

**Appendix 5d- BART determination Report for Alcoa, Inc. - Warrick  
Operations**

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BART Determination Report  
for  
Alcoa, Inc. – Warrick Operations

December 2008  
Amended July 2010

Prepared for:  
Alcoa, Inc. – Warrick Operations  
Newburgh, Indiana

BART DETERMINATION REPORT  
FOR  
ALCOA, INC. – WARRICK OPERATIONS  
NEWBURGH, INDIANA

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## ACRONYMS

acfm	actual cubic feet per minute
Alcoa	Alcoa, Inc. – Warrick Operations
AWMA	Air and Waste Management Association
BACT	Best Available Control Technology
BART	Best Available Retrofit Technology
CAA	Clean Air Act
dv	deciview
EPA	U.S. Environmental Protection Agency
ESP	Electrostatic Precipitator
FGD	Flue Gas Desulfurization
LAER	Lowest Achievable Emissions Rate
LSFO	Limestone Slurry Forced Oxidation
LSNO	Limestone Slurry Natural Oxidation
MCNP	Mammoth Cave National Park
NO <sub>x</sub>	Nitrogen Oxides
PM	Particulate Matter
PM <sub>2.5</sub>	Particulate Matter less than 2.5 micrometers in diameter
PM <sub>10</sub>	Particulate Matter less than 10 micrometers in diameter
ppm	parts per million
ppmv	parts per million by volume
RACT	Reasonably Available Control Technology
RBLC	RACT/BACT/LAER Clearinghouse
SCR	Selective Catalytic Reduction
SNCR	Selective Non-Catalytic Reduction
SO <sub>2</sub>	Sulfur Dioxide
UBC	Used Beverage Can

## 1.0 EXECUTIVE SUMMARY

The Clean Air Act (CAA) requires the protection of visibility in 156 scenic areas across the United States. Under CAA Section 169A(b)(2)(A), States must require certain existing stationary sources to install Best Available Retrofit Technology (BART). Alcoa, Inc. – Warrick Operations (Alcoa) is a “BART-eligible” source. A BART determination is required because Alcoa emits air pollutants that may reasonably be anticipated to contribute to impairment of visibility in a Class I area.

The analysis contained herein assesses the individual and collective visibility impact attributable to the BART-eligible emission units at Warrick Operations. It analyzes pollution prevention and add-on control options for the BART-eligible emission units. The BART determination and proposed alternative to BART were rendered based on the predicted visibility improvement and cost effectiveness associated with the technically feasible control options. The analyses involved in this BART determination were performed in accordance with Appendix Y to Part 51 – “*Guidelines for BART Determinations Under the regional Haze Rule*,<sup>1</sup>”

The baseline visibility conditions were determined in accordance with a facility specific BART modeling protocol, developed by TRC and submitted to IDEM for approval in May, 2006. These sources include 3 coal fired boilers, 5 aluminum reduction potlines, and 18 ingot furnaces.

Initial BART modeling projected the highest visibility impact to be in Mammoth Cave National Park (MCNP). Other Class 1 areas that were screened included Mingo, Sipsey, Great Smokey Mountains, Joyce Kilmer, Cohutta, and Shinning Rock. The BART analysis in this document was based solely on visibility impacts at MCNP, since the change in visibility in this Class 1 area would dictate the BART determination.

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<sup>1</sup> 70 FR 39161

The baseline modeled or projected 98<sup>th</sup> percentile visibility impact from the BART eligible sources at Warrick Operations range from approximately 1.8 to 1.9 deciviews (dv) at MCNP for the three modeled years (2001, 2002 and 2003). Approximately 93% to 97% of the total visibility impact is attributed to the coal fired boilers, with 3% to 7% from the potlines. Negligible visibility change during the baseline period was attributed to the ingot furnaces.

The baseline modeled or projected maximum 98<sup>th</sup> percentile visibility impact from the three coal fired boilers is 1.9 dv at MCNP for 2002. On average, 85% of the boiler visibility impact is attributable to SO<sub>2</sub> emissions, 12% is attributable to NO<sub>x</sub> emissions and the remaining 3+ percent is associated with particulate matter (PM). Results from the BART analysis for the coal fired boilers are as follows:

- BART for SO<sub>2</sub> emissions control was determined to be wet SO<sub>2</sub> scrubbing on Units 2 and 3 at 92% control efficiency.
- BART for NO<sub>x</sub> emissions control was determined to be low NO<sub>x</sub> burners on Units 2 and 3.
- BART for PM emissions was determined to be the existing electrostatic precipitators (ESPs) on Units 2, 3, and 4.

The baseline modeled or projected 98<sup>th</sup> percentile visibility impact from the potlines is 0.13 dv at MCNP in 2001. Of the 0.13 dv, approximately 92% (0.12 dv) is attributable to emissions from the primary control devices on the potlines. Ninety-four percent of the potline primary control device projected impact (0.11 dv) was from SO<sub>2</sub> emissions and the remainder was from PM emissions.

The modeling results revealed the maximum projected change in visibility to be approximately 0.01 dv for the potroom roofs and 0.005 dv for the ingot furnaces. The projected change in visibility attributed to each of these sources is less than 4% of the facility-wide threshold suggested by USEPA in Appendix Y that represents a contribution to visibility impairment. The further reduction in emissions from these sources would not result in

significant visibility improvement at MCNP. Therefore, these sources were excluded from further analysis. BART for the potroom roofs and ingot furnaces was determined to be no additional controls.

The analysis of potroom emissions resulted in a determination that BART for potline SO<sub>2</sub> is a pollution prevention limit of 3% sulfur in the calcined petroleum coke (CPC) used to manufacture anodes (i.e., coke). BART for other pollutants emitted from the potlines [particulate matter (PM) and nitrogen oxides (NO<sub>x</sub>)] was determined to be the existing level of emission control.

The BART analysis revealed the unsupportable high cost associated with potline add-on SO<sub>2</sub> controls and raised concerns about the long-term viability of lower sulfur anode grade coke as a pollution prevention measure for minimizing potline SO<sub>2</sub> emissions. Since Alcoa intends for Warrick Operations to be in operation throughout the period of the Regional Haze Program, it evaluated an alternative emission reduction strategy that minimized the future cost impacts of add-on controls and availability of low sulfur content raw materials. The alternative emission reduction strategy includes the wet SO<sub>2</sub> scrubbing of its Unit 1 coal fired boiler, which is not a BART-eligible source, and the use of up to 3.5% sulfur coke at the potlines.

The visibility benefit associated with the alternative emission reduction strategy is summarized in the Table 1. As shown in Table 1, implementation of an “Alternative to BART” control strategy, that includes the scrubbing of Unit 1 and 3.5% sulfur coke, will result in a “better than BART” visibility improvement. On average, the BART Alternative results in an additional 0.50 dv improvement over a BART-eligible source only scenario. Because the “Alternative to BART” provides Alcoa with more business certainty, and provides greater visibility improvement at MCNP, Alcoa requests IDEM to determine that the alternative emission reduction strategy described in Section No. 9.0 fulfills the best available retrofit technology requirements of Section 169A(b)(2)(A), of the 1990 Clean Air Act for this facility.

**Table 1 – 1 Summary of Baseline, BART, and Alternative to BART Visibility Impact at MCNP.**

<b>BART Option</b>	<b>Baseline Visibility Impact (98 Percentile Delta Deciview (dv))</b>				<b>Post-BART Visibility Impact (98 Percentile Delta Deciview (dv))</b>				<b>Average Visibility Improvement (dv)</b>
	2001	2002	2003	Average	2001	2002	2003	Average	
<b>BART Eligible Sources Only<sup>a</sup></b>	1.852	1.906	1.788	1.849	0.444	0.299	0.402	0.382	1.467
<b>Alternative to BART (BART Eligible Plus Unit 1 Controlled)<sup>b</sup></b>	2.311	2.774	2.549	2.545	0.686	0.463	0.595	0.581	1.964

<sup>a</sup> Based on wet SO<sub>2</sub> scrubbing on Units 2, and 3 with 3% sulfur coke for potlines

<sup>b</sup> Based on wet SO<sub>2</sub> scrubbing on Units 1, 2, and 3 with 3.5% sulfur coke for potlines.

## **2.0 INTRODUCTION**

The Clean Air Act (CAA) requires the protection of visibility in 156 scenic areas across the United States. Under CAA Section 169A(b)(2)(A), States must require certain existing stationary sources to install Best Available Retrofit Technology (BART). A “BART-eligible” source is 1 of 26 identified source categories that has the potential to emit  $\geq 250$  tons/year of any air pollutant and was put in place during the 15-year interval between August 7, 1962, and August 7, 1977. BART is required when any source meeting this definition emits any air pollutant that may reasonably be anticipated to cause or contribute to any impairment of visibility in any Class I area.

### 3.0 IDENTIFICATION OF BART-ELIGIBLE UNITS AT ALCOA WARRICK OPERATIONS

Alcoa, Inc. – Warrick Operations (Alcoa) operates emission units that fall within the categories of fossil-fuel fired steam electric plants of more than 250 MMBtu per hour heat input, primary aluminum ore reduction plants, and secondary metal production facilities – 3 of the 26 identified source categories to which BART is applicable. Three boilers, 5 potlines, and 18 furnaces within these categories were brought on-line between August 7, 1962 and August 7, 1977. The following table identifies these emission units.

**Table 3-1. BART-eligible Emission Units**

EMISSION UNIT	START-UP DATE
Boiler # 2	1964
Boiler # 3	1965
Boiler # 4	1968
Potline # 2	1962
Potline # 3	1965
Potline # 4	1965
Potline # 5	1968
Potline # 6	1968
#1 Casting Complex 1M1	1973
#1 Casting Complex 1M2	1973
#1 Casting Complex East Holder 1EH	1973
#1 Casting Complex West Holder 1WH	1973
# 5 Furnace Complex Melter 5M1	1966
# 5 Furnace Complex Melter 5M2	1966
# 5 Furnace Complex Melter 5M3	1966
# 5 HDC Complex East Holder 5EH	1966
# 5 HDC Complex West Holder 5WH	1966
# 6 Furnace Complex Melter 6M1	1966
# 6 Furnace Complex Melter 6M2	1966
# 6 Furnace Complex Melter 6M3	1966
# 6 Furnace Complex East Holder 6EH	1966
# 6 Furnace Complex West Holder 6WH	1966
# 2 Offline East Melter	1976
# 2 Offline West Melter	1976
# 2 Offline East Holder	1976
# 2 Offline West Holder	1976

The fossil-fuel fired steam electric plants of more than 250 MMBtu per hour heat input emission unit group has the potential to emit  $\geq 250$  tons/year of sulfur dioxide (SO<sub>2</sub>), a visibility impairing pollutant. As such, the Alcoa facility is defined as a BART-eligible source. Emission units within the fossil-fuel fired steam electric plants of more than 250 MMBtu per hour heat input and primary aluminum ore reduction plants that were in existence between August 7, 1962 and August 7, 1977, are the emission units at Alcoa that are BART-eligible.



## **4.0 BART-ELIGIBLE EMISSION UNIT GROUP DESCRIPTION**

### **4.1 Primary Aluminum Reduction Process**

Alcoa's primary aluminum reduction operations include five BART-eligible potlines. The potline operations manufacture metallic aluminum by the electrolytic reduction of alumina in center-worked prebake cells. Direct electrical current, passing between anodes and the cathode, electrolytically reduces the alumina to aluminum and oxygen. Molten aluminum is deposited and accumulates over time at the cathode beneath a layer of molten cryolite bath. Periodically the molten aluminum is siphoned from beneath the cryolite bath and processed to achieve specific metal properties or is retained as pure aluminum. The product aluminum is solidified into intermediate or final products. The BART-eligible Potlines, No. 2 through No. 6 emit SO<sub>2</sub>, NO<sub>x</sub>, and particulate matter (PM). These emission units are currently equipped with sophisticated emission control equipment for PM.

#### **4.1.1 Existing Potline Emissions Control**

The potlines at Alcoa consist of groups of electrolytic reduction cells connected in series that produce molten aluminum. Each potline is comprised of 150 Alcoa technology reduction cells with 26 anodes per cell. Emissions from each potline group are captured and controlled with a primary control system. Any uncaptured fume is emitted as secondary fugitive emissions through the roof monitor atop the potline buildings.

There are two different types of primary control systems employed at the Alcoa potlines. Potlines 2, 5, and 6 utilize a fluid-bed reactor type system with fabric filtration downstream of the reactor beds. Smelting grade alumina is introduced into one end of the Alcoa designed A-398 reactor. The alumina is fluidized by potline fume exhausted into the reactor through a series of perforated plates. Gaseous fluoride and a limited amount of SO<sub>2</sub> are adsorbed onto the alumina surface. Fabric filtration devices are positioned atop the reactor compartments to collect

entrained alumina particles and other PM present in the gas stream. Total fluoride and particulate removal efficiencies >99% are achieved by the control system.

Potlines 3 and 4 utilize a gas treatment system (GTS) consisting of an alumina injection system followed by fabric filtration. The alumina coats the fabric filters and adsorbs gaseous fluoride while simultaneously collecting other PM present in the gas stream. Removal efficiencies are again >99% with this control system.

#### **4.2 Ingot Furnaces**

Alcoa's Ingot plant includes seventeen (17) BART-eligible group 1 and group 2 furnaces. The # 1 Coil Casting Complex includes four (4) group 1 furnaces. Two (2) group 1 furnaces, identified as #1 Casting Complex 1M1 and 1M2, were constructed in 1973 with a maximum aluminum production rate of 6.85 tons per hour, each, when used for producing cast coils and 49 tons per hour when used as off-line melters. Emissions are uncontrolled and exhaust through stacks 134.62 and 134.64 respectively. Two (2) group 1 furnaces, identified as #1 Casting Complex East Holder 1EH and West Holder 1WH were constructed in 1973 with maximum aluminum production rates of 10.27 tons per hour, each, when used for producing cast coils and 49 tons per hour each, when used as off-line holders. Emissions are uncontrolled and exhaust through stacks 134.63 and 134.66, respectively.

The #5 Furnace Complex also includes five (5) group 1 furnaces. Three (3) group 1 furnaces are identified as Melters 5M1, 5M2 and 5M3, were constructed in 1966 with a maximum aluminum production rate of 97.5 tons per hour each. Emissions are uncontrolled and exhaust at stacks 134.33, 134.36, and 134.39, respectively. Two (2) group 1 furnaces are identified as #5 HDC Complex East Holder 5EH and West Holder 5WH, were constructed in 1966 with maximum aluminum production rate of 97.5 tons per hour each. Emissions are uncontrolled and exhaust through stacks 134.35 and 134.38, respectively.

The #6 Furnace Complex contains 5 group 1 furnaces. Three (3) group 1 furnaces are identified as Melter 6M1, 6M2, and 6M3. These furnaces were constructed in 1966 and have a maximum aluminum production rate of 12 tons per hour each. Emissions are uncontrolled and exhaust through stacks 134.40, 134.42, and 134.44, respectively. Two (2) group 1 furnaces identified as #6 Furnace Complex East Holder 6EH and West Holder 6WH were constructed in 1966 with maximum aluminum production rate of 16 tons per hour each. Emissions are uncontrolled and exhaust through stacks 134.41 and 134.43, respectively.

The #2 Offline Furnace Complex contains four (4) group 2 furnaces. Two (2) group 2 furnaces are identified as #2 Offline East Melter and West Melter. These furnaces were constructed in 1976, each with a maximum aluminum production rate of 12 tons per hour. Emissions are uncontrolled and exhaust through stacks 134.71 and 134.76 respectively. Two (2) group 2 furnaces identified as #2 Offline East Holder and West Holder were constructed in 1976 each with a maximum aluminum production rate of 12 tons per hour. Emissions are uncontrolled and exhaust through stacks 134.73 and 134.75, respectively.

#### **4.3 Coal Fired Boilers**

Alcoa's three (3) coal fired boilers that are BART-eligible are dry bottom, pulverized coal-fired boilers. They are identified as Boiler No. 2, 3, and 4. Construction of boilers 2 and 3 commenced on July 26, 1956. Boiler 2 came on-line in January 1964. Boiler 3 came on-line in October 1965. Boilers 2 and 3 each had a nominal heat input capacity of 1,357 million Btu per hour (MMBtu/hr) prior to their recent upgrade to a nominal heat input capacity of 1,589 million Btu per hour. Construction of boiler 4 started on March 16, 1968 and has a nominal heat input capacity of 2,958 MMBtu/hr. Each of the boilers is equipped with an electrostatic precipitator (ESP) for control of particulate matter. Boiler 3 was equipped with a low NO<sub>x</sub> burner and over-fire air in 2002 and Boiler 2 was equipped with a low NO<sub>x</sub> burner and over-fire air in 2004. Boiler 4 was equipped with a low- NO<sub>x</sub> burner in 1998 and a selective catalytic reduction system (SCR) in 2004. Wet flue gas desulfurization scrubbers were installed and began controlling emissions from boilers 2 and 3 in May and July, 2008 respectively.

## **5.0 BASELINE CONDITIONS AND VISIBILITY IMPACTS FOR BART-ELIGIBLE UNITS**

Before beginning the five step case-by-case BART analysis, CALPUFF modeling was performed to evaluate the overall change in visibility attributable to Warrick's BART-eligible emission units and to quantify their individual relative contribution to the total visibility impact of baseline conditions. A modeling protocol was developed by TRC Environmental Corporation and submitted to the IDEM. The protocol is included as Appendix B to this report. All modeling performed in association with this BART determination was done by TRC Environmental Corporation.

Table 5-1 presents the baseline modeling source input data that were used in the CALPUFF model to forecast the visibility impacts. Per Section IV of Part 51 Appendix Y, baseline emission rates used in the model were based on 24-hour average actual emissions from the highest emitting day. CALMET and CALPUFF simulations were conducted for 2001–2003. MM5 data at a resolution of 12 km was used for 2001 and 2002 and 20 km resolution RUC data were used for 2003 due to the unavailability of the 12 km MM5 data for 2003. This data was supplemented with available surface observations and upper air soundings within and surrounding the CALMET modeling domain. Initial BART modeling projected the highest visibility impact to be in Mammoth Cave National Park (MCNP), with minimal or no impact in more distant Class 1 areas. Other Class 1 areas that were screened included Mingo, Sipsey, Great Smokey Mountains, Joyce Kilmer, Cohutta, and Shinning Rock. The BART analysis in this document was based solely on visibility impacts at MCNP, since the change in visibility in this Class 1 area would dictate the BART determination. The results of the screening run show that visibility impacts within MCNP exceeded the 0.5 dv contribution to visibility impairment threshold suggested by USEPA; therefore, a refined modeling analysis was performed.

Table 5-1. Baseline Conditions Modeling Input Data

Index	Emission Unit ID #	Stack Name	Release Height (m)	Monitor Width (m)	Exit Veloc. (m/s)	Delta T (K)	Beginning UTM E/N (km)	Ending UTM E/N (km)	Filterable PM <sub>10</sub> - PM <sub>2.5</sub> (g/s)	Filterable PM <sub>2.5</sub> (g/s)	Org. Condensable (g/s)	Inorganic Condensable (g/s)	SO2 (g/s)	NO <sub>x</sub> (g/s)
L01	103M.1	Potline #2, Room 103	14.02	1.52	2.93	24.95	471.119, 4196.702	471.198, 4196.984	0.535	0.753	0.373	0.356	0.266	0.003
L02	104M.1	Potline #2, Room 104	14.02	1.52	2.93	24.95	471.087, 4196.711	471.166, 4196.993	0.535	0.753	0.373	0.356	0.266	0.003
L03	105M.1	Potline #3, Room 105	14.02	1.52	2.93	24.95	471.024, 4196.728	471.103, 4197.010	0.569	0.802	0.397	0.379	0.269	0.003
L04	106M.1	Potline #3, Room 106	14.02	1.52	2.93	24.95	470.992, 4196.737	471.070, 4197.019	0.569	0.802	0.397	0.379	0.269	0.003
L05	107M.1	Potline #4, Room 107	14.02	1.52	2.93	24.95	470.961, 4196.745	471.038, 4197.027	0.567	0.799	0.395	0.377	0.269	0.003
L06	108M.1	Potline #4, Room 108	14.02	1.52	2.93	24.95	470.929, 4196.754	471.007, 4197.036	0.567	0.799	0.395	0.377	0.269	0.003
L07	109M.1	Potline #5 , Room 109	14.02	1.52	2.31	23.18	470.900, 4196.770	471.976, 4197.052	0.470	0.663	0.328	0.313	0.259	0.003
L08	110M.1	Potline #5, Room 110	14.02	1.52	2.31	23.18	470.868, 4196.778	471.943, 4197.061	0.470	0.663	0.328	0.313	0.259	0.003
L09	111M.1	Potline #6 , Room 111	14.02	1.52	2.31	23.18	470.803, 4196.796	471.881, 4197.078	0.532	0.749	0.371	0.354	0.264	0.003
L10	112M.1	Potline #6, Room 112	14.02	1.52	2.31	23.18	470.771, 4196.804	471.848, 4197.086	0.532	0.749	0.371	0.354	0.264	0.003

Index	Emission Unit ID #	Stack Name	Stack Height (m)	Stack diameter (m)	Exit Veloc. (m/s)	Exit Temperature (K)	UTM Easting (km)	UTM Northing (km)	Filterable PM <sub>10</sub> - PM <sub>2.5</sub> (g/s)	Filterable PM <sub>2.5</sub> (g/s)	Org. Condensable (g/s)	Inorganic Condensable (g/s)	SO2 (g/s)	NO <sub>x</sub> (g/s)
P01	GTC	Potlines #3 & #4 GTC Pollution Controls	60.66	6.10	16.46	350	470.668	4196.863	0.986	0.116	1.757	4.409	46.868	0.581
P02	160C1.1-160C1.36	Potline #2 A-398	14.94	3.70	21.12	366	471.118	4196.953	0.393	0.046	0.700	1.758	23.312	0.289
P03	161B5.1-161B5.36	Potline #5 A-398	14.94	3.72	21.12	366	470.768	4196.888	0.555	0.065	0.989	2.482	22.008	0.291
P04	161B6.1-161B6.36	Potline #6 A-398	14.94	3.69	21.12	366	470.746	4196.888	0.563	0.066	1.002	2.514	21.86	0.301
P23	134.62	Melter 1M1	38.40	1.59	2.16	472	470.735	4197.193	0.056	0.027	0.001	0.001	0.0009	0.161
P24	134.64	Holder 1EH	38.40	1.22	2.00	445	470.718	4197.198	0.017	0.026	0.002	0.002	0.0014	0.149
P25	134.65	Melter 1M2	38.40	1.59	2.16	472	470.710	4197.201	0.065	0.030	0.001	0.001	0.002	0.402
P26	134.66	Holder 1WH	38.40	1.22	2.00	445	470.708	4197.203	0.011	0.016	0.002	0.002	0.003	0.149
P28	134.33	Melter 5M1	38.40	1.22	3.80	583	470.983	4197.133	0.061	0.028	0.001	0.001	0.023	0.253
P29	134.35	Holder 5EH	38.40	1.37	2.34	466	470.968	4197.128	0.110	0.167	0.015	0.015	0.00126	0.318
P30	134.36	Melter 5M2	38.40	1.22	3.80	583	470.963	4197.135	0.095	0.044	0.001	0.001	0.012	1.317
P31	134.38	Holder 5WH	38.40	1.37	2.34	466	470.941	4197.138	0.119	0.180	0.017	0.017	0.00126	0.318
P32	134.39	Melter 5M3	38.40	1.22	3.80	583	470.943	4197.141	0.066	0.031	0.001	0.001	0.0016	0.297
P33	134.4	Melter 6M1	38.40	1.22	3.80	583	470.933	4197.145	0.062	0.029	0.001	0.005	0.0002	0.038
P34	134.41	Holder 6EH	38.40	1.37	2.34	466	470.923	4197.141	0.119	0.180	0.017	0.017	0.0001	0.016
P35	134.42	Melter 6M2	38.40	1.22	3.80	583	470.923	4197.148	0.062	0.029	0.001	0.001	0.0002	0.038
P36	134.43	Holder 6WH	38.40	1.37	2.34	466	470.913	4197.143	0.119	0.180	0.017	0.017	0.0001	0.016
P37	134.44	Melter 6M3	38.40	1.22	3.80	583	470.913	4197.148	0.062	0.029	0.001	0.001	0.0002	0.038
P39	134.71	Offlines #2 East Melter	30.78	1.04	5.20	583	470.926	4197.245	0.007	0.003	0.000	0.000	0.006	1.140
P41	134.75	Offlines #2 West Melter	30.78	1.52	0.83	555	470.886	4197.261	0.007	0.003	0.000	0.000	0.0025	0.660
WPP01	WPP01	Warrick Power Plant Stack 1 Unit 2 Only	115.82	5.91	12.88	423	470.810	4196.399	*	8.6	1.949	2.852	372.9	71.01
WPP02	WPP02	Warrick Power Plant Stack 2 Units 2 and 3	115.82	5.91	12.59	428	470.731	4196.443	*	22.01	7.629	11.236	1245.7	203.98
WPP03	WPP03	Warrick Power Plant Stack 3 Unit 4	115.82	4.45	34.91	425	470.668	4196.433	*	49.525	8.13	11.895	0.0	0.0

\* All Solid PM is 10 microns or less. There is no data available for solid PM<sub>2.5</sub>

## 5.2 Refined Modeling Analysis

The CALPUFF modeling system was used for the BART analysis for the Class I areas within a 300-km radius of Alcoa. CALPUFF and its meteorological model CALMET are designed to handle the complexities posed by complex terrain, long source receptor distances, chemical transformation and deposition, and other issues related to Class I impacts. EPA adopted the CALPUFF modeling system as a guideline model for source-receptor distances >50 km and for use on a case-by-case basis in complex flow situations for shorter distances (Federal Register, April 15, 2003). CALPUFF was recommended for Class I impact assessments by the Federal Land Managers Workgroup in 2000 and the Interagency Workgroup on Air Quality Modeling in 1998. CALPUFF is recommended by EPA for BART analyses<sup>2</sup> (Federal Register, July 6, 2005).

Calculation of the impact on light extinction is carried out in the CALPOST postprocessor. CALPOST Method 6 is used to compute the extinction change in deciviews. Refined modeling forecasts were prepared for visibility impacts at the Class I area where the combined emissions from the BART-eligible emission units were forecast to be equal to or greater than the screening threshold limit of 0.5 dv. The complete Alcoa BART modeling report is contained in Appendix C. The refined modeling predicted visibility impacts from Alcoa emission units to be at a level equal to or greater than the threshold limit of 0.5 dv at MCNP.

Table 5-2 presents the modeled 98<sup>th</sup> percentile total source visibility impact reported as deciviews for 2001, 2002, and 2003 at the MCNP Class I area. The most significant modeled or projected visibility impact at MCNP was associated with emissions from stack 2 (50% of unit 2 and unit 3 with the maximum 98<sup>th</sup> percentile impact being 1.379 dv occurring in 2002. Of this projected impact from stack 2 (50% of unit 2 and unit 3), 74.2% was due to emissions of SO<sub>2</sub> and 24.6% was due to NO<sub>x</sub> emissions. 0.6 percent of the projected visibility impact from stack 2 (50% of unit 2 and unit 3) was attributable to emissions of particulate matter and organics combined.

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<sup>2</sup> 70 FR 39122

The modeled or projected maximum 98<sup>th</sup> percentile visibility impact at MCNP associated with emissions from stack 1 (50% of coal fired boiler unit 2) was 0.434 dv occurring in 2002. Of this projected impact from 50% of unit 2, 71.2 % was due to emissions of SO<sub>2</sub> and 27.3% was due to NO<sub>x</sub> emissions. 1.5% of the projected visibility impact from stack 1(50% of unit 2) was attributable to emissions of particulate matter and organics combined.

**Table 5-2. Baseline Visibility Modeling Results**

Year	Source Group	Modeled 98th Percentile deciview	Calculated 98th Percentile deciview	Percentage of Species Contribution				
				SO <sub>4</sub> %	NO <sub>3</sub> %	Filterable PM2.5%	Filterable PM10 %	Organic Condensable PM %
2001	Total of Sources	1.852						
2001	Unit 2, Stack 1		0.392	96.3	2.5	0.7	0.0	0.5
2001	Unit 2 & 3, Stack 2		1.306	96.6	2.2	0.6	0.0	0.6
2001	Unit 4, Stack 3		0.023	0.0	0.0	65.5	0.0	34.5
2001	Potroom		0.010	28.0	0.0	28.0	8.0	36.0
2001	A398s		0.070	94.0	0.0	2.2	0.0	3.8
2001	GTC		0.049	94.5	0.0	2.4	0.0	3.1
2001	Ingot Furnaces		0.001	0.0	66.7	33.3	0.0	0.0
2002	Total of Sources	1.906						
2002	Unit 2, Stack 1		0.434	71.3	27.3	0.8	0.0	0.6
2002	Unit 2 & 3, Stack 2		1.379	74.1	24.6	0.7	0.0	0.6
2002	Unit 4, Stack 3		0.032	0.0	0.0	67.9	0.0	32.1
2002	Potroom		0.004	20.0	0.0	30.0	10.0	40.0
2002	A398s		0.030	87.3	2.5	3.9	0.0	6.3
2002	GTC		0.026	90.0	1.4	2.9	0.0	5.7
2002	Ingot Furnaces		0.001	0.0	100	0.0	0.0	0.0
2003	Total of Sources	1.788						
2003	Unit 2, Stack 1		0.380	88.9	9.9	0.7	0.0	0.5
2003	Unit 2 & 3, Stack 2		1.261	89.5	9.3	0.6	0.0	0.6
2003	Unit 4, Stack 3		0.023	0.0	0.0	65.0	0.0	35.0
2003	Potroom		0.007	23.5	0.0	29.4	6.0	41.1
2003	A398s		0.068	92.7	0.6	3.9	0.0	2.8
2003	GTC		0.046	92.5	0.8	4.2	0.0	2.5
2003	Ingot Furnace		0.003	0.0	87.5	12.5	0.0	0.0

All other BART-eligible sources (unit 4 PM, potlines, and ingot furnaces) at Alcoa Warrick and Alcoa Power Generating Inc. – Warrick Power Plant projected individual visibility impacts of less than 0.5 dv. The modeled or projected maximum 98<sup>th</sup> percentile visibility impact from the

potlines was approximately 0.13 dv at MCNP occurring in 2001. Approximately 93% of the projected impact from the potlines or 0.12 dv was attributable to emissions from the potline primary control devices, with the remainder, 0.01 dv, from the potroom roofs. Approximately 94.2% of the potroom primary control device estimated impact or 0.112 dv was from emissions of SO<sub>2</sub>, 3.6% or 0.004 dv was from condensable organics, and 2.3% or 0.003 dv was due to emissions of fine particulates. The modeled or projected maximum 98<sup>th</sup> percentile visibility impact from unit 4 PM was approximately 0.032 dv at MCNP occurring in 2002.

The refined modeling results in Table 5-2 show visibility impacts less than 0.02 dv for the potroom roofs and less than 0.005 dv for the ingot furnaces. The impact from each of these sources is less than 4% of the facility-wide contribution to visibility impairment threshold (0.5 dv) for BART applicability suggested by USEPA in Appendix Y to Part 51- Regional Haze Regulations and Guidelines for Best Available Retrofit Technology (BART) Determinations; Final Rule. Reduction in emissions from these sources would not result in any significant visibility improvement at MCNP.

The scope and cost analysis for the Alcoa BART determination was focused on the emission units predicted to contribute greater than 0.05 dv to MCNP visibility impairment. Coal-fired boiler units 2, 3, and 4 and the potline primary control devices (A398s and GTC) showed modeled 98<sup>th</sup> percentile visibility impacts of 1.8 dv and 0.12 dv, respectively. Given these potential impacts, a detailed retrofit control assessment was performed for boilers 2, 3, and 4 and the reduction of SO<sub>2</sub> emissions emanating from the potline primary control devices (A398s and GTC). Modeling data indicates that SO<sub>2</sub> from these sources is the primary pollutant potentially impacting visibility at MCNP.



## **6.0 BART ANALYSIS FOR BART-ELIGIBLE EMISSION UNITS**

The results of the refined CALPUF modeling indicate that emissions from Alcoa's boilers 2, 3, and 4 and potline reactors 2 – 6 contribute to visibility impairment in at least one Class 1 area. The BART analysis was completed for these emissions sources. The analysis included a review of the available and technically feasible retrofit control technologies (Steps 1 and 2), a determination of control effectiveness for the feasible options (Step 3), an evaluation of the cost and secondary impacts for feasible alternatives (Step 4), and an analysis of visibility impact and improvements (Step 5).

The present controls for the potline reactors and the coal fired boilers are described by pollutant in the following sections, followed by the control options that are available for reduction of visibility impairing pollutants.

### **6.1 Potline Emission Controls**

The major pollutants emitted from the potlines are PM, hydrogen fluoride, SO<sub>2</sub>, and carbon monoxide. PM includes particulate fluoride, carbon dust, and alumina. SO<sub>2</sub> comes from the sulfur in the components used to make the anodes. NO<sub>x</sub> emissions are minimal since there is no external fuel used by the potline reduction cells, there are no burners with combustion zones and there are no large sources of nitrogen in the raw materials.

Emissions from the pots are collected by capture a system that employs hooding over each pot. The hoods enclose the pot and divert smelting fume to ducting connected to emission control equipment. During normal operation of the potlines select hoods are temporarily removed to allow anodes to be changed. The temperature of the exhaust gases entering the control equipment is typically 150–300°F [Air and Waste Management Association (AWMA) 2000]. Emissions from Potlines 2, 5, and 6 at Alcoa are each controlled using A-398 pollution control systems. The gas flow of each of the A-398 pollution control systems is approximately 480,000 acfm at 200 °F. Emissions from Potlines 3 and 4 are abated by the Gas Treatment

Center (GTC) emission control device. It is an alumina injection system equipped with a fabric filtration system to collect the injected alumina and other particulates. The gas flow rate of the GTC is approximately 1,000,000 acfm at 170 °F. Secondary emissions from all of the potlines are uncontrolled and exhaust through the potroom roof monitors.

#### **6.1.1 Potentially Applicable BART Control Options for Potlines**

##### **6.1.1.1 Potentially Applicable SO<sub>2</sub> Emission Controls for Potlines**

Sulfur in the anodes is oxidized, releasing SO<sub>2</sub> from the potlines as the anodes are consumed. Options for controlling SO<sub>2</sub> include both add-on controls and pollution prevention. Absorption and adsorption have been used for the control of SO<sub>2</sub> emissions from numerous industrial processes. As a result many commercialized control technologies have been used for SO<sub>2</sub> control. While such technologies have been proven in the power utility industry, the practical application of these controls systems down stream of the potline reactors is limited by the very low inlet SO<sub>2</sub> levels, in the range of 100 parts per million by volume (ppmv), and the expected range of gas conditions, including temperature, oxygen content, humidity, SO<sub>2</sub>/O<sub>2</sub> ratio, and gas impurities.

Eight different SO<sub>2</sub> control options were considered as having potential practical application as part of the BART analysis. Two of these technologies have been applied to the control of SO<sub>2</sub> emissions at aluminum smelters. Six of the control options use wet scrubbing and two use dry scrubbing technology. The eight potentially applicable control options are:

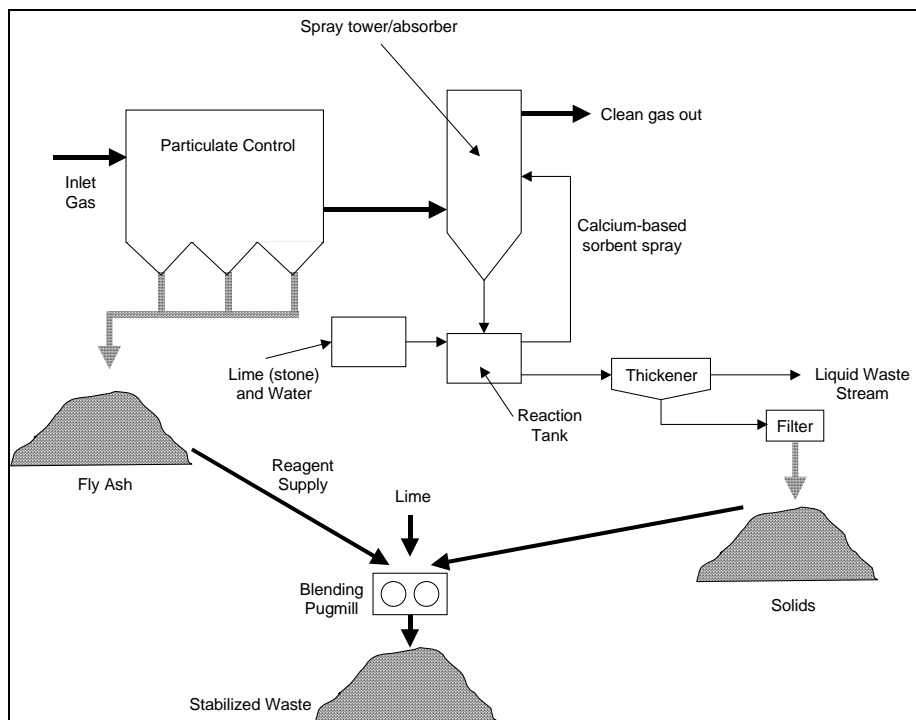
- Seawater scrubbing
- Limestone slurry scrubbing with natural oxidation
- Limestone slurry scrubbing with forced oxidation
- Conventional lime wet scrubbing
- Dual alkali sodium/lime scrubbing (dilute mode)
- Conventional sodium scrubbing
- Dry injection
- Semi-dry scrubbing

#### **6.1.1.1.1 Wet Scrubbing for Potlines**

The primary development of SO<sub>2</sub> control technology occurred because of the need to control emissions from the coal-fired, electric utility power industry (AWMA 2000). The large volumetric size of the potroom exhaust (500,000 to 1,000,000 acfm) would require a system similar to those used in the electric utility power industry.

The typical temperature range for wet scrubbers is 300–700°F. For utility combustion units, wet scrubbing systems have been installed on systems as large as 1,500 MW. Sodium compounds, lime, or limestone can be used. However, the high solubility of sodium complicates disposal of waste and wastewater. The typical sorbent material is lime or limestone. Lime is generally easier to manage on-site but is significantly more costly. Wet limestone scrubbing has a high capital and operating cost due to the handling of liquid reagent and waste, but is the preferred process for coal-fired utility power plants burning coal due to the low cost of limestone and high removal efficiencies. Typical removal efficiencies are 80–95%. Approximately 85% of the flue gas desulfurization (FGD) systems installed in the United States are wet scrubber systems (EPA 2003c).

In wet scrubbers, the waste gas enters a large vessel (spray tower or absorber), where it is sprayed with water slurry. Figure 1 is a simplified process flow diagram of a conventional wet scrubber.



**Figure 1. Wet Scrubber**

The calcium in the slurry reacts with  $\text{SO}_2$  to form  $\text{CaSO}_3$ . A portion of the slurry from the reaction tank is pumped into the thickener, where the solids settle before going to a filter for final dewatering to about 50% solids. In the utility industry, the  $\text{CaSO}_3$  waste product is usually mixed with fly ash (approximately 1:1) and fixative lime (approximately 5%) and typically disposed of in landfills. Alternately, the forced oxidation process oxidizes the spent slurry to gypsum. Gypsum crystals dewater more efficiently and reduce the size of waste handling equipment. Depending on quality and demand, the gypsum may be commercially sold, eliminating the need for landfilling the waste product.

Note that “mist eliminators,” installed at the spray tower outlet or downstream ductwork, remove droplets from the gas. In some power plant installations, the gas is reheated to avoid

corrosion downstream. Many scrubbers have gas bypassing capability, which can be used for gas reheating. If the wet scrubber is downstream of a high-efficiency particulate removal device [fabric filter or electrostatic precipitator (ESP)], the particulate concentration may be higher leaving the scrubber than entering due to the solids in mist droplets that are carried out of the scrubber.

Some disadvantages of using wet scrubbing techniques in many applications are the requirement to treat wastewater, components must be constructed from expensive alloys to resist corrosion, and energy use is much higher. A practical issue associated with a wet scrubber system is the complexity of the system. The space required for a wet system is substantial (i.e., large footprint), the systems require more maintenance due to their complexity, and more personnel are required for their operation.

#### **6.1.1.1.1.1 Seawater Scrubbing**

Globally, once-through seawater scrubbing has been installed at seven aluminum smelters, none of which are in the United States. Seawater scrubbing has been implemented in the coal fired power industry, recently at the Mawan Power Station in China and the Paiton Project in Indonesia. Seawater, which has a natural alkalinity, is pumped directly into a scrubbing tower through a system of spray nozzles where the atomized droplets make contact with the gas. The liquid effluent is discharged back into the ocean. Seawater scrubbing was automatically rejected as feasible because of Alcoa's physical location.

#### **6.1.1.1.1.2 Limestone Slurry Forced Oxidation**

Limestone slurry forced oxidation (LSFO) is used extensively in the utility flue gas desulphurization market. The raw material is finely ground limestone. There are a number of suppliers of LSFO technology. The most commonly used equipment is an open, multi-level, countercurrent spray tower scrubber equipped with spray nozzles to inject the limestone slurry droplets into the gas stream. Liquor is collected at the bottom of the tower and sparged with air

to oxidize the calcium sulfite to calcium sulfate to enhance the settling properties of the calcium sulfate. Recirculation pumps circulate the scrubbing liquor to the spray nozzles. SO<sub>2</sub> removal efficiencies of 90% have been achievable. The bleed from the scrubber is sent to a dewatering system to remove excess moisture. For an aluminum smelter, the process will produce either solid gypsum waste or commercial-grade gypsum suitable for reuse as a cement additive. Only a very small purge or blowdown stream is required.

LSFO was determined to be a technically feasible retrofit control option for the potroom reactor even though it is not ideally suited for wet scrubbing due to low SO<sub>2</sub> concentrations (<100 ppm).

#### **6.1.1.1.1.3 Limestone Slurry Natural Oxidation**

Limestone slurry natural oxidation (LSNO) is very similar to LSFO. The major difference is the absence of an oxidation stage. The gypsum/calcium sulfite product is essentially a waste product with limited possibilities of being used for agricultural purposes.

#### **6.1.1.1.1.4 Conventional Lime Wet Scrubbing**

Conventional lime wet scrubbing is also similar to LSFO except that the raw material is hydrated lime or quick lime that is either slaked on-site or purchased in the slaked form. The system typically uses forced oxidation, although natural oxidation is possible. The process will produce either solid gypsum waste or commercial-grade gypsum suitable for reuse as a cement additive.

#### **6.1.1.1.1.5 Dual Alkali Sodium/Lime Scrubbing (Dilute Mode)**

Dual alkali sodium/lime scrubbing (dilute mode) uses a caustic sodium solution in the scrubber tower. A portion of the scrubbing liquid is discharged to a neutralization stage where

lime slurry is used to regenerate the caustic, which is returned to the scrubber. The bleed from the scrubber is sent to a dewatering system to produce a gypsum byproduct. The process will produce either solid gypsum waste or commercial-grade gypsum suitable for reuse as a cement additive. It should be noted, however, that dual alkali sodium/lime scrubbing (dilute mode) is not marketed today by major FGD vendors because the system is too complicated and expensive.

#### **6.1.1.1.1.6 Conventional Sodium Scrubbing**

This technology has been successfully utilized in the power industry and globally, has been installed in at least 12 aluminum smelters. An alkaline solution of either soda ash or sodium hydroxide is pumped into the scrubbing tower and recirculated through a network of spray nozzles. Atomized droplets contact the up-flowing gas containing SO<sub>2</sub>. Where this technology has been deployed, the liquid effluent containing dissolved salts, including sodium and fluorides, has been discharged into a large receiving stream or an open body of water without treatment.

#### **6.1.1.1.2 Dry Scrubbing for Potlines**

##### **6.1.1.1.2.1 Dry Injection**

In dry injection, a reactive alkaline powder is injected into a furnace, ductwork, or a dry reactor. Typical removal efficiencies with calcium adsorbents are 50–60% and up to 80% with sodium base adsorbents. However, as with wet scrubbing, disposal of waste using sodium adsorbents must consider their high solubility in water compared to those from calcium adsorbents. The temperature range where dry scrubbing has been used is 300–1,800°F; the minimum temperature is 300–350°F. Dry systems are rarely used and according to EPA only 3% of FGD systems installed in the United States are dry systems (EPA 2003c). The dry waste material is removed using particulate control devices such as a fabric filter or an ESP.

Dry scrubbing downstream of the potline reactors is not technically feasible because of the low temperatures (<300°F) and low SO<sub>2</sub> concentrations (<100 ppm).

#### **6.1.1.1.2.2 Semi-dry Scrubbing (Spray Dryer)**

Semi-dry scrubbing is more commonly referred to as spray drying. Calcium hydroxide slurry (lime mixed with water) is introduced into a spray dryer tower. Sodium compounds can be used, but as with the dry scrubber, the high solubility of the sodium-based waste products in water complicates disposal of the waste. The slurry is atomized and injected into a reactor with the exhaust gases, where droplets react with SO<sub>2</sub> as the liquid evaporates. This system is categorized as a semi-dry system because the end product of the SO<sub>2</sub> conversion reaction is a dry material. The dry waste product is collected in the bottom of the spray dryer reactor, and a fabric filter or ESP downstream of the spray dryer removes the CaSO<sub>3</sub>, CaSO<sub>4</sub>, and unreacted lime. This air pollution control system uses water for evaporative cooling and for the SO<sub>2</sub> reaction. It operates in a temperature range of 300–350°F because the temperature of the gases must be high enough to evaporate the water portion of the slurry. Approximately 12% of the FGD systems installed in the United States are spray dry systems (EPA 2003c) with typical SO<sub>2</sub> removal efficiencies in the range of 80–90%. Unlike a wet scrubbing system there is no liquid blow-down stream from the dry system, and the collected solids are typically landfilled.

Spray dry scrubbing downstream of the potline reactors is not technically feasible because of the low temperatures (<300°F) and low SO<sub>2</sub> concentrations (<100 ppm).

#### **6.1.1.1.3 Pollution Prevention for Potlines**

The guidelines for BART determinations under the Regional Haze Rule recommend consideration of pollution prevention options in addition to add-on controls. The primary opportunity for pollution prevention in the smelting process to minimize SO<sub>2</sub> emissions is normally through limitations on the sulfur content in the incoming coke. Coke is a major raw



material used in the manufacture of green anodes. Green anodes are subsequently baked in a furnace prior to their use in the smelting process. Alcoa's current specification for incoming coke sulfur content is 2% which is significantly lower than what is required for most primary aluminum facilities. Alcoa has current SO<sub>2</sub> emission limits in their Title V permit that were established based on SIP modeling that supported uncontrolled SO<sub>2</sub> emissions of 5.11 lbs./mm Btu from the power plant boilers (Unit 1 and BART eligible units 2-4) that translate to this 2% sulfur content specification for coke used to manufacture anodes. In order to fully evaluate the potential for pollution prevention in this BART analysis, Alcoa undertook a low sulfur coke availability analysis to determine what sulfur content in coke would be available beyond 2013 when BART controls requirements are anticipated. Confidential research information belonging to the market analysts assisting with the preparation with the coke availability analysis is included in Appendix D. The coke availability and market analysis has been submitted separately pursuant to the procedures of the State of Indiana. The primary conclusions from this analysis indicate that:

- Coke is a byproduct of the oil refining process. The sulfur content of the world's crude oil supply has been and will continue increasing in sulfur content. Those refiners with coking capacity are minimizing their raw material costs by maximizing use of high sulfur crude oils to the optimal extent for their overall refinery design. The result will be a continuing increase in the sulfur content of available coke.
- Coke is a relatively small, low revenue component of the refinery's product profile. As such, the aluminum industry has little influence in controlling the quantity, quality, and price of the coke produced by refineries.
- Growth in the aluminum industry has increased the demand for the limited quantities of coke and has driven prices for coke to unprecedented levels.
- Prices for coke nearly doubled from 1994 to 2006.
- The increased global growth in aluminum production will continue to outpace the production of coke.
- Primary aluminum production is expected to grow at the rate of 3% to 4% annually resulting in a commensurate growth in demand for coke.
- Coke providers are blending imported, high cost, lower sulfur coke with domestically sourced coke in attempts to meet the current specification requirements for coke.
- Removal or reduction of the sulfur content of the coke once it has been received is not feasible.

- Aluminum smelters are experimenting with alternative cokes and technologies that are outside of the traditional specifications to ensure continued aluminum production in the face of the changing characteristics of this key raw material.
- The deterioration in coke quality and the tightness of supply is expected to continue for the foreseeable future.
- The increased demand for coke will force the aluminum industry to accept lower quality coke with higher sulfur contents.

Thus, based on the market and availability analysis of the future coke supply, Alcoa determined that it is infeasible to consider coke at sulfur contents below 3% as BART pollution prevention option because a supply of coke with sulfur contents below 3% cannot be ensured beyond 2013 when BART control requirements are anticipated. These market pressures are expected to force Alcoa to begin using higher sulfur content coke in the future. Because of this finding, Alcoa is seeking separate revision to the Indiana SIP and Title V operating permits to address this issue. Also, as a result of this analysis, pollution prevention is not technically feasible as an option to reduce SO<sub>2</sub> emissions from the potlines.

#### ***6.1.1.1.4 Potline Control Options from RBLC Database***

A review of EPA's RACT/BACT/LAER Clearinghouse (RBLC) database was also completed to determine which control technologies or techniques have been utilized by primary aluminum ore reduction plants. Results from searching the RBLC are summarized in Table 6-1.

**Table 6-1. RBLC Database Search Results for Primary Aluminum Facilities**

<b>RBLC ID</b>	<b>Facility</b>	<b>Last Update</b>	<b>Process</b>	<b>Pollutant</b>	<b>Control Option</b>	<b>Percent Efficient</b>	<b>Emission Limit</b>
KY-0070	NSA-A DIVISION OF SOUTHWIRE COMPANY	3/2/2004	POTLINE 5	SO <sub>2</sub>	WET SCRUBBER <sup>a</sup>	93%	25.51 lb/hour
SC-0037	ALUMAX OF SOUTH CAROLINA	9/17/2002	POTROOM GROUPS (4)	PM	EXISTING DRY ALUMINA SCRUBBERS (FABRIC FILTER)		5.9 lb/hour
SC-0037	ALUMAX OF SOUTH CAROLINA	9/17/2002	POTROOM GROUPS (4)	SO <sub>2</sub>	LIMIT MAX % SULFUR OF ANODE COKE TO 2.95% LIMIT MAX % SULFUR OF ANODE PITCH TO 1.2%		271 lb/hour
KY-0041	ARCO METALS CO.	12/18/2001	PRIMARY ALUMINUM REDUCTION POTLINE	SO <sub>2</sub>	FUEL SPEC: LOW S COKE AND PITCH (calc. 3% sulfur)		388 lb/hour
OR-0002	ALUMAX PACIFIC CORP.	12/18/2001	ANODE COKE	SO <sub>2</sub>			3% S in coke
WA-0003	ALCOA	12/18/2001	POTLINES 1,2,3	SO <sub>2</sub>	FUEL SPEC: LIMIT S CONTENT IN COKE, RAW		3% S in coke
NC-0003	ALCOA	1/28/2002	POT LINE 3	PM	FABRIC FILTER		26 lb/hour
NC-0003	ALCOA	1/28/2002	POT LINE 3	SO <sub>2</sub>			321 lb/hour
MO-0036	NORANDA ALUMINUM, INC.	5/9/2006	POTLINE 1 AND 3	PM <sub>10</sub>	Dry Scrubber		56.76/68.8 tons/year

<sup>a</sup> This wet scrubber is not actually used or required by permit.

The data in the RBLC database support the approach of limiting raw material sulfur content as a control option for potlines. Two facilities have limits of 3% sulfur content in coke and one has a 2.95% sulfur content limit. As previously noted, Alcoa currently operates below these limits. One facility is shown in the RBLC to have a wet scrubber to control SO<sub>2</sub> emissions; however, an investigation revealed that the wet scrubber was not required as part of a BACT determination and that the facility currently does not operate a wet scrubber to control SO<sub>2</sub>

emissions. The facility's current Title V permit for "Potline 5" simply limits coke sulfur content to 3% and coal tar pitch sulfur to 0.8%.

Dry alumina scrubbers (with fabric filters) are the controls that have been considered BACT for PM.

#### **6.1.1.2 Potentially Applicable PM Emission Controls for Potlines**

Potentially applicable PM emission controls are discussed in the following sections.

##### ***6.1.1.2.1 Fabric Filters***

Fabric filters generally provide high collection efficiencies for both coarse and fine (submicron) particles. They are relatively insensitive to fluctuations in gas stream conditions. Efficiency is relatively unaffected by large changes in inlet dust loadings. Filter outlet air is very clean (EPA 2003b). Collected material is dry, which usually simplifies processing or disposal. Fabric filters are currently applied for controlling PM emissions from the potrooms.

##### ***6.1.1.2.2 Electrostatic Precipitators***

ESPs are capable of very high removal efficiencies for large and small particles (EPA 2003a). They offer control efficiencies that are comparable to fabric filters. Because of their modular design, ESPs, like fabric filters, can be applied to a wide range of system sizes. The operating parameters that influence ESP performance include fly ash mass loading, particle size distribution, fly ash electrical resistivity, and precipitator voltage and current. Dusts with high resistivities are not well-suited for collection in dry ESPs because the particles are not easily charged. This also affects the ash layers on the collecting electrodes. An ESP is technically feasible for control of PM from potrooms.

#### ***6.1.1.2.3 Cyclones, Inertial Separators, and Wet Scrubbers***

Cyclones and inertial separators are used for collection of medium-sized and coarse particles. Wet scrubbers generally remove large particles but can remove small particles with the use of high pressure drops. However, none of these devices are as effective at removing small and submicron particles as fabric filters and ESPs (AWMA 2000).

#### **6.1.1.3 Potentially Applicable NO<sub>x</sub> Emission Controls for Potlines**

Potentially applicable NO<sub>x</sub> emission controls for the potlines include only post-combustion controls since there is no external fuel or combustion zone and there are no large sources of nitrogen in the raw materials.

##### ***6.1.1.3.1 Selective Non-Catalytic Reduction***

SNCR is an add-on technique that involves injecting ammonia or urea into a specific temperature zone in a furnace or boiler. The ammonia or urea reacts with NO<sub>x</sub> in the gas to produce nitrogen and water. SNCR typically provides 30–50% NO<sub>x</sub> reduction. The effectiveness of SNCR depends on the temperature where reagents are injected, mixing of the reagent in the gas, residence time of the reagent within the required temperature window, and the ratio of reagent to NO<sub>x</sub>. The required temperature window is 1,600–2,100°F. Typical uncontrolled NO<sub>x</sub> levels where this technology has been applied vary from 200 to 400 ppm. SNCR is less effective at lower levels of uncontrolled NO<sub>x</sub> (EPA 2003e).

