Appendix D

2008 ArcelorMittal Burns Harbor BART Modeling Report

Prepared for: ArcelorMittal Burns Harbor LLC
Burns Harbor, Indiana

Source-Specific BART Modeling Report: ArcelorMittal Burns Harbor LLC

ENSR Corporation
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1.0 Introduction

1.1 Objectives

The Regional Haze Rule regulations require 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 and/or local regulatory agencies have the option of exempting a BART-eligible source from the BART requirements based on dispersion modeling demonstrating that the source cannot reasonably be anticipated to cause or contribute to visibility impairment in a Class I area. Indiana’s BART rule at 326 IAC 26-1-6 allows Burns Harbor to submit an analysis sufficient to demonstrate that it is not subject to BART. That analysis was timely submitted in May 2008 within ninety (90) days after receiving IDEM’s BART notice. IDEM identified some outdated emission factors that were inadvertently included in the May 2008 Report. This revised Source-Specific BART Modeling Report updates the May 2008 Report with improved model inputs based on the most recent and accurate emission information available for each emissions unit.

ArcelorMittal Burns Harbor LLC (Burns Harbor) is a facility located on Lake Michigan in northwestern Indiana, approximately 50 miles southeast of Chicago. The Burns Harbor facility is a steelmaking facility that has been identified by Indiana Department of Environmental Management (IDEM) as being a BART-eligible source. The purpose of this Report is to summarize the procedures by which a refined air dispersion modeling analysis was conducted for the Burns Harbor facility and to transmit an analysis of the modeling results in accordance with 326 IAC 26-1-6 in support of a refined assessment of Burns Harbor’s contribution to visibility impairment in Class I areas.

The first step in the BART process is to model the visibility impact of baseline emissions to determine whether the BART-eligible sources at a facility are subject to BART. According to the BART rule (326 IAC 26-1-4), a facility will be exempt from BART if its 98th percentile visibility impacts for baseline emissions are less than 0.5 delta-deciviews (delta-dv) in each Class I area for each modeled year. The refined modeling provided in this Report demonstrates that Burns Harbor’s impact on all relevant Class I Areas is comfortably below 0.5 deciviews and cannot reasonably be anticipated to cause or contribute to visibility impairment in a Class I Area.

1.2 Location of Source vs. Relevant Class I Areas

Figure 1-1 shows a plot of the Burns Harbor facility relative to nearby Class I areas. There are no PSD Class I areas within 300 km of the facility, which is the outer extent of the reliability range for predicting impacts with CALPUFF air dispersion modeling. Nonetheless, the four closest Class I areas were included in the modeling to capture possible impacts from the Burns Harbor facility. These Class I areas are listed below:

- Isle Royale National Park (674 km)
- Mammoth Cave National Park (485 km)
- Mingo Wilderness (580 km)
- Seney Wilderness (539 km)

IDEM’s CALPUFF modeling screened for potential contributions to visibility impairment from the Burns Harbor facility at these four Class I areas. The refined modeling summarized in this Report offers a more accurate assessment of the potential contribution of Burns Harbor to visibility impairments at any of these far-off Class I areas. This Report describes in detail the procedures used for this refined CALPUFF modeling.

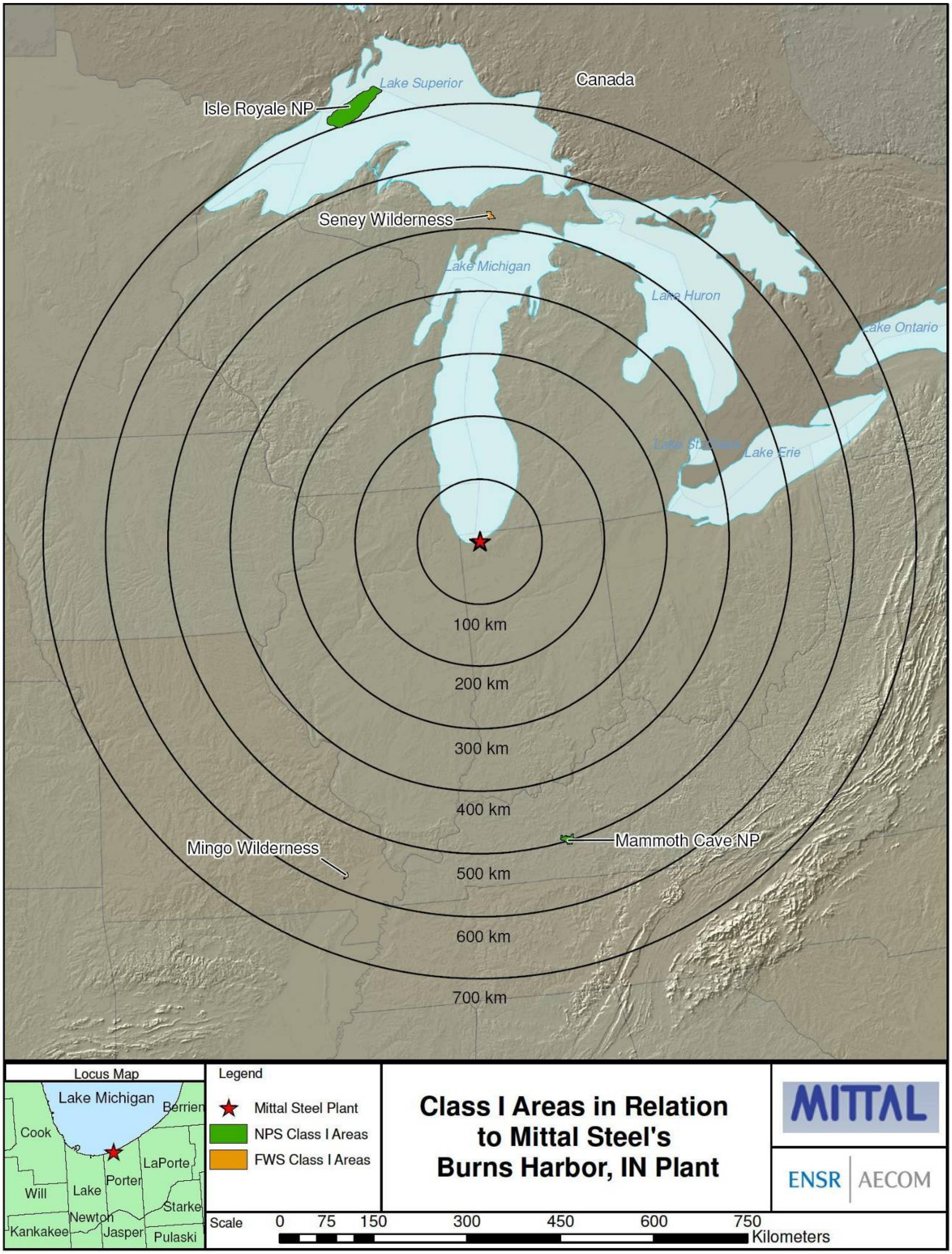
CALPUFF is the only EPA-approved model for predicting impacts for long-range emission transport beyond 50 km. The Guideline on Air Quality Models (GAQM) (Appendix W to 40 CFR Part 51) suggests that CALPUFF “had performed in a reasonable manner, and had no apparent bias toward over or under prediction, so long as the transport distance was limited to less than 300 km". Beyond 300 km, CALPUFF's modeled impacts are less reliable with a tendency toward over predicting impacts.

The closest Class I area is Mammoth Cave NP, located approximately 485 km to the south-southeast well beyond the suggested use of CALPUFF. The modeling analysis in this Report uses CALPUFF as directed by the Midwest Regional Planning Organization (MWRPO) and IDEM with the stipulation that the model's performance has tended toward over prediction of modeled impacts beyond 300 km and the fact that the federal Guidance suggests that its use beyond 300 km may not be reliable or appropriate.

1.3 Organization of Report

Section 2 of this report describes the method for determining the peak 24-hour source emissions that were used as input to the BART modeling. Section 3 describes refinements to the meteorological database and the CALMET processing that provide essential data for predicting the transport of emissions. Section 4 discusses CALPUFF technical options and modeling procedures. Section 5 presents the modeling results. References are provided in Section 6. Appendix A lists meteorological stations that were used for CALMET processing and Appendix B provides documentation of the implementation of the new IMPROVE equation. Appendix C provides a detailed description of the method used to derive the oxides of nitrogen and sulfur dioxide inputs to the model.

Figure 1-1 Location of Class I Areas in Relation the Burns Harbor Facility



2.0 Emissions and Source Parameters

The Lake Michigan Air Directors Consortium (LADCO) developed a protocol to be used in the BART CALPUFF modeling for Indiana. The LADCO protocol specifies that "States will use the 24-hour maximum emissions rate between 2002 and 2004. If this data is not available, then a short term "allowable" or "potential emission rate of emissions between the years 2002-2004 will be used. If neither of these types of emission rates is available, then the highest actual annual emissions divided by hours of operation will be applied in CALPUFF." For this Report, we calculate the 24-hour maximum emission rate for the years 2002-2004.

Emission units included in the modeling are of two main types, combustion units and process units. Combustion unit emissions are calculated using actual daily fuel use records from Burns Harbor's computerized database for 2002, 2003, and 2004 and relevant emission factors. The emission factors for combustions units are based on fuel sampling, stack testing, or U.S. EPA's AP-42 (see Table 2-4). The 24-hour emission rate was determined by multiplying the daily fuel use day for each fuel used that day by the appropriate emission factor for each combustion unit for 2002, 2003 and 2004. Emission for each fuel used was summed to determine the total emissions for each unit by day. The 24-hour maximum emission rate was determined by selecting the highest total emissions day for each unit and were used as the maximum 24-hour emissions inputs to the CALPUFF model.

Burns Harbor's Power Station contains multi-fuel Boiler Nos. 7 through 12. The Power Station is operated as one unit with switching between boilers as necessary to provide the needed steam and to maintain backup capabilities. Consequently, fuel use and emissions calculations were determined for the entire Power Station rather than for individual boilers to more accurately reflect 24-hour maximum emissions.

Process unit emissions are calculated using the maximum 24-hour production rate for each process unit during 2002, 2003 and 2004 and appropriate emission factors per unit of production. The process emission factors were derived from stack tests on the same or similar units and from AP-42 emission factors (see Table 2-5). For smaller incidental units (e.g., FM Boiler, Hot Metal Desulfurization, etc.) where only monthly production data were available, the average daily production was calculated by dividing the monthly production by the number of days in the period. The day with the highest calculated sulfur dioxide emission rate and the day with the highest oxides of nitrogen emissions rate from 2002, 2003 or 2004 were selected for each process unit as the maximum 24-hour emission inputs to the CALPUFF model.

Emissions from slag pits and steelmaking fugitives that do not vent through stacks are "volume" sources (see Table 2-1). Without stacks, volume sources have limited velocity at the point of emission and are, thus, not expected to be transported very far away from the emission source. As such, we do not expect these volume sources to contribute to visibility impacts that require the transport of emissions to Class I areas over 480 km away. Nonetheless, we conservatively included the emissions from volume sources in the modeling by adding their emissions to the combustion emissions from the Power Station.

This method combines the highest daily emission rates for each of 26 emission units (+3 volume sources) into a fictitious worst case day. A complex steel manufacturer cannot simultaneously achieve the 24-hour maximum emission rate at all 26+ emission units listed in Table 2-1. While the modeling demonstrates that Burns Harbor's visibility impact is acceptable even using this highly conservative approach (see Table 5-1), This scenario conservatively overestimates the impact on Class I areas. In order to estimate plant emissions on a more realistic basis, we calculated the maximum individual day of plant-wide sulfur dioxide and oxides of nitrogen emissions during the period of 2002 through 2004. Daily sulfur dioxide and oxides of nitrogen emissions from all emission units were summed for each day to obtain the total plant daily emissions. The plant-wide daily sulfur dioxide and oxides of nitrogen emissions for 2002, 2003 and 2004 were scanned to determine the highest daily plant-wide emissions for each of the two pollutants. These maximum 24-hour plant-wide emission rates for sulfur dioxide emissions and for oxides of nitrogen were used as inputs in a separate modeling run summarized in Table 5-2. The modeling results confirm that Burns Harbor is comfortably below the threshold that triggers BART regulation when using this more realistic assessment of the 24-hour maximum emission rate as input to the CALPUFF model.

Table 2-1 provides a summary of the baseline emissions used in the BART CALPUFF model to model the maximum day on an emission unit basis. Table 2-2 provides the modeling parameters that were used in the BART CALPUFF modeling. Table 2-3 provides a summary of the baseline emissions used in the plant-wide maximum emission day modeling. The same modeling parameters in Table 2-2 were used for the plant-wide maximum modeling. Table 2-4 contains the emission factors used to calculate emissions for combustion units. Table 2-5 provides the emission factors used to calculate emissions from process units.

Table 2-1 Burns Harbor Facility Baseline Emission Rates - Maximum by Emission Unit

Stack Description	Peak 24-Hour Emissions (g/s)		Fuel & Production Data Record Frequency
	SO_2	NO_X	
POWER STATION Boiler Nos 7-12	218.31	162.49	Daily
#1 COKE BATTERY PUSHING	1.38	0.27	Monthly
#1 COKE BATTERY UNDERFIRE	64.13	94.53	Daily
#2 COKE BATTERY PUSHING	1.39	0.27	Monthly
#2 COKE BATTERY UNDERFIRE	69.29	5.45	Daily
SINTER WINDBOX STACK	25.20	43.59	Daily
BLAST FCE D CASTHOUSE/FUG	0.00	1.02	Monthly
BLAST FURNACE C STOVES	42.03	4.27	Daily
BLAST FURNACE D STOVES	41.88	4.33	Daily
BLAST FCE C CASTHOUSE/FUG	0.00	0.99	Monthly
STEELMAKING HMD STATION #1	0.30	0.02	Monthly
STEELMAKING HMD STATION #2	0.30	0.02	Monthly
STEELMAKING VESSELS #1 & #2	0.09	2.76	Monthly
STEELMAKING VESSEL #3	0.09	1.53	Monthly
STEELMAKING FM BOILER	0.002	0.47	Monthly
HOT STRIP FURNACE #1	7.74	7.36	Daily
HOT STRIP FURNACE #3	7.93	8.16	Daily
HOT STRIP FURNACE #2	7.95	7.17	Daily
160" PLATE MILL FURNACE #1	18.17	4.09	Daily
160" PLATE MILL FURNACE #2	25.28	4.39	Daily
160" PLATE MILL FURNACE #5	0.00	0.00	Daily
160" PLATE MILL FURNACES 6 & 7	0.01	1.27	Daily
160" PLATE MILL FURNACE #8	0.00	0.00	Daily
110 PLATE MILL FURNACES 1 &2	0.00	0.00	Daily
STEELMAKING HMD STATION #3	0.26	0.02	Monthly
110" Plate Mill Normalizing Fce	0.00	0.00	Daily

Volume Source Description(1)	Model Inputs (g/s)	
	SO_2	NO_x
Blast Furnace C Slag Pit	4.04	0.00
Blast Furnace D Slag Pit	3.36	0.00
Steelmaking Fugitives	0.37	0.99

(1) Total emission from the volume sources were added to the Power Station Source when modeled. Production data frequency is monthly for all volume sources

Table 2-2 Burns Harbor Facility Modeling Stack Parameters

Stack Description	Base Elevation(m)	Stack Height (m)	Diameter (m)	Flow (m^3/s)	Temperature (K)	Exit velocity (m/sec)	UTM Easting (m)	UTM Northing (m)
POWER STATION Boiler Nos 7-12	187.14	67.06	3.43	123.2	505	13.34	488375	4609318
#1 COKE BATTERY PUSHING	187.54	20.12	0.76	4.3	323	9.44	488045	4608362
#1 COKE BATTERY UNDERFIRE	187.15	76.81	3.78	80.2	547	7.15	487968	4608346
#2 COKE BATTERY PUSHING	187.15	26.82	2.44	94.4	335	20.20	488059	4608115
#2 COKE BATTERY UNDERFIRE	187.14	75.90	4.18	63.4	505	4.48	487959	4608191
SINTER WINDBOX STACK*	187.15	24.08	2.39	247.2	319	55.12	488038	4609329
BLAST FCE D CASTHOUSE/FUG	187.14	18.90	1.56	47.2	533	24.70	488203	4609371
BLAST FURNACE C STOVES	187.15	61.26	3.48	151.1	519	15.89	488244	4609339
BLAST FURNACE D STOVES	187.14	61.26	3.59	151.1	519	14.93	488229	4609496
BLAST FCE C CASTHOUSE/FUG	187.14	18.90	1.56	47.2	533	24.70	488203	4609371
STEELMAKING HMD STATION #1	187.14	25.91	2.05	42.7	305	12.95	488512	4609936
STEELMAKING HMD STATION #2	187.14	25.91	3.04	42.7	305	5.89	488542	4609936
STEELMAKING VESSELS #1 & #2	187.15	24.99	6.02	160.7	325	5.65	488544	4609957
STEELMAKING VESSEL #3	187.15	11.58	6.71	93.4	332	2.64	488555	4610037
STEELMAKING FM BOILER	187.15	67.66	1.99	5.6	478	1.79	488690	4609918
HOT STRIP FURNACE #1	187.14	41.45	4.30	402.5	811	7.06	489030	4609212
HOT STRIP FURNACE #3	187.14	41.45	3.97	109.0	811	8.81	489063	4609212
HOT STRIP FURNACE #2	187.14	41.45	4.30	102.0	811	7.02	489046	4609212
160" PLATE MILL FURNACE #1	187.14	54.25	3.10	33.0	673	4.37	489014	4609043
160" PLATE MILL FURNACE #2	187.14	54.25	3.10	33.0	693	4.09	489035	4609043
160" PLATE MILL FURNACE #5	187.14	39.92	1.95	37.3	783	12.48	489054	4609039
160" PLATE MILL FURNACES 6 & 7	187.14	32.92	2.24	39.3	783	9.99	489042	4608914
160" PLATE MILL FURNACE #8	187.14	50.90	1.74	7.1	673	2.99	489042	4608894
110 PLATE MILL FURNACES 1 & 2	187.14	54.56	4.44	33.0	838	2.13	489030	4608811
STEELMAKING HMD STATION #3	187.14	25.91	2.05	42.7	305	12.95	488601	4609962
110" Plate Mill Normalizing Fce	187.14	45.72	1.92	12.4	505	4.27	489801	4608431

Table 2-3 Burns Harbor Facility Baseline Emission Rates - Plant-wide Maximum Emission Day

Stack Description(2)	Peak 24-Hour Emissions (g/s)	
	SO_2	NO_X
POWER STATION Boiler Nos 7-12	218.31	162.49
#1 COKE BATTERY PUSHING	1.38	0.25
#1 COKE BATTERY UNDERFIRE	61.34	81.30
#2 COKE BATTERY PUSHING	1.39	0.25
#2 COKE BATTERY UNDERFIRE	64.26	4.65
SINTER WINDBOX STACK*	25.20	37.31
BLAST FCE D CASTHOUSE/FUG	0.00	1.02
BLAST FURNACE C STOVES	29.20	3.44
BLAST FURNACE D STOVES	32.28	3.28
BLAST FCE C CASTHOUSE/FUG	0.00	0.99
STEELMAKING HMD STATION #1	0.30	0.02
STEELMAKING HMD STATION #2	0.30	0.02
STEELMAKING VESSELS #1 & #2	0.15	2.54
STEELMAKING VESSEL #3	0.08	1.53
STEELMAKING FM BOILER	0.00	0.43
HOT STRIP FURNACE #1	4.23	5.97
HOT STRIP FURNACE #3	0.00	6.09
HOT STRIP FURNACE #2	4.29	6.14
160" PLATE MILL FURNACE #1	3.23	1.89
160" PLATE MILL FURNACE #2	3.31	1.83
160" PLATE MILL FURNACE #5	0.00	0.00
160" PLATE MILL FURNACES 6 & 7	0.00	0.00
160" PLATE MILL FURNACE #8	0.00	0.00
110 PLATE MILL FURNACES 1 &2	0.00	0.00
STEELMAKING HMD STATION #3	0.26	0.02
110" Plate Mill Normalizing Fce	0.00	0.00

Volume Source Description(1)	Model Inputs (g/s)	
	SO_2	NO_x
Blast Furnace C Slag Pit	3.28	0.00
Blast Furnace D Slag Pit	2.85	0.00
Steelmaking Fugitives	0.37	0.99

(1) Total emission from the volume sources were added to the Power Station Source when modeled. Production data frequency is monthly for all volume sources

(2) Fuel use and production data record frequency is same as that shown in Table 2-1.

