west virginia department of environmental protection

Appendix E:
Modeling

West Virginia Division of Air Quality
601 57th Street, SE
Charleston, WV 25304

Promoting a healthy environment.

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Modeling Analysis Report

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AIR QUALITY MODELING REPORT

1-Hour SO_2 Nonattainment SIP

Mountain State Carbon, LLC
Follansbee, WV

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November 2015

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TABLE OF CONTENTS

1. EXECUTIVE SUMMARY 1-1

2. FACILITY BACKGROUND 2-1
- **2.1. Process Description** 2-1
- **2.2. Modeled Emission Sources** 2-3

3. SO_2 MODELING EMISSIONS INVENTORY 3-1
- **3.1. Modeled On-Site Emission Sources** 3-1
  - *3.1.1. Point Sources* 3-1
  - *3.1.2. COG Flare* 3-1
  - *3.1.3. Characterization of Coke Battery Fugitive Emissions* 3-2
  - *3.1.4. MSC Emissions during Desulfurization Plant Outage* 3-4
- **3.2. Ohio EPA Emissions Sources** 3-4

4. DISPERSION MODELING METHODOLOGY 4-1
- **4.1. Dispersion Model Selection** 4-1
- **4.2. Coordinate System** 4-2
- **4.3. Meteorological Data** 4-2
  - *4.3.1. Surface Data Observations and Processing* 4-3
  - *4.3.2. Upper Air Data Observations and Processing* 4-4
  - *4.3.3. Surface Characteristics* 4-4
  - *4.3.4. AERMET Stage 3 Processing* 4-6
- **4.4. Receptor Grid** 4-6
- **4.5. Elevated Terrain** 4-8
- **4.6. Modeled Source Types and Stack Parameters** 4-9
  - *4.6.1. MSC Source Inventory* 4-9
  - *4.6.2. Regional Inventory Sources* 4-9
- **4.7. Building Downwash** 4-9
- **4.8. GEP Stack Height analysis** 4-10
- **4.9. Ambient Background Concentration** 4-11

5. ATTAINMENT MODELING DEMONSTRATION RESULTS 5-1
- **5.1. Modeling With Desulfurization Plant Outages and Increased Flare** 5-1
- **5.2. Discussion of Results** 5-1
- **5.3. Compliance Demonstration Summary** 5-3

APPENDIX A: SO_2 MODELING EMISSION SOURCE INVENTORY

APPENDIX B: BLP SUPPORTING DOCUMENTATION

APPENDIX C: AMBIENT BACKGROUND CONCENTRATION DOCUMENTATION

APPENDIX D: MODELING FILES ON CD

1. EXECUTIVE SUMMARY

On June 22, 2010, the United State Environmental Protection Agency (U.S. EPA) published in the Federal Register (FR) a new National Ambient Air Quality Standard (NAAQS) for 1-hour average sulfur dioxide (SO_2). The new standard, 75 parts per billion (ppb), is based on the three-year average of the annual 99th percentile of 1-hour daily maximum concentrations.[1] This new short-term SO_2 NAAQS became effective on August 23, 2010.

Mountain State Carbon, LLC (MSC) owns and operates a metallurgical coke production facility in Follansbee, WV (Follansbee Plant). The Follansbee Plant is located in the Cross Creek tax district of Brooke County and is regulated by the West Virginia Department of Environmental Protection (WVDEP). On August 5, 2013, the United State Environmental Protection Agency (U.S. EPA) published the initial nonattainment area designations for the 1-hour average National Ambient Air Quality Standards (NAAQS).[2] The Cross Creek tax district was included in the nonattainment designation for the Steubenville, OH-WV nonattainment area.

WVDEP, as a regulatory agency with a SO_2 nonattainment area, is required to satisfy the requirements contained in Sections 172, 191 and 192 of the Clean Air Act. In short, WVDEP must submit a State Implementation Plan (SIP) that contains an attainment demonstration showing that the nonattainment area will attain the NAAQS by no later than October 4, 2018. The attainment demonstration includes, in part, an air quality modeling analysis that demonstrates that the SIP emission limits are appropriate for achieving the NAAQS. This report outlines the attainment demonstration modeling analyses conducted by MSC in support of WVDEP's SIP.

The remainder of this report is organized as follows:

- Section 2 – Facility Background
- Section 3 – SO_2 Modeling Emissions Inventory
- Section 4 – Dispersion Modeling Methodology
- Section 5 – Attainment Modeling Demonstration Results
- Appendix A – SO_2 Modeling Emission Source Inventory (Detailed)
- Appendix B – BLP Supporting Documentation
- Appendix C – Ambient Background Concentration Documentation (Excerpt from Ohio EPA SIP)
- Appendix D – Modeling Files on CD

[1] 75 FR 35520
[2] 78 FR 47191

2. FACILITY BACKGROUND

MSC owns and operates a metallurgical coke production facility in Follansbee, WV Follansbee Plant. Operations at the Follansbee Plant include four (4) by-product recovery coke production batteries, four (4) boilers fired with coke oven gas (COG) generated in the batteries, an excess COG flare, and other miscellaneous combustion sources. These and other emission units at the Follansbee Plant are permitted under Title V operating permit R30-00900002-2010 issued by the WVDEP on January 5, 2010. Being situated in the Steubenville, OH-WV 1-hour SO_2 nonattainment area, the Follansbee Plant is to be included in the dispersion modeling compliance demonstration as part of the SO_2 SIP submittal to U.S. EPA.

2.1. PROCESS DESCRIPTION

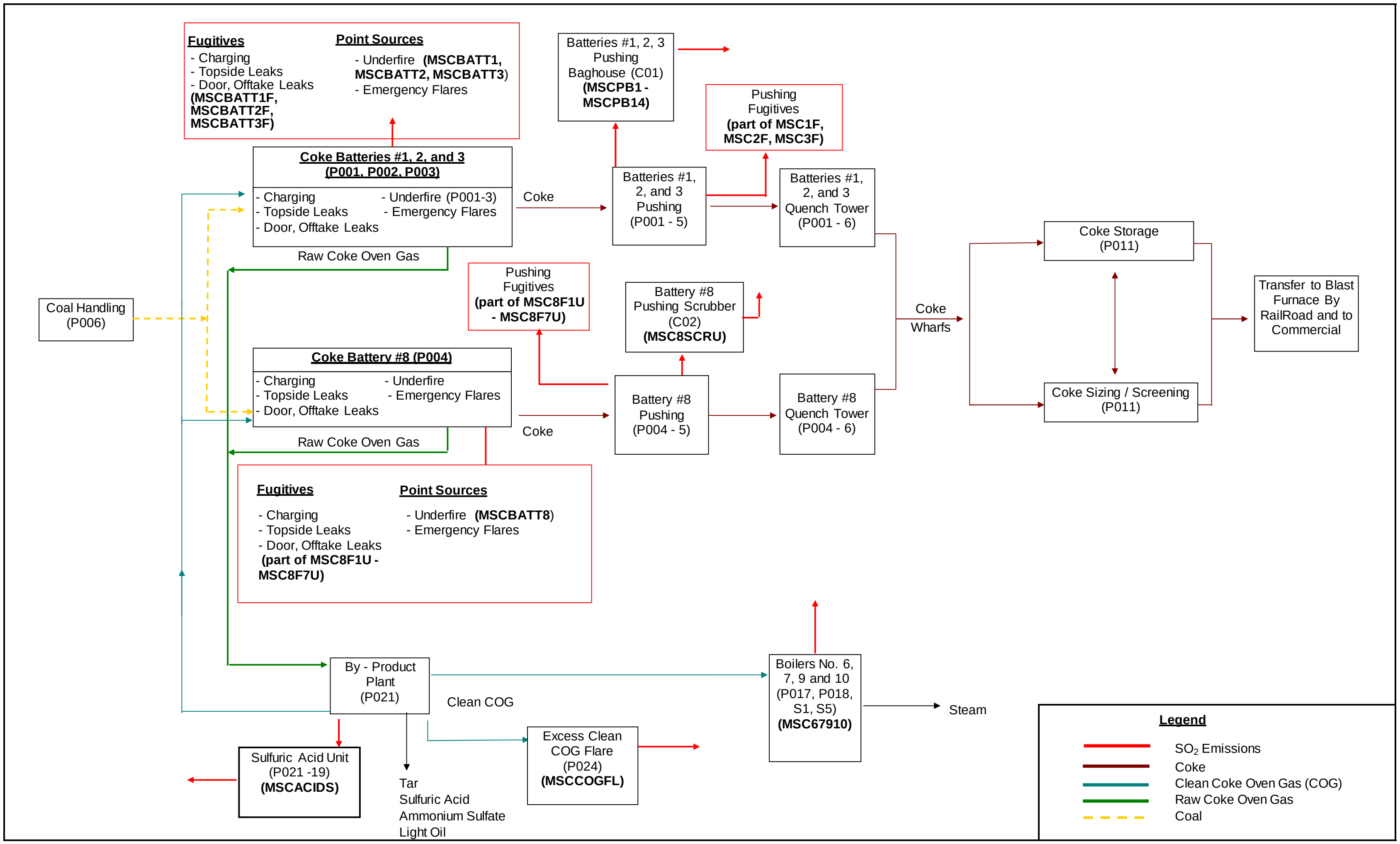
Metallurgical coke is produced by the destructive distillation of coal in coke ovens. Prepared coal is heated in an oxygen-free atmosphere ("coked") until the volatile components in the coal are removed as raw Coke Oven Gas (COG). The material remaining is a carbon mass called coke. Metallurgical coke produced at Mountain State Carbon (MSC) may be used in blast furnaces or foundry operations to reduce iron ore to iron.

The volatile components evolved from the coal at MSC are processed in the byproducts plant to produce crude coal tar, sulfuric acid, ammonium sulfate, light oil, and fuel coke oven gas. Crude coal tar is removed from the gas first due to the addition of flushing liquor used to cool the gas as it enters the collection main and secondly in the final cooler. The combined crude coal tar and flushing liquor enter the tar decanters where they are gravity separated. The tar is transferred to off-site processors, while the flushing liquor is transferred to the batteries for reuse.

With the majority of tar removed, the COG is conveyed to the H2S scrubber for desulfurization, where hydrogen sulfide is successively oxidized to produce sulfur dioxide, then sulfur trioxide, which is combined with water to produce sulfuric acid. The majority of sulfuric acid is then sprayed into the COG in the "Saturator" to remove ammonia and produce ammonium sulfate crystalline product (sold as fertilizer). Any excess sulfuric acid is either held for use during desulfurization outages, or sold as a separate product.

After sulfur and ammonia removal, the COG then enters the Final Cooler, which allows further cooling and naphthalene removal (using tar returned to the tar decanters). COG then enters the light oil process, where the light organic components are scrubbed from the COG using wash oil to produce light oil. The resulting cleaned COG is then considered 'fuel gas' and combusted either at the batteries or plant boilers. COG not needed for combustion is combusted at the excess COG flare.

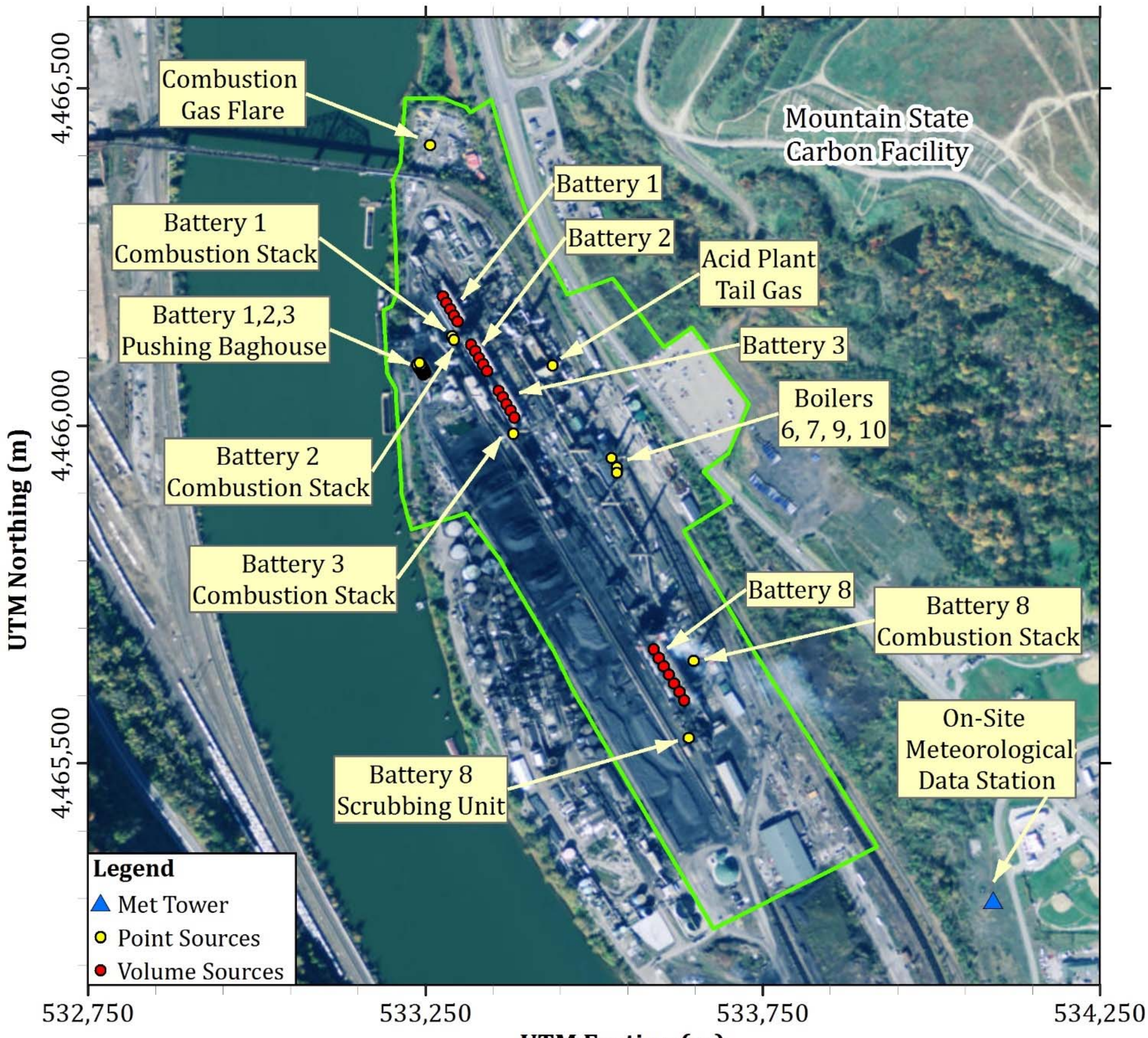
Figure 1: Follansbee Plant Process Flow Diagram



2.2. MODELED EMISSION SOURCES

In communications with WVDEP, it is MSC's understanding that the SIP submittal modeling assessment will only take into consideration those SO_2 emitting sources located at the Follansbee Plant and at nearby operations located in Ohio, the latter being addressed specifically in Ohio Environmental Protection Agency's (Ohio EPA's) SIP submittal. A process description of the Follansbee Plant, including a process flow diagram, was discussed above. Each of the MSC SO_2 sources included in the modeling analysis are listed in Table A-1 along with their corresponding Title V and modeling identification codes. The same sources are further detailed along with their corresponding source parameters (e.g. temperature, stack height, stack diameter, exit velocity) in Tables A-2 and A-3. In addition, each of these sources are annotated in Figure 2 below; depicting the location of each source within the Follansbee Plant. Each battery shown in the figure consists of several fugitive emission sources (volume sources) as well as a combustion stack (point source). In addition to the MSC sources, the modeling analysis also includes a regional inventory of SO_2 emitting facilities, which are further discussed in Section 3 of this report.

Figure 2: Facility Map with Annotated Emission Sources



All Coordinates shown in UTM Coordinates,
Zone 17, NAD 83 Datum

As previously mentioned, MSC currently operates coke oven batteries, boilers, an excess COG flare, and other miscellaneous combustion units, each of which is involved in the emission of SO_2. These emission units require the use of point, fugitive, and flare emission sources within the dispersion model in order to best represent the SO_2 dispersion within the atmosphere. Modeled emission rates are based on a combination of U.S. EPA AP-42 emission factors, engineering estimates and existing Title V permit limits. MSC controls emissions of SO_2 from the Follansbee Plant using a pre-combustion desulfurization system that reduces sulfur concentrations in the coke oven gas prior to combustion. Ammonia liquor produced at the Follansbee Plant absorbs hydrogen sulfide (H_2S) from the coke oven gas, and MSC uses a steam deacifier to extract the sulfurous compounds for the purposes of manufacturing sulfuric acid and fertilizer. The majority of by-product coke production facilities do not have desulfurization systems implemented to control SO_2.[3]

The following subsections describe the existing MSC sources, and regional sources considered in the SIP air quality modeling.

3.1. MODELED ON-SITE EMISSION SOURCES

Characterization of each source of emissions is necessary for the dispersion modeling to be performed. The AERMOD Model allows for emission sources to be represented as point, area, or volume sources where stacks are generally characterized as point sources and fugitive emissions as an area or volume source depending on the specifics of the release in terms of areal coverage, inside or outside a building, vertical extent, etc. The following subsections describe the source characterization and exhaust parameters associated with the categories of applicable emission sources at MSC. A list of all modeled emission sources at MSC is presented in Table A-1 of Appendix A along with the corresponding source designations (identification names) used in the modeling files. The basis for modeled emissions at the Follansbee Plant is outlined in Tables A-9 through A-12 of Appendix A.

3.1.1. Point Sources

Stacks and vents are modeled in the context of the AERMOD Model as point sources. Point sources can either be oriented vertically and unobstructed (V), oriented vertically and equipped with caps (C), or oriented horizontally (H). For point sources with unobstructed vertical releases, actual stack parameters (i.e., height, diameter, exhaust gas temperature, and gas exit velocity) are most appropriate to use in the dispersion modeling analyses because they best represent the characterization of the source. Except as outlined in Section 3.1.2, all point sources modeled for MSC are unobstructed vertical releases. Table A-2 of Appendix A provide the stack parameters for all MSC point sources.

3.1.2. COG Flare

One of the emissions sources at MSC is an excess COG flare. Representing a flare in an air dispersion model is different than representing a typical point source because combustion processes actually occur at the flare tip releasing heat which significantly alters all stack exhaust parameters required as inputs to the model. Neither WVDEP nor the *Guideline* describe a methodology for characterizing flares in PSD air quality analysis.[4] Flare

[3] AIST 2015 Cokemaking Byproducts Roundup – Iron & Steel Technology – March 2014 – AIST.org.

[4] EPA's *Guideline on Air Quality Models,* 40 CFR Part 51, Appendix W (Revised, November 9, 2005)

modeling guidance from other state environmental agencies and within other models was reviewed to determine the most representative methodology for the current modeling.[5,6] Overall, the emissions and characteristics of a flare can be modeled as a pseudo-point source with the modeled values of stack height, exit temperature, and exit diameter adjusted to account for the unique buoyancy flux occurring at the flare tip.

The temperature and exhaust velocity of the flare were assumed to be 1,273K (1,832°F) and 20 m/s (3,937 fpm), respectively. Using these constant parameters and the heat input for the flare, the following procedure was used to calculate the modeled stack height and diameter for the flare. As shown in the equations below, the primary factor in adjusting the stack parameters for a flare is the heat released in MMBtu/hr.

1) Compute the adjustment to stack height ($H_{eff.}$) as a function of total heat release (Q_T) in MMBtu/hr:

   $$H_{eff.} = H_{stack,\ actual} + 0.00456(Q_T)^{0.478}$$

2) Assume temperature of 1,273°K (1,832°F);

3) Assume exit velocity of 20 m/s (3,937 fpm);

4) Calculate the sensible/Net Heat Available (Q_H) for plume rise enhancement by multiplying the total heat release (Q_T) by 0.45 to account for radiative loss:

   $$Q_H = 0.45(Q_T)$$

5) Determine the effective stack diameter (D_{eff}) based on the net heat release:

   $$D_{eff.} = 9.88\text{x}10^{-4}(Q_H)^{0.5}$$

As shown in Table A-7 of Appendix A, modeled flare stack parameters were calculated in accordance with this methodology. Table A-2 of Appendix A includes derived and assumed stack parameters to characterize this flare under the 24 million cubic feet per day (MMscf/day) COG scenario.

3.1.3. Characterization of Coke Battery Fugitive Emissions

The treatment of the fugitive emissions associated with the batteries poses another unique consideration for this modeling analysis. Specifically, the fugitive emissions originate at points all along each battery and as such the most appropriate characterization in the AERMOD model is a volume source. However volume source parameterization does not directly account for the thermal, buoyant momentum associated with hot releases such as the battery fugitive emissions. As such, the Buoyant Line and Point Source (BLP) dispersion model was used in this modeling analysis to provide more reasonable release parameters for input to AERMOD for the coke battery sources. The BLP dispersion model was developed by Environmental Research and Technology Inc.

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[5] *Engineering Guide #69, Air Dispersion Modeling Guidance*. Ohio EPA, Division of Air Pollution Control, Air Quality Modeling and Planning Section. Revised July 22, 2014.

[6] *Screening Procedures for Estimating the Air Quality Impact of Stationary Sources*, Revised, EPA-454/R-92-019, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1992.

(ERT) to address the unique transport, including the unique plume rise, and diffusion of emissions from buoyant line sources (e.g., coke battery). BLP is a preferred/recommended model for representing buoyant line sources per the *Guideline.*[7] BLP can simulate dispersion from line sources either using a single day of user supplied meteorological data or a full year of data prepared using the preprocessing utilities PCRAMMET or MPRM.

3.1.3.1. BLP Processing

Modeling line sources in BLP requires the user to input the following parameters to assist in calculating dispersion: the average length, width and height of the building containing the line source, the line source width, the average separation between buildings containing the sources, and the average buoyancy parameter (which is a function of building length, line source width, exit velocity, and ambient and exit temperatures). In addition to these fixed parameters, the user must also specify the location (beginning and ending coordinates), the release height, the emission rate, and the base elevation of each line source modeled. BLP input parameters used in the current analysis were consistent with those used for Batteries 1, 2, 3, and 8 at the Mountain State Carbon facility in the March 2007 PM_{10} SIP Modeling Report and specifically, Appendix A of the Modeling report which is included as Appendix B to this report.[8] As was the case in the 2007 SIP modeling analysis, the default BLP code was modified to generate an output file containing information on hourly plume rise for each battery for use in developing input parameters to AERMOD.

One update made to the previous SIP modeling analysis was to use more recent meteorological data in BLP, with a time period consistent with that used in the current AERMOD analysis (2007 through 2009). Meteorological data gathered at a site-specific tower (the same data set used in AERMET to generate inputs for AERMOD) were supplemented by hourly surface data collected at the Pittsburgh National Weather Service (NWS) station for use in the Meteorological Processor for Regulatory Models (MPRM) utility.[9] Daily mixing height data were generated for input to MPRM using EPA's Mixing Height Program with NWS surface and upper air data gathered at Pittsburgh.

To ensure that a complete set of hourly plume rise values was available for use in AERMOD, a second set of meteorological data were generated using Pittsburgh surface and upper air data as input to PCRAMMET. These meteorological data were then used as input to BLP, using all other inputs identical to those used in the BLP runs using site-specific data. Plume rise values from these NWS meteorological data runs were then substituted into the final plume rise data set for hours with the missing site-specific meteorological data.

3.1.3.2. Volume Source Characterization

Hourly plume rise values output by BLP were used to generate an HOUREMIS file for input to AERMOD. Fugitive emissions from Batteries 1, 2, and 3 were represented in AERMOD as five volume sources, each, situated in series along each battery roof vent. The hourly-varying release height for each volume source representing Batteries 1, 2, and 3 was calculated by adding 7 meters to the battery-specific plume rise output by BLP for each hour. This value is derived based on the height of the coal side car shed for Batteries 1, 2 and 3. The initial vertical dimension of each volume source was calculated by dividing the release height by 2.15, treating each volume source as an elevated source adjacent to a building (i.e., the coke battery structures). The initial lateral dimension of each Battery 1, 2, and 3 volume source was set at 5.33 meters, the distance between each volume source divided by 2.15.

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[7] EPA's *Guideline on Air Quality Models,* 40 CFR Part 51, Appendix W (Revised, November 9, 2005)
[8] BLP inputs are provided in Tables A-8 to A-11 of Appendix A to this report.
[9] MPRM was used rather than PCRAMMET because MPRM has the ability to process non-airport meteorological data, such as that available in this case, while PCRAMMET does not.

Battery 8 fugitive emissions were represented in AERMOD as seven volume sources situated in series along the Battery 8 roof vent. The hourly-varying release height for each volume source representing the Battery was calculated by adding 13.72 meters, the approximate height of the Battery 8 structure, to the battery-specific plume rise output by BLP for each hour. The initial vertical dimension of each volume source was calculated by dividing the release height by 2.15, treating each volume source as an elevated source adjacent to a building (i.e., the coke battery structures). The initial lateral dimension of each Battery 8 volume source was 6.84 meters, the approximate distance between each volume source divided by 2.15.

The base parameters utilized for all Battery fugitive emissions, prior to consideration of additional plume rise from BLP, are listed in Table A-3 of Appendix A.

3.1.4. MSC Emissions during Desulfurization Plant Outage

The MSC desulfurization plant requires routine planned maintenance in order to continue normal operation throughout the remainder of the year. Maintenance is accomplished by shutting down the desulfurization plant operations for a period of 10 days on average throughout a planned outage timeframe. During this period, the desulfurization plant will be unable to control the SO_2 emissions from MSC emission units.

Due to the unavailability of the desulfurization plant, emissions during the outage period will be different from those during normal operation in the modeling analysis, however the emission calculation methodology is identical save for the control device reduction efficiency. To account for these temporally changing emissions during planned outages, hourly emission files were generated and utilized in the modeling analysis. The modeled desulfurization plant outages are addressed further in Section 5.1.[10]

3.2. OHIO EPA EMISSIONS SOURCES

Regional sources of SO_2 included in the modeling analysis were identified by the Ohio EPA. The only sources deemed necessary for inclusion in the analysis were those present at the Mingo Junction Energy Center, the former Wheeling Pittsburgh Mingo Junction Steel Plant ("Mingo Junction Steel Works"), and the American Electric Power (AEP) Cardinal Power Plant. These three sources fall under Ohio EPA facility identification numbers 0641090234, 0641090010, and 0641050002 respectively. The Mingo Junction Steel Works and Mingo Junction Energy Center sources are situated approximately one mile south-southwest of MSC on the opposite side of the Ohio River. The Cardinal Power Plant is located approximately six and a half miles south-southwest of MSC, also on the opposite side of the Ohio River.

The Mingo Junction Energy Center consists of four boilers permitted to burn desulfurized COG in addition to natural gas and clean blast furnace gas. The source of blast furnace gas has since been removed and it is MSC's intent to no longer provide desulfurized COG to the boilers. As such, the only remaining, potentially viable fuel for these boilers is natural gas. Thereby, the Mingo Junction Energy Center has been included in the model with emissions associated with this fuel option (0.5 pound per hour per boiler in accordance with Ohio EPA's planned SIP). Any significant SO_2 emissions associated with this site in the future will require the appropriate Ohio EPA pre-construction permitting. Note that the Mingo Junction Energy Center is situated within the Mingo Junction Steel Works property boundary.

The Mingo Junction Steel Works consists of the following emissions units:

[10] Per *Appendix W Section 8.1.2(a.) footnote (a)*, "Malfunctions which may result in excess emissions are not considered to be a normal operating condition." As such, planned outages (as opposed to unplanned outages) of the desulfurization plant are the only outages included in this modeling analysis.

- One (1) electric arc furnace (EAF);
- One (1) ladle metallurgy furnace (LMF); and
- Three (3) reheat furnaces.

Ohio EPA's SIP submittal included a compliance modeling demonstration that maintained the EAF and LMF at existing permit limits. However, the reheat furnaces are required to switch to natural gas.

AEP's Cardinal Power Plant was shown by Ohio EPA to have a negligible model predicted impact in the northern portions of the nonattainment area at times when the model predicted the largest concentrations resulting from the sources in the north (i.e., MSC and the Mingo Junction sources). Nonetheless, this analysis conservatively included Cardinal Power Plant emissions, as quantified by Ohio EPA in their SIP submittal.

These sources along with their stack parameters are further detailed in Table A-4. The stack parameters utilized for Mingo Junction Energy Center and Mingo Junction Steel Works in the analysis were provided by Ohio EPA and are reflective of those included in their SIP submittal.

