BART Determination Modeling Protocol:

Georgia Power Company
Plant Bowen

Prepared by:

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for Georgia Power Company

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1.0 Introduction

1.1 Objectives

The Regional Haze Rule requires Best Available Retrofit Technology (BART) for any BART-eligible source that "emits any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility" in any mandatory Class I federal area. Pursuant to federal regulations, states have the option of exempting a BART-eligible source from the BART requirements based on dispersion modeling demonstrating that the source cannot reasonably be anticipated to cause or contribute to visibility impairment in a Class I area. In addition, the Environmental Protection Agency (EPA) has promulgated a rule allowing states subject to the Clean Air Interstate Rule (CAIR) to determine that CAIR satisfies the BART requirements for SO_2 and NO_x for electric generating units (EGUs). Preliminary feedback from the Georgia Environmental Protection Division indicates that they anticipate making the decision that CAIR satisfies BART for SO_2 and NO_x for EGUs. Therefore, this modeling protocol focuses on performing the BART modeling analysis for particulate matter (PM) only.

Units 1, 2, 3, and 4 at Plant Bowen, located near Cartersville, which is owned and operated by Georgia Power Company, has been identified as a BART-eligible source. The purpose of this document is to summarize the procedures by which modeling analyses will be conducted for this source. Georgia Power has determined that Plant Bowen is subject to BART for PM. Therefore, the procedures below will be used to evaluate the visibility improvement factor in the BART determination step (determination modeling). The modeling procedures are consistent with those outlined in the updated final VISTAS common BART modeling protocol (dated December 22, 2005, revision 3.2 – August 31, 2006), available at http://www.vistas-sesarm.org/documents/BARTModelingProtocol_rev3.2_31Aug2006.pdf. This source-specific BART modeling protocol references relevant portions of the common VISTAS modeling protocol.

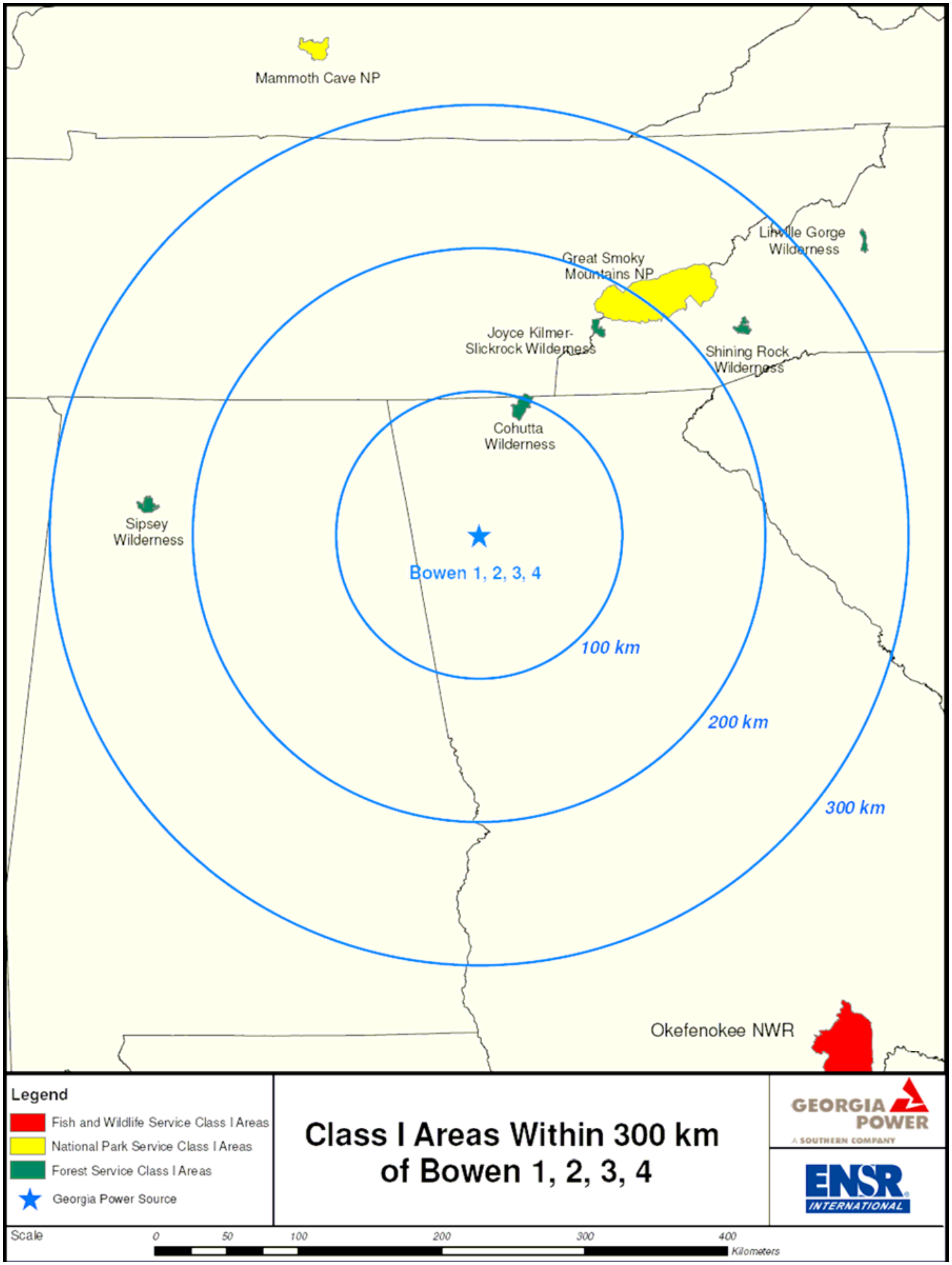
1.2 Location of source vs. relevant Class I Areas

The Georgia Environmental Protection Division, which is in charge of the state's BART program, has determined that Units 1, 2, 3, and 4 at Plant Bowen are BART-eligible for PM. Figure 1-1 shows a plot of Plant Bowen relative to nearby Class I Areas. There are five Class I areas within 300 km of the plant: Cohutta (84.8 km), Great Smoky Mountains (175.9 km), Joyce Kilmer (162.3 km), Shinning Rock (228.0 km), and Sipsey (223.5 km). Baseline modeling will be conducted for each of these Class I areas in accordance with the referenced VISTAS common BART modeling protocol and the procedures described in this source-specific BART modeling protocol. Visibility improvement modeling for the BART determination analysis will be performed for those Class I areas where the baseline modeling shows a greater than 0.5 deciview impact.

1.3 Organization of protocol document

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

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



2.0 Source description and emissions data

2.1 BART determination baseline

SO_2 scrubbers have been permitted and are under construction for all four units at Plant Bowen. The scrubbers will go on line in 2008 for Units 3 and 4, 2009 for Unit 2, and 2010 for Unit 1. So, these scrubbers will be "existing" controls for Bowen well ahead of the estimated implementation date for BART (~2014). It has been determined that impacts from Bowen 1-4 (the BART eligible source) will be greater than 0.5 deciview on at least one Class I area even with the PM emissions reductions that occur from scrubbers. In addition, using the scrubbers as baseline provides consistency that allows for straight forward (i.e., effect of emission reduction only) interpretation of results. That is, there will be consistency in stack parameters and emissions that might otherwise confound interpretation of modeling results. Finally, this approach is consistent with the BART statutory factor that requires consideration of "any existing pollution control technology in use at the source." For these reasons, scrubbers on the Bowen units will be the starting point (baseline) for the PM BART determination and visibility improvement modeling.