Table 2-4 Combustion Unit Emission Factors Used In Emissions Calculations

Sulfur Dioxide

Fuel	Emission Units	SO_2 Emission Factor (lb/MMBTU)	Source of Emission Factor
Blast Furnace Gas	All Units	0.13	Based on stack test used as basis for annual emission fees reporting
Coke Oven Gas		Varies from 1.088 to 1.395	Semi-annual testing of No. 2 Coke Battery Underfiring Stack when combusting coke oven gas
Natural Gas		0.0006	AP-42, External Combustion

Oxides of Nitrogen

Fuel	Emission Units	NOx Emission Factor (lb/MMBTU)	Source of Emission Factor
Blast Furnace Gas	All Units Except Coke Battery Underfiring and Hot Strip Mill Reheat Furnaces	0.0100	ISG Indiana Harbor test of No. 7 Boiler Stack on 5/11/04
Coke Oven Gas		0.1367	FIRE database [SCC 10200707]
Natural Gas		0.1373	AP-42, External Combustion, Table 1.4-1, Low-NOx Burners. Converted from lb/MMscf using 1020 BTU/scf.
Fuel	**Emission Units**	**NOx Emission Factor (lb/MMcf)**	**Source of Emission Factor**
Blast Furnace Gas	No. 1 Coke Battery Underfiring	168.50	Average of 1995 & 2000 Burns Harbor Stack Tests
Coke Oven Gas		987	Average of 1995 & 2000 Burns Harbor Stack Tests
Natural Gas		NA	NA
Blast Furnace Gas	No. 2 Coke Battery Underfiring	NA	NA
Coke Oven Gas		60.57	2000 Burns Harbor Stack Test
Natural Gas		NA	NA
Coke Oven Gas	Hot Strip Mill Reheat Fce. Nos. 1 ,2 & 3	82.07	2/14/06 Burns Harbor Stack Test
Natural Gas		143.14	

Table 2-5 Process Unit Emission Factors Used In Emissions Calculations

Source	Pollutant	Emission Factor Uncontrolled	Units	Capture Efficiency (Control Device)	Control Efficiency (Control Device)	Controlled Emission Factor (lb/unit)	Source of Emission Factor
HMD Station Nos. 1, 2 & 3 Baghouse Stack Emissions	NOx	0.00100	lbs/ton HM	98.00%	0.00%	0.00098	BH Test Data (HMD/transfer/skimming) 8/13/02 Stack Test @ #2 HMD
	SO2	0.01400	lbs/ton HM	98.00%	0.00%	0.01372	BH Test Data (HMD/transfer/skimming) 8/13/02 Stack Test @ #2 HMD
BOF Nos. 1 & 2 (refining/blow) Stack Primary Emissions	NOx	0.05400	lbs/ton steel	99.80%	0.00%	0.05389	BH Test 9/29/93-10/14/93
	SO2	0.00604	lbs/ton steel	99.80%	50.00%	0.00302	BH 4/7/05 Test
BOF No. 3 (refining/blow) Stack Primary Emissions	NOx	0.05400	lbs/ton steel	99.99%	0.00%	0.05399	BH Test 9/29/93-10/14/93
	SO2	0.00604	lbs/ton steel	99.99%	50.00%	0.00302	BH 4/7/05 Test
Ladle Treatment Station (LTS) Nos. 4 & 5 BH Stack Emissions	NOx	0.00300	lbs/ton steel	99.99%	0.00%	0.00300	ArcelorMittal Indiana Harbor f/k/a Inland 2001 Emission Inv 2BOF Ladle Metallurgy
	SO2	0.02500	lbs/ton steel	99.99%	0.00%	0.02500	ArcelorMittal Indiana Harbor f/k/a Inland 2001 Emission Inv 2BOF Ladle Metallurgy
Steel Ladle Desulf Station Nos. 2 & 3 BH Stack Emissions	SO2	0.00245	lbs/ton steel	90.00%	0.00%	0.00221	Same SO2 emitted/steel sulfur conc. as HMD
Vacuum Degasser Process Flare Stack Emissions	NOx	0.00015	lbs/ton steel	100.00%	0.00%	0.00015	USS Gary Works 1998 Application for RH Vacuum Degasser
Coke Battery No. 1 Pushing	NOx	N/A	lbs/ton coal	N/A	N/A	0.01900	AP-42 Table 12.2-9
	SO2	N/A	lbs/ton coal	N/A	N/A	0.09800	AP-42 Table 12.2-9
Coke Battery No. 2 Pushing	NOx	N/A	lbs/ton coal	N/A	N/A	0.01900	AP-42 Table 12.2-9
	SO2	N/A	lbs/ton coal	N/A	N/A	0.09800	AP-42 Table 12.2-9
BF C Slag Pit	SO2	0.08500	lbs/ton HM	100.00%	0.00%	0.08500	USS Gary Works and Mittal Indiana Harbor West SIP Model
BF D Slag Pit	SO2	0.08500	lbs/ton HM	100.00%	0.00%	0.08500	USS Gary Works and Mittal Indiana Harbor West SIP Model
Sinter Plant Windbox	NOx	N/A	lbs/ton sinter	N/A	N/A	0.66700	BH 1/8/97 Test
	SO2	N/A	lbs/hr	N/A	N/A	200	Engineering Estimate based on stack sampling in 2008*

* Engineering evaluation in 2008 confirmed that Sinter Plant Windbox Scrubber properly operated sustained SO2 emissions below 200 lb./ ton.

3.0 Meteorological Data

This section discusses refinements to Lake Michigan Air Directors Consortium (LADCO) and Midwest Regional Planning Organization (MWRPO) meteorological database that were used for the Burns Harbor facility BART modeling.

3.1 Elements of the Refined Analysis

ENSR refined the CALMET meteorological data produced by LADCO/MWRPO for BART CALPUFF analyses for Midwestern States. The CALMET database derived by LADCO/MWRPO has a domain that covers approximately a 3,492 km (east-west) by 3,240 km (north-south) area with a 36-km grid resolution. This area covers the entire continental United States east of the Rocky Mountains, but its large size limits the horizontal resolution of each grid element to 36 km. This coarse grid resolution can be deemed appropriate for a screening-level analysis, but it would not be considered appropriate for a more refined analysis.

ENSR developed a refined meteorological database that would include a modeling domain encompassing the four Class I areas (Seney, Mingo, Mammoth, and Isle Royale), the Burns Harbor facility, and the appropriate buffers around the source and Class I areas for puffs recirculation. This domain covers approximately a 1,002 km (east-west) by 1,374 km (north-south) area, has a grid resolution of 6 km (6 times more resolved than the LADCO/MWRPO database in both east-west and north-south directions), and contains 10 vertical levels. The refined database utilizes the same MM5 databases that were used to develop the LADCO/MWRPO 36-km CALMET database.

In addition to the use of consistent MM5 databases with the LADCO-developed meteorological data, ENSR utilized similar model switches/settings, when appropriate, that were used to develop the LADCO/MWRPO CALMET database. To improve the database even further, ENSR introduced actual surface, precipitation, and twice-daily upper air sounding observations into the refined meteorological database. These improvements in the CALMET database provide more accurate plume trajectories from the Burns Harbor facility to the distant Class I areas.

In addition, ENSR used the latest EPA-approved versions of CALMET (Version 5.8) and CALPUFF (Version 5.8), rather than the “old” EPA-approved versions suggested in the MWRPO BART common protocol (available at http://www.state.in.us/idem/programs/air/workgroups/regionalhaze/docs/BART_protocol.pdf).

3.2 CALMET Processing

ENSR used refined 6-km grid spacing for the CALMET and CALPUFF models. The modeling domain was based on a 100 km buffer around the source and a 50 km buffer around each of the four Class I areas plus an additional buffer to the east and to the west to account for puffs recirculation. The modeling domain is shown in Figure 3-1. This design allows for a 1,002 km (east-west) x 1,374 km (north-south) domain extent and, at a 6-km resolution, there are 167 x 229 horizontal grid cells.

Due to the size of the modeling domain, a Lambert Conformal Conic (LCC) coordinate system was used to account for the curvature of the Earth’s surface. The LCC projection for this analysis was based on the NAS-C datum and standard parallels of 33 and 45 degrees North, with an origin of 40 degrees North and 97 degrees West.

ENSR used the latest EPA-approved version of CALMET (Version 5.8, Level 070623) to produce three-dimensional wind fields for three years (2002-2004). Advanced meteorological data in the form of prognostic mesoscale meteorological data, such as the Fifth Generation Mesoscale Model (MM5), were used to provide a superior estimate of the initial wind fields. This application considered 3 years (2002-2004) of prognostic MM5 meteorological data at a 36-km resolution.

- 2002 MM5 data set at 36 km resolution provided by CENRAP;
- 2003 MM5 data set at 36 km resolution provided by Midwest RPO;
- 2004 MM5 data set at 36 km resolution provided by Midwest RPO.

These databases are consistent with those used by LADCO/MWRPO for their BART assessments.

These prognostic meteorological data sets were combined with the 6-km grid resolution terrain and land use data to more accurately characterize the wind flow throughout the modeling domain. The gridded terrain data was derived using several data sources because the modeling domain extends into Canadian territory. The U.S. Geological Survey (USGS) 90-meter grid spacing Digital Elevation Model (DEM) files were combined with the 100-meter grid spacing Canadian DEM files and the 90-meter spacing Shuttle RADAR Topo Mission files. These files were processed in the TERREL pre-processor program. The gridded land use data was derived from USGS 1:250,000 Composite Theme Grid land use files.

The Step 2 wind fields were produced using the input of all available National Weather Service (NWS) hourly surface and twice-daily upper air balloon sounding data within and just outside the modeling domain. Hourly surface data from both first-order and second-order stations also were considered in this analysis. Other sources of meteorological data such as CASTNET data and buoy stations were used to supplement areas lacking NWS or second-order data. Hourly precipitation data from stations within and just outside of the modeling domain were taken from a National Climatic Data Center data set. Figure 3-2 shows the meteorological stations that were used in the CALMET modeling and Appendix A provides their names and locations.

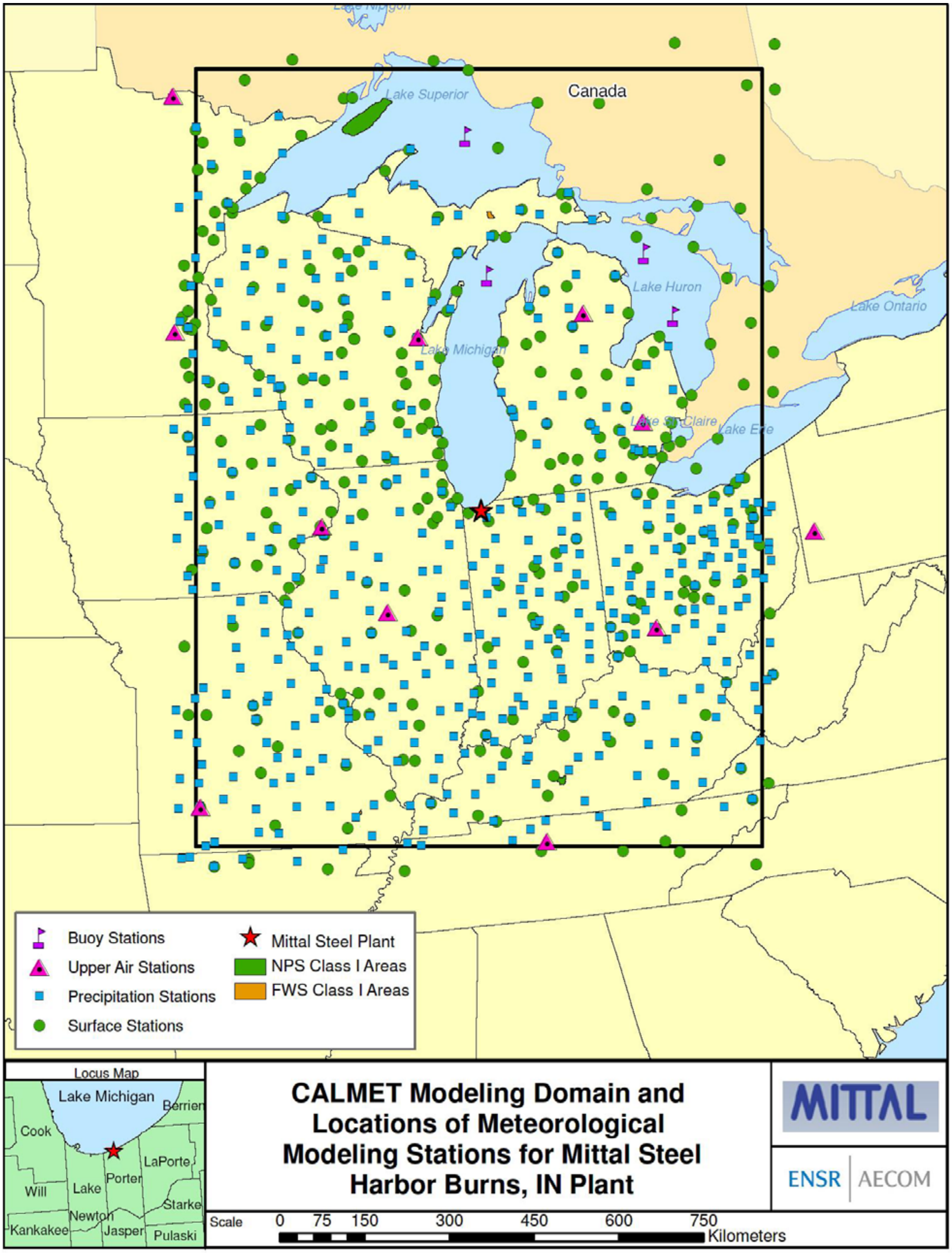
The non-default user-defined settings proposed for the CALMET processing are provided in Table 3-1.

Table 3-1 CALMET User-Defined Fields Not Specified in IWAQM Appendix A

Variable	Description	Value
NX	Number of east-west grid cells	167
NY	Number of north-south grid cells	229
DGRIDKM	Meteorology grid spacing (km)	6.0
NZ	Number of Vertical layers of input meteorology	10
ZFACE	Vertical cell face heights (m)	0.,20.,40.,80.,160.,300.,600.,1000.,1500.,2000.,3500.
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
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
IUPT	Station for lapse rates	International Falls, MN
IPROG	Gridded initial prognostic wind field – MM4/MM5 data	14

Figure 3-1 Burns Harbor CALMET and CALPUFF Modeling Domain

Figure 3-2 Location of Meteorological Stations used in CALMET Processing



4.0 CALPUFF Modeling

This section provides a summary of the modeling procedures that were used for the refined CALPUFF analysis conducted for the Burns Harbor facility.

4.1 CALPUFF Modeling Domain and Receptors

ENSR used the latest EPA-approved version of CALPUFF (Version 5.8, Level 070623) that has been posted at http://www.src.com/calpuff/download/download.htm#EPA_VERSION.

The extent of the CALMET/CALPUFF modeling domain are shown in Figure 3-1. The modeling domain included a 100 km buffer around the source and a 50 km buffer around each of the four Class I areas plus an additional buffer to the east and to the west to account for puffs recirculation. This design allows the modeling domain to extend 1,002 km east-west and 1,374 km north-south and have a 6-km grid element size.

The receptors for each of the Class I areas were based on the National Park Service database of Class I receptors.

4.2 Technical Options Used in the Modeling

For CALPUFF model technical options, inputs and processing steps, Burns Harbor followed the MWRPO common BART protocol.

For CALPUFF modeling, ENSR used seasonal ozone and ammonia ambient background concentrations that are consistent with the MWRPO common BART modeling protocol. For convenience, there values are listed in Table 4-1.

Table 4-1 MWRPO Ozone and Ammonia Seasonal Concentrations

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
O_3 (ppb)	31	31	31	37	37	37	33	33	33	27	27	27
NH_3 (ppb)	.3	.3	.3	.5	.5	.5	.5	.5	.5	.5	.5	.5

Due to the large distance to the nearest Class I area, building downwash effects were not included in the CALPUFF modeling.

4.3 Natural Conditions and Monthly f(RH) at Class I Areas

There are four Class I areas to be modeled for the Burns Harbor facility. For these Class I areas, natural background conditions must be established in order to determine a change in natural conditions related to a source's emissions.

For BART analyses, EPA has chosen to accept either the annual average or 20% best day's natural background for BART exemption and determination modeling analyses. Regional Planning Organization(s) (RPOs) have provided guidance to states within their RPOs on what values to accept, which typically has varied based on the degree of the meteorological database refinement. Since MWRPO uses the 36-km database with no observations, as a measure of conservatism, MWRPO/LADCO recommended to states that the 20% best day's background be incorporated into the analysis as opposed to the annual average. This conservative approach compensated for the inaccuracy of the 36-km meteorological data in no-obs mode.

Model refinements to improve accuracy reduce the need for conservative background assumptions. For instance, Wisconsin, a MWRPO state, has stated that they would allow sources to use the annual average background with the 98th percentile day as opposed to the 20% best days if a site-specific meteorological database is developed.

In addition, states within the VISTAS RPO* have uniformly decided to allow sources to use the annual average background coupled with the 98th percentile day when refined meteorological data (that incorporates observations) is used as input to the BART CALPUFF runs. This procedure was approved by EPA Region 4. To conduct the BART modeling, VISTAS, like the MWRPO, developed its own coarse no-obs 12-km resolution CALMET meteorological database covering all VISTAS states and Class I areas within 300 km. The 12-km CALMET meteorological data was used in the modeling analyses as a screening step to exempt BART eligible sources that, based on modeling, did not cause or contribute to visibility impairment (i.e. according to the BART rule did not have impacts greater than 0.5 dv).VISTAS also developed a more refined 4-km resolution CALMET databases that covered a sub-set of the large 12-km grid. These databases were able to be used in refined BART modeling analyses along with the annual average background. To ENSR's knowledge, all VISTAS states have accepted the use of the annual average background.

Burns Harbor used refined meteorological database with a finer grid resolution (6-km) and introduced surface observations. In addition, ENSR used the annual average background while evaluating BART exemption based on the source's impacts at the 98th percentile day. This procedure is consistent with the modeling approach taken by other eastern states and consistent with Wisconsin's approach within the MWRPO.

For the modeling described in this document, ENSR used the annual average natural background concentrations shown in Table 4-2, modified as noted below with site-specific considerations (as shown in Table 4-3), and corresponding to the annual average natural background concentrations (EPA 2003, Appendix B).

