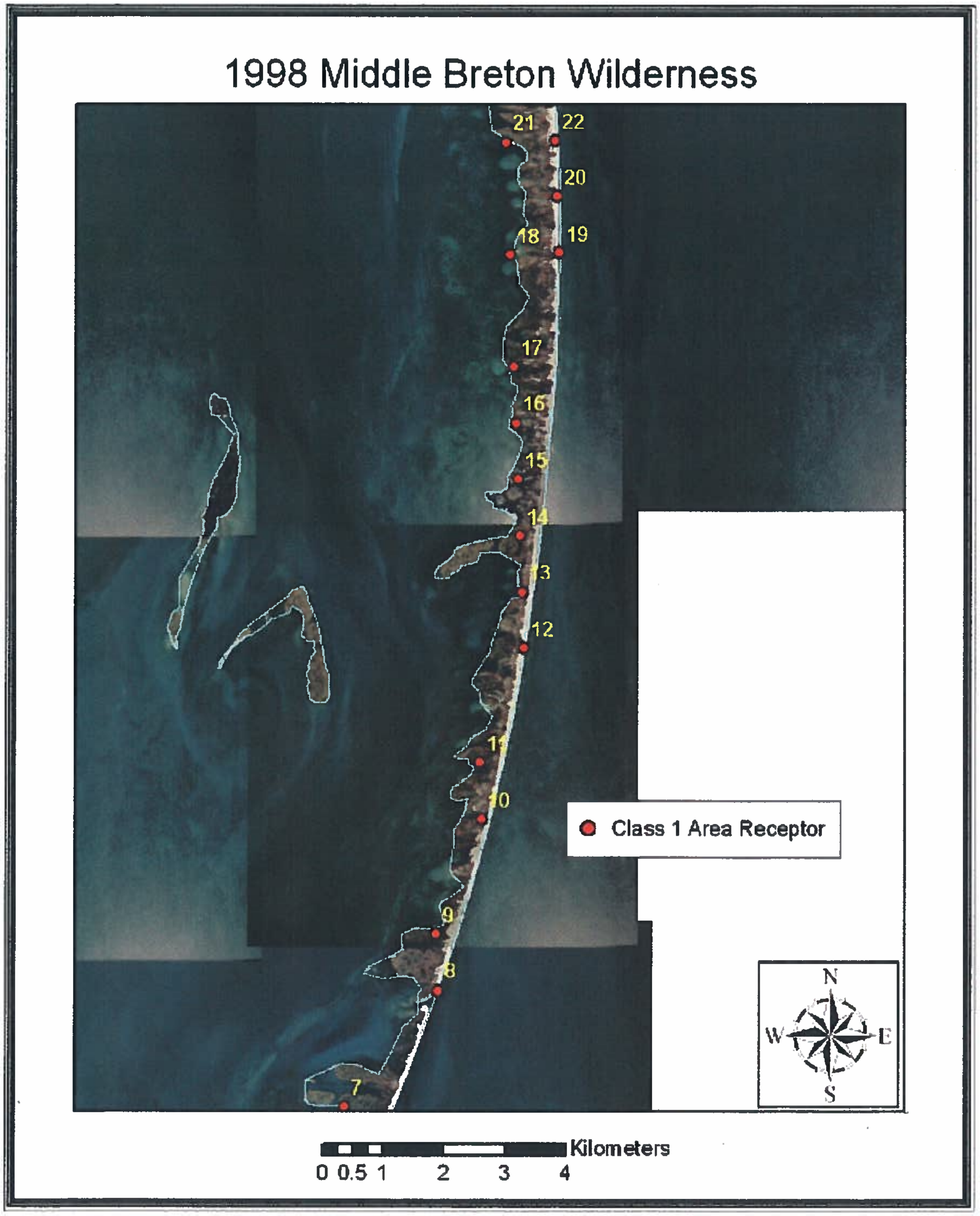


Figure 6. This image shows the middle extent of Breton Wilderness as it existed in 1998, including the receptor locations. In this image, all receptors are over land.

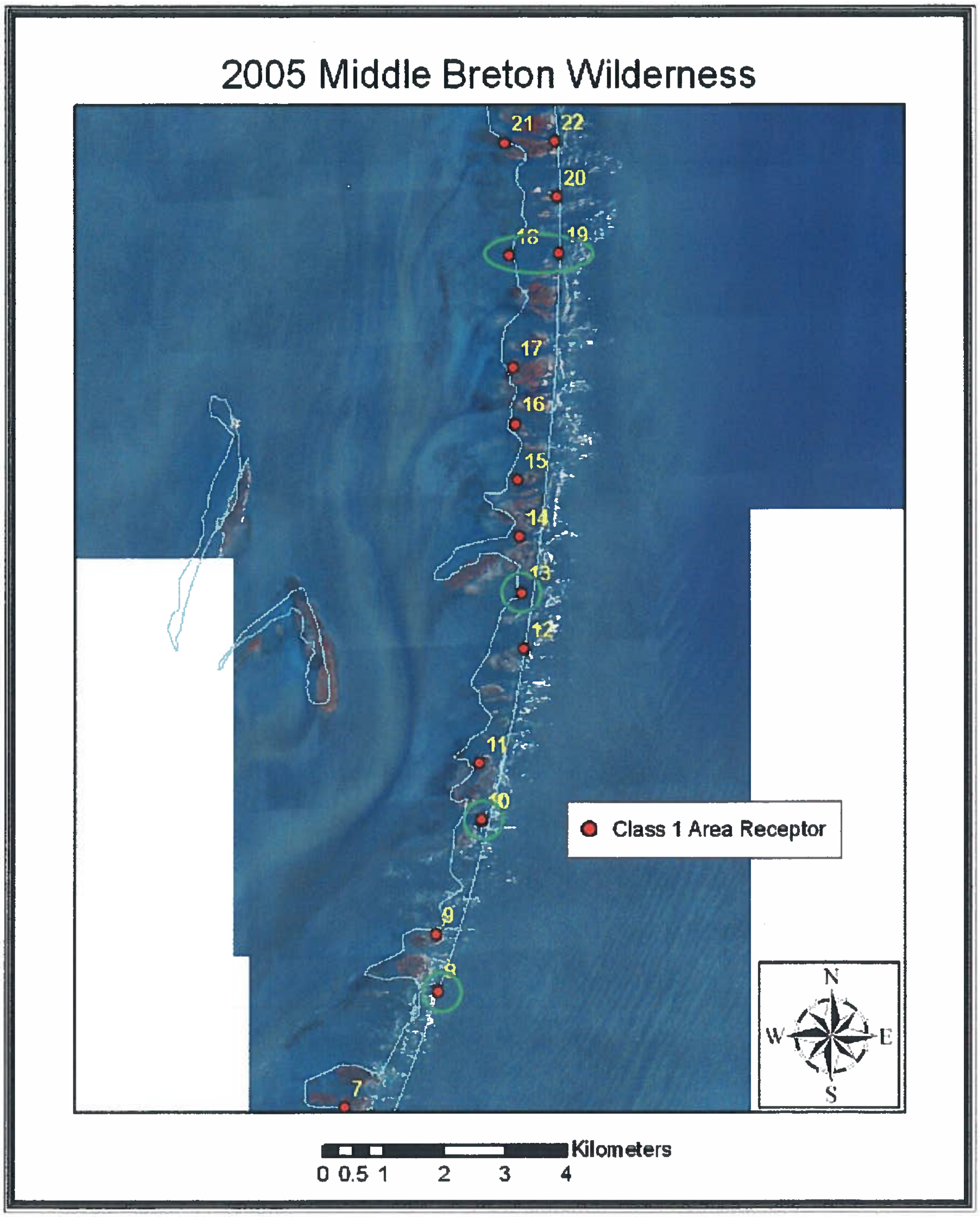


Figure 7. This image shows the middle extent of Breton Wilderness as it existed in 2005, including the receptor locations. Note that receptors 8, 10, 13, 18 and 19 are no longer over land.

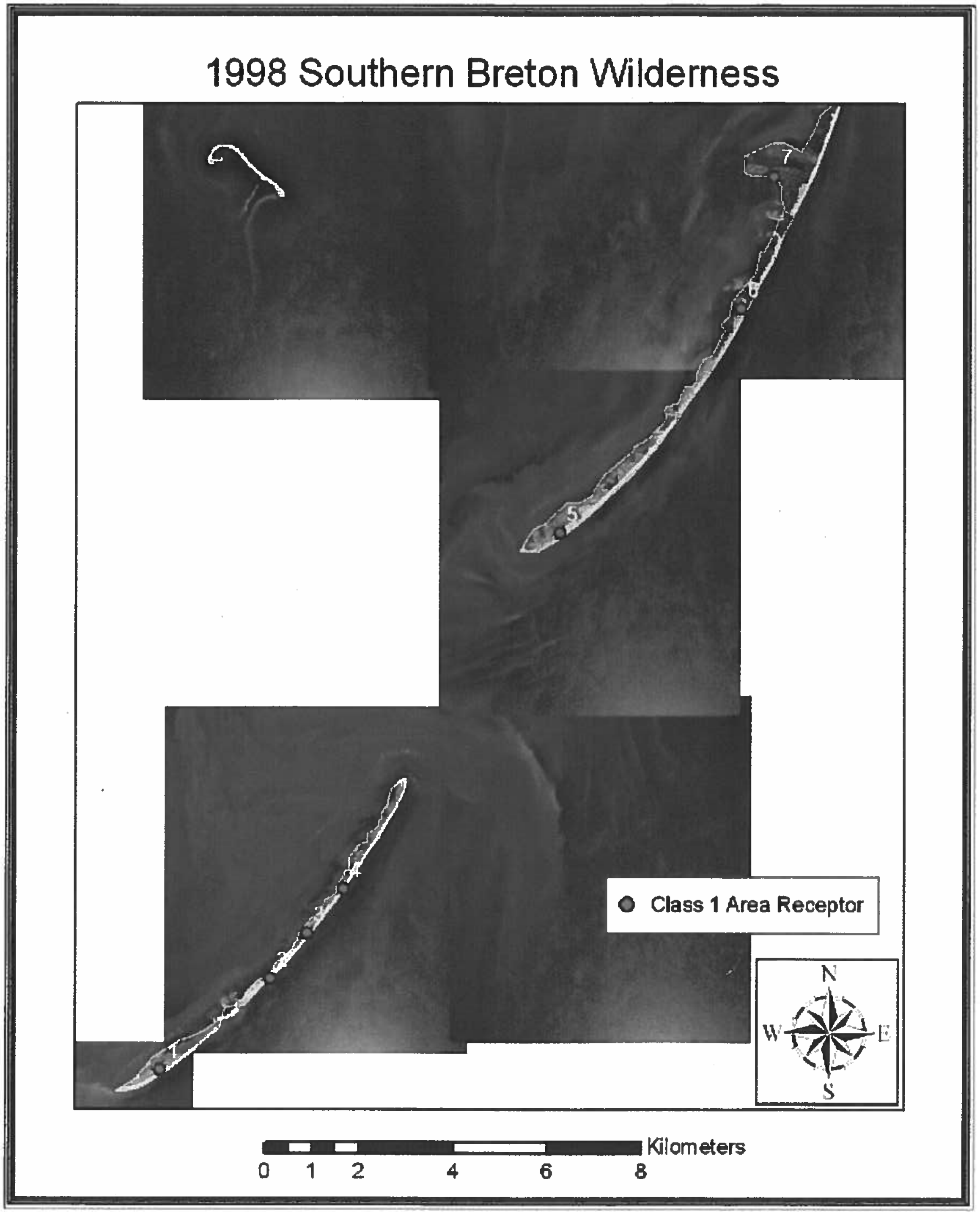


Figure 8. This image shows the southern extent of Breton Wilderness as it existed in 1998, including the receptor locations. In this image, all receptors are over land.

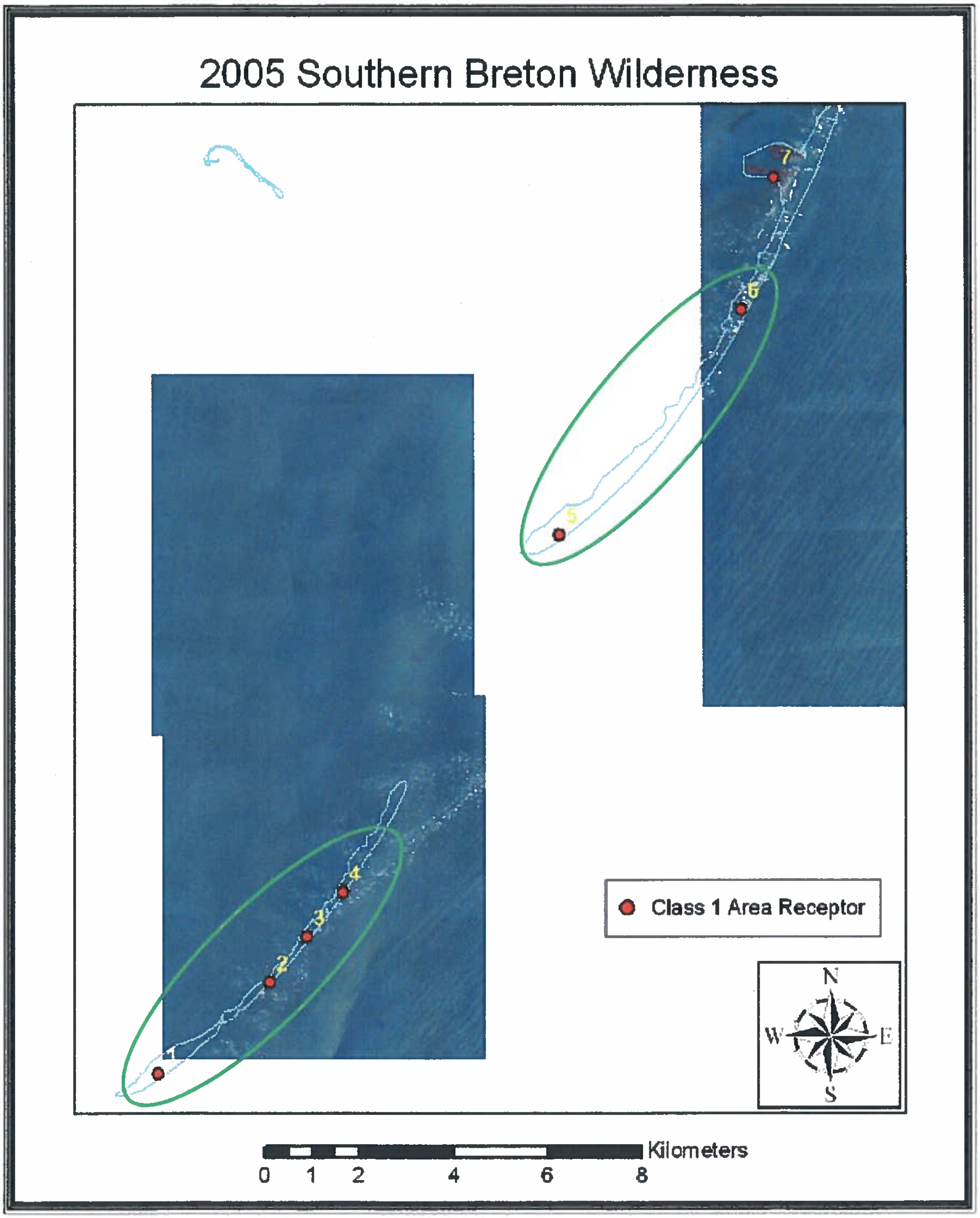


Figure 9. This image shows the southern extent of Breton Wilderness as it existed in 2005, including the receptor locations. Note that receptors 1 through 6 are no longer over land.

Figures 3 through 9 of this document were generated by ESRI® ArcMap™ 9.1. The aerial photographs are freely available online and were obtained from "Atlas: The Louisiana Statewide GIS", LSU CADGIS Research Laboratory, Baton Rouge, LA (http://atlas.lsu.edu). The photos labeled "1998" were provided by the Louisiana Oil Spill Coordinator's Office (LOSCO) and were taken during January of 1998. The photos labeled "2005" were provided by the USGS National Wetlands Research Center, CWPPRA Task Force and LA Department of Environmental Quality and were taken between October 15 and November 18 of 2005. The receptor data and boundary shapefiles used in these maps were obtained from the National Park Service web site (http://www2.nature.nps.gov/air/maps/Receptors/index.cfm), the site VISTAS recommends for downloading receptor data for BART CALPUFF modeling. The receptor data for Breton were created in September of 2003, and the boundary data were published by the USGS in November of 2002.

BART Exemption Modeling Report:

Mississippi Power Company
Plant Chevron

Prepared by:

Southern Company Services
for Mississippi Power Company

September 2011

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1.0 Introduction

1.1 Objectives

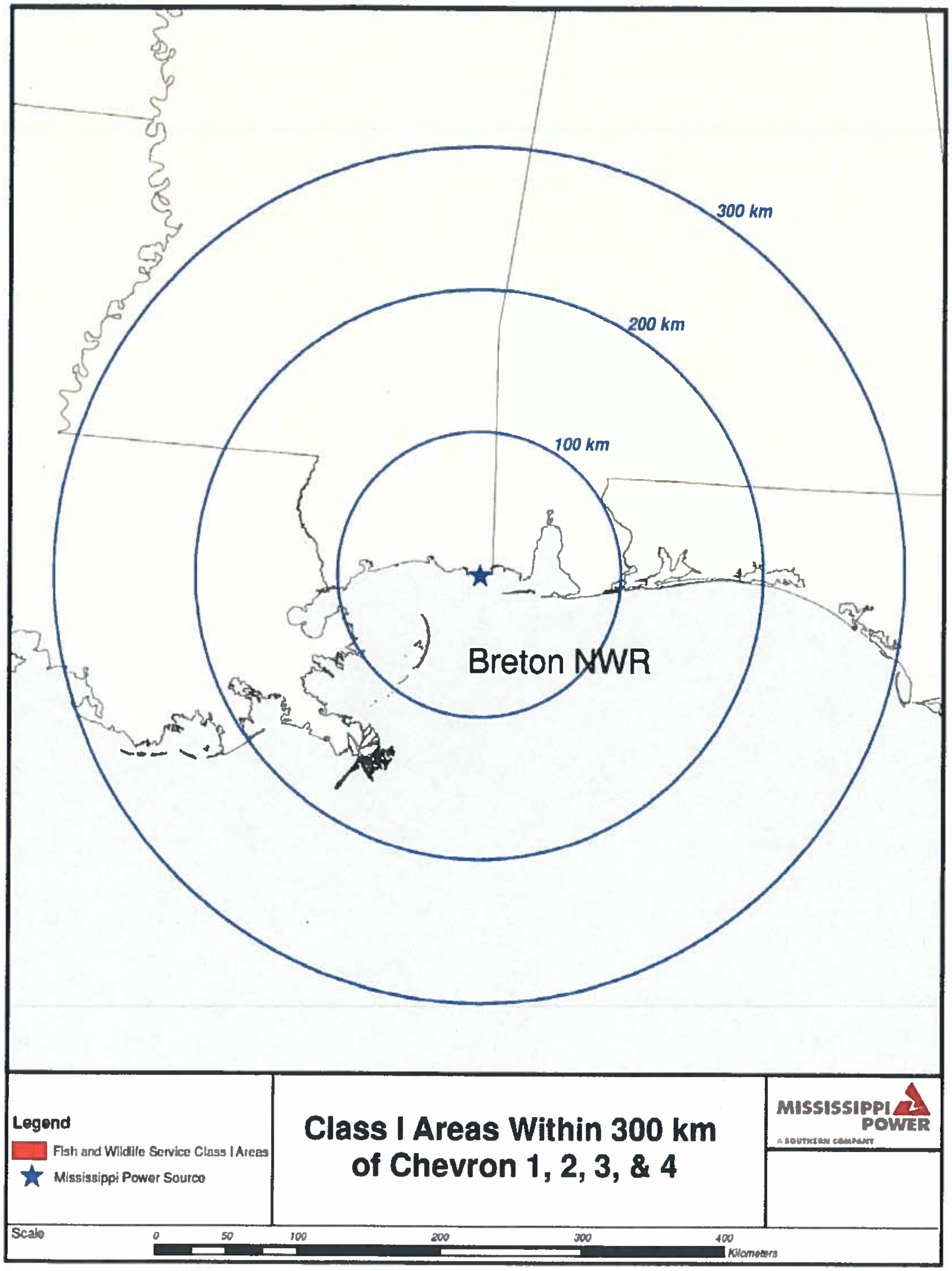
The Regional Haze Rule requires Best Available Retrofit Technology (BART) for any BART-eligible source that "emits any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility" in any mandatory Class I federal area. Pursuant to federal regulations, states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

Units 1, 2, 3, and 4 at Plant Chevron, located near Pascagoula, which are owned and operated by Mississippi Power Company, have been identified as a BART-eligible source. The modeling procedures outlined in the source-specific modeling protocol for Plant Chevron were used to determine whether the source is subject to BART requirements (exemption modeling). With the exception of model and methodology updates noted in the Plant Chevron BART Modeling Protocol (July 2011) (See Appendix B) and in this modeling report, the modeling procedures are consistent with those outlined in the updated final VISTAS common BART modeling protocol (dated December 22, 2005, revision 3.2 – August 31, 2006), available at http://www.vistas-sesarm.org/documents/BARTModelingProtocol_rev3.2_31Aug06.pdf. The source-specific BART modeling protocol references relevant portions of the common VISTAS modeling protocol.

1.2 Location of source vs. relevant Class I Areas

The Mississippi Department of Environmental Quality, which is in charge of the state's BART program, has determined that Units 1, 2, 3, and 4 at Plant Chevron are BART-eligible for SO_2, NO_x and PM_{10}. Figure 1-1 shows a plot of Plant Chevron relative to nearby Class I Areas. One Class I area is located within 300 km of the plant: Breton Island National Wildlife Refuge (Breton NWR) (48.1 km). Thus, in accordance with the VISTAS common BART modeling protocol and the procedures described in the source-specific BART modeling protocol, BART exemption modeling was conducted for this Class I area.

Figure 1-1 Location of Class I Areas in Relation to Plant Chevron



2.0 Source description and emissions data

2.1 Unit-specific source data

The emissions data used to assess the visibility impacts at the Breton NWR Class I area are discussed in this section. This BART exemption modeling analysis addresses SO_2, NO_x and PM_{10} emissions.

Baseline SO_2 and NO_x emissions are based on the highest measured 24-hour CEMS emission rate for the 3-year period of 2003-2005.

Since various components of PM_{10} emissions have different visibility extinction efficiencies, the PM_{10} emissions are divided, or "speciated," into several components (VISTAS common protocol Sections 4.3.3 and 4.4.2). The VISTAS protocol (Section 5.0) allows for the use of source-specific emissions and speciation factors and/or default values from AP-42. The PM_{10} emissions and speciation approach that were used for the modeling is indicated below. Where default speciation values are used, the data represents a combustion turbine unit firing natural gas with no post-combustion control equipment.

- Total PM_{10} is comprised of filterable and condensable emissions.
- Since stack tests are not performed for the Chevron Units, baseline filterable PM_{10} emissions are based on AP-42 emissions factors and the highest 24 hour fuel burn for the most recent 3-year period (2003-2005). This results in the "maximum 24-hour average emission rate" as required by the VISTAS protocol.
- All of the filterable PM_{10} is assumed to be fine (less than 2.5 microns in size). Of the fine portion, 6.7% is elemental carbon and the remainder is inorganic fine particulates (soil).
- Condensable PM_{10} consists of inorganic and organic compounds. The inorganic portion is by default assumed to be H_2SO_4, although other non-sulfate inorganic condensables could be present. The organic portion is modeled as organic aerosols. Total condensable PM_{10} emissions are based on the emissions factor in AP-42, Table 3.1-2a.
- Baseline H_2SO_4 emissions are calculated consistent with the method used by Mississippi Power to derive these emissions for TRI purposes. This approach assumes that the H_2SO_4 emissions released from the stack are proportional to SO_2 emissions from combustion and are dependent on the fuel type and the removal of H_2SO_4 by downstream equipment (i.e., heat recovery steam generator). Appendix A of the site-specific modeling protocol provides the basis for the site-specific value used.
- Baseline emissions of secondary organic aerosols (the remaining portion of condensable PM_{10}) are derived as the difference between the total condensable emissions and the H_2SO_4 emissions.

Table 2-1 provides a summary of the modeling emission parameters used in the BART CALPUFF modeling, consistent with the source emissions data presented in Appendix A of the site-specific modeling protocol for the baseline. All of the emissions in Table 2-1 were derived from fuel burn data for the 2003 to 2005 period and represent the maximum 24-hour average lb/hr rates (excluding days where startup, shutdown, or malfunctions occurred). For SO_2, NO_x, and filterable PM_{10}, the values are calculated using daily fuel burn data and emission factors from AP-42, Tables 3.1-1 and 3.1-2a. PM_{10} speciation was then performed as indicated above such that total filterable PM_{10} is all assumed to be fine PM (i.e., total of fine soil plus elemental carbon).

Table 2-1 Plant Chevron modeling emission parameters

Case	Source / Unit	Location UTM (Zone 16 NAD-83)		Actual Stack Ht	Base Elev.	Flue Dia-meter	Gas Exit Vel.	Stack Gas Exit Temp.	Emissions			Particle Speciation[1]							
		UTM East	UTM North						SO_2	NO_X	PM_{10}	Filt. PM_{10}	Coarse Soil	Fine PM	Fine Soil	EC	Cond. PM_{10}	H_2SO_4	Organic
		m	m	m	m	m	m/s	deg K	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr
Baseline Data - Current Configuration (Unit Basis)																			
Baseline	Unit 1	356,694	3,357,386	11.9	2.6	3.1	8.9	491.3	0.750	119.583	1.903	0.542	0.000	0.542	0.505	0.036	1.361	0.032	1.329
Baseline	Unit 2	356,662	3,357,383	11.9	2.6	3.1	8.9	498.6	0.775	122.635	1.954	0.558	0.000	0.558	0.521	0.037	1.396	0.033	1.363
Baseline	Unit 3	356,652	3,357,370	18.0	2.6	3.0	9.1	506.9	1.000	159.225	2.545	0.733	0.000	0.733	0.684	0.049	1.812	0.042	1.769
Baseline	Unit 4	356,633	3,357,391	18.0	2.6	3.0	9.1	514.7	0.983	156.842	2.502	0.717	0.000	0.717	0.669	0.048	1.785	0.042	1.743
Baseline Data - Current Configuration (Stack Basis)																			
				Modeled Stk Ht[2]															
		m	m	m	m	m	m/s	deg K	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr
Stack 1	Unit 1	356,694	3,357,386	11.9	2.6	3.1	8.9	491.3	0.750	119.583	1.903	0.542	0.000	0.542	0.505	0.036	1.361	0.032	1.329
Stack 2	Unit 2	356,662	3,357,383	11.9	2.6	3.1	8.9	498.6	0.775	122.635	1.954	0.558	0.000	0.558	0.521	0.037	1.396	0.033	1.363
Stack 3	Unit 3	356,652	3,357,370	18.0	2.6	3.0	9.1	506.9	1.000	159.225	2.545	0.733	0.000	0.733	0.684	0.049	1.812	0.042	1.769
Stack 4	Unit 4	356,633	3,357,391	18.0	2.6	3.0	9.1	514.7	0.983	156.842	2.502	0.717	0.000	0.717	0.669	0.048	1.785	0.042	1.743
Stack Basis Emissions Converted to g/sec									g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
Stack 1	Unit 1	356,694	3,357,386	11.9	2.6	3.1	8.9	491.3	0.095	15.068	0.240	0.068	0.000	0.068	0.064	0.005	0.172	0.004	0.167
Stack 2	Unit 2	356,662	3,357,383	11.9	2.6	3.1	8.9	498.6	0.098	15.452	0.246	0.070	0.000	0.070	0.066	0.005	0.176	0.004	0.172
Stack 3	Unit 3	356,652	3,357,370	18.0	2.6	3.0	9.1	506.9	0.126	20.062	0.321	0.092	0.000	0.092	0.086	0.006	0.230	0.005	0.223
Stack 4	Unit 4	356,633	3,357,391	18.0	2.6	3.0	9.1	514.7	0.124	19.762	0.315	0.090	0.000	0.090	0.084	0.006	0.225	0.005	0.220

Notes:

[1] Elemental carbon (EC) and fine PM are a part of filterable PM_{10} and H_2SO_4. Organics are a part of condensable PM_{10}. Note that H_2SO_4 is input to CALPUFF as SO_4. The molecular weights of H_2SO_4 and SO_4 are 98 and 96 respectively; therefore, the conversion factor from H_2SO_4 to SO_4 is 96/98.

[2] Stack height credit is equal to actual height; stack height is less than 65 m de minimis GEP height.

3.0 Air quality modeling procedures

The BART exemption modeling was conducted for this Class I area in accordance with the referenced VISTAS common BART modeling protocol and the procedures described in the source-specific BART modeling protocol for Plant Chevron. This section provides a discussion of additional modeling procedures that were used and describes the quality assurance procedure that was followed.

3.1 Modeling domain and receptors

The Plant Chevron BART modeling simulations used the sub-domain 4, 4-km CALMET data supplied by VISTAS, as discussed in the source-specific modeling protocol. This domain includes all Class I areas within 300 km of the source, plus a 50-km buffer.

The BART exemption modeling was conducted for Chevron Units 1 thru 4 (BART eligible units) for each Class I area within 300 km of the source (Breton NWR). The receptors used for each of the Class I areas are based on the National Park Service (NPS) database of Class I receptors, as recommended by the VISTAS common protocol (Section 4.3.3). For Breton NWR, Mississippi Power has included in the modeling analysis all of the receptors that the United States Fish and Wildlife Service (US F&WS) has identified. However, Mississippi Power does not believe that all of the receptors are still valid receptors. As a result of tropical cyclone activity, several of the receptors identified by the US F&WS for Breton NWR are now located over water, rather than over land. Pursuant to the Wilderness Act of 1964, which defines wilderness as "land," and because Congress made clear when it created the Breton NWR that only the land mass was designated as wilderness, receptors that are now over water are not relevant for assessing visibility impacts at Breton. Nevertheless, Mississippi Power is including both the valid and invalid receptors for purposes of this analysis. Appendix C of Appendix B (Plant Chevron BART Modeling Protocol) provides more detailed support for the identification and elimination of invalid receptors at Breton NWR.

3.2 Light extinction and haze impact calculations

The most recently available CALPOST postprocessor (v6.292) was used in this report for the calculation of the impact from the modeled source's primary and secondary particulate matter concentrations on light extinction. The method used to calculate light extinction was method 8 in CALPOST, which applies the new IMPROVE equation,

The new IMPROVE equation is the result of an extensive evaluation of the most recent scientific data, undertaken by an ad hoc group of scientists including representatives from the National Park Service, the National Oceanic and Atmospheric Administration, academia, and industry. The old equation was based on data and information that was over a decade old. The new equation is based on the most recent data and information gleaned from scientific studies done over the past decade. The new equation adds more accurate terms for estimating light extinction due to sulfate and nitrate, through the incorporation of size differentiation and revisions to the extinction coefficients. Organic matter estimates are improved through a refinement to the organic compound mass to organic mass ratio. Additionally, the new equation corrects several errors and omissions in the old equation. For example, sea salt, which affects light extinction, was not part of the old equation but has been added to the new equation. Moreover, the old equation's constant Rayleigh scattering term (corresponding to scattering at 10,000 feet elevation) has been revised to reflect the actual elevation of the specific Class I area.

The ad hoc group of scientists who recommended the changes to the equation drafted a technical support document entitled "Revised IMPROVE Algorithm for Estimating Light Extinction from Particle Speciation Data" (November 30, 2005). That document demonstrates that, for 21 Class I areas with nephelometer data, the new equation produces more accurate results than the old equation. The IMPROVE Steering Committee reviewed the work of the ad hoc group and its technical support document, and approved the new equation in December 2005.

The revisions to the IMPROVE equation are particularly important for coastal sites (such as Breton). Sea salt is an important component of extinction at coastal sites and, thus, should be included in the equation for estimating visibility impacts. In addition, the site-specific Rayleigh scattering term is important for coastal sites because the default value in the old equation (10 Mm^{-1}) was based on an elevation of 10,000 feet. At near-zero sea level, the new equation uses a more accurate coefficient of 11 Mm^{-1}.

The new formula is shown below.

$$\begin{aligned} b_{ext} \approx\ & 2.2 \times f_S(RH) \times [Small\ Sulfate] + 4.8 \times f_L(RH) \times [Large\ Sulfate] \\ & + 2.4 \times f_S(RH) \times [Small\ Nitrate] + 5.1 \times f_L(RH) \times [Large\ Nitrate] \\ & + 2.8 \times [Small\ Organic\ Mass] + 6.1 \times [Large\ Organic\ Mass] \\ & + 10 \times [Elemental\ Carbon] \\ & + 1 \times [Fine\ Soil] \\ & + 1.7 \times f_{SS}(RH) \times [Sea\ Salt] \\ & + 0.6 \times [Course\ Mass] \\ & + Rayleigh\ Scattering\ (Site\ Specific) \\ & + 0.33 \times [NO_2\ (ppb)] \end{aligned}$$

The apportionment of the total concentration of sulfate compounds into the concentrations of the small and large size fractions is accomplished using the following equations.

$$[Large\ Sulfate] = \frac{[Total\ Sulfate]}{20\mu g/m^3} \times [Total\ Sulfate], \quad [Total\ Sulfate] < 20\mu g/m^3$$

$$[Large\ Sulfate] = [Total\ Sulfate], \quad [Total\ Sulfate] \geq 20\mu g/m^3$$

$$[Small\ Sulfate] = [Total\ Sulfate] - [Large\ Sulfate]$$

The site-specific extinction due to Rayleigh scattering, monthly relative humidity (RH) adjustment factors and background visibility conditions that were used in the calculation of the source impacts were obtained from and recommended by the Federal Land Managers' Air Quality Related Values Work Group (FLAG) Phase 1 Report -- Revised (2010).

3.3 General quality assurance procedures

Chapter 6 of the Final VISTAS Modeling Protocol discusses Quality Assurance (QA). The purpose of the QA program is to establish procedures for ensuring that products produced by the application of the modeling techniques for BART studies satisfy the regulatory objectives of the BART program.

The air quality modeling staff at Southern Company Services (SCS) is managing and/or conducting the BART Exemption Modeling application for the subject plant owned by Mississippi Power Company. SCS personnel reviewed all recommended methods specified in the Final VISTAS Modeling Protocol, the source-specific modeling protocol, and recommendations within this report . The SCS air quality modeling team implemented a review of the modeling results and procedures of the modeling project for the subject plant to ensure that the recommended methods were followed and that the modeling was carefully and professionally conducted.

For the exemption modeling, SCS's BART modelers made sure that all checks were made manually/visually as well as by using PSPad, a file comparing software. During the modeling process, periodic progress meetings were conducted with the project management team members.

The VISTAS Modeling Protocol states, "To the extent that modeling applications are using pre-defined CALMET files and CALPUFF templates, the quality assurance will be straightforward. More detailed steps are needed for the setup of modeling files for source-specific applications of sub-regional domains finer than 4 km." For this application, the 4-km grid-spaced CALMET files for sub-domain 4 developed by VISTAS and the CALPUFF templates were used. SCS BART modelers used the test met file to "benchmark" the use of the CALMET files on their computers as indicated on page 59 of the VISTAS common protocol. For this BART exemption modeling application, input files that contain source data required by the CALPUFF modeling system (CALPUFF, CALPOST and POSTUTIL) were developed and will be sent via mail to MDEQ on CD along with a hard copy of this modeling report.

4.0 Modeling results

The exemption modeling results are provided in Table 4-1. Appendix A lists delta-deciview results for the top 20 days for each year modeled and the top 25 days for the overall three years at each Class I area. The table indicates that both the 8th highest day's impacts for each year and the 22nd highest day's impacts over all three years are below 0.5 delta-dv. These results demonstrate that Plant Chevron's SO_2, NO_x and PM_{10} emissions do not cause or contribute to visibility impairment. Therefore, the source is not subject to BART for SO_2, NO_x and PM_{10}, and no further BART analysis is required.

Electronic data related to this application are provided on the attached disk. They include all input (INP) and list (LST) files.

Table 4-1 Summary of Results – Plant Chevron Refined BART Exemption Modeling

		2001			2002			2003			Highest of the 8th Highest delta-dv for the 3-years	22nd Highest delta-dv over 3-year period
Class I Area	Distance from source to Class I area boundary	# of days and receptors beyond 98th percentile with impact > 0.5 delta-dv		8th highest delta-dv	# of days and receptors beyond 98th percentile with impact > 0.5 delta-dv		8th highest delta-dv	# of days and receptors beyond 98th percentile with impact > 0.5 delta-dv		8th Highest delta-dv		
	km	Days	Rec	delta-dv	Days	Rec	delta-dv	Days	Rec	delta-dv	delta-dv	delta-dv
Breton Island												
Original Receptors	48.1	0	0	0.27	0	0	0.22	0	0	0.17	0.27	0.24
Valid Receptors	48.1	0	0	0.24	0	0	0.20	0	0	0.15	0.24	0.21

Appendix A

Delta-Deciview Values for the Top 20 Days for Each Year/Each Class I Area and for the Top 25 Days Over Three Years

Original Receptors - Ranked Daily Visibility Change for Breton (Top 22 Days Each Year)

YEAR	DAY	RECEPTOR	BEXT (Model)	BEXT (BKG)	DELTA DV	% SO4	% NO3	% OC	% EC	% PMC	% PMF	% NO2	Small F(RH)	Large F(RH)	SSalt F(RH)	Rank
2001	293	34	9.03	8.425	0.605	1.06	58.56	8.66	0.72	0	0.98	30.03	3.92	2.82	3.99	1
2001	81	35	8.739	8.366	0.373	0.88	79.07	4.99	0.41	0	0.56	14.09	3.79	2.74	3.87	2
2001	117	30	8.719	8.347	0.372	0.86	67.09	6.93	0.57	0	0.78	23.76	3.74	2.72	3.85	3
2001	345	17	8.857	8.486	0.371	0.32	89.96	2.1	0.17	0	0.24	7.21	4.06	2.9	4.11	4
2001	326	40	8.773	8.431	0.342	0.46	85.09	3.11	0.26	0	0.35	10.72	3.93	2.83	4.01	5
2001	349	40	8.803	8.486	0.317	0.48	77.38	4.24	0.35	0	0.48	17.07	4.06	2.9	4.11	6
2001	295	40	8.709	8.425	0.284	0.52	69.03	5.45	0.45	0	0.62	23.93	3.92	2.82	3.99	7
2001	292	40	8.691	8.425	0.266	1.21	72.91	7.3	0.61	0	0.83	17.15	3.92	2.82	3.99	8
2001	325	24	8.69	8.431	0.259	0.79	81.34	4.89	0.41	0	0.55	12.01	3.93	2.83	4.01	9
2001	35	39	8.637	8.379	0.259	0.34	92.78	1.84	0.15	0	0.21	4.67	3.82	2.76	3.89	10
2001	118	30	8.586	8.347	0.239	1.1	75.31	6.49	0.54	0	0.73	15.83	3.74	2.72	3.85	11
2001	15	12	8.728	8.491	0.236	0.51	76.11	1.9	0.16	0	0.22	21.1	4.08	2.91	4.1	12
2001	27	40	8.725	8.491	0.234	0.73	74.24	4.76	0.4	0	0.54	19.35	4.08	2.91	4.1	13
2001	58	37	8.607	8.379	0.228	0.81	58.39	7.48	0.62	0	0.85	31.85	3.82	2.76	3.89	14
2001	265	37	8.76	8.541	0.219	1.77	36.77	12.89	1.07	0	1.46	46.04	4.18	2.97	4.23	15
2001	21	35	8.703	8.491	0.211	0.5	83.36	3.66	0.3	0	0.41	11.77	4.08	2.91	4.1	16
2001	119	33	8.534	8.347	0.187	0.92	63.77	7.69	0.64	0	0.87	26.11	3.74	2.72	3.85	17
2001	34	39	8.565	8.379	0.187	0.75	88.15	4.21	0.35	0	0.48	6.07	3.82	2.76	3.89	18
2001	316	34	8.617	8.431	0.186	1.59	75.95	7.45	0.62	0	0.84	13.54	3.93	2.83	4.01	19
2001	109	22	8.533	8.347	0.186	1.11	89.41	4.79	0.4	0	0.54	3.75	3.74	2.72	3.85	20
2001	344	39	8.67	8.486	0.184	0.47	76.36	4.14	0.34	0	0.47	18.22	4.06	2.9	4.11	21
2001	32	12	8.561	8.379	0.182	0.86	65.61	7.35	0.61	0	0.83	24.73	3.82	2.76	3.89	22
2002	100	33	8.913	8.347	0.566	0.86	80.24	4.66	0.39	0	0.53	13.31	3.74	2.72	3.85	1
2002	40	38	8.702	8.379	0.323	0.54	91.95	2.39	0.2	0	0.27	4.65	3.82	2.76	3.89	2
2002	146	24	8.692	8.435	0.257	0.74	80.98	4.1	0.34	0	0.46	13.37	3.94	2.83	4.02	3
2002	362	4	8.742	8.486	0.255	0.63	95.84	1.97	0.16	0	0.22	1.18	4.06	2.9	4.11	4
2002	361	38	8.737	8.486	0.251	0.95	91.51	3.63	0.3	0	0.41	3.19	4.06	2.9	4.11	5
2002	16	40	8.738	8.491	0.246	0.35	80.92	3.47	0.29	0	0.39	14.57	4.08	2.91	4.1	6
2002	46	35	8.62	8.379	0.242	0.58	69.76	5.71	0.47	0	0.65	22.83	3.82	2.76	3.89	7
2002	12	35	8.71	8.491	0.218	0.93	53.24	8.23	0.68	0	0.93	35.99	4.08	2.91	4.1	8
2002	341	40	8.696	8.486	0.21	0.62	80.86	4.23	0.35	0	0.48	13.46	4.06	2.9	4.11	9
2002	26	24	8.695	8.491	0.203	1.25	72.01	7.45	0.62	0	0.84	17.83	4.08	2.91	4.1	10
2002	27	34	8.681	8.491	0.19	0.6	73.42	5.1	0.42	0	0.58	19.87	4.08	2.91	4.1	11
2002	349	10	8.668	8.486	0.181	0.41	83.85	3.23	0.27	0	0.37	11.87	4.06	2.9	4.11	12
2002	39	19	8.559	8.379	0.181	0.92	88.07	3.94	0.33	0	0.45	6.29	3.82	2.76	3.89	13
2002	342	40	8.652	8.486	0.166	0.98	61.43	7.54	0.63	0	0.85	28.57	4.06	2.9	4.11	14
2002	346	40	8.649	8.486	0.162	0.39	81.96	3.29	0.27	0	0.37	13.71	4.06	2.9	4.11	15
2002	295	35	8.585	8.425	0.16	0.52	71.91	5.12	0.43	0	0.58	21.45	3.92	2.82	3.99	16
2002	20	40	8.635	8.491	0.144	0.48	82.31	3.68	0.31	0	0.42	12.81	4.08	2.91	4.1	17
2002	59	35	8.518	8.379	0.14	0.74	92.62	3.52	0.29	0	0.4	2.43	3.82	2.76	3.89	18
2002	330	37	8.568	8.431	0.137	1.15	81.09	5	0.42	0	0.57	11.78	3.93	2.83	4.01	19
2002	311	19	8.565	8.431	0.134	0.96	75.36	6.32	0.52	0	0.72	16.12	3.93	2.83	4.01	20
2002	34	30	8.507	8.379	0.129	0.92	63.87	7.65	0.64	0	0.87	26.06	3.82	2.76	3.89	21
2002	4	40	8.618	8.491	0.127	0.7	91.07	3.45	0.29	0	0.39	4.11	4.08	2.91	4.1	22
2003	31	40	8.943	8.491	0.452	0.42	87.49	2.37	0.2	0	0.27	9.26	4.08	2.91	4.1	1
2003	293	34	8.798	8.425	0.374	1.66	54.56	10.75	0.89	0	1.22	30.92	3.92	2.82	3.99	2
2003	25	40	8.816	8.491	0.324	0.44	86.57	3.17	0.26	0	0.36	9.2	4.08	2.91	4.1	3
2003	70	37	8.652	8.366	0.286	0.71	73.16	5.49	0.46	0	0.62	19.56	3.79	2.74	3.87	4
2003	44	15	8.605	8.379	0.227	0.51	77.95	4.3	0.36	0	0.49	16.4	3.82	2.76	3.89	5
2003	277	40	8.63	8.425	0.205	0.87	68.85	6.55	0.54	0	0.74	22.45	3.92	2.82	3.99	6
2003	144	26	8.609	8.435	0.173	1.65	52.93	10.68	0.89	0	1.21	32.64	3.94	2.83	4.02	7
2003	56	38	8.545	8.379	0.166	1	71.94	6.64	0.55	0	0.75	19.11	3.82	2.76	3.89	8
2003	26	27	8.649	8.491	0.158	0.71	70.92	6.03	0.5	0	0.68	21.16	4.08	2.91	4.1	9
2003	12	35	8.649	8.491	0.157	0.57	81.48	4.75	0.39	0	0.54	12.27	4.08	2.91	4.1	10
2003	354	6	8.636	8.486	0.149	0.61	91.8	3	0.25	0	0.34	3.99	4.06	2.9	4.11	11
2003	325	35	8.571	8.431	0.14	3.34	52.63	15.5	1.29	0	1.75	25.48	3.93	2.83	4.01	12

2003	59	38	8.515	8.379	0.137	2.19	56.76	9.74	0.81	0	1.1	29.4	3.82	2.76	3.89	13
2003	65	35	8.502	8.366	0.136	1.86	25.74	12.99	1.08	0	1.47	56.85	3.79	2.74	3.87	14
2003	42	8	8.513	8.379	0.134	0.35	81.41	3.5	0.29	0	0.4	14.05	3.82	2.76	3.89	15
2003	341	37	8.603	8.486	0.116	0.49	78.44	4.14	0.34	0	0.47	16.12	4.06	2.9	4.11	16
2003	119	40	8.463	8.347	0.116	0.51	73.4	4.83	0.4	0	0.55	20.31	3.74	2.72	3.85	17
2003	69	19	8.481	8.366	0.115	1.95	53.98	12.01	1	0	1.36	29.71	3.79	2.74	3.87	18
2003	359	40	8.6	8.486	0.114	0.63	82.95	4.05	0.34	0	0.46	11.58	4.06	2.9	4.11	19
2003	292	37	8.539	8.425	0.114	2.6	60.76	13.83	1.15	0	1.57	20.1	3.92	2.82	3.99	20
2003	286	37	8.537	8.425	0.112	3.31	17.08	19.85	1.65	0	2.25	55.87	3.92	2.82	3.99	21
2003	39	38	8.489	8.379	0.11	1.02	73.98	7.57	0.63	0	0.86	15.95	3.82	2.76	3.89	22

Original Receptors - Ranked Daily Visibility Change for Breton (Top 25 Days Over 3 Years)

YEAR	DAY	RECEP TOR	BEXT (Model)	BEXT (BKG)	DELTA DV	% SO4	% NO3	% OC	% EC	% PMC	% PMF	% NO2	Small F (RH)	Large F (RH)	SSalt F (RH)	Rank
2001	293	34	9.03	8.425	0.605	1.06	58.56	8.66	0.72	0	0.98	30.03	3.92	2.82	3.99	1
2002	100	33	8.913	8.347	0.566	0.86	80.24	4.66	0.39	0	0.53	13.31	3.74	2.72	3.85	2
2003	31	40	8.943	8.491	0.452	0.42	87.49	2.37	0.2	0	0.27	9.26	4.08	2.91	4.1	3
2003	293	34	8.798	8.425	0.374	1.66	54.56	10.75	0.89	0	1.22	30.92	3.92	2.82	3.99	4
2001	81	35	8.739	8.366	0.373	0.88	79.07	4.99	0.41	0	0.56	14.09	3.79	2.74	3.87	5
2001	117	30	8.719	8.347	0.372	0.86	67.09	6.93	0.57	0	0.78	23.76	3.74	2.72	3.85	6
2001	345	17	8.857	8.486	0.371	0.32	89.96	2.1	0.17	0	0.24	7.21	4.06	2.9	4.11	7
2001	326	40	8.773	8.431	0.342	0.46	85.09	3.11	0.26	0	0.35	10.72	3.93	2.83	4.01	8
2003	25	40	8.816	8.491	0.324	0.44	86.57	3.17	0.26	0	0.36	9.2	4.08	2.91	4.1	9
2002	40	38	8.702	8.379	0.323	0.54	91.95	2.39	0.2	0	0.27	4.65	3.82	2.76	3.89	10
2001	349	40	8.803	8.486	0.317	0.48	77.38	4.24	0.35	0	0.48	17.07	4.06	2.9	4.11	11
2003	70	37	8.652	8.366	0.286	0.71	73.16	5.49	0.46	0	0.62	19.56	3.79	2.74	3.87	12
2001	295	40	8.709	8.425	0.284	0.52	69.03	5.45	0.45	0	0.62	23.93	3.92	2.82	3.99	13
2001	292	40	8.691	8.425	0.266	1.21	72.91	7.3	0.61	0	0.83	17.15	3.92	2.82	3.99	14
2001	325	24	8.69	8.431	0.259	0.79	81.34	4.89	0.41	0	0.55	12.01	3.93	2.83	4.01	15
2001	35	39	8.637	8.379	0.259	0.34	92.78	1.84	0.15	0	0.21	4.67	3.82	2.76	3.89	16
2002	146	24	8.692	8.435	0.257	0.74	80.98	4.1	0.34	0	0.46	13.37	3.94	2.83	4.02	17
2002	362	4	8.742	8.486	0.255	0.63	95.84	1.97	0.16	0	0.22	1.18	4.06	2.9	4.11	18
2002	361	38	8.737	8.486	0.251	0.95	91.51	3.63	0.3	0	0.41	3.19	4.06	2.9	4.11	19
2002	16	40	8.738	8.491	0.246	0.35	80.92	3.47	0.29	0	0.39	14.57	4.08	2.91	4.1	20
2002	46	35	8.62	8.379	0.242	0.58	69.76	5.71	0.47	0	0.65	22.83	3.82	2.76	3.89	21
2001	118	30	8.586	8.347	0.239	1.1	75.31	6.49	0.54	0	0.73	15.83	3.74	2.72	3.85	22
2001	15	12	8.728	8.491	0.236	0.51	76.11	1.9	0.16	0	0.22	21.1	4.08	2.91	4.1	23
2001	27	40	8.725	8.491	0.234	0.73	74.24	4.76	0.4	0	0.54	19.35	4.08	2.91	4.1	24
2001	58	37	8.607	8.379	0.228	0.81	58.39	7.48	0.62	0	0.85	31.85	3.82	2.76	3.89	25

Valid Receptors - Ranked Daily Visibility Change for Breton (Top 22 Days Each Year)

YEAR	DAY	REC	BEXT (Model)	BEXT (BKG)	DELTA DV	% SO4	% NO3	% OC	% EC	% PMC	% PMF	% NO2	Small F(RH)	Large F(RH)	SSalt F(RH)	Rank
2001	293	34	9.03	8.43	0.61	1.06	58.6	8.66	0.72	0	0.98	30	3.92	2.82	3.99	1
2001	81	35	8.74	8.37	0.37	0.88	79.1	4.99	0.41	0	0.56	14.1	3.79	2.74	3.87	2
2001	117	30	8.72	8.35	0.37	0.86	67.1	6.93	0.57	0	0.78	23.8	3.74	2.72	3.85	3
2001	345	17	8.86	8.49	0.37	0.32	90	2.1	0.17	0	0.24	7.21	4.06	2.9	4.11	4
2001	349	35	8.75	8.49	0.27	0.49	78.3	4.17	0.35	0	0.47	16.3	4.06	2.9	4.11	5
2001	325	24	8.69	8.43	0.26	0.79	81.3	4.89	0.41	0	0.55	12	3.93	2.83	4.01	6
2001	35	35	8.63	8.38	0.25	0.36	92.6	1.91	0.16	0	0.22	4.8	3.82	2.76	3.89	7
2001	118	30	8.59	8.35	0.24	1.1	75.3	6.49	0.54	0	0.73	15.8	3.74	2.72	3.85	8
2001	15	12	8.73	8.49	0.24	0.51	76.1	1.9	0.16	0	0.22	21.1	4.08	2.91	4.1	9
2001	292	35	8.65	8.43	0.23	1.52	72.5	8.42	0.7	0	0.95	15.9	3.92	2.82	3.99	10
2001	58	35	8.6	8.38	0.23	0.81	58.5	7.47	0.62	0	0.85	31.8	3.82	2.76	3.89	11
2001	326	35	8.64	8.43	0.21	0.47	87.6	2.76	0.23	0	0.31	8.62	3.93	2.83	4.01	12
2001	21	35	8.7	8.49	0.21	0.5	83.4	3.66	0.3	0	0.41	11.8	4.08	2.91	4.1	13
2001	265	35	8.75	8.54	0.21	1.67	37.4	12.5	1.04	0	1.42	46	4.18	2.97	4.23	14
2001	119	33	8.53	8.35	0.19	0.92	63.8	7.69	0.64	0	0.87	26.1	3.74	2.72	3.85	15
2001	316	34	8.62	8.43	0.19	1.59	76	7.45	0.62	0	0.84	13.5	3.93	2.83	4.01	16
2001	109	22	8.53	8.35	0.19	1.11	89.4	4.79	0.4	0	0.54	3.75	3.74	2.72	3.85	17
2001	34	35	8.56	8.38	0.18	0.75	88.3	4.15	0.34	0	0.47	6.01	3.82	2.76	3.89	18
2001	32	12	8.56	8.38	0.18	0.86	65.6	7.35	0.61	0	0.83	24.7	3.82	2.76	3.89	19
2001	344	35	8.65	8.49	0.16	0.5	75.2	4.3	0.36	0	0.49	19.1	4.06	2.9	4.11	20
2001	27	35	8.65	8.49	0.16	1.12	74	5.35	0.44	0	0.61	18.5	4.08	2.91	4.1	21
2001	321	20	8.58	8.43	0.15	0.69	66.9	6.29	0.52	0	0.71	24.9	3.93	2.83	4.01	22
2002	100	33	8.91	8.35	0.57	0.86	80.2	4.66	0.39	0	0.53	13.3	3.74	2.72	3.85	1
2002	40	35	8.69	8.38	0.31	0.51	92.3	2.25	0.19	0	0.25	4.48	3.82	2.76	3.89	2
2002	146	24	8.69	8.44	0.26	0.74	81	4.1	0.34	0	0.46	13.4	3.94	2.83	4.02	3
2002	361	35	8.73	8.49	0.24	0.93	91.8	3.5	0.29	0	0.4	3.11	4.06	2.9	4.11	4
2002	46	35	8.62	8.38	0.24	0.58	69.8	5.71	0.47	0	0.65	22.8	3.82	2.76	3.89	5
2002	362	7	8.71	8.49	0.23	0.83	94	2.71	0.23	0	0.31	1.9	4.06	2.9	4.11	6
2002	12	35	8.71	8.49	0.22	0.93	53.2	8.23	0.68	0	0.93	36	4.08	2.91	4.1	7
2002	26	24	8.7	8.49	0.2	1.25	72	7.45	0.62	0	0.84	17.8	4.08	2.91	4.1	8
2002	27	34	8.68	8.49	0.19	0.6	73.4	5.1	0.42	0	0.58	19.9	4.08	2.91	4.1	9
2002	349	12	8.67	8.49	0.18	0.44	83.2	3.35	0.28	0	0.38	12.4	4.06	2.9	4.11	10
2002	39	14	8.56	8.38	0.18	0.92	87.6	3.94	0.33	0	0.45	6.72	3.82	2.76	3.89	11
2002	16	35	8.66	8.49	0.17	0.36	80.7	3.6	0.3	0	0.41	14.6	4.08	2.91	4.1	12
2002	341	35	8.65	8.49	0.17	0.7	84.5	4.04	0.34	0	0.46	9.97	4.06	2.9	4.11	13
2002	295	35	8.59	8.43	0.16	0.52	71.9	5.12	0.43	0	0.58	21.5	3.92	2.82	3.99	14
2002	59	35	8.52	8.38	0.14	0.74	92.6	3.52	0.29	0	0.4	2.43	3.82	2.76	3.89	15
2002	311	20	8.56	8.43	0.13	0.96	75.1	6.33	0.53	0	0.72	16.4	3.93	2.83	4.01	16
2002	330	35	8.56	8.43	0.13	1.1	81.5	4.82	0.4	0	0.55	11.6	3.93	2.83	4.01	17
2002	34	30	8.51	8.38	0.13	0.92	63.9	7.65	0.64	0	0.87	26.1	3.82	2.76	3.89	18
2002	297	24	8.55	8.43	0.12	2.63	44.3	10.9	0.9	0	1.23	40.1	3.92	2.82	3.99	19
2002	20	35	8.61	8.49	0.12	0.47	81.4	3.76	0.31	0	0.43	13.6	4.08	2.91	4.1	20
2002	333	24	8.55	8.43	0.12	0.67	74.4	5.32	0.44	0	0.6	18.5	3.93	2.83	4.01	21
2002	342	35	8.59	8.49	0.11	1.42	52	10.1	0.84	0	1.14	34.5	4.06	2.9	4.11	22
2003	31	35	8.87	8.49	0.38	0.49	86.4	2.6	0.22	0	0.29	9.96	4.08	2.91	4.1	1
2003	293	34	8.8	8.43	0.37	1.66	54.6	10.8	0.89	0	1.22	30.9	3.92	2.82	3.99	2
2003	70	35	8.65	8.37	0.28	0.72	73	5.54	0.46	0	0.63	19.7	3.79	2.74	3.87	3
2003	44	15	8.61	8.38	0.23	0.51	78	4.3	0.36	0	0.49	16.4	3.82	2.76	3.89	4
2003	144	26	8.61	8.44	0.17	1.65	52.9	10.7	0.89	0	1.21	32.6	3.94	2.83	4.02	5
2003	26	27	8.65	8.49	0.16	0.71	70.9	6.03	0.5	0	0.68	21.2	4.08	2.91	4.1	6
2003	12	35	8.65	8.49	0.16	0.57	81.5	4.75	0.39	0	0.54	12.3	4.08	2.91	4.1	7
2003	277	35	8.58	8.43	0.15	0.83	65	6.92	0.58	0	0.78	25.9	3.92	2.82	3.99	8
2003	354	7	8.64	8.49	0.15	0.62	91.5	3.08	0.26	0	0.35	4.2	4.06	2.9	4.11	9
2003	56	35	8.52	8.38	0.14	1.19	69.1	7.53	0.63	0	0.85	20.8	3.82	2.76	3.89	10
2003	325	35	8.57	8.43	0.14	3.34	52.6	15.5	1.29	0	1.75	25.5	3.93	2.83	4.01	11

2003	65	35	8.5	8.37	0.14	1.86	25.7	13	1.08	0	1.47	56.9	3.79	2.74	3.87	12
2003	59	35	8.51	8.38	0.14	1.71	58.8	8.67	0.72	0	0.98	29.2	3.82	2.76	3.89	13
2003	42	9	8.51	8.38	0.13	0.36	81.3	3.52	0.29	0	0.4	14.1	3.82	2.76	3.89	14
2003	25	35	8.62	8.49	0.13	0.44	87.1	3.13	0.26	0	0.35	8.76	4.08	2.91	4.1	15
2003	69	15	8.48	8.37	0.11	1.75	52.6	11.5	0.96	0	1.3	31.9	3.79	2.74	3.87	16
2003	341	35	8.6	8.49	0.11	0.48	78	4.18	0.35	0	0.47	16.6	4.06	2.9	4.11	17
2003	292	35	8.54	8.43	0.11	2.39	61.9	12.9	1.07	0	1.46	20.3	3.92	2.82	3.99	18
2003	117	14	8.45	8.35	0.11	2.24	59.6	10.5	0.87	0	1.19	25.6	3.74	2.72	3.85	19
2003	86	26	8.47	8.37	0.1	0.87	51.2	9.14	0.76	0	1.03	37	3.79	2.74	3.87	20
2003	24	12	8.59	8.49	0.1	0.34	93	2.1	0.17	0	0.24	4.18	4.08	2.91	4.1	21
2003	39	35	8.48	8.38	0.1	1.02	75.1	7.37	0.61	0	0.83	15.1	3.82	2.76	3.89	22

Valid Receptors - Ranked Daily Visibility Change for Breton (Top 25 Days Over 3 Years)

YEAR	DAY	REC	BEXT (Model)	BEXT (BKG)	DELTA DV	% SO4	% NO3	% OC	% EC	% PMC	% PMF	% NO2	Small F(RH)	Large F(RH)	SSalt F(RH)	Rank
2001	293	34	9.03	8.43	0.61	1.06	58.6	8.66	0.72	0	0.98	30	3.92	2.82	3.99	1
2002	100	33	8.91	8.35	0.57	0.86	80.2	4.66	0.39	0	0.53	13.3	3.74	2.72	3.85	2
2003	31	35	8.87	8.49	0.38	0.49	86.4	2.6	0.22	0	0.29	9.96	4.08	2.91	4.1	3
2003	293	34	8.8	8.43	0.37	1.66	54.6	10.8	0.89	0	1.22	30.9	3.92	2.82	3.99	4
2001	81	35	8.74	8.37	0.37	0.88	79.1	4.99	0.41	0	0.56	14.1	3.79	2.74	3.87	5
2001	117	30	8.72	8.35	0.37	0.86	67.1	6.93	0.57	0	0.78	23.8	3.74	2.72	3.85	6
2001	345	17	8.86	8.49	0.37	0.32	90	2.1	0.17	0	0.24	7.21	4.06	2.9	4.11	7
2002	40	35	8.69	8.38	0.31	0.51	92.3	2.25	0.19	0	0.25	4.48	3.82	2.76	3.89	8
2003	70	35	8.65	8.37	0.28	0.72	73	5.54	0.46	0	0.63	19.7	3.79	2.74	3.87	9
2001	349	35	8.75	8.49	0.27	0.49	78.3	4.17	0.35	0	0.47	16.3	4.06	2.9	4.11	10
2001	325	24	8.69	8.43	0.26	0.79	81.3	4.89	0.41	0	0.55	12	3.93	2.83	4.01	11
2002	146	24	8.69	8.44	0.26	0.74	81	4.1	0.34	0	0.46	13.4	3.94	2.83	4.02	12
2001	35	35	8.63	8.38	0.25	0.36	92.6	1.91	0.16	0	0.22	4.8	3.82	2.76	3.89	13
2002	361	35	8.73	8.49	0.24	0.93	91.8	3.5	0.29	0	0.4	3.11	4.06	2.9	4.11	14
2002	46	35	8.62	8.38	0.24	0.58	69.8	5.71	0.47	0	0.65	22.8	3.82	2.76	3.89	15
2001	118	30	8.59	8.35	0.24	1.1	75.3	6.49	0.54	0	0.73	15.8	3.74	2.72	3.85	16
2001	15	12	8.73	8.49	0.24	0.51	76.1	1.9	0.16	0	0.22	21.1	4.08	2.91	4.1	17
2001	292	35	8.65	8.43	0.23	1.52	72.5	8.42	0.7	0	0.95	15.9	3.92	2.82	3.99	18
2002	362	7	8.71	8.49	0.23	0.83	94	2.71	0.23	0	0.31	1.9	4.06	2.9	4.11	19
2003	44	15	8.61	8.38	0.23	0.51	78	4.3	0.36	0	0.49	16.4	3.82	2.76	3.89	20
2001	58	35	8.6	8.38	0.23	0.81	58.5	7.47	0.62	0	0.85	31.8	3.82	2.76	3.89	21
2002	12	35	8.71	8.49	0.22	0.93	53.2	8.23	0.68	0	0.93	36	4.08	2.91	4.1	22
2001	326	35	8.64	8.43	0.21	0.47	87.6	2.76	0.23	0	0.31	8.62	3.93	2.83	4.01	23
2001	21	35	8.7	8.49	0.21	0.5	83.4	3.66	0.3	0	0.41	11.8	4.08	2.91	4.1	24
2001	265	35	8.75	8.54	0.21	1.67	37.4	12.5	1.04	0	1.42	46	4.18	2.97	4.23	25

Appendix L.3: Mississippi Power Company—Plant Daniel

Appendix L.3 contents:

Mississippi Power Company—Plant Victor J. Daniel BART Process Summary

Mississippi Power, Plant Daniel is an Electricity Generating facility with two coal fired steam electric generators that are BART eligible. Plant Daniel is 63 km from Breton National Wildlife Refuge, a Class I area, and has a possible visibility impact on the Class 1 area. As a fossil fuel steam electric plant, MS Power—Plant Daniel meets the initial BART eligibility requirements of source category code. Therefore, on June 3, 2011, Mississippi Department of Environmental Quality (MDEQ) sent them a letter requesting information to determine BART eligibility. Based on the information received from MS Power, Plant Daniel, two units were deemed BART eligible because they met the following criteria:

- Operating or under construction between August 7, 1962 to August 7, 1977
- Having potential emissions that exceed the limit of 250 tons per year for SO_2, NO_X, or PM_{10}

Table L.3.1 shows the BART-eligible point sources for MS Power, Plant Daniel

Emission Unit	**Heat Input (MMBtu/hr)**	**Potential Emissions (tons per year)**			**Existing Control Equipment**
		SO_2	NO_X	PM_{10}	
Unit 1—Utility Boiler 1	5,460.5	4,783.41	16,741.92	511.15	Wet FGD, LNB w/OFA, ESP
Unit 2—Utility Boiler 2	5,460.5	4,783.41	16,741.92	511.15	Wet FGD, LNB w/OFA, ESP
	Totals:	9,566.82	33,483.84	1022.30	

Table L.3.1. BART-Eligible Point Sources at MS Power—Plant Daniel

Because the source meets BART-eligibility requirements, CALPUFF modeling was performed on these units. SO2 Scrubbers were installed on the units with operation beginning in September 2015. Mississippi Power performed updated CALPUFF modeling using current emissions (September 2015-August 2018) and the latest EPA approved model (version 5.8.5 Level 151214). The new IMPROVE equation was used in the modeling analysis per the VISTAS Modeling Protocol. The initial March 2019 modeling protocol was submitted to EPA Region 4 and approved in May 2019. (The final version of the modeling protocol dated June 2019 is included in Appendix L.3.2.) The modeling analysis, included in Appendix L.3.3, demonstrated a maximum 98th percentile 24-hour average visibility impact of 0.39 dv, and a 22nd highest day's visibility impact over all three years of 0.33 dv. Mississippi agrees with this modeling analysis. The threshold contribution for BART subjectivity selected by Mississippi is 0.5 dv; therefore, MS Power, Plant Daniel is not subject to BART and no further analysis is required.

BART Modeling Protocol:

Mississippi Power Company
Plant Daniel

Prepared by:

Southern Company Services
for Mississippi Power Company

March 2019
Revised June 2019

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1.0 Introduction

1.1 Background and Objectives

The Regional Haze Rule requires Best Available Retrofit Technology (BART) for any BART-eligible source that ''emits any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility" in any mandatory Class I federal area. Pursuant to federal regulations, states have the option of exempting a BART-eligible source from the BART requirements based on dispersion modeling that demonstrates that the source cannot reasonably be anticipated to cause or contribute to visibility impairment in a Class I area. It is noted that, while Mississippi is not home to any Class I areas, it is subject to the Regional Haze program requirements due to its proximity to Class I areas in other states, namely, Breton Wilderness Area in Louisiana.

In 2005, the Environmental Protection Agency (EPA) promulgated a rule (70 FR 39104, July 6, 2005) allowing states subject to the Clean Air Interstate Rule (CAIR) to determine that CAIR satisfies the BART requirements for SO_2 and/or NO_x for electric generating units (EGUs). On December 23, 2008, the U.S. Court of Appeals for the D.C. Circuit found the CAIR rule to be legally flawed and remanded the rule to EPA. In light of the uncertainty surrounding regional transport rules and the ability of the state of Mississippi to rely on an associated regional trading program as an alternative to BART, in a letter dated June 3, 2011, MDEQ requested that Mississippi Power Company (MPC) conduct BART analyses including SO_2 and NO_x, in addition to PM, for the BART-eligible units at Plant Daniel.

On July 6, 2011, in response to remand by the U.S. Court of Appeals for the D.C. Circuit, EPA replaced CAIR with the Cross-State Air Pollution Rule (CSAPR). While the state of Mississippi was included in the annual SO_2 and NO_x programs and the seasonal NOx program for CAIR, it is only included in the CSAPR seasonal NOx program. Nevertheless, MPC completed the requested analysis and submitted the BART modeling and determination report to the Mississippi Department of Environmental Quality (MDEQ) in November 2012; however, no action was taken. In its analysis, MPC proposed that previously permitted, but not yet operational, wet FGD systems for Units 1 and 2 constituted top-level control for SO_2 and, thereby, satisfy SO_2 BART requirements. The analysis also proposed no additional controls for NO_x as the visibility modeling predicted a negligible improvement in visibility at the Breton Island Class I area would be achieved by installing additional NO_x controls. Lastly, the analysis proposed no additional controls for PM as stack tests indicated PM levels less than vendor guarantees for top-level controls (i.e., baghouses).

In a meeting on October 17, 2018 with MDEQ, MPC agreed to complete a BART screening analysis based on recent emissions for NO_x, SO_2, and PM at Plant Daniel Units 1 and 2.

This modeling protocol discusses the methodology that MPC will apply for performing the BART screening modeling analysis for NO_x, SO_2, and PM for Units 1 and 2 at Plant Daniel. The modeling procedures outlined will be used to determine whether the source is subject to BART requirements (exemption modeling). If it is determined that the source is subject to BART, this protocol will be updated and used to evaluate visibility improvement in the BART determination step (determination modeling). The modeling procedures are consistent with those outlined in the updated final VISTAS common BART modeling protocol (dated December 22, 2005, revision 3.2 – August 31, 2006) (hereinafter, "VISTAS protocol"), attached as Appendix A. This source-specific BART modeling protocol references relevant portions of the VISTAS protocol.

1.2 Location of source vs. relevant Class I Areas

The MDEQ, which is responsible for implementation of the state's Regional Haze program, has determined that Units 1 and 2 at Plant Daniel are BART-eligible. Figure 1-1 shows the location of Plant Daniel relative to nearby Class I Areas. There is one Class I area within 300 km of the plant: Breton Wilderness Area (61.3 km). BART exemption modeling will be conducted for this Class I area in accordance with the referenced VISTAS protocol and the procedures described in this source-specific BART modeling protocol. If necessary, visibility improvement modeling for the BART determination step will be performed for this Class I area if the exemption modeling shows a greater than 0.5 deciview impact.

1.3 Organization of protocol document

Section 2 of this protocol describes the source emissions that will be used as input to the BART exemption modeling and, if necessary, the BART determination modeling. Section 3 describes the input data to be used for the modeling, including the modeling domain, background concentrations, and meteorological data. Section 4 describes the air quality modeling procedures and Section 5 discusses the presentation of modeling results. All references are either cited in footnotes or are included in the VISTAS common protocol (Appendix A, Section 7), so no additional references section is included in this document. Appendices B, C, D, and E provide additional information on the stack and baseline source emissions. Appendix F provides documentation and rationale for using the SEARCH Oak Grove Data for estimating ambient NH_3 concentrations over the Gulf of Mexico proposed for this modeling analysis.

Figure 1-1 Location of Class I Areas in Relation to Plant Daniel

2.0 Source description and emissions data

2.1 Unit-specific source data

The emissions data used to assess the visibility impacts at the Class I areas within 300 km of Plant Daniel are discussed in this section. This protocol addresses SO_2, NO_x and PM_{10} emissions.

Baseline SO_2 and NO_x emissions are based on the highest measured daily CEMS emission rate during normal operating conditions for the 3-year period from October 1, 2015 (Q4 2015) through September 30, 2018 (Q3 2018).[1] CEMS emissions were combined for the two units because the flue gas emits through a single stack with two liners. Each unit is equipped with flue gas desulfurization (FGD) control equipment, which began operation in early 2016.

Since various components of PM_{10} emissions have different visibility extinction efficiencies, the PM_{10} emissions are divided, or "speciated," into several components (VISTAS protocol Sections 4.3.3 and 4.4.2). Section 5 of the VISTAS protocol allows for the use of source-specific emissions and speciation factors and/or default values from AP-42. The PM_{10} emissions and speciation approach to be used for the modeling described in this protocol is indicated in the bullets below. Where default speciation values are used, the data represents the stack emissions (units 1 and 2 combined) where baseline emission controls include electrostatic precipitators (ESPs) and post-combustion FGD control equipment.

- Total PM_{10} is comprised of filterable and condensable emissions.
- Baseline filterable PM_{10} emissions are based on the highest stack test result for the 3-year period of October 1, 2015-September 30, 2018. This stack test result is combined with the highest 24-hour heat input value for this period from CEMS data to calculate the "maximum 24-hour average emission rate" as required by the VISTAS protocol.
- Filterable PM_{10} will be subdivided by size category consistent with the default approach from AP-42 Table 1-1.6, and as noted on pages 43 and 44 of the VISTAS protocol. The AP-42 Table 1-1.6 and National Park Service Particulate Matter Speciation Guidance[2] specify for the emission controls indicated above that 55.6% of filterable PM_{10} emissions is coarse (greater than 2.5 microns in size) and 44.4% is fine. Of the fine portion, 3.7% is elemental carbon and the remainder is inorganic fine particulates (soil).
- Condensable PM_{10} consists of inorganic and organic compounds. The inorganic portion is by default assumed to be H_2SO_4, although other non-sulfate inorganic condensables could be present. The organic portion is modeled as organic aerosols.
- Baseline H_2SO_4 emissions are calculated consistent with the method used by Mississippi Power to derive these emissions for Toxics Release Inventory (TRI) purposes. This approach assumes that the H_2SO_4 emissions released from the stack are proportional to SO_2 emissions from combustion and are dependent on the fuel type and the removal of H_2SO_4 by downstream equipment (i.e., ESP, air heater, and FGD). Appendix C provides the basis for the site-specific sulfuric acid values used.
- Baseline emission of condensable organics (the remaining portion of condensable PM_{10}) is derived based on the supporting field observational information in Appendix D and is estimated as 0.32% of SO_2 emitted.

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[1] The period of October 1, 2015 through September 30, 2018 was selected because it was the most recent available quality controlled reviewed data at the time the modeling protocol was developed.

[2] Available at https://www.nps.gov/subjects/air/pm-speciation.htm. The spreadsheet selected for large coal-fired boilers is "Final Dry Bottom PC w FGD+ESP PM speciation profile.xls".

- Coarse filterable particles (between 2.5 and 10 microns in size) will be modeled with a geometric mass mean diameter of 5 microns, while fine filterable and all condensable particles will be modeled with a geometric mass mean diameter of 0.48 microns, consistent with the CALPUFF default value for fine particles. The geometric standard deviation for both fine and coarse particles will be set to 2 microns, consistent with the CALPUFF default value. The 0.48 micron diameter value for fine particles comes from the default values in sample input file provided with the CALPUFF modeling system downloadable from the Exponent, Inc., website.[3] There is no default value for coarse particles presented in the sample input file. However, since 5 is the geometric mass mean diameter of 2.5 and 10 (the bounds of coarse particle sizes), it is a reasonable estimate for the geometric mass mean diameter for that class of particles.

In practice, CALPUFF allows for the user to input certain components of PM_{10} as separate species and separate sizes, which will result in more accurate estimates of wet and dry deposition velocity and more accurate impacts on light scattering. As noted above, the particle size distribution information is provided in AP-42 Table 1-1.6 and will be used for the BART exemption modeling as well as the BART determination modeling, if needed.

Table 2-1 provides a summary of the modeling emission parameters to be used in the BART CALPUFF modeling, consistent with the source emissions data presented in Appendices C and D for the baseline. All of the emissions in Table 2-1 were derived from CEMS data for the October 1, 2015 through September 30, 2018 period and represent the maximum 24-hour average lb/hr rates (excluding startup, shutdown, malfunctions, or other nonrepresentative operations, etc.)[4] For NO_x and SO_2 the values are directly from CEMS. Filterable PM_{10} emissions were calculated using the highest stack test result over the selected 3-year period previously described and multiplying these values with the maximum 24-hour average heat input derived from CEMS. These values were then adjusted using AP-42 factors from Table 1.1-6 that indicate that PM_{10} is 71% of total PM for a pulverized coal unit with an ESP and FGD. PM_{10} speciation was then performed as indicated above, such that total Filterable PM_{10} is made up of Coarse Soil plus total Fine PM and total Fine PM is made up of Fine Soil plus Elemental Carbon (EC).

If the BART exemption modeling indicates that a BART determination is required, then one or more SO_2, NO_x and particulate matter control options will be considered for the modeling to determine the incremental visibility improvement from the baseline case. The BART engineering analysis will provide the justifications for the selected, technically feasible options and the species-specific control efficiencies. Table 2-1 will be updated to provide the modeling parameters for these feasible options and resubmitted MDEQ for review. Any site-specific deviations from the default particulate matter speciation guidance would be outlined at that time.

2.2 Stack Height

The actual stack height for the stack serving Units 1 and 2 at Plant Daniel is 621 feet (189.3 m) above plant grade. The units emit through a dual-liner 621-foot stack that was constructed as part of the FGD systems commissioned in early 2016. Appendix B of the Plant Daniel Modeling Protocol provides engineering drawings of the new stack. The calculated “good engineering practice” (GEP) height for this stack is 621.3 feet (189.4 m) above plant grade, which was documented in MPCs submittal to MDEQ for Construction Permit Number 1280-00090). The BPIP files documenting GEP stack height analysis, which were developed for pre-construction permitting submittals in 2008, are provided electronically with this protocol. The dominant structures producing this GEP height are the two main boiler buildings. Because the GEP height for the stack exceeds its actual height, the actual stack height will be modeled. For this BART modeling analysis, the physical characteristics of the new scrubber stack were used.

[3] The CALPUFF modeling system is available for download from the Exponent, Inc. web site: http://www.src.com/

[4] See Appendix E of the Plant Daniel Modeling Protocol for emissions discussion.

Table 2-1 Plant Daniel modeling emission parameters

Case	Source / Unit	Location UTM (Zone 16 NAD-83)		Actual Stack Ht	Base Elev.	Flue Equivalent Diameter	Gas Exit Vel.	Stack Gas Exit Temp.	Emissions			Particle Speciation[1]							
		UTM East	UTM North						SO_2	NO_X	PM_{10}	Filt. PM_{10}	Coarse Soil	Fine PM	Fine Soil	EC	Cond. PM_{10}	H_2SO_4	Organic
		m	m	m	m	m	m/s	deg K	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr
Baseline Data Units 1 and 2 combined - Current Configuration (Stack basis: 1 liner, 2 stacks)																			
Stack 1	Units 1&2	350,592	3,378,843	189.3	7.3	11.3	14.8	328.4	169.08	2083.9	38.70	31.12	17.30	13.82	13.31	0.51	7.58	7.04	0.54
				Modeled Stk Ht[2]															
Baseline Emissions Converted to g/sec									g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
Stack 1	Units 1&2	350,592	3,378,843	189.3	7.3	11.3	14.8	328.4	21.30	262.57	4.88	3.92	2.18	1.74	1.68	0.06	0.96	0.89	0.07
Retrofit Control Options (if BART analysis is required)[3]																			
SO2 Control 1	Units 1&2																		
↓																			
SO2 Control n	Units 1&2																		
NOX Control 1	Units 1&2																		
↓																			
NOX Control n	Units 1&2																		
PM Control 1	Units 1&2																		
↓																			
PM Control n	Units 1&2																		

[1] Elemental carbon (EC) and Fine PM are a part of Filterable PM_{10} and H_2SO_4 and Organics are a part of Condensable PM_{10}. Note that H_2SO_4 is input to CALPUFF as SO_4. The molecular weights of H_2SO_4 and SO_4 are 98 and 96, respectively, therefore the conversion factor from H_2SO_4 to SO_4 is 96/98.

[2] Stack credit is equal to actual stack height since this stack is at or below GEP.

[3] Stack parameters and emissions associated with retrofit control options will be provided later if a BART determination analysis is required.

3.0 Air quality modeling procedures

Modeling analyses to assess visibility impacts in accordance with BART requirements will generally follow the VISTAS protocol. This section provides a summary of the modeling procedures that will be used for the refined CALPUFF analysis to be conducted for Plant Daniel.

3.1 Model selection and features

EPA has recommended use of the CALPUFF model for estimation of visibility impacts for BART analyses. The major features of the CALPUFF modeling system, including those of CALMET and the post processors (CALPOST and POSTUTIL), are referenced in Section 3 of the VISTAS protocol. BART modeling for Plant Daniel will use the following versions of the CALPUFF modeling system components:

CALPUFF: Version 5.8.5, Level 151214
CALMET: Version 5.8, Level 070623
POSTUTIL: Version 1.56, Level 070627
CALPOST: Version 6.221, Level 080724

3.2 Modeling domain and receptors

The initial Plant Daniel BART modeling will use the sub-domain 4, 4-km CALMET data supplied by Mr. Tim Allen of the U.S. Fish and Wildlife Service. This domain includes all Class I areas within 300 km of the source, plus a 50-km buffer.

The receptors used for each of the Class I areas are based on the NPS database of Class I receptors, as recommended by the VISTAS protocol (Section 4.3.3). Breton has a total of 40 receptors in this database. Figure 3-1 shows the receptor locations.

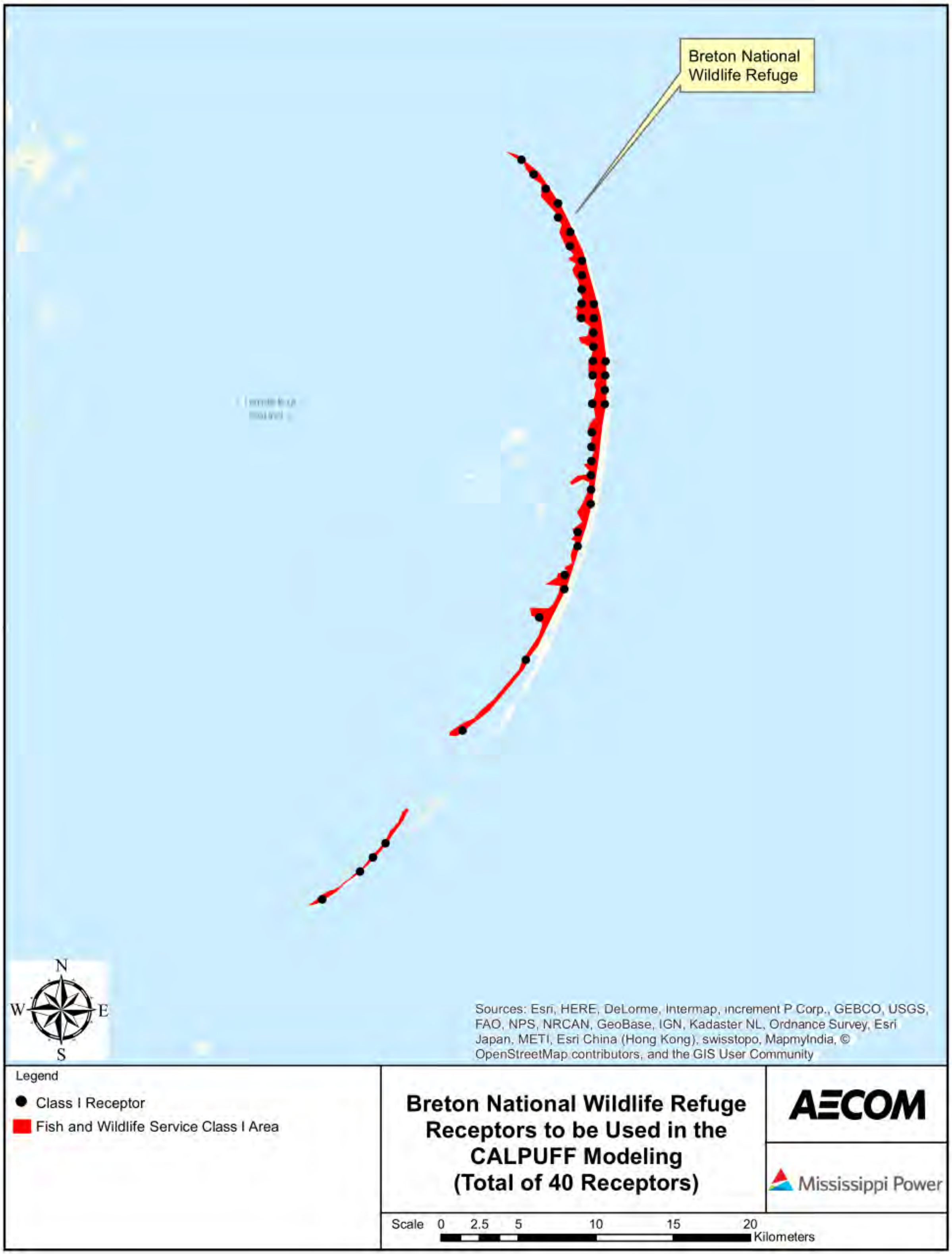
The BART exemption modeling will be conducted for Daniel Units 1 and 2 (BART eligible units) for each Class I area within 300 km of the source (specifically, the Breton Wilderness Area). If the exemption modeling shows an impact greater than 0.5 deciview at Breton, the BART determination modeling for visibility improvement will be conducted separately for each unit and each pollutant-specific control option.

3.3 Technical options used in the modeling

For CALPUFF model options, Plant Daniel will follow the VISTAS protocol (Section 4.4.1), which states that IWAQM (EPA, 1998) guidance should be followed. The VISTAS protocol (Section 4.3.3) also notes that building downwash effects are not required to be included unless the state directs the source to include these effects. Since Plant Daniel is more than 40 km from the nearest Class I area and the height of the stack is within 1 meter of GEP height, building downwash effects will not be included in the CALPUFF modeling.

The POSTUTIL utility program (VISTAS protocol Section 4.4.2) will be used to repartition HNO3 and NO3 using monthly median ambient ammonia (NH3) concentrations obtained from the nearest rural SEARCH air quality monitoring site (OAK). MPC will use ammonia data collected at the OAK SEARCH ambient monitoring site, located near Oak Grove, MS, to determine monthly background ammonia values. See section 4.2 for additional discussion.

Figure 3-1 Modeling Receptors for Breton Wilderness Area



3.4 Visibility impact calculations

Visibility impacts at Breton will be assessed using the default Method 8 in CALPOST. Inputs to Method 8 will be obtained from the Federal Land Managers' Air Quality Related Values Working Group (FLAG) 2010 report[5] and will be based on the annual average background natural conditions.

The BART rule significance threshold for the contribution to visibility impairment is 0.5 deciviews. The VISTAS protocol (Section 4.3.2) indicates that with the use of the 4-km sub-regional CALMET database, a source does not cause or contribute to visibility impairment if the 98th percentile (or 8th highest) day's change in extinction from natural conditions does not exceed 0.5 deciviews for any of the modeled years (an added check is that the 22nd highest prediction over the three years modeled should also not exceed 0.5 deciviews for a source to be exempted from a BART determination). Both the 98th percentile (or 8th highest) day's change in extinction from natural conditions for any modeled year and the 22nd highest prediction over the three years modeled will be evaluated. The maximum impact from either method should not exceed 0.5 deciviews for the source to be exempted from a BART determination.

Figure 4-1 of the VISTAS protocol presents a flow chart showing the steps of the analysis to determine whether a source is subject to BART. Again, it should be noted that the modeling for Plant Daniel will focus on Sub-regional Fine-Scale modeling as depicted in the lower half of the figure.

If the exemption modeling demonstrates that Plant Daniel does not cause or contribute to visibility impairment, then the source will not be subject to BART requirements, and no further analysis is needed. Otherwise, the source will proceed to perform BART determination analysis for each unit for the baseline and each control option in a similar manner as has been described in this document. This protocol will be supplemented with a revised Table 2-1 and any other source specific adjustments if the source is determined to be subject-to-BART.

3.5 Background Sea Salt Concentration for Breton National Wildlife Refuge

One of the particulate species that is accounted for in the CALPOST Method 8 visibility calculations is sea salt. Sea salt is present in the natural environment, especially in marine environments, and is hygroscopic in nature.

The background sea salt concentration at the various IMPROVE sites, provided in Table 6 of the 2010 FLAG guidance, comes from direct measurements of the chloride and sodium concentrations. However, the representativeness of the FLAG values for Breton Wilderness Area is questionable because the values in the 2010 FLAG report are based upon older data that has been superseded by more recent measurements.

MPC will use an updated background sea salt value based on more recent monitoring from the newer Breton monitor (BRIS1) rather than the monitor that was destroyed during Hurricane Katrina in 2005 (BRET1).

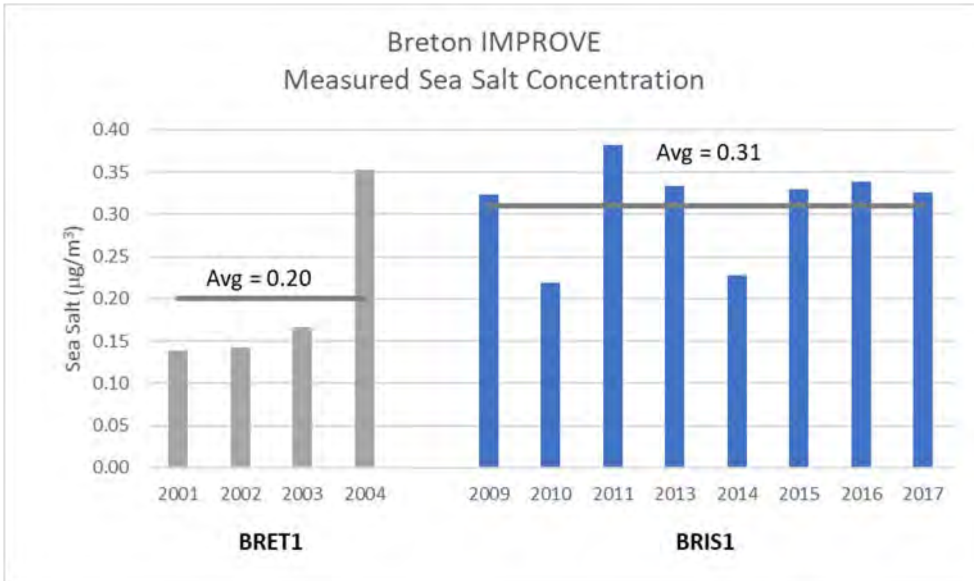
As shown in the graph below,[6] annual average sea salt concentrations measured at the BRET1 monitor over the first three years of operation (2001-2003) are substantially lower than the value measured in the last full

[5] Federal Land Managers' Air Quality Related Values Work Group (FLAG) Phase I Report (revised 2010) (U.S. Department of the Interior, 2010).

[6] Data were obtained from the IMPROVE website at the following link: http://vista.cira.colostate.edu/Improve/rhr-summary-data/. The spreadsheet available at this link titled, "SIA_group_means_10_18.csv", which provides annual average sea salt concentrations over all valid days, was most recently posted to the IMPROVE website in December 2018.

year of operation (2004). The 2004 value from BRET1 (0.35 μg/m^3) is consistent with the values that have been measured over more recent years (2009-2017) at the BRIS1 monitor (0.21-0.37 μg/m^3).

Figure 3-2 Breton IMPROVE Measured Sea Salt Concentrations



Because the BRIS1 data are more recent and more consistent over time, MPC believes that they are more representative for Breton. Therefore, MPC will use annual sea salt concentration in the calculation of visibility impairment for Breton that is based on the average of the 2009-2017 annual average sea salt concentrations from the BRIS1 monitor (0.31 μg/m^3).

3.6 General quality assurance procedures

Chapter 6 of the Final VISTAS Modeling Protocol discusses quality assurance (QA). The purpose of the QA program is to establish procedures for ensuring that products produced by the application of the modeling techniques for BART studies satisfy the regulatory objectives of the BART program.

Staff from Southern Company Services (SCS) developed the emissions inputs and are directing the outside consulting services of AECOM for the BART Exemption Modeling for MPC's Plant Daniel. The team coordinated to verify that all recommended methods specified in the Final VISTAS Modeling Protocol, the source-specific modeling protocol, and within this report were followed and that the modeling was carefully and professionally conducted. AECOM experts were provided source-specific stack parameters and emissions data for Plant Daniel, which AECOM used to complete the modeling analysis in accordance with the VISTAS common protocol.

AECOM has substantial experience conducting CALPUFF analyses for assessment of visibility impairment under the Regional Haze Rule in many applications, including those in the VISTAS (SESARM) Regional Planning Organization. Several of their BART application projects have been reviewed and accepted by the state, EPA, and Federal Land Manager agencies. AECOM uses CALDESK animation software as well as Lakes Environmental CALVIEW software with base maps to visualize the sources, receptors, and meteorology used in the analyses. AECOM also uses the CALPUFF QA output files in conjunction with ArcMap GIS software to plot the locations of the sources and receptors as CALPUFF interprets them from the input data. The output files from CALPUFF and CALPOST are reviewed by AECOM staff to assure accuracy and compliance with approved regulatory procedures.

For this application, the 4-km grid-spaced CALMET and ozone files for sub-domain 4, developed and provided by Mr. Tim Allen of the U.S. Fish & Wildlife Service, were utilized. CALPUFF input file templates that were developed by VISTAS were used. AECOM modelers used the test met file to “benchmark” the use of the CALMET files on their computers as indicated on page 59 of the VISTAS common protocol. All CALPUFF, CALPOST, and POSTUTIL input and output files will be submitted electronically along with the modeling report.

4.0 Input data to the CALPUFF model

4.1 CALMET meteorological files

VISTAS developed five sub-regional 4-km CALMET meteorological databases for three years (2001-2003) (VISTAS protocol Section 4.4.2). The sub-regional modeling domains are strategically designed to cover all potential BART eligible sources within VISTAS states and all PSD Class I areas within 300 km of those sources (to the nearest edge). Mr. Tim Allen of the U.S. Fish and Wildlife Service has updated the meteorological databases for these domains using CALMET Version 5.8. The extents of the 4-km sub-regional domains are shown in Figure 4-4 of the VISTAS protocol. The BART modeling for Plant Daniel will be done using the updated meteorological dataset for the 4-km subdomain 4 obtained from Mr. Allen.

4.2 Air quality database (background ozone and ammonia)

Hourly measurements of ozone from all non-urban monitors over the period 2001-2003, as generated by VISTAS, will be used as input to CALPUFF.

For ammonia, five years (2004-2008) of 24-hour ammonia concentrations measured at a nearby SEARCH air quality monitoring site (OAK) will be used to calculate site-specific monthly concentrations based on the geometric mean. OAK is a rural monitoring site in southern Mississippi, approximately 65 km inland from the Gulf Coast. It is reasonable to assume that this site is representative of the regional background, and that the observations from OAK are more appropriate than using the VISTAS default background of 0.5 ppb. The observed monthly background concentrations will be input into POSTUTIL for HNO_3/NO_3 partitioning. See Appendix F for a discussion of the representativeness of the OAK ammonia data for Breton. SEARCH ammonia measurement and quality assurance procedures are described in two peer-reviewed journal articles.[7,8] The quality assurance procedures were adapted from EPA Method IO-4.2.[9] Natural conditions and monthly f(RH) at Class I Areas

For each of the applicable Class I areas, natural background conditions must be established in order to determine a change from natural conditions related to a source's emissions. Inputs to CALPOST Method 8 will be obtained from the FLAG 2010[10] report and will be based on the annual average background natural conditions.

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[7] Edgerton, E.S., R.D. Saylor, B.E. Hartsell, J.J. Jansen, and D.A. Hansen. 2007. Ammonia and ammonium measurements from the southeastern United States. Atmos. Environ. 41:3339–3351. doi:10.1016/j.atmosenv.2006.12.034

[8] Saylor, R., L. Myles, D. Sibble, J. Caldwell, and J. Xing. 2015. Recent trends in gas-phase ammonia and PM2.5 ammonium in the Southeast United States. Journal of the Air & Waste Management Association. 65:3, 347-357. doi:10.1080/10962247.2014.992554

[9] U.S. EPA. 1999. IO Compendium Method IO-4.2: Compendium of Methods for the Determination of Inorganic Compounds in Ambient Air: Determination of Reactive Acidic and Basic Gases and Strong Acidity of Atmospheric Fine Particles. EPA/625/R-96/010a. Cincinnati, OH.

[10] Federal Land Managers' Air Quality Related Values Work Group (FLAG) Phase I Report (revised 2010) (U.S. Department of the Interior, 2010).

5.0 Presentation of modeling results

The BART exemption and, if necessary, BART determination modeling results for Plant Daniel will be provided to the state agency in a manner as described in the VISTAS protocol (Section 4.5). A report will be produced that includes the following elements (as suggested in the VISTAS protocol):

1. A map of the source location and Class I areas within 300 km of the source.

2. For the CALPUFF modeling domain, a table listing all Class I areas in the VISTAS domain and those in neighboring states and impacts from the BART 4-km grid exemption modeling at those Class I areas within 300 km of the source, as illustrated in Table 4-3 of the VISTAS protocol.

3. A discussion of the number of Class I areas with visibility impairment due to source emissions for the 98th percentile days in each year (and the 98th percentile over all three years modeled) greater than 0.5 dv.

4. For the Class I area with the maximum impact, a discussion of the number of days beyond those excluded (e.g., the 98th percentile for refined analyses) that the impact of the source exceeds 0.5 dv, the number of receptors in the Class I area where the impact exceeds 0.5 dv, and the maximum impact.

5. For any finer grid CALPUFF exemption modeling, results for those Class I areas for which impacts of the source exceeded 0.5 dv in the 4-km initial modeling. We would report the same type of results as provided for 4-km exemption modeling.

BART determination modeling will be performed for those Class I areas shown in the exemption modeling to exceed 0.5 dv impact. The extent of the BART determination modeling results will depend on the number of technically viable controls identified in the engineering analysis phase of the BART assessment. The results presented will be a comparison of the 98^{th} percentile value for the baseline and each control option as outlined above for the exemption modeling. The same statistics as those mentioned above in Steps 3 and 4 would be provided, and a summary of the relative results among all emission scenarios run would be produced.

The electronic files used to conduct the CALPUFF modeling will be submitted along with the modeling report on storage media.

Appendix A

VISTAS Common BART Modeling Protocol

Protocol for the Application of the CALPUFF Model for Analyses of Best Available Retrofit Technology (BART)

December 22, 2005

(Revision 3.2 – 8/31/06)

Visibility Improvement State and Tribal Association of the Southeast (VISTAS)

TABLE OF CONTENTS

SUMMARY

This Protocol for the Application of the CALPUFF Model for Analyses of Best Available Retrofit Technology (BART) for the VISTAS Regional Planning Organization (RPO) describes common procedures for carrying out air quality modeling to support BART determinations that are consistent with guidelines of the U.S. Environmental Protection Agency in 40 CFR Part 51 Appendix W and Appendix Y. The Protocol is intended to serve as the basis for a common understanding among the organizations that will be performing BART analyses or reviewing the BART modeling results in the VISTAS region.

Background

Best Available Retrofit Technology is required for any BART-eligible source that ''emits any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility" in any mandatory Class I federal area. According to 40 CFR Part 51 Appendix Y, "*You can use dispersion modeling to determine that an individual source cannot reasonably be anticipated to cause or contribute to visibility impairment in a Class I area and thus is not subject to BART*." In the "individual source attribution approach," a BART-eligible source that is responsible for a 1.0 deciview (dv) change or more is considered to "cause" visibility impairment. A BART-eligible source that is responsible for a 0.5 dv change or more is considered to "contribute" to visibility impairment in a Class I area. Any source determined to cause or contribute to visibility impairment in any Class I area is subject to BART.

The member states of the VISTAS RPO agreed to develop a common BART Modeling Protocol to guide them, their sources, and reviewers in the BART determination and review effort. The Protocol has been in preparation within VISTAS since January 2005. The original authors are Pat Brewer, VISTAS Technical Coordinator, and Ivar Tombach, VISTAS Technical Advisor. The VISTAS state BART contacts, particularly Tom Rogers, FL, Chris Arrington, WV, Leigh Bacon, AL, and Michael Kiss, VA, have directed and extensively reviewed the Protocol. The Protocol was enhanced and completed with the assistance of Joseph Scire, Christelle Escoffier-Czaja and Jelena Popovic of Earth Tech, Inc. and it has received extensive contributions and review from the VISTAS federal partners: Federal Land Managers and US EPA. The VISTAS RPO held a meeting on September 21, 2005 in Research Triangle Park, NC to discuss the Protocol with participants before starting a public comment period. The Protocol underwent formal external review during the period between September 26, 2005 and October 31, 2005. Numerous comments were received. All comments were carefully considered and discussed with VISTAS participants and federal partners. VISTAS gratefully acknowledges the very useful contributions of those that provided comments. On November 1st, 2005 VISTAS held another meeting with its participants in Nashville, TN to present and discuss the comments being considered for inclusion in the Protocol. No formal document will be prepared to address all the comments received on the Protocol.

Objectives

The objectives of the Protocol (discussed in Chapter 1) are to provide:

- A consistent approach to determine if a source is subject to BART
- A consistent model (CALPUFF) and modeling guidelines for BART determinations
- Clearly delineated modeling steps
- A common CALPUFF configuration
- Guidance for site-specific modeling
- Common expectations for reporting model results

The Protocol is not intended to define the engineering analyses required by the US EPA's BART Guidance, nor address model alternatives to the CALPUFF model, nor address emissions trading.

Chapter 2 is intended to provide summary background on EPA's guidance for BART modeling. The CALPUFF model system is reviewed in Chapter 3, while specific recommendations for applying the CALPUFF model for BART purposes appear in Chapter 4. Chapter 5 describes the specific information that should be included in site-specific protocols. Chapter 6 describes the quality assurance requirements for BART analyses in the VISTAS RPO.

Recommendations

The major recommendations for VISTAS BART modeling included in this Protocol are:

I. Process

Follow the BART process steps discussed in Chapter 2:

1. Identify BART eligible sources
2. Identify which pollutants have greater than *de minimis* emission levels
3. Identify sources that are subject to BART
4. Identify baseline visibility impact of each BART source
5. Identify feasible controls and emission changes
6. Identify the change in visibility impact for each candidate BART control option
7. Compare the visibility improvement of BART control options to other statutory factors in the engineering analysis

II. CALPUFF Model Configuration

Use the CALPUFF dispersion modeling system, as described in Chapter 4, to determine if a single source is subject to BART. VISTAS will use CALPUFF Version 5.754 and CALMET Version 5.7. These versions contain enhancements funded by the Minerals Management Service (MMS) and VISTAS. They were developed by Earth Tech, Inc. and are maintained on the CALPUFF website (www.src.com) for public access.

VISTAS is making publicly available 12-km CALMET output files for the entire VISTAS modeling domain (eastern United States) and intends to also provide CALMET output files for five 4-km grid subdomains covering the VISTAS states and VISTAS Class I areas. To create the CALMET input files, Earth Tech used the MM5 databases developed by EPA for 2001, VISTAS for 2002, and Midwest RPO for 2003. For the 12 km grid large domain covering the entire VISTAS region, Earth Tech used the No-Obs setting (i.e., did not include additional surface and upper air observations beyond those incorporated in the MM5 calculations). For finer resolution subdomains (4 km grid or less), available surface and upper air observations will be used in addition to MM5 meteorological model outputs. The specific model settings will be provided with the CALMET files and via the CALPUFF website so that users can review or replicate the work.

For CALPUFF modeling, source emissions should be defined using the maximum 24-hour actual emission rate during normal operation for the most recent 3 or 5 years. If maximum 24-hr actual emissions are not available, continuous emissions data, permit allowable emissions, potential emissions, and emissions factors from AP-42 source profiles may be used as available.

Key points from comments received on the specific CALPUFF, CALPOST, and POSTUTIL configurations are highlighted below.

- After running CALPUFF for an individual facility, repartition NO_3 in POSTUTIL.[1]
- Use ozone data from non-urban monitors as the background ozone input.
- Use the Pasquill-Gifford dispersion method.[2]

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[1] The original intent, as expressed in the Final VISTAS BART Modeling Protocol (22 December 2005) was to use CMAQ-derived background data for SO_2, NO_3 and NH_3 in POSTUTIL. After extensive discussion with the EPA and FLMs in early 2006, EPA did not approve the recommended approach so background gaseous concentrations from CMAQ 2002 modeling will not be provided by VISTAS for use in POSTUTIL. Rather the standard default NH_3 concentrations specified on page 14 of the IWAQM Phase 2 report (IWAQM, 1998) will be used.

[2] The Final VISTAS BART Modeling Protocol (Dec. 22, 2005) recommended using turbulence-based AERMOD dispersion methods, citing EPA's *Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rule.* 70 FR 68218-68261. 9 November 2005. Subsequently, EPA Region IV notified the VISTAS states that using turbulence-

- In CALPOST, use Method 6 with monthly average RH for calculating extinction, as recommended by the EPA.

- Use EPA default calculations of light extinction under current and natural background conditions. In addition to the default assumptions, a source may choose to also calculate visibility using the recently revised IMPROVE algorithm described by Pitchford, et al., (2005).

Provide results in tables as illustrated in Chapter 4 that describe, for each source:

- Number of receptors within a single Class I area with impact > 0.5 dv

- Number of days at all receptors in the Class I area with impact > 0.5 dv

- Number of Class I areas with impacts > 0.5 dv

III. CALPUFF Application for BART

For determining if a BART-eligible source is subject to BART CALPUFF modeling, use a two-tier approach. For the initial exemption modeling use CALPUFF with 12-km grid CALMET. For finer resolution of meteorological fields, use CALPUFF with CALMET of 4-km or smaller grid size.

VISTAS States are accepting EPA guidance that the threshold value to establish that a source contributes to visibility impairment is 0.5 deciview.

VISTAS States are using emissions (tons per year) divided by distance (km) from a Class I area boundary (Q/d) as a presumptive indicator that a BART-eligible source is subject to BART. If Q/d for SO_2 is greater than 10 for 2002 actual annual emissions, then the State presumes that the source is subject to BART and no exemption modeling will be performed using VISTAS funds. If the source agrees with this presumption, then the source can proceed to the BART determination using CALPUFF to evaluate impacts of control options and perform the engineering analyses. If a source disagrees, the source may perform fine grid modeling to determine if its impact is <0.5 dv.

For sources with Q/d less than or equal to 10, VISTAS intends to fund TRC Environmental Corp.[3] to assist States with the initial CALPUFF exemption modeling. Each State will prioritize which sources will be offered modeling by VISTAS. Modeling of these sources will be conducted in priority order to first accommodate States with nearer term timing constraints in their SIP development process. To conserve VISTAS resources, modeling will begin with sources at lower Q/d values and continue with sources with higher Q/d values until a Q/d value

based dispersion methods would be considered a non-guideline application of CALPUFF. Thus this Protocol has been revised to indicate Pasquill-Gifford dispersion coefficients should be used.

[3] In April 2006, Earth Tech's CALPUFF modeling staff became part of TRC Environmental Corporation. References to Earth Tech and to TRC in this protocol refer to the same technical staff, just at different times.

that consistently results in a greater than 0.5 dv impact is identified. Chapter 4 addresses the number of VISTAS sources eligible for BART based on Q/d analysis.

Note that VISTAS does not propose to use Q/d to exempt BART-eligible sources, but only to prioritize sources for modeling purposes. Thus this application is consistent with EPA guidance not to use Q/d for exemption purposes.

For the 12-km initial modeling exemption test, compare the highest single 24-hour average value across all receptors in the Class I area to the threshold value of 0.5 dv. If the highest 24-hr average value is below 0.5 dv at all Class I areas, then the source is not subject to BART. If the highest 24-hr average value is greater than 0.5 dv, then the source may choose to perform finer grid modeling for exemption purposes or may accept determination that the source is subject to BART and proceed to establish visibility impacts prior to and after BART controls. If using the single highest 24-hr average value proves, after initial 12-km grid CALPUFF modeling, to be too conservative a screening level, VISTAS may allow some exceedances of the threshold value for exemption purposes, up to no more than the 98^{th} percentile value.

The 12-km modeling results can be used to focus finer grid modeling for exemption purposes on only those Class I areas where impacts greater than 0.5 dv were projected in the 12-km modeling.

For finer grid (4 km or less) analyses, use the 98^{th} percentile impact value for the 24-hr average. Use either the 8^{th} highest day in each year or the 22^{nd} highest day in the 3-year period, whichever is more conservative, for comparison to the exemption threshold.

Use the same model assumptions for pre-BART visibility impact and for BART control options modeling: establish baseline visibility from the pre-BART run; change one control at a time; and evaluate the change in visibility impact, i.e. the delta-deciview. Note that “no control” may constitute BART.

Visibility impact is one of the five factors considered in the engineering analysis required under the USEPA BART guideline. If a source accepts to institute the most stringent control, the engineering analyses are not required.

This common VISTAS Protocol consistently recommends conservative assumptions. Individual States ultimately have responsibility to determine which, if any, BART controls are recommended in their State Implementation Plans (SIPs).

1. INTRODUCTION AND PROTOCOL OBJECTIVES

1.1 Background

Under regional haze regulations, the Environmental Protection Agency (EPA) has issued final guidelines dated July 6, 2005 for Best Available Retrofit Technology (BART) determinations (70 FR 39104-39172). The regional haze rule includes a requirement for BART for certain large stationary sources. Sources are BART-eligible if they meet three criteria including potential emissions of at least 250 tons per year of a visibility-impairing pollutant, were put in place between August 7, 1962 and August 7, 1977, and fall within one of the 26 listed source categories in the guidance. A BART engineering evaluation using five statutory factors -- 1) existing controls; 2) cost; 3) energy and non-air environmental impacts; 4) remaining useful life of the source; 5) degree of visibility improvement expected from the application of controls -- is 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. (Note that, depending on the five factors, the evaluation may result in no control.) Air quality modeling is an important tool available to the States to determine whether a source can be reasonably expected to contribute to visibility impairment in a Class I area.

Throughout this document the term "BART-eligible emission unit" is defined as any single emission unit that meets the criteria described above. A "BART-eligible source" is defined as the total of all BART-eligible emission units at a single facility. If a source has several emission units, only those that meet the BART-eligible criteria are included in the definition "BART-eligible source".

One of the listed categories is steam electric plants of more than 250 million BTU/hr heat input. To determine if such a plant has greater than 250 million BTU/hr heat input and is potentially subject to BART, the boiler capacities of all electric generating units (EGUs) should be added together regardless of construction date. In this category, electric generating sources greater than 750 MW have presumptive SO_2 and NO_x emission limits. States may presume the same limits for EGU sources between 250-750 MW. However, units at those sources constructed after the BART-eligibility dates are not subject to a BART engineering evaluation. EPA, in the Clean Air Interstate Rule (CAIR), determined that an EGU participating in the CAIR trading program satisfies the BART requirements for SO_2 and NO_x. VISTAS states are tentatively accepting this guidance. CAIR does not cover PM so EGUs would still need to evaluate impacts of PM if PM emissions are above *de minimis* values.

As illustrated in Table 1-1, as of December 5, 2005, VISTAS States had identified a total of 274 BART-eligible sources that fall into 20 of the 26 BART source categories. Of the 274 sources with BART-eligible units, 84 sources are utility EGUs and 190 are non-EGU industrial sources. (Note that these numbers are not final and are subject to slight adjustments and refinements.) No BART sources are located on Tribal lands.

Table 1-1. VISTAS BART Eligible Sources (not updated since December 2005)

State	Total Number of Sources	EGU Sources	Non-EGU Sources
AL	48	8	40
FL	50	23	27
GA	24	10	14
KY	29	12	17
MS	18	8	10
NC	16	5	11
SC	31	6	25
TN	13	2	11
VA	18	3	15
WV	26	7	19
Total	**273**	**84**	**189**

1.2 Objective of this Protocol

The objective of this VISTAS' BART Modeling Protocol is to describe common procedures for air quality modeling to support BART determinations that are consistent with the EPA guidelines. The protocol will serve as the basis for establishing a common understanding among the organizations who will be performing the BART analyses or reviewing the BART modeling results, including VISTAS State and Local air regulatory agencies, EPA, Federal Land Managers (FLMs), source operators, and contractors for the sources. This final protocol incorporates EPA final guidance and comments that were received on VISTAS' draft protocol[4] and provides additional description of modeling procedures. The original final protocol of 22 December 2005 has been revised since then to clarify items, resolve technical issues, and reflect decisions by the EPA and FLMs. This document is the third revision.

