Appendix C

Modeling Technical Support Document for the Miami Sulfur Dioxide (SO_2) Nonattainment Area

Air Quality Division
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1.0 Introduction

The United States Environmental Protection Agency (EPA) established a new 1-hour National Ambient Air Quality Standard (NAAQS) for sulfur dioxide (SO_2) of 75 parts per billion (ppb) on June 2, 2010. EPA designated the Miami area of Gila County as a Non-attainment Area (NAA) for the 2010 SO_2 Primary NAAQS on August 5, 2013, effective as of October 4, 2013. Because of this designation, the Arizona Department of Environmental Quality (ADEQ) must develop a State Implementation Plan (SIP) revision to demonstrate future attainment of the NAAQS within five years of the effective date of designation. An attainment demonstration using an EPA approved air quality dispersion model is a core component of state SO_2 NAA SIP submittals.

As described in this Attainment Demonstration Technical Support Document (TSD), the modeling will be performed in accordance with the EPA's *Guideline on Air Quality Models (GAQM)* (40 CFR 51, Appendix W) (U.S. EPA, 2005) and *Guidance for 1-Hour SO_2 Nonattainment Area SIP Submissions - Appendix A Modeling Guidance for Nonattainment Areas* (U.S. EPA, 2014a). Additionally, ADEQ will employ *Additional Clarification Regarding Application of Appendix W from Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard* (U.S. EPA, 2011a) [1].

This TSD presents the modeling methodologies ADEQ followed in completing the ambient air quality analysis of the Miami planning area. ADEQ appointed FMMI's lead modeler, Amec Foster Wheeler, to perform the attainment demonstration, while ADEQ used its expertise in an oversight and review capacity. The TSD is organized as follows:

- Section 2 provides an overview of the general regional characteristics of the Miami NAA, including topography, land use, and climate;
- Section 3 provides a discussion on the determination of the modeling domain, sources to explicitly model and the receptor grid;
- Section 4 provides a discussion on the model selection, addressing a hybrid modeling approach, and model performance evaluation for the hybrid approach;
- Section 5 provides detailed source inputs, including current and future source configuration, source emissions, source release parameters, Good Engineering Practice (GEP) stack height, and urban/rural determination;
- Section 6 provides a discussion on the selection and processing of meteorological data;
- Section 7 provides a discussion on the determination of background concentrations;
- Section 8 provides proposed emission limits and attainment demonstration results and discussion.

To help EPA's review, ADEQ is addressing all modeling components, following the structure of EPA's Modeling Guidance for Non-Attainment Areas (U.S. EPA, 2014a). Along with the TSD, ADEQ has also provided an enclosed CD-ROM, including files associated with modified BLP code, assignment of terrain elevations to receptors, and preparation of a sequential 3-year meteorological data set for use in the modeling. A list of the materials in the CD-ROM is provided in Appendix A of this document.

[1] Although this guidance is for NO_2 modeling, the common 1-hour averaging time and form of both the NO_2 and SO_2 standards makes this modeling guidance applicable to the 1-hour SO_2 NAAQS.

2.0 Overview of Miami Nonattainment Area (NAA) for 1-hour SO_2

The towns of Miami, Claypool and most of Globe lie within the Miami SO_2 NAA. The Miami SO_2 NAA is comprised of the portions of Gila County bound by the townships and ranges as presented in Figure 2-1. Figure 3-1 contains the location of the Miami Smelter. FMMI's proposed changes will occur at the existing Miami Smelter located in Claypool, Arizona. The Miami Smelter is located on a hill to the north of the communities of Claypool and Miami.

2.1 Population

The Arizona Department of Administration (ADOA) estimates the year 2011 population of Gila County at 53,577 persons. ADOA estimates 14,457 persons resided within the bounds of the Miami SO_2 NAA during 2011. The Miami SO_2 NAA represents approximately 27 percent of the population of Gila County.

2.2 Land use

The Miami NAA encompasses some 2,286 square miles within the bounds of Gila County. The majority of the land within the NAA is owned by the United States Forest Service; followed by privately held lands, the U.S. Bureau of Land Management (BLM) managed land, and Arizona State Trust land. The San Carlos Indian Reservation owns none of the land within the Miami NAA. Overall, the area has minimal commercial development.