The temperature of the potroom emission exhaust (<300°F) and NO<sub>x</sub> concentration (<1 ppm) are well outside the levels where SNCR could be used. Thus, SNCR is not technically feasible for the potroom exhaust.

#### **6.1.1.3.2 Selective Catalytic Reduction**

SCR is an add-on technique similar to SNCR that involves injecting ammonia into flue gas in the presence of a metal-based catalyst to convert NO<sub>x</sub> emissions to elemental nitrogen and water. The catalyst allows SCR systems to operate at much lower temperatures than SNCR; typical temperatures for SCR are 500–800°F, compared with 1,600–2,100°F for SNCR. The optimum temperature range is 700–750°F (EPA 2002). SCR is capable of NO<sub>x</sub> reduction efficiencies in the range of 70–90% and can be used with NO<sub>x</sub> concentrations as low as 20 ppm. However, higher NO<sub>x</sub> levels result in increased performance (EPA 2003d).

The temperature of the potroom emission exhaust (<300°F) and NO<sub>x</sub> concentration (<1 ppm) are outside the levels where SCR could be used. Thus, SCR is not technically feasible for the potroom exhaust.

### **6.1.2 Summary of Technically Feasible BART Control Options for Potlines**

#### **6.1.2.1 Feasible BART Control Options for Potline SO<sub>2</sub>**

One technically feasible option, adding a wet scrubber to the potline reactor exhausts, was identified for controlling SO<sub>2</sub> emissions from the potlines. This option was evaluated further as part of the BART determination analysis.

#### **6.1.2.2 Feasible BART Control Options for Potline PM**

Cyclones, inertial separators, wet scrubbers, ESPs, and fabric filters are all technically feasible for controlling potroom PM emissions. However, ESPs and fabric filters are superior devices for controlling fine PM.

Fabric filtration with dry alumina scrubbing has been widely used in the primary aluminum industry. Most smelters constructed within the past 20 years have used dry alumina scrubbing with fabric filters to control emissions from potlines. A few plants use control systems consisting of ESPs to collect PM followed by spray towers to scrub gaseous fluoride. Wet systems have many disadvantages, such as corrosion by hydrofluoric acid, scaling, and the requirement to treat wastewater. ESPs and wet systems are no longer installed on new smelters (AWMA 2000).

Given that fabric filters are already used for PM control and that these high-efficiency devices are superior or equal to other feasible control options, no further analysis of PM controls was performed.

#### **6.1.2.3 Feasible BART Control Options for Potline NO<sub>x</sub>**

Since there is no external fuel or combustion zone in the smelting cells, there are no technically feasible pre-combustion NO<sub>x</sub> controls. Likewise, there are no technically feasible add-on control options because of the temperature of the potroom exhaust (<300°F) and low NO<sub>x</sub> concentration (<1 ppm).

#### **6.1.3 Control Effectiveness for Feasible BART Control Options for Potlines**

Step 3 of the BART analysis is to evaluate the control effectiveness of the technically feasible control technologies.

##### **6.1.3.1 Control Effectiveness for Potline SO<sub>2</sub>**

###### **6.1.3.1.1 SO<sub>2</sub> Wet Scrubbing**

A wet scrubber was identified as a technically feasible add-on pollution control option to reduce SO<sub>2</sub> from the potline reactors. Typical removal efficiencies are 80–95%. Two vendors of

this type of equipment provided control equipment quotes. One vendor provided preliminary equipment costs for two 100% absorbers for potline 2 and two 100% absorbers for potlines 3 - 6. The second vendor provided preliminary costs for two 100% absorber systems for the potlines at a similar Alcoa facility – Tennessee Operations. This system was sized for a total flow rate of 1,920,000 acfm at Tennessee operations. For the purposes of this BART analysis, the information provided by the second vendor for the potlines at Alcoa – Tennessee Operations was scaled, based on exhaust gas volumes, to represent controls for Alcoa – Warrick Operations. The responding vendors reported that 95% SO<sub>2</sub> removal was technically feasible. Accordingly, an SO<sub>2</sub> removal efficiency of 95% was used in the BART analysis for the wet scrubber control option.

Mist droplets will be a component of the gas stream emitted from the scrubber. Solids in the droplets will become airborne PM when the water in the droplets evaporates. The PM concentration in the outlet of the wet scrubber was predicted to be 20 mg/Nm<sup>3</sup> by one of the vendors. Consequently, the wet scrubber option would cause an increase in PM from the potlines, as demonstrated in Table 6-2.

Table 6-2 summarizes the SO<sub>2</sub> emission levels under the control scenario considered for BART. The emissions represent the combined total emissions from the potline roof vents and the potline reactors for each scenario. Based on the analysis of feasible add on controls and pollution prevention actions, the BART control scenario identified as feasible is the utilization of 3% sulfur coke and addition of a wet scrubber to the potlines reactors. The emissions reductions/increases achievable by these scenarios were compared to baseline.



**Table 6-2. SO<sub>2</sub> Post-Control Emission Rates<sup>a</sup>**

Control Scenario	SO <sub>2</sub> Control Technology	SO <sub>2</sub>		NO <sub>x</sub>		PM <sub>2.5</sub>		PM <sub>10</sub>		Organics	
		Emissions (tons/yr)	% Reduction (Increase) <sup>b</sup>	Emissions (tons/yr)	% Reduction (Increase) <sup>b</sup>	Emissions (tons/yr)	% Reduction (Increase) <sup>c</sup>	Emissions (tons/year)	% Reduction (Increase) <sup>e</sup>	Emissions (tons/year)	% Reduction (Increase) <sup>g</sup>
1	3.0% Sulfur Coke with Potlines Wet Scrubber	407	95.0	50.5	0	710 <sup>d</sup>	c.	536 <sup>f</sup>	e.	254 <sup>h</sup>	G
Current Potential Emissions	2.0% Sulfur Coke Potlines	4,052		50.5		777 <sup>d</sup>		398 <sup>f</sup>		292 <sup>h</sup>	

<sup>a</sup>Emission rates include the potline primary control system and the potline roof emissions.

<sup>b</sup>Compared with current potential emissions from the dry scrubbers, and excluding 127 tons/yr. from the roof vents.

<sup>c</sup>Based on condensable PM10 removal listed in the 10/14/09 amendments letter for the #2 and 3 boiler scrubbers, i.e. 75%, the condensable inorganic emissions at the scrubber outlet will be 291 tons/yr. 39 tons/yr. will thus be solid PM<sub>2.5</sub>. The scrubber would add 194 tons of solid PM<sub>2.5</sub> to what the fabric filter portion of the dry scrubber would remove.

<sup>d</sup>Includes 122 tons of inorganic condensables and 258 tons/yr. solid PM<sub>2.5</sub> from the roof.

<sup>e</sup>Based on information provided by the scrubber vendor, solid coarse PM will be 186 tons/yr. Includes 122 tons of inorganic condensables.

<sup>f</sup>Includes 350 tons/yr. solid PM<sub>10</sub> from the roof.

<sup>g</sup>Based on condensable PM10 removal measured at the Units 1,2,and 3 boiler scrubbers, i.e. 25%, or 116 tons/yr. for the captured emissions.

<sup>h</sup>Includes 138 tons/yr. of organic condensables from the roof vents.

#### **6.1.4 Evaluation of Costs and Other Impacts for Potline Feasible BART Control Options**

##### **6.1.4.1 Cost Analysis for SO<sub>2</sub> Wet Scrubber Control Options**

The exhaust gases from potlines 2, 5, and 6 are each routed to individual Alcoa A-398 dry alumina reactors located in the courtyards between the potrooms or adjacent to the western most potroom. The exhaust gases from potlines 3 and 4 are routed to one GTC control system.

As stated previously, two vendors of this type of equipment provided control equipment quotes. One vendor provided preliminary equipment costs for two 100% wet scrubbers for potline # 2 and two 100% wet scrubbers for potlines # 3 - 6. The second vendor provided preliminary costs for two 100% wet scrubber systems for the potlines at a similar Alcoa facility – Tennessee Operations. This system was sized for a total flow rate of 1,920,000 acfm at Tennessee operations. For the purposes of this BART analysis, the information provided by the second vendor for the potlines at Alcoa – Tennessee Operations was scaled, based on exhaust gas volumes, to represent controls for Alcoa – Warrick Operations. Sodium-based scrubbers could also be used, but sodium is a less desirable reagent considering that these reagents are much more expensive. The high solubility of sodium compounds also would have higher solid and liquid waste disposal cost because there is no receiving stream near the Alcoa facility where sodium-containing wastewater could be discharged directly without pre-treatment. Other types of limestone-based scrubbers could also be used and costs for these systems would be similar. An advantage of the forced oxidation process is that the spent slurry is oxidized to gypsum, which dewateres more efficiently, resulting in less waste materials requiring disposal. Thus, a LSFO scrubber was determined to be the most appropriate control device for the cost analysis.

Neither of the two vendors provided a comprehensive installed cost estimate. Both preliminary designs were based on a central scrubbing center as the least cost approach, where exhaust from the alumina dry scrubbing systems would be ducted to a centralized scrubbing system. Both design estimates were based on systems that would provide 100% availability of

emissions control on each day of the year, given that potlines cannot be easily shutdown and restarted for control system outages.

One vendor provided an estimate of the scrubber equipment only. The other provided an “indicative price,” as an installed cost based on the scrubber equipment with installation assumed to be equal to the equipment cost. Important retrofit considerations are (1) that gases must be collected from individual dry reactor stacks, (2) the system must simultaneously maintain balanced flow from multiple potline control devices, and (3) the system installation would also require transport of new components through narrow passages in the existing potline. Coordination of the equipment delivery and the daily work schedule of the potline operation would also affect the control system installation.

One of the vendors recognized the complexity of this project, pointing out in their proposal that an extensive engineering effort was needed because of space limitations, access limitations, uncertainty as to laydown areas, and uncertainty of ductwork and supports.

For Alcoa’s BART determination, the factored cost procedures in the EPA Cost Manual (EPA 2002) were used to estimate an installed cost using the equipment costs provided by the vendors. The cost estimates are included in Appendix C.

Table 6-3 summarizes the cost of installing and operating a LSFO wet scrubber on the potlines to remove 95% of the SO<sub>2</sub>. The cost is based on an average of the two proposals. The capital and total annualized costs are high at >\$300,000,000 and \$55,000,000 per year, respectively. The wet scrubber cost effectiveness is also high at \$15,000 per ton of SO<sub>2</sub> removed, assuming use of coke with 3.0% sulfur.

**Table 6-3. Summary of the Impacts Analysis for SO<sub>2</sub> Control Scenarios**

Control Scenario	Control Technology Evaluated	Emission Rate (tons/year)	Emissions Reductions (tons/year) <sup>a</sup>	Installed Capital Cost (\$000)	Total Annualized Control Costs (\$000)	Cost Effectiveness (\$ per ton of pollutant removed)	Energy Impact (000 kW-hour/year)	Collateral Increase in other Pollutants	Non-Air Quality Environmental Impacts
1	3.0% Sulfur Coke with Potlines Wet Scrubber	393	3,662	\$305,000	\$55,000	\$15,000	41,800	PM <sub>2.5</sub> 58 tons/year	21,633 tons/year of solid waste for disposal 312 million gallons/year makeup water usage
Current Potential Emissions	2.0% Sulfur Coke Potlines	4,055							

#### 6.1.4.2 Energy Impact Analysis

A wet scrubber removes SO<sub>2</sub> by forcing the exhaust gas through a spray tower or absorber where it contacts water droplets that contain the unreacted lime or limestone. Energy is required to overcome the resistance of the scrubber components as well as falling water droplets. A substantial amount of energy is associated with a fan to move approximately 2,440,000 acfm through the scrubber. The fan alone would require 2,800 kW. Other energy is required for the slurry pumps, instrumentation, and miscellaneous items (e.g., lighting). The total energy required, based on an average of the two proposals, would be approximately 4,775 kW. As listed in Table 7, this is equivalent to 41,800,000 kW-hours of electricity per year.

#### 6.1.4.3 Non-Air Quality Environmental Impacts for Feasible Potline BART Control Options

The two wet scrubber proposals were based on using limestone. This process oxidizes the spent slurry to gypsum, which may be landfilled or commercially sold. There is no way to know at this time whether the gypsum would have commercial value or whether there would be any demand for it. Therefore, it must be assumed that 21,600 tons of waste from the potlines wet scrubber would be landfilled each year.

It is estimated that 312 million gallons of water will be required annually to operate the potline wet scrubber at a cost of \$468,000. This will significantly impact the community infrastructure in that this will increase daily water demand. There will be relatively no impact due to water discharge, this being approximately 13 gallons/minute.

It is also estimated that 41 million kWh would be needed to operate the scrubbers annually. This would impact power demand on the current generating capacity and therefore also have an environmental impact due to power production equivalent to adding over 3,500 new households in the community.

#### **6.1.4.4 Remaining Useful Life**

Alcoa has been in operation since 1960 when potline 1 and boiler unit # 1 were first brought on line. Alcoa has produced many different products for the construction, aerospace, military, consumer, and other markets. Since its inception, Warrick Operations has evolved into one of the most modern integrated aluminum production facilities in the world. The facility intends to be in operation throughout the period of the Regional Haze Program.

### **6.2 Coal Fired Industrial Boiler Emission Controls**

#### **6.2.1 Potentially Applicable BART Control Options for Industrial Boilers**

##### **6.2.1.1 Potentially Applicable SO<sub>2</sub> Emission Controls for Industrial Boilers**

Sulfur in the coal burned to create steam in the boilers is released during the combustion process as SO<sub>2</sub>.

##### ***6.2.1.1.1 Wet Scrubbing for Industrial Boilers***

The primary development of SO<sub>2</sub> control technology occurred because of the need to control emissions from the coal-fired, electric utility power industry (AWMA 2000).

The typical temperature range for wet scrubbers is 300–700°F. For utility combustion units, wet scrubbing systems have been installed on systems as large as 1,500 MW. Sodium

compounds, lime, or limestone can be used. However, the high solubility of sodium complicates disposal of waste and wastewater. The typical sorbent material is lime or limestone. Lime is generally easier to manage on-site but is significantly more costly. Wet limestone scrubbing has a high capital and operating cost due to the handling of liquid reagent and waste, but is the preferred process for coal-fired utility power plants burning coal due to the low cost of limestone and high removal efficiencies. Typical removal efficiencies are 80–95%. Approximately 85% of the flue gas desulfurization (FGD) systems installed in the United States are wet scrubber systems (EPA 2003c).

In wet scrubbers, the waste gas enters a large vessel (spray tower or absorber), where it is sprayed with water slurry. Figure 1, previously presented, is a simplified process flow diagram of a conventional wet scrubber.

The calcium in the slurry reacts with  $\text{SO}_2$  to form  $\text{CaSO}_3$ . A portion of the slurry from the reaction tank is pumped into the thickener, where the solids settle before going to a filter for final dewatering to about 50% solids. In the utility industry, the  $\text{CaSO}_3$  waste product is usually mixed with fly ash (approximately 1:1) and fixative lime (approximately 5%) and typically disposed of in landfills. Alternately, the forced oxidation process oxidizes the spent slurry to gypsum. Gypsum crystals dewater more efficiently and reduce the size of waste handling equipment. Depending on quality and demand, the gypsum may be commercially sold, eliminating the need for landfilling the waste product.

Note that “mist eliminators,” installed at the spray tower outlet or downstream ductwork, remove droplets from the gas. In some power plant installations, the gas is reheated to avoid corrosion downstream. Many scrubbers have gas bypassing capability, which can be used for gas reheating. If the wet scrubber is downstream of a high-efficiency particulate removal device [fabric filter or electrostatic precipitator (ESP)], the particulate concentration may be higher leaving the scrubber than entering due to the solids in mist droplets that are carried out of the scrubber.

Some disadvantages of using wet scrubbing techniques in many applications are the requirement to treat wastewater, components must be constructed from expensive alloys to resist corrosion, and energy use is much higher. A practical issue associated with a wet scrubber system is the complexity of the system. The space required for a wet system is substantial (i.e., large footprint), the systems require more maintenance due to their complexity, and more personnel are required for their operation.

#### **6.2.1.1.1.1 Seawater Scrubbing**

Seawater scrubbing has also been implemented in the coal fired power industry, most recently at the Mawan Power Station in China and the Paiton Project in Indonesia. Seawater, which has a natural alkalinity, is pumped directly into a scrubbing tower through a system of spray nozzles where the atomized droplets make contact with the effluent gas stream. The liquid effluent is discharged back into the ocean. Seawater scrubbing was automatically rejected as infeasible because of Alcoa's physical location.

#### **6.2.1.1.1.2 Limestone Slurry Forced Oxidation**

Limestone slurry forced oxidation (LSFO) is used extensively in the utility flue gas desulphurization market. The raw material is finely ground limestone. There are a number of suppliers of LSFO technology. The most commonly used equipment is an open, multi-level, countercurrent spray tower scrubber equipped with spray nozzles to inject the limestone slurry droplets into the gas stream. Liquor is collected at the bottom of the tower and sparged with air to oxidize the calcium sulfite to calcium sulfate to enhance the settling properties of the calcium sulfate. Recirculation pumps circulate the scrubbing liquor to the spray nozzles. SO<sub>2</sub> removal efficiencies of 90% have been achievable. The bleed from the scrubber is sent to a dewatering system to remove excess moisture. For a coal fired boiler, the process will produce either solid gypsum waste or commercial-grade gypsum suitable for reuse as a cement additive. Only a very small purge or blowdown stream is required.

LSFO was determined to be a technically feasible retrofit control option for the coal fired boilers.

#### **6.2.1.1.1.3 Limestone Slurry Natural Oxidation**

Limestone slurry natural oxidation (LSNO) is very similar to LSFO. The major difference is the absence of an oxidation stage. The gypsum/calcium sulfite product is essentially a waste product with limited possibilities of being used for agricultural purposes.

#### **6.2.1.1.1.4 Conventional Limestone Wet Scrubbing**

Conventional lime wet scrubbing is also similar to LSFO except that the raw material is hydrated lime or quick lime that is either slaked on-site or purchased in the slaked form. The system typically uses forced oxidation, although natural oxidation is possible. The process will produce either solid gypsum waste or commercial-grade gypsum suitable for reuse as a cement additive.

#### **6.2.1.1.1.5 Dual Alkali Sodium/Lime Scrubbing (Dilute Mode)**

Dual alkali sodium/lime scrubbing (dilute mode) uses a caustic sodium solution in the scrubber tower. A portion of the scrubbing liquid is discharged to a neutralization stage where lime slurry is used to regenerate the caustic, which is returned to the scrubber. The bleed from the scrubber is sent to a dewatering system to produce a gypsum byproduct. The process will produce either solid gypsum waste or commercial-grade gypsum suitable for reuse as a cement additive. It should be noted, however, that dual alkali sodium/lime scrubbing (dilute mode) is not marketed today by major FGD vendors because the system is too complicated and expensive.



#### **6.2.1.1.1.6 Conventional Sodium Scrubbing**

This technology has been successfully utilized in the power industry. An alkaline solution of either soda ash or sodium hydroxide is pumped into the scrubbing tower and recirculated through a network of spray nozzles. Atomized droplets contact the up-flowing gas containing  $\text{SO}_2$ . Where this technology has been deployed, the liquid effluent containing dissolved salts, including sodium and fluorides, has been discharged into a large receiving stream or an open body of water without treatment.

#### **6.2.1.1.2 Dry Scrubbing for Industrial Boilers**

##### **6.2.1.1.2.1 Dry Injection**

In dry injection, a reactive alkaline powder is injected into a furnace, ductwork, or a dry reactor. Typical removal efficiencies with calcium adsorbents are 50–60% and up to 80% with sodium base adsorbents. However, as with wet scrubbing, disposal of waste using sodium adsorbents must consider their high solubility in water compared to those from calcium adsorbents. The temperature range where dry scrubbing has been used is 300–1,800°F; the minimum temperature is 300–350°F. Dry systems are rarely used and according to EPA only 3% of FGD systems installed in the United States are dry systems (EPA 2003c). The dry waste material is removed using particulate control devices such as a fabric filter or an ESP.

##### **6.2.1.1.2.2 Semi-dry Scrubbing (Spray Dryer)**

Semi-dry scrubbing is more commonly referred to as spray drying. Calcium hydroxide slurry (lime mixed with water) is introduced into a spray dryer tower. Sodium compounds can be used, but as with the dry scrubber, the high solubility of the sodium-based waste products in water complicates disposal of the waste. The slurry is atomized and injected into a reactor with the exhaust gases, where droplets react with  $\text{SO}_2$  as the liquid evaporates. This system is

categorized as a semi-dry system because the end product of the SO<sub>2</sub> conversion reaction is a dry material. The dry waste product is collected in the bottom of the spray dryer reactor, and a fabric filter or ESP downstream of the spray dryer removes the CaSO<sub>3</sub>, CaSO<sub>4</sub>, and unreacted lime. This air pollution control system uses water for evaporative cooling and for the SO<sub>2</sub> reaction. It operates in a temperature range of 300–350°F because the temperature of the gases must be high enough to evaporate the water portion of the slurry. Approximately 12% of the FGD systems installed in the United States are spray dry systems (EPA 2003c) with typical SO<sub>2</sub> removal efficiencies in the range of 80–90%. Unlike a wet scrubbing system there is no liquid blow-down stream from the dry system, and the collected solids are typically landfilled.

#### ***6.2.1.1.3 Pollution Prevention for Industrial Boilers***

Several techniques may be used to reduce SO<sub>2</sub> emissions from coal combustion. One way is to switch to lower sulfur coals, since SO<sub>2</sub> emissions are proportional to the sulfur content of the coal. This alternative may not be possible where lower sulfur coal is not readily available or where a different grade of coal cannot be satisfactorily fired. In some cases, various coal cleaning processes may be employed to reduce the fuel sulfur content. Physical coal cleaning removes mineral sulfur such as pyrite but is not effective in removing organic sulfur. Chemical cleaning and solvent refining processes are being developed to remove organic sulfur.

It is not reliably known what the sulfur content of coals will be that are available to Alcoa in the future. Low sulfur coals are currently in demand as utilities comply with Acid Rain Rules and other Federal and State programs. Availability has decreased and cost has increased. Since Alcoa intends to operate the Warrick facility throughout the period of the Regional Haze Program, it is not feasible to rely on the long-term availability of low sulfur coals. Use of low-sulfur coals was rejected as a BART option.

#### ***6.2.1.1.4 Industrial Boiler SO<sub>2</sub> Control Options from RBLC Database***

A review of EPA's RACT/BACT/LAER Clearinghouse (RBLC) database was also completed to determine which control technologies or techniques have been utilized by industrial boilers. Results from searching the RBLC are summarized in Table 6-4.

Table 6-4. RBLC Database Search Results for SO<sub>2</sub> Control Industrial Boilers

RBLC ID	Facility	Last Update	Process	Control Option	Emission Limit		Percent Efficient
ND-0021	GASCOYNE GENERATING STATION	8/16/2005	BOILER, COAL-FIRED	LIMESTONE INJECTION WITH A SPRAY DRYER.	0.038	LB/MMBTU	98.9
NV-0036	TS POWER PLANT	8/31/2006	200 MW PC COAL BOILER	LIME SPRAY SPRAY DRY SCRUBBER	0.09	LB/MMBTU	
MO-0071	KANSAS CITY POWER & LIGHT COMPANY - IATAN STATION	5/7/2007	PULVERIZED COAL BOILER - UNIT 2	KCPL SHALL INSTALL SCR UNIT FOR THE UNIT 2 BOILER TO REDUCE NOX EMISSIONS AND ALSO SHALL INSTALL WET SCRUBBER TO REDUCE SOX EMISSIONS. BOTH CONTROLS ARE NOT BACT FOR NOX AND SOX	0.09	LB/MMBTU	
NE-0031	OPPD - NEBRASKA CITY STATION	8/30/2006	UNIT 2 BOILER	DRY FLUE GAS DESULFURIZATION & FABRIC FILTER	0.095	LB/MMBTU	90
MO-0060	CITY UTILITIES OF SPRINGFIELD - SOUTHWEST POWER STATION	3/8/2007	PULVERIZED COAL FIRED BOILER	DRY FLUE GAS DESULFURIZATION > 90%	0.095	LB/MMBTU	91.8
UT-0053	DESERET GENERATION AND TRANSMISSION COMPANY	12/18/2001	COAL FIRED BOILER	WET SCRUBBER	0.0976	LB/MMBTU 12 MO. AVG.	90
UT-0065	INTERMOUNTAIN POWER GENERATING STATION - UNIT #3	3/22/2006	PULVERIZED COAL FIRED ELECTRIC GENERATING UNIT	WET FLUE GAS DESULPHURIZATION, LOW SULFER COAL	0.1	LB/MMBTU	90
WI-0228	WPS - WESTON PLANT	8/31/2006	SUPER CRITICAL PULVERIZED COAL ELECTRIC STEAM BOILER (S04, P04)	DRY FGD, LIMIT ON EMISSIONS ENTERING CONTROL SYSTEM: 1.23 LBS/MMBTU 30 DAY AVG.	0.1	LB/MMBTU	92
MO-0071	KANSAS CITY POWER & LIGHT COMPANY - IATAN STATION	5/7/2007	PULVERIZED COAL BOILER - UNIT 1		0.1	LB/MMBTU	
WY-0057	WYGEN 2	9/23/2003	BOILER, 500 MW PC	SEMI-DRY LIME SPRAY DRYER ABSORBER	0.1	LB/MMBTU	
KS-0026	HOLCOMB UNIT #2	1/16/2004	BOILER, PULVERIZED COAL	DRY FLUE GAS DESULFURIZATION	0.12	LB/MMBTU	94
NE-0018	WHELAN ENERGY CENTER	8/10/2004	BOILER, UNIT 2 UTILITY	SPRAY DRYER ABSORBER (SDA)	0.12	LB/MMBTU	
SC-0104	SANTEE COOPER CROSS GENERATING STATION	8/31/2006	BOILER, NO. 3 AND NO. 4	FLUE GAS DESULFURIZATION (WET SCRUBBING)	0.13	LB/MMBTU	95
MT-0027	HARDIN GENERATOR PROJECT	7/1/2004	BOILER, PULVERIZED COAL-FIRED	WET VENTURI SCRUBBER	0.14	LB/MMBTU	
PA-0183	AES BEAVER VALLEY, LLC	9/4/2003	COAL FIRED BOILER	HYDRATED ASH RE-INJECTION SYSTEM	0.14	LB/MMBTU	
AR-0074	PLUM POINT ENERGY	3/2/2004	BOILER , UNIT 1 - SN-01	DRY FLUE GAS DESULFURIZATION	0.16	LB/MMBTU	
AR-0079	PLUM POINT ENERGY	5/2/2006	BOILER - SN-01	DRY FLUE GAS DESULFURIZATION	0.16	LB/MMBTU	
VA-0296	VIRGINIA TECH	2/7/2006	OPERATION OF BOILER 11	DRY SCRUBBER FLUE GAS DESULFURIZATION SYSTEM AND CEMS	0.161	LB/MMBTU	92
KY-0084	THOROUGHbred GENERATING STATION	8/30/2006	BOILER, COAL, (2)	WET FLUE GAS DESULFURIZATION (FGD), WESP, AND PROPER BOILER DESIGN	0.167	LB/MMBTU	
WY-0039	TWO ELK GENERATION PARTNERS, LIMITED PARTNERSHIP	3/11/2004	BOILER, STEAM ELECTRIC POWER GENERATING	LIME SPRAY DRY SCRUBBER	0.2	LB/MMBTU (2HR FIXED)	91
PA-0162	EDISON MISSION ENERGY	6/12/2006	BOILER, COAL, PULVERIZED BITUMINOUS, UNIT 3	WET LIMESTONE SCRUBBER	0.4	LB/MMBTU	92
VA-0268	THERMAL VENTURES	9/5/2003	BOILER, STEAM	GOOD COMBUSTION PRACTICES, CLEAN BURNING FUEL, AND CONTINUOUS EMISSION MONITORING DEVICE.	0.47	LB/MMBTU	
OH-0314	SMART PAPERS HOLDINGS, LLC	4/29/2008	PULVERIZED DRY BOTTOM BOILER		1.7	LB/MMBTU	
LA-0122	MANSFIELD MILL	3/17/2005	POWER BOILER #1 & #2, COMBINED FUEL	LIMIT SULFUR CONTENT OF FUEL			

NOTES:

The RBLC search was performed for industrial coal-fired boilers with capacities greater than 250 MMBtu/hr. Facilities that operate circulating fluidized bed boilers were not included in the search. Facilities with draft permits and facilities still under construction were also excluded from the search results.

Twenty-four units were identified in the RBLC database that could be considered similar to the boiler units at Alcoa. Of these 24 units, approximately half utilized a form of dry flue gas desulfurization to control SO<sub>2</sub> emissions, seven used wet scrubbing to control SO<sub>2</sub> emissions, and the remaining units used other means such as low sulfur coal and good combustion practices. Of the 24 units in the database, 10 listed an SO<sub>2</sub> removal efficiency in the range of 90% to 95% with an average of 91.8%.

Both wet scrubbing and dry scrubbing have been considered BACT for SO<sub>2</sub>.

#### **6.2.1.2 Potentially Applicable BART Control Options for PM**

The Indiana CAIR rules do not remove utility boilers from the requirement to perform a BART analysis for PM control. Industrial boilers 2 and 3 are also subject to PM BART. The sections that follow for PM are applicable for boilers 2, 3, and 4.

##### ***6.2.1.2.1 Fabric Filters***

Fabric filters generally provide high collection efficiencies for both coarse and fine (submicron) particles. They are relatively insensitive to fluctuations in gas stream conditions. Efficiency is relatively unaffected by large changes in inlet dust loadings. Filter outlet air is very clean (EPA 2003b). Collected material is dry, which usually simplifies processing or disposal.

##### ***6.2.1.2.2 Electrostatic Precipitators***

ESPs are capable of very high removal efficiencies for large and small particles (EPA 2003a). They offer control efficiencies that are comparable to fabric filters. Because of their modular design, ESPs, like fabric filters, can be applied to a wide range of system sizes. The operating parameters that influence ESP performance include fly ash mass loading, particle size distribution, fly ash electrical resistivity, and precipitator voltage and current. Dusts with high resistivities are not well-suited for collection in dry ESPs because the particles are not easily charged. This also affects the ash layers on the collecting electrodes.

#### **6.2.1.2.3 Cyclones, Inertial Separators, and Wet Scrubbers**

Cyclones and inertial separators are used for collection of medium-sized and coarse particles. Wet scrubbers generally remove large particles but can remove small particles with the use of high pressure drops. However, none of these devices are as effective at removing small and submicron particles as fabric filters and ESPs (AWMA 2000).

#### **6.2.1.3 Potentially Applicable BART Control Options for NO<sub>x</sub>**

Combustion controls and post-combustion controls are the two potential ways to reduce NO<sub>x</sub> emissions from industrial coal-fired boilers. Combustion control methods seek to suppress the formation of NO<sub>x</sub> during the combustion process by controlling the flame temperature and the fuel/oxygen ratio. Combustion control methods typically include low NO<sub>x</sub> burners (LNBs), overfire air (OFA), combustion optimization, and natural gas reburn. Post-combustion controls capture a portion of the NO<sub>x</sub> after formation. Post-combustion controls typically include selective non-catalytic reduction (SNCR) and selective catalytic reduction systems (SCR). Technologies such as Mobotec and NO<sub>x</sub>Star are also examples of emerging post-combustion control technologies. Post-combustion NO<sub>x</sub> control technologies use either ammonia or urea as a reagent. The SCR technology also requires multiple layers of reduction catalyst. Seven different NO<sub>x</sub> control options were considered as having potential practical application as part of the BART analysis.

- Low NO<sub>x</sub> Burners
- Natural Gas Reburn
- Combustion Optimization (Neural Network)
- Selective Non-catalytic Reduction (SNCR)
- SNCR/SCR Hybrid (Cascade Process)
- Selective Catalytic Reduction (SCR)
- Mobotec ROFA/ROTAMIX

- Mitsui Babcock NO<sub>x</sub>Star

For this BART analysis, emphasis was placed on evaluating technically proven and commercially available NO<sub>x</sub> control technologies. The Mobotec ROFA/ROTAMIX, the Mitsui Babcock NO<sub>x</sub>Star, and the SNCR/SCR Hybrid systems are considered emerging post-combustion control technologies and have a limited number of installations in operation in the U.S. Natural gas reburn technology requires sufficient residence time (adequate furnace height) to successfully reduce NO<sub>x</sub>; therefore, it is difficult to use as a retrofit technology in existing coal-fired boilers. Combustion optimization is also limited in effectiveness in a retrofit case depending on how well the existing boilers are operated and maintained. The commercially proven NO<sub>x</sub> control technologies evaluated in the BART analysis include LNB with OFA, SNCR, and SCR systems.

#### ***6.2.1.3.1 Low NO<sub>x</sub> Burners & Overfire Air***

LNBs limit NO<sub>x</sub> formation by controlling the stoichiometric and temperature profiles of the combustion process in each burner zone. The unique design of features of an LNB may create (1) a reduced oxygen level in the combustion zone to limit fuel NO<sub>x</sub> formation, (2) a reduced flame temperature that limits thermal NO<sub>x</sub> formation, and/or (3) a reduced residence time at peak temperature which also limits thermal NO<sub>x</sub> formation.

LNBs are applicable to tangential and wall-fired boilers of various sizes but are not applicable to other boiler types such as cyclone furnaces or stokers. They have been used as a retrofit NO<sub>x</sub> control for existing boilers and can achieve approximately 35 to 55 percent reduction from uncontrolled levels. They are also used in new boilers to meet New Source Performance Standards (NSPS) limits. LNBs can be combined with OFA to achieve even greater NO<sub>x</sub> reduction (40 to 60 percent reduction from uncontrolled levels).

#### **6.2.1.3.2 Selective Non-Catalytic Reduction**

SNCR is an add-on technique that involves injecting ammonia or urea into a specific temperature zone in a furnace or boiler. The ammonia or urea reacts with NO<sub>x</sub> in the gas to produce nitrogen and water. SNCR typically provides 30–50% NO<sub>x</sub> reduction. The effectiveness of SNCR depends on the temperature where reagents are injected, mixing of the reagent in the gas, residence time of the reagent within the required temperature window, and the ratio of reagent to NO<sub>x</sub>. The required temperature window is 1,600–2,100°F. The furnace of a pulverized coal fired boiler operates at temperature between 2,500 and 3,000 °F. Therefore, the optimum temperature window at Warrick will most likely occur somewhere at the top of the furnace and in the forward section of the pendent area backpass. Typical uncontrolled NO<sub>x</sub> levels where this technology has been applied vary from 200 to 400 ppm. SNCR is less effective at lower levels of uncontrolled NO<sub>x</sub> (EPA 2003e).

SNCR systems are capable of achieving a NO<sub>x</sub> emission reduction as high as 50 to 60 percent in optimum conditions (adequate reaction time, temperature, and reagent/flue gas mixing; high baseline NO<sub>x</sub> conditions; and multiple levels of injectors) with ammonia slips of 10 to 50 ppmvd. Lower ammonia slip values can be achieved with lower NO<sub>x</sub> reduction capabilities. Typically, optimum conditions are difficult to achieve, resulting in emission reduction levels of 20 to 40 percent. Potential performance is very site-specific and varies with fuel type, steam generator size, allowable ammonia slip, furnace CO concentrations, and steam generator heat transfer characteristics. Due to the low inlet NO<sub>x</sub> conditions of the Warrick units and small boiler height, an SNCR system is expected to only achieve around 20 to 25 percent reduction, while maintaining an ammonia slip of 2 ppmvd to 5 ppmvd. As the ammonia slip value is controlled closer to 2 ppmvd, then the NO<sub>x</sub> reduction efficiency will be 20 percent or less.

SNCR systems reduce NO<sub>x</sub> emissions using the same reduction mechanism as SCR systems. Most of the undesirable chemical reactions occur when a reagent is injected at temperatures above or below the optimum range. At best, these undesired reactions consume reagent with no reduction in NO<sub>x</sub> emissions while, at worst, the oxidation of ammonia can



actually generate NO<sub>x</sub>. Accordingly, NO<sub>x</sub> reductions and overall reaction stoichiometry are very sensitive to the temperature of the flue gas at the reagent injection point. This complicates the application of SNCR for boilers larger than 50 to 100 MW.

Reagent injection lances are usually located between the boiler soot blowers in the pendent superheat section. Optimum injector location is mainly a function of temperature and residence time. To accommodate SNCR reaction temperature and boiler turndown requirements, several levels (four to five) of injection lances are normally installed if sufficient boiler height and residence time is available. It is estimated that only one level of nozzles would be installed for the Warrick units due to design limitations. A second level of multiple lance nozzles could be installed in the boiler backpass for a 5 to 10 percent increase in NO<sub>x</sub> removal capability, but the capital cost increases significantly and there is potential that ammonia slip would exceed 5 ppmvd.

A flue gas residence time of at least 0.3 seconds in the optimum temperature range is desired to ensure adequate SNCR performance. Residence times in excess of 1 second yield high NO<sub>x</sub> reduction levels, even under less than ideal mixing conditions.

Both ammonia- and urea-based SNCR processes typically require three to eight times the theoretical amount of reagent to achieve NO<sub>x</sub> reductions, as compared to SCR systems. Considering that aqueous ammonia cost about \$100/ton and urea costs about \$280/ton, there is a significant economic consideration in selecting a suitable reagent. The increased reagent consumption is due to reagent thermal decomposition, varying temperature, and the lack of a true steady-state controlled environment, which tends to increase ammonia slip emissions. Even with best efforts (multiple levels of injection, conscientious operator attention, etc.) ammonia slip emissions from SNCR systems will be highly variable during load changes. This can result in excess or inadequate reagent injection, the increased potential for exceeding allowable NO<sub>x</sub> emission limits, or increased ammonia slip with associated air heater pluggage and fly ash contamination.

The use of anhydrous ammonia would require the same safety systems, storage tanks, and vaporizers as those required for SCR systems. A urea-based process would have a pumping skid in lieu of a vaporizer or blower. The urea is pumped and injected as a liquid (typically a 50:50 solution of urea and water). The 50:50 solution is further diluted, prior to injection, by mixing it with either steam or air. These high-pressure gases act as the carrier gas as well as providing the pressure drop that leads to atomization upon injection into the boiler. If steam is used, there may be an impact to the boiler heat rate. If air is used, an air compressor is usually required to provide adequate constant supply of high-pressure flow.

#### **6.2.1.3.3 Selective Catalytic Reduction**

SCR is an add-on technique similar to SNCR that involves injecting ammonia into flue gas in the presence of a metal-based catalyst to convert NO<sub>x</sub> emissions to elemental nitrogen and water. The catalyst allows SCR systems to operate at much lower temperatures than SNCR; typical temperatures for SCR are 500–800°F, compared with 1,600–2,100°F for SNCR. The optimum temperature range is 700–750°F (EPA 2002). SCR is capable of NO<sub>x</sub> reduction efficiencies in the range of 70–90% and can be used with NO<sub>x</sub> concentrations as low as 20 ppm. However, higher NO<sub>x</sub> levels result in increased performance (EPA 2003d).

Current U.S. SCR experience demonstrates that a coal fired boiler can be retrofitted with an SCR; however, oxidation of SO<sub>2</sub> to SO<sub>3</sub> could require moderate air heater modifications since the acid dew point temperature of the flue gas is directly related to SO<sub>3</sub> concentrations. As the SO<sub>3</sub> concentration increases, the acid dew point of the flue gas increases, potentially increasing corrosion in downstream equipment or possibly requiring an increase in the air heater gas outlet temperature. The undesired reactions described cannot be eliminated completely. However, prudent design and appropriate operation can minimize the effect of the SCR system on the existing plant. These design considerations have some impact on the capital cost of an SCR system. Limiting the ammonia slip to a level that avoids air heater washing and contamination of the fly ash is very important. Long-term operations experience has shown that a level of 2 to 3 ppmvd ammonia slip is appropriate when burning most coal types.

The ammonia injection rate is controlled by the inlet NO<sub>x</sub> concentration, flue gas flow rate, and outlet NO<sub>x</sub> emission rate. The ammonia injection rate is based on stoichiometric ratio, typically very close to 1.0.

The SCR reactor is the housing for the catalyst. The reactor is basically a widened section of ductwork modified by the addition of catalyst, catalyst support structures, access doors, and soot blowers. SCR systems have been installed in three different arrangements, high-dust, low-dust, and tail-end. In a high-dust arrangement, the catalyst is located between the outlet of the economizer and the inlet of the air heater. A low-dust arrangement typically positions the catalyst between the outlet of a hot-side electrostatic precipitator and the inlet of the air heater; however, the catalyst could be positioned at the outlet of a cold-side precipitator with supplemental heating of the flue gas. In a tail-end arrangement, the catalyst is located between the outlet of a flue gas desulfurization system and upstream of the stack which also requires supplemental heating of the flue gas. Most installations in the U.S. have been the high-dust arrangement which, in most circumstances, is the most economical arrangement alternative. The Warrick units employ a cold side ESP for particulate control and there is adequate space between the ESP and the air heater inlet; therefore, the low-dust arrangement is the most feasible arrangement.

The ammonia reagent for the SCR systems can be supplied by anhydrous ammonia, a 19 or 29 percent aqueous ammonia/water solution, or by conversion of urea to ammonia. Since the ammonia is vaporized prior to contact with the catalyst, the selection of ammonia type does not influence the catalyst performance. However, the selection of ammonia type does affect all other subsystem components, including reagent storage, vaporization, injection control, and balance-of-plant requirements. The majority of worldwide installations use anhydrous ammonia.

#### ***6.2.1.3.4 Industrial Boiler NO<sub>x</sub> Control Options from RBLC Database***

A review of EPA's RACT/BACT/LAER Clearinghouse (RBLC) database was also completed to determine which control technologies or techniques have been utilized by industrial boilers. Results from searching the RBLC are summarized in Table 6-5.

Table 6-5. RBLC Database Search Results for NO<sub>x</sub> Control Industrial Boilers

RBLC ID	Facility	Last Update	Process	Control Option	Emission Limit		Percent Efficient
NV-0036	TS POWER PLANT	8/31/2006	200 MW PC COAL BOILER	SCR & LOW NOX BURNERS	0.07	LB/MMBTU	
UT-0065	INTERMOUNTAIN POWER GENERATING STATION - UNIT #3	3/22/2006	PULVERIZED COAL FIRED ELECTRIC GENERATING UNIT	LOW NOX BURNERS, OVER FIRE AIR, SCR	0.07	LB/MMBTU	80
WI-0228	WPS - WESTON PLANT	8/31/2006	SUPER CRITICAL PULVERIZED COAL ELECTRIC STEAM BOILER (S04, P04)	LOW NOX BURNERS, GOOD COMBUSTION PRACTICES SELECTIVE CATALYTIC REDUCTION (SCR)	0.07	LB/MMBTU	
NE-0031	OPPD - NEBRASKA CITY STATION	8/30/2006	UNIT 2 BOILER	SELECTIVE CATALYTIC REDUCTION (SCR)	0.07	LB/MMBTU	90
WY-0057	WYGEN 2	9/23/2003	BOILER, 500 MW PC	LOW NOX BURNERS/SCR	0.07	LB/MMBTU	
OK-0118	HUGO GENERATING STA	9/27/2007	COAL-FIRED STEAM EGU BOILER (HU-UNIT 2)	LOW NOX BURNERS (LNB) W/ OVERFIRE AIR (OFA) AND SELECTIVE CATALYTIC REDUCTION (SCR)	0.07	LB/MMBTU	
SC-0104	SANTEE COOPER CROSS GENERATING STATION	8/31/2006	BOILER, NO. 3 AND NO. 4	LOW NOX BURNERS AND SCR	0.08	LB/MMBTU	
MO-0060	CITY UTILITIES OF SPRINGFIELD - SOUTHWEST POWER STATION	3/8/2007	PULVERIZED COAL FIRED BOILER	IT WAS DETERMINED THAT THE BACT FOR NOX FROM THE PULVERIZED COAL FIRED BOILER IS GOOD COMBUSTION PRACTICES ALONG WITH SCR HAVING A NOX EMISSION LIMIT OF 0.08 LB/MMBTU ON A 30-DAY ROOLING AVERAGE.	0.08	LB/MMBTU	82.6
KY-0084	THOROUGHbred GENERATING STATION	8/30/2006	BOILER, COAL, (2)	PROPER BOILER DESIGN, LOW NOX BURNERS, AND SCR	0.08	LB/MMBTU	
MO-0071	KANSAS CITY POWER & LIGHT COMPANY - IATAN STATION	5/7/2007	PULVERIZED COAL BOILER - UNIT 2	KCPL SHALL INSTALL SCR UNIT FOR THE UNIT 2 BOILER TO REDUCE NOX EMISSIONS AND ALSO SHALL INSTALL WET SCRUBBER TO REDUCE SOX EMISSIONS. BOTH CONTROLS ARE NOT BACT FOR NOX AND SOX	0.08	LB/MMBTU	
NE-0018	WHELAN ENERGY CENTER	8/10/2004	BOILER, UNIT 2 UTILITY	SELECTIVE CATALYTIC REDUCTION	0.08	LB/MMBTU	
MT-0027	HARDIN GENERATOR PROJECT	7/1/2004	BOILER, PULVERIZED COAL-FIRED	SELECTIVE CATALYTIC REDUCTION	0.09	LB/MMBTU	
AR-0074	PLUM POINT ENERGY	3/2/2004	BOILER , UNIT 1 - SN-01	LOW NOX BURNERS	0.09	LB/MMBTU	
AR-0079	PLUM POINT ENERGY	5/2/2006	BOILER - SN-01	LOW NOX BURNERS	0.09	LB/MMBTU	
MO-0071	KANSAS CITY POWER & LIGHT COMPANY - IATAN STATION	5/7/2007	PULVERIZED COAL BOILER - UNIT 1		0.1	LB/MMBTU	
KS-0026	HOLCOMB UNIT #2	1/16/2004	BOILER, PULVERIZED COAL	SCR, LOW NOX BURNERS, SEPARATED OVERFIRE AIR (SOFA)	0.12	LB/MMBTU	70
PA-0162	EDISON MISSION ENERGY	6/12/2006	BOILER, COAL, PULVERIZED BITUMINOUS, UNITS 1, 2 &3	SCR. SEE COMMENT ABOUT NOX EMISSION LIMITS IN FACILITY NOTES. REGULATORY BASIS IS STATE IMPLEMENTATION PLAN.	0.15	LB/MMBTU	70
WY-0039	TWO ELK GENERATION PARTNERS, LIMITED PARTNERSHIP	3/11/2004	BOILER, STEAM ELECTRIC POWER GENERATING	LOW NOX BURNERS WITH OVER FIRE AIR AND SELECTIVE CATALYTIC REDUCTION	0.15	LB/MMBTU (30D ROLL)	75
VA-0296	VIRGINIA TECH	2/7/2006	OPERATION OF BOILER 11	EMISSIONS CONTROLLED BY A MASS-FEED STOKER CONFIGURATION WITH LOW EXCESS AIR/STAGED COMBUSTION	0.25	LB/MMBTU	
TX-0489	SOUTHWESTERN PUBLIC SERVICE COMPANY-HARRINGTON STATION	3/20/2007	UNIT 3 BOILER	LOW NOX BURNERS, SEPARATED OVERFIRE AIR WINDBOX, WITH ADDITIONAL YAW CONTROL OF THE BURNERS FOR ADDITIONAL NOX CONTROL	0.3	LB/MMBTU	57
VA-0268	THERMAL VENTURES	9/5/2003	BOILER, STEAM	GOOD COMBUSTION PRACTICES, CLEAN BURNING FUEL, AND CONTINUOUS EMISSION MONITORING DEVICE.	0.4	LB/MMBTU	
PA-0176	ORION POWER MIDWEST LP	8/15/2006	BOILERS, COAL (3)	OVERFIRE AIR, LOW NOX BURNERS	0.5	LB/MMBTU	
UT-0053	DESERET GENERATION AND TRANSMISSION COMPANY	12/18/2001	COAL FIRED BOILER	BOILER DESIGN	0.55	LB/MMBTU 30-DAY AVG	99.599

NOTES

The RBLC search was performed for industrial coal-fired boilers with capacities greater than 250 MMBtu/hr. Facilities that operate circulating fluidized bed boilers were not included in the search. Facilities with draft permits and facilities still under construction were also excluded from the search results. No facilities with SNCR controls were found in the RBLC database using this search criterion.

Twenty-three units in the RBLC database were identified as potentially similar to Alcoa's boiler units. The NOx control technologies used on these units included boiler design, low NOx burners, low NOx burners combined with over-fire air, SCR, and a combination of low NOx burners, over-fire air and SCR. Each of these technologies or a combination of these technologies were considered BACT for NOx.

## **6.2.2 Summary of Technically Feasible BART Control Options for Industrial Boilers**

### **6.2.2.1 Feasible BART Control Options for Industrial Boiler SO<sub>2</sub>**

One technically feasible option was identified for controlling SO<sub>2</sub> emissions from the industrial boilers. This option includes installation of wet scrubbers and was evaluated further as part of the BART determination analysis.

### **6.2.2.2 Feasible BART Control Options for Industrial and Utility Boiler PM**

While fabric filters would be considered a technically feasible option for controlling particulate emissions from the boilers 2, 3, and 4 at Alcoa – Warrick, these units currently have cold-side ESPs. Baseline modeling results indicate that modeled or projected visibility impact at MCNP associated with particulate and organic emissions combined from coal fired boiler units 2,3, and 4 was less than 0.06 dv. Based on these data, adding additional pollution controls for PM will not significantly reduce the already very low visibility impact due to units 2, 3 and 4 at Alcoa – Warrick. For this reason, no additional analysis associated with PM controls on these units was performed for this BART analysis.

### **6.2.2.3 Feasible BART Control Options for Industrial Boiler NO<sub>x</sub>**

Combustion control options that were determined to be feasible for NOx control on units 2 and 3 include low NOx burners and overfire air. The post-combustion controls that were determined to be feasible for NOx control on units 2 and 3 include SCR and SNCR. During portions of the baseline years 2001 through 2003, units 2 and 3 had no controls for NOx.

### **6.2.3 Control Effectiveness for Feasible BART Control Options for Industrial Boilers**

Step 3 of the BART analysis is to evaluate the control effectiveness of the technically feasible control technologies.

#### **6.2.3.1 Control Effectiveness for Industrial Boiler SO<sub>2</sub>**

##### **6.2.3.1.1 SO<sub>2</sub> Wet Scrubbing**

Wet scrubbers were identified as a technically feasible add-on pollution control options to reduce SO<sub>2</sub> from boiler units 2 and 3. Typical removal efficiencies are 80–95%.

Table 6-6 summarizes the SO<sub>2</sub> emission levels under the control scenarios considered for BART. The emissions represent the combined total emissions from units 2 and 3 for each scenario. Control Scenario 1 is the utilization of two wet scrubbers to control SO<sub>2</sub> emissions from each of units 2 and 3. The emissions reductions achievable by wet scrubbing at these units were compared to baseline. Pursuant to 326 IAC 7-4-10 (Warrick County Sulfur Dioxide Emission Limitations), SO<sub>2</sub> emission limits were established for units 2 and 3 that resulted in an allowable SO<sub>2</sub> emission rate of 5.11 lbs. /mm Btu. By virtue of Units 2 and 3 being modified to increase their heat input capacity, they have become subject to 40 CFR Subpart Db, and must meet a minimum SO<sub>2</sub> removal efficiency of 90%. Based on the RBLC database analysis, which indicated an average control efficiency of 91.8% was BACT for SO<sub>2</sub> from industrial boilers, and Standards of Performance for Industrial-Commercial-Institutional Steam Generating Units (40 CFR 60 Subpart Db) requires a 92% removal efficiency for this type of source, if reconstructed, it was determined that 92% efficiency would be reasonable for units 2 and 3. (The NSPS provides an optional SO<sub>2</sub> removal requirement of 90% minimum if the units are only modified.).

In the December, 2008 BART determination, SO<sub>2</sub> and NO<sub>x</sub> emissions from utility boiler 4 were also included. Since that time, it has been determined that utility boilers meet the BART

requirements for these pollutants by virtue of their required participation in the Indiana Clean Air Interstate Rule. PM emissions from utility boiler 4 remain subject to the BART analysis requirements. Table 6-6A shows post control PM emissions from boiler 4.

Current potential emissions are based the highest 24 hour emission rate measured by the CEM systems on units 2 and 3.

#### **6.2.3.2 Control Effectiveness for Industrial Boiler NO<sub>x</sub>**

Low NO<sub>x</sub> burners combined with overfire air were identified as feasible combustion control options to reduce NO<sub>x</sub> emissions from units 2 and 3. SCR and SNCR were determined to be feasible post-combustion NO<sub>x</sub> control options for units 2 and 3.

Table 6-7 summarizes the NO<sub>x</sub> emission levels under the control scenarios considered for BART.



**Table 6-6. SO<sub>2</sub> Post-Control Emission Rates**

Control Scenario	SO <sub>2</sub> Control Technology	SO <sub>2</sub>		NO <sub>x</sub>		PM <sub>2.5</sub>		PM <sub>10</sub>		Organics	
		Emissions (tons/yr)	% Reduction (Increase) <sup>a</sup>	Emissions (tons/yr)	% Reduction (Increase) <sup>a</sup>	Emissions (tons/yr)	% Reduction (Increase) <sup>a</sup>	Emissions (tons/year)	% Reduction (Increase) <sup>a</sup>	Emissions (tons/year)	% Reduction (Increase) <sup>a</sup>
1	Wet Scrubber on each of units 2 and 3	4,497	92.0 <sup>b</sup>	9,551	0	564	63.7	0	0	84	75.0
Current Potential Emissions		56,215		9,551		1,552		0		334	

<sup>a</sup>Compared with current potential emissions.

<sup>b</sup>Based on 92% removal efficiency on units 2 and 3.

**Table 6-6A. PM Post-Control Emission Rates for Utility Boiler 4**

Control Scenario	SO <sub>2</sub> Control Technology	SO <sub>2</sub>		NO <sub>x</sub>		PM <sub>2.5</sub>		PM <sub>10</sub>		Organics	
		Emissions (tons/yr)	% Reduction (Increase) <sup>a</sup>	Emissions (tons/yr)	% Reduction (Increase) <sup>a</sup>	Emissions (tons/yr)	% Reduction (Increase) <sup>a</sup>	Emissions (tons/year)	% Reduction (Increase) <sup>a</sup>	Emissions (tons/year)	% Reduction (Increase) <sup>a</sup>
1	Wet Scrubber	NA <sup>b</sup>	NA <sup>b</sup>	NA <sup>b</sup>	0	406	81.0	0	0	213	24.6
Current Potential Emissions		NA <sup>b</sup>		NA <sup>b</sup>		2,133		0		282	

<sup>a</sup>Compared with current potential emissions.