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

Extinction (Mm^{-1}) = 10 exp(deciviews/10).

For example, for Mingo, 7.43 deciviews is equivalent to an extinction of 21.02 inverse megameters (Mm^{-1}); this extinction includes the default 10 Mm-1 for Rayleigh scattering. This remaining extinction is due to naturally occurring particles, and is held constant for the entire year's simulation. Therefore, the data provided to CALPOST for Mingo would be the total natural background extinction minus 10 (expressed in Mm^{-1}), or 11.02. This is most easily input as a fine soil concentration of 11.02 $\mu g/m^3$ 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 for f(RH) that CALPOST needs were taken from "Guidance for Tracking Progress Under the Regional Haze Rule" (EPA, 2003) Appendix A, Table A-3.

* The VISTAS states include: Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia.

Table 4-2 Annual Average Natural Background Concentrations

Component Represented	Isle Royale	Mammoth Cave	Mingo	Seney
Soil (PM fine) (deciview)	7.38	7.69	7.43	7.53
Soil (PM fine) (Mm^{-1} or $\mu g/m^3$)	20.92	21.58	21.02	21.23

* Extinction values include Rayleigh scattering.

Table 4-3 New IMPROVE Equation Background Sea Salt Concentration and Site-specific Rayleigh Scattering Coefficient

Parameter	Isle Royale	Mammoth Cave	Mingo	Seney
Sea Salt Concentration ($\mu g/m^3$)	0.03	0.02	0.01	0.02
Rayleigh Scattering Coefficient (Mm-1)	12	11	12	12

Note: Data taken from VIEWS website (http://vista.cira.colostate.edu/views/)

4.4 Light Extinction and Haze Impact Calculations

The CALPOST postprocessor was used for the calculation of the impact from the modeled source's primary and secondary particulate matter concentrations on light extinction. The formula that is used is the existing IMPROVE/EPA formula, which is applied to determine a change in light extinction due to increases in the particulate matter component concentrations. Using the notation of CALPOST, the formula is the following:

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

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).

Dr. Ivar Tombach, consultant to VISTAS, has provided a spreadsheet calculation system (see Appendix B) that incorporates the revised IMPROVE equation (also documented in Appendix B) for determining light extinction from particulate concentration estimates. We used this approach instead of the old/current IMPROVE equation in the presentation of the BART modeling. The Fish & Wildlife Service, who administer the Seney and Mingo Wilderness Areas, have previously communicated to ENSR (2006) that they approve of Dr. Tombach's procedure for implementing the new IMPROVE equation, and that this equation may be used for regional haze assessments with this approach. Notably, the Federal Land Managers associated with the US Fish and Wildlife Service recently approved the use of the new IMPROVE equation at Seney Wilderness (as implemented here using Dr. Tombach's procedures) for a PSD permit application in Michigan.

The new IMPROVE equation is fundamentally different in 3 major areas (taken from Ivar Tombach's *"Instructions: A Postprocessor for Recalculating CALPOST Visibility Outputs with the New IMPROVE Algorithm"*):

(1) The extinction efficiencies of sulfates, nitrates, and organics have been changed and are now functions of their concentrations. The extinction efficiencies of sulfate and nitrate are no longer identical, although the new hygroscopic scattering enhancement factors applied to them are the same.

(2) The contribution of fine sea salt to light extinction has been added, and is accompanied by its own hygroscopic scattering enhancement factor, fss(RH).

(3) The light scattering by air itself (Rayleigh scattering) now varies with site elevation and mean temperature. It is to be rounded off to the nearest one Mm-1 when used with the new algorithm.

States and other RPOs have allowed sources to use the new IMPROVE equation as opposed to the IMPROVE equation algorithms that are currently coded into CALPOST because these differences (noted above) represent a real improvement over how the old/current IMPROVE equation calculates light extinction. ENSR used the new IMPROVE equation for the light extinction calculations in this refined BART analysis using the guidance provided by Dr. Ivar Tombach. Table 4-3 lists sea salt concentrations and Rayleigh coefficients that were used as input to the new IMPROVE equation.

In addition to using the new IMPROVE equation, the assessment of visibility impacts at the Class I areas used CALPOST Method 6 (as standard with all BART applications). Each hour's source-caused extinction is calculated by first using the hygroscopic components of the source-caused concentrations, due to ammonium sulfate and nitrate, and monthly Class I area-specific f(RH) values. The contribution to the total source-caused extinction from ammonium sulfate and nitrate is then added to the other, non-hygroscopic components of the particulate concentration (from coarse and fine soil, secondary organic aerosols, and from elemental carbon) to yield the total hourly source-caused extinction.

5.0 Modeling Results

The BART exemption modeling results at the four Class I areas using the maximum emissions by emission unit are provided in Table 5-1. Table 5-2 provides the results of the more realistic modeling using the maximum plant-wide emission days. Both tables indicate that the 8th highest day's impacts for each year are below the 0.5 delta-deciviews threshold. These results demonstrate that the ArcelorMittal Burns Harbor emissions do not cause or contribute to regional haze in any of these four Class I area. Therefore, Burns Harbor facility is not subject to BART and no further BART analysis is required.

Table 5-1 BART Exemption Modeling Results - Maximum by Emission Unit

Class I Area	2002				2003				2004			
	Days > than		MAX Δ dv	8th Highest Δ dv_t	Days > than		MAX Δ dv	8th Highest Δ dv	Days > than		MAX Δ dv	8th Highest Δ dv_t
	0.5 Δ dv	1.0 Δ dv			0.5 D dv	1.0 D dv			0.5 D dv	1.0 D dv		
MVISBK=6, Annual Average Background, 6-km CALMET, New IMPROVE Equation												
Isle Royale National Park	0	0	0.220	0.083	2	0	0.601	0.117	2	0	0.615	0.163
Mammoth Cave National Park	2	0	0.898	0.351	3	0	0.674	0.333	1	0	0.658	0.218
Mingo Wilderness	3	0	0.705	0.199	1	0	0.559	0.224	0	0	0.414	0.181
Seney Wilderness	4	0	0.750	0.346	4	1	1.165	0.375	7	1	1.030	0.464

Table 5-2 BART Exemption Modeling Results - Plant-wide Maximum Emission Day

Class I Area	2002				2003				2004			
	Days > than		MAX Δ dv	8th Highest Δ dv_t	Days > than		MAX Δ dv	8th Highest Δ dv	Days > than		MAX Δ dv	8th Highest Δ dv_t
	0.5 Δ dv	1.0 Δ dv			0.5 D dv	1.0 D dv			0.5 D dv	1.0 D dv		
MVISBK=6, Annual Average Background, 6-km CALMET, New IMPROVE Equation												
Isle Royale National Park	0	0	0.188	0.069	2	0	0.533	0.099	2	0	0.542	0.143
Mammoth Cave National Park	2	0	0.789	0.300	2	0	0.574	0.287	1	0	0.563	0.185
Mingo Wilderness	2	0	0.629	0.170	0	0	0.474	0.189	0	0	0.352	0.155
Seney Wilderness	2	0	0.675	0.297	2	0	1.027	0.332	6	0	0.914	0.405

6.0 References

ENSR, Personal communication to Mr. Robert Paine from Mr. Tim Allen of the U.S Fish and Wildlife Service

Environmental Protection Agency (EPA), AP 42, Fifth Edition, Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, January, 1995

Environmental Protection Agency (EPA), Guidance for Tracking Progress Under the Regional Haze Rule, EPA-454/B-03-003, Appendix A, Table A-3, September, 2003a

Environmental Protection Agency (EPA), Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Program, EPA 454/B-03-005, September 2003b

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

Regional Haze Regulations and Guidelines for Best Available Retrofit Technology (BART) Determinations; Final Rule (FR Vol. 70, No. 128 published July 6, 2005)

Regional Haze Regulations; Revisions to Provisions Governing Alternative to Source-Specific Best Available Retrofit Technology (BART) Determinations; Final Rule (FR Vol. 71, NO. 198 published October 13, 2006)

Single Source Modeling to Support Regional Haze BART Modeling Protocol November 17, 2005, Lake Michigan Air Directors Consortium, Des Plaines, IL

Appendix A

Meteorological Stations used in CALMET Processing

Table A-1 Surface Stations used in CALMET Processing

Country/State	WBAN ID	Source (1)	Name	Latitude	Longitude	Elevation (m)	2002	2003	2004
Canada	712600	NNDC	SAULT STE MARIE	46.48	-84.51	192	x	x	x
Canada	712610	NNDC	GODERICH (AUT08)	43.76	-81.71	214	x	x	x
Canada	712700	NNDC	COLLINGWOOD (AUT8)	44.50	-80.21	180	x	x	x
Canada	712730	NNDC	BELLE RIVER	42.30	-82.70	184	x	x	x
Canada	713680	NNDC	WATERLOO WELL	43.46	-80.38	317	x	x	x
Canada	714330	NCDC	CARIBOU ISL (MAPS)	47.33	-85.83	187	x	x	x
Canada	714350	NCDC	UPSALA (MARS)	49.03	-90.46	489	x	x	x
Canada	714390	NCDC	COVE ISLAND (MAPS)	45.33	-81.73	181	x	x	x
Canada	714600	NCDC	KILLARNEY (MAPS)	45.96	-81.48	196	x	x	x
Canada	714620	NCDC	GREAT DUCK ISLAND	45.63	-82.96	183	x	x	x
Canada	714650	NCDC	ERIEAU (MAPS)	42.25	-81.90	178	x	x	x
Canada	714660	NCDC	S.E. SHOAL (MAPS)	41.83	-82.46	195	x	x	x
Canada	715380	NCDC	WINDSOR AIRPORT	42.26	-82.96	190	x	x	x
Canada	715730	NCDC	DELHI CS	42.83	-80.55	232	x	x	x
Canada	716230	NCDC	LONDON AIRPORT	43.03	-81.15	278	x	x	x
Canada	716310	NCDC	MOUNT FOREST(MARS)	43.98	-80.75	415	x	x	x
Canada	716330	NCDC	WIARTON AIRPORT	44.75	-81.10	222	x	x	x
Canada	716340	NCDC	SARNIA AIRPORT	43.00	-82.31	181	x	x	x
Canada	716420	NCDC	CHAPLEAU A	47.81	-83.35	447	x	x	x
Canada	717300	NCDC	SUDBURY AIRPORT	46.61	-80.80	348	x	x	x
Canada	717320	NCDC	BRITT (MARS)	45.80	-80.53	192	x	x	x
Canada	717330	NCDC	GORE BAY AIRPORT	45.88	-82.56	193	x	x	x
Canada	717334	NCDC	ELLIOT LAKE (SAWR)	46.35	-82.56	329	x	x	x
Canada	717340	NCDC	ROUYN	48.25	-79.03	318	x	x	x
Canada	717350	NCDC	EARLTON AIRPORT	47.70	-79.85	243	x	x	x
Canada	717380	NCDC	WAWA AIRPORT	47.96	-84.78	287	x	x	x
Canada	717390	NCDC	TIMMINS AIRPORT	48.56	-81.36	295	x	x	x
Canada	717470	NCDC	ATIKOKAN	48.76	-91.63	389	x	x	x
Canada	717490	NCDC	THUNDER BAY AIRPORT	48.36	-89.31	199	x	x	x
Canada	717493	NCDC	TERRACE BAY (SAWR)	48.81	-87.10	287	x	x	x
Canada	717500	NCDC	PUKASKWA	48.60	-86.30	206	x	x	x
Canada	717510	NCDC	WELCOME ISLAND	48.36	-89.11	209	x	x	x
Canada	718200	NCDC	BARRAGE ANGLIERS	47.55	-79.23	266	x	x	x
AR	723406	NCDC	WALNUT RIDGE (AWOS)	36.13	-90.91	83	x	x	x
AR	723439	NCDC	BAXTER CO RGNL APT	36.36	-92.46	283	x	x	x
AR	723446	NCDC	HARRISON FAA AP	36.26	-93.15	418	x	x	x
AR	723447	NCDC	FLIPPIN (AWOS)	36.30	-92.46	350	x	x	x
IA	725349	NCDC	DAVENPORT NEXRAD	41.61	-90.58	259	x	x	x
IA	725450	NCDC	CEDAR RAPIDS MUNICI	41.88	-91.71	256	x	x	x
IA	725454	NCDC	WASHINGTON	41.28	-91.66	230	x	x	x
IA	725455	NCDC	BURLINGTON MUNICIPA	40.78	-91.11	210	x	x	x
IA	725456	NCDC	KEOKUK MUNI	40.46	-91.43	205	x	x	x
IA	725461	NCDC	MARSHALL TOWN MUNI	42.10	-92.91	296	x	x	x
IA	725462	NCDC	IOWA CITY MUNI	41.63	-91.55	198	x	x	x
IA	725463	NCDC	CHARLES CITY	43.06	-92.61	343	x	x	x
IA	725464	NCDC	NEWTON MUNI	41.68	-93.01	290	x	x	x
IA	725465	NCDC	OTTUMWA INDUSTRIAL	41.10	-92.45	256	x	x	x
IA	725469	NCDC	CHARITON	41.03	-93.36	320	x	x	x
IA	725470	NCDC	DUBUQUE REGIONAL AP	42.40	-90.70	321	x	x	x
IA	725473	NCDC	CLINTON MUNI (AWOS)	41.83	-90.33	216	x	x	x
IA	725475	NCDC	MONTICELLO MUNI	42.23	-91.16	259	x	x	x
IA	725476	NCDC	DECORAH	43.28	-91.73	353	x	x	x
IA	725480	NCDC	WATERLOO MUNICIPAL	42.55	-92.40	263	x	x	x
IA	725483	NCDC	FORT MADISON	40.66	-91.33	221	x	x	x
IA	725485	NCDC	MASON CITY MUNICIPA	43.15	-93.33	363	x	x	x
IA	725487	NCDC	MUSCATINE	41.36	-91.15	167	x	x	x
IA	725488	NCDC	OELWEN	42.68	-91.96	328	x	x	x
IA	725493	NCDC	KNOXVILLE	41.30	-93.11	283	x	x	x
IA	726498	NCDC	FAIR FIELD	41.05	-91.98	244	x	x	x
IL	724330	NCDC	SALEM-LECKRONE	38.65	-88.96	174	x	x	x
IL	724335	NCDC	MOUNT VERNON (AWOS)	38.31	-88.86	146	x	x	x
IL	724336	NCDC	CARBONDALE/MURPHYSB	37.78	-89.25	125	x	x	x
IL	724338	NCDC	BELLEVILLE SCOTT AF	38.55	-89.85	135	x	x	x
IL	724339	NCDC	MARION REGIONAL	37.75	-89.01	144	x	x	x
IL	724390	NCDC	SPRINGFIELD CAPITAL	39.85	-89.68	178	x	x	x
IL	724395	NCDC	ALTON/ST LOUIS RGNL	38.90	-90.05	166	x	x	x
IL	724396	NCDC	QUINCY MUNI BALDWIN	39.93	-91.20	232	x	x	x
IL	724397	NCDC	BLOOMINGTON/NORMAL	40.48	-88.91	267	x	x	x
IL	725300	NCDC	CHICAGO OHARE INTL	41.98	-87.91	200	x	x	x
IL	725305	NCDC	W. CHICAGO/DU PAGE	41.91	-88.25	231	x	x	x
IL	725314	NCDC	CAHOKIA/ST. LOUIS	38.56	-90.15	126	x	x	x
IL	725315	NCDC	CHAMPAIGN/URBANA	40.03	-88.28	230	x	x	x
IL	725316	NCDC	DECATUR AIRPORT	39.83	-88.86	208	x	x	x
IL	725317	NCDC	MATTOON/CHARLESTON	39.48	-88.28	220	x	x	x
IL	725320	NCDC	PEORIA GREATER PEOR	40.66	-89.68	198	x	x	x
IL	725326	NCDC	STERLING ROCKFALLS	41.75	-89.66	197	x	x	x