2.2 PM emissions controls to be modeled

Georgia Power has initiated the PM BART determination analysis for Bowen. Preliminary results include identification of technically feasible PM controls and performance of a removal cost analysis for these controls. This preliminary cost analysis considers the installed capital and operating cost (including sorbent cost, where appropriate), capacity and energy penalties associated with station service impacts, PM species specific removal efficiencies for each control, emissions derived based on 2003-2005 actuals adjusted by removal efficiencies, and financial assumptions consistent with the EPA Control Cost Manual and industry-accepted capital and operating cost estimates..

Table 2-1 summarizes preliminary cost analysis results for each technically feasible PM control. Due to space constraints, COHPAC (on all four units) and the addition of a new electrostatic precipitator (ESP) collection field in a new case (on Units 3 and 4) were not considered. A detailed description of potentially available PM controls and their feasibility for Bowen and a detailed discussion of the cost analysis will be provided in the final BART determination analysis report to be submitted later. Further refinements to the analysis are possible, but it is not anticipated that the conclusions will be significantly different. As described in the EPA BART guidance, the data in Table 2-1 was used to create a graphical plot of the total annualized cost for the total PM emissions reductions for all feasible control alternatives (Figures 2-1 thru 2-4). A curve was fit to the data in order to identify a "least-cost envelope" of dominant control choices. Control options that lie inside of the least-cost envelope are considered inferior options based on cost because the cost per ton of particulate removed is inconsistent with other competing alternatives.

Figures 2-1 through 2-4 show that the dominant control choices for all four units include WESP, the addition of JuiceCan technology on existing transformer/rectifier (T/R) sets, the particle agglomerator, and the combination of JuiceCan/particle agglomerator. Gas flow optimization, lime injection, the addition of a new electrical field (on Units 1 and 2), and the combination of WESP/lime injection have been eliminated because they fall inside of the least-cost envelope. These options are considered inferior based on cost and, therefore, have been eliminated from further consideration. Rather than performing visibility improvement modeling for all of the remaining controls, modeling will be performed for two of the remaining options: (1) Agglomerator/Juice Can - the highest removal option of the set of relatively lower cost controls, and (2) Wet ESP - the remaining control with the overall highest total PM removal. This will bracket the overall visibility improvement results.

2.3 Unit-specific source data

The emissions data used to assess the visibility impacts at the Class I areas within 300 km of Plant Bowen are discussed in this section. As noted earlier, indications from the Georgia Environmental Protection Division are that they will issue rules stating that CAIR will suffice for EGU BART for SO_2 and NO_x. Therefore, this protocol focuses only on PM_{10}. Since various components of PM_{10} emissions have different visibility extinction efficiencies, the PM_{10} emissions are divided, or "speciated," into several components (VISTAS common protocol Sections 4.3.3 and 4.4.2). The VISTAS protocol (Section 5.) allows for the use of source-specific emissions and speciation factors and/or default values from AP-42. The PM_{10} emissions and speciation

Table 2-1 Plant Bowen Preliminary BART Cost Analysis Results

	Total PM10 Removed	Annualized Cost	Removal Cost	Total PM10 Removed	Annualized Cost	Removal Cost
Control Option	**Bowen 1**			**Bowen 2**		
	Tons	$/Yr	$ per Ton	Tons	$/Yr	$ per Ton
Optimize Gas Flow	5.6	$125,600	$22,274	7.8	$125,600	$16,089
Juice Can Retrofit	11.3	$82,317	$7,299	15.6	$82,317	$5,272
Lime Injection	33.1	$2,714,893	$82,026	38.1	$2,714,893	$71,323
Agglomerator Retrofit	62.0	$1,236,108	$19,929	85.9	$1,236,108	$14,395
Add field in new casing	65.8	$3,433,973	$52,199	91.1	$3,433,973	$37,705
Agglomerator/JuiceCan	73.3	$1,318,425	$17,986	101.5	$1,318,425	$12,991
WESP	261.0	$13,102,142	$50,209	336.2	$13,102,142	$38,973
WESP/Lime Injection	271.0	$15,817,034	$58,375	347.4	$15,817,034	$45,527
Control Option	**Bowen 3**			**Bowen 4**		
	Tons	$/Yr	$ per Ton	Tons	$/Yr	$ per Ton
Optimize Gas Flow	14.1	$161,486	$11,465	16.0	$161,486	$10,074
Juice Can Retrofit	21.1	$105,836	$5,009	24.0	$105,836	$4,402
Lime Injection	44.6	$3,490,576	$78,224	43.2	$3,490,576	$80,850
Agglomerator Retrofit	51.6	$1,589,281	$30,772	58.8	$1,589,281	$27,039
Agglomerator/JuiceCan	72.8	$1,695,117	$23,292	82.8	$1,695,117	$20,467
WESP	334.8	$16,845,611	$50,319	360.5	$16,845,611	$46,731
WESP/Lime Injection	348.2	$20,336,187	$58,396	373.6	$20,336,187	$54,440
Add field in new casing	n/a	n/a	n/a	n/a	n/a	n/a