The VISTAS States have accepted EPA's guidance to use the CALPUFF modeling system to comply with the BART modeling requirements of the regional haze rule. A BART-eligible source will be required to submit a site-specific modeling protocol to the State for review and approval prior to performing CALPUFF modeling. States will consult with FLMs and the EPA when evaluating the site-specific BART protocols. The site-specific protocol will include the

[4] *Draft Protocol for the Application of the CALPUFF Model for Analyses of Best Available Retrofit Technology (BART). VISTAS*, March 22, 2005 and September 20, 2005.

source-specific data on source location, stack parameters, and emissions. The methods of the VISTAS common modeling protocol will be followed in the site-specific protocol unless the source proposes to the State, and the State approves, alternative methods or assumptions.

Each VISTAS State or Local agency retains responsibility for the specific procedures and processes it will follow in working with the BART sources under its jurisdiction, the FLMs, EPA, and public to determine BART controls for sources in the State. Nothing in the VISTAS process replaces States' responsibility to determine BART controls.

The remainder of this document describes the CALPUFF modeling system and the application of CALPUFF to two situations:

- Air quality modeling to determine whether a BART-eligible source is "subject to BART" and therefore the BART analysis process must be applied to its operations.
- Air quality modeling of emissions from sources that have been found to be subject to BART, to evaluate regional haze benefits of alternative control options and to document the benefits of the preferred option.

Chapters 2 and 3 of this document are intended to provide background information on EPA's guidance for BART analysis modeling and on the CALPUFF modeling system. Subsequent chapters include more specific recommendations. Chapter 2 of this document reviews EPA's guidance for regional haze BART analysis modeling, as outlined in the 6 July 2005 Federal Register notice. The CALPUFF model is the preferred model recommended by the EPA for BART modeling analyses and its characteristics and limitations are discussed in Chapter 3. The specific steps to determine whether a BART-eligible source is subject to BART and to evaluate BART controls are described in Chapter 4. The procedures include initial modeling of BART-eligible sources using CALPUFF run in a conservative mode with regional meteorological datasets. For sources determined to be subject to BART based on these first modeling analyses, further finer grid CALPUFF analyses would be performed. The model configuration for the common modeling protocol is described in Chapter 4. Details of the source-specific protocol are described in Chapter 5. A quality assurance plan is outlined in Chapter 6.

EPA's guidance allows for the use of appropriate alternative models, however VISTAS will not develop a protocol for alternative models. This protocol focuses on guidance for the application of the preferred CALPUFF modeling approach. If a source wants to use an alternative model in its BART demonstration, the source will need to submit a detailed written justification to the State for review and approval. The State will provide the documentation to the EPA and Federal Land Managers for their review.

Also, this protocol does not address a preferred modeling approach to demonstrate the effectiveness of an optional emissions cap and trade program. Such a cap and trade program is not required, but can be implemented in lieu of BART if desired by the VISTAS States. VISTAS

States are not pursuing a regional trading alternative under the proposed EPA trading guidance (70 FR 44154-44175) that is to be promulgated in 2006.

2. REVIEW OF EPA'S GUIDANCE FOR BART MODELING

The final guidance for regional haze BART determinations was published in the Federal Register on 6 July 2005 (70 FR 39104 to 39172). It prescribes the modeling approaches that are to be used for various stages of the BART analysis process.

This chapter provides a summary of EPA's guidance for BART modeling. It is not intended to provide a comprehensive review of the guidance. Nor does this chapter address specific recommendations for VISTAS' approach to CALPUFF BART modeling. Those recommendations appear in Chapter 4.

2.1 Overview of the Regional Haze BART Process

The process of establishing BART emission limitations consists of four steps:

1) 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 August 7, 1962 and August 7, 1977 in order to be BART-eligible. Finally, a source is eligible for BART if potential emissions of visibility-impairing air pollutants are greater than 250 tons per year. Qualifying pollutants include primary particulate matter (PM_{10}) and gaseous precursors to secondary fine particulate matter, such as SO_2 and NO_x. Whether ammonia or volatile organic compounds (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 be considered as primary $PM_{2.5}$ emissions and not VOCs for BART purposes.

(Note: If the source is subject to BART because one visibility impairing pollutant has potential emissions > 250 TPY, the State may determine that other visibility impairing pollutants are not subject to BART if their potential emissions are less than the *de minimis* levels (40 TPY for SO_2 and NO_x and 15 TPY of PM_{10} or $PM_{2.5}$. This assumes that the other BART-eligibility criteria are met.)

2) Determine 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. The preferred approach is an assessment with an air quality model such as CALPUFF 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.[5] The threshold to determine whether a single source "causes" visibility impairment is set at

[5] A recent draft settlement agreement with the EPA (to be published in the *Federal Register* for public comment) provides that a State has the discretion to decide whether annual average or 20% best natural conditions are to be used as the reference. This ruling resolves an ambiguity in EPA's BART guidance, where the BART guideline

1.0 deciview change from natural conditions over a 24-hour averaging period in the final BART rule (70 FR 39118). 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. The test against the threshold is "driven" by the contribution level, since if a source "causes", by definition it "contributes".

EPA recommends that the 98th percentile value from the modeling be compared to the contribution threshold of 0.5 deciviews (or a lower level set by a State) to determine if a source does not contribute to visibility impairment and therefore is not subject to BART. Whether or not the 98th percentile value exceeds the threshold must be determined at each Class I area. Over an annual period, this implies the 8th highest 24-hr value at a particular Class I area is compared to the contribution threshold. Over a 3-year modeling period, the 98th percentile value may be interpreted as the highest of the three annual 98th percentile values at a particular Class I area or the 22nd highest value in the combined three year record, whichever is more conservative.

Alternatively, States have the option of considering that all BART-eligible sources within the State are subject to BART and skipping the initial impact analysis. In rare cases, a State might be able to do exactly the opposite, and use regional modeling to conclude that all BART-eligible sources in the State do not cumulatively contribute to "measurable" visibility impairment in any Class I areas. Also, the States have an option to exempt individual sources based on model plant analysis conducted by EPA in finalizing the BART rule. Under this option, sources with potential emissions of SO_2 plus NO_x of less than 500 tons and a distance from any Class I area greater than 50 kilometers or sources with SO_2 plus NO_x potential emissions of less than 1000 tons and a distance from any Class I area greater than 100 kilometers can be exempted. PM emissions are not specifically addressed in the model plant analysis, but subsequent discussions with EPA staff indicate that PM may be considered along with SO_2 and NO_x, so that a plant could be exempted if the combined potential emissions of SO_2, NO_x, plus PM meet the criteria above.

3) Determine BART controls 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

text says "natural conditions" at 70 FR 39162, col. 3, while the preamble to the BART rule says "natural visibility baseline for the 20% best visibility days" at 70 FR 39125, col. 1.

e) The degree of improvement in visibility that may reasonably be anticipated to result from the use of such technology.

Note that if a source agrees to apply the most stringent controls available to BART-eligible units, the BART analysis is essentially complete and no further analysis is necessary (70 FR 39165).

4) Incorporate the BART determination into the State Implementation Plan for Regional Haze, which is due by December 2007.

Instead of applying BART on a source-by-source basis, a State (or a group of States) has the option of implementing an emissions trading program that is designed to achieve regional haze improvements that are greater than the visibility improvements that could be expected from BART. If the geographic distributions of emissions under the two approaches are similar, determining whether trading is "better than BART" may be possible by simply comparing emissions expected under the trading program against the emissions that could be expected if BART was applied to eligible sources. If the geographic distributions of emissions are likely to be different, however, air quality modeling comparing the expected improvements in visibility from the trading program and from BART would be required. (See the proposed BART Alternative rule, at 70 FR 44160.) EPA suggests that regional modeling using a photochemical grid model may be more appropriate than CALPUFF for this purpose.

Note that EPA has indicated in the BART rule (70 FR 39138-39139) that emissions reductions under the Clean Air Interstate Rule (CAIR) meet the BART requirement for SO_2 and NO_x control for those EGUs subject to BART. However, PM emissions from EGUs are not addressed by CAIR and therefore a BART analysis may still be required for PM.

2.2 Model Recommendations for the BART Analysis

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 as "the best regulatory modeling application currently available for predicting a single source's contribution to visibility impairment" (70 FR 39162). The use of another "appropriate model" is allowed although the EPA prefers the use of CALPUFF. If a source wants to use an alternative model, the source needs to submit a written justification and source-specific modeling protocol to its State for review and approval. As part of the consultation process, the State will provide documentation to EPA and FLM.

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 PLUVUE-II plume visibility model is mentioned as a possible model to consider instead of CALPUFF for a source within less than 50 km of a Class I area.

The EPA guidance notes that "regional scale photochemical grid models may have merit, but such models have been designed to assess cumulative impacts, not impacts from individual sources" and

they are "very resource intensive and time consuming relative to CALPUFF", but States may consider their use for SIP development in the future as they may be adapted and "demonstrated to be appropriate for single source applications" (70 FR 39123). Photochemical grid models may be 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 (70 FR 39163).

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).

In the BART modeling analyses the EPA recommends that the State use the highest 24-hour average actual emission rate for the most recent three to five-year period of record. Emissions on days influenced by periods of start-up, shutdown and malfunction are not to be considered in determining the appropriate emission rates. (70 FR 39129).

If a source is found 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. Visibility improvements may be evaluated on a pollutant-specific basis in the BART determination (70 FR 39129).

For evaluating the improvement in visibility resulting from the application of BART, the EPA guidelines state that States are "encouraged to account for the magnitude, frequency, and duration of the contributions to visibility impairment caused by the source based on the natural variability of meteorology" (70 FR 39129).

2.3 Performance of a Cap and Trade Program

If a State or States elect to pursue an optional cap and trade program, they are required to demonstrate greater "reasonable progress" in reducing haze than would result if BART were applied to the same sources. In some cases, a State may simply be able to demonstrate that a trading program that achieves greater progress at reducing emissions will also achieve greater progress at reducing haze. Such would be the case if the likely geographic distribution of emissions under the trading program would not be greatly different from the distribution if BART was in place.

If the expected distribution of emissions is different under the two approaches, then "dispersion modeling" of all sources must be used to determine the difference in visibility at each impacted Class I area, in order to establish that the optional trading program will result in visibility improvements aggregated over all Class I areas that are "better than BART" (70 FR 39137-39138). The BART guidance does not specify the method to be used for this modeling. From a technical perspective, either applying CALPUFF to every source or using a regional photochemical model would satisfy the need.

A rulemaking procedure is currently underway to establish final guidance for such alternatives to BART (70 FR 44154-44175). The rule is expected to be finalized in 2006.

3. OVERVIEW OF THE CALPUFF MODELING SYSTEM

This chapter contains a general description of the CALPUFF modeling system and its capabilities and limitations. It does not include specific recommendations regarding the use of the model for BART analysis in the VISTAS region. These specific recommendations can be found in Chapter 4.

3.1 Capabilities and features of CALPUFF

The CALPUFF modeling system (Scire et al., 2000a, b) is recommended as the preferred modeling approach for use in the BART analyses. CALPUFF and its meteorological model, CALMET, are designed to handle the complexities posed by the complex terrain, the large source-receptor distances, chemical transformation and deposition, and other issues related to Class I visibility impacts. The CALPUFF modeling system has been adopted by the EPA as a *Guideline Model* for source-receptor distances greater than 50 km, and for use on a case-by-case basis in complex flow situations for shorter distances (68 FR 18440-18482). CALPUFF is recommended for Class I impact assessments by the Federal Land Managers Workgroup (FLAG 2000) and the Interagency Workgroup on Air Quality Modeling (IWAQM) (EPA 1998). The final BART guidance recommends CALPUFF as "the best modeling application available for predicting a singe source's contribution to visibility impairment" (70 FR 39122). As a result of these recommendations, the VISTAS modeling protocol is based on the use of CALPUFF for its BART determinations.

The main components of the CALPUFF modeling system are shown in Figure 3-1. CALMET is a diagnostic meteorological model that is used to drive the CALPUFF dispersion model. It produces three-dimensional wind and temperature fields and two-dimensional fields of mixing heights and other meteorological fields. It contains slope flow effects, terrain channeling, and kinematic effects of terrain. CALMET includes special algorithms for treating the overwater boundary layer and coastal interaction effects. CALMET can use meteorological observational data and/or three-dimensional output from prognostic numerical meteorological models such as MM5 (Grell et al., 1995) or RUC (Benjamin et al., 2004) in the developments of its fine-scale meteorological fields.

CALPUFF is a non-steady-state Lagrangian puff transport and dispersion model that advects Gaussian puffs of multiple pollutants from modeled sources. CALPUFF's algorithms have been designed to be applicable on spatial scales from a few tens of meters to hundreds of kilometers from a source. It includes algorithms for near-field effects such as building downwash, stack tip downwash and transitional plume rise as well as processes important in the far-field such as chemical transformation, wet deposition, and dry deposition. CALPUFF contains an option to allow puff splitting in the horizontal and vertical directions, which extends the distance range of the model. The primary outputs from CALPUFF are hourly concentrations and hourly deposition fluxes evaluated at user-specified receptor locations.

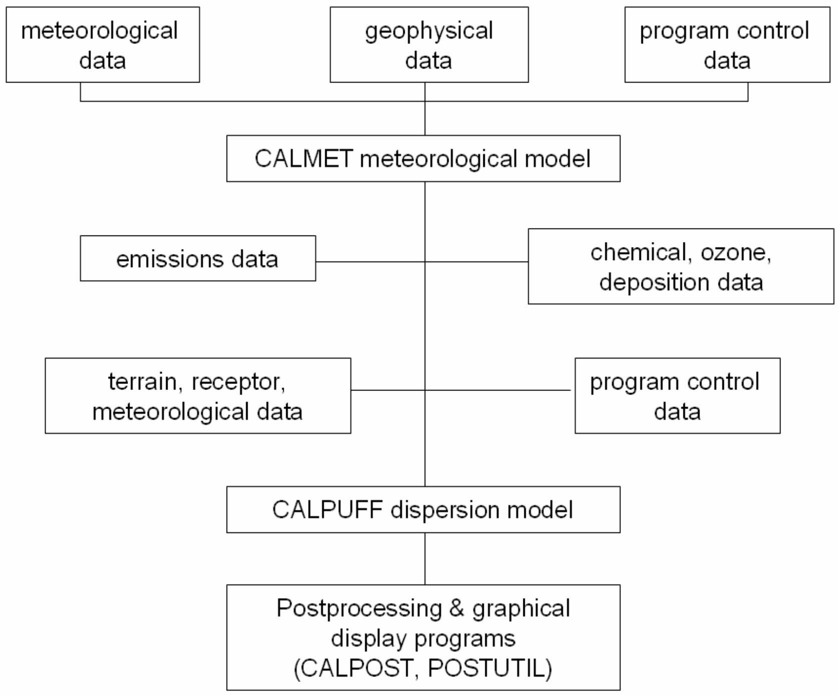

Figure 3-1. CALPUFF modeling system components.

A set of postprocessing programs associated with CALPUFF computes visibility effects and allows cumulative source impacts to be assessed, including potential non-linear effects of ammonia limitation on nitrate formation. The CALPOST postprocessor contains several options for computing change in extinction and deciviews for visibility assessments. The POSTUTIL postprocessor includes options for summing contributions of individual sources or groups of sources to assess cumulative impacts. POSTUTIL also contains CALPUFF's nitric acid-nitrate chemical equilibrium module, which allows the cumulative effects of ammonia consumption by background sources to be assessed in the postprocessor. In addition, the combination of CALPUFF and POSTUTIL allows the effects of source emissions of ammonia to be incrementally added to background ammonia levels when determining nitrate formation.

The rest of this chapter summarizes the capabilities and features of the CALPUFF modeling components in more detail.

3.1.1 *Major Features of CALMET*

The CALMET meteorological model consists of a diagnostic wind field module and micrometeorological modules for overwater and overland boundary layers. When modeling a large geographical area, as would be necessary for the regional VISTAS domain, the user has the option to use a Lambert Conformal Projection coordinate system to account for Earth's curvature.

The major features and options of the meteorological model are summarized in Table 3-1. The techniques used in the CALMET model are briefly described below.

Table 3-1. Major Features of the CALMET Meteorological Model

- **Boundary Layer Modules of CALMET**
  - Overland Boundary Layer - Energy Balance Method
  - Overwater Boundary Layer - Profile Method
    - -- COARE algorithm
    - -- OCD-based method
  - Produces Gridded Fields of:
    - -- Surface Friction Velocity
    - -- Convective Velocity Scale
    - -- Monin-Obukhov Length
    - -- Mixing Height
    - -- PGT Stability Class
    - -- Air Temperature (3-D)
    - -- Precipitation Rate

- **Diagnostic Wind Field Module of CALMET**
  - Slope Flows
  - Kinematic Terrain Effects
  - Terrain Blocking Effects
  - Divergence Minimization
  - Produces Gridded Fields of U, V, W Wind Components
  - Inputs Include Domain-Scale Winds, Observations, and (optionally) Coarse-Grid Prognostic Model Winds
  - Lambert Conformal Projection Capability

CALMET Boundary Layer Models

The CALMET model contains two boundary layer models for application to overland and overwater grid cells.

Overland Boundary Layer Model: Over land surfaces, the energy balance method of Holtslag and van Ulden (1983) is used to compute hourly gridded fields of the sensible heat flux, surface

friction velocity, Monin-Obukhov length, and convective velocity scale. Mixing heights are determined from the computed hourly surface heat fluxes and observed temperature soundings using a modified Carson (1973) method based on Maul (1980). The model also determines gridded fields of Pasquill-Gifford-Turner (PGT) stability class and hourly precipitation rates.

Overwater Boundary Layer Model: The aerodynamic and thermal properties of water surfaces suggest that a different method is best suited for calculating the boundary layer parameters in the marine environment. A profile technique, using air-sea temperature differences, is used in CALMET to compute the micro-meteorological parameters in the marine boundary layer. The version of CALMET being used by VISTAS contains improvements in the overwater boundary layer parameterizations (Fairall et al., 2003) based on the Coupled Ocean Atmosphere Response Experiment (COARE) and enhancements in the calculation of overwater mixed layer heights (Batchvarova and Gryning, 1991, 1994). Further details and the results of an evaluation of the model containing these enhancements are described in Scire et al. (2005). An upwind-looking spatial averaging scheme is optionally applied to the mixing heights and three-dimensional temperature fields in order to account for important advective effects.

Diagnostic Wind Field Module

The diagnostic wind field module uses a two-step approach to the computation of the wind fields (Douglas and Kessler, 1988). In the first step, an initial-guess wind field is adjusted for kinematic effects of terrain, slope flows, and terrain blocking effects to produce a Step 1 wind field. Gridded MM5 can be used to define the initial guess field. The second step consists of an objective analysis procedure to introduce observational data into the Step 1 wind field to produce a final wind field.

Step 1 Wind Field. Development of the Step 1 wind field begins with the initial guess field defined by the MM5 prognostic meteorological model. Normally, the CALMET computational domain is specified to be at finer grid resolution than the MM5 dataset used to initialize the initial guess field. For example, 36-km MM5 data available for VISTAS modeling may be used to develop the initial guess field on a 12-km or even a 1-km CALMET grid. The Step 1 algorithms in CALMET described below apply terrain adjustments to the initial guess field on the fine-scale CALMET grid. Thus, the CALMET winds are adjusted to respond to fine-scale terrain features not necessarily seen by the coarser scale MM5 model.

Kinematic Effects of Terrain: The approach of Liu and Yocke (1980) is used to evaluate the effects of the terrain on the wind field. The initial guess field winds are used to compute a terrain-forced vertical velocity, subject to an exponential, stability-dependent decay function. The effects of terrain on the horizontal wind components are evaluated by applying a divergence-minimization scheme to the initial guess wind field. The divergence minimization scheme is applied iteratively until the three-dimensional divergence is less than a threshold value.

Slope Flows: The original slope flow algorithm in CALMET has been upgraded (Scire and Robe, 1997) based on the shooting flow algorithm of Mahrt (1982). This scheme includes both

advective-gravity and equilibrium flow regimes. At night, the slope flow model parameterizes the flow down the sides of the valley walls into the floor of the valley, and during the day, upslope flows are parameterized. The magnitude of the slope flow depends on the local surface sensible heat flux and local terrain gradients. The slope flow wind components are added to the wind field adjusted for kinematic effects.

Blocking Effects: The thermodynamic blocking effects of terrain on the wind flow are parameterized in terms of the local Froude number (Allwine and Whiteman, 1985). If the Froude number at a particular grid point is less than a critical value and the wind has an uphill component, the wind direction is adjusted to be tangent to the terrain.

Step 2 Wind Field. The wind field resulting from the above adjustments of the initial-guess wind is the Step 1 wind field. The second step of the procedure may involve introduction of observational data into the Step 1 wind field through an objective analysis procedure. An inverse-distance squared interpolation scheme is used which weights observational data heavily in the vicinity of the observational station, while the Step 1 wind field dominates the interpolated wind field in regions with no observational data. The resulting wind field is subject to smoothing, an optional adjustment of vertical velocities based on the O'Brien (1970) method, and divergence minimization to produce a final Step 2 wind field.

The introduction of observational data in the Step 2 calculation is an option. It is also possible to run the model in "no observations" (No-Obs) mode, which involves the use only of MM5 gridded data for the initial guess field followed by fine-scale terrain adjustments by CALMET. In No-Obs mode, observational data are not used in the Step 2 calculations. The No-Obs mode is appropriate when the MM5 simulations adequately characterize the regional wind patterns and when local observations, especially surface observations, reflect local conditions on a scale smaller than that of the CALMET domain and hence their spatial representativeness may be limited. Such situations are most likely to occur when the CALMET grid scale is relatively large i.e., coarser than the scale of variation of the true wind field, which is particularly likely to occur in complex terrain or along the seashore,

3.1.2 Major Features of CALPUFF

By its puff-based formulation and through the use of three-dimensional meteorological data developed by the CALMET meteorological model, CALPUFF can simulate the effects of time- and space-varying meteorological conditions on pollutant transport from sources in complex terrain. The major features and options of the CALPUFF model are summarized in Table 3-2 at the end of this subsection. Some of the technical algorithms are briefly described below.

Complex Terrain: The effects of complex terrain on puff transport are derived from the CALMET winds. In addition, puff-terrain interactions at gridded and discrete receptor locations are simulated using one of two algorithms that modify the puff-height (either that of ISCST3 or a general "plume path coefficient" adjustment), or an algorithm that simulates enhanced vertical dispersion derived from the weakly-stratified flow and dispersion module of the Complex Terrain

Dispersion Model (CTDMPLUS) (Perry et al., 1989). The puff-height adjustment algorithms rely on the receptor elevation (relative to the elevation at the source) and the height of the puff above the surface. The enhanced dispersion adjustment relies on the slope of the gridded terrain in the direction of transport during the time step.

Subgrid Scale Complex Terrain (CTSG): An optional module in CALPUFF, CTSG treats terrain features that are not resolved by the gridded terrain field, and is based on the CTDMPLUS (Perry et al., 1989). Plume impingement on subgrid-scale hills is evaluated at the CTSG subgroup of receptors using a dividing streamline height (H_d) to determine which pollutant material is deflected around the sides of a hill (below H_d) and which material is advected over the hill (above H_d). The local flow (near the feature) used to define H_d is taken from the gridded CALMET fields. As in CTDMPLUS, each feature is modeled in isolation with its own set of receptors.

Puff Sampling Functions: A set of accurate and computationally efficient puff sampling routines is included in CALPUFF, which solve many of the computational difficulties encountered when applying a puff model to near-field releases. For near-field applications during rapidly-varying meteorological conditions, an elongated puff (slug) sampling function may be used. An integrated puff approach may be used during less demanding conditions. Both techniques reproduce continuous plume results under the appropriate steady state conditions.

Building Downwash: The Huber-Snyder and Schulman-Scire downwash models are both incorporated into CALPUFF. An option is provided to use either model for all stacks, or make the choice on a stack-by-stack and wind sector-by-wind sector basis. Both algorithms have been implemented in such a way as to allow the use of wind direction specific building dimensions. The PRIME building downwash model (Schulman et al., 2000) is also included in CALPUFF as an option.

Dispersion Coefficients: Several options are provided in CALPUFF for the computation of dispersion coefficients, including the use of turbulence measurements (σ_v and σ_w), the use of similarity theory to estimate σ_v and σ_w from modeled surface heat and momentum fluxes, or the use of Pasquill-Gifford (PG) or McElroy-Pooler (MP) dispersion coefficients, or dispersion equations based on the CTDM. Options are provided to apply an averaging time correction or surface roughness length adjustments to the PG coefficients. In version 5.754 of CALPUFF being used by VISTAS, an option is provided to use the AERMOD turbulence profiles for determining dispersion rates, which is the most recent approach to dispersion in EPA-approved regulatory modeling. In addition, turbulence advection is included. For additional details on these features, see Scire et al. (2005).

Overwater and Coastal Interaction Effects: Because the CALMET meteorological model contains both overwater and overland boundary layer algorithms, the effects of water bodies on plume transport, dispersion, and deposition can be simulated with CALPUFF. The puff formulation of CALPUFF is designed to handle spatial changes in meteorological and dispersion conditions, including the abrupt changes that occur at the coastline of a major body of water.

Dry Deposition: A resistance model is provided in CALPUFF for the computation of dry deposition rates of gases and particulate matter as a function of geophysical parameters, meteorological conditions, and pollutant species. For particles, source-specific mass distributions may be provided for use in the resistance model. Of particular interest for BART analyses is the ability to separately model the deposition of fine particulate matter (< 2.5 µm diameter) from coarse particulate matter (2.5-10 µm diameter).

Wind Shear Effects: CALPUFF contains an optional puff splitting algorithm that allows vertical wind shear effects across individual puffs to be simulated. Differential rates of dispersion and transport among the "new" puffs generated from the original, well-mixed puff can substantially increase the effective rate of horizontal spread of the material. Puffs may also be split in the horizontal when the puff size becomes large relative to the grid size, to account for wind shear across the puffs.

Wet Deposition: An empirical scavenging coefficient approach is used in CALPUFF to compute the depletion and wet deposition fluxes due to precipitation scavenging. The scavenging coefficients are specified as a function of the pollutant and precipitation type (i.e., frozen vs. liquid precipitation).

Chemical Transformation: CALPUFF includes options for parameterizing chemical transformation effects using the five species scheme (SO_2, $SO_4^=$, NO_x, HNO_3, and NO_3^-) employed in the MESOPUFF II model or a set of user-specified, diurnally-varying transformation rates. The MESOPUFF II scheme is recommended by IWAQM. It produces secondary fine particulate matter (sulfate and nitrate) from emissions of SO_2 and NO_x and thus allows analyses of visibility impacts. Ambient ozone concentrations are used in the parameterized chemical transformation module as a surrogate for OH radicals during daylight hours. Ambient ammonia concentrations are used together with a temperature and relative humidity-dependent equilibrium relationship to partition nitric acid and nitrate on an hour-by-hour and receptor-by-receptor basis.

Table 3-2. Major Features of the CALPUFF Dispersion Model

- **Source types**
  - Point sources (constant or variable emissions)
  - Line sources (constant or variable emissions)
  - Volume sources (constant or variable emissions)
  - Area sources (constant or variable emissions)

- **Non-steady-state emissions and meteorological conditions**
  - Gridded 3-D fields of meteorological variables (winds, temperature)
  - Spatially-variable fields of mixing height, friction velocity, convective velocity scale, Monin-Obukhov length, precipitation rate
  - Vertically and horizontally-varying turbulence and dispersion rates
  - Time-dependent source and emissions data for point, area, and volume sources
  - Temporal or wind-dependent scaling factors for emission rates, for all source types

- **Interface to the Emissions Production Model (EPM)**
  - Time-varying heat flux and emissions from controlled burns and wildfires

- **Efficient sampling functions**
  - Integrated puff formulation
  - Elongated puff (slug) formulation

- **Dispersion coefficient (σ_y, σ_z) options**
  - Direct measurements of σ_v and σ_w
  - Estimated values of σ_v and σ_w based on similarity theory
    - -- AERMOD turbulence profiles
    - -- Original turbulence profiles
  - Pasquill-Gifford (PG) dispersion coefficients (rural areas)
  - McElroy-Pooler (MP) dispersion coefficients (urban areas)
  - CTDM dispersion coefficients (neutral/stable)

- **Vertical wind shear**
  - Puff splitting
  - Differential advection and dispersion

- **Plume rise**
  - Buoyant and momentum rise
  - Stack tip effects
  - Building downwash effects
  - Partial penetration
  - Vertical wind shear

- **Building downwash**
  - Huber-Snyder method
  - Schulman-Scire method
  - PRIME method

- **Complex terrain**
  - Steering effects in CALMET wind field
  - Optional puff height adjustment: ISC3 or "plume path coefficient"
  - Optional enhanced vertical dispersion (neutral/weakly stable flow in CTDMPLUS)

Table 3-2. Major Features of the CALPUFF Dispersion Model (Cont'd)

- **Subgrid scale complex terrain (CTSG option)**
  - Dividing streamline, H_d, as in CTDMPLUS:
    - Above H_d, material flows over the hill and experiences altered diffusion rates
    - Below H_d, material deflects around the hill, splits, and wraps around the hill

- **Dry Deposition**
  - Gases and particulate matter
  - Three options:
    - Full treatment of space and time variations of deposition with a resistance model
    - User-specified diurnal cycles for each pollutant
    - No dry deposition

- **Overwater and coastal interaction effects**
  - Overwater boundary layer parameters (COARE algorithm or OCD-based method)
  - Abrupt change in meteorological conditions, plume dispersion at coastal boundary
  - Plume fumigation

- **Chemical transformation options**
  - Pseudo-first-order chemical mechanism for SO_2, $SO_4^=$, NO_x, HNO_3, and NO_3^- (MESOPUFF II method)
  - Pseudo-first-order chemical mechanism for SO_2, $SO_4^=$, NO, NO_2, HNO_3, and NO_3^- (RIVAD/ARM3 method)
  - User-specified diurnal cycles of transformation rates
  - No chemical conversion

- **Wet Removal**
  - Scavenging coefficient approach
  - Removal rate a function of precipitation intensity and precipitation type

3.1.3 Major Features of Postprocessors (CALPOST and POSTUTIL)

The two main postprocessors of interest for BART applications are the CALPOST and POSTUTIL programs. CALPOST is used to process the CALPUFF outputs, producing tabulations that summarize the results of the simulations, identifying, for example, the highest and second-highest hourly-average concentrations at each receptor. When performing visibility-related modeling, CALPOST uses concentrations from CALPUFF to compute light extinction and related measures of visibility (haze index in deciviews), reporting these for a 24-hour averaging time.

The CALPOST processor contains several options for evaluating visibility impacts, including the method described in the BART guidance, which uses monthly average relative humidity values. CALPOST contains implementations of the IWAQM-recommended and FLAG-recommended visibility techniques and additional options to evaluate the impact of natural weather events (fog, rain and snow) on background visibility and visibility impacts from modeled sources.

The POSTUTIL processor is a program that allows the cumulative impacts of multiple sources from different simulations to be summed, can compute the difference between two sets of

predicted impacts (useful for evaluating the benefits of BART controls), and contains a chemistry module to evaluate the equilibrium relationship between nitric acid and nitrate aerosols. This capability allows the potential non-linear effects of ammonia scavenging by sulfate and nitrate sources to be evaluated in the formation of nitrate from an individual source. CALPUFF makes the full ambient ammonia concentration available to each puff without regard for any scavenging by other puffs. POSTUTIL corrects for such scavenging when the puffs generated by the CALPUFF model overlap, as could be the case for a single source when the wind speed is low, or when nitrate formation is to be attributed to each of several sources that are in a cluster and whose plumes overlap,

POSTUTIL will also compute the impacts of individual sources or groups of sources on sulfur and nitrogen deposition into aquatic, forest and coastal ecosystems. The postprocessor allows the changes in deposition fluxes resulting from changes in emissions to be quantified. For example the output of POSTUTIL and CALPOST can be used as input into an Acid Neutralizing Capacity (ANC) analysis, or for comparison to Deposition Analysis Thresholds (DATs).

3.2 Discussion of CALPUFF Applicability and Limitations

3.2.1 Transport and Diffusion

According to the IWAQM Phase 2 report (page 18), "CALPUFF is recommended for transport distances of 200 km or less. Use of CALPUFF for characterizing transport beyond 200 to 300 km should be done cautiously with an awareness of the likely problems involved."[6]

IWAQM's 200-km limitation derives from the observation that, when compared to the data of the Cross Appalachian Tracer Experiment (CAPTEX), the basic configuration of CALPUFF overestimated inert tracer concentrations by factors of 3 to 4 at receptors that were 300 to 1000 km from the source. The apparent reason was insufficient horizontal dispersion of the simulated plume, presumably because an actual large plume does not remain coherent in the presence of vertical wind shears that typically occur, especially during the night, and of horizontal wind shears over the large puffs that arise over long transport distances.

To better represent such situations, an optional puff splitting algorithm has since been added to CALPUFF to simulate wind shear effects across a well-mixed individual puff by dividing the puff horizontally and vertically into two or more pieces. Differential rates of transport among the new puffs thus generated can increase the horizontal spread of the material in the plume due to vertical wind speed shear and wind direction shear. The horizontal puff splitting algorithm is

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[6] The IWAQM presentation at EPA's 6th Modeling Conference provides the background for this recommendation: "The IWAQM concludes that CALPUFF be recommended as providing unbiased estimates of concentration impacts for transport distances of order 200 km and less, and for transport times of order 12 hours or less. For larger transport times and distances, our experience thus far is that CALPUFF tends to underestimate the horizontal extent of the dispersion and hence tends to overestimate the surface-level concentration maxima. This does not preclude the use of CALPUFF for transport beyond 300 km, but it does suggest that results in such instances be used cautiously and with some understanding." (From page D-12 of the IWAQM Phase 2 report.)

designed to allow large puffs that may grow to be several grid cells or more in size to split into smaller puffs that can then more accurately respond to variations in the local wind field across the original large puff. This will also tend to increase horizontal dispersion of the plume. Since the creation of additional puffs via puff splitting will increase the computational requirements of the model, possibly substantially, puff splitting is not enabled by default, but can be turned on at the option of the user. Puff splitting may be appropriate for transport distances over 200 to 300 km, or possibly over shorter distances in complex terrain.

Turning to the shorter distance end of the transport range, the CALPUFF section of Appendix A of the *Guideline on Air Quality Models* (40 CFR 51, Appendix W) states, “CALPUFF is intended for use on scales from tens of meters from a source to hundreds of kilometers.” This is supported by the IWAQM Phase 2 report, which indicates that the diffusion algorithms in CALPUFF were designed to be suitable for both short and long distances. In this regard, CALPUFF does contain algorithms for such near-field effects as plume rise, building downwash, and terrain impingement and includes routines that deal with the computational difficulties encountered when applying a puff model in the field near to a source.

The recommendations for regulatory use in Appendix A of the *Guideline on Air Quality Models* state, “CALPUFF is appropriate for long range transport (source-receptor distance of 50 to several hundred kilometers)”, but provisions for using CALPUFF in the near-field in “complex flow” situations are also included in the regulatory guidance. Complex flow situations may include complex terrain, coastal areas, situations where plume fumigation is likely, and areas where stagnation, flow reversals, recirculation or spatial variability in wind fields (e.g., as due to changes in valley orientation) are important.

The tracer studies with which CALPUFF transport and diffusion capabilities were evaluated in the IWAQM Phase 2 report were generally over distances greater than 50 km. More recently, additional studies of model performance have been performed at shorter distances, including at a power plant in New York state in complex terrain (at source-receptor distances of 2 to 8.5 km) and a second power plant in Illinois in simple terrain (at source-receptor distances in arcs ranging from 0.5 km to 50 km from the stack) (Strimaitis et al., 1998). Other CALPUFF evaluation studies over short-distances include ones by Chang et al. (2001) and Morrison et al. (2003). These studies demonstrate good model performance over source-receptor distances from a few hundred meters to 50 km.

An important factor in the performance of CALPUFF is the choice of dispersion coefficients. The EPA has defined the "regulatory default" option in CALPUFF to allow either Pasquill-Gifford (PG) or turbulence-based dispersion coefficients. CALPUFF has been evaluated and shown to perform better using turbulence-based dispersion for tall stacks (Strimaitis et al, 1998). CALPUFF with turbulence-based dispersion has also been evaluated for overwater transport and coastal situations (Scire et al., 2005). In many other studies, including AERMOD evaluation studies conducted by EPA, the use of PG-dispersion, or more specifically the lack of a convective probability density function (pdf) module, has been demonstrated to result in underprediction of peak concentrations.

In November 2005, EPA approved the AERMOD model, which relies on turbulence-based dispersion, as a regulatory Guideline Model[7]. The ISCST3 model and its PG dispersion coefficients are being phased out as an acceptable regulatory approach. However, EPA Region IV has indicated that the application of turbulence-based dispersion coefficients in CALPUFF needs to be further demonstrated before they are approved for BART application. They will consider accepting the use of turbulence dispersion coefficients on a case-by-case basis for sources that are close to Class I areas.

For regional haze light extinction calculations, use of a plume-simulating model such as CALPUFF is appropriate only when the plume is sufficiently diffuse that it is not visually discernible as a plume *per se*, but nevertheless its presence could alter the visibility through the background haze. The IWAQM Phase 2 report states that such conditions occur starting 30 to 50 km from a source. In this light, the BART guidance strongly recommends using CALPUFF for source-receptor distances greater than 50 km but also presents CALPUFF as an option that can be considered for shorter transport distances.

As discussed above, there do not appear to be any scientific reasons why CALPUFF cannot be used for even shorter transport distances than 30 km, though, as long as the scale of the plume is larger than the scale of the output grid so that the maximum concentrations and the width of the plume are adequately represented and so that the sub-grid details of plume structure can be ignored when estimating effects on light extinction. The standard 1-km output grid that has been established for Class I area analyses should serve down to source-receptor distances somewhat under 30 km; how much closer than 30 km will depend on the topography and meteorology of the area and should be evaluated on a case-by-case basis. For extremely short transport distances, depiction of the concentration distribution will require a grid that is finer than 1 km. (For reference, the width of a Gaussian plume, $2\sigma_y$, is roughly 1 km after 10 km of travel distance, assuming Pasquill-Gifford dispersion rates under neutral conditions.)

As an additional consideration, if the plume width is small compared to the visual range, the atmospheric extinction along a typical sight path of tens of kilometers through the plume will be inhomogeneous and the simple CALPOST point estimate of regional light extinction at a receptor point will not be correct. However, the effect of averaging light extinction estimates for 24 hours, during which the plume location shifts over various receptor points, is likely to mitigate this problem to some degree and suggests that using CALPUFF at distances under 30 km will often be appropriate. For the narrow plumes that result from short transport distances, though, the modeled peak 24-hr average extinction at a receptor will tend to overstate the effect of the source on regional haze.

[7] *Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rule.* 70 FR 68218-68261. 9 November 2005.

The U.S. EPA has suggested that the plume visibility model, PLUVUE-II, could be used in lieu of CALPUFF for simulating visibility effects at such short distances.[8] PLUVUE-II is a Gaussian model that simulates the dispersion, chemical conversion, and optical effects of emissions of particles, SO_2, and NO_x from a single source. Its outputs include the discoloration of the sky by the plume (so called "plume blight") and the effect of the plume on visibility along user-selected sight paths that pass through the plume. The impacts of the plume on visibility depend not only on the plume composition, but also on the sight path chosen and its direction relative to the axis of the plume and the location of the sun. It isn't clear how such sight-path dependent results could be compared to the 0.5 and 1.0 deciview thresholds in the BART guidance. Since CALPUFF is designed to be useful for short transport distances (with features such as the simulation of plume downwash caused by structures at the source), CALPUFF seems more appropriate than PLUVUE-II for evaluating source impact at short distances for BART assessment purposes.

3.2.2 Aerosol Constituents

Primary $PM_{2.5}$

Appendix A of the *Guideline on Air Quality Models* (40 CFR 51, Appendix W) states that CALPUFF can treat primary pollutants such as PM_{10}. In actuality, CALPUFF can simulate PM_{10} or $PM_{2.5}$ or some other size range, because the assumed size distribution of the particles is a user input. The smaller the particles, the more they disperse like an inert gas. In most cases, the dispersion of inert $PM_{2.5}$ particles will be only minutely different from that of an inert gas, but the behavior of larger particles will differ.

A particularly important contributor to PM concentrations is the rate of deposition to the surface. $PM_{2.5}$ particles, which have a mass median diameter around 0.5 µm, have an average net deposition velocity of about 1 cm/min (or about 14 m/day) and thus the deposition of fine particles is usually not significant except for ground-level emissions. On the other hand, coarse particles (those PM_{10} particles larger than $PM_{2.5}$) have an average deposition velocity of more than 1 m/min (or 1440 m/day), which is significant, even for emissions from elevated stacks.

CALPUFF includes parametric representations of particle and gas deposition in terms of atmospheric, deposition layer, and vegetation layer "resistances" and, for particles, the gravitational settling speed. Gravitational settling, which is of particular importance for the coarse fraction of PM_{10}, is accounted for in the calculation of the deposition velocity. Effects of inertial impaction (important for the upper part of the PM_{10} distribution) and Brownian motion (important for small, sub-micron particles) and wet scavenging are also addressed. The BART guidance recommends that fine particulate matter (less than 2.5 µm diameter), which has higher light extinction efficiency than coarse particulate matter (2.5-10 µm diameters), should be treated separately in the model. CALPUFF allows for user-specified size categories to be treated as

[8] However, for the reasons given in this paragraph, VISTAS does not recommend PLUVUE-II for BART application

separate species, which includes calculating size-specific dry deposition velocities for each size category.

A primary $PM_{2.5}$ emission from coal-fired electric generating units (EGUs) that is of relevance to visibility calculations is that of primary sulfate. Although primary sulfate emissions account for only a small fraction of the total sulfur emissions from such sources, it may be important to simulate their effect with CALPUFF, especially at shorter distances before significant formation of secondary sulfate conversion from SO_2 has taken place.

Sulfur Dioxide and Secondary Particulate Sulfate

The MESOPUFF-II chemistry algorithm used in CALPUFF[9] simulates the gas phase oxidation of sulfur dioxide to sulfate by a linear transformation rate that was developed using regression relationships derived from the analysis of chemical conversion rates produced by a complex photochemical box model (see Scire et al., 1984, for a description of the development of the chemical module). As in all empirically-derived models, the relationships are based on easily-computed or observed parameters that are used as surrogates for the factors that control SO_2 oxidation.

The surrogate factors included in the parameterized chemistry during the daytime hours include solar radiation intensity, ambient ozone concentration, and atmospheric stability class. For example, gas phase SO_2 oxidation is a function of OH radical concentrations. Ozone concentrations are correlated with OH radical concentrations during daytime hours, and their use in the daytime SO_2 conversion rate in CALPUFF is based on this correlation relationship. The philosophy is that OH radical measurements are not available and cannot easily be computed within a model like CALPUFF, but ozone is commonly measured throughout the country, so the use of the well-known surrogate variable (ozone) is more useful in the empirical relationship than factors that are unknown or have a high degree of uncertainty. The same logic applies to the other variables in the relationship. They are surrogates for factors that the regression analysis has shown to be important in SO_2 oxidation rates. At night, the SO_2 conversion is set to a constant low value (default is 0.2%/hr). Aqueous phase oxidation of SO_2 is represented by an additive term that varies with relative humidity and peaks at 3%/hr at 100% relative humidity. CALPUFF represents the chemical conversion as a linear process because it requires linear independence between puffs, although as explained below, non-linear behavior in nitrate formation can be modeled.

[9] CALPUFF offers two options for parameterizing chemical transformations: the 5 species (SO_2, $SO_4^{=}$, NO_x, HNO_3, and NO_3^-) MESOPUFF-II system and the 6 species RIVAD system (which treats NO and NO_2 separately). IWAQM recommends using the MESOPUFF-II system with CALPUFF. The RIVAD system is believed to be more appropriate for clean environments, however, and therefore was used in the Southwest Wyoming Regional CALPUFF Air Quality Modeling Study in 2001. For the VISTAS region, the IWAQM- and FLM-recommended MESOPUFF-II chemistry is most appropriate.

The IWAQM Phase 2 report concludes that this chemistry algorithm is adequate for representing the gas phase sulfate formation but that it does not adequately account for the aqueous phase oxidation of SO_2. Actual aqueous phase oxidation in clouds or fog can proceed at rates much greater than 3% per hour, leading IWAQM to suggest that sulfate might be underestimated in such situations. However, aqueous phase oxidation depends on liquid water content, not relative humidity. In reality, liquid water does not exist in the atmosphere at relative humidity much below 100%, while the CALPUFF aqueous reaction term produces sulfate at lower relative humidity. This can lead CALPUFF to overestimate sulfate concentrations when the humidity is high but the cloud water that enables aqueous conversion is not present. Therefore, the direction of the bias in the aqueous chemistry simulation of sulfate formation can vary.

Other potential sources of error in the sulfate formation mechanism of CALPUFF include (1) overestimation of sulfate formation when NO_x concentrations in the plume are high and in actuality they deplete the local availability of ozone and hydrogen peroxide for oxidizing the SO_2; and (2) lack of direct consideration of the effect of temperature on the conversion rates, which may cause the model to overstate sulfate formation on cold days (below 10C or 50°F) (Morris et al., 2003). However, in CALPUFF, the effects of temperature are, to some degree, compensated for indirectly by the use of the solar radiation surrogate variable in the empirical conversion equations.

Whether these potential errors are important will depend on the setting. For example, Figure 3-2 shows a comparison of predicted and observed 24-hour sulfate concentrations, due to a large number of SO_2 sources, at the Pinedale IMPROVE site in Wyoming for the 1995 period (Scire et al., 2001). Overall, in this case there was very little bias in the sulfate predictions. Whether CALPUFF predictions would compare as well with measurements in the Southeast remains to be seen.

CALPUFF does not identify the chemical form of the sulfate compound that results from its reactions, which will generally be some form of ammoniated sulfate whose degree of neutralization will depend on the availability of ammonia in the atmosphere. This consideration, which has been found to be relevant for calculating light extinction in the VISTAS region, is not addressed by CALPUFF or CALPOST.

In most applications, the ozone concentrations required for the sulfate formation calculations are derived from ambient measurements, although concentrations simulated by regional models can be used.

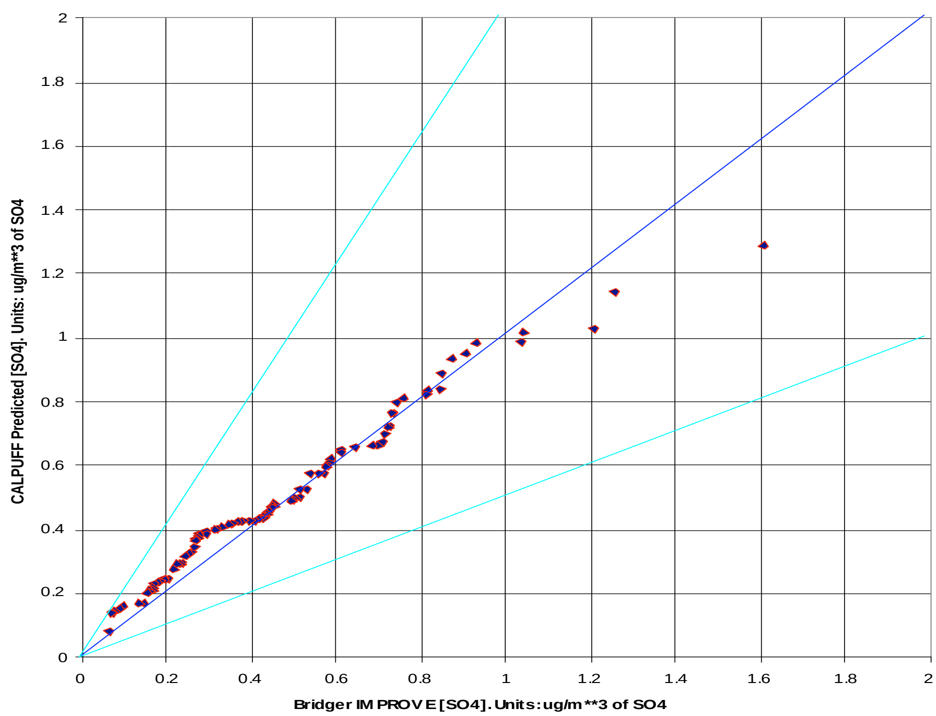

Figure 3-2. Observed vs. CALPUFF-predicted 24-hour sulfate concentrations at the IMPROVE monitoring site in Pinedale, Wyoming for 1995.

NO_x and Secondary Ammonium Nitrate

The MESOPUFF-II chemistry algorithm used in CALPUFF simulates the oxidation of NO_x to nitric acid and organic nitrates (both gases) by transformation rates that depend on NO_x concentration, ambient ozone concentration, and atmospheric stability class during the day. The conversion rate at night is set at to a constant value (default is 2.0 %/hr). The temperature- and humidity-dependent equilibrium between nitric acid gas and ammonium nitrate particles is taken into account when estimating the ammonium nitrate particle concentration, an equilibrium that depends on the ambient concentration of ammonia. The user supplies the value of the ambient concentration of ammonia. CALPUFF assumes that the sulfate reacts preferentially with that ammonia to form ammonium sulfate and the left over ammonia is available to form ammonium nitrate.

The IWAQM Phase 2 report considers that this mechanism is adequate for representing nitrate chemistry. Potential situations where this assumption may not be correct, however, include (1) plumes with high concentrations of NO_x that deplete the ambient ozone and thus limit the

transformation of NO_x to nitric acid in the plume; and (2) when ambient temperature is below 10 C, and thus the transformation rate is much slower and the nitrate concentration may be lower than that simulated by CALPUFF (Morris et al., 2003). In both cases, CALPUFF may overestimate the amount of nitrate that is produced. In particular, the impact of ammonium nitrate concentrations on visibility at Class I areas in the VISTAS region is greatest in the winter, when temperatures are lowest, the nitrate concentrations are the greatest, and the sulfate concentrations tend to be the least. CALPUFF may overstate the impacts of NO_x emissions at those times, especially in the colder northern states**.** This potential overestimate of nitrate was not evident, however, in an evaluation of CALPUFF-modeled nitrate against actual observational data in the Wyoming study, as shown in Figure 3-3a (Scire et al., 2001),

Another factor in the calculation of nitrate is that CALPUFF makes the full amount of the background concentration of ammonia available to each puff, and that amount is scavenged by the sulfate in the puff. If puffs overlap, then that approach could overstate the amount of ammonium nitrate that is formed in total if, in reality, the combined scavenging by the overlapping puffs at a location would deplete the available ammonia enough that the combined nitrate formation was limited by the availability of ammonia. This effect of such ammonia limiting can be large in summer; for a source 75 km west of Mammoth Cave National Park, one modeling analysis found the maximum light extinction impact of the source to be 7.4% (roughly 0.74 deciviews) at the park when CALPUFF was used without consideration of ammonia limiting and about 30% less, between 5.5 and 5.8% (roughly 0.55 to 0.58 dv), when the effect of ammonia limiting was considered (Escoffier-Czaja and Scire, 2002).

To address the issue, since 1999 (i.e., after the IWAQM Phase 2 report) the CALPUFF system has included the optional POSTUTIL postprocessing program, which repartitions the ammonia and nitric acid concentrations estimated by CALPUFF to reflect potential ammonia-limiting effects on the development of nitrate**.** This allows non-linearity associated with ammonia limiting effects to be included in the CALPUFF model estimates. POSTUTIL computes the total sulfate concentrations from all sources (modeled sources plus inflow boundary conditions) and estimates the amount of ammonia available for total nitrate formation after the preferential scavenging of ammonia by sulfate. That is, as new sulfate, nitrate or ammonia from the source of interest is added to an existing mix of pollutants, POSTUTIL will estimate both the nitrate formed from the new source and the change in background nitrate as a result of the incremental depletion of ammonia (due to the new sulfate and nitrate) or addition of ammonia (from a new source of ammonia).

Reliable estimates of the ambient concentrations of ammonia, especially with the temporal and spatial resolution that would be optimal for use with CALPUFF, are needed to take full advantage of the increased accuracy provided by POSTUTIL. The processor requires estimated concentrations of ammonia throughout the modeling domain and period. Such estimates can be inferred from CASTNet measurements, which are integrated over a week, from 24-hr SEARCH measurements, or from the output of a regional photochemical model such as CMAQ or CAMx. The CASTNet network is fairly sparse and the uncertainty in the ammonia measurements is large,

so defining the ammonia concentration throughout the Southeast would require extensive interpolation or extrapolation from the measured values. The quality of the SEARCH measurements is much better, but there are only 8 sites and they do not cover the entire VISTAS domain. Modeled concentrations have the advantage of being resolved in space and time, but their accuracy should be evaluated by comparison with measurements wherever possible.

Benefit is obtained by considering seasonal trends of ammonia and using POSTUTIL to determine the diurnal variability in available ammonia due to the daily cycle of nitrate formation associated with temperature and relative humidity effects. For example, results of the Wyoming study (see Figure 3-3a) show that POSTUTIL adjustments produced daily average nitrate concentrations well within the factor of two lines and with very little mean bias. On the other hand, analysis of the same results with use of constant ammonia of 0.5 ppb or 1.0 ppb produced consistent overpredictions of nitrate by factors of 2-3 and 3-4, respectively, as shown in Figure 3-3b (Scire et al., 2003).

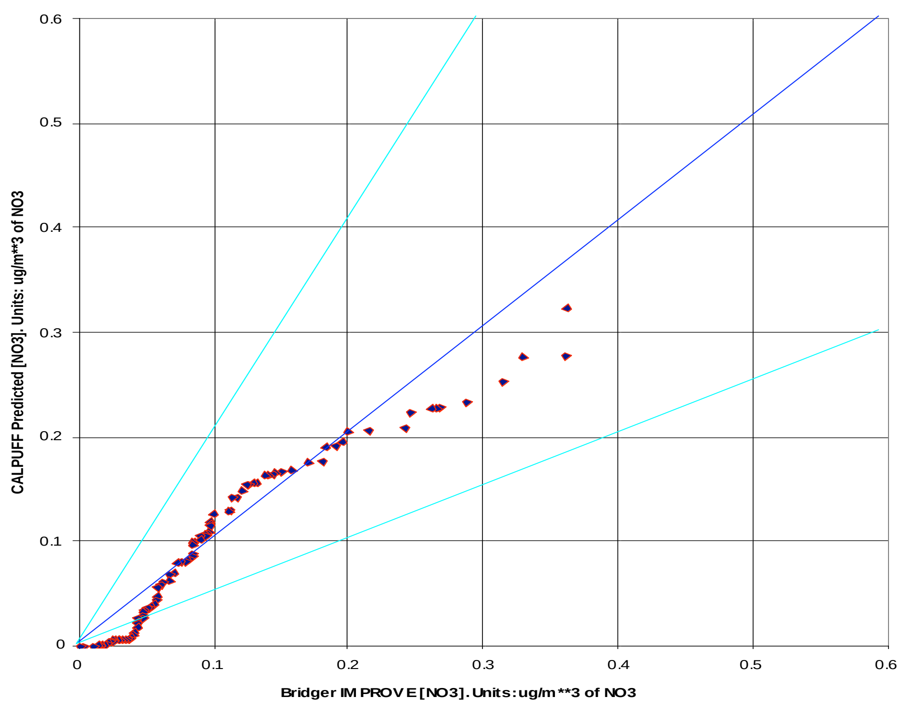

Figure 3-3a. Observed vs. CALPUFF-predicted 24-hour nitrate concentrations at the IMPROVE monitoring site in Pinedale, Wyoming for 1995 using the ammonia limiting method. (Scire et al., 2001)

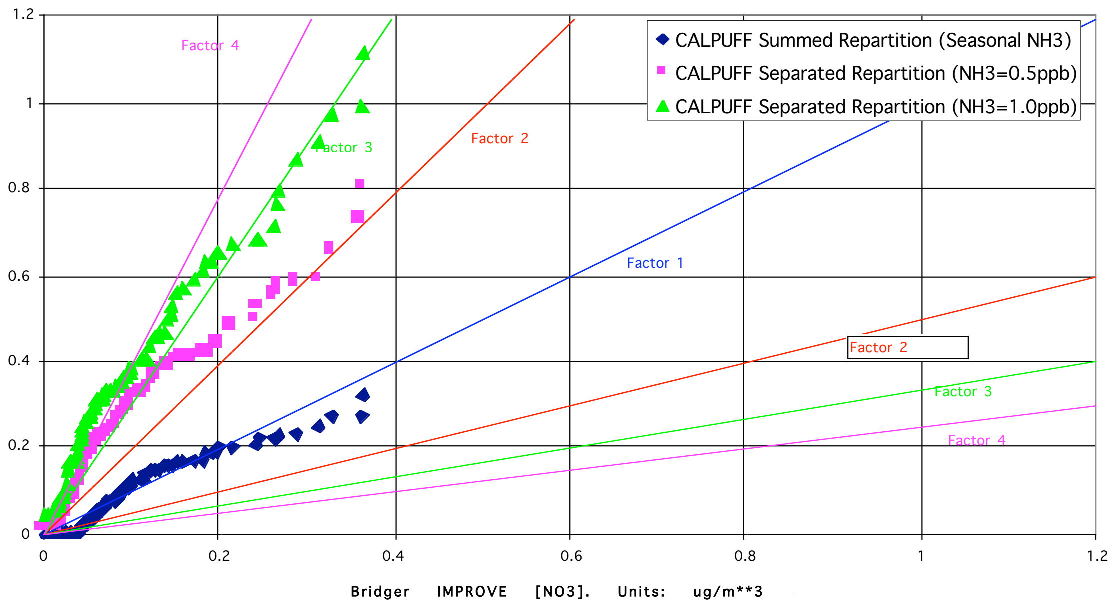

Figure 3-3b. Observed vs. CALPUFF-predicted 24-hour nitrate concentrations at the IMPROVE monitoring site in Pinedale, Wyoming for 1995 using the ammonia limiting method (blue), constant ammonia at 0.5 ppb (pink) and constant ammonia at 1.0 ppb (green). (Scire et al., 2003)

Secondary Organic Aerosol

Ongoing research studies at several Class I areas throughout the country (Fallon and Bench, 2004) and at SEARCH sites in the Southeast (Edgerton et al., 2004) are finding that, typically, 90 to 95% of the rural organic carbon fine particle concentration consists of modern carbon (e.g., that from the burning of vegetation and deriving from VOC emissions from vegetation) and only 5 to 10% is attributable to man's burning of fossil fuels. In addition, a field study at Great Smoky Mountains National Park in August 2002 (Tanner, et al., 2005) found that an average of 83% of the fine carbon was modern carbon

According to IMPROVE measurements, organics account for roughly 10% of the particle-caused light extinction in Class I areas in the Southeast. We can thus conclude that, in general, secondary organic carbon particles derived from anthropogenic fossil fuel burning emissions are unlikely to have a large impact (around 1%) on current visibility. (Man-caused burning of vegetation can have significant localized, short-term impacts, however.)

Current organic fine particle concentrations in the Southeast are typically within a factor of 2 of the 1.4 $\mu g/m^3$ concentration assumed for natural conditions by the EPA, which means that current fossil fuel burning would contribute less than 2% to visibility in an atmosphere that represents natural conditions. Thus, it is unlikely that VOC and organic particle contributions from BART

sources will cause a large impact to visibility at Class I areas, but a 5% (0.5 dv) localized impact from a particularly large VOC source cannot be dismissed out of hand.

CALPUFF has only rudimentary capabilities for addressing formation of visibility-impairing organic particles from some forms of volatile organic carbon (VOC). The capabilities that do exist include the following.

First, PM_{10} emissions (such as from power plants) are often divided into filterable and condensable components, with the condensable mass being 100-200% of the filterable mass. For purposes of visibility analyses with CALPUFF, a fraction of the condensable part is typically treated as organic particles, i.e., it is assumed that a fraction of the condensable components in the PM_{10} emissions condense into organic $PM_{2.5}$ particles. The size of this organic fraction varies with process and process equipment, and can range from 20 to 100% of the condensable mass. These fine organic particles can be readily modeled by CALPUFF. (The remaining condensable material may be sulfuric, hydrochloric, or hydrofluoric acid.)

Second, a module that treats the formation of secondary organic particles from organic emissions was recently developed and is now part of the CALPUFF system. (Scire et al., 2001). This simplified secondary organic aerosol (SOA) module is a linear, parameterized representation that is currently considered best suited for biogenic organics. It relies on the conventional wisdom that only hydrocarbons with more than six carbon atoms can form significant SOA (Grosjean and Seinfeld, 1989). For example, according to this rule, isoprene (C_5H_8) does not make SOA but terpenes do, making pine trees more important biogenic contributors to SOA than oak trees.[10]

Limited evaluation of the performance of CALPUFF at simulating SOA with its biogenic SOA module at one IMPROVE site in a regional modeling study in Wyoming found that 95% of 101 estimated 24-hr SOA concentrations were within 2% of the measured values (Scire et al., 2001). This performance seems promising, although the developers view the SOA module as needing more testing and evaluation.

Thus, CALPUFF includes approaches for dealing with condensable VOC emissions that are characterized as condensable PM_{10} and with biogenic VOCs, although the soundness of concentration estimates by these approaches when modeling a plume from a single source is largely untested.[11] The CALPUFF simulation of VOC emissions from sources whose VOC emissions are predominantly anthropogenic is problematic, however. Perhaps the approach used for the simplified biogenic SOA module may be extended to anthropogenic VOCs when speciated VOC emissions information is available. If only those VOCs with more than six carbon atoms are presumed to be of importance, this eliminates many anthropogenic sources of VOC emissions. For example, the fugitive emissions of butane and ethane during petroleum processing

[10] Recent research suggests that isoprene may be a SOA precursor, however.

[11] Note that neither of these VOC-related simulation approaches is described in the current (Version 5) CALPUFF User's Guide dated January 2001. See the Wyoming report referenced above for a description of this module.

are not important, while aromatic emissions (such as of toluene and xylene) are considered by the SOA module's mechanism. Development, testing, and evaluation would be needed before one could rely on such a module for estimating SOA from anthropogenic SOA emissions, though.

Therefore, to demonstrate the visibility impacts of VOC emissions from BART-eligible sources, means other than CALPUFF will be needed. A technical approach using a regional photochemical model to evaluate visibility impacts of VOC emissions is presented in Section 4.1.3. CALPUFF can be used to estimate the contribution from the primary condensable fraction of PM_{10} emissions, though.

3.2.3 Regional Haze

Calculation of the impact of the simulated plume particulate matter component concentrations on light extinction is carried out in the CALPOST postprocessor. The formula used is the usual IMPROVE/EPA formula, which is applied to determine a change in light extinction due to changes in component concentrations. Using the notation of CALPOST, the formula is the following:

$$b_{ext} = 3\,f(RH)\,[(NH_4)_2SO_4] + 3\,f(RH)\,[NH_4NO_3] + 4[OC] + 1[Soil] + + 0.6[Coarse\ Mass] + 10[EC] + b_{Ray} \qquad (3\text{-}1)$$

The concentrations, in square brackets, are in $\mu g/m^3$ and b_{ext} is in units of Mm^{-1}. The Rayleigh scattering term (b_{Ray}) has a default value of 10 Mm^{-1}, as recommended in EPA guidance for tracking reasonable progress (EPA, 2003a).

There are a few important differences in detail and in notation between the CALPOST formula for estimating light extinction (i.e., Equation 3-1) and that of IMPROVE and EPA. First, the *OC* in the formula above represents organic carbonaceous matter (OMC in IMPROVE's notation), which is 1.4 times the *OC* (i.e., organic carbon alone) in the IMPROVE formula. The *EC* above is synonymous with *LAC* in the IMPROVE formula. CALPOST now offers the option of using the old IMPROVE *f(RH)* curve, whose values are documented in the December 2000 FLAG report, or the *f(RH)* now used by IMPROVE and EPA (as documented in EPA's regional haze guidance documents). Also, CALPOST sets the maximum *RH* at 98% by default (although the user can change it), while the EPA's guidance now caps it at 95%.

The haze index (HI) is calculated from the extinction coefficient via the following formula:

$$HI = 10\ ln\ (b_{ext}/10) \qquad (3\text{-}2)$$

where *HI* is in units of deciviews (dv) and b_{ext} is in Mm^{-1}. The impact of a source is determined by comparing HI for estimated natural background conditions with the impact of the source and without the impact of the source.

CALPOST Methods

CALPOST uses Equation 3-1 to calculate the extinction increment due to the source of interest and provides various methods for estimating the background extinction against which the increment is compared in terms of percent or deciviews.

For background extinction, the CALPOST processor contains seven techniques for computing the change in light extinction due to a source or group of sources (called Methods 1-7). These are usually reported as 24-hour average values, consistent with EPA and FLM guidance. In addition, there are two techniques for computing the 24-hour average change in extinction (i.e., as the ratio of 24-hour average extinctions, or as the average of 24-hour ratios). A brief summary of the techniques is provided below. Method 2 is the current default, recommended by both IWAQM (EPA, 1998) and FLAG (2000) for refined analyses. Method 6 is recommended by EPA's BART guidance (70 FR 39162).

Methods 4 and 5 use optically measured hourly background extinctions, which represent current actual levels of extinction and thus are not consistent with the "natural conditions" the BART proposal says should be used as a baseline. Methods 1 through 3 and 6 and 7 allow for user inputs of estimated (e.g., natural conditions) background extinction or component concentrations, and thus are consistent with the BART proposal.

Method 1 allows the user to specify a single value of a "dry" background extinction coefficient for each receptor, specify that a certain fraction of that coefficient is due to hygroscopic species, and use relative humidity measurements to vary the extinction hourly via a 1993 IWAQM *f(RH)* curve or, optionally, the EPA regional haze f(RH) curve (EPA, 2003b). The *RH* is capped at 98% or a user-selected value (95% for the EPA curve). The same *f(RH)* is applied to both the modeled sulfate and nitrate.

For an example of the use of Method 1, one could use the dry particle extinction coefficient of 9.09 Mm^{-1} that results from EPA's default natural conditions concentrations, together with an assumption that for natural conditions, say, 0.9 Mm^{-1} (or 10%) of this amount results from hygroscopic ammonium sulfate and ammonium nitrate, and then apply *f(RH)* to this 10%.

In Method 2, user-specified, speciated monthly concentration values are used to describe the background. When applied to natural conditions, for which EPA's default natural conditions concentrations are annual averages, the same component concentrations would have to be used throughout the year (unless potential refinements to those default values resulted in concentrations that vary during the year). Hourly background extinction is then calculated using these concentrations and hourly, site-specific *f(RH)* from a 1993 IWAQM curve (a different one

than that in Method 1) or, optionally, the EPA regional haze f(RH) curve.[12] Again the *RH* is capped at either 98% (default) or a user-selected value (most commonly at 95%).

Method 3 is the same as Method 2, except that any hour in which the RH exceeds 98% (or the selected maximum) is dropped from the analysis. When 24-hr extinction is computed, no fewer than 6 valid hours are accepted at each receptor; otherwise the value for the day is tabulated as "missing".

Method 6 is similar to Method 2, except monthly f(RH) values (e.g., EPA's monthly climatologically representative values in EPA (2003a, b)) are used in place of hourly values for calculating both the extinction impact of the source emissions and the background conditions extinction. Hourly source impacts, with the effect on extinction due to sulfates and nitrates calculated using the monthly-average relative humidity in f(RH), are compared against the monthly default natural background concentrations. Thus the monthly-averaged relative humidity is applied to the hygroscopic components (i.e., sulfate and nitrate) of both the source impact and the background extinction with Method 6.

Method 7 is a new variant of Method 2 that was developed as a result of a ruling by the Assistant Secretary of the Interior for Fish and Wildlife and Parks, in response to a New Source Review case in Montana, that "natural conditions" should reflect the visibility impairment caused by significant meteorological events such as fog, precipitation, or naturally occurring haze (DOI, 2003).[13] Under Method 7, during hours when visibility is obscured by meteorological conditions, the actual measured visibility is used to represent natural conditions instead of the value that is calculated from EPA's default natural conditions concentrations under Method 2. A recent modification developed in response to FLM comments on Method 7, in which the daily average natural extinction is calculated somewhat differently, is called Method 7', i.e., "7 prime".

Refined Estimates of Extinction and Natural Background Visibility

Separate from the BART discussions, IMPROVE, EPA, and the Regional Planning Organizations are evaluating whether refinements are warranted to the methods recommended in EPA's guidance to calculate default estimates of natural background visibility. In particular, IMPROVE has recently approved an alternative to the formula (Eq. 3-1) it uses to estimate extinction from particle concentration measurements (Pitchford et al., 2005).

Refinements in the revised IMPROVE formula include the following:

- Adding a sea salt term, including a growth factor due to relative humidity

[12] Note that the hourly-varying natural background extinction in this method is not consistent with that prescribed by the EPA's natural conditions guidance (EPA, 2003b), for which a "climatologically-representative" f(RH) that only varies monthly is to be used. Method 6 uses these monthly average humidity values.

[13] The Secretary's guidance applies only to Federal Land Managers. EPA's position on this interpretation of natural conditions is unknown.

- Increasing the factor used to calculate the mass of particulate organic matter (OC in Eq. 3-1) from organic carbon measurements

- Modifying the relative humidity growth formula, f(RH), for sulfates and nitrates

- Revising the extinction efficiencies (the numerical constants in Equation 3-1) for sulfates, nitrates, and organic carbon so that they vary with concentration

- Adding a site-specific Rayleigh scattering term to the formula. Values will be calculated by IMPROVE for all Class I areas.

For the purposes of calculating current, future, and natural background visibility at VISTAS Class I areas as part of the reasonable progress analyses, VISTAS intends to present regional air quality modeling results using both the current EPA recommended assumptions and the newly revised aerosol extinction formula. If a BART-eligible source chooses to consider its projected impacts using the newly revised formula as well as the current formula, then modifications would need to be made to CALPOST to carry out calculations with the new algorithm.

4. VISTAS' COMMON MODELING PROTOCOL

4.1 Overview of Common Modeling Approach

In this section, guidance is provided on the use of the CALPUFF modeling system for two purposes:

1) Evaluating whether a BART-eligible source is exempt from BART controls because it is not reasonably expected to cause or contribute to impairment of visibility in Class I areas, and

2) Quantifying the visibility benefits of BART control options.

For purpose 1), States must determine whether a source emits any air pollutant (SO_2, NO_x, PM, and in certain cases VOC and NH_3) that "may reasonably be anticipated to cause or contribute to any impairment of visibility" in a Class I area. The States have 3 options to accomplish this:

A) Conclude that all BART-eligible sources in State are subject to BART.

B) Demonstrate that all BART-eligible sources in the State together do not cause or contribute to any visibility impairment

C) Determine if the impact from each individual BART-eligible source is greater than a threshold value.

VISTAS States intend to follow Option C (determine if the visibility impact from individual sources exceeds a contribution threshold) for SO_2 and NO_x emissions. The methods for Option C are described in Section 4.1.1. In early 2006, VISTAS pursued Option B (demonstrate that all BART eligible sources in a State do not impact visibility) for VOC, NH_3 and PM emissions. The approach and results for Option B are described in Section 4.1.3. As a result of this exercise, the VISTAS States have determined that the Option C exemption analyses should also include PM emissions and, for sources with large NH_3 emissions, NH_3. The States determined that anthropogenic VOC emissions do not cause or contribute to visibility impairment at VISTAS Class I areas and that VOC emissions do not need to be considered in BART analyses.

4.1.1 BART Exemption Analysis

As illustrated in Figure 4-1, three steps will evaluate whether a BART-eligible source of SO_2, NO_x, or PM is subject to BART:

1) VISTAS plans to use Q/d as a presumptive indicator that a source is subject to BART. If Q/d for SO_2 > 10 for 2002 actual emissions, then the State presumes that the source is subject to BART. If the source agrees with this presumption, then no exemption modeling is required and the source can proceed to the BART determination using CALPUFF to evaluate impacts of control options and can perform the engineering analyses. If a source disagrees, the source

may perform fine grid modeling as described in Section 4.4 to determine if its impact is < 0.5 dv.

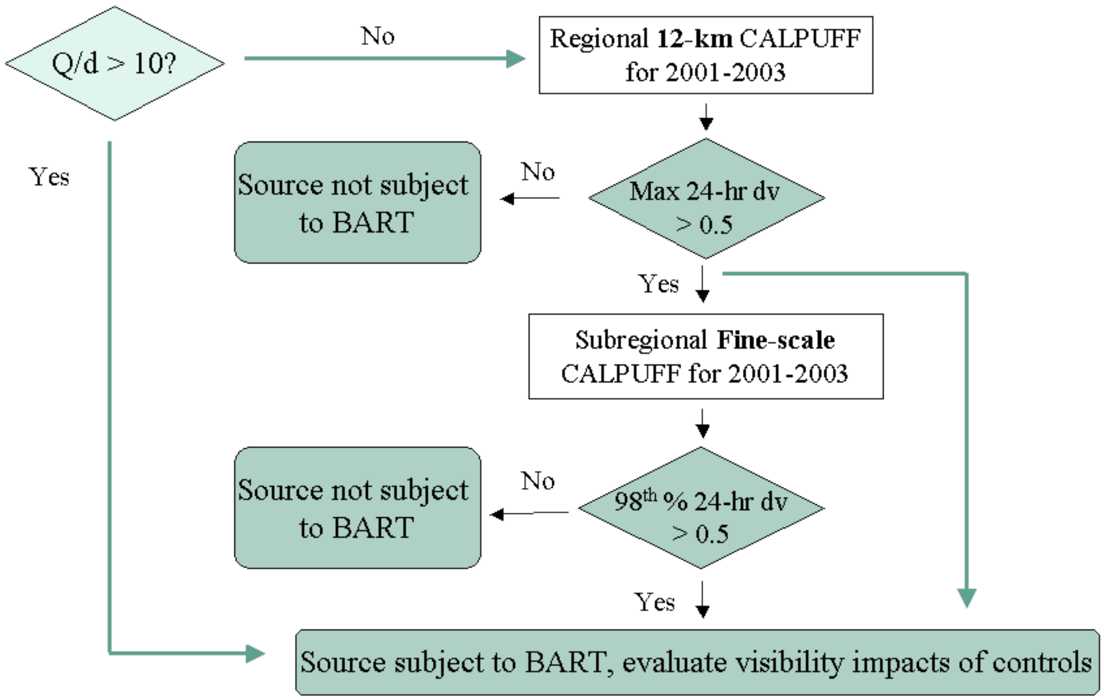

Figure 4-1. Flow chart showing the components of the VISTAS common modeling protocol. Assessment should be made for each Class I Area. (If a source agrees to install the most stringent controls then the modeling steps indicated above and engineering analyses and visibility impact modeling would not be required.)

2) An optional initial modeling assessment using the CALPUFF model with the coarse scale 12-km regional VISTAS domain can be used to answer questions whether (a) a particular source may be exempted from further BART analyses and (b) if finer grid CALPUFF analysis were to be undertaken, which Class I areas should be included. Assumptions for the initial modeling assessment are conservative so that a source that contributes to visibility impairment is not exempted in error. If a source is shown not to contribute to visibility impairment using the initial modeling assessment, the source would not be subject to BART and would be exempted from further BART analyses. If a source is shown to contribute to visibility impairment using the initial modeling assessment, the source has the option to undertake finer grid CALPUFF modeling to evaluate further whether it is subject to BART.

3) A finer grid CALPUFF modeling analysis using a subregional CALMET domain will be the definitive test as to whether a source is subject to BART.

For large sources that will clearly exceed the initial screening thresholds, this step can be skipped and the analysis may proceed directly to the finer grid modeling analysis, which is described in Section 4.4.

4.1.2 BART Control Evaluation

For sources that are determined to be subject to BART controls, part of the BART review process involves evaluating the visibility benefits of different BART control measures. These benefits will be determined by making additional CALPUFF simulations using the same CALMET and CALPUFF configuration as those used in the finer grid analysis of Step 2. The only exception is that the source and emissions data used in the CALPUFF control evaluation simulations will reflect the BART control measures being evaluated. Using the same model configuration will produce an "apples-to-apples" comparison, where differences in impacts are due to the effectiveness of the controls rather than model configuration differences. For example, a control scenario evaluation that uses more conservative assumptions than the base case simulation may produce results showing no or little improvement in visibility impacts. That control scenario run with the same model configuration as the base case may show significant visibility improvement. Therefore, in order to not obscure the response to predicted visibility improvements by differences in the modeling approach, the same model configuration should be used in the BART control evaluation simulation as in the base case simulation.

The base case to which the effectiveness of BART controls is to be compared is the "current emissions" scenario for which the finer grid Step 2 modeling was performed. The postprocessing steps and procedures are the same as in the BART eligibility simulation. Side-by-side comparison of the visibility impacts will be tabulated to quantify the effectiveness of each control scenario relative to the base case.

The modeling evaluation is a unit-by-unit evaluation and can be conducted on a pollutant specific basis. Modeling results are used with the other four statutory factors mentioned in Section 2.1 to decide which control technology, if any, is appropriate. Finally, if a source decides to use the most stringent control technology available, the BART control analysis, including modeling, is not necessary.

4.1.3 VISTAS' Treatment of VOC, NH_3, and PM

Volatile Organic Compounds

CALPUFF is currently not recommended for addressing visibility impacts from VOC because its capability to simulate secondary organic aerosol formation from VOC emissions is not adequately tested, especially for anthropogenic emissions. (Separately, condensable organic carbon can be calculated from PM_{10}.)

VISTAS has performed a weight of evidence analysis to demonstrate, using the CMAQ regional air quality model, that the combined VOC emissions from all point sources (BART-eligible and non-BART) in each State do not contribute to visibility impairment. Emissions sensitivity

simulations run for VISTAS by Georgia Institute of Technology using VISTAS' 12 x 12 km grid and CMAQ v 4.3 for episodes in July 2001 and January 2002 demonstrated very low to no response of organic carbon levels and light extinction at Class I areas to changing VOC emissions from all anthropogenic sources in the VISTAS 12-km modeling domain (eastern US). Georgia Tech repeated the sensitivity analyses using the VISTAS 12-km domain and CMAQ v 4.4 with a refined SOA module for summer (Jun 1-Jul 10) and winter (Nov 19-Dec 19) periods in 2002. VOC emissions from all anthropogenic point sources in every VISTAS State were reduced by 100% (i.e., eliminated). The maximum 24-hr impact of all VOC emissions from all point sources throughout the VISTAS domain was thus determined to be less than 0.5 dv (compared to annual average natural background) at every Class I area in the VISTAS domain and in adjacent States. It follows that the impact of any one BART-eligible source would be much less than 0.5 dv. Based on these analyses, the VISTAS States have concluded that VOC emissions from BART sources do not cause or contribute to visibility impairment and do not need to be included in BART analyses.

Ammonia

EPA has given states the option to address ammonia (NH_3) emissions from BART-eligible sources. VISTAS also contracted with Georgia Tech to calculate NH_3 emissions sensitivities using CMAQ v 4.4 with a refined SOA module and the same Jun-Jul and Nov-Dec periods in 2002 that were used for the VOC sensitivity evaluation. The NH_3 emissions from all point sources (BART-eligible and not-BART) in every State were reduced by 100% for these analyses. This sensitivity evaluation showed that the collective impact of all VISTAS region point NH_3 emissions is greater than 0.5 dv (compared to annual average natural background) at several Class I areas. When the NH_3 emissions were scaled to represent 100% reduction from only the BART-eligible sources in each State, then the maximum impact of those sources was under 0.5 dv at most, but not all Class I areas. The high values appear to result primarily from emissions from 13 large NH_3 sources. In the absence of those 13 facilities, the scaled NH_3 emissions peak impacts at Class I areas were 0.3 dv or less. Based on these analyses, the VISTAS States recommended that, except for these 13 facilities, NH_3 emissions not be included in BART modeling. States will provide instructions to those 13 sources as to how to evaluate contributions of their NH_3 emissions to visibility impairment. For documentation purposes, in summer 2006 VISTAS is repeating the NH_3 emissions sensitivity calculations, using CMAQ v4.5 with Base F emissions and reducing 100% of NH_3 emissions from only the BART-eligible sources in the VISTAS states.

Primary Particulate Matter

Primary particulate matter is considered a visibility impairing pollutant. However, the extent to which primary PM from BART-eligible sources contributes to impairment at Class I areas in the southeastern US is not clear. For EGUs, the EPA has determined that emissions reductions of SO_2 and NO_x under the CAIR rule meet the BART requirements, but these EGUs may still be subject to BART for primary PM. To determine the potential impacts of PM from EGU and non-EGU sources in the VISTAS states, two CMAQ sensitivity runs for the first and third quarters of 2002 were carried out by VISTAS' CMAQ modeling team of ENVIRON, UCR, and Alpine

Geophysics In one run, all primary PM from EGUs was removed while in the other run all primary PM from non-EGU sources was removed. All other CMAQ modeling components were held constant. At almost all Class I areas in the VISTAS region, primary PM emissions contribute to regional haze, with the collective impact of all EGU and non-EGU point primary PM emissions being greater than 0.5 dv compared to annual average natural background. In fact, the impacts of EGU PM emissions alone or of non-EGU PM emissions alone were each mostly greater than 0.5 dv. Although the impacts of BART sources alone would be smaller, the VISTAS States have concluded that all BART-eligible sources need to consider the impacts of their PM emissions.

4.2 Optional Source-Specific Modeling

In some circumstances, a source may want to apply techniques designed to evaluate the impacts in a more detailed way than the standard VISTAS common protocol. A source may propose source-specific modeling procedures to address special issues to the State for State review. For example, sources very close to Class I areas may be better treated by a finer grid resolution that the generic Step 2 “fine” grid resolution meteorological fields provided by VISTAS. In some situations, higher resolution MM5 or other prognostic meteorological datasets may be available than the standard 12-km or 36-km MM5 datasets provided by VISTAS. Because it is not possible to anticipate all of the situations where there would be a benefit to conducting more detailed source-specific analyses, the option to pursue this option is left as an open issue, to be resolved and justified based on specific factors relevant for the source in question.

A source-specific modeling protocol is required for each source. This document should describe the data sources and model configuration, and provide rationale for any changes in the model approach from the common protocol. This source-specific protocol must be provided for review and approval by the State. The State will share the protocol with EPA and the Federal Land Managers for their review. Discussion of approaches to source-specific modeling and an outline of the typical contents of the source-specific protocol are presented in Chapter 5. Discussions with the regulatory authorities should be conducted prior to development of a source-specific protocol to ensure all of the relevant issues are included in the protocol.

4.3 Initial Procedure for BART Exemption

4.3.1 Overview of Initial Approach

The first step in the common protocol, the initial assessment in Figure 4-1, is a simple procedure to evaluate whether a source can be exempted from BART controls using a consistent set of meteorological and dispersion options. A pre-computed set of meteorological files and a pre-defined CALPUFF input option configuration, based on guidance in the final BART rule (70 FR 39104-39172) and other EPA and FLAG model guidance, will allow relatively simple initial simulations. The regional initial domain is designed to allow any Class I areas within the VISTAS area to be evaluated with a single meteorological database and consistent CALPUFF modeling options. The second important question that this first screening step will answer is, if

initial modeling indicates a source may impact visibility significantly, what Class I areas should be included in a finer grid analysis? Due to the multitude of factors affecting the contribution of a source to visibility in a Class I area, simple screens or rules of thumb alone (such as that the closest Class I area will produce the controlling visibility impacts) are not likely to be universally reliable.

4.3.2 Discussion of 12-km Initial Exemption Modeling

Meteorological Fields

A regional initial domain and a set of pre-computed regional CALMET meteorological files will be prepared for VISTAS, to allow any Class I areas within the VISTAS area to be evaluated with a consistent meteorological database and consistent CALPUFF modeling options.

The following three years of MM5 meteorological data have been assembled by VISTAS for use in the regional CALPUFF modeling effort:

- 2001 MM5 dataset at 12 km and 36 km grid (developed for EPA)
- 2002 MM5 dataset at 12 km and 36 km grid (developed by VISTAS)
- 2003 MM5 dataset at 36 km grid (developed by the Midwest Regional Planning Organization).

These data sets have been provided to Earth Tech by VISTAS, and from them Earth Tech has produced annual CALMET meteorological files at 12-km grid resolution for the domain shown in Figure 4-2. The CALMET modeling output files in the form of CALPUFF-ready three-dimensional meteorological files will be available on external hard drives to the States and other parties.

The initial procedure to determine if a BART-eligible source is subject to BART uses the pre-computed CALMET meteorological fields for the years 2001-2003 on the 12-km CALMET domain in Figure 4-2 and simulates with CALPUFF any BART-eligible source to be screened. The CALMET simulations will be developed using the highest resolution MM5 data available for each year (i.e., 36-km MM5 data for 2003, 12-km MM5 data for 2001 and 2002).

The development of the regional CALMET meteorological fields from MM5 data will be conducted in No-Observations (“No-Obs”) mode. The MM5 data already reflect assimilation of observational data and are likely to adequately characterize regional wind patterns that are consistent with the 12-km grid scale. Blending of MM5 data with local observations (which are mainly at the surface) could lead to wind structures that may not be realistic under some conditions and may result in poorer characterization of the regional winds. Thus, the effort required to prepare observational data sets for CALMET for the large regional domain involves considerable effort that may not provide corresponding improvement of the wind field.

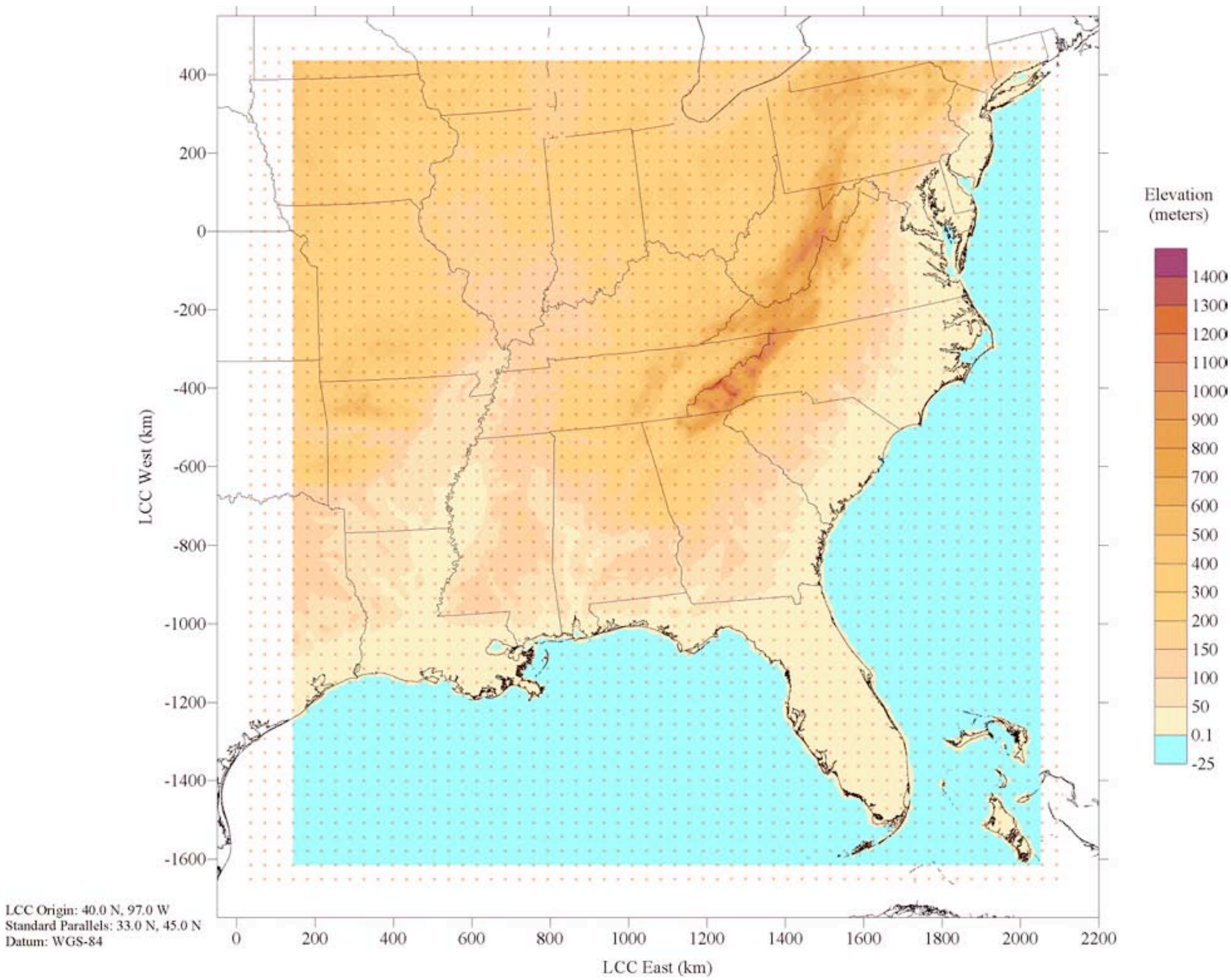

Figure 4-2. VISTAS Regional 12-km Resolution CALMET Modeling Domain (color area with terrain contours). The locations of the 36-km resolution MM5 grid points are shown on the plot.

For 2003, the 36-km MM5 data will be used as CALMET's initial guess field and then the CALMET diagnostic terrain adjustments (see Section 3.1.1) will be applied to reflect terrain on the scale of the CALMET grid (i.e., 12-km). When the 12-km MM5 (2001 and 2002) data are used, the diagnostic CALMET terrain adjustments will be turned off since the grid resolution of the MM5 data is the same as the CALMET grid and the terrain adjustments on the 12-km grid scale will already be reflected in the MM5 dataset. In this case, the MM5 winds will be interpolated by CALMET to the CALMET layers and CALMET's boundary layer modules will compute mixing heights, turbulence parameters and other meteorological parameters that are required by CALPUFF.

Impact Threshold

The final BART guidance recommends that the threshold value to define whether a source "contributes" to visibility impairment is 0.5 dv change from natural conditions[14] (although States may set a lower threshold). The 98th percentile (8th highest annual) 24-hr average predicted impact at the Class I area, as calculated using CALPOST Method 6 (monthly average relative humidity values), is to be compared to this contribution threshold value. For this comparison, the predicted impact at the Class I area on any day is taken to be the highest 24-hr average impact at any receptor in the Class I area on that day. (Note that the receptor where the highest impact occurs can change from day to day.) According to clarification of the BART guidance received from EPA, for a three-year simulation the modeling values to be compared with the threshold are the greatest of the three annual 8th highest values or the 22nd highest value over all three years combined, whichever is greater.

For the purposes of the initial analysis, however, the *highest value* over the three-year period (not the 98th percentile value) is to be compared to the contribution threshold. This ensures a significant measure of conservatism in the initial approach. VISTAS will evaluate the initial CALPUFF results to determine if using the single highest value provides too conservative a screen for exemption purposes. If so, VISTAS may increase the number of exceedances of the contribution threshold that would be allowed and still qualify to exempt a source.

4.3.3 Model Configuration and Settings for Initial Analysis

VISTAS will use CALPUFF Version 5.754 and CALMET Version 5.7. These versions contain enhancements funded by the Minerals Management Service (MMS) and VISTAS. They were developed by Earth Tech, Inc. and they are maintained on the CALPUFF website (www.src.com) for public access. This version includes CALMET, CALPUFF, CALPOST, CALSUM, and POSTUTIL as well as CALVIEW.

The initial analysis uses a CALPUFF computational domain that includes all Class I areas within 300 km of a source. These Class I areas are specified in the CALPUFF control file for analysis. States could decide to require a different value for the maximum distance threshold for the CALPUFF domain, depending on the locations of the Class I areas in their states and other factors such as meteorological conditions and the magnitudes of the emissions from BART-eligible sources. The regional CALMET domain will be unchanged by these adjustments.

Also, the initial approach is designed to significantly reduce the CALPUFF simulation time by restricting the CALPUFF computational domain size to include only areas where significant impacts are feasible rather than the entire regional domain. CALPUFF allows its computational domain to be specified as a subset of the CALMET meteorological domain by settings within the

[14] As described in Footnote 5 on page 6, States have the option of defining natural conditions as either the annual average default conditions or the average of the 20% best natural condition days.

CALPUFF input file. The advantage of selecting a smaller CALPUFF computational domain in the regional CALPUFF simulations is that CALPUFF run time is proportional to the number and residence time of the puffs on the domain (and other factors such as the number of receptors and the internal time step computed by the model). A CALPUFF domain covering an area 300 km from a source in all directions would involve only 50 x 50 12-km grid cells, which will require modest computational resources.

CALMET output files for the VISTAS regional domain shown in Figure 4-2 will be provided to VISTAS by Earth Tech. These files will be in CALPUFF-ready format, and as such, no CALMET user inputs will be required. An option in CALMET allows finer grid CALMET input files to be calculated from the 12-km CALMET files.

The basic characteristics of the CALMET, CALPUFF and CALPOST configurations for the initial analyses are listed below.

CALMET Modeling Configuration (12-km initial exemption modeling)

The CALMET model configuration for the regional CALMET simulations will be defined by Earth Tech in collaboration with the VISTAS States. The basic model configuration will follow the recommended IWAQM guidance (EPA, 1998; Pages A-1 through A-6), except as noted below.

The basic features of the modeling simulation are the following:

- Modeling period: 3 years (2001-2003)

- Meteorological inputs: MM5 data provide initial guess fields in CALMET

- CALMET grid resolution: 12-km (same Lambert Conformal coordinate system and grid cells as the 12-km 2001/2002 MM5 simulations)

- CALMET vertical layers: 10 layers. Cell face heights (meters): 0, 20, 40, 80, 160, 320, 640, 1200, 2000, 3000, 4000.

- CALMET mode: No-Observations mode including option to read overwater data directly from MM5.

- Diagnostic options: IWAQM default values, except as follows: diagnostic terrain blocking and slope flow algorithms used for 2003 simulations (using 36-km MM5 data), but no diagnostic terrain adjustments in 2001 and 2002 simulation (using 12-km MM5 data)

- CALMET options dealing with radius of influence parameters (R1, R2, RMAX1, RMAX2, RMAX3), BIAS, ICALM parameters are <u>not used</u> in No-Observations mode.

- TERRAD (terrain scale) is required for runs with diagnostic terrain adjustments (i.e., the 2003 simulations). Values of ~10-20 km will be tested, and an appropriate value determined.

- Land use defining water: JWAT1 = 55, JWAT2 = 55 (large bodies of water). This feature allows the temperature field over large bodies of water such as the Atlantic Ocean and the Great lakes to be properly characterized by buoy observations.

- Mixing height averaging parameter (MNMDAV) will be determined by Earth Tech for the regional simulations based on sensitivity tests. The purpose of the testing is to optimize the variable to allow spatial variability in the mixing height field, but without excessive noise.

- Geophysical data for regional runs: SRTM-GTOPO30 30-arcsec terrain data, Composite Theme Grid (CTG) USGS 200m land use dataset. References for these and other CALMET datasets can be found on the CALPUFF data page of the official CALPUFF site (www.src.com).

CALPUFF Modeling Configuration (Initial exemption modeling)

The CALPUFF model configuration for the regional CALPUFF initial simulations will follow the recommended IWAQM guidance (EPA, 1998; Pages B-1 through B-8), except as noted below:

- CALPUFF domain configured to include the source and all Class I areas within 300km of the source plus 50km buffer zone in each direction. CALPUFF is recommended for all source-receptor distances to be considered in the BART analyses.

- Chemical mechanism: MESOPUFF II module

- Species modeled: SO_2, SO_4, NO_x, HNO_3, NO_3 and particulate matter in size categories of <0.625 µm, 0.625-1.0 µm, 1.0-1.25 µm, 1.25-2.5 µm, 2.5-6.0 µm and 6-10 µm aerodynamic diameters. As noted below, the particulate matter emissions by size category will be combined into the appropriate species for the visibility analysis (i.e., elemental carbon (EC), fine PM or "soil" (< 2.5 µm in diameter), coarse PM (between 2.5-10 µm in diameter) and organics (called secondary organic aerosols (SOA) in the CALPOST postprocessor).

- Emission rates for modeling based on EPA BART guidance, i.e., maximum 24-hour actual emission rate with normal operations from the highest emitting day of the meteorological period modeled (excluding days where start-up, shutdown or malfunctions occurred sometime during the day.) Note that potential emissions are used to determine if a source is BART-eligible, but 24-hour average maximum emissions are used for modeling purposes (70 FR 39162). Pollutants considered include SO_2, H_2SO_4, NO_x and PM_{10}.

Condensable emissions are considered as primary fine particulate matter and allocated equally to the two submicrometer-particle size classes. If actual source emissions data are not available, the modeling should be based on permit limits. If source-specific size

categories are not available, then AP-42 factors may be used for sources where AP-42 factors are available. For sources where AP-42 factors are not available, alternative approaches to speciation are given below.

Excluded from the modeling are pollutants with plant-wide emissions less than *de minimis* levels (40 tons per year for SO_2 and NO_x and 15 tons per year for PM_{10}). *De minimis* levels are plant wide for each visibility-impairing pollutant, so individual units may be modeled even if they have emissions below *de minimis* if the plant total is greater than *de minimis*.

- Particulate emissions speciation: Break down, as appropriate, filterable and condensable particulate matter into the following species categories: elemental carbon (soot), "soil" (fine PM < 2.5 µm diameter), coarse particulate matter (2.5-10 µm diameter) and organics. The process is illustrated in Figure 4-3. If source-specific speciated emissions factors are not available, AP-42 factors or speciation information developed by the National Park Service (http://www2.nature.nps.gov/air/permits/ect/index.cfm) can be used to estimate the PM speciation for many source sectors.

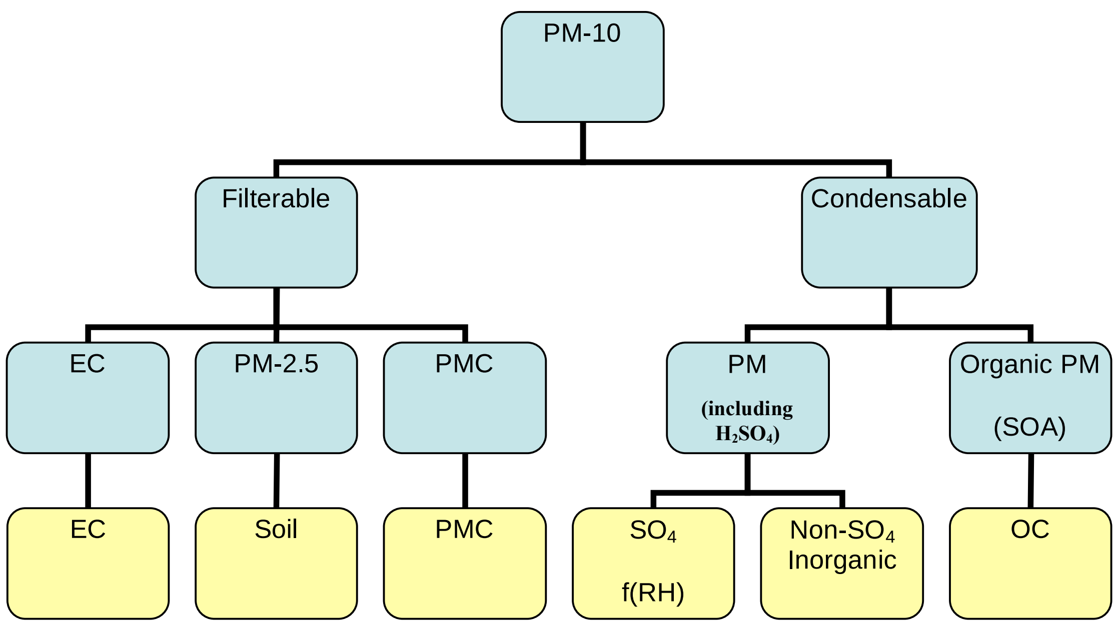

Figure 4-3. Speciation of PM-10 Emissions. (PMC is coarse particulate matter -- 2.5 to 10 µm diameter.)

Otherwise, assumptions will need to be proposed by the source, and reviewed and approved by the State. Possible acceptable alternative approaches to estimating speciation include the following:

- Speciation profiles developed by the SMOKE emissions model for use in VISTAS' CMAQ regional air quality modeling (available at http://www.vistas-sesarm.org/BART/calpuff.asp).

- The approach described in a memo available at http://www.vistas-sesarm.org/BART/calpuff.asp, which provides reasonably conservative estimates in situations where data are incomplete.

- Class I receptors: Use FLM Class I receptor list with receptor elevations provided (available from the NPS).

- CALPUFF model options: Use IWAQM (EPA, 1998) default guidance, including Pasquill-Gifford dispersion coefficients.

- Ozone dataset – use observed ozone data for 2001-2003 from CASTNet and AIRS stations. Only non-urban ozone stations should be used in the OZONE.DAT file. Monthly average ozone (backup) background values are to be computed based on daytime average ozone concentrations from the OZONE.DAT file (6am-6pm average ozone concentrations computed by month).

- Background ammonia concentration: In CALPUFF, use constant (0.5 ppb) value for ammonia.

- Puff representation: integrated puff sampling methodology.

- Building downwash: Ignore building downwash unless source is within 50-km of a Class I area and the State instructs the source to specifically consider building downwash.

CALPOST and POSTUTIL Configuration (Initial exemption modeling)

- Use Visibility Method 6 in CALPOST

- Species considered in visibility analysis: SO_4, NO_3, EC, SOA (i.e., condensable organic emissions), soil, coarse PM

- Natural background light extinction: Several options are acceptable at the discretion of the State: (1) A single annual average natural background extinction for each Class I area, as presented in Appendix B of EPA's natural conditions guidance (EPA, 2003b); (2) A single value that represents the average haze index on the 20% best natural conditions days, again as presented in the same Appendix B; or (3) A monthly average natural background as calculated by CALPOST under Method 6, based on annual average default natural

conditions component concentrations and monthly average f(RH) values for the centroid of the Class I area, from Table A-3 in the natural conditions guidance document,.

A special procedure is needed for options 1 and 2, since CALPOST requires input of natural background concentrations of PM components while the backgrounds for options 1 and 2 are expressed in EPA's guidance document as extinction coefficients or haze indices (in deciviews). In order to produce the appropriate natural background in CALPOST for these options, use Equation 3-2 to calculate the extinction coefficient that corresponds to EPA's haze index value for the Class I area (if necessary), subtract the Rayleigh scattering value of 10 Mm^{-1}, and enter a soil concentration (in $\mu g/m^3$) into CALPOST that is numerically equal to this result. (Since the extinction efficiency of soil is 1 m^2/g, Equation 3-1 shows that this process produces a background extinction that equals the EPA's value.) Leave the concentrations of all other species blank, since the number that is entered represents extinction by all components.

- Light extinction efficiencies: Use EPA (2003a) values. If a source chooses, the new IMPROVE algorithm for calculating light extinction (see Section 3.2.3) may be used in addition to the default IMPROVE algorithm. (Calculations would need to be performed outside CALPOST or CALPOST would need to be modified to accommodate the new algorithm.)

- Nitrate repartitioning in POSTUTIL: Do not use for the initial modeling.

The initial run results will be based on the highest change in light extinction (deciviews) from natural conditions over the three-year modeling period for each Class I area considered. Predicted changes exceeding the "contribution" threshold (0.5 deciviews) will trigger a finer grid CALPUFF modeling analysis.

4.4 Finer Grid Modeling Procedures

4.4.1 Rationale for and Overview of Finer Grid Modeling Approach

There are two potential applications for finer grid CALPUFF modeling:

BART Exclusion Modeling. First, finer grid CALPUFF modeling can be used to demonstrate that a source does not cause or contribute to visibility impairment in any Class I areas, and thus can be excluded from BART controls. As shown in Figure 4-1, if the initial regional modeling results are not below the threshold for visibility impacts, the next step is to conduct modeling using a finer grid resolution for the meteorological fields and the treatment of terrain effects and land use variability. In the finer grid modeling the predicted visibility impairment that is compared to the threshold is based on the BART guidance of the 98th percentile change in deciviews value rather than the more conservative highest value used in the initial analysis.

The BART guidance indicates that the emissions rate to be used for such modeling is the highest 24-hr rate during the modeling period. Depending on the availability of source data, the following

emissions information (listed in order of priority) should be used with CALPUFF for BART exclusion modeling:

- 24 hr maximum value emissions for the period 2001-2003 (Continuous Emission Monitor, CEM data)
- 24 hr maximum value from continuous emissions monitoring data
- facility stack test emissions
- potential to emit
- permit allowable emissions, if available
- emissions factors from AP-42 source profiles

Quantify Benefits of BART. The second application of refined modeling is to quantify the visibility benefits from the BART control options. This is accomplished by running CALPUFF with the baseline emissions rates and again with emissions after BART controls. It is important that emission reductions be evaluated in the postprocessing step rather than by using "negative" emission rates in the CALPUFF model. The chemical scheme requires that emission rates always be positive.

For any of these applications, a source-specific modeling protocol that defines source properties and the specific model configuration is required. As discussed in Section 5, the source specific protocol should include source-specific emissions data and can refer to this document for all methods and assumptions that follow this common protocol.

4.4.2 Model Configuration and Settings for Finer Grid Modeling

Grid resolution substantially better than 12-km is needed for a finer grid CALPUFF assessment of visibility impacts in most cases involving Class I areas in complex terrain or coastal areas. Thus, the CALMET fine grid resolution in the subregional modeling domains used for finer grid modeling will depend on the terrain, land use (especially coastal boundaries), location of the source, distance of the source from Class I areas, and total size of the subregional modeling domain.

VISTAS States have 2001-2003 CALMET files for five 4-km sub-regional domains as illustrated in Figure 4-4. The subdomains are designed to address all BART eligible sources within each VISTAS states and all Class I areas within 300 km of the BART-eligible sources. For application for a single source, a smaller domain of roughly 200-300 km by 200-300 km is recommended. Requests to obtain the 4-km CALMET files should be made to the State BART representatives.

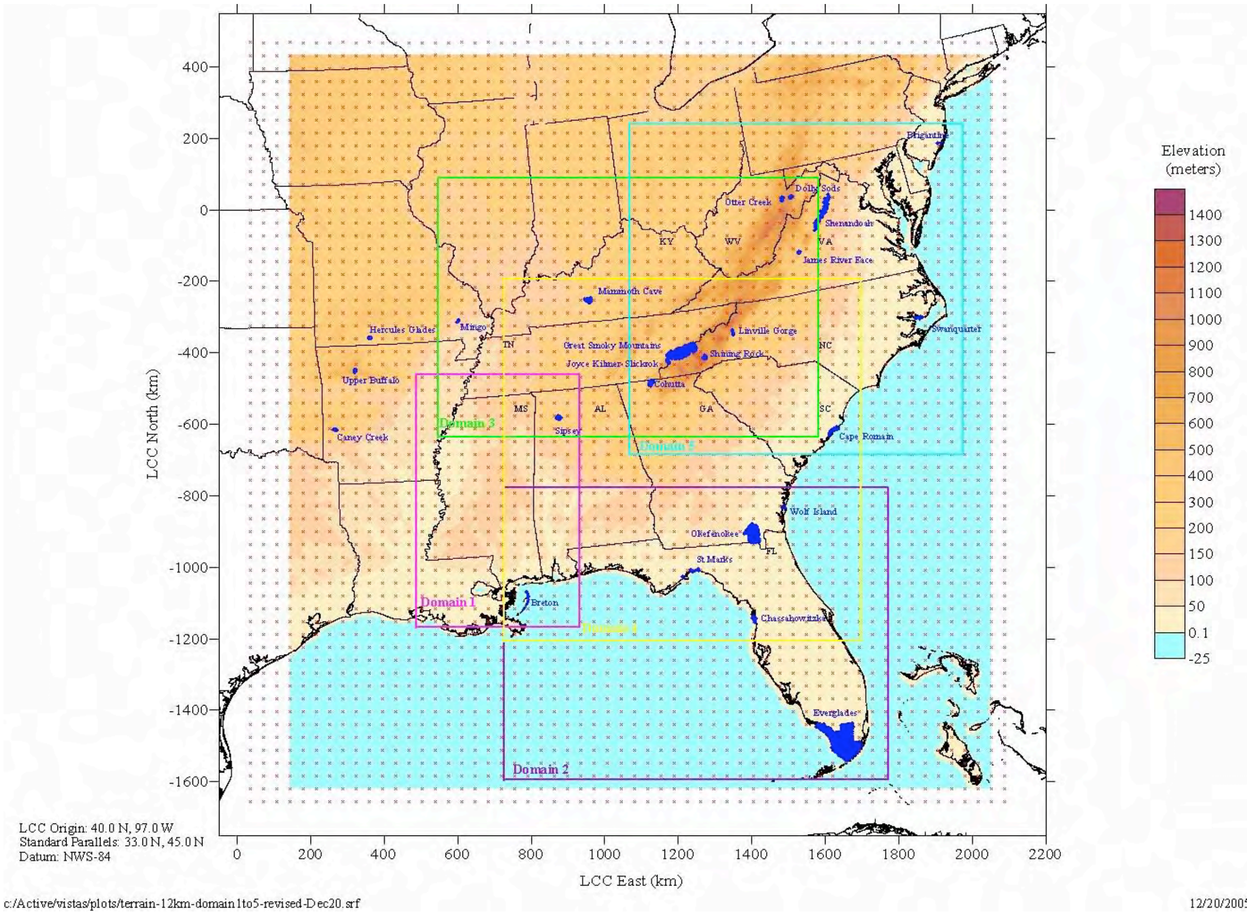

Figure 4-4. The five subregional domains for 4-km CALMET modeling.

In some instances, as part of the source-specific protocol, a source may propose to the State to use an even finer grid simulation to properly characterize the flow fields and land use changes that affect dispersion. An application for source-receptor distances within about 50 km may require a grid resolution less than 1 km if complex terrain effects are likely to be important. This determination should be made on a case-by-case basis. There is not a single distance at which a particular grid size is appropriate. It depends on factors such as the complexity of the terrain, the source-receptor distances involved, the location of the source relative to the terrain features, the physical stack parameters (e.g., a tall stack in complex terrain may be unaffected by the terrain-forced flow), proximity of the source and Class I area to a coastline, and other factors including availability of representative observational data.

The finer grid CALMET simulations were run in hybrid mode, using both MM5 data to define the initial guess fields and meteorological observational data in the Step 2 calculations. Overwater (buoy) data will be provided in addition to the hourly surface meteorological observations, precipitation observations and twice-daily upper air sounding data.

A domain-specific set of modeling parameters will be defined for each subregional domain. The proper selection of the CALMET diagnostic wind field parameters that are used to blend observations with the Step 1 wind field depends on factors such as the locations of the meteorological stations relative to terrain and coastal features (which affects the representativeness of the observational data), the terrain length scale, and the quality (resolution) of the MM5 data used to define the initial guess field and its ability to properly resolve wind flows on the fine-scale CALMET domain. The definition of the proper CALMET parameters is done as part of sensitivity testing where model performance is evaluated against available observations and expected terrain effects, such as channeling of flows within a valley.

In addition to the better grid resolution and the introduction of observational data in the finer grid simulations, several other modeling refinements can enhance the accuracy of the finer grid modeling. These include use of the higher resolution terrain DEM data (~3 arc sec USGS data) in defining the gridded terrain fields and application of the ammonia limiting method in the POSTUTIL post-processor. Otherwise, the source configuration, emissions, pollutant speciation, Class I receptors, ozone datasets and CALPUFF model options will be the same as in the initial runs. Similarly, CALPOST will be used in the same manner as for the initial analyses. However, POSTUTIL can be used to repartition nitrate in the finer grid modeling, using background ammonia concentrations according to the IWAQM Phase 2 report (IWAQM, 1998).

For the finer grid BART exclusion analysis, the test for evaluating whether a source is contributing to visibility impairment is based on the 98th percentile modeled value (rather than the highest predicted value used for the initial evaluation), which is consistent with EPA's BART guidance.

4.5 Presentation of Modeling Results

The CALPOST processing computes the daily maximum change in deciviews. A sample of the summary table produced by CALPOST is shown in Table 4-1. For evaluating compliance with the VISTAS screening threshold, the highest change in extinction value, located at the bottom of the CALPOST list file is compared to the threshold value (e.g., 0.5 dv). For example, in the sample shown in Table 4-1, the summary at the bottom shows that the highest visibility impact is 1.219 dv, with 9 days over the year showing values greater than 0.5 dv. Therefore this source would not pass the initial analysis, and finer grid modeling would be required.

In addition to the highest change in deciview value on each day over all the receptors in a particular Class I area, the CALPOST summary table in Table 4-1 contains the coordinates of the receptor, receptor type (D indicates discrete receptors), the total haze level (background + source, in dv), the background haze in deciviews, the change in haziness (delta dv), the humidity term applied to hygroscopic aerosols (f(RH)), and the contribution of each species to light extinction (in percent of the total source contribution) for SO_4, NO_3, organics, elemental carbon, coarse and fine particulate matter.