<sup>b</sup> *BART is not applicable for utility boilers, with respect to SO<sub>2</sub> and NO<sub>x</sub>, due to their required participation in the Indiana Clean Air Interstate rule (which is presumed to require a BART equivalent degree of control).*

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**Table 6-7. NOx Post-Control Emission Rates for Boilers 2 and 3**

Control Scenario	NOx Control Technology	NOx		SO <sub>2</sub>		PM <sub>2.5</sub>		PM <sub>10</sub>		Organics	
		Emissions (tons/yr)	% Reduction (Increase) <sup>a</sup>	Emissions (tons/yr)	% Reduction (Increase) <sup>a</sup>	Emissions (tons/yr)	% Reduction (Increase) <sup>a</sup>	Emissions (tons/year)	% Reduction (Increase) <sup>a</sup>	Emissions (tons/year)	% Reduction (Increase) <sup>a</sup>
3	Low NOx Burners /w Overfire Air and SCR on Units 2 & 3	2,103	78.0	56,215	0	564	63.7	0		84	75.0
2	Low NOx Burners /w Overfire Air and SNCR on Units 2 & 3	3,463	63.7	56,215	0	564	63.7	0		84	75.0
1	Low NOx Burners w/ Overfire Air on Units 2 & 3	4,700	50.8	56,215	0	564	63.7	0		84	75.0
Current Potential Emissions Units 2 and 3	Low NOx Burners w/ Overfire Air and No Controls on Units 2 & 3	9,551		56,215		1,552		0		334	

<sup>a</sup>Compared with current potential emissions.

## **6.2.4 Evaluation of Cost and Other Impacts for Feasible BART Control Options**

### **6.2.4.1 Cost Analysis for SO<sub>2</sub> Wet Scrubber Control Options**

Conventional wet scrubbers, which were determined to be one of the most effective technically feasible control options, are currently being installed to control SO<sub>2</sub> emissions on units 2, 3, and 4. Scrubbers were connected to boilers 2 and 3 in May and July, 2008 respectively.

The purpose of a control technology cost analysis in a BART determination is to evaluate which, if any, control option is feasible from a cost stand point. Since Alcoa has chosen to install the most effective technically feasible control option for SO<sub>2</sub> removal on boilers 2 and 3, a cost analysis for controlling SO<sub>2</sub> from the boilers was not deemed necessary for this BART determination.

### **6.2.4.2 Cost Analysis for NO<sub>x</sub> Control Options**

The costs for Alcoa's BART determination were based on an engineering evaluation of NO<sub>x</sub> controls for Units 2 and 3 by Black & Veatch. The cost estimates are included in Appendix C.

The approximate capital cost of adding low-NO<sub>x</sub> burners to Units 2 and 3 would be approximately \$8,100,000. The nominal cost effectiveness would be approximately \$160 per ton of NO<sub>x</sub> removed. The actual cost effectiveness would be higher because this assumes operating at 8,760 hours/year. Low NO<sub>x</sub> burners are a cost effective option for Units 2 and 3.

The cost of adding SNCR to Units 2 and 3 would primarily be the operating cost of injecting ammonia or urea. The approximate capital cost would be approximately \$3,000,000 with an operating cost of \$4,200,000 per year. The nominal cost effectiveness would be approximately \$3,392 per ton of NOx removed. The actual cost effectiveness would be higher because this assumes operating at 8,760 hours/year. Adding SNCR is not a reliable option considering the technical difficulties discussed previously. Even if SNCR were a good technical option, it is not cost effective considering that 87% of the visibility impacts are associated with SO2 emissions rather than NOx. SNCR is not a cost effective or practical BART option for these units.

The approximate capital cost of adding SCR to Units 2 and 3 would be approximately \$70,100,000 with an operating cost of \$13,400,000 per year. The nominal cost effectiveness would be approximately \$5,148 per ton of NOx removed. As with the other options, the actual cost effectiveness would be much higher because this assumes operating at 8,760 hours/year. SCR is a technically feasible option but is not cost effective considering that 87% of the visibility impacts are associated SO2 emissions rather than NOx. SCR is not a cost effective BART option for these units.

Table 6-8 summarizes the cost of installing and operating low NOx burners and over-fire air systems on units 2 and 3 and the incremental cost of adding SNCR (though its technical feasibility is questionable) on units 2 and 3 as well as the incremental cost of adding SCR on units 2 and 3.

**Table 6-8. Summary of the Impacts Analysis for NOx Control Scenarios**

Control Scenario	Control Technology Evaluated	Emission Rate (tons/year)	Emissions Reductions (tons/year) <sup>a</sup>	Installed Capital Cost (\$000)	Total Annualized Control Costs (\$000)	Incremental Cost Effectiveness (\$ per ton of pollutant removed)	Energy Impact (000 kW-hour/year)	Non-Air Quality Environmental Impacts
3	Low NOx Burners /w Overfire Air and SCR on Unit 4 and Low NOx Burners w/ Overfire Air and SCR on Units 2 & 3	4,049	2,597	\$70,144	\$13,371	\$5,148	20,533	Catalyst disposal, acid dew point corrosion, safety handling of ammonia
2	Low NOx Burners /w Overfire Air and SCR on Unit 4 and Low NOx Burners w/ Overfire Air and SNCR on Units 2 & 3	5,409	1,237	\$2,970	\$4,196	\$3,392	876	Boiler tube fouling due to formation of ammonium sulfates
1	Low NOx Burners /w Overfire Air and SCR on Unit 4 and Low NOx Burners w/ Overfire Air on Units 2 & 3	6,646	4,851	\$8,100	\$765	\$158	0	
Current Potential Emissions		11,506						

<sup>a</sup>Compared with baseline emissions.

#### **6.2.4.3 Energy Impact Analysis**

A wet scrubber removes SO<sub>2</sub> by forcing the exhaust gas through a spray tower or absorber where it contacts water droplets that contain the unreacted lime or limestone. Energy is required to overcome the resistance of the scrubber components as well as falling water droplets. A substantial amount of energy is associated with operation of fans to move the exhaust air through the scrubbers, for the slurry pumps, instrumentation, and miscellaneous items (e.g., lighting).

The energy impacts of operating an SNCR system are primarily due to pumping and atomizing the reagent. The estimated energy use would be 876,000 kWhr per year.

The energy impacts of operating an SCR system include ammonia vaporization and the additional pressure drop of moving the gas stream through the catalyst. The estimated energy use would be 20,500,000 kWhr per year.

#### **6.2.4.4 Non-air Quality Environmental Impacts for Feasible Industrial Boiler BART Control Options**

Wet scrubbers using limestone oxidizes the spent slurry to gypsum. This waste from the wet scrubbers would be landfilled each year. Several hundred million gallons of water will be required annually to operate the wet scrubbers. This will significantly impact the community infrastructure in that this will increase daily water demand. There will be relatively no impact due to water discharge. Several million kWh will be needed to operate the scrubbers annually. This would impact power demand on the current generating capacity and therefore also have an environmental impact due to power.

With SNCR, urea or ammonia is injected directly into the boiler. There it combines with sulfur oxides to form ammonium bisulfate and ammonium sulfate. These compounds are often “sticky” and difficult to remove which leads to fouling of boiler tubes. Ultimately new soot blowers may be needed or additional maintenance time is required to remove these deposits.

SCR systems typically use ammonia. An issue with SCR systems is that the safety considerations of storing and handling ammonia (which is a toxic chemical) must be addressed. The SCR catalyst is gradually poisoned by flue gas constituents and must be replaced. Another issue that must be addressed is the disposal of the spent catalyst that contains active metals (e.g., vanadium and titanium). A portion of the SO<sub>2</sub> can be oxidized to SO<sub>3</sub> by the catalyst. This results in another issue that must be addressed where the additional SO<sub>3</sub> causes a higher acid dew point downstream of the catalyst that can cause increased corrosion.

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## 7.0 EVALUATE VISIBILITY IMPACTS

Step 5 of the BART analysis involves evaluation of visibility impacts. More specifically, this is an evaluation of the potential improvement in visibility resulting from the application of feasible pollution prevention/add-on control options. Refined CALPUFF modeling of the individual emission units with the control options applied was performed. This modeling was accomplished according to the modeling protocol that was developed and submitted to IDEM (included as Appendix A). In general, this modeling was the same as the baseline modeling except stack data and emission data associated with the application of the feasible pollution prevention/add-on controls were used as model inputs.

Based on the results of steps 1 through 4 of this BART analysis, two (2) feasible control scenarios were modeled. Scenario 1 included the use of 3% sulfur coke in the anodes and existing controls on the potlines and wet scrubber controls, low NOx burners and overfire air on each of boiler units 2 and 3. SNCR and SCR controls on boiler units 2 and 3 were not modeled because it was determined in the baseline modeling that the visibility impact at MCNP was primarily due to SO<sub>2</sub> rather than NOx. It was also determined that the addition of SNCR or SCR to low NOx burners and over-fire air would not significantly increase the removal NOx. Scenario 2 included the use of 3% sulfur in coke in the anodes and wet scrubber control on the potlines and wet scrubber controls, low NOx burners and overfire air on each of boiler units 2, 3, and 4 and SCR on boiler unit 4.

Table 7-1 presents the results of modeling with the potline and boiler SO<sub>2</sub> control scenarios and boiler NOx control scenarios. The baseline modeling results indicate that the average 98<sup>th</sup> percentile visibility impact from Alcoa's BART-eligible sources at MCNP was 1.849 dv. The post-control modeling results for Scenario 1 indicate that the average 98<sup>th</sup> percentile visibility impact from Alcoa's BART-eligible sources at MCNP was 0.382 dv. The

post-control modeling results for Scenario 2 indicate that the average 98<sup>th</sup> percentile visibility impact from Alcoa's BART-eligible sources at MCNP was 0.289 dv.

**Table 7-1. SO<sub>2</sub> & NO<sub>x</sub> Controls – Visibility Modeling Results at MCNP**

Control Scenario No.	Control Technology	2001	2002	2003	Average
		Modeled 98 <sup>th</sup> Percentile Value (dv)	Modeled 98 <sup>th</sup> Percentile Value (dv)	Modeled 98 <sup>th</sup> Percentile Value (dv)	Modeled 98 <sup>th</sup> Percentile Value (dv)
Baseline		1.852	1.906	1.788	1.849
Scenario 1	3% sulfur coke in the anodes and existing controls on the potlines, ESP and wet scrubber controls, low NO <sub>x</sub> burners and overfire air on each of boiler units 2 and 3, and ESP and wet scrubber control-on boiler unit 4	0.444	0.299	0.402	0.382
Scenario 2	3% sulfur in coke in the anodes and wet scrubber control on the potlines, ESP and wet scrubber controls, low NO <sub>x</sub> burners and overfire air on each of boiler units 2 and 3, and ESP and wet scrubber control on boiler unit 4	0.374	0.218	0.268	0.289

## **8.0 DETERMINATION OF BART**

### **8.1 Aluminum Potlines**

For potline SO<sub>2</sub> emissions, BART was determined to be a limit of 3% sulfur in the coke used to manufacture anodes. Use of wet scrubbing technology to reduce potline SO<sub>2</sub> emission was rejected as BART due to excessive costs: total cost effectiveness of \$15,000 per ton of SO<sub>2</sub> removed and capital and total annualized costs of >\$300,000,000 and \$55,000,000 per year, respectively.

For PM emissions, BART was determined to be the current level of control, which is the use of baghouses to control PM emissions from the alumina dry scrubbers.

There are no feasible technologies for the control of NO<sub>x</sub> from potlines; thus, BART for NO<sub>x</sub> was determined to be no controls.

### **8.2 Coal Fired Boilers**

For SO<sub>2</sub> emissions from units 2, 3 and 4, BART was determined to be wet scrubbing with a 92% control efficiency on units 2 and 3.

The existing ESP controls on units 2, 3, and 4 were determined to be BART for PM.

For NO<sub>x</sub> emissions, BART was determined to be low NO<sub>x</sub> burners on units 2 and 3.

### **8.3 BART Visibility Modeling Analysis**

CALPUFF modeling was performed using input data based on controls that were identified as BART. Table 8-1 presents the BART modeling source input data that were used in the CALPUFF model to forecast the visibility impact. Table 8-2 presents the modeled 98<sup>th</sup> percentile total source visibility impact reported as deciviews for 2001, 2002 and 2003 at

MCNP. Table 8-3 presents the average visibility improvement associated with implementing BART at Alcoa Inc. – Warrick Operations and APGI – Warrick Power Plant.

Modeling indicates implementation of BART as determined above will reduce the potential impact on visibility at MCNP from an average 98<sup>th</sup> percentile value of 1.849 dv to an average 98<sup>th</sup> percentile value of 0.382 dv, or an improvement in visibility of 3.060 dv.

Table 8-1. BART Conditions Modeling Input Data

Index	Emission Unit ID #	Stack Name	Release Height (m)	Monitor Width (m)	Exit Veloc. (m/s)	Delta T (K)	Beginning UTM E/N (km)	Ending UTM E/N (km)	Filterable PM <sub>10</sub> - PM <sub>2.5</sub> (g/s)	Filterable PM <sub>2.5</sub> (g/s)	Org. Condensable (g/s)	Inorganic Condensable (g/s)	SO2 (g/s)	NO <sub>x</sub> (g/s)
L01	103M.1	Potline #2, Room 103	14.02	1.52	2.93	24.95	471.119, 4196.702	471.198, 4196.984	0.535	0.753	0.373	0.356	0.363	0.003
L02	104M.1	Potline #2, Room 104	14.02	1.52	2.93	24.95	471.087, 4196.711	471.166, 4196.993	0.535	0.753	0.373	0.356	0.363	0.003
L03	105M.1	Potline #3, Room 105	14.02	1.52	2.93	24.95	471.024, 4196.728	471.103, 4197.010	0.569	0.802	0.397	0.379	0.368	0.003
L04	106M.1	Potline #3, Room 106	14.02	1.52	2.93	24.95	470.992, 4196.737	471.070, 4197.019	0.569	0.802	0.397	0.379	0.368	0.003
L05	107M.1	Potline #4, Room 107	14.02	1.52	2.93	24.95	470.961, 4196.745	471.038, 4197.027	0.567	0.799	0.395	0.377	0.368	0.003
L06	108M.1	Potline #4, Room 108	14.02	1.52	2.93	24.95	470.929, 4196.754	471.007, 4197.036	0.567	0.799	0.395	0.377	0.368	0.003
L07	109M.1	Potline #5 , Room 109	14.02	1.52	2.31	23.18	470.900, 4196.770	471.976, 4197.052	0.470	0.663	0.328	0.313	0.356	0.003
L08	110M.1	Potline #5, Room 110	14.02	1.52	2.31	23.18	470.868, 4196.778	471.943, 4197.061	0.470	0.663	0.328	0.313	0.356	0.003
L09	111M.1	Potline #6 , Room 111	14.02	1.52	2.31	23.18	470.803, 4196.796	471.881, 4197.078	0.532	0.749	0.371	0.354	0.363	0.003
L10	112M.1	Potline #6, Room 112	14.02	1.52	2.31	23.18	470.771, 4196.804	471.848, 4197.086	0.532	0.749	0.371	0.354	0.363	0.003

Index	Emission Unit ID #	Stack Name	Stack Height (m)	Stack diameter (m)	Exit Veloc. (m/s)	Exit Temperature (K)	UTM Easting (km)	UTM Northing (km)	Filterable PM <sub>10</sub> - PM <sub>2.5</sub> (g/s)	Filterable PM <sub>2.5</sub> (g/s)	Org. Condensable (g/s)	Inorganic Condensable (g/s)	SO2 (g/s)	NO <sub>x</sub> (g/s)
P01	GTC	Potlines #3 & #4 GTC Pollution Controls	60.66	6.10	16.46	350	470.668	4196.863	1.185	1.667	1.757	4.409	65.826	0.581
P02	160C1.1-160C1.36	Potline #2 A-398	14.94	3.70	21.12	366	471.118	4196.953	0.535	0.753	0.700	1.758	32.744	0.289
P03	161B5.1-161B5.36	Potline #5 A-398	14.94	3.72	21.12	366	470.768	4196.888	0.541	0.760	0.989	2.482	31.612	0.291
P04	161B6.1-161B6.36	Potline #6 A-398	14.94	3.69	21.12	366	470.746	4196.888	0.532	0.748	1.002	2.514	31.381	0.301
P23	134.62	Melter 1M1	38.40	1.59	2.16	472	470.735	4197.193	0.056	0.027	0.001	0.001	0.0009	0.161
P24	134.64	Holder 1EH	38.40	1.22	2.00	445	470.718	4197.198	0.017	0.026	0.002	0.002	0.0014	0.149
P25	134.65	Melter 1M2	38.40	1.59	2.16	472	470.710	4197.201	0.065	0.030	0.001	0.001	0.002	0.402
P26	134.66	Holder 1WH	38.40	1.22	2.00	445	470.708	4197.203	0.011	0.016	0.002	0.002	0.003	0.149
P28	134.33	Melter 5M1	38.40	1.22	3.80	583	470.983	4197.133	0.061	0.028	0.001	0.001	0.0023	0.253
P29	134.35	Holder 5EH	38.40	1.37	2.34	466	470.968	4197.128	0.110	0.167	0.015	0.015	0.00126	0.318
P30	134.36	Melter 5M2	38.40	1.22	3.80	583	470.963	4197.135	0.095	0.044	0.001	0.001	0.012	1.317
P31	134.38	Holder 5WH	38.40	1.37	2.34	466	470.941	4197.138	0.119	0.180	0.017	0.017	0.00126	0.318
P32	134.39	Melter 5M3	38.40	1.22	3.80	583	470.943	4197.141	0.066	0.031	0.001	0.001	0.0016	0.297
P33	134.4	Melter 6M1	38.40	1.22	3.80	583	470.933	4197.145	0.062	0.029	0.001	0.005	0.0002	0.038
P34	134.41	Holder 6EH	38.40	1.37	2.34	466	470.923	4197.141	0.119	0.180	0.017	0.017	0.0001	0.016
P35	134.42	Melter 6M2	38.40	1.22	3.80	583	470.923	4197.148	0.062	0.029	0.001	0.001	0.0002	0.038
P36	134.43	Holder 6WH	38.40	1.37	2.34	466	470.913	4197.143	0.119	0.180	0.017	0.017	0.0001	0.016
P37	134.44	Melter 6M3	38.40	1.22	3.80	583	470.913	4197.148	0.062	0.029	0.001	0.001	0.0002	0.038
P39	134.71	Offlines #2 East Melter	30.78	1.04	5.20	583	470.926	4197.245	0.007	0.003	0.000	0.000	0.006	1.140
P41	134.75	Offlines #2 West Melter	30.78	1.52	0.83	555	470.886	4197.261	0.007	0.003	0.000	0.000	0.0025	0.660
WPP02	WPP Units 2 & 3	Units 2 and 3	115.82	5.91	12.59	428	470.727	4196.445	*	12.75	2.699	3.167	129.49	135.329
WPP03	WPP Unit 4	Unit 4	115.82	4.45	34.91	425	470.720	4196.340	*	2.745	1.268	13.806	0.00	0.00

\* All Solid PM is 10 microns or less. There is no data available for solid PM<sub>2.5</sub>

**Table 8-2. BART Visibility Modeling Results**

Year	f(RH)	Max RH (%)	Rayleigh (Mm <sup>-1</sup> )	Maximum Delta Bext (%)	98th Percentile Delta Bext (%)	Maximum Delta Deciview (dv)	98th Percentile Delta Deciview (dv)
2001	EPA	95	10	9.34	4.60	0.868	0.444
2002	EPA	95	10	10.35	3.07	0.949	0.299
2003	EPA	95	10	10.87	4.17	1.002	0.402

**Table 8-3. BART Visibility Improvement**

BART Option	Baseline Visibility Impact (98 Percentile Delta Deciview (dv))				Post-BART Visibility Impact (98 Percentile Delta Deciview (dv))				Average Visibility Improvement (dv)
	2001	2002	2003	Average	2001	2002	2003	Average	
<b>BART Eligible Sources Only<sup>a</sup></b>	1.852	1.906	1.788	1.849	0.444	0.299	0.402	0.382	1.467

## 9.0 PROPOSED BART ALTERNATIVE

The BART analysis and the associated coke availability study (see Appendix D) raised concerns for Alcoa Inc. – Warrick Operations regarding both the long-term availability of lower sulfur anode grade coke and the high costs associated with potline add-on SO<sub>2</sub> controls. To address these concerns, Alcoa is proposing an alternative to BART that will result in greater visibility improvement compared to BART, while allowing Alcoa Inc. – Warrick Operations the long term flexibility needed for purchase and use of higher sulfur coke. The alternative emission reduction strategy includes the wet SO<sub>2</sub> scrubbing of its Unit 1 coal fired boiler, which is not a BART-eligible source, and the use of up to 3.5% sulfur coke at the potlines.

### 9.1 Alternative Controls

As an alternative to BART, Alcoa is proposing to install a SO<sub>2</sub> wet scrubber on boiler unit 1 which is a unit that is not a BART eligible source. In combination with installing this scrubber, Alcoa is proposing to change the sulfur content limit for coke used to produce anodes and reduce the SO<sub>2</sub> removal efficiency for other wet scrubbers. Specifically, Table 9-1 lists changes in controls that are proposed, compared to BART.

**Table 9-1. Proposed Alternative to BART Controls**

Emission Unit	BART Control	Alternative Control
Boiler 1	No required SO <sub>2</sub> or NO <sub>x</sub> control	ESP, Wet SO <sub>2</sub> scrubber at 91% efficiency, LNBs with staged OFA
Boilers 2 and 3	Wet SO <sub>2</sub> scrubber at 92% efficiency LNBs with staged OFA	ESP, Wet SO <sub>2</sub> scrubber at 90% efficiency, LNBs with staged OFA
Boiler 4	Wet SO <sub>2</sub> scrubber and cold side ESP providing 0.015 lb./mm Btu PM control	Wet SO <sub>2</sub> scrubber and cold side ESP providing 0.10 lb./mm Btu PM control
Potlines	Anode grade coke < 3% sulfur	Anode grade coke < 3% sulfur



Table 9-2 presents the baseline modeling source input data that were used in the CALPUFF model to forecast the baseline visibility impact including boiler unit 1. Table 9-3 presents the alternative to BART modeling source input data that were used in the CALPUFF model to forecast the visibility impact.

Table 9-2. Baseline Including Boiler Unit 1 Conditions Modeling Input Data

Index	Emission Unit ID #	Stack Name	Release Height (m)	Monitor Width (m)	Exit Veloc. (m/s)	Delta T (K)	Beginning UTM E/N (km)	Ending UTM E/N (km)	Filterable PM <sub>10</sub> - PM <sub>2.5</sub> (g/s)	Filterable PM <sub>2.5</sub> (g/s)	Org. Condensable (g/s)	Inorganic Condensable (g/s)	SO2 (g/s)	NO <sub>x</sub> (g/s)
L01	103M.1	Potline #2, Room 103	14.02	1.52	2.93	24.95	471.119, 4196.702	471.198, 4196.984	0.535	0.753	0.373	0.356	0.266	0.003
L02	104M.1	Potline #2, Room 104	14.02	1.52	2.93	24.95	471.087, 4196.711	471.166, 4196.993	0.535	0.753	0.373	0.356	0.266	0.003
L03	105M.1	Potline #3, Room 105	14.02	1.52	2.93	24.95	471.024, 4196.728	471.103, 4197.010	0.569	0.802	0.397	0.379	0.269	0.003
L04	106M.1	Potline #3, Room 106	14.02	1.52	2.93	24.95	470.992, 4196.737	471.070, 4197.019	0.569	0.802	0.397	0.379	0.269	0.003
L05	107M.1	Potline #4, Room 107	14.02	1.52	2.93	24.95	470.961, 4196.745	471.038, 4197.027	0.567	0.799	0.395	0.377	0.269	0.003
L06	108M.1	Potline #4, Room 108	14.02	1.52	2.93	24.95	470.929, 4196.754	471.007, 4197.036	0.567	0.799	0.395	0.377	0.269	0.003
L07	109M.1	Potline #5 , Room 109	14.02	1.52	2.31	23.18	470.900, 4196.770	471.976, 4197.052	0.470	0.663	0.328	0.313	0.259	0.003
L08	110M.1	Potline #5, Room 110	14.02	1.52	2.31	23.18	470.868, 4196.778	471.943, 4197.061	0.470	0.663	0.328	0.313	0.259	0.003
L09	111M.1	Potline #6 , Room 111	14.02	1.52	2.31	23.18	470.803, 4196.796	471.881, 4197.078	0.532	0.749	0.371	0.354	0.264	0.003
L10	112M.1	Potline #6, Room 112	14.02	1.52	2.31	23.18	470.771, 4196.804	471.848, 4197.086	0.532	0.749	0.371	.0354	0.264	0.003

Index	Emission Unit ID #	Stack Name	Stack Height (m)	Stack diameter (m)	Exit Veloc. (m/s)	Exit Temperature (K)	UTM Easting (km)	UTM Northing (km)	Filterable PM <sub>10</sub> - PM <sub>2.5</sub> (g/s)	Filterable PM <sub>2.5</sub> (g/s)	Org. Condensable (g/s)	Inorganic Condensable (g/s)	SO2 (g/s)	NO <sub>x</sub> (g/s)
P01	GTC	Potlines #3 & #4 GTC Pollution Controls	60.66	6.10	16.46	350	470.668	4196.863	0.986	0.116	1.757	4.409	46.868	0.581
P02	160C1.1-160C1.36	Potline #2 A-398	14.94	3.70	21.12	366	471.118	4196.953	0.393	0.046	0.700	1.758	23.312	0.289
P03	161B5.1-161B5.36	Potline #5 A-398	14.94	3.72	21.12	366	470.768	4196.888	0.555	0.065	0.989	2.482	22.008	0.291
P04	161B6.1-161B6.36	Potline #6 A-398	14.94	3.69	21.12	366	470.746	4196.888	0.563	0.066	1.002	2.514	21.846	0.301
P23	134.62	Melter 1M1	38.40	1.59	2.16	472	470.735	4197.193	0.056	0.027	0.001	0.001	0.0009	0.161
P24	134.64	Holder 1EH	38.40	1.22	2.00	445	470.718	4197.198	0.017	0.026	0.002	0.002	0.0014	0.149
P25	134.65	Melter 1M2	38.40	1.59	2.16	472	470.710	4197.201	0.065	0.030	0.001	0.001	0.002	0.402
P26	134.66	Holder 1WH	38.40	1.22	2.00	445	470.708	4197.203	0.011	0.016	0.002	0.002	0.003	0.149
P28	134.33	Melter 5M1	38.40	1.22	3.80	583	470.983	4197.133	0.061	0.028	0.001	0.001	0.0023	0.253
P29	134.35	Holder 5EH	38.40	1.37	2.34	466	470.968	4197.128	0.110	0.167	0.015	0.015	0.00126	0.318
P30	134.36	Melter 5M2	38.40	1.22	3.80	583	470.963	4197.135	0.095	0.044	0.001	0.001	0.012	1.317
P31	134.38	Holder 5WH	38.40	1.37	2.34	466	470.941	4197.138	0.119	0.180	0.017	0.017	0.00126	0.318
P32	134.39	Melter 5M3	38.40	1.22	3.80	583	470.943	4197.141	0.066	0.031	0.001	0.001	0.0016	0.297
P33	134.4	Melter 6M1	38.40	1.22	3.80	583	470.933	4197.145	0.062	0.029	0.001	0.005	0.0002	0.038
P34	134.41	Holder 6EH	38.40	1.37	2.34	466	470.923	4197.141	0.119	0.180	0.017	0.017	0.0001	0.016
P35	134.42	Melter 6M2	38.40	1.22	3.80	583	470.923	4197.148	0.062	0.029	0.001	0.001	0.0002	0.038
P36	134.43	Holder 6WH	38.40	1.37	2.34	466	470.913	4197.143	0.119	0.180	0.017	0.017	0.0001	0.016
P37	134.44	Melter 6M3	38.40	1.22	3.80	583	470.913	4197.148	0.062	0.029	0.001	0.001	0.0002	0.038
P39	134.71	Offlines #2 East Melter	30.78	1.04	5.20	583	470.926	4197.245	0.007	0.003	0.000	0.000	0.006	1.140
P41	134.75	Offlines #2 West Melter	30.78	1.52	0.83	555	470.886	4197.261	0.007	0.003	0.000	0.000	0.0025	0.660
WPP01	WPP01	Warrick Power Plant Stack 1 Unit 1 & 2	115.82	5.91	12.88	423	470.810	4196.399	*	24.18	5.869	8.588	1118.71	213.02
WPP02	WPP02	Warrick Power Plant Stack 2 Unit 2 and 3	115.82	5.91	12.59	428	470.731	4196.443	*	22.01	7.679	11.236	1245.7	203.98
WPP03	WPP03	Warrick Power Plant Stack 3 Unit 4	115.82	4.45	34.91	425	470.668	4196.433	*	49.525	8.13	11.895	0.00	0.00

\* All Solid PM is 10 microns or less. There is no data available for solid PM<sub>2.5</sub>

Table 9-3. Alternative to BART Conditions Modeling Input Data

Index	Emission Unit ID #	Stack Name	Release Height (m)	Monitor Width (m)	Exit Veloc. (m/s)	Delta T (K)	Beginning UTM E/N (km)	Ending UTM E/N (km)	Filterable PM <sub>10</sub> - PM <sub>2.5</sub> (g/s)	Filterable PM <sub>2.5</sub> (g/s)	Org. Condensable (g/s)	Inorganic Condensable (g/s)	SO2 (g/s)	NO <sub>x</sub> (g/s)
L01	103M.1	Potline #2, Room 103	14.02	1.52	2.93	24.95	471.119, 4196.702	471.198, 4196.984	0.535	0.753	0.373	0.356	0.419	0.003
L02	104M.1	Potline #2, Room 104	14.02	1.52	2.93	24.95	471.087, 4196.711	471.166, 4196.993	0.535	0.753	0.373	0.356	0.419	0.003
L03	105M.1	Potline #3, Room 105	14.02	1.52	2.93	24.95	471.024, 4196.728	471.103, 4197.010	0.569	0.802	0.397	0.379	0.424	0.003
L04	106M.1	Potline #3, Room 106	14.02	1.52	2.93	24.95	470.992, 4196.737	471.070, 4197.019	0.569	0.802	0.397	0.379	0.424	0.003
L05	107M.1	Potline #4, Room 107	14.02	1.52	2.93	24.95	470.961, 4196.745	471.038, 4197.027	0.567	0.799	0.395	0.377	0.424	0.003
L06	108M.1	Potline #4, Room 108	14.02	1.52	2.93	24.95	470.929, 4196.754	471.007, 4197.036	0.567	0.799	0.395	0.377	0.424	0.003
L07	109M.1	Potline #5 , Room 109	14.02	1.52	2.31	23.18	470.900, 4196.770	471.976, 4197.052	0.470	0.663	0.328	0.313	0.412	0.003
L08	110M.1	Potline #5, Room 110	14.02	1.52	2.31	23.18	470.868, 4196.778	471.943, 4197.061	0.470	0.663	0.328	0.313	0.412	0.003
L09	111M.1	Potline #6 , Room 111	14.02	1.52	2.31	23.18	470.803, 4196.796	471.881, 4197.078	0.532	0.749	0.371	0.354	0.419	0.003
L10	112M.1	Potline #6, Room 112	14.02	1.52	2.31	23.18	470.771, 4196.804	471.848, 4197.086	0.532	0.749	0.371	0.354	0.419	0.003

	Emission Unit ID #	Stack Name	Stack Height (m)	Stack diameter (m)	Exit Veloc. (m/s)	Exit Temperature (K)	UTM Easting (km)	UTM Northing (km)	Filterable PM <sub>10</sub> - PM <sub>2.5</sub> (g/s)	Filterable PM <sub>2.5</sub> (g/s)	Org. Condensable (g/s)	Inorganic Condensable (g/s)	SO2 (g/s)	NO <sub>x</sub> (g/s)
P01	GTC	Potlines #3 & #4 GTC Pollution Controls	60.66	6.10	16.46	350	470.668	4196.863	1.185	1.667	1.757	4.409	75.616	0.581
P02	160C1.1-160C1.36	Potline #2 A-398	14.94	3.70	21.12	366	471.118	4196.953	0.535	0.753	0.700	1.758	37.619	0.289
P03	161B5.1-161B5.36	Potline #5 A-398	14.94	3.72	21.12	366	470.768	4196.888	0.541	0.760	0.989	2.482	36.575	0.291
P04	161B6.1-161B6.36	Potline #6 A-398	14.94	3.69	21.12	366	470.746	4196.888	0.532	0.748	1.002	2.514	36.306	0.301
P23	134.62	Melter 1M1	38.40	1.59	2.16	472	470.735	4197.193	0.056	0.027	0.001	0.001	0.0009	0.161
P24	134.64	Holder 1EH	38.40	1.22	2.00	445	470.718	4197.198	0.017	0.026	0.002	0.002	0.0014	0.149
P25	134.65	Melter 1M2	38.40	1.59	2.16	472	470.710	4197.201	0.065	0.030	0.001	0.001	0.002	0.402
P26	134.66	Holder 1WH	38.40	1.22	2.00	445	470.708	4197.203	0.011	0.016	0.002	0.002	0.003	0.149
P28	134.33	Melter 5M1	38.40	1.22	3.80	583	470.983	4197.133	0.061	0.028	0.001	0.001	0.0023	0.253
P29	134.35	Holder 5EH	38.40	1.37	2.34	466	470.968	4197.128	0.110	0.167	0.015	0.015	0.00126	0.318
P30	134.36	Melter 5M2	38.40	1.22	3.80	583	470.963	4197.135	0.095	0.044	0.001	0.001	0.012	
P31	134.38	Holder 5WH	38.40	1.37	2.34	466	470.941	4197.138	0.119	0.180	0.017	0.017	0.00126	0.318
P32	134.39	Melter 5M3	38.40	1.22	3.80	583	470.943	4197.141	0.066	0.031	0.001	0.001	0.0016	0.297
P33	134.4	Melter 6M1	38.40	1.22	3.80	583	470.933	4197.145	0.062	0.029	0.001	0.005	0.0002	0.038
P34	134.41	Holder 6EH	38.40	1.37	2.34	466	470.923	4197.141	0.119	0.180	0.017	0.017	0.0001	0.016
P35	134.42	Melter 6M2	38.40	1.22	3.80	583	470.923	4197.148	0.062	0.029	0.001	0.001	0.0002	0.038
P36	134.43	Holder 6WH	38.40	1.37	2.34	466	470.913	4197.143	0.119	0.180	0.017	0.017	0.0001	0.016
P37	134.44	Melter 6M3	38.40	1.22	3.80	583	470.913	4197.148	0.062	0.029	0.001	0.001	0.0002	0.038
P39	134.71	Offlines #2 East Melter	30.78	1.04	5.20	583	470.926	4197.245	0.007	0.003	0.000	0.000	0.006	1.140
P41	134.75	Offlines #2 West Melter	30.78	1.52	0.83	555	470.886	4197.261	0.007	0.003	0.000	0.000	0.0025	0.660
	WPP Units 1- 2 & 3	Units 1 - 3	115.82	5.79	12.33	329	470.727	4196.445	*	17.94	3.351	4.902	228.98	204.169
	WPP Unit 4	Unit 4	115.82	4.45	34.91	329	470.720	4196.340	*	18.303	6.12	8.953	0.00	0.00

\* All Solid PM is 10 microns or less. There is no data available for solid PM<sub>2.5</sub>

## **9.2 Visibility Impact of Proposed Alternative to BART versus BART**

Table 9-4 presents the results of modeling that was performed in association with Alcoa Inc. – Warrick Operations and APGI – Warrick Power Plant’s proposed Alternative to BART. In order to compare the visibility improvement associated with BART versus Alcoa’s proposed Alternative to BART, unit 1 was added as an emissions source to the BART-eligible sources. Even though unit 1 is not BART eligible, its baseline period uncontrolled emissions impacted visibility at MCNP. Installation of a wet scrubber for SO<sub>2</sub> control, and LNB’s for NO<sub>x</sub> control on unit 1 will provide an improvement in visibility impact. These controls are not required by the Regional Haze Program, and serve as the basis for the alternative to BART. The unit 1 controls offset the impact of increasing petroleum coke sulfur content, and slightly reduce the SO<sub>2</sub> removal efficiencies for boilers 2 and 3. Based on this modeling, it was determined that the proposed Alternative to BART would improve visibility at MCNP more than BART. The average visibility improvement due to Alcoa’s Alternative to BART was 1.947 dv while the average visibility improvement due to BART was 1.467 dv.

Implementation of an “Alternative to BART” control strategy, that includes the scrubbing of Unit 1 and 3.5% sulfur coke, will result in a “better than BART” visibility improvement. On average, the BART Alternative results in an additional 0.50 dv improvement over a BART-eligible source only scenario. Because the “Alternative to BART” provides Alcoa with more business certainty, and provides greater visibility improvement at MCNP, Alcoa requests IDEM to determine that the alternative emission reduction strategy described herein fulfills the best available retrofit technology requirements of Section 169A(b)(2)(A), of the 1990 Clean Air Act for this facility.

**Table 9 -4. Summary of Baseline, BART, and Alternative to BART Visibility Impact at MCNP.**

<b>BART Option</b>	<b>Baseline Visibility Impact (98 Percentile Delta Deciview (dv))</b>				<b>Post-BART Visibility Impact (98 Percentile Delta Deciview (dv))</b>				<b>Average Visibility Improvement (dv)</b>
	2001	2002	2003	Average	2001	2002	2003	Average	
<b>BART Eligible Sources Only<sup>a</sup></b>	1.852	1.906	1.788	1.849	0.444	0.299	0.402	0.382	1.467
<b>Alternative to BART (BART Eligible Plus Unit 1 Controlled)<sup>a</sup></b>	2.311	2.774	2.549	2.545	0.686	0.463	0.595	0.581	1.964

<sup>a</sup> Based on ESP and wet SO<sub>2</sub> scrubbing on Units 2 - 3 and 4 with 3% sulfur coke for potlines

<sup>b</sup> Based on ESP and wet SO<sub>2</sub> scrubbing on Units 1, 2, 3, ESP and wet SO<sub>2</sub> scrubbing on Unit 4 for PM control, and 3.5% sulfur coke for potlines.

## 10.0 REFERENCES

AWMA 2000. *Air Pollution Engineering Manual*, Second Edition (formerly document AP-40), Air & Waste Management Association, John Wiley & Sons, 2000.

EPA 2003a. "Air Pollution Control Technology Fact Sheet – Dry Electrostatic Precipitator," EPA-452/F-03-028, August 7.

EPA 2003b. "Air Pollution Control Technology Fact Sheet – Fabric Filter," EPA-452/F-03-025, August 7.

EPA 2003c. "Air Pollution Control Technology Fact Sheet – Flue Gas Desulfurization," EPA-452/F-03-034, August 8.

EPA 2003d. "Air Pollution Control Technology Fact Sheet – Selective Catalytic Reduction," EPA-452/F-03-032, August 8.

EPA 2003e. "Air Pollution Control Technology Fact Sheet – Selective Non-Catalytic Reduction," EPA-452/F-03-031, August 8.

EPA 2002. *EPA Air Pollution Control Cost Manual*, Sixth Edition, EPA/452/B-02-001, January 2002 (and updates).

Black & Veatch, "Alcoa Warrick Units 2 and 3 NO<sub>x</sub> Reduction Study," September 2006.

**Appendix A to  
BART determination Report for Alcoa, Inc. - Warrick Operations**

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Revisions to Appendix A, Alcoa BART Modeling Protocol

*These revisions to Appendix A were submitted in September 2010 in a format not compatible with the Appendix. The tables in this attachment replace the tables by the same numbers included in the original report.*

Table 2-3. Point and Line Source Emissions

Source ID	Emission Unit ID #	Stack Name	Filterable PM <sub>10</sub> - PM <sub>2.5</sub> (g/s)	Filterable PM <sub>2.5</sub> (g/s)	Organic Condensable PM <sub>2.5</sub> (g/s)	Inorganic Condensable PM <sub>2.5</sub> (g/s)	SO <sub>2</sub> (g/s)	NO <sub>x</sub> (g/s)
L01	103M.1	Potline #2, Room 103	0.535	0.753	0.373	0.356	0.266	0.003
L02	104M.1	Potline #2, Room 104	0.535	0.753	0.373	0.356	0.266	0.003
L03	105M.1	Potline #3, Room 105	0.569	0.802	0.397	0.379	0.269	0.003
L04	106M.1	Potline #3, Room 106	0.569	0.802	0.397	0.379	0.269	0.003
L05	107M.1	Potline #4, Room 107	0.567	0.799	0.395	0.377	0.269	0.003
L06	108M.1	Potline #4, Room 108	0.567	0.799	0.395	0.377	0.269	0.003
L07	109M.1	Potline #5, Room 109	0.470	0.663	0.328	0.313	0.259	0.003
L08	110M.1	Potline #5, Room 110	0.470	0.663	0.328	0.313	0.259	0.003
L09	111M.1	Potline #6, Room 111	0.532	0.749	0.371	0.354	0.264	0.003
L10	112M.1	Potline #6, Room 112	0.532	0.749	0.371	0.354	0.264	0.003
P01	GTC	Potlines #3 & #4 GTC Pollution Controls	0.986	0.116	1.757	4.409	<del>46.847</del> 46.868	0.581
P02	160C1.1-160C1.36	Potline #2 A-398	0.393	0.046	0.700	1.758	23.312	0.289
P03	161B5.1-161B5.36	Potline #5 A-398	0.555	0.065	0.989	2.482	22.008	0.291
P04	161B6.1-161B6.36	Potline #6 A-398	0.563	0.066	1.002	2.514	<del>21.836</del> 21.86	0.301
P23	134.62	Melter 1M1	0.056	0.027	0.001	0.001	0.0009	0.161
P24	134.64	Holder 1EH	0.017	0.026	0.002	0.002	0.0014	0.149
P25	134.65	Melter 1M2	0.065	0.030	0.001	0.001	0.002	0.402
P26	134.66	Holder 1WH	0.011	0.016	0.002	0.002	0.003	0.149
P28	134.33	Melter 5M1	0.061	0.028	0.001	0.001	<del>0.0004</del> 0.023	0.253
P29	134.35	Holder 5EH	0.110	0.167	0.015	0.015	0.00126	0.318
P30	134.36	Melter 5M2	0.095	0.044	0.001	0.001	<del>0.0004</del> 0.012	1.317
P31	134.38	Holder 5WH	0.119	0.180	0.017	0.017	0.00126	0.318
P32	134.39	Melter 5M3	0.066	0.031	0.001	0.001	<del>0.0004</del> 0.0016	0.297
P33	134.4	Melter 6M1	0.062	0.029	0.001	0.005	0.0002	0.038
P34	134.41	Holder 6EH	0.119	0.180	0.017	0.017	0.0001	0.016
P35	134.42	Melter 6M2	0.062	0.029	0.001	0.001	0.0002	0.038
P36	134.43	Holder 6WH	0.119	0.180	0.017	0.017	0.0001	0.016
P37	134.44	Melter 6M3	0.062	0.029	0.001	0.001	0.0002	0.038
P39	134.71	Offlines #2 East Melter	0.007	0.003	0.000	0.000	0.006	1.140
P41	134.75	Offlines #2 West Melter	0.007	0.003	0.000	0.000	0.0025	0.660
WPP01	WPP stack 1	WPP Stack 1 Unit 2 Only	*	8.6	1.949	2.852	372.9	71.01
WPP02	WPP stack 2	WPP Stack 2 Units 2 and 3	*	<del>22.01</del> 21.96	<del>7.629</del> 6.73	<del>11.236</del> 8.384	1245.7	203.98
WPP03	WPP stack 3	WPP Stack 3 Unit 4	*	<del>49.525</del> 49.523	8.13	11.895	<del>0.0</del> 4755.7	<del>0.0</del> 250.96

\* All Solid PM is 10 microns or less. There is no data available for solid PM<sub>2.5</sub>

**Table 2-4. PM Speciation of Particulate Matter Emitted from Lines and Stacks**

Source Index	PM <sub>10</sub> - PM <sub>2.5</sub> (g/s)	Solid PM <sub>2.5</sub> (g/s)	Org. Cond (g/s)	InOrg Cond (g/s)	Coarse PM			Fine PM			Organic Condensable	
					6-10 um (g/s)	2.5-6.0 um (g/s)	1.25-2.5 um (g/s)	1.00-1.25 um (g/s)	0.625-1.00 um <sup>1</sup> (g/s)	0.500-0.625 um <sup>1</sup> (g/s)	0.625-1.00 um (g/s)	0.500-0.625 um (g/s)
L01	0.535	0.753	0.373	0.356	0.268	0.268	0.188	0.188	0.366	0.366	0.187	0.187
L02	0.535	0.753	0.373	0.356	0.268	0.268	0.188	0.188	0.366	0.366	0.187	0.187
L03	0.569	0.802	0.397	0.379	0.285	0.285	0.201	0.201	0.390	0.390	0.199	0.199
L04	0.569	0.802	0.397	0.379	0.285	0.285	0.201	0.201	0.390	0.390	0.199	0.199
L05	0.567	0.799	0.395	0.377	0.284	0.284	0.200	0.200	0.388	0.388	0.198	0.198
L06	0.567	0.799	0.395	0.377	0.284	0.284	0.200	0.200	0.388	0.388	0.198	0.198
L07	0.470	0.663	0.328	0.313	0.235	0.235	0.166	0.166	0.322	0.322	0.164	0.164
L08	0.470	0.6630	0.328	0.313	0.235	0.235	0.166	0.166	0.322	0.322	0.164	0.164
L09	0.532	0.749	0.371	0.354	0.266	0.266	0.187	0.187	0.364	0.364	0.186	0.186
L10	0.532	0.749	0.371	0.354	0.266	0.266	0.187	0.187	0.364	0.364	0.186	0.186
P01	0.986	0.116	1.757	4.409	0.493	0.493	0.029	0.029	2.234	2.234	0.879	0.879
P02	0.393	0.046	0.700	1.758	0.197	0.197	0.012	0.012	0.891	0.891	0.350	0.350
P03	0.555	0.065	0.989	2.482	0.278	0.278	0.016	0.016	1.257	1.257	0.495	0.495
P04	0.563	0.066	1.002	2.514	0.282	0.282	0.017	0.017	1.274	1.274	0.501	0.501
P23	0.056	0.027	0.001	0.001	0.028	0.028	0.007	0.007	0.007	0.007	2.50E-04	2.50E-04
P24	0.017	0.026	0.002	0.002	0.009	0.009	0.007	0.007	0.007	0.007	7.50E-04	7.50E-04
P25	0.065	0.030	0.001	0.001	0.033	0.033	0.008	0.008	0.008	0.008	2.50E-04	2.50E-04
P26	0.011	0.016	0.002	0.002	0.006	0.006	0.004	0.004	0.005	0.005	7.50E-04	7.50E-04
P28	0.061	0.028	0.001	0.001	0.031	0.031	0.007	0.007	0.007	0.007	2.50E-04	2.50E-04
P29	0.110	0.167	0.015	0.015	0.055	0.055	0.042	0.042	0.049	0.049	7.50E-03	7.50E-03
P30	0.095	0.044	0.001	0.001	0.048	0.048	0.011	0.011	0.012	0.012	5.00E-04	5.00E-04
P31	0.119	0.180	0.017	0.017	0.060	0.060	0.045	0.045	0.053	0.053	8.25E-03	8.25E-03
P32	0.066	0.031	0.001	0.001	0.033	0.033	0.008	0.008	0.008	0.008	2.50E-04	2.50E-04
P33	0.062	0.029	0.001	0.005	0.031	0.031	0.007	0.007	0.010	0.010	2.50E-04	2.50E-04
P34	0.119	0.180	0.017	0.017	0.060	0.060	0.045	0.045	0.053	0.053	8.25E-03	8.25E-03
P35	0.062	0.029	0.001	0.001	0.031	0.031	0.007	0.007	0.008	0.008	2.50E-04	2.50E-04
P36	0.119	0.180	0.017	0.017	0.060	0.060	0.045	0.045	0.053	0.053	8.25E-03	8.25E-03
P37	0.062	0.029	0.001	0.001	0.031	0.031	0.007	0.007	0.008	0.008	2.50E-04	2.50E-04

<sup>1</sup> Emissions are fine filterable plus inorganic condensables

**Table 2-4. PM Speciation of Particulate Matter Emitted from Lines and Stacks, Continued**

Source Index	PM <sub>10</sub> - PM <sub>2.5</sub> (g/s)	Solid PM <sub>2.5</sub> (g/s)	Org. Cond (g/s)	InOrg Cond (g/s)	Coarse PM		Fine PM				Organic Condensable	
					6-10 um (g/s)	2.5-6.0 um (g/s)	1.25-2.5 um (g/s)	1.00-1.25 um (g/s)	0.625-1.00 um <sup>1</sup> (g/s)	0.500-0.625 um <sup>1</sup> (g/s)	0.625-1.00 um (g/s)	0.500-0.625 um (g/s)
<b>P39</b>	0.007	0.003	0.000	0.000	0.004	0.004	0.001	0.001	0.001	0.001	0.00	0.00
<b>P41</b>	0.007	0.003	0.000	0.000	0.004	0.004	0.001	0.001	0.001	0.001	0.00	0.00
<b>WPP1</b>	-	8.6	1.949	2.852	0.000	0.000	2.150	2.150	3.576	3.576	0.975	0.975
	-	<b>22.01</b>	<b>7.629</b>	<b>11.236</b>	0.000	0.000	<b>5.503</b>	<b>5.503</b>	<b>11.121</b>	<b>11.121</b>	<b>3.814</b>	<b>3.814</b>
<b>WPP2</b>		<del>21.96</del>	<del>5.73</del>	<del>8.384</del>			<del>5.490</del>	<del>5.490</del>	<del>9.682</del>	<del>5.490</del>	<del>2.865</del>	<del>2.865</del>
	-	<b>49.525</b>			0.000	0.000	12.381	12.381	<b>18.329</b>	<b>18.329</b>	4.065	4.065
<b>WPP3</b>		<del>49.523</del>	8.13	11.895					<del>18.328</del>	<del>18.328</del>		

<sup>1</sup> Emissions are fine filterable plus inorganic condensables

# **Modeling Protocol for a BART Assessment of the Alcoa Warrick Operations and Warrick Power Plant, Warrick County, Indiana**

## ***Prepared For:***

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Warrick County, Indiana

## ***Submitted By:***

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## 1.0 INTRODUCTION

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TRC Environmental Corporation is conducting a Best Available Retrofit Technology (BART) analysis for the Alcoa Warrick aluminum plant and Warrick Power Plant. This facility is situated in Warrick County, Indiana on the northern shores of the Ohio River along the Indiana/Kentucky border. It is approximately 23 km southeast of Evansville. The Alcoa Warrick Operations facility is a primary aluminum smelter.

On July 6, 2005 the US Environment Protection Agency produced the Federal Register document, 40 CFR Part 51 in order to introduce new National Regional Haze Regulations for Best Available Retrofit Technology. The regional haze rule requires States to submit implementation plans (SIPs) to address regional haze visibility impairment in 156 Federally-protected parks and wilderness areas, commonly referred to as “Class 1 Areas”. The final rule included a requirement for BART for certain large stationary sources that were put in place between 1962 and 1977. The regional haze rule uses the term “BART-eligible source” to describe those sources which have the potential to emit 250 tons or more of a visibility-impairing air pollutant, were put in place between August 7, 1962 and August 7, 1977 and whose operations fall within one or more of 26 specifically listed source categories, which includes primary aluminum ore reduction plants.

BART review is required when the source ‘emits any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility in any Class 1 area. In identifying a level of control of BART, States are required by section 169A(g) of the CAA to consider; (a) the costs of compliance, (b) the energy and non-air quality environmental impacts of compliance, (c) any existing pollution control technology in use at the source, (d) the remaining useful life of the source and (e) the degree of visibility improvement which may reasonably be anticipated from the use of BART.

The purpose of the modeling is to assess the ambient air quality impacts of sulfur dioxide (SO<sub>2</sub>), particulate matter (PM) and nitrogen oxides (NO<sub>x</sub>) emissions at Mammoth Cave National Park which is located in a south east direction approximately 120 km away. The impacts of the facility on visibility will be evaluated.

The topography of the domain area consists of gentle rolling terrain where elevation of the land ranges from ~120m in the Ohio River Valley in the north and west of the model domain to ~240m in the east. There is the potential for some terrain effects, both on the meteorological fields and in terms of plume-terrain interaction effects. The CALMET and CALPUFF non-steady-state models (Scire et al., 2000a,b) are used for the modeling analysis. The U.S. Environmental Protection Agency (EPA) has recommended CALPUFF as the preferred model for BART analyses (U.S. EPA, 2005). The CALPUFF modeling system is the regulatory *Guideline*

*Model* for Class I impact assessments and other long range transport applications and on a case-by-case basis for near-field applications involving complex flows (U.S. EPA, 2003a). CALPUFF is also recommended by both the Federal Land Managers Air Quality Workgroup (FLAG, 2000) and the Interagency Workgroup on Air Quality Modeling (U.S. EPA, 1998). CALPUFF is recommended in the new draft proposed updated to FLAG (FLAG, 2008).

CALMET is a diagnostic meteorological model that produces three-dimensional wind fields based on parameterized treatments of terrain effects such as slope flows, terrain blocking effects, and kinematic effects. Meteorological observations were used to determine the wind field in areas where the observations were representative. Hourly meteorological data produced by the Mesoscale Model, Version 5 (MM5) on a 12 km grid were used by CALMET for 2001 and 2002 to help define the initial estimate of the wind fields. For 2003, RUC data, (Rapid Update Cycle) has been transformed into 3D.DAT format for its inclusion into CALMET. RUC is a high frequency weather forecast and data assimilation system which is supported and developed by NCEP. The RUC model provides high frequency mesoscale analyses and short range numerical forecasts. In this analysis the 50 original vertical levels were extracted and transformed into an MM5 data input file. The horizontal resolution of the data is 20 km. Fine scale terrain effects (1 km resolution) were determined by the diagnostic wind module in CALMET. It had been expected that spatial variability would occur in the wind fields over short distances due to the terrain channeling.