Figure 2-1 **Plant Bowen Unit 1 - Annualized Cost versus PM Removed**

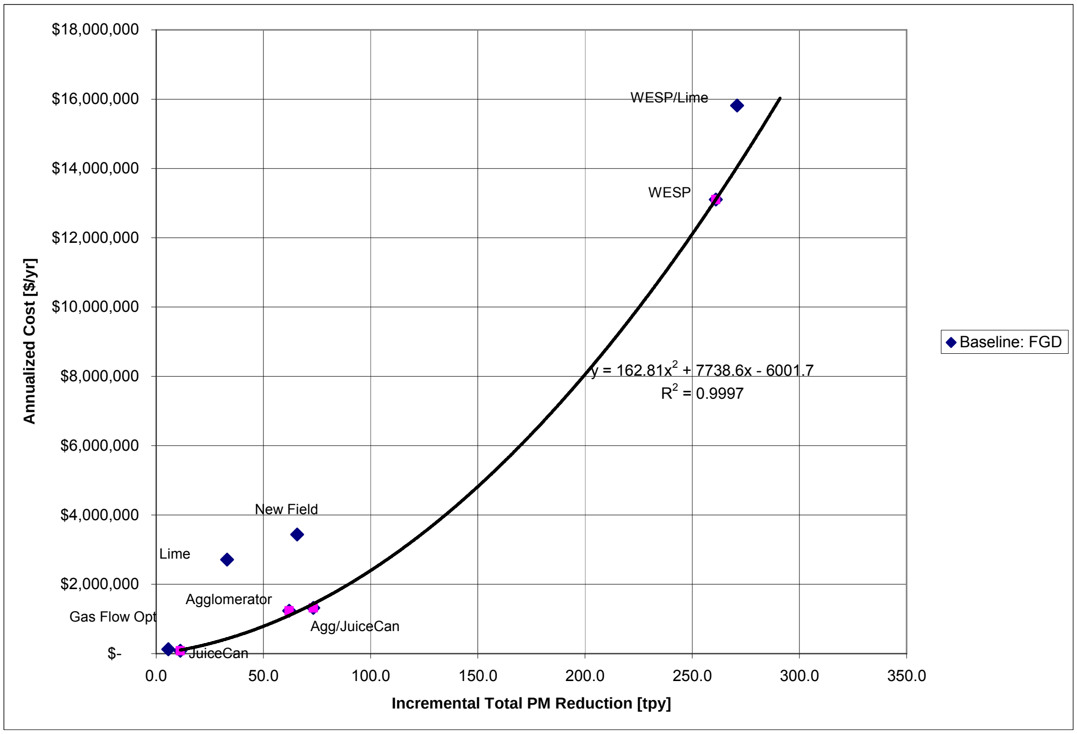


Figure 2-2 **Plant Bowen Unit 2 - Annualized Cost versus PM Removed**

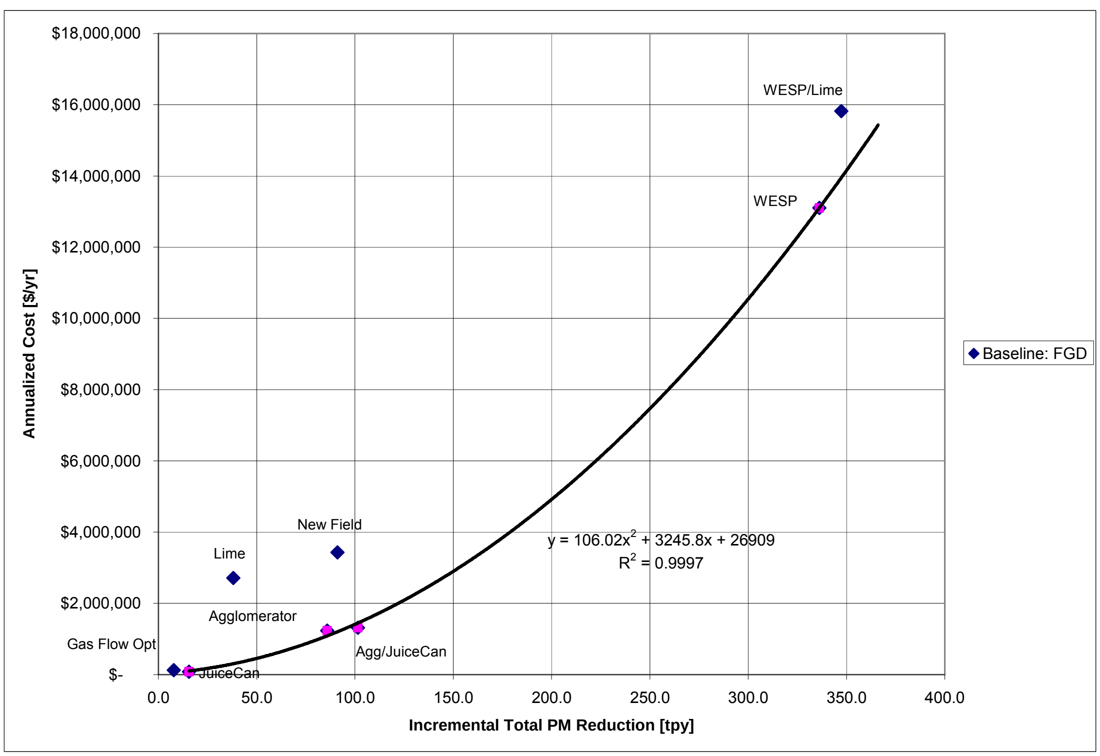


Figure 2-3 **Plant Bowen Unit 3 - Annualized Cost versus PM Removed**

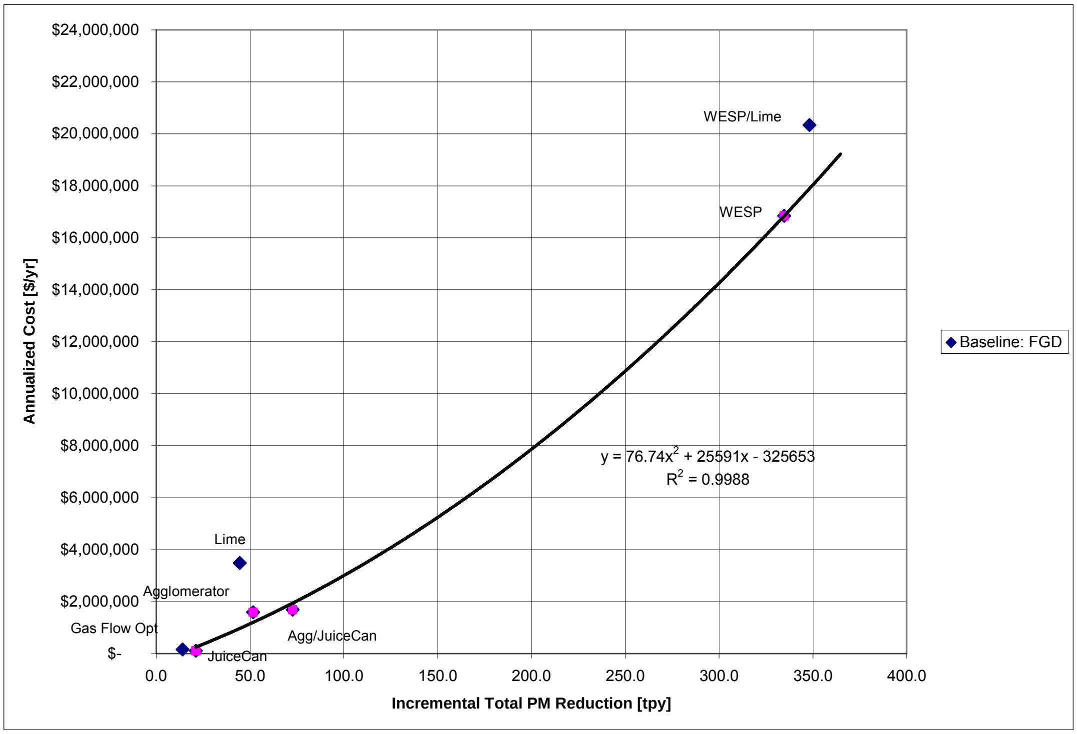
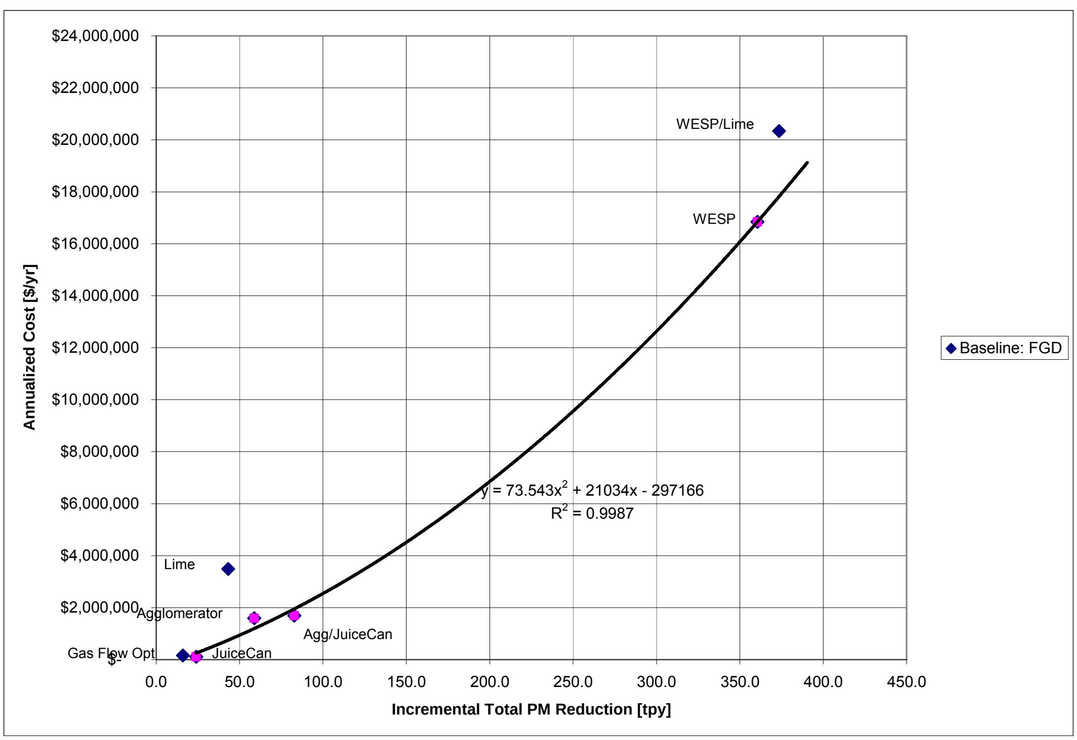