Table 4-1. Example of CALPOST Output, Showing Maximum Daily Impacts of Source and Locations of Those Impacts.

YEAR	DAY	HR	RECEPTOR	COORDINATES (km)		TYPE	DV(Total)	DV(BKG)	DELTA DV	F(RH)	%_SO4	%_NO3	%_OC	%_EC	%_PMC	%_PMF
2001	2	0	3	20.540	79.782	D	5.397	5.358	0.039	4.314	44.33	47.22	3.07	1.07	0.00	4.30
2001	3	0	9	31.680	79.822	D	4.566	4.421	0.145	1.767	40.75	33.89	9.19	3.24	0.00	12.94
2001	4	0	1	24.723	77.951	D	4.540	4.540	0.000	2.076	0.00	0.00	0.00	0.00	0.00	0.00
2001	5	0	77	30.228	94.571	D	4.950	4.939	0.011	3.144	43.13	44.74	4.64	1.45	0.00	6.05
2001	6	0	1	24.723	77.951	D	5.181	5.166	0.015	3.772	38.58	56.05	1.90	0.70	0.00	2.76
2001	7	0	3	20.540	79.782	D	6.366	5.745	0.620	5.439	44.98	44.99	3.69	1.26	0.00	5.08
.																
.																
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2001	363	0	113	27.414	103.782	D	5.725	5.652	0.073	5.164	53.49	35.51	4.03	1.39	0.00	5.58
2001	364	0	113	27.414	103.782	D	6.554	6.521	0.033	7.826	48.12	47.09	1.67	0.64	0.00	2.48
2001	365	0	1	24.723	77.951	D	6.499	6.499	0.000	7.757	0.00	0.00	0.00	0.00	0.00	0.00

```
--- Number of days with Delta-Deciview  =>   0.50:         9
--- Number of days with Delta-Deciview  =>   1.00:         2
---             Largest Delta-Deciview  =             1.219
```

For the finer grid analysis, the data in the table can be imported into a spreadsheet and sorted on the delta dv column. Table 4-2 shows an example of the ranked visibility impacts (change in dv) for each of three years at six different Class I areas. The 98th percentile (8th highest value) in the sorted table would be compared to the contribution threshold (e.g., 0.5 dv). In the example shown in this table, the source passes the finer grid analysis because the highest 98th percentile visibility impact is below the contribution threshold of 0.5 dv.

The Results section of the CALPUFF modeling report should contain the following information:

1. Map of source location and Class I areas within 300 km of the source

2. For the VISTAS 12-km CALPUFF initial exemption modeling domain, a table listing all Class I areas in the VISTAS domain and those in neighboring states and impacts at those Class I areas within 300 km of the source, as illustrated in Table 4-3**.**

3. A discussion of the number of Class I areas with visibility impairment from the source on 98th percentile days in each year greater than 0.5 dv (total visibility impairment minus impairment on 20% best days for natural background visibility equals delta-dv, the visibility impact attributed to the source).

4. For the Class I area with the maximum impact, discussion of the number of days below the 98th percentile that the impact of the source exceeds 0.5 dv, the number of receptors in the Class I area where the impact exceeds 0.5 dv, and the maximum impact.

5. For finer grid CALPUFF exemption modeling, results for those Class I areas for which impacts of the source exceeded 0.5 dv in the 12-km initial exemption modeling. Report same results as provided for 12-km initial exemption modeling.

6. For control option modeling, each control option tested should be listed in tabular format. For each control option and for each Class I area where the impact of the source exceeded 0.5 dv, report the change in pollutant emissions and the change in visibility impact from the source as a result of the control option. The effectiveness of candidate control options are to be compared to each other, not to a specific target improvement.

   States will provide further guidance on graphic presentation of results to simplify evaluation of effectiveness of control measures. For example, a temporal plot of the change in deciviews between the controlled and uncontrolled cases could be developed for the receptor with the maximum modeled impact in each Class I area.

7. Copies of all input files and input data in electronic format for the CALMET, CALPUFF, CALPOST and POSTUTIL runs should be archived and provided to the State.

Table 4-2. Example of Visibility Impact Rankings at Six Class I Areas

Class I Area	2001	2002	2003
	Delta-Deciview Ranks 1-8	Delta-Deciview Ranks 1-8	Delta-Deciview Ranks 1-8
Great Smoky NP	0.99	0.95	1.20
	0.88	0.63	0.90
	0.62	0.51	0.73
	0.59	0.50	0.72
	0.55	0.46	0.59
	0.52	0.42	0.47
	0.48	0.37	0.45
	0.47	0.36	0.42
Linville Gorge	0.67	0.81	0.76
	0.45	0.69	0.47
	0.43	0.65	0.37
	0.33	0.50	0.35
	0.29	0.45	0.31
	0.27	0.33	0.30
	0.25	0.31	0.28
	0.23	0.29	0.28
Shining Rock	0.66	0.73	0.75
	0.43	0.69	0.45
	0.41	0.63	0.36
	0.35	0.52	0.34
	0.26	0.46	0.28
	0.24	0.34	0.27
	0.23	0.29	0.26
	0.22	0.26	0.25
Cohutta	0.26	0.54	0.61
	0.23	0.47	0.42
	0.22	0.43	0.30
	0.21	0.37	0.29
	0.20	0.37	0.28
	0.19	0.31	0.28
	0.18	0.31	0.25
	0.16	0.30	0.25
Joyce Kilmer-Slickrock	0.34	0.52	0.27
	0.33	0.43	0.24
	0.31	0.32	0.23
	0.26	0.31	0.20
	0.24	0.30	0.14
	0.20	0.28	0.13
	0.18	0.24	0.11
	0.17	0.24	0.10
Mammoth Cave NP	0.56	0.57	0.50
	0.44	0.56	0.37
	0.38	0.53	0.36
	0.29	0.35	0.35
	0.25	0.33	0.31
	0.24	0.33	0.24
	0.22	0.30	0.21
	0.21	0.29	0.19

Table 4-3. Format of Summary of Results for CALPUFF Modeling in VISTAS' 12-km Modeling Domain to Determine if a BART Eligible Source is Subject to BART.

Class I area	Distance (km) from source to Class I area boundary	# of days[1] and # of receptors with impact > 0.5 dv in Class I area: 2001		# of days[1] and # of receptors with impact > 0.5 dv in Class I area: 2002		# of days[1] and # of receptors with impact > 0.5 dv in Class I area: 2003		# of days[1] and # of receptors with impact > 1.0 dv in Class I area for 3-yr period		Max. 24-hr impact over 3-yr period
Dolly Sods, WV										
Shenandoah, VA										
James River Face, VA										
Mammoth Cave, KY										
Sipsey, AL										
Great Smoky Mtns, TN										
Cohutta, GA										
Shining Rock, NC										
Linville Gorge, NC										
Swanquarter, NC										
Cape Romain, SC										
Okefenokee, GA										
Saint Marks, FL										
Chassahowitzka, FL										
Everglades, FL										
Brigantine, NJ										
Breton Island, LA										
Caney Creek, AR										
Upper Buffalo, AR										
Mingo, MO										
Hercules Glade, MO										

[1]Days below the 98th percentile of days in each year or the three-year modeling period, as appropriate

4.6 VISTAS Contribution to CALPUFF Modeling of BART Eligible Sources

VISTAS will provide updates and supporting information concerning the Common Modeling Protocol (this document) on the VISTAS website. In addition, VISTAS will make publicly available the following data bases developed by Earth Tech:

- VISTAS version of the CALPUFF modeling system, maintained on the CALPUFF website. Version 5.754 includes CALMET, CALPUFF, CALPOST, and POSTUTIL files, updated in December 2005. The last update in this VISTAS version is a CALMET update that addresses over water dispersion, which was developed for the Minerals Management Service (MMS) in fall 2005. This VISTAS version of CALPUFF will not be updated further unless errors are found in the code, except that a new one-step POSTUTIL procedure will be incorporated. BART-eligible sources in the VISTAS states will be able to use this VISTAS version throughout the BART modeling exercise.

- 12-km CALMET output files for 2001, 2002, and 2003 produced as described in previous sections. Further detail on model configuration and settings will be provided with the output files and will be made available on the CALPUFF website.

- CALMET will include a software modification to allow the meteorological data inputs into CALMET to be used to generate finer grid CALMET files without having to go back to the original MM5 output files

- Five 4-km CALMET subdomains for 2001, 2002, and 2003, produced as described in previous sections. Further detail on model configuration and settings will be provided with the output files and will be made available on the website.

- File with CALPUFF model configuration and settings sufficient to replicate CALPUFF modeling done for VISTAS using 12 km CALMET, including

    - Ozone data used to run CALPUFF

    - Ammonia concentrations used to run CALPUFF.

    - All other set up files used in VISTAS 12-km CALPUFF run

Samples of these data files and examples of their application with CALPUFF for BART screening analyses can be found on the CALPUFF web site at (http://www.src.com/verio/download/sample_files.htm).

5. SOURCE-SPECIFIC MODELING PROTOCOL

Sources are required to submit a source-specific protocol to the State for review and approval prior to source-specific modeling. States will provide the documentation to EPA and FLM for their review. An outline of the typical contents of the site-specific protocol is provided in Table 5-1.

If a source-specific modeling approach is proposed that differs from the common approach in Chapter 4, a more-detailed modeling protocol than that required under the common procedures is required. This protocol must explain the data sources, model configuration, and rationale for changes in the model approach from the common protocol and must be approved by the State.

Unit-specific source data include the following parameters:

- Location (e.g., UTM coordinates, UTM zone and datum)

- Stack height above the ground

- Stack diameter

- Exit velocity

- Exit temperature

- Emission rates (SO_2, H_2SO_4, NO_x and PM_{10}).

Additional building dimension information (building width, length, height and corner locations) is needed for short stacks that are less than Good Engineering Practice (GEP) height. This information is used in providing effective structure dimensions for building downwash calculations. (The requirement to conduct building downwash modeling may be waived by individual States or if the transport distance is greater than 50 km.)

The source coordinates must be expressed in the coordinate system used to define the CALMET and CALPUFF modeling domains. For the regional screening simulations, a Lambert Conformal Conic (LCC) coordinate system will be used. The required parameters to define an LCC coordinate include two matching parallels, latitude/longitude of the projection origin, coordinate datum, and false Easting and Northing (if used) of the projection origin. Subregional and source-specific domains may be using either an LCC or UTM projection.

The CALPUFF Graphical User Interface (GUI) system provides software (called COORDS) to compute to/from latitude/longitude, LCC and UTM coordinates for a large number of datums. In addition, the CALVIEW graphics feature allows the use of georeferenced satellite or aerial photographs to be used as base maps to confirm source locations. Links to sources of suitable base maps can be found on the CALPUFF data site (www.src.com) in the section on "Aerial Photos".

Table 5-1. Sample Table of Contents of a Source-Specific Fine-Scale Modeling Protocol.

1. INTRODUCTION
    - 1.1 Objectives
    - 1.2 Location of Source vs. Relevant Class I Areas
    - 1.3 Source Impact Evaluation Criteria
2. SOURCE DESCRIPTION
    - 2.1 Unit-specific Source Data
    - 2.2 Boundary Conditions
3. GEOPHYSICAL AND METEOROLOGICAL DATA
    - 3.1 Modeling Domain and Terrain
    - 3.2 Land Use
    - 3.3 Meteorological Data Base
        - 3.3.1 MM5 Simulations
        - 3.3.2 Measurements and Observations
    - 3.4 Air Quality Data Base
        - 3.4.1 Ozone Concentrations – Measured or Modeled
        - 3.4.2 Ammonia Concentrations – Measured or Modeled
        - 3.4.3 Concentrations of Other Pollutants – Measured or Modeled
    - 3.5 Natural Conditions at Class I Areas
4. AIR QUALITY MODELING METHODOLOGY
    - 4.1 Plume Model Selection
        - 4.1.1 Major Relevant Features of CALMET
        - 4.2.2 Major Relevant Features of CALPUFF
    - 4.2 Modeling Domain Configuration
    - 4.3 CALMET Meteorological Modeling
    - 4.4 CALPUFF Computational Domain and Receptors
    - 4.5 CALPUFF Modeling Option Selections
    - 4.6 Light Extinction and Haze Impact Calculations
    - 4.7 Modeling Products
5. REVIEW PROCESS
    - 6.1 CALMET Fields
    - 6.2 CALPUFF, CALPOST, and POSTUTIL Results
6. REFERENCES

APPENDICES

A.1 VISTAS BART MODELING PROTOCOL

A.2 … other appendices as needed

An example of the data that need to be reported is provided in Table 5-2. More detail on the stack data, emissions species, and particulate size fractions to be reported will be made available on the CALPUFF website, www.src.com, Check with your State for the more detailed format of Table 5-2 that is to be used.

Discussions with the regulatory authorities should be conducted prior to development of a protocol to ensure all of the relevant issues are included in the protocol.

Table 5-2. Example of Source Documentation for BART Eligible Source.

Unit name and/or description	**Start-up dates**	**SO_2 potential emissions (tpy)**	**NO_x potential emissions (tpy)**	**Total PM potential emissions (tpy)**
Emissions source name				
…				
Total emissions				
Potential BART-eligible emissions				

6. QUALITY ASSURANCE

6.1 Scope and Purpose of the QA program

Air quality modeling covered under this protocol is an important tool for use in determining whether a BART-eligible source can be reasonable expected to cause or contribute to visibility impairment in a Class I area, and therefore whether this source should be subject to BART controls, and if so, to determine the relative benefits of various BART controls. The purpose of the quality assurance (QA) program is to establish procedures for ensuring that products produced by the application of the modeling techniques for BART studies satisfy the regulatory objectives of the BART program.

The scope of the QA program affects different users differently. Common features of most applications will be the setup and execution of the CALPUFF air quality model and processing of modeling results to determine if a source contributes to visibility impairment at a Class I area. In many cases, users will be provided meteorological datasets that have been developed with VISTAS funding under a suitable QA program for use in the BART modeling. Other users will be involved in site-specific or source-specific analyses that will use additional datasets and potentially different modeling options and/or tools. More extensive quality assurance will be required in these latter types of applications. It is the responsibility of the modeler to ensure that an adequate QA protocol is in place for a particular application.

The CALPUFF modeling system contains built-in features to facilitate quality assurance of the modeling results. These include the automatic production of "QA" files for various datasets, including geophysical fields, sources and receptors, and imbedded tracking of model options and switches within the output files from the major modeling units of the modeling system. The Graphical User Interface system (GUI) provided as part of the latest CALPUFF modeling system allows these QA files to be displayed graphically.

In addition, a detailed software management system is in place to track version and level numbers associated each program and utility within the CALPUFF modeling system. This information is carried forward in all of the output files to create an audit trail of software versions and major model options used that can be retrieved and displayed from the model output files.

Because the required QA procedures will depend heavily on the exact application, there will be differences among different users and different applications.

In addition, the BART modeling process involves multiple organizations. The States have overall responsibility for the process and may also execute some or all of the modeling. VISTAS is contributing general guidance via this protocol and is preparing meteorological fields and performing modeling under the guidance of the States. The sources that are BART-eligible need to provide process information and emissions data for use in the analyses. In addition, those sources that are involved in BART assessments will need to be actively involved in control

technology decisions and assessments. Finally, some of the modeling steps may be carried out by contractors on behalf of VISTAS, a State, or a source.

Each of these organizations has a responsibility to ensure that it is providing correct information to others and to evaluate the quality of any analyses it is performing, whether with data of its own or from others. This chapter provides general guidance and information on those aspects of quality assurance that are specific to the CALPUFF modeling effort, irrespective of which organization is carrying out the effort. The focus is on the common protocol efforts described in Chapter 4. As described in Section 6.3, more comprehensive QA may be needed for the unique aspects of the source-specific modeling described in Chapter 5.

6.2 QA Procedures for Common Protocol Modeling

The VISTAS common protocol (Section 4) describes the methods and procedures for use in conducting regional scale screening modeling to determine the whether a particular source or group of sources is subject to BART controls. In the initial application, the regional CALPUFF-ready meteorological data files will be provided by VISTAS. The amount of effort for end-users performing QA of these pre-defined meteorological fields will be reduced from what is required in developing source-specific meteorological fields, as described below. Also, VISTAS is planning to provide five subregional CALMET meteorological datasets in a CALPUFF-ready format. The development of these CALMET datasets will be subject to a QA program as part of their development, so the necessary quality assurance activity of end-users is again reduced from what would be required in the development of the dataset. It is not expected that the quality assurance steps in the development will be repeated in each application. The VISTAS-provided regional and subregional meteorological fields will include a test case simulation for demonstrating that expected modeling results are obtained on the user's computer platform. This test should be repeated by every user.

Although the CALPUFF modeling system is recommended by the U.S. Environmental Protection Agency for application to BART analyses, a considerable amount of expertise and modeling judgment is needed at certain stages of the analysis. The modeling is not a "cookbook" exercise, a fact that was recognized by the U.S. EPA in describing the expertise needed for CALMET modeling (EPA, 1998; pp. 9-10,). Current methods for performing refined chemistry calculation also require an understanding of the chemical and meteorological processing affecting ammonium nitrate formation. VISTAS has committed to provide appropriate CALPUFF training to assist States in obtaining the necessary expertise with the latest CALPUFF modeling tools and techniques. An appropriate level of knowledge of the model formulation, technical approach and assumptions is essential for successful BART modeling.

6.2.1 Quality Control of Input Data

The input data required by the model depends on the application. At a minimum, source data is required by CALPUFF (see Section 6.2.3) along with a list of choices made about model options and switches. Most of the modeling option choices are specified or recommended by regulatory

guidance and default values (see references in Section 4.3.3). However, remodeling of the boundary conditions is not required for VISTAS-provided finer grid domains so the expertise level is not as high as it would be for development of the boundary conditions files from scratch.

To the extent that modeling applications are using pre-defined CALMET files and CALPUFF templates, the quality assurance will be straightforward. More detailed steps are needed for the setup of modeling files for source-specific applications of subregional domains finer than 4 km.

The basic procedures that will apply to all CALPUFF model applications will include a confirmation of the source data, including units, verification of the correct source and receptor locations, including datum and projection, confirmation of the switch selections relative to modeling guidance, checks of the program switches and file names for the various processing steps, and confirmation of the use of the proper version and level of each model program. It is a common and recommended procedure for an independent modeler not involved in the setup of the modeling files to independently confirm the model switches and data entry in the actual model input files and to conduct an independent run of the worst case event as a confirmation check.

In addition, common practice requires that a model project CD (or DVD or set of DVDs) be created that contains all of the data and program files needed to reproduce the model results presented in a report. The model list files from each step are included on the project CD. This information allows independent checking and confirmation of the modeling process.

6.2.2 Quality Control of Application of CALMET

For users of the VISTAS CALPUFF-ready CALMET meteorological files, a number of large datafiles will be provided by VISTAS on external USB2 or Firewire hard drives in a format ready for use with the CALPUFF model. The QA steps associated with the development of the VISTAS common datasets will be provided separately as part of the modeling documentation. It is not expected that the QA steps conducted in the development of the meteorological datasets will be repeated in each application, although tests to confirm that the dataset is suitable for the application for which it is being used should be performed as part of the QA. This is discussed in more detail below.

The regional screening CALMET grid is defined in Chapter 4 on a 12-km Lambert Conformal Conic (LCC) grid system. The subregional and source-specific domains may be defined in either LCC or Universal Transverse Mercator (UTM) coordinates. In the case of the LCC projection, two matching parallels, latitude/longitude of the projection origin, coordinate datum, and false Easting and Northing (if used) of the projection origin must also be defined. For any domains in UTM coordinates, the UTM zone (see Appendix D of the CALMET User's Guide) and datum must be defined. The appropriate projection and map factors are provided as part of the definition of the VISTAS regional grid system. For a source-specific domain, the grid parameters will be provided as part of the source-specific protocol.

Appendix A of the IWAQM report (EPA, 1998) contains a list of recommended CALMET switch settings. Except as modified in Chapter 4 of this protocol or in a source-specific protocol, the IWAQM guidance should be used in setting up the CALMET simulations. The CALMET model obtains the switch settings from an ASCII "control file" with a default name of CALMET.INP. Whether the model is run using a GUI or from the control line in a DOS, Linux, or Unix window, it is essential that the control file be reviewed as part of the CALMET QA analysis. The CALMET GUI retains all of the input descriptive information that is part of the standard CALPUFF.INP file structure. This includes the default value for each variable, a text description of the variable, the meaning of each variable option, the units of the variable and inter-relationships among variables indicating if/when the variable is used. Some third-party commercial GUIs strip out this descriptive information, which makes the QA step more difficult, although it is essential for perform nonetheless using the variable names as references for the variables in the file.

Part of the CALPUFF modeling system's built-in QA capabilities is a variable tracking system that retains the control file inputs for CALMET and CALPUFF in the output files create by the models. This information includes the Version and Level numbers of the processor codes and main model codes used in the simulations as well as the control files from the main models (CALMET and CALPUFF). The information from the preprocessing steps and the CALMET and CALPUFF model simulations is all carried forward and saved in the CALPUFF/postprocessor output files so that the final concentration/flux files contain a history of the model options and switch settings. This allows a user or reviewing agency to confirm the switch settings provided in a control file with that actually used in the model simulations. An optional switch in the CALPOST processor creates a complete listing of the QA data. This step requires access to the output CALPUFF concentration and/or flux files, which are normally practical to store on CDs or DVDs and to provide a part of the Project CD/DVD set.

6.2.3 Quality Control of Application of CALPUFF

The quality assurance of the source and emissions data is a major component of the CALPUFF modeling. Also, many errors are found in source coordinates and related projection/datum parameters, so confirmation of the source location is an important part of the modeling QA.

The locations of the Class I area receptors are another important CALPUFF input. The use of pre-defined receptors as provided by the National Park Service (NPS) receptor dataset is recommended in the VISTAS common protocol. However, although the latitude and longitude of each receptor point is provided, it is necessary to ensure that the proper UTM or LCC coordinates have been computed for computational domain selected. In particular, the datum of the NPS conversion software is not specified, so it is recommended that coordinates be checked using the CALPUFF GUI's COORDS software or another comparable coordinate translation software package that recognizes various datums.

Most of the CALPUFF input variables contain default values. Appendix B of the IWAQM report contains a list of recommended CALPUFF switch settings. Except as modified in Chapter 4 of

this protocol or in a source-specific protocol, the IWAQM guidance should be used in setting up the CALPUFF simulations. The CALPUFF model obtains the switch settings from an ASCII "control file" with a default name called the CALPUFF.INP file. As is the case with the comparable CALMET file, it is essential that the control file be reviewed manually as part of the CALPUFF QA analysis. To facilitate this process, as was the case with the CALMET GUI, the CALPUFF GUI retains all of the input descriptive information that is part of the standard CALPUFF.INP file structure. Some third-party commercial GUIs strip out this descriptive information, which makes the QA step more difficult, although it is essential for perform nonetheless using the variable names as references for the variables in the file.

6.2.4 Quality Control of Application of CALPOST and POSTUTIL

CALPOST is run separately for each Class I area in order to obtain the necessary visibility statistics for evaluating compliance with the BART screening and finer grid modeling thresholds. The inputs to CALPOST involve selection of the visibility method (Method 6 in the standard EPA BART guidance), entry of Class I area-specific data for computing background extinction (either average or best 20% natural conditions, as prescribed by the State) and monthly relative humidity factors for hygroscopic aerosols. CALPOST contains a receptor screening that allow subsets of a receptor network modeling in CALPUFF to be selected for processing in a given CALPOST run. This is how receptors within a single Class I area are selected for processing from a CALPUFF output file that may contain receptors from several Class I areas. CALPOST contains options for creating plot files that will help in the confirmation that the proper receptor subset is extracted.

The CALPOST output file contains a listing of the highest visibility impact each day of the model simulation over all receptors included in CALPOST analysis. Receptors will normally be selected in each CALPOST run so that each CALPOST run represents the impacts at a single Class I area. The table includes the data shown in the example in Table 4-1. For a screening assessment, the peak value of the change in extinction is shown at the bottom of the visibility table (see Table 4-1). For a finer grid simulation, the 98^{th} percentile value (8^{th} highest day) is used for comparison against the BART threshold of 0.5 deciviews. It is necessary to import the results of the CALPOST table into a sorting program such as a spreadsheet to rank the daily change in extinction values such as is presented in Table 4-2.

The CALPOST inputs that need to be carefully checked as part of the CALPOST quality assurance are:

- Visibility technique (Method 6 in the common VISTAS protocol)

- Monthly Class I-specific relative humidity factors for Method 6

- Background light extinction values

- Inclusion of all appropriate species from modeled sources (e.g., sulfate, nitrate, organics, (as SOA), coarse and fine particulate matter and elemental carbon.

- Appropriate species names for coarse PM used

- Extinction efficiencies for each species

- Appropriate Rayleigh scattering term (10 Mm^{-1} for screening modeling but Class I area specific value for finer grid modeling)

- Screen to select appropriate Class I receptors for each CALPOST simulation.

The CALPOST program produces plot files compatible with CALVIEW that allow confirmation of receptor locations that is useful in evaluating the receptor screening step.

POSTUTIL allows the user to sum the contributions of sources from different CALPUFF simulations into a total concentration file. In addition, it contains options to scale the concentrations from different modeled species (e.g., different particle sizes) into species-dependent size distributions for the particulate matter. For example, PM is often simulated with unit emission rates for each particle size category and, in the POSTUTIL stage, the contributions of each size category based on the species being considered (e.g., elemental carbon, coarse particulate matter, etc.) are combined to form the species concentrations for input into CALPOST. This process, although simple, requires a careful review of the weighting factors for each source. POSTUTIL also allows a repartitioning of nitric acid and nitrate to account for the effects of ammonia limiting conditions.

If source-specific modeling is performed using different sources of data or different techniques, the source-specific modeling protocol should provide justification for deviations from the VISTAS common protocol, and a QA plan specific for the application provided to address the quality assurance of the data used.

6.3 Additional QA Issues for Alternative Source-Specific Modeling

The level of QA required for application of source-specific protocols will be substantially higher than for the use of datasets that have already been subject to a QA procedure. For example, source-specific protocols may include the use of on-site meteorological datasets, the use of higher resolution prognostic meteorological (e.g., MM5) datasets, alternative visibility calculations, different extinction coefficients, or other changes to the common protocol. In addition to providing a source-specific modeling protocol describing and justifying the changes to the modeling approach from the VISTAS common protocol, the site-specific applications should include the development of a QA plan to properly evaluate the data used in the site-specific modeling.

The critical CALMET input parameters depend on the mode in which the model is run (observations mode, hybrid mode or no-observations mode), and the location and spatial

representativeness of any observational data. In a site specific protocol involving the development of a meteorological dataset, the elements of the QA process include preparation of wind rose (using observed, MM5 and CALMET-derived data), including examination of the data as a function of season and time of day (e.g., 4am, 10am, 4pm wind roses), time series analyses, and presentation of 2-D vector plots illustrating terrain effects/sea breeze circulation or other features of the flow expected to occur within the domain. For example, 2-D vector plots produced during light wind speed stable conditions (e.g., early morning such as 4 am) are good for assessing the performance of the CALMET model configuration and switches in reproducing terrain effects because these conditions are likely to maximize the terrain impacts in the model. Season wind roses at 4 am, 10 am and 4 pm would be expected to show the development of sea breeze circulations that may be important for certain applications. Customization of the QA process for the individual site-specific domain based on the availability of data and the physical processes expected to be important at that location should be conducted as part of the site-specific QA plan development.

If site-specific CALPUFF simulations involving the Ammonia Limiting Method are conducted, performance of the model in reproducing observed CASTNet or IMPROVE sulfate and nitrate concentrations at measurement sites within the site-specific modeling domain should be evaluated. The use of alternative ammonia concentration data (e.g., CMAQ output rather than derived ammonia based on aerosol measurements) will require an evaluation of the model performance relative to the techniques in the VISTAS common protocol.

In any site-specific protocol a site-specific QA plan should be prepared.

6.4 Assessment of Uncertainty in Modeling Results

Chapter 3 discussed the uncertainties and known limitations in CALPUFF. The source specific modeling report does not need to repeat the uncertainties listed in Chapter 3, but the reviewer should interpret results in light of these limitations. It is expected that the performance of the model will be better in predicting changes in visibility impacts due to BART controls than in predicting absolute visibility values. This is because uncertainties in meteorological conditions transport and dispersion are expected to be less important in evaluating a change in impact, since a comparable effect will be included in both the base and sensitivity simulations.

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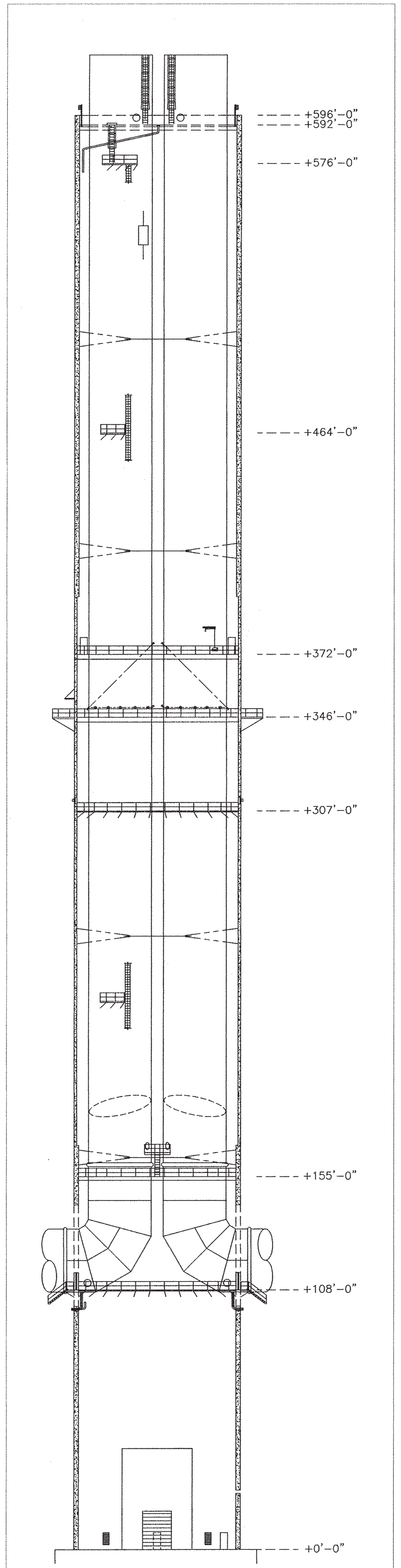
Scire, J.S., D.G. Strimaitis and F.R. Robe, 2005: Evaluation of enhancements to the CALPUFF model for offshore and coastal applications. Proceedings of the Tenth International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes. Sissi (Malia), Crete, Greece. 17-20 October 2005.

Strimaitis, D.G., J.S. Scire and J.C. Chang, 1998: Evaluation of the CALPUFF Dispersion Model with Two Power Plant Data Sets. Tenth Joint Conference on the Applications of Air Pollution Meteorology, Phoenix, Arizona. American Meteorological Society. 11-16 January 1998.

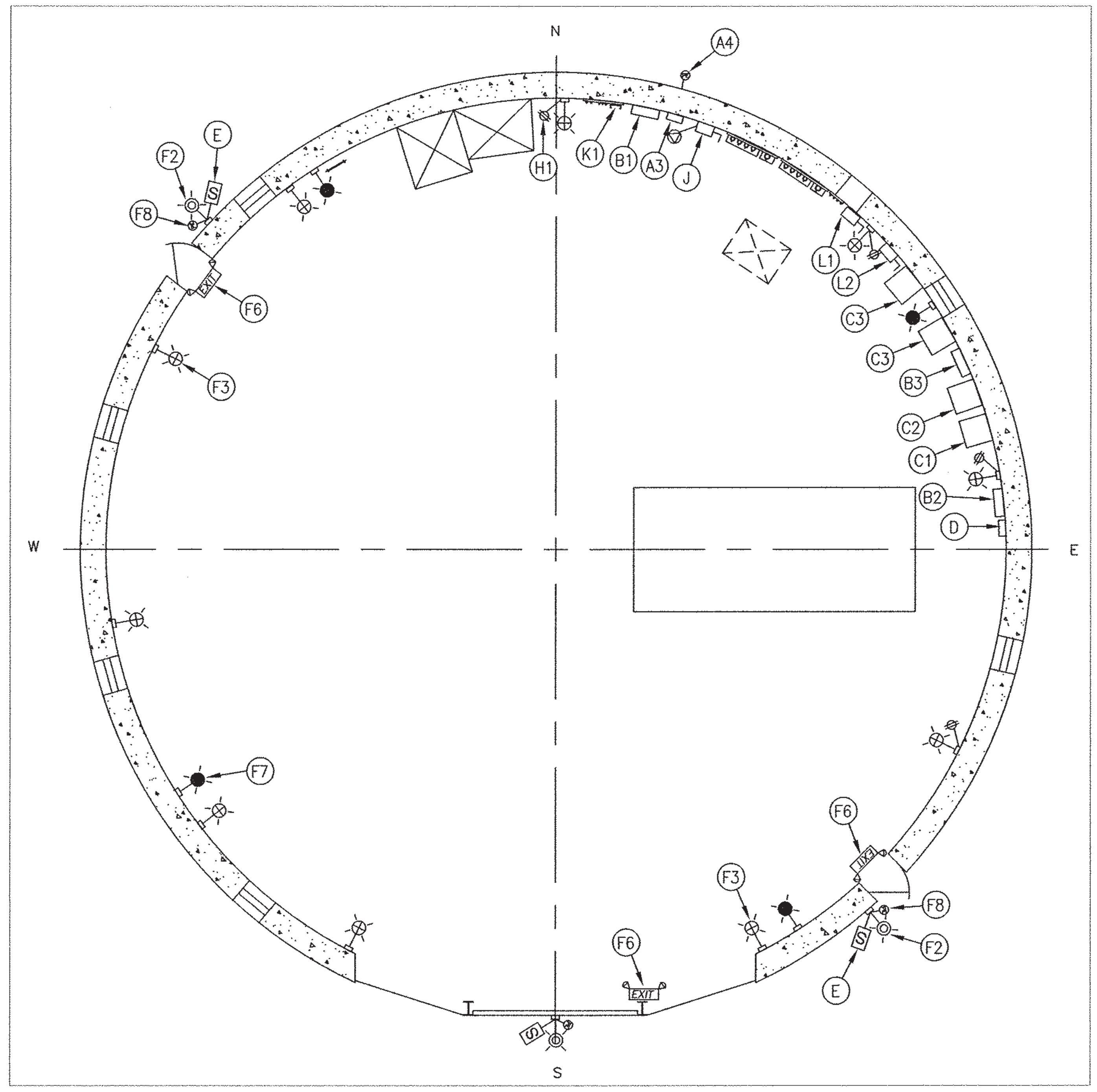
Tanner, R., M. Zheng, K. Lim, J. Schauer, and A. P. McNichol, 2005. Contributions to the Organic Aerosol Fraction in the Tennessee Valley: Seasonal and Urban-Rural Differences. Paper presented at the AAAR International Specialty Conference, PM: Supersite Program and Related Studies, Atlanta, 7-11 February 2005.

Appendix B

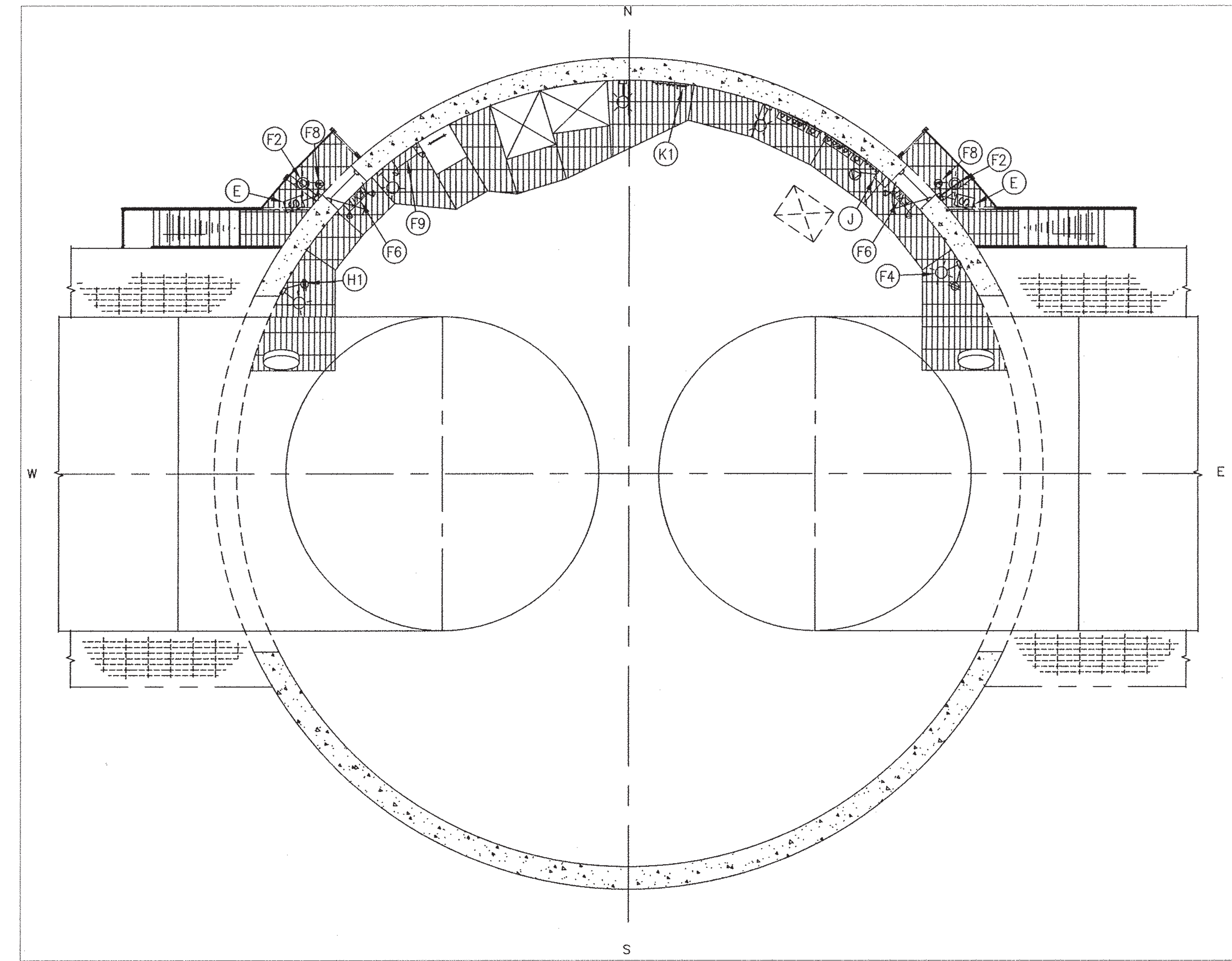
As-Built Engineering Drawing of FGD Stack



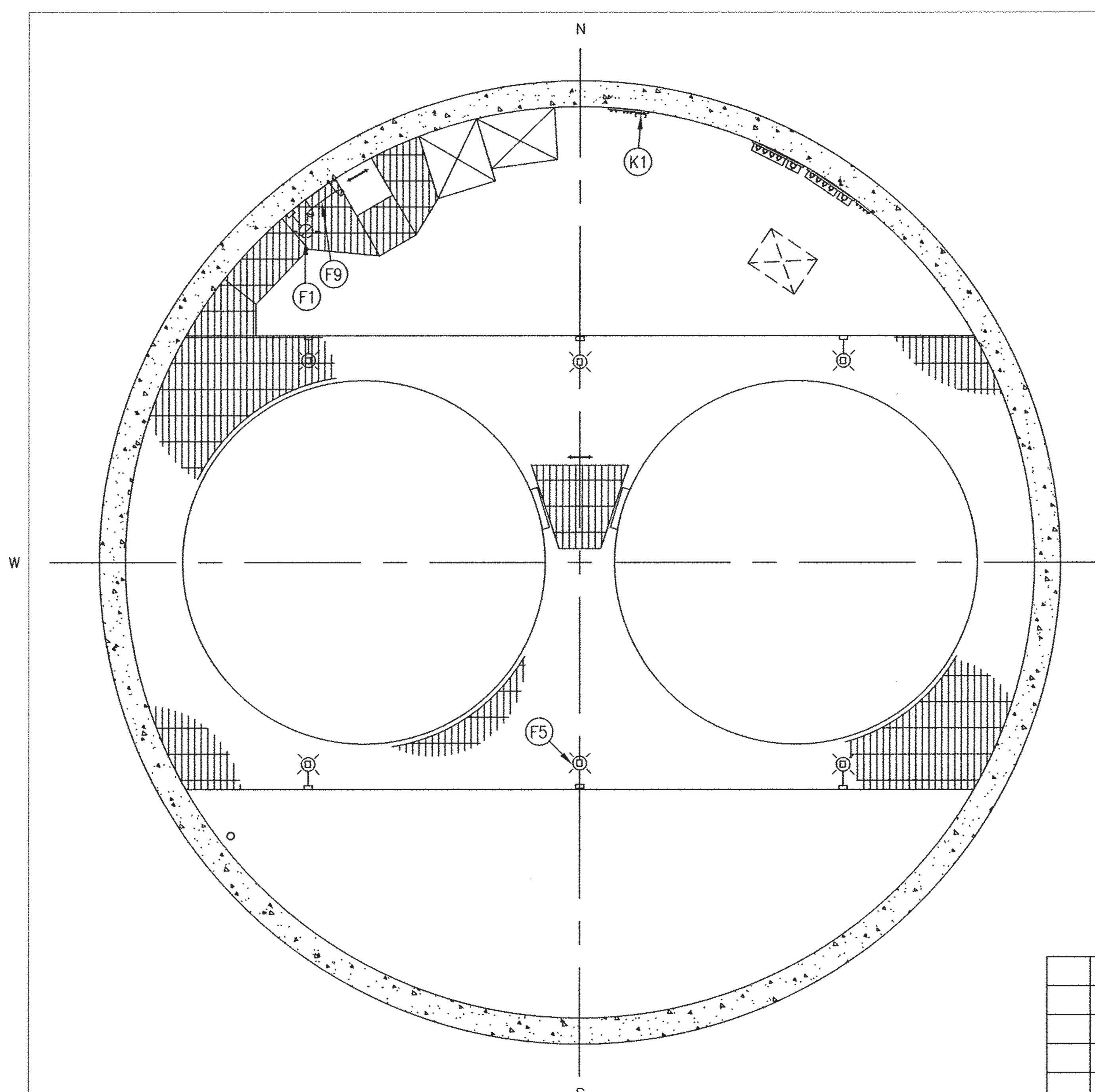
GENERAL ARRANGEMENT



PLAN VIEW @ 0'-0"



PLAN VIEW @ 108'-0"



PLAN VIEW @ 155'-0"

982

No.	REVISION	DATE	BY	CHK	DES
3	AS BUILT	3/4/15	MLA	JJ	JJ
2	REVISED PER CUSTOMER COMMENT	7/30/14	MLA	JJ	JJ
1	REVISED PER CUSTOMER COMMENT	3/22/13	MLA	JJ	JJ
0	REVISED PER CUSTOMER COMMENT	1/29/13	MLA	JJ	JJ
P	FOR PRELIMINARY REVIEW	9/11/12	MLA	JJ	JJ

DRN MLA	DATE 9/11/12
DES JJ	DATE 9/11/12
CHK JJ	DATE 9/11/12
APP JJ	DATE 9/11/12

HOWARD WAYNE ... REGISTERED PROFESSIONAL ENGINEER 10341 STATE OF MISSISSIPPI

PLOT SCALE:

Hamon Custodis, Inc.
Designers and Builders
Box 1500, Somerville, NJ 08876

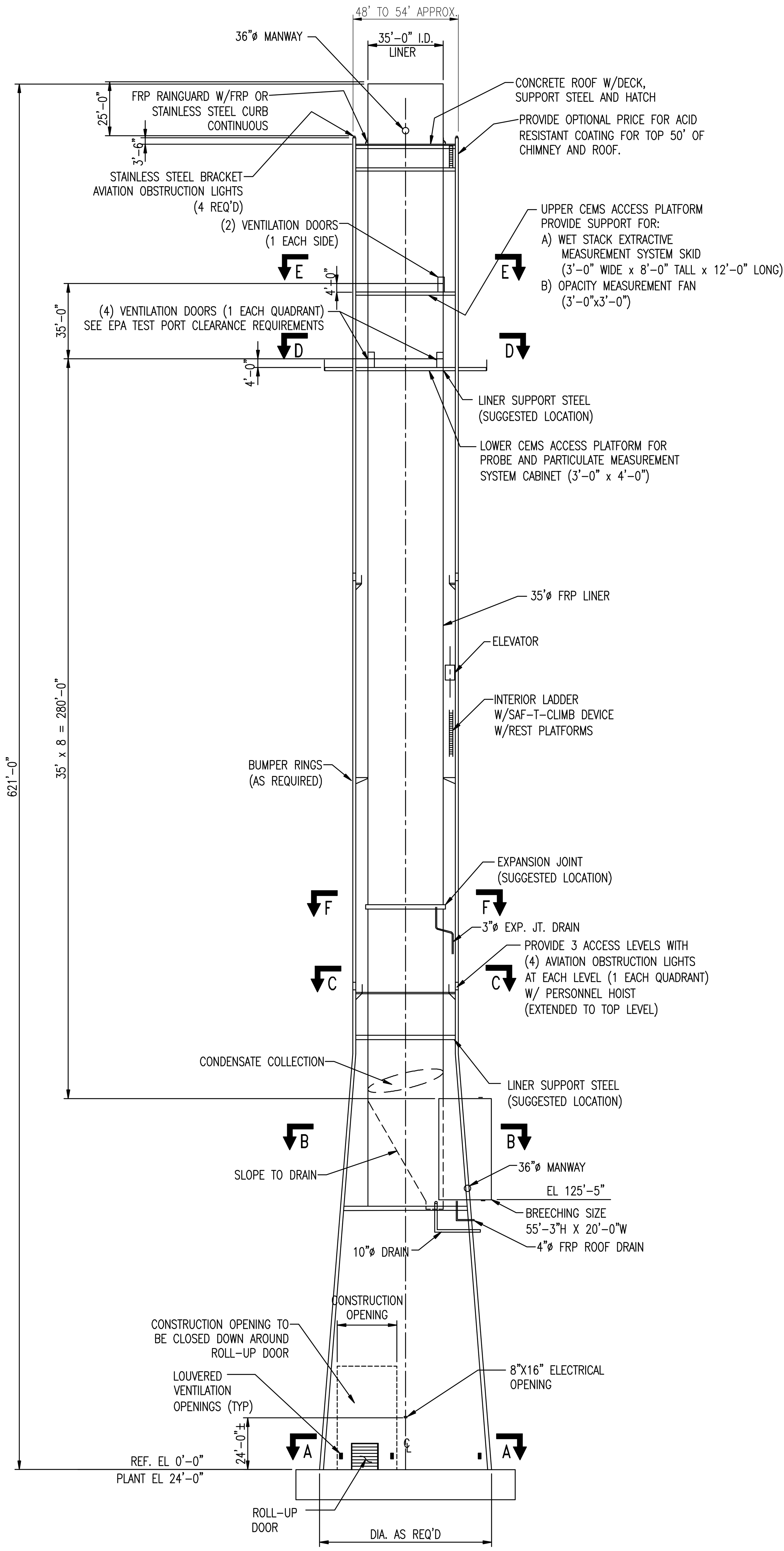
SOUTHERN COMPANY SERVICES
MISSISSIPPI POWER
PLANT DANIEL UNIT 1 & 2
ESCATAWPA, MISSISSIPPI

GENERAL ARRANGEMENT & PLAN VIEWS

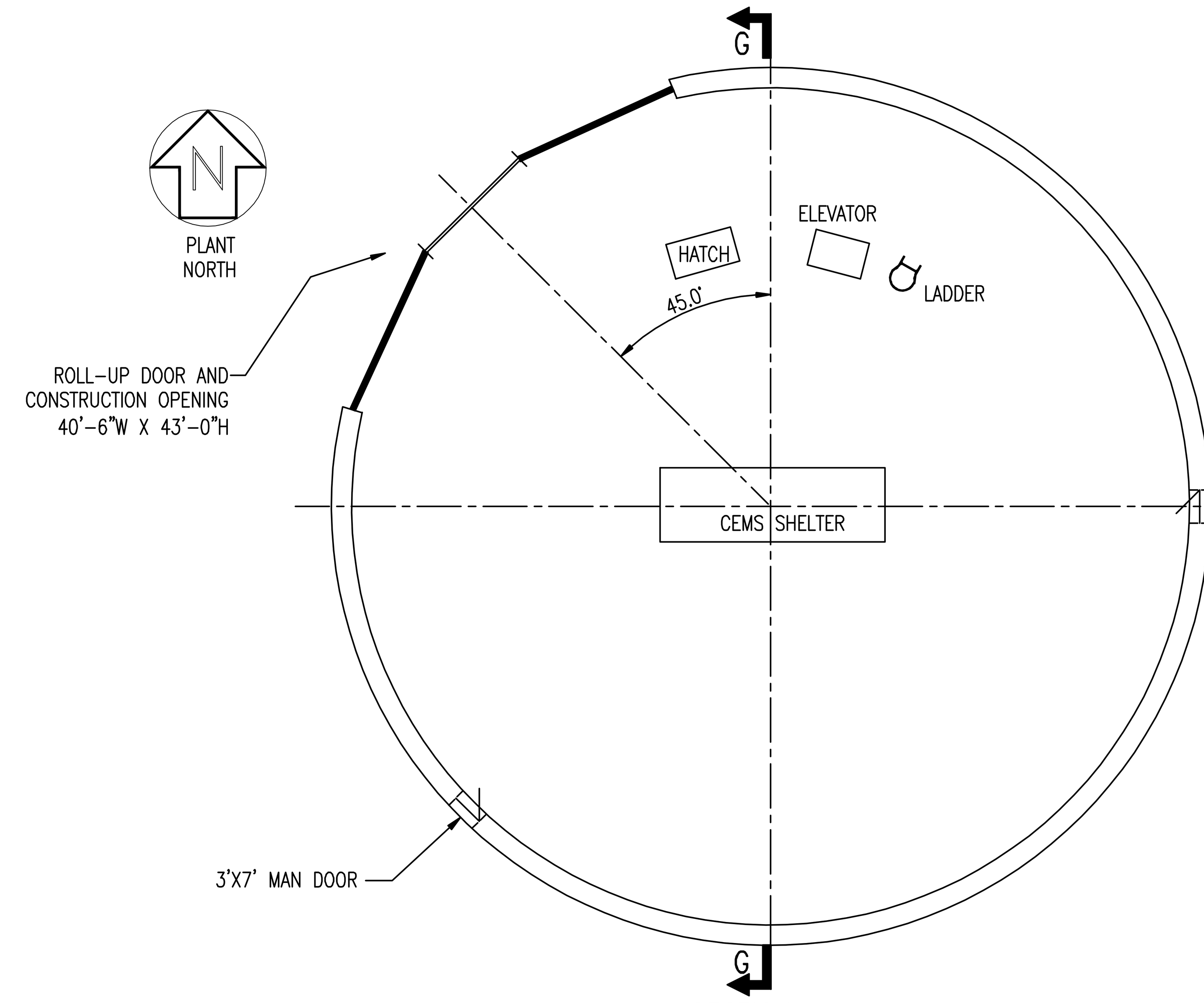
SCALE: NONE | C-0836-Z2 | 3

Southern Company Operations Daniel
MM50513 SCS REV C Units 1,2

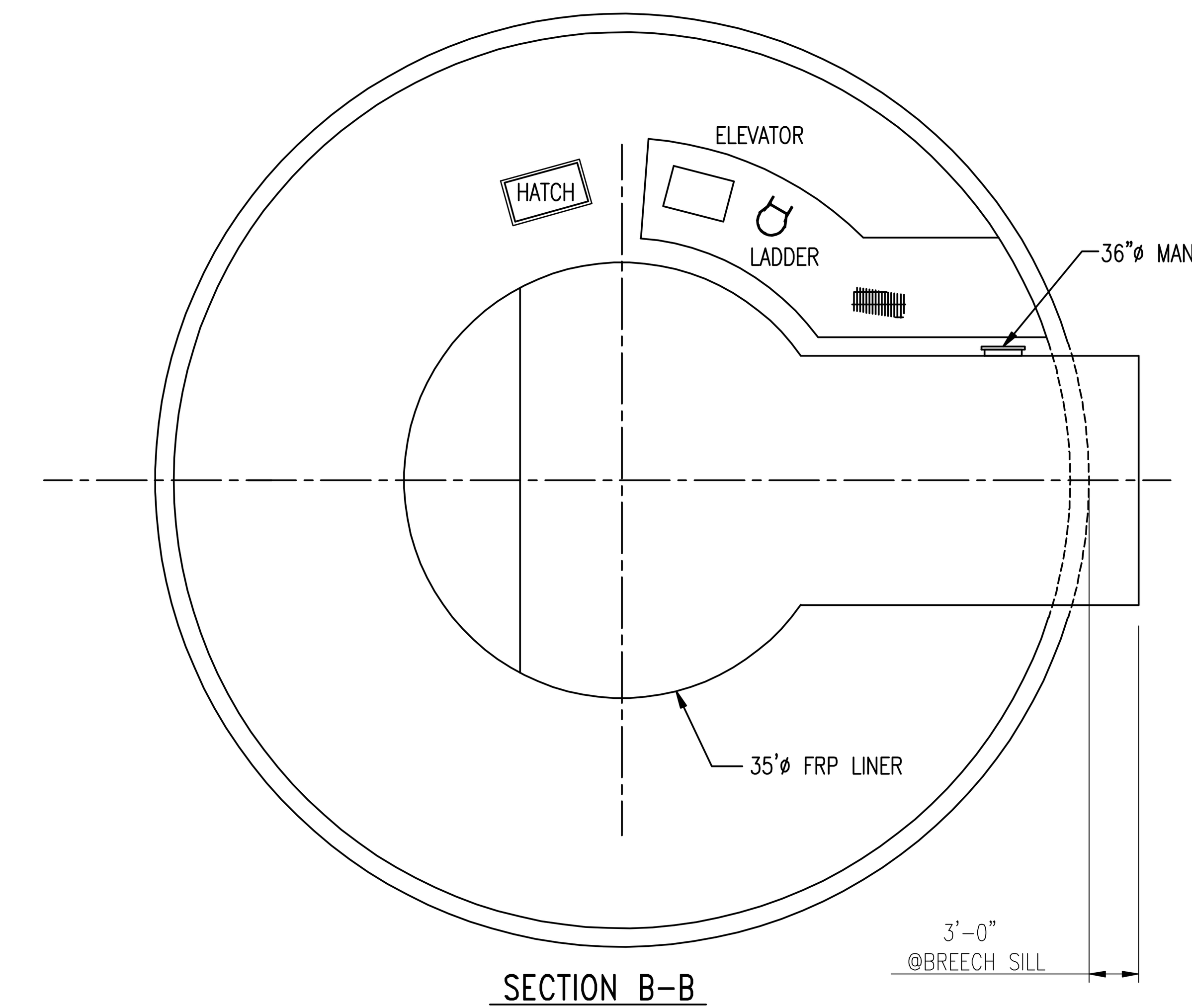
HAMON CUSTODIS PO: MPC19855-0001
C-0836-Z2 Rev 3
FGD SCRUBBER - GENERAL ARRANGEMENT AND PLAN VIEWS



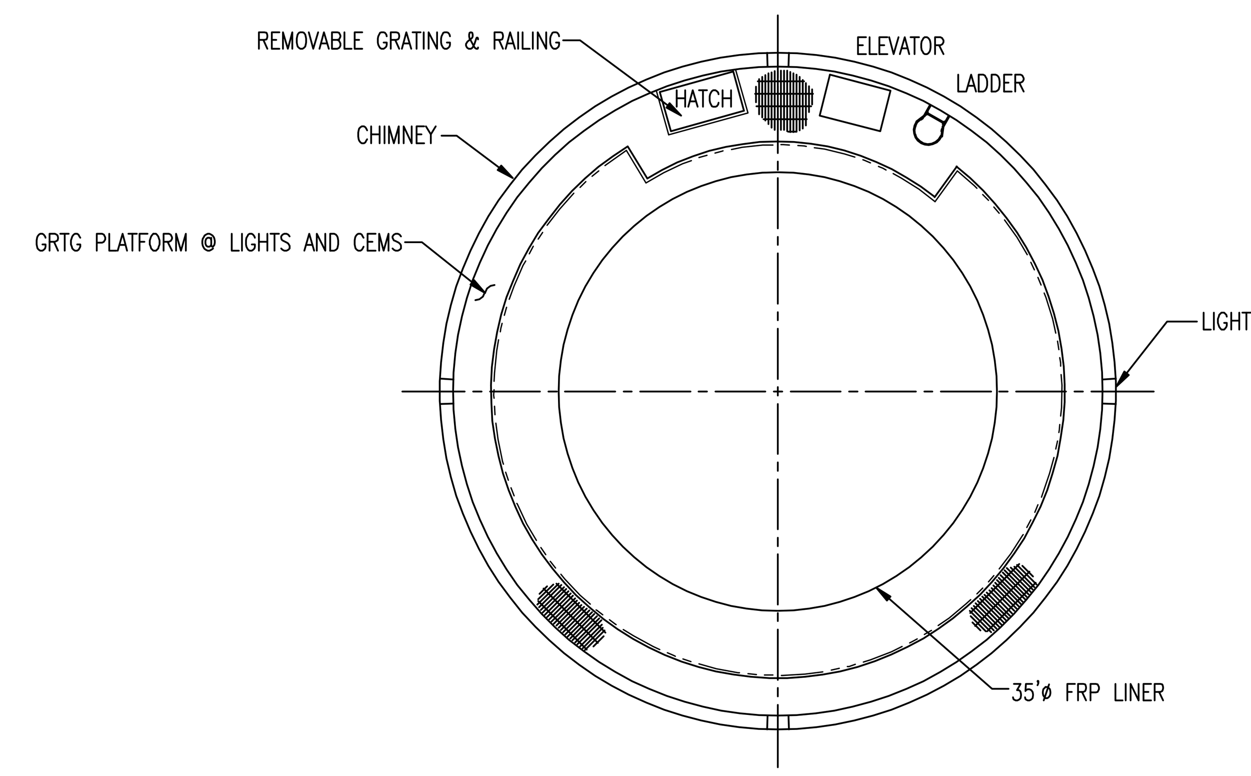
GENERAL ARRANGEMENT
SECTION G-G



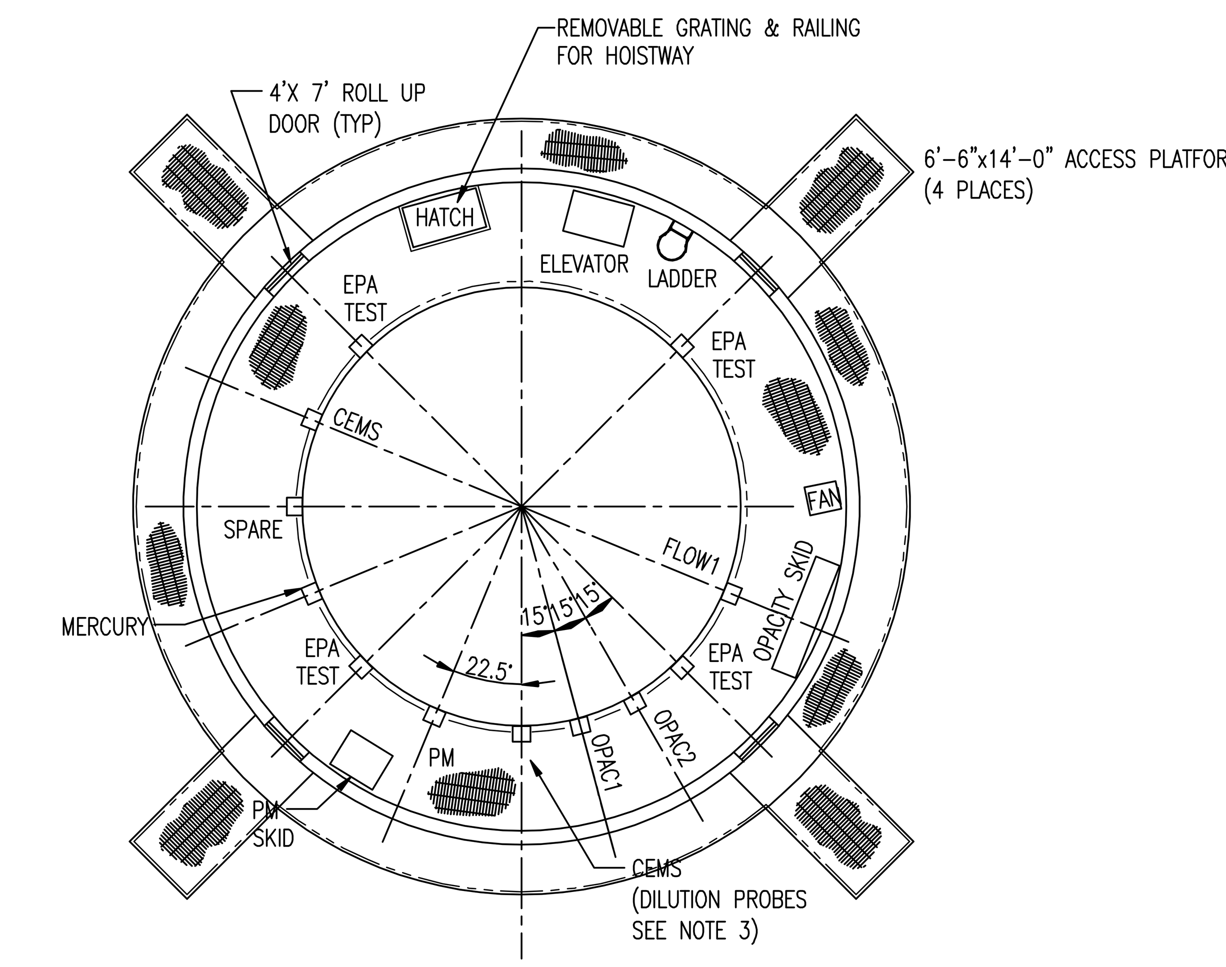
SECTION A-A
DANIEL STACK BASE



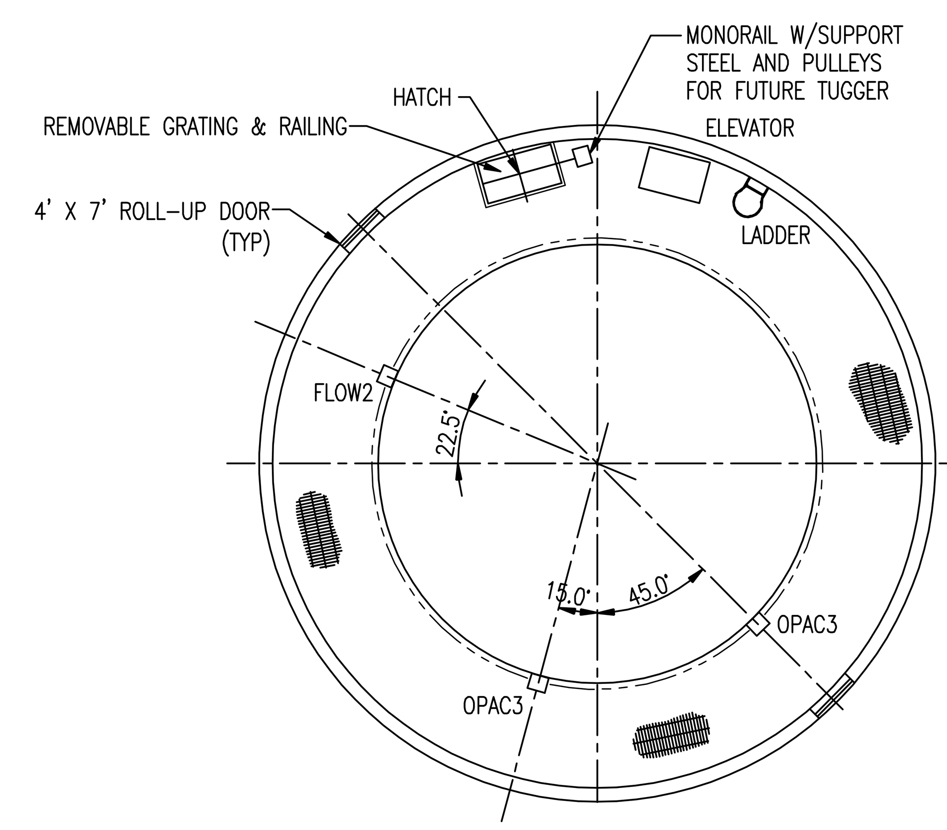
SECTION B-B
BREECH OPENING



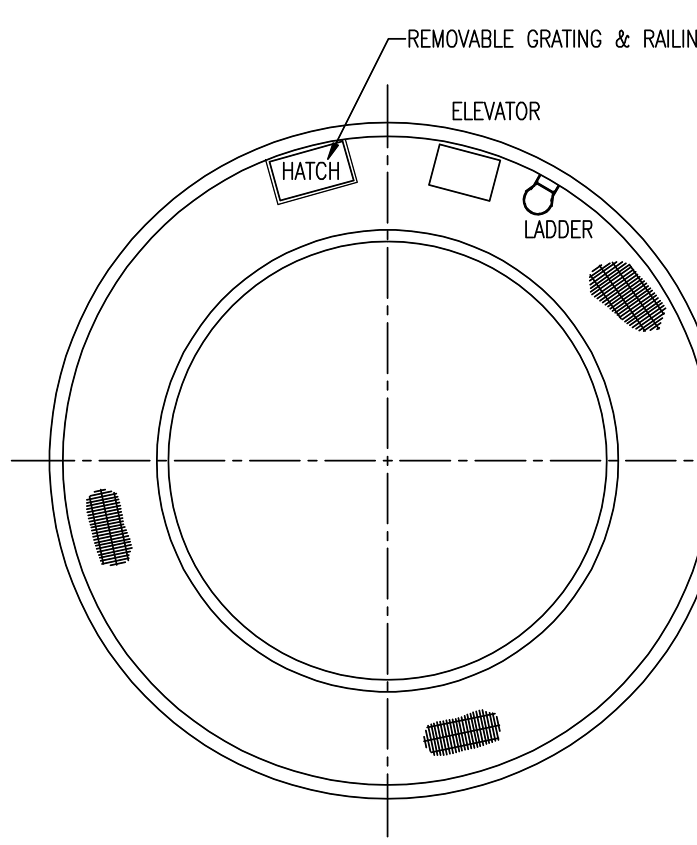
SECTION C-C
AVIATION OBSTRUCTION LIGHT PLATFORM
(2-REQUIRED)



SECTION D-D
LOWER CEMS ELEVATION



SECTION E-E
UPPER CEMS ELEVATION



SECTION F-F
EXPANSION JOINT ACCESS

NOTES:
1. PROBES SHOWN ON SECTION D-D AND E-E SHALL BE 4'-0" ABOVE THE TOP OF GRATING.
2. CEMS PROBE MAYBE CALLED DILUTION PROBE IN OTHER DOCUMENTS.

Southern Company Generation Engineering and Construction Services
FOR
Mississippi Power Company

PLANT DANIEL UNITS 1 & 2
FGD SYSTEM
621' CHIMNEY

REVISION	DATE
A — FOR INQUIRY	5/07/2009

BY	CHK'D	CIVIL APPR	ELECT APPR	I/C APPR	MECH APPR	MGR APPR
WAB	XXX	XXX	XXX	XXX	XXX	CKT

SCALE	PROJ I.D.	DRAWING NUMBER	SH	CONT'D	REV
		DAN621	1	FINAL	A

ANSI F: 28x40   Acad2004

Appendix C

Source-Specific Sulfuric Acid Emissions for BART Baseline Case

Sulfuric Acid (H2SO4) Emissions

During the combustion of sulfur-containing fuels, a percentage of the SO_2 formed is further oxidized to SO_3. As the flue gas cools across the air heater, this SO_3 combines with flue gas moisture to form vapor-phase and/or condensed sulfuric acid (H_2SO_4). The baseline H_2SO_4 emissions shown in Table 2-1 of this BART modeling protocol were calculated consistent with the method used by Southern Company to derive these emissions for Toxics Release Inventory (TRI) purposes. This method is documented in a report titled "Estimating Total Sulfuric Acid Emissions from Stationary Power Plants," published by the Electric Power Research Institute and updated in 2018. The approach described in this report assumes that H_2SO_4 emissions released from the stack are proportional to SO_2 emissions from combustion and are dependent on the fuel type and the removal of H_2SO_4 by downstream equipment (i.e., ESP, air heater, and FGD control equipment).

The calculations below show baseline sulfuric acid emissions that are expected. The baseline sulfuric acid emissions estimate accounts for the manufacture of H_2SO_4 through combustion and the removal of H2SO4 through the FDG equipment. Calculated sulfuric acid releases then account for loss or removal within the system.

Sulfuric Acid Manufactured from Combustion (EMComb):
EMComb = K x F1 x E2

where,
EMComb = total sulfuric acid manufactured from combustion, lbs/yr
K = Molecular weight and units conversion constant = 98.07 / 64.04 * 2000 = 3,063
(98.07 = Molecular weight of sulfuric acid; 64.04 = Molecular weight of SO2; Conversion from tons per year to pounds per year – multiply by 2000.)
F1 = Fuel Impact Factor (from the emissions estimating report)
E2 = Sulfur dioxide emissions, tons (from CEMS heat input and fuel data)
F2 = technology impact factors from downstream equipment and controls

Sulfuric Acid Manufactured from Combustion is:
Daniel 1 & 2
EMComb = 3,063 x 0.006893 x 3,528.38 lbs/hr / 2000 = 37.25 lbs/hr

Total Sulfuric Acid Released from Combustion (TSAR)
TSAR = EMComb x F2

where
F2 = technology impact factors from downstream equipment for the air heater, ESP, and FGD
F2 = 0.5 air preheater
F2 = 0.63 EPS
F2 = 0.6 Daniel's FGD equipment

TSAR = EMComb x (0.5) x (0.63) x (0.60) = EMComb x (0.19)
Daniel 1 & 2
TSAR = 37.25 lbs/hr x (0.19) = 7.04 lbs/hr

Appendix D

Estimated Emissions of Primary Total Carbon and Primary Sulfate From Coal-Fired Power Plants

Estimated Emissions of Primary Total Carbon and Primary Sulfate From Coal-Fired Power Plants

Prepared for

John J. Jansen

Southern Company

Birmingham, AL

Prepared by

Eric S. Edgerton

Atmospheric Research & Analysis, Inc.

Cary, NC

June 11, 2006

ABSTRACT

Data from the SEARCH network were used to estimate condensable carbon and condensable SO_3 emissions from coal-fired power plants (CFPPs). Continuous trace gas and $PM_{2.5}$ measurements were used to identify CFPP plumes and to quantify incremental fine particulate total carbon (TC) and fine particulate total sulfate (SO_4) during the period October 2005-May 2006. As measured in the field, incremental TC includes emitted particulate OC, particulate EC and condensable carbon as well as secondary organic aerosol (SOA). Incremental SO_4 includes emitted particulate SO_4, condensable SO_3, and secondary SO_4. As such, TC and SO_4 provide upper bounds for CFPP emissions of condensable carbon and condensable SO_3. Plume events were selected so as to avoid confounding of TC and SO_4 signals by other sources, and to minimize in-plume production of secondary SO_4 and SOA. Results are presented as ratios relative to SO_2, for example, pounds TC per pound SO_2 (lb TC/lb SO_2,). Plume increments can be interpreted as emission ratios for TC and primary SO_4. For TC, 14 plume events from 4 sites and 7 CFPPs exhibited sufficiently stable data for analysis. Of these, 11 events yielded an average TC/SO_2 emission ratio of 3.2×10^{-3} lb/lb (range 1.1×10^{-3} to 6.6×10^{-3}). In other words, TC emissions represented about 0.32 percent of SO_2 emissions, on a mass basis. The 3 remaining events yielded negative emission ratios using the default approach, and an average emission ratio of 1.5×10^{-3} using an alternate approach. For SO_4, a total of 20 events from 4 sites and 8 CFPPs were analyzed. Results showed an average SO_4/SO_2 emission ratio of 6.4×10^{-3} lb/lb (range 2.1×10^{-3} to 15.0×10^{-3}). On average, SO_4 was found to represent about 0.64 percent of SO_2 emissions during the study period. Inferred emission ratios should be considered upper bound estimates because: 1) the measurements include, in addition to the condensable

carbon and condensable SO_3 emissions of interest, primary particulate carbon (EC and OC) and primary particulate sulfate emitted by the CFPP; 2) may include secondary carbon and secondary sulfate produced in the atmosphere; and 3) could be inflated due to preferential loss of SO_2 from the plume (due to conversion and/or dry deposition) in transit from the CFPP to the research site.

INTRODUCTION

The Southeastern Aerosol Research and Characterization Study (SEARCH) was designed to provide extensive, long-term data on the sources and chemical characteristics of $PM_{2.5}$ and PM_{coarse} for the southeastern U. S. SEARCH is unique in that continuous $PM_{2.5}$ measurements of all major components are made at urban/rural pairs of sites in and around four southeastern U. S. cities. In conjunction with co-measured meteorological and trace gas data, continuous $PM_{2.5}$ measurements provide opportunities for: (1) investigating sources and physico-chemical dynamics of $PM_{2.5}$; (2) evaluating chemical transport and transformation models; (3) assessing the effectiveness of emissions reduction programs; and (4) examining relationships between PM mass and composition and various health end points.

CFPPs emit three forms of primary particulate carbon to the atmosphere: filterable organic carbon (OC), filterable elemental carbon (EC) and condensable carbon. OC and EC are emitted as particles, while condensable carbon is emitted in the vapor phase and is presumed to condense rapidly onto pre-existing particles. These three forms of carbon, plus secondary organic aerosol

(SOA), are measured collectively in the SEARCH network, as total carbon (TC), using continuous measurement techniques. CFPPs also emit two forms of primary particulate sulfate: filterable sulfate and condensable sulfur trioxide (SO_3). In the atmosphere, condensable SO_3 reacts more or less instantaneously with water vapor to produce particulate sulfate. These forms of sulfate, plus secondary sulfate from oxidation of SO_2, are also measured in the SEARCH network using continuous techniques.

This report uses SEARCH data to: (1) identify CFPP plumes observed at numerous sites during the fall of 2005 through spring of 2006; and, (2) calculate total carbon (TC) and total sulfate (SO_4) associated with such plumes. Results are used to estimate CFPP emission ratios of TC and SO_4, relative to SO_2. Given that the measurement techniques do not discriminate between the various form of particulate carbon and particulate sulfate present in the plume, results can be used as upper bound estimates of emission ratios for condensable carbon and condensable SO_3.

EXPERIMENTAL

Continuous measurements of trace gases fine particulate TC and fine particulate SO_4 were made at the Southeastern Aerosol Research and Characterization (SEARCH) sites shown in Figure 1. Analyzable plume events were observed at 5 of the 8 SEARCH sites between early October 2005 and early May 2006: Yorkville, GA; Jefferson Street, GA; Centreville, AL; OLF, FL; and Gulfport, MS. Brief descriptions for these 5 sites are provided below.

Yorkville, GA - Yorkville (lat. 33.9283 N, long. 85.0456 W) is a rural/agricultural site 55 km WNW and 40 km SSW of Atlanta, GA and Rome, GA, respectively. The site is on a broad ridge (elev. 395 m) in a large (>150 ha) clearing devoted largely to pasture. CFPPs in the vicinity of Yorkville are shown in Figure 2.

Centreville, AL – Centreville (lat. 32.9029 N, long. 87.2497 W) is located on private property in rural Bibb County, approximately 85 km SSW of Birmingham, AL. The surrounding area includes the Talladega National Forest and is heavily wooded with mixed deciduous (oak-hickory) and loblolly pine. CFPPs in the vicinity of Centreville are shown in Figure 2.

Jefferson Street (Atlanta), GA - Jefferson Street (lat. 33.7775 N, long. 84.4167 W) is an urban/industrial-residential site 4.5 kilometers NW of downtown Atlanta, GA. The site is located at 829 Jefferson Street NW, on Georgia Power Company property in a 70m by 125m grass-covered clearing on a knoll 15 meters above street level. CFPPs in the vicinity of Jefferson Street are shown in Figure 3.

Outlying Landing Field #8 (OLF), FL - OLF (lat. 30.5496 N, long. 87.3734 W) is a suburban site 21 km NW of downtown Pensacola, FL and 20 km N of the Gulf of Mexico. The site is adjacent to a paved, lightly traveled (< 200 vehicles/day) road on the northern edge of a large (>500 ha) grass-covered field. CFPPs in the vicinity of OLF are shown in Figure 3.

<u>Gulfport, MS</u> – Gulfport (lat. 30.3901 N, long. 89.0498 W) is located 1.5 km from the Gulf of Mexico on the premises of the Harrison County Youth Court at 47 Maples Ave. The area is covered with sparse forest and grass, with single family homes to the east, an elementary school to the north and athletic fields to the south. CFPPs in the vicinity of OLF are shown in Figure 3.

Continuous Trace Gas and Particle Measurements

SO_2, NO_y and CO are measured at each site and used to: 1) screen for periods of influence from point sources (specifically CFPPs) and non-point sources; 2) identify specific CFPPs based on SO_2:NO_y ratios; and 3) calculate TC/SO_2 and SO_4/SO_2 ratios. Continuous (1-minute average) measurements were made at a reference height of 10 m above ground level. Sample air is pulled through a weather-proof inlet box and then into the equipment shelter via ¼" o.d. heavy wall PFA Teflon tubing. The inlet box contains catalytic converters (for NOy), solenoids and plumbing for introduction of zero air and calibrant gases. Calibration gases (+/- 1% for CO and NO and +/- 2% for SO_2) were supplied by Scott-Marrin, Inc. (Riverside, CA).

SO_2 is measured via pulsed UV fluorescence with a TEI Model 43ctl analyzer operated on a 0-200 ppb scale. The instrument is calibrated every third day by gas replacement and zeroed 10 out of every 90 minutes by diverting sample air through a sodium carbonate impregnated annular denuder (URG, Carrboro, NC). The analyzer is also subjected to weekly multipoint gas replacement calibrations (GRC).

CO is measured via gas filter correlation with non-dispersive infrared detection using a TEI Model 48ctl analyzer operated on a 0-3000 ppb scale (0-10,000 ppb at JST). The analyzer is calibrated and zeroed on the same schedule as the SO2 analyzer. Zeroing is performed by diverting the sample stream through a heated (50-100C) trap containing approximately 200 grams of 1% Pt on alumina (DeGussa, Seviersville, TN).

NO_y is measured via ozone-NO chemiluminescence following reduction to NO on a 350 ºC Mo catalytic converter, using a dual-channel TEI Model ctl NO-NO_x analyzer operated on a 0-200 ppb scale. The analyzer is zeroed four times per day and calibrated every third day via gas replacement. Converter efficiency is checked once a week with n-propyl nitrate.

SO_4 is measured continuously using a variation of the Harvard School of Public Health (HSPH) approach. This method uses a 1000 °C inconel steel tube to reduce particulate SO4 to sulfur dioxide (SO_2). The SO_2 is then detected using a Thermo-Environmental Instruments (TEI, Franklin, MA) Model 43S or 43Ctl high sensitivity, pulsed ultra-violet fluorescence SO_2 analyzer. Sample air is pulled through a 2.5 μm sharp-cut cyclone inlet (BGI, Atlanta, GA), then through two 30 mm o.d., 254 mm long sodium carbonate and citric acid coated annular denuders (URG, Carrboro, NC) followed by a 30 mm o.d., 100 mm long carbon honeycomb denuder (MAST Carbon Ltd., Surrey, UK). The denuders effectively remove a wide range of interferents, including SO_2, reduced sulfur gases, nitrogen oxides and volatile organic compounds. Sample air then passes through a 300 mm section of inconel tubing heated to 1000 °C in a Lindberg/Blue M horizontal tube furnace. Every 90 minutes, the system is zeroed for 10 minutes by diverting sample air through an inline filter upstream of the converter. The SO_2 analyzer is subjected to manual and automated gas replacement audits on a weekly schedule.

Total carbon (TC) is measured continuously with a Sunset Laboratory Model RT-OCEC Aerosol Carbon Analyzer. This device operates on an hourly cycle, with 47 minutes devoted to sample collection and 13 minutes devoted to sample analysis. In sample mode, ambient air is pulled through an activated carbon monolith denuder (Novacarb™, Mast Carbon Ltd., UK) at a flow rate of 8.5 lpm, then through dual quartz fiber filters. In analysis mode, the filters are heated through several temperature plateaus to a final temperature of 900 °C. CO_2 produced during the heating cycle is quantified with a non-dispersive infra-red (NDIR) detector and TC is calculated based on CO_2 produced and sample volume. The TC analyzer is automatically calibrated with 5% methane in helium after every analysis cycle.

Trajectory Calculations

Twenty-four hour back trajectories are generated using the interactive version of the NOAA HYSPLIT4 model on the NOAA-ARL web site (*12*). Back trajectories use EDAS 40 km meteorological data and default vertical motion, with starting heights of 1000 m, 500 m and 250 m, for the time (hour) of peak SO_2 concentration during each event. The 250 m trajectory is used to determine which CFPP affected the site, as well as time of emission at the CFPP.

Event Selection and Data Reduction

Event selection attempted to identify episodes with minimal contamination from non-CFPP sources. In general, this means that different episodes are used for TC and SO_4 analyses. For TC, we look for clean, well-ventilated conditions during the middle of the day, with low and stable CO concentrations. This avoids rush hour emissions and near-surface sources that tend to accumulate under the nocturnal boundary layer. While some VOC to SOA conversion is possible, the effect should be small during fall and winter because of: 1) low biogenic precursor emissions; and 2) low temperatures; and 3) low solar insolation. For SO_4, in contrast, we are less concerned with contamination from non-CFPP sources, but want to avoid strong sunlight and consequent photochemical production of secondary SO_4 within the plume. Thus, the majority of SO_4 events selected for this analysis occurred either at night or during the early morning hours.

TC emission ratios are calculated using the "ratio of deltas" method, as shown below,

$$ER_{TC} = (TC_{Plume}-TC_{Base})/(SO2_{Plume}-SO2_{Base}) = \Delta TC/\Delta SO_2, \quad \text{(Eq. 1)}$$

where subscripts Plume and Base refer to concentrations measured during the plume event and before or after the event, respectively. The technique is illustrated in Figure 4, which shows an event that occurred at Yorkville on April 9, 2006. The upper panel shows SO_2 and CO during the course of the day. Note that the regular gaps in the time series reflect zeroing cycles. SO_2 concentrations were <5 ppb until about 1430 local standard time (LST), when they increased sharply and remained above 40 ppb until about 1630, then fell below 5 ppb for the remainder of the day. CO concentrations were between 80 and 100 ppb for the entire day, indicating no evidence of plumes from biomass burning, transportation and other activities.

The lower panel shows time series for SO_2 (red symbols) and TC (black bars), also for April 9, 2006. In this case, SO_2 concentrations have been averaged to coincide exactly with the 47-minute Sunset collection period. The plume event is shown in the red box and the downward facing arrows indicate the two values used (i.e., averaged) to calculate Base concentration. The symbols and bars at 1500 LST and 1600 LST are averaged to calculate Plume concentration. Base and Plume concentrations are then used to calculate the ratio of deltas, as shown in Equation 1. Note that ΔTC during this event (0.22 $\mu g/m^3$) is quite small compared to the overall range of TC observed during the day, despite the fact that average SO_2 concentrations exceeded 75 ppb for the 47-minute period beginning at 1600 LST. This is typical of CFPP plume events and underscores the fact that CFPPs are minor sources of particulate carbon. In other words, large plumes are needed in order to even "see" an increase in TC. The small increment of TC associated with CFPP events places a high premium on stable TC measurements.

For several CFPP events, ΔTC was negative, indicating that Base concentrations were slightly higher than the Plume concentrations. Based on Equation 1, this implies a physically unrealistic negative ER. For these events, we used the detection limit for the Sunset analyzer (0.1 $\mu g/m^3$) in the numerator of Equation 1.

SO_4 emission ratios are calculated by linear least square regression of 1-minute SO_4 concentrations versus 1-minute SO_2 concentrations. The regression slope is equivalent to the primary SO_4/SO_2 emission ratio and the intercept is equivalent to the baseline SO_4 concentration in absence of the plume. Figure 5 illustrates an example SO_4 event which occurred at Yorkville on February 25, 2006. In the upper panel, SO_2 concentration is < 5 ppb until approximately 0400 (LST), increases to nearly 50 ppb just before 0600, then falls below 5 ppb by 0900. SO_4 concentrations (right hand scale) are < 1 ppb (3.9 $\mu g/m^3$) the entire day, but show several minor excursions, some of which are associated with SO_2 excursions and some of which are not. The lower panel shows the scattergram of SO_4 versus SO_2 and associated regression statistics. Data for the regression correspond to the red box in the upper panel. Results show a highly significant relationship between SO_4 and SO_2 ($p<0.01$) with a regression slope of 0.0042 on a ppb/ppb basis. Given that the molecular weight of SO_4 is 1.5 times that of SO_2, the emission ratio for this event is 0.0063 lb/lb or 0.63 %.

It should be noted that both the ratio of deltas approach and the linear regression approach give upper bound estimates of TC and SO_4. The principal reason for this is dry deposition, which removes gaseous SO_2 from the plume much faster than particles. If we assume dry deposition to be a first order loss process, then the effect is to reduce ΔSO_2 in the denominator of equation 1 and thereby inflate the ratio $\Delta TC/\Delta SO_2$. Another reason is photochemical or non-photochemical production of secondary SO_4 and OC, which would increase SO_4 and, at the same time, decrease SO_2 in the plume. Although events have been carefully selected to minimize these effects, we cannot be certain they have been eliminated completely.

RESULTS

Table 1 summarizes results for 14 TC plume events observed at 4 sites. Data include the site which observed the CFPP plume, the likely source of the plume (based on trajectory analyses and SO_2/NO_y ratios) and concentration data for the ratio of deltas calculation. Mean $\Delta TC/\Delta SO_2$ for 11 events is 0.0032 +/- 0.0014 with a range of 0.0011 to 0.0066. OLF and Yorkville both observed 5 events. At OLF, all 5 events were from the Crist CFPP and these gave an emission ratio of 0.0020 +/- 0.0012 lb/lb. At Yorkville, the plume events likely originated from 3 different CFPPs and these gave an average ratio of 0.0033 +/- 0.0021 lb/lb. These events clearly show that TC is a small and difficult to detect component of CFPP emissions.

Table 2 summarizes results for 20 SO_4 plume events observed at 4 sites and likely originating from 8 different CFPPs. Data include the maximum observed 1-minute SO_2 concentration, plus the regression slope and r-squared for SO_4 vs. SO_2. Calculated values for $\Delta SO_4/\Delta SO_2$ range from 0.0030 to 0.0180 lb/lb with an average of 0.0064 lb/lb. In most cases, the regression is highly significant; however, r-square tends to decrease as slope decreases because instrument noise starts to dominate the SO_4 signal. These events clearly show that SO_4 is a small and difficult to detect component of CFPP emissions.

CONCLUSIONS

Continuous field measurements can be used to derive emission estimates for TC and SO_4 from CFPPs which are upper bound estimates of condensable carbon and condensable SO_3. Careful attention must be paid to plume event selection in order to avoid contamination from non-CFPP sources (TC) and photochemical activity in the CFPP plume (SO_4). Optimal conditions for both TC and SO_4 estimates appear to occur during the cooler months when photochemical activity is low and persistent winds advect relatively fresh CFPP plumes to the research sites. Plume analysis results show that primary TC emissions and primary SO_4 emissions from CFPPs are well below 1% of SO2 on a mass basis. For primary TC, analysis of 14 events from 7 different CFPPs gave an overall average emission ratio of 0.0032 lb TC/lb SO_2 (or 0.32% of SO2. For primary SO_4, analysis of 20 events from 8 different CFPPs gave an overall average emission ratio of 0.0064 lb SO_4/lb SO_2 (or 0.64% of SO_2).

Figure 1. The SEARCH Network

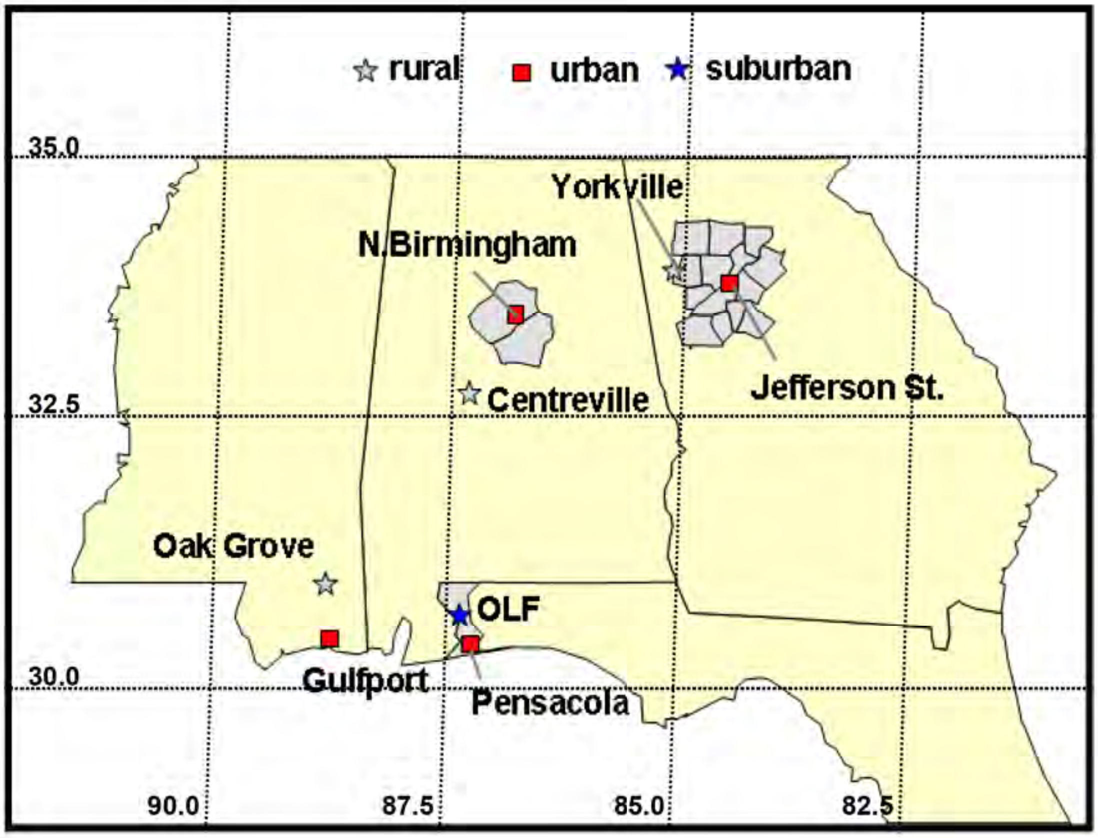


Figure 2. CFPPs observed at YRK (top) and CTR (bottom).

Figure 3. CFPPs observed at JST (top), OLF (middle) and GFP (bottom).

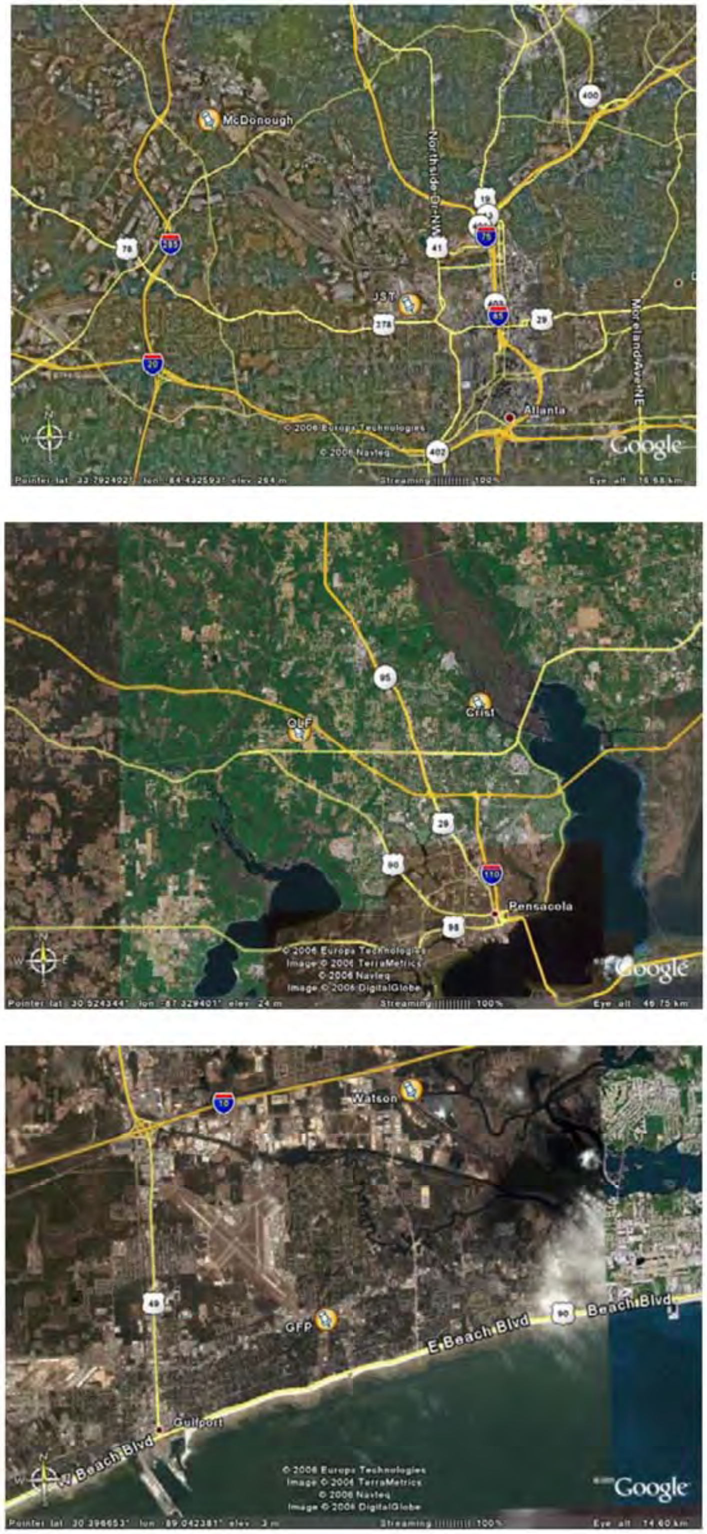
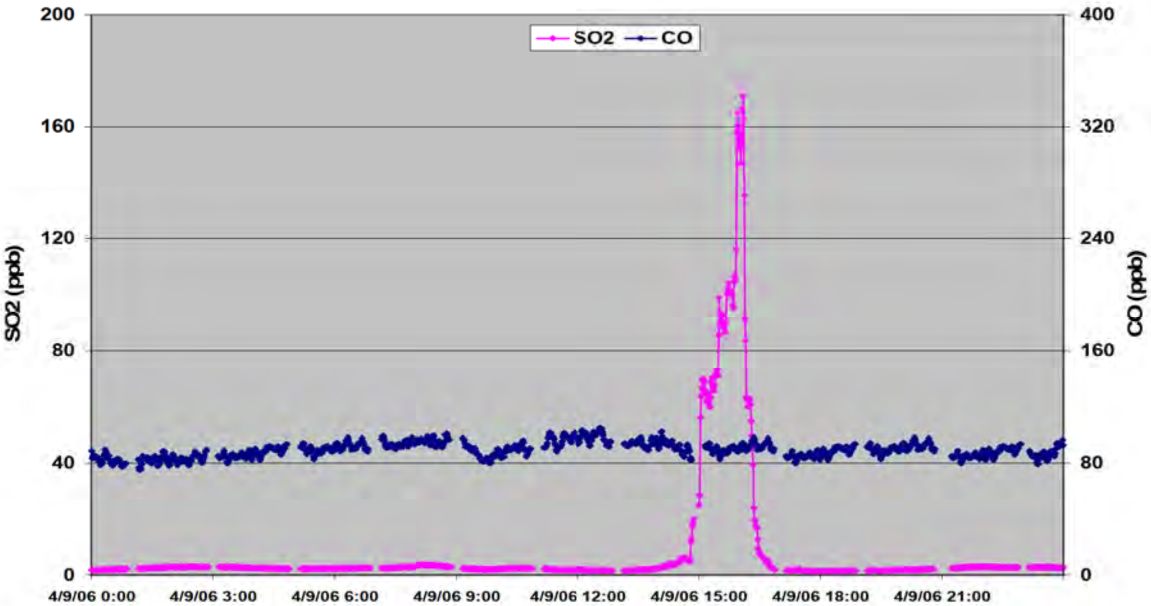


Figure 4. CFPP plume event at YRK showing 1-minute SO_2 and CO (top), 47-minute SO_2 and TC (bottom).



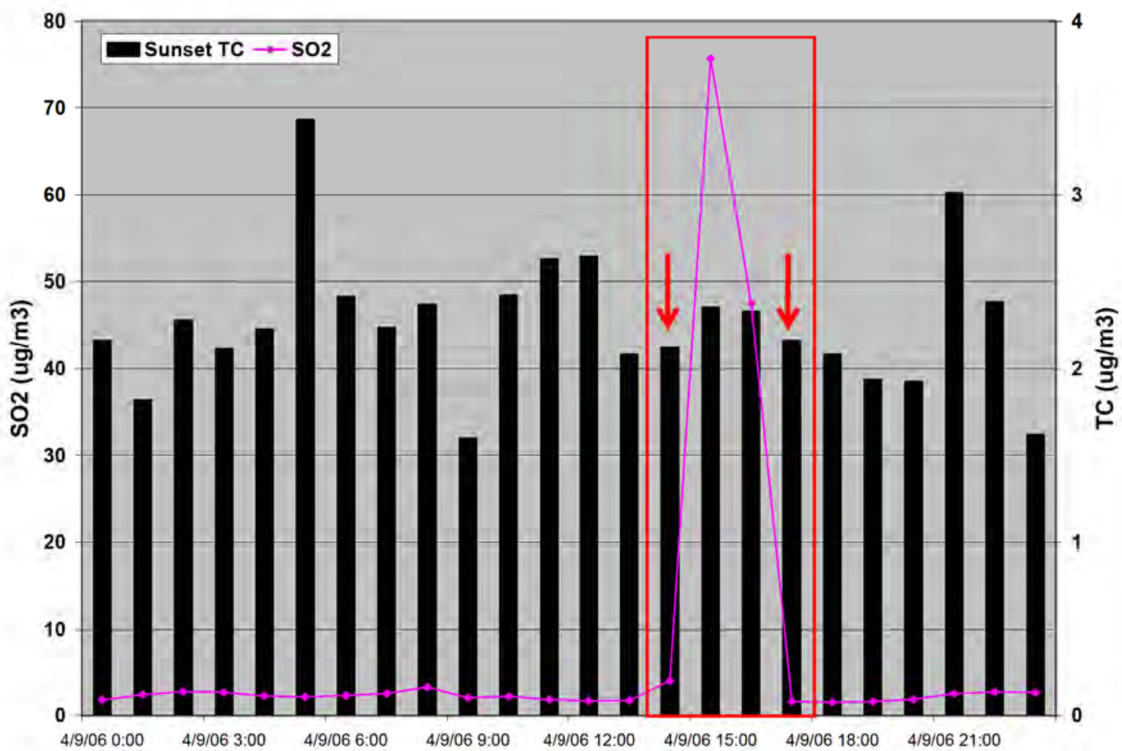


Figure 5. CFPP plume event at YRK showing SO_2 and SO_4 (top) and SO_4 vs. SO_2 (bottom).

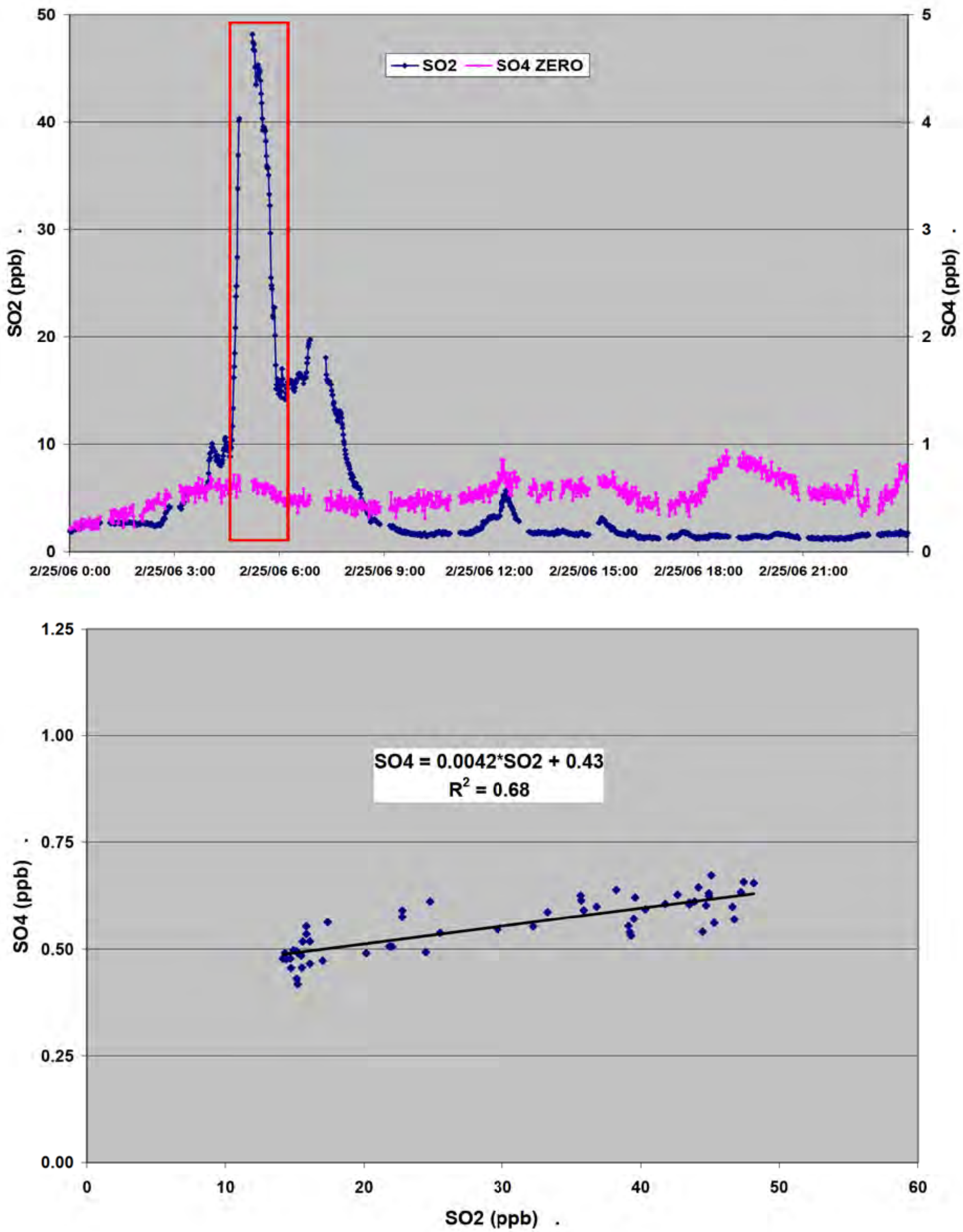


Table 1. Summary of Total Carbon Events.

Site	Date	Probable CFPP	Base SO_2 (ppb)	Plume SO_2 (ppb)	Base TC (µg/m3)	Plume TC (µg/m3)	$\Delta TC/\Delta SO_2$ (lb/lb)	Alternate $\Delta TC/\Delta SO_2$ (lb/lb)
CTR	12/18/05	Gaston	15.6	51.2	2.96	3.30	3.7×10^{-3}	
CTR	12/20/05	Gorgas	15.1	23.1	1.30	1.38	3.8×10^{-3}	
CTR	02/23/06	Miller	5.1	20.6	1.71	1.49	< 0	2.5×10^{-3}
JST	05/06/06	McDonough	3.5	64.5	3.35	3.6	1.6×10^{-3}	
OLF	11/25/05	Crist	11.9	38.9	2.22	2.38	2.3×10^{-3}	
OLF	02/07/06	Crist	4.2	34.6	2.22	2.38	2.0×10^{-3}	
OLF	02/24/06	Crist	11.1	35.0	1.48	1.70	3.5×10^{-3}	
OLF	04/28/06	Crist	4.3	41.2	3.53	3.48	< 0	1.2×10^{-3}
OLF	05/06/06	Crist	3.3	85.3	3.31	3.55	1.1×10^{-3}	
YRK	10/31/05	McDonough	6.3	48.8	2.72	3.45	6.59×10^{-3}	
YRK	02/25/06	Bowen	4.7	39.5	2.24	2.52	3.08×10^{-3}	
YRK	03/04/06	Bowen	5.5	33.4	3.49	3.72	3.15×10^{-3}	
YRK	03/11/06	Wansley	1.8	52.2	4.06	3.87	< 0	7.6×10^{-4}
YRK	04/09/06	Bowen	1.7	61.6	2.12	2.34	3.63×10^{-3}	
Mean (s.d.)							**3.2×10^{-3} (1.4×10^{-3})**	**1.5×10^{-3} (0.9×10^{-3})**

Note: Base and Peak concentrations based on 47-minute averages.

Table 2. Summary of SO_4 Events.

Site	Date	Probable CFPP	1-min Max. SO_2 (ppb)	SO_4 vs. SO_2 Slope	SO_4 vs. SO_2 R^2	$\Delta SO_4/\Delta SO_2$ (lb/lb)
CTR	12/07/05	Gorgas	49.7	5.6×10^{-3}	0.77	8.4×10^{-3}
CTR	12/17/05	Gorgas	21.4	2.0×10^{-3}	0.02	3.0×10^{-3}
CTR	12/17/05	Miller	29.6	2.5×10^{-3}	0.09	3.7×10^{-3}
CTR	12/18/05	Gaston	55.3	4.4×10^{-3}	0.70	6.6×10^{-3}
CTR	12/19/05	Gorgas	30.1	3.6×10^{-3}	0.13	5.4×10^{-3}
CTR	12/20/05	Gorgas	43.3	5.9×10^{-3}	0.81	8.9×10^{-3}
CTR	01/27/06	Miller	20.2	5.1×10^{-3}	0.20	7.7×10^{-3}
GFP	01/26/06	Watson	137.1	3.8 x 10-3	0.95	5.7×10^{-3}
GFP	02/19/06	Watson	49.9	3.6 x 10-3	0.34	5.4×10^{-3}
OLF	11/19/05	Crist	42.8	2.5×10^{-3}	0.08	3.7×10^{-3}
OLF	02/07/06	Crist	52.1	1.4×10^{-3}	0.02	2.1×10^{-3}
OLF	02/24/06	Crist	59.1	4.3×10^{-3}	0.29	6.5×10^{-3}
OLF	4/13/06	Crist	186.	5.4×10^{-3}	0.68	8.1×10^{-3}
YRK	10/09/05	Bowen	33.8	1.2×10^{-3}	0.10	1.8×10^{-3}
YRK	10/31/05	McDonough	73.4	10.0×10^{-3}	0.90	15.0×10^{-3}
YRK	11/11/05	McDonough	48.3	3.3×10^{-3}	0.43	4.9×10^{-3}
YRK	12/18/05	Bowen	202.8	6.6×10^{-3}	0.96	9.9×10^{-3}
YRK	02/08/06	Hammond	31.2	7.6×10^{-3}	0.64	11.4×10^{-3}
YRK	02/25/06	Bowen	47.4	4.4×10^{-3}	0.69	6.6×10^{-3}
YRK	03/04/06	Bowen	60.9	2.4×10^{-3}	0.09	3.6×10^{-3}
Mean (s.d.)						**6.4×10^{-3} (3.3×10^{-3})**

Appendix E

Summary of Days with Nonrepresentative Emissions

Summary

Following guidance outlined in 40 CFR 51 Appendix Y, MPC has reviewed the actual emission rates from October 1, 2015 to September 30, 2018 to identify days with periods of nonrepresentative operations. Per EPA guidance, days that include hours of nonrepresentative operation should not be included in determination of the highest actual daily emission rate used for BART exemption modeling. The table below provides a summary of days with such operation that were not included in this determination. It is noted, for SO_2, MPC excluded 25 out of 834 (2.9%). For NO_X, MPC excluded 6 out of 834 (0.7%) operating days.

Table E-1 Summary of Days with Nonrepresentative Emissions

Date	Pollutant Excluded	Units 1 and 2 (tons)	Units 1 and 2 Rate (lb/hr)	Description
10/9/2015	SO_2	23.30	1941.50	scrubber still in shake down/not commissioned
10/7/2015	SO_2	19.85	1654.08	scrubber still in shake down/not commissioned
10/8/2015	SO_2	19.75	1646.00	scrubber still in shake down/not commissioned
10/6/2015	SO_2	18.63	1552.83	scrubber still in shake down/not commissioned
10/5/2015	SO_2	17.00	1416.42	scrubber still in shake down/not commissioned
2/4/2016	SO_2	13.96	1163.42	scrubber by-pass, still in shake down
10/4/2015	SO_2	13.73	1143.92	scrubber still in shake down/not commissioned
9/6/2018	SO_2	12.48	1040.00	scrubber by-pass, malfunction, substituted data
11/10/2017	SO_2	7.68	639.58	test burn/additional FGD pumps not in operation
9/8/2018	SO_2	7.55	629.00	scrubber by-pass, malfunction, substituted data
11/14/2017	SO_2	6.61	550.67	test burn/additional FGD pumps not in operation
11/15/2017	SO_2	5.93	493.75	test burn/additional FGD pumps not in operation
1/7/2016	SO_2	5.69	473.92	scrubber by-pass, still in shake down
11/16/2017	SO_2	5.59	465.42	test burn/additional FGD pumps not in operation
9/20/2018	SO_2	5.37	447.08	scrubber by-pass, malfunction, substituted data
11/13/2017	SO_2	3.85	320.92	test burn/additional FGD pumps not in operation
10/3/2015	SO_2	3.17	263.83	scrubber still in shake down/not commissioned
9/18/2018	SO_2	3.09	257.42	scrubber by-pass, malfunction, substituted data
5/20/2017	SO_2	2.98	248.17	test burn/additional FGD pumps not in operation
5/19/2017	SO_2	2.93	244.00	test burn/additional FGD pumps not in operation
11/9/2017	SO_2	2.76	230.25	test burn/additional FGD pumps not in operation
5/25/2017	SO_2	2.34	194.75	test burn/additional FGD pumps not in operation
9/20/2016	SO_2	2.27	189.08	Start-up/substituted data
11/8/2017	SO_2	2.15	178.92	test burn/additional FGD pumps not in operation
5/23/2017	SO_2	2.06	172.00	test burn/additional FGD pumps not in operation
11/16/2017	NO_X	29.11	2426.17	test burn/OFA damper not tuned
11/14/2017	NO_X	29.06	2421.58	test burn/OFA damper not tuned
11/15/2017	NO_X	28.95	2412.67	test burn/OFA damper not tuned
7/20/2017	NO_X	28.80	2399.67	CEMS monitor calibration error/incorrect data
5/26/2018	NO_X	26.86	2238.08	mill malfunctions/hurricane preparations
1/7/2017	NO_X	25.11	2092.25	upset due to wet coal and mill fire

Appendix F

Use of Oak Grove Data for Estimating Ambient Ammonia Concentrations over the Gulf of Mexico

Use of Oak Grove Data for Estimating Ambient NH_3 Concentrations over the Gulf of Mexico

Submitted to

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Southern Company Services
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Submitted by

Eric S. Edgerton
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Cary, NC

December 20, 2011

Introduction

Gaseous ammonia (NH_3) is the predominant alkaline compound in the atmosphere and, as such, plays important roles in particle nucleation, aerosol neutralization and $PM_{2.5}$ accumulation. NH_3 is also of interest in regulatory circles as an input variable for Best Available Retrofit Technology (BART) modeling of aerosol concentrations in Class I areas. Most Class I areas are located on land, but some (including the Breton Island NWR) are located in marine environments. Hence, there is a regulatory requirement to specify NH_3 concentrations over the open waters of the Gulf of Mexico for model calculations. Unfortunately, there are no systematic measurements of NH_3 over the Gulf of Mexico. Therefore, it is necessary to estimate NH_3 concentrations based on other considerations. This report uses a weight of evidence approach to estimate NH_3 concentrations over the Gulf of Mexico and to recommend use of data from the Oak Grove, MS SEARCH site for BART calculations.