Table A-1 Surface Stations used in CALMET Processing

Country/State	WBAN ID	Source [1]	Name	Latitude	Longitude	Elevation (m)	2002	2003	2004
IL	724397	NCDC	BLOOMINGTON/NORMAL	40.48	-88.91	267	x	x	x
IL	725300	NCDC	CHICAGO OHARE INTL	41.98	-87.91	200	x	x	x
IL	725305	NCDC	W. CHICAGO/DU PAGE	41.91	-88.25	231	x	x	x
IL	725314	NCDC	CAHOKIA/ST. LOUIS	38.56	-90.15	126	x	x	x
IL	725315	NCDC	CHAMPAIGN/URBANA	40.03	-88.28	230	x	x	x
IL	725316	NCDC	DECATUR AIRPORT	39.83	-88.86	208	x	x	x
IL	725317	NCDC	MATTOON/CHARLESTON	39.48	-88.28	220	x	x	x
IL	725320	NCDC	PEORIA GREATER PEOR	40.66	-89.68	198	x	x	x
IL	725326	NCDC	STERLING ROCKFALLS	41.75	-89.66	197	x	x	x
IL	725340	NCDC	CHICAGO MIDWAY AP	41.78	-87.75	186	x	x	x
IL	725342	NCDC	LAWRENCEVILLE\VIN.	38.76	-87.60	131	x	x	x
IL	725345	NCDC	JOLIET PARK DISTRIC	41.51	-88.18	177	x	x	x
IL	725346	NCDC	CHICAGO MEIGS FIELD	41.86	-87.61	180	x	x	
IL	725347	NCDC	CHICAGO/WAUKEGAN	42.41	-87.86	222	x	x	x
IL	725348	NCDC	CHICAGO NEXRAD	41.60	-88.08	231	x	x	x
IL	725430	NCDC	ROCKFORD GREATER RO	42.20	-89.10	223	x	x	x
IL	725440	NCDC	MOLINE QUAD CITY IN	41.46	-90.51	180	x	x	x
IL	744655	NCDC	AURORA MUNICIPAL	41.76	-88.46	215	x	x	x
IL	744665	NCDC	CHICAGO/PALWAUKEE	42.11	-87.90	197		x	x
IL	ALH157	CASTNET	Alhambra	38.87	-89.62	164	x	x	x
IL	STK138	CASTNET	Stockton	42.29	-90.00	274	x	x	x
IN	724320	NCDC	EVANSVILLE REGIONAL	38.05	-87.53	116	x	x	x
IN	724356	NCDC	SHELBYVILLE MUNI	39.58	-85.80	245	x	x	x
IN	724363	NCDC	COLUMBUS BAKALAR	39.26	-85.90	199	x	x	x
IN	724365	NCDC	HUNTINGBURG	38.25	-86.95	161		x	x
IN	724373	NCDC	TERRE HAUTE HULMAN	39.45	-87.30	175	x	x	x
IN	724375	NCDC	BLOOMINGTON/MONROE	39.15	-86.61	258	x	x	x
IN	724380	NCDC	INDIANAPOLIS INTL A	39.71	-86.26	241	x	x	x
IN	724384	NCDC	EAGLE CREEK	39.83	-86.30	250	x	x	x
IN	724385	NCDC	ANDERSON MUNICIPAL	40.11	-85.61	280	x	x	x
IN	724386	NCDC	LAFAYETTE PURDUE UN	40.41	-86.93	182	x	x	x
IN	724387	NCDC	KOKOMO(AWOS)	40.53	-86.06	253		x	x
IN	724388	NCDC	GOSHEN	41.53	-85.78	252	x	x	x
IN	725327	NCDC	VALPARAISO	41.45	-87.00	234	x	x	x
IN	725330	NCDC	FORT WAYNE INTL AP	41.00	-85.20	241	x	x	x
IN	725335	NCDC	GRISSOM AFB/PERU	40.65	-86.15	247	x	x	x
IN	725336	NCDC	MUNCIE/JOHNSON FLD	40.25	-85.40	286	x	x	x
IN	725337	NCDC	GARY REGIONAL	41.61	-87.41	180	x	x	x
IN	725350	NCDC	SOUTH BEND MICHIANA	41.70	-86.33	235	x	x	x
IN	725354	NCDC	ELKHART MUNICIPAL	41.71	-86.00	237	x	x	x
IN	SAL133	CASTNET	Salamonie Reservoir	40.82	-85.66	250	x	x	x
KY	724210	NCDC	CINCINNATI NORTHERN	39.05	-84.66	264	x	x	x
KY	724220	NCDC	LEXINGTON BLUEGRASS	38.03	-84.60	294	x	x	x
KY	724230	NCDC	LOUISVILLE STANDIFO	38.18	-85.73	146	x	x	x
KY	724233	NCDC	CAPITAL CITY ARPT	38.18	-84.90	245	x	x	x
KY	724235	NCDC	LOUISVILLE BOWMAN F	38.23	-85.66	164	x	x	x
KY	724236	NCDC	JACKSON JULIAN CARR	37.58	-83.31	416	x	x	x
KY	724237	NCDC	OWENSBORO/DAVIESS	37.73	-87.16	124	x	x	x
KY	724238	NCDC	HENDERSON CITY	37.81	-87.68	117	x	x	x
KY	724240	NCDC	FORT KNOX GODMAN AA	37.90	-85.96	239	x	x	x
KY	724243	NCDC	LONDON-CORBIN AP	37.08	-84.08	362	x	x	x
KY	724350	NCDC	PADUCAH BARKLEY REG	37.05	-88.76	124	x	x	x
KY	724354	NCDC	SOMERSET(AWOS)	38.00	-84.60	283	x	x	x
KY	746710	NCDC	FORT CAMPBELL (AAF)	36.66	-87.50	173	x	x	x
KY	746716	NCDC	BOWLING GREEN WARRE	36.98	-86.43	160	x	x	x
KY	CDZ171	CASTNET	Cadiz	36.78	-87.85	189	x	x	x
KY	CKT136	CASTNET	Crockett	37.92	-83.07	455	x	x	x
KY	MCK131	CASTNET	Mackville	37.70	-85.05	353	x	x	x
KY	MAC426	CASTNET	Mammoth Cave	37.28	-86.26	236	x	x	x
MI	725370	NCDC	DETROIT METROPOLITA	42.21	-83.35	194	x	x	x
MI	725373	NCDC	GROSSE ISLE ARPT	42.10	-83.15	176	x	x	x
MI	725374	NCDC	ANN ARBOR MUNICIPAL	42.21	-83.75	256	x	x	x
MI	725375	NCDC	DETROIT CITY AIRPOR	42.40	-83.00	190	x	x	x
MI	725376	NCDC	DETROIT WILLOW RUN	42.23	-83.53	218	x	x	x
MI	725377	NCDC	MOUNT CLEMENS SELFR	42.61	-82.83	176	x	x	x
MI	725378	NCDC	HOWELL	42.63	-83.98	293	x	x	x
MI	725383	NCDC	STURGIS\KIRSH MUNI	41.81	-85.43	0	x	x	x
MI	725384	NCDC	ST.CLAIR COUNTY INT	42.91	-82.53	198	x	x	x
MI	725386	NCDC	HARBOR BEACH(RAMOS)	44.01	-82.80	183	x	x	x
MI	725387	NCDC	COPPER HARBOR RAMOS	47.45	-87.90	186	x	x	x
MI	725390	NCDC	LANSING CAPITAL CIT	42.78	-84.58	256	x	x	x
MI	725394	NCDC	HOLLAND/TULIP CITY	42.75	-86.10	210	x	x	x
MI	725395	NCDC	JACKSON REYNOLDS FI	42.26	-84.46	304	x	x	x

Table A-1 Surface Stations used in CALMET Processing

Country/State	WBAN ID	Source [1]	Name	Latitude	Longitude	Elevation (m)	2002	2003	2004
MI	725396	NCDC	BATTLE CREEK	42.30	-85.25	282	x	x	x
MI	725404	NCDC	ADRIAN	41.86	-84.08	244	x	x	x
MI	725405	NCDC	ALMA	43.31	-84.68	230	x	x	x
MI	725406	NCDC	BAD AXE	43.78	-82.98	234	x	x	x
MI	725407	NCDC	GAYLORD	45.01	-84.68	404	x	x	x
MI	725408	NCDC	MANISTIQUE	45.96	-86.18	209	x	x	x
MI	725409	NCDC	HILLSDALE	41.91	-84.58	360	x	x	x
MI	725414	NCDC	COLDWATER	41.93	-85.05	292	x	x	x
MI	725415	NCDC	MARSHALL BROOKS	42.25	-84.95	287	x	x	x
MI	725416	NCDC	BIG RAPIDS	43.71	-85.50	302	x	x	x
MI	725417	NCDC	MASON	42.56	-84.41	280	x	x	x
MI	725418	NCDC	MONROE	41.93	-83.43	188	x	x	x
MI	725424	NCDC	MT PLEASANT MUNI	43.61	-84.73	230	x	x	x
MI	726284	NCDC	GWINN SAWYER AIRPO	46.35	-87.38	372	x	x	x
MI	726350	NCDC	GRAND RAPIDS KENT C	42.88	-85.51	241	x	x	x
MI	726355	NCDC	BENTON HARBOR/ROSS	42.13	-86.43	196	x	x	x
MI	726357	NCDC	KALAMAZOO INTL ARPT	42.23	-85.55	266	x	x	x
MI	726360	NCDC	MUSKEGON COUNTY ARP	43.16	-86.23	190	x	x	x
MI	726364	NCDC	LUDINGTON/MASON	43.96	-86.40	197	x	x	x
MI	726370	NCDC	FLINT BISHOP INTL A	42.96	-83.75	233	x	x	x
MI	726375	NCDC	PONTIAC-OAKLAND	42.66	-83.41	299	x	x	x
MI	726379	NCDC	SAGINAW TRI CITY IN	43.53	-84.08	201	x	x	x
MI	726380	NCDC	HOUGHTON LAKE ROSCO	44.36	-84.68	350	x	x	x
MI	726384	NCDC	CADILLAC WEXFORD CO	44.28	-85.41	396	x	x	x
MI	726385	NCDC	MANISTEE (AWOS)	44.26	-86.25	189	x	x	x
MI	726387	NCDC	TRAVERSE CITY CHERR	44.73	-85.58	188	x	x	x
MI	726390	NCDC	ALPENA COUNTY REGIO	45.06	-83.58	210	x	x	x
MI	726394	NCDC	NEWBERRY LUCE CO.	46.31	-85.46	198	x	x	x
MI	726395	NCDC	OSCODA WURTSMITH AF	44.45	-83.40	188	x	x	x
MI	726399	NCDC	SEUL CHOIX PT(AMOS)	45.91	-85.91	180	x	x	x
MI	726480	NCDC	ESCANABA (AWOS)	45.75	-87.03	187	x	x	x
MI	726487	NCDC	MENOMINEE (AWOS)	45.13	-87.63	191	x	x	x
MI	727340	NCDC	SAULT STE MARIE SAN	46.46	-84.35	218	x	x	x
MI	727344	NCDC	CHIPPEWA INTL(AWOS)	46.25	-84.46	244	x	x	x
MI	727347	NCDC	PELLSTON EMMET COUN	45.56	-84.78	217	x	x	x
MI	727435	NCDC	MACKINACK ISLAND	46.35	-87.40	372	x	x	x
MI	727436	NCDC	ANTRIM CO ARPT	44.98	-85.20	190	x	x	x
MI	727437	NCDC	IRON MOUNTAIN/FORD	45.81	-88.11	360	x	x	x
MI	727440	NCDC	HANCOCK HOUGHTON CO	47.16	-88.50	327	x	x	x
MI	727445	NCDC	IRONWOOD (AWOS)	46.53	-90.13	375	x	x	x
MI	727449	NCDC	MOOSE LAKE CO ARPT	46.41	-92.80	184	x	x	x
MI	ANA115	CASTNET	Ann Arbor	42.42	-83.90	267	x	x	x
MI	HOX148	CASTNET	Hoxyville	44.18	-85.74	305	x	x	x
MI	UVL124	CASTNET	Unionville	43.61	-83.36	201	x	x	x
MN	726440	NCDC	ROCHESTER INTERNATI	43.90	-92.50	397	x	x	x
MN	726544	NCDC	ORR	48.01	-92.86	397	x	x	x
MN	726549	NCDC	COOK MUNI ARPT	47.81	-92.70	402	x	x	x
MN	726558	NCDC	CLOQUET (AWOS)	46.70	-92.50	390	x	x	x
MN	726563	NCDC	FARIBAULT MUNI AWOS	44.33	-93.31	322	x	x	x
MN	726564	NCDC	RED WING	44.58	-92.48	239	x	x	x
MN	726568	NCDC	OWATONNA (AWOS)	44.11	-93.25	350	x	x	x
MN	726575	NCDC	MINNEAPOLIS/CRYSTAL	45.06	-93.35	265	x	x	x
MN	726577	NCDC	MINNEAPOLIS/BLAINE	45.15	-93.21	278	x	x	x
MN	726580	NCDC	MINNEAPOLIS-ST PAUL	44.88	-93.23	254	x	x	x
MN	726584	NCDC	SAINT PAUL DOWNTOWN	44.95	-93.06	219	x	x	x
MN	726588	NCDC	WINONA MUNI (AWOS)	44.08	-91.70	200	x	x	x
MN	726589	NCDC	ALBERT LEA (AWOS)	43.68	-93.36	383	x	x	x
MN	726596	NCDC	DODGE CENTER AIRPOR	44.01	-92.81	398	x	x	x
MN	726603	NCDC	SOUTH ST PAUL MUNI	44.85	-93.15	250	x	x	x
MN	726679	NCDC	RUSH CITY RGNL ARPT	45.68	-92.95	281	x	x	x
MN	727444	NCDC	TWO HARBORS	47.05	-91.75	328	x	x	x
MN	727450	NCDC	DULUTH INTERNATIONA	46.83	-92.21	433	x	x	x
MN	727454	NCDC	GRAND MARAIS MUNI	47.83	-90.38	505	x	x	x
MN	727455	NCDC	HIBBING CHISHOLM-HI	47.38	-92.85	410	x	x	x
MN	727456	NCDC	DULUTH HARBOR (CGS)	46.76	-92.08	186	x	x	x
MN	727459	NCDC	ELY MUNI (AWOS)	47.81	-91.83	443	x	x	x
MN	727469	NCDC	GRAND MARIAS	47.83	-90.38	186	x	x	x
MN	727473	NCDC	CRANE LAKE (AWOS)	46.26	-92.56	350	x	x	x
MN	727474	NCDC	EVELETH MUNI (AWOS)	47.40	-92.50	421	x	x	x
MN	727475	NCDC	MORA MUNI (AWOS)	45.88	-93.26	309	x	x	x
MN	727503	NCDC	CAMBRIDGE MUNI	45.56	-93.26	287	x	x	x
MN	727556	NCDC	SILVER BAY	47.20	-91.40	331	x	x	x
MN	727566	NCDC	AUSTIN MUNI	43.66	-92.93	375	x	x	x

Table A-1 Surface Stations used in CALMET Processing

Country/State	WBAN ID	Source [1]	Name	Latitude	Longitude	Elevation (m)	2002	2003	2004
MO	723300	NCDC	POPLAR BLUFF(AMOS)	36.76	-90.46	146	x	x	x
MO	723484	NCDC	WEST PLAINS - ASOS	36.88	-91.90	374	x	x	x
MO	723489	NCDC	CAPE GIRARDEAU MUNI	37.23	-89.56	102	x	x	x
MO	724340	NCDC	ST LOUIS LAMBERT IN	38.75	-90.36	173	x	x	x
MO	724345	NCDC	ST LOUIS SPIRIT OF	38.65	-90.65	140	x	x	x
MO	724347	NCDC	ST CHARLES COUNTY A	38.91	-90.41	133	x	x	x
MO	724400	NCDC	SPRINGFIELD REGIONA	37.23	-93.38	383	x	x	x
MO	724450	NCDC	COLUMBIA REGIONAL A	38.81	-92.21	272	x	x	x
MO	724453	NCDC	SEDALIA MEMORIAL	38.70	-93.18	277	x	x	x
MO	724454	NCDC	FARMINGTON	37.76	-90.40	274	x	x	x
MO	724455	NCDC	KIRKSVILLE REGIONAL	40.10	-92.55	294	x	x	x
MO	724456	NCDC	VICHY ROLLA NATL AR	38.13	-91.76	335	x	x	x
MO	724457	NCDC	FORT LEONARD WOOD	37.73	-92.13	351	x	x	x
MO	724458	NCDC	JEFFERSON CITY MEM	38.58	-92.15	167	x	x	x
MO	724459	NCDC	KAISER MEM (AWOS)	38.10	-92.55	265	x	x	x
MO	724464	NCDC	CHILLICOTHE	39.81	-93.58	234	x	x	x
MO	724467	NCDC	WHITEMAN AFB	38.71	-93.55	255	x	x	x
NC	723150	NCDC	ASHEVILLE REGIONAL	35.43	-82.53	652	x	x	x
OH	724276	NCDC	DAYTON GENERL ARPT	39.60	-84.23	293	x	x	x
OH	724280	NCDC	COLUMBUS PORT COLUM	39.98	-82.88	246	x	x	x
OH	724284	NCDC	COLUMBUS/BOLTON FLD	39.90	-83.13	280	x	x	x
OH	724285	NCDC	COLUMBUS RICKENBACK	39.81	-82.93	230	x	x	x
OH	724286	NCDC	ZANESVILLE MUNICIPA	39.95	-81.90	268	x	x	x
OH	724287	NCDC	METCALF FIELD	41.55	-83.46	189	x	x	x
OH	724288	NCDC	OHIO ST U/COLUMBUS	40.08	-83.06	276	x	x	x
OH	724290	NCDC	DAYTON INTERNATIONA	39.90	-84.21	304	x	x	x
OH	724294	NCDC	LANCASTER\FAIRFIEL	39.75	-82.65	264	x	x	x
OH	724296	NCDC	WILMINGTON AIRBORNE	39.41	-83.81	328	x	x	x
OH	724297	NCDC	CINCINNATI MUNICIPA	39.10	-84.41	149	x	x	x
OH	724298	NCDC	LIMA ALLEN CO ARPT	40.40	-84.01	296	x	x	x
OH	724303	NCDC	AKRON FULTON ASOS	41.03	-81.46	326	x	x	x
OH	725208	NCDC	MARION MUNI ARPT	40.61	-83.06	303	x	x	x
OH	725210	NCDC	AKRON AKRON-CANTON	40.91	-81.43	368	x	x	x
OH	725214	NCDC	ELYRIA/LORAIN CO.	41.35	-82.18	242	x	x	x
OH	725216	NCDC	WOOSTER	40.86	-81.88	346	x	x	x
OH	725217	NCDC	HAMILTON	39.36	-84.51	193	x	x	x
OH	725224	NCDC	NEW PHILADELPHIA	40.46	-81.41	272	x	x	x
OH	725229	NCDC	NEWARK/HEATH AIRPRT	40.01	-82.45	269	x	x	x
OH	725240	NCDC	CLEVELAND HOPKINS I	41.40	-81.85	234	x	x	x
OH	725245	NCDC	CLEVELAND/BURKELAKE	41.51	-81.68	178	x	x	x
OH	725246	NCDC	MANSFIELD LAHM MUNI	40.81	-82.51	394	x	x	x
OH	725247	NCDC	CLEVELAND/CUYAHOGA	41.56	-81.48	268	x	x	x
OH	725254	NCDC	DEFIANCE MEMORIAL	41.33	-84.41	219	x	x	x
OH	725360	NCDC	TOLEDO EXPRESS AIRP	41.58	-83.80	203	x	x	x
OH	725366	NCDC	FINDLAY AIRPORT	41.01	-83.66	243	x	x	x
OH	745700	NCDC	DAYTON WRIGHT PATTE	39.83	-84.05	249	x	x	x
OH	DCP114	CASTNET	Deer Creek	39.64	-83.26	267	x	x	x
OH	LYK123	CASTNET	Lykens	40.92	-83.00	303	x	x	x
OH	OXF122	CASTNET	Oxford	39.53	-84.73	284	x	x	x
SD	726626	NCDC	ANTIGO\LANG(AWOS)	45.15	-87.15	464	x	x	x