Figure 2-4 **Plant Bowen Unit 4 - Annualized Cost versus PM Removed**



approach to be used for the modeling described in this protocol is indicated in the bullets below. Where default speciation values are used, the data represents a unit where current (baseline) emission controls include ESPs and selective catalytic reduction (SCR) systems, but no post-combustion SO_2 control equipment exists.

As indicated in Section 2.1, it has been determined that the baseline for the BART determination analysis and visibility improvement modeling will include scrubbers on all of the Bowen units. Therefore, the foundation for deriving the baseline and control option emissions for the BART determination modeling was to establish “maximum 24-hour average emission rates” based on the current configuration consistent with the VISTAS common protocol and then to apply the species specific control efficiencies as appropriate. To establish emission rates for the BART determination baseline modeling, scrubber control efficiencies were applied to the maximum 24-hour average rates.

- Total PM_{10} is comprised of filterable and condensable emissions.
- Filterable PM_{10} emissions are based on the highest stack test for the most recent 3-year period (2003-2005). This stack test is combined with the highest 24 hour heat input value for this period from CEMS data to calculate the “maximum 24-hour average emission rate” as required by the VISTAS protocol.
- Filterable PM_{10} will be subdivided by size category consistent with the default approach from AP-42 Table 1-1.6, and as noted on pages 43 and 44 of the VISTAS common BART modeling protocol. The AP-42 Table 1-1.6 specifies for the emission controls indicated above that 55.6% of filterable PM_{10} emissions is coarse (greater than 2.5 microns in size) and 44.4% is fine. Of the fine portion, 3.7% is elemental carbon and the remainder is inorganic fine particulates (soil).
- Condensable PM_{10} consists of inorganic and organic compounds. The inorganic portion is by default assumed to be H_2SO_4, although other non-sulfate inorganic condensables could be present. The organic portion is modeled as organic aerosols.
- H_2SO_4 emissions are calculated consistent with the method used by Georgia Power to derive these emissions for TRI purposes. This approach assumes that the H_2SO_4 emissions released from the stack are proportional to SO_2 emissions from combustion and are dependent on the fuel type and the removal of H_2SO_4 by downstream equipment (i.e., ESP and air heater). For eastern bituminous coal the fundamental H_2SO_4 release rate (without scrubbers or add-on PM controls) is in the range of 0.3 to 0.8% of the SO_2 emissions. Appendix A provides the basis for the site-specific values used.
- Emissions of condensable organics (the remaining portion of condensable PM_{10}) are derived based on the supporting field observational information in Appendix B and is estimated as 0.32% of SO_2 emitted.
- Coarse filterable particles (between 2.5 and 10 microns in size) will be modeled with a geometric mass mean diameter of 5 microns, while fine filterable and all condensable particles will be modeled with a geometric mass mean diameter of 0.48 microns, consistent with the CALPUFF default value for fine particles. The geometric standard deviation for both fine and coarse particles will be set to 2 microns, consistent with the CALPUFF default value. The 0.48 micron diameter value for fine particles comes from the default values in sample input files presented on the TRC web site. There is no default value presented for the coarse particles on the TRC web site. However, since 5 is the geometric mass mean diameter of 2.5 and 10 (the bounds of coarse particle sizes), it is a reasonable estimate for the geometric mass mean diameter for that class of particles.

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

Table 2-2 provides a summary of the modeling emission parameters to be used in the BART CALPUFF modeling, consistent with the source emissions data presented in Appendices A and B for the current configuration. The foundation for all of the emissions in Table 2-2 were derived from CEMS data for the 2003 to 2005 period and represent the maximum 24-hour average lb/hr rates (excluding days where startup, shutdown, or malfunctions occurred). For NO_x and SO_2 the current configuration values are directly from CEMS. Filterable PM_{10} emissions were calculated using the highest stack test over the 2003 to 2005 period and multiplying these values times the maximum 24-hour average heat input derived from CEMS. These values were then adjusted using AP-42 factors from Table 1.1-6 that indicate that PM_{10} is 67% of total PM for a pulverized coal unit with an ESP. PM_{10} speciation was then performed as indicated above such that total Filterable PM_{10} is made up of Coarse Soil plus total Fine PM and total Fine PM is made up of Fine Soil plus Elemental Carbon (EC). Since these units include SCRs, a consistent set of seasonal emissions data was developed representing periods with and without SCR operation. For these, the maximum 24-hour average rates were extracted from the seasonal (May - September) and non-seasonal (October - April) CEMS data. For visibility improvement modeling, only the emissions representing SCR operation was used as the foundation for establishing the baseline (scrubbed) emission rates and the emission rates for PM controls under consideration.