The SEARCH network is shown in Figure 1. SEARCH includes eight sites arranged in four rural-urban pairs in and around the cities of Atlanta, GA; Birmingham, AL; Pensacola, FL and Gulfport, MS. Four of the eight SEARCH sites that were operational between 2004 and 2008 are within 80 kilometers of the Gulf of Mexico. Of these, two are urban (GFP and PNS) one is suburban (OLF) and one is rural (OAK).

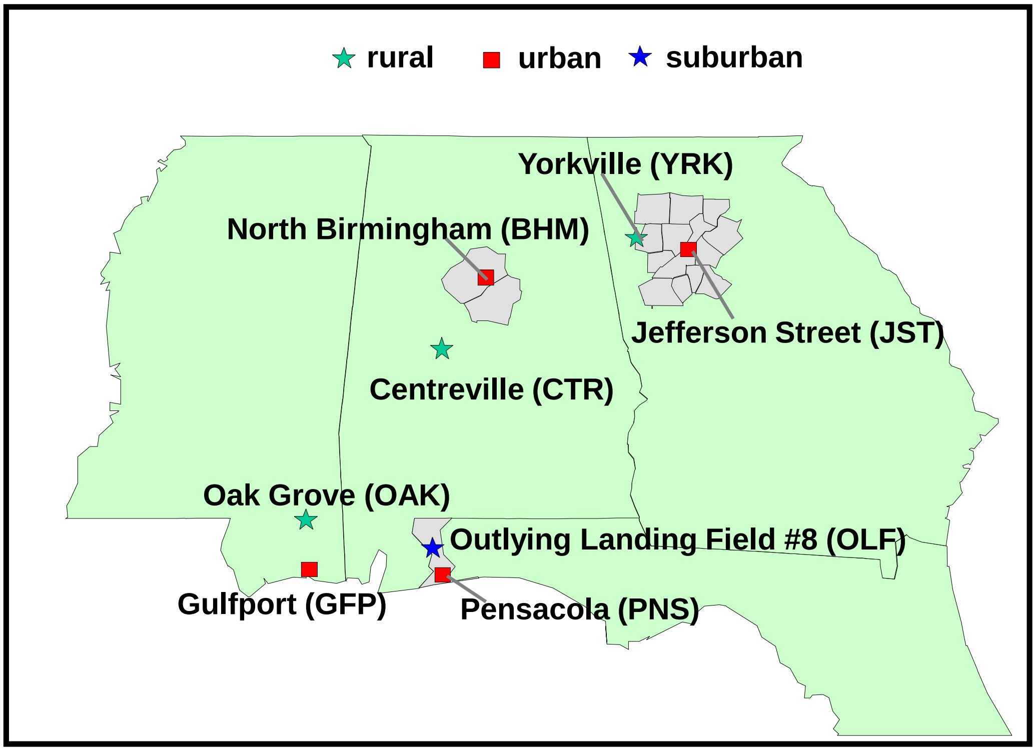

Figure 1. SEARCH air quality sites.

Figure 2 shows average NH3 concentrations for the SEARCH network for the 5-year period 2004-2008. Details of the sampling method are described in Edgerton et al. (2007). Briefly, 24-hour samples were collected on citric acid impregnated annular denuders following the USEPA 1 in 3 day national $PM_{2.5}$ sampling schedule. Denuder samples were extracted in 20 mL of deionized water then analyzed for dissolved NH_4^+ via ion chromatography. Field blanks were collected at each site and used to blank-correct data and to calculate the method detection limit (24 ppt). Measurement precision was 60 parts per trillion (ppt), based on collocated samplers at one site. SEARCH observations show roughly a 10-fold range of concentrations across the southeastern U.S. Lowest concentrations (c. 300 ppt) occur at rural-forested sites, while the highest concentrations (>2000 ppt) are observed at an urban-industrial site (BHM) or rural sites influenced by nearby animal husbandry (YRK). Average concentration for the four sites in proximity to the Gulf of Mexico range from 300 ppt at OAK to 700-800 ppt at GFP and PNS. If we take the regional signal to be on the order of 300 ppt, then the medium sized cities along the Gulf of Mexico are enhanced by about 500 ppt and the largest city (Atlanta) is enhanced by about 1000 ppt. NH_3 concentrations for the only suburban site in the network (OLF) are 50% (150 ppt) above the regional signal.

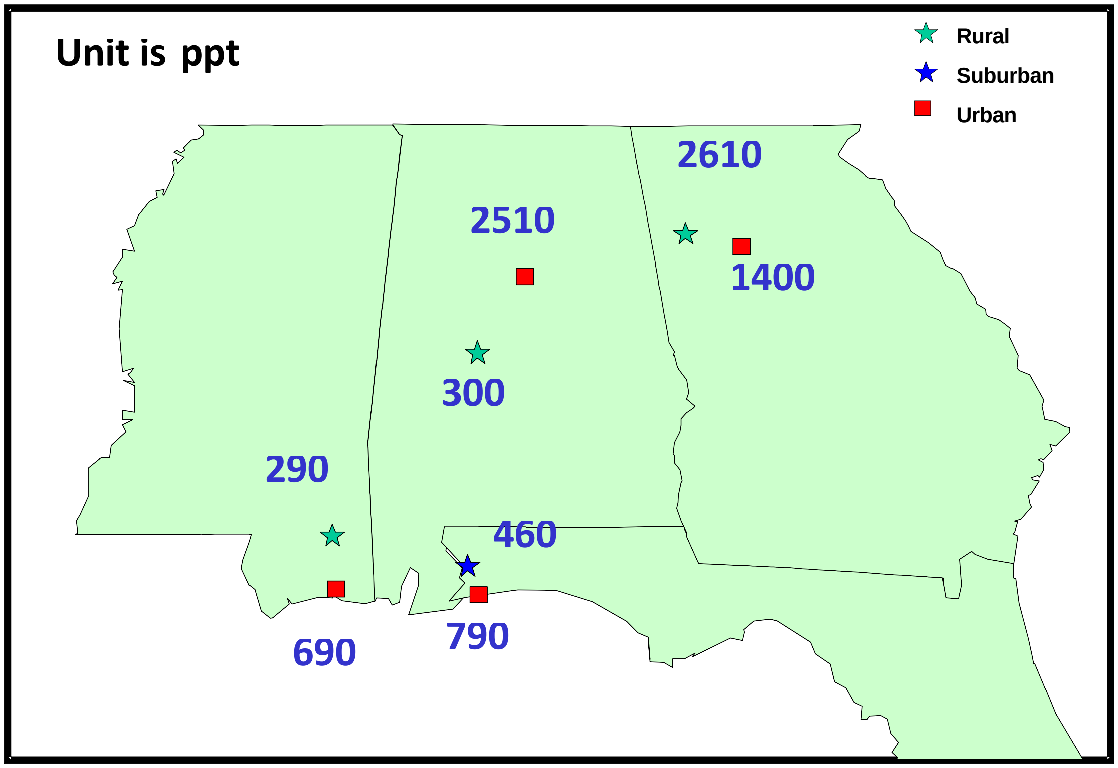

Figure 2. Average NH_3 concentrations at SEARCH sites, 2004-2008.

As a point of comparison, it is instructive to review NH_3 data from the major oceans of the world (see Table 1). These data are quite limited, but they show that NH_3 concentrations removed from terrestrial sources are uniformly <250 ppt. Data also suggest hemispheric differences, with values of approximately 100-250 ppt in the northern hemisphere and <100 ppt in the southern hemisphere. Broadly speaking, then, we would expect Gulf of Mexico NH_3 to fall somewhere in the range of northern hemispheric concentrations (i.e., 100-250 ppt).

Table 1. Mean atmospheric NH_3 concentrations from cruises in various oceanic regions.

Oceanic Region	Year	$NH_{3(g)}$ ppt	Reference
North Atlantic	2005	105	Johnson et al., 2008
Central Atlantic	2003	238	Norman and Leck, 2005
South Atlantic	2003	51	Norman and Leck, 2005
North Sea	2002	71	Johnson et al., 2008
Norwegian Sea	2001	184	Johnson et al., 2008
Indian Ocean	2003	27	Norman and Leck, 2005
Central pacific	1998	16	Quinn et al., 1990
Southern Ocean	1978	86	Ayers and Gras, 1980

NH_3 Emission Rates from Terrestrial and Marine Areas

Emission rate information can also shed light on concentrations because gradients in primary pollutants inevitably occur between areas with high emission density and those with low emission density. Figure 3 shows county-level NH_3 emission rates (kg-N/ha/yr) for the lower 48 states. These data are from the 2002 national emissions inventory compiled by the USEPA. Clearly, there is a broad range of emissions across the country as a whole as well as the southeast. The highest emission rates (>20 kg-N/ha/yr) are associated with agricultural areas (e.g., Iowa) and large urban centers (e.g., Atlanta, New York, Dallas); the lowest emission rates (≤1 kg-N/ha/yr) are associated with sparsely populated areas of the west, southeast, upper midwest and upper northeast. Not surprisingly, the pattern of emission rates across the southeast closely matches that of NH_3 concentrations observed in SEARCH. The overall ranges suggest a ratio of concentration to emission of roughly 100:1 to 200:1; that is, an emission rate of 1 kg-N/ha/yr equates to an ambient concentration of roughly 100-200 ppt.

Similar emissions data for the Gulf of Mexico would allow us to extrapolate NH_3 concentrations to the region of interest. Unfortunately, emissions data specific to the Gulf of Mexico are unavailable; however, Johnson et al. (2007) recently reviewed oceanic emission rates based on a series of research cruises that were conducted between 1995 and 2005. In general, results showed that that NH3 fluxes were higher in equatorial oceans (i.e., 20 degrees S latitude to 20 degrees N latitude) and lower in the more northern regions (i.e., ≥40 degrees N or S latitude), and that surface water temperature largely determined whether the ocean was a source or sink for NH_3 (Johnson et al. 2007). Maximum emission rates of about 0.75 kg-N/ha/yr were observed in the equatorial Atlantic and minimum emission rates of about 0.25 kg-N/ha/yr were observed in the north Atlantic. Intermediate emission rates were observed for latitudes bracketing the Gulf of Mexico. Combining these findings with the emission-concentration ratio from above suggests that average NH_3 concentrations in the Gulf of Mexico are likely to be ≤200 ppt.

Air Mass Trajectories

As noted above, average NH_3 concentrations at GFP, 1.6 kilometers from the Gulf of Mexico, are about 400 ppt higher than those at OAK, 70 kilometers from the Gulf which can be explained largely by emissions density as discussed above. This is the case on average, but there are many occasions when concentrations at GFP and OAK are much closer than 400 ppt. This feature of the data can be exploited to gain insight into concentrations over the Gulf of Mexico. Figure 4 shows individual 24-hour measurements for GFP and OAK for 2008 and 2009. GFP concentrations are usually higher, but concentrations converge to within +/- 100 ppt about 20% of the time. Air mass back trajectories were calculated to determine whether days with similar NH_3 concentrations at GFP and OAK were dominated by marine or terrestrial air masses. Twenty-four hour back trajectories were calculated for GFP with the NOAA-HY-SPLIT model using 40km resolution meteorological data as input and three starting elevations (200, 500 and 1000 meters above mean sea level). Results of these calculations show three general transport conditions for convergent NH_3 concentrations. The first and by far most common condition involves advection of air from the Gulf of Mexico (left panel). Advection from the Gulf of Mexico prevails on about 81% of the convergent days and is associated with an average NH_3 concentration of 260 ppt at GFP. The two other conditions (middle and right panels) involve rapid transport from Texas and the southwest (12%, 330 ppt) and transport from the north and northwest (8%, 220 ppt). These results show that NH_3 concentrations over the Gulf must be lower than average concentrations in GFP and are very likely on par with those at OAK.

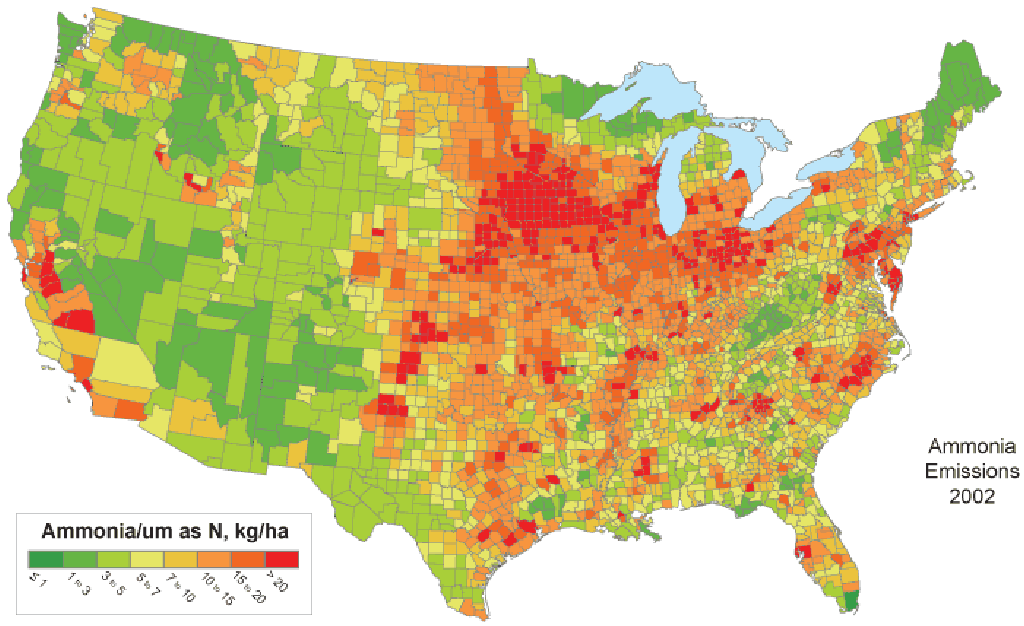

Figure 3. County-level NH_3 emission rates for CY2002 (NEI, 2002).

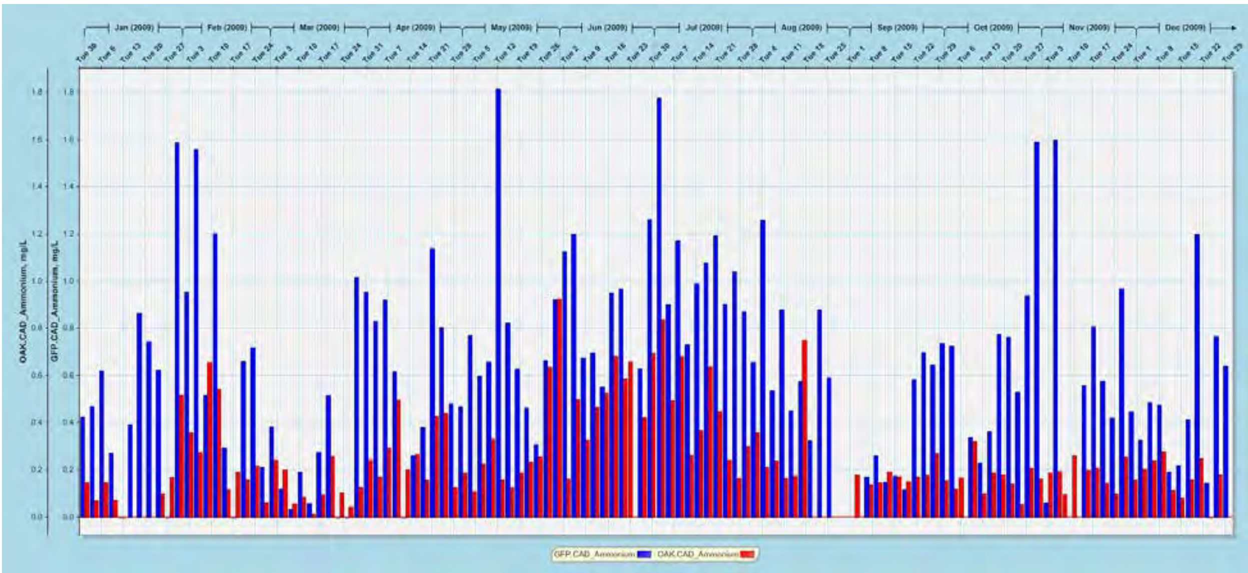

Figure 4. Daily NH_3 concentrations for GFP (blue) and OAK (red).

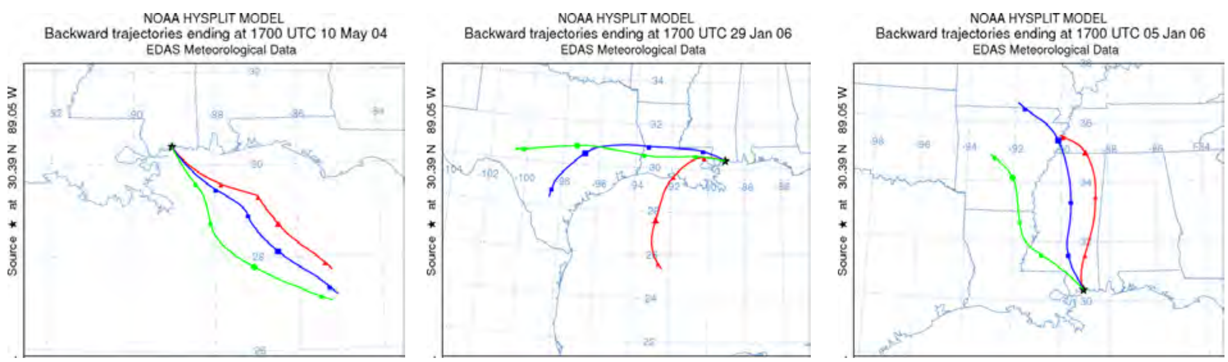

Figure 5. 1-day back trajectories for GFP illustrating transport on days when GFP NH_3 = OAK NH_3 ±100 ppt (200 m trajectory in green, 500 m blue, 1000 m red). Advection from Gulf (left), TX and SW (middle), N and NW (right).

Near-Coastal Monitoring Data from AMON

In addition to SEARCH, the National Acid Deposition Program operates the atmospheric ammonia monitoring network (AMON) to establish spatial patterns and temporal trends of NH_3 across the US and Canada. AMON has approximately 24 sites, some of which date back to 2007, but most were established in 2010. AMON uses a passive sampler (Radiello, Inc.) exposed continuously for 2-week periods to measure NH_3. The advantages of this approach include low cost and complete temporal coverage. Disadvantages of this approach include inability to quantify effects of short-term events (e.g., forest fires) and the assumption of a constant diffusion velocity to the passive collection surface. Despite the latter, long-term average concentrations from passive samplers are generally considered to be to comparable to those from active sampling techniques such as denuders.

One of the original AMON sites is located at Cape Romain, SC (see Figure 6). Cape Romain is a coastal-forested site located within a few kilometers of the Atlantic Ocean and has a complete data record for three calendar years (2008-2010).

Figure 6. Google-Earth image showing SEARCH network and Cape Romain AMON site.

Table 2 shows ranked averages of NH_3 concentrations for the SEARCH network, plus Cape Romain. As can be seen, average NH_3 for Cape Romain (280 ppt) is virtually identical to OAK and CTR and appreciably lower than any other SEARCH site. Given the proximity of Cape Romain to the Atlantic, these data confirm low concentrations for marine air masses. de Kluizenaar and Farrell (2000) reported similarly low NH_3 concentrations for several coastal sites in western Ireland. For example, data from Connemara National Park in west central Ireland showed an annual average NH_3 concentration of 260 ppt. The authors noted that concentrations were well below average when transport was from the Atlantic, but did not attempt to stratify concentrations based on marine versus terrestrial provenance.

Table. 2. Ranked NH_3 concentrations for Cape Romain and SEARCH sites, 2008-2010.

Site	Environment	Mean NH3, ppt	95% CI, ppt
Yorkville, GA	Rural-Agricultural	2600	200
Birmingham, AL	Urban-Industrial	2460	160
Jefferson Street, GA	Urban	1270	70
Gulfport, MS	Urban	700	50
OLF, FL	Suburban	450	40
Centreville, AL	Inland-Forested	310	30
Oak Grove, MS	Inland-Forested	300	30
Cape Romain, SC	*Coastal-Forested*	*280*	*40*

Atmosphere-Seawater Equilibrium Calculations

Absent direct measurements, NH_3 concentrations can be estimated based on equilibrium partitioning between seawater and the atmosphere. This calculation requires seawater measurements of total dissolved ammonium, pH, temperature and salinity as shown below (Johnson et al, 2008):

$$NH_{3(g)eq} = 24.5x10^3 K_H [NH_x] K_a^* \qquad \text{(eq. 1)}$$

where,

$NH_{3(g)eq}$ = equilibrium NH_3 concentration in air, parts per trillion
K_H = Henry's Law constant for NH_3 solubility in seawater, unitless
$= 1/[17.93x(T/273.15)exp((4092/T-9.70)]$
T = seawater temperature, K
$[NH_x]$ = total dissolved ammonium (NH_4^+ and NH_3) in seawater, nmol/L
$K_a^* = K_a/(K_a+[H^+])$, unitless
$[H^+]$ = seawater H^+ concentration = $10^{(-pH)}$
K_a = acidity constant for NH_3 = $10^{(-pKa)}$
$pK_a = -0.467 + 0.00113xS + 2887.9/T$
S = seawater salinity, parts per thousand

$NH_{3(g)eq}$ is weakly dependent on salinity, but highly dependent on both temperature and pH. As temperature increases, the Henry's Law constant increases, shifting NH_3 from the dissolved phase to the gas phase. As pH increases, K_a* increases, also shifting NH_3 to the gas phase.

There is an abundance of temperature, pH and salinity data for the Gulf of Mexico, but a paucity of good quality $[NH_x]$ data . One of the most extensive NH_x data sets was collected from July to August 2007 during the NOAA-Sponsored Gulf of Mexico East Coast Carbon (GOMECC) project (R/V Ronald H. Brown Cruise Report RB-07-05). The cruise started in Galveston, TX, traversed the Gulf of Mexico and eastern seaboard of the U.S. and ended in Boston, MA. The cruise track is shown in Figure 7. Semi-continuous surface water measurements of NH_x, salinity, temperature and pH were made at all stations (circles) in Figure 7 and along much of the path in between stations. The data set for the Gulf of Mexico includes 479 valid data points for $[NH_x]$ with an average value of 110 ± 60 nmol/L. Seawater temperature, salinity and pH during the Gulf of Mexico portion of the cruise were 29-31 degrees C, 35-36 and 8.0-8.1, respectively.

Table 3 shows estimated $NH_{3(g)eq}$ for the GoM based on GOMECC data. Bold values in Table 1 indicate the range of expected $NH_{3(g)eq}$ under observed conditions of pH and temperature, while other values are for lower temperatures outside the range of cruise observations, but encountered at other times of the year. For $[NH_x]$ = 110 nmol/L, expected $NH_{3(g)eq}$ is in the range of 197 ppt (29C, pH 8.0) and 303 ppt (31C, pH 8.1). These results are very consistent with observed concentrations from the SEARCH Oak Grove site (inland-forested) and the AMON Cape Romain site (coastal-forested). Calculations also show much lower $NH_{3(g)eq}$ (50-150 ppt) for temperatures in the range of 15-25 C. In other words, if water chemistry is assumed to be more or less constant, then water temperature will drive expected $NH_{3(g)eq}$ even lower during cooler periods of the year.

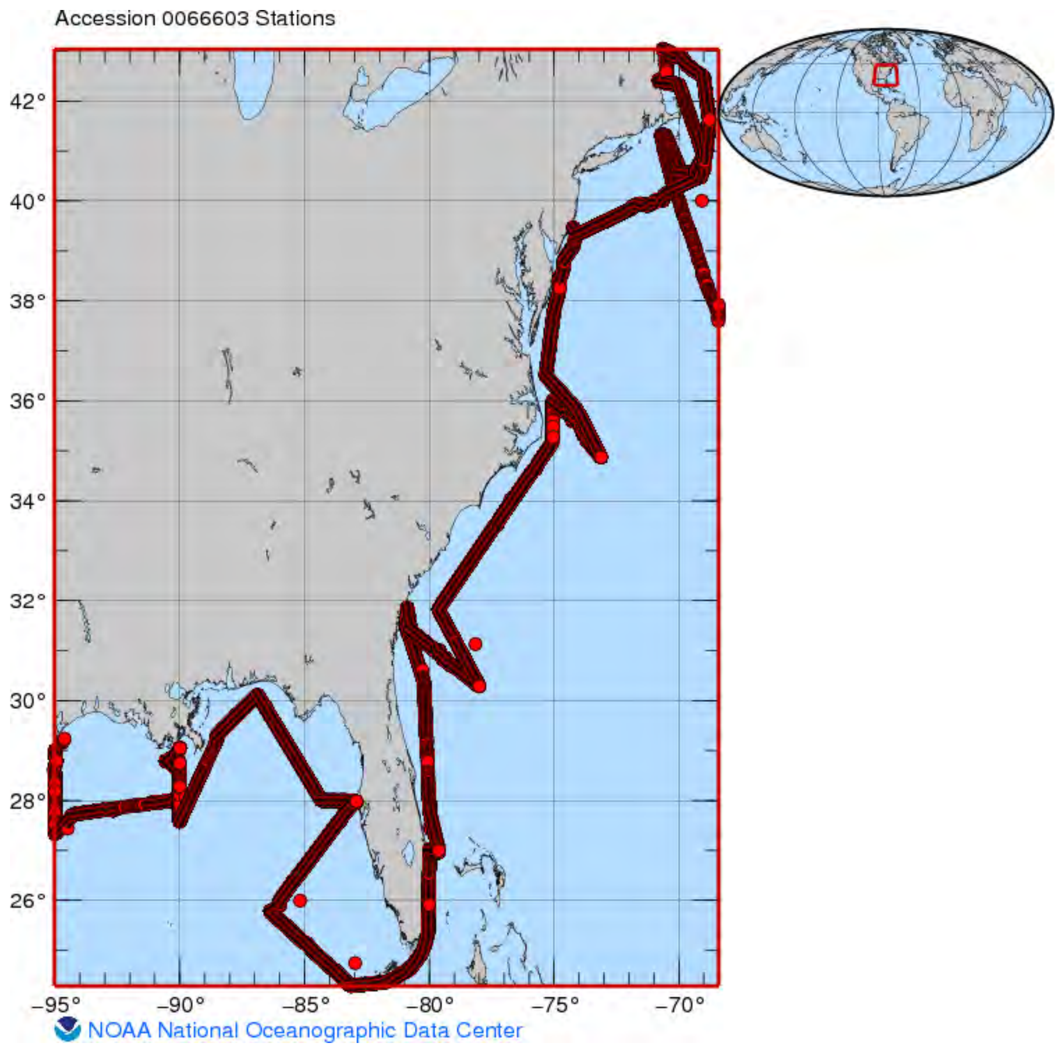

Figure 7. Cruise track for RV Brown GOMECC Project, July 11, 2007-August 4, 2007 (from R/V Ronald H. Brown Cruise Report RB-07-05).

Table 3. Calculated $NH_{3(g)eq}$ based on GOMECC observations (mean $[NH_x]$=110 nmol/L).

T, C	pH	pKa	K_H	[H+]	K_a	K_a*	$NH_{3(g)eq}$, ppt
29	**8.00**	**9.136**	**0.0011**	**1.00E-08**	**7.31E-10**	**0.068**	**197**
29	**8.05**	**9.136**	**0.0011**	**8.91E-09**	**7.31E-10**	**0.076**	**220**
29	**8.10**	**9.136**	**0.0011**	**7.94E-09**	**7.31E-10**	**0.084**	**244**
30	**8.00**	**9.105**	**0.0011**	**1.00E-08**	**7.86E-10**	**0.073**	**220**
30	**8.05**	**9.105**	**0.0011**	**8.91E-09**	**7.86E-10**	**0.081**	**245**
30	**8.10**	**9.105**	**0.0011**	**7.94E-09**	**7.86E-10**	**0.090**	**272**
31	**8.00**	**9.073**	**0.0012**	**1.00E-08**	**8.45E-10**	**0.078**	**245**
31	**8.05**	**9.073**	**0.0012**	**8.91E-09**	**8.45E-10**	**0.087**	**273**
31	**8.10**	**9.073**	**0.0012**	**7.94E-09**	**8.45E-10**	**0.096**	**303**
25	8.10	9.265	0.0009	7.94E-09	5.44E-10	0.064	157
20	8.10	9.430	0.0007	7.94E-09	3.72E-10	0.045	88
15	8.10	9.601	0.0006	7.94E-09	2.51E-10	0.031	48

Conclusions

Systematic measurements of atmospheric NH_3 concentrations over the Gulf of Mexico are non-existent and therefore it is necessary to use measurements from land-based stations or to estimate concentrations from other sources of information for the purpose of input into BART calculations. In this analysis, four convergent lines of evidence show that NH_3 concentrations at the Oak Grove, MS SEARCH site represent a realistic upper limit estimate for those over the Gulf of Mexico. These lines of evidence are as follows: 1) NH_3 emission rates imply lower NH_3 concentrations over the Gulf of Mexico than adjoining near-coastal areas; 2) NH_3 concentrations at the SEARCH site in Gulfport, MS average 260 ppt when air mass transport is on-shore from the Gulf of Mexico; 3) data from the near-coastal NADP AMON site at Cape Romain, SC exhibit long-term (2008-2010) average NH_3 concentrations of 280 ppt; and 4) equilibrium calculations based on Gulf of Mexico surface water chemistry suggest summertime NH_3 concentrations of roughly 200-300 ppt and much lower concentrations (<100 ppt) when water temperature is lower.

Table 4 contains monthly median concentration from OAK for the period 2004-2008. Given the large n for each month, it is suggested that these data comprise the most representative estimate of monthly variation over the Gulf of Mexico. It should be noted that the OAK data show peak NH3 concentrations in the spring, whereas seawater temperatures would suggest peak concentrations over the Gulf of Mexico during the summer (assuming constant seawater chemistry). Considering that fine particulate nitrate formation (i.e., NH_4NO_3) is promoted at lower temperatures (Seinfeld and Pandis, 1998), this implies that model calculations using OAK NH_3 data will tend to overestimate fine particulate nitrate concentrations over the Gulf of Mexico.

Table 4. Monthly median NH_3 concentrations at Oak Grove, MS SEARCH site, 2004-2008 (n ~ 50/month).

Month	Median NH3, ppt
1	205
2	190
3	290
4	395
5	380
6	220
7	190
8	150
9	180
10	190
11	180
12	200

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BART Exemption Modeling Report:

Mississippi Power Company
Plant Daniel

Prepared by:

Southern Company Services
for Mississippi Power Company

June 2019

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1.0 Introduction

1.1 Background and Objectives

The Regional Haze Rule requires Best Available Retrofit Technology (BART) for any BART-eligible source that ‘‘emits any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility” in any mandatory Class I federal area. Pursuant to federal regulations, states have the option of exempting a BART-eligible source from the BART requirements based on dispersion modeling that demonstrates that the source cannot reasonably be anticipated to cause or contribute to visibility impairment in a Class I area. It is noted that, while Mississippi is not home to any Class I areas, it is subject to the Regional Haze program requirements due to its proximity to Class I areas in other states, namely, Breton Wilderness Area in Louisiana.

In 2005, the Environmental Protection Agency (EPA) promulgated a rule (70 FR 39104, July 6, 2005) allowing states subject to the Clean Air Interstate Rule (CAIR) to determine that CAIR satisfies the BART requirements for SO_2 and/or NO_x for electric generating units (EGUs). On December 23, 2008, the U.S. Court of Appeals for the D.C. Circuit found the CAIR rule to be legally flawed and remanded the rule to EPA. In light of the uncertainty surrounding regional transport rules and the ability of the state of Mississippi to rely on an associated regional trading program as an alternative to BART, in a letter dated June 3, 2011, MDEQ requested that Mississippi Power Company (MPC) conduct BART analyses including SO_2 and NO_x, in addition to PM, for the BART-eligible units at Plant Daniel.

On July 6, 2011, in response to remand by the U.S. Court of Appeals for the D.C. Circuit, EPA replaced CAIR with the Cross-State Air Pollution Rule (CSAPR). While the state of Mississippi was included in the annual SO_2 and NO_x programs and the seasonal NOx program for CAIR, it is only included in the CSAPR seasonal NOx program. Nevertheless, MPC completed the requested analysis and submitted the BART modeling and determination report to the Mississippi Department of Environmental Quality (MDEQ) in November 2012; however, no action was taken. In its analysis, MPC proposed that previously permitted, but not yet operational, wet FGD systems for Units 1 and 2 constituted top-level control for SO_2 and, thereby, satisfy SO_2 BART requirements. The analysis also proposed no additional controls for NO_x as the visibility modeling predicted a negligible improvement in visibility at the Breton Island Class I area would be achieved by installing additional NO_x controls. Lastly, the analysis proposed no additional controls for PM as stack tests indicated PM levels less than vendor guarantees for top-level controls (i.e., baghouses).

In a meeting on October 17, 2018 with MDEQ, MPC agreed to complete a BART screening analysis based on recent emissions for NO_x, SO_2, and PM at Plant Daniel Units 1 and 2.

The modeling procedures outlined in the source-specific modeling protocol for Plant Daniel dated March 2019, revised June 2019 were used to determine whether Plant Daniel Units 1 and 2 are subject to BART requirements (exemption modeling). The modeling procedures are consistent with those outlined in the updated final VISTAS common BART modeling protocol (dated December 22, 2005, revision 3.2 – August 31, 2006) (hereinafter, “VISTAS protocol”), attached as an appendix in the source-specific Plant Daniel Modeling Protocol.

1.2 Location of source vs. relevant Class I Areas

The MDEQ, which is responsible for implementation of the state’s Regional Haze program, has determined that Units 1 and 2 at Plant Daniel are BART-eligible. Figure 1-1 shows the location of Plant Daniel relative to nearby Class I Areas. There is one Class I area within 300 km of the plant: Breton Wilderness Area (61.3

km). BART exemption modeling was conducted for this Class I area in accordance with the referenced VISTAS protocol and the procedures described in this source-specific BART modeling protocol.

1.3 Organization of exemption report

Section 2 of this report describes the source emissions that were used as input to the BART exemption modeling. Section 3 describes modeling results. Appendix A is a copy of the approved modeling protocol. Appendix B is a summary of the delta-deciview values for the top 20 days for each year/each Class I Area and for the Top 25 Days Over Three Years.

Figure 1-1 Location of Class I Areas in Relation to Plant Daniel

2.0 Source description and emissions data

The stack parameters and emissions data used to assess the visibility impacts at the Class I areas within 300 km of Plant Daniel were discussed in detail in the approved Plant Daniel BART Modeling Protocol. Table 2-1 provides a summary of the modeling parameters used in the BART CALPUFF exemption modeling.

Table 2-1 Plant Daniel modeling emission parameters

Case	Source / Unit	Location UTM (Zone 16 NAD-83)		Actual Stack Ht	Base Elev.	Flue Equivalent Diameter	Gas Exit Vel.	Stack Gas Exit Temp.	Emissions			Particle Speciation[1]							
		UTM East	UTM North						SO_2	NO_X	PM_{10}	Filt. PM_{10}	Coarse Soil	Fine PM	Fine Soil	EC	Cond. PM_{10}	H_2SO_4	Organic
		m	m	m	m	m	m/s	deg K	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr
Baseline Data Units 1 and 2 combined - Current Configuration (Stack basis: 1 liner, 2 stacks)																			
Stack 1	Units 1&2	350,592	3,378,843	189.3	7.3	11.3	14.8	328.4	169.08	2083.9	38.70	31.12	17.30	13.82	13.31	0.51	7.58	7.04	0.54
				Modeled Stk Ht[2]															
Baseline Emissions Converted to g/sec									g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
Stack 1	Units 1&2	350,592	3,378,843	189.3	7.3	11.3	14.8	328.4	21.30	262.57	4.88	3.92	2.18	1.74	1.68	0.06	0.96	0.89	0.07

[1] Elemental carbon (EC) and Fine PM are a part of Filterable PM_{10} and H_2SO_4 and Organics are a part of Condensable PM_{10}. Note that H_2SO_4 is input to CALPUFF as SO_4. The molecular weights of H_2SO_4 and SO_4 are 98 and 96, respectively, therefore the conversion factor from H_2SO_4 to SO_4 is 96/98.

[2] Stack credit is equal to actual stack height since this stack is at or below GEP.

3.0 Modeling results

The exemption modeling results are provided in Table 3-1. Appendix A lists delta-deciview results for the top 20 days for each year modeled and the top 25 days for the overall three years at each Class I area. The table indicates that both the 8th highest day's impacts for each year and the 22nd highest day's impacts over all three years are below 0.5 delta-dv. These results demonstrate that Plant Daniel's SO_2, NO_x and PM_{10}, emissions do not cause or contribute to visibility impairment. Therefore, the source is not subject to BART for SO_2, NO_x and PM_{10}, and no further BART analysis is required.

Model inputs and output files related to this BART exemption modeling analysis are provided on the electronic storage media submitted with this report. They include all CALPUFF, CALPOST, and POSTUTIL input and output files.

Table 3-1 Summary of Results – Plant Daniel Refined BART Exemption Modeling

		2001			2002			2003			Highest of the 8th Highest delta-dv for the 3-years	22nd Highest delta-dv over 3-year period
Class I Area	Distance from source to Class I area boundary	# of days and receptors beyond 98th percentile with impact > 0.5 delta-dv		8th highest delta-dv	# of days and receptors beyond 98th percentile with impact > 0.5 delta-dv		8th highest delta-dv	# of days and receptors beyond 98th percentile with impact > 0.5 delta-dv		8th Highest delta-dv		
	km	Days	Rec	delta-dv	Days	Rec	delta-dv	Days	Rec	delta-dv	delta-dv	delta-dv
Breton Island	61.3	7	7	0.39	3	2	0.32	3	3	0.27	0.39	0.33

Appendix A

Delta-Deciview Values for the Top 25 Days Over Three Years and for the Top 20 Days for Each Year

Table A-1 Ranked Daily Visibility Change for Breton (Top 25 Days Over Three Years)

YEAR	DAY	RCPTR	DV (Total)	DV (BKG)	DELTA DV	%SO4	%NO3	%OC	%EC	%PMC	%PMF	%NO2	Rank
2003	24	40	9.88	8.84	1.03	6.22	79.59	0.09	0.22	0.40	0.63	12.85	1
2002	1	40	9.52	8.84	0.68	7.80	64.22	0.13	0.33	0.57	0.91	26.03	2
2001	2	35	9.47	8.84	0.63	7.14	68.91	0.13	0.32	0.50	0.91	22.09	3
2003	143	26	9.40	8.78	0.62	13.69	61.23	0.16	0.40	0.67	1.11	22.74	4
2002	331	6	9.39	8.78	0.61	12.86	60.39	0.15	0.39	0.63	1.08	24.49	5
2001	22	30	9.44	8.84	0.60	5.28	76.60	0.09	0.24	0.44	0.66	16.68	6
2001	76	38	9.30	8.70	0.60	10.38	66.94	0.14	0.34	0.65	0.96	20.60	7
2003	118	36	9.24	8.68	0.56	4.96	93.65	0.02	0.06	0.07	0.15	1.09	8
2001	1	36	9.40	8.84	0.55	8.71	69.75	0.12	0.31	0.53	0.88	19.70	9
2001	3	40	9.38	8.84	0.53	7.22	76.36	0.10	0.26	0.46	0.72	14.87	10
2001	23	2	9.36	8.84	0.52	5.81	82.55	0.07	0.18	0.38	0.50	10.51	11
2001	57	16	9.23	8.72	0.51	11.98	85.26	0.05	0.13	0.23	0.35	2.00	12
2002	361	6	9.35	8.84	0.51	9.08	85.51	0.06	0.14	0.30	0.41	4.51	13
2002	39	40	9.18	8.72	0.47	8.98	78.67	0.09	0.22	0.36	0.62	11.07	14
2002	311	37	9.19	8.78	0.42	15.12	54.92	0.19	0.48	0.74	1.35	27.20	15
2001	78	2	9.09	8.70	0.39	11.56	81.20	0.06	0.15	0.29	0.41	6.34	16
2003	117	40	9.07	8.68	0.39	17.82	71.51	0.11	0.28	0.54	0.78	8.96	17
2001	325	40	9.16	8.78	0.38	18.15	62.03	0.18	0.46	0.82	1.29	17.07	18
2001	264	1	9.27	8.90	0.37	21.45	69.21	0.11	0.28	0.41	0.77	7.77	19
2002	15	6	9.21	8.84	0.37	8.50	80.12	0.09	0.23	0.46	0.65	9.95	20
2002	86	6	9.04	8.70	0.34	6.98	86.99	0.07	0.17	0.30	0.47	5.02	21
2001	**336**	**30**	**9.17**	**8.84**	**0.33**	**18.66**	**38.77**	**0.26**	**0.66**	**1.20**	**1.83**	**38.61**	**22**
2001	109	16	9.01	8.68	0.33	7.22	90.70	0.05	0.12	0.14	0.34	1.43	23
2001	69	35	9.02	8.70	0.32	7.09	64.38	0.15	0.37	0.61	1.04	26.37	24
2001	365	19	9.16	8.84	0.32	9.04	64.76	0.14	0.36	0.62	1.01	24.07	25

Table A-2 Ranked Daily Visibility Change for Breton (Top 20 Days for 2001)

YEAR	DAY	RCPTR	DV (Total)	DV (BKG)	DELTA DV	%SO4	%NO3	%OC	%EC	%PMC	%PMF	%NO2	Rank
2001	2	35	9.47	8.84	0.63	7.14	68.91	0.13	0.32	0.50	0.91	22.09	1
2001	22	30	9.44	8.84	0.60	5.28	76.60	0.09	0.24	0.44	0.66	16.68	2
2001	76	38	9.30	8.70	0.60	10.38	66.94	0.14	0.34	0.65	0.96	20.60	3
2001	1	36	9.40	8.84	0.55	8.71	69.75	0.12	0.31	0.53	0.88	19.70	4
2001	3	40	9.38	8.84	0.53	7.22	76.36	0.10	0.26	0.46	0.72	14.87	5
2001	23	2	9.36	8.84	0.52	5.81	82.55	0.07	0.18	0.38	0.50	10.51	6
2001	57	16	9.23	8.72	0.51	11.98	85.26	0.05	0.13	0.23	0.35	2.00	7
2001	**78**	**2**	**9.09**	**8.70**	**0.39**	**11.56**	**81.20**	**0.06**	**0.15**	**0.29**	**0.41**	**6.34**	**8**
2001	325	40	9.16	8.78	0.38	18.15	62.03	0.18	0.46	0.82	1.29	17.07	9
2001	264	1	9.27	8.90	0.37	21.45	69.21	0.11	0.28	0.41	0.77	7.77	10
2001	336	30	9.17	8.84	0.33	18.66	38.77	0.26	0.66	1.20	1.83	38.61	11
2001	109	16	9.01	8.68	0.33	7.22	90.70	0.05	0.12	0.14	0.34	1.43	12
2001	69	35	9.02	8.70	0.32	7.09	64.38	0.15	0.37	0.61	1.04	26.37	13
2001	365	19	9.16	8.84	0.32	9.04	64.76	0.14	0.36	0.62	1.01	24.07	14
2001	364	40	9.14	8.84	0.30	12.18	48.00	0.20	0.51	0.94	1.43	36.74	15
2001	315	12	9.08	8.78	0.30	12.35	62.65	0.15	0.39	0.71	1.09	22.66	16
2001	84	10	8.99	8.70	0.28	10.35	60.87	0.14	0.36	0.74	1.02	26.50	17
2001	85	35	8.96	8.70	0.25	12.26	52.75	0.21	0.52	0.97	1.46	31.84	18
2001	343	4	9.09	8.84	0.25	16.98	46.12	0.21	0.53	1.05	1.47	33.65	19
2001	248	40	9.15	8.90	0.24	46.56	45.82	0.17	0.43	0.71	1.19	5.13	20

Table A-3 Ranked Daily Visibility Change for Breton (Top 20 Days for 2002)

YEAR	DAY	RCPTR	DV (Total)	DV (BKG)	DELTA DV	%SO4	%NO3	%OC	%EC	%PMC	%PMF	%NO2	Rank
2002	1	40	9.52	8.84	0.68	7.80	64.22	0.13	0.33	0.57	0.91	26.03	1
2002	331	6	9.39	8.78	0.61	12.86	60.39	0.15	0.39	0.63	1.08	24.49	2
2002	361	6	9.35	8.84	0.51	9.08	85.51	0.06	0.14	0.30	0.41	4.51	3
2002	39	40	9.18	8.72	0.47	8.98	78.67	0.09	0.22	0.36	0.62	11.07	4
2002	311	37	9.19	8.78	0.42	15.12	54.92	0.19	0.48	0.74	1.35	27.20	5
2002	15	6	9.21	8.84	0.37	8.50	80.12	0.09	0.23	0.46	0.65	9.95	6
2002	86	6	9.04	8.70	0.34	6.98	86.99	0.07	0.17	0.30	0.47	5.02	7
2002	**95**	**31**	**9.00**	**8.68**	**0.32**	**12.41**	**41.19**	**0.25**	**0.63**	**0.99**	**1.75**	**42.78**	**8**
2002	16	1	9.15	8.84	0.31	3.46	90.78	0.04	0.09	0.19	0.26	5.19	9
2002	33	35	9.02	8.72	0.30	12.40	52.98	0.20	0.51	0.90	1.43	31.59	10
2002	327	40	9.07	8.78	0.29	5.34	85.55	0.06	0.16	0.23	0.45	8.20	11
2002	2	33	9.13	8.84	0.29	7.86	66.55	0.12	0.30	0.48	0.83	23.87	12
2002	44	4	8.99	8.72	0.28	10.25	86.74	0.07	0.18	0.33	0.49	1.94	13
2002	4	12	9.11	8.84	0.27	4.61	81.85	0.07	0.18	0.38	0.51	12.39	14
2002	87	2	8.96	8.70	0.26	5.84	91.21	0.04	0.10	0.17	0.28	2.35	15
2002	304	30	9.02	8.77	0.25	20.71	30.86	0.29	0.72	1.24	2.02	44.17	16
2002	94	40	8.92	8.68	0.23	14.74	29.75	0.29	0.73	1.36	2.05	51.09	17
2002	139	35	9.02	8.78	0.23	20.34	22.86	0.33	0.83	1.45	2.34	51.85	18
2002	341	40	9.06	8.84	0.22	16.95	63.33	0.14	0.35	0.60	0.98	17.66	19
2002	360	10	9.06	8.84	0.22	7.34	71.96	0.12	0.29	0.48	0.82	18.99	20

Table A-4 Ranked Daily Visibility Change for Breton (Top 20 Days for 2003)

YEAR	DAY	RCPTR	DV (Total)	DV (BKG)	DELTA DV	%SO4	%NO3	%OC	%EC	%PMC	%PMF	%NO2	Rank
2003	24	40	9.88	8.84	1.03	6.22	79.59	0.09	0.22	0.40	0.63	12.85	1
2003	143	26	9.40	8.78	0.62	13.69	61.23	0.16	0.40	0.67	1.11	22.74	2
2003	118	36	9.24	8.68	0.56	4.96	93.65	0.02	0.06	0.07	0.15	1.09	3
2003	117	40	9.07	8.68	0.39	17.82	71.51	0.11	0.28	0.54	0.78	8.96	4
2003	12	40	9.15	8.84	0.31	8.59	64.77	0.15	0.38	0.69	1.05	24.37	5
2003	354	7	9.12	8.84	0.29	9.19	78.89	0.08	0.22	0.42	0.60	10.60	6
2003	13	40	9.12	8.84	0.28	7.95	66.10	0.14	0.36	0.69	1.00	23.75	7
2003	**27**	**12**	**9.11**	**8.84**	**0.27**	**5.23**	**79.42**	**0.08**	**0.21**	**0.40**	**0.60**	**14.06**	**8**
2003	333	24	9.03	8.78	0.25	14.67	71.53	0.15	0.38	0.69	1.07	11.51	9
2003	311	40	9.02	8.78	0.24	23.20	15.78	0.32	0.81	1.65	2.26	55.99	10
2003	42	27	8.95	8.72	0.24	4.25	83.23	0.07	0.17	0.36	0.47	11.45	11
2003	221	8	9.23	8.99	0.23	45.50	38.60	0.20	0.50	0.99	1.39	12.82	12
2003	26	7	9.07	8.84	0.23	7.62	86.39	0.06	0.16	0.32	0.46	4.98	13
2003	258	37	9.13	8.90	0.23	22.22	4.49	0.38	0.96	1.94	2.69	67.33	14
2003	81	8	8.93	8.70	0.23	13.98	79.30	0.09	0.22	0.45	0.63	5.32	15
2003	359	35	9.06	8.84	0.22	5.99	74.46	0.10	0.27	0.46	0.74	17.98	16
2003	349	10	9.03	8.84	0.20	3.83	90.78	0.04	0.09	0.19	0.26	4.81	17
2003	36	30	8.91	8.72	0.19	9.95	49.66	0.20	0.51	1.06	1.42	37.20	18
2003	275	40	8.96	8.77	0.19	25.11	8.80	0.40	1.02	1.92	2.86	59.88	19
2003	278	37	8.96	8.77	0.19	33.12	63.71	0.11	0.28	0.45	0.78	1.56	20

Appendix L.4: Cooperative Energy (Formerly South Mississippi Electric Power Association)—Plant Morrow

Appendix L.4 contents:

Appendix L.4.1 – Appendix Summary

Cooperative Energy –R. D. Morrow Sr. Generating Plant (1440-00021) BART Process Summary

As a fossil fuel fired steam electric plants, R. D. Morrow meets the BART eligibility requirement of source category code. R. D. Morrow is 138km from Breton and had a possible visibility impact. The facility had two 2675 MMbtu coal fired steam boilers that met the eligibility requirements of:

- operating or under construction between Aug.7, 1962 to Aug.7, 1977 and
- having potential emissions that exceeded 250 tons per year for SO_2, NO_x, or PM_{10}.

The units were therefore determined to be BART eligible sources.

On November 17, 2018 both units were permanently retired. There are no other units at the facility that were determined BART eligible. The facility has no further BART obligations. A copy of the Acid Rain and CSARP Trading Programs Retired Unit Exemption Form is included in this appendix.

Appendix L.4.2 – Facility Shutdown Documents

United States Environmental Protection Agency
Acid Rain and CSAPR Trading Programs

OMB Nos. 2060-0258 and 2060-0667
Approval Expires 11/30/2018

EPA

Retired Unit Exemption

For more information, see instructions and refer to 40 CFR 72.8, 97.405, 97.505, 97.605, 97.705 and 97.805, or a comparable state regulation, as applicable.

This submission is: ■ New ☐ Revised

STEP 1
Identify the unit by plant (source) name, State, plant code and unit ID#.

Plant (Source) Name	State	Plant Code	Unit ID#
R. D. Morrow, Sr. Generation Station	MS	6061	1

STEP 2
Indicate the program(s) that the unit is subject to

■ Acid Rain Program
☐ CSAPR NO_x Annual Trading Program
■ CSAPR NO_x Ozone Season Trading Program
☐ CSAPR SO_2 Annual Trading Program

STEP 3
Identify the date on which the unit was (or will be) permanently retired.

11/17/2018

STEP 4
If the unit is subject to the Acid Rain Program, identify the first full calendar year in which the unit meets (or will meet) the requirements of 40 CFR 72.8(d).

January 1, ____________

STEP 5
Read the appropriate special provisions.

Acid Rain Program Special Provisions

(1) A unit exempt under 40 CFR 72.8 shall not emit any sulfur dioxide and nitrogen oxides starting on the date that the exemption takes effect. The owners and operators of the unit will be allocated allowances in accordance with 40 CFR part 73 subpart B.
(2) A unit exempt under 40 CFR 72.8 shall not resume operation unless the designated representative of the source that includes the unit submits a complete Acid Rain permit application under 40 CFR 72.31 for the unit not less than 24 months prior to the date on which the unit is first to resume operation.
(3) The owners and operators and, to the extent applicable, the designated representative of a unit exempt under 40 CFR 72.8 shall comply with the requirements of the Acid Rain Program concerning all periods for which the exemption is not in effect, even if such requirements arise, or must be complied with, after the exemption takes effect.
(4) For any period for which a unit is exempt under 40 CFR 72.8, the unit is not an affected unit under the Acid Rain Program and 40 CFR part 70 and 71 and is not eligible to be an opt-in source under 40 CFR part 74. As an unaffected unit, the unit shall continue to be subject to any other applicable requirements under 40 CFR parts 70 and 71.
(5) For a period of 5 years from the date the records are created, the owners and operators of a unit exempt under 40 CFR 72.8 shall retain, at the source that includes the unit, records demonstrating that the unit is permanently retired. The 5-year period for keeping records may be extended for cause, at any time prior to the end of the period, in writing by the Administrator or the permitting authority. The owners and operators bear the burden of proof that the unit is permanently retired.
(6) On the earlier of the following dates, a unit exempt under 40 CFR 72.8(b) or (c) shall lose its exemption and become an affected unit under the Acid Rain Program and 40 CFR part 70 and 71: (i) the date on which the designated representative submits an Acid Rain permit application under paragraph (2); or (ii) the date on which the designated representative is required under paragraph (2) to submit an Acid Rain permit application. For the purpose of applying monitoring requirements under 40 CFR part 75, a unit that loses its exemption under 40 CFR 72.8 shall be treated as a new unit that commenced commercial operation on the first date on which the unit resumes operation.

CSAPR NO_x Annual Trading Program Special Provisions

(1) A unit exempt under 40 CFR 97.405 shall not emit any NO_x, starting on the date that the exemption takes effect
(2) For a period of 5 years from the date the records are created, the owners and operators of a unit exempt under 40 CFR 97 405 shall retain, at the source that includes the unit, records demonstrating that the unit is permanently retired The 5-year period for keeping records may be extended for cause, at any time before the end of the period, in writing by the Administrator. The owners and operators bear the burden of proof that the unit is permanently retired
(3) The owners and operators and, to the extent applicable, the designated representative of a unit exempt under 40 CFR 97 405 shall comply with the requirements of the CSAPR NO_x Annual Trading Program concerning all periods for which the exemption is not in effect, even if such requirements arise, or must be complied with, after the exemption takes effect.
(4) A unit exempt under 40 CFR 97 405 shall lose its exemption on the first date on which the unit resumes operation Such unit shall be treated, for purposes of applying allocation, monitoring, reporting, and recordkeeping requirements under 40 CFR part 97 subpart AAAAA, as a unit that commences commercial operation on the first date on which the unit resumes operation

CSAPR NO_x Ozone Season Group 1 Trading Program Special Provisions

(1) A unit exempt under 40 CFR 97 505 shall not emit any NO_x, starting on the date that the exemption takes effect
(2) For a period of 5 years from the date the records are created, the owners and operators of a unit exempt under 40 CFR 97 505 shall retain, at the source that includes the unit, records demonstrating that the unit is permanently retired The 5-year period for keeping records may be extended for cause, at any time before the end of the period, in writing by the Administrator The owners and operators bear the burden of proof that the unit is permanently retired
(3) The owners and operators and, to the extent applicable, the designated representative of a unit exempt under 40 CFR 97.505 shall comply with the requirements of the CSAPR NO_x Ozone Season Group 1 Trading Program concerning all periods for which the exemption is not in effect, even if such requirements arise, or must be complied with, after the exemption takes effect
(4) A unit exempt under 40 CFR 97.505 shall lose its exemption on the first date on which the unit resumes operation Such unit shall be treated, for purposes of applying allocation, monitoring, reporting, and recordkeeping requirements under 40 CFR part 97 subpart BBBBB, as a unit that commences commercial operation on the first date on which the unit resumes operation.

CSAPR NO_x Ozone Season Group 2 Trading Program Special Provisions

(1) A unit exempt under 40 CFR 97 805 shall not emit any NO_x, starting on the date that the exemption takes effect
(2) For a period of 5 years from the date the records are created, the owners and operators of a unit exempt under 40 CFR 97 805 shall retain, at the source that includes the unit, records demonstrating that the unit is permanently retired. The 5-year period for keeping records may be extended for cause, at any time before the end of the period, in writing by the Administrator The owners and operators bear the burden of proof that the unit is permanently retired.
(3) The owners and operators and, to the extent applicable, the designated representative of a unit exempt under 40 CFR 97 805 shall comply with the requirements of the CSAPR NO_x Ozone Season Group 2 Trading Program concerning all periods for which the exemption is not in effect, even if such requirements arise, or must be complied with, after the exemption takes effect.
(4) A unit exempt under 40 CFR 97.805 shall lose its exemption on the first date on which the unit resumes operation Such unit shall be treated, for purposes of applying allocation, monitoring, reporting, and recordkeeping requirements under 40 CFR part 97 subpart EEEEE, as a unit that commences commercial operation on the first date on which the unit resumes operation

CSAPR SO_2 Group 1 Trading Program Special Provisions

(1) A unit exempt under 40 CFR 97.605 shall not emit any SO_2, starting on the date that the exemption takes effect.
(2) For a period of 5 years from the date the records are created, the owners and operators of a unit exempt under 40 CFR 97.605 shall retain, at the source that includes the unit, records demonstrating that the unit is permanently retired. The 5-year period for keeping records may be extended for cause, at any time before the end of the period, in writing by the Administrator. The owners and operators bear the burden of proof that the unit is permanently retired.
(3) The owners and operators and, to the extent applicable, the designated representative of a unit exempt under 40 CFR 97.605 shall comply with the requirements of the CSAPR SO_2 Group 1 Trading Program concerning all periods for which the exemption is not in effect, even if such requirements arise, or must be complied with, after the exemption takes effect.
(4) A unit exempt under 40 CFR 97.605 shall lose its exemption on the first date on which the unit resumes operation. Such unit shall be treated, for purposes of applying allocation, monitoring, reporting, and recordkeeping requirements under 40 CFR part 97 subpart CCCCC, as a unit that commences commercial operation on the first date on which the unit resumes operation.

CSAPR SO_2 Group 2 Trading Program Special Provisions

(1) A unit exempt under 40 CFR 97.705 shall not emit any SO_2, starting on the date that the exemption takes effect.
(2) For a period of 5 years from the date the records are created, the owners and operators of a unit exempt under 40 CFR 97.705 shall retain, at the source that includes the unit, records demonstrating that the unit is permanently retired. The 5-year period for keeping records may be extended for cause, at any time before the end of the period, in writing by the Administrator. The owners and operators bear the burden of proof that the unit is permanently retired.
(3) The owners and operators and, to the extent applicable, the designated representative of a unit exempt under 40 CFR 97.705 shall comply with the requirements of the CSAPR SO_2 Group 2 Trading Program concerning all periods for which the exemption is not in effect, even if such requirements arise, or must be complied with, after the exemption takes effect.
(4) A unit exempt under 40 CFR 97.705 shall lose its exemption on the first date on which the unit resumes operation. Such unit shall be treated, for purposes of applying allocation, monitoring, reporting, and recordkeeping requirements under 40 CFR part 97 subpart DDDDD, as a unit that commences commercial operation on the first date on which the unit resumes operation.

STEP 6
Read the statement of compliance and the appropriate certification statements and sign and date

Statement of Compliance
I certify that the unit identified above at STEP 1 was (or will be) permanently retired on the date identified at STEP 3 and will comply with the appropriate Special Provisions listed at STEP 5.

Certification (for designated representatives or alternate designated representatives <u>only</u>)
I am authorized to make this submission on behalf of the owners and operators of the source and unit for which the submission is made. I certify under penalty of law that I have personally examined, and am familiar with, the statements and information submitted in this document and all its attachments Based on my inquiry of those individuals with primary responsibility for obtaining the information, I certify that the statements and information are to the best of my knowledge and belief true, accurate, and complete I am aware that there are significant penalties for submitting false statements and information or omitting required statements and information, including the possibility of fine or imprisonment.

Name Nathan Brown	Title Sr. VP/COO
Owner Company Name Cooperative Energy	
Phone 601-268-2083	Email nbrown@cooperativeenergy.com
Signature [signature]	Date 11/9/18

Certification (for certifying officials of units subject to the Acid Rain Program <u>only</u>)
I certify under penalty of law that I have personally examined, and am familiar with, the statements and information submitted in this document and all its attachments. Based on my inquiry of those individuals with primary responsibility for obtaining the information, I certify that the statements and information are to the best of my knowledge and belief true, accurate, and complete. I am aware that there are significant penalties for submitting false statements and information or omitting required statements and information, including the possibility of fine orimprisonment.

Name	Title
Owner Company Name	
Phone	Email
Signature	Date

United States Environmental Protection Agency
Acid Rain and CSAPR Trading Programs

OMB Nos. 2060-0258 and 2060-0667
Approval Expires 11/30/2018

EPA

Retired Unit Exemption

For more information, see instructions and refer to 40 CFR 72.8, 97.405, 97.505, 97.605, 97.705 and 97.805, or a comparable state regulation, as applicable.

This submission is: ■ **New** ☐ **Revised**

STEP 1
Identify the unit by plant (source) name, State, plant code and unit ID#.

Plant (Source) Name	State	Plant Code	Unit ID#
R. D. Morrow, Sr. Generation Station	MS	6061	2

STEP 2
Indicate the program(s) that the unit is subject to

■ Acid Rain Program

☐ CSAPR NOx Annual Trading Program

■ CSAPR NOx Ozone Season Trading Program

☐ CSAPR SO_2 Annual Trading Program

STEP 3
Identify the date on which the unit was (or will be) permanently retired

11/17/2018

STEP 4
If the unit is subject to the Acid Rain Program, identify the first full calendar year in which the unit meets (or will meet) the requirements of 40 CFR 72 8(d)

January 1, 2019

STEP 5
Read the appropriate special provisions.

Acid Rain Program Special Provisions

(1) A unit exempt under 40 CFR 72.8 shall not emit any sulfur dioxide and nitrogen oxides starting on the date that the exemption takes effect. The owners and operators of the unit will be allocated allowances in accordance with 40 CFR part 73 subpart B.
(2) A unit exempt under 40 CFR 72.8 shall not resume operation unless the designated representative of the source that includes the unit submits a complete Acid Rain permit application under 40 CFR 72 31 for the unit not less than 24 months prior to the date on which the unit is first to resume operation.
(3) The owners and operators and, to the extent applicable, the designated representative of a unit exempt under 40 CFR 72 8 shall comply with the requirements of the Acid Rain Program concerning all periods for which the exemption is not in effect, even if such requirements arise, or must be complied with, after the exemption takes effect.
(4) For any period for which a unit is exempt under 40 CFR 72 8, the unit is not an affected unit under the Acid Rain Program and 40 CFR part 70 and 71 and is not eligible to be an opt-in source under 40 CFR part 74. As an unaffected unit, the unit shall continue to be subject to any other applicable requirements under 40 CFR parts 70 and 71.
(5) For a period of 5 years from the date the records are created, the owners and operators of a unit exempt under 40 CFR 72 8 shall retain, at the source that includes the unit, records demonstrating that the unit is permanently retired. The 5-year period for keeping records may be extended for cause, at any time prior to the end of the period, in writing by the Administrator or the permitting authority. The owners and operators bear the burden of proof that the unit is permanently retired
(6) On the earlier of the following dates, a unit exempt under 40 CFR 72.8(b) or (c) shall lose its exemption and become an affected unit under the Acid Rain Program and 40 CFR part 70 and 71: (i) the date on which the designated representative submits an Acid Rain permit application under paragraph (2); or (ii) the date on which the designated representative is required under paragraph (2) to submit an Acid Rain permit application. For the purpose of applying monitoring requirements under 40 CFR part 75, a unit that loses its exemption under 40 CFR 72.8 shall be treated as a new unit that commenced commercial operation on the first date on which the unit resumes operation.

CSAPR NO_x Annual Trading Program Special Provisions

(1) A unit exempt under 40 CFR 97.405 shall not emit any NO_x, starting on the date that the exemption takes effect
(2) For a period of 5 years from the date the records are created, the owners and operators of a unit exempt under 40 CFR 97.405 shall retain, at the source that includes the unit, records demonstrating that the unit is permanently retired The 5-year period for keeping records may be extended for cause, at any time before the end of the period, in writing by the Administrator The owners and operators bear the burden of proof that the unit is permanently retired
(3) The owners and operators and, to the extent applicable, the designated representative of a unit exempt under 40 CFR 97 405 shall comply with the requirements of the CSAPR NO_x Annual Trading Program concerning all periods for which the exemption is not in effect, even if such requirements arise, or must be complied with, after the exemption takes effect
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CSAPR NO_x Ozone Season Group 1 Trading Program Special Provisions

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(3) The owners and operators and, to the extent applicable, the designated representative of a unit exempt under 40 CFR 97.505 shall comply with the requirements of the CSAPR NO_x Ozone Season Group 1 Trading Program concerning all periods for which the exemption is not in effect, even if such requirements arise, or must be complied with, after the exemption takes effect
(4) A unit exempt under 40 CFR 97.505 shall lose its exemption on the first date on which the unit resumes operation Such unit shall be treated, for purposes of applying allocation, monitoring, reporting, and recordkeeping requirements under 40 CFR part 97 subpart BBBBB, as a unit that commences commercial operation on the first date on which the unit resumes operation.

CSAPR NO_x Ozone Season Group 2 Trading Program Special Provisions

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(3) The owners and operators and, to the extent applicable, the designated representative of a unit exempt under 40 CFR 97.805 shall comply with the requirements of the CSAPR NO_x Ozone Season Group 2 Trading Program concerning all periods for which the exemption is not in effect, even if such requirements arise, or must be complied with, after the exemption takes effect
(4) A unit exempt under 40 CFR 97 805 shall lose its exemption on the first date on which the unit resumes operation Such unit shall be treated, for purposes of applying allocation, monitoring, reporting, and recordkeeping requirements under 40 CFR part 97 subpart EEEEE, as a unit that commences commercial operation on the first date on which the unit resumes operation

CSAPR SO_2 Group 1 Trading Program Special Provisions

(1) A unit exempt under 40 CFR 97.605 shall not emit any SO_2, starting on the date that the exemption takes effect.
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(3) The owners and operators and, to the extent applicable, the designated representative of a unit exempt under 40 CFR 97.605 shall comply with the requirements of the CSAPR SO_2 Group 1 Trading Program concerning all periods for which the exemption is not in effect, even if such requirements arise, or must be complied with, after the exemption takes effect
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CSAPR SO_2 Group 2 Trading Program Special Provisions

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(3) The owners and operators and, to the extent applicable, the designated representative of a unit exempt under 40 CFR 97 705 shall comply with the requirements of the CSAPR SO_2 Group 2 Trading Program concerning all periods for which the exemption is not in effect, even if such requirements arise, or must be complied with, after the exemption takes effect
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STEP 6
Read the statement of compliance and the appropriate certification statements and sign and date

Statement of Compliance
I certify that the unit identified above at STEP 1 was (or will be) permanently retired on the date identified at STEP 3 and will comply with the appropriate Special Provisions listed at STEP 5.

Certification (for designated representatives or alternate designated representatives only)
I am authorized to make this submission on behalf of the owners and operators of the source and unit for which the submission is made. I certify under penalty of law that I have personally examined, and am familiar with, the statements and information submitted in this document and all its attachments. Based on my inquiry of those individuals with primary responsibility for obtaining the information, I certify that the statements and information are to the best of my knowledge and belief true, accurate, and complete. I am aware that there are significant penalties for submitting false statements and information or omitting required statements and information, including the possibility of fine or imprisonment.

Name Nathan Brown	Title Sr. VP/COO
Owner Company Name Cooperative Energy	
Phone 601-268-2083	Email nbrown@cooperativeenergy.com
Signature [signature]	Date 11/9/18

Certification (for certifying officials of units subject to the Acid Rain Program only)
I certify under penalty of law that I have personally examined, and am familiar with, the statements and information submitted in this document and all its attachments. Based on my inquiry of those individuals with primary responsibility for obtaining the information, I certify that the statements and information are to the best of my knowledge and belief true, accurate, and complete. I am aware that there are significant penalties for submitting false statements and information or omitting required statements and information, including the possibility of fine orimprisonment.

Name	Title
Owner Company Name	
Phone	Email
Signature	Date

Appendix L.5: Cooperative Energy (Formerly South Mississippi Electric Power Association)—Plant Moselle

Appendix L.5 contents:

Cooperative Energy (Formerly South Mississippi Electric Power Association)—Plant Moselle (1360-00035) BART Process Summary

Cooperative Energy, Plant Moselle is an electricity generating facility with one natural gas fired unit that meets the eligibility criteria. Plant Moselle is 170 km from Breton National Wildlife Refuge, a Class I area, and has a possible visibility impact. As a fossil fuel fired steam electric plant the facility meets the initial BART eligibility requirement of source category code. Therefore, on June 3, 2011, Mississippi Department of Environmental Quality (MDEQ) sent them a letter requesting information to determine BART subjectivity. Based on the information received from Cooperative Energy—Plant Moselle, one unit was deemed BART eligible because it met the following criteria:

- Operating or under construction between August 7, 1962 to August 7, 1977
- Having potential emissions that exceed the limit of 250 tons per year for SO_2, NO_X, or PM_{10}

Table L.5.1 below contains the BART-eligible point source for Cooperative Energy, Plant Moselle and the potential emissions.:

Emission Unit	**Heat Input (MMBtu/hr)**	**Potential Emissions Rates (tons per year)**				**Existing Control Equipment**
		SO_2	NO_X	PM_{10}	H_2SO_4	
AA-003—Unit No. 3 Boiler	868.6	1.04	1074.20	28.50	0.70	none

Table L.5.1. Moselle Eligible units and Potential Emissions Rates

Because the source meets BART eligibility requirements, Plant Moselle performed CALPUFF modeling on this unit to determine subjectivity. CALPUFF model version 5.8 Level 070623, along with the new IMPROVE equation were used in the modeling analysis per the VISTAS modeling protocol. The modeling used the maximum 24 hr average emissions rates over a three-year period of 2001-2003. These rates were .03 g/s (0.24 lb/hr) for SO_2, 30.90 g/s (245.25 lb/hr) for NO_x, and .82 g/s (6.50 lb/hr) for PM_{10}. The modeling analysis demonstrated a maximum 98th percentile 24-hour average visibility impact of 0.048 dv over the three years modeled. These values are well within the State's selected subjectivity threshold of 0.5 dv indicating that the facility is not Subject to BART. Because the CALPUFF model has been updated since the modeling was conducted in 2012, more current (2016-2018) emissions values were compared with the baseline values to give greater assurance of the determination.

Table L.5.2 compares the modeled emissions with updated 24 hr average emissions. The updated 24 hr average emissions are reported from the date 1/17/2018 —wherein SO_2 emissions were slightly higher than the modeled value. For NOx and PM_{10}, emissions over the updated period were significantly less than the modeled emissions.

Emissions Period (date)	Maximum 24-hour Emission Rates Emissions (lb/hr) (2001-2003)			Maximum 24-hour Emission Rates Emissions (lb/hr) (2016-2018)		
	SO_2	**NOx**	**PM_{10}**	**SO_2**	**NOx**	**PM_{10}**
Unit 3	0.24	245.25	6.50	0.25	217.25	3.21

Table L.5.2. Plant Moselle Modeled and 2016 through 2018 emissions

In addition, Table L.5.3 compares the annual baseline emissions of 2001 through 2003 to 2016 through 2018 annual emissions. As the table shows, the current annual emissions are much less than the baseline emissions.

Year	Annual Emissions (tons)		
	SO_2	NO_X	PM
2001	0.85	249.56	6.59
2002	0.63	317.39	7.80
2003	0.56	344.65	6.93
2016	0.11	56.35	1.37
2017	0.09	43.42	1.14
2018	0.11	58.79	1.36

Table L.5.3 baseline and current period annual emissions comparison

Since Plant Moselle's modeling found that their impact was significantly less than the .5 deciview impact threshold and a review of their current emissions finds that they are generally lower than the emissions during the modeled period, Mississippi agrees with the modeling and finds that they are not subject to BART.

CALPUFF Modeling Protocol For Analysis of Best Available Retrofit Technology

R.D. Morrow and Moselle Plants

South Mississippi Electric Power Association

August 2011

Burns & McDonnell
SINCE 1898

CALPUFF Modeling Protocol for Analysis of Best Available Retrofit Technology

prepared for

South Mississippi Electric Power Association

August 2011

Project 62680

prepared by

Burns & McDonnell Engineering Company, Inc.
Kansas City, Missouri

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1.0 INTRODUCTION

1.1 BACKGROUND

The Mississippi Department of Environmental Quality (MDEQ) has informed the South Mississippi Electric Power Association (SMEPA) that their R.D. Morrow and Moselle Plants may be subject to a Best Available Retrofit Technology determination (BART).[1] The Regional Haze Rule (40 CFR 51) requires reduction of visibility-disrupting pollutants from major stationary sources that impact Class I Areas. A Class I Area is a national park, wilderness area, or other scenic area that is afforded additional protection of its environment. Regional planning organizations (RPO) work with a state to develop a plan to improve the visibility at the Class I Areas located in that state. VISTAS[2] is the RPO that includes Mississippi.

1.2 OBJECTIVES

The purpose of this modeling protocol is to describe the methodology to be used to predict if the SMEPA BART-eligible sources may be subject to BART. This visibility analysis is source-specific and only focuses on those SMEPA sources identified by the MDEQ as being BART-eligible.

The visibility analysis will be performed consistent with the VISTAS RPO modeling guideline: *Protocol for the Application of the CALPUFF Model for Analyses of Best Available Retrofit Technology (BART)* (Revised, 2006), (VISTAS Protocol).

The purpose of this modeling protocol is not to establish CALPUFF as the appropriate modeling system for visibility analyses, nor is it to be a complete discussion of the theory or applicability of the CALPUFF modeling system to visibility modeling. A more detailed discussion of the CALPUFF modeling system is found in *A User's Guide for the CALPUFF Dispersion Model*, and in *A User's Guide for the CALMET Meteorological Model.*

1.3 LOCATION OF SOURCES VERSUS RELEVANT CLASS I AREAS

1.3.1 Moselle Plant

The Moselle Plant is a 344-megawatt (MW) electric generating facility located 2.5 miles northwest of Moselle, Mississippi, in Jones County (see Figure 1-1).

[1] Letter to Mr. Joey Ward from Mr. Elliot Bickerstaff, June 3, 2011.
[2] VISTAS: Visibility Improvement States and Tribal Association of the Southeast.

1.3.2 R.D. Morrow Plant

The R.D. Morrow Plant is a 400-MW electrical generating facility located in Purvis, Mississippi, in Lamar County (see Figure 1-1).

1.3.3 Class I Areas

The two closest Class I Areas to the Moselle and R.D. Morrow Plants are the Breton Wilderness Area (WA) in Louisiana, and Sipsey WA in Alabama (Figure 1-1). The approximate distance from each plant to each Class I Area is summarized in Table 1-1.

Table 1-1
Proximity of SMEPA Plants to Nearby Class I Areas (kilometers)

Plant Name	Breton WA	Sipsey WA
Moselle	170	344
R.D. Morrow	139	380

Because the Sipsey WA is more than 300 kilometers (km) from either SMEPA plant, it will not be involved in this BART analysis. For sources that are subject to BART, the VISTAS Protocol recommends a four-step BART process to quantify the level of visibility impairment.[3] For the Moselle and R.D. Morrow plants, the 4-step process outlined in 40 CFR 51 will be used. Those 4 steps are:

1. Identify whether a source is BART-eligible.
2. Determine 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 at a Class I Area.
3. Determine BART controls for the source by considering various control options and selecting the "best" alternative.
4. Incorporate the BART determination into the State Implementation Plan for Regional Haze

The following sections describe the methodology used in determining if the SMEPA plants are subject to BART.

[3] VISTAS Protocol, pg. 5.

1.4 SMEPA SOURCE IMPACT EVALUATION CRITERIA

As part of VISTAS' strategy to improve visibility at Class I Areas, the BART determination is used to identify those sources that are "BART-eligible," and those sources that are "subject to BART." A BART-eligible source is one that satisfies all of the following requirements.[4]

1. Has the potential to emit 250 tons per year or more of a visibility-impairing pollutant.
2. Constructed between August 7, 1962, and August 7, 1977.
3. One of 26 listed source categories.

Only the Moselle Boiler AA-003 and R.D. Morrow Boilers AA-001 and AA-002 satisfy all the BART - eligible source criteria. The other two boilers (AA-001 and AA-002) at the Moselle Plant have been replaced by heat recovery steam generators as part of a repowering project and are not subject to a BART analysis.

A source subject to BART is reasonably anticipated to either cause or contribute to visibility impairment.[5] "Causing" visibility impairment means a 1.0 deciview (dV) change in light extinction. "Contributing" to visibility impairment means a 0.5 dV change in light extinction. A dV is *a small but perceptible change in haziness under most circumstances*.[6]

1.4.1 BART Source Impact Determination

Step 2 of this process describes the modeling methodology to be used to determine SMEPA's source impacts on Class I Area visibility.

The VISTAS RPO will exempt a source from a BART analysis if the total emissions in tons per year of visibility extinction pollutants divided by the distance to the Class I Area (Q/d) is greater than 10 and within 300 km. The VISTAS RPO recommends using the maximum allowable emissions for this determination. For the Moselle Plant, the emission limits for SO_2 and PM_{10} were taken from its current Title V operating permit. NO_x emissions were calculated based on AP-42 emission factors.

For the R.D. Morrow plant, all emission limits were taken from the current Title V operating permit. A summary of the Q/d comparison is shown in Table 1-2.

---

[4] Federal Register, Vol. 70, No. 128, pg. 39105.
[5] Ibid.
[6] L. Willard Richards, *Use of the Deciview Haze Index as an Indicator for Regional Haze.* Journal of the Air and Waste Management Association. October, 1999.

Table 1-2
Q/D Assessment of the Moselle and R.D. Morrow Plants

Plant	Equip.	SO_2 (Tons/yr)	NO_x (Tons/yr)	PM_{10} (Tons/yr)	Total (Tons/yr)	Distance to Breton WA	Q/d >10?
Moselle	Boiler AA-003[1]	465	517	29	1,011	170	No
R.D. Morrow	Boiler AA-01	14,060	8,202	1,406	23,434	139	Yes
	Boiler AA-02	14,060	8,202	1,406	23,434		

[1]Emissions from natural gas

While the Q/d analysis shows that the Moselle Plant does not exceed the Q/d threshold of 10, the total visibility impairing emission is over 1,000 tons per year and therefore the Moselle Plant may have a significant impact on the Breton WA. Because the R.D. Morrow Plant's Q/d assessment exceeds 10, the plant may potentially have a significant impact on visibility at the Breton WA.

Emissions of visibility-impairing pollutants vary over the course of a year. The VISTAS modeling protocol recommends that the maximum hourly emission rates, when averaged over a 24-hour period, be used to determine if sources are subject to BART.

Because visibility impairment is so heavily dependent on weather conditions, and individual weather varies by the day, the EPA allows the 98th percentile value to be used to determine whether a source causes or contributes to visibility impairment. On an annual basis, the 98th percentile is the 8th highest 24-hour modeled impact (2 percent of 365 days is about 8 days). Alternatively, the 22nd highest 24-hour modeled impact may be used for a three-year period.

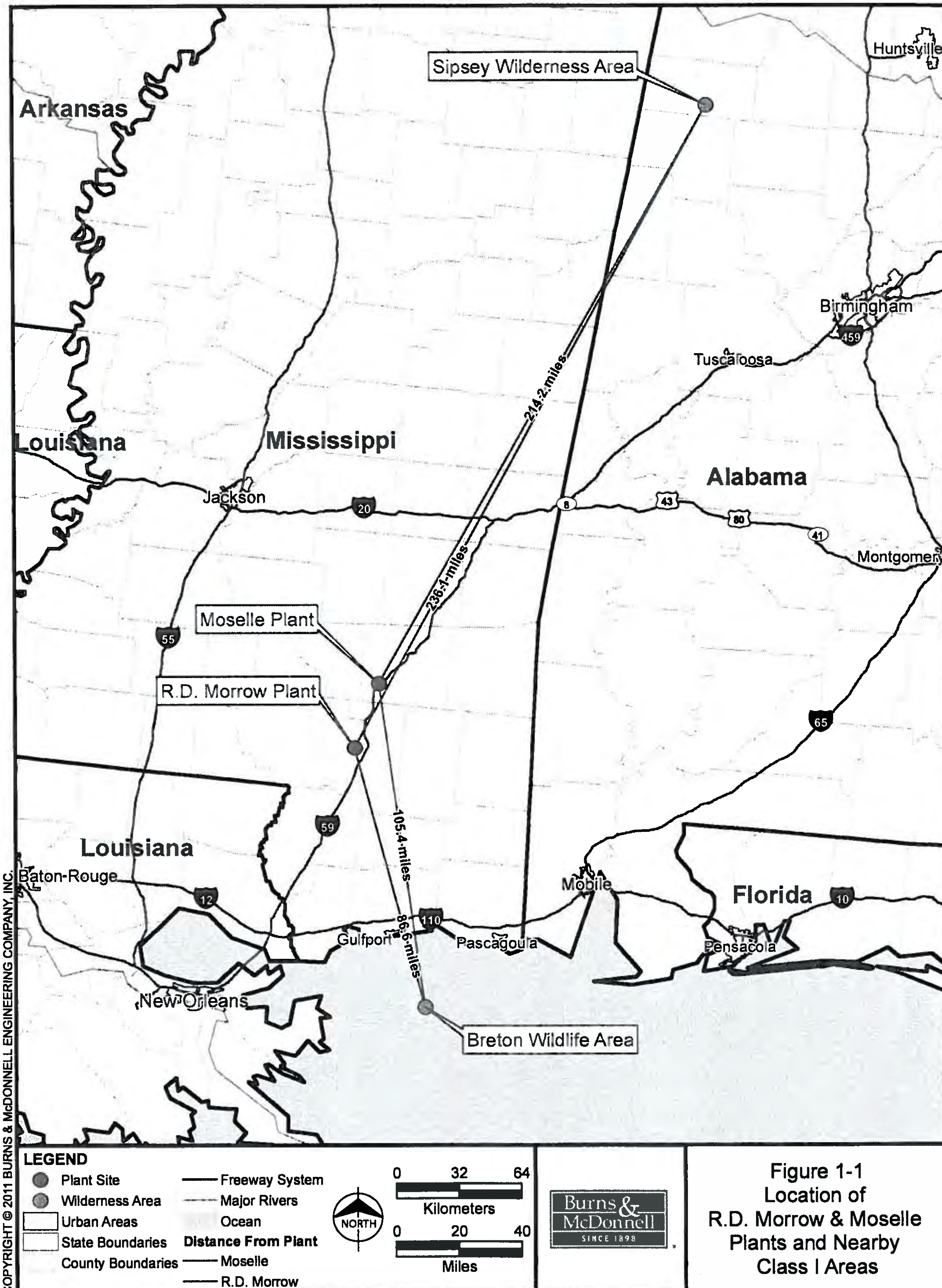


Figure 1-1
Location of
R.D. Morrow & Moselle
Plants and Nearby
Class I Areas

Source: ESRI and Burns & McDonnell

Issued: 8/1/2011

Path: \\ESPSRV\Data\Data2\Projects\SMEPA\62680\GIS\DataFiles\ArcDocs\Fig1-1_SMEPA_Wilderness_Sites_Distance_Portrait.mxd rfraser 8/1/2011

2.0 SOURCE DESCRIPTION

2.1 MOSELLE PLANT

2.1.1 Emission Source Description

The air emission source descriptions for the Moselle Plant are summarized in Table 2-1.

Table 2-1
Moselle Plant Maximum Actual Air Emissions and Source Descriptions

Unit I.D	Equip. Type	Heat Input (MMBtu/hr)	Fuel	Start-Up Date	SO_2 Emiss (lbs/hr)	NO_x Emiss (lbs/hr).	PM Emiss (lbs/hr)	H_2SO_4 Emiss (lbs/hr)
AA-001	Boiler	868.6	Nat Gas/#2 Fuel Oil	Retired				
AA-002	Boiler	868.6	Nat. Gas/#2 Fuel Oil	To Be Retired April, 2012				
AA-003	Boiler[1]	868.6	Nat. Gas/#2 Fuel Oil	1970	0.25	245.42	6.52	0.19
AA-004	Fire Pump	2.1	Gasoline	NA	NA	NA	NA	NA
AA-005	CT	1,547	Nat. Gas/#2 Fuel Oil	NA	NA	NA	NA	NA
AA-006	CT	1,143.3	Nat. Gas/#2 Fuel Oil	NA	NA	NA	NA	NA
AA-007	Nat. Gas Fired Heater	3.6	Nat. Gas	NA	NA	NA	NA	NA

MMBtu/hr= Million British Thermal Units per hour
[1]Burning natural gas.

Only the emissions from those sources that meet the BART criteria (Section 1.4) will be included in the BART visibility analysis. Except for the boilers, all other sources do not meet the BART criteria. The emission rates listed in Table 2-1 for the Moselle Plant will be used in the visibility analysis since the maximum emission rates were during combustion of natural gas.

The emissions of SO_2 and NO_x were taken from EPA's Clean Air Market Division's Part 75 (Acid Rain) Prepackaged Data Sheets website. The emissions of PM_{10} were based on permit limits, and sulfuric acid emissions (H_2SO_4) were calculated from a National Park Service website.[7]

2.1.2 Emission Source Parameters

The Moselle Plant emission parameters for the BART-eligible sources are summarized in Table 2-2.

Table 2-2

Moselle Plant Emission Source Parameters for BART Eligible Sources

Unit I.D	Stack Height (Ft)	Stack Diameter (Ft)	Stack Temperature (F)	Exhaust Flow (acfm)*	Elevation (Ft)
AA-003	101	9	285	268,500	209

*Flow rates were taken from Relative Accuracy Test Audits because no actual exhaust flow data was measured in 2001-03.

2.2 R.D. MORROW PLANT

2.2.1 Emission Source Description

The air emission source descriptions are summarized in Table 2-3.

Table 2-3

R.D. Morrow Plant Maximum Actual Air Emissions and Source Descriptions[8]

	Equip. Type	Heat Input (MMBtu/hr)	Fuel	Start-Up Date	SO_2 Pot. Emiss. (lbs/hr)	NO_x Pot. Emiss (lbs/hr)	PM Pot Emiss. (lbs/hr)	H_2SO_4 (lbs/hr)
AA-001	Boiler	2,675	Coal, Fuel Oil	1978[1]	2,215.42	1,298.08	321.00	22.47[2]
AA-002	Boiler	2,675	Coal, Fuel Oil	1978[1]	2,492.67	1,329.00	321.00	22.47[2]
AA-003	Coal Handling System	N/A	N/A	NA	NA	NA	NA	NA
AA-004	Diesel Fire Pump	1.75	Diesel	NA	NA	NA	NA	NA
AA-005	Diesel Emer. Gen.	3.5	Diesel	NA	NA	NA	NA	NA
AA-006	Cooling Tower A	N/A	N/A	NA	NA	NA	NA	NA
AA-	Cooling	N/A	N/A	NA	NA	NA	NA	NA

[7] www.nature.nps.gov/air/permits/ect/ectGasFiredCT.cfm (Accessed 7/31/11).

[8] State of Mississippi Air Pollution Control Title V Permit, June 22, 2011.

	Equip. Type	Heat Input (MMBtu/hr)	Fuel	Start-Up Date	SO_2 Pot. Emiss. (lbs/hr)	NO_x Pot. Emiss (lbs/hr)	PM Pot Emiss. (lbs/hr)	H_2SO_4 (lbs/hr)
007	Tower B							
AA-008	Gravel Roads	N/A	N/A	NA	NA	NA	NA	NA
AA-009	Bulldozer	N/A	N/A	NA	NA	NA	NA	NA
AA-010	Limestone Handling	N/A	N/A	NA	NA	NA	NA	NA
AA-011	Diesel Generator	4.1	Diesel	NA	NA	NA	NA	NA

MMBtu/hr= Million British Thermal Units per hour
[1]The R.D. Morrow Plant's Boiler AA-001 and AA-002 were constructed in 1978, but initial design contracting began before August 7, 1977.
[2]From AP-42 Table 1.1-3 SO_3 as a surrogate for sulfates: $SO_3 \approx 0.7\%$ of SO_2, probable overestimate.

Like the emission sources at the Moselle Plant, only the emissions from those sources that meet the BART criteria (Section 1.4) will be included in the BART visibility analysis. Except for the boilers, all other sources do not meet the BART criteria.

2.2.2 Emission Source Parameters

The R.D. Morrow Plant emission parameters for the BART eligible sources are summarized in Table 2-4.

Table 2-2
R.D. Morrow Plant Emission Source Parameters for BART Eligible Sources

Unit I.D	Stack Height (Ft)	Stack Diameter (Ft)	Stack Temperature (F)	Exhaust Flow (acfm)	Elevation (Ft)
AA-001	406	16.75	180	731,000	254
AA-002	406	16.75	180	677,000	254

MMBtu/hr= Million British Thermal Units per hour

3.0 GEOPHYSICAL AND METEOROLOGICAL DATA

3.1 MODELING DOMAIN AND TERRAIN

To help standardize the BART modeling process, VISTAS and the Mississippi Department of Environmental Quality (MDEQ) have prepared terrain and land use files for Domain 1. The terrain and land use data have been prepared for input into the CALPUFF modeling system. A more detailed discussion on the CALPUFF modeling modules is contained in Section 4.

3.1.1 Boundary Conditions

The domain boundary requires initialization parameters. These parameters—wind speed, wind direction, air temperature, etc., establish a starting point for the movement of a plume into or out of the domain. To accommodate this modeling requirement, the MM5 gridded wind field provides these boundary conditions. The MM5 is discussed in more detail in Section 3.3.1.

3.1.2 Terrain

The CALPUFF modeling system incorporates terrain features into its dispersion algorithms. The dispersion of a plume will be different from contact with hills versus flat river bottoms.

The effects of complex terrain on puff transport are derived from the CALMET-generated wind fields. In addition, puff-terrain interactions at gridded and discrete receptor locations are simulated using one of two algorithms that modify the puff-height or an algorithm that simulates enhanced vertical dispersion derived from the weakly-stratified flow and dispersion module of the Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations (CTDMPLUS). The puff-height adjustment algorithms rely on the receptor elevation and the height of the puff above the surface. The enhanced dispersion adjustment relies on the slope of the gridded terrain in the direction of transport during the time step.

The terrain data is drawn from a digital terrain file in either Digital Elevation Model format or the newer National Elevation Dataset format. Both sets are available from the U.S. Geological Survey, or other commercial vendors. These digital files contain coordinates in three planes: the x-plane, the y-plane, and the z-plane. The resolution of these data points varies from 10 to 30 meters or more.

3.2 LAND USE

Like the terrain, land use is also a factor in plume dispersion. The dispersion of a plume will be different as it passes over a deciduous forest versus over open pasture. The following land use categories are incorporated into the modeling system:

1. Urban or Built Up Land;
2. Agricultural Land;
3. Rangeland;
4. Forest Land;
5. Water;
6. Wetland;
7. Barren Land;
8. Tundra; and
9. Perennial Snowfields.

3.3 METEOROLOGICAL DATA BASE

3.3.1 MM5 Simulations

CALMET is a diagnostic meteorological model that produces three-dimensional wind and temperature fields and two-dimensional fields of mixing heights and other meteorological fields. CALMET incorporates surface, upper air meteorological observations and has the option of using the MM5 gridded wind fields.[9] The MM5 is a terrain-following model "designed to simulate or predict mesoscale and regional-scale atmospheric circulation".[10]

A MM5 grid is much like a three-dimensional maze with each level containing the following meteorological parameters:

1. Barometric pressure;
2. Elevation;
3. Air temperature;
4. Wind direction;
5. Wind speed;
6. Vertical velocity of the air;
7. Relative humidity;
8. Vapor mixing ratio;
9. Cloud mixing ratio;
10. Rain mixing ratio;
11. Ice mixing ratio;

[9] MM5 is the UCAR/Penn State meteorological model, 5th generation. An MM4 dataset also exists, but was not used for this analysis.

12. Snow mixing ratio; and
13. Graupel mixing ratio.

The MM5 dataset has the following grid sizes available;

- 2001 – 12 km and 36 km grid;
- 2002 – 12 km and 36 km grid; and
- 2003 – 36 km grid.

The MM5 data was used by VISTAS and the MDEQ to produce a 4-km resolution CALMET.dat output file for the modeling area .[11] These files were provided to SMEPA for this BART analysis.

3.3.2 Meteorological Measurements and Observations

Surface, upper air and precipitation data for the years 2001-2003 were used. The location of each reporting station is shown in Figure A-1.[12] Lists of the stations are in Tables A-1 through A-3 in Appendix A. These stations will provide representative observational meteorological data to supplement the MM5 gridded wind fields. For a BART screening analysis VISTAS recommends using the CALPUFF "No-Obs" mode which only utilizes the MM5 gridded wind fields without meteorological observation dataset. However, the CALMET files sent to SMEPA from the MDEQ did not utilize the No-Obs option.

3.4 AIR QUALITY DATA BASE

3.4.1 Ozone Concentrations

Ambient ozone data was taken from the VISTAS webpage for the years 2001-03.[13]

3.4.2 Ammonia Concentrations

SMEPA will use the VISTAS default background ammonia concentration of 0.5 parts per billion (ppb).

3.4.3 Concentrations of Other Pollutants

The CALPUFF model can incorporate other pollutants into the visibility impairment prediction. Background concentrations of hydrogen peroxide (H_2O_2) and secondary organic aerosols (SOA) may

[10] http://www.mmm.ucar.edu/mm5/overview.html. Accessed 7/19/11.
[11] The VISTAS BART modeling protocol recommends that 12-km grid resolution be used for the screening evaluation. A 4-km grid resolution dataset was provided to SMEPA.
[12] The precipitation stations are too numerous to include in this diagram. A full list of the precipitation stations are in Table A-3.
[13] http://www.src.com/datasets/datasets_modelready.html#12KM_DOMAIN. Accessed July 27, 2011.

optionally be included in the CALPUFF modeling. For this visibility analysis, H_2O_2 and SOA were not included.

3.5 NATURAL CONDITIONS AT CLASS I AREAS

The Interagency Workgroup for Air Quality Modeling (IWAQM) developed a set of procedures for use in evaluating visibility impacts (EPA, 1998) that are referenced in the Federal Land Managers Air Quality Related Values' Workgroup (FLAG) guidance document on assessing air quality related values in Class I areas (FLAG 2000 and FLAG, 2008).[14] The procedures focus on the contribution of anthropogenically-generated fine particles such as SO_4 and NO_3 to visibility degradation compared to "natural conditions." Natural conditions are a description of the atmosphere absent any anthropogenic influence. Each Class I Area has characteristic air quality that would affect visibility. The FLAG guidance has quantified the factors that naturally affect visibility (particulate matter, nitrates, other molecules of gasses, etc.). A summary of the natural visibility factors are found in Tables 3-1 and 3-2.

[14] EPA, FLAG 2000, pg. 47; EPA FLAG 2008, pg. 45.

Table 3-1 Annual Averaged Background Reference Visibility Conditions by Class I Area (for CALPOST Method 6 Application)

Class I Area	Components of Dry Extinction (Mm^{-1}) Non-Hygroscopic	Hygroscopic	Rayleigh
Breton Wildlife Area	8.5	0.9	10

Source: FLAG (2000)

Table 3-2 Annual Average 20% Best Natural Conditions – Concentrations and Rayleigh Scattering

Class I Area	$(NH_4)_2SO_4$ ($\mu g/m^3$)	NH_4NO_3 ($\mu g/m^3$)	OM ($\mu g/m^3$)	EC ($\mu g/m^3$)	Soil ($\mu g/m^3$)	CM ($\mu g/m^3$)	Sea Salt ($\mu g/m^3$)	Rayleigh Mm^{-1}	Type
Breton Wildlife Area	0.23	0.10	1.78	0.02	0.48	3.01	0.19	11	Annual

Source: FLAG (2008)
$(NH_4)_2SO_4$- Ammonium sulfate
NH_4NO_3- Ammonium nitrate
OM- Organic mass
EC-Elemental carbon
Soil- Inorganic particulate
CM-Coarse mass
Rayleigh-Light scattering from atmospheric gases

4.0 AIR QUALITY MODELING METHODOLOGY

4.1 PLUME MODEL SELECTION

CALPUFF and its meteorological model CALMET, are designed to handle complex terrain, the long source to receptor distances, chemical transformation and deposition, and other issues related to Class I impacts. The CALPUFF modeling system has been adopted by the EPA as a guideline model for long-range transport (source to receptor distances of 50 km or more), and for use on a case-by-case basis in complex flow for shorter distances. CALPUFF is recommended for Class I visibility assessments by the IWAQM (1998) guidance.

SMEPA is proposing to use the following versions of the CALPUFF modeling system:

- CALMET Version 5.724, Level060414
- CALPUFF Version 5.754 Level 060202
- POSTUTIL Version 1.520, Level 060402
- CALPOST Version 5.6393, Level 060202

4.1.1 Major Relevant Features of CALMET

CALMET consists of a diagnostic wind field module and micrometeorological modules for overwater and over land boundary layers. This analysis will use the Lambert Conic conformal (LCC) option and default wind-field diagnostic setups. A summary of major characteristics of the CALMET model from the CALMET User's Guide is summarized in Appendix B.

4.1.2 Major Relevant Features of CALPUFF

By using its puff-based formulation, and through the use of three-dimensional meteorological data developed by the CALMET meteorological model, CALPUFF can simulate the effects of time- and space-varying meteorological conditions on pollutant transport from sources in complex terrain. The major features and options of the CALPUFF model from the CALPUFF User's Guide are summarized in Appendix C.

4.2 MODEL DOMAIN CONFIGURATION

4.2.1 Selection of Domain

VISTAS divided the southeastern U.S. into "domains. A domain is a geographic area representing BART eligible sources and nearby Class I Areas. The domain sets the boundary for both atmospheric and terrestrial parameters that will impact a plume. Domain parameters include the following:

- Atmospheric parameters (air temperature, wind speed, precipitation, etc.) for both surface and upper air
- Terrain elevation
- Land use (including oceans and lakes)

For SMEPA, the VISTA Domain 1 was selected (Figure 4-1). The specifications for Domain 1 are shown in Table 4-1.

Table 4-1: Domain 1 Specifications

Domain	SW Coord	Number of X Grid Cells	Number of Y Grid Cells	Horizontal Grid Spacing
Domain 1	NWS-84 X (km)=478.004 Y(km)=-1177.998	116	182	4

The VISTAS' Domain 1 is 464 by 728 kilometers. Ten vertical levels were used. The cell face heights are located at 0, 20, 40, 80, 160, 320, 640, 1200, 2000, 3000, and 4000 meters. The grid size is large enough to extend 50 kilometers beyond the two Class I areas that are within 380 kilometers of the SMEPA plants, but the grid cell density is enough to accurately simulate the surface features of the domain.

4.3 CALMET METEOROLOGICAL MODELING

4.3.1 CALMET Configuration

The parameter values used in the CALMET module were based on the IWAQM, 1998 guidelines and the VISTAS modeling protocol guidelines (VISTAS, 2006). The values used are listed in Table D-1 in Appendix D.

4.3.2 Initial Guess Field

In this application, the Class I modeling analysis uses a mesoscale gridded wind field designed to simulate or predict mesoscale and regional-scale atmospheric circulation. This wind field, called MM5, (Mesoscale Modeling System 5th Generation) is a three-dimensional grid into which the plume is released, and its dimensions match the CALMET domain.

The MM5 gridded meteorological data was used to define the initial guess field for the CALMET simulations. MM5 data with horizontal spatial resolution of 12 kilometers for 2001 and 2002 and 36 kilometers for 2003 was used.

4.3.3 Step 1 Field: Terrain Effects

In the Step 1 wind field, CALMET adjusts the initial guess field to reflect effects of terrain including slope flows and blocking effects. Slope flows are a function of the local slope and altitude of the nearest crest. The crest is defined as the highest peak within a radius TERRAD around each grid point. The value of TERRAD was determined by the VISTAS RPO and is shown in Table D-1.

4.3.4 Step 2 Field: Observational Data Interpolation

The refined modeling approach requires the inclusion of both surface and upper air observations in the CALMET simulations. This is accomplished in Step 2 where observations are incorporated into the Step 1 field (Section 4.3.3 above) where terrain effects are added to the CALMET wind field. The surface, upper air, and overwater meteorological sites included in this analysis are shown in Figure A-1 in Appendix A. The meteorological data covers the same years as the MM5 data. CALMET also incorporates precipitation data into the MM5 gridded wind field. Precipitation contributes to pollutant scavenging and deposition. The location of the precipitation stations are listed in Table A-3 in Appendix A.

Each observation site influences the final wind field within a set of specified radii of influence parameters. These radii of influence parameters consist of R1 and RMAX1 for surface observations, and R2 and RMAX2 for upper air observations. At a distance R1 from an observation site, the Step 1 wind field and the surface observations are weighted equally, while at a distance of RMAX1 the influence of the observation site becomes zero. In complex terrain, channeling and slope flows contribute significantly to the wind field, thus, the radii of influence parameters must be selected so that the influence of observations do not unrealistically remove the effects of terrain on the wind. The VISTAS RPO determined the values for R1, R2, and RMAX1 and are shown in Table D-1.

4.3.5 CALMET Output File

CALMET produces a CALMET.dat output file that has integrated terrain, land use, meteorological, and MM5 gridded wind field data into a single file that is read by CALPUFF. The CALMET.dat file is the "maze" into which CALPUFF releases the plume. For this analysis, the maze had 4-km spacing.

4.4 CALPUFF COMPUTATIONAL DOMAIN AND RECEPTORS

4.4.1 Computational Domain

SMEPA used a computational domain that encompassed the geographic area of Domain 1, with a 50-km buffer around the facilities and Class I Area. A diagram of the computational domain is shown in Figure 4-1.

4.4.2 Modeling Receptors

A receptor is a point where the CALPUFF model calculates a visibility value. The National Park Service prepared a set of receptors that will best represent the geography of the Class I Area. A diagram of the receptors in the Breton WA are shown in Figure A-1.

4.5 CALPUFF MODELING OPTION SELECTIONS

The CALPUFF simulations will be conducted for the years 2001 to 2003 using the following model options:

- Gaussian near-field distribution
- Transitional plume rise
- Stack tip downwash
- PG dispersion coefficients (rural areas), MP dispersion coefficients (urban areas)
- Transition of σ_y to time-dependent (Heffter) growth rates
- Partial plume path adjustment for terrain
- Wet deposition, dry deposition, and chemical transformation using the MESOPUFF II scheme

4.5.1 CALPUFF Configuration

The parameter values used in the CALPUFF module were based on the IWAQM, 1998 guidelines and the VISTAS modeling protocol guidelines (VISTAS, 2006). The values used are listed in Table D-2 in Appendix D.

4.5.2 CALPUFF Output File

CALPUFF produces a CONC.dat and a VISB.dat output file that are input into the CALPOST and POSTUTIL modules. The CONC.dat file contains the concentrations of pollutants at the receptor points. Since the VISTAS RPO recommends a monthly averaged relative humidity value be used, the VISB.dat file normally created by CALPUFF will not be needed.

4.5.3 Particulate Matter Speciation

Apportionment of particulate matter from the proposed boiler was made in accord with the spreadsheet provided by the U.S. Fish and Wildlife Service (FWS) (see Appendix E, Tables E-1 and E-2 for a detailed listing of particulate speciation methodology for coal and natural gas, respectively). The speciation spreadsheet uses EPA AP-42 emission factors to determine the mix of particulate types: coarse, inorganic fines, elemental carbon, sulfates, and secondary organic aerosols.

Particulate matter, especially fine and hygroscopic particles, are ideal for scattering light.

4.6 LIGHT EXTINCTION AND HAZE IMPACT CALCULATIONS

Light extinction is a measure of scattered and absorbed light. A dV is a convenient unit to measure light extinction. The relationship between light extinction and dV is in this equation:

$$dV = 10\ln(b_{ext}/10Mm^{-1})$$ [15]

Where:

dV = light extinction in deciviews

$b_{ext} = b_{scattered} + b_{absorbed}$

b_{ext}, $b_{scattered}$, and $b_{absorbed}$ are the light extinction coefficients. $b_{scattered}$ can be expressed in the following relationship:

$$b_{scattered} = b_{SO4} + b_{NO3} + b_{OC} + b_{Soil} + b_{Coarse} + b_{Ray}$$

Where:

b_{SO4} = $3[(NH_4)_2SO_4]f(RH)$

b_{NO3} = $3[NH_4NO_3]f(RH)$

b_{OC} = 4[OC]

b_{Soil} = 1[Soil]

b_{Coarse} = 0.6[Coarse Mass]

b_{Ray} = $10Mm^{-1}$

Where:

NH_4-Nitrate

SO_4-Sulfates

f(RH)- Relative Humidity factor

OC-Organic Carbon

Soil-Soil or inorganic carbon

Coarse Mass-Particulate matter greater than 2.5 microns (μ) in diameter

[15] Mm^{-1}= Inverse megameters.

The light extinction from absorption is summarized in the following equations:

$$B_{absorbed} = 10EC$$

Where:

EC-Elemental carbon

For this analysis, SMEPA will follow the VISTAS BART modeling protocol and use the monthly-averaged f(RH).

The resulting b_{ext} value is then compared to the background value using the following equation:

$$\Delta dV = (dV_{calculated}/dV_{background}) \times 100$$

The ΔdV is then compared to the 0.5 dV BART visibility threshold.

For a BART visibility analysis, a monthly-averaged f(RH) value is acceptable. The VISTAS RPO developed default monthly f(RH) values as shown in Table 4-2.

Table 4-2: Monthly Averaged f(RH) Values

Class I Area	Jan.	Feb.	Mar.	Apr.	May	Jun.
Breton Wildlife Area	3.5	3.3	3.3	3.3	3.4	3.6
	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Breton Wildlife Area	3.8	3.8	3.6	3.4	3.4	3.5

4.7 MODELING PRODUCTS

4.7.1 CALPOST

Only the CALPOST module produces visibility impact output. The CALPOST.lst file compares natural visibility to the visibility impairment predicted to occur from emissions from the SMEPA sources. The CALPOST Method 6 is the VISTAS RPO recommended method for calculating visibility impairment and is based on the monthly f(RH) values. The modeled impacts will be sorted in descending order for each of the three meteorological data years for each Class I Area.

4.7.2 Modeling Report

The VISTAS Protocol requires inclusion of the following information except where noted.[16]

1. A map of the source location and Class I areas within 300 km of the source
2. The VISTAS 12-km CALPUFF initial exemption modeling will not be performed. See Step 5.
3. A discussion of the number of Class I areas with visibility impairment from the source on 98th percentile days in each year greater than 0.5 dV (total visibility impairment minus impairment on 20% best days for natural background visibility equals ΔdV, the visibility impact attributed to the source).
4. For the Class I area with the maximum impact, discussion of the number of days below the 98th percentile that the impact of the source exceeds 0.5 dV, the number of receptors in the Class I area where the impact exceeds 0.5 dV, and the maximum impact.
5. For finer (4 km) grid CALPUFF exemption modeling, results for those Class I areas for which impacts of the source exceeded 0.5 dV in the 12-km initial exemption modeling. The report will include the same results as provided for 12-km initial exemption modeling as listed in Table 4-3.
6. Pollutant control option modeling will not be performed at this time.
7. Copies of all input files and input data in electronic format for the CALMET, CALPUFF, CALPOST and POSTUTIL runs should be archived and provided to the MDEQ.

4.7.3 POSTUTIL

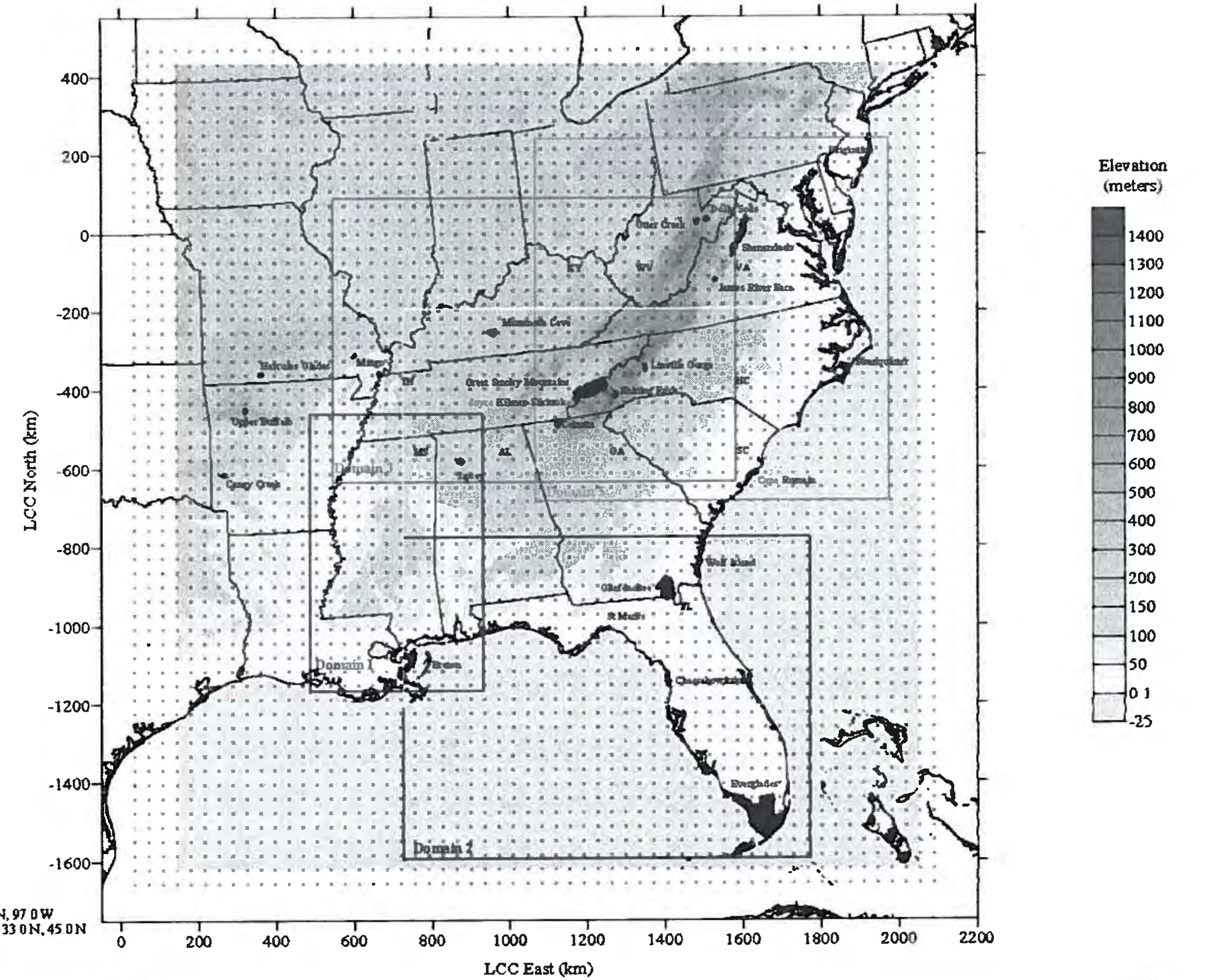
POSTUTIL is a post-processing program that can supplement the CALPUFF output data by partitioning particulate matter and sulfate emissions into the light-extinction parameters needed for the dV calculation. Tables E-1 and E-2 summarize the particulate matter partitioning for natural gas and coal combustion.

POSTUTIL can also partition nitrate compounds to avoid overproducing the visibility-obscuring particle formation. The POSTUTIL's default settings typically use worst-case modeling settings. One of the default settings does not partition nitrate between ammonia and sulfur. This setting, in effect, "double-counts" the nitrogen in the air. For this screening analysis, nitrate partitioning will not be included.

[16] VISTAS Protocol, pg. 51.

4.8 SAMPLE CALPUFF INPUT FILES

A CD with sample CALPUFF.inp, POSTUTIL.inp, and CALPOST.inp files are in Appendix F.