Table A-1 Surface Stations used in CALMET Processing

Country/State	WBAN ID	Source [1]	Name	Latitude	Longitude	Elevation (m)	2002	2003	2004
TN	723183	NCDC	BRISTOL TRI CITY AI	36.46	-82.40	457	x	x	x
TN	723246	NCDC	OAK RIDGE	36.01	-84.23	277	x	x	x
TN	723260	NCDC	KNOXVILLE MCGHEE TY	35.81	-83.98	293	x	x	x
TN	723265	NCDC	CROSSVILLE MEMORIAL	35.95	-85.08	569	x	x	x
TN	723270	NCDC	NASHVILLE INTERNATI	36.11	-86.68	176	x	x	x
TN	723347	NCDC	DYERSBURG MUNICIPAL	36.01	-89.40	102	x	x	x
TN	SPD111	CASTNET	Speedwell	36.47	-83.83	361	x	x	x
VA	724058	NCDC	ABINGTON	36.68	-82.03	631	x	x	x
VA	724117	NCDC	WISE/LONESOME PINE	36.98	-82.53	817	x	x	x
WI	726400	NCDC	MILWAUKEE MITCHELL	42.95	-87.90	204	x	x	x
WI	726404	NCDC	MINOCQUA/WOODRUFF	45.93	-89.73	496	x	x	x
WI	726405	NCDC	MILWAUKEE TIMMERMAN	43.11	-88.05	224	x	x	x
WI	726409	NCDC	WAUKESHA	43.03	-88.23	284	x	x	x
WI	726410	NCDC	MADISON DANE CO REG	43.13	-89.35	261	x	x	x
WI	726413	NCDC	WEST BEND MUNI	43.41	-88.11	270	x	x	x
WI	726414	NCDC	MONROE MUNICIPAL AI	42.60	-89.58	331	x	x	x
WI	726415	NCDC	JANESVILLE/ROCK CO.	42.61	-89.03	246	x	x	x
WI	726416	NCDC	LONE ROCK FAA AP	43.20	-90.18	219	x	x	x
WI	726417	NCDC	MEDFORD	45.10	-90.30	448	x	x	x
WI	726418	NCDC	OSCEOLA	45.31	-92.68	275	x	x	x
WI	726419	NCDC	ASHLAND KENNEDY ME	46.55	-90.91	251	x	x	x
WI	726424	NCDC	RACINE	42.76	-87.81	205	x	x	x
WI	726425	NCDC	SHEBOYGAN	43.78	-87.85	228	x	x	x
WI	726426	NCDC	STEVENS POINT	44.55	-89.53	338	x	x	x
WI	726427	NCDC	SUPERIOR	46.68	-92.10	206	x	x	x
WI	726430	NCDC	LA CROSSE MUNICIPAL	43.86	-91.25	198	x	x	x
WI	726435	NCDC	EAU CLAIRE COUNTY A	44.86	-91.48	271	x	x	x
WI	726436	NCDC	VOLK FIELD ANG	43.93	-90.26	280	x	x	x
WI	726437	NCDC	MCCOY (USA-AF)	43.96	-90.73	256	x	x	x
WI	726438	NCDC	BOSCOBEL AIRPORT	43.15	-90.42	205	x	x	x
WI	726444	NCDC	PRAIRIE DU CHIEN	43.01	-91.11	201	x	x	x
WI	726449	NCDC	MERRILL MUNI ARPT	45.18	-89.70	401	x	x	x
WI	726450	NCDC	GREEN BAY AUSTIN ST	44.48	-88.13	209	x	x	x
WI	726452	NCDC	WISCONSIN RAPIDS	44.35	-89.83	308	x	x	x
WI	726455	NCDC	MANITOWAC MUNI AWOS	44.13	-87.68	198	x	x	x
WI	726456	NCDC	OSHKOSH/WITTMAN FLD	43.96	-88.55	246	x	x	x
WI	726457	NCDC	APPLETON/OUTAGAMIE	44.25	-88.51	280	x	x	x
WI	726458	NCDC	STURGEON BAY	44.85	-87.41	221	x	x	x
WI	726463	NCDC	WAUSAU MUNICIPAL AR	44.91	-89.63	365	x	x	x
WI	726464	NCDC	WATERTOWN	43.16	-88.71	254	x	x	x
WI	726465	NCDC	MOSINEE/CENTRAL WI	44.78	-89.66	389	x	x	x
WI	726466	NCDC	APPLETON MUNI ARPT	44.55	-89.53	338	x	x	x
WI	726467	NCDC	RICE LAKE MUNICIPAL	45.48	-91.71	347	x	x	x
WI	726468	NCDC	PHILLIPS/PRICE CO.	45.70	-90.40	449	x	x	x
WI	726502	NCDC	CLINTONVILLE MUNI	44.61	-88.73	0	x	x	x
WI	726503	NCDC	WISCONSIN DELLS	43.51	-89.76	0	x	x	x
WI	726504	NCDC	EAGLE RIVER UNION	45.93	-89.26	500	x	x	x
WI	726505	NCDC	KENOSHA REGIONAL	42.60	-87.93	226	x	x	x
WI	726506	NCDC	FOND DU LAC CO.	43.76	-88.48	246		x	x
WI	726507	NCDC	MINERAL POINT	42.88	-90.23	0	x	x	x
WI	726508	NCDC	HAYWARD MUNI ARPT	46.03	-91.45	370	x	x	x
WI	726509	NCDC	JUNEAU\DODGE CO	43.43	-88.70	285	x	x	x
WI	726574	NCDC	MARSHFIELD MUNI	44.63	-90.18	389	x	x	x
WI	727415	NCDC	RHINELANDER/ONEIDA	45.63	-89.46	495	x	x	x
WI	PRK134	CASTNET	Perkinstown	45.21	-90.60	472	x	x	x
WV	724140	NCDC	CHARLESTON YEAGER A	38.38	-81.58	309	x	x	x
WV	724250	NCDC	HUNTINGTON TRI-STAT	38.38	-82.55	253	x	x	x
WV	724273	NCDC	PARKERSBURG WOOD CO	39.35	-81.43	253	x	x	x

x - Data is used in CALMET

(1) The Clean Air Status and Trends Network (CASTNET): http://www.epa.gov/castnet/site.html

National Climatic Data Center (NCDC): http://www.ncdc.noaa.gov/oa/ncdc.html

NOAA National Data Centers (NNDC): http://ols.nndc.noaa.gov/plolstore/plsql/olstore.main?look=1

Table A-2 Upper Air Stations used in CALMET Processing

State	Station Name	Station ID	Latitude	Longitude	Base Elevation (m)	2002	2003	2004
IA	DAVENPORT MUNICIPAL AP	94982	41.60	-90.57	229	x	x	x
IL	LINCOLN-LOGAN COUNTY AP	04833	40.15	-89.33	178	x	x	x
MI	GAYLORD / ALPENA	04837	44.55	-84.43	448	x	x	x
MI	DETROIT/PONTIAC	04830	42.70	-83.47	329	x	x	x
MN	INTERNATIONAL FALLS	14918	48.57	-93.38	359	x	x	x
MN	MINNEAPOLIS	94983	44.83	-93.55	287	x	x	x
MO	SPRINGFIELD REGIONAL AP	13995	37.23	-93.40	394	x	x	x
OH	WILMINGTON	13841	39.42	-83.82	317	x	x	x
PA	PITTSBURGH/MOON TOWNSHIP	94823	40.53	-80.23	360	x	x	x
TN	NASHVILLE	13897	36.25	-86.57	180	x	x	x
WI	GREEN BAY	14898	44.48	-88.13	210	x	x	x
x - Data is used in CALMET								

Table A-3 Buoy Stations used in CALMET Processing

Buoy Name	Station ID	Latitude	Longitude	Anemometer Height (m)	2002	2003	2004
N Michigan	45002	45.33	-86.42	5	x	x	x
N Huron	45003	45.35	-82.84	5	x	x	x
E Superior	45004	47.57	-86.55	5	x	x	x
S Huron	45008	44.29	-82.42	5	x	x	x
x - Data is used in CALMET							

Table A-4 Precipitation Stations used in CALMET Processing

State	ID	Station Name	Latitude	Longitude	Elevation (m)	2002	2003	2004
AR	030616	BERRYVILLE 5 NW	36.4294	-93.6256	1180	x	x	x
AR	031020	BULL SHOALS DAM	36.3647	-92.5781	480	x	x	x
AR	031632	CORNING	36.4197	-90.5858	300	x	x	x
AR	032356	EUREKA SPRINGS 3 WNW	36.4164	-93.7917	1420	x	x	x
AR	033132	HARDY	36.2747	-91.5056	400	x	x	x
AR	033165	HARRISON BOONE CNTY AP	36.2667	-93.1567	1374	x	x	x
IL	110082	ALEXIS 1 SW	41.0639	-90.5639	680	x	x	x
IL	110281	ASHLEY	38.3306	-89.1814	555	x	x	x
IL	110330	AUGUSTA	40.2378	-90.9456	680	x	x	x
IL	110510	BELLEVILLE SIU RESEARCH	38.5200	-89.8467	450	x	x	x
IL	110583	BELVIDERE	42.2550	-88.8644	738	x	x	x
IL	111166	CAIRO 3 N	37.0425	-89.1856	310	x	x	x
IL	111284	CARLINVILLE 2	39.2881	-89.8700	621	x	x	x
IL	111290	CARLYLE RESERVOIR	38.6308	-89.3658	501	x	x	x
IL	111302	CARMI 3	38.0781	-88.1831	335	x	x	x
IL	111549	CHICAGO OHARE AP	41.9950	-87.9336	658	x	x	x
IL	111577	CHICAGO MIDWAY AP 3SW	41.7372	-87.7775	620	x	x	x
IL	111664	CISNE 2 S	38.5047	-88.4094	454	x	x	x
IL	112011	CRETE	41.4492	-87.6222	664	x	x	x
IL	112140	DANVILLE	40.1389	-87.6483	558	x	x	x
IL	112193	DECATUR	39.8275	-88.9525	620	x	x	x
IL	112353	DIXON SPRINGS AGRIC CNT	37.4367	-88.6672	540	x	x	x
IL	112687	EFFINGHAM	39.1189	-88.6242	625	x	x	x
IL	112923	FAIRBURY WWTP	40.7511	-88.4983	690	x	x	x
IL	113262	FREEPORT WASTE WTR PL	42.2972	-89.6039	750	x	x	x
IL	113666	GREENFIELD	39.3425	-90.2058	548	x	x	x
IL	113683	GREENUP 3SE	39.2283	-88.1261	545	x	x	x
IL	113879	HARRISBURG	37.7408	-88.5244	365	x	x	x
IL	114198	HOOPESTON 1 NE	40.4744	-87.6558	710	x	x	x
IL	114317	HUTSONVILLE POWER PLANT	39.1333	-87.6578	455	x	x	x
IL	114355	ILLINOIS CITY DAM 16	41.4253	-91.0094	550	x	x	x
IL	114442	JACKSONVILLE 2E	39.7353	-90.2153	610	x	x	x
IL	114603	KANKAKEE METRO WASTWTR	41.1381	-87.8856	640	x	x	x
IL	114629	KASKASKIA RIV NAV LOCK	37.9842	-89.9492	380	x	x	x
IL	114710	KEWANEE 1 E	41.2483	-89.8992	780	x	x	x
IL	114805	LACON 1 N	41.0414	-89.4061	460	x	x	x
IL	114879	LANARK	42.0925	-89.8422	830	x	x	x
IL	114957	LAWRENCEVILLE	38.7267	-87.6903	442	x	x	x
IL	115272	MACKINAW 1N	40.5525	-89.3336	710	x	x	x
IL	115334	MARIETTA	40.5019	-90.3892	640	x	x	x
IL	115413	MASON CITY 1 E	40.2003	-89.6775	575	x	x	x
IL	115493	MCHENRY WG STRATTON L&D	42.3103	-88.2525	742	x	x	x
IL	115751	MOLINE WSO AP	41.4653	-90.5233	592	x	x	x
IL	115768	MONMOUTH	40.9247	-90.6392	745	x	x	x
IL	115825	MORRIS 1 NW	41.3708	-88.4336	524	x	x	x
IL	115841	MORRISONVILLE	39.4158	-89.4614	630	x	x	x
IL	115888	MT CARMEL	38.4106	-87.7578	430	x	x	x
IL	115983	MURPHYSBORO 2 SW	37.7608	-89.3656	550	x	x	x
IL	116185	NOKOMIS	39.3053	-89.2828	680	x	x	x
IL	116610	PARIS WATERWORKS	39.6356	-87.6933	680	x	x	x
IL	116711	PEORIA GTR PEORIA RGNL	40.6675	-89.6839	650	x	x	x
IL	116819	PIPER CITY	40.7569	-88.1828	670	x	x	x
IL	116837	PITTSFIELD NO 2	39.6222	-90.8058	670	x	x	x
IL	117014	PROPHETSTOWN	41.6808	-89.9403	605	x	x	x
IL	117072	QUINCY REGIONAL AP	39.9369	-91.1919	769	x	x	x
IL	117077	QUINCY DAM 21	39.9058	-91.4281	483	x	x	x
IL	117150	RANTOUL	40.3131	-88.1594	740	x	x	x
IL	117187	REND LAKE DAM	38.0406	-88.9883	455	x	x	x
IL	117382	ROCKFORD AIRPORT	42.1928	-89.0931	730	x	x	x
IL	117391	ROCK ISLAND L&D 15	41.5194	-90.5644	568	x	x	x
IL	117833	SHABBONA 3S	41.7322	-88.8653	850	x	x	x
IL	117876	SHELBYVILLE DAM	39.4106	-88.7800	655	x	x	x
IL	118020	SMITHLAND LOCK & DAM	37.1644	-88.4311	357	x	x	x
IL	118147	SPARTA 1 W	38.1167	-89.7167	535	x	x	x
IL	118179	SPRINGFIELD CAPITAL AP	39.8447	-89.6839	594	x	x	x
IL	118389	SULLIVAN 3 S	39.5608	-88.6067	659	x	x	x
IL	118740	URBANA	40.0842	-88.2406	721	x	x	x
IL	118781	VANDALIA	38.9703	-89.0922	540	x	x	x
IL	119193	WEST SALEM	38.5306	-88.0219	445	x	x	x
IL	119816	YATES CITY	40.7764	-90.0203	675	x	x	x

Table A-4 Precipitation Stations used in CALMET Processing

State	ID	Station Name	Latitude	Longitude	Elevation (m)	2002	2003	2004
IN	120132	ALPINE 2 NE	39.5736	-85.1583	850	x	x	x
IN	120177	ANDERSON SEWAGE PLANT	40.1122	-85.7175	845	x	x	x
IN	120200	ANGOLA	41.6397	-84.9900	1010	x	x	x
IN	120331	ATTICA 2E	40.2839	-87.1964	727	x	x	x
IN	120482	BATESVILLE WATERWORKS	39.2969	-85.2186	970	x	x	x
IN	120830	BLUFFTON 1 N	40.7478	-85.1733	825	x	x	x
IN	120922	BRAZIL	39.5108	-87.1242	680	x	x	x
IN	121147	BURLINGTON 1 NW	40.4875	-86.4089	724	x	x	x
IN	121256	CANNELTON	37.8994	-86.7072	402	x	x	x
IN	121415	CHALMERS	40.6628	-86.8814	700	x	x	x
IN	121628	CLINTON 2 W	39.6592	-87.4392	605	x	x	x
IN	121739	COLUMBIA CITY	41.1450	-85.4897	850	x	x	x
IN	121752	COLUMBUS UTILITIES	39.2106	-85.8883	632	x	x	x
IN	121814	CORYDON	38.2181	-86.1178	590	x	x	x
IN	121873	CRAWFORDSVILLE 6 SE	39.9664	-86.9289	840	x	x	x
IN	121929	CROTHERSVILLE	38.7908	-85.8483	560	x	x	x
IN	122309	DUBOIS SRN IN FORAGE FA	38.4558	-86.7000	690	x	x	x
IN	122738	EVANSVILLE REGIONAL AP	38.0431	-87.5203	400	x	x	x
IN	122825	FARMLAND 5 NNW	40.2539	-85.1483	965	x	x	x
IN	123037	FORT WAYNE WSO AP	41.0061	-85.2056	791	x	x	x
IN	123082	FRANKFORT DISPOSAL PLT	40.2986	-86.5067	824	x	x	x
IN	123091	FRANKLIN WWTP	39.4689	-86.0408	719	x	x	x
IN	123104	FREELANDVILLE	38.8672	-87.3083	550	x	x	x
IN	123206	GARRETT	41.3411	-85.1292	880	x	x	x
IN	123418	GOSHEN 3W	41.5575	-85.8825	875	x	x	x
IN	123714	HARRISON CRAWFORD S F	38.1975	-86.2686	850	x	x	x
IN	123777	HARTFORD CITY 4 ESE	40.4356	-85.2892	942	x	x	x
IN	124181	HUNTINGTON	40.8556	-85.4981	725	x	x	x
IN	124259	INDIANAPOLIS INTL AP	39.7317	-86.2789	790	x	x	x
IN	124286	INDIANAPOLIS ZOO	39.7681	-86.1806	710	x	x	x
IN	124372	JASPER	38.3861	-86.9408	460	x	x	x
IN	124527	KENTLAND	40.7592	-87.4353	695	x	x	x
IN	124730	LAGRANGE 1 N	41.6739	-85.4250	915	x	x	x
IN	124782	LAKEVILLE	41.5269	-86.2692	841	x	x	x
IN	124837	LA PORTE	41.6117	-86.7297	845	x	x	x
IN	124908	LEBANON WATER WORKS	40.0517	-86.4750	950	x	x	x
IN	124973	LEWISVILLE	39.8061	-85.3483	1065	x	x	x
IN	125337	MARION 2 N	40.5800	-85.6586	790	x	x	x
IN	125407	MARTINSVILLE 2 SW	39.4042	-86.4517	610	x	x	x
IN	125535	MEDARYVILLE 5 N	41.1589	-86.9014	695	x	x	x
IN	126151	NEWBURGH LOCK & DAM	37.9325	-87.3744	380	x	x	x
IN	126580	OOLITIC PURDUE EXP FRM	38.8894	-86.5519	650	x	x	x
IN	126697	PALMYRA	38.4075	-86.1106	770	x	x	x
IN	126864	PERU WASTE WATER PLANT	40.7453	-86.0717	645	x	x	x
IN	127069	PORTLAND 1 SW	40.4356	-85.2889	910	x	x	x
IN	127125	PRINCETON 1 W	38.3567	-87.5906	480	x	x	x
IN	127298	RENSSELAER	40.9356	-87.1564	650	x	x	x
IN	127370	RICHMOND WTR WKS	39.8833	-84.8833	1015	x	x	x
IN	127482	ROCHESTER	41.0658	-86.2094	770	x	x	x
IN	127930	SEYMOUR HIGHWAY GARAGE	38.9617	-85.8608	595	x	x	x
IN	127959	SHAKAMAK STATE PARK	39.1614	-87.2436	530	x	x	x
IN	127999	SHELBYVILLE SEWAGE PL	39.5283	-85.7917	750	x	x	x
IN	128036	SHOALS 8 S	38.5897	-86.7989	506	x	x	x
IN	128187	SOUTH BEND WSO AP	41.7072	-86.3331	773	x	x	x
IN	128442	STENDAL	38.2692	-87.1631	635	x	x	x
IN	128784	TIPTON 5 SW	40.2233	-86.1086	895	x	x	x
IN	128967	J T MYERS LOCKS & DAM	37.7953	-87.9931	340	x	x	x
IN	128999	VALPARAISO WATERWORKS	41.5114	-87.0378	800	x	x	x
IN	129069	VERSAILLES WATERWORKS	39.0717	-85.2453	939	x	x	x
IN	129174	WALDRON 2 W	39.4539	-85.6964	825	x	x	x
IN	129430	WEST LAFAYETTE 6 NW	40.4750	-86.9919	715	x	x	x
IA	130149	ALLERTON	40.7039	-93.3639	1090	x	x	x
IA	130608	BELLEVUE L AND D 12	42.2614	-90.4233	603	x	x	x
IA	131060	BURLINGTON RADIO KBUR	40.8167	-91.1667	703	x	x	x
IA	131257	CASCADE	42.2975	-91.0133	850	x	x	x
IA	131354	CENTERVILLE	40.7364	-92.8692	980	x	x	x
IA	131363	CENTRAL CITY	42.2011	-91.5286	870	x	x	x
IA	131724	COLUMBIA	41.1756	-93.1522	950	x	x	x
IA	132195	DERBY	40.9308	-93.4581	1190	x	x	x
IA	132203	DES MOINES AP	41.5339	-93.6531	957	x	x	x