Industrial sources within the Miami NAA are provided in Section 3.1.1 of this TSD. Further discussion of land use, as it pertains to dispersion modeling and meteorological processing inputs, is provided in Sections 5.6 and 6.1.3 of this TSD.

2.3 Topography

Miami is at roughly 3,500 feet above mean sea level (AMSL), located in the southwest-northeast tending river valley of the Bloody Tanks Wash. The Miami Smelter project site sits about 3,600 feet AMSL on a hill above US Route 60. To the northeast, this valley joins the Pinal Wash at a right angle; the Wash then tends northwest and merges with the Pinal Creek Valley. Northeast beyond this juncture, the Apache Peaks rise to 4,300 feet, and to 6,200 feet a bit outside of the nonattainment area. To the northwest, Webster Mountain rises to 5,000 feet, the Pinal and other mountain ranges to the south and southwest rise to 6,500 feet.

The highest terrain feature in the vicinity, but outside of the nonattainment area, is Pinal Peak with an elevation of 7,850 feet and located 15.1 kilometers south of the facility. Another prominent terrain feature 44.4 kilometers to the north of the facility is Aztec Mountain with an elevation of 7,748 feet.

Further discussion of topography, as it pertains to dispersion modeling inputs, is provided in Section 3.2 of this TSD.

2.4 Climate

One can find both desert terrain and mountain ranges in the region and as such, one can find both warm desert and cool alpine climates near the Miami SO_2 NAA. In Miami, the hottest month of the year is July, when the average daily maximum temperature is 96.4 ˚F. January is the coolest month with an average daily minimum temperature of 33.6 ˚F.

Precipitation generally occurs in two seasons. The wettest month in Miami is August when monsoonal thunderstorms produce an average monthly total of 2.7 inches (") of rain. Pacific winter storms moving across the area from December through March produce monthly averages of 2.0" to 2.2" of precipitation in the form of rain or snow. The driest month is June, with an average of 0.3" of rain. The average yearly precipitation is 19.5".

The local terrain heavily influences winds in the Miami planning area. The valley is oriented on a southwesterly-northeasterly axis, and wind directions tend to follow that orientation. The elevated terrain in the region also contributes to diurnal downslope and upslope winds, which FMMI expects to be more pronounced near the higher peaks such as Pinal Peak.

Further discussion of meteorology, as it pertains to dispersion modeling and meteorological processing inputs, is provided in Section 6 of this TSD.