Table 2-2 Plant Bowen modeling emission parameters

Case	Source / Unit	Location UTM (Zone 16 NAD-83)		Actual Stack Ht	Base Elev.	Flue Dia-meter	Gas Exit Vel.	Stack Gas Exit Temp.	Emissions[1]			Particle Speciation[2]							
		UTM East	UTM North						SO_2	NO_X	PM_{10}	Filt. PM_{10}	Coarse Soil	Fine PM	Fine Soil	EC	Cond. PM_{10}	H_2SO_4	Organic
		m	m	m	m	m	m/s	deg K	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr
FUNDAMENTAL EMISSIONS DATA																			
Fundamental Data (Unit Basis)																			
Current Config.	Unit 1	691,893	3,778,033	304.8	219.8	7.6	20.8	403.0	15374.22	1565.42	510.21	378.07	210.20	167.86	161.65	6.21	132.14	82.95	49.20
Current Config.	Unit 2	691,893	3,778,033	304.8	219.8	7.6	20.8	403.0	16059.38	1253.44	545.86	407.51	226.58	180.94	174.24	6.69	138.35	86.96	51.39
Current Config.	Unit 3	691,893	3,778,033	304.8	219.8	7.6	27.1	409.7	18519.37	773.00	478.86	268.01	149.01	119.00	114.59	4.40	210.85	151.58	59.26
Current Config.	Unit 4	691,893	3,778,033	304.8	219.8	7.6	27.1	409.7	19504.06	971.92	521.14	297.26	165.28	131.98	127.10	4.88	223.88	161.47	62.41
BART DETERMINATION BASELINE EMISSIONS																			
Scrubber Baseline Data (Unit Basis)																			
Baseline	Unit 1	691,893	3,778,033	207.5	219.5	7.6	12.5	327.0	768.71	1565.42	174.58	75.61	42.04	33.57	32.33	1.24	98.97	49.77	49.20
Baseline	Unit 2	691,893	3,778,033	207.5	219.5	7.6	12.5	327.0	802.97	1253.44	185.07	81.50	45.32	36.19	34.85	1.34	103.56	52.17	51.39
Baseline	Unit 3	691,893	3,778,033	207.5	219.5	7.6	15.8	327.0	925.97	773.00	173.03	53.60	29.80	23.80	22.92	0.88	119.43	60.16	59.26
Baseline	Unit 4	691,893	3,778,033	207.5	219.5	7.6	15.8	327.0	975.20	971.92	185.10	59.45	33.06	26.40	25.42	0.98	125.65	63.24	62.41
Scrubber Baseline Data (Stack Basis)																			
				Modeled Stk Ht[3]		**Eq. Dia.**													
		m	m	m	m	m	m/s	deg K	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr
Stack 1	1&2	691,893	3,778,033	207.5	219.5	14.2	12.5	327.0	1571.68	2818.85	359.64	157.12	87.36	69.76	67.18	2.58	202.53	101.94	100.59
Stack 2	3&4	691,893	3,778,033	207.5	219.5	14.2	15.8	327.0	1901.17	1744.92	358.13	113.05	62.86	50.20	48.34	1.86	245.08	123.40	121.67
Stack Basis Emissions Converted to g/sec									g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
Stack 1	1&2	691,893	3,778,033	207.5	219.5	14.2	12.5	327.0	198.03	355.18	45.32	19.80	11.01	8.79	8.46	0.33	25.52	12.84	12.67
Stack 2	3&4	691,893	3,778,033	207.5	219.5	14.2	15.8	327.0	239.55	219.86	45.12	14.24	7.92	6.32	6.09	0.23	30.88	15.55	15.33

Table 2-2 (Continued) Plant Bowen modeling emission parameters

Case	Source / Unit	Location UTM (Zone 16 NAD-83) UTM East	UTM North	Actual Stack Ht	Base Elev.	Flue Dia-meter	Gas Exit Vel.	Stack Gas Exit Temp.	Emissions[1] SO_2	NO_X	PM_{10}	Particle Speciation[2] Filt. PM_{10}	Coarse Soil	Fine PM	Fine Soil	EC	Cond. PM_{10}	H_2SO_4	Organic
		m	m	m	m	m	m/s	deg K	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr
EMISSIONS for MODELED CONTROL OPTIONS																			
Agglomerator/Juice Can Data (Unit Basis)																			
Agglom/JC	Unit 1	691,893	3,778,033	207.5	219.5	7.6	12.5	327.0	768.71	1565.42	145.09	46.12	25.98	20.14	19.40	0.75	98.97	49.77	49.20
Agglom/JC	Unit 2	691,893	3,778,033	207.5	219.5	7.6	12.5	327.0	802.97	1253.44	153.28	49.72	28.00	21.71	20.91	0.80	103.56	52.17	51.39
Agglom/JC	Unit 3	691,893	3,778,033	207.5	219.5	7.6	15.8	327.0	925.97	773.00	156.41	36.99	23.42	13.57	13.06	0.50	119.43	60.16	59.26
Agglom/JC	Unit 4	691,893	3,778,033	207.5	219.5	7.6	15.8	327.0	975.20	971.92	166.67	41.02	25.98	15.05	14.49	0.56	125.65	63.24	62.41
Agglomerator/Juice Can Data (Stack Basis) - Unit 1 Only Controlled																			
				Modeled Stk Ht[3]		Eq. Dia.													
		m	m	m	m	m	m/s	deg K	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr
Stack 1	1&2	691,893	3,778,033	207.5	219.5	14.2	12.5	327.0	1571.68	2818.85	330.16	127.63	71.30	56.33	54.25	2.08	202.53	101.94	100.59
Stack 2	3&4	691,893	3,778,033	207.5	219.5	14.2	15.8	327.0	1901.17	1744.92	358.13	113.05	62.86	50.20	48.34	1.86	245.08	123.40	121.67
Stack Basis Emissions Converted to g/sec									g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
Stack 1	1&2	691,893	3,778,033	207.5	219.5	14.2	12.5	327.0	198.03	355.18	41.60	16.08	8.98	7.10	6.84	0.26	25.52	12.84	12.67
Stack 2	3&4	691,893	3,778,033	207.5	219.5	14.2	15.8	327.0	239.55	219.86	45.12	14.24	7.92	6.32	6.09	0.23	30.88	15.55	15.33
Agglomerator/Juice Can Data (Stack Basis) - Unit 2 Only Controlled																			
				Modeled Stk Ht[3]		Eq. Dia.													
		m	m	m	m	m	m/s	deg K	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr
Stack 1	1&2	691,893	3,778,033	207.5	219.5	14.2	12.5	327.0	1571.68	2818.85	327.86	125.33	70.05	55.28	53.24	2.05	202.53	101.94	100.59
Stack 2	3&4	691,893	3,778,033	207.5	219.5	14.2	15.8	327.0	1901.17	1744.92	358.13	113.05	62.86	50.20	48.34	1.86	245.08	123.40	121.67
Stack Basis Emissions Converted to g/sec									g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
Stack 1	1&2	691,893	3,778,033	207.5	219.5	14.2	12.5	327.0	198.03	355.18	41.31	15.79	8.83	6.97	6.71	0.26	25.52	12.84	12.67
Stack 2	3&4	691,893	3,778,033	207.5	219.5	14.2	15.8	327.0	239.55	219.86	45.12	14.24	7.92	6.32	6.09	0.23	30.88	15.55	15.33