This section of the modeling report describes the procedures and data resources utilized in the air quality modeling analyses performed to demonstrate attainment of the SO_2 NAAQS. In general, the air dispersion modeling analyses were conducted in accordance with applicable EPA guidance documents, including the following:

- EPA's *Guideline on Air Quality Models,* 40 CFR Part 51, Appendix W (Revised, November 9, 2005)
- EPA 's *AERMOD Implementation Guide* (Revised, March 19, 2009)[11]
- EPA's *Addendum to the User's Guide for the AMS/EPA Regulatory Model – AERMOD* (Revised May 2014)[12]
- EPA's *Technical Support Document, Area Designations For the 2010 SO_2 Primary National Ambient Air Quality Standard*
- Ohio EPA, Division of Air Pollution Control. *Ohio's 2010 Revised Sulfur Dioxide National Ambient Air Quality Standard Recommended Designations and Nonattainment Boundaries* (June 1, 2011)
- Ohio EPA's *State of Ohio Nonattainment Area State Implementation Plan and Demonstration of Attainment for 1-Hour SO2 Nonattainment Areas* (April 3, 2015).

4.1. DISPERSION MODEL SELECTION

Dispersion models predict pollutant concentrations downwind of a source by simulating the evolution of the pollutant plume over time and space given data inputs that include the quantity of emissions and the initial exhaust release conditions (e.g., velocity, flow rate, and temperature). In collaboration with both WVDEP and Ohio EPA, MSC selected the EPA-recommended AERMOD Model (Version 14134). AERMOD is a refined, steady-state (both emissions and meteorology over a one hour time step), multiple source, dispersion model that was promulgated by U.S. EPA in December 2005 as the preferred model to use for industrial sources in this type of air quality analysis.[13] Following procedures outlined in the *Guideline on Air Quality Models*, the AERMOD modeling was performed using the regulatory default options in all cases.

In coordination with the use of AERMOD, the BLP model, which is the preferred/recommended model for representing buoyant line sources, was utilized to assist with the characterization of coke battery fugitive emissions included in the hourly emissions files. This approach, which is described more fully in Section 3.1.3, is consistent with historic modeling of the Mountain State Carbon facility such as that performed in support of 2007 PM_{10} SIP modeling and current SO_2 SIP modeling efforts conducted by Ohio EPA for the nonattainment area. Specifically, BLP was executed to inform AERMOD of the release height parameters for the volume sources modeled to represent the coke battery fugitives. This is necessary since AERMOD's volume source parameterization does not directly account for the thermal, buoyant momentum associated with hot releases such as the coke battery fugitive emissions. EPA has recognized this need through the inclusion of the buoyant

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[11] EPA, OAQPS AERMOD Implementation Workgroup, *AERMOD Implementation Guide*, March 19, 2009, available at http://www.epa.gov/scram001/7thconf/aermod/aermod_implmtn_guide_19March2009.pdf

[12] *Addendum to the User's Guide for the AMS/EPA Regulatory Model – AERMOD*, EPA-454/B-03-001, EPA, OAQPS, Research Triangle Park, NC, May 2014.

[13] 40 CFR 51, Appendix W–*Guideline on Air Quality Models*, Appendix A.1– AMS/EPA Regulatory Model (AERMOD).

line source type as a "Beta" test option in AERMOD. The hybrid approach used in this modeling analysis achieves the same goal through the use of preferred models.

4.2. COORDINATE SYSTEM

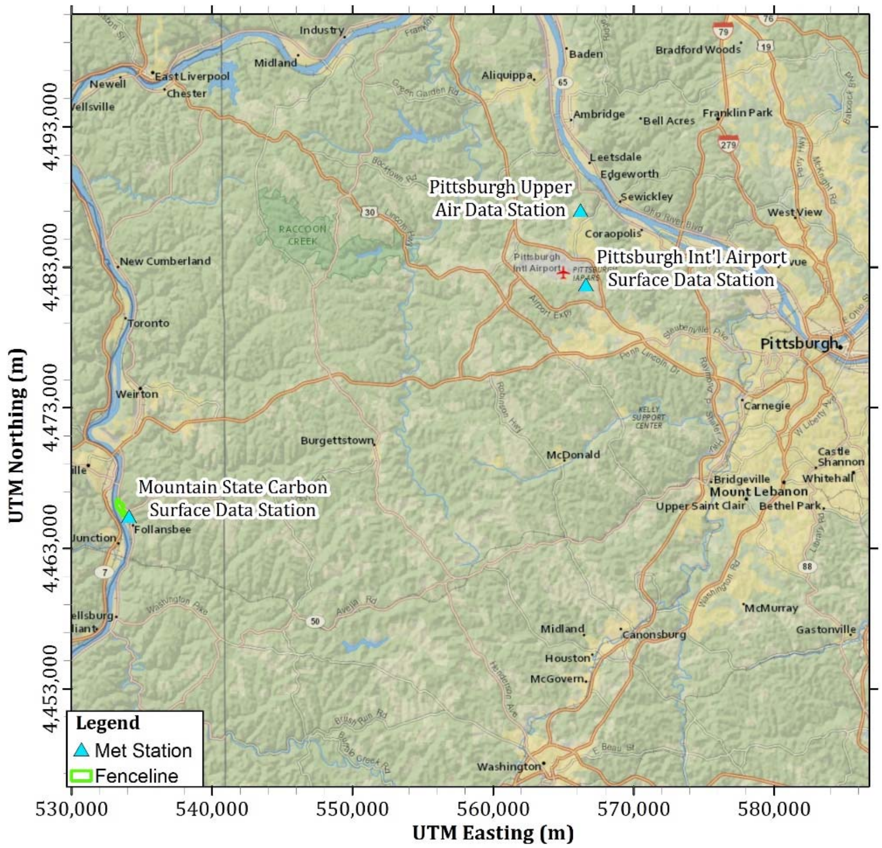
In all modeling analyses conducted for the MSC facility, the locations of emission sources, structures, and receptors, are represented in the Universal Transverse Mercator (UTM) coordinate system. The UTM grid divides the world into coordinates that are measured in north meters (measured from the equator) and east meters (measured from the central meridian of a particular zone, which is set at 500 km). The datum for this modeling analysis is based on North American Datum 1983 (NAD 83). UTM coordinates for this analysis all reside within UTM Zone 17 which serves as the reference point for all MSC data as well as all regional receptors and sources.

4.3. METEOROLOGICAL DATA

To perform the transport and dispersion modeling analysis in AERMOD, the procurement and pre-processing of meteorological data is required. The AERMET program (Version 14134) is the companion program to AERMOD that generates both a surface file and vertical profile file of meteorological observations and turbulence parameters pertinent to the use of AERMOD. AERMET meteorological data are refined for a particular analysis based on the choice of micrometeorological parameters that are linked to the land use and land cover (LULC) around the particular meteorological site. By incorporating measured surface and upper air station National Weather Service (NWS) observation data to AERMET, a complete set of model-ready meteorological data is created.

AERMET processing is performed in a 3-stage system. The first stage reads and performs quality assurance/quality control (QA/QC) on the raw NWS surface and upper air data files. The second stage synchronizes the observation times and merges the surface and upper air files together. The third stage incorporates user-specified micrometeorological parameters (albedo, Bowen Ratio, and surface roughness) with the observed meteorological data and computes specific atmospheric variables for use in the AERMOD Model. These variables are used to characterize the state of the atmosphere and its related turbulence and transport characteristics and includes wind speed, wind direction, convective velocity, friction velocity, Monin-Obukhov Length, convective and mechanical mixing heights, etc. Meteorological input files for this modeling analysis were developed by using the most current version of the AERMET program (Version 14134) following the procedures described below. The location of the meteorological data stations utilized in this modeling analysis, as outlined below, are shown in Figure 3.

Figure 3: Meteorological Data Stations Utilized in Modeling Analysis



All Coordinates shown in UTM Coordinates,
Zone 17, NAD 83 Datum

4.3.1. Surface Data Observations and Processing

On-site measurements from a tower and SODAR located near MSC's Follansbee, WV facility formed the basis for the surface data processing and were provided by Mountain State Carbon. The tower collects temperature, wind and solar radiation measurements at levels ranging from 2 meters (m) to 50 m above ground level. As discussed in the AERMET User's Guide Addendum, AERMET preferentially utilizes the on-site measurements wherever available. If all of the on-site measurements are missing for a given hour, AERMET then looks for surface observations from a user-specified NWS/FAA surface station location; Pittsburgh, PA (WBAN ID: 94823) in this case. Per the guidance, surface stations with 1-minute ASOS wind data are preferred for this process to alleviate numerous calm and/or variable wind observations present in the routine hourly observations. In the absence of on-site wind data for a given hour, the routine processed ASOS hourly observations from the surface station are then utilized. If such filling is not performed, then AERMOD will not compute a concentration for the hours with missing wind observations.

To complete the surface data processing, the formatted on-site tower data file along with the 1-minute ASOS data and hourly surface data from Pittsburgh, PA were utilized. The 1-minute ASOS data from Pittsburgh were then processed through AERMINUTE. In order for AERMINUTE to interpret observations from ice-free wind sensors, an installation date of July 28, 2009 was included in the AERMINUTE processing.

Once the AERMINUTE processing was completed, the Stage 1 AERMET processing was performed for the on-site and hourly surface data observations. Stage 2 processing was then completed to assimilate the 1-minute ASOS data and merge all of the records together.

4.3.2. Upper Air Data Observations and Processing

Upper air radiosonde data from the same data period (1/1/2007-12/31/2009) taken from the Pittsburgh, PA radiosonde site were input during the Stage 1 AERMET processing and then the merge step in Stage 2 of AERMET. No upper-air sounding information was missing such that observations were filled during the meteorological data processing efforts.

4.3.3. Surface Characteristics

Stage 3 processing in AERMET requires the user to input surface characteristics (albedo, Bowen ratio, and surface roughness) which are a function of land use and precipitation. The AERSURFACE program currently uses gridded land use data from the 1992 version of the National Land cover Database (NLCD92) in order to determine appropriate land use characteristics for area surrounding the surface station location(s). In cases where on-site tower observations are used, AERSURFACE is run for the tower location. As previously discussed, where all the on-site observations are missing for a given hour, the NWS surface data were substituted in the processing. As such, AERSURFACE was run for that station location, so that the appropriate land use characteristics were paired with the correct surface observation. Table 4-1 presents the data periods in 2007 that were missing from the Follansbee tower observations, requiring the substitution of Pittsburgh, PA surface observations. The 2008-2009 tower observations were all complete. As such, data substitution using Pittsburgh, PA surface observations occurred infrequently (approximately 0.6% over the three year period), thus limiting the ultimate effect of this substitution on the modeling analysis.

TABLE 4-1. MISSING METEOROLOGICAL DATA PERIODS IN 2007

Beginning of Period			End of Period			Number
Month	**Day**	**Hour**	**Month**	**Day**	**Hour**	**of Hours**
3	8	4	3	8	24	21
4	3	24	4	4	5	6
4	6	14	4	6	21	8
4	27	3	4	27	18	16
6	19	3	6	19	12	10
11	10	3	11	14	9	103
					Total:	**164**

The U.S. EPA default settings in the AERSURFACE data processing were used to generate surface characteristics for both the Follansbee tower location (40.338N, 80.599W) and Pittsburgh surface station (40.485N, 80.214W) to input in Stage 3 of the AERMET processing. Those settings pertain to both the seasonal distribution of land use data as well as the wind direction sectors over which land use categories are evaluated. The default settings for standard seasonal distributions as outlined in EPA's *AERSURFACE User's Guide,* for the seasons to correspond to their calendar months and for the wind sectors to consist of 12, 30 degree arcs were utilized. Since the river valley does not experience continuous snow depths for extended periods of time (e.g., more than a month), the

"Winter with continuous snow on ground" setting was not utilized. These setting selections are very reasonable for a mid-latitude location such as Follansbee, WV.

In order to estimate the Bowen ratio, actual monthly precipitation totals from the Steubenville, OH observation site (GHCND: USC00338025), which is very near to and representative of the Follansbee, WV area, were utilized. Those actual monthly precipitation totals were then compared to their 30 year climatological normals in order to determine if a given month was relatively dry, average or wet from a precipitation standpoint. AERSURFACE was run 3 separate times to generate land use characteristics for each moisture condition so that the combined AERMOD-ready file would contain the appropriate Bowen ratios for each data month. Information relative to the Bowen Ratio assignment is included with the modeling files and is summarized below in Table 4-2.

TABLE 4-2. MOISTURE DERIVED BOWEN RATIO CONDITIONS

Month	2007	2008	2009
January	Average	Average	Average
February	Average	Wet	Dry
March	Wet	Average	Dry
April	Average	Average	Dry
May	Average	Average	Dry
June	Average	Average	Dry
July	Average	Average	Average
August	Average	Dry	Average
September	Average	Average	Dry
October	Average	Average	Average
November	Average	Average	Dry
December	Average	Average	Average

4.3.4. AERMET Stage 3 Processing

For this modeling analysis, the Stage 3 AERMET processing was performed in order to generate the AERMOD-ready files to be used in the model. Stage 3 was run 3 times, using Bowen ratio values corresponding to dry, average and wet surface conditions. The appropriate monthly Bowen ratio values from each of the 3 AERMOD surface (.sfc) files were then extracted to create a single .sfc file for the 1/1/2007 through 12/31/2009 data period with accurate monthly Bowen ratio values throughout.

4.4. RECEPTOR GRID

For the SIP air dispersion modeling analyses, ground-level concentrations were calculated from the fence line out to approximately 12 km for the 1-hr SO_2 analysis using a series of nested receptor grids. These receptors were developed in coordination with Ohio EPA and are identical to those utilized by the Ohio EPA to evaluate SO_2 impacts in the prescribed area. The following nested grids were used to determine the extent of significance:

- **Fence Line Grid:** "Fence line" grid consisting of evenly-spaced receptors 25 meters apart placed along the main property boundary of each facility,

- **Fine Cartesian Grid:** A "fine" grid containing 50-meter spaced receptors extending approximately 1 km from the fence lines of the MSC, Mingo Junction, and AEP facilities,

- **Medium Cartesian Grid:** A "medium" grid containing 100-meter spaced receptors extending from 1 km to 2.5 km from the facility fence lines, exclusive of receptors on the fine grid, and

- **Coarse Cartesian Grid:** A "coarse grid" containing 250-meter spaced receptors extending from 2.5 km to 5 km from facility fence lines, exclusive of receptors on the fine and medium grids.

- **Very Coarse Cartesian Grid:** A "very coarse grid" containing 500-meter spaced receptors extending from 5 km up to 12 km from facility fence lines, exclusive of receptors on the fine, medium, and coarse grids.

This grid generally matched the defined nonattainment area and was sufficiently large to ensure that the impacts from all sources were captured. Additionally, the receptor grid was of an appropriate density to evaluate the spatial extents of the SO_2 impacts generated by the American Electric Power (AEP) Cardinal Power Plant. Due to the limited extent of impacts from AEP as shown in Ohio EPA's SIP April 2015 SIP submittal, it became evident that the inclusion of the AEP sources within the modeling analysis was not necessary. Nonetheless, AEP sources have been included in this analysis as a conservative measure.

The only receptors excluded from the analysis were those which would have been present on property owned by the involved companies to which public access is restricted because it is fenced or access is otherwise restricted, and thus, was not to be considered "ambient air." For example, there is a single Norfolk-Southern railroad line which is considered within MSC property for purposes of modeling. This length of rail is bounded by private property and natural boundaries (e.g. steep slopes) to the north and south, and MSC property on the east and west. The limited length of this line is close to MSC's main gate, which is occupied by security personnel continuously (24 hours a day, 7 days a week and 365 days per year). In addition, mounted cameras are used by security to continuously observe the railroad track area both to the north and south of the crossing, allowing security personnel to identify trespassers along the rail. It is MSC policy to immediately confront trespassers and escort them away from MSC property. In addition, there is a bridge near MSC that is in fact owned by MSC and access is restricted. As such, it does not meet the definition of ambient air and was excluded from the analysis.

Figure 4 depicts the receptor grid utilized in the modeling. Figure 5 shows the grid in the area immediately surrounding the Follansbee Plant.

Figure 4: Receptor Grid Utilized in Modeling Analysis

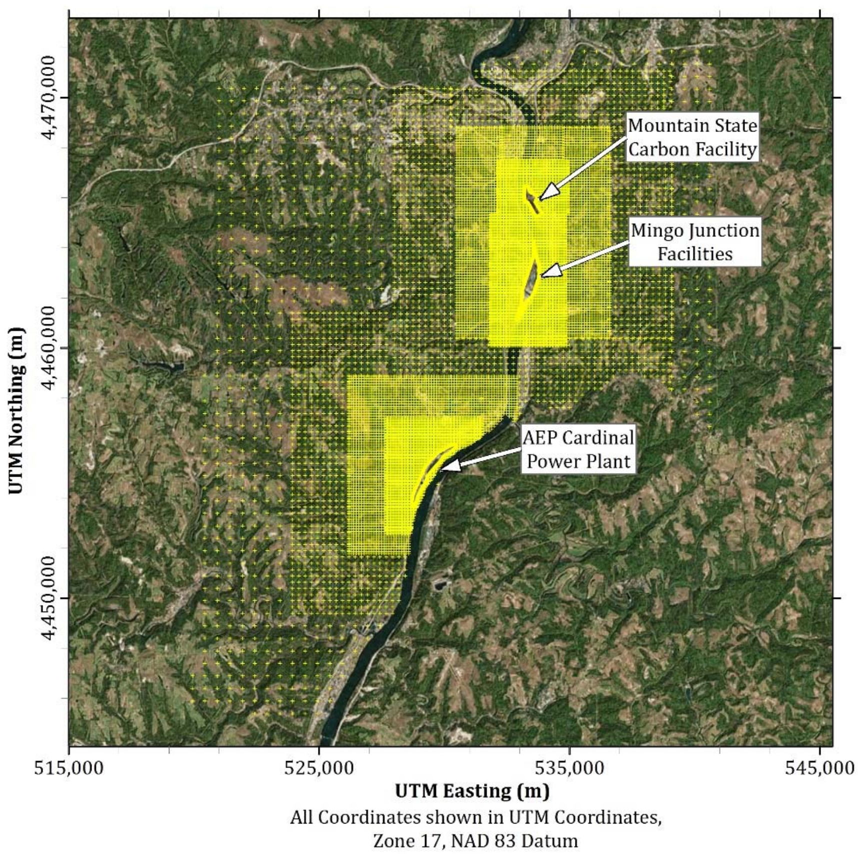
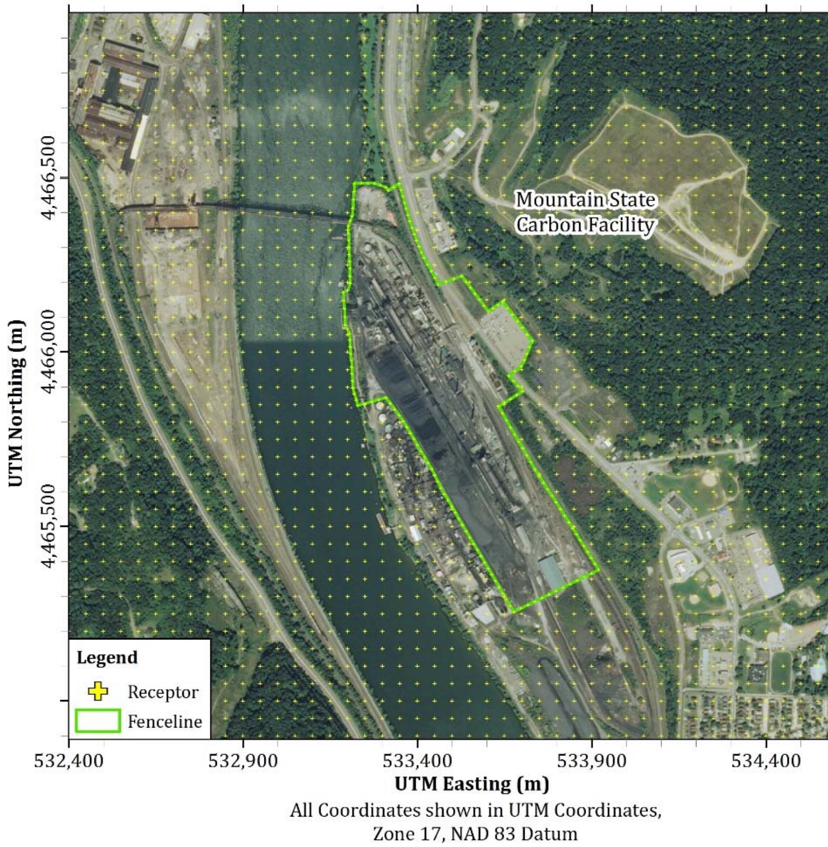


Figure 5: Receptor Grid Utilized in Modeling Analysis (Zoomed In)



4.5. ELEVATED TERRAIN

Due to the nature of the terrain surrounding the MSC facility (e.g., river valley considerations) and following the general guidance of the *Guideline on Air Quality Models*, terrain elevations were considered in the modeling analysis. The elevations of receptors, buildings, and sources were included to refine the modeled impacts between the sources at one elevation and receptor locations at various other elevations at the fence line and beyond. This was accomplished through the use of the AERMOD terrain preprocessor called AERMAP (Version 11103), which can generate base elevations above mean sea level for each source, building and receptor. For this analysis, AERMAP was not used for the vast majority of source and building base elevations as a common base elevation equivalent to the MSC final grade level was used for any MSC-related model objects. For all receptors, AERMAP was used to calculate the base elevation of each and an effective hill height scale that determines the magnitude of each source plume-elevated terrain feature interaction. AERMOD used both the receptor elevation and the hill height scale to calculate the effect of terrain on each source plume for each time step in the model.

Regional source base elevations which were required in the modeling analysis were also derived from AERMAP analysis as provided by Ohio EPA. Base elevations for select sources and buildings, terrain elevations for receptors, and other regional source base elevations input to the model was interpolated from 1/3 arc second resolution (approximately 10 meter spacing between data points) National Elevation Dataset (NED) data obtained from the U.S. Geological Survey (USGS).[14]

4.6. MODELED SOURCE TYPES AND STACK PARAMETERS

4.6.1. MSC Source Inventory

A list of all sources at MSC included in the dispersion modeling analysis is included in Table A-1 along with the corresponding cross-referenced source names used in the modeling files. Appendix A also provides a complete inventory of emission rates and source parameters for new and existing emission sources modeled in the SIP modeling analyses. All sources of SO_2 included in this analysis are treated as either point sources with unobstructed vertical releases, pseud-point sources or volume sources as previously indicated in Sections 2. For point sources, the actual stack parameters including location, height, inside stack diameter, exhaust gas temperature, and gas exit velocity were used in the modeling analyses as summarized in Table A-2. While volume source parameters including release height, initial lateral dimension, and initial vertical dimension are summarized in Table A-3.

4.6.2. Regional Inventory Sources

Dispersion modeling for the SO_2 air quality impacts was also required to include the impacts of regional sources of SO_2 emissions. These regional source parameters and emission rates are summarized in Tables A-4 and A-6, respectively.

4.7. BUILDING DOWNWASH

The stacks and flare at MSC may be subject to building downwash effects. These effects are caused by air flow over and around buildings and structures disrupting the free flow movement of the wind. The result of this phenomenon is increased turbulence near buildings and structures. These downwash affects are addressed through the implementation of the Plume Rise Model Enhancements (PRIME) program in AERMOD, this being the regulatory AERMOD version. Direction-specific building downwash dimensions (height and width of each influencing building or structure) were determined by the Building Profile Input Program, PRIME version (BPIPPRM), version 04274[15] and used in the AERMOD Model. BPIPPRM is designed to incorporate the concepts and procedures expressed in the GEP Technical Support document and the Building Downwash Guidance document,[16] while incorporating the PRIME enhancements to improve prediction of ambient impacts in building cavities (very near the buildings) and wake regions (farther from the buildings).

The building inventory utilized in the modeling analysis was developed by first reviewing existing MSC building parameters against aerial imagery. This review resulted in the adjustment of coordinates for a number of MSC buildings as well as the addition of recently erected buildings and multi-tier structures. Following this review, updated building information for MSC was relayed to the Ohio EPA and WVDEP. Building inventory information for the Mingo Junction facilities was provided by the Ohio EPA and also incorporated into the modeling analysis.

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[14] Multi-Resolution Land Characteristics Consortium (MRLC) online viewer and data retrieval system - http://www.mrlc.gov/viewerjs/

[15] Earth Tech, Inc., Addendum to the ISC3 User's Guide, The PRIME Plume Rise and Building Downwash Model, November 1997, http://www.epa.gov/scram001/7thconf/iscprime/useguide.pdf.

[16] EPA, Office of Air Quality Planning and Standards, Guidelines for Determination of Good Engineering Practice Stack Height (Technical Support Document for the Stack Height Regulations) (Revised), Research Triangle Park, North Carolina, EPA 450/4-80-023R, June 1985.

4.8. GEP STACK HEIGHT ANALYSIS

EPA promulgated stack height regulations that restrict the use of stack heights in excess of "Good Engineering Practice" (GEP) in air dispersion modeling analyses[17]. Under these regulations, that portion of a stack in excess of the GEP is generally not creditable when modeling to determine source impacts. This essentially prevents the use of excessively tall stacks to reduce ground-level pollutant concentrations. The minimum stack height which enable a stack to not be subject to the effects of building and structure downwash, called the GEP stack height, is defined by the following regulation formula:

$$H_{GEP} = H + 1.5L$$

where:

H_{GEP} = minimum GEP stack height,
H = structure height, and
L = lesser dimension of the structure (height or projected width).

The application of this equation and its results within the context of each building and stack is limited to stacks located within 5L downwind of a structure, 2L upwind, and 0.5L on the sides of a structure. The differentiation of the applicable distance is dependent on the direction of the wind at each hourly step in the modeling analysis. For each hourly wind direction, the determination of the influence zone of each structure must be determined and then the determination made as to whether a stack is in the influence zone of that structure. Stacks located at distances greater than the 0.5L, 2L, or 5L influence zone are not subject to the wake effects of the structure for that hour although subsequent hours and related wind directions could result in applicable downwash effects. The wind direction-specific downwash dimensions (for 36, 10-degree wind directions) and the dominant downwash structures used in this analysis are determined using the BPIPPRM (Version 04274, BPIP-Prime) program[18]. Using the building coordinates and dimensions for all on-site structures, a GEP analysis of all existing and proposed MSC stacks in relation to each building for each of the 36 wind directions was performed to evaluate which building height and dimensions have the greatest influence in terms of building downwash (enhanced dispersion) on each source's emissions. Building downwash input and output files are provided on the modeling file CD described in in Appendix D.

There are two stacks at MSC with a stack height greater than 65 meters: Battery 3 combustion stack and Battery 8 combustion stack. Battery 8 combustion stack is 76.2 meters tall, however it is less than the EPA GEP formula height, 85 meters, as determined by the BPIPBRM (Version 04274, BPIP-Prime) program. Therefore, Battery 8 combustion stack is compliant with GEP requirements. Battery 3 combustion stack also exceeds 65 meters height, however, as noted in MSC's Title V operating permit, the stack was in existence before December 31, 1970 and as such is not restricted to GEP stack height for the purposes of this attainment demonstration. As such, all MSC sources in the model comply with GEP.

GEP regulations were also considered for sources other than MSC (i.e., Ohio-based sources). All nearby stacks at the Mingo Junction property meet the definition of GEP. For AEP Cardinal Power Plant, the stack heights for Units 1 and 2 are consistent with those used by Ohio EPA in their SIP demonstration. Ohio EPA employed an alternative approach that involved representing Unit 3 as a volume source. Accordingly, a stack height value falling within the range of the release height values in Ohio EPA's analysis was included.

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[17] *Stack Height Regulation; Final Rule*. 40 CFR Part 51, FR Vol. 50, No. 130, July 8, 1985, pp 27891-27907.

[18] *User's Guide to the Building Profile Input Program*, EPA-454/R-93-038, U.S. Environmental Protection Agency, Research Triangle Park, NC, Revised April 21, 2004.

4.9. AMBIENT BACKGROUND CONCENTRATION

The SIP modeling analysis incorporated a background concentration of 8.1 ppb SO_2 (approximately 21.17 $\mu g/m^3$)[19] into the AERMOD results contained in this report. Given the cooperative, multi-state nature of the nonattainment area, this ambient background concentration utilized in the modeling demonstration is consistent with those derived by Ohio EPA. This concentration was determined after consideration of design values from the SO_2 monitors nearest the MSC facility (e.g. 618 Logan Street in Steubenville, OH and Mahan Lane in Follansbee, WV).[20] The Ohio EPA further describes the background selection process in their SIP Appendix E modeling protocol, an excerpt of which is included as Appendix C to this report.[21] Note that the Ohio EPA SIP submittal effectively concludes that AEP's Cardinal Plant contributions are incorporated into the background for the areas surrounding Mingo Junction and MSC. Nonetheless, this modeling analysis conservatively considers AEP's Cardinal Plant as a separate modeled source.

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[19] *Ohio EPA's Information for 2010 SO2 Attainment Demonstration Appendix K, Dispersion Modeling and Weight-of-Evidence Analysis for Steubenville, OH-WV, 2010 SO2 NAAQS Nonattainment Area* (April 3, 2015).