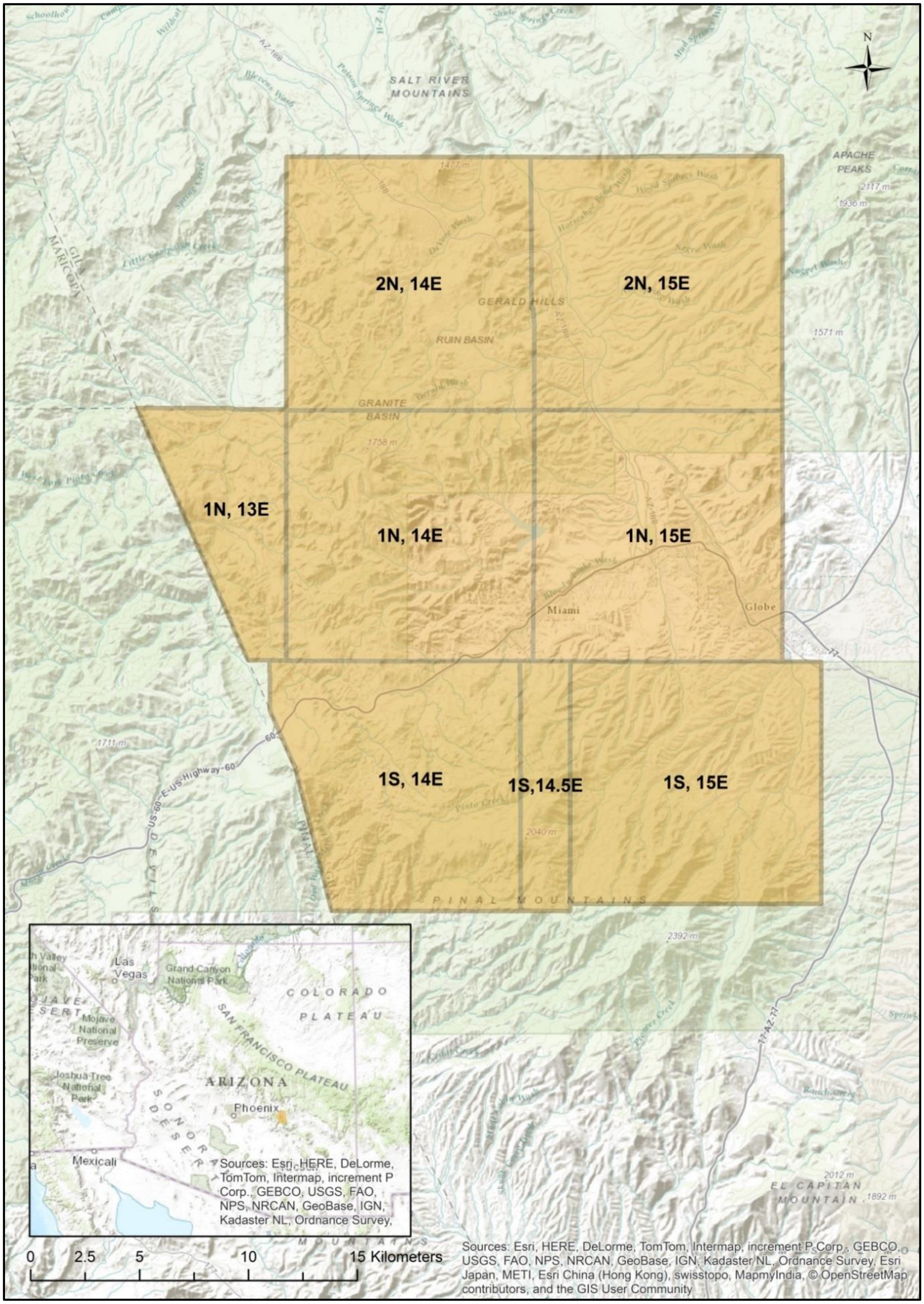
2.5 Summary of Attainment Status for Criteria Pollutants

Gila County is designated as "unclassified" or in "attainment" for the 8-hour ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), particulate matter (PM) with a diameter less than 2.5 microns ($PM_{2.5}$), and lead (Pb) NAAQS.

EPA designated a portion of Gila County as "nonattainment" for the particulate matter with a diameter less than 10 microns (PM_{10}) NAAQS, specifically the Miami and Hayden planning areas. The Miami Smelter is located in the Miami planning area. In July 2006, ADEQ requested EPA split the Hayden/Miami PM_{10} NAA into separate nonattainment areas. EPA concurred with this request in January 2007. In addition, EPA also issued a clean data finding for the Miami PM_{10} NAA in the same decision. In July 2008, ADEQ submitted to the EPA the *Miami Moderate Area PM_{10} Limited Maintenance Plan and Request for Re-designation to Attainment*. EPA has yet to publish formal approval of this submittal.

EPA recently designated the Miami planning area as nonattainment for the 2010 SO_2 NAAQS, effective October 4, 2013. The Miami Planning Area remains designated as attainment for the historic 3-hour, 24-hour and annual SO_2 NAAQS but is classified as a "maintenance area" for the historic NAAQS due to the area's former nonattainment status.

Figure 2-1 Miami Nonattainment Area Townships and Ranges



3.0 Modeling Domain

The first step of the SIP modeling exercise is to determine the area of the modeling domain—which is dependent on the number of sources to explicitly model and the size of the receptor network—in order to account for the areas of impact (U.S. EPA, 2014a). The modeling domain should, at a minimum, encompass the nonattainment area and include the sources thought most likely to cause or contribute to violations of the Primary SO_2 NAAQS in and around the nonattainment area. In the modeling exercise, all modeled receptors should exhibit modeled attainment of the NAAQS.

3.1 Determining Sources to explicitly model

ADEQ classifies the Miami Smelter as a major source pursuant to A.A.C. R18-2-101.75. The potential emission rates of the following pollutants are greater than major source thresholds: (i) particulate matter with an aerodynamic diameter less than 10 microns, (ii) sulfur dioxide, (iii) nitrogen oxides, (iv) carbon monoxide and (v) hazardous air pollutants.