Table 2-2 (Continued) Plant Bowen modeling emission parameters

Case	Source / Unit	Location UTM (Zone 16 NAD-83)		Actual Stack Ht	Base Elev.	Flue Dia-meter	Gas Exit Vel.	Stack Gas Exit Temp.	Emissions[1]			Particle Speciation[2]							
		UTM East	UTM North						SO_2	NO_X	PM_{10}	Filt. PM_{10}	Coarse Soil	Fine PM	Fine Soil	EC	Cond. PM_{10}	H_2SO_4	Organic
Agglomerator/Juice Can Data (Stack Basis) - Unit 3 Only Controlled																			
				Modeled Stk Ht[3]		Eq. Dia.													
		m	m	m	m	m	m/s	deg K	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr
Stack 1	1&2	691,893	3,778,033	207.5	219.5	14.2	12.5	327.0	1571.68	2818.85	359.64	157.12	87.36	69.76	67.18	2.58	202.53	101.94	100.59
Stack 2	3&4	691,893	3,778,033	207.5	219.5	14.2	15.8	327.0	1901.17	1744.92	341.51	96.44	56.48	39.96	38.48	1.48	245.08	123.40	121.67
Stack Basis Emissions Converted to g/sec									g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
Stack 1	1&2	691,893	3,778,033	207.5	219.5	14.2	12.5	327.0	198.03	355.18	45.32	19.80	11.01	8.79	8.46	0.33	25.52	12.84	12.67
Stack 2	3&4	691,893	3,778,033	207.5	219.5	14.2	15.8	327.0	239.55	219.86	43.03	12.15	7.12	5.04	4.85	0.19	30.88	15.55	15.33
Agglomerator/Juice Can Data (Stack Basis) - Unit 4 Only Controlled																			
				Modeled Stk Ht[3]		Eq. Dia.													
		m	m	m	m	m	m/s	deg K	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr
Stack 1	1&2	691,893	3,778,033	207.5	219.5	14.2	12.5	327.0	1571.68	2818.85	359.64	157.12	87.36	69.76	67.18	2.58	202.53	101.94	100.59
Stack 2	3&4	691,893	3,778,033	207.5	219.5	14.2	15.8	327.0	1901.17	1744.92	339.70	94.62	55.78	38.85	37.41	1.44	245.08	123.40	121.67
Stack Basis Emissions Converted to g/sec									g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
Stack 1	1&2	691,893	3,778,033	207.5	219.5	14.2	12.5	327.0	198.03	355.18	45.32	19.80	11.01	8.79	8.46	0.33	25.52	12.84	12.67
Stack 2	3&4	691,893	3,778,033	207.5	219.5	14.2	15.8	327.0	239.55	219.86	42.80	11.92	7.03	4.89	4.71	0.18	30.88	15.55	15.33

Table 2-2 (Continued) Plant Bowen modeling emission parameters

Case	Source / Unit	Location UTM (Zone 16 NAD-83)		Actual Stack Ht	Base Elev.	Flue Dia-meter	Gas Exit Vel.	Stack Gas Exit Temp.	Emissions[1]			Particle Speciation[2]							
		UTM East	UTM North						SO_2	NO_X	PM_{10}	Filt. PM_{10}	Coarse Soil	Fine PM	Fine Soil	EC	Cond. PM_{10}	H_2SO_4	Organic
Wet ESP Data (Unit Basis)																			
Wet ESP	Unit 1	691,893	3,778,033	207.5	219.5	7.6	12.5	327.0	768.71	1565.42	66.71	7.56	4.20	3.36	3.23	0.12	59.15	9.95	49.20
Wet ESP	Unit 2	691,893	3,778,033	207.5	219.5	7.6	12.5	327.0	802.97	1253.44	69.98	8.15	4.53	3.62	3.48	0.13	61.82	10.43	51.39
Wet ESP	Unit 3	691,893	3,778,033	207.5	219.5	7.6	15.8	327.0	925.97	773.00	76.65	5.36	2.98	2.38	2.29	0.09	71.29	12.03	59.26
Wet ESP	Unit 4	691,893	3,778,033	207.5	219.5	7.6	15.8	327.0	975.20	971.92	81.01	5.95	3.31	2.64	2.54	0.10	75.06	12.65	62.41
Wet ESP Data (Stack Basis) - Unit 1 Only Controlled																			
				Modeled Stk Ht[3]		**Eq. Dia.**													
		m	**m**	**m**	**m**	**m**	**m/s**	**deg K**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**
Stack 1	1&2	691,893	3,778,033	207.5	219.5	14.2	12.5	327.0	1571.68	2818.85	251.78	89.06	49.52	39.54	38.08	1.46	162.72	62.13	100.59
Stack 2	3&4	691,893	3,778,033	207.5	219.5	14.2	15.8	327.0	1901.17	1744.92	358.13	113.05	62.86	50.20	48.34	1.86	245.08	123.40	121.67
Stack Basis Emissions Converted to g/sec									**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**
Stack 1	1&2	691,893	3,778,033	207.5	219.5	14.2	12.5	327.0	198.03	355.18	31.72	11.22	6.24	4.98	4.80	0.18	20.50	7.83	12.67
Stack 2	3&4	691,893	3,778,033	207.5	219.5	14.2	15.8	327.0	239.55	219.86	45.12	14.24	7.92	6.32	6.09	0.23	30.88	15.55	15.33
Wet ESP Data (Stack Basis) - Unit 2 Only Controlled																			
				Modeled Stk Ht[3]		**Eq. Dia.**													
		m	**m**	**m**	**m**	**m**	**m/s**	**deg K**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**
Stack 1	1&2	691,893	3,778,033	207.5	219.5	14.2	12.5	327.0	1571.68	2818.85	244.55	83.76	46.57	37.19	35.81	1.38	160.79	60.20	100.59
Stack 2	3&4	691,893	3,778,033	207.5	219.5	14.2	15.8	327.0	1901.17	1744.92	358.13	113.05	62.86	50.20	48.34	1.86	245.08	123.40	121.67
Stack Basis Emissions Converted to g/sec									**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**
Stack 1	1&2	691,893	3,778,033	304.8	219.5	14.2	12.5	327.0	198.03	355.18	30.81	10.55	5.87	4.69	4.51	0.17	20.26	7.59	12.67
Stack 2	3&4	691,893	3,778,033	304.8	219.5	14.2	15.8	327.0	239.55	219.86	45.12	14.24	7.92	6.32	6.09	0.23	30.88	15.55	15.33
Wet ESP Data (Stack Basis) - Unit 3 Only Controlled																			
				Modeled Stk Ht[3]		**Eq. Dia.**													
		m	**m**	**m**	**m**	**m**	**m/s**	**deg K**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**	**lbs/hr**
Stack 1	1&2	691,893	3,778,033	207.5	219.5	14.2	12.5	327.0	1571.68	2818.85	359.64	157.12	87.36	69.76	67.18	2.58	202.53	101.94	100.59
Stack 2	3&4	691,893	3,778,033	207.5	219.5	14.2	15.8	327.0	1901.17	1744.92	261.76	64.81	36.04	28.78	27.71	1.06	196.94	75.27	121.67
Stack Basis Emissions Converted to g/sec									**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**
Stack 1	1&2	691,893	3,778,033	207.5	219.5	14.2	12.5	327.0	198.03	355.18	45.32	19.80	11.01	8.79	8.46	0.33	25.52	12.84	12.67
Stack 2	3&4	691,893	3,778,033	207.5	219.5	14.2	15.8	327.0	239.55	219.86	32.98	8.17	4.54	3.63	3.49	0.13	24.81	9.48	15.33