CALPUFF is a non-steady-state puff dispersion model. It accounts for spatial changes in the CALMET-produced meteorological fields, variability in surface conditions (elevation, surface roughness, vegetation type, etc.), chemical transformation, wet removal due to rain and snow, dry deposition, and terrain influences on plume interaction with the surface. CALPUFF contains a module to compute visibility effects, based on a humidity-dependent relationship between particulate matter concentrations and light extinction, as well as wet and dry acid deposition fluxes. The refined meteorological and dispersion modeling simulations will be conducted for a three-year period (2001, 2002 and 2003). Visibility impacts from SO<sub>2</sub>, PM, and NO<sub>x</sub>, and their secondary products resulting from emissions from the proposed sources will be predicted by the model at receptors in the Class I area.

The Lake Michigan Air Directors Consortium (LADCO) 2006 Document was used as a starting point for establishing the modeling procedures for the Warrick BART analysis. A few exceptions to the procedures from (LADCO, 2006) are proposed such as the use of the EPA-approved version of the model (Version 5.8), a more refined modeling domain with 1 km grid instead of 36 km grid spacing, modeling of 2001-2003 using the different meteorological data set from what is specified in (LADCO, 2006) in order to allow the use of higher resolution meteorological data.

In Section 2, a general description of the study area and the source configuration is provided. The results of a screening analysis that allows the identification of the primary Class I area controlling the BART analysis to be determined are presented in Section 3. Descriptions of the site characteristics and the data bases (meteorological, geophysical, and aerometric) used in the analysis are provided in Section 4. Section 5 includes an overview of the CALMET and CALPUFF models, and the importance of evaluating non-steady-state effects.

## 2.0 SOURCE DESCRIPTION

---

The Alcoa Warrick Operations facility is a primary aluminum smelter located in Warrick County, Indiana on the northern shore of the Ohio River along the Indiana/Kentucky border. It is approximately 23 km southeast of Evansville, IN.

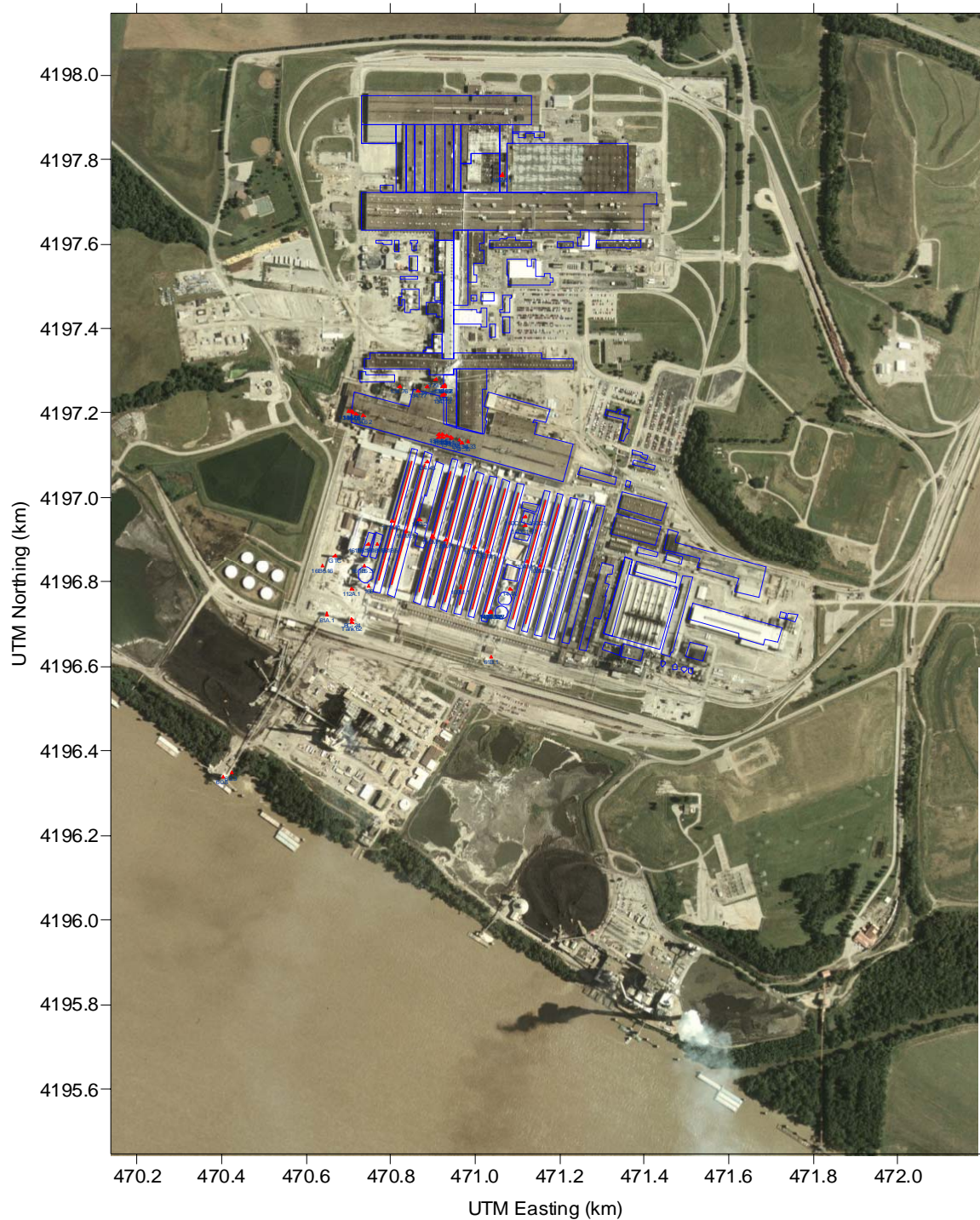
The potential BART-eligible facilities consists of five potlines (10 potrooms), and 16 melting and/or holding furnaces. Figure 2-1 shows an aerial photo of the facility with the potrooms and other major buildings outlined. In the existing facility configuration, there are 16 furnace stacks, and 108 stacks associated with the A-398 reactors for Lines 2, 5, and 6. Each A-398 has 36 stacks. The common pollution control system for Potline 3 and 4 emissions exit through a 199 ft stack.

Three stacks for the Warrick Power Plant will be modeled using the parameters listed in Table 2-2.

For modeling purposes, banks of closely-spaced stacks of identical stack characteristics will be treated as a single effective stack. The effective stack uses the same exit velocity and exit temperature as the individual stacks, but the effective diameter was computed so that the volumetric flow of the effective stack is equal to the sum of the flows of the individual stacks in the bank. Therefore each bank of stacks is replaced by a single point source.

Table 2-1 lists the line source parameters while Table 2-2 shows the source parameters for the point sources. Table 2-3 summarizes the line and point source emissions and Table 2-4 summarizes the particulate speciation for all the sources.

## ALCOA Warrick: Plant Layout



(UTM Zone = 16, Hemisphere = N, Datum = NAD83: GRS80/NAR-C)

Figure 2-1. An aerial photo of the facility with the potrooms and other major buildings outlined.

**Table 2-1. Line Source Parameters used in CALPUFF**

Source ID	Emission Unit ID #	Stack Name	Release Height (m)	Monitor Width (m)	Exit Velocity (m/s)	Delta Temp (°K)	Begin UTM E/N (km)	Ending UTM E/N (km)
<b>L01</b>	103M.1	Potline #2, Room 103	14.02	1.52	2.93	24.95	471.119, 4196.702	471.198, 4196.984
<b>L02</b>	104M.1	Potline #2, Room 104	14.02	1.52	2.93	24.95	471.087, 4196.711	471.166, 4196.993
<b>L03</b>	105M.1	Potline #3, Room 105	14.02	1.52	2.93	24.95	471.024, 4196.728	471.103, 4197.010
<b>L04</b>	106M.1	Potline #3, Room 106	14.02	1.52	2.93	24.95	470.992, 4196.737	471.070, 4197.019
<b>L05</b>	107M.1	Potline #4, Room 107	14.02	1.52	2.93	24.95	470.961, 4196.745	471.038, 4197.027
<b>L06</b>	108M.1	Potline #4, Room 108	14.02	1.52	2.93	24.95	470.929, 4196.754	471.007, 4197.036
<b>L07</b>	109M.1	Potline #5, Room 109	14.02	1.52	2.31	23.18	470.900, 4196.770	471.976, 4197.052
<b>L08</b>	110M.1	Potline #5, Room 110	14.02	1.52	2.31	23.18	470.868, 4196.778	471.943, 4197.061
<b>L09</b>	111M.1	Potline #6, Room 111	14.02	1.52	2.31	23.18	470.803, 4196.796	471.881, 4197.078
<b>L10</b>	112M.1	Potline #6, Room 112	14.02	1.52	2.31	23.18	470.771, 4196.804	471.848, 4197.086

**Notes:****L01-L02, L03-L04, L05-L06:**

$F' = 1002.186$ ; Ave. line source width = 1.52m; Ave. building dimension = 292.6m; H = 13.61m, W = 16.0m; Ave. building separation = 20.57m

**L07-L08, L09-L10:**

$F' = 736.541$ ; Ave. line source width = 1.52m; Ave. building dimension = 292.24m; H = 13.15m, W = 17.0m; Ave. building separation = 26.67m

The release height (m), monitor width (m), exit velocity (m/s) and exit temperature (°K) were all taken from the 2002 Alcoa Warrick CO study

All the coordinates were digitized to match aerial photos in NAD83 datum

**L01-L06: Average Line Source Buoyancy Parameter (F') Calculation**

$F' = [gLW_m w(T_s - T_a)]/T_s = 1002.186 \text{ m}^4/\text{s}^3$  where

g = acceleration of gravity = 9.81 m/s<sup>2</sup>

L = line source length = 292.6 m

Wm = line source width = 1.52 m

w = line source exit velocity = 2.93 m/s

Ts = line source exit temperature = 318.3 K

Ta = ambient air temperature = 293.3 K

Ts - Ta =  $\Delta T$  = 24.95 K

**L07-L10: Average Line Source Buoyancy Parameter (F') Calculation**

$F' = [gLW_m w(T_s - T_a)]/T_s = 736.541 \text{ m}^4/\text{s}^3$ , where,

g = acceleration of gravity = 9.81 m/s<sup>2</sup>

L = line source length = 292.24

Wm = line source width = 1.52 m

w = line source exit velocity = 2.31 m/s

Ts = line source exit temperature = 316.8 K

Ta = ambient air temperature = 293.6 K

Ts - Ta =  $\Delta T$  = 23.18 K

**Table 2-2. Point Source Parameters used in CALPUFF**

<b>Index</b>	<b>Emission Unit ID #</b>	<b>Stack Name</b>	<b>Stack Height (m)</b>	<b>Stack Diameter (m)</b>	<b>Exit Velocity (m/s)</b>	<b>Exit Temp (°K)</b>	<b>UTM Easting (km)</b>	<b>UTM Northing (km)</b>
<b>P01</b>	GTC	Potlines #3 & #4 GTC Pollution Controls	60.66	6.10	16.46	350	470.668	4196.863
<b>P02</b>	160C1.1-160C1.36	Potline #2 A-398	14.94	3.70	21.12	366	471.118	4196.953
<b>P03</b>	161B5.1-161B5.36	Potline #5 A-398	14.94	3.72	21.12	366	470.768	4196.888
<b>P04</b>	161B6.1-161B6.36	Potline #6 A-398	14.94	3.69	21.12	366	470.746	4196.888
<b>P23</b>	134.62	Melter 1M1	38.40	1.59	2.16	472	470.735	4197.193
<b>P24</b>	134.64	Holder 1EH	38.40	1.22	2.00	445	470.718	4197.198
<b>P25</b>	134.65	Melter 1M2	38.40	1.59	2.16	472	470.710	4197.201
<b>P26</b>	134.66	Holder 1WH	38.40	1.22	2.00	445	470.708	4197.203
<b>P28</b>	134.33	Melter 5M1	38.40	1.22	3.80	583	470.983	4197.133
<b>P29</b>	134.35	Holder 5EH	38.40	1.37	2.34	466	470.968	4197.128
<b>P30</b>	134.36	Melter 5M2	38.40	1.22	3.80	583	470.963	4197.135
<b>P31</b>	134.38	Holder 5WH	38.40	1.37	2.34	466	470.941	4197.138
<b>P32</b>	134.39	Melter 5M3	38.40	1.22	3.80	583	470.943	4197.141
<b>P33</b>	134.4	Melter 6M1	38.40	1.22	3.80	583	470.933	4197.145
<b>P34</b>	134.41	Holder 6EH	38.40	1.37	2.34	466	470.923	4197.141
<b>P35</b>	134.42	Melter 6M2	38.40	1.22	3.80	583	470.923	4197.148
<b>P36</b>	134.43	Holder 6WH	38.40	1.37	2.34	466	470.913	4197.143
<b>P37</b>	134.44	Melter 6M3	38.40	1.22	3.80	583	470.913	4197.148
<b>P39</b>	134.71	Offlines #2 East Melter	30.78	1.04	5.20	583	470.926	4197.245
<b>P41</b>	134.75	Offlines #2 West Melter	30.78	1.52	0.83	555	470.886	4197.261
<b>WPP1</b>	WPP stack 1	WPP Stack 1, Unit 2 only	115.82	5.91	12.88	423	470.810	4196.399
<b>WPP2</b>	WPP stack 2	WPP Stack 2, Units 2 and 3	115.82	5.91	12.59	428	470.731	4196.443
<b>WPP3</b>	WPP stack 3	WPP Stack 3, Unit 4	115.82	4.45	34.91	425	470.668	4196.433

**Table 2-3. Point and Line Source Emissions**

Source ID	Emission Unit ID #	Stack Name	Filterable PM <sub>10</sub> -PM <sub>2.5</sub> (g/s)	Filterable PM <sub>2.5</sub> (g/s)	Organic Condensable PM <sub>2.5</sub> (g/s)	Inorganic Condensable PM <sub>2.5</sub> (g/s)	SO <sub>2</sub> (g/s)	NO <sub>x</sub> (g/s)
L01	103M.1	Potline #2, Room 103	0.535	0.753	0.373	0.356	0.266	0.003
L02	104M.1	Potline #2, Room 104	0.535	0.753	0.373	0.356	0.266	0.003
L03	105M.1	Potline #3, Room 105	0.569	0.802	0.397	0.379	0.269	0.003
L04	106M.1	Potline #3, Room 106	0.569	0.802	0.397	0.379	0.269	0.003
L05	107M.1	Potline #4, Room 107	0.567	0.799	0.395	0.377	0.269	0.003
L06	108M.1	Potline #4, Room 108	0.567	0.799	0.395	0.377	0.269	0.003
L07	109M.1	Potline #5, Room 109	0.470	0.663	0.328	0.313	0.259	0.003
L08	110M.1	Potline #5, Room 110	0.470	0.663	0.328	0.313	0.259	0.003
L09	111M.1	Potline #6, Room 111	0.532	0.749	0.371	0.354	0.264	0.003
L10	112M.1	Potline #6, Room 112	0.532	0.749	0.371	0.354	0.264	0.003
P01	GTC	Potlines #3 & #4 GTC Pollution Controls	0.986	0.116	1.757	4.409	46.817	0.581
P02	160C1.1-160C1.36	Potline #2 A-398	0.393	0.046	0.700	1.758	23.312	0.289
P03	161B5.1-161B5.36	Potline #5 A-398	0.555	0.065	0.989	2.482	22.008	0.291
P04	161B6.1-161B6.36	Potline #6 A-398	0.563	0.066	1.002	2.514	21.836	0.301
P23	134.62	Melter 1M1	0.056	0.027	0.001	0.001	9.00E-04	0.161
P24	134.64	Holder 1EH	0.017	0.026	0.002	0.002	1.40E-03	0.149
P25	134.65	Melter 1M2	0.065	0.030	0.001	0.001	2.00E-03	0.402
P26	134.66	Holder 1WH	0.011	0.016	0.002	0.002	3.00E-03	0.149
P28	134.33	Melter 5M1	0.061	0.028	0.001	0.001	4.00E-04	0.253
P29	134.35	Holder 5EH	0.110	0.167	0.015	0.015	1.26E-03	0.318
P30	134.36	Melter 5M2	0.095	0.044	0.001	0.001	4.00E-04	1.317
P31	134.38	Holder 5WH	0.119	0.180	0.017	0.017	1.26E-03	0.318
P32	134.39	Melter 5M3	0.066	0.031	0.001	0.001	4.00E-04	0.297
P33	134.4	Melter 6M1	0.062	0.029	0.001	0.005	2.00E-04	0.038
P34	134.41	Holder 6EH	0.119	0.180	0.017	0.017	1.00E-04	0.016
P35	134.42	Melter 6M2	0.062	0.029	0.001	0.001	2.00E-04	0.038
P36	134.43	Holder 6WH	0.119	0.180	0.017	0.017	1.00E-04	0.016
P37	134.44	Melter 6M3	0.062	0.029	0.001	0.001	2.00E-04	0.038
P39	134.71	Offlines #2 East Melter	0.007	0.003	0.000	0.000	6.00E-03	1.140
P41	134.75	Offlines #2 West Melter	0.007	0.003	0.000	0.000	2.50E-03	0.660
WPP1	WPP stack 1	WPP Stack 1, Unit 2 only	*	8.6	1.949	2.852	372.9	71.01
WPP2	WPP stack 2	WPP Stack 2, Units 2 and 3	*	21.96	5.73	8.384	1245.7	203.98
WPP3	WPP stack 3	WPP Stack 3, Unit 4	*	49.523	8.13	11.895	1755.7	250.96



**Table 2-4. PM Speciation of Particulate Matter Emitted from Lines and Stacks**

Source Index	PM10-PM2.5 (g/s)	Solid PM2.5 (g/s)	Org. Cond (g/s)	InOrg. Cond (g/s)	Coarse PM		Fine PM				Organic Condensable	
					6-10µm (g/s)	2.5-6.00µm (g/s)	1.25-2.5µm (g/s)	1.00-1.25µm (g/s)	0.625-1.00µm <sup>1</sup> (g/s)	0.500-0.625µm <sup>1</sup> (g/s)	0.625-1.00µm (g/s)	0.500-0.625µm (g/s)
L01	0.535	0.753	0.373	0.356	0.268	0.268	0.188	0.188	0.366	0.366	0.187	0.187
L02	0.535	0.753	0.373	0.356	0.268	0.268	0.188	0.188	0.366	0.366	0.187	0.187
L03	0.569	0.802	0.397	0.379	0.285	0.285	0.201	0.201	0.390	0.390	0.199	0.199
L04	0.569	0.802	0.397	0.379	0.285	0.285	0.201	0.201	0.390	0.390	0.199	0.199
L05	0.567	0.799	0.395	0.377	0.284	0.284	0.200	0.200	0.388	0.388	0.198	0.198
L06	0.567	0.799	0.395	0.377	0.284	0.284	0.200	0.200	0.388	0.388	0.198	0.198
L07	0.470	0.663	0.328	0.313	0.235	0.235	0.166	0.166	0.322	0.322	0.164	0.164
L08	0.470	0.663	0.328	0.313	0.235	0.235	0.166	0.166	0.322	0.322	0.164	0.164
L09	0.532	0.749	0.371	0.354	0.266	0.266	0.187	0.187	0.364	0.364	0.186	0.186
L10	0.532	0.749	0.371	0.354	0.266	0.266	0.187	0.187	0.364	0.364	0.186	0.186
P01	0.986	0.116	1.757	4.409	0.493	0.493	0.029	0.029	2.234	2.234	0.879	0.879
P02	0.393	0.046	0.700	1.758	0.197	0.197	0.012	0.012	0.891	0.891	0.350	0.350
P03	0.555	0.065	0.989	2.482	0.278	0.278	0.016	0.016	1.257	1.257	0.495	0.495
P04	0.563	0.066	1.002	2.514	0.282	0.282	0.017	0.017	1.274	1.274	0.501	0.501
P23	0.056	0.027	0.001	0.001	0.028	0.028	0.007	0.007	0.007	0.007	2.50E-04	2.50E-04
P24	0.017	0.026	0.002	0.002	0.009	0.009	0.007	0.007	0.007	0.007	7.50E-04	7.50E-04
P25	0.065	0.030	0.001	0.001	0.033	0.033	0.008	0.008	0.008	0.008	2.50E-04	2.50E-04
P26	0.011	0.016	0.002	0.002	0.006	0.006	0.004	0.004	0.005	0.005	7.50E-04	7.50E-04
P28	0.061	0.028	0.001	0.001	0.031	0.031	0.007	0.007	0.007	0.007	2.50E-04	2.50E-04
P29	0.110	0.167	0.015	0.015	0.055	0.055	0.042	0.042	0.049	0.049	7.50E-03	7.50E-03
P30	0.095	0.044	0.001	0.001	0.048	0.048	0.011	0.011	0.012	0.012	5.00E-04	5.00E-04
P31	0.119	0.180	0.017	0.017	0.060	0.060	0.045	0.045	0.053	0.053	8.25E-03	8.25E-03
P32	0.066	0.031	0.001	0.001	0.033	0.033	0.008	0.008	0.008	0.008	2.50E-04	2.50E-04
P33	0.062	0.029	0.001	0.005	0.031	0.031	0.007	0.007	0.010	0.010	2.50E-04	2.50E-04
P34	0.119	0.180	0.017	0.017	0.060	0.060	0.045	0.045	0.053	0.053	8.25E-03	8.25E-03
P35	0.062	0.029	0.001	0.001	0.031	0.031	0.007	0.007	0.008	0.008	2.50E-04	2.50E-04
P36	0.119	0.180	0.017	0.017	0.060	0.060	0.045	0.045	0.053	0.053	8.25E-03	8.25E-03
P37	0.062	0.029	0.001	0.001	0.031	0.031	0.007	0.007	0.008	0.008	2.50E-04	2.50E-04
P39	0.007	0.003	0.000	0.000	0.004	0.004	0.001	0.001	0.001	0.001	0.00E+00	0.00E+00
P41	0.007	0.003	0.000	0.000	0.004	0.004	0.001	0.001	0.001	0.001	0.00E+00	0.00E+00
wpp1	-	8.6	1.949	2.852	0.000	0.000	2.150	2.150	3.576	3.576	0.975	0.975
wpp2	-	21.96	5.73	8.384	0.000	0.000	5.490	5.490	9.682	9.682	2.865	2.865
wpp3	-	49.523	8.13	11.895	0.000	0.000	12.381	12.381	18.328	18.328	4.065	4.065

<sup>1</sup> Emissions are fine filterable plus inorganic condensables.

### 3.0 SCREENING MODELING

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As a first step into the BART analysis for Alcoa Warrick and Warrick Power Plant, screening simulations were made to analyze the influence of the facilities at Class I Areas located up to 500 km from the site (Table 2-1). For the screening simulations and BART analysis, VISTAS 12-km regional CALMET domain was used (VISTAS, 2005) with CALPUFF computational subdomain to cover the facility, all seven Class I areas and sufficient buffer zone of 100 km around the facility and Class I areas (Figure 3-1). This is a sufficient buffer zone at the boundaries which allows for the effects of flow curvature and possible small-scale recirculation to be evaluated.

Method 6 visibility was used with monthly average relative humidity factors as listed in Table 2-2 and estimated natural concentrations for East United States as listed in Table 2-3.

As indicated in the LADCO (2006) protocol, emission controls for the Warrick facility will be based on impacts at the Class I area with the highest predicted visibility impairment. The results of the screening simulations show that this will always be Mammoth Cave, which is by a large margin the closest Class I area to the facility (Table 2-4). Mammoth Cave is approximately 120 km from the facility while the next nearest Class I area (Mingo) is more than twice as far away. The other Class I areas on the list are all close to or beyond 400 km away from the facility.

Results in Table 2-4 are presented for each of the modeled year separately (2001 to 2003) and for all 3 years together. The 98<sup>th</sup> percentile value for a single year is the 8<sup>th</sup> highest values, while for three-year period is the 22<sup>nd</sup> highest.

Since Mammoth Cave is the Class I area with the highest impacts and controls for Warrick facility will be based on the influence at Mammoth Cave, the refined modeling is proposed with the domain that is appropriate for refined modeling the visibility impacts from the Warrick sources on Mammoth Cave. The description of this domain, its characteristics and methodology used in the refined modeling is described in the next section

**Table 3-1. Class I Areas within 500 km of Alcoa Warrick**

Class I Area	Distance from Warrick (km)
Mammoth Cave	120
Mingo	268
Sipsey	391
Great Smoky Mountains	394
Joyce Kilmer	401
Cohutta	404
Shining Rock	481

**Table 3-2. Monthly f(RH) Values Based on Area Centroids for Application with Visibility Method 6**

Class I area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mammoth Cave	3.4	3.1	2.9	2.6	3.2	3.5	3.7	3.9	3.9	3.4	3.2	3.5
Mingo	3.3	3.0	2.8	2.6	3.0	3.2	3.3	3.5	3.5	3.1	3.1	3.3
Sipsey	3.4	3.1	2.9	2.8	3.3	3.7	3.9	3.9	3.9	3.6	3.3	3.4
Great Smoky	3.3	3.0	2.9	2.7	3.2	3.9	3.8	4.0	4.2	3.8	3.3	3.4
Joyce Kilmer	3.3	3.1	2.9	2.7	3.3	3.8	4.0	4.2	4.2	3.8	3.3	3.5
Cohutta	3.3	3.1	3.0	2.8	3.4	3.8	4.0	4.2	4.2	3.8	3.4	3.5
Shining Rock	3.3	3.0	2.9	2.7	3.4	3.9	4.1	4.5	4.4	3.8	3.3	3.4

Source: *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule (U.S EPA, 2003), Appendix A*

**Table 3-3. Average Natural Levels of Aerosol Components**

	East ( $\mu\text{g}/\text{m}^3$ )
Ammonium sulfate	0.23
Ammonium nitrate	0.1
Organic carbon	1.4
Elemental carbon	0.02
Soil	0.5
Coarse Mass	3

Source: *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule (U.S EPA, 2003), Table 2-1*

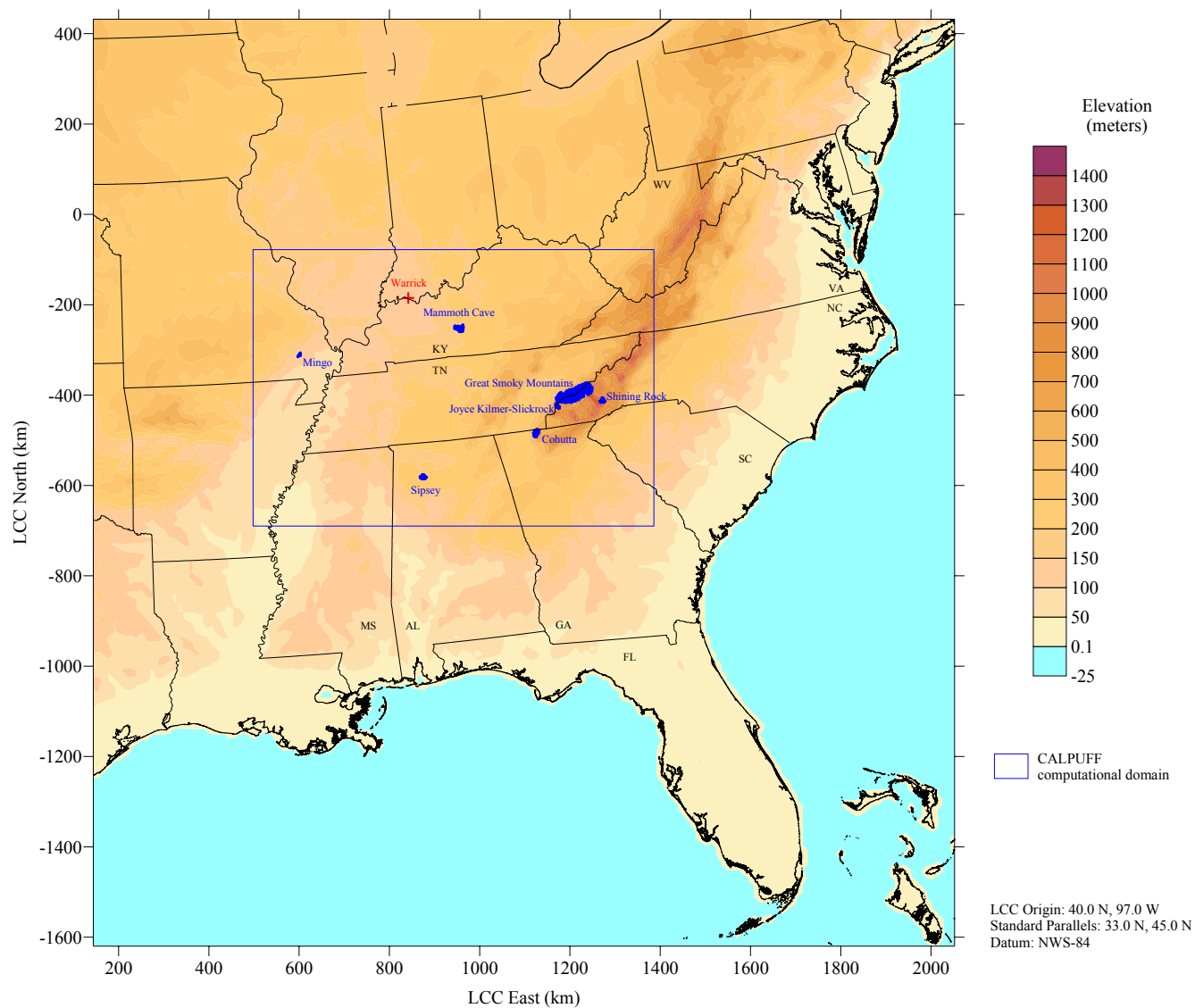


Figure 3-1. Terrain elevations for the VISTAS CALMET 12-km regional domain. CALPUFF computational subdomain, the Class I areas and the locations of Warrick facilities are also shown.

**Table 3-4. Results of the Screening Simulations**

<b>Class I Area (distance from Warrick (km))</b>	<b>Year</b>	<b>Maximum Delta Bext (%) (#days&gt;5%, #days&gt;10%)</b>	<b>98th Percentile Delta Bext (%)</b>	<b>Maximum Delta Deciview (dv) (#days&gt;0.5dv, #days&gt;1dv)</b>	<b>98th Percentile Delta Deciview (dv)</b>
Mammoth Cave (120)	2001	94.68 (105,74)	60.12	6.662 (105,73)	<b>4.708</b>
Mingo (268)	2001	71.84 (44,33)	39.44	5.414 (44,32)	<b>3.325</b>
Sipsey (391)	2001	67.69 (53,25)	25.52	5.169 (52,24)	<b>2.273</b>
Great Smoky (394)	2001	51.04 (40,20)	15.00	4.124 (37,18)	<b>1.397</b>
Joyce Kilmer (401)	2001	43.27 (35,12)	11.66	3.596 (32,11)	<b>1.103</b>
Cohutta (404)	2001	25.44 (37,11)	12.92	2.267 (35,10)	<b>1.255</b>
Shining Rock (481)	2001	32.84 (21,10)	12.70	2.839 (20,10)	<b>1.195</b>
Mammoth Cave (120)	2002	133.75 (89,62)	68.73	8.491 (87,59)	<b>5.232</b>
Mingo (268)	2002	92.30 (67,47)	53.87	6.463 (66,47)	<b>4.286</b>
Sipsey (391)	2002	67.10 (56,33)	31.72	5.134 (55,32)	<b>2.755</b>
Great Smoky (394)	2002	32.51 (47,19)	16.46	2.815 (46,18)	<b>1.524</b>
Joyce Kilmer (401)	2002	29.75 (38,18)	16.85	2.604 (37,17)	<b>1.557</b>
Cohutta (404)	2002	82.52 (40,22)	20.89	6.017 (39,20)	<b>1.903</b>
Shining Rock (481)	2002	13.97 (21,1)	7.49	1.307 (21,1)	<b>0.725</b>
Mammoth Cave (120)	2003	150.13 (134,107)	85.01	9.168 (132,105)	<b>6.153</b>
Mingo (268)	2003	142.82 (44,33)	30.98	8.872 (44,33)	<b>2.699</b>
Sipsey (391)	2003	50.01 (61,38)	28.70	4.056 (61,38)	<b>2.523</b>
Great Smoky (394)	2003	32.95 (59,29)	24.26	2.848 (58,28)	<b>2.172</b>
Joyce Kilmer (401)	2003	37.78 (49,19)	22.79	3.205 (49,18)	<b>2.053</b>
Cohutta (404)	2003	38.66 (57,24)	23.38	3.269 (56,22)	<b>2.101</b>
Shining Rock (481)	2003	20.87 (30,13)	14.28	1.895 (30,12)	<b>1.335</b>
Mammoth Cave (120)	2001-2003	150.13 (328,243)	72.38	9.168 (324,237)	<b>5.445</b>
Mingo (268)	2001-2003	142.82 (155,113)	43.39	8.872 (154,112)	<b>3.604</b>
Sipsey (391)	2001-2003	67.69 (170,96)	29.31	5.169 (168,94)	<b>2.570</b>
Great Smoky (394)	2001-2003	51.04 (146,68)	19.53	4.124 (141,64)	<b>1.784</b>
Joyce Kilmer (401)	2001-2003	43.27 (122,49)	16.85	3.596 (118,46)	<b>1.557</b>
Cohutta (404)	2001-2003	82.52 (134,57)	18.07	6.017 (130,52)	<b>1.661</b>
Shining Rock (481)	2001-2003	32.84 (72,24)	11.70	2.839 (71,23)	<b>1.107</b>

## **4.0 GEOPHYSICAL AND METEOROLOGICAL DATA FOR REFINED MODELING**

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### **4.1 Terrain**

Gridded terrain elevations for the proposed modeling domain are derived from 3 arc-second digital elevation models (DEMs) produced by the United States Geological Survey (USGS). Data are provided in files covering 1 degree by 1 degree blocks of latitude and longitude. The 1-degree DEMs are produced by the Defense Mapping Agency using cartographic and photographic sources. USGS 1:250,000 scale topographic maps are the primary source of 1-degree DEMs.

One degree DEM data consists of an array of 1201 by 1201 elevations referenced on the geographic (latitude/longitude) coordinate system of the World Geodetic System 1972 Datum. Elevations are in meters relative to mean sea level, and the spacing of the elevations along each profile is 3 arc-seconds, which corresponds to a spacing of approximately 90 meters.

The proposed CALMET computational domain is located over Warrick County, Indiana. The modeling domain will cover an area of 225 km by 195 km (Figure 4-1) which includes Mammoth Cave National Park, located directly southeast of the source. The domain includes an adequate buffer of more than 50 km in each direction both from the Class I area and the facility. The terrain is gently rolling, with terrain height increasing to the east of the model domain. A horizontal resolution of 1 km is proposed to represent the variations of the terrain elevations and land use in the area. Figure 4-1 shows contours of the terrain averaged to 1 km. The USGS elevation records located within each grid cell in the computational domain were averaged to produce a mean elevation at each grid point. Adequate representation of the important terrain features and valleys associated with the Class I area and the surrounding area are captured by the 225 x 195 grid cells, a workable number of cells. The CALPUFF computational domain will be the same as the CALMET domain. The domain extends beyond the Class I area in order to provide an adequate buffer zone at the boundaries, and to allow the effects of flow curvature and possible small-scale recirculation to be evaluated.

### **4.2 Land Use**

The USGS Land Use data in the vicinity of the facility will be used to produce a gridded field of dominant Land Use categories. The land use data proposed for the analysis are the Composite Theme Grid land use data (CTG) from the USGS, at a resolution of 200 m.

Land use data were processed to produce a 1 km resolution gridded field of fractional Land Use categories. The 37 USGS Land Use categories were then mapped into 14 CALMET LU categories. Surface properties such as albedo, Bowen ratio, roughness length, and leaf area index were computed proportionally to the fractional LU. The USGS Land Use categories are described in Table 4-1. Table 4-2 displays the 14 CALMET land use categories and their associated geophysical parameters. Figure 4-2 show the dominant land use categories to be used in the modeling.

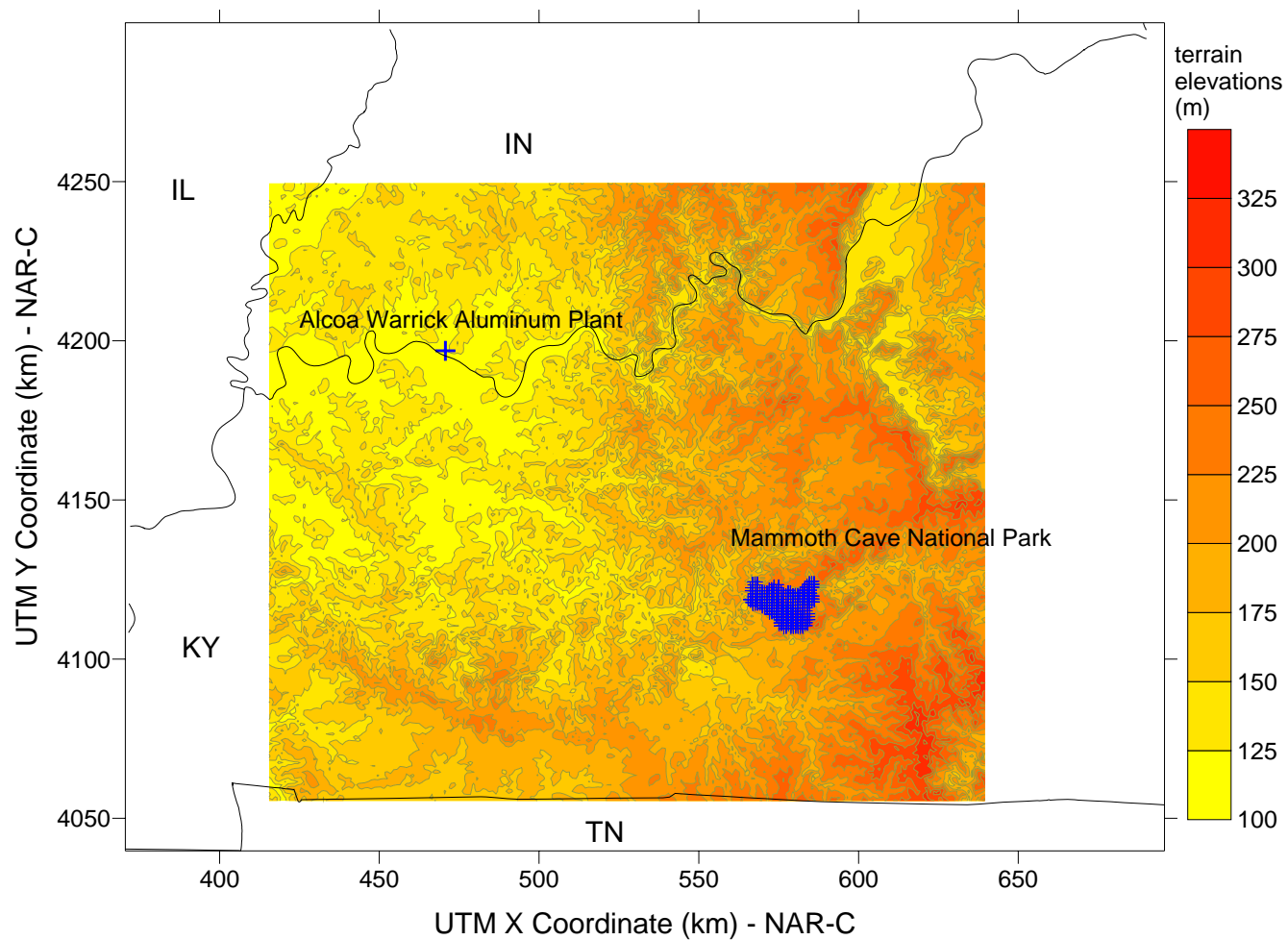


Figure 4-1. Terrain contours (m MSL) at 1 km resolution for the 225 x 195 CALMET and CALPUFF computational domains. The Class I area, Mammoth Cave NP and the Alcoa Warrick facility are shown.

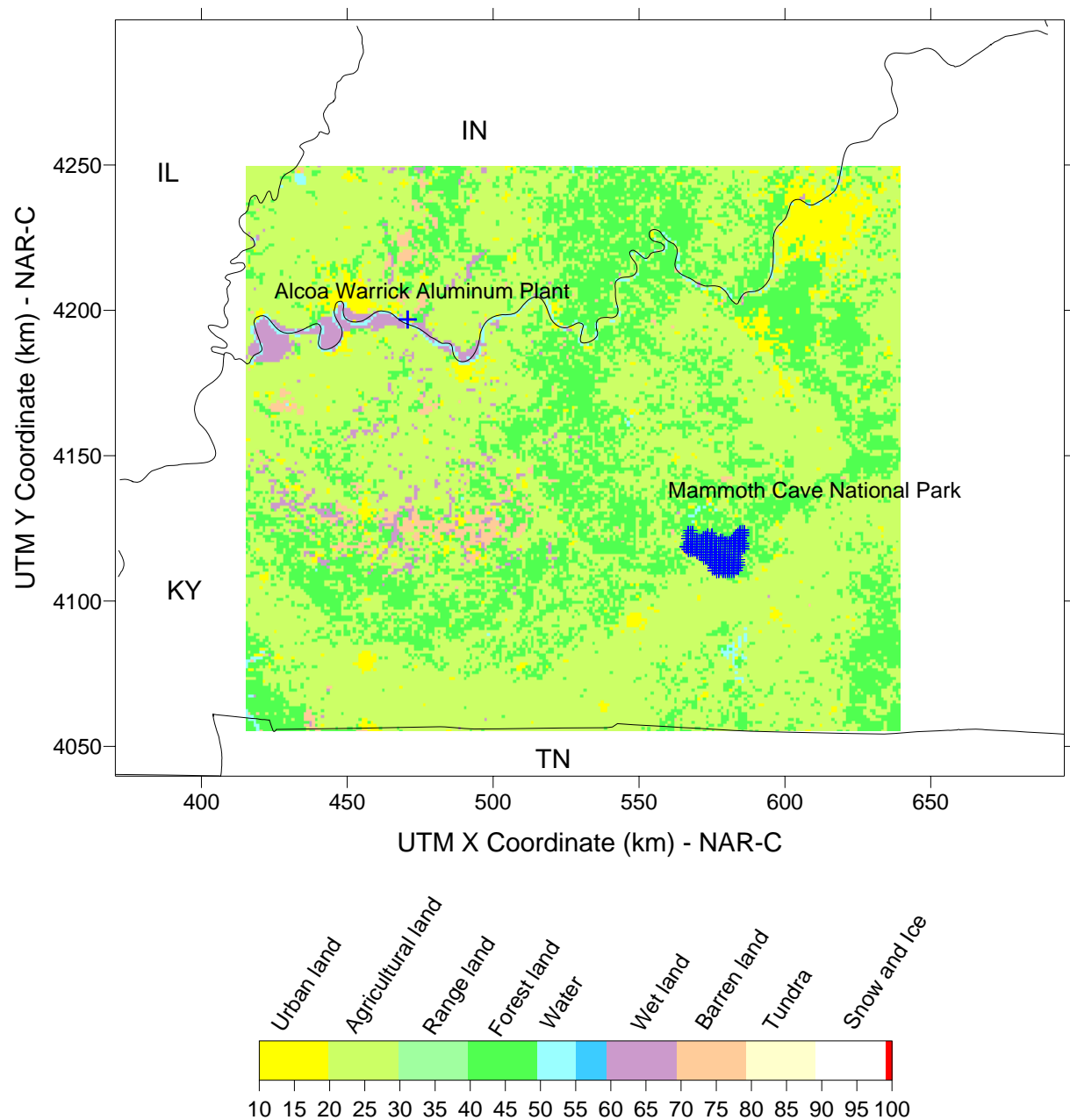


Figure 4-2. Dominant land use categories at 1 km resolution on the 225 km x 195 km CALMET and CALPUFF model domains. Mammoth Cave National Park and the facility are also shown.



### 4.3 Meteorological Data Base

The wind fields in the modeling domain are expected to be variable. Depending on the location, some of the observational data is only representative of a small area around itself. The local terrain is expected to influence the local flow, much of the structure in the wind fields will be determined by CALMET using its diagnostic wind field module, rather than being driven by observations.

The CALMET model requires meteorological information from the surface and upper air as well as geophysical information about the Land Use and terrain heights. Specifically, CALMET requires surface observations of wind speed, wind direction, temperature, cloud cover, ceiling height, surface pressure, relative humidity, and precipitation type (e.g., snow, rain, etc.). These variables are routinely measured at the National Weather Service (NWS) surface stations. The upper air data will include twice-daily observations of vertical profiles of wind speed, wind direction, temperature, and pressure. In addition, hourly precipitation measurements will be included in the modeling and are required for wet deposition calculations in CALPUFF. Three-dimensional gridded data from the prognostic numerical model MM5 are also included as well as RUC data for the 2003 modeling. Table 4-3 lists the types of observational and modeled data available that will be used in the modeling. There are ten surface meteorological stations that are proposed to be used, all located within or near the modeling domain (Table 4-4): Louisville Standiford, KY; Capitol City, KY; Louisville Bowman, KY; Owensboro, KY; Henderson City, KY; Fort Knox, KY; Evansville, KY; Huntingsburg, KY; Lawrenceville, KY; Fort Campbell, KY, and, Bowling Green, KY. The surface data will be extracted from the Integrated Surface Hourly Weather Observations (ISHWO) CD-roms (Volume 19 for 2001, Volume 23 for 2002) and 2003 ISHWO DVD. Upper air data will be extracted from the FSL/NCDC Radiosonde Database at <http://raob.fsl.noaa.gov/>. The available upper air sites are Nashville, TN and Lincoln-Logan County, IL (Table 4-5). Both these sites are located well off the model domain.

Approximately 16 precipitation stations are available for use in the modeling (Table 4-6). These data will be obtained from NCDC in TD3240 format. Figure 4-3, Figure 4-4 and Figure 4-5 show the locations and spatial coverage of all of these stations for 2001, 2002 and 2003.

**Table 4-1. U.S. Geological Survey Land Use and Land Cover Classification System**

	Level I		Level II
10	Urban or Built-up Land	11	Residential
		12	Commercial and Services
		13	Industrial
		14	Transportation, Communications and Utilities
		15	Industrial and Commercial Complexes
		16	Mixed Urban or Built-up Land
		17	Other Urban or Built-up Land
20	Agricultural Land	21	Cropland and Pasture
		22	Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas
		23	Confined Feeding Operations
		24	Other Agricultural Land
30	Rangeland	31	Herbaceous Rangeland
		32	Shrub and Brush Rangeland
		33	Mixed Rangeland
40	Forest Land	41	Deciduous Forest Land
		42	Evergreen Forest Land
		43	Mixed Forest Land
50	Water	51	Streams and Canals
		52	Lakes
		53	Reservoirs
		54	Bays and Estuaries
		55	Oceans and Seas
60	Wetland	61	Forested Wetland
		62	Nonforested Wetland
70	Barren Land	71	Dry Salt Flats
		72	Beaches
		73	Sandy Areas Other than Beaches
		74	Bare Exposed Rock
		75	Strip Mines, Quarries, and Gravel Pits
		76	Transitional Areas
		77	Mixed Barren Land
80	Tundra	81	Shrub and Brush Tundra
		82	Herbaceous Tundra
		83	Bare Ground
		84	Wet Tundra
		85	Mixed Tundra
90	Perennial Snow or Ice	91	Perennial Snowfields
		92	Glaciers

**Table 4-2. Default CALMET Land Use Categories and Associated Geophysical Parameters Based on the U.S. Geological Survey Land Use Classification System (14-Category System)**

<u>Land Use Type</u>	<u>Description</u>	<u>Surface Roughness (m)</u>	<u>Albedo</u>	<u>Bowen Ratio</u>	<u>Soil Heat Flux Parameter</u>	<u>Anthropogenic Heat Flux (W/m<sup>2</sup>)</u>	<u>Leaf Area Index</u>
10	Urban or Built-up Land	1.0	0.18	1.5	.25	0.0	0.2
20	Agricultural Land - Unirrigated	0.25	0.15	1.0	.15	0.0	3.0
-20*	Agricultural Land - Irrigated	0.25	0.15	0.5	.15	0.0	3.0
30	Rangeland	0.05	0.25	1.0	.15	0.0	0.5
40	Forest Land	1.0	0.10	1.0	.15	0.0	7.0
50	Water	0.001	0.10	0.0	1.0	0.0	0.0
54	Small Water Body	0.001	0.10	0.0	1.0	0.0	0.0
55	Large Water Body	0.001	0.10	0.0	1.0	0.0	0.0
60	Wetland	1.0	0.10	0.5	.25	0.0	2.0
61	Forested Wetland	1.0	0.1	0.5	0.25	0.0	2.0
62	Nonforested Wetland	0.2	0.1	0.1	0.25	0.0	1.0
70	Barren Land	0.05	0.30	1.0	.15	0.0	0.05
80	Tundra	.20	0.30	0.5	.15	0.0	0.0
90	Perennial Snow or Ice	.05	0.70	0.5	.15	0.0	0.0

\* Negative values indicate "irrigated" land use

**Table 4-3. Meteorological Data Sources and Parameters Available**

Type of Dataset	Frequency	Source	Parameters
Surface obs.	Hourly	NWS/NCDC	Wind speed, wind direction, temperature, ceiling height, cloud cover, relative humidity, surface pressure, precipitation type
Upper Air	Twice-daily	NWS/NCDC	Soundings of wind speed, wind direction, temperature, and pressure
Precipitation	Hourly	NWS/NCDC	Hourly precipitation amounts
Modeled Profiles MM5 for 2001, 2002	Hourly	VISTAS	Hourly, gridded fields of winds, temperature, pressure, and humidity and liquid water content on 12 km grid for 2001 and 2002.
RUC data for 2003	Hourly	NCEP	Same as MM5 above, but on 20 km grid for 2003.

**Table 4-4. NWS Hourly Surface Stations**

WMO	INIT	Station Name	State	Year	Latitude (deg)	Longitude (deg)	Elevation (m)	UTM X <sup>1</sup> (km)	UTM Y <sup>1</sup> (km)
724230	KSDF	Louisville Standiford	KY	01,02,03	38.18	85.73	146.6	611.232	4226.549
724233	KFFT	Capitol City Ap	KY	01,02,03	38.18	84.90	245.0	683.933	4227.871
724235	KLOU	Louisville Bowman Fld	KY	01,02,03	38.23	85.67	164.6	616.407	4232.171
724237	KOWB	Owensboro/Davies	KY	01,02,03	37.73	87.17	124.0	485.020	4175.872
724238	KEHR	Henderson City	KY	01,02,03	37.82	87.68	117.0	440.152	4186.062
724240	KFTK	Fort Knox Godman Ap	KY	01,02,03	37.90	85.97	239.0	590.555	4195.220
724320	KEVV	Evansville Regional Ap	KY	01,02,03	38.05	87.53	116.1	453.499	4211.495
724365	KHNB	Huntingburg	KY	01,03	38.25	86.95	161.0	504.375	4233.555
725342	KLWW	Lawrenceville	IL	01,02,03	38.77	87.60	131.0	447.877	4291.425
744656	KFWC	Fairfield	IL	03	38.42	88.42	133.0	376.296	4253.035
744659	KOLY	Olney-Noble	IL	03	38.72	88.18	147.0	397.154	4286.037
746710	KHOP	Fort Campbell Ap	KY	01,02,03	36.67	87.48	173.1	455.320	4058.382
746716	KBWG	Bowling Green Warren	KY	01,02,03	36.98	86.43	160.9	550.730	4092.806

<sup>1</sup> Datum is NAD83, UTM Zone 16.

**Table 4-5. Upper Air Stations**

#	Station Name	WBAN#	Latitude (deg)	Longitude (deg)	UTM X <sup>1</sup> (km)	UTM Y <sup>1</sup> (km)	Elevation (m)
1	Lincoln-Logan County, Ap, IL	04833	36.25	86.57	301.538	4447.009	180.0
2	Nashville, TN	13897	40.15	89.33	538.632	4011.764	178.0

<sup>1</sup> Datum is NAD83, UTM Zone 16.

**Table 4-6. Hourly NWS Precipitation Stations**

Station Name	Station ID	Year of Data	Longitude (deg)	Latitude (deg)	UTM X <sup>1</sup> (km)	UTM Y <sup>1</sup> (km)
Newburgh Lock & Dam, IN	126151	03	37.93	87.37	467.484	4198.113
JT Myers Locks & Dam, IN	128967	02,03	37.8	87.99	412.844	4184.087
Cannelton, IN	121256	01	37.9	86.63	532.529	4194.785
Calhoun Lock, KY	151227	01,02,03	37.53	87.27	476.144	4153.704
Custer 4 SE, KY	151980	01,02,03	37.72	86.22	568.742	4175.036
Dundee 2 NE, KY	152358	02,03	37.58	86.78	519.425	4159.240
Fordsville, KY	152979	01,02,03	37.63	86.72	524.703	4165.911
Herndon 5 S, KY	153798	01,02,03	36.67	87.58	449.959	4058.412
Hodgenville Lincoln, KY KY	153929	01,03	37.53	85.73	611.329	4154.416
Lebanon 5 S, KY	154650	01,02	37.52	85.3	650.229	4153.918
Madisonville, KY	155067	01,03	37.35	87.52	453.945	4133.827
Munfordville 5 NW, KY	155684	01,02	37.33	85.95	593.021	4131.998
Princeton 1 SE, KY	156580	01,03	37.12	87.87	422.712	4108.539
Scottsville 3 SSW, KY	157215	01,02	36.73	86.22	569.656	4064.095
Willisburg, KY	158719	01,02,03	37.8	85.12	665.514	4185.290
Woodbury, KY	158824	01,02,03	37.18	86.63	532.843	4114.905
Carthage, TN	401480	03	36.25	85.95	594.336	4012.189
Celina, TN	401561	01,02,03	36.54	85.46	637.849	4044.948
Lebanon, TN	405108	03	36.23	86.32	561.109	4009.674
Springfield Exp Stn, TN	408562	01,02,03	36.47	86.85	513.439	4036.091

<sup>1</sup> Datum is NAD83, UTM Zone 16.