[20] *Ohio EPA's State of Ohio Nonattainment Area State Implementation Plan Appendix A, Nonattainment Area AQS SO2 Monitoring Data Retrievals.*

[21] *Ohio EPA's State of Ohio Nonattainment Area State Implementation Plan Appendix E, Modeling Protocol: Dispersion Modeling to Demonstrate Attainment of the 2010 SO2 NAAQS.*

5. ATTAINMENT MODELING DEMONSTRATION RESULTS

This section summarizes the results of the attainment modeling demonstration. The modeling was conducted using the methodology outlined in Section 4 and includes the sources outlined in Section 3. The results are based on a future compliance considering normal operations with desulfurization plant outages and increased COG flowrate to excess COG flare.

5.1. MODELING WITH DESULFURIZATION PLANT OUTAGES AND INCREASED FLARE

As discussed in Section 3.1.4, there are periods of time during each year when the plant's primary control system, the desulfurization plant, is non-operable. To address these desulfurization plant outages, MSC performed an analysis of the three modeled years which included emissions from both normal operations and outage periods. The modeling analysis considered two (2) ten day outage periods for each modeled year; one during April and one during November; and in doing so contemplates that the outage events occur during meteorologically desirable periods to ensure that ground level concentrations are minimized.

In addition to analysis of emissions during normal plant operations and desulfurization plant outages, MSC also included consideration that MSC has operational plans such that the excess COG flare will operate with a flowrate of 24 MMCF/day COG. The excess COG flare flowrate is currently limited at 7.1 MMCF/day in the facility's Title V permit. While MSC will evaluate and apply for the appropriate permit(s) at such time it desires to pursue a 24 MMCF/day operational limitation, this modeling analysis demonstrates compliance with the 1-hour SO_2 NAAQS for the purposes of the future compliance SIP modeling demonstration. The determination of flare parameters utilized in this analysis are listed in Table A-7 of Appendix A.

5.2. DISCUSSION OF RESULTS

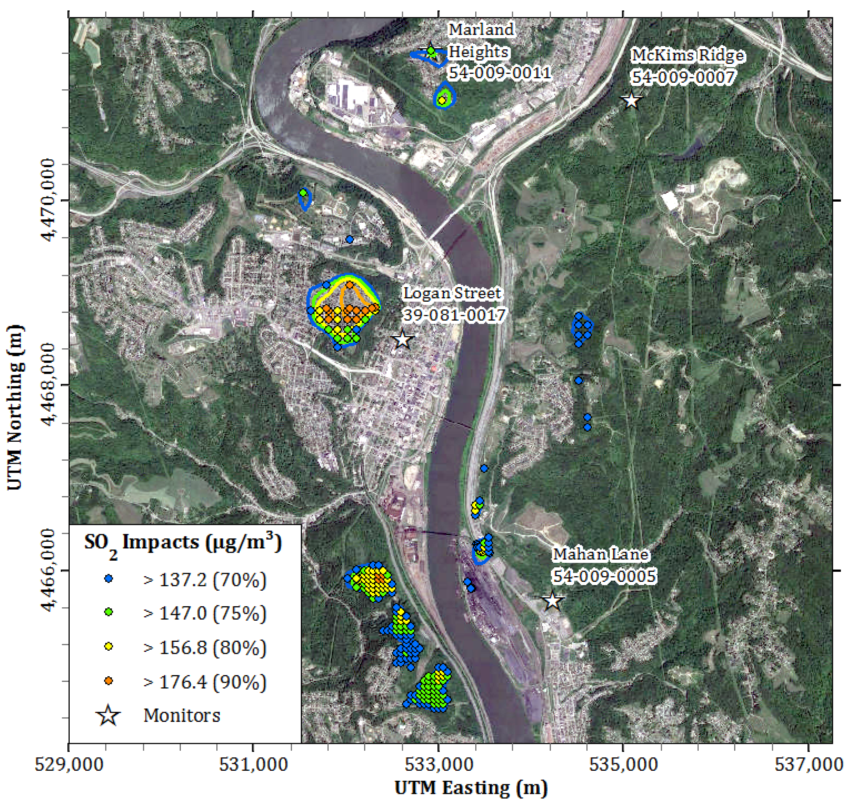
As described above, this modeling analysis addresses both the normal operations of the facility and the limited duration planned maintenance outage periods required to maintain SO_2 emission reduction equipment in suitable operating condition. For the 1-hr SO_2 NAAQS, the modeling constraint is related to time periods of planned maintenance outages which implies that normal operating modes result in compliance with this NAAQS by even greater compliance margins. The results from this analysis are displayed in Table 5-1. As shown in the table, the model predicts concentrations below the NAAQS when considering this scenario.

Table 5-1. 1-Hour Average SO_2 Modeling Results

Source Group	Years	Maximum Model Output including background	UTM East	UTM North	NAAQS Standard
Total	2007 -2009	195.9	532115.0	4468809.0	196.2
MSC	2007 -2009	193.0	532115.0	4468809.0	196.2
Ohio Sources	2007 -2009	133.2	530897.0	4457677.0	196.2

Figure 6 provides a contour map of the high 4th-high (H4H) max daily 1-hour model output concentrations for the "Total" source group.

Figure 6: SO_2 1hr H4H Contour Map



All Coordinates shown in UTM Coordinates, Zone 17, NAD 83 Datum

As shown in Figure 6, the maximum impacts associated with the modeling scenario are proximally located to the ambient air monitoring network (specifically the Logan Street monitor). This indicates the existing monitors are in ideal locations to provide an accurate means of monitoring NAAQS compliance for the nonattainment area.

5.3. COMPLIANCE DEMONSTRATION SUMMARY

As outlined in Sections 5.1 of this report, the modeling analyses completed by MSC for the 1-hour SO_2 nonattainment SIP demonstrate compliance with the 1-hour SO_2 NAAQS. Furthermore, the modeling analysis demonstrates that the existing ambient monitoring network is ideally situated to monitor compliance moving forward.

APPENDIX A: SO_2 MODELING EMISSION SOURCE INVENTORY

Table A-1. List of MSC Sources for SIP Modeling Analysis

Model ID	2010 Title V Emission Unit ID#	Title V Emission Point ID#	Emission Unit Description	Emission Point Description
MSCCOGFL	P024-1	Stack 14	Excess Oven Coke Oven Gas (COG) Flare	Excess COG Flare Stack
MSCBATT1	P001-4	Stack 01	Underfire Stack for Battery # 1	Battery 1 Combustion Stack
MSCBATT2	P002-4	Stack 02	Underfire Stack for Battery # 2	Battery 2 Combustion Stack
MSCBATT3	P003-4	Stack 03	Underfire Stack for Battery # 3	Battery 3 Combustion Stack
MSCBATT8	P004-4	Stack 04	Underfire Stack for Battery # 8	Battery 8 Combustion Stack
MSC8SCRU	P004-5 C02	Stack 06	Battery # 8 Pushing Venturi Scrubber (control device)	MSC Battery 8 Scrubber Stack
MSC67910	P017 P018 S1 S5	Stack 11	COG Boilers # 6, 7, 9, 10	MSC Boilers 6-7-9-10 Merged Stack
MSCACIDS	P021-19 C15	Stack 15	Sulfuric Acid Plant Tail Gas Stack Tail Gas Scrubber (control device)	Acid Plant Tail Gas Stack
MSCPB1 MSCPB2 MSCPB3 MSCPB4 MSCPB5 MSCPB6 MSCPB7 MSCPB8 MSCPB9 MSCPB10 MSCPB11 MSCPB12 MSCPB13 MSCPB14	P001-5 C01	Stacks 05	Batteries #1, #2, and #3 Pushing Baghouse (control device)	Battery 1-2-3 Pushing Baghouse Stack 1 Battery 1-2-3 Pushing Baghouse Stack 2 Battery 1-2-3 Pushing Baghouse Stack 3 Battery 1-2-3 Pushing Baghouse Stack 4 Battery 1-2-3 Pushing Baghouse Stack 5 Battery 1-2-3 Pushing Baghouse Stack 6 Battery 1-2-3 Pushing Baghouse Stack 7 Battery 1-2-3 Pushing Baghouse Stack 8 Battery 1-2-3 Pushing Baghouse Stack 9 Battery 1-2-3 Pushing Baghouse Stack 10 Battery 1-2-3 Pushing Baghouse Stack 11 Battery 1-2-3 Pushing Baghouse Stack 12 Battery 1-2-3 Pushing Baghouse Stack 13 Battery 1-2-3 Pushing Baghouse Stack 14
MSCB1F1U MSCB1F2U MSCB1F3U MSCB1F4U MSCB1F5U	P001-5	F13	Battery 1 Fugitive Emissions (pushing and soaking)	Battery 1 Fugitives Source 1 Battery 1 Fugitives Source 2 Battery 1 Fugitives Source 3 Battery 1 Fugitives Source 4 Battery 1 Fugitives Source 5
MSCB2F1U MSCB2F2U MSCB2F3U MSCB2F4U MSCB2F5U	P001-5	F14	Battery 2 Fugitive Emissions (pushing and soaking)	Battery 2 Fugitive Source 1 Battery 2 Fugitive Source 2 Battery 2 Fugitive Source 3 Battery 2 Fugitive Source 4 Battery 2 Fugitive Source 5
MSCB3F1U MSCB3F2U MSCB3F3U MSCB3F4U MSCB3F5U	P001-5	F15	Battery 3 Fugitive Emissions (pushing and soaking)	Battery 3 Fugitive Source 1 Battery 3 Fugitive Source 2 Battery 3 Fugitive Source 3 Battery 3 Fugitive Source 4 Battery 3 Fugitive Source 5
MSCB8F1U MSCB8F2U MSCB8F3U MSCB8F4U MSCB8F5U MSCB8F6U MSCB8F7U	P004-5	F16	Battery 8 Fugitive Emissions (pushing and soaking)	Battery 8 Fugitive Source 1 Battery 8 Fugitive Source 2 Battery 8 Fugitive Source 3 Battery 8 Fugitive Source 4 Battery 8 Fugitive Source 5 Battery 8 Fugitive Source 6 Battery 8 Fugitive Source 7

Table A-2. List of Stack Parameters for MSC Point Sources

Model Stack ID	Description	UTM East[1] (m)	UTM North[1] (m)	Elevation[2] (m)	Stack Height (m)	Stack Temperature (K)	Exit Velocity (m/s)	Stack Diameter (m)
MSCCOGFL	Excess COG Flare	533,257.0	4,466,415.0	205.43	63.93	1273.00	20.00	3.88
MSCBATT1	Battery 1 Combustion Stack	533,290.0	4,466,132.0	205.43	60.96	583.15	5.06	2.28
MSCBATT2	Battery 2 Combustion Stack	533,293.0	4,466,127.0	205.43	60.96	583.15	5.06	2.28
MSCBATT3	Battery 3 Combustion Stack	533,381.0	4,465,988.0	205.43	68.58	588.71	5.00	2.44
MSCBATT8	Battery 8 Combustion Stack	533,648.0	4,465,651.0	205.43	76.20	422.04	8.32	3.76
MSC8SCRU	MSC Battery 8 Scrubber Stack	533,640.7	4,465,537.0	205.43	18.29	318.20	13.41	2.28
MSC67910	MSC Boilers 6-7-9-10 Merged Stack	533,526.0	4,465,952.0	205.43	53.34	483.87	15.35	2.74
MSCACIDS	Acid Plant Tail Gas Stack	533,439.0	4,466,089.0	205.43	21.34	299.82	10.45	0.51
MSCPB1	Battery 1-2-3 Pushing Baghouse Stack 1	533,246.5	4,466,076.0	205.43	17.07	332.59	23.20	0.70
MSCPB2	Battery 1-2-3 Pushing Baghouse Stack 2	533,245.1	4,466,078.0	205.43	17.07	332.59	23.20	0.70
MSCPB3	Battery 1-2-3 Pushing Baghouse Stack 3	533,243.8	4,466,081.0	205.43	17.07	332.59	23.20	0.70
MSCPB4	Battery 1-2-3 Pushing Baghouse Stack 4	533,242.0	4,466,084.0	205.43	17.07	332.59	23.20	0.70
MSCPB5	Battery 1-2-3 Pushing Baghouse Stack 5	533,240.6	4,466,086.0	205.43	17.07	332.59	23.20	0.70
MSCPB6	Battery 1-2-3 Pushing Baghouse Stack 6	533,239.2	4,466,088.0	205.43	17.07	332.59	23.20	0.70
MSCPB7	Battery 1-2-3 Pushing Baghouse Stack 7	533,237.8	4,466,091.0	205.43	17.07	332.59	23.20	0.70
MSCPB8	Battery 1-2-3 Pushing Baghouse Stack 8	533,250.3	4,466,078.0	205.43	17.07	332.59	23.20	0.70
MSCPB9	Battery 1-2-3 Pushing Baghouse Stack 9	533,248.9	4,466,081.0	205.43	17.07	332.59	23.20	0.70
MSCPB10	Battery 1-2-3 Pushing Baghouse Stack 10	533,247.5	4,466,083.0	205.43	17.07	332.59	23.20	0.70
MSCPB11	Battery 1-2-3 Pushing Baghouse Stack 11	533,245.8	4,466,086.0	205.43	17.07	332.59	23.20	0.70
MSCPB12	Battery 1-2-3 Pushing Baghouse Stack 12	533,244.3	4,466,088.0	205.43	17.07	332.59	23.20	0.70
MSCPB13	Battery 1-2-3 Pushing Baghouse Stack 13	533,242.9	4,466,090.0	205.43	17.07	332.59	23.20	0.70
MSCPB14	Battery 1-2-3 Pushing Baghouse Stack 14	533,241.5	4,466,093.0	205.43	17.07	332.59	23.20	0.70

[1] Coordinates are in the UTM NAD83 Zone 17 coordinate system.
[2] Elevation of the plant grade.

Table A-3. List of Modeled Parameters for MSC Volume Sources

Model Stack ID	Description	UTM East[1] (m)	UTM North[1] (m)	Elevation[2] (m)	Release Height[3] (m)	Initial Lateral Dimension (m)	Initial Vertical Dimension[3] (m)
MSCB1F1U	Battery 1 Fugitives Source 1	533,275.7	4,466,191.0	205.43	7.00	5.33	3.26
MSCB1F2U	Battery 1 Fugitives Source 2	533,281.3	4,466,182.0	205.43	7.00	5.33	3.26
MSCB1F3U	Battery 1 Fugitives Source 3	533,286.8	4,466,172.5	205.43	7.00	5.33	3.26
MSCB1F4U	Battery 1 Fugitives Source 4	533,292.4	4,466,163.0	205.43	7.00	5.33	3.26
MSCB1F5U	Battery 1 Fugitives Source 5	533,297.9	4,466,153.5	205.43	7.00	5.33	3.26
MSCB2F1U	Battery 2 Fugitive Source 1	533,318.2	4,466,120.0	205.43	7.00	5.33	3.26
MSCB2F2U	Battery 2 Fugitive Source 2	533,324.0	4,466,110.0	205.43	7.00	5.33	3.26
MSCB2F3U	Battery 2 Fugitive Source 3	533,329.9	4,466,100.5	205.43	7.00	5.33	3.26
MSCB2F4U	Battery 2 Fugitive Source 4	533,335.8	4,466,090.5	205.43	7.00	5.33	3.26
MSCB2F5U	Battery 2 Fugitive Source 5	533,341.6	4,466,080.5	205.43	7.00	5.33	3.26
MSCB3F1U	Battery 3 Fugitive Source 1	533,358.9	4,466,051.5	205.43	7.00	5.33	3.26
MSCB3F2U	Battery 3 Fugitive Source 2	533,364.7	4,466,041.5	205.43	7.00	5.33	3.26
MSCB3F3U	Battery 3 Fugitive Source 3	533,370.6	4,466,032.0	205.43	7.00	5.33	3.26
MSCB3F4U	Battery 3 Fugitive Source 4	533,376.4	4,466,022.0	205.43	7.00	5.33	3.26
MSCB3F5U	Battery 3 Fugitive Source 5	533,382.3	4,466,012.0	205.43	7.00	5.33	3.26
MSCB8F1U	Battery 8 Fugitive Source 1	533,588.4	4,465,668.5	205.43	13.72	6.84	6.38
MSCB8F2U	Battery 8 Fugitive Source 2	533,596.1	4,465,656.0	205.43	13.72	6.84	6.38
MSCB8F3U	Battery 8 Fugitive Source 3	533,603.7	4,465,643.0	205.43	13.72	6.84	6.38
MSCB8F4U	Battery 8 Fugitive Source 4	533,611.3	4,465,630.5	205.43	13.72	6.84	6.38
MSCB8F5U	Battery 8 Fugitive Source 5	533,618.9	4,465,618.0	205.43	13.72	6.84	6.38
MSCB8F6U	Battery 8 Fugitive Source 6	533,626.5	4,465,605.5	205.43	13.72	6.84	6.38
MSCB8F7U	Battery 8 Fugitive Source 7	533,634.1	4,465,593.0	205.43	13.72	6.84	6.38

[1] Coordinates are in the UTM NAD83 Zone 17 coordinate system.

[2] Elevation of the plant grade.

[3] Release height and initial vertical dimension vary for each source on an hourly basis per BLP model plume rise. Values shown are reflective of values without any additional BLP consideration.

Table A-4. List of Stack Parameters for Regional Inventory Point Sources[1]

Model Stack ID	Description	UTM East (m)	UTM North (m)	Elevation (m)	Stack Height (m)	Stack Temperature (K)	Exit Velocity (m/s)	Stack Diameter (m)
MJERGCT1	Mingo Junction Energy Center Unit 1	533,615.0	4,463,399.0	203.94	42.67	449.82	6.06	3.05
MJERGCT2	Mingo Junction Energy Center Unit 2	533,611.0	4,463,404.0	203.92	42.67	449.82	6.06	3.05
MJERGCT3	Mingo Junction Energy Center Unit 3	533,608.0	4,463,409.0	203.90	42.67	449.82	6.06	3.05
MJERGCT4	Mingo Junction Energy Center Unit 4	533,605.0	4,463,414.0	203.88	42.67	449.82	6.06	3.05
AEPCARD1	AEP Cardinal Plant Unit 1	530,035.8	4,455,909.0	204.66	304.80	327.59	15.21	8.86
AEPCARD2	AEP Cardinal Plant Unit 2	530,041.8	4,455,900.0	204.56	304.80	327.59	15.21	8.86
AEPCARD3	AEP Cardinal Plant Unit 3	529,131.6	4,454,598.0	201.78	274.32	435.90	29.20	7.32
MJSTRPM2	Mingo Junction Steel Works Reheat Furnace 2	533,410.4	4,462,652.0	204.09	57.00	783.20	3.93	3.96
MJSTRPM3	Mingo Junction Steel Works Reheat Furnace 3	533,415.6	4,462,672.0	203.95	57.00	783.20	3.93	3.96
MJSTRPM4	Mingo Junction Steel Works Reheat Furnace 4	533,421.5	4,462,690.0	203.81	57.00	783.20	3.93	3.96
MJEAFBAG	Mingo Junction Steel Works EAF Baghouse	533,711.6	4,462,675.0	203.44	42.67	408.06	13.59	6.10
MJLMFBH	Mingo Junction Steel Works LMF Baghouse	533,575.2	4,462,881.0	203.74	22.86	399.82	5.35	3.35

[1] All data provided by Ohio Environmental Protection Agency.

Table A-5. SO_2 Modeled Emission Rates for MSC Sources

Model ID	Emission Point Description	Emissions During Desulfurization Plant Operation (lb/hr)	Basis	Emissions During Desulfurization Plant Outage (lb/hr)[1]
MSCCOGFL	Excess COG Flare	139.8	Engineering Estimate (See Table A-10).	241.5
MSCBATT1	Battery 1 Combustion Stack	22.9	Engineering Estimate (See Table A-9)	76.8
MSCBATT2	Battery 2 Combustion Stack	22.9	Engineering Estimate (See Table A-9)	76.8
MSCBATT3	Battery 3 Combustion Stack	25.7	Engineering Estimate (See Table A-9)	76.8
MSCBATT8	Battery 8 Combustion Stack	122.1	Engineering Estimate (See Table A-9)	360.6
MSC8SCRU	MSC Battery 8 Scrubber Stack	15.7	2010 Title V Permit Limit, Condition 4.1.33	9.8
MSC67910	MSC Boilers 6-7-9-10 Merged Stack	90.0	Engineering Estimate (See Table A-12)	344.8
MSCACIDS	Acid Plant Tail Gas Stack	6.0	Engineering Estimate	0.0
MSCPB1	Battery 1-2-3 Pushing Baghouse Stack 1	0.7	2010 Title V Permit Limit, Condition 4.1.32 (aggregate of all stacks)	0.3
MSCPB2	Battery 1-2-3 Pushing Baghouse Stack 2	0.7		0.3
MSCPB3	Battery 1-2-3 Pushing Baghouse Stack 3	0.7		0.3
MSCPB4	Battery 1-2-3 Pushing Baghouse Stack 4	0.7		0.3
MSCPB5	Battery 1 -2-3 Pushing Baghouse Stack 5	0.7		0.3
MSCPB6	Battery 1-2-3 Pushing Baghouse Stack 6	0.7		0.3
MSCPB7		0.7		0.3
MSCPB8	Battery 1-2-3 Pushing Baghouse Stack 8	0.7		0.3
MSCPB9	Battery 1-2-3 Pushing Baghouse Stack 9	0.7		0.3
MSCPB10	Battery 1-2-3 Pushing Baghouse Stack 10	0.7		0.3
MSCPB11	Battery 1-2-3 Pushing Baghouse Stack 11	0.7		0.3
MSCPB12	Battery 1 -2-3 Pushing Baghouse Stack 12	0.7		0.3
MSCPB13	Battery 1-2-3 Pushing Baghouse Stack 13	0.7		0.3
MSCPB14	Battery 1-2-3 Pushing Baghouse Stack 14	0.7		0.3
MSCB1F1U	Battery 1 Fugitives Source 1	0.7	Engineering Estimate (See Table A-11)	0.2
MSCB1F2U	Battery 1 Fugitives Source 2	0.7		0.2
MSCB1F3U	Battery 1 Fugitives Source 3	0.7		0.2
MSCB1F4U	Battery 1 Fugitives Source 4	0.7		0.2
MSCB1F5U	Battery 1 Fugitives Source 5	0.7		0.2
MSCB2F1U	Battery 2 Fugitive Source 1	0.7	Engineering Estimate (See Table A-11)	0.2
MSCB2F2U	Battery 2 Fugitive Source 2	0.7		0.2
MSCB2F3U	Battery 2 Fugitive Source 3	0.7		0.2
MSCB2F4U	Battery 2 Fugitive Source 4	0.7		0.2
MSCB2F5U	Battery 2 Fugitive Source 5	0.7		0.2
MSCB3F1U	Battery 3 Fugitive Source 1	0.7	Engineering Estimate (See Table A-11)	0.2
MSCB3F2U	Battery 3 Fugitive Source 2	0.7		0.2
MSCB3F3U	Battery 3 Fugitive Source 3	0.7		0.2
MSCB3F4U	Battery 3 Fugitive Source 4	0.7		0.2
MSCB3F5U	Battery 3 Fugitive Source 5	0.7		0.2
MSCB8F1U	Battery 8 Fugitive Source 1	2.3	Engineering Estimate (See Table A-11)	1.3
MSCB8F2U	Battery 8 Fugitive Source 2	2.3		1.3
MSCB8F3U	Battery 8 Fugitive Source 3	2.3		1.3
MSCB8F4U	Battery 8 Fugitive Source 4	2.3		1.3
MSCB8F5U	Battery 8 Fugitive Source 5	2.3		1.3
MSCB8F6U	Battery 8 Fugitive Source 6	2.3		1.3
MSCB8F7U	Battery 8 Fugitive Source 7	2.3		1.3

[1] Emissions during desulfurization plant outage periods reflect current operational practices and are based on engineering estimates and an approximate production rate of 63 ovens per day on Battery 8 and 72 ovens per day combined for Battery 1, 2, 3.

Table A-6. SO_2 Modeled Emission Rates for Regional Sources

Model ID	Emission Point Description	Emissions Rate (lb/hr)
MJERGCT1	Mingo Junction Energy Center Unit 1	0.5
MJERGCT2	Mingo Junction Energy Center Unit 2	0.5
MJERGCT3	Mingo Junction Energy Center Unit 3	0.5
MJERGCT4	Mingo Junction Energy Center Unit 4	0.5
AEPCARD1	AEP Cardinal Plant Unit 1	2621.0
AEPCARD2	AEP Cardinal Plant Unit 2	2121.7
AEPCARD3	AEP Cardinal Plant Unit 3	1259.9
MJSTRPM2	Mingo Junction Steel Works Reheat Furnace 2	1.0
MJSTRPM3	Mingo Junction Steel Works Reheat Furnace 3	1.0
MJSTRPM4	Mingo Junction Steel Works Reheat Furnace 4	1.0
MJEAFBAG	Mingo Junction Steel Works EAF Baghouse	105.0
MJLMFBH	Mingo Junction Steel Works LMF Baghouse	14.1

Table A-7 Modeled Flare Stack Parameters - Increased Flowrate Scenario[1]

Parameters	Units	Excess COG Flare
COG Flowrate at Flare	MMCF/day	24
Average COG Heat Content	Btu/scf	489
Heat Input	MMBtu/day	11,736.0
Heat Input	cal/s	3.42E+07
Modeled Calculated Equivalent Diameter	m	3.88
Actual Physical Stack Height	m	45.72
Modeled Calculated Flare Height	m	63.93
Modeled Exit Temperature	K	1,273
Modeled Exit Velocity	m/s	20.00

[1] Following the U.S. EPA's *AERSCREEN User's Guide* (Equations 1 and 2) and Ohio *EPA's Engineering Guide 69 (Page 14)* , MSC has calculated the equivalent flare height and diameter based on the actual flare height and the maximum heat input rate for the excess COG flare. The stack temperature and exit velocity are based on the recommendations in Section 2.5 of the *AERSCREEN User's Guide* .

Effective Height (H_{eff}) = $H_s + 4.56*10^{-3}*HR^{0.478}$

Effective Diameter (D_{eff}): $D_{eff} = 9.88*10^{-4}*\sqrt{[HR*(1-HL)]}$

HL = radiation heat loss (0.55)

Table A-8 Basis of Emissions Estimates - MSC Battery Combustion Stacks

Source during Desulfurization Plant Operation	Heat Input (MMBtu/hr)	Fuel Consumption (COG scf/hr)	SO_2 Emission Rate (lb/hr)
Battery 1 Combustion Stack	80	163599	22.9
Battery 2 Combustion Stack	80	163599	22.9
Battery 3 Combustion Stack	90	184049	25.7
Battery 8 Combustion Stack	427	873211	122.1

1. COG Heat Content [average per 2010 Title V permit conditions 5.1.16(1), 5.1.17(1) and 5.1.18(1)]	489	Btu/scf
2. Sulfur content in COG during desulfurization plant operation	52	gr/100 dscf
3. Molecular Weight of SO_2	64	
4. Molecular Weight of H_2S	34	

5. Throughputs are based on estimated design capacities and engineering estimates.

Table A-9 Basis of Emissions Estimates - MSC Excess COG Flare

Source during Desulfurization Plant Operation	COG Flow Rate (MMSCF/day)	SO_2 Emission Rate (lb/hr)
Flare - Increased Capacity	24.0	139.8

1. COG Heat Content [average per 2010 Title V permit conditions 5.1.16(1), 5.1.17(1) and 5.1.18(1)]	489	Btu/scf
2. Sulfur content in COG during desulfurization plant operation	52	gr/100 dscf
3. Molecular Weight of SO_2	64	
4. Molecular Weight of H_2S	34	

Table A-10 Basis of Emissions Estimates - MSC Battery Fugitives

Source during Desulfurization Plant Operation	Charge (tons coal/hr)	Emission Factor (lbs SO_2/ton coal)	SO_2 Emission Rate (lb/hr)
Battery 1 Fugitives	31.6	0.1039	3.28
Battery 2 Fugitives	31.6	0.1039	3.28
Battery 3 Fugitives	34.0	0.1039	3.53
Battery 8 Fugitives	152.6	0.1039	15.86

1. Emission factors are based on U.S. EPA AP-42. The AP-42 factors for the ovens are the same, regardless of oven type/size.