Table A-4 Precipitation Stations used in CALMET Processing

State	ID	Station Name	Latitude	Longitude	Elevation (m)	2002	2003	2004
IA	132367	DUBUQUE WSO AP	42.3978	-90.7036	1056	x	x	x
IA	132977	FOREST CITY 2 NNE	43.2844	-93.6306	1300	x	x	x
IA	133473	GRINNELL 3 SW	41.7203	-92.7489	905	x	x	x
IA	134101	IOWA CITY	41.6092	-91.5050	640	x	x	x
IA	134142	IOWA FALLS	42.5189	-93.2536	1130	x	x	x
IA	134381	KEOKUK LOCK DAM 19	40.3969	-91.3767	527	x	x	x
IA	134502	KNOXVILLE	41.3336	-93.1117	920	x	x	x
IA	134963	LOWDEN	41.8564	-90.9300	715	x	x	x
IA	135198	MARSHALLTOWN	42.0647	-92.9244	870	x	x	x
IA	135235	MASON CITY MUNI AP	43.1544	-93.3269	1225	x	x	x
IA	135295	MAXWELL	41.8875	-93.3919	875	x	x	x
IA	135315	MCGREGOR	43.0239	-91.1747	627	x	x	x
IA	135796	MOUNT PLEASANT 1 SSW	40.9486	-91.5647	730	x	x	x
IA	136076	NORTH ENGLISH	41.5119	-92.0725	797	x	x	x
IA	136389	OTTUMWA INDUSTRIAL AP	41.1078	-92.4467	842	x	x	x
IA	137326	ST ANSGAR	43.3817	-92.9156	1170	x	x	x
IA	137572	SHEFFIELD 3 NW	42.9217	-93.2828	1045	x	x	x
IA	137602	SHELL ROCK 2W	42.7081	-92.6153	912	x	x	x
IA	137855	SPILLVILLE	43.2053	-91.9536	1080	x	x	x
IA	137985	STORY CITY	42.1792	-93.5817	975	x	x	x
IA	138009	STRAWBERRY POINT	42.6842	-91.5353	1200	x	x	x
IA	138315	TRAER	42.1869	-92.4728	950	x	x	x
IA	138688	WASHINGTON	41.2828	-91.7069	690	x	x	x
IA	138706	WATERLOO MUNICIPAL AP	42.5544	-92.4011	868	x	x	x
KY	150381	BARBOURVILLE	36.8825	-83.8819	990	x	x	x
KY	150450	BAXTER	36.8583	-83.3303	1164	x	x	x
KY	150611	BENTON	36.8581	-88.3364	365	x	x	x
KY	150619	BEREA COLLEGE	37.5733	-84.2908	1070	x	x	x
KY	151080	BUCKHORN LAKE	37.3500	-83.3833	936	x	x	x
KY	151227	CALHOUN LOCK 2	37.5317	-87.2667	402	x	x	x
KY	151631	CLINTON 4 S	36.6267	-88.9608	350	x	x	x
KY	151855	COVINGTON WSO	39.0431	-84.6717	869	x	x	x
KY	152358	DUNDEE 2NE	37.5806	-86.7769	450	x	x	x
KY	152979	FORDSVILLE	37.6372	-86.7206	480	x	x	x
KY	153741	HEIDELBERG	37.5500	-83.7667	665	x	x	x
KY	153798	HERNDON 5 S	36.6703	-87.5589	560	x	x	x
KY	153929	HODGENVILLE-LINCOLN NP	37.5317	-85.7350	788	x	x	x
KY	154202	JACKSON WSO	37.5914	-83.3144	1365	x	x	x
KY	154650	LEBANON 5 S	37.5050	-85.3086	660	x	x	x
KY	154746	LEXINGTON BLUEGRASS AP	38.0408	-84.6058	980	x	x	x
KY	154948	LOUISA 5 W	38.1250	-82.6947	753	x	x	x
KY	154954	LOUISVILLE INTL AP	38.1811	-85.7392	488	x	x	x
KY	154955	LOUISVILLE UPPER GAGE	38.2833	-85.8000	440	x	x	x
KY	155067	MADISONVILLE	37.3467	-87.5244	440	x	x	x
KY	155243	MAYSVILLE SEWAGE PLANT	38.6869	-83.7872	515	x	x	x
KY	155555	MOREHEAD 3 NW	38.2167	-83.4833	830	x	x	x
KY	155684	MUNFORDVILLE 5 NW	37.3347	-85.9503	680	x	x	x
KY	156012	OLIVE HILL 5 NE	38.3422	-83.1036	891	x	x	x
KY	156110	PADUCAH BARKLEY AP	37.0564	-88.7742	413	x	x	x
KY	156170	PARIS	38.2047	-84.2392	810	x	x	x
KY	156580	PRINCETON 1 SE	37.1244	-87.8672	497	x	x	x
KY	157074	SADIEVILLE	38.4078	-84.6836	945	x	x	x
KY	157473	SMITHFIELD 4 S	38.3333	-85.2861	850	x	x	x
KY	157508	SOMERSET 2 NE	37.1167	-84.6000	955	x	x	x
KY	157622	STAFFORDSVILLE 2 NW	37.8500	-82.8667	760	x	x	x
KY	157677	STEARNS 2 S	36.6667	-84.4833	1220	x	x	x
KY	158070	TOMPKINSVILLE 9 NW	36.8136	-85.7081	1060	x	x	x
KY	158719	WILLISBURG	37.8014	-85.1131	870	x	x	x
KY	158824	WOODBURY	37.1842	-86.6353	465	x	x	x
MI	200128	ALLEGAN 5 NE	42.5797	-85.7894	750	x	x	x
MI	200164	ALPENA COUNTY RGNL AP	45.0717	-83.5644	684	x	x	x
MI	200230	ANN ARBOR U OF MICH	42.2947	-83.7108	900	x	x	x
MI	200373	AVOCA 4 N	43.1256	-82.6886	770	x	x	x
MI	200662	BELLAIRE	44.9758	-85.1978	625	x	x	x
MI	200766	BIG BAY 8 NW	46.8867	-87.8642	612	x	x	x
MI	201088	BRUCE CROSSING	46.5333	-89.1833	1135	x	x	x
MI	201361	CASS CITY 1 SSW	43.5861	-83.1806	698	x	x	x
MI	201486	CHATHAM EXP FARM 2	46.3467	-86.9289	870	x	x	x
MI	201680	COLDWTR WASTEWTR PLT	41.9397	-85.0183	950	x	x	x
MI	201780	COPPER HARBOR FT WILKIN	47.4675	-87.8669	625	x	x	x

Table A-4 Precipitation Stations used in CALMET Processing

State	ID	Station Name	Latitude	Longitude	Elevation (m)	2002	2003	2004
MI	202094	DETOUR VILLAGE	45.9983	-83.9014	595	x	x	x
MI	202103	DETROIT METRO AP	42.2314	-83.3308	631	x	x	x
MI	202395	EAST LANSING 4 S	42.6742	-84.4850	880	x	x	x
MI	202626	ESCANABA	45.7500	-87.0333	591	x	x	x
MI	202788	FIFE LAKE 3WSW	44.5650	-85.4133	1112	x	x	x
MI	202846	FLINT BISHOP INTL AP	42.9667	-83.7494	770	x	x	x
MI	203170	GLADWIN	43.9758	-84.4908	775	x	x	x
MI	203199	GLENNIE ALCONA DAM	44.5617	-83.8031	805	x	x	x
MI	203295	GRAND HAVEN WASTEWTR PL	43.0608	-86.2047	605	x	x	x
MI	203333	GRAND RAPIDS INTL AP	42.8825	-85.5239	803	x	x	x
MI	203391	GRAYLING	44.6542	-84.6994	1136	x	x	x
MI	203516	GWINN 1 W	46.2864	-87.4511	1162	x	x	x
MI	203585	HARBOR BEACH 1 SSE	43.8322	-82.6428	595	x	x	x
MI	203936	HOUGHTON LAKE ROSCOMMON	44.3592	-84.6739	1151	x	x	x
MI	203947	HOWELL WWTP	42.5936	-83.9322	917	x	x	x
MI	204090	IRON MTN-KINGSFORD WWTP	45.7858	-88.0842	1071	x	x	x
MI	204155	JACKSON 3 N	42.2833	-84.4167	950	x	x	x
MI	204320	KENT CITY 2 SW	43.1994	-85.7717	840	x	x	x
MI	204641	LANSING CAPITAL CITY A	42.7803	-84.5789	841	x	x	x
MI	205073	MANISTIQUE WWTP	45.9511	-86.2511	620	x	x	x
MI	205567	MONTAGUE 4 NW	43.4614	-86.4175	650	x	x	x
MI	205712	MUSKEGON COUNTY AP	43.1711	-86.2367	625	x	x	x
MI	205816	NEWBERRY 3 S	46.3133	-85.5106	850	x	x	x
MI	206215	ONTONAGON	46.8561	-89.3119	673	x	x	x
MI	206300	OWOSSO WWTP	43.0161	-84.1800	730	x	x	x
MI	206438	PELLSTON REGIONAL AP	45.5644	-84.7928	705	x	x	x
MI	207366	SAULT STE MARIE SNDRSN	46.4794	-84.3572	722	x	x	x
MI	207812	STAMBAUGH 2 SSE	46.0556	-88.6278	1450	x	x	x
MI	207828	STANTON	43.2908	-85.0922	930	x	x	x
MI	208246	TRAVERSE CITY	44.7683	-85.5761	604	x	x	x
MI	208293	TROUT LAKE 2WNW	46.1989	-85.0728	871	x	x	x
MI	208417	VANDERBILT 11ENE	45.1703	-84.4397	905	x	x	x
MI	208443	VASSAR	43.3656	-83.5828	630	x	x	x
MI	208559	WAKEFIELD	46.4792	-89.9322	1600	x	x	x
MI	209218	YPSILANTI E MICH U	42.2475	-83.6253	780	x	x	x
MN	210075	ALBERT LEA 3 SE	43.6064	-93.3019	1230	x	x	x
MN	211227	CAMBRIDGE 5ESE	45.5506	-93.1264	960	x	x	x
MN	212166	DODGE CENTER	44.0419	-92.8814	1250	x	x	x
MN	212248	DULUTH INTL AP	46.8369	-92.1833	1433	x	x	x
MN	212543	ELY	47.9239	-91.8586	1382	x	x	x
MN	212645	EVELETH WASTE WATER PLA	47.4581	-92.5303	1445	x	x	x
MN	212842	FLOODWOOD 3 NE	46.9728	-92.8700	1260	x	x	x
MN	213202	GOLDEN VALLEY	44.9944	-93.4075	910	x	x	x
MN	213417	GUNFLINT LAKE 10 NW	48.1603	-90.8842	1455	x	x	x
MN	213793	HINCKLEY	45.9919	-92.9928	1035	x	x	x
MN	213863	HOLYOKE	46.4675	-92.3903	1034	x	x	x
MN	214418	LA CRESCENT DAM 7	43.8658	-91.3100	647	x	x	x
MN	215435	MINNEAPOLIS/ST PAUL AP	44.8831	-93.2289	872	x	x	x
MN	215987	NORTHFIELD 2 NNE	44.4761	-93.1486	890	x	x	x
MN	216213	ORR	48.0553	-92.8425	1390	x	x	x
MN	216822	RED WING DAM 3	44.6103	-92.6100	677	x	x	x
MN	217004	ROCHESTER INTERNATIONAL	43.9042	-92.4917	1304	x	x	x
MN	217184	RUSHFORD	43.8053	-91.7500	770	x	x	x
MN	217460	SANDY LAKE DAM LIBBY	46.7953	-93.3211	1234	x	x	x
MN	217941	SPRING VALLEY	43.6933	-92.3925	1280	x	x	x
MN	218280	TOFTE RANGER STATION	47.5681	-90.8500	680	x	x	x
MN	218613	WALES 2E	47.2561	-91.7017	1675	x	x	x
MO	230022	ADVANCE 1 S	37.0956	-89.9058	360	x	x	x
MO	230088	ALLEY SPRING RGR STA	37.1528	-91.4439	700	x	x	x
MO	230789	BOLIVAR 1 NE	37.6167	-93.3911	1034	x	x	x
MO	231283	CAP AU GRIS LOCK & DAM	39.0031	-90.6886	450	x	x	x
MO	231600	CLARENCE CANNON DAM	39.5253	-91.6450	702	x	x	x
MO	231640	CLARKSVILLE L&D 24	39.3731	-90.9053	460	x	x	x
MO	231674	CLEARWATER DAM	37.1319	-90.7756	660	x	x	x
MO	231711	CLINTON	38.3950	-93.7711	770	x	x	x
MO	231791	COLUMBIA REGIONAL AP	38.8169	-92.2183	893	x	x	x
MO	232302	DORA	36.7797	-92.2328	990	x	x	x
MO	232318	DOWNING	40.4822	-92.3636	870	x	x	x
MO	232809	FARMINGTON	37.7922	-90.4103	928	x	x	x
MO	233079	FULTON	38.8581	-91.9300	870	x	x	x

Table A-4 Precipitation Stations used in CALMET Processing

State	ID	Station Name	Latitude	Longitude	Elevation (m)	2002	2003	2004
MO	233601	HANNIBAL WATER WORKS	39.7233	-91.3719	712	x	x	x
MO	234271	JEFFERSON CITY WTR PL	38.5850	-92.1825	670	x	x	x
MO	234273	JEFFERSON BARRACKS	38.5039	-90.2800	490	x	x	x
MO	234544	KIRKSVILLE	40.2058	-92.5747	970	x	x	x
MO	234825	LEBANON 2W	37.6850	-92.6936	1279	x	x	x
MO	234919	LICKING 4N	37.5544	-91.8831	1180	x	x	x
MO	235050	LONG BRANCH RESERVOIR	39.7506	-92.5064	820	x	x	x
MO	235130	LURAY 2 N	40.4892	-91.8781	740	x	x	x
MO	235207	MALDEN MUNICIPAL AP	36.5994	-89.9894	290	x	x	x
MO	235298	MARSHALL	39.1342	-93.2225	790	x	x	x
MO	235307	MARSHFIELD	37.3381	-92.9097	1490	x	x	x
MO	235415	MC CREDIE EXPERIMENT ST	38.9500	-91.9000	850	x	x	x
MO	235562	MIDDLETOWN	39.1244	-91.4142	680	x	x	x
MO	235594	MILLER 1 E	37.2147	-93.8228	1296	x	x	x
MO	235671	MOBERLY	39.4194	-92.4369	860	x	x	x
MO	235834	MOUNTAIN GROVE 2 N	37.1528	-92.2636	1450	x	x	x
MO	236012	NEW FRANKLIN 1 W	39.0172	-92.7558	641	x	x	x
MO	236460	OZARK BEACH	36.6597	-93.1261	700	x	x	x
MO	236777	POMME DE TERRE DAM	37.9050	-93.3169	900	x	x	x
MO	236826	POTOSI 5 SW	37.8908	-90.8600	1030	x	x	x
MO	237263	ROLLA UNI OF MISSOURI	37.9572	-91.7758	1167	x	x	x
MO	237300	ROSEBUD	38.4506	-91.3756	960	x	x	x
MO	237452	ST LOUIS SCIENCE CENTER	38.6292	-90.2706	545	x	x	x
MO	237455	ST LOUIS LAMBERT INTL	38.7525	-90.3736	531	x	x	x
MO	237506	SALEM	37.6331	-91.5364	1200	x	x	x
MO	237976	SPRINGFIELD REG AP	37.2397	-93.3897	1259	x	x	x
MO	238043	STEELVILLE 2 N	38.0053	-91.3706	700	x	x	x
MO	238051	STEFFENVILLE	39.9714	-91.8872	690	x	x	x
MO	238082	STOCKTON DAM	37.6967	-93.7722	873	x	x	x
MO	238223	SWEET SPRINGS	38.9631	-93.4000	670	x	x	x
MO	238252	TABLE ROCK DAM	36.5972	-93.3075	820	x	x	x
MO	238466	TRUMAN DAM & RESERVOIR	38.2581	-93.3989	632	x	x	x
MO	238609	VIBURNUM	37.7119	-91.1328	1276	x	x	x
MO	238620	VIENNA 2 WNW	38.2017	-91.9811	770	x	x	x
MO	238700	WAPPAPELLO DAM	36.9231	-90.2836	410	x	x	x
MO	238712	WARRENSBURG 4 NW	38.7842	-93.8008	796	x	x	x
MO	238746	WASHINGTON	38.5425	-90.9719	490	x	x	x
MO	238827	WENTZVILLE	38.8128	-90.8561	580	x	x	x
MO	238880	WEST PLAINS	36.7425	-91.8347	1010	x	x	x
OH	330058	AKRON CANTON WSO AP	40.9167	-81.4333	1208	x	x	x
OH	330059	AKRON WPCS	41.1500	-81.5667	750	x	x	x
OH	330107	ALLIANCE 3 NNW	40.9550	-81.1169	1055	x	x	x
OH	330256	ASHLAND 2 SW	40.8333	-82.3500	1265	x	x	x
OH	330493	BEACH CITY LAKE	40.6333	-81.5667	985	x	x	x
OH	330639	BERLIN LAKE	41.0333	-81.0167	1040	x	x	x
OH	330862	BOWLING GREEN WWTP	41.3831	-83.6111	675	x	x	x
OH	331042	BRYAN 2 SE	41.4619	-84.5272	730	x	x	x
OH	331197	CAMBRIDGE	40.0167	-81.5833	800	x	x	x
OH	331404	CENTERBURG 2 SE	40.3000	-82.6500	1205	x	x	x
OH	331466	CHARLES MILL LAKE	40.7400	-82.3569	1025	x	x	x
OH	331528	CHILLICOTHE MOUND CITY	39.3744	-83.0036	650	x	x	x
OH	331536	CHILO MELDAHL L&D	38.7983	-84.1731	500	x	x	x
OH	331541	CHIPPEWA LAKE	41.0517	-81.9361	1180	x	x	x
OH	331592	CIRCLEVILLE	39.6106	-82.9547	673	x	x	x
OH	331651	CLEVELAND EASTERLY	41.5667	-81.5833	550	x	x	x
OH	331657	CLEVELAND WSFO AP	41.4050	-81.8528	770	x	x	x
OH	331786	COLUMBUS WSO AIRPORT	39.9914	-82.8808	810	x	x	x
OH	331905	COSHOCTON AGRI RS STA	40.3708	-81.7908	1140	x	x	x
OH	332075	DAYTON WSO AIRPORT	39.9061	-84.2186	1000	x	x	x
OH	332090	DEER CREEK LAKE	39.6253	-83.2128	860	x	x	x
OH	332098	DEFIANCE	41.2778	-84.3853	700	x	x	x
OH	332124	DELAWARE LAKE	40.3667	-83.0667	930	x	x	x
OH	332272	DOVER DAM	40.5667	-81.4167	930	x	x	x
OH	332485	EATON	39.7347	-84.6336	1002	x	x	x
OH	332651	FAIRFIELD	39.3500	-84.5833	575	x	x	x
OH	332791	FINDLAY WPCC	41.0461	-83.6622	768	x	x	x
OH	332956	FREDERICKTOWN 4 S	40.4167	-82.5333	1050	x	x	x
OH	332974	FREMONT	41.3333	-83.1167	600	x	x	x
OH	333021	GALION WATER WORKS	40.7167	-82.8000	1170	x	x	x