LCC Origin 40 0 N, 97 0 W
Standard Parallels 33 0 N, 45 0 N
Datum NWS-84

c/Active/vistas/plots/terrain 12km-domain1to5-revised-Dec20 srf

12/20/2005

Burns & McDonnell

Figure 4-1
VISTAS BART Domains

Table 4-3
Modeling to Determine if BART Eligible Sources are Subject to BART

Class I Area	Distance from Moselle	# Days and # Receptors w/Impacts >0.5 dV: 2001		# Days and # Receptors w/Impacts >0.5 dV: 2002		# Days and # Receptors w/Impacts >0.5 dV: 2003		# Days and # Receptors w/Impacts >1.0 dV for 3-Year Period		Max, 24 hr Impact for 2001-03
		# Days	# Receptors	# Days	# Receptors	# Days	# Receptors	# Days	# Receptors	
Breton WA										
	Distance from R.D. Morrow	# Days and # Receptors w/Impacts >0.5 dV: 2001		# Days and # Receptors w/Impacts >0.5 dV: 2001		# Days and # Receptors w/Impacts >0.5 dV: 2001		# Days and # Receptors w/Impacts >0.5 dV: 2001		Max, 24 hr Impact for 2001-03
		# Days	# Receptors	# Days	# Receptors	# Days	# Receptors	# Days	# Receptors	
Breton WA										

5.0 REVIEW PROCESS

5.1 CALMET FIELDS

The CALMET fields were determined by the VISTAS RPO for all domains. The files to be called by CALPUFF should not be modified. The option is available to modify and rerun CALMET with different parameters, but approval from the MDEQ would be needed.

5.2 CALPUFF, CALPOST, AND POSTUTIL RESULTS

The CALPUFF, CALPOST, and POSTUTIL input files will be reviewed and compared to the emission source parameters listed in this protocol. The accompanying tables summarize the plant emissions, stack parameters, and location of the Class I Areas.

The VISTAS RPO has also provided sample CALPUFF, CASLPOST, and POSTUTIL input files that have incorporated the VISTAS BART modeling protocol recommendations for model settings, switches, and coordinates to be called.

The diagrams of the SMEPA facilities, location of the meteorological stations, and the Class I Areas were taken from the coordinates in the CALPUFF input files. The correct input parameters will produce representative visibility impairment results.

Inputs that should be checked in the CALPOST input file are the following:

- Visibility technique (Method 6);
- Monthly Class I Area specific relative humidity factors for Method 6;
- Background light extinction values;
- Inclusion of all appropriate species from modeled sources (sulfates, nitrate, organics, coarse and fine particulate matter, and elemental carbon;
- Appropriate species names for coarse PM;
- Light extinction efficiencies for each species of particulate;
- Appropriate Rayleigh scattering term for each Class I Area; and
- Select appropriate Class I receptors for each CALPOST simulation.

6.0 REFERENCES

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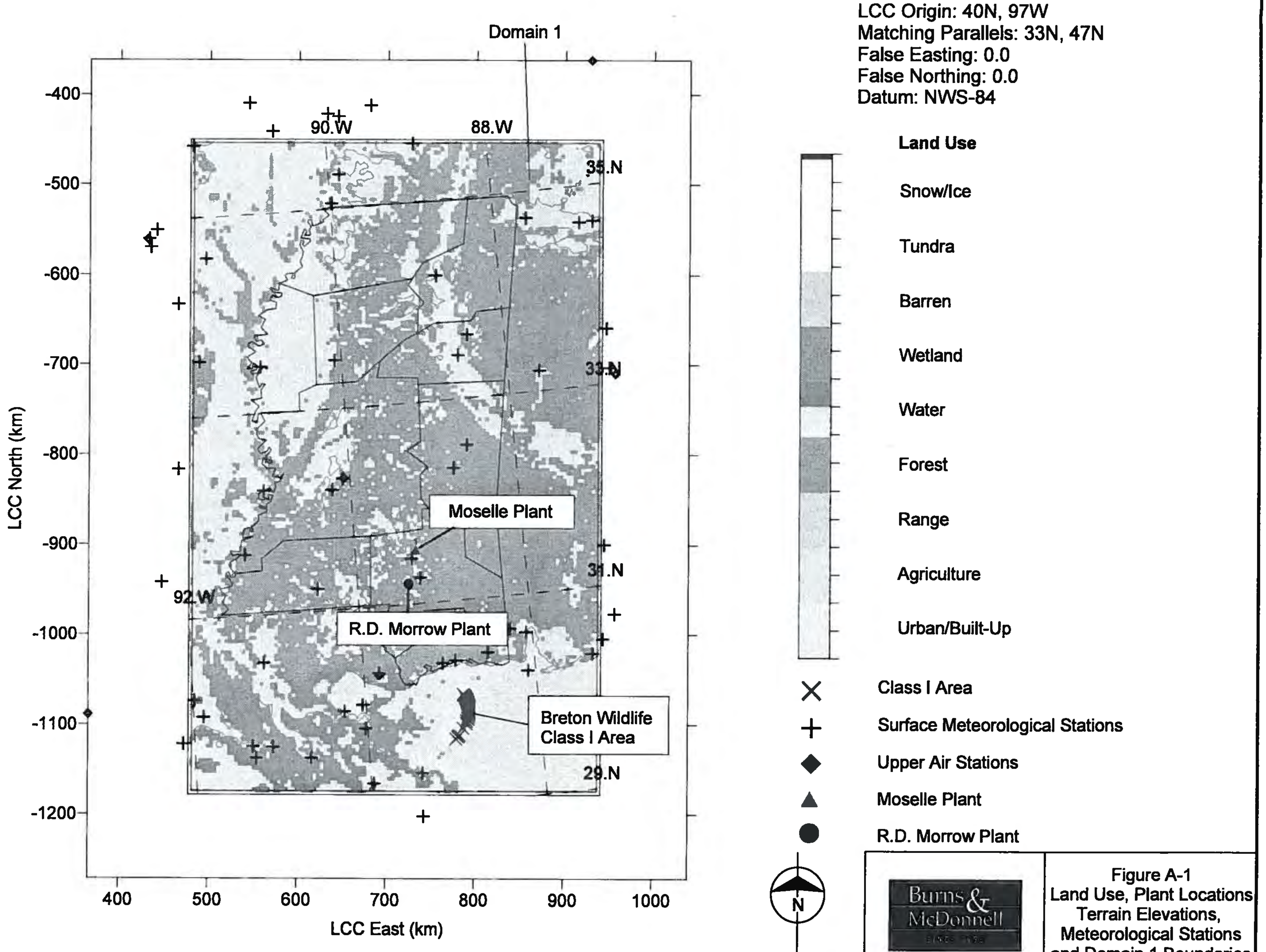
APPENDIX A

LOCATION OF METEOROLOGICAL STATIONS

LAND USE, TERRAIN, AND DOMAIN 1



Burns & McDonnell

Figure A-1
Land Use, Plant Locations
Terrain Elevations,
Meteorological Stations
and Domain 1 Boundaries

Meteorological Stations Used
Table A-1
Surface Stations

Modeling ID	Name	Station Number	X-Coordinate	Y-Coordinate	Time Zone	Anemometer Height (m)
SS1	PNS	722220	942.383	-1006.697	5	10
SS2	KPNS	722223	943.818	-1004.742	5	10
SS3	KNPA	722225	932.565	-1020.909	5	10
SS4	KNSE	722226	956.847	-977.013	5	10
SS5	KMOB	722230	839.423	-992.977	5	10
SS6	KBFM	722235	857.471	-996.829	5	10
SS7	KGZH	722276	945.158	-899.692	5	10
SS8	KDCU	722279	914.948	-541.382	5	10
SS9	KBHM	722280	946.607	-658.775	5	10
SS10	KTCL	722286	870.844	-706.104	5	10
SS11	KEET	722300	950.037	-703.113	5	10
SS12	K9F2	722308	666	-1185.711	5	10
SS13	KAXO	722309	687.474	-1167.2	5	10
SS14	KMSY	722310	653.628	-1085.506	5	10
SS15	KARA	722314	495.484	-1092.146	5	10
SS16	KNEW	722315	674.172	-1078.342	5	10
SS17	KNBG	722316	677.719	-1104.227	5	10
SS18	KBTR	722317	562.772	-1032.061	5	10
SS19	BVE	722320	741.996	-1153.463	5	10
SS20	K7R3	722328	573.622	-1124.753	5	10
SS21	KPTN	722329	550.88	-1124.295	5	10
SS22	KLIX	722330	692.531	-1045.156	5	10
SS23	KMEI	722340	774.911	-814.225	5	10
SS24	KNMM	722345	789.813	-788.601	5	10
SS25	HBG	722347	738.183	-936.724	5	10
SS26	KPIB	722348	728.416	-915.165	5	10
SS27	KJAN	722350	650.105	-826.451	5	10
SS28	KHKS	722354	638.398	-838.947	5	10
SS29	KGLH	722356	557.071	-703.097	5	10
SS30	KHEZ	722357	540.777	-912.22	5	10
SS31	KMCB	722358	622.755	-949.618	5	10
SS32	KGWO	722359	640.102	-695.286	5	10
SS33	KASD	722366	692.381	-1043.261	5	10
SS34	KP92	722403	554.905	-1137.175	5	10
SS35	KLFT	722405	484.78	-1074.03	5	10
SS36	KHUM	722406	616.692	-1136.784	5	10
SS37	K7R4	722408	472.798	-1121.421	5	10
SS38	KMLU	722486	465.834	-816.211	5	10
SS39	KESF	722487	447.248	-941.814	5	10
SS40	KTVR	722488	561.446	-840.225	5	10
SS41	KHSV	723230	930.088	-539.687	5	10
SS42	KMSL	723235	854.846	-536.687	5	10
SS43	KNQA	723284	643.959	-489.149	5	10
SS44	KCBM	723306	789.252	-665.842	5	10
SS45	KGTR	723307	779.065	-689.108	5	10
SS46	KTUP	723320	753.875	-600.337	5	10
SS47	KMEM	723340	635.927	-521.232	5	10
SS48	KMKL	723346	727.051	-454.384	5	10
SS49	KDYR	723347	679.852	-412.113	5	10
SS50	KLZK	723400	432.063	-560.441	5	10
SS51	KLIT	723403	434.091	-569.549	5	10
SS52	KLRF	723405	440.654	-550.661	5	10
SS53	KARG	723406	543.52	-409.516	5	10
SS54	KJBR	723407	569.657	-441.022	5	10
SS55	KBYH	723408	631.185	-421.598	5	10
SS56	KHKA	723409	643.364	-424.419	5	10
SS57	KSGT	723416	495.664	-582.75	5	10
SS58	KPBF	723417	464.986	-632.639	5	10
SS59	KLLQ	723424	488.655	-698.008	5	10
SS60	KBVX	723448	480.712	-457.853	5	10
SS61	KGPT	747685	764.012	-1031.681	5	10
SS62	KBIX	747686	778.252	-1028.515	5	10
SS63	KPQL	747688	814.6	-1019.583	5	10
SS64	BURL	994010	742.823	-1202.142	5	10
SS65	DPIA	994420	860.135	-1039.589	5	10
SS66	MPCL	994440	819.196	-1139.109	5	10

Table A-2
Upper Air Stations

Modeling ID	Name	Station Number	X-Coordinate	Y-Coordinate	Time Zone
US1	BMX	53823	957.073	-709.81	6
US2	SIL	53813	692.269	-1045.514	6
US3	JAN	3940	651.299	-826.026	6
US4	LCH	3937	365.704	-1088.757	6
US5	BNA	13897	929.093	-361.386	6
US6	LZK	3952	430.263	-560.867	6

Table A-3
Precipitation Stations

Modeling ID	Name	Station Number	X-Coordinate	Y-Coordinate
PS1	0002	10063	901.47	-592.97
PS2	0003	10140	899.851	-812.449
PS3	0007	10390	913.303	-527.396
PS4	0008	10402	911.205	-930.73
PS5	0010	10748	867.194	-661.917
PS6	0011	10831	947.079	-658.833
PS7	0015	12172	860.135	-1039.589
PS8	0019	13519	977.559	-847.934
PS9	0020	13620	857.596	-594.276
PS10	0021	13645	826.576	-612.369
PS11	0022	13655	939.325	-604.29
PS12	0023	14064	929.89	-540.379
PS13	0024	14193	860.847	-896.439
PS14	0025	15112	909.221	-759.52
PS15	0027	15478	839.752	-992.384
PS16	0030	15749	854.914	-537.348
PS17	0031	16370	922.493	-882.976
PS18	0032	18178	864.924	-894.236
PS19	0033	18209	962.013	-729.276
PS20	0035	18385	873.05	-706.658
PS21	0036	18517	817.92	-653.157
PS22	0037	18670	937.99	-632.704
PS23	0038	18673	856.011	-757.134
PS24	0039	30064	530.52	-436.897
PS25	0043	30326	506.775	-505.001
PS26	0044	30458	467.167	-447.769
PS27	0045	30530	462.793	-533.129
PS28	0052	30936	528.196	-549.406
PS29	0061	32148	503.624	-661.749
PS30	0070	32978	450.588	-483.091
PS31	0074	34248	433.678	-572.125
PS32	0078	34900	479.781	-695.182
PS33	0083	35320	431.143	-560.267
PS34	0085	35754	456.743	-626.538
PS35	0089	36920	510.237	-596.644
PS36	0092	38052	560.866	-505.922
PS37	0124	86997	943.495	-1005.339
PS38	0429	160103	433.825	-959.253
PS39	0430	160548	565.242	-1044.896
PS40	0431	160549	563.032	-1031.597
PS41	0432	161246	552.589	-1049.513
PS42	0433	161287	462.563	-991.296
PS43	0434	161411	436.341	-818.219
PS44	0435	161899	577.665	-999.177
PS45	0436	162534	577.432	-1083.33
PS46	0437	164030	638.241	-1030.567
PS47	0438	164407	610.152	-1135.441
PS48	0439	164696	455.096	-911.703
PS49	0440	164739	489.502	-930.252
PS50	0441	165021	476.568	-1072.575
PS51	0443	165620	562.33	-1050.685
PS52	0444	165624	698.594	-1129.111
PS53	0447	166314	462.551	-814.607
PS54	0449	166660	653.589	-1086.295
PS55	0451	168539	697.928	-1052.131
PS56	0452	168788	463.081	-796.751
PS57	0453	169357	525.184	-916.983
PS58	0455	169806	498.134	-860.883
PS59	0489	220021	780.855	-646.556
PS60	0490	220955	768.025	-554.48
PS61	0491	221094	621.827	-914.236
PS62	0492	221314	704.355	-649.239
PS63	0493	221389	651.286	-786.518
PS64	0494	221707	589.893	-621.056
PS65	0495	221743	579.228	-666.31
PS66	0496	221852	705.596	-897.598

Modeling ID	Name	Station Number	X-Coordinate	Y-Coordinate
PS61	0491	221094	621.827	-914.236
PS62	0492	221314	704.355	-649.239
PS63	0493	221389	651.286	-786.518
PS64	0494	221707	589.893	-621.056
PS65	0495	221743	579.228	-666.31
PS66	0496	221852	705.596	-897.598
PS67	0497	221900	725.121	-804.871
PS68	0498	221962	769.439	-526.51
PS69	0499	222281	778.101	-763.653
PS70	0500	222658	715.73	-767.371
PS71	0501	222773	649.814	-622.155
PS72	0502	222870	700.042	-733.204
PS73	0503	222896	718.163	-684.062
PS74	0504	223107	706.168	-821.767
PS75	0505	223619	630.724	-694.102
PS76	0506	223650	666.636	-659.798
PS77	0507	223917	624.001	-878.652
PS78	0508	224001	712.459	-564.027
PS79	0509	224173	687.965	-544.85
PS80	0510	224265	736.011	-640.935
PS81	0511	224472	650.642	-826.076
PS82	0512	224778	708.886	-747.303
PS83	0513	224966	805.885	-943.78
PS84	0514	225062	644.688	-735.834
PS85	0515	225074	594.247	-959.23
PS86	0516	225361	784.423	-721.643
PS87	0517	225614	622.775	-955.21
PS88	0518	225704	581.406	-926.335
PS89	0519	225776	775.453	-813.952
PS90	0520	226084	676.598	-536.558
PS91	0521	226400	739.076	-742.482
PS92	0522	226718	820.097	-1026.591
PS93	0523	226816	681.338	-824.012
PS94	0524	227132	571.096	-867.487
PS95	0525	227220	725.02	-950.94
PS96	0526	227276	701.769	-842.91
PS97	0527	227467	732.591	-550.354
PS98	0528	227560	570.518	-767.584
PS99	0529	227592	749.072	-842.581
PS100	0530	227714	637.599	-932.987
PS101	0531	227815	658.33	-593.661
PS102	0532	227820	706.599	-621.201
PS103	0533	227840	763.369	-1005.595
PS104	0534	228053	784.328	-865.479
PS105	0535	228374	760.434	-688.921
PS106	0536	228445	562.793	-706.724
PS107	0537	229003	753.52	-600.481
PS108	0538	229048	650.026	-952.199
PS109	0539	229079	682.845	-593.571
PS110	0540	229218	576.667	-833.631
PS111	0541	229648	751.7	-982.279
PS112	0542	229860	617.241	-763.859
PS113	0562	233999	615.193	-413.387
PS114	0882	400876	723.888	-492.258
PS115	0884	401150	695.807	-458.999
PS116	0887	401587	858.333	-424.902
PS117	0893	402680	681.354	-409.653
PS118	0896	404561	734.417	-451.832
PS119	0898	405089	871.368	-477.661
PS120	0900	405187	919.024	-455.381
PS121	0901	405210	773.196	-444.907
PS122	0903	405720	673.591	-481.206
PS123	0904	405954	635.797	-521.909
PS124	0905	405956	651.563	-513.003
PS125	0909	406358	648.076	-477.043
PS126	0919	408108	785.617	-499.036

APPENDIX B

CALMET USERS GUIDE

CALMET METEOROLOGICAL MODEL DESCRIPTION

Table 1-1

Major Features of the CALMET and CSUMM Meteorological Models

- **Boundary Layer Modules of CALMET**

  - Overland Boundary Layer - Energy Balance Method
  - Overwater Boundary Layer - Profile Method
  - Produces Gridded Fields of:
    - Surface Friction Velocity
    - Convective Velocity Scale
    - Monin-Obukhov Length
    - Mixing Height
    - PGT Stability Class
    - Air Temperature (3-D)
    - Precipitation Rate

- **Diagnostic Wind Field Module of CALMET**

  - Slope Flows
  - Kinematic Terrain Effects
  - Terrain Blocking Effects
  - Divergence Minimization
  - Produces Gridded Fields of U, V, W Wind Components
  - Inputs Include Domain-Scale Winds, Observations, and (optionally) Coarse-Grid Prognostic Model Winds
  - Lambert Conformal Projection Capability

- **Prognostic Wind Field Model (CSUMM)**

  - Hydrostatic Primitive Equation (PE) Model
  - Flows Generated in Response to Differential Surface Heating and Complex Terrain
  - Land-Sea Breeze Circulations
  - Slope-Valley Winds
  - Produces Gridded Fields of U, V, W Wind Components, and other Meteorological Variables

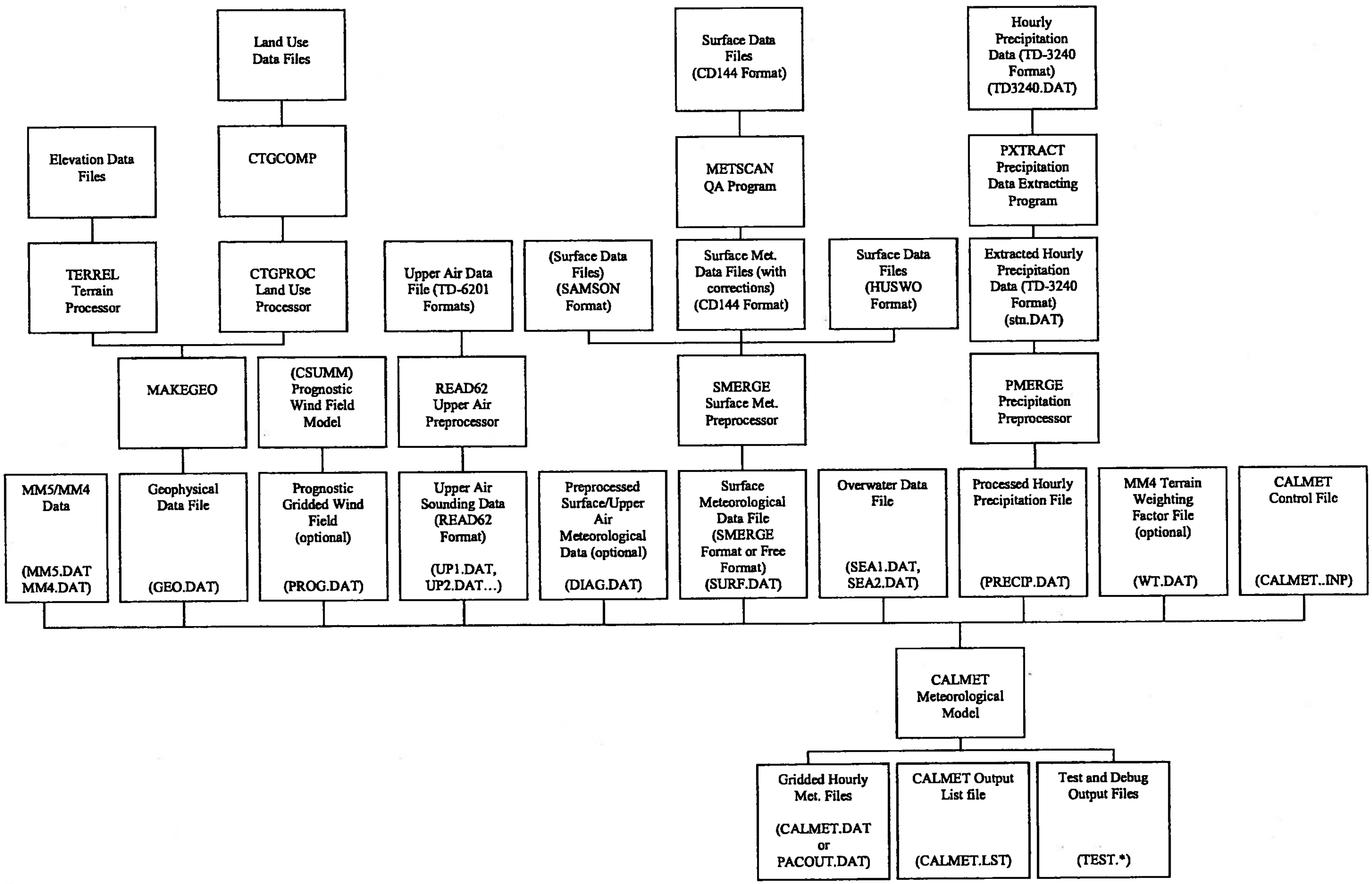


Figure 1-2. Meteorological modeling: CALMET modeling flow diagram.

APPENDIX C

CALPUFF USER GUIDE

CALPUFF MODEL DESCRIPTION

Table 1-3

Summary of Input Data Used by CALPUFF

Geophysical Data (CALMET.DAT)

Gridded fields of:
- surface roughness lengths (z_o)
- land use categories
- terrain elevations
- leaf area indices

Meteorological Data (CALMET.DAT)

Gridded fields of:
- u, v, w wind components (3-D)
- air temperature (3-D)
- surface friction velocity (u_*)
- convective velocity scale (w_*)
- mixing height (z_i)
- Monin-Obukhov length (L)
- PGT stability class
- Precipitation rate

Hourly values of the following parameters at surface met. stations:
- air density (ρ_a)
- air temperature
- short-wave solar radiation
- relative humidity
- precipitation type

Meteorological Data (ISCMET.DAT)

Hourly values (standard records)
- wind speed, flow direction
- temperature, stability class
- mixing height (z_i) for rural/urban

Hourly values (extended records)
- surface friction velocity (u_*), Monin-Obukhov length (L)
- surface roughness (z_o)
- precipitation code and rate
- potential temperature gradient
- wind speed profile power-law exponent
- short-wave solar radiation
- relative humidity

(Continued)

Table 1-3 (Continued)

Summary of Input Data Used by CALPUFF

Meteorological Date (PLMMET.DAT)

Hourly values (standard records)
- wind speed, wind direction
- temperature, stability class
- mixing height (z_i)
- turbulence (σ_0)
- wind speed profile power-law exponent
- potential temperature gradient

Hourly values (extended records)
- precipitation code and rate
- short-wave solar radiation
- relative humidity

Meteorological Data (SURFACE.DAT, PROFILE.DAT)

Hourly values (SURFACE.DAT - standard records)
- mixing height (z_i)
- surface friction velocity (u_*), Monin-Obukhov length (L)
- surface roughness (z_o)

Hourly values (SURFACE.DAT - extended records)
- precipitation code and rate
- short-wave solar radiation
- relative humidity

Hourly values at multiple levels (PROFILE.DAT)
- height
- wind speed (scalar, vector)
- wind direction
- temperature
- turbulence (σ_v/σ_0, σ_w)

Restart Data (RESTARTB.DAT)

Model puff data generated from a previous run (allows continuation of a previous model run)

(Continued)

Table 1-3 (Concluded)
Summary of Input Data Used by CALPUFF

Emissions Data (CALPUFF.INP, PTEMARB.DAT, BAEMARB.DAT, VOLEM.DAT, LNEMARB.DAT)

Point source emissions:

- Source and emissions data for point sources with constant or cyclical emission parameters (CALPUFF.INP)
- Source and emissions data for point sources with arbitrarily-varying emission parameters (PTEMARB.DAT)

Area source emissions

- Emissions and initial size, height, and location for area sources with constant or cyclical emission parameters (CALPUFF.INP)
- Gridded emissions data for buoyant area sources with arbitrarily-varying emission parameters (BAEMARB.DAT)

Volume source emissions

- Emissions, height, size, and location of volume sources with constant or cyclical emission parameters (CALPUFF.INP)
- Emissions data for volume sources with arbitrarily-varying emission parameters (VOLEM.DAT)

Line source emissions

- Source and emissions data, height, length, location, spacing, and orientation of buoyant line sources with constant or cyclical emission parameters (CALPUFF.INP)
- Emissions data for buoyant line sources with arbitrarily-varying emission parameters (LNEMARB.DAT)

Deposition Velocity Data (VD.DAT)

- Deposition velocity for each user-specified species for each hour of a diurnal cycle

Ozone Monitoring Data (OZONE.DAT)

- Hourly ozone measurements at one or more monitoring stations

Chemical Transformation Data (CHEM.DAT)

- Species-dependent chemical transformation rates for each hour of a diurnal cycle

Hill Data (HILL.DAT)

- Hill shape and height parameters in CTDMPLUS format for use in the subgrid-scale complex terrain module (CTSG)

CTSG Receptors (HILLRCT.DAT)

- Receptor locations and associated hill ID in CTDMPLUS format

Subgrid Scale Coastal Boundary Data (COASTLN.DAT)

- File containing X,Y coordinates of subgrid scale coastlines to be treated by CALPUFF

Boundary Data for Diagnostic Mass Flux Option (FLUXBDY.DAT)

- File containing X,Y coordinates of boundaries used to evaluate hourly mass transport

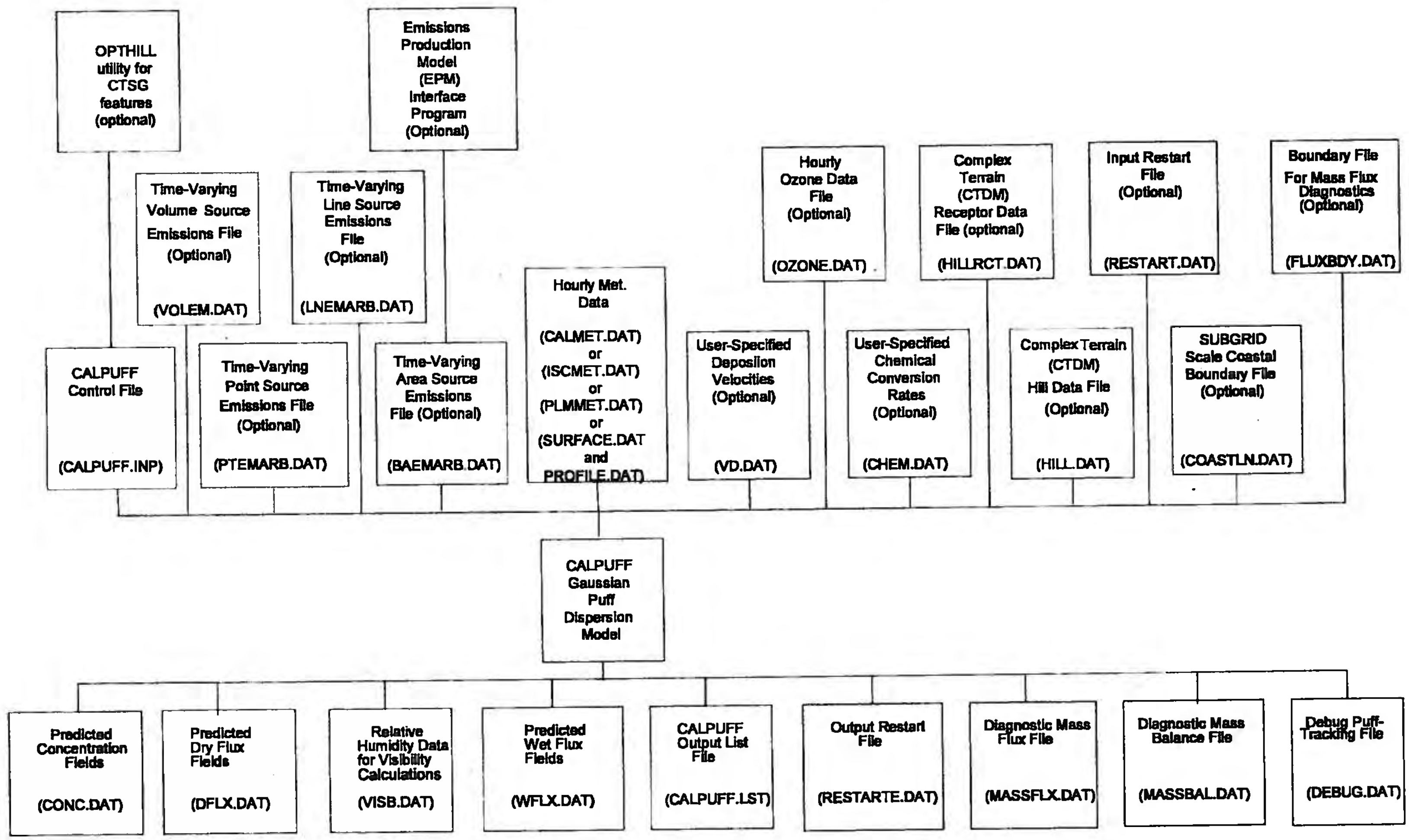


Figure 1-3. Dispersion Modeling: CALPUFF modeling flow diagram.

APPENDIX D
CALMET AND CALPUFF MODEL CONFIGURATIONS USED

Table D-1
FLAG, 1998 and VISTAS CALMET Recommended Parameter Settings

Variable	Description	Value
GEO.DAT	Name of Geophysical data file	geo-domain1-4km-comb-g.dat
SURF.DAT	Name of Surface data file	See Calmet Input Files
PRECIP.DAT	Name of Precipitation data file	See Calmet Input Files
NUSTA	Number of upper air data sites	5
UPn.DAT	Names of NUSTA upper air data files	See Calmet Input Files
IBYR	Beginning year	See Calmet Input Files
IBMO	Beginning month	See Calmet Input Files
IBDY	Beginning day	See Calmet Input Files
IBHR	Beginning hour	See Calmet Input Files
IBTZ	Base time zone	5
IRLG	Number of hours to simulate	See Calmet Input Files
IRTYPE	Output file type to create (must be 1 for CALPUFF)	1
LCALGRD	Are w-components and temperature needed?	T
NX	Number of east-west grid cells	116
NY	Number of north-south grid cells	184
DGRIDKM	Grid spacing	4
XORIGKM	Southwest grid cell X coordinate	478.004
YORIGKM	Southwest grid cell Y coordinate	-1177.998
XLAT0	Southwest grid cell latitude	NA
YLON0	Southwest grid cell longitude	NA
IUTMZN	UTM Zone	NA
LLCONF	When using Lambert Conformal map coordinates, rotate winds from true north to map north?	F
XLAT1	Latitude of 1st standard parallel	33N
XLAT2	Latitude of 2nd standard parallel	45N
RLON0	Longitude used if LLCONF = T	97W
RLAT0	Latitude used if LLCONF = T	40
NZ	Number of vertical layers	10
ZFACE	Vertical cell face heights (NZ+1 values)	11
LSAVE	Save met. data fields in an unformatted file?	T
IFORMO	Format of unformatted file (1 for CALPUFF)	1
NSSTA	Number of stations in SURF.DAT file	66
NPSTA	Number of stations in PRECIP.DAT	126
ICLOUD	Is cloud data to be input as gridded fields? (0 = No)	0
IFORMS	Format of surface data (2 = formatted)	2
IFORMP	Format of precipitation data (2 = formatted)	2
IFORMC	Format of cloud data (2 = formatted)	2

Table D-1
FLAG, 1998 and VISTAS CALMET Recommended Parameter Settings

Variable	Description	Value
IWFCOD	Generate winds by diagnostic wind module? (1 = Yes)	1
IFRADJ	Adjust winds using Froude number effects? (1 = Yes)	1
IKINE	Adjust winds using kinematic effects? (1 = Yes)	0
IOBR	Use O'Brien procedure for vertical winds? (0 = No)	0
ISLOPE	Compute slope flows? (1 = Yes)	1
IEXTRP	Extrapolate surface winds to upper layers? (-4 = use similarity theory and ignore layer 1 of upper air station data)	-4
ICALM	Extrapolate surface calms to upper layers? (0 = No)	0
BIAS	Surface/upper-air weighting factors (NZ values)	0
IPROG	Using prognostic or MM-FDDA data? (0 = No)	0
LVARY	Use varying radius to develop surface winds?	F
RMAX1	Max surface over-land extrapolation radius (km)	40
RMAX2	Max aloft over-land extrapolation radius (km)	40
RMAX3	Maximum over-water extrapolation radius (km)	100
RMIN	Minimum extrapolation radius (km)	0.1
RMIN2	Distance (km) around an upper air site where vertical extrapolation is excluded (Set to -1 if IEXTRP = ±4)	4
TERRAD	Radius of influence of terrain features (km)	15
R1	Relative weight at surface of Step 1 field and obs	5
R2	Relative weight aloft of Step 1 field and obs	5
DIVLIM	Maximum acceptable divergence	5.E-6
NITER	Max number of passes in divergence minimization	50
NSMTH	Number of passes in smoothing (NZ values)	2, 4*(NZ-1)
NINTR2	Max number of stations for interpolations (NA values)	99
CRITFN	Critical Froude number	1
ALPHA	Empirical factor triggering kinematic effects	0.1
IDIOPT1	Compute temperatures from observations (0 = True)	0
ISURFT	Surface station to use for surface temperature (between 1 and NSSTA)	NA
IDIOPT2	Compute domain-average lapse rates? (0 = True)	0
IUPT	Station for lapse rates (between 1 and NUSTA)	3
ZUPT	Depth of domain-average lapse rate (m)	200
IDIOPT3	Compute internally inital guess winds? (0 = True)	0
IUPWND	Upper air station for domain winds (-1 = 1/r**2 interpolation of all stations)	-1
ZUPWND	Bottom and top of layer for 1st guess winds (m)	1, 1000
IDIOPT4	Read surface winds from SURF.DAT? (0 = True)	0
IDIOPT5	Read aloft winds from UPn.DAT? (0 = True)	0
CONSTB	Neutral mixing height B constant	1.41
CONSTE	Convective mixing height E constant	0.15
CONSTN	Stable mixing height N constant	2400
CONSTW	Over-water mixing height W constant	0.16
FCORIOL	Absolute value of Coriolis parameter	1.E-4
IAVEXZI	Spatial averaging of mixing heights? (1 = True)	1
MNMDAV	Max averaging radius (number of grid cells)	1
HAFANG	Half-angle for looking upwind (degrees)	30
ILEVZI	Layer to use in upwind averaging (between 1 and NZ)	1

Table D-1
FLAG, 1998 and VISTAS CALMET Recommended Parameter Settings

Variable	Description	Value
DPTMIN	Minimum capping potential temperature lapse rate	0.001
DZZI	Depth for computing capping lapse rate (m)	200
ZIMIN	Minimum over-land mixing height (m)	50
ZIMAX	Maximum over-land mixing height (m)	3000
ZIMINW	Minimum over-water mixing height (m)	50
ZIMAXW	Maximum over-water mixing heigh (m)	3000
IRAD	Form of temperature interpolation (1 = 1/r)	1
TRADKM	Radius of temperature interpolation (km)	500
NUMTS	Max number of stations in temperature interpolations	5
IAVET	Conduct spatial averaging of temperature? (1 = True)	1
TGDEFB	Default over-water mixed layer lapse rate (K/m)	-0.0098
TGDEFA	Default over-water capping lapse rate (K/m)	-0.0045
JWAT1	Beginning landuse type defining water	55
JWAT2	Ending landuse type defining water	55
NFLAGP	Method for precipitation interpolation (2 = 1/r**2)	2
SIGMAP	Precip radius for interpolations (km)	100
CUTP	Minimum cut off precip rate (mm/hr)	0.01
SSn	NSSTA input records for surface stations	NA
USn	NUSTA input records for upper-air stations	NA
PSn	NPSTA input records for precipitation stations	NA

(shaded) =SMEPA Site Data

Bold =VISTAS recommended settings

Table D-2

FLAG, 1998 and VISTAS CALPUFF Recommended Parameter Settings

Variable	Description	Value
METDAT	CALMET input data filename	CALMET.DAT
PUFLST	Filename for general output from CALPUFF	CALPUFF.LST
CONDAT	Filename for output concentration data	CONC.DAT
DFDAT	Filename for output dry deposition fluxes	DFLX.DAT
WFDAT	Filename for output wet deposition fluxes	WFLX.DAT
VISDAT	Filename for output relative humidities (for visibility)	VISB.DAT
METRUN	Do we run all periods (1) or a subset (0)?	0
IBYR	Beginning year	See Calpuff.inp
IBMO	Beginning month	See Calpuff.inp
IBDY	Beginning day	See Calpuff.inp
IBHR	Beginning hour	See Calpuff.inp
IRLG	Length of run (hours)	See Calpuff.inp
NSPEC	Number of species modeled (for MESOPUFF II chemistry)	5
NSE	Number of species emitted	3
MRESTART	Restart options (0 = no restart), allows splitting runs into smaller segments	0
METFM	Format of input meteorology (1 = CALMET)	1
AVET	Averaging time lateral dispersion parameters (minutes)	60
MGAUSS	Near-field vertical distribution (1 = Gaussian)	1
MCTADJ	Terrain adjustments to plume path (3 = Plume path)	3
MCTSG	Do we have subgrid hills? (0 = No), allows CTDM-like treatment for subgrid scale hills	0
MSLUG	Near-field puff treatment (0 = No slugs)	0
MTRANS	Model transitional plume rise? (1 = Yes)	1
MTIP	Treat stack tip downwash? (1 = Yes)	1
MSHEAR	Treat vertical wind shear? (0 = No)	0
MSPLIT	Allow puffs to split? (0 = No)	0
MCHEM	MESOPUFF-II Chemistry? (1 = Yes)	1
MWET	Model wet deposition? (1 = Yes)	1
MDRY	Model dry deposition? (1 = Yes)	1
MDISP	Method for dispersion coefficients (3 = PG & MP)	3
MTURBVW	Turbulence characterization? (Only if MDISP = 1 or 5)	3
MDISP2	Backup coefficients (Only if MDISP = 1 or 5)	3
MROUGH	Adjust PG for surface roughness? (0 = No)	0
MPARTL	Model partial plume penetration? (0 = No)	1
MTINV	Elevated inversion strength (0 = compute from data)	0
MPDF	Use PDF for convective dispersion? (0 = No)	0
MSGTIBL	Use TIBL module? (0 = No) allows treatment of subgrid scale coastal areas	0
MREG	Regulatory default checks? (1 = Yes)	1
CSPECn	Names of species modeled (for MESOPUFF II, must be SO2, SO4, NOX, HNO3, NO3)	SO2, SO4, NOX, HNO3, NO3
Specie Names (Morrow)	Manner species will be modeled	pm056, pm081, pm112, pm187, pm425, pm800
Specie Names (Moselle)	Manner species will be modeled	pm0005, pm0010, pm015, pm020, pm025, pm100

Table D-2
FLAG, 1998 and VISTAS CALPUFF Recommended Parameter Settings

Variable	Description	Value
Specie Groups	Grouping of species, if any.	NA
NX	Number of east-west grids of input meteorology	116
NY	Number of north-south grids of input meteorology	182
NZ	Number of vertical layers of input meteorology	10
DGRIDKM	Meteorology grid spacing (km)	4
ZFACE	Vertical cell face heights of input meteorology	0.,20.,40.,80.,160.,320.,6401 200.,2000.,3000.,4000
XORIGKM	Southwest corner (east-west) of input meteorology	478.004
YORIGIM	Southwest corner (north-south) of input meteorology	-1177.998
IUTMZN	UTM zone	NA
XLAT	Latitude of center of meteorology domain	40
XLONG	Longitude of center of meteorology domain	97
XTZ	Base time zone of input meteorology	5
IBCOMP	Southwest X-index of computational domain	2
JBCOMP	Southwest Y-index of computational domain	2
IECOMP	Northeast X-index of computational domain	115
JECOMP	Northeast Y-index of computational domain	181
LSAMP	Use gridded receptors? (T = Yes)	F
IBSAMP	Southwest X-index of receptor grid	1
JBSAMP	Southwest Y-index of receptor grid	1
IESAMP	Northeast X-index of receptor grid	1
JESAMP	Northeast Y-index of receptor grid	1
MESHDN	Gridded recpetor spacing = DGRIDKM/MESHDN	1
ICON	Output concentrations? (1 = Yes)	1
IDRY	Output dry deposition flux? (1 = Yes)	1
IWET	Output west deposition flux? (1 = Yes)	1
IVIS	Output RH for visibility calculations (1 = Yes)	1
LCOMPRS	Use compression option in output? (T = Yes)	T
ICPRT	Print concentrations? (0 = No)	0
IDPRT	Print dry deposition fluxes (0 = No)	0
IWPRT	Print wet deposition fluxes (0 = No)	0
ICFRQ	Concentration print interval (1 = hourly)	1
IDFRQ	Dry deposition flux print interval (1 = hourly)	1
IWFRQ	West deposition flux print interval (1 = hourly)	1
IPRTU	Print output units (1 = g/m**3; g/m**2/s)	1
IMESG	Status messages to screen? (1 = Yes)	1
Output Species	Where to output various species	See Calpuff.inp
LDEBUG	Turn on debug tracking? (F = No)	F
Dry Gas Dep	Chemical parameters of gaseous deposition species	See Calpuff.inp
Dry Part. Dep	Chemical parameters of particulate deposition species	SeeCalpuff.inp
RCUTR	Reference cuticle resistance (s/cm)	30.
RGR	Reference ground resistance (s/cm)	10.
REACTR	Reference reactivity	8
NINT	Number of particle-size intervals	9
IVEG	Vegetative state (1 = active and unstressed)	1
Wet Dep	Wet deposition parameters	See Calpuff.inp
MOZ	Ozone background? (1 = read from ozone.dat)	1
BCKO3	Ozone default (ppb) (Use only for missing data)	80

Table D-2

FLAG, 1998 and VISTAS CALPUFF Recommended Parameter Settings

Variable	Description	Value
BCKNH3	Ammonia background (ppb)	0.5
RNITE1	Nighttime SO2 loss rate (%/hr)	0.2
RNITE2	Nighttime NOx loss rate (%/hr)	2
RNITE3	Nighttime HNO3 loss rate (%/hr)	2
SYTDEP	Horizontal size (m) to switch to time dependence	550.
MHFTSE	Use Heffter for vertical dispersion? (0 = No)	0
JSUP	PG Stability class above mixed layer	5
CONK1	Stable dispersion constant (Eq 2.7-3)	0.01
CONK2	Neutral dispersion constant (Eq 2.7-4)	0.1
TBD	Transition for downwash algorithms (0.5 = ISC)	0.5
IURB1	Beginning urban landuse type	10
IURB2	Ending urban landuse type	19
Use Following Only For Single-Point Meteorological Input (CALPUFF Screen)		
ILANDUIN	Land use type (20 = Unirrigated agricultural land)	20
ZOIN	Roughness length (m)	0.25
XLAIIN	Leaf area index	3
ELEVIN	Met. Station elevation (m above MSL)	0
XLATIN	Met. Station North latitude (degrees)	NA
XLONIN	Met. Station West longitude (degrees)	NA
ANEMHT	Anemometer height of ISC meteorological data (m)	10.0
ISIGMAV	Lateral turbulence (Not used with ISC meteorology)	1
IMIXCTDM	Mixing heights (Not used with ISC meteorology)	0
End of Single Point Meteorology Input Variables		
XMXLEN	Maximum slug length in units of DGRIDKM	1
XSAMLEN	Maximum puff travel distance per sampling step (units of DGRIDKM)	1
MXNEW	Maximum number of puffs per hour	99
MXSAM	Maximum sampling steps per hour	99
SL2PF	Maximum Sy/puff length	10
PLX0	Wind speed power-law exponents	7,0.07,0.10,0. 15,0.35,0.55
WSCAT	Upper bounds 1st 5 wind speed classes (m/s)	1.54,3.09,5.14,8. 23.10.8
PGGO	Potential temperature gradients PG E and F (deg/km)	0.020, 0.035
SYMIN	Minimum lateral dispersion of new puff (m)	1.0
SZMIN	Minimum vertical dispersion of new puff (m)	1.0
SVMIN	Array of minimum lateral turbulence (m/s)	6*0.50
SWMIN	Array of minimum vertical turbulence (m/s)	.12, 0.08, 0.06, 0.03, 0.016
CDIV	Divergence criterion for dw/dz (1/s)	0.01
WSCALM	Minimum non-calm wind speed (m/s)	0.5
XMAXZI	Maximum mixing height (m)	3000
XMINZI	Minimum mixing height (m)	50
PPC	Plume path coefficients (only if MCTADJ = 3)	0.5,0.5,0.5,0.5,0. 35,0.35
NSPLIT	Number of puffs when puffs split	3
IRESPLIT	Hours when puff are eligible to split	17
ZISPLIT	Previous hour's mixing height (minimum), (m)	100
ROLDMAX	Previous Max mixing height/current mixing height ratio, must be less the	0.25
EPSSLUG	Convergence criterion for slug sampling integration	1.0E-04
PESAREA	Convergence criterion for area source integration	1.0E-06
NPT1	Number of point sources	See Calpuff.inp
IPTU	Units of emission rates (1 = g/s)	1
NSPT1	Number of point source-species combinations	0
NPT2	Number of point sources with fully variable emission rates	0
Point Sources	Point sources characteristics	See Calpuff.inp
Area Sources	Area sources characteristics	NA
Line Sources	Buoyant lines source characteristics	NA

Table D-2

FLAG, 1998 and VISTAS CALPUFF Recommended Parameter Settings

Variable	Description	Value
Volume Sour	Volume sources characteristics	NA
NREC	Number of user defined receptors	See Calpuff.inp
Receptor Dat	Location and elevation (MSL) of receptors	See Calpuff.inp

=SMEPA Site Data

Bold =VISTAS recommended settings

APPENDIX E
PARTICULATE MATTER SPECIATION TABLES

Table E-1

Particulate Matter Speciation for Natural Gas

Consensus Gas-fired Turbine Example (Also applicable for natural gas-fired boiler)

Example of Consensus Approach where H_2SO_4 emissions are not provided by applicant

Applicant's estimates are in BOLD.

	Heat Input	Filterable PM (25% Estimate)		Condensible PM (75% Estimate)		Total PM (Applicant)		SO2 (Applicant)		
Turbine	(mmBtu/hr)	(lb/mmBtu)	(lb/hr)	(lb/mmBtu)	(lb/hr)	(lb/mmBtu)	(lb/hr)	(gr/100scf)		(lb/hr)
Boiler	**869**	0.00	1.63	0.01	4.89	0.01	**6.52**			**0.38**

Particle Size	% of Total	Filterable Emiss Rate (lb/hr)	Condensible Emiss Rate (lb/hr)
PM0005	15.00%	0.24	0.73
PM0010	25.00%	0.41	1.22
PM0015	23.00%	0.37	1.12
PM0020	15.00%	0.24	0.73
PM0025	11.00%	0.18	0.54
PM100	11.00%	0.18	0.54

SO4
(lb/hr)
0.19

Organic Carbon
(lb/hr)
4.70

SO2 (Applicant-33%)
(lb/hr)
0.25

Impact of Consensus Combined Cycle Turbine Example on Extinction

Type	Name	Extinction Coef.	f(RH)*	Efficiency	Emissions (lb/hr)	Total Relative bext 1/Mm
Filterable	EC	10		10	1.63	16.29
Inorganic CPM	SOIL	1		1		0.00
Inorganic CPM	SO4	3	2	6	0.19	1.13
Organic CPM	SOA	4		4	4.70	18.80
						36.22

* f(RH) will vary

comparison from AP-42

	Heat Input	Filterable PM (AP-42)		Condensible PM (AP-42)		Total PM (AP-42)		SO2 (AP-42)		
Turbine	(mmBtu/hr)	(lb/mmBtu)	(lb/hr)	(lb/mmBtu)	(lb/hr)	(lb/mmBtu)	(lb/hr)	(lb/mmBtu)	%S	(lb/hr)
Boiler	869	0.0019	1.65	0.0056	4.87	0.0075	6.52	0.94	0.004	2.95

From: http://www.nature.nps.gov/air/permits/ect/ectGasFiredCT.cfm (Accessed 7/31/11)

Table E-2
Particulate Matter Speciation for Combustion of Coal

	total	filterable	condensable		condensable split: H_2SO_4	condensable split: condensable - H_2SO_4
%		41%	59%		12%	88%
(lb/hr)	**321.000**	131.61	189.39		22.47	166.92

				FILTERABLE		fine filterable			CONDENSABLE			
		Diameter	%	filterable	coarse filterable inorganic	inorganic (96.3% of fine filterable)	elemental carbon (3.7% of fine filterable)		H_2SO_4	organic condensable	inorganic condensable	Diameter
		(µm)	%	(lb/hr)	(lb/hr)	(lb/hr)	(lb/hr)		(lb/hr)	(lb/hr)	(lb/hr)	(µm)
coarse (42.4%)	PM800	6.00 - 10.00	16.3%	21.45	**21.4524**							6.00 - 10.00
	PM425	2.50-6.00	26.1%	34.35	**34.3502**							2.50-6.00
fine (57.6%)	PM187	1.25-2.50	23.9%	31.45		**30.2910**	**1.1638**					1.25-2.50
	PM112	1.00-1.25	6.5%	8.55		**8.2381**	**0.3165**					1.00-1.25
	PM081	0.625-1.00	12.0%	15.79		**15.2089**	**0.5843**			**83.4600**		0.625-1.00
	PM056	0.50-0.625	15.2%	20.00		**19.2645**	**0.7402**			**83.4600**		0.50-0.625
total			100%	131.61	**55.80**	**73.00**	**2.80**		**22.47**	**166.92**		
					PMC	**SOIL**	**EC**		**H_2SO_4**	**SOA**	**SOIL**	
Ext. coefficient					0.6	1	10		3*f(RH)	4	1	

APPENDIX F

CD WITH CALPUFF, POSTUTIL AND CALPOST FILES

Analysis of Best Available Retrofit Technology Screening Modeling

R.D. Morrow and Moselle Plants

South Mississippi Electric Power Association

October 2011

Burns & McDonnell
SINCE 1898

Analysis of Best Available Retrofit Technology Screening Modeling

R.D. Morrow and Moselle Plants

prepared for

South Mississippi Electric Power Association

October 2011

Project 62680

prepared by

Burns & McDonnell Engineering Company, Inc.
Kansas City, Missouri

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1.0 INTRODUCTION

1.1 BACKGROUND

The Mississippi Department of Environmental Quality (MDEQ) has informed the South Mississippi Electric Power Association (SMEPA) that their R.D. Morrow and Moselle Plants may be subject to a Best Available Retrofit Technology (BART) determination.[1] The Regional Haze Rule (40 CFR 51) requires reduction of visibility-disrupting pollutants from major stationary sources that impact Class I Areas. A Class I Area is a national park, wilderness area, or other scenic area that is afforded additional air quality protection. Regional planning organizations (RPO) work with a state to develop a plan to improve the visibility at the Class I Areas located in that state. VISTAS[2] is the RPO that includes Mississippi.

1.2 OBJECTIVES

The Regional Haze Rule requires BART for any BART-eligible source that "emits any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility" in any mandatory Class I federal area. Pursuant to federal regulations, states have the option of exempting a BART-eligible source from the BART requirements based on dispersion modeling that demonstrate the source cannot reasonably be anticipated to cause or contribute to visibility impairment in a Class I area.

The visibility analysis was performed consistent with the VISTAS RPO modeling guideline: *Protocol for the Application of the CALPUFF Model for Analyses of Best Available Retrofit Technology (BART)* (Revised, 2006), (VISTAS Protocol), and only focused on the SMEPA sources identified by the MDEQ as being BART-eligible.

The purpose of this modeling report is not to establish CALPUFF as the appropriate modeling system for visibility analyses, nor is it to be a complete discussion of the theory or applicability of the CALPUFF modeling system to visibility modeling. A more detailed discussion of the CALPUFF modeling system is found in *A User's Guide for the CALPUFF Dispersion Model*, and in *A User's Guide for the CALMET Meteorological Model*.

[1] Letter to Mr. Joey Ward of SMEPA from Mr. Elliot Bickerstaff of the MDEQ, June 3, 2011.
[2] VISTAS: Visibility Improvement State and Tribal Association of the Southeast.

1.3 LOCATION OF SOURCES VERSUS RELEVANT CLASS I AREAS

1.3.1 Moselle Plant

The Moselle Plant is a 344-megawatt (MW) gas-fired electric generating facility located 2.5 miles northwest of Moselle, Mississippi, in Jones County (see Figure 1-1).

1.3.2 R.D. Morrow Plant

The R.D. Morrow Plant is a 400-MWcoal-fired electrical generating facility located in Purvis, Mississippi, in Lamar County (see Figure 1-1).

1.3.3 Class I Areas

The two closest Class I Areas to the Moselle and R.D. Morrow Plants are the Breton Wilderness Area in Louisiana and Sipsey Wilderness Area in Alabama (Figure 1-1). The approximate distance from each plant to each Class I Area is summarized in Table 1-1.

Table 1-1
Proximity of SMEPA Plants to Nearby Class I Areas (kilometers)

Plant Name	Breton Wilderness Area	Sipsey Wilderness Area
Moselle	170 kilometers	344 kilometers
R.D. Morrow	139 kilometers	380 kilometers

Because the Sipsey Wilderness Area is more than 300 kilometers (km) from either SMEPA plant, it will not be involved in this BART analysis.

1.4 SMEPA SOURCE IMPACT EVALUATION CRITERIA

As part of VISTAS' strategy to improve visibility at Class I Areas, the BART determination is used to identify those sources that are "BART-eligible," and those sources that are "subject to BART." A BART-eligible source is one that satisfies all of the following requirements.[3]

1. Has the potential to emit 250 tons per year or more of a visibility-impairing pollutant.

2. Constructed between August 7, 1962, and August 7, 1977.

[3] Federal Register, Vol. 70, No. 128, pg. 39105.

3. One or more of the listed source categories.

Only the Moselle Boiler AA-003 and R.D. Morrow Boilers AA-001 and AA-002 satisfy all the BART - eligible source criteria. The other two boilers (AA-001 and AA-002) at the Moselle Plant have been permanently replaced by heat recovery steam generators as part of a repowering project and are not subject to a BART analysis.

A source subject to BART is reasonably anticipated to either cause or contribute to visibility impairment.[4] "Causing" visibility impairment means a 1.0 deciview (dV) change in light extinction. "Contributing" to visibility impairment means a 0.5 dV change in light extinction. A dV is *a small but perceptible change in haziness under most circumstances.*[5]

Because visibility impairment is so heavily dependent on weather conditions, and individual weather varies by the day, the U.S. Environmental Protection Agency (EPA) allows the 98th percentile value to be used to determine whether a source causes or contributes to visibility impairment. On an annual basis, the 98th percentile is the 8th highest 24-hour modeled impact (2 percent of 365 days is about 8 days). Alternatively, the 22nd highest 24-hour modeled impact may be used for a three-year period.

[4] Ibid.

[5] L. Willard Richards, *Use of the Deciview Haze Index as an Indicator for Regional Haze.* Journal of the Air and Waste Management Association. October, 1999.

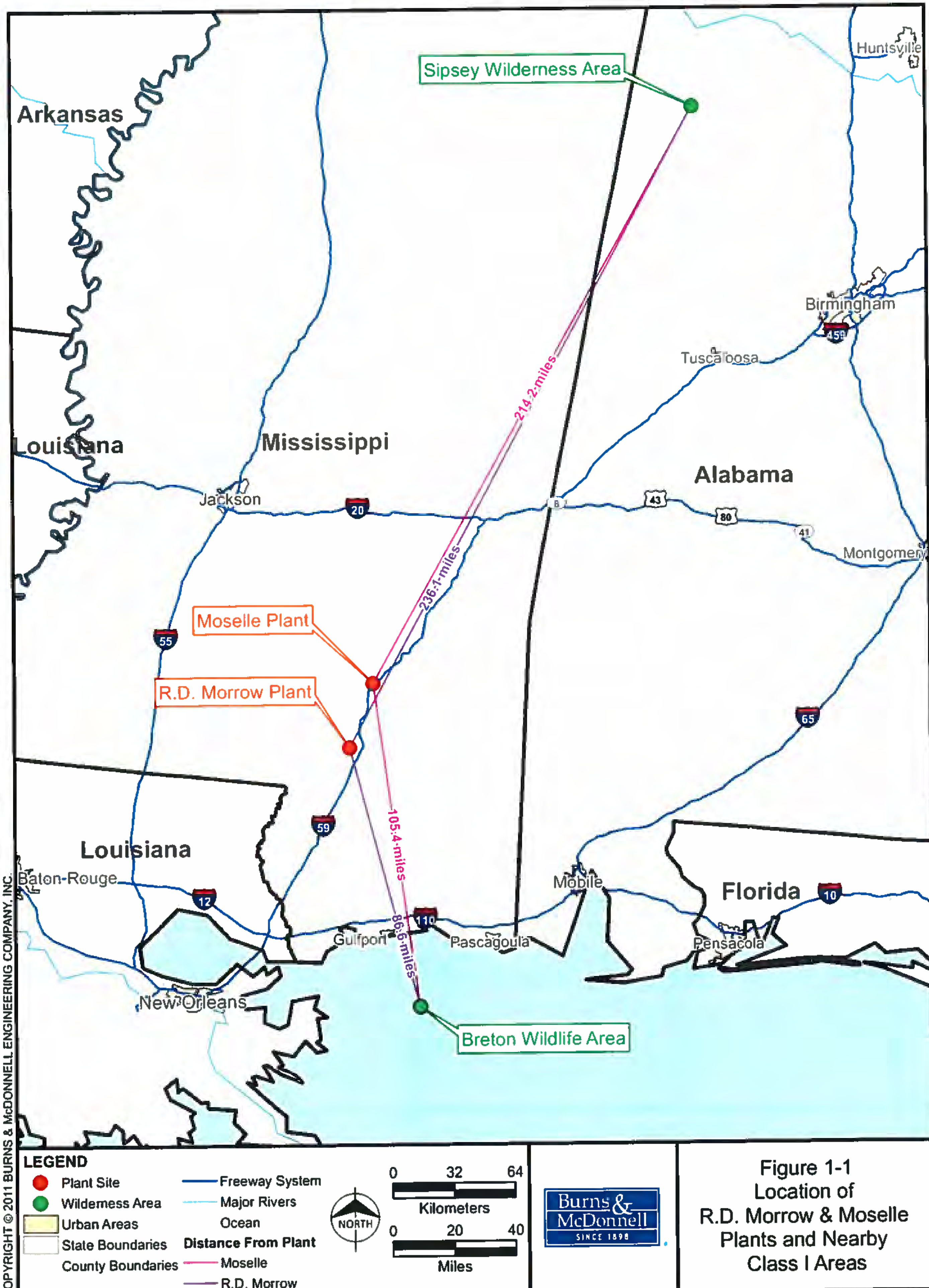


Figure 1-1
Location of
R.D. Morrow & Moselle
Plants and Nearby
Class I Areas

Source: ESRI and Burns & McDonnell

Issued 8/1/2011

Path: \\ESPSRV\Data\Data2\Projects\SMEPA\62680\GIS\DataFiles\ArcDocs\Fig1-1_SMEPA_Wilderness_Sites_Distance_Portrait.mxd rfraser 8/1/2011

2.0 SOURCE DESCRIPTION

2.1 MOSELLE PLANT

2.1.1 Emission Source Description

The air emission source description for the Moselle Plant is summarized in Table 2-1. A detailed breakdown of the particulate matter speciation is found in Table A-1 and A-2 in Appendix A.

Table 2-1
Moselle Plant Maximum Actual Air Emissions and Source Descriptions

Unit I.D	Equip. Type	Heat Input (MMBtu/hr)	Fuel	Start-Up Date	SO_2 Emiss (g/s)	NO_x Emiss (g/s)	PM Emiss (g/s)	H_2SO_4 Emiss (g/s)
AA-003	Boiler	868.6	Nat. Gas/#2 Fuel Oil[1]	1970	0.03	30.90	0.82	0.02

MMBtu/hr= Million British Thermal Units per hour
g/s= Grams per second
[1]The boiler combusts both natural gas and #2 fuel oil as back-up; this analysis is based on 100 percent combustion of natural gas

Only the emissions from those sources that meet the BART source impact criteria (Section 1.4) were included in the BART visibility analysis. Except for the eligible boiler, all other sources do not meet the BART criteria. The natural gas emissions listed in Table 2-1 for the Moselle Plant were used in the visibility analysis since the maximum hourly emission rates occurred during combustion of natural gas.

The VISTAS Protocol recommends using the actual maximum 24-hour emission rate for sulfur dioxide (SO_2), nitrogen oxides (NO_X), particulate matter (PM), and sulfuric acid (H_2SO_4). The emissions of SO_2 and NO_x were taken from EPA's Clean Air Market Division's Part 75 (Acid Rain) Prepackaged Data Sheets website. The emissions of PM were calculated from AP-42, and H_2SO_4 emissions were calculated from AP-42 and the National Park Service website.[6]

2.1.2 Emission Source Parameters

The Moselle Plant stack parameters for the BART-eligible source are summarized in Table 2-2.

[6] www.nature.nps.gov/air/permits/ect/ectGasFiredCT.cfm (Accessed 7/31/11).

Table 2-2
Moselle Plant Stack Parameters for BART-Eligible Source

Unit I.D	Stack Height (m)	Stack Diameter (m)	Stack Temperature (K)	Exhaust Velocity (m/s)[1]	Elevation (m)
AA-003	30.8	2.7	413.7	21.5	63.7

m=Meters
K=degrees Kelvin
m/s= meters per second
[1]Flow rates were taken from Relative Accuracy Test Audits because no actual exhaust flow data was measured from 2001-2003.

2.2 R.D. MORROW PLANT

2.2.1 Emission Source Description

The air emission source descriptions are summarized in Table 2-3. A detailed breakdown of the particulate matter speciation is found in Table A-1 and A-2 in Appendix A.

Table 2-3
R.D. Morrow Plant Maximum Actual Air Emissions and Source Descriptions[7]

Unit I.D	Equip. Type	Heat Input (MMBtu/hr)	Fuel	Start-Up Date	SO_2 Emiss. (g/s)	NO_x Emiss (g/s)	PM Emiss. (g/s)	H_2SO_4 (g/s)[2]
AA-001	Boiler	2,675	Coal, Fuel Oil	1978[1]	279.14	163.56	40.45	2.83
AA-002	Boiler	2,675	Coal, Fuel Oil	1978[1]	314.08	167.45	40.45	2.83

MMBtu/hr= Million British Thermal Units per hour
g/s= Grams per second
[1]The R.D. Morrow Plant's Boiler AA-001 and AA-002 were constructed in 1978, but initial design contracting began before August 7, 1977.
[2]From AP-42 Table 1.1-, 3 SO_3 as a surrogate for sulfates: $SO_3 \approx 0.7\%$ of SO_2, probable overestimate.

Like the emission sources at the Moselle Plant, only the emissions from those sources that meet the BART source impact criteria (Section 1.4) were included in the BART visibility analysis. Except for the eligible boilers, all other sources do not meet the BART criteria.

The SO_2 and NO_X emission rates are the maximum 24-hour averaged rates taken from the EPA's Clean Air Market Division's Part 75 (Acid Rain) Prepackaged Data Sheets website. Emission rates of PM and H_2SO_4 were permit limits or calculated from AP-42.

[7] State of Mississippi Air Pollution Control Title V Permit, June 22, 2011.

2.2.2 Emission Source Parameters

The R.D. Morrow Plant stack parameters for the BART-eligible sources are summarized in Table 2-4. A diagram showing the location of stacks AA-001 and AA-002 is in Appendix B. The Good Engineering Practice (GEP) stack height downwash file is on the attached CD.

Table 2-4
R.D. Morrow Plant Emission Stack Parameters for BART-Eligible Sources

Unit I.D	Stack Height (m)	Stack Diameter (m)	Stack Temperature (K)	Exhaust Velocity (m/s)	Elevation (m)
AA-001	123.5	5.1	355.4	16.86	77.5
AA-002	123.5	5.1	355.4	15.61	77.5

MMBtu/hr= Million British Thermal Units per hour
m=Meters
K=degrees Kelvin
m/s= meters per second

2.2.3 BART Modeling Files

The BART modeling files are on the accompanying CD. The CALMET files are on the accompanying external hard drive.

3.0 REVISIONS TO MODELING PROTOCOL

Subsequent discussions with the MDEQ about the BART visibility modeling required a different modeling approach. This section describes the changes to the modeling methodology compared to the CALPUFF Modeling Protocol, dated August, 2011.

3.1 RESPONSE TO EPA COMMENTS ON MODELING PROTOCOL

The EPA Region IV air dispersion modeling team provided comments on the SMEPA BART modeling protocol on September 13, 2011. The EPA offered the option of revising the BART Modeling Protocol, or including the modeling changes in the modeling report. SMEPA has opted to include a response to the EPA comments in this modeling report. The EPA comments are listed below, with the SMEPA response to the comments in bolded text.

1. GEP Stack Heights: It is unclear if the stack heights presented in the protocol for the R. D. Morrow Plant represent the good engineering practice (GEP) stack height. Modeling for regulatory purposes using GEP stack heights is required under 6.2.2 of 40 CFR Part 51, Appendix W: Guideline on Air Quality Models. This documentation should be included in the BART exemption modeling reports if a revision to the modeling protocol is not developed. **A building downwash analysis was performed on the R.D. Morrow Plant to show that the stack heights used for the BART screening modeling met GEP stack height requirements. The location of stacks AA-001 and AA-002 in relation to the major structures at the R.D. Morrow Plant are shown in Figure B-1 in Appendix B. The EPA-approved BPIP-PRIME downwash program was run and showed that the GEP stack height was 144.02 meters (m) for both stacks AA-001 and AA-002 and the modeled stack heights were 123.90 m, which satisfies the GEP requirement of 40 CFR Part 51 Appendix W Guideline on Air Quality Models. The BPIP-PRIME downwash file is located on the attached CD.**

2. Documentation: The BART exemption modeling protocol did specify input choices for CALMET and CALPUFF. We recommend that input choices for the simulation of POSTUTIL and CALPOST are also documented. A rationale for why a non-regulatory default was chosen and whether an area is rural or urban should be included in a revised modeling protocol or in the modeling report that documents the BART modeling. **The input choices used for the POSTUTIL and CALPOST modules are listed in Tables C-1 and C-2 in Appendix C. Included in the input choice discussion is the reason for the selection of a non-default option. Rural and urban settings were set within the CALMET files provided by the MDEQ.**

3. It is unclear when boiler AA-001 at the Moselle Plant was retired and if this action was permanent and enforceable (e.g., permits revoked and/or permanently dismantled). We request documentation to show that the action is permanent and enforceable to clarify why the boiler should not be included in the BART exemption modeling. **Boiler AA-001 has been permanently converted to a heat recovery steam generator (HRSG) as**

required in Mississippi Department of Environmental Quality (MDEQ) permit number 1360-00035, dated August 17, 2010. There will be no emissions associated with the operation of Boiler AA-001.

4. Boiler AA-002 at the Moselle Plant is a best available retrofit technology (BART) eligible emission unit. It was not proposed for inclusion in the modeling because it is to be retired April 2012. Unless the boiler is officially scheduled to be retired in a manner that is permanent and enforceable, it is eligible for the exemption modeling. If the modeling indicates that a BART control determination is required, then the retiring of the AA-002 boiler could be discussed as the control for that boiler. **Boiler AA-002 has been permanently converted to a HRSG as required in Mississippi Department of Environmental Quality (MDEQ) permit number 1360-00035, dated August 17, 2010. There will be no emissions associated with the operation of Boiler AA-002.**

5. The protocol provides version number of the models (CALMET, CALPUFF, POSTUTIL and CALPOST) that are inconsistent with EPA's current model versions of the regulatory models. EPA Region 4 recommends that the current regulatory versions of CALPUFF and CALMET available on EPA's SCRAM website (http://www.epa.gov/ttn/scram/dispersion_prefrec.htm#calpuff) be used to perform the modeling. The current regulatory versions are: CALPUFF version 5.8, level 070623 and CALMET version 5.8, level 070623. **The following versions of the CALPUFF model were used:**
    - **CALPUFF version 5.8 level 070623**
    - **CALMET version 5.8 level 070623**
    - **CALPOST version 6.221 level 082724**
    - **POSTUTIL version 1.56 level 070627**

6. The U.S. Fish and Wildlife Service (USFWS) has reprocessed the original VISTAS 4-km CALMET dataset using CALMET v5.8, level 070623. EPA Region 4 recommends that this reprocessed CALMET dataset be used. It is unclear if this dataset is being used in the modeling. **The CALMET data used was created by version 5.8 level 070623.**

7. Metric units are required and recommended for the modeling report. **The units used in the modeling report will be in metric.**

8. The Heffter time-dependent growth rates and partial plume path adjustment for terrain are not a part of the regulatory default input for CALPUFF. We recommend that only those inputs that are regulatory defaults be used in simulating the CALPUFF modeling system. **The Heffter-time dependent growth rates function was disabled for the SMEPA BART analysis.**

4.0 MODELING RESULTS

4.1 SCREENING MODELING RESULTS

The 8th highest 24-hour modeled impact (measured in delta dV) for each year is summarized in Table 4-1. For the Moselle Plant, the highest delta dV was 0.048, this level will not cause or contribute to visibility impairment. Because the delta dV is below 0.5, the Moselle Plant is not subject to BART.

For the R.D. Morrow Plant, the 8th highest delta dV was 1.09, this level may cause or contribute to visibility impairment. Therefore, the R.D. Morrow Plant is subject to BART.

Table 4-1

Modeling to Determine if BART-Eligible Sources are Subject to BART

SMEPA Plant	Distance from Breton WA (km)	2001 8th Highest High ΔdV	# Days and # Receptors w/Impacts >0.5 ΔdV: 2001		2002 8th Highest High ΔdV	# Days and # Receptors w/Impacts >0.5 ΔdV: 2002		2003 8th Highest High ΔdV	# Days and # Receptors w/Impacts >0.5 ΔdV: 2003		# Days and # Receptors w/Impacts >1.0 ΔdV for 3-Year Period		Max, 24 hr Impact for 2001-03 (ΔdV)
			# Days	# Receptors		# Days	# Receptors		# Days	# Receptors	# Days	# Receptors	
Moselle	170	0.029	0	0	0.034	0	0	0.048	0	0	0	0	0.132
R.D. Morrow	139	0.83	23	587	1.05	30	762	1.09	34	848	24	581	2.552

ΔdV =Delta deciview

5.0 REFERENCES

Burns & McDonnell. *Draft CALPUFF Modeling Protocol for Analysis of Best Available Retrofit Technology: R.D. Morrow and Moselle Plants*, August, 2011. Available on request.

Federal Register, Vol. 70, No. 128, pg. 39105.

National Park Service, U.S. Department of the Interior. Federal Land Managers' *Air Quality Related Values Work Group (FLAG) Phase I Report – Revised 2010*. Natural Resource Report NPS/NRPC/NRR – 2010/232.

Protocol for the Application of the CALPUFF Model for Analyses of Best Available Retrofit Technology (BART) (Revised, 2006), (VISTAS Protocol),

L. Willard Richards, *Use of the Deciview Haze Index as an Indicator for Regional Haze*. Journal of the Air and Waste Management Association. October, 1999.

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

Scire, J.S., F.R. Robe, M.E. Fernau, and R.J. Yamartino. *A User's Guide for the CALMET Meteorological Model (Version 5)*. Earth Tech, Inc., Concord, Massachusetts, 2000b

U.S. Environmental Protection Agency. *Guideline for Determination of Good Engineering Practice Stack Height (Technical Support Document for Stack Height Regulations)*. EPA-450/4-80-023LR. North Carolina: Office of Air Quality Planning and Standards, 1985.

www.nature.nps.gov/air/permits/ect/ectGasFiredCT.cfm (Accessed 7/31/11).

APPENDIX A

DETAILED PARTICULATE MATTER SPECIATION TABLES

Table A-1

Particulate Matter Speciation for Natural Gas Combustion

Consensus Gas-fired Turbine Example (Also applicable for natural gas-fired boiler)

Example of Consensus Approach where H_2SO_4 emissions are not provided by applicant

Applicant's estimates are in **BOLD**.

	Heat Input	Filterable PM (25% Estimate)		Condensible PM (75% Estimate)		Total PM (Applicant)		SO2 (Applicant)		
Turbine	(mmBtu/hr)	(lb/mmBtu)	(lb/hr)	(lb/mmBtu)	(lb/hr)	(lb/mmBtu)	(lb/hr)	(gr/100scf)		(lb/hr)
Boiler	**869**	0.00	1.63	0.01	4.89	0.01	**6.52**			**0.38**

Particle Size	% of Total	Filterable Emiss Rate (lb/hr)	Condensible Emiss Rate (lb/hr)
PM0005	15.00%	0.24	0.73
PM0010	25.00%	0.41	1.22
PM0015	23.00%	0.37	1.12
PM0020	15.00%	0.24	0.73
PM0025	11.00%	0.18	0.54
PM100	11.00%	0.18	0.54

SO4
(lb/hr)
0.19

Organic Carbon
(lb/hr)
4.70

SO2 (Applicant-33%)
(lb/hr)
0.25

Impact of Consensus Combined Cycle Turbine Example on Extinction

Type	Name	Extinction Coef.	f(RH)*	Efficiency	Emissions (lb/hr)	Total Relative bext 1/Mm
Filterable	EC	10		10	1.63	16.29
Inorganic CPM	SOIL	1		1		0.00
Inorganic CPM	SO4	3	2	6	0.19	1.13
Organic CPM	SOA	4		4	4.70	18.80
						36.22

* f(RH) will vary

comparison from AP-42

	Heat Input	Filterable PM (AP-42)		Condensible PM (AP-42)		Total PM (AP-42)		SO2 (AP-42)		
Turbine	(mmBtu/hr)	(lb/mmBtu)	(lb/hr)	(lb/mmBtu)	(lb/hr)	(lb/mmBtu)	(lb/hr)	(lb/mmBtu)	%S	(lb/hr)
Boiler	869	0.0019	1.65	0.0056	4.87	0.0075	6.52	0.94	0.004	2.95

From: http://www.nature.nps.gov/air/permits/ect/ectGasFiredCT.cfm (Accessed 7/31/11)

Table A-2

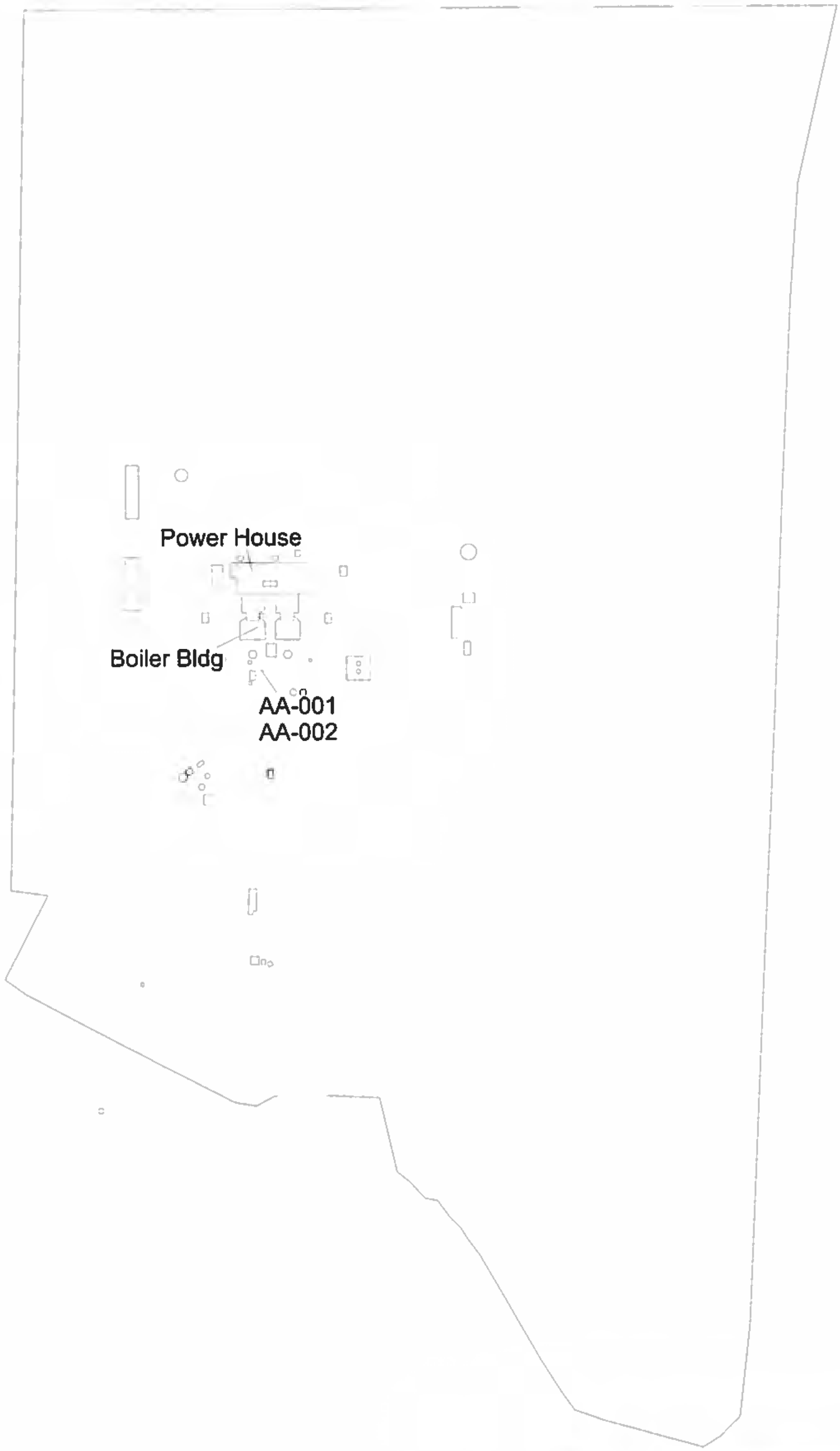
Particulate Matter Speciation for Combustion of Coal

	total	filterable	condensable		condensable split H_2SO_4	condensable - H_2SO_4
%		41%	59%		12%	88%
(lb/hr)	**321.000**	131.61	189.39		22.47	166.92

		FILTERABLE				fine filterable			CONDENSABLE			
		Diameter		filterable	coarse filterable inorganic	inorganic (96.3% of fine filterable)	elemental carbon (3.7% of fine filterable)		H_2SO_4	organic condensable	inorganic condensable	Diameter
		(µm)	%	(lb/hr)	(lb/hr)	(lb/hr)	(lb/hr)		(lb/hr)	(lb/hr)	(lb/hr)	(µm)
coarse (42.4%)	PM800	6.00 - 10.00	16.3%	21.45	**21.4524**							6.00 - 10.00
	PM425	2.50-6.00	26.1%	34.35	**34.3502**							2.50-6.00
fine (57.6%)	PM187	1.25-2.50	23.9%	31.45		**30.2910**	**1.1638**					1.25-2.50
	PM112	1.00-1.25	6.5%	8.55		**8.2381**	**0.3165**					1.00-1.25
	PM081	0.625-1.00	12.0%	15.79		**15.2089**	**0.5843**			**83.4600**		0.625-1.00
	PM056	0.50-0.625	15.2%	20.00		**19.2645**	**0.7402**			**83.4600**		0.50-0.625
total			100%	131.61	**55.80**	**73.00**	**2.80**		**22.47**	**166.92**		
					PMC	**SOIL**	**EC**		**H_2SO_4**	**SOA**	**SOIL**	
Ext. coefficient					0.6	1	10		3*f(RH)	4	1	

APPENDIX B

BOILER STACK GEP ANALYSIS



Burns & McDonnell
SINCE 1898

Figure B-1
R.D. Morrow Plant Layout
For GEP Analysis

APPENDIX C

CALPOST AND POSTUTIL INPUT CHOICES

Table C-1
POSTUTIL Version 5.8 Parameter Settings

Variable	Description	Value	Reason Values Differ From Default Settings
UTLLIST	Filename for general output from POSTUTIL	See POSTUTIL.inp	All Defaults Settings Used
UTLDAT	POSTUTIL input data filename	See POSTUTIL.inp	
BCKGALM	Background ammonia data	NA	
NFILES	Number of CALPUFF input files used	See POSTUTIL.inp	
METFM	Meterological data files for HNO#/NO3 partitioning	0	
NMET	Number of meteorological data file tim periods.	0	
LCFILES	Convert to lower case	T	
UTLMET	CALMET data file name	NA	
MET1D	1-D dat files	NA	
M2DRHU	Relative humidity data file	NA	
M2DTMP	Temperature data file	NA	
M2DRHO	Rho data file	NA	
MODDAT	CALPUFF data file name	See POSTUTIL.inp	
IBYR	Beginning year	See POSTUTIL.inp	
IBMO	Beginning month	See POSTUTIL.inp	
IBDY	Beginning day	See POSTUTIL.inp	
IBHR	Beginning hour	See POSTUTIL.inp	
NPER	Number of periods to process	See POSTUTIL.inp	
NSPECINP	Number of species to proces from CALPUFF runs	11	
NSPECOUT	Number of species to write to output file	9	
NSPECCMP	Number of species to compute	4	
MDUPLCT	Stop run if duplicate species name	0	
NSCALED	Number of CALPUFF data files to be scaled	0	
MNITRATE	Nitrogen partitioning?	0	
NH3TYP	Input source for ammonia	0	
BCKNH3	Backgorund ammonia	-999	
BCKTNH3	Background total ammonia	-999	
ASPECI	Species processed	See POSTUTIL.inp	
ASPECO	species written	See POSTUTIL.inp	
CSPECCMP	Species computed	EC	
CSPECCMP	Species computed	SOIL	
CSPECCMP	Species computed	SOA	
CSPECCMP	Species computed	PMC	

(yellow) =SMEPA Site Data
Bold =VISTAS recommended settings

Table C-2

CALPOST Version 6.221 Parameter Settings

Variable	Description	Value	Reason Values Differ From Default Settings
MODDAT	Conc/Dep Flux file name	See CALPOST.inp	
VISDAT	Relative humidity file	NA	
BACKDAT	Background data file	NA	
VSRDAT	Transmissometer file	NA	
MET1DAT	Single point met file	NA	
PSTLST	CALPOST list file name	See CALPOST.inp	
TSPATH	Time series file name	NA	
TSUNAME	Plot file path name	NA	
VUNAM	Visibility plot	V	
DVISDAT	Visibility change	NA	
LCFILES	Convert to lower case	T	
METRUN	Option to run all periods in met files	1	Uses met file time periods
ISYR	Starting date: year	NA	
ISMO	Starting date: month	NA	
ISDY	Starting date: day	NA	
ISHR	Starting time: hour	NA	
ISMIN	Starting time: minute	NA	
ISSEC	Starting time: second	NA	
IEYR	Ending date: year	NA	
IEMO	Ending date: month	NA	
IEDY	Ending date: day	NA	
IEHR	Ending time: hour	NA	
IEMIN	Ending time: minute	NA	
IESEC	Ending time: second	NA	
BTZONE	Base time zone	5	
NREP	Process every period?	1	
ASPEC	Process visibility	VISB	
ILAYEr	Layer/deposition code	1	
A	Scaling factors	0.0	
B	Scaling factors	0.0	
LBACK	Add hourly background concentration/fluexes?	F	
NO2CALC	Source of NO2	1	
RNO2NOX	Single NO2/NOx ratio	1.0	
CNOX	Table of NO2/NOx ratios	1.0,2.0,3.0,4.0,5.0,6.0,7.0,8.0,9.0,10.0,11.0,12.0,13.0,14.0	
TNO2NOX	No2/NOx ratio for each NOx concentration	1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0,	
MSOURCE	Process source contribution	0	
MCALMPRO	Calm wind processing	0	
MET1FMT	Format of single point met file	1	
LG	Gridded receptors processed?	F	
LD	Discrete receptors processed?	T	Only needed discrete
LCT	CTSG complex terrain receptors processed?	F	
LDRING	Discrete receptor ring?	F	
NDRECEP	Flag for all receptors after the last one assigned is set to 0	-1	
IBGRID	Select range of gridded receptors; X index of LL corner	-1	
JBGRID	Select range of gridded receptors; Y index of LL corner	-1	
IEGRID	Select range of gridded receptors; X index of UR corner	-1	
JEGRID	Select range of gridded receptors; Y index of UR corner	-1	
NGONOFF	Number of gridded recpetor rows	0	
NGXRECEP	Specific gridded receptors excluded from CALPOST processing	1	
MVISCHECK	Test visibility option	1	
AREANAME	Name of Class I area	USER	
MFRH	Particle growth curve	4	
RHMAX	Maximum relative humidity used in particle growth curve	98	

Table C-2

CALPOST Version 6.221 Parameter Settings

Variable	Description	Value	Reason Values Differ From Default Settings
LVSO4	Modeled species to include SULFATE?	T	
LVNO3	Modeled species to include NITRATE?	T	
LVOC	Modeled species to include ORGANIC CARBON?	T	
LVPMC	Modeled species to include COARSE PARTICLES?	T	
LVPMF	Modeled species to include FINE PARTICLES? (Moselle)	F	
LVPMF	Modeled species to include FINE PARTICLES? (Morrow)	T	
LVEC	Modeled species to include ELEMENTAL CARBON?	T	
LVNO2	Modeled species to include NO2 absorption?	T	
LVBAK	Include background	T	
SPECPMC	Coarse particules	PMC	
SPECPMF	Fine particles (Moselle)	SOA	Fines are all considered SOA
SPECPMF	Fine particles (Morrow)	SOIL	
EEPMC	Extinction efficiency PM coarse	0.6	
EEPMF	Extinction efficiency PM fine	1.0	
EEPMCBK	Extinction efficiency background coarse	0.6	
EESO4	Extinction efficiency ammonium sulfate	3.0	
EENO3	Extinction efficiency ammonium nitrate	3.0	
EEOC	Extinction efficiency organic carbon	4.0	
EESOIL	Extinction efficiency soil	1.0	
EEEC	Extinction efficiency elemental carbon	10	
EENO2	Extinction efficiency NO2 gas	0.17	
MVISBK	Method used for background light extinction	8.0	
BEXBK	Background light extinction	NA	
RHFRAC	Percentage of particles affected by relative humidity	NA	
RHFAC	Extinction coefficients for hygroscopic species	3.5, 3.3, 3.3, 3.3, 3.4, 3.6, 3.8, 3.8, 3.6, 3.4, 3.4, 3.5	
IDWSTA	Identification of weather stations as part of VSRN.DAT file	NA	
TZONE	Time zone	NA	
BKSO4		0.23, 0.23, 0.23, 0.23,0.23, 0.23, 0.23, 0.23,0.23, 0.23, 0.23, 0.23,	
BKNO3		0.1, 0.1, 0.1, 0.1,0.1, 0.1, 0.1, 0.1,0.1, 0.1, 0.1, 0.1,	
BKPMC		3.01, 3.01, 3.01, 3.01 3.01, 3.1, 3.01, 3.01, 3.01, 3.01, 3.01, 3.01	
BKOC		1.78, 1.78, 1.78, 1.78, 1.78, 1.78, 1.78, 1.78, 1.78, 1.78, 1.78, 1.78	
BKSOIL		0.48, 0.48, 0.48, 0.48, 0.48, 0.48, 0.48, 0.48, 0.48, 0.48, 0.48, 0.48	
BKEC		0.02, 0.02, 0.02, 0.02, 0.02, 0.02, 0.02, 0.02, 0.02, 0.02, 0.02, 0.02	
M8_MODE	Extinction coefficients for hygroscopic species	5	
BKSALT	Background extinction coefficients for sea salt	0.19, 0.19, 0.19, 0.19,0.19, 0.19, 0.19, 0.19,0.19, 0.19, 0.19, 0.19,	
RHFSML	Monthly adjustment factors; small ammonium sulfate & ammonium nitrate	4.08, 3.82, 3.79, 3.74, 3.94, 4.12, 4.41, 4.37, 4.18, 3.92, 3.93, 4.06	
RHFLRG	Monthly adjustment factors; large ammonium sulfate & ammonium nitrate	2.91, 2.76, 2.74, 2.72, 2.83, 2.94, 3.10, 3.07, 2.97, 2.82, 2.83, 2.90	

Table C-2
CALPOST Version 6.221 Parameter Settings

Variable	Description	Value	Reason Values Differ From Default Settings
RHFSEA	Monthly adjustment factors; sea salt particles	4.10, 3.89, 3.87, 3.85, 4.02, 4.21, 4.44, 4.38, 4.23, 3.99, 4.01, 4.11	
BEXTRAY	Beta extinction from Rayleigh scattering	11	
LDOC	Documentation records	F	
IPRTU	Units for output	3	μg/m³
L1PD	Averaging times; 1 period	F	Not Needed
L1HR	Averaging times; 1-hour average	F	Not Needed
L3HR	Averaging times; 3-hour average	F	Not Needed
L24HR	Averaging times; 24-hour average	T	
LRUNL	Averaging times; run length	F	Not Needed
NAVGH	User specified averaging time; hours	0	
NAVGM	User specified averaging time; minutes	0	
NAVGS	User specified averaging time; seconds	0	
LT50	Top 50 table for each averaging time	F	Not Needed
LTOPN	Top 'N' values each receptor	T	Need top values
NTOP	Number of 'Top N' values each receptor	2	Do not need top 4 values
ITOP	Specific rank of 'Top N' values	1,2	Do not need top 4 values
LEXCD	Threshold exceedance counts	F	
THRESH1	Threshold for each averaging time; 1-hour average	-1.0	
THRESH3	Threshold for each averaging time; 3-hour average	-1.0	
THRESH24	Threshold for each averaging time; 24-hour average	-1.0	
THRESHN	Threshold for each averaging time; NAVG-hour average	-1.0	
NDAY	Counts for shortest averaging period	0.0	
NCOUNT	Number of exceedances	1.0	
LECHO	Echo option	F	
LTIME	Time series option	F	
LPEAK	Peak value option	F	
LPLT	Generate plot file ouput?	F	
LGRD	Use GRID format?	F	
MDVIS	Output file with the visibility change at each receptor?	1	Summary needed for BART
LDEBUG	output selected infrmation to List file for debug?	F	
LVEXTHR	Output hourly extinction fomation to REPORT.HRV?	F	

(yellow) =SMEPA Site Data
Bold =Non-default setting

APPENDIX D

CD WITH CALPUFF, CALPOST, AND POSTUTIL INPUT FILES

Appendix L.6: Entergy Gerald Andrus Power Plant

Appendix L.6 contents:

Appendix L.6.1 – Appendix Summary

Entergy Mississippi, Gerald Andrus Power Plant (28-151-00048) BART Process Summary

Entergy Mississippi, Gerald Andrus Power Plant is an electricity generating facility with one natural gas fired unit that meets the eligibility criteria for BART. Gerald Andrus is 290 km east of the Caney Creek Wilderness Area in Arkansas, a Class I area. As a fossil fuel fired steam electric plant, the facility meets the BART eligibility requirement of source category code. Therefore, on June 3, 2011, Mississippi Department of Environmental Quality (MDEQ) sent them a letter requesting information to determine BART subjectivity. Based on the information received from Entergy, one unit was deemed BART eligible because it met the following criteria:

- Operating or under construction between August 7, 1962 to August 7, 1977
- Having potential emissions that exceed the limit of 250 tons per year for SO_2, NO_X, or PM_{10}

Table L.6.1 below contains the BART-eligible point source for Entergy Gerald Andrus Plant and the potential emissions.:

Emission Unit	**Heat Input (MMBtu/hr)**	**Potential Emissions Rates (tons per year)**			**Existing Control Equipment**
		SO_2	NO_X	PM_{10}	
Unit No. 1	7275	89,020	23,010	5,836	none

Table L.6.1. Gerald Andrus Eligible units and Potential Emissions Rates

Because the source meets BART eligibility requirements, Gerald Andrus performed CALPUFF modeling on this unit to determine subjectivity. CALPUFF model version 5.8, Level 070623 along with the new IMPROVE equation were used in the modeling analysis per the VISTAS modeling protocol (which can be found in Appendix M of the SIP). The modeling used the maximum 24 hr average emissions rates utilizing natural gas over a three-year period of 2001-2003. These rates are shown in Table L.6.2. The modeling analysis demonstrated a 98th percentile 24-hour average visibility impact over the three years modeled of 0.15 dv. This value is well within the State's selected subjectivity threshold of 0.5 dv indicating that the facility is not Subject to BART. Also of note is that the BART-eligible unit has removed the ability to burn fuel oil. Since the CALPUFF model has been updated since the modeling was conducted in 2012, more current (2016-2018) emissions values were compared with the baseline values to give greater assurance of the determination.

Table L.6.2 compares the modeled emissions with updated 24 hr average emissions. The evaluation finds that the SO2 emissions from 2016 to 2018 were slightly higher than the modeled value, PM_{10} emissions were slightly lower, and that the NOx emissions were significantly less than the modeled emissions.

Emission Unit	Maximum 24-hour average emissions (2001-2003)			Maximum 24-hour average emissions (2016-2018)		
	SO2 (lb/hr)	NOx (lb/hr)	PM_{10} (lb/hr)	SO2 (lb/hr)	NOx (lb/hr)	PM_{10} (lb/hr)
Unit 1	3.66	3971	54.2	3.83	1813	47.13

Table L.6.2 baseline and current period hourly emissions comparison (SO2 and NOX are from the EPA Air Markets Database, PM_{10} is calculated using AP-42 factors and the highest daily heat input value for 2016-2018)

In addition, Table L.6.3 compares the annual baseline emissions of 2001 through 2003 to 2016 through 2018 annual emissions. As the table shows, the current annual emissions are much less than the baseline emissions for all pollutants.

Year	Annual Emissions (tons)		
	SO_2	NO_X	PM_{10}
2001	32,725.12	8,417.70	2180.27
2002	8.44	4,809.19	103.72
2003	12,568.21	6,626.94	1096.43
2016	2.22	763.67	26.36
2017	1.53	436.82	17.26
2018	3.15	1138.78	36.39

Table L.6.3 baseline and current period annual emissions comparison (Emissions are from MDEQ Title V Air Emissions Reporting Forms.)

Since Gerald Andrus's modeling found that their impact was significantly less than the .5 deciview impact threshold and a review of their current emissions finds that they are lower than the emissions during the modeled period, Mississippi agrees with the modeling and finds that they are not subject to BART.

Appendix L.6.2 – Modeling Protocol

AECOM Environment

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Source-Specific BART Dispersion Modeling Protocol: Gerald Andrus Unit 1

AECOM Environment

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Source-Specific BART Dispersion Modeling Protocol: Gerald Andrus Unit 1

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1.0 Introduction

The Gerald Andrus power plant, owned and operated by Entergy Mississippi Inc., has been identified by the Mississippi Department of Environmental Quality (MDEQ) as a source that is eligible for consideration of BART controls for SO_2, NO_X, and PM_{10}. This document describes the procedures by which a modeling analysis and a BART engineering review will be conducted for the BART-eligible Gerald Andrus Unit 1.

1.1 Location of Source vs. Relevant Class I Areas

The Gerald Andrus power plant is located in Greenville, Mississippi. Figure 1-1 shows a plot of the Gerald Andrus plant relative to nearby Class I Areas. The closest Class I area is the Caney Creek Wilderness Area, located in western Arkansas approximately 290 km to the west-northwest of the plant. Upper Buffalo Wilderness Area, located in the same general direction as Caney Creek, is the next closest Class I area located in Arkansas and is located about 360 km from the plant, which is beyond the VISTAS- and EPA-recommended 300-km limit for CALPUFF application. The Breton National Wildlife Refuge is even further away, more than 400 km. Accordingly, the BART exemption modeling will be conducted for Caney Creek in accordance with the VISTAS common BART modeling protocol and the procedures described in this source-specific BART modeling protocol.

1.2 Haze Composition at Caney Creek Wilderness

A review of the haze monitor that is representative of conditions at Caney Creek is shown in Figure 2-1 for 2002. This information comes from an IMPROVE (Interagency Monitoring of Protected Visual Environments) monitor, and data for these monitors is available at http://views.cira.colostate.edu/web/Composition/. The figure indicates that the predominant contributor to haze at the Caney Creek Wilderness Area for the worst 20% haze days is caused by sulfates due to SO_2 emissions. Other particulate species have a minor impact.

1.3 Organization of Protocol Document

Section 2 of this report describes the source emissions that will be used as input to the BART modeling. Section 3 describes the input data used for the modeling including the modeling domain, geophysical data, meteorological data, and air quality modeling procedures. Section 5 discusses the presentation of modeling results. References are provided in Section 6.

Figure 1-1: Location of Class I Areas in Relation to Gerald Andrus Plant

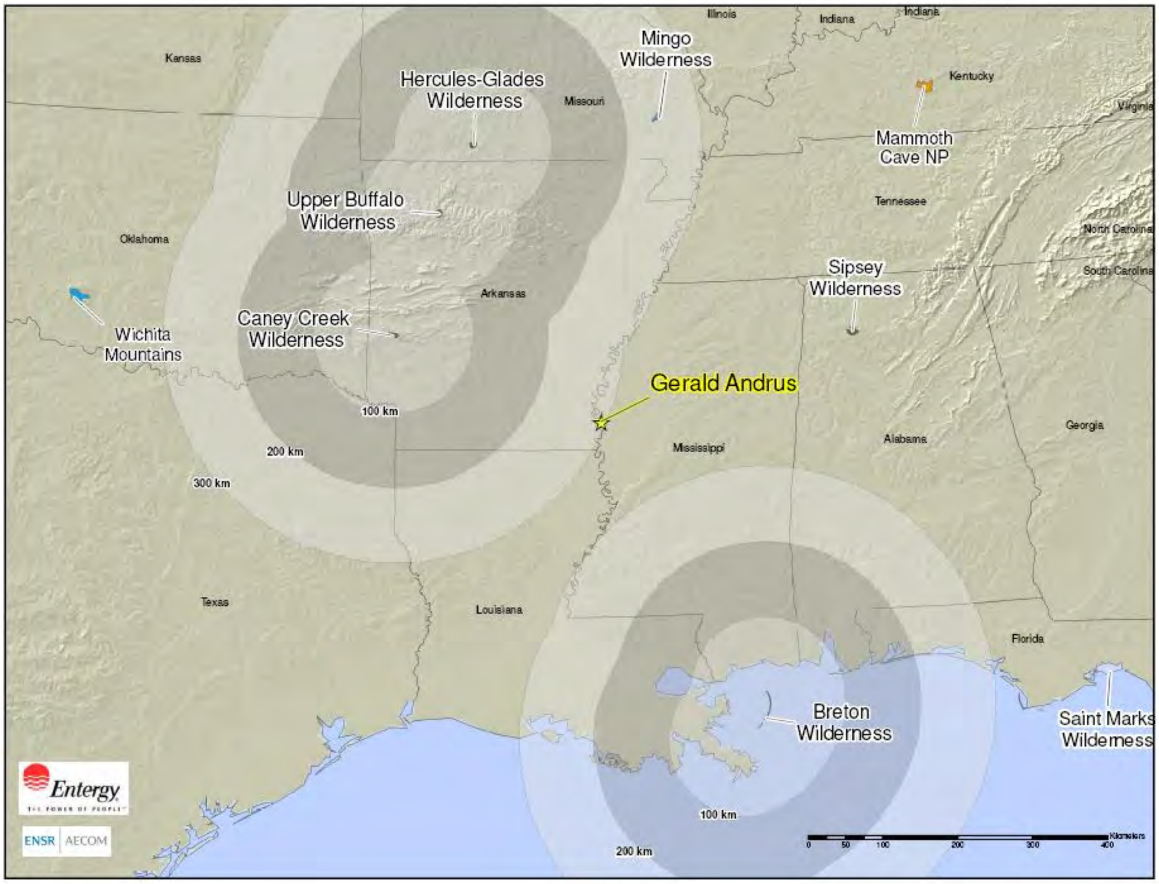
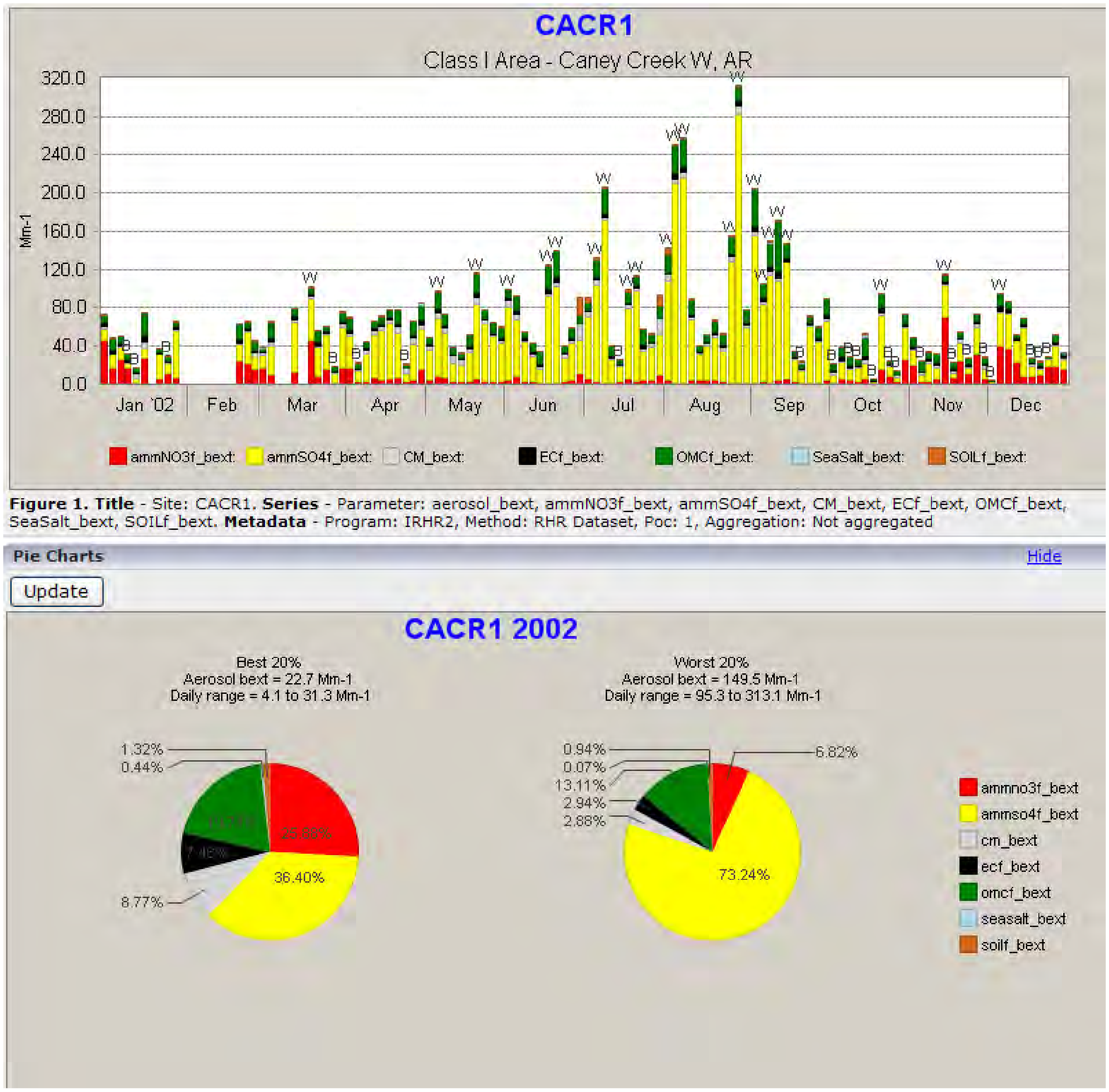


Figure 1-2: Haze Composition Plot for Caney Creek Wilderness for 2002



2.0 Source Data

2.1 Unit-Specific Source Data

The emissions data used to assess the visibility impacts at the selected Class I areas is discussed in this section. This analysis includes all potential visibility impairing pollutants.

Unit 1 at the Gerald Andrus plant is an oil and gas-fired unit with a permitted rating of 7,275 MMBtu/hr. The highest daily emissions from each fuel in the 2001 to 2003 baseline period are the focus of this emission characterization. Add-on PM and SO_2 controls are not used on the unit.

The maximum daily SO_2 emission rate and NO_X emission rate for both fuel oil combustion and natural gas combustion were determined from Part 75 monitoring data (Clean Air Markets Database) and the facility's CEMS data. The maximum heat input used in the PM emission calculations is based on the design rating for each fuel.

Because various components of PM_{10} emissions have different visibility extinction efficiencies, the PM_{10} emissions are divided, or "speciated" into several components. The VISTAS protocol allows for the use of source-specific emissions and speciation factors. Otherwise, default values from EPA's AP-42 reference document can be used. PM_{10} was speciated in a manner consistent with the VISTAS guidance. The PM_{10} emissions and the speciation approach that were used for the modeling described in this report are described in the bullets below.

Total PM_{10} is comprised of filterable and condensable emissions.

For oil firing:

- Baseline filterable PM emissions were conservatively based on the permitted rated heat input rate for oil firing and the PM filterable equation in AP-42 Section 1.3. A fuel oil heating value of 0.15 MMBtu/gal and a sulfur content of 2.9% were also used in the determination of the baseline filterable PM emissions.
- Filterable PM is subdivided by size category consistent with the default approach from AP-42 Table 1.3-4. The cumulative size distribution given in AP-42 Table 1.3-4 indicates 71% of the filterable PM emissions are filterable PM_{10} and 52% of the PM emissions are fine filterable PM_{10} emissions (less than 2.5 microns in size). Coarse PM_{10} is then the difference between the total PM_{10} and the fine PM_{10}. For oil-fired utility boilers, elemental carbon is expected to be 7.4% of fine PM_{10}.
- Condensable PM_{10} consists of inorganic and organic compounds. The inorganic portion is assumed to consist of 100% Sulfates. Organic condensable PM_{10} was based on application of AP-42 Table 1.3-2, (calculated as 0.15 x (1.5 lb/1,000 gallons)). The maximum daily oil usage rate was calculated from the maximum daily heat input rate using an oil heating value of 0.15 MMBtu/gal.

For natural gas firing:

- Baseline filterable PM emissions were based on the design rated heat input rate for natural gas firing and the PM filterable emission rate in AP-42 Section 1.4. A natural gas heating value of 1,020 Btu/scf was also used in the determination of the baseline filterable PM emissions.
- According to AP-42 Table 1.3-4, all PM (total, condensable, and filterable) is assumed to be less than 1.0 micrometer in diameter. Therefore, the fine filterable PM_{10} emissions are equal to the filterable PM emissions. Coarse PM_{10} is the difference between the total PM_{10} and the fine PM_{10} which in this case is zero. For natural gas-fired utility boilers, elemental carbon is expected to be 6.7% of fine PM_{10}.
- Condensable PM_{10} consists of inorganic and organic compounds. The inorganic portion is assumed to be 100% Sulfates. The sulfates were calculated conservatively as 20% of the unit's SO_2 emissions. Organic condensable PM_{10} is equal to the total condensable PM minus the total inorganic condensable PM. The maximum daily natural gas usage rate was calculated from the maximum daily heat input rate using a natural gas heating value of 1,020 Btu/scf.

In practice, CALPUFF allows for the user to input certain components of PM_{10} as separate species and separate sizes, which will result in more accurate wet and dry deposition velocity results and also more accurate effects on light scattering. As noted above, the particle size distribution information is provided in AP-42 Table 1.3-4, and this information was used for the BART exemption modeling that uses the maximum 24-hour emissions from the baseline period as input to CALPUFF.

Table 2-1 provides a summary of the modeling emission parameters that will be used in the BART CALPUFF modeling.

Table 2-1: Gerald Andrus Modeling Emissions Parameters

EMISSION UNIT ID	EMISSION UNIT DESCRIPTION	FUEL USED	MAX DAILY OPERATING RATE (MMBtu/hr) (2)	PM condensable Emission Factor (3) (lb/1000 gal)	SO_2 Emissions (lb/hr) (1)	NO_x Emissions (lb/hr) (1)	PM filterable (lb/hr) (2)	PM condensable (lb/hr) (4)	PM_{10} Emissions (lb/hr): Total PM_{10} Emissions (filterable + condensable)	Filterable: Total FPM_{10} (5)	Filterable: Coarse PM_{10} (5)	Filterable: Fine PM_{10} (5)	Filterable: Fine Soil (6)	Filterable: Fine Elemental Carbon (6)	Condensable: Total CPM_{10}	Condensable: CPM IOR: Total CPM IOR (7)	Condensable: CPM IOR: Sulfates (8)	Condensable: Total CPM OR (7)
Gerald Andrus Unit 1	Gas/oil boiler	#6 Oil	7,275	1.5	24,395	7,605	1,560.3	72.8	1180.5	1107.8	296.5	811.3	751.3	60.04	72.75	61.8	61.8	10.9

Notes:

(1) Baseline period for the BART analysis is 2001 - 2003.
SO_2 emissions based on 1/3/01.
NO_x emissions based on 1/3/01.

(2) Max hourly heat input rate based on design rating of boiler firing oil. Filterable PM emission rate is based on AP-42 Section 1.3 (Filt PM = 9.19 (S) + 3.22).
Sulfur content of Fuel Oil = 2.9 % Heating Value of Fuel Oil = 0.15 MMBtu/gal

(3) Condensable PM Emission factor based on AP-42 Table 1.3-2 (1.5 lb/1000 gal) for #6 oil fired boiler.

(4) Condensable PM_{10} emissions (lb/hr) calculated using the factor given in Note (3) above. Max. daily oil usage rate was calculated from the max daily heat input rate using an oil heating value of 0.15 MMBtu/gal.

(5) Filterable PM_{10} portion of total filterable PM is calculated using the cumulative size distributions given in AP-42 Table 1.3-4 (uncontrolled size fractions). Fine PM_{10} is calculated as Total Filterable PM * 0.52. Coarse PM_{10} is calculated as the difference between total PM_{10} and fine PM_{10}.

(6) Elemental carbon or black carbon is 7.4% of fine PM_{10} based on the best estimates for industrial petroleum in Table 6 of "Catalog of Global Emissions Inventories and Emission Inventory Tools for Black Carbon", William Battye and Kathy Boyer, EPA Contract No. 68-D-98-046, January 2002. Fine soil is the difference between fine total and fine EC.

(7) Per AP-42 Table1.3-2, inorganic CPM is 85% of total CPM and organic CPM is 15% of total CPM.

(8) All inorganic CPM_{10} is assumed to be sulfates.

EMISSION UNIT ID	EMISSION UNIT DESCRIPTION	FUEL USED	MAX DAILY OPERATING RATE (MMBtu/hr) (2)	PM condensable Emission Factor (3) (lb/10^6 scf)	SO_2 Emissions (lb/hr) (1)	NO_x Emissions (lb/hr) (1)	PM filterable (lb/hr) (2)	PM condensable (lb/hr) (4)	PM_{10} Emissions (lb/hr): Total PM_{10} Emissions (filterable + condensable)	Filterable: Total FPM_{10} (5)	Filterable: Coarse PM_{10} (5)	Filterable: Fine PM_{10} (5)	Filterable: Fine Soil (6)	Filterable: Fine Elemental Carbon (6)	Condensable: Total CPM_{10}	Condensable: CPM IOR: Total CPM IOR (7)	Condensable: CPM IOR: Sulfates (8)	Condensable: Total CPM OR (7)
Gerald Andrus Unit 1	Gas/oil boiler	Natural Gas	7,275	5.7	3.66	3,971	13.6	40.7	54.2	13.6	0.00	13.6	12.6	0.91	40.7	1.12	1.12	39.5

Notes:

(1) Baseline period for the BART analysis is 2001 - 2003.
SO_2 emissions based on 8/5/02.
NO_x emissions based on 10/10/01.