Pushing fugitives (uncontrolled, AP-42 Table 12.2-9):	0.098	lb/ton coal charged
Pushing fugitives (controlled, assuming 95% capture for scrubber/baghouse):	0.0049	lb/ton coal charged
Soaking fugitives (AP-42 Table 12.2-18):	0.099	lb/ton coal charged
Total factor:	**0.1039**	**lb/ton coal charged**

2. Throughputs are based on estimated design capacities and engineering estimates.

Table A-11 Basis of Emissions Estimates - Other MSC Sources

Source during Desulfurization Plant Operation	Throughput	Units	SO_2 Emission Rate (lb/hr)
Boilers 6-7-9-10 Merged Stack	15.5	MMSCF/day	90.0

1. Sulfur content in COG during desulfurization plant operation	52	gr/100 dscf
2. Molecular Weight of SO_2	64	
3. Molecular Weight of H_2S	34	

APPENDIX B: BLP SUPPORTING DOCUMENTATION

Appendix A to 2007 PM_{10} SIP Modeling Report

APPENDIX A

BLP PLUME RISE FOR THE BLAST FURNACE CASTHOUSE, BASIC OXYGEN FURNACE ROOF MONITOR AND COKE BATTERIES

1.0 INTRODUCTION

Vertical rise of a heated fugitive emission is a function of the temperature difference of the emission and ambient, the exhaust velocity and configuration of the source. The buoyancy parameter used within the Buoyant Line and Point Source (BLP) Dispersion Model is represented by the following equation:

$$F' = \frac{g\,L\,W_m\,w\,(T_s - T_a)}{T_s} \qquad \text{Equation 1}$$

where

- F' is the average line source buoyancy parameter (m^4/s^3)
- g is the acceleration of gravity (9.81 m/s^2)
- L is the line source length (m)
- W_m is the line source width (m)
- w is the exit velocity (m/s)
- T_s is the exit temperature (°K)
- T_a is the ambient temperature (°K)[1]

The BLP model was developed to represent fugitive emissions from elevated line sources. A BOF Roof Monitor (RM), Blast Furnace Casthouse and Coke Battery are long line sources that have heated fugitives releases and are well suited for application for BLP.

This report presents results of testing at the BF #5 Casthouse and BOF RM at Mingo Junction and Battery #8 at Follansbee to develop the independent variables for input to Equation 1.

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[1] Defined as Equation 2-47 in "Buoyant Line and Point Source (BLP) Dispersion Model User's Guide," PB81-164642, July 1980.

2.0 MONITORING PROTOCOL

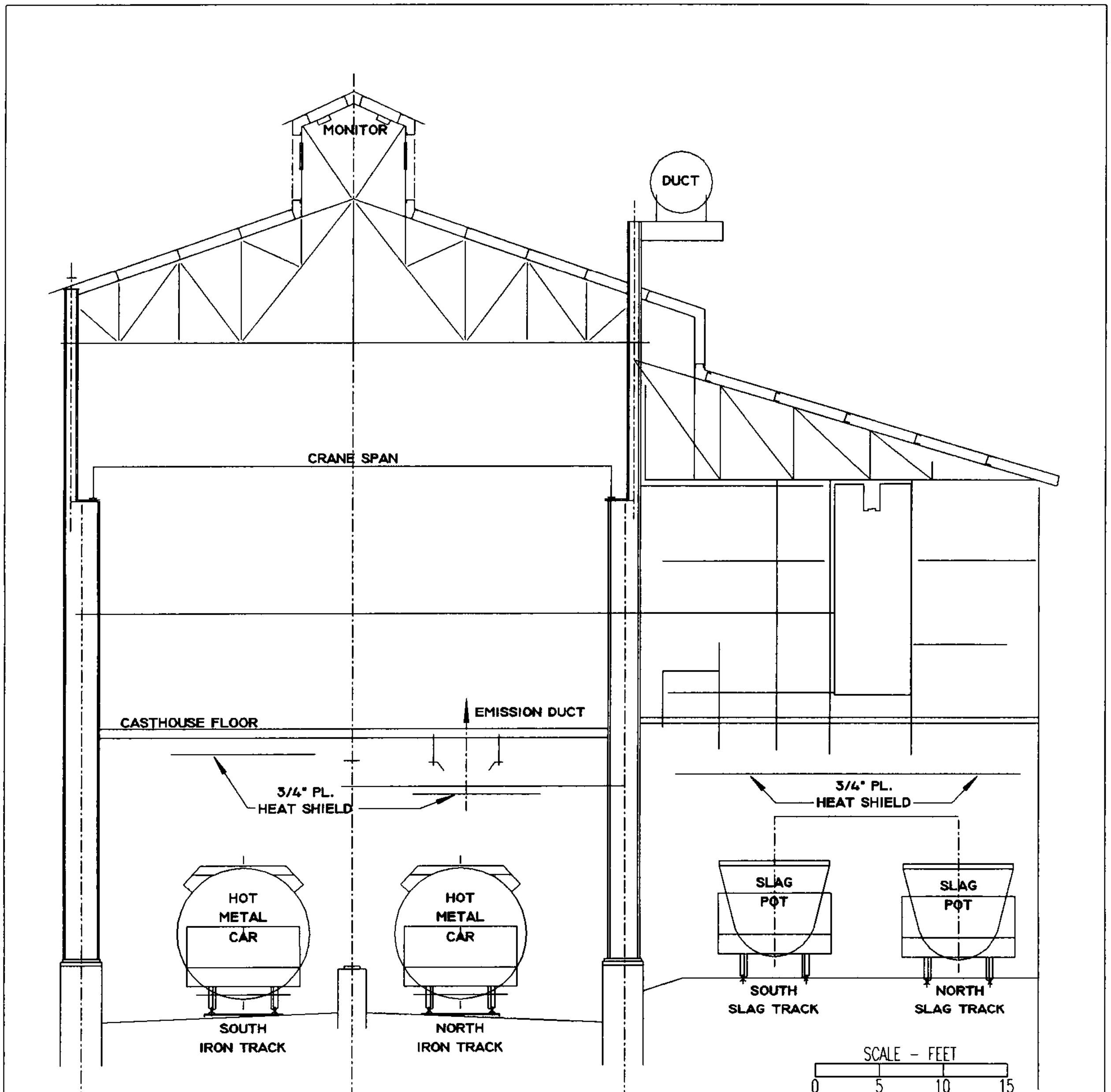
2.1 BF ROOF MONITOR

Field tests were run at Blast Furnace No. 3 from December 29, 1993 through January 4, 1994. A single thermocouple and wind speed sensor were placed in the roof monitor of Blast Furnace No. 3. Temperature data were adequate from this test, but the wind sensor and recorder were not well matched electronically. Revised testing included the installation of a ducted velocity sensor and thermocouple at four locations in the roof monitor of Blast Furnace No. 5 as shown in Figure A-1. Output signals from the sensors were read every 15 seconds and recorded. The test was run for approximately one week. A video camera was directed toward the south side of the casthouse for the duration of the study.

2.2 BOF ROOF MONITOR

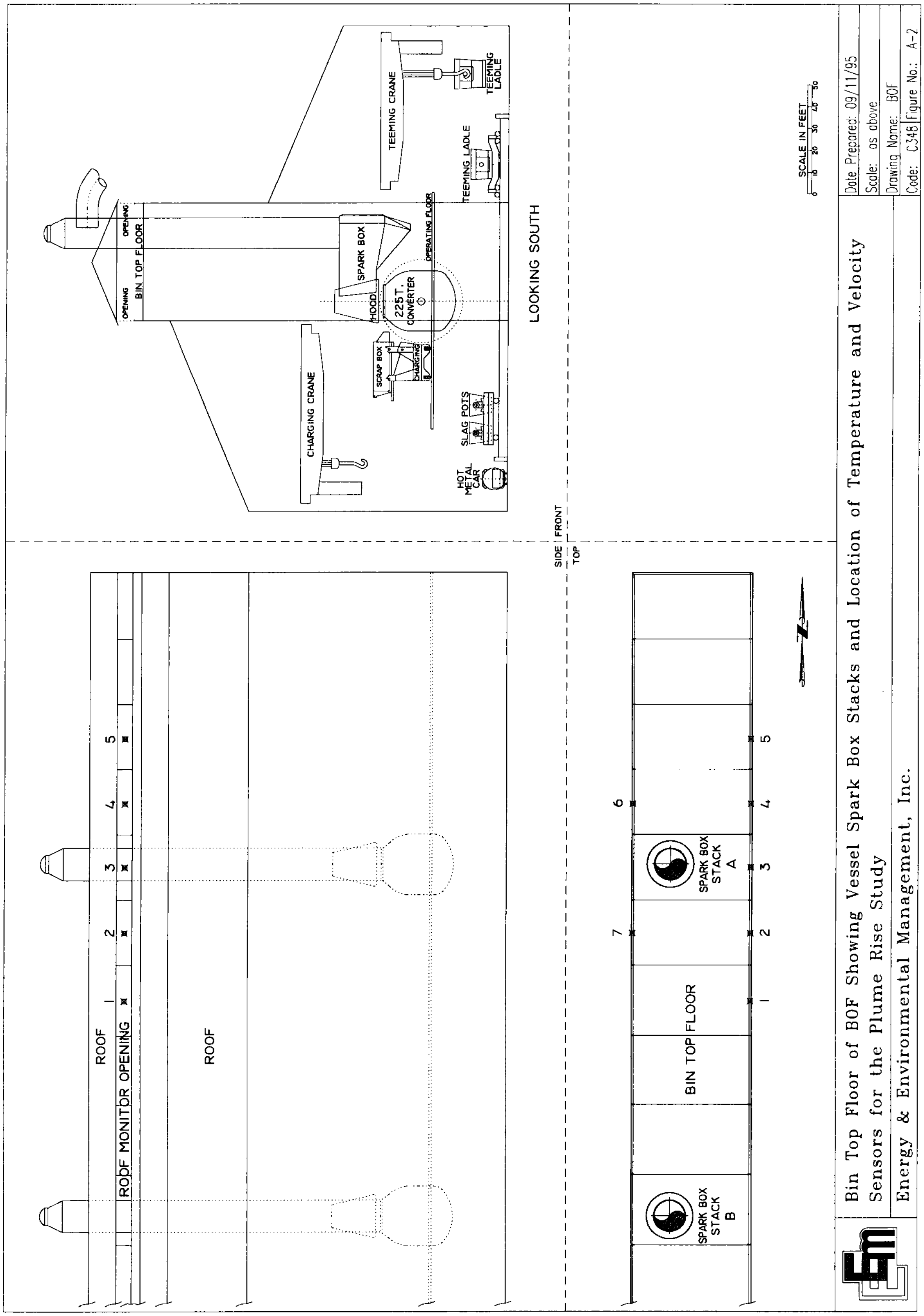
Field tests were run at the BOF from March 22 through March 25, 1994. A single thermocouple was placed in the roof monitor above the vessel and was recorded continuously during the test period. A hot-wire anemometer was used during a portion of the study with its output logged manually. Revised testing used an expanded version of that procedure by placing a total of seven thermocouples/ducted anemometers in the roof monitor. Results were recorded continuously every 15 seconds and referenced to the BOF clock to understand how plant operations influenced the exhaust temperature and speed.

The seven sensors were spaced to measure the influence of a single vessel. Location of the sensors is shown in Figure A-2. A video camera was directed toward the east roof monitor for the duration of the study. The sensors were spaced at 9.2 meter intervals.



Blast Furnace No. 5 Casthouse	Date Prepared: 05/02/96	
	Scale: as above	
	Drawing Name: bf5	
Energy & Environmental Management, Inc.	Code: C348	Figure No.: A-1

APPENDIX A, Page A-3

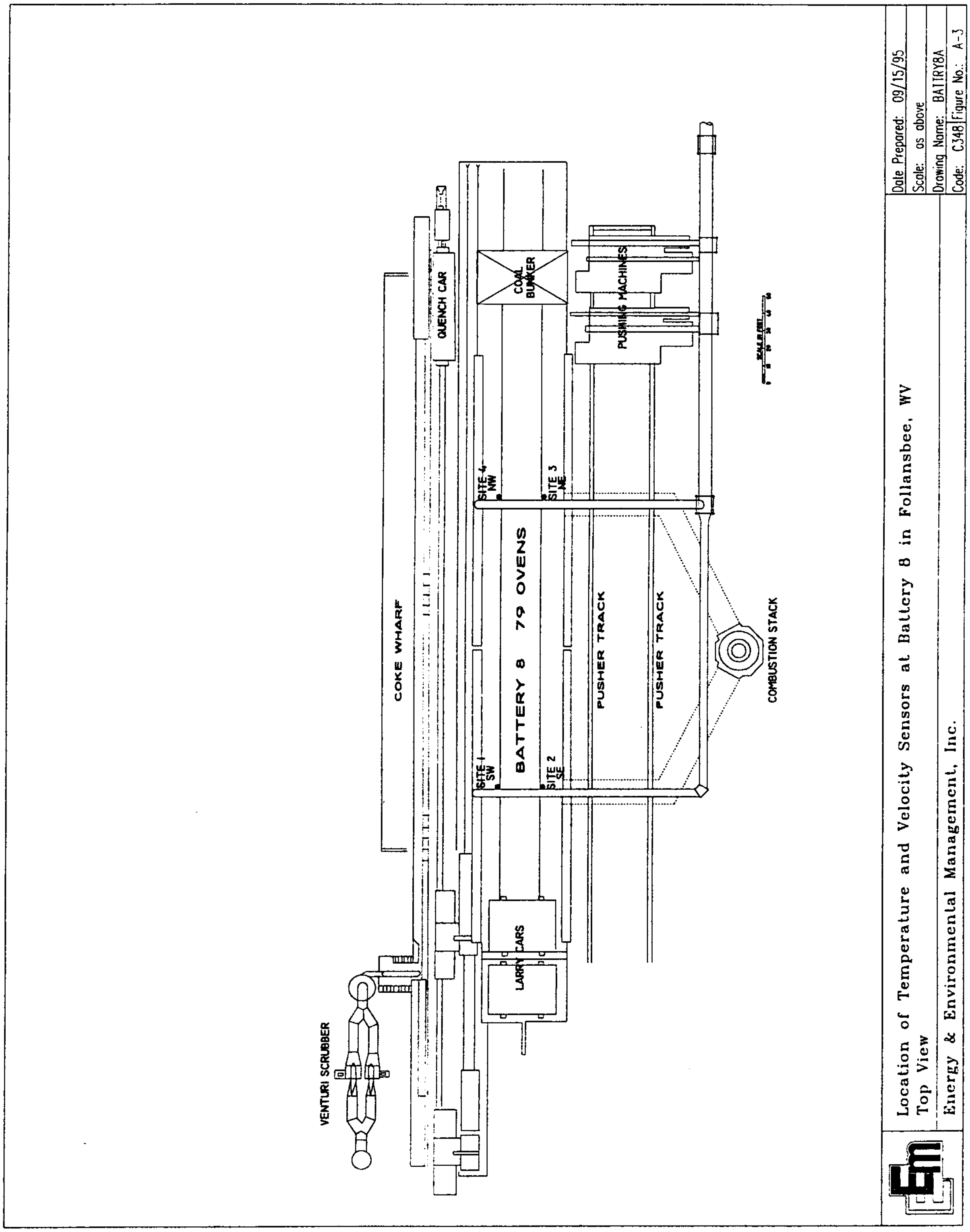


APPENDIX A, Page A-4

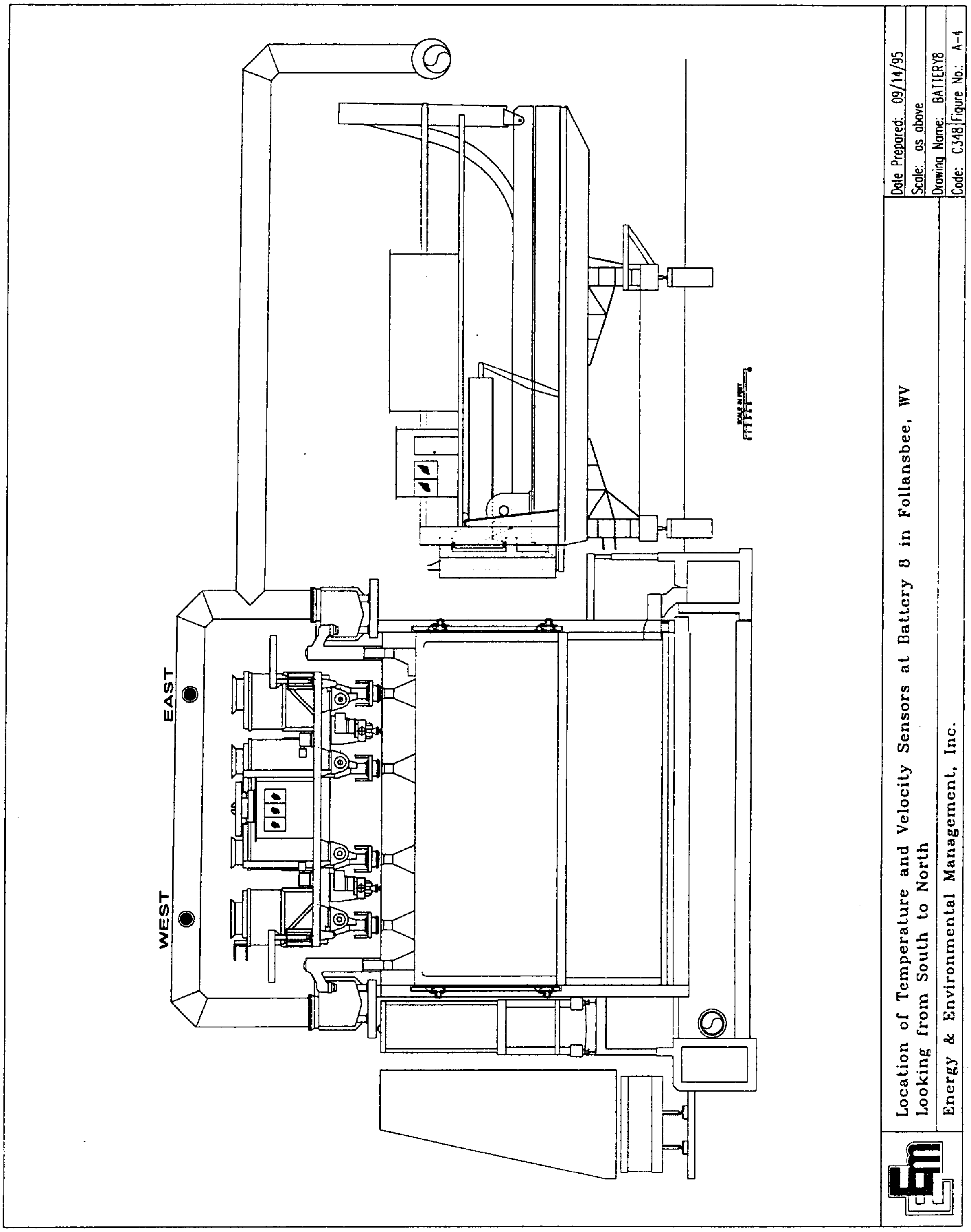
2.3 COKE BATTERIES

Initial testing at the batteries in Follansbee was done using colored smoke recorded against a contrasting background. Results from that effort showed significant plume rise but interpretation of the video tape was difficult. Since the ducted wind sensors had worked so well at the BOF RM and the BF RM, we decided to use the ducted wind sensors to measure the vertical wind speed above Battery No. 8 and to also measure air temperature. Sensors were located at four sites shown in Figure A-3 at the coke oven gas (COG) cross-over pipes. The wind sensor was pointed toward the top of the battery. This orientation exposed the sensor bearings to moisture during rainfall events. We removed the sensors during the midnight to 8:00 a.m. period to protect them from rain and reinstalled at 8:00 a.m. the next morning.

An end view of the sensor locations is shown in Figure A-4. Sensors were located approximately 8.5 meters above the top of the battery. Significantly higher vertical velocities were noted when the sensors were located out between the standpipes and doors. However, we could not leave the sensors there because the heat from the standpipes would destroy the velocity sensor.



APPENDIX A, Page A-6



APPENDIX A, Page A-7

3.0 RESULTS

3.1 BLAST FURNACE #5

Testing was initiated on August 17, 1995 with sensors on only the south side of the casthouse. Testing was suspended until sensors were available to install in the north side of the casthouse. During that interim period, the blast furnace personnel removed the runner cover to do maintenance work. Temperatures in the casthouse roof monitor were such that the plastic shrouds on the velocity meters were melted as was the insulation on the sensor cables. Damaged equipment was replaced and testing began on September 2 and terminated on September 8.

Data were recorded every 15 seconds and processed for hourly averages. The hourly average data are presented in Table A-1. Missing data are designated as -1. Gaps in the data occurred due to computer failure. Two computers were damaged by the magnetic fields in the control room before the problem was identified.

Meteorological data from the West Virginia DEP tower are also listed in Table A-1 and forms the base temperatures against which the four sensors are compared. A summary of the data in Table A-1 is listed below:

	Diff (F°)	Speed (FPM)
Site 1	40.19	313.60
Site 2	43.73	322.62
Site 3	40.36	341.74
Site 4	38.17	322.60
Mean	40.61	325.14

The 115 hours of testing resulted in a mean temperature difference of 40.61 F° and a mean exhaust speed of 325.14 feet per minute.

Ohio EPA reviewed earlier calculations of plume rise. Ohio EPA wanted plume rise (F') calculated for each pair of temperature

TABLE A-1

HOURLY SUMMARY OF BLAST FURNACE NO. 5
CASTHOUSE PLUME RISE RESULTS

		Follansbee 30 m			Site 1		Site 2		Site 3		Site 4		
Date	Hr	Direction (Deg)	Speed (MPH)	Temp (°F)	Diff (F°)	Speed (FPM)	Diff (F°)	Speed (FPM)	Diff (F°)	Speed (FPM)	Diff (F°)	Speed (FPM)	F' (m^4/s^3)
09/02/95	16	339.7	8.7	74.68	27.8	290	31.8	240	31.3	-1	30.4	-1	17.7
09/02/95	17	336.2	8.1	73.42	39.1	340	42.4	333	40.2	-1	40.1	-1	29.6
09/02/95	18	333.9	5.8	69.69	39.0	349	42.7	368	39.1	-1	37.1	-1	31.0
09/02/95	19	64.2	2.5	61.60	48.1	311	47.3	336	44.2	-1	42.4	-1	32.4
09/02/95	20	113.2	3.1	57.60	43.4	317	44.8	340	40.9	-1	39.6	-1	30.9
09/02/95	21	130.6	3.5	56.01	49.2	322	48.8	334	45.0	-1	43.1	-1	33.8
09/02/95	22	124.1	3.6	54.43	42.1	306	41.6	329	40.2	-1	38.7	-1	29.0
09/02/95	23	134.5	4.1	53.59	46.7	340	46.7	359	44.1	-1	42.4	-1	35.1
09/03/95	0	137.4	3.8	53.40	40.6	300	42.0	314	40.7	-1	38.1	-1	27.9
09/03/95	1	131.2	4.1	52.31	49.6	356	53.6	341	46.0	-1	41.9	-1	37.1
09/03/95	2	134.0	4.0	52.06	40.3	294	42.0	304	38.3	-1	35.9	-1	26.5
09/03/95	3	116.4	3.9	51.50	45.7	329	46.2	327	41.2	-1	38.8	-1	31.7
09/03/95	4	100.4	4.2	50.86	41.7	327	41.8	351	39.8	-1	38.6	-1	31.0
09/03/95	5	104.1	4.1	50.82	43.9	287	43.3	285	37.7	-1	36.3	-1	26.1
09/03/95	6	128.1	3.3	51.30	49.8	352	49.3	362	45.7	-1	43.7	-1	37.6
09/03/95	7	154.5	4.1	54.87	46.3	286	43.6	267	38.3	-1	36.4	-1	25.5
09/03/95	9	162.1	5.9	68.58	47.3	272	50.5	251	47.1	-1	42.7	307	16.1
09/03/95	10	192.3	6.3	75.53	47.3	298	49.2	268	46.2	-1	43.9	318	17.2
09/03/95	11	213.3	7.2	78.59	47.7	329	48.3	317	47.1	-1	44.3	340	19.7
09/03/95	12	267.9	7.8	79.43	38.9	272	42.0	257	39.9	-1	37.4	310	13.7
09/03/95	13	277.8	8.2	79.69	37.5	241	37.9	239	38.9	-1	38.1	299	12.0
09/03/95	14	279.2	7.5	79.80	37.6	229	38.1	240	41.6	-1	41.4	272	11.6
09/03/95	15	272.8	6.6	79.95	28.0	219	35.1	213	39.2	-1	37.8	-1	16.4
09/03/95	16	250.4	6.7	78.34	30.9	240	36.2	247	39.5	-1	37.7	-1	19.1
09/03/95	17	268.1	8.1	77.08	40.0	310	42.6	310	37.2	-1	34.5	-1	25.9
09/03/95	18	278.3	8.0	74.46	41.3	327	41.3	329	38.1	-1	36.3	-1	28.0
09/03/95	19	290.0	6.5	72.54	42.1	340	45.3	358	40.8	-1	38.6	-1	31.6
09/03/95	20	48.3	2.7	69.40	43.1	341	48.3	343	42.2	-1	39.7	-1	32.2
09/03/95	21	147.4	3.9	67.99	44.5	370	46.0	385	43.2	-1	41.3	-1	36.0
09/03/95	22	135.0	3.3	65.36	44.5	321	44.2	332	40.2	-1	40.1	-1	30.3
09/03/95	23	141.0	4.0	62.69	45.9	405	50.0	424	48.7	-1	46.3	-1	43.2
09/04/95	0	142.6	3.8	60.91	51.8	434	56.3	449	53.8	-1	50.8	-1	51.0
09/04/95	1	132.9	3.6	61.33	46.2	426	49.1	450	47.0	-1	45.9	-1	45.2
09/04/95	2	143.7	3.8	60.96	50.7	413	56.7	448	55.3	-1	50.7	-1	49.8
09/04/95	3	150.2	4.2	59.90	50.8	440	52.8	468	51.0	-1	50.8	-1	50.9
09/04/95	4	134.5	3.8	58.25	51.0	423	53.3	449	53.0	-1	50.3	-1	49.5
09/04/95	5	127.0	3.7	57.19	52.9	442	55.2	464	53.9	-1	52.7	-1	53.1
09/04/95	6	138.0	3.9	57.39	52.0	423	54.1	435	52.7	-1	50.3	-1	49.1
09/04/95	10	318.6	8.7	75.28	50.7	328	45.9	355	43.1	352	40.4	-1	33.4
09/04/95	11	357.3	8.0	77.05	48.0	362	45.7	389	41.0	394	39.0	-1	35.6
09/04/95	12	3.8	7.6	78.95	40.8	277	36.8	292	33.3	336	32.5	-1	23.5
09/04/95	13	351.4	8.8	80.92	42.2	301	39.0	314	38.3	366	36.7	-1	27.4
09/04/95	14	341.9	10.0	81.73	50.2	386	50.7	364	49.5	413	45.8	-1	40.1
09/04/95	15	338.5	7.7	80.19	44.9	383	45.0	385	42.3	417	42.3	-1	36.8
09/04/95	16	352.9	8.8	80.47	43.5	390	44.6	391	45.8	388	43.0	-1	36.7
09/04/95	17	346.1	8.3	78.79	34.2	321	35.3	319	33.0	313	32.9	-1	23.4
09/04/95	18	354.8	7.5	73.57	38.1	341	42.2	353	37.9	326	38.0	-1	28.9
09/04/95	19	12.0	6.6	65.87	39.3	288	42.6	298	41.6	300	40.0	-1	26.6
09/04/95	20	4.9	5.6	62.24	47.1	382	54.9	398	50.6	386	46.5	-1	42.2
09/04/95	21	11.9	4.2	60.58	37.7	323	41.8	357	40.4	336	39.5	-1	30.0
09/04/95	22	46.6	3.5	57.82	43.0	290	48.1	293	43.0	341	40.9	-1	29.9
09/04/95	23	97.6	3.0	55.81	44.6	311	48.0	306	44.0	353	41.5	-1	32.0
09/05/95	0	95.8	2.5	53.55	39.2	271	41.8	278	38.9	326	38.0	-1	26.0
09/05/95	1	100.8	3.3	52.48	46.8	314	50.5	320	46.0	356	43.1	-1	34.3
09/05/95	2	24.0	3.0	50.74	40.3	306	42.8	331	40.4	326	38.3	-1	29.4
09/05/95	3	23.1	3.9	50.35	42.9	327	46.7	334	42.7	338	39.2	-1	32.2
09/05/95	4	12.2	4.9	50.23	40.5	338	45.8	356	41.2	339	37.9	-1	32.2
09/05/95	5	19.0	4.4	50.00	40.0	350	45.6	368	41.7	349	37.9	-1	33.2
09/05/95	6	12.5	4.8	51.57	39.2	320	41.1	335	37.1	328	34.9	-1	28.3
09/05/95	7	5.8	3.2	54.77	45.4	416	48.9	449	46.5	399	43.9	-1	43.2

TABLE A-1 (Continued)