Table A-4 Precipitation Stations used in CALMET Processing

State	ID	Station Name	Latitude	Longitude	Elevation (m)	2002	2003	2004
OH	333120	GERMANTOWN DAM	39.6358	-84.4003	740	x	x	x
OH	333356	GREENFIELD 1 WNW	39.3542	-83.4056	970	x	x	x
OH	333375	GREENVILLE WATER PLANT	40.1000	-84.6500	1024	x	x	x
OH	333758	HILLSBORO	39.2000	-83.6167	1100	x	x	x
OH	334004	JACKSON 3 NW	39.0775	-82.7053	800	x	x	x
OH	334189	KENTON	40.6489	-83.6061	995	x	x	x
OH	334403	LANCASTER	39.7156	-82.6072	840	x	x	x
OH	334459	LEBANON 4 SE	39.3689	-84.2394	680	x	x	x
OH	334473	LEESVILLE LAKE	40.4667	-81.2000	980	x	x	x
OH	334551	LIMA WWTP	40.7247	-84.1294	850	x	x	x
OH	334672	LOGAN	39.5292	-82.3850	722	x	x	x
OH	334681	LONDON	39.8833	-83.4500	1020	x	x	x
OH	334865	MANSFIELD WSO AP	40.8203	-82.5178	1295	x	x	x
OH	334942	MARION 2 N	40.6167	-83.1333	965	x	x	x
OH	334979	MARYSVILLE	40.2411	-83.3669	1000	x	x	x
OH	334992	MASSILLON	40.7667	-81.5333	930	x	x	x
OH	335029	MC ARTHUR	39.2503	-82.4822	785	x	x	x
OH	335041	MC CONNELSVILLE LOCK 7	39.6539	-81.8569	760	x	x	x
OH	335297	MILLERSBURG	40.5500	-81.9167	819	x	x	x
OH	335398	MOHAWK DAM	40.3486	-82.0908	865	x	x	x
OH	335585	MOUNT VERNON	40.3833	-82.4667	980	x	x	x
OH	335747	NEWARK WATER WORKS	40.0875	-82.4131	835	x	x	x
OH	336123	NORWALK 5 SE	41.1833	-82.5667	925	x	x	x
OH	336196	OBERLIN	41.2667	-82.2167	816	x	x	x
OH	336375	OXFORD	39.5167	-84.7333	860	x	x	x
OH	336616	PIEDMONT LAKE	40.1833	-81.2167	940	x	x	x
OH	336650	PIQUA WWTP	40.1311	-84.2342	800	x	x	x
OH	336702	PLEASANT HILL LAKE	40.6167	-82.3333	1125	x	x	x
OH	336781	PORTSMOUTH SCIOTOVILLE	38.7569	-82.8872	540	x	x	x
OH	336949	RAVENNA 2 S	41.1333	-81.2833	1107	x	x	x
OH	337383	ST MARYS 3 W	40.5447	-84.4375	875	x	x	x
OH	337559	SENECAVILLE LAKE	39.9222	-81.4347	875	x	x	x
OH	337698	SIDNEY HIGHWAY DEPT	40.2983	-84.1633	1030	x	x	x
OH	337935	SPRINGFIELD NEW WTR WKS	39.9667	-83.8167	930	x	x	x
OH	338240	TAPPAN DAM	40.3561	-81.2281	950	x	x	x
OH	338313	TIFFIN	41.1167	-83.1667	740	x	x	x
OH	338357	TOLEDO EXPRESS WSO AP	41.5886	-83.8014	669	x	x	x
OH	338378	TOM JENKINS DAM-BURR OA	39.5444	-82.0589	760	x	x	x
OH	338539	UPPER SANDUSKY WATER WK	40.8167	-83.2833	820	x	x	x
OH	338552	URBANA WWTP	40.1000	-83.7833	1000	x	x	x
OH	338810	WATERLOO	38.7003	-82.4736	625	x	x	x
OH	339211	WILLS CREEK LAKE	40.1500	-81.8500	780	x	x	x
OH	339224	WILMINGTON	39.4333	-83.8500	975	x	x	x
OH	339312	WOOSTER EXP STN	40.7833	-81.9167	1020	x	x	x
OH	339357	XENIA TREATMENT PLANT	39.7167	-83.9667	820	x	x	x
OH	339422	ZANESVILLE WWTP	39.9125	-82.0042	700	x	x	x
TN	401094	BRISTOL AP	36.4731	-82.4044	1500	x	x	x
TN	401561	CELINA	36.5408	-85.4594	540	x	x	x
TN	401663	CHEATHAM LOCK & DAM	36.3244	-87.2244	392	x	x	x
TN	405332	LIVINGSTON RADIO WLIV	36.3772	-85.3394	975	x	x	x
TN	407359	PORTLAND SEWAGE PLANT	36.5875	-86.5258	794	x	x	x
TN	407884	ROGERSVILLE 1 NE	36.4161	-82.9839	1355	x	x	x
TN	408065	SAMBURG W. L. REFUGE	36.4528	-89.3028	310	x	x	x
TN	408562	SPRINGFIELD EXPERIMENT	36.4739	-86.8472	745	x	x	x
TN	409219	UNION CITY	36.3925	-89.0317	350	x	x	x
VA	444180	HURLEY 4 S	37.3653	-82.0561	1088	x	x	x
VA	449215	WISE 3E	36.9986	-82.5389	2549	x	x	x
WV	461570	CHARLESTON YEAGER AP	38.3794	-81.5914	910	x	x	x
WV	461579	CHARLESTON WSFO	38.3139	-81.7186	918	x	x	x
WV	463749	GRIFFITHSVILLE	38.2381	-81.9853	780	x	x	x
WV	464393	HUNTINGTON TRI/STATE	38.3650	-82.5550	824	x	x	x
WV	465323	LIVERPOOL	38.8956	-81.5311	665	x	x	x
WV	465353	LOGAN	37.8611	-81.9961	640	x	x	x
WV	468351	SOUTHSIDE 3 NNW	38.7506	-81.9808	576	x	x	x
WI	470045	AFTON	42.6475	-89.0644	742	x	x	x
WI	470124	ALMA DAM 4	44.3272	-91.9194	670	x	x	x

Table A-4 Precipitation Stations used in CALMET Processing

State	ID	Station Name	Latitude	Longitude	Elevation (m)	2002	2003	2004
WI	470308	ARLINGTON UNIV FARM	43.3008	-89.3269	1080	x	x	x
WI	470349	ASHLAND EXP FARM	46.5728	-90.9714	650	x	x	x
WI	470456	BABCOCK 1 WNW	44.2994	-90.1306	980	x	x	x
WI	470855	BLACK RVR FALLS SWG	44.2903	-90.8536	810	x	x	x
WI	470890	BLANCHARDVILLE	42.8169	-89.8628	830	x	x	x
WI	471416	CHARMANY FARM	43.0603	-89.4781	910	x	x	x
WI	471568	CHILTON	44.0328	-88.1469	840	x	x	x
WI	471578	CHIPPEWA FALLS	44.9278	-91.4081	850	x	x	x
WI	471667	CLINTON	42.5492	-88.8753	960	x	x	x
WI	471676	CLINTONVILLE	44.6225	-88.7483	800	x	x	x
WI	471897	CRIVITZ HIGH FALLS	45.3581	-88.1925	1050	x	x	x
WI	471913	CUBA CITY 2NW	42.6253	-90.4592	900	x	x	x
WI	472447	EAU PLEINE RESERVOIR	44.7247	-89.7567	1138	x	x	x
WI	472973	FRIENDSHIP	43.9750	-89.8308	945	x	x	x
WI	473038	GENOA DAM 8	43.5706	-91.2294	639	x	x	x
WI	473269	GREEN BAY A S INTL AP	44.4794	-88.1378	687	x	x	x
WI	473453	HARTFORD 2 W	43.3311	-88.4114	980	x	x	x
WI	473511	HAYWARD RANGER STA	46.0003	-91.5075	1200	x	x	x
WI	473636	HILES	45.6811	-88.9603	1633	x	x	x
WI	473756	HORICON	43.4406	-88.6325	880	x	x	x
WI	474370	LA CROSSE MUNICIPAL AIR	43.8789	-91.2528	652	x	x	x
WI	474396	LADYSMITH WTP	45.4431	-91.0894	1160	x	x	x
WI	474404	LA FARGE	43.5753	-90.6417	810	x	x	x
WI	474546	LANCASTER 4 WSW	42.8278	-90.7889	1040	x	x	x
WI	474894	LUCK	45.5733	-92.4850	1220	x	x	x
WI	474937	LYNXVILLE DAM 9	43.2117	-91.0986	633	x	x	x
WI	474961	MADISON DANE COUNTY AP	43.1406	-89.3453	866	x	x	x
WI	475120	MARSHFIELD EXP FARM	44.6322	-90.1314	1250	x	x	x
WI	475255	MEDFORD	45.1308	-90.3439	1470	x	x	x
WI	475335	MENOMONIE	44.8742	-91.9364	780	x	x	x
WI	475352	MERCER RANGER STN	46.1683	-90.0722	1600	x	x	x
WI	475364	MERRILL	45.1706	-89.6614	1253	x	x	x
WI	475479	MILWAUKEE MITCHELL AP	42.9550	-87.9044	670	x	x	x
WI	475524	MINONG RANGER STN	46.1006	-91.8178	1080	x	x	x
WI	475948	NEW RICHMOND	45.1167	-92.5639	1000	x	x	x
WI	476398	PARK FALLS DNR HQ	45.9336	-90.4506	1525	x	x	x
WI	476510	PESHTIGO	45.0203	-87.7342	600	x	x	x
WI	476518	PHELPS	46.0658	-89.0756	1776	x	x	x
WI	476718	PORTAGE	43.5278	-89.4342	775	x	x	x
WI	476854	PRENTICE	45.5478	-90.2883	1540	x	x	x
WI	476939	RAINBOW RSVR-LK TOMAHAW	45.8342	-89.5494	1600	x	x	x
WI	477132	RICE LAKE	45.4164	-91.7719	1103	x	x	x
WI	477140	RICE RESERVOIR TOMAHAWK	45.5406	-89.7481	1465	x	x	x
WI	478027	SPOONER EXPERMNT FARM	45.8236	-91.8761	1100	x	x	x
WI	478259	STRUM 4 S	44.4964	-91.3964	976	x	x	x
WI	478267	STURGEON BAY EXP FARM	44.8722	-87.3353	656	x	x	x
WI	478316	SULLIVAN 3SE	42.9675	-88.5497	933	x	x	x
WI	478515	TOMAH RANGER STATION	43.9908	-90.5053	960	x	x	x
WI	478589	TREMPEALEAU DAM 6	43.9994	-91.4378	660	x	x	x
WI	479176	WHITE LAKE 3 NE	45.1817	-88.7344	1285	x	x	x
WI	479218	WILLARD	44.7314	-90.7217	1490	x	x	x
WI	479304	WINTER	45.8231	-91.0139	1397	x	x	x
x - Data is used in CALMET								

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Appendix B

Re-Calculating CALPOST Visibility Outputs with the New IMPROVE Algorithm

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Instructions:
A Postprocessor for Recalculating CALPOST Visibility Outputs with the New IMPROVE Algorithm

Version 2
14 October 2006

Introduction

CALPOST can be used to processes outputs from CALPUFF modeling of a source's emissions to calculate the 24-hr average visibility impairments caused by primary and secondary particulate matter attributable to emissions from the modeled source. Those increments are presented in two tables, both labeled "Ranked Daily Visibility Change", in the CALPOST output (.LST) file. The table of interest to us has the subtitle "Modeled Extinction by Species" and lists the dates and locations of such incremental impacts in light extinction (b_{ext}) in ranked order, starting with the one that represents the largest percentage change in light extinction.[1]

In addition, with a different setup of the control file CALPOST.INP, the CALPOST postprocessor can be used to calculate 24-hr averages of NO_x concentrations. As described below, the outputs from that additional CALPOST run can be used to assess the visibility impact of the NO_2 gas in the source plume.

Visibility effects due to particulate matter are calculated in CALPOST from CALPUFF-modeled particulate matter component concentrations using effectively the "traditional" IMPROVE algorithm. CALPOST allows for choice of the humidity scattering enhancement function (f(RH)) to be used with the IMPROVE algorithm; for modeling in connection with the US EPA's Regional Haze Regulations (RHR), the appropriate form of f(RH) is the one described and tabulated in the EPA's 2003 guidance for tracking progress under the RHR. Visibility effects due to NO_2 are not considered in the CALPOST visibility calculation.

Recently, the IMPROVE Steering Committee developed a new algorithm for estimating light extinction from particulate matter component concentrations. This algorithm (the "new IMPROVE algorithm") provides a better correspondence between the measured visibility and

[1] The other table in the CALPOST visibility output file, with the subtitle "% of Modeled Extinction by Species", provides equivalent results in terms of changes in the haze index, in deciviews. The two tables represent the same results, with identical ranking of events, while just using different (but mathematically related) metrics.

that calculated from particulate matter component concentrations. The new algorithm differs in several substantive ways from the traditional one:

- The extinction efficiencies of sulfates, nitrates, and organics have been changed and are now functions of their concentrations. The extinction efficiencies of sulfate and nitrate are no longer identical, although the new hygroscopic scattering enhancement factors applied to them are the same.
- The concentration of particulate organic matter (POM; variously also labeled OCM or OMC, and sometimes just called "organics") is now taken to be 1.8 times that of the measured organic carbon (OC) concentration. (Confusingly, CALPOST labels the organics concentration as OC.)
- The contribution of fine sea salt to light extinction has been added, and is accompanied by its own hygroscopic scattering enhancement factor, $f_{ss}(RH)$.
- The light scattering by air itself (Rayleigh scattering) now varies with site elevation and mean temperature. It is to be rounded off to the nearest one Mm^{-1} when used with the new algorithm.
- The light absorption by NO_2 gas has been added.

The new IMPROVE algorithm is represented by the following formula:[2]

$$\begin{aligned} b_{ext} = \ & 2.2 \bullet f_S(RH) \bullet [small\ sulfate] + 4.8 \bullet f_L(RH) \bullet [large\ sulfate] \\ & + 2.4 \bullet f_S(RH) \bullet [small\ nitrate] + 5.1 \bullet f_L(RH) \bullet [large\ nitrate] \\ & + 2.8 \bullet [small\ organics] + 6.1 \bullet [large\ organics] \\ & + 10 \bullet [elemental\ carbon] \\ & + 1 \bullet [fine\ soil] \\ & + 1.7 \bullet f_{SS}(RH) \bullet [sea\ salt] \\ & + 0.6 \bullet [coarse\ matter] \\ & + Rayleigh\ scattering\ (site\ specific) \\ & + 0.33 \bullet [NO_2(ppb)] \end{aligned} \qquad \text{(Eq. 1)}$$

The concentrations of "large" and "small" sulfate particles are calculated as follows:

$$[large\ sulfate] = \{[total\ sulfate]/20\} \bullet [total\ sulfate]\ if\ [total\ sulfate] < 20\ \mu g^3$$

$$[large\ sulfate] = [total\ sulfate]\ if\ [total\ sulfate] \geq 20\ \mu g/m^3 \qquad \text{(Eqs. 2)}$$

$$[small\ sulfate] = [total\ sulfate] - [large\ sulfate].$$

Identical formulas, with changes in component names, are used for nitrate and organics. In effect, these formulas conclude that low concentrations of these components are mainly in the form of "small" particles with their own extinction efficiency and $f_S(RH)$, while high

[2] Square brackets denote concentrations.

concentrations (approaching 20 $\mu g/m^3$) are mainly in the form of "large" particles with a different extinction efficiency and $f_L(RH)$. The scaling factor [total sulfate]/20 sets the fraction of total sulfate that is small.

The sea salt concentration is taken to be 1.8•[Cl^-] or, if chloride ion measurements are not available, the chlorine concentration can be used in its place. Site specific Rayleigh scattering values have been calculated for all IMPROVE sites.[3] Nitrogen dioxide concentrations are not measured at IMPROVE sites, but the ambient NO_2 concentrations under natural conditions can be expected to be negligibly small. The higher NO_2 concentration in a source plume may be great enough to cause a change in visibility, however.

In order to enable CALPOST to calculate CALPUFF-modeled source impacts on visibility using the new IMPROVE algorithm, it would have to be extensively reprogrammed. As an alternative, such a calculation could be done "off line" by adding another layer of post processing after CALPOST. To this end, I have developed a processor, in the form of an Excel workbook, that takes the CALPOST "Ranked Daily Visibility Change: Modeled Extinction by Species" output table, referenced against default annual average natural conditions concentrations, and creates an equivalent table of results based on the new algorithm. It can also incorporate the visibility impact due to light absorption by NO_2 in the plume.

The following describes the science behind the processor (which we'll call the CALPOST-IMPROVE Processor) and provides instructions for using it.

Concepts

In addition to the mechanical changes imposed by all the new terms in the new IMPROVE formula, applying the new algorithm also requires some conceptual changes. The biggest of these is that the extinction efficiencies of sulfates, nitrates, and organics now depend on the concentrations of those species. The practical implication of this is that extinction is no longer linearly additive. To calculate total extinction, you cannot take a background level of extinction and add to it CALPOST's calculation of extinction caused by the particulate matter coming from a source, because when the two aerosols mix in the atmosphere their combined mass concentration results in increases in the extinction efficiencies of both the background and the source contribution. This means that combining background particulate matter with the particulate matter from a source gives an extinction result that is greater than the sum of the two separate extinctions.

With the nonlinear behavior resulting from applying the new IMPROVE algorithm, the extinction impact of the source (i.e., the increase in extinction resulting from introducing source emissions into the atmosphere) is the sum of three parts:

1. The source impact calculated by the new IMPROVE algorithm using the CALPOST outputs for a plume in isolation;

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[3] *Revised IMPROVE Algorithm for estimating Light Extinction from Particle Speciation Data.* Report to IMPROVE Steering Committee, November 2005.

2. An increase in that source impact because the extinction efficiency increases when the source's aerosol combines with the background aerosol; and correspondingly,

3. An increase in the extinction of the background aerosol because of that same mixing.

The total new extinction is the sum of the above three components plus the original background extinction. The original background extinction is just that calculated by the new IMPROVE algorithm from background concentrations of the various components, without any consideration of the effects of the plume. For this application, the background is taken to be that described by EPA's default natural conditions. The difference between the total extinction and the background is the impact of the source.

More details about the calculation are given in the appendix.

Description of Processor

The CALPOST-IMPROVE Processor is a Microsoft Excel workbook that consists of four worksheets. In Version 2 the worksheets are the following.

1. Input & Output – The output table from CALPOST is imported to here and user entries are made for the Rayleigh scattering coefficient and, if desired, for a sea salt concentration at the Class I area of interest. The NO_x concentration on each day attributable to the emissions from the source can also be entered together with an assumption of what fraction of the NO_x is in the form of NO_2. A revised table, with extinction based on the new IMPROVE algorithm is then presented on the same page. This is the only page on which user input takes place, and the results of the calculations appear on this page.

2. Calculations -- The calculations themselves are all done on this worksheet. There is no user input to this page. The variables are explained on the worksheet itself, so the user can find intermediate values if so inclined.

3. F(RH) – This worksheet tabulates the traditional IMPROVE f(RH) against RH, and then also lists values for the three new humidity growth functions, $f_S(RH)$, $f_L(RH)$, and $f_{SS}(RH)$. It serves as a lookup table for the "Calculations" worksheet.

4. Rayleigh & Sea Salt – This page tabulates the IMPROVE-recommended Rayleigh scattering coefficients for all VISTAS Class I areas and for Class I areas in adjacent states. It also lists the average sea salt concentrations for the same locations, as tabulated on the VIEWS web site, based on chloride or chlorine measurements by IMPROVE monitors between 2000 and 2004. This sheet just provides information for the user; it is not linked to the rest of the workbook. The user can obtain Rayleigh and sea salt numbers for the Class I area of interest from this table and then manually enter them in the designated spaces in worksheet 1.

Instructions for Using the CALPOST-IMPROVE Processor

These instructions apply to Version 2 of the processor. Version 2 includes the ability to calculate the light extinction effects of NO_2 resulting from the source's emissions.

Step 1. Begin by opening the output (.LST) file from a CALPOST visibility calculation run in a text editor or word processing program.[4] In the second half of the file, locate the table "Ranked Daily Visibility Change" with the subheading "Modeled Extinction by Species".[5]

Step 2. Copy this table and paste it onto a new page. Save it as a text (.txt) file, not as a formatted (e.g., MS Word .doc or .rtf) file. The final table should contain only the column headings and the data. Delete all other captions, any additional data summaries at the end, and blank lines before or after the table. The processor can handle a maximum of 22 lines of data (i.e., the highest rank in the last, unlabeled, column should be 22) plus a row of column captions. Delete any data that exceed this limit. (Fewer than 22 lines of data are OK.) The result should look like the example in Figure 1, although the line wrapping may differ.