## ALCOA Warrick: 2001 ALL Stations

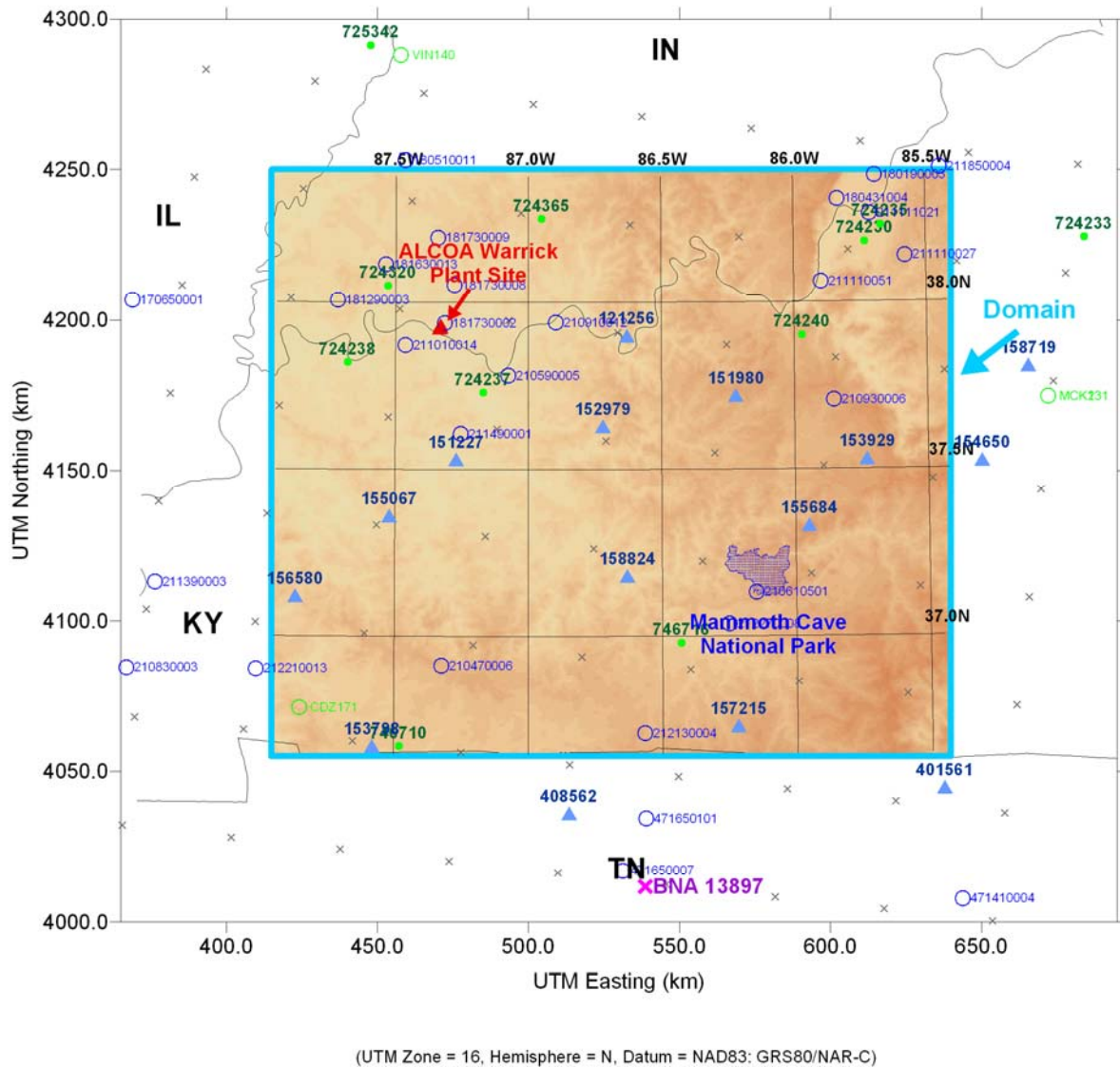


Figure 4-3. Plot of all the surface, upper air, MM5 and precipitation stations to be used in the refined 2001 modeling. Mammoth Cave National Park and the facility are also shown.

## ALCOA Warrick: 2002 ALL Stations

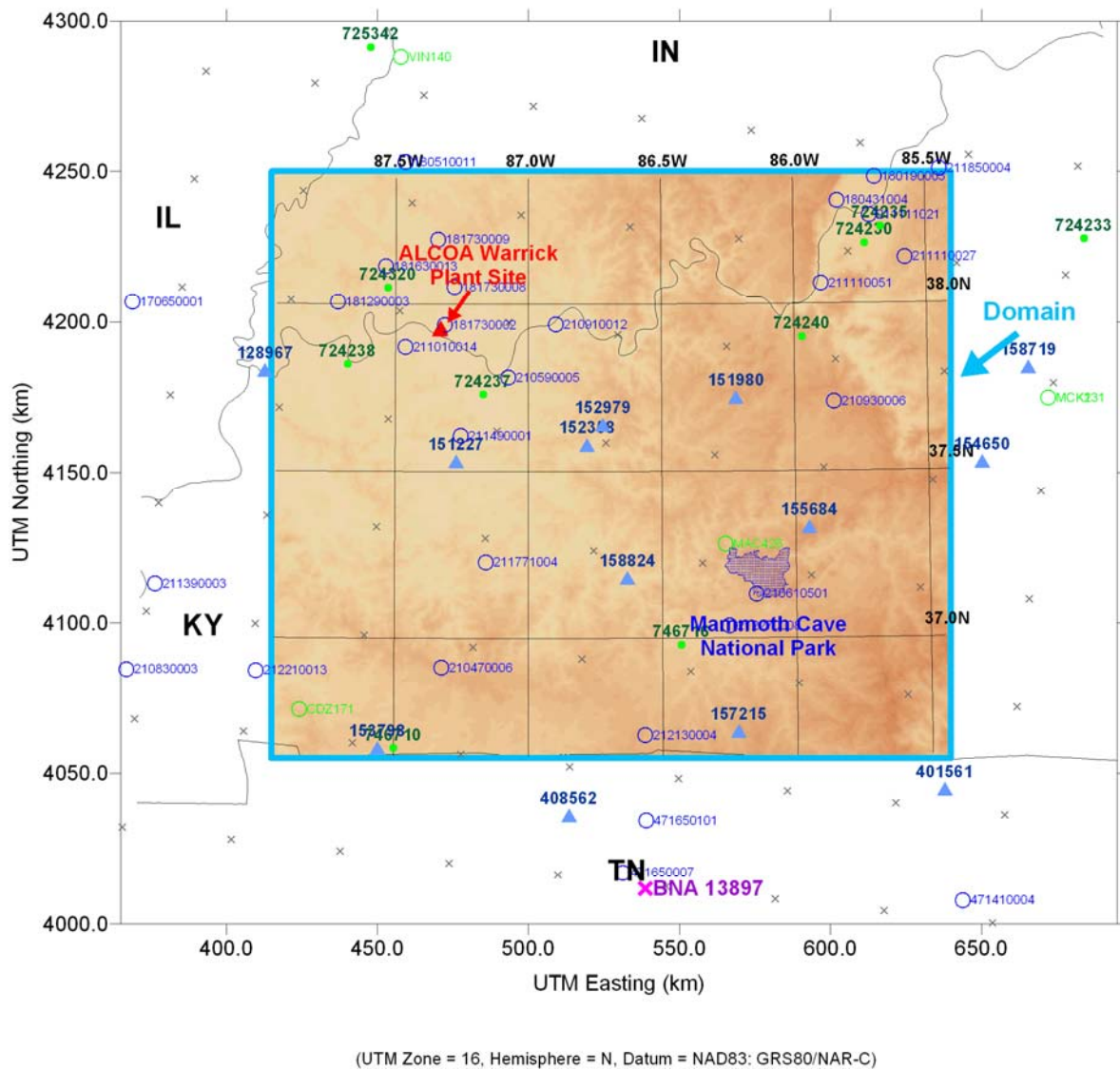


Figure 4-4. Plot of all the surface, upper air, MM5 and precipitation stations to be used in the refined 2002 modeling. Mammoth Cave National Park and the facility are also shown.



### ALCOA Warrick: 2003 ALL Stations

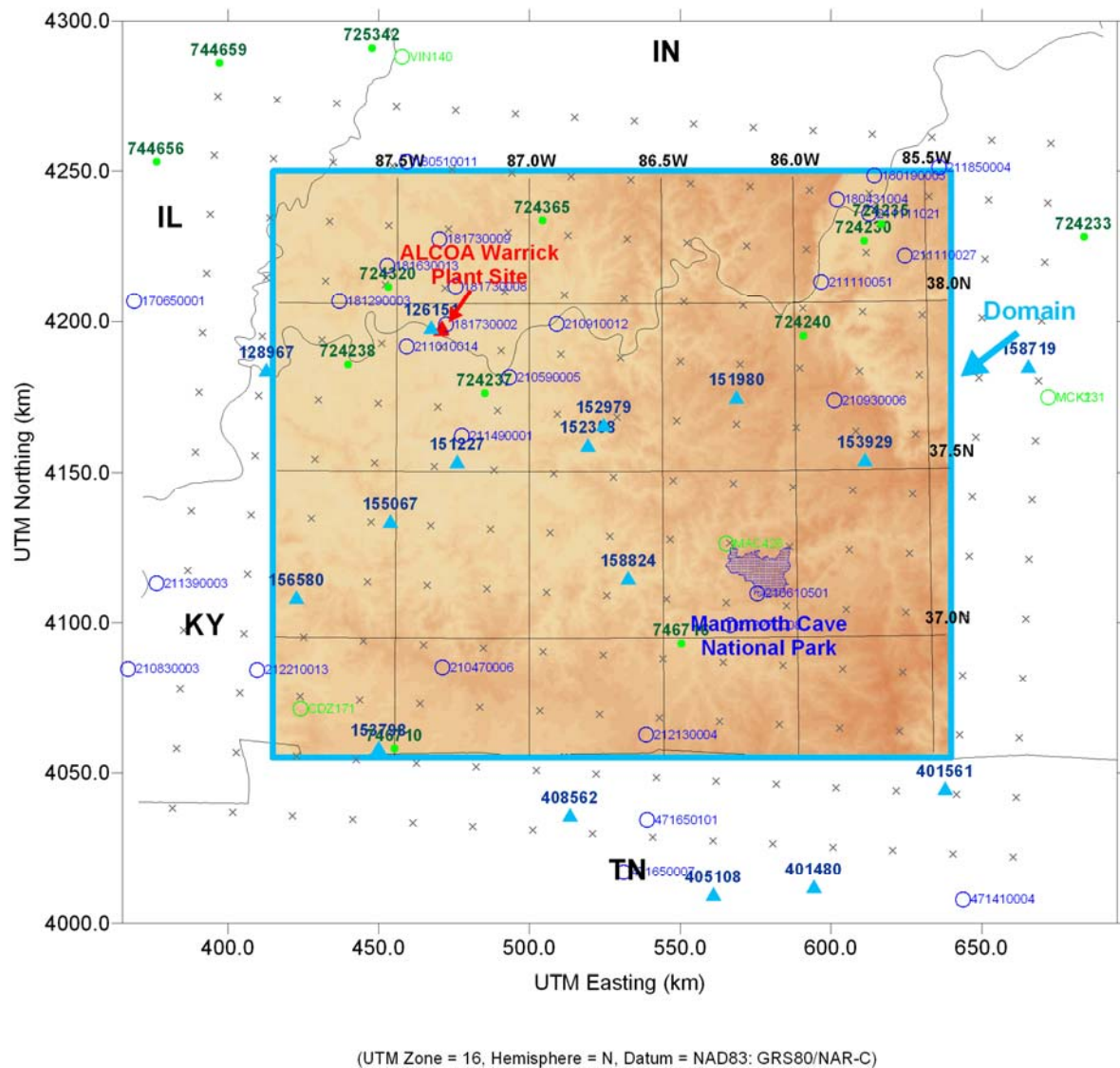


Figure 4-5. Plot of all the surface, upper air, RUC data and precipitation stations to be used in the refined 2003 modeling. Mammoth Cave National Park and the facility are also shown.

#### 4.4 Air Quality Monitoring Data

CALPUFF uses hourly ozone concentration measurements in the chemical transformation rates ( $\text{SO}_2$  to  $\text{SO}_4$ ,  $\text{NO}_x$  to  $\text{HNO}_3/\text{NO}_3$ ). The ambient ozone measurements are used in determining  $\text{SO}_2$  loss rates due to chemical transformation to sulfate and in determining  $\text{NO}_x$  loss rates to nitrate. Ambient ozone monitoring data for 2001, 2002 and 2003 will be extracted from the U.S. EPA AIRS and CASTNet networks and will be used to develop hourly ozone monitoring data files for the each year of the modeling analysis. A total of ~35 monitoring stations, listed in Table 4-7, are available for use in the modeling (see Figure 4-6, Figure 4-7 and Figure 4-8 which show the locations of each of the available stations for each year to be modeled.) This is a refinement to the LADCO procedure in that spatially varying hourly ozone data are used in the modeling instead of the monthly ozone values constant in space recommended in Table 2 of LADCO protocol.

A constant ammonia concentration of 0.5 parts per billion (ppb) will be used in the modeling. If a more refined treatment of ammonia is justified, the use of time-varying ammonia concentrations may be requested.

**Table 4-7. Ozone Stations**

Network	Year	ID	Latitude (deg)	Longitude (deg)	UTM X <sup>1</sup> (km)	UTM Y <sup>1</sup> (km)
AIRS	01,02,03	170650001	37.99822	-88.49311	368.898	4206.676
AIRS	01,02,03	180190003	38.37695	-85.69028	614.405	4248.458
AIRS	01,02,03	180431004	38.30806	-85.83417	601.933	4240.645
AIRS	01,02,03	180510011	38.42525	-87.46589	459.333	4253.108
AIRS	01,02,03	181290003	38.00528	-87.71833	436.935	4206.651
AIRS	01,02,03	181630013	38.11389	-87.53694	452.93	4218.594
AIRS	01,02,03	181730002	37.93750	-87.31416	472.393	4198.934
AIRS	01,02,03	181730008	38.05195	-87.27834	475.58	4211.622
AIRS	01,02,03	181730009	38.19444	-87.34139	470.105	4227.451
AIRS	01,02,03	210470006	36.91167	-87.32361	471.173	4085.131
AIRS	01,02,03	210590005	37.78083	-87.07555	493.347	4181.508
AIRS	01,02,03	210610501	37.13139	-86.14806	575.675	4109.796
AIRS	01,02,03	210830003	36.89917	-88.49361	366.921	4084.737
AIRS	01,02,03	210910012	37.93889	-86.89694	509.056	4199.047
AIRS	01,02,03	210930006	37.70639	-85.85167	601.226	4173.867
AIRS	01,02,03	211010014	37.87139	-87.46333	459.249	4191.653
AIRS	01,02,03	211110027	38.13722	-85.57833	624.593	4222.001
AIRS	01,02,03	211110051	38.06083	-85.89611	596.843	4213.146
AIRS	01,02,03	211111021	38.26361	-85.71167	612.712	4235.855
AIRS	01,02,03	211390003	37.15556	-88.39306	376.297	4113.046
AIRS	01,02,03	211490001	37.60639	-87.25389	477.590	4162.182
AIRS	02	211771004	37.22729	-87.15833	485.954	4120.099
AIRS	01,02,03	211850004	38.39861	-85.44334	635.936	4251.196
AIRS	01,02,03	212130004	36.70861	-86.56639	538.729	4062.645
AIRS	01,02,03	212210013	36.90139	-88.01361	409.693	4084.422
AIRS	01,02,03	212270008	37.03667	-86.25056	566.653	4099.211
AIRS	01,02,03	471410004	36.20500	-85.39945	643.89	4007.884
AIRS	01,02,03	471650007	36.29778	-86.65278	531.178	4017.043
AIRS	01,02,03	471650101	36.45389	-86.56416	539.056	4034.391
CASTNet	01,02,03	CDZ171	36.7841	-87.8499	424.165	4071.259
CASTNet	01,02,03	VIN140	38.7408	-87.4853	457.824	4288.125
CASTNet	02,03	MAC426	37.2806	-86.2639	565.254	4126.255
CASTNet	01,02,03	MCK131	37.7046	-85.0485	672.0299	4174.833
CASTNet	01,02,03	MCK231	37.7046	-85.0485	672.0299	4174.833

<sup>1</sup> Datum is NAD83, UTM Zone 16.

(BLUE = AIRS Data, GREEN = CASTNET Data)



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*Geophysical and Meteorological Data*

(BLUE = AIRS Data, GREEN = CASTNET Data)



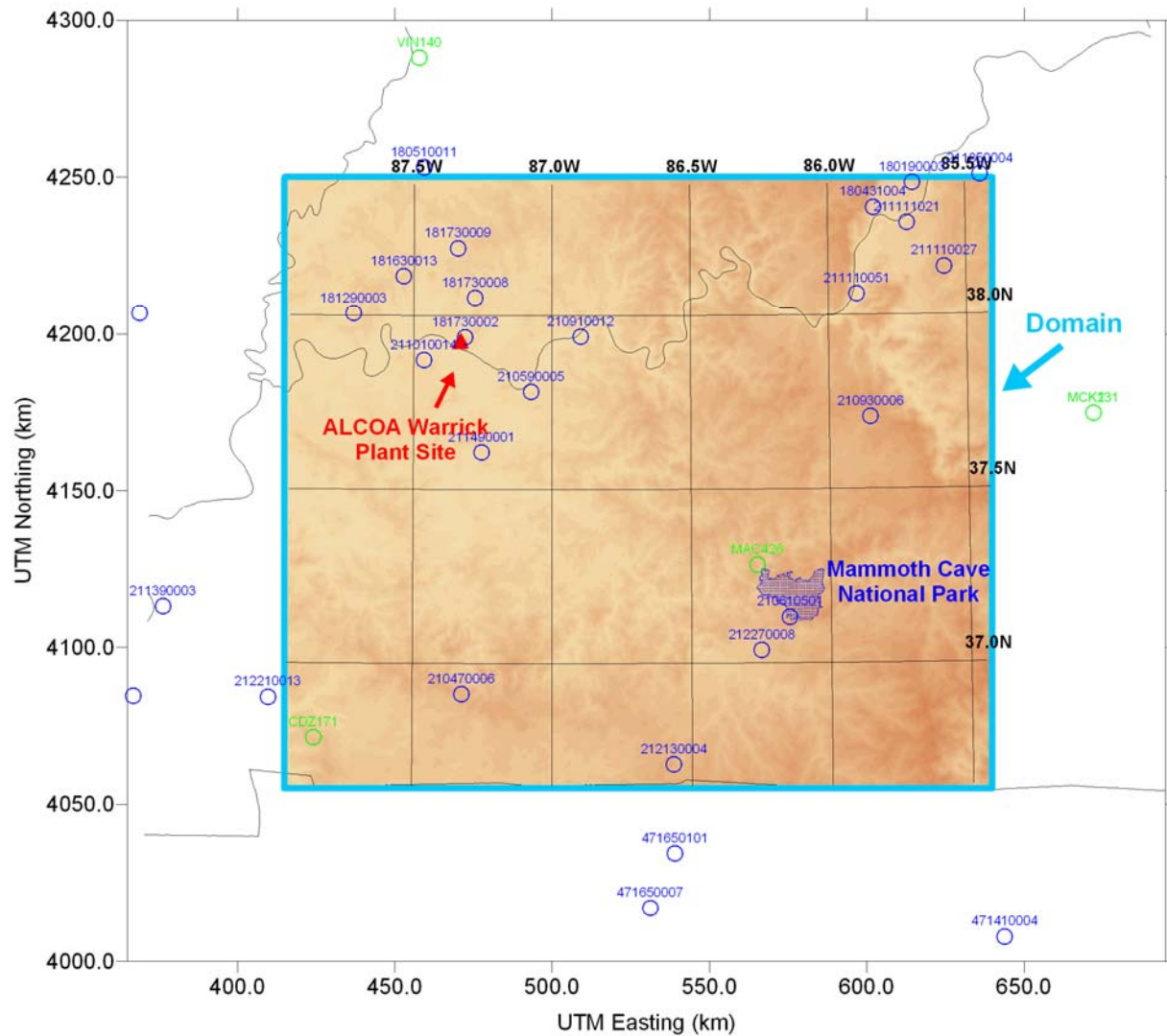
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*Geophysical and Meteorological Data*

## ALCOA Warrick: 2003 Ozone Stations

(BLUE = AIRS Data, GREEN = CASTNET Data)



(UTM Zone = 16, Hemisphere = N, Datum = NAD83: GRS80/NAR-C)

Figure 4-8. Plot of all the ozone stations, both CASTNet and AIRS proposed for the refined 2003 modeling. Mammoth Cave National Park and the facility are also shown.

## 5.0 AIR QUALITY MODELING METHODOLOGY

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### 5.1 Model Selection

The terrain of the region, the large source-receptor distances, and the importance of chemical transformation, wet deposition, and dry deposition are important factors in the modeling that are treated in the recommended modeling approach using the CALPUFF model (Scire et al., 2000a,b) for the BART analysis for Mammoth Cave National Park. CALPUFF and its meteorological model CALMET, are designed to handle the complexities posed by complex terrain, the long source receptor distances, chemical transformation and deposition, and other issues related to Class I impacts. The U.S. Environmental Protection Agency (EPA) has recommended CALPUFF as the preferred model for BART analyses (U.S. EPA, 2005). The CALPUFF modeling system is the regulatory Guideline Model for Class I impact assessments and other long range transport applications and on a case-by-case basis for near-field applications involving complex flows (U.S. EPA, 2003a). CALPUFF is also recommended by both the Federal Land Managers Air Quality Workgroup (FLAG, 2000) and the Interagency Workgroup on Air Quality Modeling (U.S. EPA, 1998). CALPUFF is also recommended by the draft revised FLAG procedures (FLAG (2008)). The modeling simulations will be using the EPA regulatory version of the CALPUFF modeling system (Version 5.8 series).

CALMET is a diagnostic meteorological model that produces three-dimensional wind and temperature fields and two-dimensional fields of mixing heights and other meteorological fields. It contains slope flow effects, terrain channeling, and kinematic effects of terrain. CALPUFF is a non-steady-state Gaussian puff model. It includes algorithms for building downwash effects as well as chemical transformation, wet deposition, and dry deposition. One capability of CALPUFF not found in many specialized models such as CTDMPLUS is the ability to treat the combined effects of multiple processes (e.g., building downwash effects in complex terrain; dry deposition and overwater dispersion, etc.). A complete summary of the capabilities and features of CALMET and CALPUFF is provided in Sections 4.1.1 and 4.1.2.

#### 5.1.1 Major Features of CALMET

The CALMET meteorological model consists of a diagnostic wind field module and micrometeorological modules for overwater and overland boundary layers. When using large domains, the user has the option to adjust input winds to a Lambert Conformal Projection coordinate system to account for Earth's curvature. The diagnostic wind field module uses a two-step approach to the computation of the wind fields (Douglas and Kessler, 1988). In the first step, an initial-guess wind field is adjusted for kinematic effects of terrain, slope flows, and terrain blocking effects to produce a Step 1 wind field. The second step consists of an objective analysis procedure to introduce observational data into the Step 1 wind field to produce a final wind field.

The major features and options of the meteorological model are summarized in Table 5-1. The techniques used in the CALMET model are briefly described below.



## Step 1 Wind Field

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

Slope Flows: The slope flow algorithm in CALMET has recently been upgraded (Scire and Robe, 1997). It is based on the shooting flow algorithm of Mahrt (1982). This scheme includes both advective-gravity and equilibrium flow regimes. At night, the slope flow model parameterizes the flow down the sides of the valley walls into the floor of the valley, and during the day, upslope flows are parameterized. The magnitude of the slope flow depends on the local surface sensible heat flux and local terrain gradients. The slope flow wind components are added to the wind field adjusted for kinematic effects.

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

## Step 2 Wind Field

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



**Table 5-1. Major Features of the CALMET Meteorological Model**

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**Boundary Layer Modules of CALMET**

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

• **Diagnostic Wind Field Module of CALMET**

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

## CALMET Boundary Layer Models

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

Overland Boundary Layer Model: Over land surfaces, the energy balance method of Holtslag and van Ulden (1983) is used to compute hourly gridded fields of the sensible heat flux, surface friction velocity, Monin-Obukhov length, and convective velocity scale. Mixing heights are determined from the computed hourly surface heat fluxes and observed temperature soundings using a modified Carson (1973) method based on Maul (1980). Gridded fields of Pasquill-Gifford-Turner (PGT) stability class and optional hourly precipitation rates are also determined by the model.

Overwater Boundary Layer Model: The aerodynamic and thermal properties of water surfaces suggest that a different method is best suited for calculating the boundary layer parameters in the marine environment. A profile technique, using air-sea temperature differences, is used in CALMET to compute the micrometeorological parameters in the marine boundary layer.

An upwind-looking spatial averaging scheme is optionally applied to the mixing heights and 3 dimensional temperature fields in order to account for important advective effects.

### 5.1.2 Major Features of CALPUFF

By its puff-based formulation and through the use of three-dimensional meteorological data developed by the CALMET meteorological model, CALPUFF can simulate the effects of time- and space-varying meteorological conditions on pollutant transport from sources in complex terrain. The major features and options of the CALPUFF model are summarized in Table 5-2. Some of the technical algorithms are briefly described below.

**Complex Terrain:** The effects of complex terrain on puff transport are derived from the CALMET winds. In addition, puff-terrain interactions at gridded and discrete receptor locations are simulated using one of two algorithms that modify the puff-height (either that of ISCST3 or a general "plume path coefficient" adjustment), or an algorithm that simulates enhanced vertical dispersion derived from the weakly-stratified flow and dispersion module of the Complex Terrain Dispersion Model (CTDMPLUS) (Perry et al., 1989). The puff-height adjustment algorithms rely on the receptor elevation (relative to the elevation at the source) and the height of the puff above the surface. The enhanced dispersion adjustment relies on the slope of the gridded terrain in the direction of transport during the time step.

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

gridded CALMET fields. As in CTDMPLUS, each feature is modeled in isolation with its own set of receptors.

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

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

**Dispersion Coefficients:** Several options are provided in CALPUFF for the computation of dispersion coefficients, including the use of turbulence measurements ( $\sigma_v$  and  $\sigma_w$ ), the use of similarity theory to estimate  $\sigma_v$  and  $\sigma_w$  from modeled surface heat and momentum fluxes, or the use of Pasquill-Gifford (PG) or McElroy-Pooler (MP) dispersion coefficients, or dispersion equations based on the Complex Terrain Dispersion Model (CTDM). Options are provided to apply an averaging time correction or surface roughness length adjustments to the PG coefficients.

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

**Dry Deposition:** A full resistance model is provided in CALPUFF for the computation of dry deposition rates of gases and particulate matter as a function of geophysical parameters, meteorological conditions, and pollutant species. Options are provided to allow user-specified, diurnally varying deposition velocities to be used for one or more pollutants instead of the resistance model (e.g., for sensitivity testing) or to by-pass the dry deposition model completely. For particles, source-specific mass distributions may be provided for use in the resistance model.

**Wind Shear Effects:** CALPUFF contains an optional puff splitting algorithm that allows vertical wind shear effects across individual puffs to be simulated. Differential rates of dispersion and transport among the "new" puffs generated from the original, well-mixed puff can substantially increase the effective rate of horizontal spread of the material.

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

**Chemical Transformation:** CALPUFF includes options for parameterizing chemical transformation effects using the five species scheme ( $\text{SO}_2$ ,  $\text{SO}_4^{=}$ ,  $\text{NO}_x$ ,  $\text{HNO}_3$ , and  $\text{NO}_3^-$ ) employed in the MESOPUFF II model or a set of user-specified, diurnally-varying transformation rates.

**Table 5-2. Major Features of the CALPUFF Model**

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- **Source types**
  - Point sources (constant or variable emissions)
  - Line sources (constant or variable emissions)
  - Volume sources (constant or variable emissions)
  - Area sources (constant or variable emissions)
- **Non-steady-state emissions and meteorological conditions**
  - Gridded 3-D fields of meteorological variables (winds, temperature)
  - Spatially-variable fields of mixing height, friction velocity, convective velocity scale, Monin-Obukhov length, precipitation rate
  - Vertically and horizontally-varying turbulence and dispersion rates
  - Time-dependent source and emissions data for point, area, and volume sources
  - Temporal or wind-dependent scaling factors for emission rates, for all source types
- **Interface to the Emissions Production Model (EPM)**
  - Time-varying heat flux and emissions from controlled burns and wildfires
- **Efficient sampling functions**
  - Integrated puff formulation
  - Elongated puff (slug) formulation
- **Dispersion coefficient ( $\sigma_y$ ,  $\sigma_z$ ) options**
  - Direct measurements of  $\sigma_y$  and  $\sigma_z$
  - Estimated values of  $\sigma_y$  and  $\sigma_z$  based on similarity theory
  - Pasquill-Gifford (PG) dispersion coefficients (rural areas)
  - McElroy-Pooler (MP) dispersion coefficients (urban areas)
  - CTDM dispersion coefficients (neutral/stable)
- **Vertical wind shear**
  - Puff splitting
  - Differential advection and dispersion
- **Plume rise**
  - Buoyant and momentum rise
  - Stack tip effects
  - Building downwash effects
  - Partial penetration
  - Vertical wind shear
- **Building downwash**
  - Huber-Snyder method
  - Schulman-Scire method
  - PRIME method
- **Complex terrain**
  - Steering effects in CALMET wind field
  - Optional puff height adjustment: ISC3 or "plume path coefficient"
  - Optional enhanced vertical dispersion (neutral/weakly stable flow in CTDMPLUS)

**Table 5-2. Major Features of the CALPUFF Model (Cont'd)**

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- **Subgrid scale complex terrain (CTSG option)**
  - Dividing streamline,  $H_d$ , as in CTDMPLUS:
    - Above  $H_d$ , material flows over the hill and experiences altered diffusion rates
    - Below  $H_d$ , material deflects around the hill, splits, and wraps around the hill
- **Dry Deposition**
  - Gases and particulate matter
  - Three options:
    - Full treatment of space and time variations of deposition with a resistance model
    - User-specified diurnal cycles for each pollutant
    - No dry deposition
- **Overwater and coastal interaction effects**
  - Overwater boundary layer parameters
  - Abrupt change in meteorological conditions, plume dispersion at coastal boundary
  - Plume fumigation
- **Chemical transformation options**
  - Pseudo-first-order chemical mechanism for  $\text{SO}_2$ ,  $\text{SO}_4^-$ ,  $\text{NO}_x$ ,  $\text{HNO}_3$ , and  $\text{NO}_3^-$  (MESOPUFF II method)
  - Pseudo-first-order chemical mechanism for  $\text{SO}_2$ ,  $\text{SO}_4^-$ ,  $\text{NO}$ ,  $\text{NO}_2$ ,  $\text{HNO}_3$ , and  $\text{NO}_3^-$  (RIVAD/ARM3 method)
  - User-specified diurnal cycles of transformation rates
  - No chemical conversion
- **Wet Removal**
  - Scavenging coefficient approach
  - Removal rate a function of precipitation intensity and precipitation type
- **Graphical User Interface**
  - Point-and-click model setup and data input
  - Enhanced error checking of model inputs
  - On-line Help files
- **Interface Utilities**
  - Scan ISCST3 and AUSPLUME meteorological data files for problems
  - Translate ISCST3 and AUSPLUME input files to CALPUFF input format

## **5.2 Modeling Domain Configuration**

CALMET and CALPUFF use terrain-following coordinates. In order to cover a large enough area, a modeling domain of 225 x 195 grid cells, uniform in the horizontal with a spatial resolution of 1 km is proposed. In the vertical, a stretched grid is proposed with finer resolution in the lower layers and somewhat coarser resolution aloft thus allowing adequate representation of the mixed layer. The ten vertical levels were centered at: 10, 30, 60, 120, 240, 480, 820, 1250, 1850 and 2600 meters.

## **5.3 Meteorological Modeling Options**

### **Initial Guess Field**

MM5 data and RUC data will be used to define the initial guess field for the CALMET simulations. For 2001 and 2002 hourly MM5 data with a grid spacing of 12 km and 34 vertical levels will be used as the initial guess wind field. RUC data with a grid spacing of 20 km and 50 vertical levels will be used as the initial guess wind field for 2003.

This data set provides better resolution prognostic data from the 36 km MM5 data set for 2002-2004 in LADCO (2006). The higher resolution of the prognostic meteorological data set was the driving force for choosing the years 2001-2003 over the 2002-2004 period from LADCO.

### **Step 1 Field: Terrain Effects**

In developing the Step 1 wind field, CALMET adjusts the initial guess field to reflect kinematic effects of the terrain, slope flows and blocking effects. Slope flows are a function of the local slope and altitude of the nearest crest. The crest is defined as the highest peak within a radius TERRAD around each grid point. A value of TERRAD of 10 km was determined based on an analysis of the scale of the terrain and will be used in the CALMET simulations. The Step 1 field produces a flow field consistent with the fine-scale CALMET terrain resolution (1 km).

### **Step 2 Field: Objective Analysis**

In Step 2, observations are incorporated into the Step 1 wind field to produce a final wind field. Each observation site influences the final wind field within a radius of influence (parameters RMAX1 at the surface and RMAX2 aloft). Observations and Step 1 field are weighted by means of parameters R1 at the surface and R2 aloft: at a distance R1 from an observation site, the Step 1 wind field and the surface observations are weighted equally. RMAX1 and RMAX2 will be set to large values (40 km), while moderate values of R1 and R2 (10 km) will be used in order to allow diagnostically-generated terrain effects to be retained in the final wind fields.

## **5.4 CALPUFF Computational Domain and Receptors**

CALPUFF will be run for three years, 2001, 2002 and 2003. A gridded field of discrete receptors will be located within the boundaries of the Mammoth Cave National Park.

The CALPUFF computational domain is the same as the CALMET computational domain. The modeling domain include a buffer zone of at least 50 km from the source and beyond the borders of the Class I area. This minimizes the edge effects and allow pollutants involved in flow reversals to be brought back into the Class I areas. CALPUFF will be run for three years, 2001, 2002 and 2003.

The receptor locations along with receptor elevations were available from the National Park Service (NPS). This gridded field of discrete receptors will be used and is located within the boundaries of the Mammoth Cave National Park.

## 5.5 Dispersion Modeling Options

The CALPUFF simulations will be conducted using the following model options:

- Gaussian near-field distribution
- Transitional plume rise
- Stack tip downwash
- Pasquill-Gifford (PG) dispersion coefficients (rural areas) and McElroy-Pooler coefficients (urban areas)
- Transition of  $\sigma_y$  to time-dependent (Heffter) growth rates
- Partial plume path adjustment for terrain
- Wet deposition, dry deposition, and chemical transformation will be considered.

Two important computational parameters in CALPUFF are XMXLLEN (maximum length of an emitted puff, in grid units) and XSAMLEN (maximum travel distance of a puff, in grid units, during one time step). Both of these variables will be set to 1.0 in the CALPUFF simulations in order to allow the strong wind channeling effects to be accounted for in the puff trajectory calculations. The first parameter ensures that the length of an emitted puff does not become so large so that it cannot respond to changes in the wind field on the scale of the meteorological grid. The model automatically increases the frequency of puff releases to ensure the length of a single puff is not larger than the grid size. The second parameter decreases the internal time step to ensure the travel distance during one time step does not exceed the grid size.

The partial plume path adjustment option will be used in CALPUFF for this analysis (MCTADJ=3). The CALMET wind field incorporates the effect of the terrain on the plume trajectories. The plume path coefficient is used to characterize the local effect on ground-level concentrations. The default plume path coefficients (PPC) used for this analysis are listed below:

Stability Class	A	B	C	D	E	F
PPC	0.5	0.5	0.5	0.5	0.35	0.35

Deposition and chemical transformation effects will be modeled using the default dry deposition model, the scavenging coefficient wet removal module, and the default chemical transformation mechanism.



Eleven species will be modeled with CALPUFF for this analysis: SO<sub>2</sub>, SO<sub>4</sub>, NO<sub>x</sub>, HNO<sub>3</sub>, NO<sub>3</sub>, and six subcategories of PM<sub>10</sub>, (PM<sub>800</sub>, PM<sub>425</sub>, PM<sub>187</sub>, PM<sub>112</sub>, PM<sub>081</sub>, PM<sub>056</sub>). Of these eleven species, five are emitted by the project sources: SO<sub>2</sub>, SO<sub>4</sub>, NO<sub>x</sub>, PM<sub>10</sub>, and NH<sub>3</sub>. The chemical mechanism computes transformation rates of SO<sub>2</sub> to SO<sub>4</sub> and NO<sub>x</sub> to NO<sub>3</sub>/HNO<sub>3</sub>. Hourly measured ozone concentrations will be provided in an external OZONE.DAT file for use with the chemical transformation module. These ozone concentrations, along with radiation intensity, will be used as surrogates for the OH concentration during the day when the gas phase free radical chemistry was active.

To allow for flexibility each source will be modeled individually and their source contributions will be summed at the end.

## 5.6 Visibility Calculations

Calculations of the impact of the simulated plume particulate matter component concentrations on light extinction is carried out in the CALPOST postprocessor. The annual average values will be used for the natural background values. The equation used is the usual IMPROVE/EPA equation which is applied to determine the change in light extinction due to changes in component concentrations. Using the notations of CALPOST, the formula is the following:

$$B_{\text{ext}} = 3f(\text{RH})[(\text{NH}_4)_2\text{SO}_4] + 3f(\text{RH})[\text{NH}_4\text{NO}_3] + 4[\text{OC}] + 1[\text{Soil}] + 0.6[\text{Coarse Mass}] + 10[\text{EC}] + b_{\text{ray}}$$

The concentrations, in square brackets, are in µg/m<sup>3</sup> and  $b_{\text{ext}}$  is in units of Mm<sup>-1</sup>. The Rayleigh scattering term ( $b_{\text{ray}}$ ) has a default value of 10 Mm<sup>-1</sup>, as recommended in EPA Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Program (U.S. EPA, 2003b). Note that organic carbon (OC) consists of condensable particulates which are assumed to be split evenly between the lowest two particle size categories. Soil is fine particulates which is defined as PM<sub>2.5</sub>. These species were created through scaling and summing of the CALPUFF output files using the POSTUTIL program.

As a refinement to this analysis, a new IMPROVE algorithm may be used in the visibility analysis. The new IMPROVE algorithm includes revisions to the factor used to calculate organic mass from the measured organic carbon, the addition of a term for sea salt light scattering; revised dry extinction efficiencies for inorganic (e.g., sulfate and nitrate) and organic constituents that may vary depending on the measured concentrations; new relative humidity adjustment functions ( $f(\text{RH})$ ), to be technically consistent with the newly selected dry efficiency terms for the hygroscopic components.

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

$$\text{HI} = 10 \ln(b_{\text{ext}}/10)$$

where HI is in units of deciviews (dv) and  $b_{\text{ext}}$  is in Mm<sup>-1</sup>. The impact of a source is determined by comparing HI for estimated natural background conditions with the impact of the source and without the impact of the source.

CALPOST Method 6 will be used to compute the extinction change in deciviews consistent with the procedures outlined in the LADCO (2006) modeling protocol

A monthly background concentration must be entered into the CALPOST input control file. The annual average natural visibility conditions for Mammoth Cave will be used. Annual background concentrations for the eastern United States are give in the Guidance for Estimating Natural Visibility Conditions in Table 2-1 (U.S. EPA, 2003b), and are also provided in Table 5-3 below. These background concentrations are entered in CALPOST.

Table 5-4 provides the monthly f(RH) values based on the centroid of the Class I area as recommended by EPA for application of Method 6. The monthly f(RH) values for each month are extracted from Appendix A of *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule (2003)*.

The 8<sup>th</sup> highest (98<sup>th</sup> percentile) predicted light extinction change value expressed in deciviews will then be compared to the threshold value of 0.5 deciviews.

**Table 5-3. Background Natural Visibility Concentrations for the Eastern United States**

	East ( $\mu\text{g}/\text{m}^3$ )
Ammonium sulfate	0.23
Ammonium nitrate	0.1
Organic carbon	1.4
Elemental carbon	0.02
Soil	0.5
Coarse Mass	3

Source: *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule (2003)*, Table 2-1

**Table 5-4. Monthly f(RH) Values for Mammoth Cave Based on the Area Centroid**

Class I area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mammoth Cave NP	3.4	3.1	2.9	2.6	3.2	3.5	3.7	3.9	3.9	3.4	3.2	3.5

Source: *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule (2003)*, Appendix A

## 5.7 Modeling Products

The change in light extinction relative to the natural background due to sulfur dioxide, particulate matter and nitrogen oxides from the BART-eligible sources will be computed. BART methodology with CALPOST Method 6 and 98<sup>th</sup> percentile day results will be used to determine light extinction. The light

extinction impacts at Mammoth Cave will be presented for each modeled year in units of change in deciview, as well as for a full three-year period.

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**Appendix B to  
BART determination Report for Alcoa, Inc. - Warrick Operations**

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## Appendix B Revisions to Alcoa BART Modeling Report

*These revisions to Appendix B were submitted in September 2010 in a format not compatible with the Appendix. The tables in this attachment replace the tables by the same numbers included in the original report.*

Table 2-3. Point and Line Source Emissions, 'BART Eligible Baseline' Case

Source ID	Emission Unit ID #	Stack Name	Filterable PM <sub>10</sub> - PM <sub>2.5</sub> (g/s)	Filterable PM <sub>2.5</sub> (g/s)	Organic Condensable PM <sub>2.5</sub> (g/s)	Inorganic Condensable PM <sub>2.5</sub> (g/s)	SO <sub>2</sub> (g/s)	NO <sub>x</sub> (g/s)
L01	103M.1	Potline #2, Room 103	0.535	0.753	0.373	0.356	0.266	0.003
L02	104M.1	Potline #2, Room 104	0.535	0.753	0.373	0.356	0.266	0.003
L03	105M.1	Potline #3, Room 105	0.569	0.802	0.397	0.379	0.269	0.003
L04	106M.1	Potline #3, Room 106	0.569	0.802	0.397	0.379	0.269	0.003
L05	107M.1	Potline #4, Room 107	0.567	0.799	0.395	0.377	0.269	0.003
L06	108M.1	Potline #4, Room 108	0.567	0.799	0.395	0.377	0.269	0.003
L07	109M.1	Potline #5, Room 109	0.470	0.663	0.328	0.313	0.259	0.003
L08	110M.1	Potline #5, Room 110	0.470	0.663	0.328	0.313	0.259	0.003
L09	111M.1	Potline #6, Room 111	0.532	0.749	0.371	0.354	0.264	0.003
L10	112M.1	Potline #6, Room 112	0.532	0.749	0.371	0.354	0.264	0.003
P01	GTC	Potlines #3 & #4 GTC Pollution Controls	0.986	0.116	1.757	4.409	<del>46.817</del> <b>46.868</b>	0.581
P02	160C1.1-160C1.36	Potline #2 A-398	0.393	0.046	0.700	1.758	23.312	0.289
P03	161B5.1-161B5.36	Potline #5 A-398	0.555	0.065	0.989	2.482	22.008	0.291
P04	161B6.1-161B6.36	Potline #6 A-398	0.563	0.066	1.002	2.514	<del>21.836</del> <b>21.86</b>	0.301
P23	134.62	Melter 1M1	0.056	0.027	0.001	0.001	0.0009	0.161
P24	134.64	Holder 1EH	0.017	0.026	0.002	0.002	0.0014	0.149
P25	134.65	Melter 1M2	0.065	0.030	0.001	0.001	0.002	0.402
P26	134.66	Holder 1WH	0.011	0.016	0.002	0.002	0.003	0.149
P28	134.33	Melter 5M1	0.061	0.028	0.001	0.001	<del>0.0004</del> <b>0.023</b>	0.253
P29	134.35	Holder 5EH	0.110	0.167	0.015	0.015	0.00126	0.318
P30	134.36	Melter 5M2	0.095	0.044	0.001	0.001	<del>0.0004</del> <b>0.012</b>	1.317
P31	134.38	Holder 5WH	0.119	0.180	0.017	0.017	0.00126	0.318
P32	134.39	Melter 5M3	0.066	0.031	0.001	0.001	<del>0.0004</del> <b>0.0016</b>	0.297
P33	134.4	Melter 6M1	0.062	0.029	0.001	0.005	0.0002	0.038
P34	134.41	Holder 6EH	0.119	0.180	0.017	0.017	0.0001	0.016
P35	134.42	Melter 6M2	0.062	0.029	0.001	0.001	0.0002	0.038
P36	134.43	Holder 6WH	0.119	0.180	0.017	0.017	0.0001	0.016
P37	134.44	Melter 6M3	0.062	0.029	0.001	0.001	0.0002	0.038
P39	134.71	Offlines #2 East Melter	0.007	0.003	0.000	0.000	0.006	1.140
P41	134.75	Offlines #2 West Melter	0.007	0.003	0.000	0.000	0.0025	0.660
WPP01	WPP stack 1	WPP Stack 1 Unit 2 Only	*	8.6	1.949	2.852	372.9	71.01
WPP02	WPP stack 2	WPP Stack 2 Units 2 and 3	*	<del>22.01 21.96</del> <b>22.01</b>	<del>7.629 5.73</del> <b>7.629</b>	<del>11.236 8.384</del> <b>11.236</b>	1245.7	203.98
WPP03	WPP stack 3	WPP Stack 3 Unit 4	*	<del>49.525 49.523</del> <b>49.525</b>	8.13	11.895	<del>0.0 1755.7</del> <b>0.0</b>	<del>0.0 250.96</del> <b>0.0</b>

\* All Solid PM is 10 microns or less. There is no data available for solid PM<sub>2.5</sub>

Table 2-4. Point and Line Source Emissions, 'BART Eligible Baseline + Unit 1' Case

Source ID	Emission Unit ID #	Stack Name	Filterable PM <sub>10</sub> - PM <sub>2.5</sub> (g/s)	Filterable PM <sub>2.5</sub> (g/s)	Organic Condensable PM <sub>2.5</sub> (g/s)	Inorganic Condensable PM <sub>2.5</sub> (g/s)	SO <sub>2</sub> (g/s)	NO <sub>x</sub> (g/s)
L01	103M.1	Potline #2, Room 103	0.535	0.753	0.373	0.356	0.266	0.003
L02	104M.1	Potline #2, Room 104	0.535	0.753	0.373	0.356	0.266	0.003
L03	105M.1	Potline #3, Room 105	0.569	0.802	0.397	0.379	0.269	0.003
L04	106M.1	Potline #3, Room 106	0.569	0.802	0.397	0.379	0.269	0.003
L05	107M.1	Potline #4, Room 107	0.567	0.799	0.395	0.377	0.269	0.003
L06	108M.1	Potline #4, Room 108	0.567	0.799	0.395	0.377	0.269	0.003
L07	109M.1	Potline #5, Room 109	0.470	0.663	0.328	0.313	0.259	0.003
L08	110M.1	Potline #5, Room 110	0.470	0.663	0.328	0.313	0.259	0.003
L09	111M.1	Potline #6, Room 111	0.532	0.749	0.371	0.354	0.264	0.003
L10	112M.1	Potline #6, Room 112	0.532	0.749	0.371	0.354	0.264	0.003
P01	GTC	Potlines #3 & #4 GTC Pollution Controls	0.986	0.116	1.757	4.409	<del>46.868</del> 46.847	0.581
P02	160C1.1-160C1.36	Potline #2 A-398	0.393	0.046	0.700	1.758	23.312	0.289
P03	161B5.1-161B5.36	Potline #5 A-398	0.555	0.065	0.989	2.482	22.008	0.291
P04	161B6.1-161B6.36	Potline #6 A-398	0.563	0.066	1.002	2.514	<del>21.86</del> 21.836	0.301
P23	134.62	Melter 1M1	0.056	0.027	0.001	0.001	0.0009	0.161
P24	134.64	Holder 1EH	0.017	0.026	0.002	0.002	0.0014	0.149
P25	134.65	Melter 1M2	0.065	0.030	0.001	0.001	0.002	0.402
P26	134.66	Holder 1WH	0.011	0.016	0.002	0.002	0.003	0.149
P28	134.33	Melter 5M1	0.061	0.028	0.001	0.001	<del>0.023</del> 0.0004	0.253
P29	134.35	Holder 5EH	0.110	0.167	0.015	0.015	0.00126	0.318
P30	134.36	Melter 5M2	0.095	0.044	0.001	0.001	<del>0.012</del> 0.0004	1.317
P31	134.38	Holder 5WH	0.119	0.180	0.017	0.017	0.00126	0.318
P32	134.39	Melter 5M3	0.066	0.031	0.001	0.001	<del>0.0016</del> 0.0004	0.297
P33	134.4	Melter 6M1	0.062	0.029	0.001	0.005	0.0002	0.038
P34	134.41	Holder 6EH	0.119	0.180	0.017	0.017	0.0001	0.016
P35	134.42	Melter 6M2	0.062	0.029	0.001	0.001	0.0002	0.038
P36	134.43	Holder 6WH	0.119	0.180	0.017	0.017	0.0001	0.016
P37	134.44	Melter 6M3	0.062	0.029	0.001	0.001	0.0002	0.038
P39	134.71	Offlines #2 East Melter	0.007	0.003	0.000	0.000	0.006	1.140
P41	134.75	Offlines #2 West Melter	0.007	0.003	0.000	0.000	0.0025	0.660
WPP1a	WPP Stack 1	WPP Stack 1 Unit 1 and 2	*	<del>24.18</del> 17.576	<del>5.869</del> 3.92	<del>8.588</del> 5.735	<del>1118.71</del> 808.84	<del>142.01</del> 243.02
WPP2	WPP Stack 2	WPP Stack 2 Unit 2 and 3		<del>22.01</del> 21.96	<del>7.679</del> 5.73	<del>11.236</del> 8.384	1245.7	203.98
WPP3	WPP Stack 3	WPP Stack 3 Unit 4	*	<del>49.525</del> 49.523	8.13	11.895	<del>0.00</del> 4755.7	<del>0.00</del> 250.96

\* All Solid PM is 10 microns or less. There is no data available for solid PM<sub>2.5</sub>

Table 2-5. Point and Line Source Emissions, 'Alternative to BART' Case

Source ID	Emission Unit ID #	Stack Name	Filterable PM <sub>10</sub> - PM <sub>2.5</sub> (g/s)	Filterable PM <sub>2.5</sub> (g/s)	Organic Condensable PM <sub>2.5</sub> (g/s)	Inorganic Condensable PM <sub>2.5</sub> (g/s)	SO <sub>2</sub> (g/s)	NO <sub>x</sub> (g/s)
L01	103M.1	Potline #2, Room 103	0.535	0.753	0.373	0.356	<del>0.419</del> 0.407	0.003
L02	104M.1	Potline #2, Room 104	0.535	0.753	0.373	0.356	<del>0.419</del> 0.407	0.003
L03	105M.1	Potline #3, Room 105	0.569	0.802	0.397	0.379	<del>0.424</del> 0.412	0.003
L04	106M.1	Potline #3, Room 106	0.569	0.802	0.397	0.379	<del>0.424</del> 0.412	0.003
L05	107M.1	Potline #4, Room 107	0.567	0.799	0.395	0.377	<del>0.424</del> 0.412	0.003
L06	108M.1	Potline #4, Room 108	0.567	0.799	0.395	0.377	<del>0.424</del> 0.412	0.003
L07	109M.1	Potline #5, Room 109	0.470	0.663	0.328	0.313	<del>0.412</del> 0.400	0.003
L08	110M.1	Potline #5, Room 110	0.470	0.663	0.328	0.313	<del>0.412</del> 0.400	0.003
L09	111M.1	Potline #6, Room 111	0.532	0.749	0.371	0.354	<del>0.419</del> 0.407	0.003
L10	112M.1	Potline #6, Room 112	0.532	0.749	0.371	0.354	<del>0.419</del> 0.407	0.003
P01	GTC	Potlines #3 & #4 GTC Pollution Controls	<del>1.185</del> 0.986	<del>1.667</del> 0.416	1.757	4.409	<del>75.616</del> 73.442	0.581
P02	160C1.1-160C1.36	Potline #2 A-398	<del>0.535</del> 0.393	<del>0.753</del> 0.046	0.700	1.758	<del>37.619</del> 35.439	0.289
P03	161B5.1-161B5.36	Potline #5 A-398	<del>0.541</del> 0.555	<del>0.760</del> 0.065	0.989	2.482	<del>36.575</del> 35.497	0.291
P04	161B6.1-161B6.36	Potline #6 A-398	<del>0.532</del> 0.563	<del>0.748</del> 0.066	1.002	2.514	<del>36.306</del> 35.229	0.301
P23	134.62	Melter 1M1	0.056	0.027	0.001	0.001	0.0009	0.161
P24	134.64	Holder 1EH	0.017	0.026	0.002	0.002	0.0014	0.149
P25	134.65	Melter 1M2	0.065	0.030	0.001	0.001	0.002	0.402
P26	134.66	Holder 1WH	0.011	0.016	0.002	0.002	0.003	0.149
P28	134.33	Melter 5M1	0.061	0.028	0.001	0.001	<del>0.0023</del> 0.0004	0.253
P29	134.35	Holder 5EH	0.110	0.167	0.015	0.015	0.00126	0.318
P30	134.36	Melter 5M2	0.095	0.044	0.001	0.001	<del>0.012</del> 0.0004	
P31	134.38	Holder 5WH	0.119	0.180	0.017	0.017	0.00126	0.318
P32	134.39	Melter 5M3	0.066	0.031	0.001	0.001	<del>0.0016</del> 0.0004	0.297
P33	134.4	Melter 6M1	0.062	0.029	0.001	0.005	0.0002	0.038
P34	134.41	Holder 6EH	0.119	0.180	0.017	0.017	0.0001	0.016
P35	134.42	Melter 6M2	0.062	0.029	0.001	0.001	0.0002	0.038
P36	134.43	Holder 6WH	0.119	0.180	0.017	0.017	0.0001	0.016
P37	134.44	Melter 6M3	0.062	0.029	0.001	0.001	0.0002	0.038
P39	134.71	Offlines #2 East Melter	0.007	0.003	0.000	0.000	0.006	1.140
P41	134.75	Offlines #2 West Melter	0.007	0.003	0.000	0.000	0.0025	0.660
WPP123	WPP Units 1-3		*	<del>17.94</del> 45.36	<del>3.351</del> 3.254	<del>4.902</del> 3.845	<del>228.98</del> 229.28	204.169
WPP4	WPP	Unit 4	*	18.303	<del>6.12</del> 43.806	<del>8.953</del> 4.268	<del>0.00</del> 422.897	<del>0.00</del> 55.956

\* All Solid PM is 10 microns or less. There is no data available for solid PM<sub>2.5</sub>