		Follansbee 30 m			Site 1		Site 2		Site 3		Site 4		
Date	Hr	Direction (Deg)	Speed (MPH)	Temp (°F)	Diff (F°)	Speed (FPM)	Diff (F°)	Speed (FPM)	Diff (F°)	Speed (FPM)	Diff (F°)	Speed (FPM)	F' (m^4/s^3)
09/05/95	8	289.0	3.0	61.48	45.7	389	43.7	407	42.8	384	41.5	-1	37.7
09/06/95	11	220.6	4.8	83.86	33.1	214	34.1	193	29.0	328	26.0	-1	16.2
09/06/95	12	166.4	6.0	86.14	23.7	170	27.5	194	27.1	321	22.0	-1	12.5
09/06/95	13	142.2	5.3	86.57	24.1	148	30.5	150	30.0	269	23.0	-1	11.1
09/06/95	14	121.6	5.5	87.30	29.2	162	32.6	178	30.1	291	24.3	-1	13.2
09/06/95	15	235.2	6.6	88.00	35.2	222	36.0	229	36.5	377	33.1	-1	20.8
09/06/95	16	241.1	5.9	86.68	29.8	214	32.9	196	31.3	357	29.6	-1	17.0
09/06/95	17	242.6	5.6	84.85	36.8	263	40.1	277	36.9	366	36.1	-1	24.2
09/06/95	18	97.2	3.0	75.92	39.8	339	44.8	354	42.7	357	40.1	-1	31.6
09/06/95	19	146.0	4.1	70.07	37.5	298	39.4	314	38.8	322	37.6	-1	26.2
09/06/95	20	139.9	4.4	67.46	43.8	307	44.1	324	42.0	331	41.2	-1	30.0
09/06/95	22	136.8	3.8	61.94	43.2	288	44.4	299	40.1	324	38.9	-1	28.0
09/06/95	23	134.3	4.2	61.04	36.7	250	38.4	261	35.4	306	34.5	-1	22.1
09/07/95	0	132.5	3.8	60.17	43.3	281	44.0	297	39.6	329	38.3	-1	27.7
09/07/95	1	144.6	4.4	59.38	35.9	264	35.4	284	34.1	311	33.9	-1	22.4
09/07/95	2	138.4	4.7	58.22	40.8	285	43.1	285	39.9	308	37.8	-1	26.4
09/07/95	3	143.2	4.6	57.61	39.1	270	39.4	281	35.9	290	35.2	-1	23.5
09/07/95	4	148.7	5.2	58.39	39.3	293	37.2	315	36.2	321	35.7	-1	25.8
09/07/95	5	148.2	5.5	58.24	40.7	317	41.9	335	38.2	329	37.1	-1	28.9
09/07/95	6	156.2	5.1	58.98	38.6	340	40.4	377	39.5	348	37.8	-1	31.0
09/07/95	7	167.5	5.0	62.63	50.9	361	47.8	403	49.4	372	48.9	-1	40.6
09/07/95	8	172.8	8.4	70.65	33.9	296	37.8	301	46.5	442	42.3	-1	30.3
09/07/95	9	178.3	10.0	75.26	14.1	193	14.9	210	28.4	433	26.5	-1	13.1
09/07/95	10	176.9	8.9	77.92	10.4	164	11.0	173	22.4	387	22.6	388	10.4
09/07/95	11	197.1	8.5	80.40	13.8	182	15.3	180	24.8	366	23.7	382	12.0
09/07/95	12	235.8	7.2	82.56	23.6	260	26.2	246	27.9	326	25.0	336	16.4
09/07/95	13	267.7	8.4	82.44	22.7	264	28.4	239	27.7	341	26.8	343	17.2
09/07/95	14	242.8	6.8	81.91	65.1	429	70.3	436	74.0	459	66.2	476	63.3
09/07/95	15	220.6	7.0	80.48	39.9	265	45.6	272	43.1	359	40.6	365	28.5
09/07/95	16	228.6	6.3	79.47	42.5	295	45.4	308	44.2	373	43.1	370	31.5
09/07/95	17	286.6	6.1	77.03	33.0	340	49.2	332	39.6	359	32.1	365	29.1
09/07/95	18	21.3	3.5	73.99	37.5	320	46.5	295	38.4	332	33.4	332	27.1
09/07/95	19	77.3	3.0	70.63	39.6	352	45.9	358	40.3	347	37.8	349	31.4
09/07/95	20	104.7	3.0	69.35	34.7	282	38.5	283	32.6	305	32.0	310	22.5
09/07/95	21	145.7	3.6	67.95	43.6	346	48.0	353	40.5	352	37.3	358	32.6
09/07/95	22	52.8	4.2	65.63	40.0	279	43.4	282	37.4	309	34.7	311	25.3
09/07/95	23	35.2	3.3	64.44	37.2	293	39.8	309	35.5	325	34.2	319	25.4
09/08/95	0	31.6	4.1	63.01	43.5	332	47.1	345	41.4	346	39.1	345	32.2
09/08/95	1	14.7	4.3	62.38	38.1	300	41.0	316	36.5	324	34.8	317	26.3
09/08/95	2	2.6	5.4	62.45	42.2	326	48.3	335	43.1	320	39.6	323	31.1
09/08/95	3	356.2	3.9	62.45	46.2	370	50.5	401	45.5	395	45.0	382	39.7
09/08/95	4	351.2	4.5	62.69	47.6	395	53.8	411	48.8	389	46.7	397	42.7
09/08/95	5	359.9	3.7	63.01	42.2	344	47.0	345	42.7	284	40.0	315	30.5
09/08/95	6	345.5	4.8	62.94	34.7	311	38.8	305	35.9	259	33.9	288	23.2
09/08/95	7	22.7	3.8	64.72	39.2	331	43.1	337	40.8	307	37.4	312	28.5
09/08/95	8	1.5	5.3	66.51	39.4	343	39.6	375	39.6	372	37.9	340	30.8
09/08/95	9	3.1	4.4	68.67	40.1	323	45.6	334	40.1	321	35.9	307	28.4
09/08/95	10	4.5	3.5	70.46	40.0	325	44.7	341	41.1	315	36.6	311	28.6
09/08/95	11	349.3	6.3	71.31	45.2	346	47.7	358	45.0	354	42.0	343	34.1
09/08/95	12	354.5	5.3	73.25	35.7	310	35.8	317	35.0	301	31.8	304	23.4
09/08/95	13	280.1	4.1	76.55	35.5	307	36.8	329	34.2	297	30.2	302	23.0
09/08/95	14	316.1	4.6	77.72	34.7	319	33.6	346	32.1	323	31.0	313	23.3
09/08/95	15	340.8	4.3	78.42	35.5	320	32.9	332	31.3	325	30.4	323	23.1
09/08/95	16	0.5	6.5	76.24	31.4	301	32.6	318	31.3	294	30.3	278	20.5
09/08/95	17	4.0	6.3	73.65	28.1	280	30.2	277	31.1	250	29.0	249	17.3

APPENDIX A, Page A-10

difference and velocity data and those values averaged rather than using mean temperature difference and mean velocity as input to the equation. This suggested procedure was followed using a source length of 25 meters and source height of 1 meter for each matched pair of data. Results are listed in the last column of Table A-1.

The F′ determined from the September 2 through September 8, 1995 testing reported in Table A-1 was 28.96 m^4/s^3 and compares favorably to the F′ of 31.20 m^4/s^3 measured at the No. 3 casthouse over the period December 29, 1993 through January 5, 1994. The BLP input files are presented as Table A-2 for BF No. 1 and Table A-3 for BF No. 5.

3.2 BOF ROOF MONITOR

Testing was initiated on August 17 and concluded on August 28. Data were recorded every 15 seconds and processed for hourly averages. The hourly average data are presented in Table A-4. Meteorological data from the West Virginia DEP tower are also listed in Table A-4 and form the base temperature against which the seven sensors are compared. A summary of the data in Table A-4 is listed below:

	Diff (F°)	Speed (FPM)
Site 1	23.0	542.4
Site 2	24.1	579.1
Site 3	21.7	513.2
Site 4	17.6	518.5
Site 5	16.4	456.4
Site 6	23.5	385.4
Site 7	17.7	305.1
Mean for East Side	20.6	521.9
Mean for West Side	20.6	345.3

TABLE A-2

BLP INPUT FILE FOR BLAST FURNACE NO. 1

```
 WPSC BF #1 Cast House Roof Monitor emissions at 1 g/s
&GEN
NLINES=1
NREC=10
LPART=.TRUE.
LCOMPR=.TRUE.
LINPUT=.TRUE.
LUTMS=.TRUE.
LTRANS=.FALSE.
/
&RISE
L=25.0
HB=14.9
WB=9.0
WM=1.0
DX=100.
FPRIME=29.0
/
&METIN
LMETIN=.FALSE.
IDSURF=94823
IYSURF=89
IDUPER=94823
IYUPER=89
ZMEAS=30.0
IDELS=1
IRU=1
IDAYS=365*1,0
/
&CALC
/
&OUTPUT
IPCL=1,0,0,0,0,0,0,0,0,0,1
/
   533000.  4466500.      196.
   533000.  4466000.      196.
   533000.  4466750.      196.
   529000.  4472000.      335.
   532750.  4467000.      201.
   532750.  4466750.      201.
   533000.  4466250.      196.
   533000.  4465750.      196.
   532750.  4465500.      216.
   532500.  4465750.      280.
  532677.0 4466224.0  532702.0 4466224.0      14.9      1.00      201.2
```

APPENDIX A, Page A-12

TABLE A-3

BLP INPUT FILE FOR BLAST FURNACE NO. 5

```
 WPSC BF #5 Cast House Roof Monitor emissions at 1 g/s
&GEN
NLINES=1
NREC=10
LPART=.TRUE.
LCOMPR=.TRUE.
LINPUT=.TRUE.
LUTMS=.TRUE.
LTRANS=.FALSE.
/
&RISE
L=25.0
HB=12.2
WB=9.0
WM=1.0
DX=100.
FPRIME=29.0
/
&METIN
LMETIN=.FALSE.
IDSURF=94823
IYSURF=89
IDUPER=94823
IYUPER=89
ZMEAS=30.0
IDELS=1
IRU=1
IDAYS=365*1,0
/
&CALC
/
&OUTPUT
IPCL=1,0,0,0,0,0,0,0,0,0,1
/
   533000.  4466500.       196.
   533000.  4466000.       196.
   533000.  4466750.       196.
   529000.  4472000.       335.
   532750.  4467000.       201.
   532750.  4466750.       201.
   533000.  4466250.       196.
   533000.  4465750.       196.
   532750.  4465500.       216.
   532500.  4465750.       280.
  533615.0 4463076.0  533640.0 4463076.0      12.2      1.00      204.2
```

APPENDIX A, Page A-13

TABLE A-4

HOURLY SUMMARY OF BASIC OXYGEN FURNACE ROOF MONITOR PLUME RISE RESULTS

		Follansbee 30 m			Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 7		F' (m^4/s^3)	
Date	Hr	Direction (Deg)	Speed (MPH)	Temp (°F)	Diff (F°)	Speed (FPM)	Diff (F°)	Speed (FPM)	Diff (F°)	Speed (FPM)	Diff (F°)	Speed (FPM)	Diff (F°)	Speed (FPM)	Diff (F°)	Speed (FPM)	Diff (F°)	Speed (FPM)	East RM	West RM
08/17/95	18	348.6	8.2	82.42	19.1	602	18.0	716	13.7	620	14.6	596	15.0	535	12.1	367	8.3	212	155.4	47.0
08/17/95	19	337.8	8.6	79.07	20.2	556	19.0	659	16.8	600	17.7	590	17.1	543	16.0	286	11.2	209	169.0	53.6
08/17/95	20	3.3	4.0	77.31	20.6	562	21.3	651	18.6	575	17.5	546	16.2	493	18.1	259	15.0	184	168.5	58.2
08/17/95	21	6.1	4.3	75.34	20.9	530	22.9	617	20.7	546	17.5	506	16.7	461	23.4	297	19.2	232	166.4	89.0
08/17/95	22	6.0	4.6	73.35	20.7	507	23.9	598	22.5	529	17.9	498	17.2	457	24.2	305	19.2	226	168.1	91.3
08/17/95	23	44.4	3.0	72.21	19.3	510	23.6	601	21.2	523	16.8	499	15.3	442	25.0	329	18.0	221	158.0	93.9
08/18/95	0	34.3	2.8	71.92	17.4	478	20.7	575	17.8	503	16.6	504	14.5	435	21.6	324	18.1	209	139.0	84.3
08/18/95	1	112.0	3.1	72.51	16.1	487	19.1	593	16.4	518	15.7	511	14.0	441	19.1	286	17.3	171	132.9	66.4
08/18/95	2	55.5	3.8	71.71	16.8	460	20.3	542	17.6	477	16.7	485	14.8	426	23.8	357	19.1	259	132.0	105.0
08/18/95	3	45.7	2.1	72.08	16.2	467	19.0	552	16.3	488	15.4	495	14.2	434	21.8	351	17.5	243	126.8	93.0
08/18/95	4	68.8	2.5	72.08	15.9	481	18.7	559	15.1	486	13.4	478	12.2	415	21.3	317	14.4	182	117.1	71.2
08/18/95	5	36.4	3.3	71.81	15.8	454	17.6	517	14.9	461	14.0	456	13.4	416	20.4	338	14.4	236	112.2	80.0
08/18/95	6	57.8	4.1	71.88	16.4	471	18.3	535	15.6	478	14.7	472	14.2	430	20.5	343	14.6	261	121.4	84.8
08/18/95	7	25.5	5.3	73.07	15.7	343	16.7	389	14.4	348	13.9	360	14.0	310	18.5	409	14.2	349	83.9	99.2
08/18/95	8	359.1	4.0	73.82	14.6	407	15.6	467	14.3	423	13.4	430	13.6	403	19.2	383	13.7	289	97.8	88.3
08/18/95	9	36.1	3.0	78.09	12.4	396	13.6	440	13.0	407	12.5	446	13.0	421	13.7	455	13.0	345	86.9	85.2
08/18/95	10	83.4	3.1	82.58	10.9	415	12.3	481	11.1	420	10.3	447	10.3	417	14.1	452	12.2	359	76.1	84.4
08/18/95	11	171.1	4.4	87.10	10.4	416	12.9	476	10.9	414	9.8	434	9.6	402	14.9	450	12.7	362	72.4	87.9
08/18/95	12	238.3	6.6	88.42	10.1	516	12.8	611	11.3	538	10.0	524	9.6	455	11.3	260	10.9	180	89.5	38.4
08/18/95	13	276.6	5.2	87.72	12.2	491	14.3	582	13.2	506	11.7	485	11.4	418	13.1	240	12.0	173	97.9	40.7
08/18/95	14	320.7	6.7	89.44	10.8	525	10.4	629	10.2	568	11.0	556	10.5	488	8.7	271	8.6	162	91.9	29.5
08/18/95	15	350.0	5.8	89.22	13.0	476	15.1	576	13.6	510	13.0	510	12.4	450	17.2	243	14.2	166	105.8	50.0
08/18/95	16	1.2	7.0	88.56	13.3	384	14.5	482	13.6	441	13.4	464	13.5	423	15.8	290	13.6	279	93.8	65.3
08/18/95	17	24.1	5.5	85.36	17.3	332	17.3	415	16.3	389	16.3	433	16.3	372	17.1	349	16.1	333	101.4	88.6
08/18/95	18	34.8	7.2	82.92	9.0	315	11.5	266	11.8	228	11.9	280	11.5	234	16.9	535	16.7	462	46.8	131.6
08/18/95	19	35.8	8.8	80.14	12.7	267	14.0	306	13.0	284	12.5	315	10.8	254	18.4	500	16.1	402	57.2	122.8
08/18/95	20	47.8	4.3	74.27	18.1	464	18.5	550	17.5	506	16.5	515	15.3	453	18.8	387	17.4	282	136.3	96.4
08/18/95	21	105.1	2.7	69.86	19.1	472	19.8	554	19.0	509	18.4	522	17.5	473	18.7	393	19.0	287	152.2	102.7
08/18/95	22	117.7	3.8	70.01	17.8	465	19.1	526	17.9	473	16.1	488	15.1	432	20.0	396	17.7	307	131.8	106.2
08/18/95	23	105.9	2.8	68.73	17.6	474	19.8	552	17.6	497	15.9	498	14.6	434	24.4	382	17.1	268	135.3	107.9
08/19/95	0	96.3	2.7	67.00	19.1	490	21.8	553	19.1	490	15.8	481	14.4	422	23.9	359	18.1	288	141.8	109.0
08/19/95	1	31.5	3.3	65.61	22.3	544	26.2	602	22.0	513	17.2	485	16.3	429	28.6	368	20.9	269	172.3	126.0
08/19/95	2	55.5	2.3	64.72	24.2	567	27.2	592	23.3	518	18.6	508	17.1	444	30.3	366	20.2	273	186.7	129.0
08/19/95	3	79.1	2.5	63.79	23.9	566	27.6	592	23.0	523	18.9	515	16.9	444	28.6	377	20.9	259	187.7	126.2
08/19/95	4	87.3	3.1	63.78	22.5	551	24.6	561	21.0	500	17.8	496	15.9	428	26.5	374	18.8	254	166.9	114.5
08/19/95	5	79.4	2.1	63.20	22.7	557	24.1	566	21.6	484	17.1	485	15.8	424	26.5	346	16.7	246	165.0	103.2
08/19/95	6	68.8	1.6	64.63	22.9	555	24.8	546	21.4	492	17.3	498	16.6	432	23.2	366	16.1	292	167.7	104.5
08/19/95	7	61.3	2.0	70.16	19.1	509	21.2	504	16.5	470	14.2	479	14.7	429	21.1	415	12.9	306	131.7	98.5
08/19/95	8	86.7	2.5	77.42	17.3	402	17.8	416	14.6	382	12.1	400	12.1	356	17.9	462	10.7	377	92.1	95.6
08/19/95	9	124.6	6.5	83.76	13.8	348	13.7	426	11.1	391	9.1	391	9.1	348	14.3	428	7.6	370	68.5	69.3
08/19/95	10	131.2	7.3	86.96	13.2	379	14.0	387	12.4	382	10.3	392	10.9	348	14.1	506	9.1	463	72.2	88.5
08/19/95	11	166.7	8.3	89.25	11.2	457	12.8	499	10.0	460	8.8	469	7.0	414	16.0	470	9.2	384	72.0	84.2
08/19/95	12	182.1	7.8	90.30	13.4	427	14.1	468	10.3	422	8.4	416	7.0	372	17.4	441	9.5	365	70.2	84.6
08/19/95	13	194.5	6.8	90.79	16.4	455	15.4	516	11.9	471	10.6	479	10.3	437	17.4	435	11.4	334	95.1	86.2
08/19/95	14	190.5	7.0	92.57	17.6	522	19.3	588	15.9	517	11.5	518	10.8	462	24.4	436	13.2	323	121.4	109.8
08/19/95	15	160.4	5.8	92.80	20.4	502	22.3	566	18.3	493	11.9	481	11.3	434	26.5	448	14.7	326	128.8	122.3
08/19/95	16	130.5	4.8	92.26	19.7	534	21.0	630	16.3	544	11.9	535	10.8	464	20.0	286	13.7	223	133.6	66.3
08/19/95	17	86.4	4.3	90.21	22.5	480	21.4	538	16.1	493	14.1	495	12.6	440	23.5	449	15.4	357	131.5	121.0

TABLE A-4 (Continued)

Date	Hr	Follansbee 30 m Direction (Deg)	Follansbee 30 m Speed (MPH)	Follansbee 30 m Temp (°F)	Site 1 Diff (F°)	Site 1 Speed (FPM)	Site 2 Diff (F°)	Site 2 Speed (FPM)	Site 3 Diff (F°)	Site 3 Speed (FPM)	Site 4 Diff (F°)	Site 4 Speed (FPM)	Site 5 Diff (F°)	Site 5 Speed (FPM)	Site 6 Diff (F°)	Site 6 Speed (FPM)	Site 7 Diff (F°)	Site 7 Speed (FPM)	F′ (m^4/s^3) East RM	F′ (m^4/s^3) West RM
08/19/95	18	87.9	5.1	84.09	27.5	458	24.2	541	20.7	498	19.3	499	18.9	450	25.5	490	21.4	411	168.1	163.7
08/19/95	19	101.0	6.1	79.08	26.1	436	24.7	536	22.3	490	21.0	500	20.7	462	25.8	512	21.8	408	174.2	171.1
08/19/95	20	122.4	4.5	74.22	31.2	511	29.5	607	26.4	552	23.9	586	22.7	513	28.6	503	24.5	386	232.2	185.1
08/19/95	21	113.0	3.5	72.33	30.6	495	30.3	572	26.6	537	24.2	555	24.0	499	28.4	511	24.9	420	226.8	195.2
08/19/95	22	98.3	3.6	70.52	34.4	518	33.6	556	28.4	523	24.5	548	24.1	486	28.5	500	25.0	416	239.9	193.4
08/19/95	23	93.2	3.4	69.70	31.0	571	30.4	555	26.2	518	22.7	529	22.4	475	28.2	494	23.0	387	222.2	178.6
08/20/95	0	111.9	2.9	68.25	32.2	573	32.8	544	29.0	493	23.2	530	22.5	479	28.5	488	23.7	388	231.4	181.4
08/20/95	1	121.8	3.2	67.07	31.7	546	31.0	562	26.3	503	22.7	525	22.0	474	27.9	490	23.4	408	221.7	183.3
08/20/95	2	108.3	3.6	66.99	29.7	575	30.7	575	26.2	522	22.1	549	21.5	490	28.5	482	23.4	389	224.5	179.8
08/20/95	3	131.6	5.2	66.51	30.4	605	31.5	600	26.0	530	20.8	550	20.2	497	29.2	467	22.1	366	228.4	170.2
08/20/95	4	116.2	3.5	65.87	30.8	557	29.6	559	24.0	514	20.0	517	19.8	469	26.0	465	20.3	384	207.6	157.4
08/20/95	5	132.0	4.5	65.66	27.4	585	27.6	577	22.8	524	19.2	540	19.1	471	24.0	452	19.5	377	200.7	144.9
08/20/95	6	115.7	5.5	67.35	26.9	602	28.6	593	23.9	537	19.5	558	19.2	498	25.2	465	19.7	369	210.2	149.8
08/20/95	7	123.6	4.4	72.09	27.4	614	28.0	587	23.7	524	16.9	543	16.0	478	22.7	466	16.2	371	195.1	129.8
08/20/95	8	166.0	5.1	77.59	26.9	611	26.0	590	21.1	513	14.7	540	14.4	489	21.0	513	14.5	425	178.2	131.8
08/20/95	9	189.0	6.2	81.45	25.0	608	25.1	586	22.5	519	15.0	532	14.1	482	22.0	531	14.2	455	173.7	140.3
08/20/95	10	195.1	5.1	84.60	23.5	622	24.5	621	19.4	553	14.4	575	14.2	508	20.0	455	14.1	383	172.5	111.9
08/20/95	11	207.6	5.4	87.34	18.6	579	21.7	569	18.2	515	13.2	554	12.8	495	19.2	458	13.4	347	142.9	102.4
08/20/95	12	191.1	5.3	89.79	19.4	555	20.1	562	16.1	502	12.5	531	12.1	474	18.9	518	13.2	401	130.8	114.6
08/20/95	13	200.7	5.8	90.80	21.1	570	21.1	579	16.1	535	13.1	544	12.1	479	19.3	513	13.6	388	140.1	114.9
08/20/95	14	165.3	4.8	91.60	22.2	545	24.8	514	21.9	444	15.4	484	12.8	443	19.8	441	13.2	344	145.4	100.3
08/20/95	15	132.6	5.0	92.38	20.6	562	22.0	557	17.6	496	13.0	509	11.9	453	19.5	368	13.2	266	135.5	80.2
08/20/95	16	156.0	3.8	91.24	18.9	565	20.1	584	18.7	514	12.2	503	11.3	448	21.3	328	14.3	230	131.6	76.8
08/20/95	17	85.1	3.7	87.87	19.2	506	20.8	515	19.5	455	14.8	453	13.8	425	22.4	356	16.3	254	129.0	91.5
08/20/95	18	63.6	3.0	81.33	23.3	559	24.7	580	23.4	516	18.8	516	18.0	466	25.6	361	19.3	269	178.3	110.3
08/20/95	19	96.1	2.8	76.75	23.0	540	24.2	575	23.0	507	18.0	485	16.8	424	23.0	351	18.0	277	167.6	101.6
08/20/95	20	127.8	3.3	74.12	21.5	544	23.2	583	20.5	524	17.4	521	17.0	459	21.0	372	17.3	310	166.4	103.8
08/20/95	21	126.6	3.4	72.02	22.8	547	22.3	575	19.1	512	17.4	522	16.6	454	19.0	365	17.3	271	163.5	92.3
08/20/95	22	127.3	4.0	72.62	23.7	546	23.5	579	21.0	510	16.3	520	14.7	449	20.9	339	16.0	257	164.5	87.8
08/20/95	23	140.5	4.4	72.28	23.8	576	23.0	607	19.7	539	16.5	554	16.2	471	19.0	363	15.8	274	173.6	88.7
08/21/95	0	127.0	4.0	71.32	24.8	600	24.9	618	23.0	548	17.0	554	15.5	474	21.3	308	17.2	211	187.2	79.8
08/21/95	1	127.5	3.9	70.63	26.4	623	25.8	645	21.9	563	18.0	580	17.9	507	21.6	389	17.8	279	204.3	105.2
08/21/95	2	110.8	3.3	69.34	23.2	598	24.9	616	23.7	551	17.9	552	16.5	472	23.9	338	18.2	214	189.3	92.8
08/21/95	3	80.2	2.3	68.45	27.0	638	27.0	640	25.3	575	18.8	569	16.8	485	24.8	337	19.2	208	213.1	95.8
08/21/95	4	101.2	2.8	67.81	27.4	646	26.4	650	25.5	575	18.7	564	16.8	474	23.6	313	18.4	203	213.3	86.8
08/21/95	5	30.4	2.9	67.34	28.0	640	27.5	648	27.3	579	20.1	564	17.8	474	24.7	335	20.2	210	223.7	97.9
08/21/95	6	2.6	4.0	68.94	25.5	626	25.9	643	25.2	559	17.0	541	14.0	441	23.5	327	17.4	209	193.2	87.7
08/21/95	7	359.2	4.1	70.75	25.7	570	25.3	555	22.2	500	16.8	529	15.7	448	21.3	374	15.8	278	175.3	96.8
08/21/95	8	13.1	3.7	73.92	26.1	534	27.8	525	25.5	448	18.3	506	15.4	451	22.1	400	16.4	330	176.2	111.7
08/21/95	9	344.6	4.6	78.43	21.1	520	24.2	540	22.1	488	15.3	512	13.1	458	21.0	388	15.6	283	152.2	97.0
08/21/95	10	344.8	5.6	82.30	19.8	524	21.7	522	20.7	465	14.5	482	12.1	426	17.0	342	12.8	284	134.9	73.6
08/21/95	11	9.7	4.5	83.84	19.5	571	21.7	611	20.5	540	15.5	557	13.8	479	16.5	287	12.8	185	157.1	54.4
08/21/95	12	266.2	6.3	86.94	13.9	596	13.3	660	13.7	581	10.5	551	9.2	470	7.5	200	9.1	167	109.0	24.1
08/21/95	13	282.4	7.6	87.69	13.0	589	10.5	660	11.0	581	11.1	547	9.5	476	5.2	281	6.4	258	99.0	24.8
08/21/95	14	282.1	9.2	90.14	12.6	644	12.1	760	11.6	671	12.7	636	12.6	556	4.8	294	8.0	273	125.9	28.7
08/21/95	15	298.7	10.9	89.72	15.9	731	14.9	842	12.8	752	14.3	715	14.8	623	5.2	361	5.6	319	166.0	29.1
08/21/95	16	284.6	11.9	88.53	20.0	763	15.2	862	11.0	784	12.8	750	14.6	652	10.4	481	3.2	210	175.2	37.2
08/21/95	17	293.4	10.3	87.45	19.3	718	18.8	802	15.8	700	15.2	670	15.8	588	12.3	281	10.2	179	184.1	40.7
08/21/95	18	327.1	8.5	82.88	21.4	654	21.7	728	19.1	645	18.4	620	18.2	549	17.7	252	13.4	117	197.4	45.2
08/21/95	19	343.9	6.9	77.25	25.2	643	26.2	718	23.2	613	21.7	599	21.0	535	19.2	250	14.7	99	228.7	46.9
08/21/95	20	355.9	6.6	71.79	27.4	587	29.6	643	26.4	553	23.4	538	21.9	467	28.4	278	21.7	151	226.4	84.9

TABLE A-4 (Continued)