Per EPA's guidance for 1-Hour SO_2 Nonattainment Area SIP Submissions, Appendix A, there are two key criteria for the determination of sources to explicitly model: whether sources could cause or contribute to a NAAQS violation, and whether the background concentrations include the ambient impacts from sources other than the Smelter in and around the Miami NAA (U.S. EPA, 2014a).

3.1.1 Sources that Could Cause or Contribute to a NAAQS Violation in the Miami NAA

ADEQ has completed the emission inventory for sources within the Miami NAA and a 50-km buffer zone extending from the boundaries of the NAA based on data from 2009-2011. Figure 3-1 is a geographical representation of these sources. Table 3-3 lists the facility names that correspond to the numerical identifiers in figure 3-1. Tables 3-1 and 3-2 are an inventory of the annual emissions for the point sources within the Miami NAA and point sources within the 50-km buffer zone surrounding the Miami NAA, respectively. As shown in Tables 3-1 and 3-2, the primary smelting of copper ore has proven to be the most significant source category in contributing to SO_2 emissions in the Miami NAA and the surrounding 50 km buffer zone. The SO_2 emissions from the FMMI Miami Smelter represent more than 99.9 % of actual SO_2 emissions in the Miami NAA during 2009-2011. Similarly, the Asarco LLC Hayden Smelter accounted for 99.9% of actual SO_2 emissions in the Miami NAA 50 km buffer zone during 2009-2011. Excluding the two smelters, there are no sources that emitted more than 25 tons per year (TPY) of SO_2 during 2009-2011. Due to their insignificant emissions, it is very unlikely that sources other than the smelters could cause or contribute to a NAAQS violation in the Miami NAA.

A preliminary question is whether the Asarco LLC Hayden Smelter could cause or contribute to a NAAQS violation in the Miami NAA. As mountains surround Miami in all directions, ADEQ does not expect sources outside the Miami NAA to contribute to exceedances at monitors in the Miami planning area. ADEQ expects the Asarco LLC Hayden Smelter, located around 46 km south of the Miami Smelter, to have negligible ambient impacts on Miami NAA because of the following facts:

- The 7,850-foot Pinal Mountain topographically separates the Hayden Smelter from the Miami NAA;
- Preliminary analysis of air quality and meteorological data indicate that exceedances of the 1-hour SO_2 standard generally occur under light winds. These lights winds would typically follow mountain / valley drainage wind patterns and since the Hayden and Miami Smelters are located in two different air sheds, the influence of one on the other would likely be minimal;
- ADEQ modeled the Asarco's 1000-ft main stack with the existing emissions and determined that the modeled impact from Asarco on the FMMI's monitors is negligible;

- Asarco is proposing a Converter Retrofit Project (CRP), which is an integral part of Asarco's proposed plan to attain the 1-hour SO_2 Primary NAAQS. The CRP will result in a substantial reduction of SO_2 emissions from the Asarco's smelter operation, which further supports the fact Asarco will have negligible ambient impacts on the SO_2 State or Local Air Monitoring Stations (SLAMS) located in the Miami Planning Area in the future.

ADEQ proposed two separate 1-hour SO_2 nonattainment areas for Miami and Hayden and concluded that the Miami and Hayden smelters are the sources causing the violation in their respective nonattainment areas. EPA concurred with the ADEQ's proposal and conclusions. In the *Draft Technical Arizona Area Designations for the 2010 SO_2 Primary National Ambient Air Quality Standard* (U.S. EPA, 2013a), EPA concludes:

> "*The Freeport-McMoRan Miami Inc. (FMMI) copper smelter located less than 1,400 meters (less than 0.86 mile) away from the violating monitor is expected to be the source of the emissions causing the violation. Miami is essentially surrounded by mountains in all directions. Due to the constraints imposed by the complex terrain in the Miami area, the extent of the area exceeding the SO_2 standard is expected to be confined to a relatively small area around the main source of SO_2 emissions, the FMMI copper smelter. For the same reason, locations outside the particular valley containing Miami are not expected to contribute to Miami monitor's exceedances*".