(2) Max hourly heat input rate based on design rating of boiler firing onatural gas. Filterable PM emission rate is based on AP-42 Section 1.3 (Filt PM = 9.19 (S) + 3.22).

Heating Value of natural gas = 1020 Btu/scf

(3) Condensable PM Emission factor based on AP-42 Table 1.4-2 (5.7 lb/10^6 scf) for natural gas fired boiler.

(4) Condensable PM_{10} emissions (lb/hr) calculated using the factor given in Note (3) above. Max. daily natural gas usage rate was calculated from the max daily heat input rate using a natural gas heating value of 1020 Btu/scf.

(5) Filterable PM_{10} and Fine PM_{10} are both assumed to be 100% of total filterable PM as given in AP-42 Table 1.4-2. Coarse PM_{10} is calculated as the difference between total PM_{10} and fine PM_{10}.

(6) Elemental carbon or black carbon is 6.7% of fine PM_{10} based on the best estimates for natural gas in Table 6 of "Catalog of Global Emissions Inventories and Emission Inventory Tools for Black Carbon", William Battye and Kathy Boyer, EPA Contract No. 68-D-98-046, January 2002. Fine soil is the difference between fine total and fine EC.

(7) Total organic CPM = total CPM minus total inorganic CPM. Total inorganic CPM = all sulfates.

(8) All inorganic CPM_{10} is assumed to be sulfates. Sulfates calculated as 20% of SO_2 * (98/64)

3.0 Input Data to the CALPUFF Model

3.1 General Modeling Procedures:

VISTAS has developed five sub-regional 4-km CALMET meteorological databases for three years (2001-2003), as well as a 12-km screening meteorological database for the same years. The sub-regional modeling domains are strategically designed to cover all potential BART eligible sources within VISTAS states and most PSD Class I areas within 300 km of those sources. The extents of the 4-km sub-regional domains are shown here: http://www.vistas-sesarm.org/BART/CALMETSubdomains_21Dec2005.jpg.

To conduct consistent CALPUFF modeling for both Entergy BART-eligible plants in Mississippi (Gerald Andrus and Baxter Wilson), it is necessary for us to create a CALPUFF modeling domain that extends into a portion of Arkansas, which would lie outside the 4-km VISTAS database. An alternative database would be the CENRAP screening subdomain 6-km database, but CENRAP has not provided the supplemental meteorological data that VISTAS provides. Therefore, we are proposing to use the VISTAS meteorological data to create a single CALMET database for assessing regional haze impacts in Class I areas for both Entergy BART-eligible plants in Mississippi.

3.2 Model Selection and Features

The EPA-approved version of CALMET (V5.8), CALPUFF (V5.8), and POSTUTIL (V1.56) is proposed for BART modeling with the meteorological databases described in this protocol. CALPOST Version 6.292 will be used to process modeling results and compute regional haze impacts at each receptor. CALPOST V6.292 contains the recommended FLAG (2010) techniques on visibility assessment, specifically the new IMPROVE equation.

3.3 Modeling Domain and Receptors

The modeling domain was designed to encompass the closest Class I areas to the specific Entergy plants (Gerald Andrus and Baxter Wilson), plus a 50-km buffer. The resultant modeling domain extends 636 km East-West and 600 km North-South with a 4-km grid resolution. The domain is shown in Figure 3-1.

The receptors to be used for Caney Creek are based on the National Park Service database of Class I receptors, as recommended by VISTAS (found at: http://www2.nature.nps.gov/air/maps/Receptors/index.htm).

3.4 CALMET Processing

The CALMET control input file contains numerous switches and settings that drive how the 3-dimensional wind-field will be produced, which in turn can affect dispersion within the CALPUFF model and ultimately estimates of the modeled ground level concentrations. In August 2009, the USEPA Model Clearinghouse (in cooperation with the Federal Land Managers [FLMs]) issued a memo containing recommended settings for use in CALMET (http://www.epa.gov/ttn/scram/CALMET%20CLARIFICATION.pdf). For this application, we propose to run CALMET with all USEPA-FLM recommended values.

For the hourly wind field initialization, CALMET will use gridded prognostic mesoscale meteorological (MM5) data for all three years (2001-2003). The following three years of MM5 data have been assembled by VISTAS for use in the regional CALPUFF modeling:

- 2001 and 2002 MM5 data set with 12-km resolution
- 2003 MM5 dataset with 36-km resolution.

These prognostic meteorological data sets will be combined with 4-km grid resolution terrain and land use data to more accurately characterize the wind flow throughout the modeling domain. The 4-km gridded terrain data will be derived from United States Geological Survey (USGS) 1:250,000 (3 arc second or 90-meter grid spacing) Digital Elevation Model (DEM) files using the TERREL pre-processor program. The gridded land use data will be derived from USGS 1:250,000 Composite Theme Grid (CTG) land use files.

The Step 2 wind field will be produced with the input of hourly surface and twice daily upper air balloon sounding data. Hourly precipitation data will also included in the CALMET simulations. Surface, upper air and precipitation files have been prepared by TRC for use in the VISTAS regional CALPUFF modeling effort.

The following files were previously downloaded from the TRC website (link no longer works) http://www.src.com/verio/download/sample_files.htm#STANDARD_SURF.

- Standard surface files (2001-2003)
- Standard precipitation files (2001-2003)
- VISTAS Regional Domain 1 upper air data files (2001-2003). Only four upper air stations were selected from the dataset due to their proximity to this proposed modeling domain.

CALPUFF PROfessional System software, SUBDOMN tool will be used to extract a smaller subset of the surface and precipitation datasets. (The software is created and distributed by TRC). .

3.5 CALPUFF Processing

Similar to CALMET, the CALPUFF control input file also contains numerous switches and settings that drive how certain data will be processed, which in turn can affect dispersion within the CALPUFF model and, ultimately, estimates of the modeled regional haze impacts. In March 2006, the USEPA Model Clearinghouse issued a memo containing recommended settings for use in CALPUFF.

For this application, CALPUFF will be run with all USEPA recommended settings. Most other CALPUFF settings that require user-definition and have not been specified in the March 2006 memo are meant to be tailored to specific applications. Much like CALMET, these values pertain to selection of file names, specification of beginning and ending time period for the simulation, and map.

3.6 Background Ozone and Ammonia

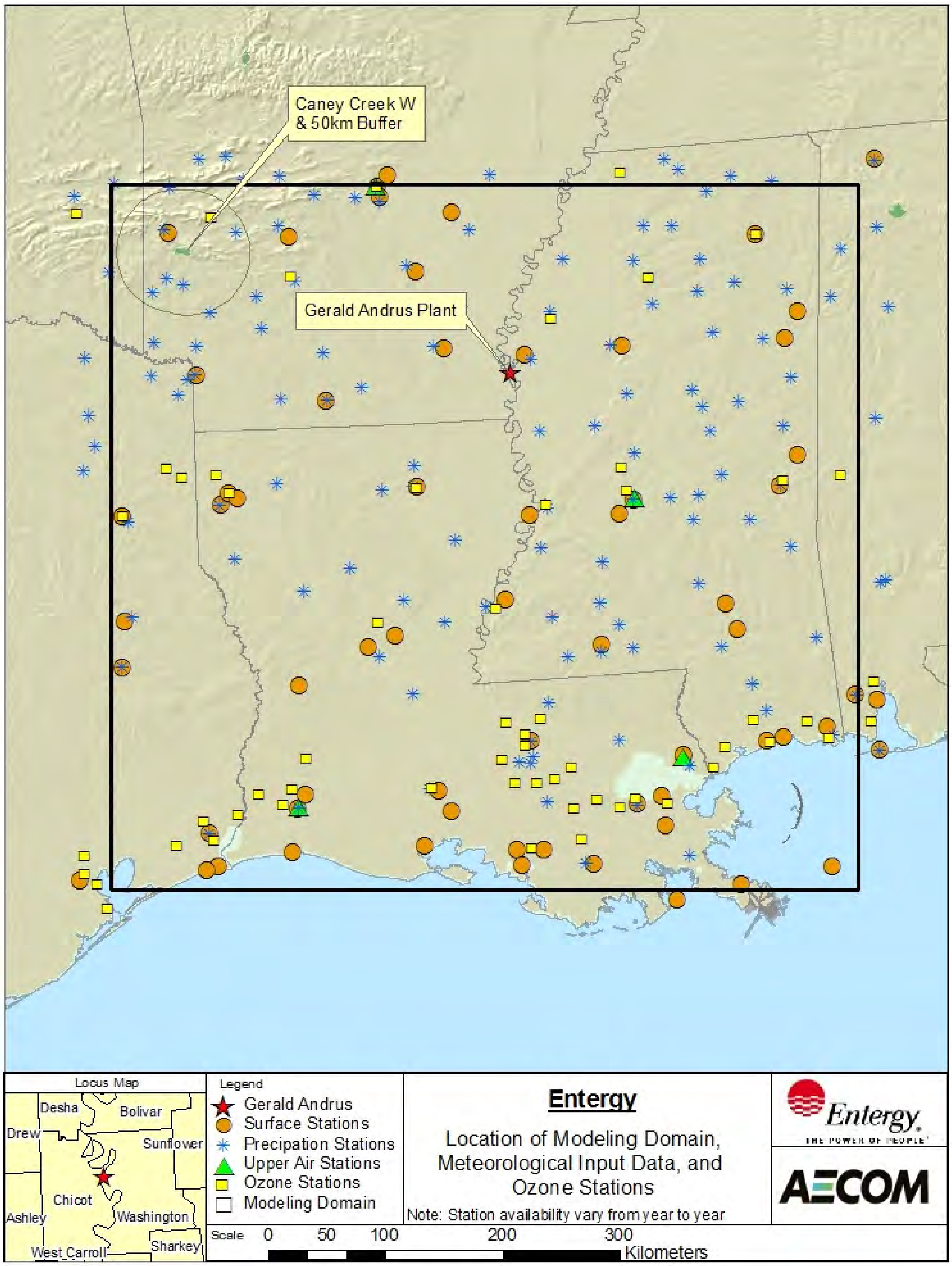
Hourly measurements of ozone from all non-urban monitors, as generated by VISTAS will be used as input to CALPUFF. As for ammonia, we propose to follow the approach recommended by VISTAS. Currently, VISTAS advises sources to use a background ammonia concentration of 0.5 ppb, and not to use the ammonia limiting.

3.7 CALPOST Visibility Impacts Processing

The CALPOST postprocessor will be used for the calculation of the impact of the modeled source's primary and secondary particulate matter concentrations on light extinction. In accordance with FLAG 2010 guidance, the visibility impacts at Caney Creek Wilderness will be processed using CALPOST Method 8 (MVISBK=8) and sub-mode five (M8_MODE=5). The Method 8 (new IMPROVE equation) allows a spit between large and small sulfate, nitrate and organic particles when calculating natural background conditions and change in light extinction.

The annual average concentrations, Raleigh scatting coefficient, and sea salt concentrations will be taken from FLAG (2010) Table 6. The monthly relative humidity adjustment factors for large sulfate and nitrate particles will be taken from FLAG Table 7 and for small particles from FLAG Table 8. The sea salt relative humidity adjustment factors for Caney Creek Wilderness will be taken from FLAG Table 9.

Figure 3-1: Location of Modeling Domain, Meteorological Input Data, and Ozone Stations



4.0 Presentation of Modeling Results

The BART exemption analysis will be conducted for Gerald Andrus Unit 1. The modeling analysis will be done separately for the 100% oil-firing emissions case and for the 100% natural gas-firing emissions case, as shown in Table 2-1. The 98th percentile regional haze results at Caney Creek Wilderness for each emissions case will be compared to the 0.5 delta-deciview (dv) threshold. If the exemption modeling demonstrates that the BART-eligible unit at the Gerald Andrus plant do not cause or contribute to visibility impairment with either gas-firing emissions case or oil-firing emissions case (or both cases), then that case/fuel will not be subject to BART requirements, and no further analysis will be needed. Otherwise, Entergy will proceed to perform BART determination modeling for the baseline and each selected control option for any remaining case/fuel. One exception to this requirement could occur if the selected case (e.g., oil firing) was limited to a number of days per year corresponding to the 98th percentile BART-relevant statistic (8th highest day) weighted by the likelihood of winds blowing toward the Caney Creek Wilderness Area. For example, if a representative wind rose indicated that the probability of wind from the east-southeast is 20% as an annual average, then the allowable frequency of a specific emission case that could trigger the 98th percentile day's impact at Caney Creek would be 40 or more days per year.

The BART analysis will address the five statutory factors required by Section 169A (g) (7) of the Clean Air Act that States must consider in making BART determinations:

(1) the costs of compliance,

(2) the energy and non-air quality environmental impacts of compliance,

(3) any existing pollution control technology in use at the source,

(4) the remaining useful life of the source, and,

(5) the degree of improvement in visibility which may reasonably be anticipated to result from the use of such technology.

Entergy will consider SO_2, NO_X and PM_{10} control cases based on their cost effectiveness and feasibility. Based on cost considerations (e.g., $5,000 or more per ton removed), physical space constraints, infeasibility of the controls, or legal contractual conditions, Entergy will determine whether a control option is feasible. If feasible, then emissions associated with each selected option will be modeled to determine visibility improvement relative to the baseline.

In numerous correspondence[1] to states, the Federal Land Managers have referred to a benchmark of $20 million per deciview as a threshold for excessively high costs for the degree of visibility improvements. This value is computed as the 3-year average of the 98th percentile day's deciview

[1] See http://www.nature.nps.gov/air/regs/sipLetters/pdf/Pennsylvania_08-02-2010.pdf, http://www.nature.nps.gov/air/regs/sipLetters/pdf/Nevada_EPA_Letter_08-17-2011.pdf, http://www.dec.state.ak.us/AIR/ap/docs/GVEA%20BART%20NPS%20Comments%206-15-09.pdf.

improvement predicted by CALPUFF (for the two emission cases being compared) divided by the incremental annualized cost of the proposed control. For example, if the average deciview improvement were 0.5, then incremental annualized costs in excess of $40 million would render the control option as ineffective and too expensive, and would likely be rejected as BART.

5.0 References

Environmental Protection Agency (EPA), Tyler Fox Memorandum: Clarification on EPA-FLM Recommended Settings for CALMET. August 31, 2009.

Environmental Protection Agency (EPA), Dennis Atkinson Memorandum: Dispersion Coefficients for Regulatory Air Quality Modeling in CALPUFF. March 16, 2006.

Environmental Protection Agency (EPA), 40 CFR Part 51, FRL -7925-9, RIN: 2060-AJ31, Regional Haze Regulations and Guidelines for Best Available Retrofit Technology (BART) Determinations (Appendix Y), updated June 24, 2005

Environmental Protection Agency (EPA), Guidance for Tracking Progress Under the Regional Haze Rule, EPA-454/B-03-003, Appendix A, Table A-3, September, 2003

Federal Land Managers' Air Quality Related Values Work Group (FLAG). Phase I Report. Revised 2010.

Visibility Improvement State and Tribal Association of the Southeast (VISTAS), Revision 3, Protocol for the Application of the CALPUFF Model for Analyses of Best Available Retrofit Technology (BART), updated July 18, 2006.

Appendix L.6.3 – BART Exemption Modeling Report

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Source-Specific BART Exemption Report: Gerald Andrus Unit 1

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Source-Specific BART Exemption Report: Gerald Andrus Unit 1

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Executive Summary

Entergy Mississippi Inc. owns and operates the Gerald Andrus Power Plant (“Gerald Andrus”), located in Greenville, Mississippi. The Power Plant consists of one dual-fuel oil and gas-fired unit (Unit 1) rated at about 781 megawatt (MW). Unit 1 commenced commercial operation in 1975, thus meeting the in-service date for Best Available Retrofit Technology (BART) eligibility. Over the past several years, the plant has had emissions exceeding 250 tons per year of sulfur dioxide (SO_2) and/or nitrogen oxide (NOx). Therefore, the plant is BART-eligible. Unit 1 is fired with natural gas and/or No.6 fuel oil and has a maximum heat input rate of 7,275 MMBtu/hr. The plant burns primarily natural gas, but also uses residual fuel oil as a secondary fuel, especially in the event of a curtailment in the natural gas supply. In practice, Entergy has reduced the No.6 residual fuel oil used at this facility by nearly 70% (since the Regional Haze Rule (RHR) baseline period of 2001-2003) to a maximum sulfur level content of 1.0%. This operational practice is considered in our modeling analysis as a “current baseline” for purposes of determining BART eligibility.

The Mississippi State BART rules require that sources that are subject to BART perform a site-specific BART analysis including a control technology review and CALPUFF modeling to assess the visibility impact of the emission units for various candidate BART controls. A subject-to-BART analysis was conducted separately for the oil-fired and natural gas-fired baseline emissions to determine whether visibility impacts exceeding the contribution threshold of 0.5 delta-dv on the 98^{th} percentile day, averaged over 3 years, were found at any Class I area within 300 km (there is one such area, Caney Creek Wilderness Area).

CALPUFF modeling was conducted for the baseline natural gas and oil emission cases for Gerald Andrus consistent with the VISTAS Regional Planning Organization’s CALPUFF BART modeling protocol[1], with appropriate updates. The modeling used the EPA-approved version of CALPUFF, the VISTAS ammonia background concentration of 0.5 ppb, and post-processing with the new IMPROVE equation along with the annual average natural background concentrations.

The modeling results indicated that natural gas firing visibility impacts are below the contribution threshold, while oil-fired impacts (assuming 24-hour-per-day operations) are above the threshold. We provide results for partial-day oil-firing operations that would not trigger the contribution threshold, so that days with more extensive oil-firing operations are referred to as “oil burn days”. Consistent with the modeling protocol, Entergy is willing to agree to limited oil-fired operations such that the frequency of oil burn days cannot affect the 98^{th} percentile day at any Class I area. The number of oil burn days that would trigger a BART review is thus related to the form of the 98^{th} percentile criterion (the 8^{th} highest day) as well as the frequency for winds to blow in any one direction from the source. A conservative assessment of the wind direction frequency indicates that if the average number of oil burn days is limited to no more than 18 per year (averaged over 3 years and excluding emergency conditions), then there would be no oil firing emissions on the 98^{th} percentile day. Therefore, natural gas firing operations are not subject to BART due to modeling results, while limited oil firing operations are exempt from BART because they are too infrequent.

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[1] Available at http://www.vistas-sesarm.org/documents/BARTModelingProtocol_rev3.2_31Aug06.pdf.

1.0 Introduction

The Gerald Andrus power plant, owned and operated by Entergy Mississippi Inc., has been identified by the Mississippi Department of Environmental Quality (MDEQ) as a source that is eligible for consideration of BART controls for SO_2, NO_X, and PM_{10}. This document describes the procedures by which a modeling analysis and a BART exemption conducted for the BART-eligible Gerald Andrus Unit 1.

1.1 Location of Source vs. Relevant Class I Areas

The Gerald Andrus power plant is located in Greenville, Mississippi. Figure 1-1 shows a plot of the Gerald Andrus plant relative to nearby Class I Areas. The closest Class I area is the Caney Creek Wilderness Area, located in western Arkansas approximately 290 km to the west-northwest of the plant. Upper Buffalo Wilderness Area, located in the same general direction as Caney Creek, is the next closest Class I area located in Arkansas and is located about 360 km from the plant, which is beyond the VISTAS- and EPA-recommended 300-km limit for CALPUFF application. The Breton National Wildlife Refuge is even further away, more than 400 km. Accordingly, the BART modeling was conducted for Caney Creek in accordance with the BART modeling protocol[2], VISTAS common BART modeling protocol and the procedures described in this source-specific BART modeling protocol. In early 2012, EPA provided minor comments on the AECOM modeling protocol for Gerald Andrus and Baxter Wilson BART analyses. Responses to those comments that were incorporated into the final modeling approach are provided in Appendix A.

1.2 Haze Composition at Caney Creek Wilderness

A review of the haze monitor that is representative of conditions at Caney Creek is shown in Figure 2-1 for 2002. This information comes from an IMPROVE (Interagency Monitoring of Protected Visual Environments) monitor, and data for these monitors is available at http://views.cira.colostate.edu/web/Composition/. The figure indicates that the predominant contributor to haze at the Caney Creek Wilderness Area for the worst 20% haze days is caused by sulfates due to SO_2 emissions. Other particulate species have a relatively minor impact.

1.3 Organization of Report Document

This report documents the BART exemption analysis conducted for SO_2, NOx and PM emissions from Unit 1 at the Gerald Andrus Power Plant. Section 2 provides a description of Gerald Andrus Unit 1 and its baseline emissions for both natural gas and oil fired operations. The available meteorological data and the CALPUFF modeling procedures are described in Sections 4. The results of the visibility exemption modeling using CALPUFF and the results are presented in Section 5. References are provided in Section 6.

[2] Source-Specific Modeling Protocol: Gerald Andrus Unit 1. Prepared by AECOM. November 2011. The EPA and MDEQ provided minor comments on this protocol in January 2012.

Figure 1-1: Location of Class I Areas in Relation to Gerald Andrus Plant

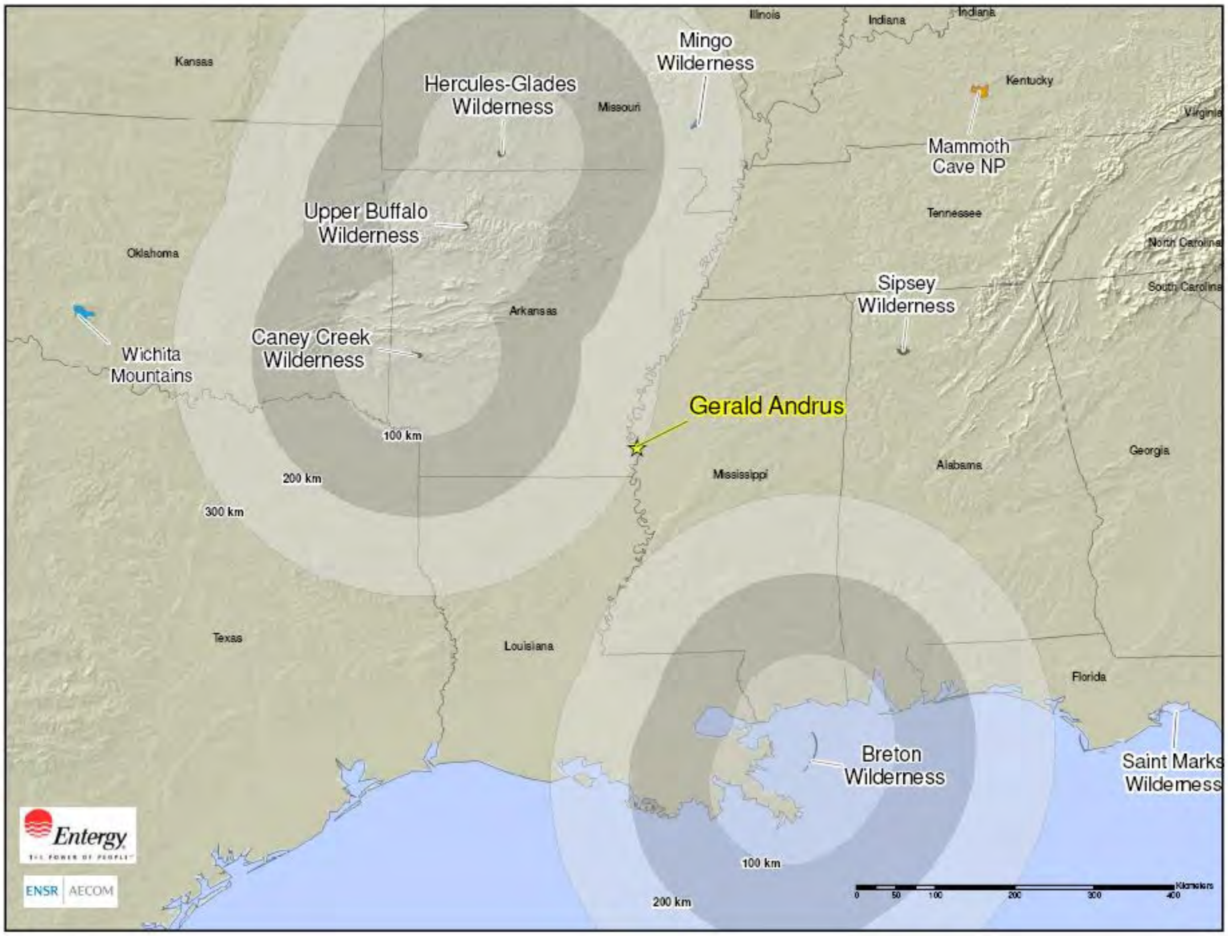
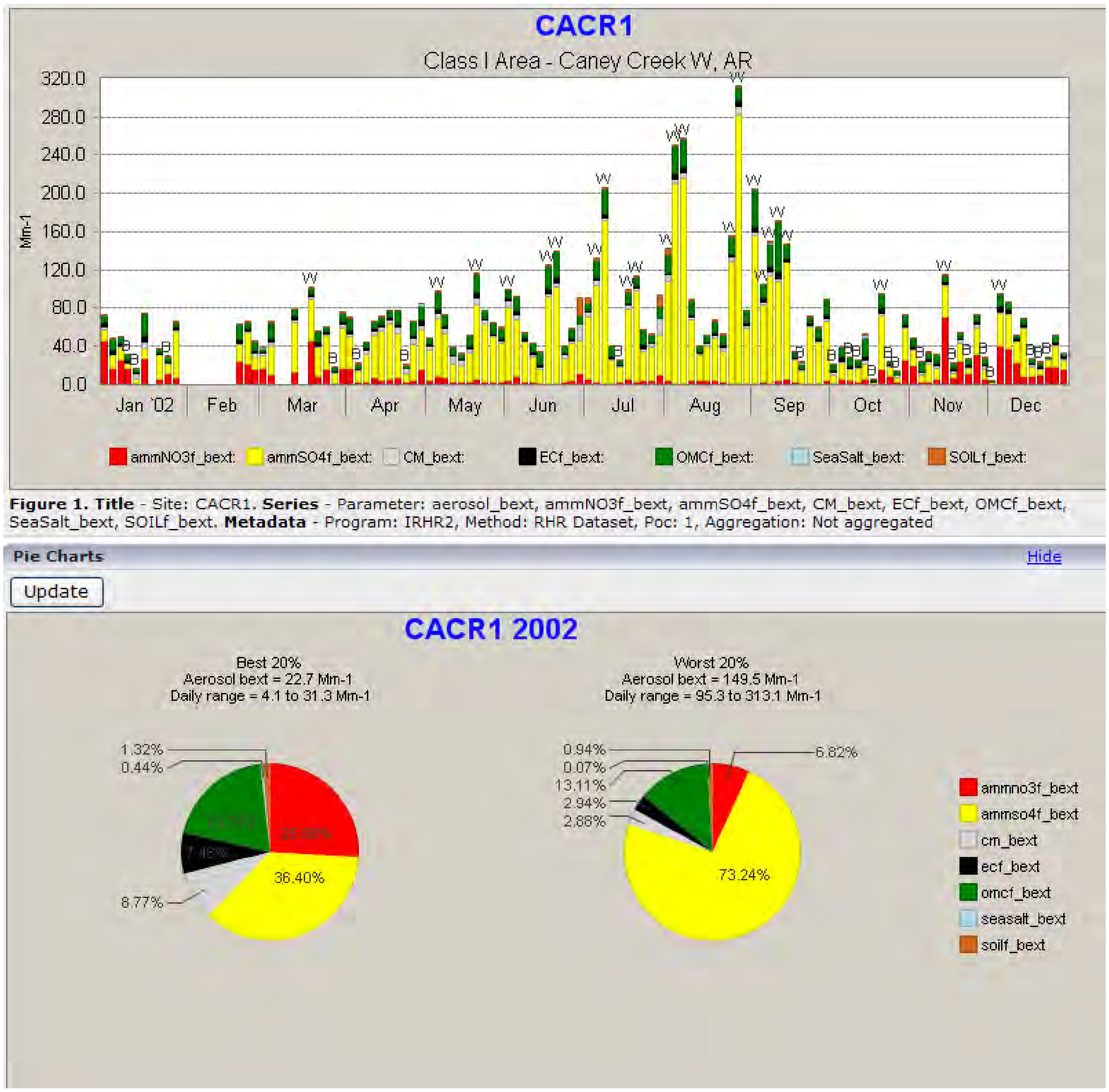


Figure 1-2: Haze Composition Plot for Caney Creek Wilderness for 2002



2.0 Background Data

2.1 Unit-Specific Source Data

The emissions data used to assess the visibility impacts at Caney Creek Wilderness are discussed in this section. This analysis includes all potential visibility impairing pollutants.

Unit 1 at the Gerald Andrus plant is gas-fired unit with oil backup, with a permitted rating of 7,275 MMBtu/hr. The highest daily emissions from each fuel in the 2001 to 2003 baseline period are the focus of this emission characterization. Add-on PM and SO_2 controls are not used on the unit.

The maximum daily SO_2 emission rate and NO_X emission rate for both fuel oil combustion and natural gas combustion were determined from Part 75 monitoring data (Air Markets Program Data) and the facility's CEMS data. The maximum heat input used in the PM emission calculations is based on the design firing rate for each fuel.

Because various components of PM_{10} emissions have different visibility extinction efficiencies, the PM_{10} emissions are divided, or "speciated" into several components. The VISTAS protocol allows for the use of source-specific emissions and speciation factors. Otherwise, default values from EPA's AP-42 reference document can be used. PM_{10} was speciated in a manner consistent with the VISTAS guidance. The PM_{10} emissions and the speciation approach that were used for the modeling described in this report are described in the bullets below.

Total PM_{10} is comprised of filterable and condensable emissions.

For oil firing:

- Baseline filterable PM emissions were conservatively based on the permitted rated heat input rate for oil firing and the PM filterable equation in AP-42 Section 1.3. A fuel oil heating value of 0.15 MMBtu/gal and a sulfur content of 2.9% were also used in the determination of the baseline filterable PM emissions.
- Filterable PM is subdivided by size category consistent with the default approach from AP-42 Table 1.3-4. The cumulative size distribution given in AP-42 Table 1.3-4 indicates 71% of the filterable PM emissions are filterable PM_{10} and 52% of the PM emissions are fine filterable PM_{10} emissions (less than 2.5 microns in size). Coarse PM_{10} is then the difference between the total PM_{10} and the fine PM_{10}. For oil-fired utility boilers, elemental carbon is expected to be 7.4% of fine PM_{10}.
- Condensable PM_{10} consists of inorganic and organic compounds. The inorganic portion is assumed to consist of 100% Sulfates. Organic condensable PM_{10} was based on application of AP-42 Table 1.3-2, (calculated as 0.15 x (1.5 lb/1,000 gallons)). The maximum daily oil usage rate was calculated from the maximum daily heat input rate using an oil heating value of 0.15 MMBtu/gal.

For natural gas firing:

- Baseline filterable PM emissions were based on the design rated heat input rate for natural gas firing and the PM filterable emission rate in AP-42 Section 1.4. A natural gas heating value of 1,020 Btu/scf was also used in the determination of the baseline filterable PM emissions.
- According to AP-42 Table 1.3-4, all PM (total, condensable, and filterable) is assumed to be less than 1.0 micrometer in diameter. Therefore, the fine filterable PM_{10} emissions are equal to the filterable PM emissions. Coarse PM_{10} is the difference between the total PM_{10} and the fine PM_{10} which in this case is zero. For natural gas-fired utility boilers, elemental carbon is expected to be 6.7% of fine PM_{10}.
- Condensable PM_{10} consists of inorganic and organic compounds. The inorganic portion is assumed to be 100% Sulfates. The sulfates were calculated conservatively as 20% of the unit's SO_2 emissions. Organic condensable PM_{10} is equal to the total condensable PM minus the total inorganic condensable PM. The maximum daily natural gas usage rate was calculated from the maximum daily heat input rate using a natural gas heating value of 1,020 Btu/scf.

In practice, CALPUFF allows for the user to input certain components of PM_{10} as separate species and separate sizes, which will result in more accurate wet and dry deposition velocity results and also more accurate effects on light scattering. As noted above, the particle size distribution information is provided in AP-42 Table 1.3-4, and this information was used for the BART exemption modeling that uses the maximum 24-hour emissions from the baseline period as input to CALPUFF.

Table 2-1 summarizes modeling exhaust stack parameters. AECOM has conducted a GEP analysis for the Gerald Andrus Unit 1 stack and concluded that the stack height is fully creditable. Therefore, the actual stack height, shown in the table below, was used in modeling, along with the appropriate building downwash inputs.

Tables 2-2 and 2-3 show a summary of the modeling emission parameters that were used in the BART CALPUFF modeling for baseline natural gas and oil emissions (RHR baseline period, which is equal to 2.9 % sulfur), respectively. Table 2-4 presents the current baseline 1% sulfur oil emission rates.

Table 2-1: Gerald Andrus Unit 1 – Baseline Modeling Stack Parameters

Unit	Actual Stack Height (m)	Base Elevation (m)	Stack Diameter (m)	Exit Velocity (m/s)	Temp (K)
Unit 1	152.10	45.42	8.77	19.65	434.30

Table 2-2: Gerald Andrus Unit 1 – Baseline Modeling Emissions for Natural Gas Firing

EMISSION UNIT ID	EMISSION UNIT DESCRIPTION	FUEL USED	MAX DAILY OPERATING RATE (MMBtu/hr) (2)	PM condensable Emission Factor (3) (lb/10^6 scf)	SO_2 Emissions (lb/hr) (1)	NO_x Emissions (lb/hr) (1)	PM filterable (lb/hr) (2)	PM condensable (lb/hr) (4)	PM_{10} Emissions (lb/hr)									
									Total PM_{10} Emissions (filterable + condensable)	Filterable					Condensable			
																CPM IOR		
										Total FPM_{10} (5)	Coarse PM_{10} (5)	Fine PM_{10} (5)	Fine Soil (6)	Fine Elemental Carbon (6)	Total CPM_{10}	Total CPM IOR (7)	Sulfates (8)	Total CPM OR (7)
Gerald Andrus Unit 1	Gas/oil boiler	Natural Gas	7,275	5.7	3.66	3,971	13.6	40.7	54.2	13.6	0.00	13.6	12.6	0.91	40.7	1.12	1.12	39.5

Notes:

(1) Baseline period for the BART analysis is 2001 - 2003.
SO_2 emissions based on 8/5/02.
NO_x emissions based on 10/10/01.

(2) Max hourly heat input rate based on design rating of boiler firing natural gas. Filterable PM emission rate is based on AP-42 Section 1.3 (Filt PM = 9.19 (S) + 3.22).

Heating Value of natural gas = 1020 Btu/scf

(3) Condensable PM Emission factor based on AP-42 Table 1.4-2 (5.7 lb/10^6 scf) for natural gas fired boiler.
(4) Condensable PM_{10} emissions (lb/hr) calculated using the factor given in Note (3) above. Max. daily natural gas usage rate was calculated from the max daily heat input rate using a natural gas heating value of 1020 Btu/scf.
(5) Filterable PM_{10} and Fine PM_{10} are both assumed to be 100% of total filterable PM as given in AP-42 Table 1.4-2. Coarse PM_{10} is calculated as the difference between total PM_{10} and fine PM_{10}.
(6) Elemental carbon or black carbon is 6.7% of fine PM_{10} based on the best estimates for natural gas in Table 6 of "Catalog of Global Emissions Inventories and Emission Inventory Tools for Black Carbon", William Battye and Kathy Boyer, EPA Contract No. 68-D-98-046, January 2002. Fine soil is the difference between fine total and fine EC.
(7) Total organic CPM = total CPM minus total inorganic CPM. Total inorganic CPM = all sulfates.
(8) All inorganic CPM_{10} is assumed to be sulfates. Sulfates calculated as 20% of SO_2 * (98/64)

Table 2-3: Gerald Andrus Unit 1 – Baseline Modeling Emissions for Oil Firing (2.9% Sulfur)

EMISSION UNIT ID	EMISSION UNIT DESCRIPTION	FUEL USED	MAX DAILY OPERATING RATE (MMBtu/hr) (2)	PM condensable Emission Factor (3) (lb/1000 gal)	SO_2 Emissions (lb/hr) (1)	NO_x Emissions (lb/hr) (1)	PM filterable (lb/hr) (2)	PM condensable (lb/hr) (4)	PM_{10} Emissions (lb/hr)									
										Filterable					Condensable			
																CPM IOR		
									Total PM_{10} Emissions (filterable + condensable)	Total FPM_{10} (5)	Coarse PM_{10} (5)	Fine PM_{10} (5)	Fine Soil (6)	Fine Elemental Carbon (6)	Total CPM_{10}	Total CPM IOR (7)	Sulfates (8)	Total CPM OR (7)
Gerald Andrus Unit 1	Gas/oil boiler	#6 Oil	7,275	1.5	24,395	7,605	1,560.3	72.8	1180.5	1107.8	296.5	811.3	751.3	60.04	72.75	61.8	61.8	10.9

Notes:
(1) Baseline period for the BART analysis is 2001 - 2003.
SO_2 emissions based on 1/3/01.
NO_x emissions based on 1/3/01.
(2) Max hourly heat input rate based on design rating of boiler firing oil. Filterable PM emission rate is based on AP-42 Section 1.3 (Filt PM = 9.19 (S) + 3.22).
Sulfur content of Fuel Oil = 2.9 % Heating Value of Fuel Oil = 0.15 MMBtu/gal
(3) Condensable PM Emission factor based on AP-42 Table 1.3-2 (1.5 lb/1000 gal) for #6 oil fired boiler.
(4) Condensable PM_{10} emissions (lb/hr) calculated using the factor given in Note (3) above. Max. daily oil usage rate was calculated from the max daily heat input rate using an oil heating value of 0.15 MMBtu/gal.
(5) Filterable PM_{10} portion of total filterable PM is calculated using the cumulative size distributions given in AP-42 Table 1.3-4 (uncontrolled size fractions). Fine PM_{10} is calculated as Total Filterable PM * 0.52. Coarse PM_{10} is calculated as the difference between total PM_{10} and fine PM_{10}.
(6) Elemental carbon or black carbon is 7.4% of fine PM_{10} based on the best estimates for industrial petroleum in Table 6 of "Catalog of Global Emissions Inventories and Emission Inventory Tools for Black Carbon", William Battye and Kathy Boyer, EPA Contract No. 68-D-98-046, January 2002. Fine soil is the difference between fine total and fine EC.
(7) Per AP-42 Table1.3-2, inorganic CPM is 85% of total CPM and organic CPM is 15% of total CPM.
(8) All inorganic CPM_{10} is assumed to be sulfates.

Table 2-4: Gerald Andrus Unit 1 – Baseline Modeling Emissions for Oil Firing (1% Sulfur)

EMISSION UNIT ID	EMISSION UNIT DESCRIPTION	FUEL USED	MAX DAILY OPERATING RATE (MMBtu/hr) (2)	PM condensable Emission Factor (3) (lb/1000 gal)	SO_2 Emissions (lb/hr) (1)	NO_x Emissions (lb/hr) (1)	PM filterable (lb/hr) (2)	PM condensable (lb/hr) (4)	PM_{10} Emissions (lb/hr)									
									Total PM_{10} Emissions (filterable + condensable)	Filterable					Condensable			
																CPM IOR		
										Total FPM_{10} (5)	Coarse PM_{10} (5)	Fine PM_{10} (5)	Fine Soil (6)	Fine Elemental Carbon (6)	Total CPM_{10}	Total CPM IOR (7)	Sulfates (8)	Total CPM OR (7)
Gerald Andrus Unit 1	Gas/oil boiler	#6 Oil	7,275	1.5	7,615	7,605	602	72.8	500	427	114	313	290	23.2	72.8	61.8	61.8	10.91

Notes:
(1) Baseline period for the BART analysis is 2001 - 2003.
SO_2 emissions based on 1/3/01.
NO_x emissions based on 1/3/01.
(2) Max hourly heat input rate based on design rating of boiler firing oil. Filterable PM emission rate is based on AP-42 Section 1.3 (Filt PM = 9.19 (S) + 3.22).
Sulfur content of Fuel Oil = 1.0 % Heating Value of Fuel Oil = 0.15 MMBtu/gal
(3) Condensable PM Emission factor based on AP-42 Table 1.3-2 (1.5 lb/1000 gal) for #6 oil fired boiler.
(4) Condensable PM_{10} emissions (lb/hr) calculated using the factor given in Note (3) above. Max. daily oil usage rate was calculated from the max daily heat input rate using an oil heating value of 0.15 MMBtu/gal.
(5) Filterable PM_{10} portion of total filterable PM is calculated using the cumulative size distributions given in AP-42 Table 1.3-4 (uncontrolled size fractions). Fine PM_{10} is calculated as Total Filterable PM * 0.52. Coarse PM_{10} is calculated as the difference between total PM_{10} and fine PM_{10}.
(6) Elemental carbon or black carbon is 7.4% of fine PM_{10} based on the best estimates for industrial petroleum in Table 6 of "Catalog of Global Emissions Inventories and Emission Inventory Tools for Black Carbon", William Battye and Kathy Boyer, EPA Contract No. 68-D-98-046, January 2002. Fine soil is the difference between fine total and fine EC.
(7) Per AP-42 Table1.3-2, inorganic CPM is 85% of total CPM and organic CPM is 15% of total CPM.
(8) All inorganic CPM_{10} is assumed to be sulfates.

3.0 Meteorological Data used in Visibility Improvement Modeling

This section discusses the meteorological CALMET database that was used for the Gerald Andrus BART modeling.

3.1 General Modeling Procedures

VISTAS developed five sub-regional 4-km CALMET meteorological databases for three years (2001-2003), as well as a 12-km screening meteorological database for the same years. The sub-regional modeling domains were strategically designed to cover all potential BART eligible sources within VISTAS states and most PSD Class I areas within 300 km of those sources. The extents of the 4-km sub-regional domains are shown here: http://www.vistas-sesarm.org/BART/CALMETSubdomains_21Dec2005.jpg.

To conduct consistent CALPUFF modeling for both Entergy BART-eligible plants in Mississippi (Gerald Andrus and Baxter Wilson), it was necessary for us to create a CALPUFF modeling domain that extends into a portion of Arkansas, which would lie outside the 4-km VISTAS database. An alternative database would be the CENRAP screening subdomain 6-km database, but CENRAP has not provided the supplemental meteorological data that VISTAS provides. Therefore, we used the VISTAS meteorological data to create a single CALMET database for assessing regional haze impacts in Class I areas for both Entergy BART-eligible plants in Mississippi.

3.2 Modeling Domain and Receptors

The modeling domain was designed to encompass the closest Class I areas to the specific Entergy plants (Gerald Andrus and Baxter Wilson), plus a 50-km buffer. The resultant modeling domain extends 636 km East-West and 600 km North-South with a 4-km grid resolution. The domain is shown in Figure 3-1.

The receptors used for Caney Creek are based on the National Park Service database of Class I receptors, as recommended by VISTAS (found at: http://www2.nature.nps.gov/air/maps/Receptors/index.htm).

3.3 CALMET Processing

The CALMET control input file contains numerous switches and settings that drive how the 3-dimensional wind-field will be produced, which in turn can affect dispersion within the CALPUFF model and ultimately estimates of the modeled ground level concentrations. In August 2009, the USEPA Model Clearinghouse (in cooperation with the Federal Land Managers [FLMs]) issued a memo containing recommended settings for use in CALMET (http://www.epa.gov/ttn/scram/guidance/clarification/CALMET%20CLARIFICATION.pdf). For this application, we propose to run three year s (2001-2003) of CALMET (Version 5.8) with all USEPA-FLM recommended values.

For the hourly wind field initialization, CALMET uses gridded prognostic mesoscale meteorological (MM5) data for all three years (2001-2003). The following three years of MM5 data have been assembled by VISTAS for use in the regional CALPUFF modeling:

- 2001 and 2002 MM5 data set with 12-km resolution
- 2003 MM5 dataset with 36-km resolution.

These prognostic meteorological data sets were combined with 4-km grid resolution terrain and land use data to more accurately characterize the wind flow throughout the modeling domain. The 4-km gridded terrain data was derived from United States Geological Survey (USGS) 1:250,000 (3 arc second or 90-meter grid spacing) Digital Elevation Model (DEM) files using the TERREL pre-processor program. The gridded land use data was derived from USGS 1:250,000 Composite Theme Grid (CTG) land use files.

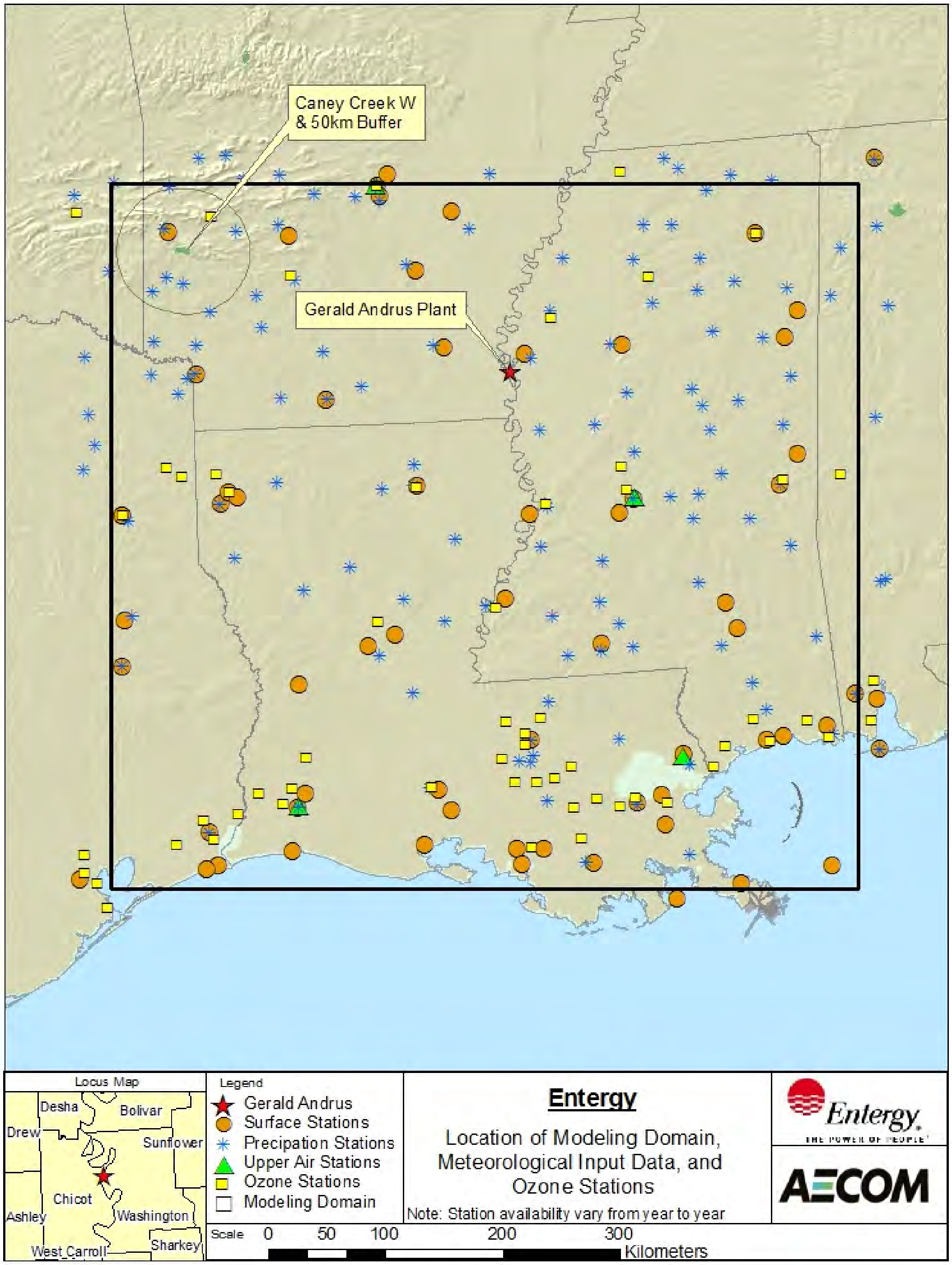
The Step 2 wind field was produced with the input of hourly surface and twice daily upper air balloon sounding data. Hourly precipitation data was also included in the CALMET simulations. Surface, upper air and precipitation files have been prepared by TRC for use in the VISTAS regional CALPUFF modeling effort. Appendix B lists stations IDs and coordinates projected in Lambert Conformal projection. Please note that the stations (surface and precipitation) vary from year to year and the tables in Appendix B represent the most complete year (2003) out of the three year period.

The following files were previously downloaded from the TRC website (link no longer works) http://www.src.com/verio/download/sample_files.htm#STANDARD_SURF.

- Standard surface files (2001-2003)
- Standard precipitation files (2001-2003)
- VISTAS Regional Domain 1 upper air data files (2001-2003). Only four upper air stations were selected from the dataset due to their proximity to this proposed modeling domain.

CALPUFF PROfessional System software, SUBDOMN tool was used to extract a smaller subset of the surface and precipitation datasets. (The software is created and distributed by TRC).

Figure 3-1: Location of Modeling Domain, Meteorological Input Data, and Ozone Stations



4.0 CALPUFF Modeling Procedures

This section provides a summary of the modeling procedures that were used for the refined CALPUFF analysis conducted for the Gerald Andrus Power Plant.

4.1 CALPUFF Processing

Similar to CALMET, the CALPUFF control input file also contains numerous switches and settings that drive how certain data will be processed, which in turn can affect dispersion within the CALPUFF model and, ultimately, estimates of the modeled regional haze impacts. In March 2006, the USEPA Model Clearinghouse issued a memo containing recommended settings for use in CALPUFF.

For this application, CALPUFF was run with all USEPA recommended settings. Most other CALPUFF settings that require user-definition and have not been specified in the March 2006 memo are meant to be tailored to specific applications. Much like CALMET, these values pertain to selection of file names, specification of beginning and ending time period for the simulation, and map.

4.2 Model Selection and Features

The EPA-approved version CALPUFF (V5.8), and POSTUTIL (V1.56) was used for BART modeling. CALPOST Version 6.292 was used to process modeling results and compute regional haze impacts at each receptor. CALPOST V6.292 contains the recommended FLAG (2010) techniques on visibility assessment, specifically the new IMPROVE equation.

4.3 Background Ozone and Ammonia

Three years (2001-2003) of hourly measurements of ozone from all non-urban monitors, as generated by VISTAS, was used as input to CALPUFF. The ozone data is consistent with the years of meteorological data. AECOM used the CALPUFF professional System software tool (SUBDOMN) to extract ozone stations inside the modeling domain from the VISTAS ozone database. Appendix B lists the selected station ID numbers and coordinates in Lambert Conformal projection. For ammonia, we followed the VISTAS-recommended approach to use a background ammonia concentration of 0.5 ppb, and not to use the ammonia limiting method.

4.4 CALPOST Visibility Impacts Processing

The CALPOST postprocessor was used for the calculation of the impact of the modeled source's primary and secondary particulate matter concentrations on light extinction. In accordance with FLAG 2010 guidance, the visibility impacts at Caney Creek Wilderness were processed using CALPOST Method 8 (MVISBK=8) and sub-mode five (M8_MODE=5). The Method 8 (new IMPROVE equation) allows a spit between large and small sulfate, nitrate and organic particles when calculating natural background conditions and change in light extinction.

The annual average concentrations, Raleigh scatting coefficient, and sea salt concentrations were taken from FLAG (2010) Table 6. The monthly relative humidity adjustment factors for large sulfate and nitrate particles were taken from FLAG Table 7 and for small particles from FLAG Table 8. The sea salt relative humidity adjustment factors were taken from FLAG Table 9.

5.0 CALPUFF Modeling and BART Exemption Results

This section provides a summary of the modeled visibility impacts due to the baseline emissions on Gerald Andrus Unit 1.

5.1 Modeling Results for Baseline Emissions

5.1.1 Results for Natural Gas Firing

CALPUFF modeling results of the baseline emissions at Caney Creek Wilderness are presented in Table 5-1. The modeling results indicated that natural gas firing visibility impacts (8^{th} highest) are far below the contribution threshold of 0.5 delta-deciviews, while oil-fired impacts are above the threshold. Therefore, natural gas firing operations are not subject to BART.

5.1.2 Results for Oil Firing

While the oil-fired impacts, with the RHR baseline (2.9 % sulfur oil) and current baseline emissions (1.0 % sulfur oil), assuming 24-hour-per-day operation both show modeled visibility impacts over the contribution threshold of 0.5 delta-deciviews, scaling of the current baseline results indicates that the minimum number of hours of oil firing required to exceed this impact is as follows:

- 14 hours per day firing 1.0 % sulfur oil for Unit 1.

These operations in terms of oil firing hours per day thus define an “oil burn day” for purposes of the discussion provided below.

The modeling protocol states:

“If the exemption modeling demonstrates that the BART-eligible unit at the Gerald Andrus plant does not cause or contribute to visibility impairment with either gas-firing emissions case or oil-firing emissions case (or both cases), then that case/fuel will not be subject to BART requirements, and no further analysis will be needed. Otherwise, Entergy will proceed to perform BART determination modeling for the baseline and each selected control option for any remaining case/fuel. One exception to this requirement could occur if the selected case (e.g., oil firing) was limited to a number of days per year corresponding to the 98^{th} percentile BART-relevant statistic (8^{th} highest day) weighted by the likelihood of winds blowing toward the Caney Creek Wilderness Area. For example, if a representative wind rose indicated that the probability of wind from the east-southeast is 20% as an annual average, then the allowable frequency of a specific emission case that could trigger the 98^{th} percentile day’s impact at Caney Creek would be 40 or more days per year.”

Entergy has elected to select this exemption by limiting the number of oil burn days per year. The restriction on the number of oil burn days was computed by examining representative wind roses from nearby major airports (Greenville, MS, Jackson, MS, McComb Pike County, MS, and Little Rock, AR, as shown in Figure 5-1 and their locations are plotted in Figure 5-2) and conservatively selecting the most restrictive result. The wind roses indicate that the highest probability of wind from the most frequent 90-degree sector[3] is about 43% as an annual average (Jackson, MS). The other two airport locations have a lesser wind frequency from the 90-degree sector, as presented in Table 5-2. The allowable frequency of the oil firing operations that could trigger the 98th percentile day's impact at Caney Creek is thus conservatively computed from 8 days/43%, which exceeds 18. Therefore, restricting oil burn days to no more than 18 days will ensure that that the frequency of oil firing cannot affect the 98th percentile day at any Class I area. Due to the conservatism of this approach, it is reasonable to express this operational condition as a 3-year average which would exclude any infrequent need to fire oil due to emergency conditions such as natural gas fuel disruptions.

Table 5-1: Regional Haze Impacts due to Baseline Emissions

Fuel Type	2001 8th Highest Change in Extinction (delta-dv)	2002 8th Highest Change in Extinction (delta-dv)	2003 8th Highest Change in Extinction (delta-dv)
Natural Gas Combustion	0.12	0.08	0.15
Oil Combustion (RHR baseline, 2.9 % sulfur)	1.00	1.62	2.08
Oil Combustion (current baseline, 1.0 % sulfur)	0.68	0.34	0.73

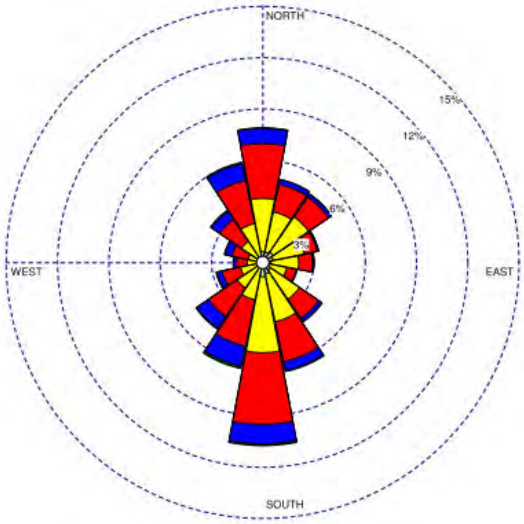
5.2 Conclusions

The modeling results indicate that natural has firing visibility impacts that are far below the contribution threshold of 0.5 delta-deciviews for each year. Therefore, natural gas firing operations are not subject to BART. The modeling results for oil firing are above the contribution threshold of 0.5 delta-deciviews for all three years. However, consistent with the modeling protocol, Entergy agrees to restrict oil burning days (as defined in Section 5.1.2) to no more than 18 per year (averaged over 3 years and excluding emergency conditions) to avoid BART review.

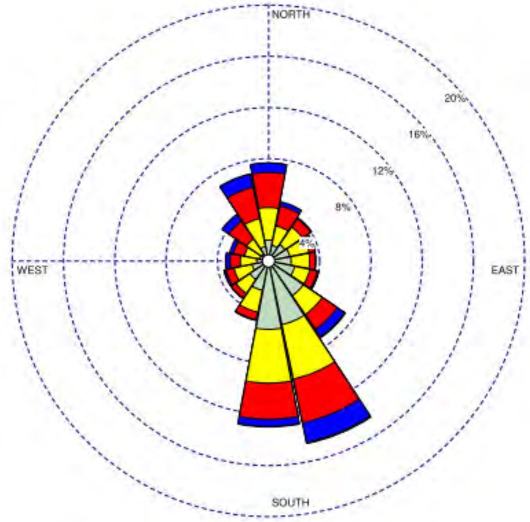
[3] A 90-degree sector is selected as a source-affected wind direction, consistent with the discussion in Section 8.2.2 of EPA's modeling guidance (40 CFR Part 51, Appendix W).

Figure 5-1: Wind Roses for the Nearest Regional Airports

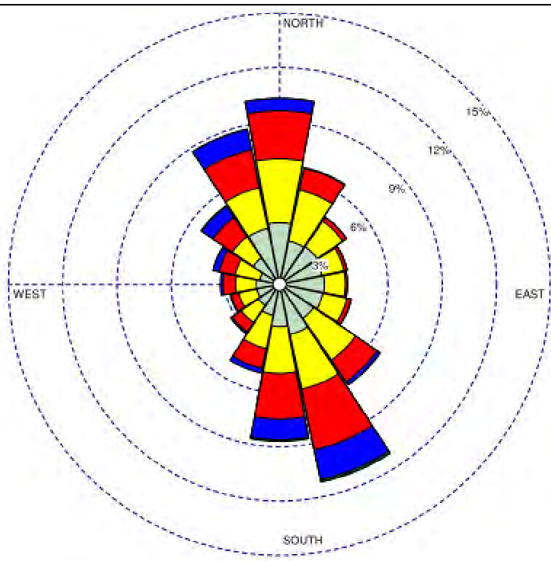
Greenville Airport, MS Wind Rose



Jackson Airport, MS Wind Rose



McComb Pike County Airport, MS Wind Rose



Little Rock, AR Wind Rose

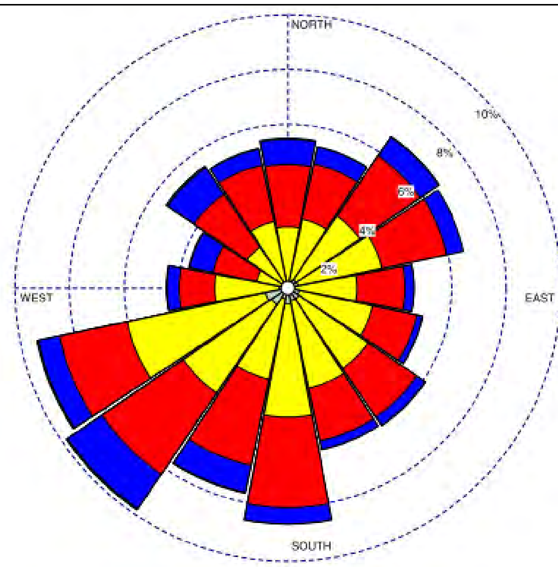


Figure 5-2: Location of Major Regional Airports Relative to Gerald Andrus Plant

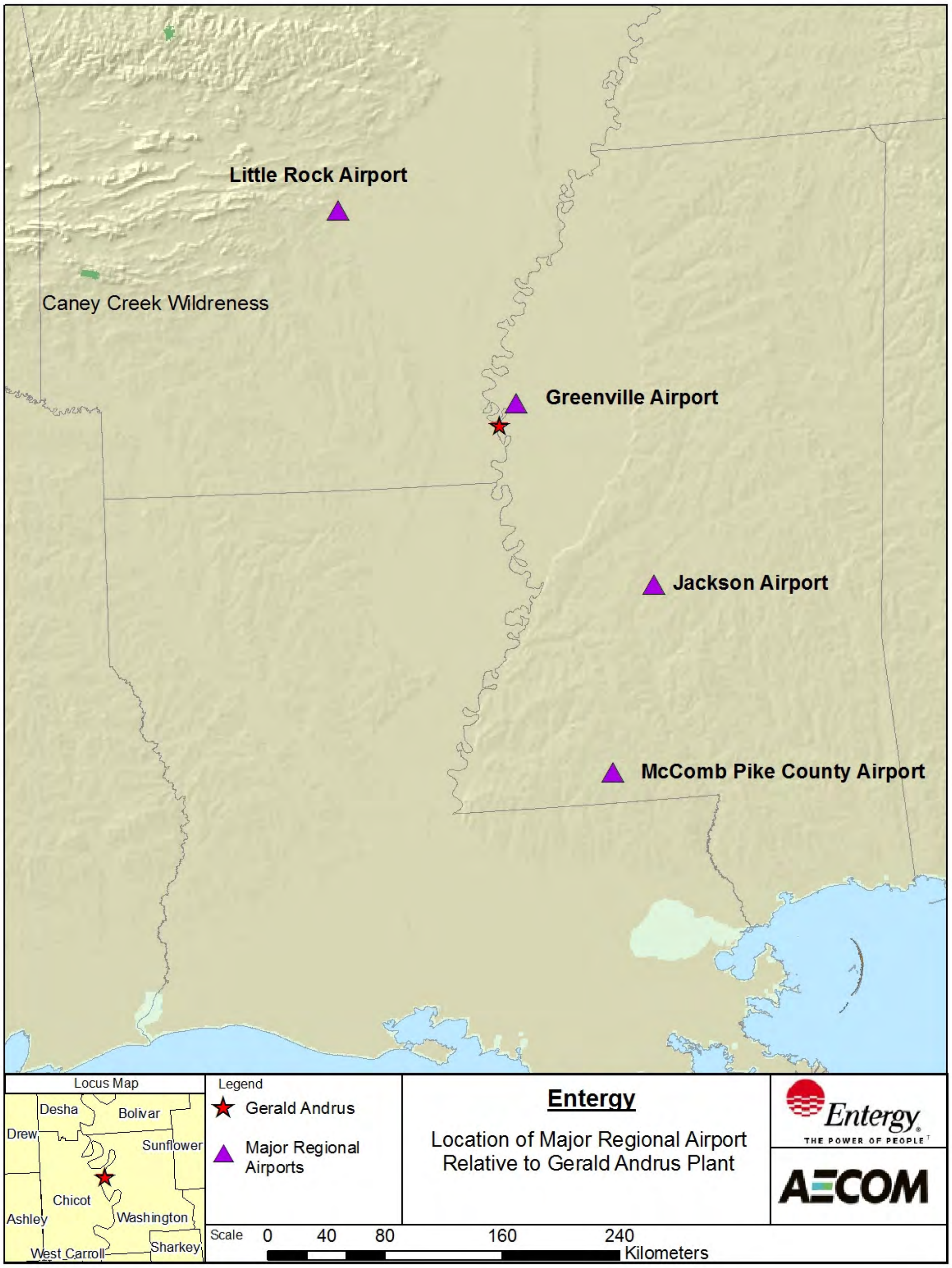


Table 5-2: Wind Direction Frequencies for the 90-degree Sector at the Nearest Regional Airports

	Greenville Airport, MS	Jackson Airport, MS	McComb Pike County Airport, MS	Little Rock Airport, AR
Total Wind Frequency for the 90-Degree Sector	31%	43%	36%	40%

6.0 References

Environmental Protection Agency (EPA), Tyler Fox Memorandum: Clarification on EPA-FLM Recommended Settings for CALMET. August 31, 2009.

Environmental Protection Agency (EPA), Dennis Atkinson Memorandum: Dispersion Coefficients for Regulatory Air Quality Modeling in CALPUFF. March 16, 2006.

Environmental Protection Agency (EPA), 40 CFR Part 51, FRL -7925-9, RIN: 2060-AJ31, Regional Haze Regulations and Guidelines for Best Available Retrofit Technology (BART) Determinations (Appendix Y), updated June 24, 2005

Environmental Protection Agency (EPA), Guidance for Tracking Progress Under the Regional Haze Rule, EPA-454/B-03-003, Appendix A, Table A-3, September, 2003

Federal Land Managers' Air Quality Related Values Work Group (FLAG). Phase I Report. Revised 2010.

Visibility Improvement State and Tribal Association of the Southeast (VISTAS), Revision 3, Protocol for the Application of the CALPUFF Model for Analyses of Best Available Retrofit Technology (BART), updated July 18, 2006.

Appendix A Responses to EPA R4 Comments-BART Modeling Protocols-Entergy MS

Entergy Responses to U.S. EPA Region 4 Comments on BART Exemption Modeling Protocols for

Entergy Mississippi's Gerald Andrus Unit 1 and Baxter Wilson Units 1 and 2

1. GEP Stack Heights: The protocols do not discuss the stack height and stack parameters for the units that will be modeled nor if they will comply with good engineering practice (GEP). Please document that the modeling for regulatory purposes includes the GEP stack heights.

   Entergy Response: *The table below summarizes stack exhaust parameters that were used in the CALPUFF modeling; these are included in the BART reports. AECOM has conducted a GEP analysis for the Gerald Andrus Unit 1 stack and Baxter Wilson Unit 1 and Unit 2 stacks and concluded that they are fully creditable. Therefore, actual stack heights, shown in the table below, were used in modeling, along with the appropriate building downwash inputs.*

Unit	Actual Stack Height (m)	Base Elevation (m)	Stack Diameter (m)	Exit Velocity (m/s)	Temp (K)
Gerald Andrus Unit 1	152.10	45.42	8.77	19.65	434.30
Baxter Wilson Unit 1	149.40	32.00	5.80	24.08	380.40
Baxter Wilson Unit 2	149.40	32.00	7.00	33.23	449.30

2. The U.S. Fish and Wildlife Service (USFWS) reprocessed the original VISTAS 4-km CALMET dataset using CALMET v5.8, level 070623. It is unclear if this dataset is being used in the modeling or if the FLMs were consulted in the development of a new dataset. EPA Region 4 recommends that this reprocessed CALMET dataset be used.

   Entergy Response: *The VISTAS 4-km CALMET dataset reprocessed by USFWS is not big enough to cover a modeling domain that encompasses both Gerald Andrus and Baxter Wilson plants along with Breton Wilderness area and Caney Creek Class I area (plus a 50 kilometers buffer). However, AECOM created, in a manner consistent with the USFWS reprocessing approach, a single CALMET database for assessing regional haze impacts in Class I areas for both Entergy plants. The CALMET database used the same inputs that were used to develop the regional 12-kilometers VISTAS dataset for screening modeling, such as surface observations, upper air data, precipitation, and MM5 data. The EPA-approved version of CALMET v5.8, level 070623 was used.*
3. The report should document how the EPA modeling recommendations, etc., are applied. EPA recommends including, in the modeling report, specific details documenting the switches, assumptions, years of data and names of meteorological and air quality monitoring stations, etc. used in developing and simulating CALMET, CALPUFF, CALPOST, POSTUTIL and the CALPUFF professional System software tool (SUBDOMN).

Entergy Response: *CALPUFF was run with all USEPA recommended settings specified in the March 2006 USEPA Model Clearinghouse memo and the May 15, 2009 EPA Model Clearinghouse recommendations.*

Three years (2001-2003) of hourly CALMET input data (surface observations, upper air, precipitation) were extracted from the VISTAS database using CALPUFF professional System software tool (SUBDOMN). AECOM has listed the selected station ID numbers and coordinates in the modeling report.

4. For the Gerald Andrus Unit, the 24-hour emissions from the baseline period will be used for the unit. It is unclear if the emissions were determined from continuous emissions monitoring or stack tests, etc. data for specific pollutants. EPA recommends clarifying, in the modeling report, how the emissions were determined (i.e. continuous emissions monitoring or stack heights for specific pollutants.)

   Entergy Response: *Baseline SO_2 and NOx emissions from the unit were based on the maximum actual daily SO_2 and NOx emission rates recorded by the CEMS during the period 2001-2003. Determination of filterable particulate matter and speciation of the particulate matter emissions from the unit into filterable and condensable PM_{10} components was conducted using the following approach:*

   - *The total filterable PM emission rate for oil firing was determined using AP-42 Section 1.3 and that for gas firing was based on AP-42 Section 1.4.*
   - *For oil firing, the filterable PM_{10} portion of the total filterable PM was calculated using the cumulative size distributions given in AP-42 Table 1.3-4 (uncontrolled size fractions). The total filterable PM_{10} is 71% of the filterable PM. The fine PM_{10} (i.e., $PM_{2.5}$) was calculated as the 52% of total filterable PM. The coarse PM_{10} (particles with aerodynamic diameters between 10 microns and 2.5 microns) was calculated as the difference between the total filterable PM_{10} and the fine PM_{10} (filterable $PM_{2.5}$). For gas firing, all filterable PM is considered to be total filterable $PM_{10.}$ Moreover, total filterable PM_{10} is considered to all $PM_{2.5}$.*
   - *Elemental carbon (EC) or black carbon was estimated to be 7.4% of fine PM_{10} ($PM_{2.5}$) based on the best estimates for industrial petroleum in Table 6 of "Catalog of Global Emissions Inventories and Emission Inventory Tools for Black Carbon", William Battye and Kathy Boyer, EPA Contract No. 68-D-98-046, January 2002. For gas firing, elemental carbon or black carbon was estimated to be 6.7% of fine PM_{10} ($PM_{2.5}$) based on the best estimates for natural gas in Table 6 of "Catalog of Global Emissions Inventories and Emission Inventory Tools for Black Carbon", William Battye and Kathy Boyer, EPA Contract No. 68-D-98-046, January 2002. For both gas and oil firing cases, fine soil is the difference between fine total PM and fine EC.*
   - *For oil firing, the condensable PM emission factor was based on AP-42 Table 1.3-2 (1.5 lb/1000 gal) for No.6 oil-fired boilers. All inorganic condensable PM_{10} was assumed to be sulfates (i.e. no soil component). For gas firing, the condensable PM emission factor was based on AP-42 Table 1.4-2 (5.7 lb/MMcf) for gas-fired boilers. Organic condensable PM is the difference between total condensable PM and inorganic condensable PM.*

5. EPA recommends the use of metric units for the modeling report.

   Entergy Response: *We are using metric units for the BART report.*

6. Please clarify if the ozone data used is consistent with the year of meteorological data.

Entergy: *Three years (2001-2003) of hourly measurements of ozone from all non-urban monitors, as generated by VISTAS, were used as input to CALPUFF. The ozone data is consistent with the years of meteorological data. AECOM used the CALPUFF professional System software tool (SUBDOMN) to extract ozone stations inside the modeling domain from the VISTAS ozone database. We list the selected station ID numbers and coordinates in the BART report.*

Appendix B

Surface, Precipitation, Upper Air, and Ozone Stations used in CALMET and CALPUFF

Table B-1: Surface Stations Used in CALMET

Surface Station ID	Surface Station No.	X LC (km)	Y LC (km)
KMOB	722230	839.42	-992.98
KBFM	722235	857.47	-996.83
K7R5	722293	359.50	-1126.77
KAXO	722309	687.47	-1167.20
KMSY	722310	653.63	-1085.51
KHDC	722312	633.30	-1029.02
KARA	722314	495.48	-1092.15
KNEW	722315	674.17	-1078.34
KNBG	722316	677.72	-1104.23
KBTR	722317	562.77	-1032.06
KIER	722319	369.58	-908.32
BVE	722320	742.00	-1153.46
K7R3	722328	573.62	-1124.75
KPTN	722329	550.88	-1124.30
KMEI	722340	774.91	-814.23
KNMM	722345	789.81	-788.60
HBG	722347	738.18	-936.72
KPIB	722348	728.42	-915.17
KJAN	722350	650.11	-826.45
KHKS	722354	638.40	-838.95
KGLH	722356	557.07	-703.10
KHEZ	722357	540.78	-912.22
KMCB	722358	622.76	-949.62
KGWO	722359	640.10	-695.29
KASD	722366	692.38	-1043.26
KPOE	722390	364.92	-984.77
KLCH	722400	364.46	-1089.15
KP92	722403	554.91	-1137.18
KCWF	722404	370.37	-1077.70
KLFT	722405	484.78	-1074.03
KHUM	722406	616.69	-1136.78
K7R4	722408	472.80	-1121.42
KBPT	722410	289.25	-1110.64

Surface Station ID	Surface Station No.	X LC (km)	Y LC (km)
KEFD	722436	178.51	-1150.88
KLFK	722446	214.64	-969.36
KBBB	722447	214.57	-841.16
KRPE	722453	296.69	-1138.40
KGGG	722470	214.57	-841.16
KSHV	722480	298.87	-831.17
KDTN	722484	304.83	-821.71
KBAD	722485	312.74	-825.10
KMLU	722486	465.83	-816.21
KESF	722487	447.25	-941.81
KTVR	722488	561.45	-840.23
KOCH	722499	216.81	-930.25
KMSL	723235	854.85	-536.69
KCBM	723306	789.25	-665.84
KGTR	723307	779.07	-689.11
KTUP	723320	753.88	-600.34
KLZK	723400	432.06	-560.44
KLIT	723403	434.09	-569.55
KLRF	723405	440.65	-550.66
KHOT	723415	356.47	-602.90
KSGT	723416	495.66	-582.75
KPBF	723417	464.99	-632.64
KTXK	723418	278.02	-720.62
KELD	723419	388.78	-742.15
KLLQ	723424	488.66	-698.01
KMWT	723435	254.18	-599.22
KDEQ	743312	239.06	-655.17
KAEX	747540	423.93	-952.26
KGPT	747685	764.01	-1031.68
KBIX	747686	778.25	-1028.52
KPQL	747688	814.60	-1019.58
SRST	994260	287.08	-1142.42
GDIL	994290	687.33	-1165.30
DPIA	994420	860.14	-1039.59

Table B-2: Precipitation Stations Used in CALMET

Station No.	X LC (km)	Y LC (km)
10748	867.19	-661.92
12172	860.14	-1039.59
13620	857.60	-594.28
13645	826.58	-612.37
14193	860.85	-896.44
15478	839.75	-992.38
15749	854.91	-537.35
18178	864.92	-894.24
18517	817.92	-653.16
18673	856.01	-757.13
30130	378.44	-567.18
30178	329.09	-653.66
30220	361.85	-640.42
30764	347.38	-593.62
30798	303.54	-534.77
30832	280.21	-536.82
30900	318.62	-553.95
30936	528.20	-549.41
31140	419.13	-730.91
31152	386.23	-700.79
31952	241.47	-649.55
32020	267.30	-643.54
32148	503.62	-661.75
32300	389.04	-741.70
32489	413.84	-569.59
32544	241.87	-692.18
34185	318.41	-729.09
34248	433.68	-572.13
34548	349.89	-740.07
34756	251.18	-596.76
34839	278.11	-695.39
34900	479.78	-695.18
34988	311.64	-598.26
35110	301.43	-642.05
35112	289.98	-666.88
35200	348.86	-550.84
35320	431.14	-560.27
35754	456.74	-626.54
35908	334.10	-679.90
36920	510.24	-596.64
37048	277.36	-720.20
37488	255.09	-560.48
160103	433.83	-959.25
160537	466.82	-788.08

Station No.	X LC (km)	Y LC (km)
169803	409.18	-884.89
169806	498.13	-860.88
220021	780.86	-646.56
220237	624.92	-557.32
220797	767.49	-1027.22
220955	768.03	-554.48
221094	621.83	-914.24
221314	704.36	-649.24
221389	651.29	-786.52
221707	589.89	-621.06
221743	579.23	-666.31
221852	705.60	-897.60
221900	725.12	-804.87
222281	778.10	-763.65
222658	715.73	-767.37
222773	649.81	-622.16
222870	700.04	-733.20
222896	718.16	-684.06
223619	630.72	-694.10
223650	666.64	-659.80
223920	619.18	-882.80
224001	712.46	-564.03
224173	687.97	-544.85
224265	736.01	-640.94
224472	650.64	-826.08
224778	708.89	-747.30
224966	805.89	-943.78
225062	644.69	-735.83
225074	594.25	-959.23
225247	737.46	-728.23
225361	784.42	-721.64
225614	622.78	-955.21
225704	581.41	-926.34
225776	775.45	-813.95
226084	676.60	-536.56
226400	739.08	-742.48
226718	820.10	-1026.59
226750	748.87	-853.22
226816	681.34	-824.01
227132	571.10	-867.49
227220	725.02	-950.94
227276	701.77	-842.91
227444	767.42	-923.09
227467	732.59	-550.35

Station No.	X LC (km)	Y LC (km)
160548	565.24	-1044.90
160549	563.03	-1031.60
161246	552.59	-1049.51
161287	462.56	-991.30
161411	436.34	-818.22
161899	577.67	-999.18
162534	577.43	-1083.33
164030	638.24	-1030.57
164407	610.15	-1135.44
164696	455.10	-911.70
164700	418.74	-1077.43
164739	489.50	-930.25
165021	476.57	-1072.58
165078	364.91	-1088.23
165287	355.36	-985.17
165620	562.33	-1050.69
165624	698.59	-1129.11
165874	311.04	-876.52
166244	347.15	-812.08
166303	465.09	-816.36
166314	462.55	-814.61
166394	565.69	-1127.17
166582	369.77	-903.96
166660	653.59	-1086.30
166664	665.64	-1093.92
167738	316.27	-834.21
168163	544.68	-874.79
168440	298.22	-831.52
168539	697.93	-1052.13
169357	525.18	-916.98

Station No.	X LC (km)	Y LC (km)
227560	570.52	-767.58
227592	749.07	-842.58
227815	658.33	-593.66
227820	706.60	-621.20
227840	763.37	-1005.60
228053	784.33	-865.48
228374	760.43	-688.92
228445	562.79	-706.72
229003	753.52	-600.48
229048	650.03	-952.20
229079	682.85	-593.57
229218	576.67	-833.63
229617	701.23	-992.11
229648	751.70	-982.28
229860	617.24	-763.86
340670	174.40	-568.01
341544	204.00	-632.12
349724	208.61	-557.02
411773	182.94	-705.45
413546	182.41	-801.51
415348	220.69	-845.02
415424	214.25	-969.03
416108	186.06	-754.61
416177	223.55	-926.18
416270	240.11	-721.23
417066	192.25	-781.27
417174	288.86	-1110.54
417936	277.15	-986.68
418942	270.45	-724.54
419916	262.50	-737.35

Table B-3: Upper Air Stations Used in CALMET

Station ID	Station No.	X LC (km)	Y LC (km)
SIL	53813	692.27	-1045.51
JAN	3940	651.30	-826.03
LCH	3937	365.70	-1088.76
LZK	3952	430.26	-560.87

Table B-4: Ozone Stations Used in CALPUFF

Station No.	X LC (km)	Y LC (km)
CAD150	358.02	-636.53
CVL151	661.92	-637.61
10970003	854.01	-981.82
10972005	852.11	-1015.16
11190002	825.90	-805.98
50970001	290.34	-586.97
51191002	431.22	-560.76
220050004	582.44	-1064.29
220110002	371.30	-1046.89
220150008	304.85	-821.58
220170001	293.99	-806.13
220190002	350.91	-1086.75
220190008	358.85	-1073.18
220190009	330.60	-1078.08
220330013	570.60	-1012.82
220331001	556.92	-1026.37
220430001	431.44	-931.20
220470007	537.26	-1048.56
220470009	549.00	-1067.94
220470012	567.05	-1068.31
220511001	650.85	-1080.85
220550005	478.07	-1072.44
220570004	605.63	-1115.44
220630002	596.87	-1054.51
220730004	464.65	-817.09
220770001	540.91	-1016.46
220870002	678.08	-1085.68
220890003	638.24	-1088.42
220930002	598.56	-1090.05

Station No.	X LC (km)	Y LC (km)
220950002	618.53	-1081.50
221010003	562.83	-1123.73
221210001	557.26	-1035.89
280010004	532.62	-919.05
280110001	579.09	-672.32
280330002	637.59	-548.38
280450001	717.48	-1054.68
280450002	727.56	-1037.04
280470008	765.77	-1032.63
280470009	751.50	-1014.04
280490010	644.10	-819.25
280590006	815.43	-1029.48
280590007	797.18	-1014.93
280750003	776.33	-810.59
280810005	753.97	-600.56
280890002	639.07	-799.63
281490004	574.61	-831.22
481671002	201.82	-1174.86
481830001	215.00	-841.21
482010026	182.12	-1130.02
482011015	186.83	-1134.19
482011039	182.18	-1144.93
482011041	186.31	-1135.63
482011050	193.34	-1154.40
482030002	265.15	-807.73
482450009	283.34	-1100.82
482450011	292.32	-1116.79
482450022	260.38	-1121.19
483611001	313.47	-1094.76

Appendix L.7: Entergy Baxter Wilson Power Plant

Appendix L.7 contents:

Appendix L.7.1 – Appendix Summary

Entergy Mississippi, Baxter Wilson Power Plant (28-149-00027) BART Process Summary

Entergy Mississippi, Baxter Wilson Power Plant is an electricity generating facility that had two natural gas fired unit that meet the eligibility criteria for BART. Baxter Wilson is in Vicksburg, Mississippi and is 310 km from the Breton National Wildlife Refuge, a Class I area. As a fossil fuel fired steam electric plant the facility meets the initial BART eligibility requirement of source category code. Therefore, on June 3, 2011, Mississippi Department of Environmental Quality (MDEQ) sent them a letter requesting information to determine BART subjectivity. Based on the information received from Entergy, two units were deemed BART eligible because it met the following criteria:

- Operating or under construction between August 7, 1962 to August 7, 1977
- Having potential emissions that exceed the limit of 250 tons per year for SO_2, NO_X, or PM_{10}

Table L.7.1 below contains the BART-eligible point source for the Baxter Wilson Plant and the potential emissions:

Emission Unit	Heat Input (MMBtu/hr)	Potential Emissions Rates (tons per year)			Existing Control Equipment
		SO_2	NO_X	PM_{10}	
Unit No. 1	4790	64,124	8,812	4,204	None
Unit No. 2	6680	89,421	26,918	5862	None

Table L.7.1. Baxter Wilson Eligible units and Potential Emissions Rates

Because the source meets BART eligibility requirements, Entergy performed CALPUFF modeling on this unit to determine subjectivity. CALPUFF model version 5.8, Level 07623, along with the new IMPROVE equation were used in the modeling analysis per the VISTAS modeling protocol (which can be found in Appendix M of the SIP). The modeling used the maximum 24 hr average emissions rates over a three-year period of 2001-2003. These rates are shown in Table L.7.2 The modeling analysis demonstrated a 98^{th} percentile 24-hour average visibility impact over the three years modeled of 0.49 dv. This value is within the State's selected subjectivity threshold of 0.5 dv indicating that the facility is not Subject to BART. Also of note is that Baxter Wilson's BART-eligible units have removed the ability to burn fuel oil. Because the CALPUFF model has been updated since the modeling was conducted in 2012, more current (2016-2018) emissions values were compared with the baseline values to give greater assurance of the determination.

Since the modeling was performed Unit 2 at the facility has been shut down. A copy of the Acid Rain and CSAPR Trading Programs Retired Unit Exemption Form is included in this appendix. Table L.7.2 compares the modeled emissions with updated maximum 24 hr average emissions. The evaluation finds that for Unit 1, the SO2 and PM emissions which are very low were slightly higher than the modeled value but that the NOx emissions over the updated period were significantly less than the modeled emissions. Since Unit 2 has been shut down it has no emissions. The combined current emissions are about one-fifth of the modeled emissions.

Emission Unit	Modeled Emissions (Maximum 24-hour average emissions 2001-2003)			Current Emissions (Maximum 24-hour average emissions 2016-2018)		
	SO2 (lb/hr)	NOx (lb/hr)	PM_{10} (lb/hr)	SO2 (lb/hr)	NOx (lb/hr)	PM_{10} (lb/hr)
Unit 1	2.71	2030	35.69	3.67	1337	36.17
Unit 2 (decommissioned 6/2018)	2.40	4674	49.77	0	0	0
Total Units 1 and 2	5.11	6704	85.46	3.67	1337	36.17

Table L.7.2 modeled and current period hourly emissions comparison (SO2 and NOX are from the EPA Air Markets Database, PM10 is calculated using AP-42 factors and the highest daily heat input value for 2016-2018)

In addition, Table L.7.3 compares the annual baseline emissions of 2001 through 2003 to 2016 through 2018 annual emissions. As the table shows, the current annual emissions are much less than the baseline emissions.

Year	**Annual Emissions (tons)**		
	SO_2	NO_X	PM
2001	34,117.18	14,274.82	2796.09
2002	8.34	6,375.26	102.94
2003	1.99	1,325.02	24.51
2016	2.49	1,550.71	25.19
2017	2.65	794.41	25.06
2018	3.08	1,111.63	34.08

Table L.7.3 baseline and current period annual emissions comparison (Emissions are from MDEQ Title V Air emissions reporting forms.)

Since Baxter Wilson's modeling found that their impact was less than the .5 deciview impact threshold and a review of their current emissions finds that they are significantly lower than the modeled emissions, Mississippi agrees with the modeling and finds that they are not subject to BART.

Appendix L.7.2 – Modeling Protocol

AECOM Environment

Prepared for:
Entergy Mississippi, Inc.
Vicksburg, MS

Prepared by:
AECOM
Chelmsford, MA
60224627.101
November 2011

Source-Specific BART Dispersion Modeling Protocol: Baxter Wilson Units 1 & 2

AECOM Environment

Prepared for:
Entergy Mississippi, Inc.
Vicksburg, MS

Prepared by:
AECOM
Chelmsford, MA
60224627.101
November 2011

Source-Specific BART Dispersion Modeling Protocol: Baxter Wilson Units 1 & 2

Prepared By: Olga Kostrova

Reviewed By: Robert J. Paine

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1.0 Introduction

The Baxter Wilson power plant, owned and operated by Entergy Mississippi Inc., has been identified by the Mississippi Department of Environmental Quality (MDEQ) as a source that is eligible for consideration of BART controls for SO_2, NO_X, and PM_{10}. This document describes the procedures by which a modeling analysis and a BART engineering review will be conducted for the BART-eligible Baxter Wilson Units 1 and 2.

1.1 Location of Source vs. Relevant Class I Areas

The Baxter Wilson power plant is located in Vicksburg, Mississippi. Figure 1-1 shows a plot of the Baxter Wilson plant relative to nearby Class I Areas. There are no Class I areas within 300 km of the plant. The closest Class I area is Breton National Wildlife Refuge, located offshore in the Gulf of Mexico approximately 310 km to the south-southeast of the plant. Caney Creek Wilderness area is the next closest Class I area located in Arkansas and is more than 370 km from the plant. Although the VISTAS modeling protocol generally recommends that only Class I areas within 300 km are modeled for BART exemption status, in this case, Entergy will conduct BART exemption modeling for Breton, since it is only slightly more than 300 km away. The BART exemption modeling will be conducted for Breton in accordance with the VISTAS common BART modeling protocol and the procedures described in this source-specific BART modeling protocol.

1.2 Haze Composition at Breton National Wildlife Refuge

A review of the haze monitor that is representative of conditions at Breton is shown in Figure 1-2 for 2002. This information comes from an IMPROVE (Interagency Monitoring of Protected Visual Environments) monitor, and data for these monitors is available at http://views.cira.colostate.edu/web/Composition/. The figure indicates that the predominant contributor to haze at Breton National Wildlife Refuge for the worst 20% haze days is caused by sulfates due to SO_2 emissions. Other particulate species have a minor impact. The peak haze events that occurred in February 2002 were due, in large part, to a chemical explosion and fire at a petrochemical facility.

1.3 Organization of Protocol Document

Section 2 of this report describes the source emissions that will be used as input to the BART modeling. Section 3 describes the input data used for the modeling including the modeling domain, geophysical data, meteorological data, and air quality modeling procedures. Section 5 discusses the presentation of modeling results. References are provided in Section 6.

Figure 1-1: Location of Class I Areas in Relation to Baxter Wilson Plant

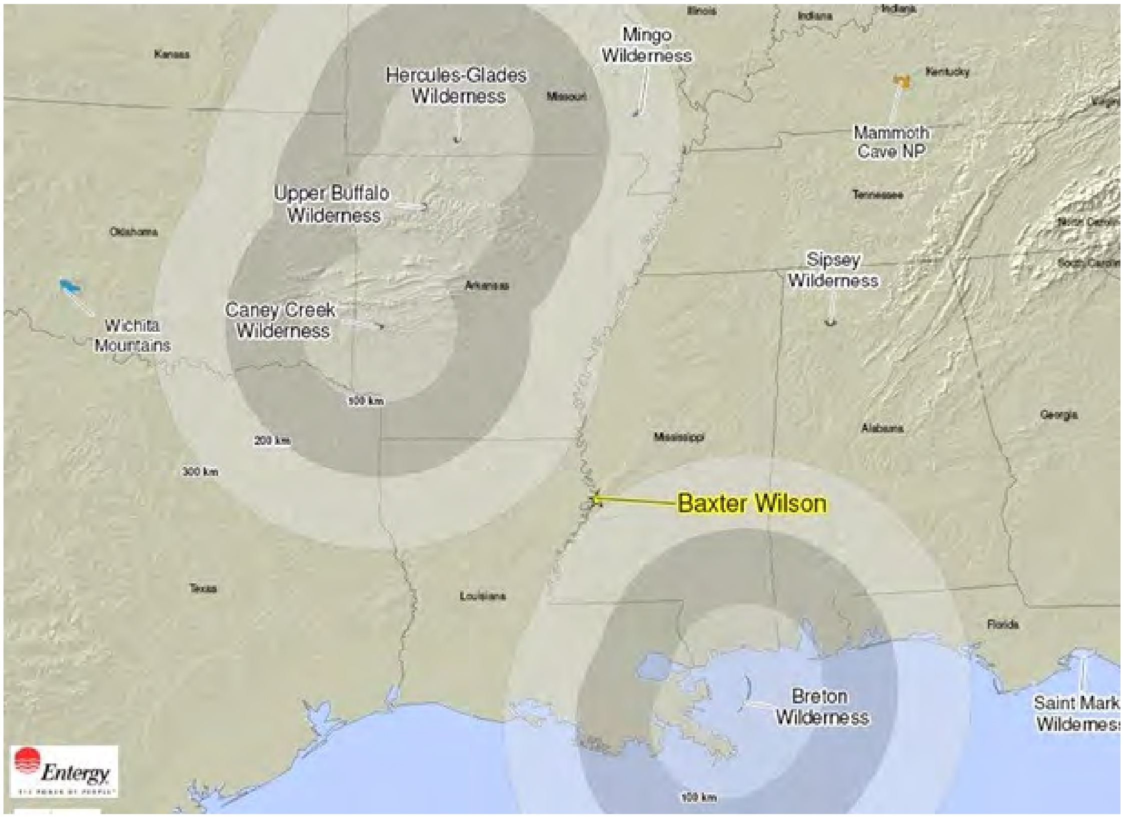
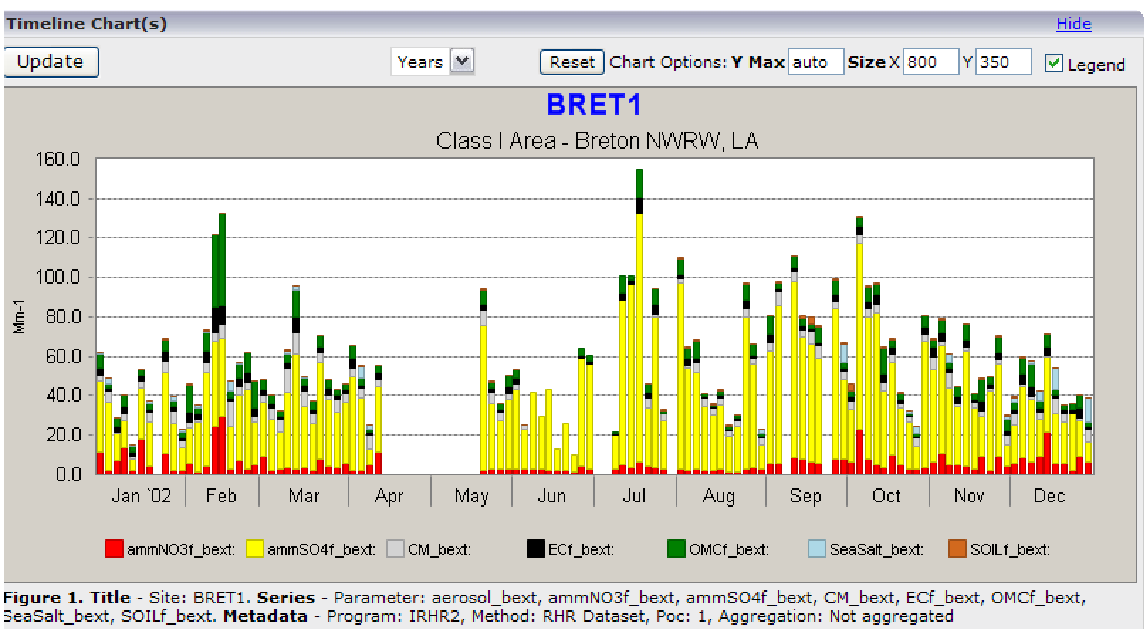


Figure 1-2: Haze Composition Plot for Breton National Wildlife Refuge for 2002



2.0 Source Data

2.1 Unit-Specific Source Data

The emissions data used to assess the visibility impacts at the selected Class I areas is discussed in this section. This analysis includes all potential visibility impairing pollutants.

Units 1 and 2 at the Baxter Wilson plant are oil and gas-fired units with a design rating of 4790 and 6680 MMBtu/hour heat input, respectively. The highest daily emissions from each fuel in the 2001 to 2003 baseline period are the focus of this emission characterization. Due to the predominant use of natural gas firing, add-on PM and SO_2 controls are not used on either unit.

The maximum hourly heat input rate for each boiler is the design rating. The SO_2 emission rate and NO_X emission rate for both fuel oil combustion and natural gas combustion were determined from Part 75 monitoring data (Clean Air Markets Database) and the facility's CEMS data. The maximum heat input used in the PM emission calculations is based on the design rating for each fuel.

Because various components of PM_{10} emissions have different visibility extinction efficiencies, the PM_{10} emissions are divided, or "speciated" into several components. The VISTAS protocol allows for the use of source-specific emissions and speciation factors. Otherwise, default values from EPA's AP-42 reference document can be used. PM_{10} was speciated in a manner that is consistent with the VISTAS guidance. The PM_{10} emissions and speciation approach used for the modeling described in this report are indicated in the bullets below.

Total PM_{10} is comprised of filterable and condensable emissions.

For oil firing:

- Baseline filterable PM emissions are conservatively based on the design rated heat input rate for oil firing and the PM filterable equation in AP-42 Section 1.3. A fuel oil heating value of 0.15 MMBtu/gal and a sulfur content of 2% are also used in the determination of the baseline filterable PM emissions.
- Filterable PM is subdivided by size category consistent with the default approach from AP-42 Table 1.3-4. For both units, the cumulative size distribution given in AP-42 Table 1.3-4 indicates 71% of the filterable PM emissions are filterable PM_{10} and 52% of the PM emissions are fine filterable PM_{10} emissions (less than 2.5 microns in size). Coarse PM_{10} is then the difference between the total PM_{10} and the fine PM_{10}. For oil-fired utility boilers, elemental carbon is expected to be 7.4% of fine PM_{10}.
- Condensable PM_{10} consists of inorganic and organic compounds. The inorganic portion is conservatively assumed to consist of 100% sulfates. Organic condensable PM_{10} is based on application of AP-42 Table 1.3-2, (calculated as 0.15 x (1.5 lb/1000 gallons)). The maximum daily oil usage rate was calculated from the maximum daily heat input rate using an oil heating value of 0.15 MMBtu/gal.

For natural gas firing:

- Baseline filterable PM emissions were based on the design rated heat input rate for natural gas firing and the PM filterable emission rate in AP-42 Section 1.4. A natural gas heating value of 1020 Btu/scf was also used in the determination of the baseline filterable PM emissions.
- According to AP-42 Table 1.3-4, all PM (total, condensable, and filterable) is assumed to be less than 1.0 micrometer in diameter. Therefore, the fine filterable PM_{10} emissions are equal to the filterable PM emissions. Coarse PM_{10} is the difference between the total PM_{10} and the fine PM_{10}, which in this case is zero. For natural gas-fired utility boilers, elemental carbon is expected to be 6.7% of fine PM_{10}.
- Condensable PM_{10} consists of inorganic and organic compounds. The inorganic portion is assumed to be 100% sulfates. The sulfates were calculated conservatively as 20% of the unit's SO_2 emissions. Organic condensable PM_{10} is equal to the total condensable PM minus the total inorganic condensable PM. The maximum daily natural gas usage rate was calculated from the maximum daily heat input rate using a natural gas heating value of 1020 Btu/scf.

In practice, CALPUFF allows for the user to input certain components of PM_{10} as separate species and separate sizes, which will result in more accurate wet and dry deposition velocity results and also more accurate effects on light scattering. As noted above, the particle size distribution information is provided in AP-42 Table 1.3-4, and this information was used for the BART exemption modeling that uses the maximum 24-hour emissions from the baseline period as input to CALPUFF.

Table 2-1 provides a summary of the modeling emission parameters that will be used in the BART CALPUFF modeling.

Table 2-1: Baxter Wilson Modeling Emissions Parameters

EMISSION UNIT ID	EMISSION UNIT DESCRIPTION	FUEL USED	MAX DAILY OPERATING RATE (MMBtu/hr) (2)	PM condensable Emission Factor (3) (lb/1000 gal)	SO_2 Emissions (lb/hr) (1)	NO_x Emissions (lb/hr) (1)	PM filterable (lb/hr) (2)	PM condensable (lb/hr) (4)	PM_{10} Emissions (lb/hr)									
										Filterable					Condensable			
																CPM IOR		
									Total PM_{10} Emissions (filterable + condensable)	Total FPM_{10} (5)	Coarse PM_{10} (5)	Fine PM_{10} (5)	Fine Soil (6)	Fine Elemental Carbon (6)	Total CPM_{10}	Total CPM IOR (7)	Sulfates (8)	Total CPM OR (7)
Baxter Wilson Unit 1	Gas/oil boiler	#6 Oil	4,790	1.5	8,968	1,841	689.76	47.9	537.63	489.73	131.05	358.68	332.13	26.54	47.9	40.7	40.7	7.19
Baxter Wilson Unit 2	Gas/oil boiler	#6 Oil	6,680	1.5	14,712	6,823	1,371	66.8	749.76	682.96	182.76	500.20	463.18	37.01	66.8	56.8	56.8	10.0

Notes:
(1) Baseline period for the BART analysis is 2001 - 2003.
Unit 1: SO_2 emissions based on 2/5/01. Unit 2: SO_2 emissions based on 8/9/01
NO_x emissions based on 5/9/01 NO_x emissions based on 8/02/01
(2) Max hourly heat input rate based on design rating of boiler firing oil. Filterable PM emission rate is based on AP-42 Section 1.3 (Filt PM = 9.19 (S) + 3.22).
Sulfur content of Fuel Oil = 2 % Heating Value of Fuel Oil = 0.15 MMBtu/gal
(3) Condensable PM Emission factor based on AP-42 Table 1.3-2 (1.5 lb/1000 gal) for #6 oil fired boiler.
(4) Condensable PM_{10} emissions (lb/hr) calculated using the factor given in Note (3) above. Max. daily oil usage rate was calculated from the max daily heat input rate using an oil heating value of 0.15 MMBtu/gal.
(5) Filterable PM_{10} portion of total filterable PM is calculated using the cumulative size distributions given in AP-42 Table 1.3-4 (uncontrolled size fractions). Fine PM_{10} is calculated as Total Filterable PM * 0.52. Coarse PM_{10} is calculated as the difference between total PM_{10} and fine PM_{10}.
(6) Elemental carbon or black carbon is 7.4% of fine PM_{10} based on the best estimates for industrial petroleum in Table 6 of "Catalog of Global Emissions Inventories and Emission Inventory Tools for Black Carbon", William Battye and Kathy Boyer, EPA Contract No. 68-D-98-046, January 2002. Fine soil is the difference between fine total and fine EC.
(7) Per AP-42 Table1.3-2, inorganic CPM is 85% of total CPM and organic CPM is 15% of total CPM.
(8) All inorganic CPM_{10} is assumed to be sulfates.

EMISSION UNIT ID	EMISSION UNIT DESCRIPTION	FUEL USED	MAX DAILY OPERATING RATE (MMBtu/hr) (2)	PM condensable Emission Factor (3) (lb/MMscf)	SO_2 Emissions (lb/hr) (1)	NO_x Emissions (lb/hr) (1)	PM filterable (lb/hr) (2)	PM condensable (lb/hr) (4)	PM_{10} Emissions (lb/hr)									
										Filterable					Condensable			
																CPM IOR		
									Total PM_{10} Emissions (filterable + condensable)	Total FPM_{10} (5)	Coarse PM_{10} (5)	Fine PM_{10} (5)	Fine Soil (6)	Fine Elemental Carbon (6)	Total CPM_{10}	Total CPM IOR (7)	Sulfates (8)	Total CPM OR (7)
Baxter Wilson Unit 1	Gas/oil boiler	Natural Gas	4,790	5.7	2.71	2,030	8.92	26.77	35.69	8.92	0.00	8.92	8.32	0.60	26.77	0.83	0.83	25.94
Baxter Wilson Unit 2	Gas/oil boiler	Natural Gas	6,680	5.7	2.4	4,674	12.4	37.33	49.77	12.4	0.00	12.4	11.6	0.83	37.33	1.38	1.38	35.95

Notes:
(1) Baseline period for the BART analysis is 2001 - 2003.
Unit 1: SO_2 emissions based on 5/9/02. Unit 2: SO_2 emissions based on 10/1/02
NO_x emissions based on 3/3/02 NO_x emissions based on 12/5/02
(2) Max hourly heat input rate based on design rating of boiler firing natural gas. Filterable PM emission rate is based on AP-42 Section 1.4 (Filt PM = 1.9 lb/MMcf).
Heating Value of natural gas = 1020 Btu/scf
(3) Condensable PM Emission factor based on AP-42 Table 1.4-2 (5.7 lb/MMscf) for natural gas fired boiler.
(4) Condensable PM_{10} emissions (lb/hr) calculated using the factor given in Note (3) above. Max. daily natural gas usage rate was calculated from the max daily heat input rate using an natural gas heating value of 1020 btu/scf.
(5) Filterable PM_{10} and Fine PM_{10} are both assumed to be 100% of total filterable PM as given in AP-42 Table 1.4-2. Coarse PM_{10} is calculated as the difference between total PM_{10} and fine PM_{10}.
(6) Elemental carbon or black carbon is 6.7% of fine PM_{10} based on the best estimates for natural gas in Table 6 of "Catalog of Global Emissions Inventories and Emission Inventory Tools for Black Carbon", William Battye and Kathy Boyer, EPA Contract No. 68-D-98-046, January 2002. Fine soil is the difference between fine total and fine EC.
(7) Total organic CPM = total CPM minus total inorganic CPM. Total inorganic CPM = all sulfates.
(8) All inorganic CPM_{10} is assumed to be sulfates. Sulfates calculated as 20 % of SO_2 * (98/64)

3.0 Input Data to the CALPUFF Model

3.1 General Modeling Procedures:

VISTAS has developed five sub-regional 4-km CALMET meteorological databases for three years (2001-2003), as well as a 12-km screening meteorological database for the same years. The sub-regional modeling domains are strategically designed to cover all potential BART eligible sources within VISTAS states and most PSD Class I areas within 300 km of those sources. The extents of the 4-km sub-regional domains are shown here: http://www.vistas-sesarm.org/BART/CALMETSubdomains_21Dec2005.jpg.

To conduct consistent CALPUFF modeling for both Entergy BART-eligible plants in Mississippi (Baxter Wilson and Gerald Andrus), it is necessary for us to create a CALPUFF modeling domain that extends into a portion of Arkansas, which would lie outside the 4-km VISTAS database. An alternative database would be the CENRAP screening subdomain 6-km database, but CENRAP has not provided the supplemental meteorological data that VISTAS provides. Therefore, we are proposing to use the VISTAS meteorological data to create a single CALMET database for assessing regional haze impacts in Class I areas for both Entergy BART-eligible plants in Mississippi.

3.2 Model Selection and Features

The EPA-approved version of CALMET (V5.8), CALPUFF (V5.8), and POSTUTIL (V1.56) is proposed for BART modeling with the meteorological databases described in this protocol. CALPOST Version 6.292 will be used to process modeling results and compute regional haze impacts at each receptor. CALPOST V6.292 contains the recommended FLAG (2010) techniques on visibility assessment, specifically the new IMPROVE equation.

3.3 Modeling Domain and Receptors

The modeling domain is designed to encompass the closest Class I areas to the specific Entergy plants (Baxter Wilson and Gerald Andrus), plus a 50-km buffer. The resultant modeling domain extends 636 km East-West and 600 km North-South with a 4-km grid resolution. The domain is shown in Figure 3-1.

The receptors to be used for Breton are based on the National Park Service database of Class I receptors, as recommended by VISTAS (found at: http://www2.nature.nps.gov/air/maps/Receptors/index.htm).

3.4 CALMET Processing

The CALMET control input file contains numerous switches and settings that drive how the 3-dimensional wind-field will be produced, which in turn can affect dispersion within the CALPUFF model and ultimately estimates of the modeled ground level concentrations. In August 2009, the USEPA Model Clearinghouse (in cooperation with the Federal Land Managers [FLMs]) issued a memo containing recommended settings for use in CALMET (http://www.epa.gov/ttn/scram/CALMET%20CLARIFICATION.pdf). For this application, we propose to run CALMET with all USEPA-FLM recommended values.

For the hourly wind field initialization, CALMET will use gridded prognostic mesoscale meteorological (MM5) data for all three years (2001-2003). The following three years of MM5 data have been assembled by VISTAS for use in the regional CALPUFF modeling:

- 2001 and 2002 MM5 data set with 12-km resolution
- 2003 MM5 dataset with 36-km resolution.

These prognostic meteorological data sets will be combined with 4-km grid resolution terrain and land use data to more accurately characterize the wind flow throughout the modeling domain. The 4-km gridded terrain data will be derived from United States Geological Survey (USGS) 1:250,000 (3 arc second or 90-meter grid spacing) Digital Elevation Model (DEM) files using the TERREL pre-processor program. The gridded land use data will be derived from USGS 1:250,000 Composite Theme Grid (CTG) land use files.

The Step 2 wind field will be produced with the input of hourly surface and twice daily upper air balloon sounding data. Hourly precipitation data will also included in the CALMET simulations. Surface, upper air and precipitation files have been prepared by TRC for use in the VISTAS regional CALPUFF modeling effort.

The following files were previously downloaded from the TRC website (link no longer works) http://www.src.com/verio/download/sample_files.htm#STANDARD_SURF.

- Standard surface files (2001-2003)
- Standard precipitation files (2001-2003)
- VISTAS Regional Domain 1 upper air data files (2001-2003). Only four upper air stations were selected from the dataset due to their proximity to this proposed modeling domain.

CALPUFF PROfessional System software, SUBDOMN tool will be used to extract a smaller subset of the surface and precipitation datasets. (The software is created and distributed by TRC).

3.5 CALPUFF Processing

Similar to CALMET, the CALPUFF control input file also contains numerous switches and settings that drive how certain data will be processed, which in turn can affect dispersion within the CALPUFF model and, ultimately, estimates of the modeled regional haze impacts. In March 2006, the USEPA Model Clearinghouse issued a memo containing recommended settings for use in CALPUFF.

For this application, CALPUFF will be run with all USEPA recommended settings. Most other CALPUFF settings that require user-definition and have not been specified in the March 2006 memo are meant to be tailored to specific applications. Much like CALMET, these values pertain to selection of file names, specification of beginning and ending time period for the simulation, and map.

3.6 Background Ozone and Ammonia

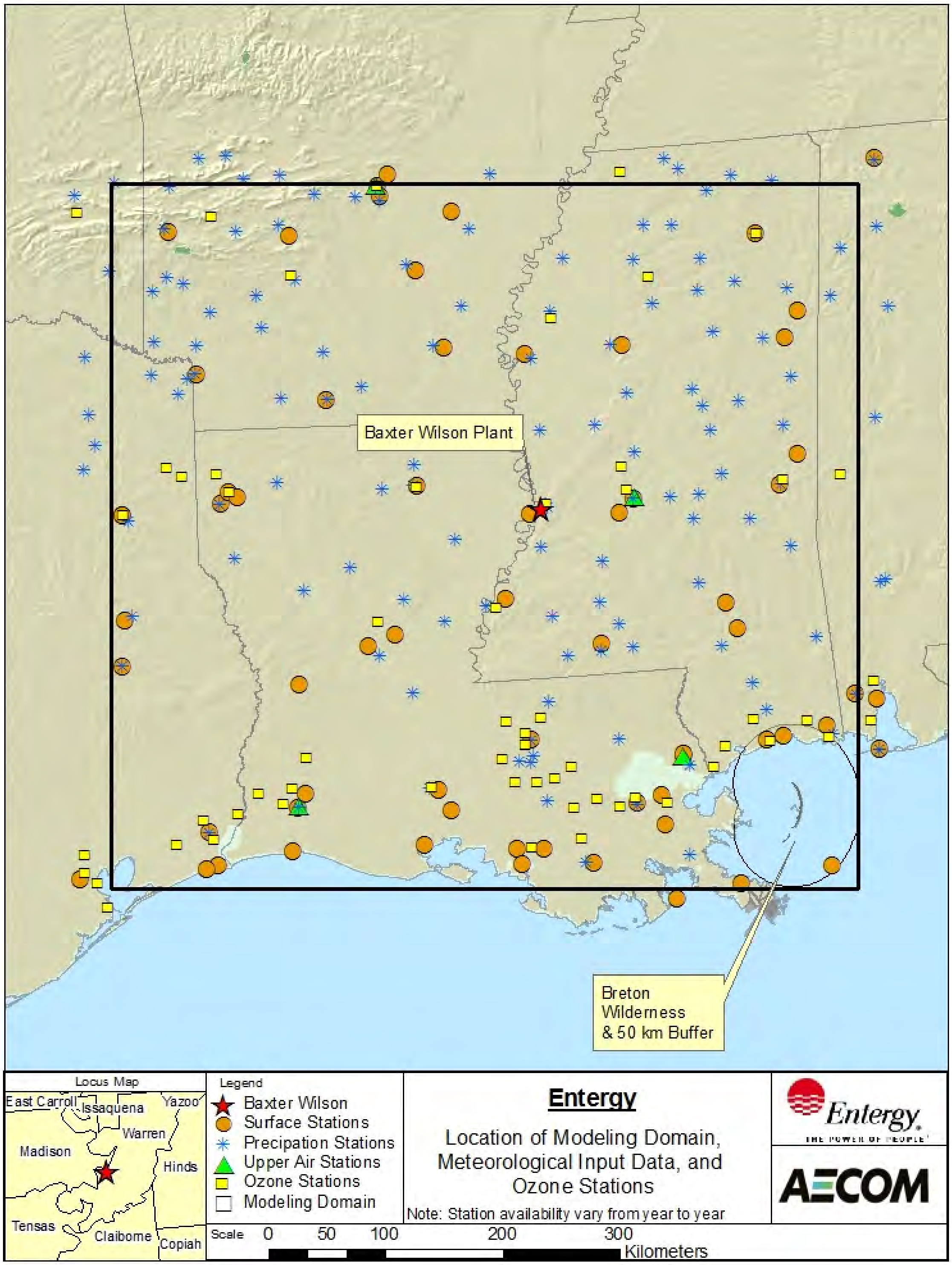
Hourly measurements of ozone from all non-urban monitors, as generated by VISTAS will be used as input to CALPUFF. As for ammonia, we propose to follow the approach recommended by VISTAS. Currently, VISTAS advises sources to use a background ammonia concentration of 0.5 ppb, and not to use the ammonia limiting.