Date	Hr	Follansbee 30 m Direction (Deg)	Follansbee 30 m Speed (MPH)	Follansbee 30 m Temp (°F)	Site 1 Diff (F°)	Site 1 Speed (FPM)	Site 2 Diff (F°)	Site 2 Speed (FPM)	Site 3 Diff (F°)	Site 3 Speed (FPM)	Site 4 Diff (F°)	Site 4 Speed (FPM)	Site 5 Diff (F°)	Site 5 Speed (FPM)	Site 6 Diff (F°)	Site 6 Speed (FPM)	Site 7 Diff (F°)	Site 7 Speed (FPM)	F' (m^4/s^3) East RM	F' (m^4/s^3) West RM
08/21/95	21	10.7	4.5	66.00	29.0	550	31.9	598	29.4	520	24.2	483	22.1	418	33.5	346	26.4	191	223.1	127.2
08/21/95	22	71.5	2.5	64.02	26.1	576	28.8	654	26.8	562	21.0	509	19.3	432	27.7	292	22.3	161	213.9	90.7
08/21/95	23	133.9	5.0	63.75	22.5	564	25.0	624	21.5	541	18.5	539	16.3	450	25.5	345	18.5	266	182.3	108.3
08/22/95	0	137.7	4.3	63.50	25.0	584	26.7	623	21.8	539	18.0	543	15.8	465	26.0	386	18.3	287	190.8	120.1
08/22/95	1	124.0	3.5	62.49	26.9	614	27.6	638	24.6	557	18.3	546	16.5	479	27.3	348	18.2	255	208.3	110.6
08/22/95	2	70.3	2.7	60.85	28.9	602	29.7	637	28.4	552	19.7	527	18.1	450	26.2	318	19.6	209	222.7	97.6
08/22/95	3	10.1	4.4	60.14	34.9	634	32.6	604	28.6	535	22.0	545	21.1	461	29.1	351	20.8	265	248.4	124.0
08/23/95	14	233.7	5.3	83.79	14.2	525	18.2	577	14.6	499	11.0	514	10.4	472	22.0	467	13.8	368	111.7	117.0
08/23/95	15	245.7	5.8	84.37	15.5	546	19.8	592	16.9	524	12.3	538	11.2	473	23.5	343	15.2	248	127.2	89.2
08/23/95	16	248.7	4.7	84.45	19.3	656	22.2	721	21.3	615	13.2	591	12.1	505	21.2	200	16.3	121	170.3	47.0
08/23/95	17	234.9	5.6	82.56	23.2	638	25.5	697	25.4	599	16.3	563	14.1	468	26.1	193	20.6	119	193.5	56.6
08/23/95	18	63.0	3.1	75.25	23.3	539	30.5	592	27.5	510	19.8	523	18.7	463	33.0	345	24.8	247	198.0	133.4
08/23/95	19	110.5	3.4	67.99	25.4	573	30.5	606	28.8	525	19.7	527	18.2	471	31.3	369	22.5	242	210.9	130.3
08/23/95	20	132.6	4.1	64.50	29.0	604	30.8	629	27.7	539	19.6	535	17.4	462	31.4	374	21.5	278	220.8	137.7
08/23/95	21	143.9	4.0	62.43	28.5	606	29.5	633	27.9	546	18.8	528	16.7	457	31.8	374	21.1	273	216.4	137.1
08/23/95	22	128.0	3.5	61.10	27.3	605	28.6	642	27.5	547	18.3	526	16.1	456	29.4	360	20.1	239	211.2	119.4
08/23/95	23	137.0	4.3	60.12	29.7	600	29.0	616	26.9	525	18.6	531	16.8	458	27.8	386	18.9	299	213.5	129.4
08/24/95	0	135.6	4.2	58.88	27.7	608	28.2	617	26.8	547	18.0	536	16.6	465	28.6	391	19.5	284	211.0	131.5
08/24/95	1	137.1	4.5	58.92	26.6	593	26.4	601	25.1	531	16.3	517	15.0	462	25.8	377	17.7	318	192.4	123.0
08/24/95	2	129.5	4.2	59.31	24.2	599	24.6	604	24.0	540	16.2	551	14.1	483	24.4	395	17.2	331	186.6	123.0
08/24/95	3	96.8	3.0	59.32	26.2	619	26.3	619	25.0	528	16.6	529	12.7	455	25.5	343	16.6	281	191.1	106.9
08/24/95	4	129.7	4.2	58.59	24.2	594	24.2	588	22.8	508	15.1	519	12.7	461	25.1	369	16.3	292	172.7	111.6
08/24/95	5	111.4	4.4	57.83	22.2	606	23.3	609	23.0	538	14.9	542	13.6	482	25.5	381	16.4	280	176.4	113.0
08/24/95	6	108.1	4.8	57.89	20.9	581	22.6	597	22.6	517	14.0	509	12.7	454	25.0	356	15.4	247	161.8	99.6
08/24/95	7	115.1	4.0	60.20	18.6	535	22.5	558	19.1	497	14.0	496	12.7	437	24.5	388	17.1	292	143.5	115.0
08/24/95	8	143.5	4.2	65.63	16.1	511	20.1	532	17.2	472	12.4	476	12.1	436	20.9	397	16.0	344	122.9	110.5
08/24/95	9	159.2	4.8	73.73	10.8	463	15.1	500	11.1	449	8.6	457	8.1	424	16.8	436	13.1	363	79.6	95.7
08/24/95	10	198.0	5.0	80.78	11.3	460	15.0	499	11.3	448	8.4	461	8.4	426	15.4	364	10.8	290	79.6	68.0
08/24/95	11	255.5	5.1	84.28	14.2	564	16.8	630	14.2	545	10.1	525	8.9	442	10.6	238	7.9	158	109.7	29.1
08/24/95	12	236.8	7.1	86.96	13.3	560	16.6	628	14.9	555	10.8	534	8.9	452	12.0	265	11.2	184	110.6	41.0
08/24/95	13	266.6	7.3	87.66	15.0	594	17.6	690	17.0	585	11.5	549	9.4	454	9.6	217	12.1	155	126.8	31.8
08/24/95	14	273.0	9.2	88.09	18.4	650	18.7	746	17.2	643	14.5	602	12.0	501	8.7	260	10.4	222	158.3	36.3
08/24/95	15	322.1	10.3	85.74	22.6	745	19.7	817	18.7	717	16.8	680	12.3	582	10.8	368	6.2	194	199.1	37.9
08/24/95	16	347.8	10.7	82.63	24.9	731	21.0	813	18.5	712	17.2	682	12.7	606	15.1	425	7.5	188	209.4	55.0
08/24/95	17	348.9	9.7	80.44	23.0	635	21.4	711	17.8	643	16.5	639	13.3	598	20.9	406	8.0	199	186.8	69.3
08/24/95	18	341.7	10.1	77.86	26.0	757	20.9	836	16.7	716	17.6	702	13.5	614	11.7	453	6.0	195	216.9	46.1
08/24/95	19	347.4	7.9	76.21	26.5	703	25.7	771	23.4	649	19.6	626	16.1	527	15.2	252	10.9	126	229.7	39.5
08/24/95	20	357.4	8.8	74.45	26.6	595	25.5	638	25.0	558	20.8	557	16.0	458	20.5	258	15.6	220	201.8	68.7
08/24/95	21	1.7	8.0	70.49	25.7	414	26.0	459	26.6	443	21.3	459	17.4	400	28.3	359	21.8	390	161.6	148.5
08/24/95	22	343.2	6.7	66.16	29.4	495	30.7	493	30.2	442	24.8	477	21.3	429	29.4	380	23.6	373	202.5	158.8
08/24/95	23	337.2	5.1	63.06	30.0	517	31.0	517	29.3	464	24.5	487	23.2	435	31.2	462	25.2	428	213.4	200.2
08/25/95	0	0.2	3.0	59.81	34.0	513	33.4	499	30.7	452	25.2	478	25.0	429	33.2	489	25.7	454	225.1	222.4
08/25/95	1	1.8	3.7	57.24	34.4	550	34.9	543	32.3	473	25.7	508	25.0	455	34.1	478	26.8	411	247.4	217.4
08/25/95	2	16.3	3.4	54.88	33.0	550	33.5	539	29.8	475	24.6	498	24.1	446	34.9	457	25.7	371	235.2	202.4
08/25/95	4	353.6	4.3	54.69	33.1	587	32.9	576	30.8	502	23.6	531	22.3	472	33.1	465	24.7	386	246.6	199.0
08/25/95	5	3.9	4.7	55.31	31.1	578	31.2	574	29.9	500	23.1	519	22.0	460	32.1	449	23.8	382	234.2	188.0
08/25/95	6	353.2	5.4	57.52	28.0	543	27.8	548	28.5	474	24.2	491	19.4	415	28.2	424	22.9	393	204.7	169.0
08/25/95	7	11.3	5.6	62.10	25.5	553	25.6	554	25.2	482	19.7	493	16.9	422	25.0	454	19.7	412	182.6	156.3
08/25/95	8	20.7	6.5	66.64	23.5	471	22.3	502	21.0	433	15.0	453	13.5	388	25.1	477	16.2	438	138.1	151.8
08/25/95	9	27.0	5.8	71.76	20.4	453	19.7	493	18.5	440	13.5	453	13.3	398	21.7	479	14.6	437	122.5	133.0

TABLE A-4 (Continued)

Date	Hr	Follansbee 30 m Direction (Deg)	Follansbee 30 m Speed (MPH)	Follansbee 30 m Temp (°F)	Site 1 Diff (F°)	Site 1 Speed (FPM)	Site 2 Diff (F°)	Site 2 Speed (FPM)	Site 3 Diff (F°)	Site 3 Speed (FPM)	Site 4 Diff (F°)	Site 4 Speed (FPM)	Site 5 Diff (F°)	Site 5 Speed (FPM)	Site 6 Diff (F°)	Site 6 Speed (FPM)	Site 7 Diff (F°)	Site 7 Speed (FPM)	F' (m^4/s^3) East RM	F' (m^4/s^3) West RM
08/25/95	10	27.1	7.2	75.24	19.2	471	19.6	502	17.8	446	13.2	453	12.8	403	21.5	442	14.0	390	119.8	117.4
08/25/95	11	47.4	6.6	79.34	14.0	397	16.4	450	15.3	397	10.7	395	10.4	344	18.4	417	13.6	379	84.3	100.9
08/25/95	12	15.9	6.7	81.36	12.3	358	14.1	389	12.8	341	10.1	366	9.9	308	17.2	456	12.4	428	66.3	103.5
08/25/95	13	9.8	8.2	81.69	15.7	412	17.5	464	16.3	416	12.0	416	11.1	360	20.1	347	14.0	335	95.0	91.5
08/25/95	14	21.2	7.8	84.04	10.5	374	12.7	429	11.6	377	9.3	391	9.2	352	16.3	377	11.9	375	65.0	83.5
08/25/95	15	13.0	8.3	84.22	13.3	402	16.3	477	15.3	420	11.7	441	11.6	395	21.8	386	16.1	378	91.8	113.1
08/25/95	16	6.4	7.5	83.77	15.7	424	19.1	503	17.0	447	13.4	459	12.7	404	23.7	293	15.3	313	109.6	92.3
08/25/95	17	16.4	6.9	81.80	18.1	446	20.8	521	19.9	469	15.3	483	14.3	426	23.7	228	17.8	317	130.4	88.4
08/25/95	18	29.9	5.9	73.85	23.9	454	26.5	514	25.0	466	21.2	455	20.6	403	31.1	356	24.6	339	169.6	151.5
08/25/95	19	35.4	8.6	72.30	22.7	490	24.6	543	22.7	486	19.5	482	19.3	429	27.0	420	20.4	335	167.9	141.5
08/25/95	20	65.0	4.8	67.44	25.7	564	28.1	604	23.5	541	19.8	542	18.8	479	29.3	413	21.0	321	202.2	146.9
08/25/95	21	45.2	2.5	60.04	30.5	602	33.2	652	28.8	570	23.0	563	22.0	493	33.9	388	24.8	293	254.4	160.0
08/25/95	22	74.5	2.5	58.61	30.2	618	32.2	673	29.9	585	22.3	571	20.9	476	31.1	371	23.3	276	255.3	141.8
08/25/95	23	16.5	2.2	57.05	30.5	615	32.5	647	27.8	579	24.2	592	22.9	493	30.9	402	24.5	302	260.6	157.4
08/26/95	0	66.2	2.1	56.82	29.6	613	31.4	643	27.1	568	23.0	591	20.6	479	30.9	400	23.9	299	246.9	154.8
08/26/95	1	80.5	2.1	56.50	29.8	636	31.0	655	26.5	579	22.8	609	20.5	502	31.2	413	23.3	298	252.4	156.7
08/26/95	2	45.8	2.2	55.27	26.5	600	28.9	634	25.9	569	22.1	583	20.3	494	31.4	418	23.0	306	232.1	159.6
08/26/95	3	94.1	2.5	54.80	25.2	589	28.4	637	25.2	566	21.5	579	20.9	504	29.5	390	22.3	281	227.4	141.4
08/26/95	4	75.0	1.6	54.27	26.9	615	28.6	649	25.4	576	21.3	581	19.6	492	29.3	387	22.4	278	231.7	140.0
08/26/95	5	105.2	2.4	54.12	26.3	588	27.9	629	24.3	560	20.6	566	18.7	481	29.0	395	21.3	307	217.7	144.0
08/26/95	16	67.4	4.5	89.77	15.1	432	17.9	520	15.3	466	14.7	454	14.9	419	22.8	448	16.6	364	111.1	123.5
08/26/95	17	31.6	4.7	86.48	15.6	366	18.9	465	16.5	433	16.6	432	16.2	387	23.7	449	18.7	366	109.0	133.8
08/26/95	18	26.3	5.1	79.26	21.7	430	24.6	526	22.5	472	22.0	481	21.6	434	28.6	401	23.8	310	164.9	144.9
08/26/95	19	82.4	2.6	72.83	25.0	538	27.7	619	24.6	554	23.7	564	23.4	507	31.5	435	25.2	322	218.3	168.2
08/26/95	20	117.4	3.0	69.04	29.6	573	31.2	613	27.3	550	24.9	567	23.6	500	32.3	445	25.6	361	242.1	183.9
08/26/95	21	72.3	1.4	65.51	31.7	629	33.2	659	28.6	590	25.4	605	24.3	528	34.5	411	26.3	288	273.7	168.1
08/26/95	22	93.0	1.8	63.59	32.9	655	33.8	686	30.0	608	25.8	628	25.1	542	33.7	433	26.6	310	292.8	177.9
08/26/95	23	124.9	3.7	63.47	32.1	654	32.8	699	28.8	613	24.3	630	23.5	544	32.1	417	25.1	283	283.3	159.5
08/27/95	0	73.2	2.2	61.75	33.2	658	33.7	639	30.2	572	23.8	583	23.0	516	30.7	401	23.3	334	272.9	159.0
08/27/95	1	53.4	2.0	60.73	29.2	633	30.7	654	30.1	582	22.8	571	22.4	505	32.8	394	24.1	279	255.7	153.3
08/27/95	2	18.2	3.6	61.70	27.5	628	29.0	652	29.0	579	21.5	556	20.7	462	29.5	366	21.6	266	236.2	129.8
08/27/95	3	18.1	3.5	60.78	25.2	586	27.9	637	27.5	561	20.3	532	18.6	459	28.5	339	20.2	228	214.2	111.4
08/27/95	4	35.2	2.6	59.97	25.5	592	27.6	638	27.3	567	20.4	544	19.5	479	29.4	359	20.5	246	219.4	121.8
08/27/95	5	40.0	2.8	59.45	24.3	567	26.3	610	25.8	539	19.8	522	18.5	455	28.6	350	19.3	255	200.4	117.3
08/27/95	6	59.4	2.2	59.92	23.6	578	26.2	632	24.5	555	18.7	535	18.4	465	27.2	379	19.4	277	199.9	123.7
08/27/95	7	6.0	2.9	64.33	24.2	583	25.8	611	23.1	545	18.6	546	18.1	485	26.6	423	18.2	335	195.9	136.6
08/27/95	8	355.3	3.1	71.44	25.9	593	25.8	598	22.5	523	18.1	541	17.2	480	23.3	438	16.9	381	190.4	131.3
08/27/95	9	348.7	3.5	79.08	24.6	556	24.6	551	21.7	480	16.5	525	15.4	462	20.5	434	13.6	387	166.3	110.7
08/27/95	10	358.1	5.6	84.77	23.0	531	24.4	515	22.3	451	17.3	493	15.9	437	20.5	400	14.6	375	155.4	106.4
08/27/95	11	17.8	7.6	88.63	21.8	471	22.8	481	21.5	436	16.3	482	15.8	422	19.0	360	14.6	373	139.3	95.8
08/27/95	12	358.4	8.3	89.52	21.9	467	24.3	469	22.3	420	17.7	471	15.9	410	20.8	399	15.8	366	141.0	108.4
08/27/95	14	5.4	7.5	91.90	21.0	475	24.1	474	22.8	421	17.2	468	14.9	408	22.5	415	16.9	367	138.2	118.5
08/27/95	15	355.8	7.9	92.24	19.4	498	20.9	508	21.0	455	15.8	477	12.9	419	21.9	303	14.9	309	130.9	86.8
08/27/95	16	359.7	8.4	90.98	22.0	499	24.4	511	24.6	444	19.7	479	14.8	421	24.5	299	17.8	339	152.7	103.7
08/27/95	17	0.4	8.6	87.93	23.7	495	24.1	523	25.1	478	23.1	519	16.7	459	23.8	243	19.9	364	171.9	102.4
08/27/95	18	2.0	7.4	80.73	27.8	482	28.6	502	29.8	453	28.8	497	21.7	441	29.5	289	27.1	392	201.1	148.9
08/27/95	19	25.9	3.9	71.43	33.4	515	33.5	526	33.5	449	30.1	480	26.6	425	33.3	357	28.3	355	235.2	171.5
08/27/95	20	6.8	5.0	68.51	31.8	544	33.6	557	30.3	505	27.2	513	26.1	472	35.3	429	28.9	377	243.3	203.0
08/27/95	21	4.2	5.1	67.59	36.1	552	35.9	573	34.1	510	28.3	521	27.2	472	36.6	447	29.0	390	266.8	215.4
08/27/95	22	352.8	4.5	67.65	37.0	571	35.8	580	34.0	511	27.2	521	25.4	459	35.8	444	28.1	406	264.8	213.4

TABLE A-4 (Continued)

Date	Hr	Follansbee 30 m Direction (Deg)	Follansbee 30 m Speed (MPH)	Follansbee 30 m Temp (°F)	Site 1 Diff (F°)	Site 1 Speed (FPM)	Site 2 Diff (F°)	Site 2 Speed (FPM)	Site 3 Diff (F°)	Site 3 Speed (FPM)	Site 4 Diff (F°)	Site 4 Speed (FPM)	Site 5 Diff (F°)	Site 5 Speed (FPM)	Site 6 Diff (F°)	Site 6 Speed (FPM)	Site 7 Diff (F°)	Site 7 Speed (FPM)	F' (m^4/s^3) East RM	F' (m^4/s^3) West RM
08/27/95	23	352.9	4.8	66.97	33.6	523	32.8	547	32.6	487	24.6	485	23.2	444	33.4	439	25.6	432	230.8	203.1
08/28/95	0	343.8	5.4	65.81	27.6	477	30.3	512	30.4	457	24.5	467	23.2	429	32.7	408	25.5	392	202.6	184.5
08/28/95	1	358.3	5.6	66.52	27.7	522	29.0	539	28.2	483	22.9	492	21.6	442	31.0	417	23.8	408	204.2	179.5
08/28/95	2	354.4	4.9	65.18	29.9	555	30.8	546	29.7	479	24.1	507	22.5	466	30.4	420	23.5	353	222.7	165.9
08/28/95	3	349.0	4.6	63.46	31.1	574	30.6	577	28.4	512	23.7	535	23.3	494	30.4	425	23.7	359	235.7	169.4
08/28/95	4	354.5	4.7	63.11	29.5	543	28.0	559	26.1	490	21.8	501	21.3	474	28.5	415	22.1	365	208.6	158.2
08/28/95	5	12.7	4.6	62.85	28.9	560	28.1	581	25.7	509	22.1	523	21.6	487	28.1	439	22.6	376	215.8	165.7
08/28/95	6	7.2	3.5	63.05	28.4	561	27.9	573	25.0	509	21.4	521	20.9	473	27.0	427	20.8	375	209.3	154.1
08/28/95	7	350.6	4.0	67.19	26.3	544	27.2	549	23.7	495	19.1	510	18.5	459	25.7	420	19.0	380	187.7	143.1
08/28/95	8	0.4	3.6	71.15	28.9	594	27.8	593	24.0	521	18.4	541	18.0	497	25.5	479	18.2	431	204.0	158.1
08/28/95	9	339.2	5.1	75.55	29.5	594	30.2	562	27.8	484	20.4	529	18.5	454	23.4	421	17.2	404	208.0	132.5
08/28/95	10	12.0	3.6	80.45	23.8	571	23.6	568	20.6	491	14.2	522	14.0	483	20.8	475	14.3	425	159.3	124.5
08/28/95	11	213.6	4.7	85.05	23.8	636	23.5	620	19.4	540	12.7	549	12.2	491	20.5	428	13.0	334	162.2	99.9

Preliminary testing results from August 2 through August 10, 1995 show that the operational status of any single vessel does not have a dramatic effect on the temperature difference and exhaust velocity from the roof monitor. As long as one of the two vessels is operational, we expect that the mean values listed above are representative of BOF operations. Accordingly, the above results can be used for both Vessel A and Vessel B in calculating the F′ for BLP.

As noted by Ohio EPA for the blast furnace, two changes were suggested for the BOF RM, specifically:

- recalculate plume rise as the average of plume rise calculated from matched pairs of temperature rise and velocity; and

- use only the separation distance between sensors and not roof opening dimensions to determine maximum active roof length for plume rise.

Ohio EPA suggested that the maximum roof length should be 72 meters because the text of the earlier report indicated "sensors were spaced at approximately 9 meter intervals," which has been clarified in this version to be 9.2 meter spacing. A total roof length of 73.5 meters results from the 9.2 meter spacing.

Plume rise was recalculated for each match pair of temperature difference and velocity. Results are presented in the last two columns of Table A-4 for a source length of 73.5 meters and a source height of 2.4 meters. The East RM had a plume rise of 167.9 m^4/s^3. The West RM had a plume rise of 110.9 m^4/s^3. The BLP manual recommends averaging the two values. Therefore, the F′ will be:

$$F' = (167.9 + 110.9)/2 = 139.4\ m^4/s^3$$

The BLP input file for the BOF RM is presented in Table A-5. The F′ of 139.4 m^4/s^3 developed from the August 1995 testing is larger than the 114.0 m^4/s^3 developed from the limited testing conducted in March 1994.

3.3 BATTERIES

Testing was initiated on August 31 and concluded on September 7. Data were recorded every 15 seconds and processed for hourly averages. The hourly average data are presented in Table A-6. Meteorological data from the West Virginia DEP tower are also listed in Table A-6 and form the base temperature against which the four sensors are compared. A summary of the data in Table A-6 is listed below:

	Diff (F°)	Speed (FPM)
Site 1	23.87	210.1
Site 2	22.43	148.6
Site 3	31.40	210.4
Site 4	28.55	189.9
Mean	26.56	189.8

The 112 hours of testing resulted in a mean temperature difference of 26.56 F° and a mean exhaust speed of 189.8 feet per minute. Since the sensors were located above the battery and inside the highest temperature and velocity area (near doors and standpipes), the entire width of the battery is considered in the plume rise equation in the initial submittal of results to the agencies. Ohio EPA required that the width of the battery considered for plume rise be limited to that distance separating the sensors or 9.8 meters. Plume rise was calculated for Battery 8 using a source length of 103 meters and a source width of 9.8 meters for each matched pair of data. Results are listed in Table A-6. Average plume rise for Battery 8 was 449.7 m^4/s^3 by this method.

No testing was done for Batteries 1, 2 or 3. No COG cross-over pipes exist for the other batteries. Results from Battery 8 were

TABLE A-5

BLP INPUT FILE FOR BASIC OXYGEN FURNACE ROOF MONITOR

```
 WPSC BOF Roof Monitor emissions at 1 g/s
&GEN
NLINES=1
NREC=10
LPART=.TRUE.
LCOMPR=.TRUE.
LINPUT=.TRUE.,
LUTMS=.TRUE.
LTRANS=.FALSE.
/
&RISE
L=73.5
HB=51.2
WB=90.0
WM=2.5
DX=100.
FPRIME=139.4
/
&METIN
LMETIN=.FALSE.
IDSURF=94823
IYSURF=89
IDUPER=94823
IYUPER=89
ZMEAS=30.0
IDELS=1
IRU=1
IDAYS=365*1,0
/
&CALC
/
&OUTPUT
IPCL=1,0,0,0,0,0,0,0,0,0,1
/
   533000.  4466500.      196.
   533000.  4466000.      196.
   533000.  4466750.      196.
   529000.  4472000.      335.
   532750.  4467000.      201.
   532750.  4466750.      201.
   533000.  4466250.      196.
   533000.  4465750.      196.
   532750.  4465500.      216.
   532500.  4465750.      280.
  533643.0 4462578.0  533672.0 4462667.0      51.2      1.00      204.2
```

APPENDIX A, Page A-21

TABLE A-6

HOURLY SUMMARY OF BATTERY NO. 8
PLUME RISE RESULTS

Date	Hr	Follansbee 30 m Direction (Deg)	Follansbee 30 m Speed (MPH)	Follansbee 30 m Temp (°F)	Site 1 Diff (F°)	Site 1 Speed (FPM)	Site 2 Diff (F°)	Site 2 Speed (FPM)	Site 3 Diff (F°)	Site 3 Speed (FPM)	Site 4 Diff (F°)	Site 4 Speed (FPM)	F′ (m^4/s^3)
08/31/95	18	215.8	8.0	86.31	14.2	258	15.7	109	31.5	257	37.9	172	435.3
08/31/95	19	217.3	7.9	84.26	26.2	272	17.3	105	41.8	223	47.4	154	545.0
08/31/95	20	250.8	7.5	82.90	21.2	294	21.6	156	46.4	258	51.4	163	666.4
08/31/95	21	300.7	5.2	79.96	12.3	252	15.5	142	47.0	209	55.1	132	524.6
08/31/95	22	1.5	3.0	74.92	18.8	251	24.6	198	58.3	170	41.7	302	727.8
09/01/95	8	356.6	7.2	68.60	19.6	207	13.6	153	8.5	287	5.2	173	223.9
09/01/95	9	0.7	8.8	70.55	17.7	207	9.5	169	11.2	367	11.8	172	266.0
09/01/95	10	0.4	8.1	70.72	15.7	167	8.3	178	30.9	223	23.5	159	325.8
09/01/95	11	352.1	8.3	71.09	23.0	212	14.3	180	34.7	243	25.3	138	426.0
09/01/95	12	352.2	6.9	72.32	26.2	256	21.0	183	31.0	193	26.6	187	483.4
09/01/95	13	345.8	9.4	72.92	23.5	238	23.3	241	33.7	228	25.6	175	526.2
09/01/95	14	340.1	12.0	74.33	17.3	209	15.0	196	30.3	235	29.8	201	438.5
09/01/95	15	335.6	14.8	74.47	16.8	230	15.5	242	26.1	307	21.8	220	454.5
09/01/95	16	332.4	12.7	74.11	14.4	223	16.6	217	17.4	209	15.0	285	338.7
09/01/95	17	346.1	11.2	72.88	17.9	226	13.8	245	17.4	327	15.3	236	381.5
09/01/95	18	343.9	9.4	70.10	19.0	216	21.2	191	15.4	273	22.6	277	428.3
09/01/95	19	359.6	7.6	65.07	29.7	214	20.1	214	30.8	261	34.6	174	564.6
09/01/95	20	359.6	6.8	60.83	31.9	215	20.4	200	46.9	215	38.3	123	586.6
09/01/95	21	9.1	5.9	57.37	34.1	233	22.0	161	52.8	111	38.9	88	497.4
09/01/95	22	5.3	5.2	55.56	35.6	301	37.8	291	51.9	106	39.6	93	736.9
09/01/95	23	26.8	3.1	53.92	36.3	272	40.9	293	51.3	70	40.6	93	696.2
09/02/95	9	351.3	7.9	65.59	21.0	202	17.6	157	26.3	202	16.4	196	354.6
09/02/95	10	15.0	7.5	68.39	17.4	202	14.1	144	27.4	227	23.9	172	353.4
09/02/95	11	335.3	7.5	70.17	21.1	220	15.9	154	24.6	289	17.3	248	411.2
09/02/95	12	344.2	8.1	71.80	17.4	212	16.1	162	32.8	225	32.0	191	439.0
09/02/95	13	332.2	7.9	73.18	19.7	236	16.0	161	36.5	203	33.6	165	454.9
09/02/95	14	334.0	7.4	74.20	22.5	245	17.9	155	38.5	210	33.7	176	495.1
09/02/95	15	356.1	9.0	74.69	24.7	267	22.8	198	41.5	217	33.9	183	591.4
09/02/95	16	339.7	8.7	74.68	23.6	282	23.5	210	42.4	197	38.4	166	607.0
09/02/95	17	336.2	8.1	73.42	20.3	211	17.5	133	40.2	194	38.1	191	473.3
09/02/95	18	333.9	5.8	69.69	17.2	180	21.3	150	42.3	185	50.7	151	489.7
09/02/95	19	64.2	2.5	61.60	32.2	247	27.0	137	52.3	224	46.9	237	750.2
09/02/95	20	113.2	3.1	57.60	32.4	206	26.1	93	45.2	300	43.4	290	742.0
09/02/95	21	130.6	3.5	56.01	29.2	130	23.7	49	47.1	226	41.3	249	527.2
09/02/95	22	124.1	3.6	54.43	28.8	146	24.1	57	37.7	298	38.2	312	602.6
09/02/95	23	134.5	4.1	53.59	26.4	100	21.0	26	21.7	343	33.7	391	515.7
09/03/95	9	162.1	5.9	68.58	22.2	176	24.4	103	4.4	186	6.7	152	206.2
09/03/95	10	192.3	6.3	75.53	21.7	239	23.7	147	12.3	163	16.3	152	294.5
09/03/95	11	213.3	7.2	78.59	21.8	281	21.9	150	26.4	190	28.8	187	446.2
09/03/95	12	267.9	7.8	79.43	16.0	212	20.5	148	34.7	169	39.5	209	453.1
09/03/95	13	277.8	8.2	79.69	14.3	236	19.7	139	41.7	188	49.0	200	524.3
09/03/95	14	279.2	7.5	79.80	18.6	266	23.1	138	45.4	195	48.3	247	628.1
09/03/95	15	272.8	6.6	79.95	18.0	237	25.0	144	44.1	192	40.3	259	583.1
09/03/95	16	250.4	6.7	78.34	18.3	196	22.8	111	49.5	198	51.9	205	554.5
09/03/95	17	268.1	8.1	77.08	15.9	188	22.8	145	58.1	155	63.0	172	574.9
09/03/95	18	278.3	8.0	74.46	26.0	240	25.9	153	60.8	147	65.2	172	688.2
09/03/95	19	290.0	6.5	72.54	32.3	293	30.4	157	58.4	140	62.4	159	747.4
09/03/95	20	48.3	2.7	69.40	35.3	249	45.7	268	49.7	235	48.4	223	956.6
09/03/95	21	147.4	3.9	67.99	31.0	193	24.7	122	46.9	214	42.7	229	613.9
09/03/95	22	135.0	3.3	65.36	28.6	134	23.4	89	45.6	220	41.1	235	528.2
09/03/95	23	141.0	4.0	62.69	28.5	99	23.7	81	45.1	220	39.9	304	545.5
09/04/95	10	318.6	8.7	75.28	17.2	249	12.1	161	18.5	249	11.6	202	292.4
09/04/95	11	357.3	8.0	77.05	21.0	224	12.2	165	31.5	248	24.8	157	399.6
09/04/95	12	3.8	7.6	78.95	22.2	238	15.6	165	32.8	216	26.3	174	429.2
09/04/95	13	351.4	8.8	80.92	25.5	283	20.4	193	29.5	219	26.3	185	497.1
09/04/95	14	341.9	10.0	81.73	24.2	309	23.2	197	31.0	198	28.3	192	529.1
09/04/95	15	338.5	7.7	80.19	19.1	211	18.5	161	33.3	217	33.8	161	436.1