Table 2-6. Point and Line Source Emissions, 'BART with Potlines Scrubbed' Case

Source ID	Emission Unit ID #	Stack Name	Filterable PM <sub>10</sub> - PM <sub>2.5</sub> (g/s)	Filterable PM <sub>2.5</sub> (g/s)	Organic Condensable PM <sub>2.5</sub> (g/s)	Inorganic Condensable PM <sub>2.5</sub> (g/s)	SO <sub>2</sub> (g/s)	NO <sub>x</sub> (g/s)
L01	103M.1	Potline #2, Room 103	0.535	0.753	0.373	0.356	<del>0.363</del> 0.353	0.003
L02	104M.1	Potline #2, Room 104	0.535	0.753	0.373	0.356	<del>0.363</del> 0.353	0.003
L03	105M.1	Potline #3, Room 105	0.569	0.802	0.397	0.379	<del>0.368</del> 0.357	0.003
L04	106M.1	Potline #3, Room 106	0.569	0.802	0.397	0.379	<del>0.368</del> 0.357	0.003
L05	107M.1	Potline #4, Room 107	0.567	0.799	0.395	0.377	<del>0.368</del> 0.357	0.003
L06	108M.1	Potline #4, Room 108	0.567	0.799	0.395	0.377	<del>0.368</del> 0.357	0.003
L07	109M.1	Potline #5, Room 109	0.470	0.663	0.328	0.313	<del>0.356</del> 0.346	0.003
L08	110M.1	Potline #5, Room 110	0.470	0.663	0.328	0.313	<del>0.356</del> 0.346	0.003
L09	111M.1	Potline #6, Room 111	0.532	0.749	0.371	0.354	<del>0.363</del> 0.354	0.003
L10	112M.1	Potline #6, Room 112	0.532	0.749	0.371	0.354	<del>0.363</del> 0.354	0.003
W01		Lines 3-6 Common Scrubber		1.591	4.335	10.879	<del>8.876</del> 6.247	0.581
W02		Line 2 SO <sub>2</sub> Scrubber		0.374	0.700	1.758	<del>2.166</del> 1.542	0.289
P23	134.62	Melter 1M1	0.056	0.027	0.001	0.001	0.0009	<del>0.161</del> 0.294
P24	134.64	Holder 1EH	0.017	0.026	0.002	0.002	0.0014	<del>0.149</del> 0.304
P25	134.65	Melter 1M2	0.065	0.030	0.001	0.001	0.002	0.402
P26	134.66	Holder 1WH	0.011	0.016	0.002	0.002	0.003	0.149
P28	134.33	Melter 5M1	0.061	0.028	0.001	0.001	<del>0.0023</del> 0.0004	0.253
P29	134.35	Holder 5EH	0.110	0.167	0.015	0.015	0.00126	0.318
P30	134.36	Melter 5M2	0.095	0.044	0.001	0.001	<del>0.012</del> 0.0004	1.317
P31	134.38	Holder 5WH	0.119	0.180	0.017	0.017	0.00126	0.318
P32	134.39	Melter 5M3	0.066	0.031	0.001	0.001	<del>0.0016</del> 0.0004	0.297
P33	134.4	Melter 6M1	0.062	0.029	0.001	0.005	0.0002	0.038
P34	134.41	Holder 6EH	0.119	0.180	0.017	0.017	0.0001	0.016
P35	134.42	Melter 6M2	0.062	0.029	0.001	0.001	0.0002	0.038
P36	134.43	Holder 6WH	0.119	0.180	0.017	0.017	0.0001	0.016
P37	134.44	Melter 6M3	0.062	0.029	0.001	0.001	0.0002	0.038
P39	134.71	Offlines #2 East Melter	0.007	0.003	0.000	0.000	0.006	1.140
P41	134.75	Offlines #2 West Melter	0.007	0.003	0.000	0.000	0.0025	0.660
WPP123	WPP Unit 2&3		*	12.75	2.699	3.167	129.49	135.329
WPP4	WPP	Unit 4	*	2.745	1.268	13.806	<del>0.00</del> 87.784	<del>0.00</del> 55.956

\* All Solid PM is 10 microns or less. There is no data available for solid PM<sub>2.5</sub>

Table 2-7. Point and Line Source Emissions, 'BART Control Level' Case

Source ID	Emission Unit ID #	Stack Name	Filterable PM <sub>10</sub> - PM <sub>2.5</sub> (g/s)	Filterable PM <sub>2.5</sub> (g/s)	Organic Condensable PM <sub>2.5</sub> (g/s)	Inorganic Condensable PM <sub>2.5</sub> (g/s)	SO <sub>2</sub> (g/s)	NO <sub>x</sub> (g/s)
L01	103M.1	Potline #2, Room 103	0.535	0.753	0.373	0.356	<del>0.363</del> 0.353	0.003
L02	104M.1	Potline #2, Room 104	0.535	0.753	0.373	0.356	<del>0.363</del> 0.353	0.003
L03	105M.1	Potline #3, Room 105	0.569	0.802	0.397	0.379	<del>0.368</del> 0.367	0.003
L04	106M.1	Potline #3, Room 106	0.569	0.802	0.397	0.379	<del>0.368</del> 0.367	0.003
L05	107M.1	Potline #4, Room 107	0.567	0.799	0.395	0.377	<del>0.368</del> 0.367	0.003
L06	108M.1	Potline #4, Room 108	0.567	0.799	0.395	0.377	<del>0.368</del> 0.367	0.003
L07	109M.1	Potline #5, Room 109	0.470	0.663	0.328	0.313	<del>0.356</del> 0.346	0.003
L08	110M.1	Potline #5, Room 110	0.470	0.663	0.328	0.313	<del>0.356</del> 0.346	0.003
L09	111M.1	Potline #6, Room 111	0.532	0.749	0.371	0.354	<del>0.363</del> 0.354	0.003
L10	112M.1	Potline #6, Room 112	0.532	0.749	0.371	0.354	<del>0.363</del> 0.354	0.003
P01	GTC	Potlines #3 & #4 GTC Pollution Controls	<del>1.185</del> 0.986	<del>1.667</del> 0.446	1.757	4.409	<del>65.826</del> 46.817	0.581
P02	160C1.1-160C1.36	Potline #2 A-398	<del>0.535</del> 0.393	<del>0.753</del> 0.046	0.700	1.758	<del>32.744</del> 23.342	0.289
P03	161B5.1-161B5.36	Potline #5 A-398	<del>0.541</del> 0.555	<del>0.760</del> 0.065	0.989	2.482	<del>31.612</del> 22.008	0.291
P04	161B6.1-161B6.36	Potline #6 A-398	<del>0.532</del> 0.563	<del>0.748</del> 0.066	1.002	2.514	<del>31.381</del> 21.836	0.301
P23	134.62	Melter 1M1	0.056	0.027	0.001	0.001	0.0009	0.161
P24	134.64	Holder 1EH	0.017	0.026	0.002	0.002	0.0014	0.149
P25	134.65	Melter 1M2	0.065	0.030	0.001	0.001	0.002	0.402
P26	134.66	Holder 1WH	0.011	0.016	0.002	0.002	0.003	0.149
P28	134.33	Melter 5M1	0.061	0.028	0.001	0.001	<del>0.0023</del> 0.0004	0.253
P29	134.35	Holder 5EH	0.110	0.167	0.015	0.015	0.00126	0.318
P30	134.36	Melter 5M2	0.095	0.044	0.001	0.001	<del>0.012</del> 0.0004	1.317
P31	134.38	Holder 5WH	0.119	0.180	0.017	0.017	0.00126	0.318
P32	134.39	Melter 5M3	0.066	0.031	0.001	0.001	<del>0.0016</del> 0.0004	0.297
P33	134.4	Melter 6M1	0.062	0.029	0.001	0.005	0.0002	0.038
P34	134.41	Holder 6EH	0.119	0.180	0.017	0.017	0.0001	0.016
P35	134.42	Melter 6M2	0.062	0.029	0.001	0.001	0.0002	0.038
P36	134.43	Holder 6WH	0.119	0.180	0.017	0.017	0.0001	0.016
P37	134.44	Melter 6M3	0.062	0.029	0.001	0.001	0.0002	0.038
P39	134.71	Offlines #2 East Melter	0.007	0.003	0.000	0.000	0.006	1.140
P41	134.75	Offlines #2 West Melter	0.007	0.003	0.000	0.000	0.0025	0.660
WPP123	WPP Unit 2&3	WPP units 2&3	*	12.75	2.699	3.167	129.49	135.329
WPP4	WPP	Unit 4	*	2.745	1.268	13.806	<del>0.00</del> 87.784	<del>0.00</del> 55.956

\* All Solid PM is 10 microns or less. There is no data available for solid PM<sub>2.5</sub>

**Table 2-8. PM Speciation of Particulate Matter Emitted from Lines and Stacks, 'BART Eligible Baseline' Case**

Source Index	PM <sub>10</sub> - PM <sub>2.5</sub> (g/s)	Solid PM <sub>2.5</sub> (g/s)	Org. Cond (g/s)	InOrg Cond (g/s)	Coarse PM			Fine PM			Organic Condensable	
					6-10 um (g/s)	2.5-6.0 um (g/s)	1.25-2.5 um (g/s)	1.00-1.25 um (g/s)	0.625-1.00 um <sup>1</sup> (g/s)	0.500-0.625 um <sup>1</sup> (g/s)	0.625-1.00 um (g/s)	0.500-0.625 um (g/s)
L01	0.535	0.753	0.373	0.356	0.268	0.268	0.188	0.188	0.366	0.366	0.187	0.187
L02	0.535	0.753	0.373	0.356	0.268	0.268	0.188	0.188	0.366	0.366	0.187	0.187
L03	0.569	0.802	0.397	0.379	0.285	0.285	0.201	0.201	0.390	0.390	0.199	0.199
L04	0.569	0.802	0.397	0.379	0.285	0.285	0.201	0.201	0.390	0.390	0.199	0.199
L05	0.567	0.799	0.395	0.377	0.284	0.284	0.200	0.200	0.388	0.388	0.198	0.198
L06	0.567	0.799	0.395	0.377	0.284	0.284	0.200	0.200	0.388	0.388	0.198	0.198
L07	0.470	0.663	0.328	0.313	0.235	0.235	0.166	0.166	0.322	0.322	0.164	0.164
L08	0.470	0.6630	0.328	0.313	0.235	0.235	0.166	0.166	0.322	0.322	0.164	0.164
L09	0.532	0.749	0.371	0.354	0.266	0.266	0.187	0.187	0.364	0.364	0.186	0.186
L10	0.532	0.749	0.371	0.354	0.266	0.266	0.187	0.187	0.364	0.364	0.186	0.186
P01	0.986	0.116	1.757	4.409	0.493	0.493	0.029	0.029	2.234	2.234	0.879	0.879
P02	0.393	0.046	0.700	1.758	0.197	0.197	0.012	0.012	0.891	0.891	0.350	0.350
P03	0.555	0.065	0.989	2.482	0.278	0.278	0.016	0.016	1.257	1.257	0.495	0.495
P04	0.563	0.066	1.002	2.514	0.282	0.282	0.017	0.017	1.274	1.274	0.501	0.501
P23	0.056	0.027	0.001	0.001	0.028	0.028	0.007	0.007	0.007	0.007	2.50E-04	2.50E-04
P24	0.017	0.026	0.002	0.002	0.009	0.009	0.007	0.007	0.007	0.007	7.50E-04	7.50E-04
P25	0.065	0.030	0.001	0.001	0.033	0.033	0.008	0.008	0.008	0.008	2.50E-04	2.50E-04
P26	0.011	0.016	0.002	0.002	0.006	0.006	0.004	0.004	0.005	0.005	7.50E-04	7.50E-04
P28	0.061	0.028	0.001	0.001	0.031	0.031	0.007	0.007	0.007	0.007	2.50E-04	2.50E-04
P29	0.110	0.167	0.015	0.015	0.055	0.055	0.042	0.042	0.049	0.049	7.50E-03	7.50E-03
P30	0.095	0.044	0.001	0.001	0.048	0.048	0.011	0.011	0.012	0.012	5.00E-04	5.00E-04
P31	0.119	0.180	0.017	0.017	0.060	0.060	0.045	0.045	0.053	0.053	8.25E-03	8.25E-03
P32	0.066	0.031	0.001	0.001	0.033	0.033	0.008	0.008	0.008	0.008	2.50E-04	2.50E-04
P33	0.062	0.029	0.001	0.005	0.031	0.031	0.007	0.007	0.010	0.010	2.50E-04	2.50E-04
P34	0.119	0.180	0.017	0.017	0.060	0.060	0.045	0.045	0.053	0.053	8.25E-03	8.25E-03
P35	0.062	0.029	0.001	0.001	0.031	0.031	0.007	0.007	0.008	0.008	2.50E-04	2.50E-04
P36	0.119	0.180	0.017	0.017	0.060	0.060	0.045	0.045	0.053	0.053	8.25E-03	8.25E-03
P37	0.062	0.029	0.001	0.001	0.031	0.031	0.007	0.007	0.008	0.008	2.50E-04	2.50E-04

<sup>1</sup> Emissions are fine filterable plus inorganic condensables

**Table 2-8. PM Speciation of Particulate Matter Emitted from Lines and Stacks, ‘BART Eligible Baseline’ Case, cont.**

Source Index	PM <sub>10</sub> - PM <sub>2.5</sub> (g/s)	Solid PM <sub>2.5</sub> (g/s)	Org. Cond (g/s)	InOrg Cond (g/s)	Coarse PM		Fine PM				Organic Condensable	
					6-10 um (g/s)	2.5-6.0 um (g/s)	1.25-2.5 um (g/s)	1.00-1.25 um (g/s)	0.625-1.00 um <sup>1</sup> (g/s)	0.500-0.625 um <sup>1</sup> (g/s)	0.625-1.00 um (g/s)	0.500-0.625 um (g/s)
<b>P39</b>	0.007	0.003	0.000	0.000	0.004	0.004	0.001	0.001	0.001	0.001	0.00	0.00
<b>P41</b>	0.007	0.003	0.000	0.000	0.004	0.004	0.001	0.001	0.001	0.001	0.00	0.00
<b>WPP1</b>	-	8.6	1.949	2.852	0.000	0.000	2.150	2.150	3.576	3.576	0.975	0.975
	-	<b>22.01</b>	<b>7.629</b>	<b>11.236</b>	0.000	0.000	<b>5.503</b>	<b>5.503</b>	<b>11.121</b>	<b>11.121</b>	<b>3.814</b>	<b>3.814</b>
<b>WPP2</b>		21.96	6.73	8.384			5.490	5.490	9.682	5.490	2.865	2.865
	-	<b>49.525</b>			0.000	0.000	12.381	12.381	<b>18.329</b>	<b>18.329</b>	4.065	4.065
<b>WPP3</b>		49.523	8.13	11.895					18.328	18.328		

<sup>1</sup> Emissions are fine filterable plus inorganic condensables



**Table 2-9. Speciation of Particulate Matter Emitted from Lines and Stacks, ‘BART Eligible Baseline + Unit 1’ Case.**

Source Index	PM <sub>10</sub> - PM <sub>2.5</sub> (g/s)	Solid PM <sub>2.5</sub> (g/s)	Org. Cond (g/s)	InOrg Cond (g/s)	Coarse PM			Fine PM			Organic Condensable	
					6-10 um (g/s)	2.5-6.0 um (g/s)	1.25-2.5 um (g/s)	1.00-1.25 um (g/s)	0.625-1.00 um <sup>1</sup> (g/s)	0.500-0.625 um <sup>1</sup> (g/s)	0.625-1.00 um (g/s)	0.500-0.625 um (g/s)
WPP1	-	24.18	5.869	8.588	0.000	0.000	6.045	6.045	10.339	10.339	2.935	2.935
		24.476		8.587			6.044	6.044	10.338	10.338		

**Table 2-10. Speciation of Particulate Matter Emitted from Lines and Stacks, ‘Alternative to BART’ Case.**

Source Index	PM <sub>10</sub> - PM <sub>2.5</sub> (g/s)	Solid PM <sub>2.5</sub> (g/s)	Org. Cond (g/s)	InOrg Cond (g/s)	Coarse PM			Fine PM			Organic Condensable	
					6-10 um (g/s)	2.5-6.0 um (g/s)	1.25-2.5 um (g/s)	1.00-1.25 um (g/s)	0.625-1.00 um <sup>1</sup> (g/s)	0.500-0.625 um <sup>1</sup> (g/s)	0.625-1.00 um (g/s)	0.500-0.625 um (g/s)
WPP123	-	17.94	3.351	4.902	0.000	0.000	4.485	4.485	6.936	6.936	1.676	1.676
		45.36	3.254	3.845			3.840	3.840	5.748	5.748	1.626	1.626
WPP4	-	18.303	6.12	8.953	0.000	0.000	4.576	4.576	9.053	9.053	3.060	3.060
			43.806	4.268					5.210	5.210	6.903	6.903

**Table 2-11. Speciation of Particulate Matter Emitted from Lines and Stacks, ‘BART with Potlines Scrubbed’ Case.**

Source Index	PM <sub>10</sub> - PM <sub>2.5</sub> (g/s)	Solid PM <sub>2.5</sub> (g/s)	Org. Cond (g/s)	InOrg Cond (g/s)	Coarse PM			Fine PM			Organic Condensable	
					6-10 um (g/s)	2.5-6.0 um (g/s)	1.25-2.5 um (g/s)	1.00-1.25 um (g/s)	0.625-1.00 um <sup>1</sup> (g/s)	0.500-0.625 um <sup>1</sup> (g/s)	0.625-1.00 um (g/s)	0.500-0.625 um (g/s)
W01	-	1.591	4.335	10.879	0.000	0.000	0.398	0.398	5.837	5.837	2.168	2.168
W02	-	0.374	0.700	1.758	0.000	0.000	0.094	0.094	0.973	0.973	0.350	0.350
WPP23	-	12.75	2.699	3.167	0.000	0.000	3.188	3.188	4.771	4.771	1.350	1.350
WPP4	-	2.745	1.268	13.806	0.000	0.000	0.686	0.686	7.589	7.589	0.634	0.634

**Table 2-12. Speciation of Particulate Matter Emitted from Lines and Stacks, ‘BART Control Level’ Case.**

Source Index	PM <sub>10</sub> - PM <sub>2.5</sub> (g/s)	Solid PM <sub>2.5</sub> (g/s)	Org. Cond (g/s)	InOrg Cond (g/s)	Coarse PM			Fine PM			Organic Condensable	
					6-10 um (g/s)	2.5-6.0 um (g/s)	1.25-2.5 um (g/s)	1.00-1.25 um (g/s)	0.625-1.00 um <sup>1</sup> (g/s)	0.500-0.625 um <sup>1</sup> (g/s)	0.625-1.00 um (g/s)	0.500-0.625 um (g/s)
WPP23	-	12.75	2.699	3.167	0.000	0.000	3.188	3.188	4.771	4.771	1.350	1.350
WPP4	-	2.745	1.268	13.806	0.000	0.000	0.686	0.686	7.589	7.589	0.634	0.634

**Table 6-1. Summary of Visibility Impacts at Mammoth Cave National Park due to ‘BART Eligible Baseline’ Case Emissions.**

<b>Year</b>	<b>Maximum Delta Bext</b>	<b>98<sup>th</sup> Percentile Delta Bext</b>	<b>Maximum Delta Deciview</b>	<b>98<sup>th</sup> Percentile Delta Deciview</b>
	(%)	(%)	(dv)	(dv)
2001	<i>46.13</i> <del>91.62</del>	<i>22.36</i> <del>44.46</del>	<i>3.275</i> <del>6.504</del>	<i>1.852</i> <del>3.678</del>
2002	<i>56.17</i> <del>116.68</del>	<i>23.38</i> <del>48.57</del>	<i>3.722</i> <del>7.732</del>	<i>1.906</i> <del>3.959</del>
2003	<i>37.03</i> <del>72.21</del>	<i>21.40</i> <del>41.73</del>	<i>2.787</i> <del>5.435</del>	<i>1.788</i> <del>3.487</del>
2001 - 2003	<i>56.17</i> <del>116.68</del>	<i>22.38</i> <del>44.69</del>	<i>3.722</i> <del>7.732</del>	<i>1.849</i> <del>3.694</del>

**Table 6-2. Summary of Visibility Impacts at Mammoth Cave National Park due to ‘BART Eligible Baseline+ Unit 1’ Case Emissions.**

<b>Year</b>	<b>Maximum Delta Bext</b>	<b>98<sup>th</sup> Percentile Delta Bext</b>	<b>Maximum Delta Deciview</b>	<b>98<sup>th</sup> Percentile Delta Deciview</b>
	(%)	(%)	(dv)	(dv)
2001	<i>60.69</i> <del>114.74</del>	<i>28.81</i> <del>54.46</del>	<i>4.042</i> <del>7.642</del>	<i>2.311</i> <del>4.369</del>
2002	<i>85.38</i> <del>144.44</del>	<i>35.39</i> <del>59.88</del>	<i>4.570</i> <del>7.732</del>	<i>2.774</i> <del>4.693</del>
2003	<i>55.30</i> <del>90.32</del>	<i>31.61</i> <del>51.63</del>	<i>3.329</i> <del>5.435</del>	<i>2.549</i> <del>4.163</del>
2001 - 2003	<i>85.38</i> <del>144.44</del>	<i>31.94</i> <del>55.65</del>	<i>4.570</i> <del>7.732</del>	<i>2.545</i> <del>4.424</del>

**Table 6-3. Summary of Visibility Impacts at Mammoth Cave National Park due to ‘Alternative to BART’ Case Emissions.**

<b>Year</b>	<b>Maximum Delta Bext (%)</b>	<b>98<sup>th</sup> Percentile Delta Bext (%)</b>	<b>Maximum Delta Deciview (dv)</b>	<b>98<sup>th</sup> Percentile Delta Deciview (dv)</b>
2001	<i>13.98</i> <del>21.76</del>	<i>7.24</i> <del>11.27</del>	<i>1.265</i> <del>1.969</del>	<i>0.686</i> <del>1.068</del>
2002	<i>16.33</i> <del>26.76</del>	<i>4.81</i> <del>7.89</del>	<i>1.446</i> <del>2.371</del>	<i>0.463</i> <del>0.759</del>
2003	<i>14.85</i> <del>24.42</del>	<i>5.75</i> <del>9.45</del>	<i>1.323</i> <del>2.185</del>	<i>0.549</i> <del>0.903</del>
2001 - 2003	<i>16.33</i> <del>26.76</del>	<i>5.93</i> <del>9.84</del>	<i>1.345</i> <del>2.371</del>	<i>0.566</i> <del>0.938</del>

**Table 6-4. Summary of Visibility Impacts at Mammoth Cave National Park due to ‘BART with Potlines Scrubbed’ Case Emissions.**

<b>Year</b>	<b>Maximum Delta Bext (%)</b>	<b>98<sup>th</sup> Percentile Delta Bext (%)</b>	<b>Maximum Delta Deciview (dv)</b>	<b>98<sup>th</sup> Percentile Delta Deciview (dv)</b>
2001	<i>6.38</i> <del>11.42</del>	<i>3.86</i> <del>6.91</del>	<i>0.604</i> <del>1.081</del>	<i>0.374</i> <del>0.669</del>
2002	<i>8.41</i> <del>16.75</del>	<i>2.23</i> <del>4.43</del>	<i>0.778</i> <del>1.549</del>	<i>0.218</i> <del>0.434</del>
2003	<i>7.83</i> <del>15.19</del>	<i>2.75</i> <del>5.34</del>	<i>0.729</i> <del>1.414</del>	<i>0.268</i> <del>0.520</del>
2001 - 2003	<i>8.41</i> <del>16.75</del>	<i>2.95</i> <del>5.41</del>	<i>0.704</i> <del>1.549</del>	<i>0.289</i> <del>0.527</del>

**Table 6-5. Summary of Visibility Impacts at Mammoth Cave National Park due to ‘BART Control Level’ Case Emissions.**

<b>Year</b>	<b>Maximum Delta Bext</b>	<b>98<sup>th</sup> Percentile Delta Bext</b>	<b>Maximum Delta Deciview</b>	<b>98<sup>th</sup> Percentile Delta Deciview</b>
	(%)	(%)	(dv)	(dv)
2001	<i>9.18</i> <del>15.19</del>	<i>4.60</i> <del>7.66</del>	<i>0.850</i> <del>1.414</del>	<i>0.444</i> <del>0.739</del>
2002	<i>10.46</i> <del>18.89</del>	<i>3.07</i> <del>5.55</del>	<i>0.958</i> <del>1.731</del>	<i>0.299</i> <del>0.540</del>
2003	<i>10.75</i> <del>17.30</del>	<i>4.16</i> <del>6.69</del>	<i>0.992</i> <del>1.596</del>	<i>0.402</i> <del>0.647</del>
2001 - 2003	<i>10.46</i> <del>18.89</del>	<i>3.94</i> <del>6.88</del>	<i>0.933</i> <del>1.731</del>	<i>0.382</i> <del>0.665</del>

**Table 6-7. Source and Species Contributions to the 8<sup>th</sup> Highest Extinction Coefficient Changes for ‘BART Eligible Baseline’ Case at Mammoth Cave National Park.**

Source	Bext	Contrib. to	Modeled	Species Contribution to Modeled Extinction Coefficient in 1/Mm						Percentage of Species Contribution to Modeled Extinction Coefficient					
Group	Change	Total Bext	Ext.	SO4	NO3	Organics	E.Carbon	PM_Coarse	PM_Fine	SO4	NO3	Organics	E.Carbon	PM_Coarse	PM_Fine
	(%)	Change (%)	1/Mm	1/Mm	1/Mm	1/Mm	1/Mm	1/Mm	1/Mm	%	%	%	%	%	%
<b>2001: 8<sup>th</sup> highest impact is 1.852 3.678 Deciview</b>															
All	<b>22.36</b> 44.46	100.00	<b>4.757</b> 9.456	<b>4.508</b> 9.118	<b>0.100</b> 0.196	<b>0.064</b> 0.060	0.000	<b>0.000</b> 0.003	<b>0.081</b> 0.079	<b>94.77</b> 96.43	<b>2.10</b> 2.07	<b>1.35</b> 0.63	0.00	<b>0.00</b> 0.03	<b>1.78</b> 0.84
Lines	0.12	<b>0.53</b> 0.26	0.025	0.007	0.000	0.009	0.000	0.002	0.007	28.00	0.00	36.00	0.00	8.00	28.00
GTC	0.60	<b>2.67</b> 1.34	0.127	0.120	0.000	0.004	0.000	0.000	0.003	94.49	0.00	3.15	0.00	0.00	2.36
A-398s	0.86	<b>3.85</b> 1.94	0.183	0.172	0.000	0.007	0.000	0.000	0.004	93.99	0.00	3.83	0.00	0.00	2.19
Melter / Holder	0.01	<b>0.06</b> 0.03	0.003	0.000	0.002	0.000	0.000	0.000	0.001	0.00	66.67	0.00	0.00	0.00	33.33
wpp01	4.73	<b>21.17</b> 10.65	1.007	0.970	0.025	0.005	0.000	0.000	0.007	96.33	2.48	0.50	0.00	0.00	0.70
wpp02	<b>15.77</b> 15.74	<b>70.51</b> 35.40	<b>3.354</b> 3.347	3.239	0.075	0.014	0.000	0.000	0.019	96.77	2.24	0.42	0.00	0.00	0.57
wpp03	<b>0.27</b> 22.39	<b>1.21</b> 50.35	<b>0.058</b> 4.761	<b>0.000</b> 4.610	<b>0.000</b> 0.093	0.020	0.000	0.000	0.038	<b>0.00</b> 96.83	<b>0.00</b> 1.95	<b>34.48</b> 0.42	0.00	0.00	<b>65.52</b> 0.80
<b>2002: 8<sup>th</sup> highest impact is 1.906 3.959 Deciview</b>															
All	<b>23.38</b> 48.57	100.00	<b>5.042</b> 10.473	<b>3.655</b> 7.877	<b>1.214</b> 2.425	0.069	0.000	0.001	<b>0.103</b> 0.101	<b>72.49</b> 75.21	<b>24.08</b> 23.15	<b>1.37</b> 0.66	0.00	<b>0.02</b> 0.01	<b>2.04</b> 0.96
Lines	0.04	<b>0.20</b> 0.10	0.010	0.002	0.000	0.004	0.000	0.001	0.003	20.00	0.00	40.00	0.00	10.00	30.00
GTC	0.33	<b>1.39</b> 0.67	0.070	0.063	0.001	0.004	0.000	0.000	0.002	90.00	1.43	5.71	0.00	0.00	2.86
A-398s	0.36	<b>1.57</b> 0.75	0.079	0.069	0.002	0.005	0.000	0.000	0.003	87.34	2.53	6.33	0.00	0.00	3.80
Melter / Holder	0.01	<b>0.04</b> 0.02	0.002	0.000	0.002	0.000	0.000	0.000	0.000	0.00	100.00	0.00	0.00	0.00	0.00
wpp01	5.33	<b>22.77</b> 10.96	1.148	0.818	0.313	0.007	0.000	0.000	0.010	71.25	27.26	0.61	0.00	0.00	0.87
wpp02	<b>16.92</b> 16.90	<b>72.37</b> 34.80	<b>3.649</b> 3.645	2.703	0.896	0.020	0.000	0.000	0.026	74.16	24.58	0.55	0.00	0.00	0.71
wpp03	<b>0.39</b> 25.60	<b>1.66</b> 52.71	<b>0.084</b> 5.520	<b>0.000</b> 4.223	<b>0.000</b> 1.210	<b>0.027</b> 0.030	0.000	0.000	0.057	<b>0.00</b> 76.50	<b>0.00</b> 21.92	<b>32.14</b> 0.54	0.00	0.00	<b>67.86</b> 1.03

**Table 6-7. Source and Species Contributions to the 8<sup>th</sup> Highest Extinction Coefficient Changes for ‘BART Eligible Baseline’ Case at Mammoth Cave National Park, continued.**

Source	Bext	Contrib. to	Modeled	Species Contribution to Modeled Extinction Coefficient in 1/Mm						Percentage of Species Contribution to Modeled Extinction Coefficient					
Group	Change	Total Bext	Ext.	SO4	NO3	Organics	E.Carbon	PM_Coarse	PM_Fine	SO4	NO3	Organics	E.Carbon	PM_Coarse	PM_Fine
	(%)	Change (%)	1/Mm	1/Mm	1/Mm	1/Mm	1/Mm	1/Mm	1/Mm	%	%	%	%	%	%
<b>2003: 8<sup>th</sup> highest impact is 1.788 3.487 Deciview</b>															
All	<b>21.40</b> <del>41.73</del>	100.00	<b>4.656</b> <del>9.081</del>	<b>4.097</b> <del>8.161</del>	<b>0.411</b> <del>0.777</del>	<b>0.065</b> <del>0.061</del>	0.000	<b>0.001</b> <del>0.002</del>	<b>0.082</b> <del>0.080</del>	<b>87.99</b> <del>89.87</del>	<b>8.83</b> <del>8.56</del>	<b>1.40</b> <del>0.67</del>	0.00	0.02	<b>1.76</b> <del>0.88</del>
Lines	0.08	<b>0.37</b> <del>0.19</del>	0.017	0.004	0.000	0.007	0.000	<b>0.001</b> <del>0.002</del>	0.005	23.53	0.00	41.18	0.00	5.88	29.41
GTC	0.55	<b>2.58</b> <del>4.32</del>	0.120	0.111	0.001	0.005	0.000	<b>0.000</b> <del>0.001</del>	0.003	92.50	0.83	4.17	0.00	0.00	2.50
A-398s	0.82	<b>3.80</b> <del>1.95</del>	0.177	0.164	0.001	0.007	0.000	0.000	0.005	92.66	0.56	3.95	0.00	0.00	2.82
Melter / Holder	0.04	<b>0.00</b> <del>0.09</del>	<b>0.000</b> <del>0.008</del>	0.000	0.007	0.000	0.000	0.000	0.001	0.00	87.50	0.00	0.00	0.00	12.50
wpp01	4.55	<b>21.28</b> <del>10.91</del>	0.991	0.881	0.098	0.005	0.000	0.000	0.007	88.90	9.89	0.50	0.00	0.00	0.71
wpp02	<b>15.08</b> <del>45.05</del>	<b>70.51</b> <del>36.08</del>	<b>3.283</b> <del>3.276</del>	2.937	0.304	<b>0.02</b> <del>0.015</del>	0.000	0.000	<b>0.022</b> <del>0.020</del>	<b>89.46</b> <del>89.65</del>	<b>9.26</b> <del>9.28</del>	<b>0.61</b> <del>0.46</del>	0.00	0.00	<b>0.67</b> <del>0.61</del>
wpp03	<b>0.28</b> <del>20.63</del>	<b>1.46</b> <del>49.45</del>	<b>0.06</b> <del>4.491</del>	<b>0.00</b> <del>4.064</del>	<b>0.00</b> <del>0.367</del>	0.021	0.000	0.000	0.039	<b>0.00</b> <del>90.49</del>	<b>0.00</b> <del>8.17</del>	<b>35.00</b> <del>0.47</del>	0.00	0.00	<b>65.00</b> <del>0.87</del>

## Revisions to Appendix A, Alcoa BART Modeling Protocol



Table 2-3. Point and Line Source Emissions

Source ID	Emission Unit ID #	Stack Name	Filterable PM <sub>10</sub> - PM <sub>2.5</sub> (g/s)	Filterable PM <sub>2.5</sub> (g/s)	Organic Condensable PM <sub>2.5</sub> (g/s)	Inorganic Condensable PM <sub>2.5</sub> (g/s)	SO <sub>2</sub> (g/s)	NO <sub>x</sub> (g/s)
L01	103M.1	Potline #2, Room 103	0.535	0.753	0.373	0.356	0.266	0.003
L02	104M.1	Potline #2, Room 104	0.535	0.753	0.373	0.356	0.266	0.003
L03	105M.1	Potline #3, Room 105	0.569	0.802	0.397	0.379	0.269	0.003
L04	106M.1	Potline #3, Room 106	0.569	0.802	0.397	0.379	0.269	0.003
L05	107M.1	Potline #4, Room 107	0.567	0.799	0.395	0.377	0.269	0.003
L06	108M.1	Potline #4, Room 108	0.567	0.799	0.395	0.377	0.269	0.003
L07	109M.1	Potline #5, Room 109	0.470	0.663	0.328	0.313	0.259	0.003
L08	110M.1	Potline #5, Room 110	0.470	0.663	0.328	0.313	0.259	0.003
L09	111M.1	Potline #6, Room 111	0.532	0.749	0.371	0.354	0.264	0.003
L10	112M.1	Potline #6, Room 112	0.532	0.749	0.371	0.354	0.264	0.003
P01	GTC	Potlines #3 & #4 GTC Pollution Controls	0.986	0.116	1.757	4.409	<del>46.817</del> <b>46.868</b>	0.581
P02	160C1.1-160C1.36	Potline #2 A-398	0.393	0.046	0.700	1.758	23.312	0.289
P03	161B5.1-161B5.36	Potline #5 A-398	0.555	0.065	0.989	2.482	22.008	0.291
P04	161B6.1-161B6.36	Potline #6 A-398	0.563	0.066	1.002	2.514	<del>21.836</del> <b>21.86</b>	0.301
P23	134.62	Melter 1M1	0.056	0.027	0.001	0.001	0.0009	0.161
P24	134.64	Holder 1EH	0.017	0.026	0.002	0.002	0.0014	0.149
P25	134.65	Melter 1M2	0.065	0.030	0.001	0.001	0.002	0.402
P26	134.66	Holder 1WH	0.011	0.016	0.002	0.002	0.003	0.149
P28	134.33	Melter 5M1	0.061	0.028	0.001	0.001	<del>0.0004</del> <b>0.023</b>	0.253
P29	134.35	Holder 5EH	0.110	0.167	0.015	0.015	0.00126	0.318
P30	134.36	Melter 5M2	0.095	0.044	0.001	0.001	<del>0.0004</del> <b>0.012</b>	1.317
P31	134.38	Holder 5WH	0.119	0.180	0.017	0.017	0.00126	0.318
P32	134.39	Melter 5M3	0.066	0.031	0.001	0.001	<del>0.0004</del> <b>0.0016</b>	0.297
P33	134.4	Melter 6M1	0.062	0.029	0.001	0.005	0.0002	0.038
P34	134.41	Holder 6EH	0.119	0.180	0.017	0.017	0.0001	0.016
P35	134.42	Melter 6M2	0.062	0.029	0.001	0.001	0.0002	0.038
P36	134.43	Holder 6WH	0.119	0.180	0.017	0.017	0.0001	0.016
P37	134.44	Melter 6M3	0.062	0.029	0.001	0.001	0.0002	0.038
P39	134.71	Offlines #2 East Melter	0.007	0.003	0.000	0.000	0.006	1.140
P41	134.75	Offlines #2 West Melter	0.007	0.003	0.000	0.000	0.0025	0.660
WPP01	WPP stack 1	WPP Stack 1 Unit 2 Only	*	8.6	1.949	2.852	372.9	71.01
WPP02	WPP stack 2	WPP Stack 2 Units 2 and 3	*	<del>22.01 21.96</del> <b>22.01</b>	<del>7.629 5.73</del> <b>7.629</b>	<del>11.236 8.384</del> <b>11.236</b>	1245.7	203.98
WPP03	WPP stack 3	WPP Stack 3 Unit 4	*	<del>49.525 49.523</del> <b>49.525</b>	8.13	11.895	<del>0.0 1755.7</del> <b>0.0</b>	<del>0.0 250.96</del> <b>0.0</b>

\* All Solid PM is 10 microns or less. There is no data available for solid PM<sub>2.5</sub>

**Table 2-4. PM Speciation of Particulate Matter Emitted from Lines and Stacks**

Source Index	PM <sub>10</sub> - PM <sub>2.5</sub> (g/s)	Solid PM <sub>2.5</sub> (g/s)	Org. Cond (g/s)	InOrg Cond (g/s)	Coarse PM			Fine PM			Organic Condensable	
					6-10 um (g/s)	2.5-6.0 um (g/s)	1.25-2.5 um (g/s)	1.00-1.25 um (g/s)	0.625-1.00 um <sup>1</sup> (g/s)	0.500-0.625 um <sup>1</sup> (g/s)	0.625-1.00 um (g/s)	0.500-0.625 um (g/s)
L01	0.535	0.753	0.373	0.356	0.268	0.268	0.188	0.188	0.366	0.366	0.187	0.187
L02	0.535	0.753	0.373	0.356	0.268	0.268	0.188	0.188	0.366	0.366	0.187	0.187
L03	0.569	0.802	0.397	0.379	0.285	0.285	0.201	0.201	0.390	0.390	0.199	0.199
L04	0.569	0.802	0.397	0.379	0.285	0.285	0.201	0.201	0.390	0.390	0.199	0.199
L05	0.567	0.799	0.395	0.377	0.284	0.284	0.200	0.200	0.388	0.388	0.198	0.198
L06	0.567	0.799	0.395	0.377	0.284	0.284	0.200	0.200	0.388	0.388	0.198	0.198
L07	0.470	0.663	0.328	0.313	0.235	0.235	0.166	0.166	0.322	0.322	0.164	0.164
L08	0.470	0.6630	0.328	0.313	0.235	0.235	0.166	0.166	0.322	0.322	0.164	0.164
L09	0.532	0.749	0.371	0.354	0.266	0.266	0.187	0.187	0.364	0.364	0.186	0.186
L10	0.532	0.749	0.371	0.354	0.266	0.266	0.187	0.187	0.364	0.364	0.186	0.186
P01	0.986	0.116	1.757	4.409	0.493	0.493	0.029	0.029	2.234	2.234	0.879	0.879
P02	0.393	0.046	0.700	1.758	0.197	0.197	0.012	0.012	0.891	0.891	0.350	0.350
P03	0.555	0.065	0.989	2.482	0.278	0.278	0.016	0.016	1.257	1.257	0.495	0.495
P04	0.563	0.066	1.002	2.514	0.282	0.282	0.017	0.017	1.274	1.274	0.501	0.501
P23	0.056	0.027	0.001	0.001	0.028	0.028	0.007	0.007	0.007	0.007	2.50E-04	2.50E-04
P24	0.017	0.026	0.002	0.002	0.009	0.009	0.007	0.007	0.007	0.007	7.50E-04	7.50E-04
P25	0.065	0.030	0.001	0.001	0.033	0.033	0.008	0.008	0.008	0.008	2.50E-04	2.50E-04
P26	0.011	0.016	0.002	0.002	0.006	0.006	0.004	0.004	0.005	0.005	7.50E-04	7.50E-04
P28	0.061	0.028	0.001	0.001	0.031	0.031	0.007	0.007	0.007	0.007	2.50E-04	2.50E-04
P29	0.110	0.167	0.015	0.015	0.055	0.055	0.042	0.042	0.049	0.049	7.50E-03	7.50E-03
P30	0.095	0.044	0.001	0.001	0.048	0.048	0.011	0.011	0.012	0.012	5.00E-04	5.00E-04
P31	0.119	0.180	0.017	0.017	0.060	0.060	0.045	0.045	0.053	0.053	8.25E-03	8.25E-03
P32	0.066	0.031	0.001	0.001	0.033	0.033	0.008	0.008	0.008	0.008	2.50E-04	2.50E-04
P33	0.062	0.029	0.001	0.005	0.031	0.031	0.007	0.007	0.010	0.010	2.50E-04	2.50E-04
P34	0.119	0.180	0.017	0.017	0.060	0.060	0.045	0.045	0.053	0.053	8.25E-03	8.25E-03
P35	0.062	0.029	0.001	0.001	0.031	0.031	0.007	0.007	0.008	0.008	2.50E-04	2.50E-04
P36	0.119	0.180	0.017	0.017	0.060	0.060	0.045	0.045	0.053	0.053	8.25E-03	8.25E-03
P37	0.062	0.029	0.001	0.001	0.031	0.031	0.007	0.007	0.008	0.008	2.50E-04	2.50E-04

<sup>1</sup> Emissions are fine filterable plus inorganic condensables

**Table 2-4. PM Speciation of Particulate Matter Emitted from Lines and Stacks, Continued**

Source Index	PM <sub>10</sub> - PM <sub>2.5</sub> (g/s)	Solid PM <sub>2.5</sub> (g/s)	Org. Cond (g/s)	InOrg Cond (g/s)	Coarse PM		Fine PM				Organic Condensable	
					6-10 um (g/s)	2.5-6.0 um (g/s)	1.25-2.5 um (g/s)	1.00-1.25 um (g/s)	0.625-1.00 um <sup>1</sup> (g/s)	0.500-0.625 um <sup>1</sup> (g/s)	0.625-1.00 um (g/s)	0.500-0.625 um (g/s)
<b>P39</b>	0.007	0.003	0.000	0.000	0.004	0.004	0.001	0.001	0.001	0.001	0.00	0.00
<b>P41</b>	0.007	0.003	0.000	0.000	0.004	0.004	0.001	0.001	0.001	0.001	0.00	0.00
<b>WPP1</b>	-	8.6	1.949	2.852	0.000	0.000	2.150	2.150	3.576	3.576	0.975	0.975
	-	<b>22.01</b>	<b>7.629</b>	<b>11.236</b>	0.000	0.000	<b>5.503</b>	<b>5.503</b>	<b>11.121</b>	<b>11.121</b>	<b>3.814</b>	<b>3.814</b>
<b>WPP2</b>		<del>21.96</del>	<del>5.73</del>	<del>8.384</del>			<del>5.490</del>	<del>5.490</del>	<del>9.682</del>	<del>5.490</del>	<del>2.865</del>	<del>2.865</del>
	-	<b>49.525</b>			0.000	0.000	12.381	12.381	<b>18.329</b>	<b>18.329</b>	4.065	4.065
<b>WPP3</b>		<del>49.523</del>	8.13	11.895					<del>18.328</del>	<del>18.328</del>		

<sup>1</sup> Emissions are fine filterable plus inorganic condensables

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# **BART Assessment of the Alcoa Warrick Operations and Warrick Power Plant, Warrick County, Indiana**

## ***Prepared For:***

Alcoa Warrick Operations  
Warrick County, Indiana

## ***Submitted By:***

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## 1.0 INTRODUCTION

---

TRC Environmental Corporation conducted a Best Available Retrofit Technology (BART) analysis for the Alcoa Warrick aluminum plant and Warrick Power Plant. This facility is situated in Warrick County, Indiana on the northern shores of the Ohio River along the Indiana/Kentucky border. It is approximately 23 km southeast of Evansville. The Alcoa Warrick Operations facility is a primary aluminum smelter.

On July 6, 2005 the US Environment Protection Agency produced the Federal Register document, 40 CFR Part 51 in order to introduce new National Regional Haze Regulations for Best Available Retrofit Technology. The regional haze rule requires States to submit implementation plans (SIPs) to address regional haze visibility impairment in 156 Federally-protected parks and wilderness areas, commonly referred to as “Class 1 Areas”. The final rule included a requirement for BART for certain large stationary sources that were put in place between 1962 and 1977. The regional haze rule uses the term “BART-eligible source” to describe those sources which have the potential to emit 250 tons or more of a visibility-impairing air pollutant, were put in place between August 7, 1962 and August 7, 1977 and whose operations fall within one or more of 26 specifically listed source categories, which includes primary aluminum ore reduction plants.

BART review is required when the source ‘emits any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility in any Class 1 area. In identifying a level of control of BART, States are required by section 169A(g) of the CAA to consider; (a) the costs of compliance, (b) the energy and non-air quality environmental impacts of compliance, (c) any existing pollution control technology in use at the source, (d) the remaining useful life of the source and (e) the degree of visibility improvement which may reasonably be anticipated from the use of BART.

The purpose of the modeling was to assess the ambient air quality impacts of sulfur dioxide (SO<sub>2</sub>), particulate matter (PM) and nitrogen oxides (NO<sub>x</sub>) emissions at Mammoth Cave National Park which is located in a south east direction approximately 120 km away. The impacts of the facility on visibility was evaluated.

The topography of the domain area consists of gentle rolling terrain where elevation of the land ranges from ~120m in the Ohio River Valley in the north and west of the model domain to ~240m in the east. There is the potential for some terrain effects, both on the meteorological fields and in terms of plume-terrain interaction effects. The CALMET and CALPUFF non-steady-state models (Scire et al., 2000a,b) were used for the modeling analysis. The U.S. Environmental Protection Agency (EPA) has recommended CALPUFF as the preferred model for BART analyses (U.S. EPA, 2005). The CALPUFF modeling system is the regulatory *Guideline*

*Model* for Class I impact assessments and other long range transport applications and on a case-by-case basis for near-field applications involving complex flows (U.S. EPA, 2003a). CALPUFF is also recommended by both the Federal Land Managers Air Quality Workgroup (FLAG, 2000) and the Interagency Workgroup on Air Quality Modeling (U.S. EPA, 1998). CALPUFF is also recommended in the new draft proposed updated to FLAG (FLAG, 2008).

CALMET is a diagnostic meteorological model that produces three-dimensional wind fields based on parameterized treatments of terrain effects such as slope flows, terrain blocking effects, and kinematic effects. Meteorological observations were used to determine the wind field in areas where the observations were representative. Hourly meteorological data produced by the Mesoscale Model, Version 5 (MM5) on a 12 km grid were used by CALMET for 2001 and 2002 to help define the initial estimate of the wind fields. For 2003, RUC data, (Rapid Update Cycle) has been transformed into 3D.DAT format for its inclusion into CALMET. RUC is a high frequency weather forecast and data assimilation system which is supported and developed by NCEP. The RUC model provides high frequency mesoscale analyses and short range numerical forecasts. In this analysis the 50 original vertical levels were extracted and transformed into an MM5 data input file. The horizontal resolution of the data is 20 km. Fine scale terrain effects (1 km resolution) were determined by the diagnostic wind module in CALMET. It had been expected that spatial variability would occur in the wind fields over short distances due to the terrain channeling.

CALPUFF is a non-steady-state puff dispersion model. It accounts for spatial changes in the CALMET-produced meteorological fields, variability in surface conditions (elevation, surface roughness, vegetation type, etc.), chemical transformation, wet removal due to rain and snow, dry deposition, and terrain influences on plume interaction with the surface. CALPUFF contains a module to compute visibility effects, based on a humidity-dependent relationship between particulate matter concentrations and light extinction, as well as wet and dry acid deposition fluxes. The refined meteorological and dispersion modeling simulations were conducted for a three-year period (2001, 2002 and 2003). Visibility impacts from SO<sub>2</sub>, PM, and NO<sub>x</sub>, and their secondary products resulting from emissions from the Alcoa sources were predicted by the model at receptors in the Class I area.

The Lake Michigan Air Directors Consortium (LADCO) 2006 Document was used as a starting point for establishing the modeling procedures for the Warrick BART analysis. A few exceptions to the procedures from (LADCO, 2006) were made such as the use of the EPA-approved version of the model (Version 5.8), a more refined modeling domain with 1 km grid instead of 36 km grid spacing, modeling of 2001-2003 using the different meteorological data set from what is specified in (LADCO, 2006) in order to allow the use of higher resolution meteorological data.

In Section 2, a general description of the study area and the source configuration is provided. The results of a screening analysis that allowed the identification of the primary Class I area controlling the BART analysis are presented in Section 3. Descriptions of the site characteristics and the data bases (meteorological, geophysical, and aerometric) used in the analysis are provided in Section 4. Section 5 includes an overview of the CALMET and CALPUFF models, and the importance of evaluating non-steady-state effects. Results of the refined modeling BART analysis are provided in Section 6.

## 2.0 SOURCE DESCRIPTION

---

The Alcoa Warrick Operations facility is a primary aluminum smelter located in Warrick County, Indiana on the northern shore of the Ohio River along the Indiana/Kentucky border. It is approximately 23 km southeast of Evansville, IN.

The potential BART-eligible facilities consists of five potlines (10 potrooms), and 16 melting and/or holding furnaces. Figure 2-1 shows an aerial photo of the facility with the potrooms and other major buildings outlined. In the existing facility configuration, there are 16 furnace stacks, and 108 stacks associated with the A-398 reactors for Lines 2, 5, and 6. Each A-398 has 36 stacks. The common pollution control system for Potlines 3 and 4 emissions exit through a 199 ft stack.

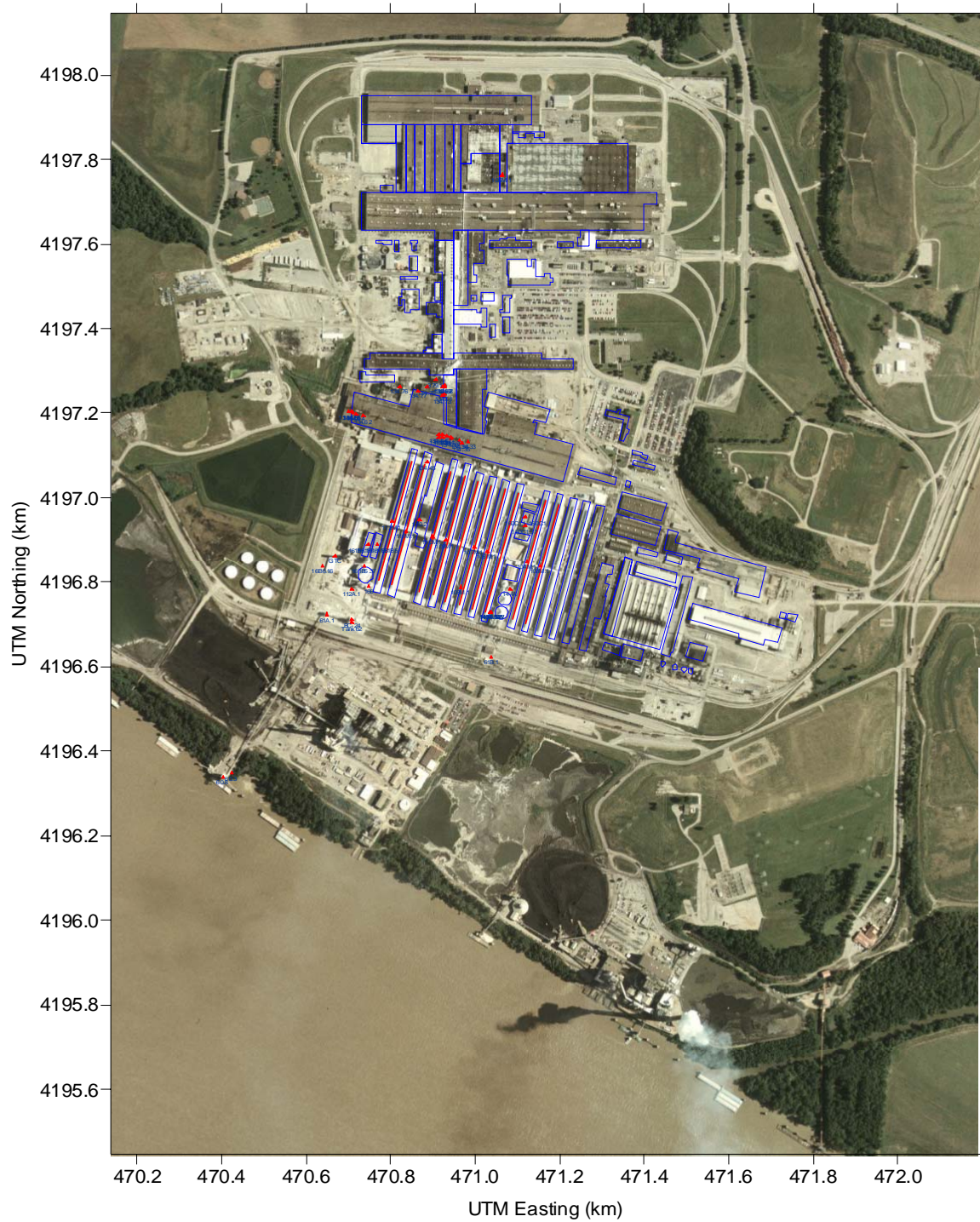
Three stacks for the Warrick Power Plant were modeled using the parameters listed in Table 2-2.

For modeling purposes, banks of closely-spaced stacks of identical stack characteristics were treated as a single effective stack. The effective stack uses the same exit velocity and exit temperature as the individual stacks, but the effective diameter was computed so that the volumetric flow of the effective stack is equal to the sum of the flows of the individual stacks in the bank. Therefore each bank of stacks is replaced by a single point source.

Table 2-1 lists the line source parameters while Table 2-2 shows the source parameters for the point sources. Tables 2-3 through 2-7 summarizes the line and point source emissions for the following six cases, respectively: (1) 'BART Eligible Baseline', (2) 'BART Eligible Baseline + Unit 1', (3) 'Alternative to BART', (4) 'BART with Potlines Scrubbed', and (5) 'BART Control Level' case.

Table 2-8 summarizes the particulate speciation for the 'BART Eligible Baseline' case. In the following four tables (Tables 2-9 through 2-12), for each of the four additional scenarios, speciation for only those stacks for which PM emission rates are different from the 'BART Eligible Baseline' case is presented.

## ALCOA Warrick: Plant Layout



(UTM Zone = 16, Hemisphere = N, Datum = NAD83: GRS80/NAR-C)

Figure 2-1. An aerial photo of the facility with the potrooms and other major buildings outlined.