Step 3. Open the CALPOST-IMPROVE Processor in Microsoft Excel. Save the open file under a new name so that the original empty processor will remain available for future use. The front worksheet, labeled "Input & Output" looks like Figure 2. There is a large empty box, surrounded by double lines, into which the table created above will be imported, as described below.[6] On the right is a box into which NO_x concentrations may be entered manually, and a small box below this box is provided for entry of the user's assumption of what fraction of that NO_x is in the form of NO_2. Two smaller boxes provide for user input of the Rayleigh scattering coefficient and, optionally, sea salt concentration for the Class I area, as described below. Results of the new IMPROVE algorithm calculations appear in blue in the lower half of the worksheet and some additional results, that are also useful for quality control, appear in green to the right of the large box. At the moment, many results cells will display nonsensical numbers and error messages, such as shown in Figure 2.

Step 4. Select the upper left cell (A7) in the large box. On the Excel menu bar, go to *Data>Get External Data* and click on *Import Text File.*[7] (If the large box is not empty, click on *Edit Text Import* instead.) Select the file that contains the table created in Step 2 and click on the *Get Data* button. Go through the Text Import Wizard steps, checking that all values appear correctly in separate columns. (The label "COORDINATES (km)" will be split over two columns; this is OK.) When everything appears in order, click *Finish.*

[4] The background concentrations that were entered into CALPOST must be the EPA-prescribed default annual average natural conditions concentrations for the East. The processor will not give correct answers if other concentrations were used in CALPOST.
[5] For future reference in Step 7, this may also be a good time to locate the table with the same title but with the subtitle "% of Modeled Extinction by Species", which appears later in the output file.
[6] If the workbook has already been used, the boxes may not be empty. This does not matter.
[7] The exact wording may vary slightly between different versions of Microsoft Excel. The terminology used here is from Excel 2004 for Macintosh.

```
YEAR DAY HR  RECEPTOR    COORDINATES (km)  TYPE BEXT(Model) BEXT(BKG)
BEXT(Total) %CHANGE  F(RH)  bxSO4  bxNO3   bxOC    bxEC  bxPMC  bxPMF
2002 175  0  1027        1479.069    24.683   D       5.495      21.650      27.145
25.38   3.500  5.401  0.045  0.042  0.002  0.001  0.004    1
2002 172  0  1021        1479.244    23.778   D       4.923      21.650      26.573
22.74   3.500  4.475  0.404  0.038  0.001  0.001  0.004    2
2002 284  0  1045        1484.348    27.580   D       3.150      21.470      24.620
14.67   3.300  2.684  0.428  0.033  0.001  0.001  0.003    3
2002 353  0  1026        1482.762    24.457   D       2.594      21.290      23.884
12.18   3.100  2.017  0.557  0.018  0.001  0.000  0.002    4
2002 283  0  1026        1482.762    24.457   D       2.502      21.470      23.972
11.65   3.300  2.269  0.201  0.028  0.001  0.001  0.003    5
2002 195  0  1045        1484.348    27.580   D       2.011      21.830      23.841
9.21   3.700  1.963  0.031  0.015  0.001  0.000  0.001    6
2002  20  0  1117        1486.636    34.592   D       1.872      21.200      23.072
8.83   3.000  1.542  0.320  0.009  0.000  0.000  0.001    7
2002 173  0  1128        1479.259    35.042   D       1.649      21.650      23.299
7.62   3.500  1.625  0.012  0.010  0.000  0.000  0.001    8
2002 234  0  1021        1479.244    23.778   D       1.524      22.190      23.714
6.87   4.100  1.482  0.029  0.011  0.000  0.000  0.001    9
2002 298  0  1021        1479.244    23.778   D       1.459      21.470      22.929
6.80   3.300  1.284  0.160  0.014  0.001  0.000  0.001   10
2002 299  0  1021        1479.244    23.778   D       1.436      21.470      22.906
6.69   3.300  1.281  0.140  0.013  0.000  0.000  0.001   11
2002 275  0  1026        1482.762    24.457   D       1.270      21.470      22.740
5.92   3.300  1.202  0.058  0.009  0.000  0.000  0.001   12
2002 263  0  1045        1484.348    27.580   D       1.237      22.100      23.337
5.60   4.000  1.223  0.008  0.005  0.000  0.000  0.001   13
2002 252  0  1026        1482.762    24.457   D       1.189      22.100      23.289
5.38   4.000  1.166  0.013  0.009  0.000  0.000  0.001   14
2002 285  0  1021        1479.244    23.778   D       0.992      21.470      22.462
4.62   3.300  0.813  0.179  0.001  0.000  0.000  0.000   15
2002 161  0  1026        1482.762    24.457   D       0.873      21.650      22.523
4.03   3.500  0.842  0.020  0.009  0.000  0.000  0.001   16
2002 150  0  1026        1482.762    24.457   D       0.857      21.380      22.237
4.01   3.200  0.822  0.026  0.007  0.000  0.000  0.001   17
2002 340  0  1140        1481.017    37.258   D       0.817      21.290      22.107
3.84   3.100  0.663  0.153  0.001  0.000  0.000  0.000   18
2002 151  0  1117        1486.636    34.592   D       0.745      21.380      22.125
3.49   3.200  0.704  0.033  0.007  0.000  0.000  0.001   19
2002 160  0  1021        1479.244    23.778   D       0.735      21.650      22.385
3.40   3.500  0.710  0.014  0.010  0.000  0.000  0.001   20
2002 346  0  1021        1479.244    23.778   D       0.703      21.290      21.993
3.30   3.100  0.620  0.080  0.002  0.000  0.000  0.000   21
2002 247  0  1021        1479.244    23.778   D       0.661      22.100      22.761
2.99   4.000  0.654  0.004  0.002  0.000  0.000  0.000   22
```

Figure 1. Example of CALPOST Output Table, in Proper Format for Importing into the CALPOST-IMPROVE Processor.

Step 5.[8] The "Import Data" window will appear, with cell A7 indicated as the location at which data will be entered. Click on the *Properties* button. In the window that appears, select "Overwrite existing cells with new data, clear unused cells" and uncheck "Adjust column width", then click on *OK*. Now click on the *OK* button in the "Import Data" window.

Step 6. Assuming that your Excel application is set up to automatically recalculate whenever any entries are changed, you should now have filled the cells in the large box on the first worksheet,

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[8] If the processor already had data in it and *Edit Text Import* was clicked in Step 4, then the "Import Data" window will not appear and Step 5 can be skipped.

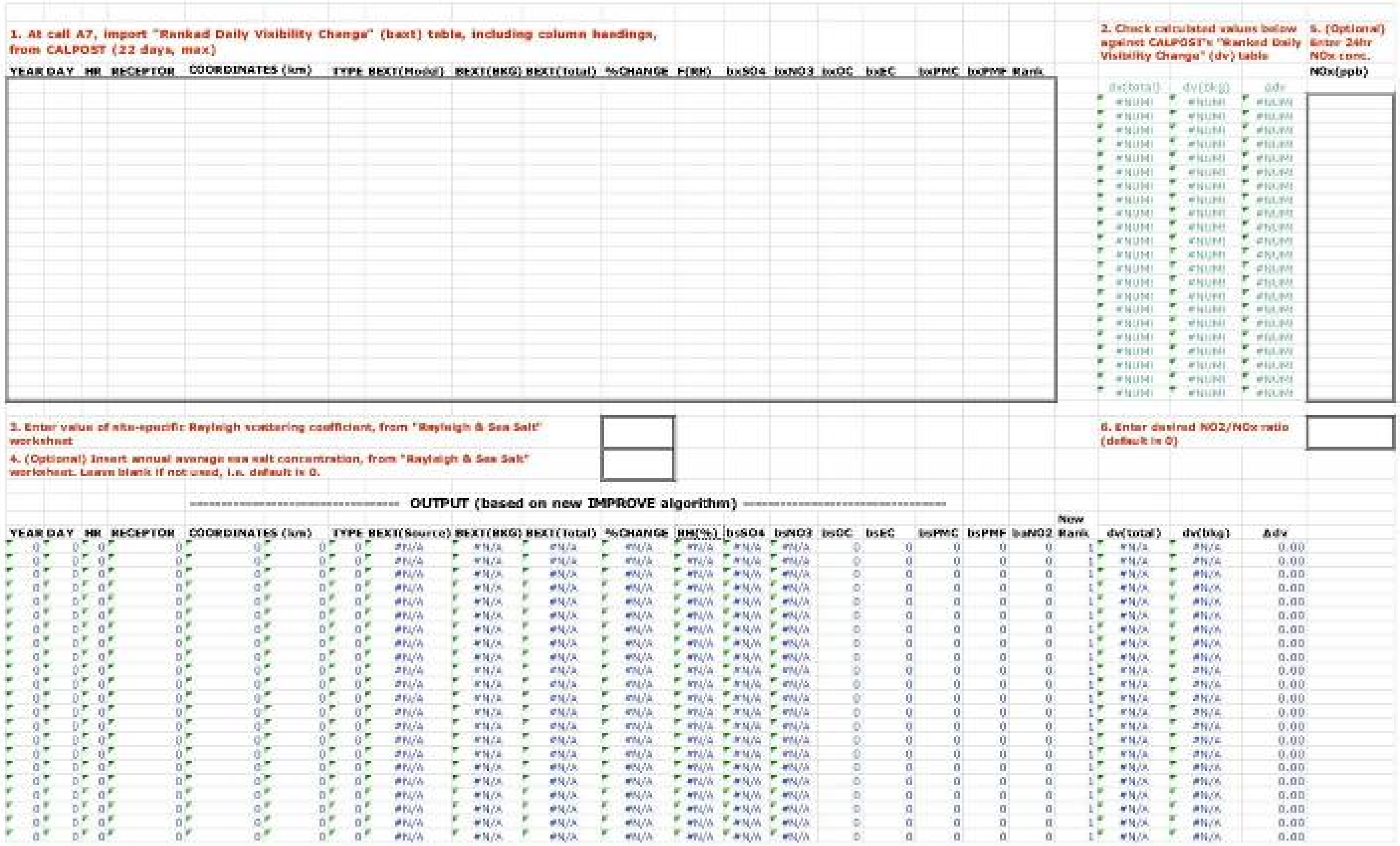

Figure 2. Example of Appearance of Input & Output Worksheet before Data Entry.

numbers should have appeared in the green columns to the right, and some numbers will have appeared in the output table in blue on the lower half of the worksheet. If the data import worked properly, none of the imported data should have spilled out of the large box. Check that all the column captions in bold outside the large box are now duplicated on the first line in the box. (There won't be a caption for Rank.)

Step 7. As a further check on whether everything is correct so far, the dv information in the three columns to the right of the large box should be the same as that in the second CALPOST table "Ranked Daily Visibility Change: % of Modeled Extinction by Species", which was mentioned in Footnote 1.

Step 8. Beneath the large box that was just filled with imported data, enter the Rayleigh scattering coefficient for the Class I area of interest into the top small box after red instruction 3. Also, if you wish, fill in the other small box, the one after red instruction 4, with the annual average sea salt concentration. (The sea salt box may be left blank, but the Rayleigh scattering coefficient box must be filled in.) To help with filling in these two boxes, the fourth worksheet, "Rayleigh & Sea Salt", provides IMPROVE-calculated values of the Rayleigh coefficients for Class I areas in the VISTAS region and in adjacent states. Also, average sea salt concentrations for 2000-2004, calculated in accordance with the new IMPROVE procedures, can be found there.

Step 9.[9] If the impact due to NO_2 is to be considered, a second CALPOST run will be needed to provide the 24-hr average NO_x concentrations estimated by CALPUFF. For this purpose, run CALPOST using the ASPEC = NOX option in Input Group 1 of the CALPOST.INP control file. The NO_x values to insert in the NO_x input box on the Input & Output page of the processor have to be extracted manually from the CALPOST output file for each date and receptor listed in the file that was imported in Steps 1 through 5 above and are displayed in the left hand columns in the large box.

Step 10. Select a value between 0 and 1 to represent what fraction of NO_x is in the form of NO_2. Enter this value into the small box at red instruction 6 below the column where the NO_x concentrations were entered.[10]

Step 11. The blue data table at the bottom of the page represents the new IMPROVE algorithm outputs. An example is shown in Figure 3. This table can be compared with the original CALPOST table at the top of the page. All of the columns in both tables show exactly the same variables, except that the F(RH) column in the top table is replaced by just the RH in the lower table (since the new procedure has three different f(RH) functions) and a new $baNO_2$ column has been added to the bottom table to show the light absorption due to NO_2 (in Mm^{-1}). Although the events are listed in the same order in both tables, note that their rankings may have changed, as is the case for many of the lines in the blue output table in Figure 3.

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[9] Steps 8 and 9 are optional. If the impact due to NO_2 is not of interest, just leave the entry fields mentioned in these steps blank.

[10] An easy way to see the effect of the NO_2 on the source's impact in the output table in the lower half of the page is to toggle this NO_2/NO_x value between the selected value and zero.

For those who are interested in more detail concerning the calculations that take place, values of the three f(RH) functions appear in columns M through O on the second, "Calculations" spreadsheet. The extinction impact of the source, including enhancement of the extinction efficiencies for sulfates, nitrates, and organics because of greater total mass concentrations, appears in columns V through AC. Extinction due to the annual average natural background appears in Columns AJ through AN; natural background extinctions for those components that are enhanced by greater total mass concentrations appear in columns AU through AX.

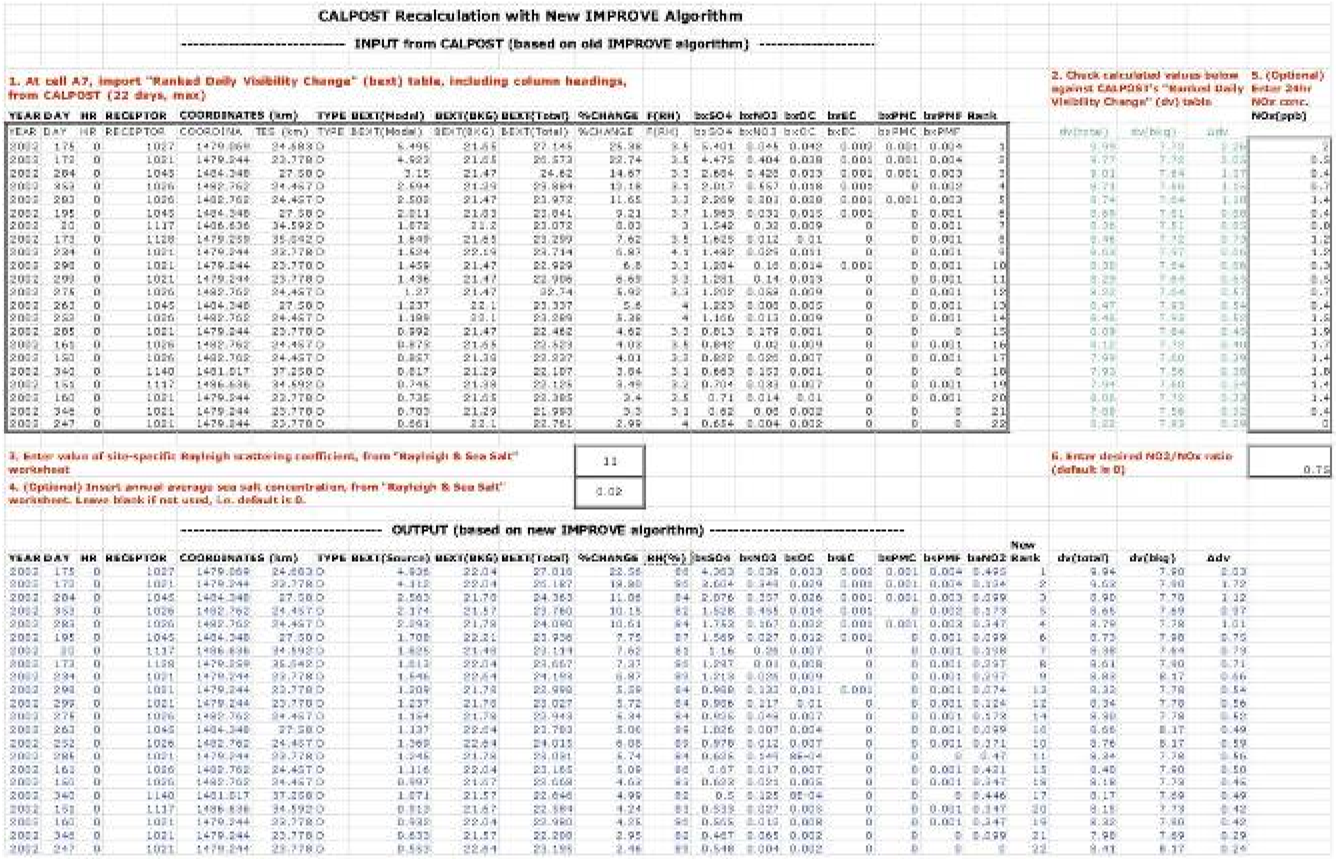

Figure 3. Example of Appearance of Finished Input & Output Worksheet.

Appendix
Details of Calculation Approach

As an example of the calculation steps, assume that the sulfate concentration resulting from emissions from a source is $[S_E]$ and the sulfate in the undisturbed natural background is $[S_N]$, for a total ambient sulfate concentration of $[S_T]$. According to Equations 1 and 2 in the main body of this document, the total extinction due to sulfate for this combination is

$$b_{ext}(sulfate) = 2.2 \bullet f_S(RH) \bullet [small\ sulfate] + 4.8 \bullet f_L(RH) \bullet [large\ sulfate], \qquad \text{(Eq. A-1)}$$

where

$$[large\ sulfate_T] = \{[S_T]/20\} \bullet [S_T]\ if\ [S_T] < 20\ \mu g^3$$

$$[large\ sulfate_T] = [S_T]\ if\ [S_T] \geq 20\ \mu g/m^3 \qquad \text{(Eqs. A-2)}$$

$$[small\ sulfate_T] = [S_T] - [large\ sulfate_T],$$

and the subscript T denotes total sulfate

For the original background, where there is no source impact, the corresponding formulas for the terms in Equations A-2 are

$$[large\ sulfate_N] = \{[S_N]/20\} \bullet [S_N]\ if\ [S_N] < 20\ \mu g^3$$

$$[large\ sulfate_N] = [S_N]\ if\ [S_N] \geq 20\ \mu g/m^3 \qquad \text{(Eqs. A-3)}$$

$$[small\ sulfate_N] = [S_N] - [large\ sulfate_N],$$

where the subscript N denotes natural sulfate.

Similar calculations need to be carried out for nitrates. Contributions of the other particulate components are linear and can just be calculated according to Equation 1.

If the impact due to NO_2 is also to be considered, then the source impact due to this component is, according to Equation 1,

$$b_{ext}(NO_2) = 0.33 \bullet [NO_2], \qquad \text{(Eq. A-4)}$$

where $[NO_2]$ is in ppb. It is reasonable to assume that the ambient NO_2 concentrations under natural conditions would be so small as to cause negligible light absorption, so the corresponding term is not needed in the natural conditions calculation.

The contributions due to the various components are summed together as in Equation 1 to obtain the total extinction $b_{ext,T}$ and the natural background extinction $b_{ext,N}$. The fractional change in extinction is then calculated as the difference, normalized by the natural background extinction

$$(b_{ext,T} - b_{ext,N})/b_{ext,N}, \quad \text{(Eq. A-5)}$$

a result that can also be expressed in deciviews.

These formulas are used in the CALPOST-IMPROVE Processor. Similar formulas apply for nitrates and organics. There is no nonlinearity in the remaining terms in Equation 1.

Appendix C

Indiana Harbor West Four Factor Analysis Submittal

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