TABLE A-6 (Continued)

Date	Hr	Follansbee 30 m Direction (Deg)	Follansbee 30 m Speed (MPH)	Follansbee 30 m Temp (°F)	Site 1 Diff (F°)	Site 1 Speed (FPM)	Site 2 Diff (F°)	Site 2 Speed (FPM)	Site 3 Diff (F°)	Site 3 Speed (FPM)	Site 4 Diff (F°)	Site 4 Speed (FPM)	F′ (m⁴/s³)
09/04/95	16	352.9	8.8	80.47	19.0	228	12.8	176	34.1	286	21.9	194	434.1
09/04/95	17	346.1	8.3	78.79	16.8	231	10.2	164	26.2	260	17.6	183	335.4
09/04/95	18	354.8	7.5	73.57	24.9	188	14.9	146	22.7	302	15.7	143	346.4
09/04/95	19	12.0	6.6	65.87	27.1	173	19.2	102	29.8	145	25.5	105	304.4
09/04/95	20	4.9	5.6	62.24	36.4	257	24.1	132	37.4	121	25.6	102	429.8
09/04/95	21	11.9	4.2	60.58	37.8	308	28.0	182	26.2	150	16.6	188	516.4
09/04/95	22	46.6	3.5	57.82	34.9	276	33.1	204	24.7	155	16.8	193	523.1
09/04/95	23	97.6	3.0	55.81	36.2	201	29.1	89	23.6	184	15.0	199	406.0
09/05/95	8	289.0	3.0	61.48	29.9	264	38.9	284	15.9	197	9.5	183	504.5
09/05/95	9	348.7	3.6	68.18	22.8	187	17.6	144	15.3	192	4.1	173	241.1
09/05/95	10	12.6	7.4	73.43	20.4	196	16.5	182	9.6	230	1.8	182	220.0
09/05/95	11	11.6	7.9	77.30	21.0	211	15.3	153	-3.0	362	-5.6	251	156.4
09/05/95	12	11.6	9.6	79.73	16.6	220	10.4	178	1.7	326	1.8	176	157.8
09/05/95	13	4.2	11.5	81.03	17.0	196	9.6	199	12.8	310	7.3	168	232.0
09/05/95	14	21.6	9.1	82.33	18.5	201	12.4	182	12.9	269	7.0	160	233.8
09/05/95	15	18.5	8.7	82.83	18.9	210	11.8	182	17.7	247	10.3	153	262.3
09/05/95	16	16.2	7.9	82.80	26.1	246	26.2	209	17.5	223	7.8	141	355.6
09/05/95	17	22.3	7.3	81.47	31.2	255	33.6	241	19.8	200	12.2	161	461.3
09/05/95	18	42.8	4.5	74.11	29.1	173	23.2	107	29.4	144	20.7	112	308.5
09/05/95	19	136.1	3.3	67.34	33.2	182	25.8	89	23.3	208	16.0	220	391.6
09/05/95	20	136.2	3.6	64.39	31.2	158	24.6	88	14.7	276	11.4	229	355.1
09/05/95	21	137.6	3.8	61.71	30.4	92	25.4	67	10.2	233	8.2	222	265.3
09/05/95	22	141.0	3.4	60.25	29.3	80	22.2	59	-6.2	354	6.3	214	215.2
09/05/95	23	122.9	3.5	58.99	31.7	75	24.4	62	12.0	245	12.0	236	288.9
09/06/95	9	196.0	3.6	73.52	24.2	198	26.0	119	1.2	241	6.0	186	245.2
09/06/95	10	206.2	5.2	80.36	20.5	184	23.9	98	11.7	178	15.6	129	237.9
09/06/95	11	220.6	4.8	83.86	29.9	296	27.1	144	23.4	173	25.0	167	453.5
09/06/95	12	166.4	6.0	86.14	28.2	274	23.2	119	32.2	156	33.9	148	447.6
09/06/95	13	142.2	5.3	86.57	22.0	216	23.9	113	40.4	174	40.9	167	463.5
09/06/95	14	121.6	5.5	87.30	23.2	254	24.3	143	43.1	181	42.6	169	539.1
09/06/95	15	235.2	6.6	88.00	15.3	231	23.3	129	40.3	179	27.0	279	474.3
09/06/95	16	241.1	5.9	86.68	17.8	217	23.2	106	45.7	227	43.8	215	542.1
09/06/95	17	242.6	5.6	84.85	19.5	206	23.6	116	59.7	151	63.5	107	517.4
09/06/95	18	97.2	3.0	75.92	30.8	210	27.6	126	67.7	269	64.5	259	887.6
09/06/95	19	146.0	4.1	70.07	30.6	138	24.2	73	58.2	226	53.0	256	633.1
09/06/95	20	139.9	4.4	67.46	36.2	123	55.4	284	41.3	132	34.0	171	654.9
09/06/95	21	140.6	4.1	64.14	33.6	127	31.6	101	33.2	137	25.3	169	374.3
09/06/95	22	136.8	3.8	61.94	30.3	112	25.3	109	29.3	126	19.7	163	306.2
09/06/95	23	134.3	4.2	61.04	30.0	73	22.6	70	29.8	88	19.6	142	219.0
09/07/95	7	167.5	5.0	62.63	26.1	268	33.9	145	12.6	101	13.7	87	299.8
09/07/95	8	172.8	8.4	70.65	17.1	171	27.3	139	10.5	141	12.4	121	221.2
09/07/95	9	178.3	10.0	75.26	17.7	193	25.0	106	18.0	158	12.0	181	263.6
09/07/95	10	176.9	8.9	77.92	13.9	160	21.9	117	16.5	184	2.7	280	232.4
09/07/95	11	197.1	8.5	80.40	13.7	163	22.1	109	24.1	158	17.6	205	276.5
09/07/95	12	235.8	7.2	82.56	14.2	211	23.0	148	34.5	161	39.5	190	435.4
09/07/95	13	267.7	8.4	82.44	20.1	231	23.4	147	37.3	157	41.6	205	497.2
09/07/95	14	242.8	6.8	81.91	28.9	316	28.7	145	37.8	135	45.7	157	579.0
09/07/95	15	220.6	7.0	80.48	15.9	189	26.3	99	44.2	123	50.9	140	414.0
09/07/95	16	228.6	6.3	79.47	12.1	143	24.1	112	50.3	115	57.9	126	391.4
09/07/95	17	286.6	6.1	77.03	15.3	172	24.4	125	46.3	179	54.3	189	513.0
09/07/95	18	21.3	3.5	73.99	26.3	212	26.5	154	33.9	264	36.6	252	605.6
09/07/95	19	77.3	3.0	70.63	29.5	228	25.3	153	21.4	321	-1.0	240	541.4
09/07/95	20	104.7	3.0	69.35	27.7	130	23.2	70	24.2	264	20.2	229	375.5
09/07/95	21	145.7	3.6	67.95	27.3	86	22.0	56	20.3	210	20.0	249	307.8
09/07/95	22	52.8	4.2	65.63	31.9	204	28.8	158	28.4	160	25.2	189	461.3

used as a guide for the other batteries. Temperature difference and exhaust flows were assumed to be one-half those of Battery 8 for Batteries 1, 2 and 3 because of the pusher side shed on Batteries 1, 2 and 3. Again, matched pairs of reduced temperature difference and reduced velocity scaled from Battery 8 coupled with a source length of 110.5 meters for the three batteries and a source width of 9.8 meters gave hourly plume rises listed in Table A-7. Average plume rise for Battery 1, 2 and 3 block was 123.8 m^4/s^3.

The estimated plume rise is 123.8 m^4/s^3 for Batteries 1, 2 and 3 and 449.7 m^4/s^3 for Battery 8. Batteries 1, 2 and 3 are 110.5 meters long or 7 percent longer than Battery 8. Reducing the measured temperature difference and velocity by one-half from Battery 8 to Batteries 1, 2 and 3 would yield a plume rise for Batteries 1, 2 and 3 of only one-quarter that for Battery 8, for the same length batteries. Adding the additional length for the old battery block increases the plume rise to approximately 28 percent of that for Battery 8. This value can also be checked against the battery stack firing rates in Appendix B.3, Page B.3-2. The combined underfire rate for Batteries 1, 2 and 3 is 63 percent of the rate for Battery 8. Based on this energy input comparison, one might expect plume rise from the old battery block to be 63 percent of that from Battery 8. The reduction to only 28 percent for the old battery block is probably attributable to the coke side shed on the old battery block.

The BLP input files for Batteries 1, 2, 3 and 8 are presented in Tables A-8, A-9, A-10 and A-11, respectively. An F' value of 123.8 m^4/s^3 reflects the combined plume rise of Batteries 1, 2 and 3. F' for each battery would be one-third of that value or 41.3 m^4/s^3. Individual battery length would be 36.8 meters.

TABLE A-7

LISTING OF HOURLY PLUME RISE FROM BATTERIES 1, 2, 3 AND 8

AT FOLLANSBEE COKE PLANT

Date	Hr	F' (m^4/s^3) 8	F' (m^4/s^3) 1,2&3
08/31/95	18	435.3	119.4
08/31/95	19	545.0	150.5
08/31/95	20	666.4	184.3
08/31/95	21	524.6	144.8
08/31/95	22	727.8	201.5
09/01/95	8	223.9	60.7
09/01/95	9	266.0	72.2
09/01/95	10	325.8	89.0
09/01/95	11	426.0	116.8
09/01/95	12	483.4	132.8
09/01/95	13	526.2	144.5
09/01/95	14	438.5	120.1
09/01/95	15	454.5	124.1
09/01/95	16	338.7	92.2
09/01/95	17	381.5	103.9
09/01/95	18	428.3	116.9
09/01/95	19	564.6	155.5
09/01/95	20	586.6	162.4
09/01/95	21	497.4	138.0
09/01/95	22	736.9	205.2
09/01/95	23	696.2	194.1
09/02/95	9	354.6	96.9
09/02/95	10	353.4	96.6
09/02/95	11	411.2	112.3
09/02/95	12	439.0	120.4
09/02/95	13	454.9	125.0
09/02/95	14	495.1	136.2
09/02/95	15	591.4	163.1
09/02/95	16	607.0	167.5
09/02/95	17	473.3	130.3
09/02/95	18	489.7	135.3
09/02/95	19	750.2	208.6
09/02/95	20	742.0	205.8
09/02/95	21	527.2	146.1
09/02/95	22	602.6	166.5
09/02/95	23	515.7	141.7
09/03/95	9	206.2	56.1
09/03/95	10	294.5	80.3
09/03/95	11	446.2	122.4
09/03/95	12	453.1	124.6
09/03/95	13	524.3	144.6
09/03/95	14	628.1	173.6
09/03/95	15	583.1	160.9
09/03/95	16	554.5	153.5
09/03/95	17	574.9	159.7
09/03/95	18	688.2	192.0
09/03/95	19	747.4	208.7
09/03/95	20	956.6	267.0
09/03/95	21	613.9	170.1
09/03/95	22	528.2	146.2
09/03/95	23	545.5	150.9
09/04/95	10	292.4	79.5
09/04/95	11	399.6	109.4
09/04/95	12	429.2	117.6
09/04/95	13	497.1	136.4
09/04/95	14	529.1	145.3
09/04/95	15	436.1	119.7
09/04/95	16	434.1	118.7
09/04/95	17	335.4	91.4
09/04/95	18	346.4	94.6
09/04/95	19	304.4	83.6
09/04/95	20	429.8	118.6
09/04/95	21	516.4	142.0
09/04/95	22	523.1	143.9
09/04/95	23	406.0	111.6
09/05/95	8	504.5	138.3
09/05/95	9	241.1	65.6
09/05/95	10	220.0	59.7
09/05/95	11	156.4	42.2
09/05/95	12	157.8	42.6
09/05/95	13	232.0	62.9
09/05/95	14	233.8	63.4
09/05/95	15	262.3	71.3
09/05/95	16	355.6	97.0
09/05/95	17	461.3	126.4
09/05/95	18	308.5	84.7
09/05/95	19	391.6	107.4
09/05/95	20	355.1	97.1
09/05/95	21	265.3	72.4
09/05/95	22	215.2	58.4
09/05/95	23	288.9	78.9
09/06/95	9	245.2	66.6
09/06/95	10	237.9	64.9
09/06/95	11	453.5	124.5
09/06/95	12	447.6	123.2
09/06/95	13	463.5	127.8
09/06/95	14	539.1	148.8
09/06/95	15	474.3	130.2
09/06/95	16	542.1	149.6
09/06/95	17	517.4	143.9
09/06/95	18	887.6	248.2
09/06/95	19	633.1	176.2
09/06/95	20	654.9	182.3
09/06/95	21	374.3	103.3
09/06/95	22	306.2	84.1
09/06/95	23	219.0	60.1
09/07/95	7	299.8	82.0
09/07/95	8	221.2	60.2
09/07/95	9	263.6	71.9
09/07/95	10	232.4	63.1
09/07/95	11	276.5	75.5
09/07/95	12	435.4	119.7
09/07/95	13	497.2	137.0
09/07/95	14	579.0	160.2
09/07/95	15	414.0	114.5
09/07/95	16	391.4	108.4
09/07/95	17	513.0	141.9
09/07/95	18	605.6	167.0
09/07/95	19	541.4	148.6
09/07/95	20	375.5	102.9
09/07/95	21	307.8	84.3
09/07/95	22	461.3	127.0
	Mean	449.7	123.8

TABLE A-8

BLP INPUT FILE BATTERY NO. 1

```
 WPSC FOLLANSBEE BATTERY 1 emissions at 1 g/s
&GEN
NLINES=3
NREC=10
LPART=.TRUE.
LCOMPR=.TRUE.
LINPUT=.TRUE.
LUTMS=.TRUE.
LTRANS=.FALSE.
/
&RISE
L=36.8
HB=7.0
WB=13.7
WM=1.0
DX=10.0
FPRIME=41.3
/
&METIN
LMETIN=.FALSE.
IDSURF=94823
IYSURF=89
IDUPER=94823
IYUPER=89
ZMEAS=30.0
IDELS=1
IRU=1
IDAYS=365*1,0
/
&CALC
/
&OUTPUT
IPCL=1,1,0,0,0,0,0,0,0,0,1
/
   533000.  4466500.      196.
   533000.  4466000.      196.
   533000.  4466750.      196.
   529000.  4472000.      335.
   532750.  4467000.      201.
   532750.  4466750.      201.
   533000.  4466250.      196.
   533000.  4465750.      196.
   532750.  4465500.      216.
   532500.  4465750.      280.
  533240.0 4465970.0  533259.0 4465942.0       7.0      1.00     205.7
```

APPENDIX A, Page A-26

TABLE A-9

BLP INPUT FILE BATTERY NO. 2

```
 WPSC FOLLANSBEE BATTERY 2 emissions at 1 g/s
&GEN
NLINES=3
NREC=10
LPART=.TRUE.
LCOMPR=.TRUE.
LINPUT=.TRUE.
LUTMS=.TRUE.
LTRANS=.FALSE.
/
&RISE
L=36.8
HB=7.0
WB=13.7
WM=1.0
DX=10.0
FPRIME=41.3
/
&METIN
LMETIN=.FALSE.
IDSURF=94823
IYSURF=89
IDUPER=94823
IYUPER=89
ZMEAS=30.0
IDELS=1
IRU=1
IDAYS=365*1,0
/
&CALC
/
&OUTPUT
IPCL=1,1,0,0,0,0,0,0,0,0,1
/
   533000.  4466500.      196.
   533000.  4466000.      196.
   533000.  4466750.      196.
   529000.  4472000.      335.
   532750.  4467000.      201.
   532750.  4466750.      201.
   533000.  4466250.      196.
   533000.  4465750.      196.
   532750.  4465500.      216.
   532500.  4465750.      280.
  533285.0 4465904.0  533305.0 4465876.0       7.0       1.00      205.7
```

APPENDIX A, Page A-27

TABLE A-10

BLP INPUT FILE BATTERY NO. 3

```
 WPSC FOLLANSBEE BATTERY 3 emissions at 1 g/s
&GEN
NLINES=3
NREC=10
LPART=.TRUE.
LCOMPR=.TRUE.
LINPUT=.TRUE.
LUTMS=.TRUE.
LTRANS=.FALSE.
/
&RISE
L=36.8
HB=7.0
WB=13.7
WM=1.0
DX=10.0
FPRIME=41.3
/
&METIN
LMETIN=.FALSE.
IDSURF=94823
IYSURF=89
IDUPER=94823
IYUPER=89
ZMEAS=30.0
IDELS=1
IRU=1
IDAYS=365*1,0
/
&CALC
/
&OUTPUT
IPCL=1,1,0,0,0,0,0,0,0,0,1
/
   533000.  4466500.      196.
   533000.  4466000.      196.
   533000.  4466750.      196.
   529000.  4472000.      335.
   532750.  4467000.      201.
   532750.  4466750.      201.
   533000.  4466250.      196.
   533000.  4465750.      196.
   532750.  4465500.      216.
   532500.  4465750.      280.
  533324.0 4465848.0  533350.0 4465810.0       7.0       1.00      205.7
```

APPENDIX A, Page A-28

TABLE A-11

BLP INPUT FILE BATTERY NO. 8

```
 WPSC FOLLANSBEE BATTERY 8 emissions at 1 g/s
&GEN
NLINES=1
NREC=10
LPART=.TRUE.
LCOMPR=.TRUE.
LINPUT=.TRUE.
LUTMS=.TRUE.
LTRANS=.FALSE.
/
&RISE
L=103.0
HB=13.7
WB=17.0
WM=15.5
DX=100.0
FPRIME=449.7
/
&METIN
LMETIN=.FALSE.
IDSURF=94823
IYSURF=89
IDUPER=94823
IYUPER=89
ZMEAS=30.0
IDELS=1
IRU=1
IDAYS=365*1,0
/
&CALC
/
&OUTPUT
IPCL=1,1,0,0,0,0,0,0,0,0,1
/
   533000.  4466500.      196.
   533000.  4466000.      196.
   533000.  4466750.      196.
   529000.  4472000.      335.
   532750.  4467000.      201.
   532750.  4466750.      201.
   533000.  4466250.      196.
   533000.  4465750.      196.
   532750.  4465500.      216.
   532500.  4465750.      280.
  533560.0 4465480.0  533610.0 4465390.0      13.7      1.00     205.7
```

APPENDIX A, Page A-29

APPENDIX C: AMBIENT BACKGROUND CONCENTRATION DOCUMENTATION

Ohio EPA 1-hour SO_2 Nonattainment SIP Excerpt
(Pages 38-41 of Appendix E)

manually selected sectors for both locations. The sectors were chosen based on manual inspection of the land use within 1 kilometer of the monitoring location. Precipitation data used to determine the dry, average, or wet classification for the specific month was obtained from the PRISM CoCoRaHS Climate Portal[10] based on the Dam Site, since it is the primary site being used to supply the meteorological data and is the closest site to the Cardinal Plant. Wet surface values were used anytime the monthly precipitation values were greater than 20% of the 30 year average precipitation and dry values were used for months where the monthly precipitation values were less than 20% of the 30 year average precipitation. Table 12 shows the data used in making this determination.

Month	30 Yr Average	Monthly Precipitation	Classification
July 2013	4.22	5.86	Wet
Aug 2013	3.48	1.81	Dry
Sept 2013	3.34	2.07	Dry
Oct 2013	2.73	2.42	Avg
Nov 2013	3.30	3.46	Avg
Dec 2013	2.85	3.59	Wet
Jan 2014	2.81	2.08	Dry
Feb 2014	2.29	2.65	Avg
Mar 2014	3.02	2.01	Dry
Apr 2014	3.44	4.02	Avg
May 2014	4.17	4.70	Avg
June 2014	4.22	4.53	Avg

Table 12: Precipitation data used in determining monthly moisture classification for AERMET.

Background Concentrations

Ohio EPA considered background concentrations of SO2 in all modeling analyses performed for this submittal. U.S. EPA guidance suggests that a “first tier” approach to applying a background concentration should be considered by adding the overall highest hourly background value from a representative monitor to the modeled design value, but acknowledges that this approach may be overly conservative in many cases and could be prone to reflecting source-oriented impacts. While Ohio’s SO2 monitoring network is extensive, there are few SO2 monitors not sited specifically to monitor

[10] http://cocorahs.nacse.org/index.php?&, last checked April 1, 2015.

facility-specific impacts. This is especially true in the nonattainment areas modeled for this submittal.

As such, Ohio EPA considered other approaches to the determination of appropriate background concentrations. Section 8.2.2 of Appendix W provides an approach in which source specific impacts can be identified and eliminated from monitor data prior to determining a background concentration. This section of Appendix W (as paraphrased in the Nonattainment SIP Guidance) states:

> *Use air quality data collected in the vicinity of the source to determine the background concentration for the averaging times of concern. Determine the mean background concentration at each monitor by excluding values when the source in question is impacting the monitor. The mean annual background is the average of the annual concentrations so determined at each monitor. For shorter averaging periods, the meteorological conditions accompanying the concentrations of concern should be identified. Monitoring sites inside a 90° sector downwind of the source may be used to determine the area of impact.*

Based on the guidance and the lack of "regional" ambient air quality monitors representative of the nonattainment area, Ohio EPA considered and applied multiple approaches, including the elimination of readily identifiable source-specific impacts, statistical analysis of available monitoring data to determine conservative and appropriate background concentrations. Ohio EPA did not consider the use of temporally varying backgrounds, but instead added background concentration directly to modeled design values.

Source-oriented impacts and the lack of a regional background monitor are major obstacles in determining a background concentration for the Steubenville, OH-WV nonattainment area. This is further complicated by the large number of facilities shutting down entirely, installing controls, or sharply curtailing operations. Ohio EPA estimates that between 2008 and 2013, actual emissions from sources not explicitly included in Ohio's modeling located the surrounding counties of Jefferson, Harrison, and Belmont Counties in Ohio and Marshall, Ohio, and Brooke Counties in West Virginia decreased by a factor of approximately 7 (152,824 TPY in 2008, 21,904 in 2013). This sharp decrease in emissions has undoubtedly reduced background concentrations contributing to the nonattainment area monitors and should be reflected in the background determination for the Steubenville, OH-WV nonattainment area.

Ohio EPA established a background concentration for the Steubenville, OH-WV nonattainment area using ambient air quality data collected at the four AQS monitors in the area. No regional monitors were available for this area, and data collected at each of these monitors demonstrate strong and readily identifiable source-oriented impacts. Following Appendix W and the Nonattainment SIP Guidance, Ohio EPA conducted a background analysis using the following methodology, for years 2007-2009 and 2010-2012.

1. Hourly monitoring data were collected for each monitor from AQS.

2. Representative meteorological data for the same time period was collected.
3. Using a 90° sector centered on each monitor and the closest facility, concentrations recorded during hours when wind directions originate from this sector were eliminated.
4. The average concentration at each monitor from these abbreviated datasets were determined.

The results of this analysis are shown in Table 13, below.

Monitor ID	2007-2009 Average SO2 (ppb)	2010-2012 Average SO2 (ppb)
54-009-0005	8.2	4.8
39-081-0017	3.4	3.5
54-009-0007	8.6	5.2
54-009-0011	8.4	5.1

Table 13: Average monitor values corrected for facility impacts, 2007-2009 and 2010-2012.

Ohio EPA conservatively chose to eliminate from further background analysis the results obtained for the 2010-2012 period to maintain conservatism in the background determination.

In addition to the four AQS monitors located in the northern portion of the nonattainment area, a network of four monitors is maintained by the Cardinal Power Plant. These monitors began collecting data in 2011 as part the Permit-to-Install process for the scrubber/cooling tower configuration at Cardinal Unit 3. These monitors are located in the southern portion of the nonattainment area, and should represent sources not explicitly modeled but potentially impacting the nonattainment area. In consultation with American Electric Power, Ohio EPA very conservatively represented the 95th percentile of maximum daily values at the Cardinal monitoring network as representative of periods when emissions from Cardinal are not impacting the monitors. Given that these monitors were sited specifically to monitor emissions from Cardinal, it is highly unlikely that the 95th percentile is reflective of periods when Cardinal is not impacting these monitors to some degree, and as such, this is considered by Ohio EPA to represent an additional measure of conservatism in the background determination. Table 14 below shows the 95th percentile for years 2011-2014 at each of the four Cardinal network monitors.

Monitor ID	2011 95th Pctile (ppb)	2012 95th Pctile (ppb)	2013 95th Pctile (ppb)	2014 95th Pctile (ppb)
54-009-6000	9	5	3	6
39-081-0020	9	7	6	6
39-081-0018	11	10	9	9
Unit 3 Monitor	10	8	7	4

Table 14: 95th percentile values, Cardinal monitoring network, 2011-2014.

To derive a final background concentration that is both conservative and reflective of the large decrease in emissions in the nonattainment area and surrounding Counties, Ohio

EPA averaged the 2007 to 2009 average SO2 concentrations (less facility specific impacts) for monitors 54-009-0005, 54-009-0007, and 54-009-0011 (excluding monitor 39-081-0017 to maintain conservatism), with the 2011 and 2012 95^{th} percentile values from the Cardinal monitor network. Ohio EPA excluded the 2013 and 2014 data from the Cardinal network to maintain conservatism. The resultant background of 8.1 ppb is similar to those values observed in the 2007-2009 period at the AQS monitors, and well above those observed at these monitors for the 2010-2012 period. Further, this value is well in line with conservative 95^{th} percentile values at the Cardinal monitors. Ohio EPA concludes that this background is both conservative with respect to observed monitor data and is reflective of the large decrease in emissions from the nonattainment area and surrounding Counties.

Determining Design Value Metrics

Refer to the General Modeling Protocol.

The Nonattainment SIP Guidance allows for the flexibility to perform separate AERMOD runs in situations where the simultaneous modeling of all explicitly modeled sources is not possible, as was the case in the Steubenville, OH-WV nonattainment area. With respect to these situations, the Nonattainment SIP Guidance states, “the use of hourly POSTFILES, which can be quite large, and external post-processing would be needed to calculate design values”. Ohio EPA applied this recommendation for specific modeling analyses. In these situations, Ohio EPA includes those POSTFILES with the relevant modeling input and output files.