**Table 2-1. Line Source Parameters used in CALPUFF**

Source ID	Emission Unit ID #	Stack Name	Release Height (m)	Monitor Width (m)	Exit Velocity (m/s)	Delta Temp (°K)	Begin UTM E/N (km)	Ending UTM E/N (km)
<b>L01</b>	103M.1	Potline #2, Room 103	14.02	1.52	2.93	24.95	471.119, 4196.702	471.198, 4196.984
<b>L02</b>	104M.1	Potline #2, Room 104	14.02	1.52	2.93	24.95	471.087, 4196.711	471.166, 4196.993
<b>L03</b>	105M.1	Potline #3, Room 105	14.02	1.52	2.93	24.95	471.024, 4196.728	471.103, 4197.010
<b>L04</b>	106M.1	Potline #3, Room 106	14.02	1.52	2.93	24.95	470.992, 4196.737	471.070, 4197.019
<b>L05</b>	107M.1	Potline #4, Room 107	14.02	1.52	2.93	24.95	470.961, 4196.745	471.038, 4197.027
<b>L06</b>	108M.1	Potline #4, Room 108	14.02	1.52	2.93	24.95	470.929, 4196.754	471.007, 4197.036
<b>L07</b>	109M.1	Potline #5, Room 109	14.02	1.52	2.31	23.18	470.900, 4196.770	471.976, 4197.052
<b>L08</b>	110M.1	Potline #5, Room 110	14.02	1.52	2.31	23.18	470.868, 4196.778	471.943, 4197.061
<b>L09</b>	111M.1	Potline #6, Room 111	14.02	1.52	2.31	23.18	470.803, 4196.796	471.881, 4197.078
<b>L10</b>	112M.1	Potline #6, Room 112	14.02	1.52	2.31	23.18	470.771, 4196.804	471.848, 4197.086

**Notes:**

**L01-L02, L03-L04, L05-L06:**

F' = 1002.186; Ave. line source width = 1.52m; Ave. building dimension = 292.6m; H = 13.61m, W = 16.0m; Ave. building separation = 20.57m

**L07-L08, L09-L10:**

F' = 736.541; Ave. line source width = 1.52m; Ave. building dimension = 292.24m; H = 13.15m, W = 17.0m; Ave. building separation = 26.67m

The release height (m), monitor width (m), exit velocity (m/s) and exit temperature (°K) were all taken from the 2002 Alcoa Warrick CO study

All the coordinates were digitized to match aerial photos in NAD83 datum

**L01-L06: Average Line Source Buoyancy Parameter (F') Calculation**

$F' = [gLW_m w(T_s - T_a)]/T_s = 1002.186 \text{ m}^4/\text{s}^3$  where

g = acceleration of gravity = 9.81 m/s<sup>2</sup>

L = line source length = 292.6 m

Wm = line source width = 1.52 m

w = line source exit velocity = 2.93 m/s

Ts = line source exit temperature = 318.3 K

Ta = ambient air temperature = 293.3 K

Ts - Ta = ΔT = 24.95 K

**L07-L10: Average Line Source Buoyancy Parameter (F') Calculation**

$F' = [gLW_m w(T_s - T_a)]/T_s = 736.541 \text{ m}^4/\text{s}^3$ , where,

g = acceleration of gravity = 9.81 m/s<sup>2</sup>

L = line source length = 292.24

Wm = line source width = 1.52 m

w = line source exit velocity = 2.31 m/s

Ts = line source exit temperature = 316.8 K

Ta = ambient air temperature = 293.6 K

Ts - Ta = ΔT = 23.18 K

**Table 2-2. Point Source Parameters used in CALPUFF**

<b>Index</b>	<b>Emission Unit ID #</b>	<b>Stack Name</b>	<b>Stack Height (m)</b>	<b>Stack Diameter (m)</b>	<b>Exit Velocity (m/s)</b>	<b>Exit Temp (°K)</b>	<b>UTM Easting (km)</b>	<b>UTM Northing (km)</b>
<b>P01</b>	GTC	Potlines #3 & #4 GTC Pollution Controls	60.66	6.10	16.46	350	470.668	4196.863
<b>P02</b>	160C1.1-160C1.36	Potline #2 A-398	14.94	3.70	21.12	366	471.118	4196.953
<b>P02a</b>	C1.GTC	Potline #2 GTC	60.66	3.05	31.46	366	471.118	4196.473
<b>P03</b>	161B5.1-161B5.36	Potline #5 A-398	14.94	3.72	21.12	366	470.768	4196.888
<b>P04</b>	161B6.1-161B6.36	Potline #6 A-398	14.94	3.69	21.12	366	470.746	4196.888
<b>W01</b>		Lines 3-6 ,Common Scrubber	60.66	7.92	16.46	314	470.668	4196.625
<b>W02</b>		Line 2 SO2 Scrubber	60.66	3.05	26.82	317	471.118	4196.473
<b>P23</b>	134.62	Melter 1M1	38.40	1.59	2.16	472	470.735	4197.193
<b>P24</b>	134.64	Holder 1EH	38.40	1.22	2.00	445	470.718	4197.198
<b>P25</b>	134.65	Melter 1M2	38.40	1.59	2.16	472	470.710	4197.201
<b>P26</b>	134.66	Holder 1WH	38.40	1.22	2.00	445	470.708	4197.203
<b>P28</b>	134.33	Melter 5M1	38.40	1.22	3.80	583	470.983	4197.133
<b>P29</b>	134.35	Holder 5EH	38.40	1.37	2.34	466	470.968	4197.128
<b>P30</b>	134.36	Melter 5M2	38.40	1.22	3.80	583	470.963	4197.135
<b>P31</b>	134.38	Holder 5WH	38.40	1.37	2.34	466	470.941	4197.138
<b>P32</b>	134.39	Melter 5M3	38.40	1.22	3.80	583	470.943	4197.141
<b>P33</b>	134.4	Melter 6M1	38.40	1.22	3.80	583	470.933	4197.145
<b>P34</b>	134.41	Holder 6EH	38.40	1.37	2.34	466	470.923	4197.141
<b>P35</b>	134.42	Melter 6M2	38.40	1.22	3.80	583	470.923	4197.148
<b>P36</b>	134.43	Holder 6WH	38.40	1.37	2.34	466	470.913	4197.143
<b>P37</b>	134.44	Melter 6M3	38.40	1.22	3.80	583	470.913	4197.148
<b>P39</b>	134.71	Offlines #2 East Melter	30.78	1.04	5.20	583	470.926	4197.245
<b>P41</b>	134.75	Offlines #2 West Melter	30.78	1.52	0.83	555	470.886	4197.261
<b>WPP123</b>	WPP units 1-3		115.82	12.33	5.79	329	470.727	4196.445
<b>WPP4</b>	WPP	Unit 4	115.82	6.10	15.80	329	470.720	4196.340
<b>WPP1</b>	WPP stack 1	WPP Stack 1, Unit 2 only	115.82	5.91	12.88	423	470.810	4196.399
<b>WPP2</b>	WPP stack 2	WPP Stack 2, Units 2 and 3	115.82	5.91	12.59	428	470.731	4196.443
<b>WPP3</b>	WPP stack 3	WPP Stack 3, Unit 4	115.82	4.45	34.91	425	470.668	4196.433



**Table 2-3. Point and Line Source Emissions, ‘BART Eligible Baseline’ Case**

Source ID	Emission Unit ID #	Stack Name	Filterable PM <sub>10</sub> -PM <sub>2.5</sub> (g/s)	Filterable PM <sub>2.5</sub> (g/s)	Organic Condensable PM <sub>2.5</sub> (g/s)	Inorganic Condensable PM <sub>2.5</sub> (g/s)	SO <sub>2</sub> (g/s)	NO <sub>x</sub> (g/s)
L01	103M.1	Potline #2, Room 103	0.535	0.753	0.373	0.356	0.266	0.003
L02	104M.1	Potline #2, Room 104	0.535	0.753	0.373	0.356	0.266	0.003
L03	105M.1	Potline #3, Room 105	0.569	0.802	0.397	0.379	0.269	0.003
L04	106M.1	Potline #3, Room 106	0.569	0.802	0.397	0.379	0.269	0.003
L05	107M.1	Potline #4, Room 107	0.567	0.799	0.395	0.377	0.269	0.003
L06	108M.1	Potline #4, Room 108	0.567	0.799	0.395	0.377	0.269	0.003
L07	109M.1	Potline #5, Room 109	0.470	0.663	0.328	0.313	0.259	0.003
L08	110M.1	Potline #5, Room 110	0.470	0.663	0.328	0.313	0.259	0.003
L09	111M.1	Potline #6, Room 111	0.532	0.749	0.371	0.354	0.264	0.003
L10	112M.1	Potline #6, Room 112	0.532	0.749	0.371	0.354	0.264	0.003
P01	GTC	Potlines #3 & #4 GTC Pollution Controls	0.986	0.116	1.757	4.409	46.817	0.581
P02	160C1.1-160C1.36	Potline #2 A-398	0.393	0.046	0.700	1.758	23.312	0.289
P03	161B5.1-161B5.36	Potline #5 A-398	0.555	0.065	0.989	2.482	22.008	0.291
P04	161B6.1-161B6.36	Potline #6 A-398	0.563	0.066	1.002	2.514	21.836	0.301
P23	134.62	Melter 1M1	0.056	0.027	0.001	0.001	9.00E-04	0.161
P24	134.64	Holder 1EH	0.017	0.026	0.002	0.002	1.40E-03	0.149
P25	134.65	Melter 1M2	0.065	0.030	0.001	0.001	2.00E-03	0.402
P26	134.66	Holder 1WH	0.011	0.016	0.002	0.002	3.00E-03	0.149
P28	134.33	Melter 5M1	0.061	0.028	0.001	0.001	4.00E-04	0.253
P29	134.35	Holder 5EH	0.110	0.167	0.015	0.015	1.26E-03	0.318
P30	134.36	Melter 5M2	0.095	0.044	0.001	0.001	4.00E-04	1.317
P31	134.38	Holder 5WH	0.119	0.180	0.017	0.017	1.26E-03	0.318
P32	134.39	Melter 5M3	0.066	0.031	0.001	0.001	4.00E-04	0.297
P33	134.4	Melter 6M1	0.062	0.029	0.001	0.005	2.00E-04	0.038
P34	134.41	Holder 6EH	0.119	0.180	0.017	0.017	1.00E-04	0.016
P35	134.42	Melter 6M2	0.062	0.029	0.001	0.001	2.00E-04	0.038
P36	134.43	Holder 6WH	0.119	0.180	0.017	0.017	1.00E-04	0.016
P37	134.44	Melter 6M3	0.062	0.029	0.001	0.001	2.00E-04	0.038
P39	134.71	Offlines #2 East Melter	0.007	0.003	0.000	0.000	6.00E-03	1.140
P41	134.75	Offlines #2 West Melter	0.007	0.003	0.000	0.000	2.50E-03	0.660
WPP1	WPP stack 1	WPP Stack 1, Unit 2 only	*	8.6	1.949	2.852	372.9	71.01
WPP2	WPP stack 2	WPP Stack 2, Units 2 and 3	*	21.96	5.73	8.384	1245.7	203.98
WPP3	WPP stack 3	WPP Stack 3, Unit 4	*	49.523	8.13	11.895	1755.7	250.96

**Table 2-4. Point and Line Source Emissions, ‘BART Eligible Baseline + Unit 1’ Case.**

Source ID	Emission Unit ID #	Stack Name	Filterable PM <sub>10</sub> -PM <sub>2.5</sub> (g/s)	Filterable PM <sub>2.5</sub> (g/s)	Organic Condensable PM <sub>2.5</sub> (g/s)	Inorganic Condensable PM <sub>2.5</sub> (g/s)	SO <sub>2</sub> (g/s)	NO <sub>x</sub> (g/s)
L01	103M.1	Potline #2, Room 103	0.535	0.753	0.373	0.356	0.266	0.003
L02	104M.1	Potline #2, Room 104	0.535	0.753	0.373	0.356	0.266	0.003
L03	105M.1	Potline #3, Room 105	0.569	0.802	0.397	0.379	0.269	0.003
L04	106M.1	Potline #3, Room 106	0.569	0.802	0.397	0.379	0.269	0.003
L05	107M.1	Potline #4, Room 107	0.567	0.799	0.395	0.377	0.269	0.003
L06	108M.1	Potline #4, Room 108	0.567	0.799	0.395	0.377	0.269	0.003
L07	109M.1	Potline #5, Room 109	0.470	0.663	0.328	0.313	0.259	0.003
L08	110M.1	Potline #5, Room 110	0.470	0.663	0.328	0.313	0.259	0.003
L09	111M.1	Potline #6, Room 111	0.532	0.749	0.371	0.354	0.264	0.003
L10	112M.1	Potline #6, Room 112	0.532	0.749	0.371	0.354	0.264	0.003
P01	GTC	Potlines #3 & #4 GTC Pollution Controls	0.986	0.116	1.757	4.409	46.817	0.581
P02	160C1.1-160C1.36	Potline #2 A-398	0.393	0.046	0.700	1.758	23.312	0.289
P03	161B5.1-161B5.36	Potline #5 A-398	0.555	0.065	0.989	2.482	22.008	0.291
P04	161B6.1-161B6.36	Potline #6 A-398	0.563	0.066	1.002	2.514	21.836	0.301
P23	134.62	Melter 1M1	0.056	0.027	0.001	0.001	9.00E-04	0.161
P24	134.64	Holder 1EH	0.017	0.026	0.002	0.002	1.40E-03	0.149
P25	134.65	Melter 1M2	0.065	0.030	0.001	0.001	2.00E-03	0.402
P26	134.66	Holder 1WH	0.011	0.016	0.002	0.002	3.00E-03	0.149
P28	134.33	Melter 5M1	0.061	0.028	0.001	0.001	4.00E-04	0.253
P29	134.35	Holder 5EH	0.110	0.167	0.015	0.015	1.26E-03	0.318
P30	134.36	Melter 5M2	0.095	0.044	0.001	0.001	4.00E-04	1.317
P31	134.38	Holder 5WH	0.119	0.180	0.017	0.017	1.26E-03	0.318
P32	134.39	Melter 5M3	0.066	0.031	0.001	0.001	4.00E-04	0.297
P33	134.4	Melter 6M1	0.062	0.029	0.001	0.005	2.00E-04	0.038
P34	134.41	Holder 6EH	0.119	0.180	0.017	0.017	1.00E-04	0.016
P35	134.42	Melter 6M2	0.062	0.029	0.001	0.001	2.00E-04	0.038
P36	134.43	Holder 6WH	0.119	0.180	0.017	0.017	1.00E-04	0.016
P37	134.44	Melter 6M3	0.062	0.029	0.001	0.001	2.00E-04	0.038
P39	134.71	Offlines #2 East Melter	0.007	0.003	0.000	0.000	6.00E-03	1.140
P41	134.75	Offlines #2 West Melter	0.007	0.003	0.000	0.000	2.50E-03	0.660
WPP1a	WPP stack 1	WPP Stack 1, Unit 2 only	*	15.576	3.92	5.735	808.81	142.01
WPP2	WPP stack 2	WPP Stack 2, Units 2 and 3	*	21.96	5.73	8.384	1245.7	203.98
WPP3	WPP stack 3	WPP Stack 3, Unit 4	*	49.523	8.13	11.895	1755.7	250.96

**Table 2-5. Point and Line Source Emissions, ‘Alternative to BART’ Case.**

Source ID	Emission Unit ID #	Stack Name	Filterable PM <sub>10</sub> -PM <sub>2.5</sub> (g/s)	Filterable PM <sub>2.5</sub> (g/s)	Organic Condensable PM <sub>2.5</sub> (g/s)	Inorganic Condensable PM <sub>2.5</sub> (g/s)	SO <sub>2</sub> (g/s)	NO <sub>x</sub> (g/s)
L01	103M.1	Potline #2, Room 103	0.535	0.753	0.373	0.356	0.407	0.003
L02	104M.1	Potline #2, Room 104	0.535	0.753	0.373	0.356	0.407	0.003
L03	105M.1	Potline #3, Room 105	0.569	0.802	0.397	0.379	0.412	0.003
L04	106M.1	Potline #3, Room 106	0.569	0.802	0.397	0.379	0.412	0.003
L05	107M.1	Potline #4, Room 107	0.567	0.799	0.395	0.377	0.412	0.003
L06	108M.1	Potline #4, Room 108	0.567	0.799	0.395	0.377	0.412	0.003
L07	109M.1	Potline #5, Room 109	0.470	0.663	0.328	0.313	0.400	0.003
L08	110M.1	Potline #5, Room 110	0.470	0.663	0.328	0.313	0.400	0.003
L09	111M.1	Potline #6, Room 111	0.532	0.749	0.371	0.354	0.407	0.003
L10	112M.1	Potline #6, Room 112	0.532	0.749	0.371	0.354	0.407	0.003
P01	GTC	Potlines #3 & #4 GTC Pollution Controls	0.986	0.116	1.757	4.409	73.442	0.581
P02	C1.GTC	Potline #2 GTC	0.393	0.046	0.700	1.758	35.439	0.289
P03	161B5.1-	Potline #5 A-398	0.555	0.065	0.989	2.482	35.497	0.291
P04	161B6.1-	Potline #6 A-398	0.563	0.066	1.002	2.514	35.220	0.301
P23	134.62	Melter 1M1	0.056	0.027	0.001	0.001	9.00E-04	0.161
P24	134.64	Holder 1EH	0.017	0.026	0.002	0.002	1.40E-03	0.149
P25	134.65	Melter 1M2	0.065	0.030	0.001	0.001	2.00E-03	0.402
P26	134.66	Holder 1WH	0.011	0.016	0.002	0.002	3.00E-03	0.149
P28	134.33	Melter 5M1	0.061	0.028	0.001	0.001	4.00E-04	0.253
P29	134.35	Holder 5EH	0.110	0.167	0.015	0.015	1.26E-03	0.318
P30	134.36	Melter 5M2	0.095	0.044	0.001	0.001	4.00E-04	1.317
P31	134.38	Holder 5WH	0.119	0.180	0.017	0.017	1.26E-03	0.318
P32	134.39	Melter 5M3	0.066	0.031	0.001	0.001	4.00E-04	0.297
P33	134.4	Melter 6M1	0.062	0.029	0.005	0.001	2.00E-04	0.038
P34	134.41	Holder 6EH	0.119	0.180	0.017	0.017	1.00E-04	0.016
P35	134.42	Melter 6M2	0.062	0.029	0.001	0.001	2.00E-04	0.038
P36	134.43	Holder 6WH	0.119	0.180	0.017	0.017	1.00E-04	0.016
P37	134.44	Melter 6M3	0.062	0.029	0.001	0.001	2.00E-04	0.038
P39	134.71	Offlines #2 East Melter	0.007	0.003	0.000	0.000	6.00E-03	1.140
P41	134.75	Offlines #2 West Melter	0.007	0.003	0.000	0.000	2.50E-03	0.660
WPP123	WPP units 1-3		*	15.36	3.251	3.815	229.28	204.17
WPP4	WPP	Unit 4	*	18.303	13.806	1.268	122.9	55.956

**Table 2-6. Point and Line Source Emissions, 'BART with Potlines Scrubbed' Case.**

Source ID	Emission Unit ID #	Stack Name	Filterable PM <sub>10</sub> -PM <sub>2.5</sub> (g/s)	Filterable PM <sub>2.5</sub> (g/s)	Organic Condensable PM <sub>2.5</sub> (g/s)	Inorganic Condensable PM <sub>2.5</sub> (g/s)	SO <sub>2</sub> (g/s)	NO <sub>x</sub> (g/s)
L01	103M.1	Potline #2, Room 103	0.535	0.753	0.373	0.356	0.353	0.003
L02	104M.1	Potline #2, Room 104	0.535	0.753	0.373	0.356	0.353	0.003
L03	105M.1	Potline #3, Room 105	0.569	0.802	0.397	0.379	0.357	0.003
L04	106M.1	Potline #3, Room 106	0.569	0.802	0.397	0.379	0.357	0.003
L05	107M.1	Potline #4, Room 107	0.567	0.799	0.395	0.377	0.357	0.003
L06	108M.1	Potline #4, Room 108	0.567	0.799	0.395	0.377	0.357	0.003
L07	109M.1	Potline #5, Room 109	0.470	0.663	0.328	0.313	0.346	0.003
L08	110M.1	Potline #5, Room 110	0.470	0.663	0.328	0.313	0.346	0.003
L09	111M.1	Potline #6, Room 111	0.532	0.749	0.371	0.354	0.351	0.003
L10	112M.1	Potline #6, Room 112	0.532	0.749	0.371	0.354	0.351	0.003
W01		Lines 3-6, Common Scrubber		1.591	4.335	10.879	6.247	0.581
W02		Line 2 SO <sub>2</sub> Scrubber		0.374	0.700	1.758	1.542	0.289
P23	134.62	Melter 1M1	0.056	0.027	0.001	0.001	9.00E-04	0.291
P24	134.64	Holder 1EH	0.017	0.026	0.002	0.002	1.40E-03	0.301
P25	134.65	Melter 1M2	0.065	0.030	0.001	0.001	2.00E-03	0.402
P26	134.66	Holder 1WH	0.011	0.016	0.002	0.002	3.00E-03	0.149
P28	134.33	Melter 5M1	0.061	0.028	0.001	0.001	4.00E-04	0.253
P29	134.35	Holder 5EH	0.110	0.167	0.015	0.015	1.26E-03	0.318
P30	134.36	Melter 5M2	0.095	0.044	0.001	0.001	4.00E-04	1.317
P31	134.38	Holder 5WH	0.119	0.180	0.017	0.017	1.26E-03	0.318
P32	134.39	Melter 5M3	0.066	0.031	0.001	0.001	4.00E-04	0.297
P33	134.4	Melter 6M1	0.062	0.029	0.001	0.005	2.00E-04	0.038
P34	134.41	Holder 6EH	0.119	0.180	0.017	0.017	1.00E-04	0.016
P35	134.42	Melter 6M2	0.062	0.029	0.001	0.001	2.00E-04	0.038
P36	134.43	Holder 6WH	0.119	0.180	0.017	0.017	1.00E-04	0.016
P37	134.44	Melter 6M3	0.062	0.029	0.001	0.001	2.00E-04	0.038
P39	134.71	Offlines #2 East Melter	0.007	0.003	0.000	0.000	6.00E-03	1.140
P41	134.75	Offlines #2 West Melter	0.007	0.003	0.000	0.000	2.50E-03	0.660
WPP123	WPP unit 2&3	WPP unit 2&3	*	12.750	2.699	3.167	129.485	135.329
WPP4	WPP unit 4	WPP unit 4	*	2.745	1.268	13.806	87.784	55.956

**Table 2-7. Point and Line Source Emissions, 'BART Control Level' Case.**

Source ID	Emission Unit ID #	Stack Name	Filterable PM <sub>10</sub> -PM <sub>2.5</sub> (g/s)	Filterable PM <sub>2.5</sub> (g/s)	Organic Condensable PM <sub>2.5</sub> (g/s)	Inorganic Condensable PM <sub>2.5</sub> (g/s)	SO <sub>2</sub> (g/s)	NO <sub>x</sub> (g/s)
L01	103M.1	Potline #2, Room 103	0.535	0.753	0.373	0.356	0.353	0.003
L02	104M.1	Potline #2, Room 104	0.535	0.753	0.373	0.356	0.353	0.003
L03	105M.1	Potline #3, Room 105	0.569	0.802	0.397	0.379	0.357	0.003
L04	106M.1	Potline #3, Room 106	0.569	0.802	0.397	0.379	0.357	0.003
L05	107M.1	Potline #4, Room 107	0.567	0.799	0.395	0.377	0.357	0.003
L06	108M.1	Potline #4, Room 108	0.567	0.799	0.395	0.377	0.357	0.003
L07	109M.1	Potline #5, Room 109	0.470	0.663	0.328	0.313	0.346	0.003
L08	110M.1	Potline #5, Room 110	0.470	0.663	0.328	0.313	0.346	0.003
L09	111M.1	Potline #6, Room 111	0.532	0.749	0.371	0.354	0.351	0.003
L10	112M.1	Potline #6, Room 112	0.532	0.749	0.371	0.354	0.351	0.003
P01	GTC	Potlines #3 & #4 GTC Pollution Controls	0.986	0.116	1.757	4.409	63.881	0.581
P02	160C1.1-160C1.36	Potline #2 A-398	0.393	0.046	0.700	1.758	30.834	0.289
P03	161B5.1-161B5.36	Potline #5 A-398	0.555	0.065	0.989	2.482	30.653	0.291
P04	161B6.1-161B6.36	Potline #6 A-398	0.563	0.066	1.002	2.514	30.414	0.301
P23	134.62	Melter 1M1	0.056	0.027	0.001	0.001	9.00E-04	0.161
P24	134.64	Holder 1EH	0.017	0.026	0.002	0.002	1.40E-03	0.149
P25	134.65	Melter 1M2	0.065	0.030	0.001	0.001	2.00E-03	0.402
P26	134.66	Holder 1WH	0.011	0.016	0.002	0.002	3.00E-03	0.149
P28	134.33	Melter 5M1	0.061	0.028	0.001	0.001	4.00E-04	0.253
P29	134.35	Holder 5EH	0.110	0.167	0.015	0.015	1.26E-03	0.318
P30	134.36	Melter 5M2	0.095	0.044	0.001	0.001	4.00E-04	1.317
P31	134.38	Holder 5WH	0.119	0.180	0.017	0.017	1.26E-03	0.318
P32	134.39	Melter 5M3	0.066	0.031	0.001	0.001	4.00E-04	0.297
P33	134.4	Melter 6M1	0.062	0.029	0.001	0.005	2.00E-04	0.038
P34	134.41	Holder 6EH	0.119	0.180	0.017	0.017	1.00E-04	0.016
P35	134.42	Melter 6M2	0.062	0.029	0.001	0.001	2.00E-04	0.038
P36	134.43	Holder 6WH	0.119	0.180	0.017	0.017	1.00E-04	0.016
P37	134.44	Melter 6M3	0.062	0.029	0.001	0.001	2.00E-04	0.038
P39	134.71	Offlines #2 East Melter	0.007	0.003	0.000	0.000	6.00E-03	1.140
P41	134.75	Offlines #2 West Melter	0.007	0.003	0.000	0.000	2.50E-03	0.660
WPP123	WPP units 2&3	WPP units 2&3	*	12.75	2.699	3.167	129.49	135.33
WPP4	WPP unit 4	WPP unit 4	*	2.745	1.268	13.806	87.784	55.956

**Table 2-8. PM Speciation of Particulate Matter Emitted from Lines and Stacks, ‘BART Eligible Baseline’ Case**

Source Index	PM10-PM2.5 (g/s)	Solid PM2.5 (g/s)	Org. Cond (g/s)	InOrg. Cond (g/s)	Coarse PM		Fine PM				Organic Condensable	
					6-10µm (g/s)	2.5-6.00µm (g/s)	1.25-2.5µm (g/s)	1.00-1.25µm (g/s)	0.625-1.00µm <sup>1</sup> (g/s)	0.500-0.625µm <sup>1</sup> (g/s)	0.625-1.00µm (g/s)	0.500-0.625µm (g/s)
L01	0.535	0.753	0.373	0.356	0.268	0.268	0.188	0.188	0.366	0.366	0.187	0.187
L02	0.535	0.753	0.373	0.356	0.268	0.268	0.188	0.188	0.366	0.366	0.187	0.187
L03	0.569	0.802	0.397	0.379	0.285	0.285	0.201	0.201	0.390	0.390	0.199	0.199
L04	0.569	0.802	0.397	0.379	0.285	0.285	0.201	0.201	0.390	0.390	0.199	0.199
L05	0.567	0.799	0.395	0.377	0.284	0.284	0.200	0.200	0.388	0.388	0.198	0.198
L06	0.567	0.799	0.395	0.377	0.284	0.284	0.200	0.200	0.388	0.388	0.198	0.198
L07	0.470	0.663	0.328	0.313	0.235	0.235	0.166	0.166	0.322	0.322	0.164	0.164
L08	0.470	0.663	0.328	0.313	0.235	0.235	0.166	0.166	0.322	0.322	0.164	0.164
L09	0.532	0.749	0.371	0.354	0.266	0.266	0.187	0.187	0.364	0.364	0.186	0.186
L10	0.532	0.749	0.371	0.354	0.266	0.266	0.187	0.187	0.364	0.364	0.186	0.186
P01	0.986	0.116	1.757	4.409	0.493	0.493	0.029	0.029	2.234	2.234	0.879	0.879
P02	0.393	0.046	0.700	1.758	0.197	0.197	0.012	0.012	0.891	0.891	0.350	0.350
P03	0.555	0.065	0.989	2.482	0.278	0.278	0.016	0.016	1.257	1.257	0.495	0.495
P04	0.563	0.066	1.002	2.514	0.282	0.282	0.017	0.017	1.274	1.274	0.501	0.501
P23	0.056	0.027	0.001	0.001	0.028	0.028	0.007	0.007	0.007	0.007	2.50E-04	2.50E-04
P24	0.017	0.026	0.002	0.002	0.009	0.009	0.007	0.007	0.007	0.007	7.50E-04	7.50E-04
P25	0.065	0.030	0.001	0.001	0.033	0.033	0.008	0.008	0.008	0.008	2.50E-04	2.50E-04
P26	0.011	0.016	0.002	0.002	0.006	0.006	0.004	0.004	0.005	0.005	7.50E-04	7.50E-04
P28	0.061	0.028	0.001	0.001	0.031	0.031	0.007	0.007	0.007	0.007	2.50E-04	2.50E-04
P29	0.110	0.167	0.015	0.015	0.055	0.055	0.042	0.042	0.049	0.049	7.50E-03	7.50E-03
P30	0.095	0.044	0.001	0.001	0.048	0.048	0.011	0.011	0.012	0.012	5.00E-04	5.00E-04
P31	0.119	0.180	0.017	0.017	0.060	0.060	0.045	0.045	0.053	0.053	8.25E-03	8.25E-03
P32	0.066	0.031	0.001	0.001	0.033	0.033	0.008	0.008	0.008	0.008	2.50E-04	2.50E-04
P33	0.062	0.029	0.001	0.005	0.031	0.031	0.007	0.007	0.010	0.010	2.50E-04	2.50E-04
P34	0.119	0.180	0.017	0.017	0.060	0.060	0.045	0.045	0.053	0.053	8.25E-03	8.25E-03
P35	0.062	0.029	0.001	0.001	0.031	0.031	0.007	0.007	0.008	0.008	2.50E-04	2.50E-04
P36	0.119	0.180	0.017	0.017	0.060	0.060	0.045	0.045	0.053	0.053	8.25E-03	8.25E-03
P37	0.062	0.029	0.001	0.001	0.031	0.031	0.007	0.007	0.008	0.008	2.50E-04	2.50E-04
P39	0.007	0.003	0.000	0.000	0.004	0.004	0.001	0.001	0.001	0.001	0.00E+00	0.00E+00
P41	0.007	0.003	0.000	0.000	0.004	0.004	0.001	0.001	0.001	0.001	0.00E+00	0.00E+00
wpp1	-	8.6	1.949	2.852	0.000	0.000	2.150	2.150	3.576	3.576	0.975	0.975
wpp2	-	21.96	5.73	8.384	0.000	0.000	5.490	5.490	9.682	9.682	2.865	2.865
wpp3	-	49.523	8.13	11.895	0.000	0.000	12.381	12.381	18.328	18.328	4.065	4.065

<sup>1</sup> Emissions are fine filterable plus inorganic condensables.

**Table 2-9. Speciation of Particulate Matter Emitted from Lines and Stacks, ‘BART Eligible Baseline + Unit 1’ Case.**

Source Index	PM10-PM2.5 (g/s)	Solid PM2.5 (g/s)	Org. Cond (g/s)	InOrg. Cond (g/s)	Coarse PM			Fine PM			Organic Condensable	
					6-10µm (g/s)	2.5-6.00µm (g/s)	1.25-2.5µm (g/s)	1.00-1.25µm (g/s)	0.625-1.00µm <sup>1</sup> (g/s)	0.500-0.625µm <sup>1</sup> (g/s)	0.625-1.00µm (g/s)	0.500-0.625µm (g/s)
wpp1		24.176	5.869	8.587	0.000	0.000	6.044	6.044	10.338	10.338	2.935	2.935

**Table 2-10. Speciation of Particulate Matter Emitted from Lines and Stacks, ‘Alternative to BART’ Case.**

Source Index	PM10-PM2.5 (g/s)	Solid PM2.5 (g/s)	Org. Cond (g/s)	InOrg. Cond (g/s)	Coarse PM			Fine PM			Organic Condensable	
					6-10µm (g/s)	2.5-6.00µm (g/s)	1.25-2.5µm (g/s)	1.00-1.25µm (g/s)	0.625-1.00µm <sup>1</sup> (g/s)	0.500-0.625µm <sup>1</sup> (g/s)	0.625-1.00µm (g/s)	0.500-0.625µm (g/s)
wpp123		15.36	3.251	3.815	0.000	0.000	3.840	3.840	5.748	5.748	1.626	1.626
wpp4		18.303	13.806	1.268	0.000	0.000	4.576	4.576	5.210	5.210	6.903	6.903

**Table 2-11. Speciation of Particulate Matter Emitted from Lines and Stacks, ‘BART with Potlines Scrubbed’ Case.**

Source Index	PM10-PM2.5 (g/s)	Solid PM2.5 (g/s)	Org. Cond (g/s)	InOrg. Cond (g/s)	Coarse PM			Fine PM			Organic Condensable	
					6-10µm (g/s)	2.5-6.00µm (g/s)	1.25-2.5µm (g/s)	1.00-1.25µm (g/s)	0.625-1.00µm <sup>1</sup> (g/s)	0.500-0.625µm <sup>1</sup> (g/s)	0.625-1.00µm (g/s)	0.500-0.625µm (g/s)
W01		1.591	4.335	10.879	0.000	0.000	0.398	0.398	5.837	5.837	2.168	2.168
W02		0.374	0.700	1.758	0.000	0.000	0.094	0.094	0.973	0.973	0.350	0.350
wpp23		12.750	2.699	3.167	0.000	0.000	3.188	3.188	4.771	4.771	1.350	1.350
wpp4		2.745	1.268	13.806	0.000	0.000	0.686	0.686	7.589	7.589	0.634	0.634

**Table 2-12. Speciation of Particulate Matter Emitted from Lines and Stacks, ‘BART Control Level’ Case.**

Source Index	PM10-PM2.5 (g/s)	Solid PM2.5 (g/s)	Org. Cond (g/s)	InOrg. Cond (g/s)	Coarse PM			Fine PM			Organic Condensable	
					6-10µm (g/s)	2.5-6.00µm (g/s)	1.25-2.5µm (g/s)	1.00-1.25µm (g/s)	0.625-1.00µm <sup>1</sup> (g/s)	0.500-0.625µm <sup>1</sup> (g/s)	0.625-1.00µm (g/s)	0.500-0.625µm (g/s)
wpp23		12.75	2.699	3.167	0.000	0.000	3.188	3.188	4.771	4.771	1.350	1.350
wpp4		2.745	1.268	13.806	0.000	0.000	0.686	0.686	7.589	7.589	0.634	0.634

### 3.0 SCREENING MODELING

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As a first step into the BART analysis for Alcoa Warrick and Warrick Power Plant, screening simulations were made to analyze the influence of the facilities at Class I Areas located up to 500 km from the site (Table 3-1). For the screening simulations and BART analysis, VISTAS 12-km regional CALMET domain was used (VISTAS, 2005) with CALPUFF computational subdomain to cover the facility, all seven Class I areas and sufficient buffer zone of 100 km around the facility and Class I areas (Figure 3-1). This is a sufficient buffer zone at the boundaries which allows for the effects of flow curvature and possible small-scale recirculation to be evaluated.

Method 6 visibility was used with monthly average relative humidity factors as listed in Table 3-2 and estimated natural concentrations for East United States as listed in Table 3-3.

As indicated in the LADCO (2006) protocol, emission controls for the Warrick facility are normally based on impacts at the Class I area with the highest predicted visibility impairment. The results of the screening simulations showed that this will always be Mammoth Cave, which is by a large margin the closest Class I area to the facility (Table 2-4). Mammoth Cave is approximately 120 km from the facility while the next nearest Class I area (Mingo) is more than twice as far away. The other Class I areas on the list are all close to or beyond 400 km away from the facility.

Results in Table 3-4 are presented for each of the modeled year separately (2001 to 2003) and for all 3 years together. The 98<sup>th</sup> percentile value for a single year is the 8<sup>th</sup> highest values, while for three-year period is the 22<sup>nd</sup> highest.

Since Mammoth Cave is the Class I area with the highest impacts, the modeling presented in this report is conducted with the domain that is appropriate for refined modeling of the visibility impacts from the Warrick sources on Mammoth Cave. The description of this domain, its characteristics and methodology used in the refined modeling is described in the next section.

An additional modeling domain will be constructed for the supplemental refined modeling of the visibility impacts in the Mingo Class I area. Although Mingo is nearly 270 km away from the source, while Mammoth cave is only 120 km away, visibility impacts at Mingo will be evaluated at the request of IDEM. These results will be reported separately within 60 days, as agreed to by IDEM.



**Table 3-1. Class I Areas within 500 km of Alcoa Warrick**

Class I Area	Distance from Warrick (km)
Mammoth Cave	120
Mingo	268
Sipsey	391
Great Smoky Mountains	394
Joyce Kilmer	401
Cohutta	404
Shining Rock	481

**Table 3-2. Monthly f(RH) Values Based on Area Centroids for Application with Visibility Method 6**

Class I area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mammoth Cave	3.4	3.1	2.9	2.6	3.2	3.5	3.7	3.9	3.9	3.4	3.2	3.5
Mingo	3.3	3.0	2.8	2.6	3.0	3.2	3.3	3.5	3.5	3.1	3.1	3.3
Sipsey	3.4	3.1	2.9	2.8	3.3	3.7	3.9	3.9	3.9	3.6	3.3	3.4
Great Smoky	3.3	3.0	2.9	2.7	3.2	3.9	3.8	4.0	4.2	3.8	3.3	3.4
Joyce Kilmer	3.3	3.1	2.9	2.7	3.3	3.8	4.0	4.2	4.2	3.8	3.3	3.5
Cohutta	3.3	3.1	3.0	2.8	3.4	3.8	4.0	4.2	4.2	3.8	3.4	3.5
Shining Rock	3.3	3.0	2.9	2.7	3.4	3.9	4.1	4.5	4.4	3.8	3.3	3.4

Source: *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule (U.S EPA, 2003), Appendix A*

**Table 3-3. Average Natural Levels of Aerosol Components**

	East ( $\mu\text{g}/\text{m}^3$ )
Ammonium sulfate	0.23
Ammonium nitrate	0.1
Organic carbon	1.4
Elemental carbon	0.02
Soil	0.5
Coarse Mass	3

Source: *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule (U.S EPA, 2003), Table 2-1*

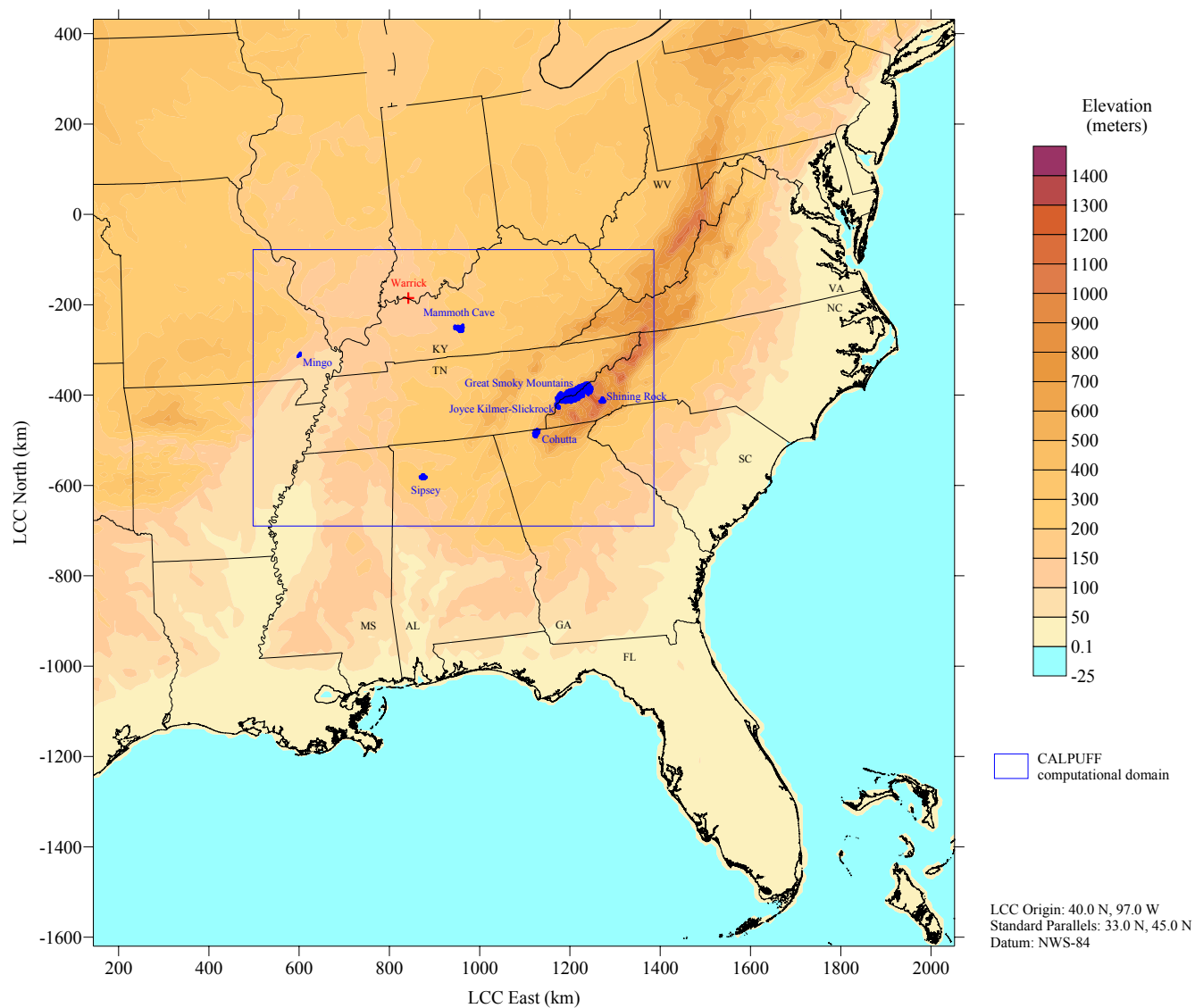


Figure 3-1. Terrain elevations for the VISTAS CALMET 12-km regional domain. CALPUFF computational subdomain, the Class I areas and the locations of Warrick facilities are also shown.

**Table 3-4. Results of the Screening Simulations**

<b>Class I Area (distance from Warrick (km))</b>	<b>Year</b>	<b>Maximum Delta Bext (%) (#days&gt;5%, #days&gt;10%)</b>	<b>98th Percentile Delta Bext (%)</b>	<b>Maximum Delta Deciview (dv) (#days&gt;0.5dv, #days&gt;1dv)</b>	<b>98th Percentile Delta Deciview (dv)</b>
Mammoth Cave (120)	2001	94.68 (105,74)	60.12	6.662 (105,73)	<b>4.708</b>
Mingo (268)	2001	71.84 (44,33)	39.44	5.414 (44,32)	<b>3.325</b>
Sipsey (391)	2001	67.69 (53,25)	25.52	5.169 (52,24)	<b>2.273</b>
Great Smoky (394)	2001	51.04 (40,20)	15.00	4.124 (37,18)	<b>1.397</b>
Joyce Kilmer (401)	2001	43.27 (35,12)	11.66	3.596 (32,11)	<b>1.103</b>
Cohutta (404)	2001	25.44 (37,11)	12.92	2.267 (35,10)	<b>1.255</b>
Shining Rock (481)	2001	32.84 (21,10)	12.70	2.839 (20,10)	<b>1.195</b>
Mammoth Cave (120)	2002	133.75 (89,62)	68.73	8.491 (87,59)	<b>5.232</b>
Mingo (268)	2002	92.30 (67,47)	53.87	6.463 (66,47)	<b>4.286</b>
Sipsey (391)	2002	67.10 (56,33)	31.72	5.134 (55,32)	<b>2.755</b>
Great Smoky (394)	2002	32.51 (47,19)	16.46	2.815 (46,18)	<b>1.524</b>
Joyce Kilmer (401)	2002	29.75 (38,18)	16.85	2.604 (37,17)	<b>1.557</b>
Cohutta (404)	2002	82.52 (40,22)	20.89	6.017 (39,20)	<b>1.903</b>
Shining Rock (481)	2002	13.97 (21,1)	7.49	1.307 (21,1)	<b>0.725</b>
Mammoth Cave (120)	2003	150.13 (134,107)	85.01	9.168 (132,105)	<b>6.153</b>
Mingo (268)	2003	142.82 (44,33)	30.98	8.872 (44,33)	<b>2.699</b>
Sipsey (391)	2003	50.01 (61,38)	28.70	4.056 (61,38)	<b>2.523</b>
Great Smoky (394)	2003	32.95 (59,29)	24.26	2.848 (58,28)	<b>2.172</b>
Joyce Kilmer (401)	2003	37.78 (49,19)	22.79	3.205 (49,18)	<b>2.053</b>
Cohutta (404)	2003	38.66 (57,24)	23.38	3.269 (56,22)	<b>2.101</b>
Shining Rock (481)	2003	20.87 (30,13)	14.28	1.895 (30,12)	<b>1.335</b>
Mammoth Cave (120)	2001-2003	150.13 (328,243)	72.38	9.168 (324,237)	<b>5.445</b>
Mingo (268)	2001-2003	142.82 (155,113)	43.39	8.872 (154,112)	<b>3.604</b>
Sipsey (391)	2001-2003	67.69 (170,96)	29.31	5.169 (168,94)	<b>2.570</b>
Great Smoky (394)	2001-2003	51.04 (146,68)	19.53	4.124 (141,64)	<b>1.784</b>
Joyce Kilmer (401)	2001-2003	43.27 (122,49)	16.85	3.596 (118,46)	<b>1.557</b>
Cohutta (404)	2001-2003	82.52 (134,57)	18.07	6.017 (130,52)	<b>1.661</b>
Shining Rock (481)	2001-2003	32.84 (72,24)	11.70	2.839 (71,23)	<b>1.107</b>

## **4.0 GEOPHYSICAL AND METEOROLOGICAL DATA FOR REFINED MODELING**

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### **4.1 Terrain**

Gridded terrain elevations for the modeling domain are derived from 3 arc-second digital elevation models (DEMs) produced by the United States Geological Survey (USGS). Data are provided in files covering 1 degree by 1 degree blocks of latitude and longitude. The 1-degree DEMs are produced by the Defense Mapping Agency using cartographic and photographic sources. USGS 1:250,000 scale topographic maps are the primary source of 1-degree DEMs.

One degree DEM data consists of an array of 1201 by 1201 elevations referenced on the geographic (latitude/longitude) coordinate system of the World Geodetic System 1972 Datum. Elevations are in meters relative to mean sea level, and the spacing of the elevations along each profile is 3 arc-seconds, which corresponds to a spacing of approximately 90 meters.

The CALMET computational domain is located over Warrick County, Indiana. The modeling domain covers an area of 225 km by 195 km (Figure 4-1) which includes Mammoth Cave National Park, located directly southeast of the source. The domain includes an adequate buffer of more than 50 km in each direction both from the Class I area and the facility. The terrain is gently rolling, with terrain height increasing to the east of the model domain. A horizontal resolution of 1 km represents the variations of the terrain elevations and land use in the area. Figure 4-1 shows contours of the terrain averaged to 1 km. The USGS elevation records located within each grid cell in the computational domain were averaged to produce a mean elevation at each grid point. Adequate representation of the important terrain features and valleys associated with the Class I area and the surrounding area are captured by the 225 x 195 grid cells, a workable number of cells. The CALPUFF computational domain is the same as the CALMET domain. The domain extends beyond the Class I area in order to provide an adequate buffer zone at the boundaries, and to allow the effects of flow curvature and possible small-scale recirculation to be evaluated.

### **4.2 Land Use**

The USGS Land Use data in the vicinity of the facility were used to produce a gridded field of dominant Land Use categories. The land use data used in the analysis are the Composite Theme Grid land use data (CTG) from the USGS, at a resolution of 200 m.

Land use data were processed to produce a 1 km resolution gridded field of fractional Land Use categories. The 37 USGS Land Use categories were then mapped into 14 CALMET LU categories. Surface properties such as albedo, Bowen ratio, roughness length, and leaf area index were computed proportionally to the fractional LU. The USGS Land Use categories are described in Table 4-1 of the Alcoa Warrick Modeling Protocol (2008). Table 4-2 in the same Protocol displays the 14 CALMET land use categories and their associated geophysical parameters. Figure 4-2 show the dominant land use categories used in the modeling.

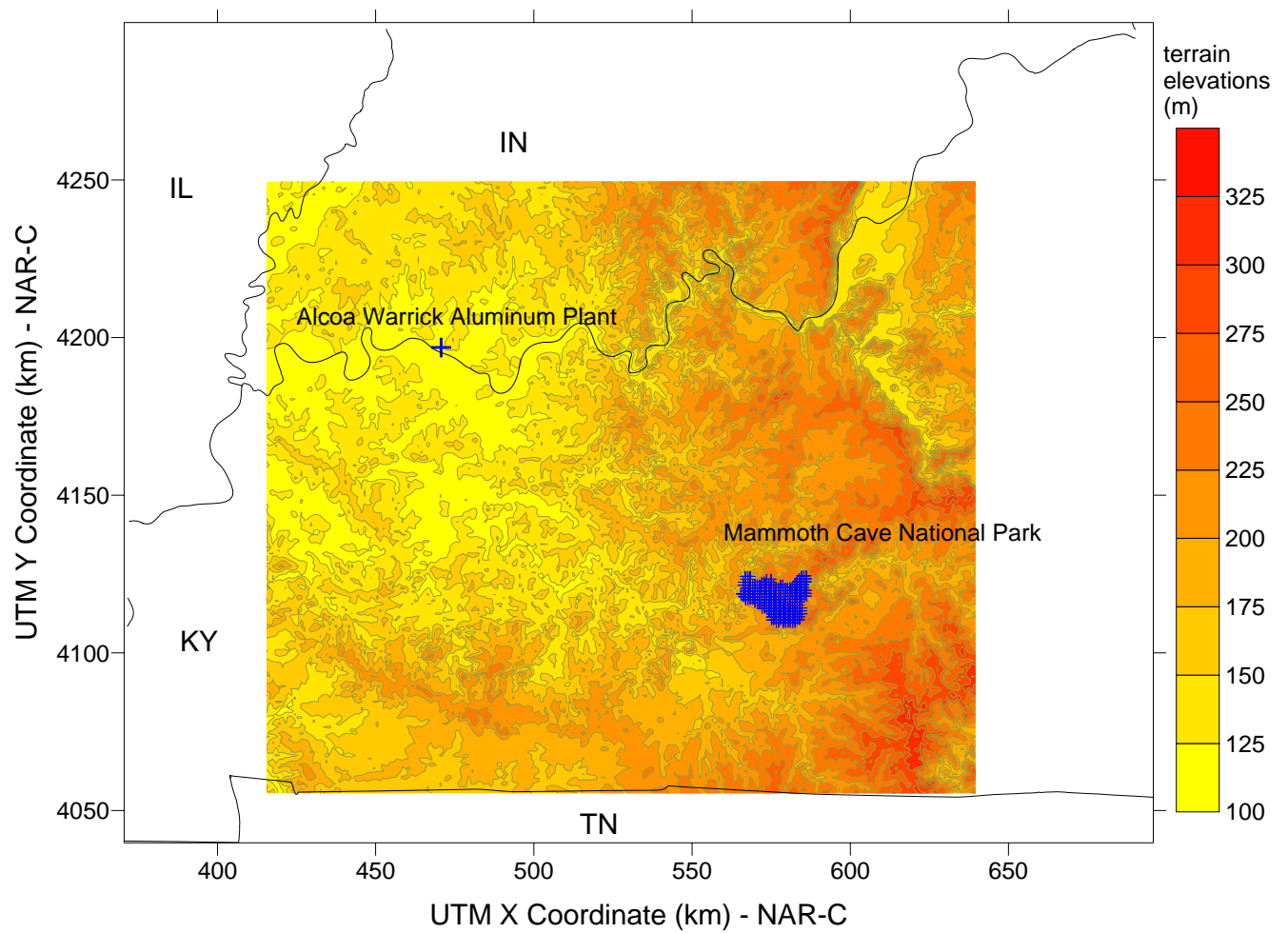


Figure 4-1. Terrain contours (m MSL) at 1 km resolution for the 225 x 195 CALMET and CALPUFF computational domains. The Class I area, Mammoth Cave NP and the Alcoa Warrick facility are shown.