3.7 CALPOST Visibility Impacts Processing

The CALPOST postprocessor will be used for the calculation of the impact of the modeled source's primary and secondary particulate matter concentrations on light extinction. In accordance with FLAG 2010 guidance, the visibility impacts at Breton National Wildlife Refuge will be processed using CALPOST Method 8 (MVISBK=8) and sub-mode five (M8_MODE=5). The Method 8 (new IMPROVE equation) allows a spit between large and small sulfate, nitrate and organic particles when calculating natural background conditions and change in light extinction.

The annual average concentrations, Raleigh scatting coefficient, and sea salt concentrations will be taken from FLAG (2010) Table 6. The monthly relative humidity adjustment factors for large sulfate and nitrate particles will be taken from FLAG Table 7 and for small particles from FLAG Table 8. The sea salt relative humidity adjustment factors for Breton National Wildlife Refuge will be taken from FLAG Table 9.

Figure 3-1: Location of Modeling Domain, Meteorological Input Data, and Ozone Stations



4.0 Presentation of Modeling Results

The BART exemption analysis will be conducted for Baxter Wilson Units 1 and 2. The modeling analysis will be done separately for the 100% oil-firing emissions case and for the 100% natural gas-firing emissions case, as shown in Table 2-1. The 98^{th} percentile regional haze results at Breton National Wildlife Refuge for each emissions case will be compared to the 0.5 delta-deciview (dv) threshold. If the exemption modeling demonstrates that the BART-eligible units at the Baxter Wilson plant do not cause or contribute to visibility impairment with either gas-firing emissions case or oil-firing emissions case (or both cases), then that case/fuel will not be subject to BART requirements, and no further analysis will be needed. Otherwise, Entergy will proceed to perform BART determination modeling for the baseline and each selected control option for any remaining case/fuel. One exception to this requirement could occur if the selected case (e.g., oil firing) was limited to a number of days per year corresponding to the 98^{th} percentile BART-relevant statistic (8^{th} highest day) weighted by the likelihood of winds blowing toward the Breton Wildlife National Refuge. For example, if a representative wind rose indicated that the probability of wind from the northwest is 20% as an annual average, then the allowable frequency of a specific emission case that could trigger the 98^{th} percentile day's impact at Breton would be 40 or more days per year.

The BART analysis will address the five statutory factors required by Section 169A (g) (7) of the Clean Air Act that States must consider in making BART determinations:

(1) the costs of compliance,

(2) the energy and non-air quality environmental impacts of compliance,

(3) any existing pollution control technology in use at the source,

(4) the remaining useful life of the source, and,

(5) the degree of improvement in visibility which may reasonably be anticipated to result from the use of such technology.

Entergy will consider SO_2, NO_X and PM_{10} control cases based on their cost effectiveness and feasibility. Based on cost considerations (e.g., $5,000 or more per ton removed), physical space constraints, infeasibility of the controls, or legal contractual conditions, Entergy will determine whether a control option is feasible. If feasible, then emissions associated with each selected option will be modeled to determine visibility improvement relative to the baseline.

In numerous correspondence[1] to states, the Federal Land Managers have referred to a benchmark of $20 million per deciview as a threshold for excessively high costs for the degree of visibility improvements. This value is computed as the 3-year average of the 98^{th} percentile day's deciview

[1] See http://www.nature.nps.gov/air/regs/sipLetters/pdf/Pennsylvania_08-02-2010.pdf, http://www.nature.nps.gov/air/regs/sipLetters/pdf/Nevada_EPA_Letter_08-17-2011.pdf, http://www.dec.state.ak.us/AIR/ap/docs/GVEA%20BART%20NPS%20Comments%206-15-09.pdf.

improvement predicted by CALPUFF (for the two emission cases being compared) divided by the incremental annualized cost of the proposed control. For example, if the average deciview improvement were 0.5, then incremental annualized costs in excess of $40 million would render the control option as ineffective and too expensive, and would likely be rejected as BART.

5.0 References

Environmental Protection Agency (EPA), Tyler Fox Memorandum: Clarification on EPA-FLM Recommended Settings for CALMET. August 31, 2009.

Environmental Protection Agency (EPA), Dennis Atkinson Memorandum: Dispersion Coefficients for Regulatory Air Quality Modeling in CALPUFF. March 16, 2006.

Environmental Protection Agency (EPA), 40 CFR Part 51, FRL -7925-9, RIN: 2060-AJ31, Regional Haze Regulations and Guidelines for Best Available Retrofit Technology (BART) Determinations (Appendix Y), updated June 24, 2005

Environmental Protection Agency (EPA), Guidance for Tracking Progress Under the Regional Haze Rule, EPA-454/B-03-003, Appendix A, Table A-3, September, 2003

Federal Land Managers' Air Quality Related Values Work Group (FLAG). Phase I Report. Revised 2010.

Visibility Improvement State and Tribal Association of the Southeast (VISTAS), Revision 3, Protocol for the Application of the CALPUFF Model for Analyses of Best Available Retrofit Technology (BART), updated July 18, 2006.

Appendix L.7.3 – BART Exemption Modeling Report

AECOM Environment

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Prepared by:
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December 2012

Source-Specific BART Exemption Report: Baxter Wilson Units 1 & 2

AECOM Environment

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Entergy Mississippi, Inc.
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December 2012

Source-Specific BART Exemption Report: Baxter Wilson Units 1 & 2

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Reviewed By: Robert J. Paine

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Executive Summary

Entergy Mississippi Inc. owns and operates the Baxter Wilson Power Plant ("Baxter Wilson"), located in Vicksburg, Mississippi. The Power Plant consists of two dual-fuel oil and gas-fired units (Unit 1 and Unit 2) rated at about 1327 megawatt (MW). Units 1 and 2 commenced their commercial operation in 1967 and 1971, respectively, thus meeting the in-service date for Best Available Retrofit Technology (BART) eligibility. Over the past several years, the plant has had emissions exceeding 250 tons per year of sulfur dioxide (SO_2) and/or nitrogen oxide (NOx). Therefore, the plant is BART-eligible. Units 1 and 2 are oil and gas-fired units with a design rating of 4790 and 6680 MMBtu/hour heat input, respectively. The plant burns primarily natural gas, but also uses residual fuel oil as a secondary fuel, especially in the event of a curtailment in the natural gas supply. In practice, Entergy has reduced the No.6 residual fuel oil used at this facility by nearly 50% (since the Regional Haze Rule baseline period of 2001-2003) to a maximum sulfur level content of 1.0%. This operational practice is considered in our modeling analysis as a "current baseline" for purposes of determining BART eligibility.

The Mississippi State BART rules require that sources that are subject to BART perform a site-specific BART analysis including a control technology review and CALPUFF modeling to assess the visibility impact of the emission units for various candidate BART controls. A subject-to-BART analysis was conducted separately for the oil-fired and natural gas-fired baseline emissions to determine whether visibility impacts exceeding the contribution threshold of 0.5 delta-dv on the 98^{th} percentile day, averaged over 3 years, were found at any Class I area within 300 km (there is one such area, Breton National Wildlife Refuge).

CALPUFF modeling was conducted for the baseline natural gas and oil emission cases for Baxter Wilson consistent with the VISTAS Regional Planning Organization's CALPUFF BART modeling protocol[1], with appropriate updates. The modeling used the EPA-approved version of CALPUFF, the VISTAS ammonia background concentration of 0.5 ppb, and post-processing with the new IMPROVE equation along with the annual average natural background concentrations.

The modeling results indicated that natural gas firing visibility impacts are below the contribution threshold, while oil-fired impacts (assuming 24-hour-per-day operations) are above the threshold. We provide results for partial-day oil-firing operations that would not trigger the contribution threshold, so that days with more extensive oil-firing operations are referred to as "oil burn days". Consistent with the modeling protocol, Entergy is willing to agree to limited oil-fired operations such that the frequency of oil burn days cannot affect the 98^{th} percentile day at any Class I area. The number of oil burn days that would trigger a BART review is thus related to the form of the 98^{th} percentile criterion (the 8^{th} highest day) as well as the frequency for winds to blow in any one direction from the source. A conservative assessment of the wind direction frequency indicates that if the average number of oil burn days is limited to no more than 18 per year (averaged over 3 years and excluding emergency conditions), then there would be no oil firing emissions on the 98^{th} percentile day. Therefore, natural gas firing operations are not subject to BART due to modeling results, while limited oil firing operations are exempt from BART because they are too infrequent.

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[1] Available at http://www.vistas-sesarm.org/documents/BARTModelingProtocol_rev3.2_31Aug06.pdf.

1.0 Introduction

The Baxter Wilson power plant, owned and operated by Entergy Mississippi Inc., has been identified by the Mississippi Department of Environmental Quality (MDEQ) as a source that is eligible for consideration of BART controls for SO_2, NO_X, and PM_{10}. This document describes the procedures by which a modeling analysis and a BART exemption conducted for the BART-eligible Baxter Wilson Units 1 and 2.

1.1 Location of Source vs. Relevant Class I Areas

The Baxter Wilson power plant is located in Vicksburg, Mississippi. Figure 1-1 shows a plot of the Baxter Wilson plant relative to nearby Class I Areas. There are no Class I areas within 300 km of the plant. The closest Class I area is Breton National Wildlife Refuge, located offshore in the Gulf of Mexico approximately 310 km to the south-southeast of the plant. Caney Creek Wilderness area is the next closest Class I area located in Arkansas and is more than 370 km from the plant. Although the VISTAS modeling protocol generally recommends that only Class I areas within 300 km are modeled for BART exemption status, in this case, Entergy conducted BART exemption modeling for Breton, since it is only slightly more than 300 km away. Accordingly, the BART modeling was conducted for Breton in accordance with the BART modeling protocol[2], VISTAS common BART modeling protocol and the procedures described in this source-specific BART modeling protocol. In early 2012, EPA provided minor comments on the AECOM modeling protocol for Baxter Wilson and Baxter Wilson BART analyses. Responses to those comments that were incorporated into the final modeling approach are provided in Appendix A.

A review of the haze monitor that is representative of conditions at Breton is shown in Figure 1-2 for 2002. This information comes from an IMPROVE (Interagency Monitoring of Protected Visual Environments) monitor, and data for these monitors is available at http://views.cira.colostate.edu/web/Composition/. The figure indicates that the predominant contributor to haze at Breton National Wildlife Refuge for the worst 20% haze days is caused by sulfates due to SO_2 emissions. Other particulate species have a minor impact. The peak haze events that occurred in February 2002 were due, in large part, to a chemical explosion and fire at a petrochemical facility.

1.2 Organization of Report Document

This report documents the BART exemption analysis conducted for SO_2, NOx and PM emissions from Units 1 and 2 at the Baxter Wilson Power Plant. Section 2 provides a description of Baxter Wilson Units 1 and 2 and their baseline emissions for both natural gas and oil fired operations. The available meteorological data and the CALPUFF modeling procedures are described in Sections 4. The results of the visibility exemption modeling using CALPUFF and the results are presented in Section 5. References are provided in Section 6.

[2] Source-Specific Modeling Protocol: Baxter Wilson Units 1 & 2. Prepared by AECOM. November 2011. The EPA and MDEQ provided minor comments on this protocol in January 2012.

Figure 1-1: Location of Class I Areas in Relation to Baxter Wilson Plant

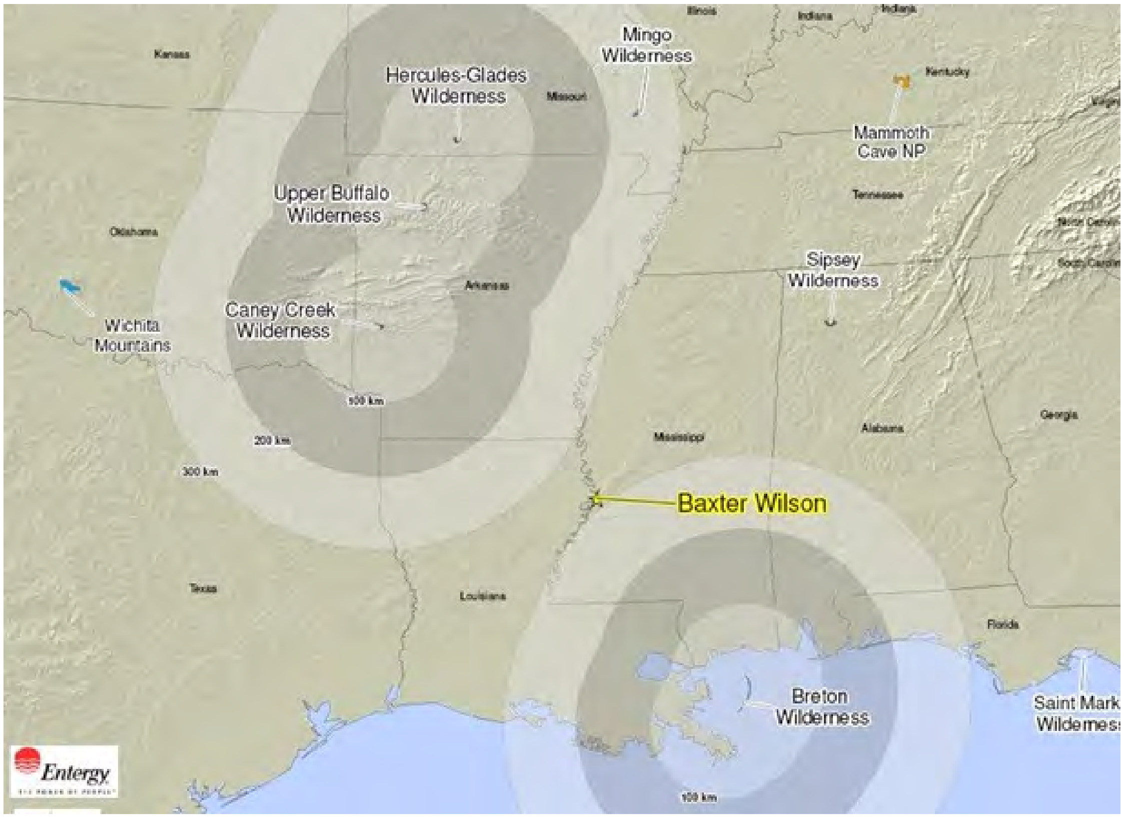


Figure 1-2: Haze Composition Plot for Breton National Wildlife Refuge for 2002

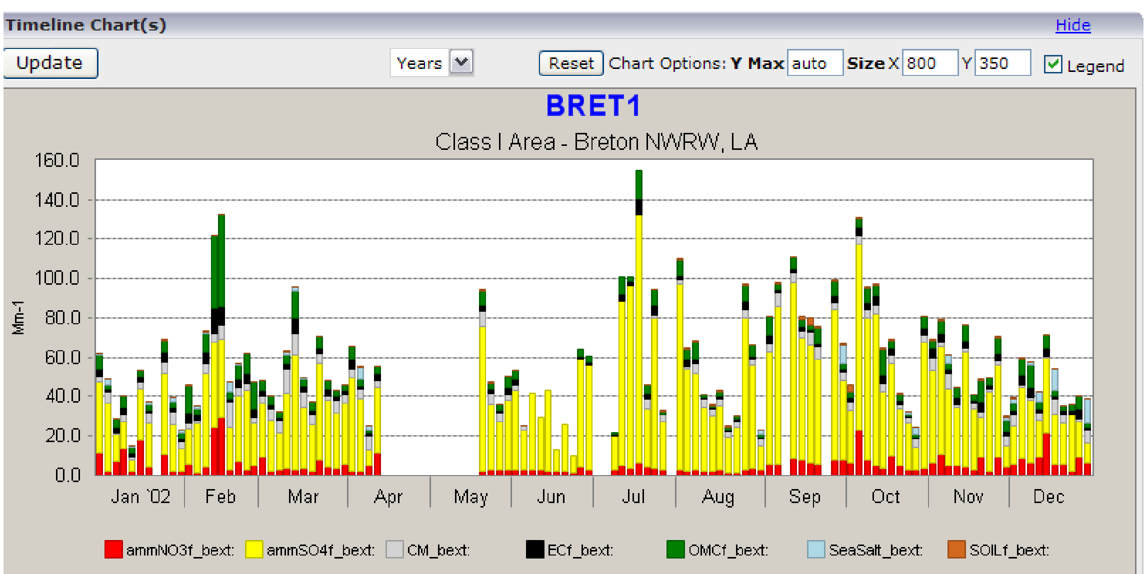


Figure 1. Title - Site: BRET1. **Series** - Parameter: aerosol_bext, ammNO3f_bext, ammSO4f_bext, CM_bext, ECf_bext, OMCf_bext, SeaSalt_bext, SOILf_bext. **Metadata** - Program: IRHR2, Method: RHR Dataset, Poc: 1, Aggregation: Not aggregated

2.0 Background Data

2.1 Unit-Specific Source Data

The emissions data used to assess the visibility impacts at Breton National Wildlife Refuge are discussed in this section. This analysis includes all potential visibility impairing pollutants.

Units 1 and 2 at the Baxter Wilson plant are oil and gas-fired units with a design rating of 4790 and 6680 MMBtu/hour heat input, respectively. The highest daily emissions from each fuel in the 2001 to 2003 baseline period are the focus of this emission characterization. Due to the predominant use of natural gas firing, add-on PM and SO_2 controls are not used on either unit.

The maximum hourly heat input rate for each boiler is the design rating. The SO_2 emission rate and NO_X emission rate for both fuel oil combustion and natural gas combustion were determined from Part 75 monitoring data (Clean Air Markets Database) and the facility's CEMS data. The maximum heat input used in the PM emission calculations is based on the design rating for each fuel.

Because various components of PM_{10} emissions have different visibility extinction efficiencies, the PM_{10} emissions are divided, or "speciated" into several components. The VISTAS protocol allows for the use of source-specific emissions and speciation factors. Otherwise, default values from EPA's AP-42 reference document can be used. PM_{10} was speciated in a manner consistent with the VISTAS guidance. The PM_{10} emissions and the speciation approach that were used for the modeling described in this report are described in the bullets below.

Total PM_{10} is comprised of filterable and condensable emissions.

For oil firing:

- Baseline filterable PM emissions were conservatively based on the permitted rated heat input rate for oil firing and the PM filterable equation in AP-42 Section 1.3. A fuel oil heating value of 0.15 MMBtu/gal and a sulfur content of about 2% were also used in the determination of the baseline filterable PM emissions.
- Filterable PM is subdivided by size category consistent with the default approach from AP-42 Table 1.3-4. The cumulative size distribution given in AP-42 Table 1.3-4 indicates 71% of the filterable PM emissions are filterable PM_{10} and 52% of the PM emissions are fine filterable PM_{10} emissions (less than 2.5 microns in size). Coarse PM_{10} is then the difference between the total PM_{10} and the fine PM_{10}. For oil-fired utility boilers, elemental carbon is expected to be 7.4% of fine PM_{10}.
- Condensable PM_{10} consists of inorganic and organic compounds. The inorganic portion is assumed to consist of 100% Sulfates. Organic condensable PM_{10} was based on application of AP-42 Table 1.3-2, (calculated as 0.15 x (1.5 lb/1,000 gallons)). The maximum daily oil usage rate was calculated from the maximum daily heat input rate using an oil heating value of 0.15 MMBtu/gal.

For natural gas firing:

- Baseline filterable PM emissions were based on the design rated heat input rate for natural gas firing and the PM filterable emission rate in AP-42 Section 1.4. A natural gas heating value of 1,020 Btu/scf was also used in the determination of the baseline filterable PM emissions.
- According to AP-42 Table 1.3-4, all PM (total, condensable, and filterable) is assumed to be less than 1.0 micrometer in diameter. Therefore, the fine filterable PM_{10} emissions are equal to the filterable PM emissions. Coarse PM_{10} is the difference between the total PM_{10} and the fine PM_{10} which in this case is zero. For natural gas-fired utility boilers, elemental carbon is expected to be 6.7% of fine PM_{10}.
- Condensable PM_{10} consists of inorganic and organic compounds. The inorganic portion is assumed to be 100% Sulfates. The sulfates were calculated conservatively as 20% of the unit's SO_2 emissions. Organic condensable PM_{10} is equal to the total condensable PM minus the total inorganic condensable PM. The maximum daily natural gas usage rate was calculated from the maximum daily heat input rate using a natural gas heating value of 1,020 Btu/scf.

In practice, CALPUFF allows for the user to input certain components of PM_{10} as separate species and separate sizes, which will result in more accurate wet and dry deposition velocity results and also more accurate effects on light scattering. As noted above, the particle size distribution information is provided in AP-42 Table 1.3-4, and this information was used for the BART exemption modeling that uses the maximum 24-hour emissions from the baseline period as input to CALPUFF.

Table 2-1 summarizes modeling exhaust stack parameters. AECOM has conducted a GEP analysis for the Baxter Wilson Units 1 and 2 stack and concluded that the stack height is fully creditable. Therefore, the actual stack height, shown in the table below, was used in modeling, along with the appropriate building downwash inputs.

Tables 2-2 and 2-3 show a summary of the modeling emission parameters that were used in the BART CALPUFF modeling for baseline natural gas and oil emissions, respectively. Table 2-4 contains the emissions for the oil-firing case with 1% sulfur.

Table 2-1: Baxter Wilson Units 1 and 2 – Baseline Modeling Stack Parameters

Unit	Actual Stack Height (m)	Base Elevation (m)	Stack Diameter (m)	Exit Velocity (m/s)	Temp (K)
Unit 1	149.40	32.00	5.80	24.08	380.40
Unit 2	149.40	32.00	7.00	33.23	449.30

Table 2-2: Baxter Wilson Units 1 and 2 – Baseline Modeling Emissions for Natural Gas Firing

EMISSION UNIT ID	EMISSION UNIT DESCRIPTION	FUEL USED	MAX DAILY OPERATING RATE (MMBtu/hr) (2)	PM condensable Emission Factor (3) ($lb/10^6$ scf)	SO_2 Emissions (lb/hr) (1)	NO_x Emissions (lb/hr) (1)	PM filterable (lb/hr) (2)	PM condensable (lb/hr) (4)	PM_{10} Emissions (lb/hr)									
									Total PM_{10} Emissions (filterable + condensable)	Filterable					Condensable			
																CPM IOR		
										Total FPM_{10} (5)	Coarse PM_{10} (5)	Fine PM_{10} (5)	Fine Soil (6)	Fine Elemental Carbon (6)	Total CPM_{10}	Total CPM IOR (7)	Sulfates (8)	Total CPM OR (7)
Baxter Wilson Unit 1	Gas/oil boiler	Natural Gas	**4,790**	5.7	2.71	2,030	8.92	26.77	35.69	8.92	0.00	8.92	8.32	0.60	26.77	0.83	0.83	25.94
Baxter Wilson Unit 2	Gas/oil boiler	Natural Gas	**6,680**	5.7	2.40	4,674	12.44	37.33	49.77	12.44	0.00	12.44	11.61	0.83	37.33	0.74	0.74	36.59

Notes:

(1) Baseline period for the BART analysis is 2001 - 2003.

Unit 1: SO_2 emissions based on 5/9/02. Unit 2: SO_2 emissions based on 10/1/02

NO_x emissions based on 3/3/02 NO_x emissions based on 12/5/02

(2) Max hourly heat input rate based on design rating of boiler firing natural gas. Filterable PM emission rate is based on AP-42 Section 1.4 (Filt PM = 1.9 lb/MMcf).

Heating Value of natural gas = 1020 Btu/scf

(3) Condensible PM Emission factor based on AP-42 Table 1.4-2 (5.7 lb/MMscf) for natural gas fired boiler.

(4) Condensible PM_{10} emissions (lb/hr) calculated using the factor given in Note (3) above. Max. daily natural gas usage rate was calculated from the max daily heat input rate using an natural gas heating value of 1020 btu/scf.

(5) Filterable PM_{10} and Fine PM_{10} are both assumed to be 100% of total filterable PM as given in AP-42 Table 1.4-2. Coarse PM_{10} is calculated as the difference between total PM_{10} and fine PM_{10}.

(6) Elemental carbon or black carbon is 6.7% of fine PM_{10} based on the best estimates for natural gas in Table 6 of "Catalog of Global Emissions Inventories and Emission Inventory Tools for Black Carbon", William Battye and Kathy Boyer, EPA Contract No. 68-D-98-046, January 2002. Fine soil is the difference between fine total and fine EC.

(7) Total organic CPM = total CPM minus total inorganic CPM. Total inorganic CPM = all sulfates.

(8) All inorganic CPM_{10} is assumed to be sulfates. Sulfates calculated as 20 % of SO_2 * (98/64)

Table 2-3: Baxter Wilson Units 1 and 2 – Baseline Modeling Emissions for Oil Firing (2.0 % Sulfur Oil)

EMISSION UNIT ID	EMISSION UNIT DESCRIPTION	FUEL USED	MAX DAILY OPERATING RATE (MMBtu/hr) (2)	PM condensable Emission Factor (3) ($lb/10^6$ scf)	SO_2 Emissions (lb/hr) (1)	NO_x Emissions (lb/hr) (1)	PM filterable (lb/hr) (2)	PM condensable (lb/hr) (4)	PM_{10} Emissions (lb/hr)									
										Filterable					Condensable			
																CPM IOR		
									Total PM_{10} Emissions (filterable + condensable)	Total FPM_{10} (5)	Coarse PM_{10} (5)	Fine PM_{10} (5)	Fine Soil (6)	Fine Elemental Carbon (6)	Total CPM_{10}	Total CPM IOR (7)	Sulfates (8)	Total CPM OR (7)
Baxter Wilson Unit 1	Gas/oil boiler	**#6 Oil**	4790	2	8,968	1,841	689.8	48	538	490	131	359	332.1	26.5	47.9	40.7	40.7	7.2
Baxter Wilson Unit 2	Gas/oil boiler	**#6 Oil**	6680	2	14,712	6,823	961.9	67	750	683	183	500	463.2	37.0	66.8	56.8	56.8	10.0

Notes:
(1) Baseline period for the BART analysis is 2001 - 2003.
Unit 1: SO_2 emissions based on 2/5/01. Unit 2: SO_2 emissions based on 8/9/01
NO_x emissions based on 5/9/01 NO_x emissions based on 8/2/01
(2) Max hourly heat input rate based on design rating of boiler firing oil. Filterable PM emission rate is based on AP-42 Section 1.3 (Filt PM = 9.19 (S) + 3.22).
Sulfur content of Fuel Oil = 2 % Heating Value of Fuel Oil = 0.15 MMBtu/gal
(3) Condensible PM Emission factor based on AP-42 Table 1.3-2 (1.5 lb/1000 gal) for #6 oil fired boiler.
(4) Condensible PM_{10} emissions (lb/hr) calculated using the factor given in Note (3) above. Max. daily oil usage rate was calculated from the max daily heat input rate using an oil heating value of 0.15 MMBtu/gal.
(5) Filterable PM_{10} portion of total filterable PM is calculated using the cumulative size distributions given in AP-42 Table 1.3-4 (uncontrolled size fractions). Fine PM_{10} is calculated as Total Filterable PM * 0.52. Coarse PM_{10} is calculated as the difference between total PM_{10} and fine PM_{10}.
(6) Elemental carbon or black carbon is 7.4% of fine PM_{10} based on the best estimates for industrial petroleum in Table 6 of "Catalog of Global Emissions Inventories and Emission Inventory Tools for Black Carbon", William Battye and Kathy Boyer, EPA Contract No. 68-D-98-046, January 2002. Fine soil is the difference between fine total and fine EC.
(7) Per AP-42 Table1.3-2, inorganic CPM is 85% of total CPM and organic CPM is 15% of total CPM.
(8) All inorganic CPM_{10} is assumed to be sulfates.

Table 2-4: Baxter Wilson Units 1 and 2 – Baseline Modeling Emissions for Oil Firing (1.0 % Sulfur Oil)

EMISSION UNIT ID	EMISSION UNIT DESCRIPTION	FUEL USED	MAX DAILY OPERATING RATE (MMBtu/hr) (2)	PM condensable Emission Factor (3) (lb/10^6 scf)	SO_2 Emissions (lb/hr) (1)	NO_x Emissions (lb/hr) (1)	PM filterable (lb/hr) (2)	PM condensable (lb/hr) (4)	PM_{10} Emissions (lb/hr)									
										Filterable					Condensable			
																CPM IOR		
									Total PM_{10} Emissions (filterable + condensable)	Total FPM_{10} (5)	Coarse PM_{10} (5)	Fine PM_{10} (5)	Fine Soil (6)	Fine Elemental Carbon (6)	Total CPM_{10}	Total CPM IOR (7)	Sulfates (8)	Total CPM OR (7)
Baxter Wilson Unit 1	Gas/oil boiler	**#6 Oil**	4790	2	5,014	1,841	396	48	329	281	75	206	191	15.2	47.9	40.7	40.7	7.2
Baxter Wilson Unit 2	Gas/oil boiler	**#6 Oil**	6680	2	6,992	6,823	553	67	459	392	105	287	266	21.3	66.8	56.8	56.8	10.0

Notes:

(1) Baseline period for the BART analysis is 2001 - 2003.

Unit 1: SO_2 emissions based on 2/5/01. Unit 2: SO_2 emissions based on 8/9/01

NO_x emissions based on 5/9/01 NO_x emissions based on 8/2/01

(2) Max hourly heat input rate based on design rating of boiler firing oil. Filterable PM emission rate is based on AP-42 Section 1.3 (Filt PM = 9.19 (S) + 3.22).

Sulfur content of Fuel Oil = 1 % Heating Value of Fuel Oil = 0.15 MMBtu/gal

(3) Condensible PM Emission factor based on AP-42 Table 1.3-2 (1.5 lb/1000 gal) for #6 oil fired boiler.

(4) Condensible PM_{10} emissions (lb/hr) calculated using the factor given in Note (3) above. Max. daily oil usage rate was calculated from the max daily heat input rate using an oil heating value of 0.15 MMBtu/gal.

(5) Filterable PM_{10} portion of total filterable PM is calculated using the cumulative size distributions given in AP-42 Table 1.3-4 (uncontrolled size fractions). Fine PM_{10} is calculated as Total Filterable PM * 0.52. Coarse PM_{10} is calculated as the difference between total PM_{10} and fine PM_{10}.

(6) Elemental carbon or black carbon is 7.4% of fine PM_{10} based on the best estimates for industrial petroleum in Table 6 of "Catalog of Global Emissions Inventories and Emission Inventory Tools for Black Carbon", William Battye and Kathy Boyer, EPA Contract No. 68-D-98-046, January 2002. Fine soil is the difference between fine total and fine EC.

(7) Per AP-42 Table1.3-2, inorganic CPM is 85% of total CPM and organic CPM is 15% of total CPM.

(8) All inorganic CPM_{10} is assumed to be sulfates.

3.0 Meteorological Data used in Visibility Improvement Modeling

This section discusses the meteorological CALMET database that was used for the Baxter Wilson BART modeling.

3.1 General Modeling Procedures

VISTAS developed five sub-regional 4-km CALMET meteorological databases for three years (2001-2003), as well as a 12-km screening meteorological database for the same years. The sub-regional modeling domains were strategically designed to cover all potential BART eligible sources within VISTAS states and most PSD Class I areas within 300 km of those sources. The extents of the 4-km sub-regional domains are shown here: http://www.vistas-sesarm.org/BART/CALMETSubdomains_21Dec2005.jpg.

To conduct consistent CALPUFF modeling for both Entergy BART-eligible plants in Mississippi (Gerald Andrus and Baxter Wilson), it was necessary for us to create a CALPUFF modeling domain that extends into a portion of Arkansas, which would lie outside the 4-km VISTAS database. An alternative database would be the CENRAP screening subdomain 6-km database, but CENRAP has not provided the supplemental meteorological data that VISTAS provides. Therefore, we used the VISTAS meteorological data to create a single CALMET database for assessing regional haze impacts in Class I areas for both Entergy BART-eligible plants in Mississippi.

3.2 Modeling Domain and Receptors

The modeling domain was designed to encompass the closest Class I areas to the specific Entergy plants (Gerald Andrus and Baxter Wilson), plus a 50-km buffer. The resultant modeling domain extends 636 km East-West and 600 km North-South with a 4-km grid resolution. The domain is shown in Figure 3-1.

The receptors used for Breton NWR are based on the National Park Service database of Class I receptors, as recommended by VISTAS (found at: http://www2.nature.nps.gov/air/maps/Receptors/index.htm).

3.3 CALMET Processing

The CALMET control input file contains numerous switches and settings that drive how the 3-dimensional wind-field will be produced, which in turn can affect dispersion within the CALPUFF model and ultimately estimates of the modeled ground level concentrations. In August 2009, the USEPA Model Clearinghouse (in cooperation with the Federal Land Managers [FLMs]) issued a memo containing recommended settings for use in CALMET (http://www.epa.gov/ttn/scram/guidance/clarification/CALMET%20CLARIFICATION.pdf). For this application, we propose to run three year s (2001-2003) of CALMET (Version 5.8) with all USEPA-FLM recommended values.

For the hourly wind field initialization, CALMET uses gridded prognostic mesoscale meteorological (MM5) data for all three years (2001-2003). The following three years of MM5 data have been assembled by VISTAS for use in the regional CALPUFF modeling:

- 2001 and 2002 MM5 data set with 12-km resolution
- 2003 MM5 dataset with 36-km resolution.

These prognostic meteorological data sets were combined with 4-km grid resolution terrain and land use data to more accurately characterize the wind flow throughout the modeling domain. The 4-km gridded terrain data was derived from United States Geological Survey (USGS) 1:250,000 (3 arc second or 90-meter grid spacing) Digital Elevation Model (DEM) files using the TERREL pre-processor program. The gridded land use data was derived from USGS 1:250,000 Composite Theme Grid (CTG) land use files.

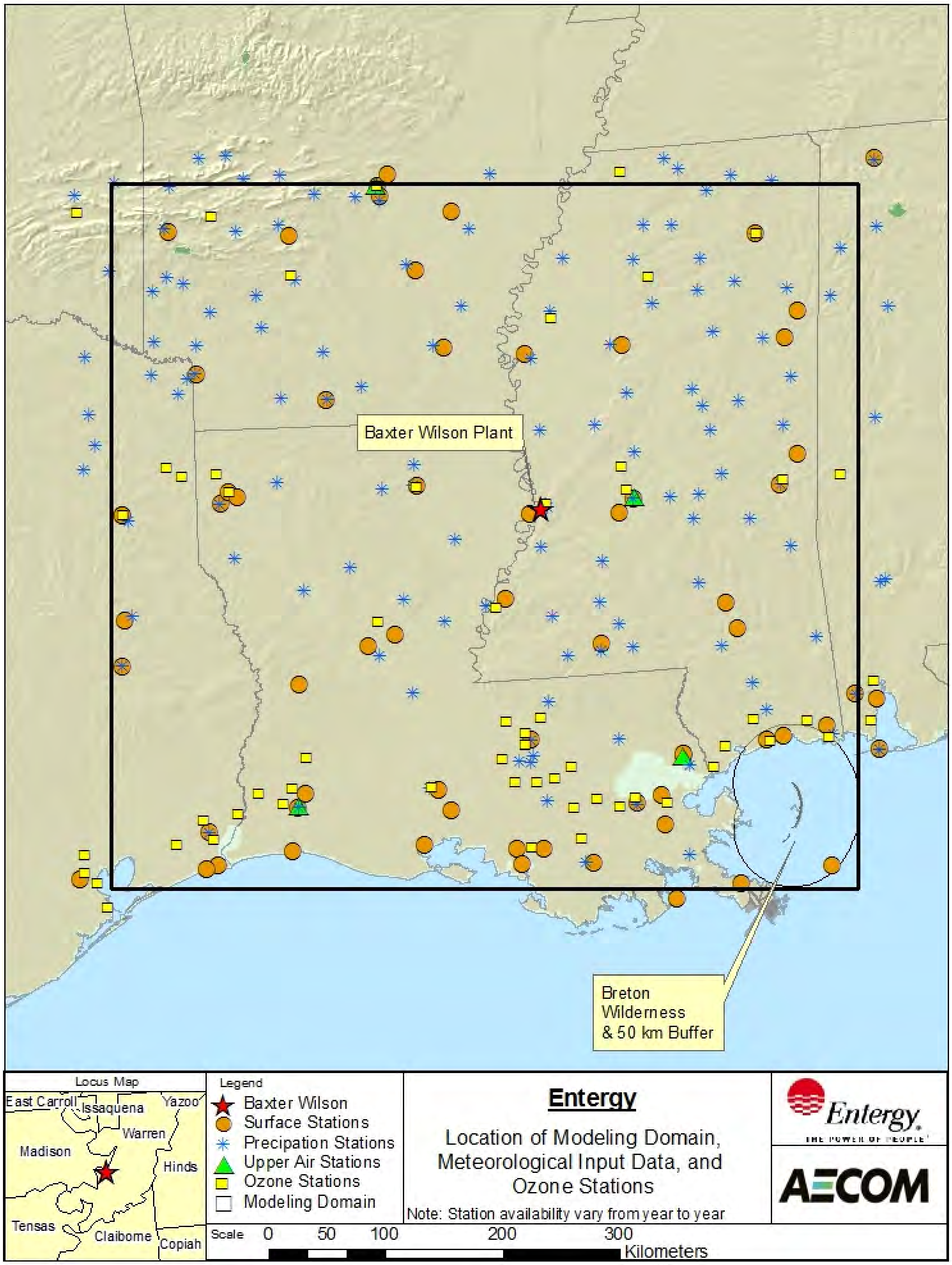
The Step 2 wind field was produced with the input of hourly surface and twice daily upper air balloon sounding data. Hourly precipitation data was also included in the CALMET simulations. Surface, upper air and precipitation files have been prepared by TRC for use in the VISTAS regional CALPUFF modeling effort. Appendix B lists stations IDs and coordinates projected in Lambert Conformal projection. Please note that the stations (surface and precipitation) vary from year to year and the tables in Appendix B represent the most complete year (2003) out of the three year period.

The following files were previously downloaded from the TRC website (link no longer works) http://www.src.com/verio/download/sample_files.htm#STANDARD_SURF.

- Standard surface files (2001-2003)
- Standard precipitation files (2001-2003)
- VISTAS Regional Domain 1 upper air data files (2001-2003). Only four upper air stations were selected from the dataset due to their proximity to this proposed modeling domain.

CALPUFF PROfessional System software, SUBDOMN tool was used to extract a smaller subset of the surface and precipitation datasets. (The software is created and distributed by TRC).

Figure 3-1: Location of Modeling Domain, Meteorological Input Data, and Ozone Stations



4.0 CALPUFF Modeling Procedures

This section provides a summary of the modeling procedures that were used for the refined CALPUFF analysis conducted for the Baxter Wilson Power Plant.

4.1 CALPUFF Processing

Similar to CALMET, the CALPUFF control input file also contains numerous switches and settings that drive how certain data will be processed, which in turn can affect dispersion within the CALPUFF model and, ultimately, estimates of the modeled regional haze impacts. In March 2006, the USEPA Model Clearinghouse issued a memo containing recommended settings for use in CALPUFF.

For this application, CALPUFF was run with all USEPA recommended settings. Most other CALPUFF settings that require user-definition and have not been specified in the March 2006 memo are meant to be tailored to specific applications. Much like CALMET, these values pertain to selection of file names, specification of beginning and ending time period for the simulation, and map.

4.2 Model Selection and Features

The EPA-approved version CALPUFF (V5.8), and POSTUTIL (V1.56) was used for BART modeling. CALPOST Version 6.292 was used to process modeling results and compute regional haze impacts at each receptor. CALPOST V6.292 contains the recommended FLAG (2010) techniques on visibility assessment, specifically the new IMPROVE equation.

4.3 Background Ozone and Ammonia

Three years (2001-2003) of hourly measurements of ozone from all non-urban monitors, as generated by VISTAS, was used as input to CALPUFF. The ozone data is consistent with the years of meteorological data. AECOM used the CALPUFF professional System software tool (SUBDOMN) to extract ozone stations inside the modeling domain from the VISTAS ozone database. Appendix B lists the selected station ID numbers and coordinates in Lambert Conformal projection. For ammonia, we followed the VISTAS-recommended approach to use a background ammonia concentration of 0.5 ppb, and not to use the ammonia limiting method.

4.4 CALPOST Visibility Impacts Processing

The CALPOST postprocessor was used for the calculation of the impact of the modeled source's primary and secondary particulate matter concentrations on light extinction. In accordance with FLAG 2010 guidance, the visibility impacts at Breton were processed using CALPOST Method 8 (MVISBK=8) and sub-mode five (M8_MODE=5). The Method 8 (new IMPROVE equation) allows a spit between large and small sulfate, nitrate and organic particles when calculating natural background conditions and change in light extinction.

The annual average concentrations, Raleigh scatting coefficient, and sea salt concentrations were taken from FLAG (2010) Table 6. The monthly relative humidity adjustment factors for large sulfate and nitrate particles were taken from FLAG Table 7 and for small particles from FLAG Table 8. The sea salt relative humidity adjustment factors were taken from FLAG Table 9.

5.0 CALPUFF Modeling and BART Exemption Results

This section provides a summary of the modeled visibility impacts due to the baseline emissions on Baxter Wilson Units 1 and 2.

5.1 Modeling Results for Baseline Emissions

5.1.1 Results for Natural Gas Firing

CALPUFF modeling results of the baseline emissions at Breton National Wildlife Refuge are presented in Table 5-1. The modeling results indicated that natural gas firing visibility impacts (8^{th} highest) are below the contribution threshold of 0.5 delta-deciviews, while oil-fired impacts are above the threshold. Therefore, natural gas firing operations are not subject to BART.

5.1.2 Results for Oil Firing

While the oil-fired impacts, with the RHR baseline (2.0 % sulfur oil) and current baseline emissions (1.0 % sulfur oil), assuming 24-hour-per-day operation both show modeled visibility impacts over the contribution threshold of 0.5 delta-deciviews, scaling of the current baseline results indicates that the minimum number of hours of oil firing required to exceed this impact is as follows:

- 22 hours per day firing 1.0 % sulfur oil for Unit 1 only (Unit 2 is off).
- 12 hours per day firing 1.0 % sulfur oil for Unit 2 only (Unit 1 is off).
- 7 hours per day firing 1.0 % sulfur oil for Units 1 and 2 on together.

These operations in terms of oil firing hours per day thus define an “oil burn day” for purposes of the discussion provided below.

The modeling protocol states:

“If the exemption modeling demonstrates that the BART-eligible units at the Baxter Wilson plant do not cause or contribute to visibility impairment with either gas-firing emissions case or oil-firing emissions case (or both cases), then that case/fuel will not be subject to BART requirements, and no further analysis will be needed. Otherwise, Entergy will proceed to perform BART determination modeling for the baseline and each selected control option for any remaining case/fuel. One exception to this requirement could occur if the selected case (e.g., oil firing) was limited to a number of days per year corresponding to the 98^{th} percentile BART-relevant statistic (8^{th} highest day) weighted by the likelihood of winds blowing toward the Breton Wildlife National Refuge. For example, if a representative wind rose indicated that the probability of wind from the northwest is 20% as an annual average, then the allowable frequency of a specific emission case that could trigger the 98^{th} percentile day’s impact at Breton would be 40 or more days per year.“

Entergy has elected to select this exemption by limiting the number of oil burn days per year. The restriction on the number of oil burn days was computed by examining representative wind roses from nearby major airports (Greenville, MS, Jackson, MS, McComb Pike County, MS, and Little Rock, AR, as shown in Figure 5-1 and their locations are plotted in Figure 5-2) and conservatively selecting the most restrictive result. The wind roses indicate that the highest probability of wind from the most frequent 90-degree sector[3] is about 43% as an annual average (Jackson, MS). The other two airport locations have a lesser wind frequency from the 90-degree sector, as presented in Table 5-2. The allowable frequency of the oil firing operations that could trigger the 98th percentile day's impact at Caney Creek is thus conservatively computed from 8 days/43%, which exceeds 18. Therefore, restricting oil burn days to no more than 18 days will ensure that that the frequency of oil firing cannot affect the 98th percentile day at any Class I area. Due to the conservatism of this approach, it is reasonable to express this operational condition as a 3-year average which would exclude any infrequent need to fire oil due to emergency conditions such as natural gas fuel disruptions.

Table 5-1: Regional Haze Impacts due to Baseline Emissions

Fuel Type	2001 8th Highest Change in Extinction (delta-dv)	2002 8th Highest Change in Extinction (delta-dv)	2003 8th Highest Change in Extinction (delta-dv)
Natural Gas Combustion	0.30	0.31	0.49
Oil Combustion (RHR baseline, 2.0 % sulfur)	1.03	1.59	2.10
Oil Combustion (current baseline, 1.0 % sulfur)	0.64	0.94	1.33

5.2 Conclusions

The modeling results indicate that natural has firing visibility impacts that are far below the contribution threshold of 0.5 delta-deciviews for each year. Therefore, natural gas firing operations are not subject to BART. The modeling results for oil firing are above the contribution threshold of 0.5 delta-deciviews for all three years. However, consistent with the modeling protocol, Entergy agrees to restrict oil burning days (as defined in Section 5.1.2) to no more than 18 per year (averaged over 3 years and excluding emergency conditions) to avoid BART review.

[3] A 90-degree sector is selected as a source-affected wind direction, consistent with the discussion in Section 8.2.2 of EPA's modeling guidance (40 CFR Part 51, Appendix W).

Figure 5-1: Wind Roses for the Nearest Regional Airports

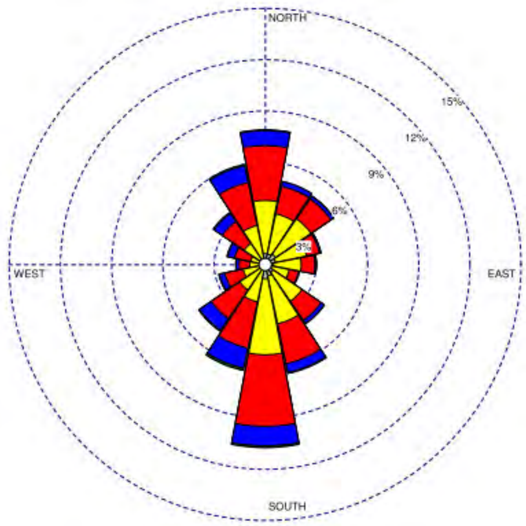
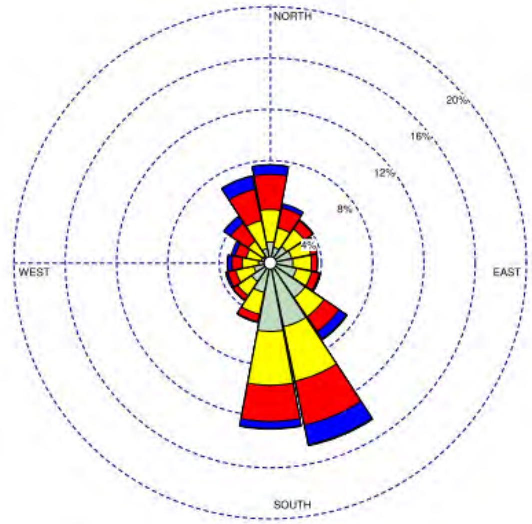
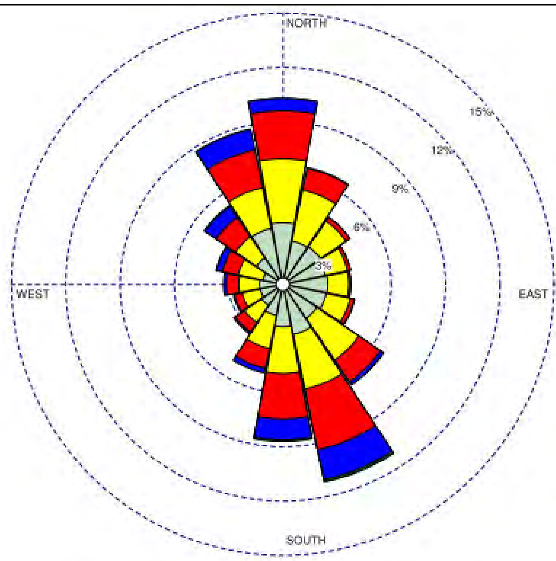
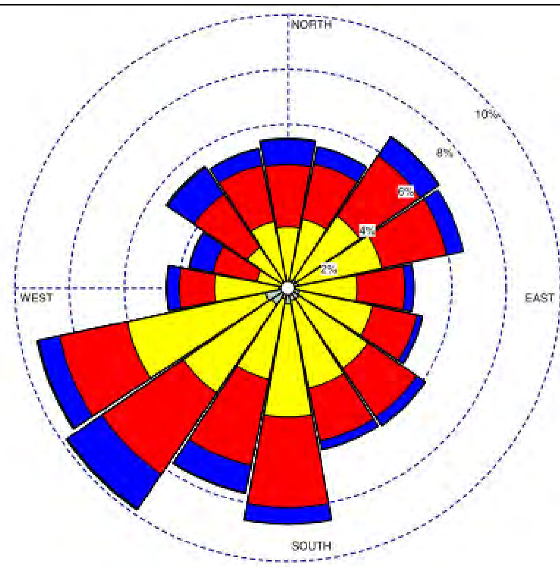
Greenville Airport, MS Wind Rose	Jackson Airport, MS Wind Rose
	
McComb Pike County Airport, MS Wind Rose	Little Rock, AR Wind Rose
	

Figure 5-2: Location of Major Regional Airports Relative to Baxter Wilson Plant

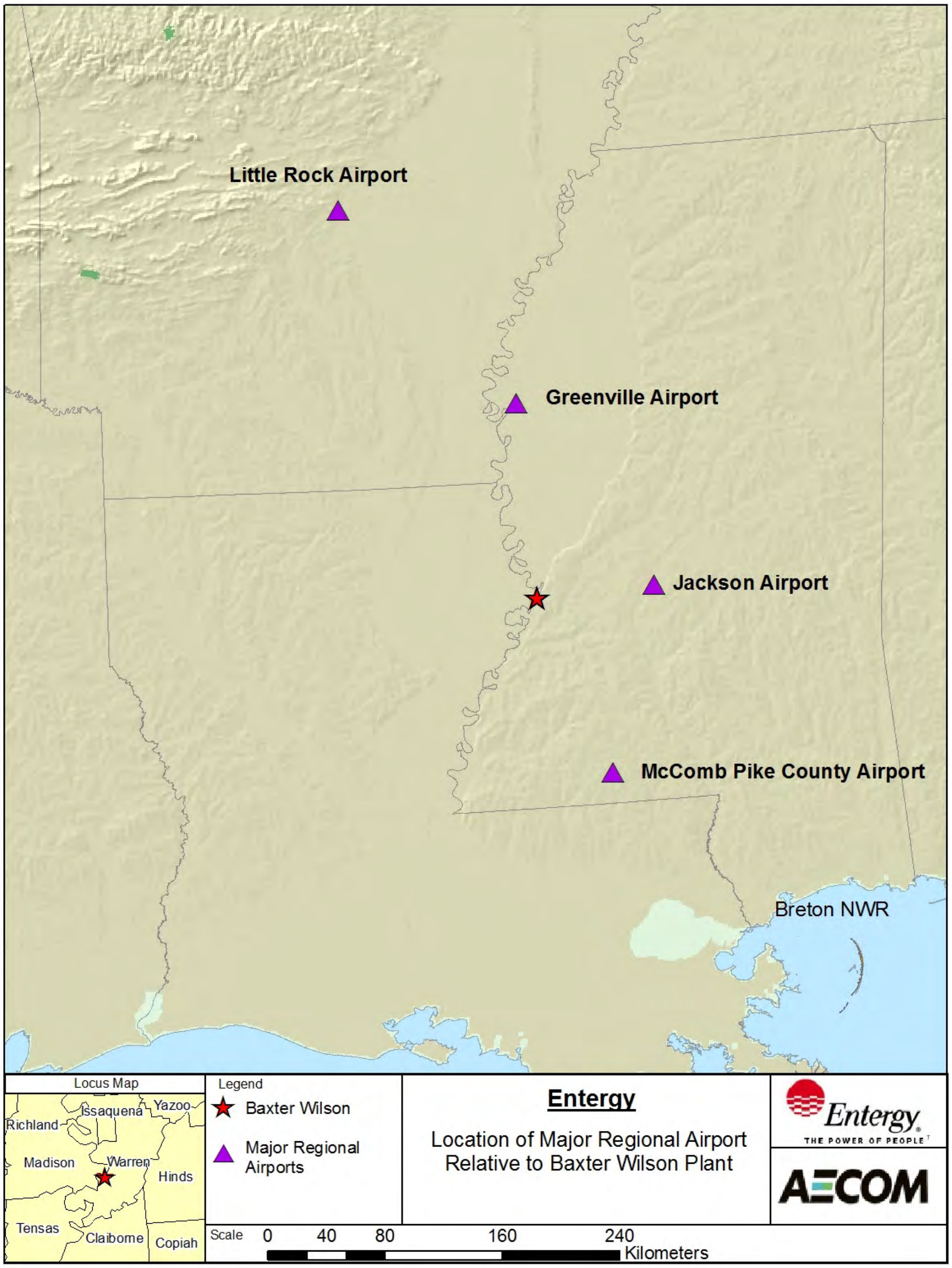


Table 5-2: Wind Direction Frequencies for the 90-degree Sector at the Nearest Regional Airports

	Greenville Airport, MS	Jackson Airport, MS	McComb Pike County Airport, MS	Little Rock Airport, AR
Total Wind Frequency for the 90-Degree Sector	31%	43%	36%	40%

6.0 References

Environmental Protection Agency (EPA), Tyler Fox Memorandum: Clarification on EPA-FLM Recommended Settings for CALMET. August 31, 2009.

Environmental Protection Agency (EPA), Dennis Atkinson Memorandum: Dispersion Coefficients for Regulatory Air Quality Modeling in CALPUFF. March 16, 2006.

Environmental Protection Agency (EPA), 40 CFR Part 51, FRL -7925-9, RIN: 2060-AJ31, Regional Haze Regulations and Guidelines for Best Available Retrofit Technology (BART) Determinations (Appendix Y), updated June 24, 2005

Environmental Protection Agency (EPA), Guidance for Tracking Progress Under the Regional Haze Rule, EPA-454/B-03-003, Appendix A, Table A-3, September, 2003

Federal Land Managers' Air Quality Related Values Work Group (FLAG). Phase I Report. Revised 2010.

Visibility Improvement State and Tribal Association of the Southeast (VISTAS), Revision 3, Protocol for the Application of the CALPUFF Model for Analyses of Best Available Retrofit Technology (BART), updated July 18, 2006.

Appendix A Responses to EPA R4 Comments-BART Modeling Protocols-Entergy MS

Entergy Responses to U.S. EPA Region 4 Comments on BART Exemption Modeling Protocols for

Entergy Mississippi's Baxter Wilson Unit 1 and Baxter Wilson Units 1 and 2

1. GEP Stack Heights: The protocols do not discuss the stack height and stack parameters for the units that will be modeled nor if they will comply with good engineering practice (GEP). Please document that the modeling for regulatory purposes includes the GEP stack heights.

   Entergy Response: *The table below summarizes stack exhaust parameters that were used in the CALPUFF modeling; these are included in the BART reports. AECOM has conducted a GEP analysis for the Gerald Andrus Unit 1 stack and Baxter Wilson Unit 1 and Unit 2 stacks and concluded that they are fully creditable. Therefore, actual stack heights, shown in the table below, were used in modeling, along with the appropriate building downwash inputs.*

Unit	Actual Stack Height (m)	Base Elevation (m)	Stack Diameter (m)	Exit Velocity (m/s)	Temp (K)
Gerald Andrus Unit 1	152.10	45.42	8.77	19.65	434.30
Baxter Wilson Unit 1	149.40	32.00	5.80	24.08	380.40
Baxter Wilson Unit 2	149.40	32.00	7.00	33.23	449.30

2. The U.S. Fish and Wildlife Service (USFWS) reprocessed the original VISTAS 4-km CALMET dataset using CALMET v5.8, level 070623. It is unclear if this dataset is being used in the modeling or if the FLMs were consulted in the development of a new dataset. EPA Region 4 recommends that this reprocessed CALMET dataset be used.

   Entergy Response: *The VISTAS 4-km CALMET dataset reprocessed by USFWS is not big enough to cover a modeling domain that encompasses both Gerald Andrus and Baxter Wilson plants along with Breton Wilderness area and Caney Creek Class I area (plus a 50 kilometers buffer). However, AECOM created, in a manner consistent with the USFWS reprocessing approach, a single CALMET database for assessing regional haze impacts in Class I areas for both Entergy plants. The CALMET database used the same inputs that were used to develop the regional 12-kilometers VISTAS dataset for screening modeling, such as surface observations, upper air data, precipitation, and MM5 data. The EPA-approved version of CALMET v5.8, level 070623 was used.*
3. The report should document how the EPA modeling recommendations, etc., are applied. EPA recommends including, in the modeling report, specific details documenting the switches, assumptions, years of data and names of meteorological and air quality monitoring stations, etc. used in developing and simulating CALMET, CALPUFF, CALPOST, POSTUTIL and the CALPUFF professional System software tool (SUBDOMN).

Entergy Response: *CALPUFF was run with all USEPA recommended settings specified in the March 2006 USEPA Model Clearinghouse memo and the May 15, 2009 EPA Model Clearinghouse recommendations.*

Three years (2001-2003) of hourly CALMET input data (surface observations, upper air, precipitation) were extracted from the VISTAS database using CALPUFF professional System software tool (SUBDOMN). AECOM has listed the selected station ID numbers and coordinates in the modeling report.

4. For the Gerald Andrus Unit, the 24-hour emissions from the baseline period will be used for the unit. It is unclear if the emissions were determined from continuous emissions monitoring or stack tests, etc. data for specific pollutants. EPA recommends clarifying, in the modeling report, how the emissions were determined (i.e. continuous emissions monitoring or stack heights for specific pollutants.)

   Entergy Response: *Baseline SO_2 and NOx emissions from the unit were based on the maximum actual daily SO_2 and NOx emission rates recorded by the CEMS during the period 2001-2003. Determination of filterable particulate matter and speciation of the particulate matter emissions from the unit into filterable and condensable PM_{10} components was conducted using the following approach:*

   - *The total filterable PM emission rate for oil firing was determined using AP-42 Section 1.3 and that for gas firing was based on AP-42 Section 1.4.*
   - *For oil firing, the filterable PM_{10} portion of the total filterable PM was calculated using the cumulative size distributions given in AP-42 Table 1.3-4 (uncontrolled size fractions). The total filterable PM_{10} is 71% of the filterable PM. The fine PM_{10} (i.e., $PM_{2.5}$) was calculated as the 52% of total filterable PM. The coarse PM_{10} (particles with aerodynamic diameters between 10 microns and 2.5 microns) was calculated as the difference between the total filterable PM_{10} and the fine PM_{10} (filterable $PM_{2.5}$). For gas firing, all filterable PM is considered to be total filterable $PM_{10.}$ Moreover, total filterable PM_{10} is considered to all $PM_{2.5}$.*
   - *Elemental carbon (EC) or black carbon was estimated to be 7.4% of fine PM_{10} ($PM_{2.5}$) based on the best estimates for industrial petroleum in Table 6 of "Catalog of Global Emissions Inventories and Emission Inventory Tools for Black Carbon", William Battye and Kathy Boyer, EPA Contract No. 68-D-98-046, January 2002. For gas firing, elemental carbon or black carbon was estimated to be 6.7% of fine PM_{10} ($PM_{2.5}$) based on the best estimates for natural gas in Table 6 of "Catalog of Global Emissions Inventories and Emission Inventory Tools for Black Carbon", William Battye and Kathy Boyer, EPA Contract No. 68-D-98-046, January 2002. For both gas and oil firing cases, fine soil is the difference between fine total PM and fine EC.*
   - *For oil firing, the condensable PM emission factor was based on AP-42 Table 1.3-2 (1.5 lb/1000 gal) for No.6 oil-fired boilers. All inorganic condensable PM_{10} was assumed to be sulfates (i.e. no soil component). For gas firing, the condensable PM emission factor was based on AP-42 Table 1.4-2 (5.7 lb/MMcf) for gas-fired boilers. Organic condensable PM is the difference between total condensable PM and inorganic condensable PM.*

5. EPA recommends the use of metric units for the modeling report.

   Entergy Response: *We are using metric units for the BART report.*

6. Please clarify if the ozone data used is consistent with the year of meteorological data.

Entergy: *Three years (2001-2003) of hourly measurements of ozone from all non-urban monitors, as generated by VISTAS, were used as input to CALPUFF. The ozone data is consistent with the years of meteorological data. AECOM used the CALPUFF professional System software tool (SUBDOMN) to extract ozone stations inside the modeling domain from the VISTAS ozone database. We list the selected station ID numbers and coordinates in the BART report.*

Appendix B

Surface, Precipitation, Upper Air, and Ozone Stations used in CALMET and CALPUFF

Table B-1: Surface Stations Used in CALMET

Surface Station ID	Surface Station No.	X LC (km)	Y LC (km)
KMOB	722230	839.42	-992.98
KBFM	722235	857.47	-996.83
K7R5	722293	359.50	-1126.77
KAXO	722309	687.47	-1167.20
KMSY	722310	653.63	-1085.51
KHDC	722312	633.30	-1029.02
KARA	722314	495.48	-1092.15
KNEW	722315	674.17	-1078.34
KNBG	722316	677.72	-1104.23
KBTR	722317	562.77	-1032.06
KIER	722319	369.58	-908.32
BVE	722320	742.00	-1153.46
K7R3	722328	573.62	-1124.75
KPTN	722329	550.88	-1124.30
KMEI	722340	774.91	-814.23
KNMM	722345	789.81	-788.60
HBG	722347	738.18	-936.72
KPIB	722348	728.42	-915.17
KJAN	722350	650.11	-826.45
KHKS	722354	638.40	-838.95
KGLH	722356	557.07	-703.10
KHEZ	722357	540.78	-912.22
KMCB	722358	622.76	-949.62
KGWO	722359	640.10	-695.29
KASD	722366	692.38	-1043.26
KPOE	722390	364.92	-984.77
KLCH	722400	364.46	-1089.15
KP92	722403	554.91	-1137.18
KCWF	722404	370.37	-1077.70
KLFT	722405	484.78	-1074.03
KHUM	722406	616.69	-1136.78
K7R4	722408	472.80	-1121.42
KBPT	722410	289.25	-1110.64

Surface Station ID	Surface Station No.	X LC (km)	Y LC (km)
KEFD	722436	178.51	-1150.88
KLFK	722446	214.64	-969.36
KBBB	722447	214.57	-841.16
KRPE	722453	296.69	-1138.40
KGGG	722470	214.57	-841.16
KSHV	722480	298.87	-831.17
KDTN	722484	304.83	-821.71
KBAD	722485	312.74	-825.10
KMLU	722486	465.83	-816.21
KESF	722487	447.25	-941.81
KTVR	722488	561.45	-840.23
KOCH	722499	216.81	-930.25
KMSL	723235	854.85	-536.69
KCBM	723306	789.25	-665.84
KGTR	723307	779.07	-689.11
KTUP	723320	753.88	-600.34
KLZK	723400	432.06	-560.44
KLIT	723403	434.09	-569.55
KLRF	723405	440.65	-550.66
KHOT	723415	356.47	-602.90
KSGT	723416	495.66	-582.75
KPBF	723417	464.99	-632.64
KTXK	723418	278.02	-720.62
KELD	723419	388.78	-742.15
KLLQ	723424	488.66	-698.01
KMWT	723435	254.18	-599.22
KDEQ	743312	239.06	-655.17
KAEX	747540	423.93	-952.26
KGPT	747685	764.01	-1031.68
KBIX	747686	778.25	-1028.52
KPQL	747688	814.60	-1019.58
SRST	994260	287.08	-1142.42
GDIL	994290	687.33	-1165.30
DPIA	994420	860.14	-1039.59

Table B-2: Precipitation Stations Used in CALMET

Station No.	X LC (km)	Y LC (km)
10748	867.19	-661.92
12172	860.14	-1039.59
13620	857.60	-594.28
13645	826.58	-612.37
14193	860.85	-896.44
15478	839.75	-992.38
15749	854.91	-537.35
18178	864.92	-894.24
18517	817.92	-653.16
18673	856.01	-757.13
30130	378.44	-567.18
30178	329.09	-653.66
30220	361.85	-640.42
30764	347.38	-593.62
30798	303.54	-534.77
30832	280.21	-536.82
30900	318.62	-553.95
30936	528.20	-549.41
31140	419.13	-730.91
31152	386.23	-700.79
31952	241.47	-649.55
32020	267.30	-643.54
32148	503.62	-661.75
32300	389.04	-741.70
32489	413.84	-569.59
32544	241.87	-692.18
34185	318.41	-729.09
34248	433.68	-572.13
34548	349.89	-740.07
34756	251.18	-596.76
34839	278.11	-695.39
34900	479.78	-695.18
34988	311.64	-598.26
35110	301.43	-642.05
35112	289.98	-666.88
35200	348.86	-550.84
35320	431.14	-560.27
35754	456.74	-626.54
35908	334.10	-679.90
36920	510.24	-596.64
37048	277.36	-720.20
37488	255.09	-560.48
160103	433.83	-959.25
160537	466.82	-788.08

Station No.	X LC (km)	Y LC (km)
169803	409.18	-884.89
169806	498.13	-860.88
220021	780.86	-646.56
220237	624.92	-557.32
220797	767.49	-1027.22
220955	768.03	-554.48
221094	621.83	-914.24
221314	704.36	-649.24
221389	651.29	-786.52
221707	589.89	-621.06
221743	579.23	-666.31
221852	705.60	-897.60
221900	725.12	-804.87
222281	778.10	-763.65
222658	715.73	-767.37
222773	649.81	-622.16
222870	700.04	-733.20
222896	718.16	-684.06
223619	630.72	-694.10
223650	666.64	-659.80
223920	619.18	-882.80
224001	712.46	-564.03
224173	687.97	-544.85
224265	736.01	-640.94
224472	650.64	-826.08
224778	708.89	-747.30
224966	805.89	-943.78
225062	644.69	-735.83
225074	594.25	-959.23
225247	737.46	-728.23
225361	784.42	-721.64
225614	622.78	-955.21
225704	581.41	-926.34
225776	775.45	-813.95
226084	676.60	-536.56
226400	739.08	-742.48
226718	820.10	-1026.59
226750	748.87	-853.22
226816	681.34	-824.01
227132	571.10	-867.49
227220	725.02	-950.94
227276	701.77	-842.91
227444	767.42	-923.09
227467	732.59	-550.35

Station No.	X LC (km)	Y LC (km)
160548	565.24	-1044.90
160549	563.03	-1031.60
161246	552.59	-1049.51
161287	462.56	-991.30
161411	436.34	-818.22
161899	577.67	-999.18
162534	577.43	-1083.33
164030	638.24	-1030.57
164407	610.15	-1135.44
164696	455.10	-911.70
164700	418.74	-1077.43
164739	489.50	-930.25
165021	476.57	-1072.58
165078	364.91	-1088.23
165287	355.36	-985.17
165620	562.33	-1050.69
165624	698.59	-1129.11
165874	311.04	-876.52
166244	347.15	-812.08
166303	465.09	-816.36
166314	462.55	-814.61
166394	565.69	-1127.17
166582	369.77	-903.96
166660	653.59	-1086.30
166664	665.64	-1093.92
167738	316.27	-834.21
168163	544.68	-874.79
168440	298.22	-831.52
168539	697.93	-1052.13
169357	525.18	-916.98

Station No.	X LC (km)	Y LC (km)
227560	570.52	-767.58
227592	749.07	-842.58
227815	658.33	-593.66
227820	706.60	-621.20
227840	763.37	-1005.60
228053	784.33	-865.48
228374	760.43	-688.92
228445	562.79	-706.72
229003	753.52	-600.48
229048	650.03	-952.20
229079	682.85	-593.57
229218	576.67	-833.63
229617	701.23	-992.11
229648	751.70	-982.28
229860	617.24	-763.86
340670	174.40	-568.01
341544	204.00	-632.12
349724	208.61	-557.02
411773	182.94	-705.45
413546	182.41	-801.51
415348	220.69	-845.02
415424	214.25	-969.03
416108	186.06	-754.61
416177	223.55	-926.18
416270	240.11	-721.23
417066	192.25	-781.27
417174	288.86	-1110.54
417936	277.15	-986.68
418942	270.45	-724.54
419916	262.50	-737.35

Table B-3: Upper Air Stations Used in CALMET

Station ID	Station No.	X LC (km)	Y LC (km)
SIL	53813	692.27	-1045.51
JAN	3940	651.30	-826.03
LCH	3937	365.70	-1088.76
LZK	3952	430.26	-560.87

Table B-4: Ozone Stations Used in CALPUFF

Station No.	X LC (km)	Y LC (km)
CAD150	358.02	-636.53
CVL151	661.92	-637.61
10970003	854.01	-981.82
10972005	852.11	-1015.16
11190002	825.90	-805.98
50970001	290.34	-586.97
51191002	431.22	-560.76
220050004	582.44	-1064.29
220110002	371.30	-1046.89
220150008	304.85	-821.58
220170001	293.99	-806.13
220190002	350.91	-1086.75
220190008	358.85	-1073.18
220190009	330.60	-1078.08
220330013	570.60	-1012.82
220331001	556.92	-1026.37
220430001	431.44	-931.20
220470007	537.26	-1048.56
220470009	549.00	-1067.94
220470012	567.05	-1068.31
220511001	650.85	-1080.85
220550005	478.07	-1072.44
220570004	605.63	-1115.44
220630002	596.87	-1054.51
220730004	464.65	-817.09
220770001	540.91	-1016.46
220870002	678.08	-1085.68
220890003	638.24	-1088.42
220930002	598.56	-1090.05

Station No.	X LC (km)	Y LC (km)
220950002	618.53	-1081.50
221010003	562.83	-1123.73
221210001	557.26	-1035.89
280010004	532.62	-919.05
280110001	579.09	-672.32
280330002	637.59	-548.38
280450001	717.48	-1054.68
280450002	727.56	-1037.04
280470008	765.77	-1032.63
280470009	751.50	-1014.04
280490010	644.10	-819.25
280590006	815.43	-1029.48
280590007	797.18	-1014.93
280750003	776.33	-810.59
280810005	753.97	-600.56
280890002	639.07	-799.63
281490004	574.61	-831.22
481671002	201.82	-1174.86
481830001	215.00	-841.21
482010026	182.12	-1130.02
482011015	186.83	-1134.19
482011039	182.18	-1144.93
482011041	186.31	-1135.63
482011050	193.34	-1154.40
482030002	265.15	-807.73
482450009	283.34	-1100.82
482450011	292.32	-1116.79
482450022	260.38	-1121.19
483611001	313.47	-1094.76

Appendix L.7.4 – Retired Unit Exemption Report

CAMD (Clean Air Markets Division) Business System Logo CAMD (Clean Air Markets Division) Business System Logo

Retired Unit Exemption Report

Baxter Wilson (2050) - MS

Units with Retired Unit Exemptions

Unit ID	Program(s)	Form Received Date	Form Submitted By	Unit Retirement Date	First Full Year of Exemption (ARP)	End Date
2	ARP, CAIRNOX, CAIROS, CAIRSO2, CSNOXOS, CSOSG2	05/31/2018	Keys, Renee	06/01/2018	2019	

United States Environmental Protection Agency

Appendix L.8: VISTAS Protocol

Protocol for the Application of the CALPUFF Model for Analyses of Best Available Retrofit Technology (BART)

December 22, 2005

(Revision 3.2 – 8/31/06)

Visibility Improvement State and Tribal Association of the Southeast (VISTAS)

TABLE OF CONTENTS

SUMMARY

This Protocol for the Application of the CALPUFF Model for Analyses of Best Available Retrofit Technology (BART) for the VISTAS Regional Planning Organization (RPO) describes common procedures for carrying out air quality modeling to support BART determinations that are consistent with guidelines of the U.S. Environmental Protection Agency in 40 CFR Part 51 Appendix W and Appendix Y. The Protocol is intended to serve as the basis for a common understanding among the organizations that will be performing BART analyses or reviewing the BART modeling results in the VISTAS region.

Background

Best Available Retrofit Technology is required for any BART-eligible source that ‘‘emits any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility” in any mandatory Class I federal area. According to 40 CFR Part 51 Appendix Y, “*You can use dispersion modeling to determine that an individual source cannot reasonably be anticipated to cause or contribute to visibility impairment in a Class I area and thus is not subject to BART*.” In the “individual source attribution approach,” a BART-eligible source that is responsible for a 1.0 deciview (dv) change or more is considered to “cause” visibility impairment. A BART-eligible source that is responsible for a 0.5 dv change or more is considered to “contribute” to visibility impairment in a Class I area. Any source determined to cause or contribute to visibility impairment in any Class I area is subject to BART.

The member states of the VISTAS RPO agreed to develop a common BART Modeling Protocol to guide them, their sources, and reviewers in the BART determination and review effort. The Protocol has been in preparation within VISTAS since January 2005. The original authors are Pat Brewer, VISTAS Technical Coordinator, and Ivar Tombach, VISTAS Technical Advisor. The VISTAS state BART contacts, particularly Tom Rogers, FL, Chris Arrington, WV, Leigh Bacon, AL, and Michael Kiss, VA, have directed and extensively reviewed the Protocol. The Protocol was enhanced and completed with the assistance of Joseph Scire, Christelle Escoffier-Czaja and Jelena Popovic of Earth Tech, Inc. and it has received extensive contributions and review from the VISTAS federal partners: Federal Land Managers and US EPA. The VISTAS RPO held a meeting on September 21, 2005 in Research Triangle Park, NC to discuss the Protocol with participants before starting a public comment period. The Protocol underwent formal external review during the period between September 26, 2005 and October 31, 2005. Numerous comments were received. All comments were carefully considered and discussed with VISTAS participants and federal partners. VISTAS gratefully acknowledges the very useful contributions of those that provided comments. On November 1st, 2005 VISTAS held another meeting with its participants in Nashville, TN to present and discuss the comments being considered for inclusion in the Protocol. No formal document will be prepared to address all the comments received on the Protocol.

Objectives

The objectives of the Protocol (discussed in Chapter 1) are to provide:

- A consistent approach to determine if a source is subject to BART
- A consistent model (CALPUFF) and modeling guidelines for BART determinations
- Clearly delineated modeling steps
- A common CALPUFF configuration
- Guidance for site-specific modeling
- Common expectations for reporting model results

The Protocol is not intended to define the engineering analyses required by the US EPA's BART Guidance, nor address model alternatives to the CALPUFF model, nor address emissions trading.

Chapter 2 is intended to provide summary background on EPA's guidance for BART modeling. The CALPUFF model system is reviewed in Chapter 3, while specific recommendations for applying the CALPUFF model for BART purposes appear in Chapter 4. Chapter 5 describes the specific information that should be included in site-specific protocols. Chapter 6 describes the quality assurance requirements for BART analyses in the VISTAS RPO.

Recommendations

The major recommendations for VISTAS BART modeling included in this Protocol are:

I. Process

Follow the BART process steps discussed in Chapter 2:

1. Identify BART eligible sources
2. Identify which pollutants have greater than *de minimis* emission levels
3. Identify sources that are subject to BART
4. Identify baseline visibility impact of each BART source
5. Identify feasible controls and emission changes
6. Identify the change in visibility impact for each candidate BART control option
7. Compare the visibility improvement of BART control options to other statutory factors in the engineering analysis

II. CALPUFF Model Configuration

Use the CALPUFF dispersion modeling system, as described in Chapter 4, to determine if a single source is subject to BART. VISTAS will use CALPUFF Version 5.754 and CALMET Version 5.7. These versions contain enhancements funded by the Minerals Management Service (MMS) and VISTAS. They were developed by Earth Tech, Inc. and are maintained on the CALPUFF website (www.src.com) for public access.

VISTAS is making publicly available 12-km CALMET output files for the entire VISTAS modeling domain (eastern United States) and intends to also provide CALMET output files for five 4-km grid subdomains covering the VISTAS states and VISTAS Class I areas. To create the CALMET input files, Earth Tech used the MM5 databases developed by EPA for 2001, VISTAS for 2002, and Midwest RPO for 2003. For the 12 km grid large domain covering the entire VISTAS region, Earth Tech used the No-Obs setting (i.e., did not include additional surface and upper air observations beyond those incorporated in the MM5 calculations). For finer resolution subdomains (4 km grid or less), available surface and upper air observations will be used in addition to MM5 meteorological model outputs. The specific model settings will be provided with the CALMET files and via the CALPUFF website so that users can review or replicate the work.

For CALPUFF modeling, source emissions should be defined using the maximum 24-hour actual emission rate during normal operation for the most recent 3 or 5 years. If maximum 24-hr actual emissions are not available, continuous emissions data, permit allowable emissions, potential emissions, and emissions factors from AP-42 source profiles may be used as available.

Key points from comments received on the specific CALPUFF, CALPOST, and POSTUTIL configurations are highlighted below.

- After running CALPUFF for an individual facility, repartition NO_3 in POSTUTIL.[1]
- Use ozone data from non-urban monitors as the background ozone input.
- Use the Pasquill-Gifford dispersion method.[2]

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[1] The original intent, as expressed in the Final VISTAS BART Modeling Protocol (22 December 2005) was to use CMAQ-derived background data for SO_2, NO_3 and NH_3 in POSTUTIL. After extensive discussion with the EPA and FLMs in early 2006, EPA did not approve the recommended approach so background gaseous concentrations from CMAQ 2002 modeling will not be provided by VISTAS for use in POSTUTIL. Rather the standard default NH_3 concentrations specified on page 14 of the IWAQM Phase 2 report (IWAQM, 1998) will be used.

[2] The Final VISTAS BART Modeling Protocol (Dec. 22, 2005) recommended using turbulence-based AERMOD dispersion methods, citing EPA's *Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rule.* 70 FR 68218-68261. 9 November 2005. Subsequently, EPA Region IV notified the VISTAS states that using turbulence-

- In CALPOST, use Method 6 with monthly average RH for calculating extinction, as recommended by the EPA.
- Use EPA default calculations of light extinction under current and natural background conditions. In addition to the default assumptions, a source may choose to also calculate visibility using the recently revised IMPROVE algorithm described by Pitchford, et al., (2005).

Provide results in tables as illustrated in Chapter 4 that describe, for each source:

- Number of receptors within a single Class I area with impact > 0.5 dv
- Number of days at all receptors in the Class I area with impact > 0.5 dv
- Number of Class I areas with impacts > 0.5 dv

III. CALPUFF Application for BART

For determining if a BART-eligible source is subject to BART CALPUFF modeling, use a two-tier approach. For the initial exemption modeling use CALPUFF with 12-km grid CALMET. For finer resolution of meteorological fields, use CALPUFF with CALMET of 4-km or smaller grid size.

VISTAS States are accepting EPA guidance that the threshold value to establish that a source contributes to visibility impairment is 0.5 deciview.

VISTAS States are using emissions (tons per year) divided by distance (km) from a Class I area boundary (Q/d) as a presumptive indicator that a BART-eligible source is subject to BART. If Q/d for SO_2 is greater than 10 for 2002 actual annual emissions, then the State presumes that the source is subject to BART and no exemption modeling will be performed using VISTAS funds. If the source agrees with this presumption, then the source can proceed to the BART determination using CALPUFF to evaluate impacts of control options and perform the engineering analyses. If a source disagrees, the source may perform fine grid modeling to determine if its impact is <0.5 dv.

For sources with Q/d less than or equal to 10, VISTAS intends to fund TRC Environmental Corp.[3] to assist States with the initial CALPUFF exemption modeling. Each State will prioritize which sources will be offered modeling by VISTAS. Modeling of these sources will be conducted in priority order to first accommodate States with nearer term timing constraints in their SIP development process. To conserve VISTAS resources, modeling will begin with sources at lower Q/d values and continue with sources with higher Q/d values until a Q/d value

based dispersion methods would be considered a non-guideline application of CALPUFF. Thus this Protocol has been revised to indicate Pasquill-Gifford dispersion coefficients should be used.

[3] In April 2006, Earth Tech's CALPUFF modeling staff became part of TRC Environmental Corporation. References to Earth Tech and to TRC in this protocol refer to the same technical staff, just at different times.

that consistently results in a greater than 0.5 dv impact is identified. Chapter 4 addresses the number of VISTAS sources eligible for BART based on Q/d analysis.

Note that VISTAS does not propose to use Q/d to exempt BART-eligible sources, but only to prioritize sources for modeling purposes. Thus this application is consistent with EPA guidance not to use Q/d for exemption purposes.

For the 12-km initial modeling exemption test, compare the highest single 24-hour average value across all receptors in the Class I area to the threshold value of 0.5 dv. If the highest 24-hr average value is below 0.5 dv at all Class I areas, then the source is not subject to BART. If the highest 24-hr average value is greater than 0.5 dv, then the source may choose to perform finer grid modeling for exemption purposes or may accept determination that the source is subject to BART and proceed to establish visibility impacts prior to and after BART controls. If using the single highest 24-hr average value proves, after initial 12-km grid CALPUFF modeling, to be too conservative a screening level, VISTAS may allow some exceedances of the threshold value for exemption purposes, up to no more than the 98th percentile value.

The 12-km modeling results can be used to focus finer grid modeling for exemption purposes on only those Class I areas where impacts greater than 0.5 dv were projected in the 12-km modeling.

For finer grid (4 km or less) analyses, use the 98th percentile impact value for the 24-hr average. Use either the 8th highest day in each year or the 22nd highest day in the 3-year period, whichever is more conservative, for comparison to the exemption threshold.

Use the same model assumptions for pre-BART visibility impact and for BART control options modeling: establish baseline visibility from the pre-BART run; change one control at a time; and evaluate the change in visibility impact, i.e. the delta-deciview. Note that “no control” may constitute BART.

Visibility impact is one of the five factors considered in the engineering analysis required under the USEPA BART guideline. If a source accepts to institute the most stringent control, the engineering analyses are not required.

This common VISTAS Protocol consistently recommends conservative assumptions. Individual States ultimately have responsibility to determine which, if any, BART controls are recommended in their State Implementation Plans (SIPs).

1. INTRODUCTION AND PROTOCOL OBJECTIVES

1.1 Background

Under regional haze regulations, the Environmental Protection Agency (EPA) has issued final guidelines dated July 6, 2005 for Best Available Retrofit Technology (BART) determinations (70 FR 39104-39172). The regional haze rule includes a requirement for BART for certain large stationary sources. Sources are BART-eligible if they meet three criteria including potential emissions of at least 250 tons per year of a visibility-impairing pollutant, were put in place between August 7, 1962 and August 7, 1977, and fall within one of the 26 listed source categories in the guidance. A BART engineering evaluation using five statutory factors -- 1) existing controls; 2) cost; 3) energy and non-air environmental impacts; 4) remaining useful life of the source; 5) degree of visibility improvement expected from the application of controls -- is 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. (Note that, depending on the five factors, the evaluation may result in no control.) Air quality modeling is an important tool available to the States to determine whether a source can be reasonably expected to contribute to visibility impairment in a Class I area.

Throughout this document the term “BART-eligible emission unit” is defined as any single emission unit that meets the criteria described above. A “BART-eligible source” is defined as the total of all BART-eligible emission units at a single facility. If a source has several emission units, only those that meet the BART-eligible criteria are included in the definition “BART-eligible source”.

One of the listed categories is steam electric plants of more than 250 million BTU/hr heat input. To determine if such a plant has greater than 250 million BTU/hr heat input and is potentially subject to BART, the boiler capacities of all electric generating units (EGUs) should be added together regardless of construction date. In this category, electric generating sources greater than 750 MW have presumptive SO_2 and NO_x emission limits. States may presume the same limits for EGU sources between 250-750 MW. However, units at those sources constructed after the BART-eligibility dates are not subject to a BART engineering evaluation. EPA, in the Clean Air Interstate Rule (CAIR), determined that an EGU participating in the CAIR trading program satisfies the BART requirements for SO_2 and NO_x. VISTAS states are tentatively accepting this guidance. CAIR does not cover PM so EGUs would still need to evaluate impacts of PM if PM emissions are above *de minimis* values.

As illustrated in Table 1-1, as of December 5, 2005, VISTAS States had identified a total of 274 BART-eligible sources that fall into 20 of the 26 BART source categories. Of the 274 sources with BART-eligible units, 84 sources are utility EGUs and 190 are non-EGU industrial sources. (Note that these numbers are not final and are subject to slight adjustments and refinements.) No BART sources are located on Tribal lands.

Table 1-1. VISTAS BART Eligible Sources (not updated since December 2005)

State	Total Number of Sources	EGU Sources	Non-EGU Sources
AL	48	8	40
FL	50	23	27
GA	24	10	14
KY	29	12	17
MS	18	8	10
NC	16	5	11
SC	31	6	25
TN	13	2	11
VA	18	3	15
WV	26	7	19
Total	**273**	**84**	**189**

1.2 Objective of this Protocol

The objective of this VISTAS' BART Modeling Protocol is to describe common procedures for air quality modeling to support BART determinations that are consistent with the EPA guidelines. The protocol will serve as the basis for establishing a common understanding among the organizations who will be performing the BART analyses or reviewing the BART modeling results, including VISTAS State and Local air regulatory agencies, EPA, Federal Land Managers (FLMs), source operators, and contractors for the sources. This final protocol incorporates EPA final guidance and comments that were received on VISTAS' draft protocol[4] and provides additional description of modeling procedures. The original final protocol of 22 December 2005 has been revised since then to clarify items, resolve technical issues, and reflect decisions by the EPA and FLMs. This document is the third revision.

The VISTAS States have accepted EPA's guidance to use the CALPUFF modeling system to comply with the BART modeling requirements of the regional haze rule. A BART-eligible source will be required to submit a site-specific modeling protocol to the State for review and approval prior to performing CALPUFF modeling. States will consult with FLMs and the EPA when evaluating the site-specific BART protocols. The site-specific protocol will include the

[4] *Draft Protocol for the Application of the CALPUFF Model for Analyses of Best Available Retrofit Technology (BART). VISTAS*, March 22, 2005 and September 20, 2005.

source-specific data on source location, stack parameters, and emissions. The methods of the VISTAS common modeling protocol will be followed in the site-specific protocol unless the source proposes to the State, and the State approves, alternative methods or assumptions.

Each VISTAS State or Local agency retains responsibility for the specific procedures and processes it will follow in working with the BART sources under its jurisdiction, the FLMs, EPA, and public to determine BART controls for sources in the State. Nothing in the VISTAS process replaces States' responsibility to determine BART controls.

The remainder of this document describes the CALPUFF modeling system and the application of CALPUFF to two situations:

- Air quality modeling to determine whether a BART-eligible source is "subject to BART" and therefore the BART analysis process must be applied to its operations.

- Air quality modeling of emissions from sources that have been found to be subject to BART, to evaluate regional haze benefits of alternative control options and to document the benefits of the preferred option.

Chapters 2 and 3 of this document are intended to provide background information on EPA's guidance for BART analysis modeling and on the CALPUFF modeling system. Subsequent chapters include more specific recommendations. Chapter 2 of this document reviews EPA's guidance for regional haze BART analysis modeling, as outlined in the 6 July 2005 Federal Register notice. The CALPUFF model is the preferred model recommended by the EPA for BART modeling analyses and its characteristics and limitations are discussed in Chapter 3. The specific steps to determine whether a BART-eligible source is subject to BART and to evaluate BART controls are described in Chapter 4. The procedures include initial modeling of BART-eligible sources using CALPUFF run in a conservative mode with regional meteorological datasets. For sources determined to be subject to BART based on these first modeling analyses, further finer grid CALPUFF analyses would be performed. The model configuration for the common modeling protocol is described in Chapter 4. Details of the source-specific protocol are described in Chapter 5. A quality assurance plan is outlined in Chapter 6.

EPA's guidance allows for the use of appropriate alternative models, however VISTAS will not develop a protocol for alternative models. This protocol focuses on guidance for the application of the preferred CALPUFF modeling approach. If a source wants to use an alternative model in its BART demonstration, the source will need to submit a detailed written justification to the State for review and approval. The State will provide the documentation to the EPA and Federal Land Managers for their review.

Also, this protocol does not address a preferred modeling approach to demonstrate the effectiveness of an optional emissions cap and trade program. Such a cap and trade program is not required, but can be implemented in lieu of BART if desired by the VISTAS States. VISTAS

States are not pursuing a regional trading alternative under the proposed EPA trading guidance (70 FR 44154-44175) that is to be promulgated in 2006.

2. REVIEW OF EPA'S GUIDANCE FOR BART MODELING

The final guidance for regional haze BART determinations was published in the Federal Register on 6 July 2005 (70 FR 39104 to 39172). It prescribes the modeling approaches that are to be used for various stages of the BART analysis process.

This chapter provides a summary of EPA's guidance for BART modeling. It is not intended to provide a comprehensive review of the guidance. Nor does this chapter address specific recommendations for VISTAS' approach to CALPUFF BART modeling. Those recommendations appear in Chapter 4.

2.1 Overview of the Regional Haze BART Process

The process of establishing BART emission limitations consists of four steps:

1) 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 August 7, 1962 and August 7, 1977 in order to be BART-eligible. Finally, a source is eligible for BART if potential emissions of visibility-impairing air pollutants are greater than 250 tons per year. Qualifying pollutants include primary particulate matter (PM_{10}) and gaseous precursors to secondary fine particulate matter, such as SO_2 and NO_x. Whether ammonia or volatile organic compounds (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 be considered as primary $PM_{2.5}$ emissions and not VOCs for BART purposes.

(Note: If the source is subject to BART because one visibility impairing pollutant has potential emissions > 250 TPY, the State may determine that other visibility impairing pollutants are not subject to BART if their potential emissions are less than the *de minimis* levels (40 TPY for SO_2 and NO_x and 15 TPY of PM_{10} or $PM_{2.5}$. This assumes that the other BART-eligibility criteria are met.)

2) Determine 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. The preferred approach is an assessment with an air quality model such as CALPUFF 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.[5] The threshold to determine whether a single source "causes" visibility impairment is set at

[5] A recent draft settlement agreement with the EPA (to be published in the *Federal Register* for public comment) provides that a State has the discretion to decide whether annual average or 20% best natural conditions are to be used as the reference. This ruling resolves an ambiguity in EPA's BART guidance, where the BART guideline

1.0 deciview change from natural conditions over a 24-hour averaging period in the final BART rule (70 FR 39118). 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. The test against the threshold is "driven" by the contribution level, since if a source "causes", by definition it "contributes".

EPA recommends that the 98^{th} percentile value from the modeling be compared to the contribution threshold of 0.5 deciviews (or a lower level set by a State) to determine if a source does not contribute to visibility impairment and therefore is not subject to BART. Whether or not the 98^{th} percentile value exceeds the threshold must be determined at each Class I area. Over an annual period, this implies the 8^{th} highest 24-hr value at a particular Class I area is compared to the contribution threshold. Over a 3-year modeling period, the 98^{th} percentile value may be interpreted as the highest of the three annual 98^{th} percentile values at a particular Class I area or the 22^{nd} highest value in the combined three year record, whichever is more conservative.

Alternatively, States have the option of considering that all BART-eligible sources within the State are subject to BART and skipping the initial impact analysis. In rare cases, a State might be able to do exactly the opposite, and use regional modeling to conclude that all BART-eligible sources in the State do not cumulatively contribute to "measurable" visibility impairment in any Class I areas. Also, the States have an option to exempt individual sources based on model plant analysis conducted by EPA in finalizing the BART rule. Under this option, sources with potential emissions of SO_2 plus NO_x of less than 500 tons and a distance from any Class I area greater than 50 kilometers or sources with SO_2 plus NO_x potential emissions of less than 1000 tons and a distance from any Class I area greater than 100 kilometers can be exempted. PM emissions are not specifically addressed in the model plant analysis, but subsequent discussions with EPA staff indicate that PM may be considered along with SO_2 and NO_x, so that a plant could be exempted if the combined potential emissions of SO_2, NO_x, plus PM meet the criteria above.

3) Determine BART controls 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

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text says "natural conditions" at 70 FR 39162, col. 3, while the preamble to the BART rule says "natural visibility baseline for the 20% best visibility days" at 70 FR 39125, col. 1.

e) The degree of improvement in visibility that may reasonably be anticipated to result from the use of such technology.

Note that if a source agrees to apply the most stringent controls available to BART-eligible units, the BART analysis is essentially complete and no further analysis is necessary (70 FR 39165).

4) Incorporate the BART determination into the State Implementation Plan for Regional Haze, which is due by December 2007.

Instead of applying BART on a source-by-source basis, a State (or a group of States) has the option of implementing an emissions trading program that is designed to achieve regional haze improvements that are greater than the visibility improvements that could be expected from BART. If the geographic distributions of emissions under the two approaches are similar, determining whether trading is "better than BART" may be possible by simply comparing emissions expected under the trading program against the emissions that could be expected if BART was applied to eligible sources. If the geographic distributions of emissions are likely to be different, however, air quality modeling comparing the expected improvements in visibility from the trading program and from BART would be required. (See the proposed BART Alternative rule, at 70 FR 44160.) EPA suggests that regional modeling using a photochemical grid model may be more appropriate than CALPUFF for this purpose.

Note that EPA has indicated in the BART rule (70 FR 39138-39139) that emissions reductions under the Clean Air Interstate Rule (CAIR) meet the BART requirement for SO_2 and NO_x control for those EGUs subject to BART. However, PM emissions from EGUs are not addressed by CAIR and therefore a BART analysis may still be required for PM.

2.2 Model Recommendations for the BART Analysis

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 as "the best regulatory modeling application currently available for predicting a single source's contribution to visibility impairment" (70 FR 39162). The use of another "appropriate model" is allowed although the EPA prefers the use of CALPUFF. If a source wants to use an alternative model, the source needs to submit a written justification and source-specific modeling protocol to its State for review and approval. As part of the consultation process, the State will provide documentation to EPA and FLM.

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 PLUVUE-II plume visibility model is mentioned as a possible model to consider instead of CALPUFF for a source within less than 50 km of a Class I area.

The EPA guidance notes that "regional scale photochemical grid models may have merit, but such models have been designed to assess cumulative impacts, not impacts from individual sources" and

they are “very resource intensive and time consuming relative to CALPUFF”, but States may consider their use for SIP development in the future as they may be adapted and “demonstrated to be appropriate for single source applications” (70 FR 39123). Photochemical grid models may be 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 (70 FR 39163).

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).

In the BART modeling analyses the EPA recommends that the State use the highest 24-hour average actual emission rate for the most recent three to five-year period of record. Emissions on days influenced by periods of start-up, shutdown and malfunction are not to be considered in determining the appropriate emission rates. (70 FR 39129).

If a source is found 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. Visibility improvements may be evaluated on a pollutant-specific basis in the BART determination (70 FR 39129).

For evaluating the improvement in visibility resulting from the application of BART, the EPA guidelines state that States are “encouraged to account for the magnitude, frequency, and duration of the contributions to visibility impairment caused by the source based on the natural variability of meteorology” (70 FR 39129).

2.3 Performance of a Cap and Trade Program

If a State or States elect to pursue an optional cap and trade program, they are required to demonstrate greater “reasonable progress” in reducing haze than would result if BART were applied to the same sources. In some cases, a State may simply be able to demonstrate that a trading program that achieves greater progress at reducing emissions will also achieve greater progress at reducing haze. Such would be the case if the likely geographic distribution of emissions under the trading program would not be greatly different from the distribution if BART was in place.

If the expected distribution of emissions is different under the two approaches, then “dispersion modeling” of all sources must be used to determine the difference in visibility at each impacted Class I area, in order to establish that the optional trading program will result in visibility improvements aggregated over all Class I areas that are “better than BART” (70 FR 39137-39138). The BART guidance does not specify the method to be used for this modeling. From a technical perspective, either applying CALPUFF to every source or using a regional photochemical model would satisfy the need.

A rulemaking procedure is currently underway to establish final guidance for such alternatives to BART (70 FR 44154-44175). The rule is expected to be finalized in 2006.

3. OVERVIEW OF THE CALPUFF MODELING SYSTEM

This chapter contains a general description of the CALPUFF modeling system and its capabilities and limitations. It does not include specific recommendations regarding the use of the model for BART analysis in the VISTAS region. These specific recommendations can be found in Chapter 4.

3.1 Capabilities and features of CALPUFF

The CALPUFF modeling system (Scire et al., 2000a, b) is recommended as the preferred modeling approach for use in the BART analyses. CALPUFF and its meteorological model, CALMET, are designed to handle the complexities posed by the complex terrain, the large source-receptor distances, chemical transformation and deposition, and other issues related to Class I visibility impacts. The CALPUFF modeling system has been adopted by the EPA as a *Guideline Model* for source-receptor distances greater than 50 km, and for use on a case-by-case basis in complex flow situations for shorter distances (68 FR 18440-18482). CALPUFF is recommended for Class I impact assessments by the Federal Land Managers Workgroup (FLAG 2000) and the Interagency Workgroup on Air Quality Modeling (IWAQM) (EPA 1998). The final BART guidance recommends CALPUFF as "the best modeling application available for predicting a singe source's contribution to visibility impairment" (70 FR 39122). As a result of these recommendations, the VISTAS modeling protocol is based on the use of CALPUFF for its BART determinations.

The main components of the CALPUFF modeling system are shown in Figure 3-1. CALMET is a diagnostic meteorological model that is used to drive the CALPUFF dispersion model. It produces three-dimensional wind and temperature fields and two-dimensional fields of mixing heights and other meteorological fields. It contains slope flow effects, terrain channeling, and kinematic effects of terrain. CALMET includes special algorithms for treating the overwater boundary layer and coastal interaction effects. CALMET can use meteorological observational data and/or three-dimensional output from prognostic numerical meteorological models such as MM5 (Grell et al., 1995) or RUC (Benjamin et al., 2004) in the developments of its fine-scale meteorological fields.

CALPUFF is a non-steady-state Lagrangian puff transport and dispersion model that advects Gaussian puffs of multiple pollutants from modeled sources. CALPUFF's algorithms have been designed to be applicable on spatial scales from a few tens of meters to hundreds of kilometers from a source. It includes algorithms for near-field effects such as building downwash, stack tip downwash and transitional plume rise as well as processes important in the far-field such as chemical transformation, wet deposition, and dry deposition. CALPUFF contains an option to allow puff splitting in the horizontal and vertical directions, which extends the distance range of the model. The primary outputs from CALPUFF are hourly concentrations and hourly deposition fluxes evaluated at user-specified receptor locations.

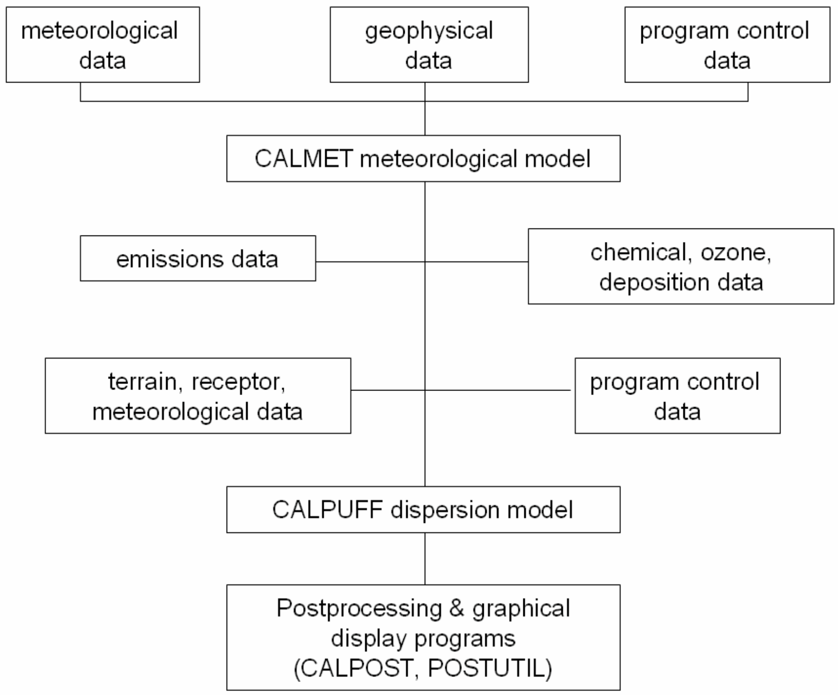

Figure 3-1. CALPUFF modeling system components.

A set of postprocessing programs associated with CALPUFF computes visibility effects and allows cumulative source impacts to be assessed, including potential non-linear effects of ammonia limitation on nitrate formation. The CALPOST postprocessor contains several options for computing change in extinction and deciviews for visibility assessments. The POSTUTIL postprocessor includes options for summing contributions of individual sources or groups of sources to assess cumulative impacts. POSTUTIL also contains CALPUFF's nitric acid-nitrate chemical equilibrium module, which allows the cumulative effects of ammonia consumption by background sources to be assessed in the postprocessor. In addition, the combination of CALPUFF and POSTUTIL allows the effects of source emissions of ammonia to be incrementally added to background ammonia levels when determining nitrate formation.

The rest of this chapter summarizes the capabilities and features of the CALPUFF modeling components in more detail.

3.1.1 *Major Features of CALMET*

The CALMET meteorological model consists of a diagnostic wind field module and micrometeorological modules for overwater and overland boundary layers. When modeling a large geographical area, as would be necessary for the regional VISTAS domain, the user has the option to use a Lambert Conformal Projection coordinate system to account for Earth's curvature.

The major features and options of the meteorological model are summarized in Table 3-1. The techniques used in the CALMET model are briefly described below.

Table 3-1. Major Features of the CALMET Meteorological Model

- **Boundary Layer Modules of CALMET**
  - Overland Boundary Layer - Energy Balance Method
  - Overwater Boundary Layer - Profile Method
    - -- COARE algorithm
    - -- OCD-based method
  - Produces Gridded Fields of:
    - -- Surface Friction Velocity
    - -- Convective Velocity Scale
    - -- Monin-Obukhov Length
    - -- Mixing Height
    - -- PGT Stability Class
    - -- Air Temperature (3-D)
    - -- Precipitation Rate

- **Diagnostic Wind Field Module of CALMET**
  - Slope Flows
  - Kinematic Terrain Effects
  - Terrain Blocking Effects
  - Divergence Minimization
  - Produces Gridded Fields of U, V, W Wind Components
  - Inputs Include Domain-Scale Winds, Observations, and (optionally) Coarse-Grid Prognostic Model Winds
  - Lambert Conformal Projection Capability

CALMET Boundary Layer Models

The CALMET model contains two boundary layer models for application to overland and overwater grid cells.

Overland Boundary Layer Model: Over land surfaces, the energy balance method of Holtslag and van Ulden (1983) is used to compute hourly gridded fields of the sensible heat flux, surface

friction velocity, Monin-Obukhov length, and convective velocity scale. Mixing heights are determined from the computed hourly surface heat fluxes and observed temperature soundings using a modified Carson (1973) method based on Maul (1980). The model also determines gridded fields of Pasquill-Gifford-Turner (PGT) stability class and hourly precipitation rates.

Overwater Boundary Layer Model: The aerodynamic and thermal properties of water surfaces suggest that a different method is best suited for calculating the boundary layer parameters in the marine environment. A profile technique, using air-sea temperature differences, is used in CALMET to compute the micro-meteorological parameters in the marine boundary layer. The version of CALMET being used by VISTAS contains improvements in the overwater boundary layer parameterizations (Fairall et al., 2003) based on the Coupled Ocean Atmosphere Response Experiment (COARE) and enhancements in the calculation of overwater mixed layer heights (Batchvarova and Gryning, 1991, 1994). Further details and the results of an evaluation of the model containing these enhancements are described in Scire et al. (2005). An upwind-looking spatial averaging scheme is optionally applied to the mixing heights and three-dimensional temperature fields in order to account for important advective effects.

Diagnostic Wind Field Module

The diagnostic wind field module uses a two-step approach to the computation of the wind fields (Douglas and Kessler, 1988). In the first step, an initial-guess wind field is adjusted for kinematic effects of terrain, slope flows, and terrain blocking effects to produce a Step 1 wind field. Gridded MM5 can be used to define the initial guess field. The second step consists of an objective analysis procedure to introduce observational data into the Step 1 wind field to produce a final wind field.

Step 1 Wind Field. Development of the Step 1 wind field begins with the initial guess field defined by the MM5 prognostic meteorological model. Normally, the CALMET computational domain is specified to be at finer grid resolution than the MM5 dataset used to initialize the initial guess field. For example, 36-km MM5 data available for VISTAS modeling may be used to develop the initial guess field on a 12-km or even a 1-km CALMET grid. The Step 1 algorithms in CALMET described below apply terrain adjustments to the initial guess field on the fine-scale CALMET grid. Thus, the CALMET winds are adjusted to respond to fine-scale terrain features not necessarily seen by the coarser scale MM5 model.

Kinematic Effects of Terrain: The approach of Liu and Yocke (1980) is used to evaluate the effects of the terrain on the wind field. The initial guess field winds are used to compute a terrain-forced vertical velocity, subject to an exponential, stability-dependent decay function. The effects of terrain on the horizontal wind components are evaluated by applying a divergence-minimization scheme to the initial guess wind field. The divergence minimization scheme is applied iteratively until the three-dimensional divergence is less than a threshold value.

Slope Flows: The original slope flow algorithm in CALMET has been upgraded (Scire and Robe, 1997) based on the shooting flow algorithm of Mahrt (1982). This scheme includes both

advective-gravity and equilibrium flow regimes. At night, the slope flow model parameterizes the flow down the sides of the valley walls into the floor of the valley, and during the day, upslope flows are parameterized. The magnitude of the slope flow depends on the local surface sensible heat flux and local terrain gradients. The slope flow wind components are added to the wind field adjusted for kinematic effects.

Blocking Effects: The thermodynamic blocking effects of terrain on the wind flow are parameterized in terms of the local Froude number (Allwine and Whiteman, 1985). If the Froude number at a particular grid point is less than a critical value and the wind has an uphill component, the wind direction is adjusted to be tangent to the terrain.

Step 2 Wind Field. The wind field resulting from the above adjustments of the initial-guess wind is the Step 1 wind field. The second step of the procedure may involve introduction of observational data into the Step 1 wind field through an objective analysis procedure. An inverse-distance squared interpolation scheme is used which weights observational data heavily in the vicinity of the observational station, while the Step 1 wind field dominates the interpolated wind field in regions with no observational data. The resulting wind field is subject to smoothing, an optional adjustment of vertical velocities based on the O'Brien (1970) method, and divergence minimization to produce a final Step 2 wind field.

The introduction of observational data in the Step 2 calculation is an option. It is also possible to run the model in "no observations" (No-Obs) mode, which involves the use only of MM5 gridded data for the initial guess field followed by fine-scale terrain adjustments by CALMET. In No-Obs mode, observational data are not used in the Step 2 calculations. The No-Obs mode is appropriate when the MM5 simulations adequately characterize the regional wind patterns and when local observations, especially surface observations, reflect local conditions on a scale smaller than that of the CALMET domain and hence their spatial representativeness may be limited. Such situations are most likely to occur when the CALMET grid scale is relatively large i.e., coarser than the scale of variation of the true wind field, which is particularly likely to occur in complex terrain or along the seashore,

3.1.2 Major Features of CALPUFF

By its puff-based formulation and through the use of three-dimensional meteorological data developed by the CALMET meteorological model, CALPUFF can simulate the effects of time- and space-varying meteorological conditions on pollutant transport from sources in complex terrain. The major features and options of the CALPUFF model are summarized in Table 3-2 at the end of this subsection. Some of the technical algorithms are briefly described below.

Complex Terrain: The effects of complex terrain on puff transport are derived from the CALMET winds. In addition, puff-terrain interactions at gridded and discrete receptor locations are simulated using one of two algorithms that modify the puff-height (either that of ISCST3 or a general "plume path coefficient" adjustment), or an algorithm that simulates enhanced vertical dispersion derived from the weakly-stratified flow and dispersion module of the Complex Terrain

Dispersion Model (CTDMPLUS) (Perry et al., 1989). The puff-height adjustment algorithms rely on the receptor elevation (relative to the elevation at the source) and the height of the puff above the surface. The enhanced dispersion adjustment relies on the slope of the gridded terrain in the direction of transport during the time step.

Subgrid Scale Complex Terrain (CTSG): An optional module in CALPUFF, CTSG treats terrain features that are not resolved by the gridded terrain field, and is based on the CTDMPLUS (Perry et al., 1989). Plume impingement on subgrid-scale hills is evaluated at the CTSG subgroup of receptors using a dividing streamline height (H_d) to determine which pollutant material is deflected around the sides of a hill (below H_d) and which material is advected over the hill (above H_d). The local flow (near the feature) used to define H_d is taken from the gridded CALMET fields. As in CTDMPLUS, each feature is modeled in isolation with its own set of receptors.

Puff Sampling Functions: A set of accurate and computationally efficient puff sampling routines is included in CALPUFF, which solve many of the computational difficulties encountered when applying a puff model to near-field releases. For near-field applications during rapidly-varying meteorological conditions, an elongated puff (slug) sampling function may be used. An integrated puff approach may be used during less demanding conditions. Both techniques reproduce continuous plume results under the appropriate steady state conditions.

Building Downwash: The Huber-Snyder and Schulman-Scire downwash models are both incorporated into CALPUFF. An option is provided to use either model for all stacks, or make the choice on a stack-by-stack and wind sector-by-wind sector basis. Both algorithms have been implemented in such a way as to allow the use of wind direction specific building dimensions. The PRIME building downwash model (Schulman et al., 2000) is also included in CALPUFF as an option.

Dispersion Coefficients: Several options are provided in CALPUFF for the computation of dispersion coefficients, including the use of turbulence measurements (σ_v and σ_w), the use of similarity theory to estimate σ_v and σ_w from modeled surface heat and momentum fluxes, or the use of Pasquill-Gifford (PG) or McElroy-Pooler (MP) dispersion coefficients, or dispersion equations based on the CTDM. Options are provided to apply an averaging time correction or surface roughness length adjustments to the PG coefficients. In version 5.754 of CALPUFF being used by VISTAS, an option is provided to use the AERMOD turbulence profiles for determining dispersion rates, which is the most recent approach to dispersion in EPA-approved regulatory modeling. In addition, turbulence advection is included. For additional details on these features, see Scire et al. (2005).

Overwater and Coastal Interaction Effects: Because the CALMET meteorological model contains both overwater and overland boundary layer algorithms, the effects of water bodies on plume transport, dispersion, and deposition can be simulated with CALPUFF. The puff formulation of CALPUFF is designed to handle spatial changes in meteorological and dispersion conditions, including the abrupt changes that occur at the coastline of a major body of water.

Dry Deposition: A resistance model is provided in CALPUFF for the computation of dry deposition rates of gases and particulate matter as a function of geophysical parameters, meteorological conditions, and pollutant species. For particles, source-specific mass distributions may be provided for use in the resistance model. Of particular interest for BART analyses is the ability to separately model the deposition of fine particulate matter (< 2.5 μm diameter) from coarse particulate matter (2.5-10 μm diameter).

Wind Shear Effects: CALPUFF contains an optional puff splitting algorithm that allows vertical wind shear effects across individual puffs to be simulated. Differential rates of dispersion and transport among the "new" puffs generated from the original, well-mixed puff can substantially increase the effective rate of horizontal spread of the material. Puffs may also be split in the horizontal when the puff size becomes large relative to the grid size, to account for wind shear across the puffs.

Wet Deposition: An empirical scavenging coefficient approach is used in CALPUFF to compute the depletion and wet deposition fluxes due to precipitation scavenging. The scavenging coefficients are specified as a function of the pollutant and precipitation type (i.e., frozen vs. liquid precipitation).

Chemical Transformation: CALPUFF includes options for parameterizing chemical transformation effects using the five species scheme (SO_2, $SO_4^{=}$, NO_x, HNO_3, and NO_3^-) employed in the MESOPUFF II model or a set of user-specified, diurnally-varying transformation rates. The MESOPUFF II scheme is recommended by IWAQM. It produces secondary fine particulate matter (sulfate and nitrate) from emissions of SO_2 and NO_x and thus allows analyses of visibility impacts. Ambient ozone concentrations are used in the parameterized chemical transformation module as a surrogate for OH radicals during daylight hours. Ambient ammonia concentrations are used together with a temperature and relative humidity-dependent equilibrium relationship to partition nitric acid and nitrate on an hour-by-hour and receptor-by-receptor basis.