Documentation

Ohio EPA is providing as part of this SIP submittal all necessary information, including the following elements specifically enumerated in the Nonattainment SIP Guidance.

- Characterization of the nonattainment problem or characterization of the modeled area in absence of a violating monitor.
- An emissions analysis around the violating monitor or area under consideration for the attainment and maintenance demonstration in absence of a violating monitor.
- Description of any other supplemental analyses (in addition to the characterization and emissions analyses noted above) intended to strengthen the attainment demonstration.
- Methodology for preparing air quality and meteorology inputs including choice of meteorological data and representativeness of the data.
- Summary and analysis of modeling results.
- Modeling data inputs and outputs in electronic form.
- Results of any supplemental analyses.

Supplemental Analysis

APPENDIX D: MODELING FILES ON CD

The CD included with this appendix contains all input and output data files used to generate the results from the air quality analyses presented in this report. The following provides a description of the contents of each folder included on the attached CD.

AERMAP

- Contains the AERMAP input (.inp), output (.out), and receptor (.rec) files for the analysis modeling grids described in Section 4.5.

AERMET

- AERMET - Contains the AERMET input and output files that were used to create the model-ready meteorological files based on the onsite observations as well as surface and upper air observations from Pittsburgh, PA. This folder also includes the raw meteorological data and AERSURFACE processing.
- Model-Ready - FOL2007-2009– Contains the surface (.sfc) and profile (.pfl) meteorological data files that were utilized in this modeling analysis.

BPIP

- Contains the input, output, and summary files from the building downwash analysis. This analysis includes all modeled sources and buildings at the Follansbee plant as well as the Ohio EPA sources.

BLP Processing

- BLP Model runs - Contains the model input, plume rise file written as output, and all other supporting BLP documentation.
- BLP Met – Contains the meteorological data (in the format necessary) as used by BLP

Hourly File

- Contains the hourly emissions file utilized in the analysis.

SO_2 Model

- Contains the model input and output files associated with operation of the Follansbee Plant when considering desulfurization plant outages and increased COG flare operation (See Section 5.1)

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Averaging Period Analysis

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trinityconsultants.com

Trinity Consultants

June 26, 2015

Mr. Russ Dudek
Environmental Manager
AK Steel Corporation
210 Pittsburgh Road
Butler, PA 16001

RE: Averaging Period Analysis for SO_2 Emission Limitations
Mountain State Carbon, LLC – Follansbee, WV

Dear Mr. Dudek:

Trinity Consultants (Trinity) has conducted a statistical analysis to support the development of appropriate emission limitations for sulfur dioxide (SO_2) generated by operations at Mountain State Carbon's (MSC's) metallurgical coke manufacturing facility in Follansbee, WV (Follansbee Facility). This letter describes the approach used to derive this adjustment factor, and supporting calculations are included as an attachment to this letter.

In summary, Trinity has used actual historic operating data for the Follansbee Facility to calculate a factor that could be used to adjust an emission limit established over an hourly averaging period to an equivalent emission limit established over a 24-hour block averaging period. As described in detail below, this analysis was conducted using data from the 2007-2009 operating period.

Because these short-term emission limits will apply only during periods of normal operation, Trinity believes that the data used to develop the adjustment factor should exclude any hydrogen sulfide (H_2S) concentrations or coke oven gas (COG) flow rates measured during startup, shutdown, or malfunction (SSM) events as well as any planned outages of the Follansbee Facility's desulfurization system. Trinity calculated the adjustment factors provided in the following table using historic data for normal operation and by applying methods suggested in the applicable U.S. EPA guidance.

Table 1. Adjustment Factors for SO_2 Sources at the Follansbee Facility

Combustion Source	Adjustment Factor
Excess COG Flare	0.985
Battery 1 Underfiring System	0.935
Battery 2 Underfiring System	0.933
Battery 3 Pushing Side Underfiring System	0.951
Battery 3 Coke Side Underfiring System	0.957
Battery 8 Underfiring System	0.945

HEADQUARTERS >
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USA | China | Middle East

Combustion Source	Adjustment Factor
COG Boiler #6	0.968
COG Boiler #7	0.968
COG Boiler #9	0.947
COG Boiler #10	0.928

U.S. EPA GUIDANCE

Trinity derived this adjustment factor in accordance with U.S. EPA's April 23, 2014 Guidance for 1-Hour SO_2 Nonattainment Area State Implementation Plan (SIP) Submittals. This guidance recommends the following.

- Calculate the adjustment factor by dividing the 99^{th} percentile of 24-hour average pound per hour (lb/hr) emission rates by the 99^{th} percentile of 1-hour average emission rates; and
- Hours without operation may be excluded from the 24-hour average.

Using U.S. EPA's recommended approach as a guide, Trinity calculated the adjustment factor for the Follansbee Facility as described in the following section.

ADJUSTMENT FACTOR DEVELOPMENT

Sources of Input Data

For the 2007-2009 operating period, Trinity calculated hourly emission rates for sulfur dioxide (SO_2) using the hourly hydrogen sulfide (H_2S) concentrations in the coke oven gas (COG) measured by MSC's existing analyzer, daily average COG flow rates for each of the following combustion sources, and an assumption of complete stoichiometric conversion of H_2S to SO_2 during combustion of the COG.

- Excess COG Flare;
- Underfiring System for Battery #1;
- Underfiring System for Battery #2;
- Push-side Underfiring System for Battery #3;
- Coke-side Underfiring System for Battery #3;
- Underfiring System for Battery #8;
- COG Boiler #6;
- COG Boiler #7;
- COG Boiler #9; and
- COG Boiler #10.

Data Selection Criteria for Normal Operation

Trinity used the following data selection criteria to calculate a factor that would most accurately represent the degree of variability expected in hourly SO_2 emission rates during normal operation of the Follansbee Facility.

- Trinity excluded from the analysis all hours during which the desulfurization system was out of service for a planned outage;
- Trinity excluded from the analysis all hours during which malfunction events were occurring; and
- Trinity excluded from the analysis all hours during which the H_2S concentration was greater than 50 grains per 100 standard cubic feet (gr/100scf) given that MSC would not expect concentrations above this level during normal operation. This concentration is also the proposed value used to define the start and end of a planned or unplanned maintenance event.

For every hour of data excluded according to the selection criteria described above, Trinity has provided annotations explaining the exclusion in column J of the attached spreadsheet (See Tables A-2 through A-11).

Note that Trinity calculates the 24-hr average emission rate once per day at the end of the 24th hour of the day (i.e., a block average) consistent with Step 3 in Appendix C to U.S. EPA's April 2014 guidance which generally suggests that facilities could calculate long-term averages at the end of each operating day. Also note that Trinity's calculated adjustment factors are nearly equivalent to the 24-hour adjustment factor provided for sources without add-on SO_2 control devices in Table 1 on Page D-2 of U.S. EPA's April 2014 guidance. A summary of the 1-hour average emission rates utilized in the modeling demonstration and the resultant 24-hour average emission limit during normal operation is included as Table A-1.

Consideration of Startup, Shutdown, and Malfunction Events

In recent discussions with MSC, the West Virginia Department of Environmental Protection (WVDEP) raised a question as to the appropriateness of not including emissions associated with startup, shutdown and malfunction (SSM) events in the statistical analysis. WVDEP's basis for this question was U.S. EPA's recent regulatory actions (i.e., the SSM SIP Call) regarding SSM events in State Implementation Plans (SIPs) and the court cases that required those regulatory actions. MSC has assessed this issue further and remains convinced that SSM events that otherwise would constitute noncompliance are properly excluded from the statistical analysis and the underlying modeling.

First, the guidance for conducting the statistical analysis does not contemplate including SSM emissions in the analysis. Pursuant to Appendix C of the April 2014 "Guidance for 1-Hour SO_2 Nonattainment Area SIP Submissions," the second step of the statistical analysis for setting longer term average emissions limits is to "compile emissions data reflecting the distribution of emission that is expected once the attainment plan is implemented." Noncompliant SSM emissions events are not "expected." A source expects to operate in compliance. Thus, the statistical analysis guidance itself argues against including SSM emissions.

Second, it is important to keep in mind that the statistical analysis is merely an extension of the underlying air dispersion modeling conducted to demonstrate compliance with the National Ambient Air Quality Standards (NAAQS). It provides a means to adjust the averaging time of an emissions limit developed through modeling. And applicable U.S. EPA modeling guidance expressly directs sources to not include malfunction events in NAAQS modeling. Specifically, 40 CFR Part 51, Appendix W (Guideline on Air Quality Models), Section 8.1.2.a states that "malfunctions which may result in excess emissions are not considered to be a normal operating condition. They generally should not be considered in determining allowable emissions. However, if the excess emissions are the result of poor maintenance, careless operation, or other preventable conditions, it may be necessary to consider them in determining source impact." Thus, U.S. EPA modeling guidance relevant to modeling SO_2 emissions does not allow inclusion of malfunction events in the model.

Furthermore, on March 1, 2011, U.S. EPA issued additional modeling guidance clarifying the application of Appendix W when developing air dispersion models for comparison to short-term ambient air-quality standards.[1] This memorandum clarifies that intermittent sources may be excluded from short-term modeling

[1] Tyler Fox, Leader, U.S. EPA Air Quality Modeling Group, "Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard." March 1, 2011.

analyses given that inclusion of such sources would involve the excessively conservative assumption that the intermittent source would operate during the same single hour as the worst-case meteorological conditions. Because SSM events are inherently intermittent, the March 1, 2011 guidance memo authorizes the exclusion of these events from modeling analyses which, by extension, suggests that SSM events should also be excluded from the averaging period analysis based on the modeling effort.

This notion of not including excess or noncompliant emissions in an emissions evaluation is not limited to NAAQS modeling, and is included elsewhere in Clean Air Act regulations. For example, in a New Source Review emissions analysis, in calculating baseline emissions, the emission rate “shall be adjusted downward to exclude any noncompliant emissions that occurred while the source was operating above any emissions limitation” pursuant to Title 45, West Virginia Code of State Rules (CSR) 19-2.9.a.2. Quite simply, since the SSM emissions associated with unplanned outages that WVDEP has questioned would be considered noncompliance, they are not appropriately part of the emissions evaluation to determine a statistical emissions rate.

Third, we have not identified anything in U.S. EPA’s recent SSM actions that would undermine or alter the general approach of not including noncompliant SSM events in modeling or other emissions evaluations. Primarily, in U.S. EPA’s recent final regulation on the SSM SIP Call, the agency stated that the purpose of the regulation was to remove provisions from SIPs that allowed for exemptions for noncompliant emissions during SSM events.[2] Thus, this purpose is no different than not including noncompliant emissions in an NSR analysis, or not including noncompliant emission in NAAQS modeling. This is likewise consistent with the court cases that preceded U.S. EPA’s SSM SIP Call rulemaking, which generally held that certain emissions standards must be met “continuously,” and that EPA did not have the authority to exempt sources from this continuous standard during SSM events.

In sum, the exclusion of SSM events from MSC’s statistical analysis is consistent with relevant guidance, and is consistent with U.S. EPA’s current regulatory approach to managing SSM events. Noncompliant emissions, whether from SSM events or otherwise, are handled as noncompliance, not by somehow including such noncompliant emissions in a modeling exercise or emissions evaluation.

CONCLUSION

Trinity believes that MSC should establish hourly emission limitations for SO_2 as 24-hour averages by adjusting the 1-hour average emission rates by the factors provided above. Trinity also believes that the data and techniques used to derive these factors are consistent with the criteria and procedures recommended in U.S. EPA’s April 23, 2014 guidance.

[2] 80 Fed. Reg. 33843 – June 12, 2015

***

Should you have any questions regarding this analysis, please contact me at (614) 433-0733.

Sincerely,

TRINITY CONSULTANTS

Daniel Wheeler
Senior Consultant

Attachments

cc: Patrick Smith (MSC)
Mike Remsberg (Trinity)
Ian Donaldson (Trinity)

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ATTACHMENT A

Averaging Period Analysis

Table A.1 - Averaging Period Analysis for SO_2 Emission Rates - MSC - Follansbee Plant

The following table outlines for normal plant operations the modeled emission rates and equivalent 24-hour limit for inclusion in the SO_2 SIP. The equivalent, proposed 24-hour limits were based on the adjustment factor computed in accordance with U.S. EPA's April 23, 2014 Guidance for 1-Hour SO_2 Nonattainment Area SIP Submittals (See Table A-1).

Source[a]	Modeled 1-hour Average SO_2 Emission Rate during Normal Operation (lb/hr)	Proposed 24-hour Average SO_2 Emission Limit during Normal Operation (lb/hr)
Battery 1 Combustion	22.9	21.4
Battery 2 Combustion	22.9	21.4
Battery 3 Combustion[b]	25.7	24.5
Battery 8 Combustion	122.1	115.4
Boilers 6 - 10 (merged stack)[c]	90.0	85.7
Excess COG Flare	139.8	137.7

[a.] Other SO_2 emissions sources included in the modeling demonstration (e.g., acid plant tail gas stack) do not rely on a CEM and emission limits are reflective of a 1-hour average.

[b.] The adjustment factor for the Battery 3 Underfiring System Combustion Stack is calculated as the average of the adjustment factors for the Pushing Side and Coke Side underfiring systems.

[c.] The adjustment factor for COG Boilers #6 - 10 is calculated as the average of the adjustment factors for the individual COG Boilers.

Table A.2 - Averaging Period Analysis for SO_2 Emission Rates - MSC - Follansbee Plant - Excess COG Flare

MSC used the data provided below to calculate an adjustment factor for converting a 1-hr average emission limit to a 24-hour average emission limit in accordance with U.S. EPA's April 23, 2014 Guidance for 1-Hour SO_2 Nonattainment Area SIP Submittals.

STOICHIOMETRIC CONSTANTS

SO_2 Molecular Weight	64.064	lb/lbmol
H_2S Molecular Weight	34.0809	lb/lbmol

AVERAGING PERIOD ADJUSTMENT FACTOR

99th Percentile 1-hr Average Emission Rate	88.81	lb/hr	*Excludes planned outages, malfunction events, and concentrations >50 gr/100scf*
99th Percentile 24-hr Average Emission Rate	87.46	lb/hr	*Excludes planned outages, malfunction events, and concentrations >50 gr/100scf*
Averaging Period Adjustment Factor	**0.985**		*= 99th Percentile 24-hr Average Emission Rate (lb/hr) / 99th Percentile 1-hr Average Emission Rate (lb/hr)*

HOURLY OPERATIONAL DATA

MSC obtained hourly H_2S concentrations (gr/100scf) from the existing COG analyzer.

*SO_2 Emission Rate (lb/hr) = Excess COG Flare Flow Rate (scf/day) / 24 (hr/day) / 100 (scf/100scf) * H_2S Concentration (gr/100scf) / 7,000 (lb/ton) / H_2S Molecular Weight (lb/lbmol) * SO_2 Molecular Weight (lb/lbmol)*

Table A.3 - Averaging Period Analysis for SO_2 Emission Rates - MSC - Follansbee Plant - Battery 1 Underfiring System

MSC used the data provided below to calculate an adjustment factor for converting a 1-hr average emission limit to a 24-hour average emission limit in accordance with U.S. EPA's April 23, 2014 Guidance for 1-Hour SO_2 Nonattainment Area SIP Submittals.

STOICHIOMETRIC CONSTANTS

SO_2 Molecular Weight	64.064	lb/lbmol
H_2S Molecular Weight	34.0809	lb/lbmol

AVERAGING PERIOD ADJUSTMENT FACTOR

99th Percentile 1-hr Average Emission Rate	12.69	lb/hr	*Excludes planned outages, malfunction events, and concentrations >50 gr/100scf*
99th Percentile 24-hr Average Emission Rate	11.86	lb/hr	*Excludes planned outages, malfunction events, and concentrations >50 gr/100scf*
Averaging Period Adjustment Factor	**0.935**		*= 99th Percentile 24-hr Average Emission Rate (lb/hr) / 99th Percentile 1-hr Average Emission Rate (lb/hr)*

HOURLY OPERATIONAL DATA

MSC obtained hourly H_2S concentrations (gr/100scf) from the existing COG analyzer.

*SO_2 Emission Rate (lb/hr) = Battery 1 COG Flow Rate (scf/day) / 24 (hr/day) / 100 (scf/100scf) * H_2S Concentration (gr/100scf) / 7,000 (lb/ton) / H_2S Molecular Weight (lb/lbmol) * SO_2 Molecular Weight (lb/lbmol)*

Table A.4 - Averaging Period Analysis for SO_2 Emission Rates - MSC - Follansbee Plant - Battery 2 Underfiring System

MSC used the data provided below to calculate an adjustment factor for converting a 1-hr average emission limit to a 24-hour average emission limit in accordance with U.S. EPA's April 23, 2014 Guidance for 1-Hour SO_2 Nonattainment Area SIP Submittals.

STOICHIOMETRIC CONSTANTS

SO_2 Molecular Weight	64.064	lb/lbmol
H_2S Molecular Weight	34.0809	lb/lbmol

AVERAGING PERIOD ADJUSTMENT FACTOR

99th Percentile 1-hr Average Emission Rate	15.83	lb/hr	*Excludes planned outages, malfunction events, and concentrations >50 gr/100scf*
99th Percentile 24-hr Average Emission Rate	14.77	lb/hr	*Excludes planned outages, malfunction events, and concentrations >50 gr/100scf*
Averaging Period Adjustment Factor	**0.933**		*= 99th Percentile 24-hr Average Emission Rate (lb/hr) / 99th Percentile 1-hr Average Emission Rate (lb/hr)*

HOURLY OPERATIONAL DATA

MSC obtained hourly H_2S concentrations (gr/100scf) from the existing COG analyzer.

*SO_2 Emission Rate (lb/hr) = Battery 2 COG Flow Rate (scf/day) / 24 (hr/day) / 100 (scf/100scf) * H_2S Concentration (gr/100scf) / 7,000 (lb/ton) / H_2S Molecular Weight (lb/lbmol) * SO_2 Molecular Weight (lb/lbmol)*

Table A.5 - Averaging Period Analysis for SO_2 Emission Rates - MSC - Follansbee Plant - Battery 3 Pushing Side Underfiring System

MSC used the data provided below to calculate an adjustment factor for converting a 1-hr average emission limit to a 24-hour average emission limit in accordance with U.S. EPA's April 23, 2014 Guidance for 1-Hour SO_2 Nonattainment Area SIP Submittals.

STOICHIOMETRIC CONSTANTS

SO_2 Molecular Weight	64.064	lb/lbmol
H_2S Molecular Weight	34.0809	lb/lbmol

AVERAGING PERIOD ADJUSTMENT FACTOR

99th Percentile 1-hr Average Emission Rate	8.07	lb/hr	*Excludes planned outages, malfunction events, and concentrations >50 gr/100scf*
99th Percentile 24-hr Average Emission Rate	7.68	lb/hr	*Excludes planned outages, malfunction events, and concentrations >50 gr/100scf*
Averaging Period Adjustment Factor	**0.951**		*= 99th Percentile 24-hr Average Emission Rate (lb/hr) / 99th Percentile 1-hr Average Emission Rate (lb/hr)*

HOURLY OPERATIONAL DATA

MSC obtained hourly H_2S concentrations (gr/100scf) from the existing COG analyzer.

*SO_2 Emission Rate (lb/hr) = Battery 3 Push Side COG Flow Rate (scf/day) / 24 (hr/day) / 100 (scf/100scf) * H_2S Concentration (gr/100scf) / 7,000 (lb/ton) / H_2S Molecular Weight (lb/lbmol) * SO_2 Molecular Weight (lb/lbmol)*

Table A.6 - Averaging Period Analysis for SO_2 Emission Rates - MSC - Follansbee Plant - Battery 3 Coke Side Underfiring System

MSC used the data provided below to calculate an adjustment factor for converting a 1-hr average emission limit to a 24-hour average emission limit in accordance with U.S. EPA's April 23, 2014 Guidance for 1-Hour SO_2 Nonattainment Area SIP Submittals.

STOICHIOMETRIC CONSTANTS

SO_2 Molecular Weight	64.064	lb/lbmol
H_2S Molecular Weight	34.0809	lb/lbmol

AVERAGING PERIOD ADJUSTMENT FACTOR

99th Percentile 1-hr Average Emission Rate	8.32	lb/hr	*Excludes planned outages, malfunction events, and concentrations >50 gr/100scf*
99th Percentile 24-hr Average Emission Rate	7.97	lb/hr	*Excludes planned outages, malfunction events, and concentrations >50 gr/100scf*
Averaging Period Adjustment Factor	**0.957**		*= 99th Percentile 24-hr Average Emission Rate (lb/hr) / 99th Percentile 1-hr Average Emission Rate (lb/hr)*

HOURLY OPERATIONAL DATA

MSC obtained hourly H_2S concentrations (gr/100scf) from the existing COG analyzer.

*SO_2 Emission Rate (lb/hr) = Battery 3 Coke Side COG Flow Rate (scf/day) / 24 (hr/day) / 100 (scf/100scf) * H_2S Concentration (gr/100scf) / 7,000 (lb/ton) / H_2S Molecular Weight (lb/lbmol) * SO_2 Molecular Weight (lb/lbmol)*

Table A.7 - Averaging Period Analysis for SO_2 Emission Rates - MSC - Follansbee Plant - Battery 8 Underfiring System

MSC used the data provided below to calculate an adjustment factor for converting a 1-hr average emission limit to a 24-hour average emission limit in accordance with U.S. EPA's April 23, 2014 Guidance for 1-Hour SO_2 Nonattainment Area SIP Submittals.

STOICHIOMETRIC CONSTANTS

SO_2 Molecular Weight	64.064	lb/lbmol
H_2S Molecular Weight	34.0809	lb/lbmol

AVERAGING PERIOD ADJUSTMENT FACTOR

99th Percentile 1-hr Average Emission Rate	84.35	lb/hr	*Excludes planned outages, malfunction events, and concentrations >50 gr/100scf*
99th Percentile 24-hr Average Emission Rate	79.73	lb/hr	*Excludes planned outages, malfunction events, and concentrations >50 gr/100scf*
Averaging Period Adjustment Factor	**0.945**		*= 99th Percentile 24-hr Average Emission Rate (lb/hr) / 99th Percentile 1-hr Average Emission Rate (lb/hr)*

HOURLY OPERATIONAL DATA

MSC obtained hourly H_2S concentrations (gr/100scf) from the existing COG analyzer.

*SO_2 Emission Rate (lb/hr) = Battery 8 COG Flow Rate (scf/day) / 24 (hr/day) / 100 (scf/100scf) * H_2S Concentration (gr/100scf) / 7,000 (lb/ton) / H_2S Molecular Weight (lb/lbmol) * SO_2 Molecular Weight (lb/lbmol)*

Table A.8 - Averaging Period Analysis for SO_2 Emission Rates - MSC - Follansbee Plant - COG Boiler 6

MSC used the data provided below to calculate an adjustment factor for converting a 1-hr average emission limit to a 24-hour average emission limit in accordance with U.S. EPA's April 23, 2014 Guidance for 1-Hour SO_2 Nonattainment Area SIP Submittals.

STOICHIOMETRIC CONSTANTS

SO_2 Molecular Weight	64.064	lb/lbmol
H_2S Molecular Weight	34.0809	lb/lbmol

AVERAGING PERIOD ADJUSTMENT FACTOR

99th Percentile 1-hr Average Emission Rate	19.49	lb/hr	*Excludes planned outages, malfunction events, and concentrations >50 gr/100scf*
99th Percentile 24-hr Average Emission Rate	18.86	lb/hr	*Excludes planned outages, malfunction events, and concentrations >50 gr/100scf*
Averaging Period Adjustment Factor	**0.968**		*= 99th Percentile 24-hr Average Emission Rate (lb/hr) / 99th Percentile 1-hr Average Emission Rate (lb/hr)*

HOURLY OPERATIONAL DATA

MSC obtained hourly H_2S concentrations (gr/100scf) from the existing COG analyzer.
*SO_2 Emission Rate (lb/hr) = COG Boiler 6 Flow Rate (scf/day) / 24 (hr/day) / 100 (scf/100scf) * H_2S Concentration (gr/100scf) / 7,000 (lb/ton) / H_2S Molecular Weight (lb/lbmol) * SO_2 Molecular Weight (lb/lbmol)*

Table A.9 - Averaging Period Analysis for SO_2 Emission Rates - MSC - Follansbee Plant - COG Boiler 7

MSC used the data provided below to calculate an adjustment factor for converting a 1-hr average emission limit to a 24-hour average emission limit in accordance with U.S. EPA's April 23, 2014 Guidance for 1-Hour SO_2 Nonattainment Area SIP Submittals.

STOICHIOMETRIC CONSTANTS

SO_2 Molecular Weight	64.064	lb/lbmol
H_2S Molecular Weight	34.0809	lb/lbmol

AVERAGING PERIOD ADJUSTMENT FACTOR

99th Percentile 1-hr Average Emission Rate	19.06	lb/hr	*Excludes planned outages, malfunction events, and concentrations >50 gr/100scf*
99th Percentile 24-hr Average Emission Rate	18.45	lb/hr	*Excludes planned outages, malfunction events, and concentrations >50 gr/100scf*
Averaging Period Adjustment Factor	**0.968**		*= 99th Percentile 24-hr Average Emission Rate (lb/hr) / 99th Percentile 1-hr Average Emission Rate (lb/hr)*

HOURLY OPERATIONAL DATA

MSC obtained hourly H_2S concentrations (gr/100scf) from the existing COG analyzer.

*SO_2 Emission Rate (lb/hr) = COG Boiler 7 Flow Rate (scf/day) / 24 (hr/day) / 100 (scf/100scf) * H_2S Concentration (gr/100scf) / 7,000 (lb/ton) / H_2S Molecular Weight (lb/lbmol) * SO_2 Molecular Weight (lb/lbmol)*

Table A.10 - Averaging Period Analysis for SO_2 Emission Rates - MSC - Follansbee Plant - COG Boiler 9

MSC used the data provided below to calculate an adjustment factor for converting a 1-hr average emission limit to a 24-hour average emission limit in accordance with U.S. EPA's April 23, 2014 Guidance for 1-Hour SO_2 Nonattainment Area SIP Submittals.

STOICHIOMETRIC CONSTANTS

SO_2 Molecular Weight	64.064	lb/lbmol
H_2S Molecular Weight	34.0809	lb/lbmol

AVERAGING PERIOD ADJUSTMENT FACTOR

99th Percentile 1-hr Average Emission Rate	17.35	lb/hr	*Excludes planned outages, malfunction events, and concentrations >50 gr/100scf*
99th Percentile 24-hr Average Emission Rate	16.43	lb/hr	*Excludes planned outages, malfunction events, and concentrations >50 gr/100scf*
Averaging Period Adjustment Factor	**0.947**		*= 99th Percentile 24-hr Average Emission Rate (lb/hr) / 99th Percentile 1-hr Average Emission Rate (lb/hr)*

HOURLY OPERATIONAL DATA

MSC obtained hourly H_2S concentrations (gr/100scf) from the existing COG analyzer.

*SO_2 Emission Rate (lb/hr) = COG Boiler 9 Flow Rate (scf/day) / 24 (hr/day) / 100 (scf/100scf) * H_2S Concentration (gr/100scf) / 7,000 (lb/ton) / H_2S Molecular Weight (lb/lbmol) * SO_2 Molecular Weight (lb/lbmol)*

Table A.11 - Averaging Period Analysis for SO_2 Emission Rates - MSC - Follansbee Plant - COG Boiler 10

MSC used the data provided below to calculate an adjustment factor for converting a 1-hr average emission limit to a 24-hour average emission limit in accordance with U.S. EPA's April 23, 2014 Guidance for 1-Hour SO_2 Nonattainment Area SIP Submittals.

STOICHIOMETRIC CONSTANTS

SO_2 Molecular Weight	64.064	lb/lbmol
H_2S Molecular Weight	34.0809	lb/lbmol

AVERAGING PERIOD ADJUSTMENT FACTOR

99th Percentile 1-hr Average Emission Rate	15.67	lb/hr	*Excludes planned outages, malfunction events, and concentrations >50 gr/100scf*
99th Percentile 24-hr Average Emission Rate	14.54	lb/hr	*Excludes planned outages, malfunction events, and concentrations >50 gr/100scf*
Averaging Period Adjustment Factor	**0.928**		*= 99th Percentile 24-hr Average Emission Rate (lb/hr) / 99th Percentile 1-hr Average Emission Rate (lb/hr)*

HOURLY OPERATIONAL DATA

MSC obtained hourly H_2S concentrations (gr/100scf) from the existing COG analyzer.

*SO_2 Emission Rate (lb/hr) = COG Boiler 10 Flow Rate (scf/day) / 24 (hr/day) / 100 (scf/100scf) * H_2S Concentration (gr/100scf) / 7,000 (lb/ton) / H_2S Molecular Weight (lb/lbmol) * SO_2 Molecular Weight (lb/lbmol)*