Table 2-2 (Continued)   Plant Bowen modeling emission parameters

Case	Source / Unit	Location UTM (Zone 16 NAD-83)		Actual Stack Ht	Base Elev.	Flue Dia-meter	Gas Exit Vel.	Stack Gas Exit Temp.	Emissions[1]			Particle Speciation[2]							
		UTM East	UTM North						SO_2	NO_X	PM_{10}	Filt. PM_{10}	Coarse Soil	Fine PM	Fine Soil	EC	Cond. PM_{10}	H_2SO_4	Organic
Wet ESP Data (Stack Basis) - Unit 4 Only Controlled																			
				Modeled Stk Ht[3]		Eq. Dia.													
		m	m	m	m	m	m/s	deg K	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr	lbs/hr
Stack 1	1&2	691,893	3,778,033	207.5	219.5	14.2	12.5	327.0	1571.68	2818.85	359.64	157.12	87.36	69.76	67.18	2.58	202.53	101.94	100.59
Stack 2	3&4	691,893	3,778,033	207.5	219.5	14.2	15.8	327.0	1901.17	1744.92	254.03	59.55	33.11	26.44	25.46	0.98	194.49	72.81	121.67
Stack Basis Emissions Converted to g/sec									g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
Stack 1	1&2	691,893	3,778,033	207.5	219.5	14.2	12.5	327.0	198.03	355.18	45.32	19.80	11.01	8.79	8.46	0.33	25.52	12.84	12.67
Stack 2	3&4	691,893	3,778,033	207.5	219.5	14.2	15.8	327.0	239.55	219.86	32.01	7.50	4.17	3.33	3.21	0.12	24.51	9.17	15.33

Notes:

[1] SO_2 and NO_x emissions are not BART-applicable for EGU sources in CAIR states, if the state agency agrees with EPA's interpretation of the BART final rule. The emissions for SO_2 and NO_x are provided for information purposes, and for reference in the computation of certain particle species such as H_2SO_4.

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

[3] Stack credit is equal to actual stack height since this stack is grandfathered.

3.0 Input data to the CALPUFF model

3.1 General modeling procedures:

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

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

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

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

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

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

3.2 Air quality database (background ozone and ammonia)

Hourly measurements of ozone from all non-urban monitors, as generated by VISTAS and available on the VISTAS CALPUFF page on the Earth Tech web site (http://www.src.com/verio/download/sample_files.htm), will be used as input to CALPUFF. For ammonia, a 0.5 ppb background value as recommended by VISTAS will be used. However, since only PM emissions are being modeled, ozone and ammonia data is not really needed given that this data has no effect on PM results in CALPUFF.

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

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

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

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

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

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

4.0 Air quality modeling procedures

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

4.1 Model selection and features

As noted in the VISTAS protocol (Summary, Recommendations Section II.), VISTAS will use CALPUFF Version 5.754 and CALMET Version 5.7, which can be obtained at http://www.src.com/verio/download/download.htm#VISTAS_VERSION. These versions contain enhancements funded by the Minerals Management Service (MMS) and VISTAS. They are maintained on TRC's Atmospheric Studies Group CALPUFF website for public access. This release includes CALMET, CALPUFF, CALPOST, CALSUM, and POSTUTIL as well as CALVIEW.

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

The baseline BART modeling will be conducted for Bowen Units 1 thru 4 (BART eligible units) for each Class I area within 300 km of the source. Unit 1 thru 4 will each be modeled separately for the visibility improvement modeling for the BART determination step for the Class I areas where baseline modeling shows a greater than 0.5 deciview impact.

4.2 Modeling domain and receptors

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

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

4.3 Technical options used in the modeling

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

For CALPUFF model options, Plant Bowen will follow the VISTAS common BART modeling protocol (Section 4.4.1), which states that we should use IWAQM (EPA, 1998) guidance. The VISTAS protocol (Section 4.3.3) also notes that building downwash effects are not required to be included unless the state directs the source to include these effects. Since Plant Bowen is more than 50 km from the nearest Class I area, building downwash effects will not be included in the CALPUFF modeling.

The POSTUTIL utility program (VISTAS common protocol Section 4.4.2) will be used to repartition HNO_3 and NO_3 using VISTAS-provided ammonia concentrations derived from previous 2002 CMAQ modeling conducted by EPA or the alternate ammonia concentrations approach recommended by VISTAS, if the CMAQ data is unavailable. As indicated earlier, since only PM emissions are being modeled, the treatment of ammonia should not have an affect on PM results from CALPUFF.

4.4 Light extinction and haze impact calculations

The CALPOST postprocessor will be used as prescribed in the VISTAS protocol for the calculation of the impact from the modeled source's primary and secondary particulate matter concentrations on light extinction. The formula that is currently used in CALPOST is the existing (not the November 2005 revised) IMPROVE/EPA formula, which is applied to determine a change in light extinction due to increases in the particulate matter component concentrations. Using the notation of CALPOST, the formula is the following:

b_{ext} = 3 f(RH) [$(NH_4)2SO_4$] + 3 f(RH) [NH_4NO_3] + 4[OC] + 1[Soil] + 0.6[Coarse Mass] + 10[EC] + b_{Ray}

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

The extinction formula shown above is known to be inadequate in its representation of light extinction from sea salt and its usage of 1.4 as the organic mass to carbon mass ratio. Furthermore, guidance for this formula did not provide for site-specific Rayleigh scattering. In December of 2005, the IMPROVE Steering Committee adopted a new formula for determining light extinction that addresses these and other shortcomings. The new formula is shown below..

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

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

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

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

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

This revised version of the IMPROVE Equation will be used to calculate visibility improvement results for the BART determination modeling. Dr. Ivar Tombach (VISTAS consultant) has produced a spreadsheet tool (September 29, 2006) to allow the new IMPROVE formula results to be derived from the basic CALPOST outputs. Also, since the BART determination modeling is focused only on PM, NO_2 will be set to zero in the new formula. For informational purposes only, results from the old equation will also be presented.

The assessment of visibility impacts at the Class I areas will use CALPOST Method 6 (VISTAS common protocol Section 4.3.2). Each hour's source-caused extinction is calculated by first using the hygroscopic components of the source-caused concentrations, due to ammonium sulfate and nitrate, and monthly Class I area-specific f(RH) values. The contribution to the total source-caused extinction from ammonium sulfate and nitrate is then added to the other, non-hygroscopic components of the particulate concentration (from coarse and fine soil, secondary organic aerosols, and from elemental carbon) to yield the total hourly source-caused extinction.

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

Figure 4-1 of the VISTAS common BART modeling protocol presents a flow chart showing the components of that common protocol. The modeling for Plant Bowen will focus on Subregional Fine-Scale modeling as depicted in the lower half of the figure.

The source will perform BART determination modeling for the baseline and each control option in the manner described in this document.

5.0 Presentation of modeling results

The BART determination modeling results for Plant Bowen will be provided to the state agency in a manner as described in the VISTAS protocol (Section 4.5). The results will include the following elements (as suggested in the VISTAS protocol):

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

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

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

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

The BART determination modeling will be performed for those Class I areas shown in the baseline modeling to exceed 0.5 dv impact. The results presented will be a comparison of the 98th percentile value for the baseline and each control option and emissions unit derived as is outlined above for the baseline modeling. A summary of the relative results among all emission scenarios run would be produced.