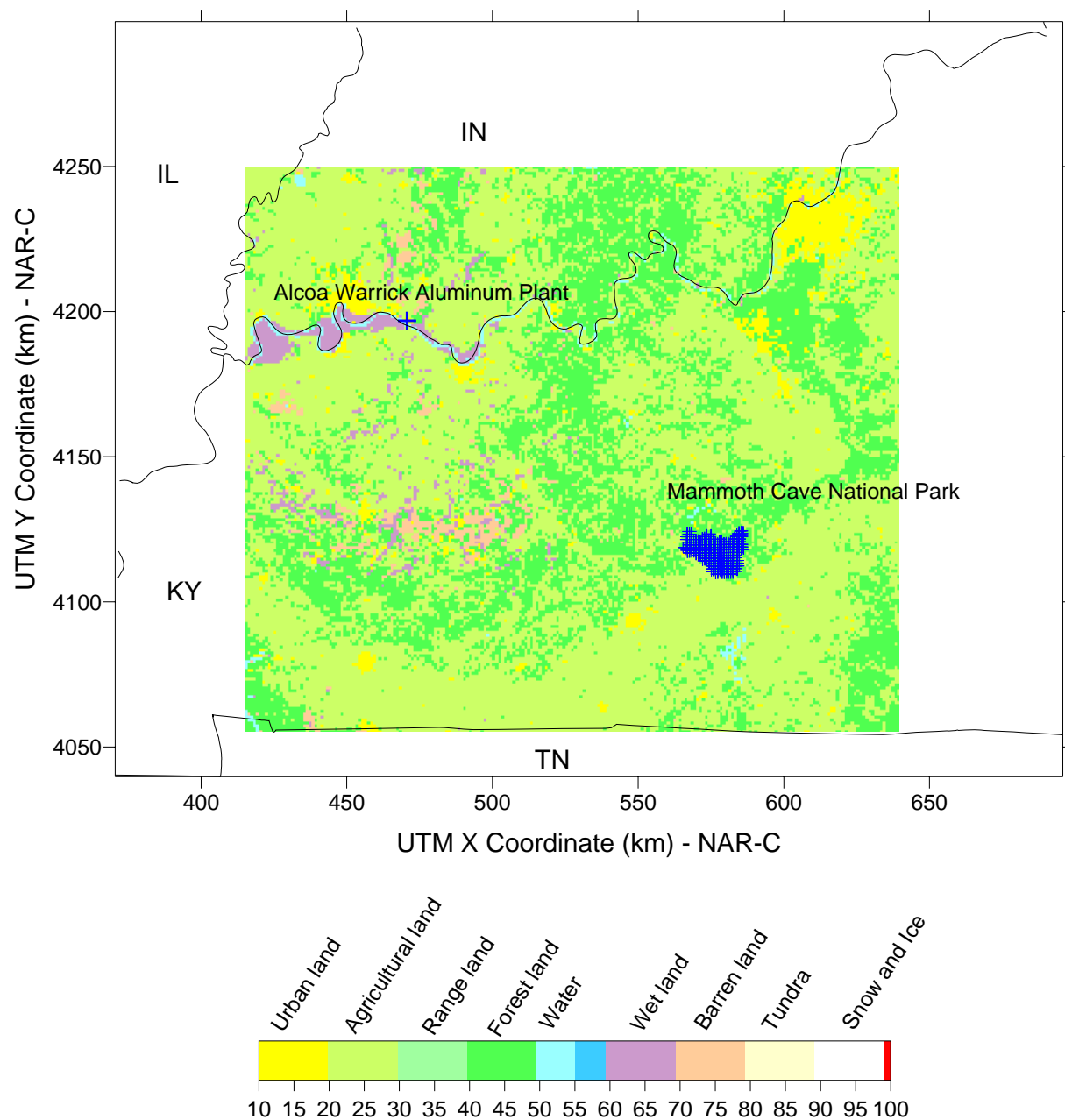


Figure 4-2. Dominant land use categories at 1 km resolution on the 225 km x 195 km CALMET and CALPUFF model domains. Mammoth Cave National Park and the facility are also shown.

### 4.3 Meteorological Data Base

The wind fields in the modeling domain are expected to be variable. Depending on the location, some of the observational data is only representative of a small area around itself. The local terrain is expected to influence the local flow, much of the structure in the wind fields were determined by CALMET using its diagnostic wind field module, rather than being driven by observations.

The CALMET model requires meteorological information from the surface and upper air as well as geophysical information about the Land Use and terrain heights. Specifically, CALMET requires surface observations of wind speed, wind direction, temperature, cloud cover, ceiling height, surface pressure, relative humidity, and precipitation type (e.g., snow, rain, etc.). These variables are routinely measured at the National Weather Service (NWS) surface stations. The upper air data include twice-daily observations of vertical profiles of wind speed, wind direction, temperature, and pressure. In addition, hourly precipitation measurements were included in the modeling and are required for wet deposition calculations in CALPUFF. Three-dimensional gridded data from the prognostic numerical model MM5 were also included as well as RUC data for the 2003 modeling. Table 4-1 lists the types of observational and modeled data available that were used in the modeling. There are ten surface meteorological stations that were used, all located within or near the modeling domain (Table 4-2): Louisville Standiford, KY; Capitol City, KY; Louisville Bowman, KY; Owensboro, KY; Henderson City, KY; Fort Knox, KY; Evansville, KY; Huntingburg, KY; Lawrenceville, KY; Fort Campbell, KY, and, Bowling Green, KY. The surface data were extracted from the Integrated Surface Hourly Weather Observations (ISHWO) CD-roms (Volume 19 for 2001, Volume 23 for 2002) and 2003 ISHWO DVD. Upper air data were extracted from the FSL/NCDC Radiosonde Database at <http://raob.fsl.noaa.gov/>. The available upper air sites are Nashville, TN and Lincoln-Logan County, IL (Table 4-3). Both these sites are located well off the model domain. Precipitation stations used in modeling are listed in Table 4-4. These data were obtained from NCDC in TD3240 format. Figure 4-3, Figure 4-4 and Figure 4-5 show the locations and spatial coverage of all of these stations for 2001, 2002 and 2003.

### 4.4 Air Quality Monitoring Data

CALPUFF uses hourly ozone concentration measurements in the chemical transformation rates ( $\text{SO}_2$  to  $\text{SO}_4$ ,  $\text{NO}_x$  to  $\text{HNO}_3/\text{NO}_3$ ). The ambient ozone measurements are used in determining  $\text{SO}_2$  loss rates due to chemical transformation to sulfate and in determining  $\text{NO}_x$  loss rates to nitrate. Ambient ozone monitoring data for 2001, 2002 and 2003 were extracted from the U.S. EPA AIRS and CASTNet networks and were used to develop hourly ozone monitoring data files for the each year of the modeling analysis. A total of ~35 monitoring stations, listed in Table 4-5, were available for use in the modeling (see Figure 4-6, Figure 4-7 and Figure 4-8 which show the locations of each of the available stations for each year to be modeled.) This is a refinement to the LADCO procedure in that spatially varying hourly ozone data were used in the modeling instead of the monthly ozone values constant in space recommended in Table 2 of LADCO protocol.

A constant ammonia concentration of 0.5 parts per billion (ppb) was used in the modeling.

**Table 4-1. Meteorological Data Sources and Parameters Available**

Type of Dataset	Frequency	Source	Parameters
Surface obs.	Hourly	NWS/NCDC	Wind speed, wind direction, temperature, ceiling height, cloud cover, relative humidity, surface pressure, precipitation type
Upper Air	Twice-daily	NWS/NCDC	Soundings of wind speed, wind direction, temperature, and pressure
Precipitation	Hourly	NWS/NCDC	Hourly precipitation amounts
Modeled Profiles MM5 for 2001, 2002	Hourly	VISTAS	Hourly, gridded fields of winds, temperature, pressure, and humidity and liquid water content on 12 km grid for 2001 and 2002.
RUC data for 2003	Hourly	NCEP	Same as MM5 above, but on 20 km grid for 2003.



**Table 4-2. NWS Hourly Surface Stations**

WMO	INIT	Station Name	State	Year	Latitude (deg)	Longitude (deg)	Elevation (m)	UTM X <sup>1</sup> (km)	UTM Y <sup>1</sup> (km)
724230	KSDF	Louisville Standiford	KY	01,02,03	38.18	85.73	146.6	611.232	4226.549
724233	KFFT	Capitol City Ap	KY	01,02,03	38.18	84.90	245.0	683.933	4227.871
724235	KLOU	Louisville Bowman Fld	KY	01,02,03	38.23	85.67	164.6	616.407	4232.171
724237	KOWB	Owensboro/Davies	KY	01,02,03	37.73	87.17	124.0	485.020	4175.872
724238	KEHR	Henderson City	KY	01,02,03	37.82	87.68	117.0	440.152	4186.062
724240	KFTK	Fort Knox Godman Ap	KY	01,02,03	37.90	85.97	239.0	590.555	4195.220
724320	KEVV	Evansville Regional Ap	KY	01,02,03	38.05	87.53	116.1	453.499	4211.495
724365	KHNB	Huntingburg	KY	01,03	38.25	86.95	161.0	504.375	4233.555
725342	KLWW	Lawrenceville	IL	01,02,03	38.77	87.60	131.0	447.877	4291.425
744656	KFWC	Fairfield	IL	03	38.42	88.42	133.0	376.296	4253.035
744659	KOLY	Olney-Noble	IL	03	38.72	88.18	147.0	397.154	4286.037
746710	KHOP	Fort Campbell Ap	KY	01,02,03	36.67	87.48	173.1	455.320	4058.382
746716	KBWG	Bowling Green Warren	KY	01,02,03	36.98	86.43	160.9	550.730	4092.806

<sup>1</sup> Datum is NAD83, UTM Zone 16.

**Table 4-3. Upper Air Stations**

#	Station Name	WBAN#	Latitude (deg)	Longitude (deg)	UTM X <sup>1</sup> (km)	UTM Y <sup>1</sup> (km)	Elevation (m)
1	Lincoln-Logan County, Ap, IL	04833	36.25	86.57	301.538	4447.009	180.0
2	Nashville, TN	13897	40.15	89.33	538.632	4011.764	178.0

<sup>1</sup> Datum is NAD83, UTM Zone 16.

**Table 4-4. Hourly NWS Precipitation Stations**

Station Name	Station ID	Year of Data	Longitude (deg)	Latitude (deg)	UTM X <sup>1</sup> (km)	UTM Y <sup>1</sup> (km)
Newburgh Lock & Dam, IN	126151	03	37.93	87.37	467.484	4198.113
JT Myers Locks & Dam, IN	128967	02,03	37.8	87.99	412.844	4184.087
Cannelton, IN	121256	01	37.9	86.63	532.529	4194.785
Calhoun Lock, KY	151227	01,02,03	37.53	87.27	476.144	4153.704
Custer 4 SE, KY	151980	01,02,03	37.72	86.22	568.742	4175.036
Dundee 2 NE, KY	152358	02,03	37.58	86.78	519.425	4159.240
Fordsville, KY	152979	01,02,03	37.63	86.72	524.703	4165.911
Herndon 5 S, KY	153798	01,02,03	36.67	87.58	449.959	4058.412
Hodgenville Lincoln, KY KY	153929	01,03	37.53	85.73	611.329	4154.416
Lebanon 5 S, KY	154650	01,02	37.52	85.3	650.229	4153.918
Madisonville, KY	155067	01,03	37.35	87.52	453.945	4133.827
Munfordville 5 NW, KY	155684	01,02	37.33	85.95	593.021	4131.998
Princeton 1 SE, KY	156580	01,03	37.12	87.87	422.712	4108.539
Scottsville 3 SSW, KY	157215	01,02	36.73	86.22	569.656	4064.095
Willisburg, KY	158719	01,02,03	37.8	85.12	665.514	4185.290
Woodbury, KY	158824	01,02,03	37.18	86.63	532.843	4114.905
Carthage, TN	401480	03	36.25	85.95	594.336	4012.189
Celina, TN	401561	01,02,03	36.54	85.46	637.849	4044.948
Lebanon, TN	405108	03	36.23	86.32	561.109	4009.674
Springfield Exp Stn, TN	408562	01,02,03	36.47	86.85	513.439	4036.091

<sup>1</sup> Datum is NAD83, UTM Zone 16.

## ALCOA Warrick: 2001 ALL Stations

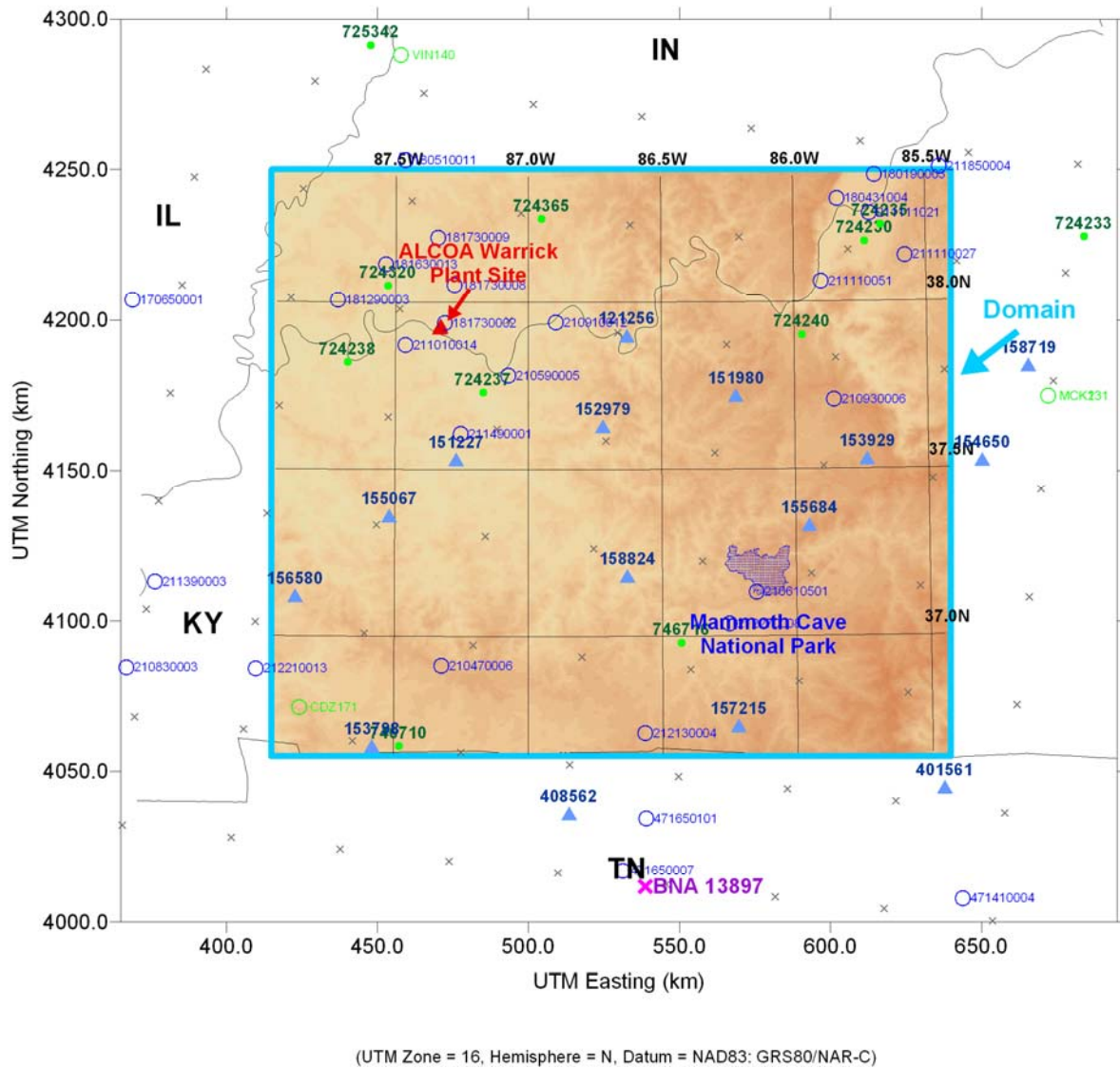


Figure 4-3. Plot of all the surface, upper air, MM5 and precipitation stations to be used in the refined 2001 modeling. Mammoth Cave National Park and the facility are also shown.

## ALCOA Warrick: 2002 ALL Stations

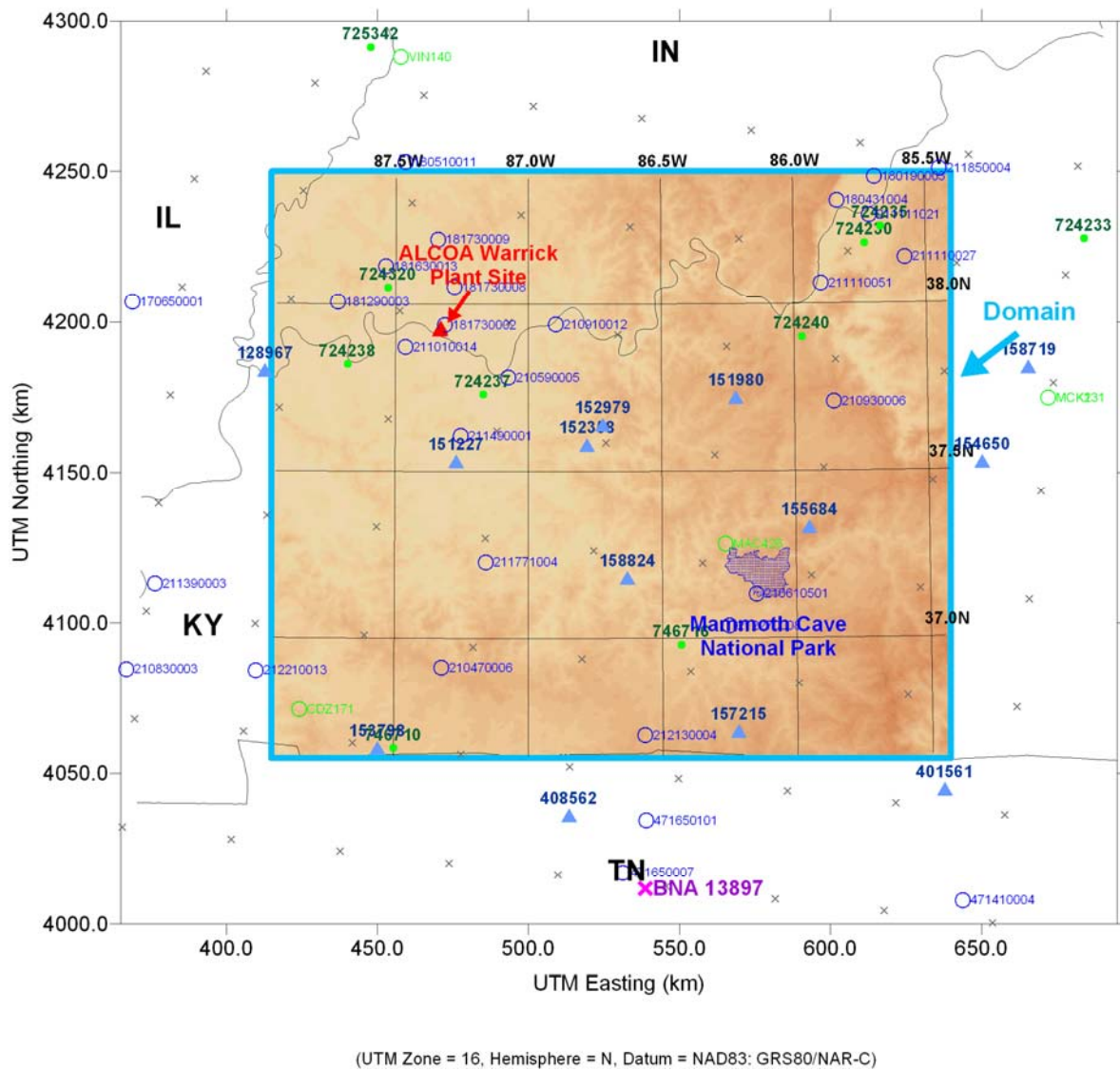


Figure 4-4. Plot of all the surface, upper air, MM5 and precipitation stations to be used in the refined 2002 modeling. Mammoth Cave National Park and the facility are also shown.

### ALCOA Warrick: 2003 ALL Stations

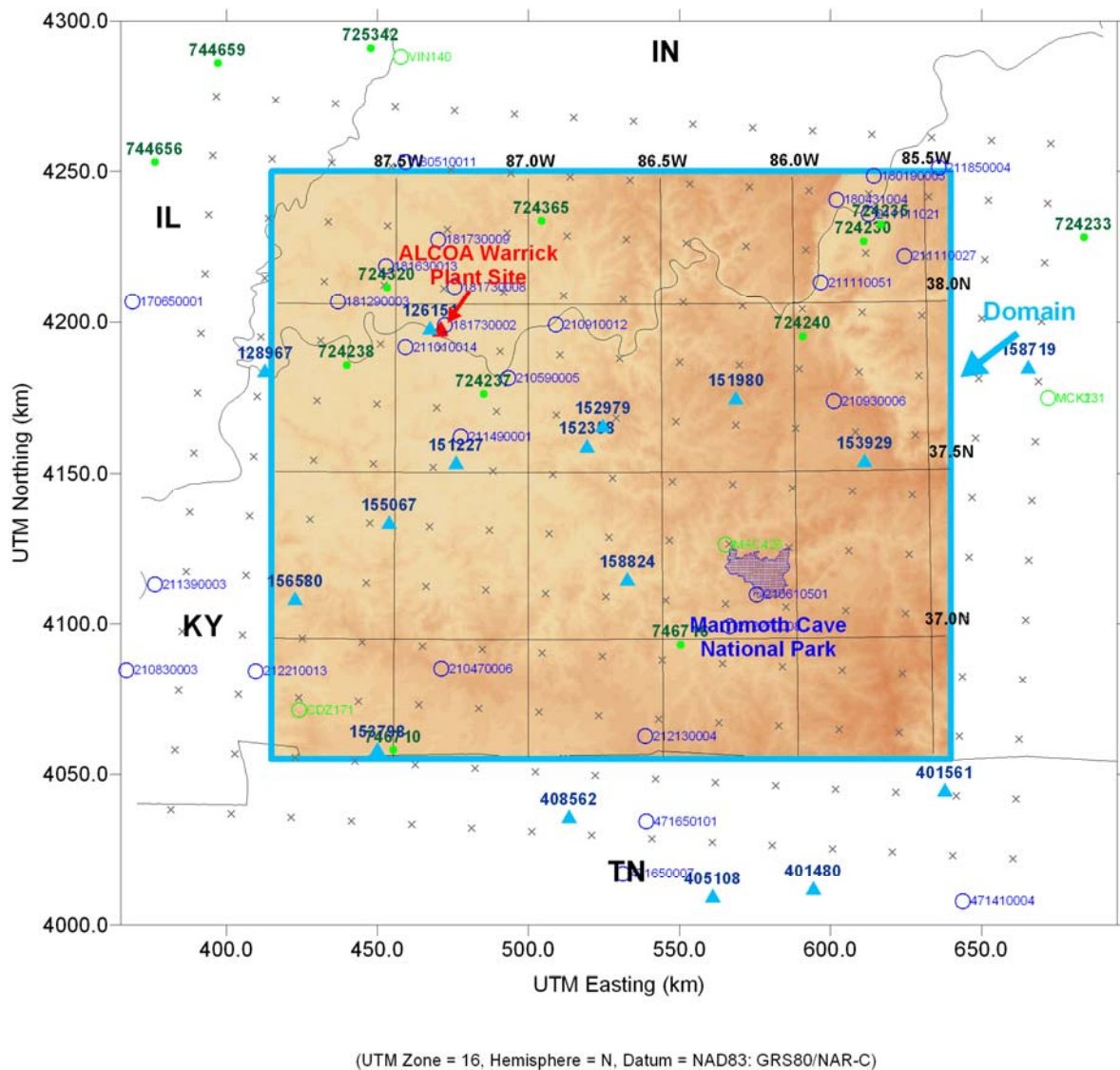


Figure 4-5. Plot of all the surface, upper air, RUC data and precipitation stations to be used in the refined 2003 modeling. Mammoth Cave National Park and the facility are also shown.

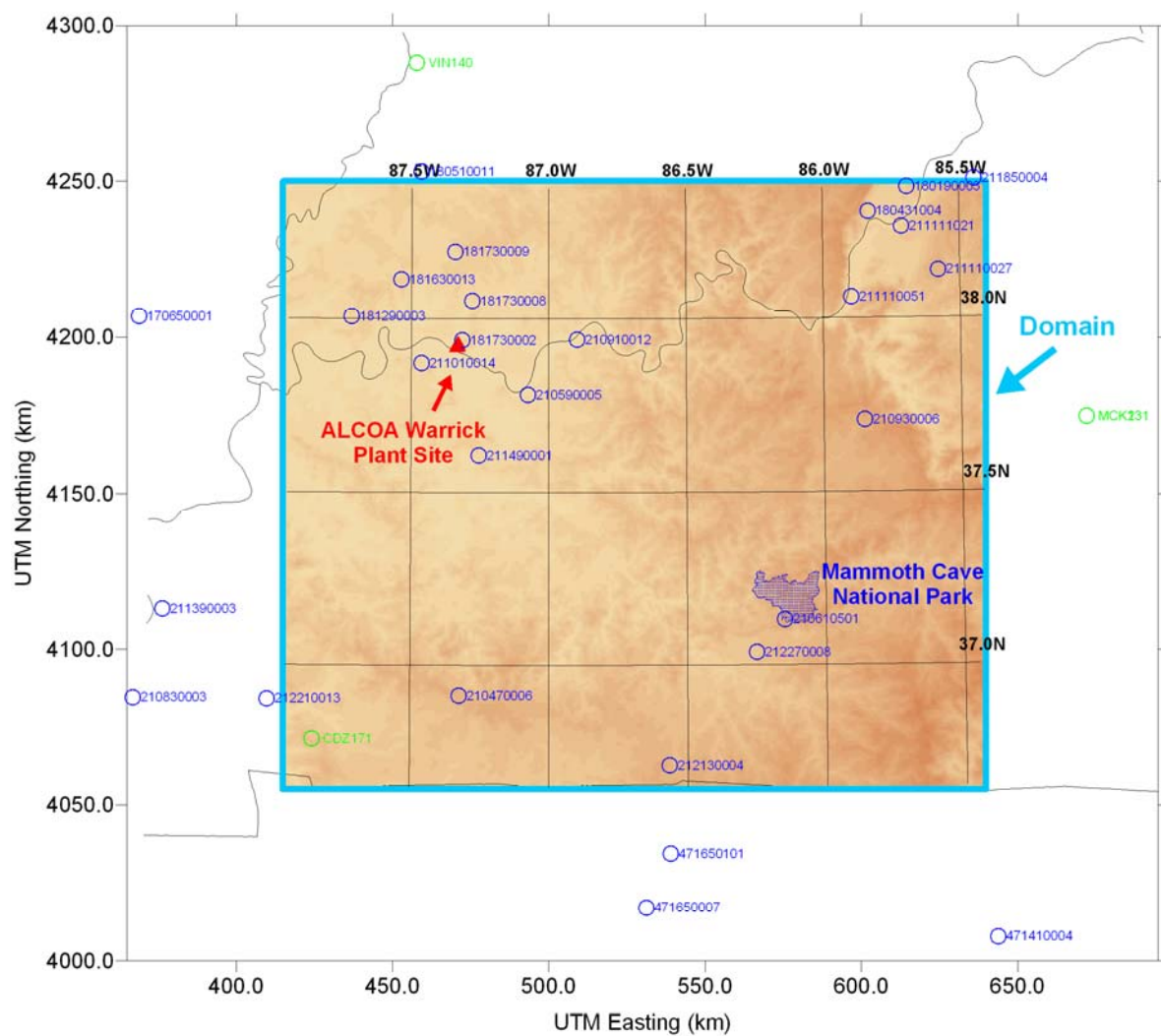
**Table 4-5. Ozone Stations**

Network	Year	ID	Latitude (deg)	Longitude (deg)	UTM X <sup>1</sup> (km)	UTM Y <sup>1</sup> (km)
AIRS	01,02,03	170650001	37.99822	-88.49311	368.898	4206.676
AIRS	01,02,03	180190003	38.37695	-85.69028	614.405	4248.458
AIRS	01,02,03	180431004	38.30806	-85.83417	601.933	4240.645
AIRS	01,02,03	180510011	38.42525	-87.46589	459.333	4253.108
AIRS	01,02,03	181290003	38.00528	-87.71833	436.935	4206.651
AIRS	01,02,03	181630013	38.11389	-87.53694	452.93	4218.594
AIRS	01,02,03	181730002	37.93750	-87.31416	472.393	4198.934
AIRS	01,02,03	181730008	38.05195	-87.27834	475.58	4211.622
AIRS	01,02,03	181730009	38.19444	-87.34139	470.105	4227.451
AIRS	01,02,03	210470006	36.91167	-87.32361	471.173	4085.131
AIRS	01,02,03	210590005	37.78083	-87.07555	493.347	4181.508
AIRS	01,02,03	210610501	37.13139	-86.14806	575.675	4109.796
AIRS	01,02,03	210830003	36.89917	-88.49361	366.921	4084.737
AIRS	01,02,03	210910012	37.93889	-86.89694	509.056	4199.047
AIRS	01,02,03	210930006	37.70639	-85.85167	601.226	4173.867
AIRS	01,02,03	211010014	37.87139	-87.46333	459.249	4191.653
AIRS	01,02,03	211110027	38.13722	-85.57833	624.593	4222.001
AIRS	01,02,03	211110051	38.06083	-85.89611	596.843	4213.146
AIRS	01,02,03	211111021	38.26361	-85.71167	612.712	4235.855
AIRS	01,02,03	211390003	37.15556	-88.39306	376.297	4113.046
AIRS	01,02,03	211490001	37.60639	-87.25389	477.590	4162.182
AIRS	02	211771004	37.22729	-87.15833	485.954	4120.099
AIRS	01,02,03	211850004	38.39861	-85.44334	635.936	4251.196
AIRS	01,02,03	212130004	36.70861	-86.56639	538.729	4062.645
AIRS	01,02,03	212210013	36.90139	-88.01361	409.693	4084.422
AIRS	01,02,03	212270008	37.03667	-86.25056	566.653	4099.211
AIRS	01,02,03	471410004	36.20500	-85.39945	643.89	4007.884
AIRS	01,02,03	471650007	36.29778	-86.65278	531.178	4017.043
AIRS	01,02,03	471650101	36.45389	-86.56416	539.056	4034.391
CASTNet	01,02,03	CDZ171	36.7841	-87.8499	424.165	4071.259
CASTNet	01,02,03	VIN140	38.7408	-87.4853	457.824	4288.125
CASTNet	02,03	MAC426	37.2806	-86.2639	565.254	4126.255
CASTNet	01,02,03	MCK131	37.7046	-85.0485	672.0299	4174.833
CASTNet	01,02,03	MCK231	37.7046	-85.0485	672.0299	4174.833

<sup>1</sup> Datum is NAD83, UTM Zone 16.

## ALCOA Warrick: 2001 Ozone Stations

(BLUE = AIRS Data, GREEN = CASTNET Data)



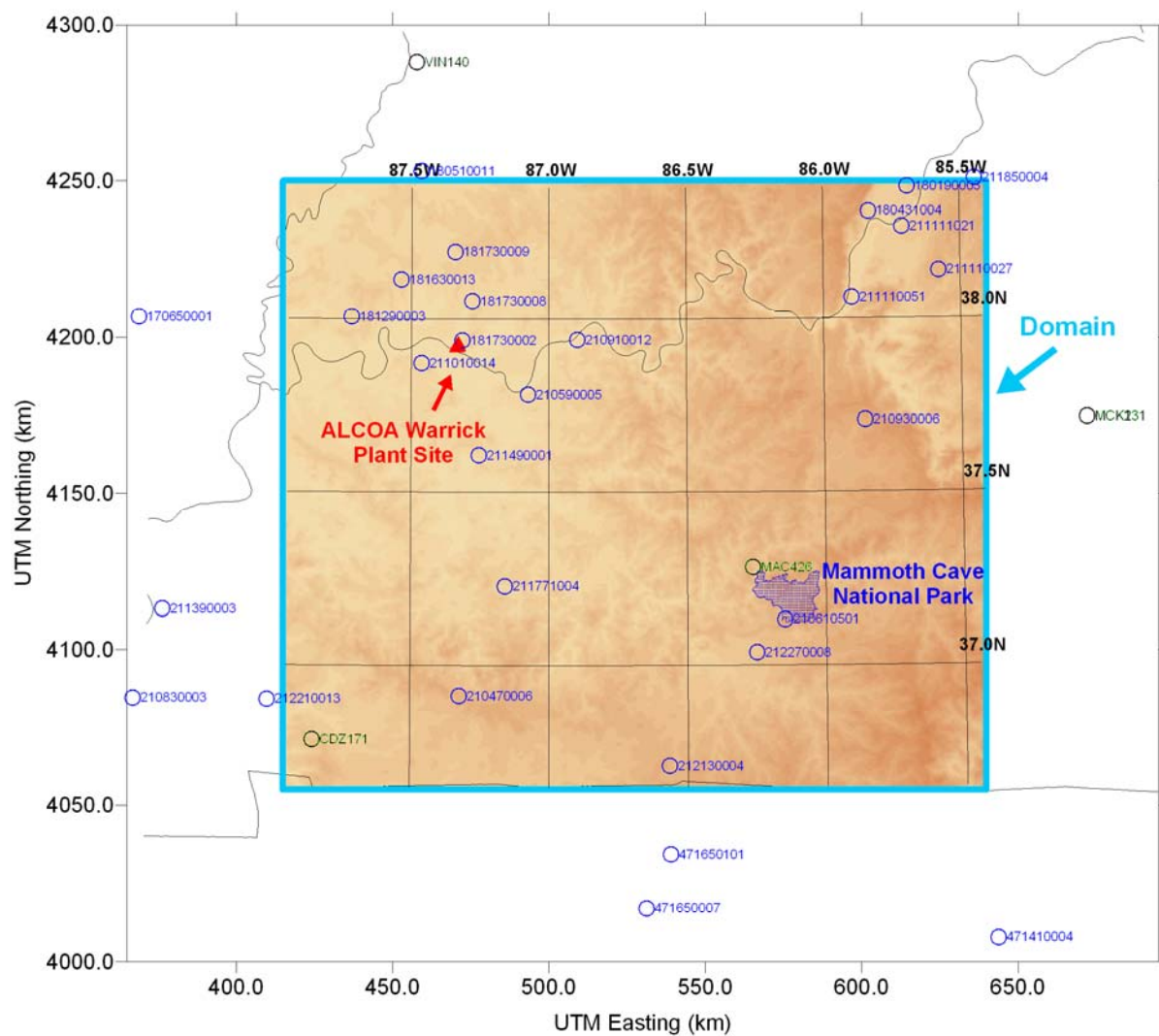
(UTM Zone = 16, Hemisphere = N, Datum = NAD83: GRS80/NAR-C)

Figure 4-6. Plot of all the ozone stations, both CASTNet and AIRS, used in the refined 2001 modeling. Mammoth Cave National Park and the facility are also shown.



## ALCOA Warrick: 2002 Ozone Stations

(BLUE = AIRS Data, GREEN = CASTNET Data)

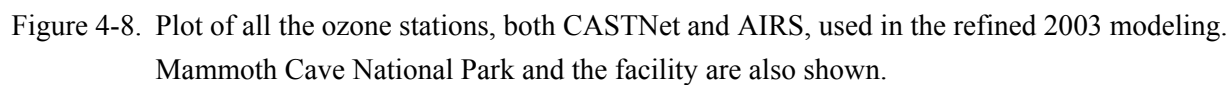


(UTM Zone = 16, Hemisphere = N, Datum = NAD83: GRS80/NAR-C)

Figure 4-7. Plot of all the ozone stations, both CASTNet and AIRS, used in the refined 2002 modeling. Mammoth Cave National Park and the facility are also shown.



(BLUE = AIRS Data, GREEN = CASTNET Data)



## **5.0 AIR QUALITY MODELING METHODOLOGY**

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### **5.1 Model Selection**

The terrain of the region, the large source-receptor distances, and the importance of chemical transformation, wet deposition, and dry deposition are important factors in the modeling. All these factors are treated in the chosen modeling approach using the CALPUFF model (Scire et al., 2000a,b) for the BART analysis for Mammoth Cave National Park. CALPUFF and its meteorological model CALMET, are designed to handle the complexities posed by complex terrain, the long source receptor distances, chemical transformation and deposition, and other issues related to Class I impacts. The U.S. Environmental Protection Agency (EPA) has recommended CALPUFF as the preferred model for BART analyses (U.S. EPA, 2005). The CALPUFF modeling system is the regulatory Guideline Model for Class I impact assessments and other long range transport applications and on a case-by-case basis for near-field applications involving complex flows (U.S. EPA, 2003a). CALPUFF is also recommended by both the Federal Land Managers Air Quality Workgroup (FLAG, 2000) and the Interagency Workgroup on Air Quality Modeling (U.S. EPA, 1998). CALPUFF is also recommended by the draft revised FLAG procedures (FLAG (2008)). The modeling simulations used the EPA regulatory version of the CALPUFF modeling system (Version 5.8 series).

CALMET is a diagnostic meteorological model that produces three-dimensional wind and temperature fields and two-dimensional fields of mixing heights and other meteorological fields. It contains slope flow effects, terrain channeling, and kinematic effects of terrain. CALPUFF is a non-steady-state Gaussian puff model. It includes algorithms for building downwash effects as well as chemical transformation, wet deposition, and dry deposition. One capability of CALPUFF not found in many specialized models such as CTDMPPLUS is the ability to treat the combined effects of multiple processes (e.g., building downwash effects in complex terrain; dry deposition and overwater dispersion, etc.). A complete summary of the capabilities and features of CALMET and CALPUFF is provided in Sections 5.1.1 and 5.1.2 of the Alcoa Warrick Modeling Protocol (2008).

### **5.2 Modeling Domain Configuration**

CALMET and CALPUFF use terrain-following coordinates. In order to cover a large enough area, a modeling domain of 225 x 195 grid cells, uniform in the horizontal with a spatial resolution of 1 km was used. In the vertical, a stretched grid was used with finer resolution in the lower layers and somewhat coarser resolution aloft thus allowing adequate representation of the mixed layer. The ten vertical levels were centered at: 10, 30, 60, 120, 240, 480, 820, 1250, 1850 and 2600 meters.

### **5.3 Meteorological Modeling Options**

#### **Initial Guess Field**

MM5 data and RUC data were used to define the initial guess field for the CALMET simulations. For 2001 and 2002 hourly MM5 data with a grid spacing of 12 km and 34 vertical levels were used as the initial guess wind field. RUC data with a grid spacing of 20 km and 50 vertical levels were used as the initial guess wind field for 2003.

This data set provides better resolution prognostic data from the 36 km MM5 data set for 2002-2004 in LADCO (2006). The higher resolution of the prognostic meteorological data set was the driving force for choosing the years 2001-2003 over the 2002-2004 period from LADCO.

#### **Step 1 Field: Terrain Effects**

In developing the Step 1 wind field, CALMET adjusts the initial guess field to reflect kinematic effects of the terrain, slope flows and blocking effects. Slope flows are a function of the local slope and altitude of the nearest crest. The crest is defined as the highest peak within a radius TERRAD around each grid point. A value of TERRAD of 10 km was determined based on an analysis of the scale of the terrain and that value was used in the CALMET simulations. The Step 1 field produces a flow field consistent with the fine-scale CALMET terrain resolution (1 km).

#### **Step 2 Field: Objective Analysis**

In Step 2, observations are incorporated into the Step 1 wind field to produce a final wind field. Each observation site influences the final wind field within a radius of influence (parameters RMAX1 at the surface and RMAX2 aloft). Observations and Step 1 field are weighted by means of parameters R1 at the surface and R2 aloft: at a distance R1 from an observation site, the Step 1 wind field and the surface observations are weighted equally. RMAX1 and RMAX2 were set to large values (40 km), while moderate values of R1 and R2 (10 km) were used in order to allow diagnostically-generated terrain effects to be retained in the final wind fields.

### **5.4 CALPUFF Computational Domain and Receptors**

CALPUFF was run for three years, 2001, 2002 and 2003. The CALPUFF computational domain is the same as the CALMET computational domain. The modeling domain includes a buffer zone of at least 50 km from the source and beyond the borders of the Class I area. This minimizes the edge effects and allows pollutants involved in flow reversals to be brought back into the Class I areas.

The receptor locations along with receptor elevations were available from the National Park Service (NPS). This gridded field of discrete receptors was used and is located within the boundaries of the Mammoth Cave National Park.

## 5.5 Dispersion Modeling Options

The CALPUFF simulations were conducted using the following model options:

- Gaussian near-field distribution
- Transitional plume rise
- Stack tip downwash
- Pasquill-Gifford (PG) dispersion coefficients (rural areas) and McElroy-Pooler coefficients (urban areas)
- Transition of  $\sigma_y$  to time-dependent (Heffter) growth rates
- Partial plume path adjustment for terrain
- Wet deposition, dry deposition, and chemical transformation were considered.

Two important computational parameters in CALPUFF are XMLEN (maximum length of an emitted puff, in grid units) and XSAMLEN (maximum travel distance of a puff, in grid units, during one time step). Both of these variables were set to 1.0 in the CALPUFF simulations in order to allow the strong wind channeling effects to be accounted for in the puff trajectory calculations. The first parameter ensures that the length of an emitted puff does not become so large so that it cannot respond to changes in the wind field on the scale of the meteorological grid. The model automatically increases the frequency of puff releases to ensure the length of a single puff is not larger than the grid size. The second parameter decreases the internal time step to ensure the travel distance during one time step does not exceed the grid size.

The partial plume path adjustment option was used in CALPUFF for this analysis (MCTADJ=3). The CALMET wind field incorporates the effect of the terrain on the plume trajectories. The plume path coefficient is used to characterize the local effect on ground-level concentrations. The default plume path coefficients (PPC) used for this analysis are listed below:

Stability Class	A	B	C	D	E	F
PPC	0.5	0.5	0.5	0.5	0.35	0.35

Deposition and chemical transformation effects were modeled using the default dry deposition model, the scavenging coefficient wet removal module, and the default chemical transformation mechanism. Eleven species were modeled with CALPUFF for this analysis: SO<sub>2</sub>, SO<sub>4</sub>, NO<sub>x</sub>, HNO<sub>3</sub>, NO<sub>3</sub>, and six subcategories of PM<sub>10</sub>, (PM<sub>800</sub>, PM<sub>425</sub>, PM<sub>187</sub>, PM<sub>112</sub>, PM<sub>081</sub>, PM<sub>056</sub>). Of these eleven species, five are emitted by the project sources: SO<sub>2</sub>, SO<sub>4</sub>, NO<sub>x</sub>, PM<sub>10</sub>, and NH<sub>3</sub>. The chemical mechanism computes transformation rates of SO<sub>2</sub> to SO<sub>4</sub> and NO<sub>x</sub> to NO<sub>3</sub>/HNO<sub>3</sub>. Hourly measured ozone concentrations were provided in an external OZONE.DAT file for use with the chemical transformation module. These ozone concentrations, along with radiation intensity, were used as surrogates for the OH concentration during the day when the gas phase free radical chemistry was active.

To allow for flexibility each source was modeled individually and their source contributions were summed at the end.

## 5.6 Visibility Calculations

Calculations of the impact of the simulated plume particulate matter component concentrations on light extinction is carried out in the CALPOST postprocessor. The annual average values were used for the natural background values. The equation used is the usual IMPROVE/EPA equation which is applied to determine the change in light extinction due to changes in component concentrations. Using the notations of CALPOST, the formula is the following:

$$B_{\text{ext}} = 3f(\text{RH})[(\text{NH}_4)_2\text{SO}_4] + 3f(\text{RH})[\text{NH}_4\text{NO}_3] + 4[\text{OC}] + 1[\text{Soil}] + 0.6[\text{Coarse Mass}] + 10[\text{EC}] + b_{\text{ray}}$$

The concentrations, in square brackets, are in  $\mu\text{g}/\text{m}^3$  and  $b_{\text{ext}}$  is in units of  $\text{Mm}^{-1}$ . The Rayleigh scattering term ( $b_{\text{ray}}$ ) has a default value of  $10 \text{ Mm}^{-1}$ , as recommended in EPA Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Program (U.S. EPA, 2003b). Note that organic carbon (OC) consists of condensable particulates which are assumed to be split evenly between the lowest two particle size categories. Soil is fine particulates which is defined as  $\text{PM}_{2.5}$ . These species were created through scaling and summing of the CALPUFF output files using the POSTUTIL program.

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

$$\text{HI} = 10 \ln(b_{\text{ext}}/10)$$

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

CALPOST Method 6 was used to compute the extinction change in deciviews consistent with the procedures outlined in the LADCO (2006) modeling protocol.

A monthly background concentrations were entered into the CALPOST input control file. The annual average natural visibility conditions for Mammoth Cave were used. Annual background concentrations for the eastern United States are give in the Guidance for Estimating Natural Visibility Conditions in Table 2-1 (U.S. EPA, 2003b), and are also provided in Table 5-1 below. These background concentrations were entered in CALPOST.

Table 5-2 provides the monthly  $f(\text{RH})$  values based on the centroid of the Class I area as recommended by EPA for application of Method 6. The monthly  $f(\text{RH})$  values for each month are extracted from Appendix A of *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule (2003)*.

The 8<sup>th</sup> highest (98<sup>th</sup> percentile) predicted light extinction change value expressed in deciviews were compared to the threshold value of 0.5 deciviews (Section 6).

**Table 5-1. Background Natural Visibility Concentrations for the Eastern United States**

	East ( $\mu\text{g}/\text{m}^3$ )
Ammonium sulfate	0.23
Ammonium nitrate	0.1
Organic carbon	1.4
Elemental carbon	0.02
Soil	0.5
Coarse Mass	3

Source: *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule (2003), Table 2-1*

**Table 5-2. Monthly f(RH) Values for Mammoth Cave Based on the Area Centroid**

Class I area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mammoth Cave NP	3.4	3.1	2.9	2.6	3.2	3.5	3.7	3.9	3.9	3.4	3.2	3.5

Source: *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule (2003), Appendix A*

## 6.0 RESULTS

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The change in light extinction relative to the natural background due to sulfur dioxide, particulate matter and nitrogen oxides from the BART-eligible sources was computed. BART methodology with CALPOST Method 6 and 98<sup>th</sup> percentile day results were used to determine light extinction. The light extinction impacts at Mammoth Cave are presented for each modeled year in units of change in deciview and as a percent change in the light extinction coefficient, for each year separately as well as for a full three-year period. The results of the visibility calculations are presented in Table 6-1 through Table 6-5 for the ‘BART Eligible Baseline’ case and five other scenarios.

For the ‘BART Eligible Baseline’ case, contribution from the sources is determined. Table 6-6 shows how are sources being grouped for the contribution, while Table 6-7 shows the contribution of the sources for each of the three modeled years.

**Table 6-1. Summary of Visibility Impacts at Mammoth Cave National Park due to ‘BART Eligible Baseline’ Case Emissions.**

<b>Year</b>	<b>Maximum Delta Bext (%)</b>	<b>98th Percentile Delta Bext (%)</b>	<b>Maximum Delta Deciview (dv)</b>	<b>98th Percentile Delta Deciview (dv)</b>
2001	91.62	44.46	6.504	3.678
2002	116.68	48.57	7.732	3.959
2003	72.21	41.73	5.435	3.487
2001-2003	116.68	44.69	7.732	3.694

**Table 6-2. Summary of Visibility Impacts at Mammoth Cave National Park due to ‘BART Eligible Baseline + Unit 1’ Case Emissions.**

<b>Year</b>	<b>Maximum Delta Bext (%)</b>	<b>98th Percentile Delta Bext (%)</b>	<b>Maximum Delta Deciview (dv)</b>	<b>98th Percentile Delta Deciview (dv)</b>
2001	114.74	54.80	7.642	4.369
2002	144.44	59.88	8.938	4.693
2003	90.32	51.63	6.435	4.163
2001-2003	114.74	55.65	8.938	4.424

**Table 6-3. Summary of Visibility Impacts at Mammoth Cave National Park due to ‘Alternative to BART’ Case Emissions.**

<b>Year</b>	<b>Maximum Delta Bext (%)</b>	<b>98th Percentile Delta Bext (%)</b>	<b>Maximum Delta Deciview (dv)</b>	<b>98th Percentile Delta Deciview (dv)</b>
2001	21.76	11.27	1.969	1.068
2002	26.76	7.89	2.371	0.759
2003	24.42	9.45	2.185	0.903
2001-2003	26.76	9.84	2.371	0.938



**Table 6-4. Summary of Visibility Impacts at Mammoth Cave National Park due to ‘BART with Potlines Scrubbed’ Case Emissions.**

<b>Year</b>	<b>Maximum Delta Bext (%)</b>	<b>98th Percentile Delta Bext (%)</b>	<b>Maximum Delta Deciview (dv)</b>	<b>98th Percentile Delta Deciview (dv)</b>
2001	11.42	6.91	1.081	0.669
2002	16.75	4.43	1.549	0.434
2003	15.19	5.34	1.414	0.520
2001-2003	16.75	5.41	1.549	0.527

**Table 6-5. Summary of Visibility Impacts at Mammoth Cave National Park due to ‘BART Control Level’ Case Emissions.**

<b>Year</b>	<b>Maximum Delta Bext (%)</b>	<b>98th Percentile Delta Bext (%)</b>	<b>Maximum Delta Deciview (dv)</b>	<b>98th Percentile Delta Deciview (dv)</b>
2001	15.19	7.66	1.414	0.739
2002	18.89	5.55	1.731	0.540
2003	17.30	6.69	1.596	0.647
2001-2003	18.89	6.88	1.731	0.665

**Table 6-6. Grouping of the Sources for the Contribution Values.**

Index	Emission Unit ID #	Stack Name	Group Name
L01	103M.1	Potline #2, Room 103	Lines
L02	104M.1	Potline #2, Room 104	
L03	105M.1	Potline #3, Room 105	
L04	106M.1	Potline #3, Room 106	
L05	107M.1	Potline #4, Room 107	
L06	108M.1	Potline #4, Room 108	
L07	109M.1	Potline #5 , Room 109	
L08	110M.1	Potline #5, Room 110	
L09	111M.1	Potline #6 , Room 111	
L10	112M.1	Potline #6, Room 112	
P01	GTC	Potlines #3 & 4 GTC Controls	GTC
P02	160C1.1-160C1.36	Potline #2 A-398	A398
P03	161B5.1-161B5.36	Potline #5 A-398	
P04	161B6.1-161B6.36	Potline #6 A-398	
P23	134.62	Melter 1M1	Holder/Melter
P24	134.64	Holder 1EH	
P25	134.65	Melter 1M2	
P26	134.66	Holder 1WH	
P28	134.33	Melter 5M1	
P29	134.35	Holder 5EH	
P30	134.36	Melter 5M2	
P31	134.38	Holder 5WH	
P32	134.39	Melter 5M3	
P33	134.4	Melter 6M1	
P34	134.41	Holder 6FH	
P35	134.42	Melter 6M2	
P36	134.43	Holder 6WH	
P37	134.44	Melter 6M3	
P39	134.71	Offlines #2 East Melter	
P41	134.75	Offlines #2 West Melter	
wpp01	wpp01	Warrick Power Plant Units 2	wpp01
wpp02	wpp02	Warrick Power Plant Units 3	wpp02
wpp03	wpp03	Warrick Power Plant Unit 4	wpp03

**Table 6-7. Source and Species Contributions to the 8<sup>th</sup> Highest Extinction Coefficient Changes for ‘BART Eligible Baseline’ Case at Mammoth Cave National Park.**

Source Group	Bext	Contrib. to	Modeled	Species Contribution to Modeled Extinction Coefficient in 1/Mm						Percentage of Species Contribution to Modeled Extinction Coefficient					
	Change	Total Bext	Ext.	SO4	NO3	Organics	E. Carbon	PM_Coarse	PM_Fine	SO4	NO3	Organics	E. Carbon	PM_Coarse	PM_Fine
	(%)	Change(%)	1/Mm	1/Mm	1/Mm	1/Mm	1/Mm	1/Mm	1/Mm	%	%	%	%	%	%
<b>2001: 8th highest impact is 3.678 Deciview</b>															
All	44.46	100.00	9.456	9.118	0.196	0.060	0.000	0.003	0.079	96.43	2.07	0.63	0.00	0.03	0.84
Lines	0.12	0.26	0.025	0.007	0.000	0.009	0.000	0.002	0.007	28.00	0.00	36.00	0.00	8.00	28.00
GTC	0.60	1.34	0.127	0.120	0.000	0.004	0.000	0.000	0.003	94.49	0.00	3.15	0.00	0.00	2.36
A398s	0.86	1.94	0.183	0.172	0.000	0.007	0.000	0.000	0.004	93.99	0.00	3.83	0.00	0.00	2.19
Melter/Holder	0.01	0.03	0.003	0.000	0.002	0.000	0.000	0.000	0.001	0.00	66.67	0.00	0.00	0.00	33.33
wpp01	4.73	10.65	1.007	0.970	0.025	0.005	0.000	0.000	0.007	96.33	2.48	0.50	0.00	0.00	0.70
wpp02	15.74	35.40	3.347	3.239	0.075	0.014	0.000	0.000	0.019	96.77	2.24	0.42	0.00	0.00	0.57
wpp03	22.39	50.35	4.761	4.610	0.093	0.020	0.000	0.000	0.038	96.83	1.95	0.42	0.00	0.00	0.80
<b>2002: 8th highest impact is 3.959 Deciview</b>															
All	48.57	100.00	10.473	7.877	2.425	0.069	0.000	0.001	0.101	75.21	23.15	0.66	0.00	0.01	0.96
Lines	0.04	0.10	0.010	0.002	0.000	0.004	0.000	0.001	0.003	20.00	0.00	40.00	0.00	10.00	30.00
GTC	0.33	0.67	0.070	0.063	0.001	0.004	0.000	0.000	0.002	90.00	1.43	5.71	0.00	0.00	2.86
A398s	0.36	0.75	0.079	0.069	0.002	0.005	0.000	0.000	0.003	87.34	2.53	6.33	0.00	0.00	3.80
Melter/Holder	0.01	0.02	0.002	0.000	0.002	0.000	0.000	0.000	0.000	0.00	100.00	0.00	0.00	0.00	0.00
wpp01	5.33	10.96	1.148	0.818	0.313	0.007	0.000	0.000	0.010	71.25	27.26	0.61	0.00	0.00	0.87
wpp02	16.90	34.80	3.645	2.703	0.896	0.020	0.000	0.000	0.026	74.16	24.58	0.55	0.00	0.00	0.71
wpp03	25.60	52.71	5.520	4.223	1.210	0.030	0.000	0.000	0.057	76.50	21.92	0.54	0.00	0.00	1.03
<b>2003: 8th highest impact is 3.487 Deciview</b>															
All	41.73	100.00	9.081	8.161	0.777	0.061	0.000	0.002	0.080	89.87	8.56	0.67	0.00	0.02	0.88
Lines	0.08	0.19	0.017	0.004	0.000	0.007	0.000	0.001	0.005	23.53	0.00	41.18	0.00	5.88	29.41
GTC	0.55	1.32	0.120	0.111	0.001	0.005	0.000	0.000	0.003	92.50	0.83	4.17	0.00	0.00	2.50
A398s	0.82	1.95	0.177	0.164	0.001	0.007	0.000	0.000	0.005	92.66	0.56	3.95	0.00	0.00	2.82
Melter/Holder	0.04	0.09	0.008	0.000	0.007	0.000	0.000	0.000	0.001	0.00	87.50	0.00	0.00	0.00	12.50
wpp01	4.55	10.91	0.991	0.881	0.098	0.005	0.000	0.000	0.007	88.90	9.89	0.50	0.00	0.00	0.71
wpp02	15.05	36.08	3.276	2.937	0.304	0.015	0.000	0.000	0.020	89.65	9.28	0.46	0.00	0.00	0.61
wpp03	20.63	49.45	4.491	4.064	0.367	0.021	0.000	0.000	0.039	90.49	8.17	0.47	0.00	0.00	0.87

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**Appendix C to  
BART determination Report for Alcoa, Inc. - Warrick Operations**

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