Table 3-2. Major Features of the CALPUFF Dispersion Model

- **Source types**
  - Point sources (constant or variable emissions)
  - Line sources (constant or variable emissions)
  - Volume sources (constant or variable emissions)
  - Area sources (constant or variable emissions)

- **Non-steady-state emissions and meteorological conditions**
  - Gridded 3-D fields of meteorological variables (winds, temperature)
  - Spatially-variable fields of mixing height, friction velocity, convective velocity scale, Monin-Obukhov length, precipitation rate
  - Vertically and horizontally-varying turbulence and dispersion rates
  - Time-dependent source and emissions data for point, area, and volume sources
  - Temporal or wind-dependent scaling factors for emission rates, for all source types

- **Interface to the Emissions Production Model (EPM)**
  - Time-varying heat flux and emissions from controlled burns and wildfires

- **Efficient sampling functions**
  - Integrated puff formulation
  - Elongated puff (slug) formulation

- **Dispersion coefficient (σ_y, σ_z) options**
  - Direct measurements of σ_v and σ_w
  - Estimated values of σ_v and σ_w based on similarity theory
    - -- AERMOD turbulence profiles
    - -- Original turbulence profiles
  - Pasquill-Gifford (PG) dispersion coefficients (rural areas)
  - McElroy-Pooler (MP) dispersion coefficients (urban areas)
  - CTDM dispersion coefficients (neutral/stable)

- **Vertical wind shear**
  - Puff splitting
  - Differential advection and dispersion

- **Plume rise**
  - Buoyant and momentum rise
  - Stack tip effects
  - Building downwash effects
  - Partial penetration
  - Vertical wind shear

- **Building downwash**
  - Huber-Snyder method
  - Schulman-Scire method
  - PRIME method

- **Complex terrain**
  - Steering effects in CALMET wind field
  - Optional puff height adjustment: ISC3 or "plume path coefficient"
  - Optional enhanced vertical dispersion (neutral/weakly stable flow in CTDMPLUS)

Table 3-2. Major Features of the CALPUFF Dispersion Model (Cont'd)

- **Subgrid scale complex terrain (CTSG option)**
  - Dividing streamline, H_d, as in CTDMPLUS:
    - Above H_d, material flows over the hill and experiences altered diffusion rates
    - Below H_d, material deflects around the hill, splits, and wraps around the hill

- **Dry Deposition**
  - Gases and particulate matter
  - Three options:
    - Full treatment of space and time variations of deposition with a resistance model
    - User-specified diurnal cycles for each pollutant
    - No dry deposition

- **Overwater and coastal interaction effects**
  - Overwater boundary layer parameters (COARE algorithm or OCD-based method)
  - Abrupt change in meteorological conditions, plume dispersion at coastal boundary
  - Plume fumigation

- **Chemical transformation options**
  - Pseudo-first-order chemical mechanism for SO_2, $SO_4^{=}$, NO_x, HNO_3, and NO_3^- (MESOPUFF II method)
  - Pseudo-first-order chemical mechanism for SO_2, $SO_4^{=}$, NO, NO_2, HNO_3, and NO_3^- (RIVAD/ARM3 method)
  - User-specified diurnal cycles of transformation rates
  - No chemical conversion

- **Wet Removal**
  - Scavenging coefficient approach
  - Removal rate a function of precipitation intensity and precipitation type

3.1.3 Major Features of Postprocessors (CALPOST and POSTUTIL)

The two main postprocessors of interest for BART applications are the CALPOST and POSTUTIL programs. CALPOST is used to process the CALPUFF outputs, producing tabulations that summarize the results of the simulations, identifying, for example, the highest and second-highest hourly-average concentrations at each receptor. When performing visibility-related modeling, CALPOST uses concentrations from CALPUFF to compute light extinction and related measures of visibility (haze index in deciviews), reporting these for a 24-hour averaging time.

The CALPOST processor contains several options for evaluating visibility impacts, including the method described in the BART guidance, which uses monthly average relative humidity values. CALPOST contains implementations of the IWAQM-recommended and FLAG-recommended visibility techniques and additional options to evaluate the impact of natural weather events (fog, rain and snow) on background visibility and visibility impacts from modeled sources.

The POSTUTIL processor is a program that allows the cumulative impacts of multiple sources from different simulations to be summed, can compute the difference between two sets of

predicted impacts (useful for evaluating the benefits of BART controls), and contains a chemistry module to evaluate the equilibrium relationship between nitric acid and nitrate aerosols. This capability allows the potential non-linear effects of ammonia scavenging by sulfate and nitrate sources to be evaluated in the formation of nitrate from an individual source. CALPUFF makes the full ambient ammonia concentration available to each puff without regard for any scavenging by other puffs. POSTUTIL corrects for such scavenging when the puffs generated by the CALPUFF model overlap, as could be the case for a single source when the wind speed is low, or when nitrate formation is to be attributed to each of several sources that are in a cluster and whose plumes overlap,

POSTUTIL will also compute the impacts of individual sources or groups of sources on sulfur and nitrogen deposition into aquatic, forest and coastal ecosystems. The postprocessor allows the changes in deposition fluxes resulting from changes in emissions to be quantified. For example the output of POSTUTIL and CALPOST can be used as input into an Acid Neutralizing Capacity (ANC) analysis, or for comparison to Deposition Analysis Thresholds (DATs).

3.2 Discussion of CALPUFF Applicability and Limitations

3.2.1 Transport and Diffusion

According to the IWAQM Phase 2 report (page 18), "CALPUFF is recommended for transport distances of 200 km or less. Use of CALPUFF for characterizing transport beyond 200 to 300 km should be done cautiously with an awareness of the likely problems involved."[6]

IWAQM's 200-km limitation derives from the observation that, when compared to the data of the Cross Appalachian Tracer Experiment (CAPTEX), the basic configuration of CALPUFF overestimated inert tracer concentrations by factors of 3 to 4 at receptors that were 300 to 1000 km from the source. The apparent reason was insufficient horizontal dispersion of the simulated plume, presumably because an actual large plume does not remain coherent in the presence of vertical wind shears that typically occur, especially during the night, and of horizontal wind shears over the large puffs that arise over long transport distances.

To better represent such situations, an optional puff splitting algorithm has since been added to CALPUFF to simulate wind shear effects across a well-mixed individual puff by dividing the puff horizontally and vertically into two or more pieces. Differential rates of transport among the new puffs thus generated can increase the horizontal spread of the material in the plume due to vertical wind speed shear and wind direction shear. The horizontal puff splitting algorithm is

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[6] The IWAQM presentation at EPA's 6^{th} Modeling Conference provides the background for this recommendation: "The IWAQM concludes that CALPUFF be recommended as providing unbiased estimates of concentration impacts for transport distances of order 200 km and less, and for transport times of order 12 hours or less. For larger transport times and distances, our experience thus far is that CALPUFF tends to underestimate the horizontal extent of the dispersion and hence tends to overestimate the surface-level concentration maxima. This does not preclude the use of CALPUFF for transport beyond 300 km, but it does suggest that results in such instances be used cautiously and with some understanding." (From page D-12 of the IWAQM Phase 2 report.)

designed to allow large puffs that may grow to be several grid cells or more in size to split into smaller puffs that can then more accurately respond to variations in the local wind field across the original large puff. This will also tend to increase horizontal dispersion of the plume. Since the creation of additional puffs via puff splitting will increase the computational requirements of the model, possibly substantially, puff splitting is not enabled by default, but can be turned on at the option of the user. Puff splitting may be appropriate for transport distances over 200 to 300 km, or possibly over shorter distances in complex terrain.

Turning to the shorter distance end of the transport range, the CALPUFF section of Appendix A of the *Guideline on Air Quality Models* (40 CFR 51, Appendix W) states, “CALPUFF is intended for use on scales from tens of meters from a source to hundreds of kilometers.” This is supported by the IWAQM Phase 2 report, which indicates that the diffusion algorithms in CALPUFF were designed to be suitable for both short and long distances. In this regard, CALPUFF does contain algorithms for such near-field effects as plume rise, building downwash, and terrain impingement and includes routines that deal with the computational difficulties encountered when applying a puff model in the field near to a source.

The recommendations for regulatory use in Appendix A of the *Guideline on Air Quality Models* state, “CALPUFF is appropriate for long range transport (source-receptor distance of 50 to several hundred kilometers)”, but provisions for using CALPUFF in the near-field in “complex flow” situations are also included in the regulatory guidance. Complex flow situations may include complex terrain, coastal areas, situations where plume fumigation is likely, and areas where stagnation, flow reversals, recirculation or spatial variability in wind fields (e.g., as due to changes in valley orientation) are important.

The tracer studies with which CALPUFF transport and diffusion capabilities were evaluated in the IWAQM Phase 2 report were generally over distances greater than 50 km. More recently, additional studies of model performance have been performed at shorter distances, including at a power plant in New York state in complex terrain (at source-receptor distances of 2 to 8.5 km) and a second power plant in Illinois in simple terrain (at source-receptor distances in arcs ranging from 0.5 km to 50 km from the stack) (Strimaitis et al., 1998). Other CALPUFF evaluation studies over short-distances include ones by Chang et al. (2001) and Morrison et al. (2003). These studies demonstrate good model performance over source-receptor distances from a few hundred meters to 50 km.

An important factor in the performance of CALPUFF is the choice of dispersion coefficients. The EPA has defined the "regulatory default" option in CALPUFF to allow either Pasquill-Gifford (PG) or turbulence-based dispersion coefficients. CALPUFF has been evaluated and shown to perform better using turbulence-based dispersion for tall stacks (Strimaitis et al, 1998). CALPUFF with turbulence-based dispersion has also been evaluated for overwater transport and coastal situations (Scire et al., 2005). In many other studies, including AERMOD evaluation studies conducted by EPA, the use of PG-dispersion, or more specifically the lack of a convective probability density function (pdf) module, has been demonstrated to result in underprediction of peak concentrations.

In November 2005, EPA approved the AERMOD model, which relies on turbulence-based dispersion, as a regulatory Guideline Model[7]. The ISCST3 model and its PG dispersion coefficients are being phased out as an acceptable regulatory approach. However, EPA Region IV has indicated that the application of turbulence-based dispersion coefficients in CALPUFF needs to be further demonstrated before they are approved for BART application. They will consider accepting the use of turbulence dispersion coefficients on a case-by-case basis for sources that are close to Class I areas.

For regional haze light extinction calculations, use of a plume-simulating model such as CALPUFF is appropriate only when the plume is sufficiently diffuse that it is not visually discernible as a plume *per se*, but nevertheless its presence could alter the visibility through the background haze. The IWAQM Phase 2 report states that such conditions occur starting 30 to 50 km from a source. In this light, the BART guidance strongly recommends using CALPUFF for source-receptor distances greater than 50 km but also presents CALPUFF as an option that can be considered for shorter transport distances.

As discussed above, there do not appear to be any scientific reasons why CALPUFF cannot be used for even shorter transport distances than 30 km, though, as long as the scale of the plume is larger than the scale of the output grid so that the maximum concentrations and the width of the plume are adequately represented and so that the sub-grid details of plume structure can be ignored when estimating effects on light extinction. The standard 1-km output grid that has been established for Class I area analyses should serve down to source-receptor distances somewhat under 30 km; how much closer than 30 km will depend on the topography and meteorology of the area and should be evaluated on a case-by-case basis. For extremely short transport distances, depiction of the concentration distribution will require a grid that is finer than 1 km. (For reference, the width of a Gaussian plume, $2\sigma_y$, is roughly 1 km after 10 km of travel distance, assuming Pasquill-Gifford dispersion rates under neutral conditions.)

As an additional consideration, if the plume width is small compared to the visual range, the atmospheric extinction along a typical sight path of tens of kilometers through the plume will be inhomogeneous and the simple CALPOST point estimate of regional light extinction at a receptor point will not be correct. However, the effect of averaging light extinction estimates for 24 hours, during which the plume location shifts over various receptor points, is likely to mitigate this problem to some degree and suggests that using CALPUFF at distances under 30 km will often be appropriate. For the narrow plumes that result from short transport distances, though, the modeled peak 24-hr average extinction at a receptor will tend to overstate the effect of the source on regional haze.

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[7] *Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rule.* 70 FR 68218-68261. 9 November 2005.

The U.S. EPA has suggested that the plume visibility model, PLUVUE-II, could be used in lieu of CALPUFF for simulating visibility effects at such short distances.[8] PLUVUE-II is a Gaussian model that simulates the dispersion, chemical conversion, and optical effects of emissions of particles, SO_2, and NO_x from a single source. Its outputs include the discoloration of the sky by the plume (so called "plume blight") and the effect of the plume on visibility along user-selected sight paths that pass through the plume. The impacts of the plume on visibility depend not only on the plume composition, but also on the sight path chosen and its direction relative to the axis of the plume and the location of the sun. It isn't clear how such sight-path dependent results could be compared to the 0.5 and 1.0 deciview thresholds in the BART guidance. Since CALPUFF is designed to be useful for short transport distances (with features such as the simulation of plume downwash caused by structures at the source), CALPUFF seems more appropriate than PLUVUE-II for evaluating source impact at short distances for BART assessment purposes.

3.2.2 Aerosol Constituents

Primary $PM_{2.5}$

Appendix A of the *Guideline on Air Quality Models* (40 CFR 51, Appendix W) states that CALPUFF can treat primary pollutants such as PM_{10}. In actuality, CALPUFF can simulate PM_{10} or $PM_{2.5}$ or some other size range, because the assumed size distribution of the particles is a user input. The smaller the particles, the more they disperse like an inert gas. In most cases, the dispersion of inert $PM_{2.5}$ particles will be only minutely different from that of an inert gas, but the behavior of larger particles will differ.

A particularly important contributor to PM concentrations is the rate of deposition to the surface. $PM_{2.5}$ particles, which have a mass median diameter around 0.5 µm, have an average net deposition velocity of about 1 cm/min (or about 14 m/day) and thus the deposition of fine particles is usually not significant except for ground-level emissions. On the other hand, coarse particles (those PM_{10} particles larger than $PM_{2.5}$) have an average deposition velocity of more than 1 m/min (or 1440 m/day), which is significant, even for emissions from elevated stacks.

CALPUFF includes parametric representations of particle and gas deposition in terms of atmospheric, deposition layer, and vegetation layer "resistances" and, for particles, the gravitational settling speed. Gravitational settling, which is of particular importance for the coarse fraction of PM_{10}, is accounted for in the calculation of the deposition velocity. Effects of inertial impaction (important for the upper part of the PM_{10} distribution) and Brownian motion (important for small, sub-micron particles) and wet scavenging are also addressed. The BART guidance recommends that fine particulate matter (less than 2.5 µm diameter), which has higher light extinction efficiency than coarse particulate matter (2.5-10 µm diameters), should be treated separately in the model. CALPUFF allows for user-specified size categories to be treated as

[8] However, for the reasons given in this paragraph, VISTAS does not recommend PLUVUE-II for BART application

separate species, which includes calculating size-specific dry deposition velocities for each size category.

A primary $PM_{2.5}$ emission from coal-fired electric generating units (EGUs) that is of relevance to visibility calculations is that of primary sulfate. Although primary sulfate emissions account for only a small fraction of the total sulfur emissions from such sources, it may be important to simulate their effect with CALPUFF, especially at shorter distances before significant formation of secondary sulfate conversion from SO_2 has taken place.

Sulfur Dioxide and Secondary Particulate Sulfate

The MESOPUFF-II chemistry algorithm used in CALPUFF[9] simulates the gas phase oxidation of sulfur dioxide to sulfate by a linear transformation rate that was developed using regression relationships derived from the analysis of chemical conversion rates produced by a complex photochemical box model (see Scire et al., 1984, for a description of the development of the chemical module). As in all empirically-derived models, the relationships are based on easily-computed or observed parameters that are used as surrogates for the factors that control SO_2 oxidation.

The surrogate factors included in the parameterized chemistry during the daytime hours include solar radiation intensity, ambient ozone concentration, and atmospheric stability class. For example, gas phase SO_2 oxidation is a function of OH radical concentrations. Ozone concentrations are correlated with OH radical concentrations during daytime hours, and their use in the daytime SO_2 conversion rate in CALPUFF is based on this correlation relationship. The philosophy is that OH radical measurements are not available and cannot easily be computed within a model like CALPUFF, but ozone is commonly measured throughout the country, so the use of the well-known surrogate variable (ozone) is more useful in the empirical relationship than factors that are unknown or have a high degree of uncertainty. The same logic applies to the other variables in the relationship. They are surrogates for factors that the regression analysis has shown to be important in SO_2 oxidation rates. At night, the SO_2 conversion is set to a constant low value (default is 0.2%/hr). Aqueous phase oxidation of SO_2 is represented by an additive term that varies with relative humidity and peaks at 3%/hr at 100% relative humidity. CALPUFF represents the chemical conversion as a linear process because it requires linear independence between puffs, although as explained below, non-linear behavior in nitrate formation can be modeled.

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[9] CALPUFF offers two options for parameterizing chemical transformations: the 5 species (SO_2, $SO_4^{=}$, NO_x, HNO_3, and NO_3^-) MESOPUFF-II system and the 6 species RIVAD system (which treats NO and NO_2 separately). IWAQM recommends using the MESOPUFF-II system with CALPUFF. The RIVAD system is believed to be more appropriate for clean environments, however, and therefore was used in the Southwest Wyoming Regional CALPUFF Air Quality Modeling Study in 2001. For the VISTAS region, the IWAQM- and FLM-recommended MESOPUFF-II chemistry is most appropriate.

The IWAQM Phase 2 report concludes that this chemistry algorithm is adequate for representing the gas phase sulfate formation but that it does not adequately account for the aqueous phase oxidation of SO_2. Actual aqueous phase oxidation in clouds or fog can proceed at rates much greater than 3% per hour, leading IWAQM to suggest that sulfate might be underestimated in such situations. However, aqueous phase oxidation depends on liquid water content, not relative humidity. In reality, liquid water does not exist in the atmosphere at relative humidity much below 100%, while the CALPUFF aqueous reaction term produces sulfate at lower relative humidity. This can lead CALPUFF to overestimate sulfate concentrations when the humidity is high but the cloud water that enables aqueous conversion is not present. Therefore, the direction of the bias in the aqueous chemistry simulation of sulfate formation can vary.

Other potential sources of error in the sulfate formation mechanism of CALPUFF include (1) overestimation of sulfate formation when NO_x concentrations in the plume are high and in actuality they deplete the local availability of ozone and hydrogen peroxide for oxidizing the SO_2; and (2) lack of direct consideration of the effect of temperature on the conversion rates, which may cause the model to overstate sulfate formation on cold days (below 10C or 50°F) (Morris et al., 2003). However, in CALPUFF, the effects of temperature are, to some degree, compensated for indirectly by the use of the solar radiation surrogate variable in the empirical conversion equations.

Whether these potential errors are important will depend on the setting. For example, Figure 3-2 shows a comparison of predicted and observed 24-hour sulfate concentrations, due to a large number of SO_2 sources, at the Pinedale IMPROVE site in Wyoming for the 1995 period (Scire et al., 2001). Overall, in this case there was very little bias in the sulfate predictions. Whether CALPUFF predictions would compare as well with measurements in the Southeast remains to be seen.

CALPUFF does not identify the chemical form of the sulfate compound that results from its reactions, which will generally be some form of ammoniated sulfate whose degree of neutralization will depend on the availability of ammonia in the atmosphere. This consideration, which has been found to be relevant for calculating light extinction in the VISTAS region, is not addressed by CALPUFF or CALPOST.

In most applications, the ozone concentrations required for the sulfate formation calculations are derived from ambient measurements, although concentrations simulated by regional models can be used.

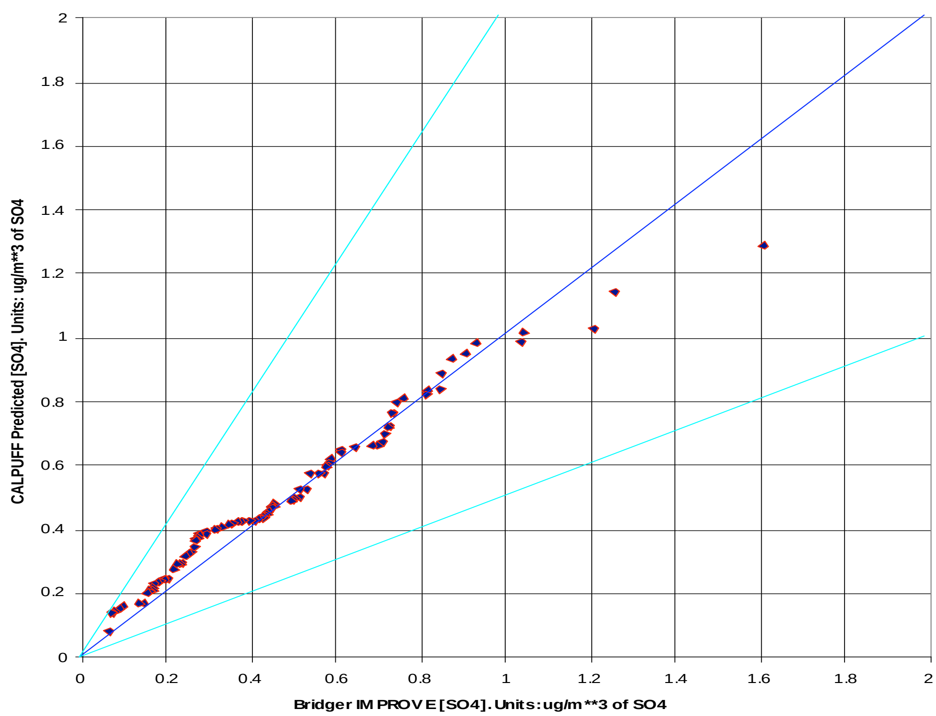

Figure 3-2. Observed vs. CALPUFF-predicted 24-hour sulfate concentrations at the IMPROVE monitoring site in Pinedale, Wyoming for 1995.

NO_x and Secondary Ammonium Nitrate

The MESOPUFF-II chemistry algorithm used in CALPUFF simulates the oxidation of NO_x to nitric acid and organic nitrates (both gases) by transformation rates that depend on NO_x concentration, ambient ozone concentration, and atmospheric stability class during the day. The conversion rate at night is set at to a constant value (default is 2.0 %/hr). The temperature- and humidity-dependent equilibrium between nitric acid gas and ammonium nitrate particles is taken into account when estimating the ammonium nitrate particle concentration, an equilibrium that depends on the ambient concentration of ammonia. The user supplies the value of the ambient concentration of ammonia. CALPUFF assumes that the sulfate reacts preferentially with that ammonia to form ammonium sulfate and the left over ammonia is available to form ammonium nitrate.

The IWAQM Phase 2 report considers that this mechanism is adequate for representing nitrate chemistry. Potential situations where this assumption may not be correct, however, include (1) plumes with high concentrations of NO_x that deplete the ambient ozone and thus limit the

transformation of NO_x to nitric acid in the plume; and (2) when ambient temperature is below 10 C, and thus the transformation rate is much slower and the nitrate concentration may be lower than that simulated by CALPUFF (Morris et al., 2003). In both cases, CALPUFF may overestimate the amount of nitrate that is produced. In particular, the impact of ammonium nitrate concentrations on visibility at Class I areas in the VISTAS region is greatest in the winter, when temperatures are lowest, the nitrate concentrations are the greatest, and the sulfate concentrations tend to be the least. CALPUFF may overstate the impacts of NO_x emissions at those times, especially in the colder northern states**.** This potential overestimate of nitrate was not evident, however, in an evaluation of CALPUFF-modeled nitrate against actual observational data in the Wyoming study, as shown in Figure 3-3a (Scire et al., 2001),

Another factor in the calculation of nitrate is that CALPUFF makes the full amount of the background concentration of ammonia available to each puff, and that amount is scavenged by the sulfate in the puff. If puffs overlap, then that approach could overstate the amount of ammonium nitrate that is formed in total if, in reality, the combined scavenging by the overlapping puffs at a location would deplete the available ammonia enough that the combined nitrate formation was limited by the availability of ammonia. This effect of such ammonia limiting can be large in summer; for a source 75 km west of Mammoth Cave National Park, one modeling analysis found the maximum light extinction impact of the source to be 7.4% (roughly 0.74 deciviews) at the park when CALPUFF was used without consideration of ammonia limiting and about 30% less, between 5.5 and 5.8% (roughly 0.55 to 0.58 dv), when the effect of ammonia limiting was considered (Escoffier-Czaja and Scire, 2002).

To address the issue, since 1999 (i.e., after the IWAQM Phase 2 report) the CALPUFF system has included the optional POSTUTIL postprocessing program, which repartitions the ammonia and nitric acid concentrations estimated by CALPUFF to reflect potential ammonia-limiting effects on the development of nitrate**.** This allows non-linearity associated with ammonia limiting effects to be included in the CALPUFF model estimates. POSTUTIL computes the total sulfate concentrations from all sources (modeled sources plus inflow boundary conditions) and estimates the amount of ammonia available for total nitrate formation after the preferential scavenging of ammonia by sulfate. That is, as new sulfate, nitrate or ammonia from the source of interest is added to an existing mix of pollutants, POSTUTIL will estimate both the nitrate formed from the new source and the change in background nitrate as a result of the incremental depletion of ammonia (due to the new sulfate and nitrate) or addition of ammonia (from a new source of ammonia).

Reliable estimates of the ambient concentrations of ammonia, especially with the temporal and spatial resolution that would be optimal for use with CALPUFF, are needed to take full advantage of the increased accuracy provided by POSTUTIL. The processor requires estimated concentrations of ammonia throughout the modeling domain and period. Such estimates can be inferred from CASTNet measurements, which are integrated over a week, from 24-hr SEARCH measurements, or from the output of a regional photochemical model such as CMAQ or CAMx. The CASTNet network is fairly sparse and the uncertainty in the ammonia measurements is large,

so defining the ammonia concentration throughout the Southeast would require extensive interpolation or extrapolation from the measured values. The quality of the SEARCH measurements is much better, but there are only 8 sites and they do not cover the entire VISTAS domain. Modeled concentrations have the advantage of being resolved in space and time, but their accuracy should be evaluated by comparison with measurements wherever possible.

Benefit is obtained by considering seasonal trends of ammonia and using POSTUTIL to determine the diurnal variability in available ammonia due to the daily cycle of nitrate formation associated with temperature and relative humidity effects. For example, results of the Wyoming study (see Figure 3-3a) show that POSTUTIL adjustments produced daily average nitrate concentrations well within the factor of two lines and with very little mean bias. On the other hand, analysis of the same results with use of constant ammonia of 0.5 ppb or 1.0 ppb produced consistent overpredictions of nitrate by factors of 2-3 and 3-4, respectively, as shown in Figure 3-3b (Scire et al., 2003).

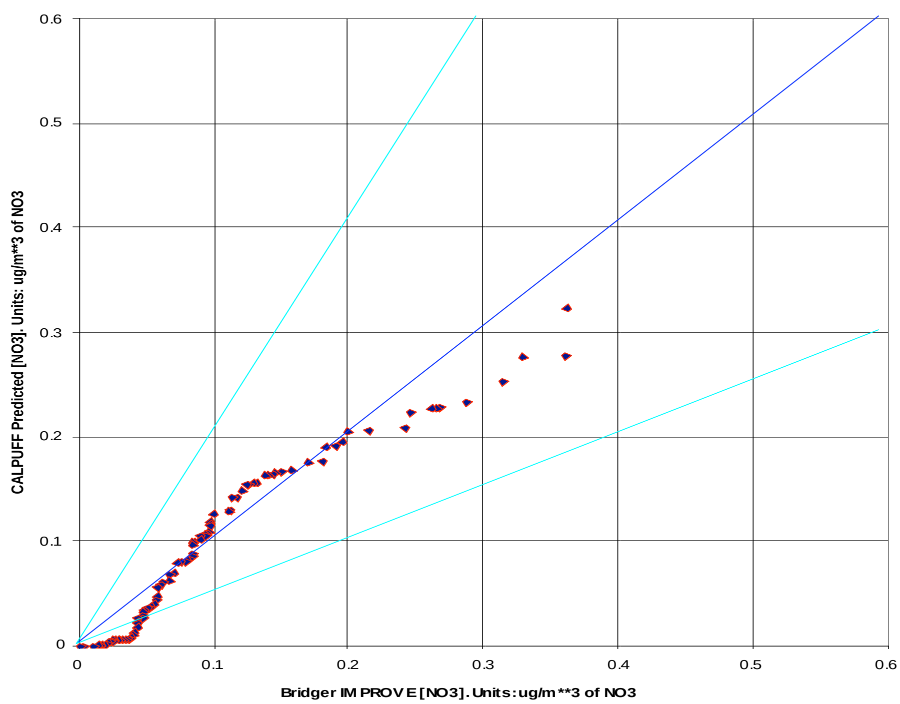

Figure 3-3a. Observed vs. CALPUFF-predicted 24-hour nitrate concentrations at the IMPROVE monitoring site in Pinedale, Wyoming for 1995 using the ammonia limiting method. (Scire et al., 2001)

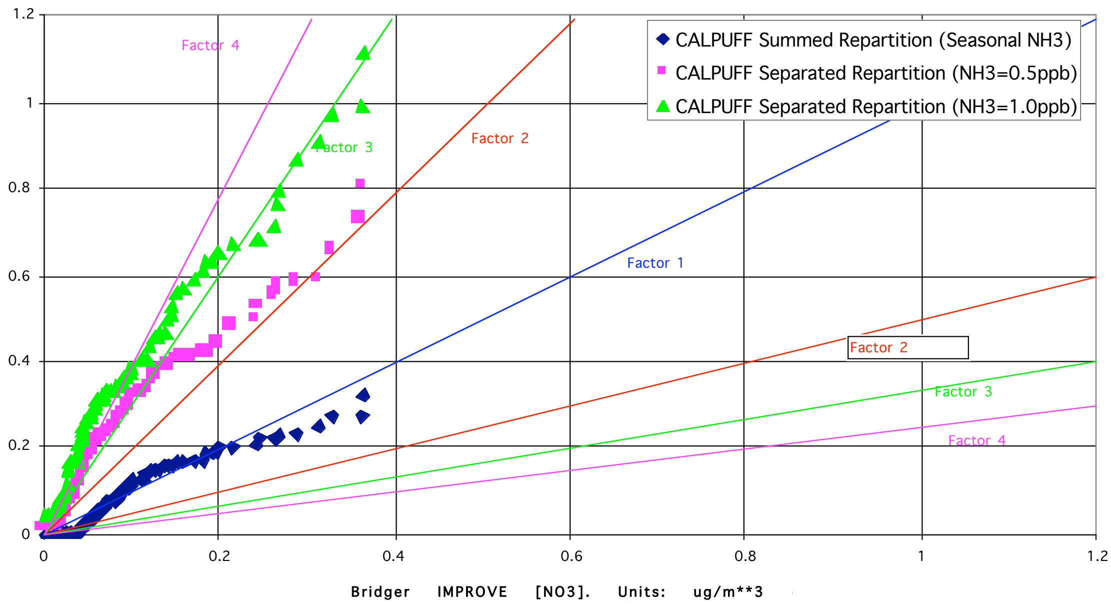

Figure 3-3b. Observed vs. CALPUFF-predicted 24-hour nitrate concentrations at the IMPROVE monitoring site in Pinedale, Wyoming for 1995 using the ammonia limiting method (blue), constant ammonia at 0.5 ppb (pink) and constant ammonia at 1.0 ppb (green). (Scire et al., 2003)

Secondary Organic Aerosol

Ongoing research studies at several Class I areas throughout the country (Fallon and Bench, 2004) and at SEARCH sites in the Southeast (Edgerton et al., 2004) are finding that, typically, 90 to 95% of the rural organic carbon fine particle concentration consists of modern carbon (e.g., that from the burning of vegetation and deriving from VOC emissions from vegetation) and only 5 to 10% is attributable to man's burning of fossil fuels. In addition, a field study at Great Smoky Mountains National Park in August 2002 (Tanner, et al., 2005) found that an average of 83% of the fine carbon was modern carbon

According to IMPROVE measurements, organics account for roughly 10% of the particle-caused light extinction in Class I areas in the Southeast. We can thus conclude that, in general, secondary organic carbon particles derived from anthropogenic fossil fuel burning emissions are unlikely to have a large impact (around 1%) on current visibility. (Man-caused burning of vegetation can have significant localized, short-term impacts, however.)

Current organic fine particle concentrations in the Southeast are typically within a factor of 2 of the 1.4 $\mu g/m^3$ concentration assumed for natural conditions by the EPA, which means that current fossil fuel burning would contribute less than 2% to visibility in an atmosphere that represents natural conditions. Thus, it is unlikely that VOC and organic particle contributions from BART

sources will cause a large impact to visibility at Class I areas, but a 5% (0.5 dv) localized impact from a particularly large VOC source cannot be dismissed out of hand.

CALPUFF has only rudimentary capabilities for addressing formation of visibility-impairing organic particles from some forms of volatile organic carbon (VOC). The capabilities that do exist include the following.

First, PM_{10} emissions (such as from power plants) are often divided into filterable and condensable components, with the condensable mass being 100-200% of the filterable mass. For purposes of visibility analyses with CALPUFF, a fraction of the condensable part is typically treated as organic particles, i.e., it is assumed that a fraction of the condensable components in the PM_{10} emissions condense into organic $PM_{2.5}$ particles. The size of this organic fraction varies with process and process equipment, and can range from 20 to 100% of the condensable mass. These fine organic particles can be readily modeled by CALPUFF. (The remaining condensable material may be sulfuric, hydrochloric, or hydrofluoric acid.)

Second, a module that treats the formation of secondary organic particles from organic emissions was recently developed and is now part of the CALPUFF system. (Scire et al., 2001). This simplified secondary organic aerosol (SOA) module is a linear, parameterized representation that is currently considered best suited for biogenic organics. It relies on the conventional wisdom that only hydrocarbons with more than six carbon atoms can form significant SOA (Grosjean and Seinfeld, 1989). For example, according to this rule, isoprene (C_5H_8) does not make SOA but terpenes do, making pine trees more important biogenic contributors to SOA than oak trees.[10]

Limited evaluation of the performance of CALPUFF at simulating SOA with its biogenic SOA module at one IMPROVE site in a regional modeling study in Wyoming found that 95% of 101 estimated 24-hr SOA concentrations were within 2% of the measured values (Scire et al., 2001). This performance seems promising, although the developers view the SOA module as needing more testing and evaluation.

Thus, CALPUFF includes approaches for dealing with condensable VOC emissions that are characterized as condensable PM_{10} and with biogenic VOCs, although the soundness of concentration estimates by these approaches when modeling a plume from a single source is largely untested.[11] The CALPUFF simulation of VOC emissions from sources whose VOC emissions are predominantly anthropogenic is problematic, however. Perhaps the approach used for the simplified biogenic SOA module may be extended to anthropogenic VOCs when speciated VOC emissions information is available. If only those VOCs with more than six carbon atoms are presumed to be of importance, this eliminates many anthropogenic sources of VOC emissions. For example, the fugitive emissions of butane and ethane during petroleum processing

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[10] Recent research suggests that isoprene may be a SOA precursor, however.

[11] Note that neither of these VOC-related simulation approaches is described in the current (Version 5) CALPUFF User's Guide dated January 2001. See the Wyoming report referenced above for a description of this module.

are not important, while aromatic emissions (such as of toluene and xylene) are considered by the SOA module's mechanism. Development, testing, and evaluation would be needed before one could rely on such a module for estimating SOA from anthropogenic SOA emissions, though.

Therefore, to demonstrate the visibility impacts of VOC emissions from BART-eligible sources, means other than CALPUFF will be needed. A technical approach using a regional photochemical model to evaluate visibility impacts of VOC emissions is presented in Section 4.1.3. CALPUFF can be used to estimate the contribution from the primary condensable fraction of PM_{10} emissions, though.

3.2.3 Regional Haze

Calculation of the impact of the simulated plume particulate matter component concentrations on light extinction is carried out in the CALPOST postprocessor. The formula used is the usual IMPROVE/EPA formula, which is applied to determine a change in light extinction due to changes in component concentrations. Using the notation of CALPOST, the formula is the following:

$$b_{ext} = 3\,f(RH)\,[(NH_4)_2SO_4] + 3\,f(RH)\,[NH_4NO_3] + 4[OC] + 1[Soil] + \\ + 0.6[Coarse\ Mass] + 10[EC] + b_{Ray} \qquad (3\text{-}1)$$

The concentrations, in square brackets, are in $\mu g/m^3$ and b_{ext} is in units of Mm^{-1}. The Rayleigh scattering term (b_{Ray}) has a default value of 10 Mm^{-1}, as recommended in EPA guidance for tracking reasonable progress (EPA, 2003a).

There are a few important differences in detail and in notation between the CALPOST formula for estimating light extinction (i.e., Equation 3-1) and that of IMPROVE and EPA. First, the *OC* in the formula above represents organic carbonaceous matter (OMC in IMPROVE's notation), which is 1.4 times the *OC* (i.e., organic carbon alone) in the IMPROVE formula. The *EC* above is synonymous with *LAC* in the IMPROVE formula. CALPOST now offers the option of using the old IMPROVE *f(RH)* curve, whose values are documented in the December 2000 FLAG report, or the *f(RH)* now used by IMPROVE and EPA (as documented in EPA's regional haze guidance documents). Also, CALPOST sets the maximum *RH* at 98% by default (although the user can change it), while the EPA's guidance now caps it at 95%.

The haze index (HI) is calculated from the extinction coefficient via the following formula:

$$HI = 10 \ln (b_{ext}/10) \qquad (3\text{-}2)$$

where *HI* is in units of deciviews (dv) and b_{ext} is in Mm^{-1}. The impact of a source is determined by comparing HI for estimated natural background conditions with the impact of the source and without the impact of the source.

CALPOST Methods

CALPOST uses Equation 3-1 to calculate the extinction increment due to the source of interest and provides various methods for estimating the background extinction against which the increment is compared in terms of percent or deciviews.

For background extinction, the CALPOST processor contains seven techniques for computing the change in light extinction due to a source or group of sources (called Methods 1-7). These are usually reported as 24-hour average values, consistent with EPA and FLM guidance. In addition, there are two techniques for computing the 24-hour average change in extinction (i.e., as the ratio of 24-hour average extinctions, or as the average of 24-hour ratios). A brief summary of the techniques is provided below. Method 2 is the current default, recommended by both IWAQM (EPA, 1998) and FLAG (2000) for refined analyses. Method 6 is recommended by EPA's BART guidance (70 FR 39162).

Methods 4 and 5 use optically measured hourly background extinctions, which represent current actual levels of extinction and thus are not consistent with the "natural conditions" the BART proposal says should be used as a baseline. Methods 1 through 3 and 6 and 7 allow for user inputs of estimated (e.g., natural conditions) background extinction or component concentrations, and thus are consistent with the BART proposal.

Method 1 allows the user to specify a single value of a "dry" background extinction coefficient for each receptor, specify that a certain fraction of that coefficient is due to hygroscopic species, and use relative humidity measurements to vary the extinction hourly via a 1993 IWAQM *f(RH)* curve or, optionally, the EPA regional haze f(RH) curve (EPA, 2003b). The *RH* is capped at 98% or a user-selected value (95% for the EPA curve). The same *f(RH)* is applied to both the modeled sulfate and nitrate.

For an example of the use of Method 1, one could use the dry particle extinction coefficient of 9.09 Mm^{-1} that results from EPA's default natural conditions concentrations, together with an assumption that for natural conditions, say, 0.9 Mm^{-1} (or 10%) of this amount results from hygroscopic ammonium sulfate and ammonium nitrate, and then apply *f(RH)* to this 10%.

In Method 2, user-specified, speciated monthly concentration values are used to describe the background. When applied to natural conditions, for which EPA's default natural conditions concentrations are annual averages, the same component concentrations would have to be used throughout the year (unless potential refinements to those default values resulted in concentrations that vary during the year). Hourly background extinction is then calculated using these concentrations and hourly, site-specific *f(RH)* from a 1993 IWAQM curve (a different one

than that in Method 1) or, optionally, the EPA regional haze f(RH) curve.[12] Again the *RH* is capped at either 98% (default) or a user-selected value (most commonly at 95%).

Method 3 is the same as Method 2, except that any hour in which the RH exceeds 98% (or the selected maximum) is dropped from the analysis. When 24-hr extinction is computed, no fewer than 6 valid hours are accepted at each receptor; otherwise the value for the day is tabulated as "missing".

Method 6 is similar to Method 2, except monthly f(RH) values (e.g., EPA's monthly climatologically representative values in EPA (2003a, b)) are used in place of hourly values for calculating both the extinction impact of the source emissions and the background conditions extinction. Hourly source impacts, with the effect on extinction due to sulfates and nitrates calculated using the monthly-average relative humidity in f(RH), are compared against the monthly default natural background concentrations. Thus the monthly-averaged relative humidity is applied to the hygroscopic components (i.e., sulfate and nitrate) of both the source impact and the background extinction with Method 6**.**

Method 7 is a new variant of Method 2 that was developed as a result of a ruling by the Assistant Secretary of the Interior for Fish and Wildlife and Parks, in response to a New Source Review case in Montana, that "natural conditions" should reflect the visibility impairment caused by significant meteorological events such as fog, precipitation, or naturally occurring haze (DOI, 2003).[13] Under Method 7, during hours when visibility is obscured by meteorological conditions, the actual measured visibility is used to represent natural conditions instead of the value that is calculated from EPA's default natural conditions concentrations under Method 2. A recent modification developed in response to FLM comments on Method 7, in which the daily average natural extinction is calculated somewhat differently, is called Method 7', i.e., "7 prime".

Refined Estimates of Extinction and Natural Background Visibility

Separate from the BART discussions, IMPROVE, EPA, and the Regional Planning Organizations are evaluating whether refinements are warranted to the methods recommended in EPA's guidance to calculate default estimates of natural background visibility. In particular, IMPROVE has recently approved an alternative to the formula (Eq. 3-1) it uses to estimate extinction from particle concentration measurements (Pitchford et al., 2005).

Refinements in the revised IMPROVE formula include the following:

- Adding a sea salt term, including a growth factor due to relative humidity

[12] Note that the hourly-varying natural background extinction in this method is not consistent with that prescribed by the EPA's natural conditions guidance (EPA, 2003b), for which a "climatologically-representative" f(RH) that only varies monthly is to be used. Method 6 uses these monthly average humidity values.

[13] The Secretary's guidance applies only to Federal Land Managers. EPA's position on this interpretation of natural conditions is unknown.

- Increasing the factor used to calculate the mass of particulate organic matter (OC in Eq. 3-1) from organic carbon measurements

- Modifying the relative humidity growth formula, f(RH), for sulfates and nitrates

- Revising the extinction efficiencies (the numerical constants in Equation 3-1) for sulfates, nitrates, and organic carbon so that they vary with concentration

- Adding a site-specific Rayleigh scattering term to the formula. Values will be calculated by IMPROVE for all Class I areas.

For the purposes of calculating current, future, and natural background visibility at VISTAS Class I areas as part of the reasonable progress analyses, VISTAS intends to present regional air quality modeling results using both the current EPA recommended assumptions and the newly revised aerosol extinction formula. If a BART-eligible source chooses to consider its projected impacts using the newly revised formula as well as the current formula, then modifications would need to be made to CALPOST to carry out calculations with the new algorithm.

4. VISTAS' COMMON MODELING PROTOCOL

4.1 Overview of Common Modeling Approach

In this section, guidance is provided on the use of the CALPUFF modeling system for two purposes:

1) Evaluating whether a BART-eligible source is exempt from BART controls because it is not reasonably expected to cause or contribute to impairment of visibility in Class I areas, and

2) Quantifying the visibility benefits of BART control options.

For purpose 1), States must determine whether a source emits any air pollutant (SO_2, NO_x, PM, and in certain cases VOC and NH_3) that "may reasonably be anticipated to cause or contribute to any impairment of visibility" in a Class I area. The States have 3 options to accomplish this:

A) Conclude that all BART-eligible sources in State are subject to BART.

B) Demonstrate that all BART-eligible sources in the State together do not cause or contribute to any visibility impairment

C) Determine if the impact from each individual BART-eligible source is greater than a threshold value.

VISTAS States intend to follow Option C (determine if the visibility impact from individual sources exceeds a contribution threshold) for SO_2 and NO_x emissions. The methods for Option C are described in Section 4.1.1. In early 2006, VISTAS pursued Option B (demonstrate that all BART eligible sources in a State do not impact visibility) for VOC, NH_3 and PM emissions. The approach and results for Option B are described in Section 4.1.3. As a result of this exercise, the VISTAS States have determined that the Option C exemption analyses should also include PM emissions and, for sources with large NH_3 emissions, NH_3. The States determined that anthropogenic VOC emissions do not cause or contribute to visibility impairment at VISTAS Class I areas and that VOC emissions do not need to be considered in BART analyses.

4.1.1 BART Exemption Analysis

As illustrated in Figure 4-1, three steps will evaluate whether a BART-eligible source of SO_2, NO_x, or PM is subject to BART:

1) VISTAS plans to use Q/d as a presumptive indicator that a source is subject to BART. If Q/d for SO_2 > 10 for 2002 actual emissions, then the State presumes that the source is subject to BART. If the source agrees with this presumption, then no exemption modeling is required and the source can proceed to the BART determination using CALPUFF to evaluate impacts of control options and can perform the engineering analyses. If a source disagrees, the source

may perform fine grid modeling as described in Section 4.4 to determine if its impact is < 0.5 dv.

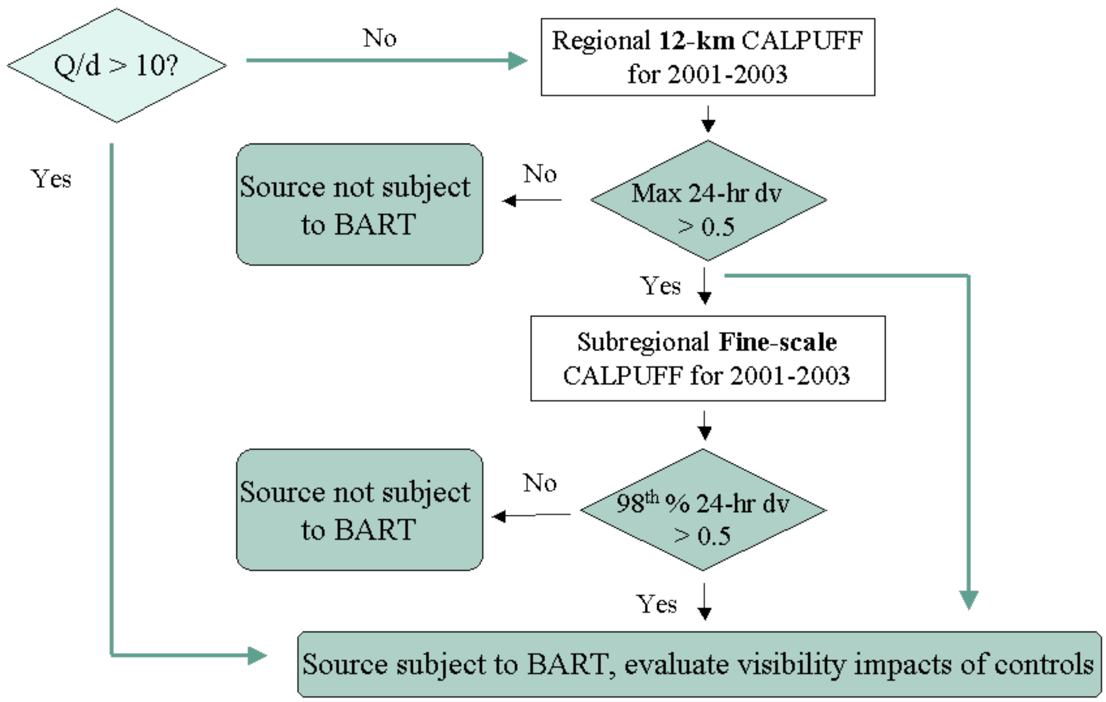

Figure 4-1. Flow chart showing the components of the VISTAS common modeling protocol. Assessment should be made for each Class I Area. (If a source agrees to install the most stringent controls then the modeling steps indicated above and engineering analyses and visibility impact modeling would not be required.)

2) An optional initial modeling assessment using the CALPUFF model with the coarse scale 12-km regional VISTAS domain can be used to answer questions whether (a) a particular source may be exempted from further BART analyses and (b) if finer grid CALPUFF analysis were to be undertaken, which Class I areas should be included. Assumptions for the initial modeling assessment are conservative so that a source that contributes to visibility impairment is not exempted in error. If a source is shown not to contribute to visibility impairment using the initial modeling assessment, the source would not be subject to BART and would be exempted from further BART analyses. If a source is shown to contribute to visibility impairment using the initial modeling assessment, the source has the option to undertake finer grid CALPUFF modeling to evaluate further whether it is subject to BART.

3) A finer grid CALPUFF modeling analysis using a subregional CALMET domain will be the definitive test as to whether a source is subject to BART.

For large sources that will clearly exceed the initial screening thresholds, this step can be skipped and the analysis may proceed directly to the finer grid modeling analysis, which is described in Section 4.4.

4.1.2 BART Control Evaluation

For sources that are determined to be subject to BART controls, part of the BART review process involves evaluating the visibility benefits of different BART control measures. These benefits will be determined by making additional CALPUFF simulations using the same CALMET and CALPUFF configuration as those used in the finer grid analysis of Step 2. The only exception is that the source and emissions data used in the CALPUFF control evaluation simulations will reflect the BART control measures being evaluated. Using the same model configuration will produce an "apples-to-apples" comparison, where differences in impacts are due to the effectiveness of the controls rather than model configuration differences. For example, a control scenario evaluation that uses more conservative assumptions than the base case simulation may produce results showing no or little improvement in visibility impacts. That control scenario run with the same model configuration as the base case may show significant visibility improvement. Therefore, in order to not obscure the response to predicted visibility improvements by differences in the modeling approach, the same model configuration should be used in the BART control evaluation simulation as in the base case simulation.

The base case to which the effectiveness of BART controls is to be compared is the "current emissions" scenario for which the finer grid Step 2 modeling was performed. The postprocessing steps and procedures are the same as in the BART eligibility simulation. Side-by-side comparison of the visibility impacts will be tabulated to quantify the effectiveness of each control scenario relative to the base case.

The modeling evaluation is a unit-by-unit evaluation and can be conducted on a pollutant specific basis. Modeling results are used with the other four statutory factors mentioned in Section 2.1 to decide which control technology, if any, is appropriate. Finally, if a source decides to use the most stringent control technology available, the BART control analysis, including modeling, is not necessary.

4.1.3 VISTAS' Treatment of VOC, NH_3, and PM

Volatile Organic Compounds

CALPUFF is currently not recommended for addressing visibility impacts from VOC because its capability to simulate secondary organic aerosol formation from VOC emissions is not adequately tested, especially for anthropogenic emissions. (Separately, condensable organic carbon can be calculated from PM_{10}.)

VISTAS has performed a weight of evidence analysis to demonstrate, using the CMAQ regional air quality model, that the combined VOC emissions from all point sources (BART-eligible and non-BART) in each State do not contribute to visibility impairment. Emissions sensitivity

simulations run for VISTAS by Georgia Institute of Technology using VISTAS' 12 x 12 km grid and CMAQ v 4.3 for episodes in July 2001 and January 2002 demonstrated very low to no response of organic carbon levels and light extinction at Class I areas to changing VOC emissions from all anthropogenic sources in the VISTAS 12-km modeling domain (eastern US). Georgia Tech repeated the sensitivity analyses using the VISTAS 12-km domain and CMAQ v 4.4 with a refined SOA module for summer (Jun 1-Jul 10) and winter (Nov 19-Dec 19) periods in 2002. VOC emissions from all anthropogenic point sources in every VISTAS State were reduced by 100% (i.e., eliminated). The maximum 24-hr impact of all VOC emissions from all point sources throughout the VISTAS domain was thus determined to be less than 0.5 dv (compared to annual average natural background) at every Class I area in the VISTAS domain and in adjacent States. It follows that the impact of any one BART-eligible source would be much less than 0.5 dv. Based on these analyses, the VISTAS States have concluded that VOC emissions from BART sources do not cause or contribute to visibility impairment and do not need to be included in BART analyses.

Ammonia

EPA has given states the option to address ammonia (NH_3) emissions from BART-eligible sources. VISTAS also contracted with Georgia Tech to calculate NH_3 emissions sensitivities using CMAQ v 4.4 with a refined SOA module and the same Jun-Jul and Nov-Dec periods in 2002 that were used for the VOC sensitivity evaluation. The NH_3 emissions from all point sources (BART-eligible and not-BART) in every State were reduced by 100% for these analyses. This sensitivity evaluation showed that the collective impact of all VISTAS region point NH_3 emissions is greater than 0.5 dv (compared to annual average natural background) at several Class I areas. When the NH_3 emissions were scaled to represent 100% reduction from only the BART-eligible sources in each State, then the maximum impact of those sources was under 0.5 dv at most, but not all Class I areas. The high values appear to result primarily from emissions from 13 large NH_3 sources. In the absence of those 13 facilities, the scaled NH_3 emissions peak impacts at Class I areas were 0.3 dv or less. Based on these analyses, the VISTAS States recommended that, except for these 13 facilities, NH_3 emissions not be included in BART modeling. States will provide instructions to those 13 sources as to how to evaluate contributions of their NH_3 emissions to visibility impairment. For documentation purposes, in summer 2006 VISTAS is repeating the NH_3 emissions sensitivity calculations, using CMAQ v4.5 with Base F emissions and reducing 100% of NH_3 emissions from only the BART-eligible sources in the VISTAS states.

Primary Particulate Matter

Primary particulate matter is considered a visibility impairing pollutant. However, the extent to which primary PM from BART-eligible sources contributes to impairment at Class I areas in the southeastern US is not clear. For EGUs, the EPA has determined that emissions reductions of SO_2 and NO_x under the CAIR rule meet the BART requirements, but these EGUs may still be subject to BART for primary PM. To determine the potential impacts of PM from EGU and non-EGU sources in the VISTAS states, two CMAQ sensitivity runs for the first and third quarters of 2002 were carried out by VISTAS' CMAQ modeling team of ENVIRON, UCR, and Alpine

Geophysics In one run, all primary PM from EGUs was removed while in the other run all primary PM from non-EGU sources was removed. All other CMAQ modeling components were held constant. At almost all Class I areas in the VISTAS region, primary PM emissions contribute to regional haze, with the collective impact of all EGU and non-EGU point primary PM emissions being greater than 0.5 dv compared to annual average natural background. In fact, the impacts of EGU PM emissions alone or of non-EGU PM emissions alone were each mostly greater than 0.5 dv. Although the impacts of BART sources alone would be smaller, the VISTAS States have concluded that all BART-eligible sources need to consider the impacts of their PM emissions.

4.2 Optional Source-Specific Modeling

In some circumstances, a source may want to apply techniques designed to evaluate the impacts in a more detailed way than the standard VISTAS common protocol. A source may propose source-specific modeling procedures to address special issues to the State for State review. For example, sources very close to Class I areas may be better treated by a finer grid resolution that the generic Step 2 "fine" grid resolution meteorological fields provided by VISTAS. In some situations, higher resolution MM5 or other prognostic meteorological datasets may be available than the standard 12-km or 36-km MM5 datasets provided by VISTAS. Because it is not possible to anticipate all of the situations where there would be a benefit to conducting more detailed source-specific analyses, the option to pursue this option is left as an open issue, to be resolved and justified based on specific factors relevant for the source in question.

A source-specific modeling protocol is required for each source. This document should describe the data sources and model configuration, and provide rationale for any changes in the model approach from the common protocol. This source-specific protocol must be provided for review and approval by the State. The State will share the protocol with EPA and the Federal Land Managers for their review. Discussion of approaches to source-specific modeling and an outline of the typical contents of the source-specific protocol are presented in Chapter 5. Discussions with the regulatory authorities should be conducted prior to development of a source-specific protocol to ensure all of the relevant issues are included in the protocol.

4.3 Initial Procedure for BART Exemption

4.3.1 Overview of Initial Approach

The first step in the common protocol, the initial assessment in Figure 4-1, is a simple procedure to evaluate whether a source can be exempted from BART controls using a consistent set of meteorological and dispersion options. A pre-computed set of meteorological files and a pre-defined CALPUFF input option configuration, based on guidance in the final BART rule (70 FR 39104-39172) and other EPA and FLAG model guidance, will allow relatively simple initial simulations. The regional initial domain is designed to allow any Class I areas within the VISTAS area to be evaluated with a single meteorological database and consistent CALPUFF modeling options. The second important question that this first screening step will answer is, if

initial modeling indicates a source may impact visibility significantly, what Class I areas should be included in a finer grid analysis? Due to the multitude of factors affecting the contribution of a source to visibility in a Class I area, simple screens or rules of thumb alone (such as that the closest Class I area will produce the controlling visibility impacts) are not likely to be universally reliable.

4.3.2 Discussion of 12-km Initial Exemption Modeling

Meteorological Fields

A regional initial domain and a set of pre-computed regional CALMET meteorological files will be prepared for VISTAS, to allow any Class I areas within the VISTAS area to be evaluated with a consistent meteorological database and consistent CALPUFF modeling options.

The following three years of MM5 meteorological data have been assembled by VISTAS for use in the regional CALPUFF modeling effort:

- 2001 MM5 dataset at 12 km and 36 km grid (developed for EPA)
- 2002 MM5 dataset at 12 km and 36 km grid (developed by VISTAS)
- 2003 MM5 dataset at 36 km grid (developed by the Midwest Regional Planning Organization).

These data sets have been provided to Earth Tech by VISTAS, and from them Earth Tech has produced annual CALMET meteorological files at 12-km grid resolution for the domain shown in Figure 4-2. The CALMET modeling output files in the form of CALPUFF-ready three-dimensional meteorological files will be available on external hard drives to the States and other parties.

The initial procedure to determine if a BART-eligible source is subject to BART uses the pre-computed CALMET meteorological fields for the years 2001-2003 on the 12-km CALMET domain in Figure 4-2 and simulates with CALPUFF any BART-eligible source to be screened. The CALMET simulations will be developed using the highest resolution MM5 data available for each year (i.e., 36-km MM5 data for 2003, 12-km MM5 data for 2001 and 2002).

The development of the regional CALMET meteorological fields from MM5 data will be conducted in No-Observations (“No-Obs”) mode. The MM5 data already reflect assimilation of observational data and are likely to adequately characterize regional wind patterns that are consistent with the 12-km grid scale. Blending of MM5 data with local observations (which are mainly at the surface) could lead to wind structures that may not be realistic under some conditions and may result in poorer characterization of the regional winds. Thus, the effort required to prepare observational data sets for CALMET for the large regional domain involves considerable effort that may not provide corresponding improvement of the wind field.

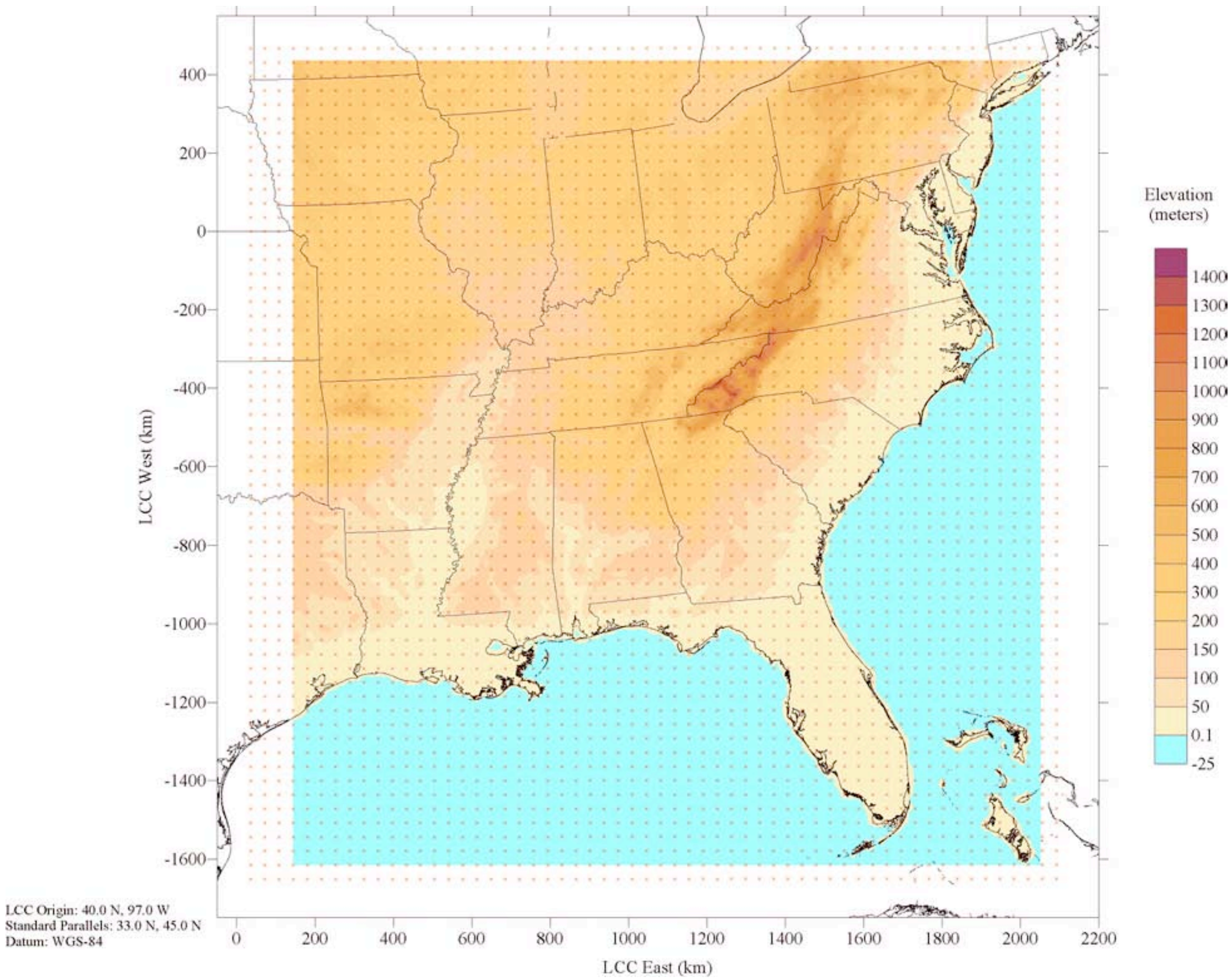

Figure 4-2. VISTAS Regional 12-km Resolution CALMET Modeling Domain (color area with terrain contours). The locations of the 36-km resolution MM5 grid points are shown on the plot.

For 2003, the 36-km MM5 data will be used as CALMET's initial guess field and then the CALMET diagnostic terrain adjustments (see Section 3.1.1) will be applied to reflect terrain on the scale of the CALMET grid (i.e., 12-km). When the 12-km MM5 (2001 and 2002) data are used, the diagnostic CALMET terrain adjustments will be turned off since the grid resolution of the MM5 data is the same as the CALMET grid and the terrain adjustments on the 12-km grid scale will already be reflected in the MM5 dataset. In this case, the MM5 winds will be interpolated by CALMET to the CALMET layers and CALMET's boundary layer modules will compute mixing heights, turbulence parameters and other meteorological parameters that are required by CALPUFF.

Impact Threshold

The final BART guidance recommends that the threshold value to define whether a source "contributes" to visibility impairment is 0.5 dv change from natural conditions[14] (although States may set a lower threshold). The 98th percentile (8th highest annual) 24-hr average predicted impact at the Class I area, as calculated using CALPOST Method 6 (monthly average relative humidity values), is to be compared to this contribution threshold value. For this comparison, the predicted impact at the Class I area on any day is taken to be the highest 24-hr average impact at any receptor in the Class I area on that day. (Note that the receptor where the highest impact occurs can change from day to day.) According to clarification of the BART guidance received from EPA, for a three-year simulation the modeling values to be compared with the threshold are the greatest of the three annual 8th highest values or the 22nd highest value over all three years combined, whichever is greater.

For the purposes of the initial analysis, however, the *highest value* over the three-year period (not the 98th percentile value) is to be compared to the contribution threshold. This ensures a significant measure of conservatism in the initial approach. VISTAS will evaluate the initial CALPUFF results to determine if using the single highest value provides too conservative a screen for exemption purposes. If so, VISTAS may increase the number of exceedances of the contribution threshold that would be allowed and still qualify to exempt a source.

4.3.3 Model Configuration and Settings for Initial Analysis

VISTAS will use CALPUFF Version 5.754 and CALMET Version 5.7. These versions contain enhancements funded by the Minerals Management Service (MMS) and VISTAS. They were developed by Earth Tech, Inc. and they are maintained on the CALPUFF website (www.src.com) for public access. This version includes CALMET, CALPUFF, CALPOST, CALSUM, and POSTUTIL as well as CALVIEW.

The initial analysis uses a CALPUFF computational domain that includes all Class I areas within 300 km of a source. These Class I areas are specified in the CALPUFF control file for analysis. States could decide to require a different value for the maximum distance threshold for the CALPUFF domain, depending on the locations of the Class I areas in their states and other factors such as meteorological conditions and the magnitudes of the emissions from BART-eligible sources. The regional CALMET domain will be unchanged by these adjustments.

Also, the initial approach is designed to significantly reduce the CALPUFF simulation time by restricting the CALPUFF computational domain size to include only areas where significant impacts are feasible rather than the entire regional domain. CALPUFF allows its computational domain to be specified as a subset of the CALMET meteorological domain by settings within the

[14] As described in Footnote 5 on page 6, States have the option of defining natural conditions as either the annual average default conditions or the average of the 20% best natural condition days.

CALPUFF input file. The advantage of selecting a smaller CALPUFF computational domain in the regional CALPUFF simulations is that CALPUFF run time is proportional to the number and residence time of the puffs on the domain (and other factors such as the number of receptors and the internal time step computed by the model). A CALPUFF domain covering an area 300 km from a source in all directions would involve only 50 x 50 12-km grid cells, which will require modest computational resources.

CALMET output files for the VISTAS regional domain shown in Figure 4-2 will be provided to VISTAS by Earth Tech. These files will be in CALPUFF-ready format, and as such, no CALMET user inputs will be required. An option in CALMET allows finer grid CALMET input files to be calculated from the 12-km CALMET files.

The basic characteristics of the CALMET, CALPUFF and CALPOST configurations for the initial analyses are listed below.

CALMET Modeling Configuration (12-km initial exemption modeling)

The CALMET model configuration for the regional CALMET simulations will be defined by Earth Tech in collaboration with the VISTAS States. The basic model configuration will follow the recommended IWAQM guidance (EPA, 1998; Pages A-1 through A-6), except as noted below.

The basic features of the modeling simulation are the following:

- Modeling period: 3 years (2001-2003)

- Meteorological inputs: MM5 data provide initial guess fields in CALMET

- CALMET grid resolution: 12-km (same Lambert Conformal coordinate system and grid cells as the 12-km 2001/2002 MM5 simulations)

- CALMET vertical layers: 10 layers. Cell face heights (meters): 0, 20, 40, 80, 160, 320, 640, 1200, 2000, 3000, 4000.

- CALMET mode: No-Observations mode including option to read overwater data directly from MM5.

- Diagnostic options: IWAQM default values, except as follows: diagnostic terrain blocking and slope flow algorithms used for 2003 simulations (using 36-km MM5 data), but no diagnostic terrain adjustments in 2001 and 2002 simulation (using 12-km MM5 data)

- CALMET options dealing with radius of influence parameters (R1, R2, RMAX1, RMAX2, RMAX3), BIAS, ICALM parameters are <u>not used</u> in No-Observations mode.

- TERRAD (terrain scale) is required for runs with diagnostic terrain adjustments (i.e., the 2003 simulations). Values of ~10-20 km will be tested, and an appropriate value determined.

- Land use defining water: JWAT1 = 55, JWAT2 = 55 (large bodies of water). This feature allows the temperature field over large bodies of water such as the Atlantic Ocean and the Great lakes to be properly characterized by buoy observations.

- Mixing height averaging parameter (MNMDAV) will be determined by Earth Tech for the regional simulations based on sensitivity tests. The purpose of the testing is to optimize the variable to allow spatial variability in the mixing height field, but without excessive noise.

- Geophysical data for regional runs: SRTM-GTOPO30 30-arcsec terrain data, Composite Theme Grid (CTG) USGS 200m land use dataset. References for these and other CALMET datasets can be found on the CALPUFF data page of the official CALPUFF site (www.src.com).

CALPUFF Modeling Configuration (Initial exemption modeling)

The CALPUFF model configuration for the regional CALPUFF initial simulations will follow the recommended IWAQM guidance (EPA, 1998; Pages B-1 through B-8), except as noted below:

- CALPUFF domain configured to include the source and all Class I areas within 300km of the source plus 50km buffer zone in each direction. CALPUFF is recommended for all source-receptor distances to be considered in the BART analyses.

- Chemical mechanism: MESOPUFF II module

- Species modeled: SO_2, SO_4, NO_x, HNO_3, NO_3 and particulate matter in size categories of <0.625 µm, 0.625-1.0 µm, 1.0-1.25 µm, 1.25-2.5 µm, 2.5-6.0 µm and 6-10 µm aerodynamic diameters. As noted below, the particulate matter emissions by size category will be combined into the appropriate species for the visibility analysis (i.e., elemental carbon (EC), fine PM or "soil" (< 2.5 µm in diameter), coarse PM (between 2.5-10 µm in diameter) and organics (called secondary organic aerosols (SOA) in the CALPOST postprocessor).

- Emission rates for modeling based on EPA BART guidance, i.e., maximum 24-hour actual emission rate with normal operations from the highest emitting day of the meteorological period modeled (excluding days where start-up, shutdown or malfunctions occurred sometime during the day.) Note that potential emissions are used to determine if a source is BART-eligible, but 24-hour average maximum emissions are used for modeling purposes (70 FR 39162). Pollutants considered include SO_2, H_2SO_4, NO_x and PM_{10}.

Condensable emissions are considered as primary fine particulate matter and allocated equally to the two submicrometer-particle size classes. If actual source emissions data are not available, the modeling should be based on permit limits. If source-specific size

categories are not available, then AP-42 factors may be used for sources where AP-42 factors are available. For sources where AP-42 factors are not available, alternative approaches to speciation are given below.

Excluded from the modeling are pollutants with plant-wide emissions less than *de minimis* levels (40 tons per year for SO_2 and NO_x and 15 tons per year for PM_{10}). *De minimis* levels are plant wide for each visibility-impairing pollutant, so individual units may be modeled even if they have emissions below *de minimis* if the plant total is greater than *de minimis*.

- Particulate emissions speciation: Break down, as appropriate, filterable and condensable particulate matter into the following species categories: elemental carbon (soot), "soil" (fine PM < 2.5 µm diameter), coarse particulate matter (2.5-10 µm diameter) and organics. The process is illustrated in Figure 4-3. If source-specific speciated emissions factors are not available, AP-42 factors or speciation information developed by the National Park Service (http://www2.nature.nps.gov/air/permits/ect/index.cfm) can be used to estimate the PM speciation for many source sectors.

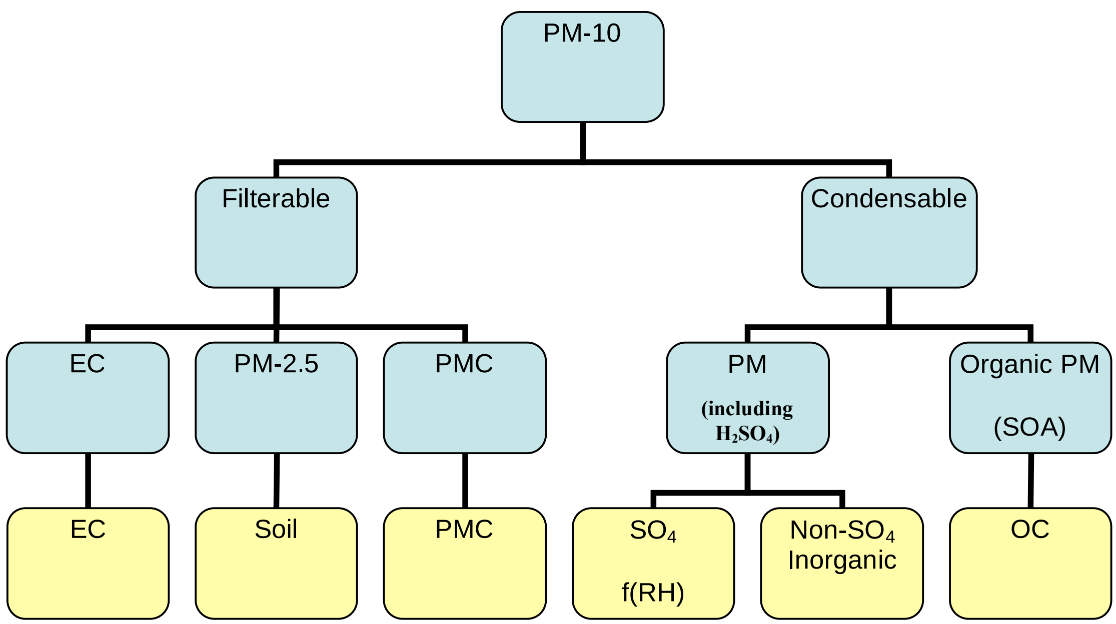

Figure 4-3. Speciation of PM-10 Emissions. (PMC is coarse particulate matter -- 2.5 to 10 µm diameter.)

Otherwise, assumptions will need to be proposed by the source, and reviewed and approved by the State. Possible acceptable alternative approaches to estimating speciation include the following:

- Speciation profiles developed by the SMOKE emissions model for use in VISTAS' CMAQ regional air quality modeling (available at http://www.vistas-sesarm.org/BART/calpuff.asp).

- The approach described in a memo available at http://www.vistas-sesarm.org/BART/calpuff.asp, which provides reasonably conservative estimates in situations where data are incomplete.

- Class I receptors: Use FLM Class I receptor list with receptor elevations provided (available from the NPS).

- CALPUFF model options: Use IWAQM (EPA, 1998) default guidance, including Pasquill-Gifford dispersion coefficients.

- Ozone dataset – use observed ozone data for 2001-2003 from CASTNet and AIRS stations. Only non-urban ozone stations should be used in the OZONE.DAT file. Monthly average ozone (backup) background values are to be computed based on daytime average ozone concentrations from the OZONE.DAT file (6am-6pm average ozone concentrations computed by month).

- Background ammonia concentration: In CALPUFF, use constant (0.5 ppb) value for ammonia.

- Puff representation: integrated puff sampling methodology.

- Building downwash: Ignore building downwash unless source is within 50-km of a Class I area and the State instructs the source to specifically consider building downwash.

CALPOST and POSTUTIL Configuration (Initial exemption modeling)

- Use Visibility Method 6 in CALPOST

- Species considered in visibility analysis: SO_4, NO_3, EC, SOA (i.e., condensable organic emissions), soil, coarse PM

- Natural background light extinction: Several options are acceptable at the discretion of the State: (1) A single annual average natural background extinction for each Class I area, as presented in Appendix B of EPA's natural conditions guidance (EPA, 2003b); (2) A single value that represents the average haze index on the 20% best natural conditions days, again as presented in the same Appendix B; or (3) A monthly average natural background as calculated by CALPOST under Method 6, based on annual average default natural

conditions component concentrations and monthly average f(RH) values for the centroid of the Class I area, from Table A-3 in the natural conditions guidance document,.

A special procedure is needed for options 1 and 2, since CALPOST requires input of natural background concentrations of PM components while the backgrounds for options 1 and 2 are expressed in EPA's guidance document as extinction coefficients or haze indices (in deciviews). In order to produce the appropriate natural background in CALPOST for these options, use Equation 3-2 to calculate the extinction coefficient that corresponds to EPA's haze index value for the Class I area (if necessary), subtract the Rayleigh scattering value of 10 Mm^{-1}, and enter a soil concentration (in $\mu g/m^3$) into CALPOST that is numerically equal to this result. (Since the extinction efficiency of soil is 1 m^2/g, Equation 3-1 shows that this process produces a background extinction that equals the EPA's value.) Leave the concentrations of all other species blank, since the number that is entered represents extinction by all components.

- Light extinction efficiencies: Use EPA (2003a) values. If a source chooses, the new IMPROVE algorithm for calculating light extinction (see Section 3.2.3) may be used in addition to the default IMPROVE algorithm. (Calculations would need to be performed outside CALPOST or CALPOST would need to be modified to accommodate the new algorithm.)

- Nitrate repartitioning in POSTUTIL: Do not use for the initial modeling.

The initial run results will be based on the highest change in light extinction (deciviews) from natural conditions over the three-year modeling period for each Class I area considered. Predicted changes exceeding the "contribution" threshold (0.5 deciviews) will trigger a finer grid CALPUFF modeling analysis.

4.4 Finer Grid Modeling Procedures

4.4.1 Rationale for and Overview of Finer Grid Modeling Approach

There are two potential applications for finer grid CALPUFF modeling:

BART Exclusion Modeling. First, finer grid CALPUFF modeling can be used to demonstrate that a source does not cause or contribute to visibility impairment in any Class I areas, and thus can be excluded from BART controls. As shown in Figure 4-1, if the initial regional modeling results are not below the threshold for visibility impacts, the next step is to conduct modeling using a finer grid resolution for the meteorological fields and the treatment of terrain effects and land use variability. In the finer grid modeling the predicted visibility impairment that is compared to the threshold is based on the BART guidance of the 98^{th} percentile change in deciviews value rather than the more conservative highest value used in the initial analysis.

The BART guidance indicates that the emissions rate to be used for such modeling is the highest 24-hr rate during the modeling period. Depending on the availability of source data, the following

emissions information (listed in order of priority) should be used with CALPUFF for BART exclusion modeling:

- 24 hr maximum value emissions for the period 2001-2003 (Continuous Emission Monitor, CEM data)
- 24 hr maximum value from continuous emissions monitoring data
- facility stack test emissions
- potential to emit
- permit allowable emissions, if available
- emissions factors from AP-42 source profiles

Quantify Benefits of BART. The second application of refined modeling is to quantify the visibility benefits from the BART control options. This is accomplished by running CALPUFF with the baseline emissions rates and again with emissions after BART controls. It is important that emission reductions be evaluated in the postprocessing step rather than by using "negative" emission rates in the CALPUFF model. The chemical scheme requires that emission rates always be positive.

For any of these applications, a source-specific modeling protocol that defines source properties and the specific model configuration is required. As discussed in Section 5, the source specific protocol should include source-specific emissions data and can refer to this document for all methods and assumptions that follow this common protocol.

4.4.2 Model Configuration and Settings for Finer Grid Modeling

Grid resolution substantially better than 12-km is needed for a finer grid CALPUFF assessment of visibility impacts in most cases involving Class I areas in complex terrain or coastal areas. Thus, the CALMET fine grid resolution in the subregional modeling domains used for finer grid modeling will depend on the terrain, land use (especially coastal boundaries), location of the source, distance of the source from Class I areas, and total size of the subregional modeling domain.

VISTAS States have 2001-2003 CALMET files for five 4-km sub-regional domains as illustrated in Figure 4-4. The subdomains are designed to address all BART eligible sources within each VISTAS states and all Class I areas within 300 km of the BART-eligible sources. For application for a single source, a smaller domain of roughly 200-300 km by 200-300 km is recommended. Requests to obtain the 4-km CALMET files should be made to the State BART representatives.

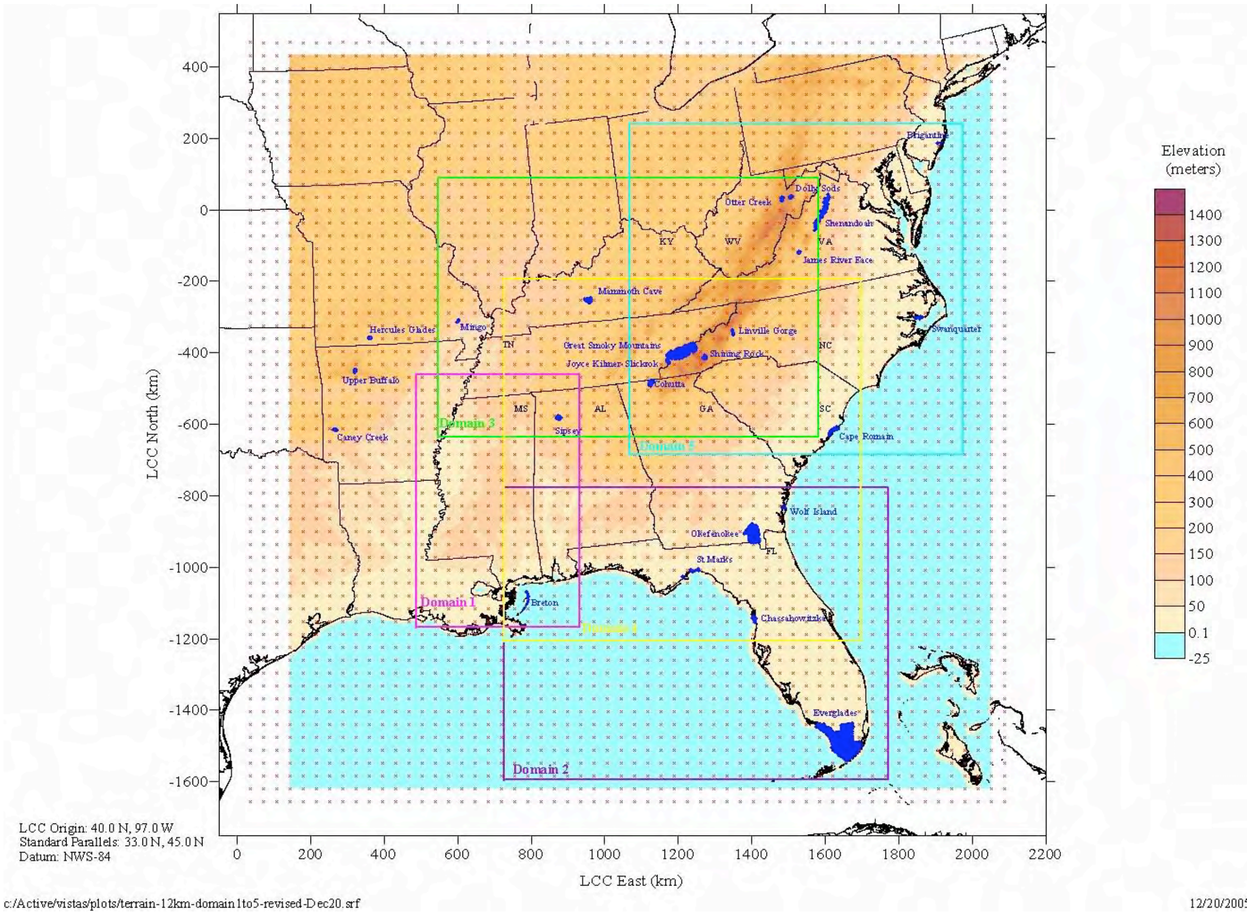

Figure 4-4. The five subregional domains for 4-km CALMET modeling.

In some instances, as part of the source-specific protocol, a source may propose to the State to use an even finer grid simulation to properly characterize the flow fields and land use changes that affect dispersion. An application for source-receptor distances within about 50 km may require a grid resolution less than 1 km if complex terrain effects are likely to be important. This determination should be made on a case-by-case basis. There is not a single distance at which a particular grid size is appropriate. It depends on factors such as the complexity of the terrain, the source-receptor distances involved, the location of the source relative to the terrain features, the physical stack parameters (e.g., a tall stack in complex terrain may be unaffected by the terrain-forced flow), proximity of the source and Class I area to a coastline, and other factors including availability of representative observational data.

The finer grid CALMET simulations were run in hybrid mode, using both MM5 data to define the initial guess fields and meteorological observational data in the Step 2 calculations. Overwater (buoy) data will be provided in addition to the hourly surface meteorological observations, precipitation observations and twice-daily upper air sounding data.

A domain-specific set of modeling parameters will be defined for each subregional domain. The proper selection of the CALMET diagnostic wind field parameters that are used to blend observations with the Step 1 wind field depends on factors such as the locations of the meteorological stations relative to terrain and coastal features (which affects the representativeness of the observational data), the terrain length scale, and the quality (resolution) of the MM5 data used to define the initial guess field and its ability to properly resolve wind flows on the fine-scale CALMET domain. The definition of the proper CALMET parameters is done as part of sensitivity testing where model performance is evaluated against available observations and expected terrain effects, such as channeling of flows within a valley.

In addition to the better grid resolution and the introduction of observational data in the finer grid simulations, several other modeling refinements can enhance the accuracy of the finer grid modeling. These include use of the higher resolution terrain DEM data (~3 arc sec USGS data) in defining the gridded terrain fields and application of the ammonia limiting method in the POSTUTIL post-processor. Otherwise, the source configuration, emissions, pollutant speciation, Class I receptors, ozone datasets and CALPUFF model options will be the same as in the initial runs. Similarly, CALPOST will be used in the same manner as for the initial analyses. However, POSTUTIL can be used to repartition nitrate in the finer grid modeling, using background ammonia concentrations according to the IWAQM Phase 2 report (IWAQM, 1998).

For the finer grid BART exclusion analysis, the test for evaluating whether a source is contributing to visibility impairment is based on the 98^{th} percentile modeled value (rather than the highest predicted value used for the initial evaluation), which is consistent with EPA's BART guidance.

4.5 Presentation of Modeling Results

The CALPOST processing computes the daily maximum change in deciviews. A sample of the summary table produced by CALPOST is shown in Table 4-1. For evaluating compliance with the VISTAS screening threshold, the highest change in extinction value, located at the bottom of the CALPOST list file is compared to the threshold value (e.g., 0.5 dv). For example, in the sample shown in Table 4-1, the summary at the bottom shows that the highest visibility impact is 1.219 dv, with 9 days over the year showing values greater than 0.5 dv. Therefore this source would not pass the initial analysis, and finer grid modeling would be required.

In addition to the highest change in deciview value on each day over all the receptors in a particular Class I area, the CALPOST summary table in Table 4-1 contains the coordinates of the receptor, receptor type (D indicates discrete receptors), the total haze level (background + source, in dv), the background haze in deciviews, the change in haziness (delta dv), the humidity term applied to hygroscopic aerosols (f(RH)), and the contribution of each species to light extinction (in percent of the total source contribution) for SO_4, NO_3, organics, elemental carbon, coarse and fine particulate matter.

Table 4-1. Example of CALPOST Output, Showing Maximum Daily Impacts of Source and Locations of Those Impacts.

YEAR	DAY	HR	RECEPTOR	COORDINATES (km)		TYPE	DV(Total)	DV(BKG)	DELTA DV	F(RH)	%_SO4	%_NO3	%_OC	%_EC	%_PMC	%_PMF
2001	2	0	3	20.540	79.782	D	5.397	5.358	0.039	4.314	44.33	47.22	3.07	1.07	0.00	4.30
2001	3	0	9	31.680	79.822	D	4.566	4.421	0.145	1.767	40.75	33.89	9.19	3.24	0.00	12.94
2001	4	0	1	24.723	77.951	D	4.540	4.540	0.000	2.076	0.00	0.00	0.00	0.00	0.00	0.00
2001	5	0	77	30.228	94.571	D	4.950	4.939	0.011	3.144	43.13	44.74	4.64	1.45	0.00	6.05
2001	6	0	1	24.723	77.951	D	5.181	5.166	0.015	3.772	38.58	56.05	1.90	0.70	0.00	2.76
2001	7	0	3	20.540	79.782	D	6.366	5.745	0.620	5.439	44.98	44.99	3.69	1.26	0.00	5.08
.																
.																
.																
2001	363	0	113	27.414	103.782	D	5.725	5.652	0.073	5.164	53.49	35.51	4.03	1.39	0.00	5.58
2001	364	0	113	27.414	103.782	D	6.554	6.521	0.033	7.826	48.12	47.09	1.67	0.64	0.00	2.48
2001	365	0	1	24.723	77.951	D	6.499	6.499	0.000	7.757	0.00	0.00	0.00	0.00	0.00	0.00

```
--- Number of days with Delta-Deciview  =>   0.50:         9
--- Number of days with Delta-Deciview  =>   1.00:         2
---             Largest Delta-Deciview  =             1.219
```

For the finer grid analysis, the data in the table can be imported into a spreadsheet and sorted on the delta dv column. Table 4-2 shows an example of the ranked visibility impacts (change in dv) for each of three years at six different Class I areas. The 98^{th} percentile (8^{th} highest value) in the sorted table would be compared to the contribution threshold (e.g., 0.5 dv). In the example shown in this table, the source passes the finer grid analysis because the highest 98^{th} percentile visibility impact is below the contribution threshold of 0.5 dv.

The Results section of the CALPUFF modeling report should contain the following information:

1. Map of source location and Class I areas within 300 km of the source

2. For the VISTAS 12-km CALPUFF initial exemption modeling domain, a table listing all Class I areas in the VISTAS domain and those in neighboring states and impacts at those Class I areas within 300 km of the source, as illustrated in Table 4-3**.**

3. A discussion of the number of Class I areas with visibility impairment from the source on 98^{th} percentile days in each year greater than 0.5 dv (total visibility impairment minus impairment on 20% best days for natural background visibility equals delta-dv, the visibility impact attributed to the source).

4. For the Class I area with the maximum impact, discussion of the number of days below the 98^{th} percentile that the impact of the source exceeds 0.5 dv, the number of receptors in the Class I area where the impact exceeds 0.5 dv, and the maximum impact.

5. For finer grid CALPUFF exemption modeling, results for those Class I areas for which impacts of the source exceeded 0.5 dv in the 12-km initial exemption modeling. Report same results as provided for 12-km initial exemption modeling.

6. For control option modeling, each control option tested should be listed in tabular format. For each control option and for each Class I area where the impact of the source exceeded 0.5 dv, report the change in pollutant emissions and the change in visibility impact from the source as a result of the control option. The effectiveness of candidate control options are to be compared to each other, not to a specific target improvement.

   States will provide further guidance on graphic presentation of results to simplify evaluation of effectiveness of control measures. For example, a temporal plot of the change in deciviews between the controlled and uncontrolled cases could be developed for the receptor with the maximum modeled impact in each Class I area.

7. Copies of all input files and input data in electronic format for the CALMET, CALPUFF, CALPOST and POSTUTIL runs should be archived and provided to the State.

Table 4-2. Example of Visibility Impact Rankings at Six Class I Areas

Class I Area	2001	2002	2003
	Delta-Deciview Ranks 1-8	Delta-Deciview Ranks 1-8	Delta-Deciview Ranks 1-8
Great Smoky NP	0.99	0.95	1.20
	0.88	0.63	0.90
	0.62	0.51	0.73
	0.59	0.50	0.72
	0.55	0.46	0.59
	0.52	0.42	0.47
	0.48	0.37	0.45
	0.47	0.36	0.42
Linville Gorge	0.67	0.81	0.76
	0.45	0.69	0.47
	0.43	0.65	0.37
	0.33	0.50	0.35
	0.29	0.45	0.31
	0.27	0.33	0.30
	0.25	0.31	0.28
	0.23	0.29	0.28
Shining Rock	0.66	0.73	0.75
	0.43	0.69	0.45
	0.41	0.63	0.36
	0.35	0.52	0.34
	0.26	0.46	0.28
	0.24	0.34	0.27
	0.23	0.29	0.26
	0.22	0.26	0.25
Cohutta	0.26	0.54	0.61
	0.23	0.47	0.42
	0.22	0.43	0.30
	0.21	0.37	0.29
	0.20	0.37	0.28
	0.19	0.31	0.28
	0.18	0.31	0.25
	0.16	0.30	0.25
Joyce Kilmer-Slickrock	0.34	0.52	0.27
	0.33	0.43	0.24
	0.31	0.32	0.23
	0.26	0.31	0.20
	0.24	0.30	0.14
	0.20	0.28	0.13
	0.18	0.24	0.11
	0.17	0.24	0.10
Mammoth Cave NP	0.56	0.57	0.50
	0.44	0.56	0.37
	0.38	0.53	0.36
	0.29	0.35	0.35
	0.25	0.33	0.31
	0.24	0.33	0.24
	0.22	0.30	0.21
	0.21	0.29	0.19

Table 4-3. Format of Summary of Results for CALPUFF Modeling in VISTAS' 12-km Modeling Domain to Determine if a BART Eligible Source is Subject to BART.

Class I area	Distance (km) from source to Class I area boundary	# of days[1] and # of receptors with impact > 0.5 dv in Class I area: 2001		# of days[1] and # of receptors with impact > 0.5 dv in Class I area: 2002		# of days[1] and # of receptors with impact > 0.5 dv in Class I area: 2003		# of days[1] and # of receptors with impact > 1.0 dv in Class I area for 3-yr period		Max. 24-hr impact over 3-yr period
Dolly Sods, WV										
Shenandoah, VA										
James River Face, VA										
Mammoth Cave, KY										
Sipsey, AL										
Great Smoky Mtns, TN										
Cohutta, GA										
Shining Rock, NC										
Linville Gorge, NC										
Swanquarter, NC										
Cape Romain, SC										
Okefenokee, GA										
Saint Marks, FL										
Chassahowitzka, FL										
Everglades, FL										
Brigantine, NJ										
Breton Island, LA										
Caney Creek, AR										
Upper Buffalo, AR										
Mingo, MO										
Hercules Glade, MO										

[1]Days below the 98th percentile of days in each year or the three-year modeling period, as appropriate

4.6 VISTAS Contribution to CALPUFF Modeling of BART Eligible Sources

VISTAS will provide updates and supporting information concerning the Common Modeling Protocol (this document) on the VISTAS website. In addition, VISTAS will make publicly available the following data bases developed by Earth Tech:

- VISTAS version of the CALPUFF modeling system, maintained on the CALPUFF website. Version 5.754 includes CALMET, CALPUFF, CALPOST, and POSTUTIL files, updated in December 2005. The last update in this VISTAS version is a CALMET update that addresses over water dispersion, which was developed for the Minerals Management Service (MMS) in fall 2005. This VISTAS version of CALPUFF will not be updated further unless errors are found in the code, except that a new one-step POSTUTIL procedure will be incorporated. BART-eligible sources in the VISTAS states will be able to use this VISTAS version throughout the BART modeling exercise.

- 12-km CALMET output files for 2001, 2002, and 2003 produced as described in previous sections. Further detail on model configuration and settings will be provided with the output files and will be made available on the CALPUFF website.

- CALMET will include a software modification to allow the meteorological data inputs into CALMET to be used to generate finer grid CALMET files without having to go back to the original MM5 output files

- Five 4-km CALMET subdomains for 2001, 2002, and 2003, produced as described in previous sections. Further detail on model configuration and settings will be provided with the output files and will be made available on the website.

- File with CALPUFF model configuration and settings sufficient to replicate CALPUFF modeling done for VISTAS using 12 km CALMET, including

    - Ozone data used to run CALPUFF

    - Ammonia concentrations used to run CALPUFF.

    - All other set up files used in VISTAS 12-km CALPUFF run

Samples of these data files and examples of their application with CALPUFF for BART screening analyses can be found on the CALPUFF web site at (http://www.src.com/verio/download/sample_files.htm).

5. SOURCE-SPECIFIC MODELING PROTOCOL

Sources are required to submit a source-specific protocol to the State for review and approval prior to source-specific modeling. States will provide the documentation to EPA and FLM for their review. An outline of the typical contents of the site-specific protocol is provided in Table 5-1.

If a source-specific modeling approach is proposed that differs from the common approach in Chapter 4, a more-detailed modeling protocol than that required under the common procedures is required. This protocol must explain the data sources, model configuration, and rationale for changes in the model approach from the common protocol and must be approved by the State.

Unit-specific source data include the following parameters:

- Location (e.g., UTM coordinates, UTM zone and datum)

- Stack height above the ground

- Stack diameter

- Exit velocity

- Exit temperature

- Emission rates (SO_2, H_2SO_4, NO_x and PM_{10}).

Additional building dimension information (building width, length, height and corner locations) is needed for short stacks that are less than Good Engineering Practice (GEP) height. This information is used in providing effective structure dimensions for building downwash calculations. (The requirement to conduct building downwash modeling may be waived by individual States or if the transport distance is greater than 50 km.)

The source coordinates must be expressed in the coordinate system used to define the CALMET and CALPUFF modeling domains. For the regional screening simulations, a Lambert Conformal Conic (LCC) coordinate system will be used. The required parameters to define an LCC coordinate include two matching parallels, latitude/longitude of the projection origin, coordinate datum, and false Easting and Northing (if used) of the projection origin. Subregional and source-specific domains may be using either an LCC or UTM projection.

The CALPUFF Graphical User Interface (GUI) system provides software (called COORDS) to compute to/from latitude/longitude, LCC and UTM coordinates for a large number of datums. In addition, the CALVIEW graphics feature allows the use of georeferenced satellite or aerial photographs to be used as base maps to confirm source locations. Links to sources of suitable base maps can be found on the CALPUFF data site (www.src.com) in the section on "Aerial Photos".

Table 5-1. Sample Table of Contents of a Source-Specific Fine-Scale Modeling Protocol.

An example of the data that need to be reported is provided in Table 5-2. More detail on the stack data, emissions species, and particulate size fractions to be reported will be made available on the CALPUFF website, www.src.com, Check with your State for the more detailed format of Table 5-2 that is to be used.

Discussions with the regulatory authorities should be conducted prior to development of a protocol to ensure all of the relevant issues are included in the protocol.

Table 5-2. Example of Source Documentation for BART Eligible Source.

Unit name and/or description	**Start-up dates**	**SO_2 potential emissions (tpy)**	**NO_x potential emissions (tpy)**	**Total PM potential emissions (tpy)**
Emissions source name				
…				
Total emissions				
Potential BART-eligible emissions				

6. QUALITY ASSURANCE

6.1 Scope and Purpose of the QA program

Air quality modeling covered under this protocol is an important tool for use in determining whether a BART-eligible source can be reasonable expected to cause or contribute to visibility impairment in a Class I area, and therefore whether this source should be subject to BART controls, and if so, to determine the relative benefits of various BART controls. The purpose of the quality assurance (QA) program is to establish procedures for ensuring that products produced by the application of the modeling techniques for BART studies satisfy the regulatory objectives of the BART program.

The scope of the QA program affects different users differently. Common features of most applications will be the setup and execution of the CALPUFF air quality model and processing of modeling results to determine if a source contributes to visibility impairment at a Class I area. In many cases, users will be provided meteorological datasets that have been developed with VISTAS funding under a suitable QA program for use in the BART modeling. Other users will be involved in site-specific or source-specific analyses that will use additional datasets and potentially different modeling options and/or tools. More extensive quality assurance will be required in these latter types of applications. It is the responsibility of the modeler to ensure that an adequate QA protocol is in place for a particular application.

The CALPUFF modeling system contains built-in features to facilitate quality assurance of the modeling results. These include the automatic production of “QA” files for various datasets, including geophysical fields, sources and receptors, and imbedded tracking of model options and switches within the output files from the major modeling units of the modeling system. The Graphical User Interface system (GUI) provided as part of the latest CALPUFF modeling system allows these QA files to be displayed graphically.

In addition, a detailed software management system is in place to track version and level numbers associated each program and utility within the CALPUFF modeling system. This information is carried forward in all of the output files to create an audit trail of software versions and major model options used that can be retrieved and displayed from the model output files.

Because the required QA procedures will depend heavily on the exact application, there will be differences among different users and different applications.

In addition, the BART modeling process involves multiple organizations. The States have overall responsibility for the process and may also execute some or all of the modeling. VISTAS is contributing general guidance via this protocol and is preparing meteorological fields and performing modeling under the guidance of the States. The sources that are BART-eligible need to provide process information and emissions data for use in the analyses. In addition, those sources that are involved in BART assessments will need to be actively involved in control

technology decisions and assessments. Finally, some of the modeling steps may be carried out by contractors on behalf of VISTAS, a State, or a source.

Each of these organizations has a responsibility to ensure that it is providing correct information to others and to evaluate the quality of any analyses it is performing, whether with data of its own or from others. This chapter provides general guidance and information on those aspects of quality assurance that are specific to the CALPUFF modeling effort, irrespective of which organization is carrying out the effort. The focus is on the common protocol efforts described in Chapter 4. As described in Section 6.3, more comprehensive QA may be needed for the unique aspects of the source-specific modeling described in Chapter 5.

6.2 QA Procedures for Common Protocol Modeling

The VISTAS common protocol (Section 4) describes the methods and procedures for use in conducting regional scale screening modeling to determine the whether a particular source or group of sources is subject to BART controls. In the initial application, the regional CALPUFF-ready meteorological data files will be provided by VISTAS. The amount of effort for end-users performing QA of these pre-defined meteorological fields will be reduced from what is required in developing source-specific meteorological fields, as described below. Also, VISTAS is planning to provide five subregional CALMET meteorological datasets in a CALPUFF-ready format. The development of these CALMET datasets will be subject to a QA program as part of their development, so the necessary quality assurance activity of end-users is again reduced from what would be required in the development of the dataset. It is not expected that the quality assurance steps in the development will be repeated in each application. The VISTAS-provided regional and subregional meteorological fields will include a test case simulation for demonstrating that expected modeling results are obtained on the user's computer platform. This test should be repeated by every user.

Although the CALPUFF modeling system is recommended by the U.S. Environmental Protection Agency for application to BART analyses, a considerable amount of expertise and modeling judgment is needed at certain stages of the analysis. The modeling is not a "cookbook" exercise, a fact that was recognized by the U.S. EPA in describing the expertise needed for CALMET modeling (EPA, 1998; pp. 9-10,). Current methods for performing refined chemistry calculation also require an understanding of the chemical and meteorological processing affecting ammonium nitrate formation. VISTAS has committed to provide appropriate CALPUFF training to assist States in obtaining the necessary expertise with the latest CALPUFF modeling tools and techniques. An appropriate level of knowledge of the model formulation, technical approach and assumptions is essential for successful BART modeling.

6.2.1 Quality Control of Input Data

The input data required by the model depends on the application. At a minimum, source data is required by CALPUFF (see Section 6.2.3) along with a list of choices made about model options and switches. Most of the modeling option choices are specified or recommended by regulatory

guidance and default values (see references in Section 4.3.3). However, remodeling of the boundary conditions is not required for VISTAS-provided finer grid domains so the expertise level is not as high as it would be for development of the boundary conditions files from scratch.

To the extent that modeling applications are using pre-defined CALMET files and CALPUFF templates, the quality assurance will be straightforward. More detailed steps are needed for the setup of modeling files for source-specific applications of subregional domains finer than 4 km.

The basic procedures that will apply to all CALPUFF model applications will include a confirmation of the source data, including units, verification of the correct source and receptor locations, including datum and projection, confirmation of the switch selections relative to modeling guidance, checks of the program switches and file names for the various processing steps, and confirmation of the use of the proper version and level of each model program. It is a common and recommended procedure for an independent modeler not involved in the setup of the modeling files to independently confirm the model switches and data entry in the actual model input files and to conduct an independent run of the worst case event as a confirmation check.

In addition, common practice requires that a model project CD (or DVD or set of DVDs) be created that contains all of the data and program files needed to reproduce the model results presented in a report. The model list files from each step are included on the project CD. This information allows independent checking and confirmation of the modeling process.

6.2.2 Quality Control of Application of CALMET

For users of the VISTAS CALPUFF-ready CALMET meteorological files, a number of large datafiles will be provided by VISTAS on external USB2 or Firewire hard drives in a format ready for use with the CALPUFF model. The QA steps associated with the development of the VISTAS common datasets will be provided separately as part of the modeling documentation. It is not expected that the QA steps conducted in the development of the meteorological datasets will be repeated in each application, although tests to confirm that the dataset is suitable for the application for which it is being used should be performed as part of the QA. This is discussed in more detail below.

The regional screening CALMET grid is defined in Chapter 4 on a 12-km Lambert Conformal Conic (LCC) grid system. The subregional and source-specific domains may be defined in either LCC or Universal Transverse Mercator (UTM) coordinates. In the case of the LCC projection, two matching parallels, latitude/longitude of the projection origin, coordinate datum, and false Easting and Northing (if used) of the projection origin must also be defined. For any domains in UTM coordinates, the UTM zone (see Appendix D of the CALMET User's Guide) and datum must be defined. The appropriate projection and map factors are provided as part of the definition of the VISTAS regional grid system. For a source-specific domain, the grid parameters will be provided as part of the source-specific protocol.

Appendix A of the IWAQM report (EPA, 1998) contains a list of recommended CALMET switch settings. Except as modified in Chapter 4 of this protocol or in a source-specific protocol, the IWAQM guidance should be used in setting up the CALMET simulations. The CALMET model obtains the switch settings from an ASCII "control file" with a default name of CALMET.INP. Whether the model is run using a GUI or from the control line in a DOS, Linux, or Unix window, it is essential that the control file be reviewed as part of the CALMET QA analysis. The CALMET GUI retains all of the input descriptive information that is part of the standard CALPUFF.INP file structure. This includes the default value for each variable, a text description of the variable, the meaning of each variable option, the units of the variable and inter-relationships among variables indicating if/when the variable is used. Some third-party commercial GUIs strip out this descriptive information, which makes the QA step more difficult, although it is essential for perform nonetheless using the variable names as references for the variables in the file.

Part of the CALPUFF modeling system's built-in QA capabilities is a variable tracking system that retains the control file inputs for CALMET and CALPUFF in the output files create by the models. This information includes the Version and Level numbers of the processor codes and main model codes used in the simulations as well as the control files from the main models (CALMET and CALPUFF). The information from the preprocessing steps and the CALMET and CALPUFF model simulations is all carried forward and saved in the CALPUFF/postprocessor output files so that the final concentration/flux files contain a history of the model options and switch settings. This allows a user or reviewing agency to confirm the switch settings provided in a control file with that actually used in the model simulations. An optional switch in the CALPOST processor creates a complete listing of the QA data. This step requires access to the output CALPUFF concentration and/or flux files, which are normally practical to store on CDs or DVDs and to provide a part of the Project CD/DVD set.

6.2.3 Quality Control of Application of CALPUFF

The quality assurance of the source and emissions data is a major component of the CALPUFF modeling. Also, many errors are found in source coordinates and related projection/datum parameters, so confirmation of the source location is an important part of the modeling QA.

The locations of the Class I area receptors are another important CALPUFF input. The use of pre-defined receptors as provided by the National Park Service (NPS) receptor dataset is recommended in the VISTAS common protocol. However, although the latitude and longitude of each receptor point is provided, it is necessary to ensure that the proper UTM or LCC coordinates have been computed for computational domain selected. In particular, the datum of the NPS conversion software is not specified, so it is recommended that coordinates be checked using the CALPUFF GUI's COORDS software or another comparable coordinate translation software package that recognizes various datums.

Most of the CALPUFF input variables contain default values. Appendix B of the IWAQM report contains a list of recommended CALPUFF switch settings. Except as modified in Chapter 4 of

this protocol or in a source-specific protocol, the IWAQM guidance should be used in setting up the CALPUFF simulations. The CALPUFF model obtains the switch settings from an ASCII "control file" with a default name called the CALPUFF.INP file. As is the case with the comparable CALMET file, it is essential that the control file be reviewed manually as part of the CALPUFF QA analysis. To facilitate this process, as was the case with the CALMET GUI, the CALPUFF GUI retains all of the input descriptive information that is part of the standard CALPUFF.INP file structure. Some third-party commercial GUIs strip out this descriptive information, which makes the QA step more difficult, although it is essential for perform nonetheless using the variable names as references for the variables in the file.

6.2.4 Quality Control of Application of CALPOST and POSTUTIL

CALPOST is run separately for each Class I area in order to obtain the necessary visibility statistics for evaluating compliance with the BART screening and finer grid modeling thresholds. The inputs to CALPOST involve selection of the visibility method (Method 6 in the standard EPA BART guidance), entry of Class I area-specific data for computing background extinction (either average or best 20% natural conditions, as prescribed by the State) and monthly relative humidity factors for hygroscopic aerosols. CALPOST contains a receptor screening that allow subsets of a receptor network modeling in CALPUFF to be selected for processing in a given CALPOST run. This is how receptors within a single Class I area are selected for processing from a CALPUFF output file that may contain receptors from several Class I areas. CALPOST contains options for creating plot files that will help in the confirmation that the proper receptor subset is extracted.

The CALPOST output file contains a listing of the highest visibility impact each day of the model simulation over all receptors included in CALPOST analysis. Receptors will normally be selected in each CALPOST run so that each CALPOST run represents the impacts at a single Class I area. The table includes the data shown in the example in Table 4-1. For a screening assessment, the peak value of the change in extinction is shown at the bottom of the visibility table (see Table 4-1). For a finer grid simulation, the 98^{th} percentile value (8^{th} highest day) is used for comparison against the BART threshold of 0.5 deciviews. It is necessary to import the results of the CALPOST table into a sorting program such as a spreadsheet to rank the daily change in extinction values such as is presented in Table 4-2.

The CALPOST inputs that need to be carefully checked as part of the CALPOST quality assurance are:

- Visibility technique (Method 6 in the common VISTAS protocol)
- Monthly Class I-specific relative humidity factors for Method 6
- Background light extinction values

- Inclusion of all appropriate species from modeled sources (e.g., sulfate, nitrate, organics, (as SOA), coarse and fine particulate matter and elemental carbon.

- Appropriate species names for coarse PM used

- Extinction efficiencies for each species

- Appropriate Rayleigh scattering term (10 Mm^{-1} for screening modeling but Class I area specific value for finer grid modeling)

- Screen to select appropriate Class I receptors for each CALPOST simulation.

The CALPOST program produces plot files compatible with CALVIEW that allow confirmation of receptor locations that is useful in evaluating the receptor screening step.

POSTUTIL allows the user to sum the contributions of sources from different CALPUFF simulations into a total concentration file. In addition, it contains options to scale the concentrations from different modeled species (e.g., different particle sizes) into species-dependent size distributions for the particulate matter. For example, PM is often simulated with unit emission rates for each particle size category and, in the POSTUTIL stage, the contributions of each size category based on the species being considered (e.g., elemental carbon, coarse particulate matter, etc.) are combined to form the species concentrations for input into CALPOST. This process, although simple, requires a careful review of the weighting factors for each source. POSTUTIL also allows a repartitioning of nitric acid and nitrate to account for the effects of ammonia limiting conditions.

If source-specific modeling is performed using different sources of data or different techniques, the source-specific modeling protocol should provide justification for deviations from the VISTAS common protocol, and a QA plan specific for the application provided to address the quality assurance of the data used.

6.3 Additional QA Issues for Alternative Source-Specific Modeling

The level of QA required for application of source-specific protocols will be substantially higher than for the use of datasets that have already been subject to a QA procedure. For example, source-specific protocols may include the use of on-site meteorological datasets, the use of higher resolution prognostic meteorological (e.g., MM5) datasets, alternative visibility calculations, different extinction coefficients, or other changes to the common protocol. In addition to providing a source-specific modeling protocol describing and justifying the changes to the modeling approach from the VISTAS common protocol, the site-specific applications should include the development of a QA plan to properly evaluate the data used in the site-specific modeling.

The critical CALMET input parameters depend on the mode in which the model is run (observations mode, hybrid mode or no-observations mode), and the location and spatial

representativeness of any observational data. In a site specific protocol involving the development of a meteorological dataset, the elements of the QA process include preparation of wind rose (using observed, MM5 and CALMET-derived data), including examination of the data as a function of season and time of day (e.g., 4am, 10am, 4pm wind roses), time series analyses, and presentation of 2-D vector plots illustrating terrain effects/sea breeze circulation or other features of the flow expected to occur within the domain. For example, 2-D vector plots produced during light wind speed stable conditions (e.g., early morning such as 4 am) are good for assessing the performance of the CALMET model configuration and switches in reproducing terrain effects because these conditions are likely to maximize the terrain impacts in the model. Season wind roses at 4 am, 10 am and 4 pm would be expected to show the development of sea breeze circulations that may be important for certain applications. Customization of the QA process for the individual site-specific domain based on the availability of data and the physical processes expected to be important at that location should be conducted as part of the site-specific QA plan development.

If site-specific CALPUFF simulations involving the Ammonia Limiting Method are conducted, performance of the model in reproducing observed CASTNet or IMPROVE sulfate and nitrate concentrations at measurement sites within the site-specific modeling domain should be evaluated. The use of alternative ammonia concentration data (e.g., CMAQ output rather than derived ammonia based on aerosol measurements) will require an evaluation of the model performance relative to the techniques in the VISTAS common protocol.

In any site-specific protocol a site-specific QA plan should be prepared.

6.4 Assessment of Uncertainty in Modeling Results

Chapter 3 discussed the uncertainties and known limitations in CALPUFF. The source specific modeling report does not need to repeat the uncertainties listed in Chapter 3, but the reviewer should interpret results in light of these limitations. It is expected that the performance of the model will be better in predicting changes in visibility impacts due to BART controls than in predicting absolute visibility values. This is because uncertainties in meteorological conditions transport and dispersion are expected to be less important in evaluating a change in impact, since a comparable effect will be included in both the base and sensitivity simulations.

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