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

Appendix A

Basis for Source-Specific Sulfuric Acid Emissions

Appendix A

Basis for Source-Specific Sulfuric Acid Emissions

<u>Sulfuric Acid (H2SO4) Emissions</u>

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

Since this facility contains post-combustion NOx control (SCR), the baseline sulfuric acid emissions estimate accounts for the manufacture of H_2SO_4 through combustion and through further oxidation of SO_2 in the SCR. Calculated sulfuric acid releases then account for loss or removal within the system. The equations below show how the manufacture and release calculations are made. Table A-1 shows the resulting H_2SO_4 emissions calculations .

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

Sulfuric Acid Released from Combustion (ERComb)
ERComb = EMComb x F2 (technology impact factors for air heater and ESP)
ERComb = EMComb x (0.49) x (0.49)

Sulfuric Acid Manufactured by SCR (EMSCR)
EMSCR = K * S2 * fs * E2
where,
EMSCR = Total sulfuric acid manufactured from SCR, lbs per year
K = Conversion factor = 3063
S2 = SCR catalyst SO2 oxidation rate (specified as a decimal)
fs = Operating factor of SCR system, fraction of coal burn when SCR operates
E2 = SO2 produced, tons per year

Sulfuric Acid Released from SCR (ERSCR)
ERSCR = [EMSCR – (Ks * B * fs * SNH3)] * F2x
where,
ERSCR = Total sulfuric acid released from SCR, lbs per year
EMSCR = Total sulfuric acid manufactured from SCR, lbs per year
Ks = Conversion factor = 3799
B = Coal burn in TBtu/hr

fs = Operating factor of SCR system, fraction of coal burn when SCR operates
SNH3 = NH3 slip from SCR, ppmv at 3% O2
F2x = Technology Impact Factors, all that apply

Sulfuric Acid Manufactured from Flue Gas Conditioning (EMfgc):
EMfgc = Ke x B x fe x Is
where,
EMfgc = total sulfuric acid manufactured from flue gas conditioning system, lbs/hr
Ke = Conversion Factor = 3,799
B = Coal burn in TBtu/hr
fe = Operating factor of FGC system, fraction of coal burned when FGC operates
Is =SO3 injection rate in ppmv at 6% O2, wet

Sulfuric Acid Released from FGC (ERfgc)
ERfgc = [EMfgc – (Ke * B * fe * I_{NH3})] * F3 x F2
where,
ERfgc = Total sulfuric acid released from FGC, lbs per hour
EMfgc = Total sulfuric acid manufactured from FGC, lbs per hour
Ke = Conversion factor = 3799
B = Coal burn in TBtu/hr
fe = Operating factor of FGC system, fraction of coal burn when FGC operates
I_{NH3} = NH3 injection for dual flue gas conditioning system, ppmv at 6% O2, wet (= 0 if no NH3 used)
F3 = Technology Impact Factors for FGC
F2 = Technology Impact Factors <u>for equipment after ESP only</u>
    If no control after ESP, F2 = 1

Total Sulfuric Acid Released (TSAR):
TSAR = ERComb + ERSCR + ERfgc[Bowen 3 and 4 only]

Table A-1 Plant Bowen sulfuric acid calculations

Case		Source / Unit	SO2	Conv. Factor	Fuel Impact Factor	Manuf from Combut.	APH Factor	ESP Factor	Released From Combust.	SCR Oxid. Rate	SCR Op. Factor	Manuf by SCR	Coal Burn, B	Conv. Factor	NH3 Slip	Releas. from SCR
			lbs/hr	K	F1	lbs/hr	F2	F2	lbs/hr	S2	fs	lbs/hr	TBtu/hr	Ks	SNH3	lbs/hr
EC	NS	Unit 1	17069.4	3063	0.008	209.1	0.49	0.49	50.2	0.0075	0	0.0	0.00684	3799	0.75	0.0
EC	S	Unit 1	15374.2	3063	0.008	188.4	0.49	0.49	45.2	0.0075	1	176.6	0.00684	3799	0.75	37.7
Baseline	S	Unit 1	15374.2	3063	0.008	188.4	0.49	0.49	45.2	0.0075	1	176.6	0.00684	3799	0.75	37.7
EC	NS	Unit 2	17247.6	3063	0.008	211.3	0.49	0.49	50.7	0.0075	0	0.0	0.00669	3799	0.75	0.0
EC	S	Unit 2	16059.4	3063	0.008	196.8	0.49	0.49	47.2	0.0075	1	184.5	0.00669	3799	0.75	39.7
Baseline	S	Unit 2	16059.4	3063	0.008	196.8	0.49	0.49	47.2	0.0075	1	184.5	0.00669	3799	0.75	39.7
EC	NS	Unit 3	20652.4	3063	0.008	253.0	0.49	0.49	60.8	0.0075	0	0.0	0.00772	3799	0.75	0.0
EC	S	Unit 3	18519.4	3063	0.008	226.9	0.49	0.49	54.5	0.0075	1	212.7	0.00772	3799	0.75	45.8
Baseline	S	Unit 3	18519.4	3063	0.008	226.9	0.49	0.49	54.5	0.0075	1	212.7	0.00772	3799	0.75	45.8
EC	NS	Unit 4	20097.2	3063	0.008	246.2	0.49	0.49	59.1	0.0075	0	0.0	0.00843	3799	0.75	0.0
EC	S	Unit 4	19504.1	3063	0.008	239.0	0.49	0.49	57.4	0.0075	1	224.0	0.00843	3799	0.75	48.0
Baseline	S	Unit 4	19504.1	3063	0.008	239.0	0.49	0.49	57.4	0.0075	1	224.0	0.00843	3799	0.75	48.0

EC= Existing Configuration (i.e., no scrubber) Baseline=Scrubbed NS = No SCR Operation S= SCR Operation

Case		Source / Unit	Conv. Factor	FGC Op. Factor	SO3 Injection Rate	Manuf by FGC	Tech Impact Factor for FGC	Tech Impact Factor for Equip after ESP	NH3 Injection Rate	Released From FGC	Total Released without Scrubber	Removal Rate for Scrubber	Total Released after Scrubber
			Ke	fe	Is	lbs/hr	F3	F2	I_{NH3}	lbs/hr	lbs/hr	%	lbs/hr
EC	NS	Unit 1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	50.2		
EC	S	Unit 1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	83.0		
Baseline	S	Unit 1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	83.0	40	49.8
EC	NS	Unit 2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	50.7		
EC	S	Unit 2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	87.0		
Baseline	S	Unit 2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	87.0	40	52.2
EC	NS	Unit 3	3799	1.0	7.0	205.2	0.25	1.0	0.0	51.3	112.1		
EC	S	Unit 3	3799	1.0	7.0	205.5	0.25	1.0	0.0	51.3	151.6		
Baseline	S	Unit 3	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	100.3	40	60.2
EC	NS	Unit 4	3799	1.0	7.0	224.3	0.25	1.0	0.0	56.1	115.2		
EC	S	Unit 4	3799	1.0	7.0	224.3	0.25	1.0	0.0	56.1	161.5		
Baseline	S	Unit 4	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	105.4	40	63.2

EC= Existing Configuration (i.e., no scrubber) Baseline=Scrubbed NS = No SCR Operation S= SCR Operation

Appendix B

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

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