Table 3-1: 2011 Miami SO_2 Nonattainment Area Point Source Emission Inventory

Source	Longitude	Latitude	2009 Emissions (tons)	2010 Emissions (tons)	2011 Emissions (tons)	Facility PTE[2] (TPY)
Primary Metal Production						
Freeport-McMoRan Miami Smelter	-110.8565	33.412655	3401	3082	2545.06[3]	10600[4]
Mineral Products						
Freeport-McMoRan Miami Mine	-110.88677	33.399399	0.0670	2.063	7.053	7.412
BHP Copper-Pinto Valley Operations-Miami Unit	-110.8706	33.408741	0.01	0.01	0.004	0.03
BHP Copper- Pinto Valley Operations-PV Mine	-110.98421	33.417445	0.1907	0.035	0.073	14.062
Carlota Copper Co-Pinto Valley Mine	-110.98956	33.384777	19.6887	6.3241	3.3	3.41
Total Emissions			**3420.956**	**3090.432**	**2555.49**	**10624.9**

[2] Facility equipment list PTE at 100% load capacity or federally enforceable permit limit in TPY as of December 31, 2011.
[3] Estimate based on FMMI sulfur balance methodology outlined in section 4.3 and attached as an appendix in section 10.3
[4] Maximum allowable emissions as reported in: A.A.C. R18-2-715(H)

Table 3-2: 2011 Miami SO_2 Nonattainment Area 50 km Buffer Zone Point Source Emission Inventory

Source	Longitude	Latitude	2009 Emissions (tons)	2010 Emissions (tons)	2011 Emissions (tons)	Facility PTE[5] (TPY)
Primary Metal Production						
Asarco LLC Hayden Concentrator	-110.77632	33.003378	0.0006	0.0019	0.002	0.03[6]
Asarco LLC Hayden Smelter	-110.77795	33.001796	23659.5	24187	21747	31435
Mineral Products						
Asarco Ray Mine Complex	-110.978	33.156	21.238	24.385	24.191	115.60
Omya Calcium Carbonate Quarry	-111.121	33.288	0.004	0.004	0.005	1.0643
Omya Arizona Limestone Quarry	-111.068	33.343	TS[7]	TS	TS	1.10375
Queen Creek Plant	-111.416	33.251	0.202	0.357	0.529	4.00375
Winkleman Plant #546	-110.691	32.876	1.02	1.34	1.35	2.40375
Industrial Equipment						
ACI Florence	-111.374	33.027	1.140	0.001	0.005	1.0327
Apache Junction Landfill	-111.529	33.37	0.020	0.060	0.080	27.44
Eyman Prison Complex	-111.338	33.033	0.090	0.080	0.090	2.65375
Florence Correctional Center	-111.371	33.043	0.058	0.405	0.075	1.934
Industrial Equipment: Airports and Helipads						
SRP-Stewart Mountain Dam	-111.549	33.5523			0.00131	0.0015[8]
Horse Mesa Dam NR2	-111.344	33.5906			0.00131	
Horse Mesa NR1	-111.357	33.5825			0.00131	
Mormon Flat Dam	-111.445	33.5534			0.00131	
Roosevelt Dam	-111.162	33.6079			0.00131	
Tonto Ranger Station	-111.124	33.6664			0.00131	
San Carlos Apache	-110.66736	33.35315			0.00131	
San Carlos	-110.4618	33.3778			0.00047	
Total Emissions			**23683.47**	**24213.68**	**21773.43**	**31592.2**

[5] Facility equipment list PTE at 100% load capacity or federally enforceable permit limit in TPY as of December 31, 2011. Some sources have no established SO_2 emission limit listed in their respective permit so ADEQ calculated a PTE for these sources based on 100% load capacity of equipment plus de minimis for small equipment not listed in the permit (where applicable). Sources without permitted equipment with the potential to emit SO_2 emissions were excluded from the point source inventory. Permits and PTE calculations are available for all point sources included in this inventory.

[6] Current Permit M070399P1-99 expired on 5/30/2006. PTE was determined based on the PTE calculations workbook maintained on ADEQ servers and located in the directory with the aforementioned permit. The facility submitted an application for renewal of this permit (LTF No. 38459), but ADEQ denied this permit application as the Asarco mine and Smelter should have a single permit since they are adjacent to each other. For this reason, the Asarco smelter and concentrator are listed as separate entities.

[7] TS indicates the facility is still permitted, but Temporarily Shutdown

[8] In surveys completed by PCAQCD, PDEQ and MCAQD, only the SRP Stewart Mountain Dam facility had a permitted limit for SO_2 emissions. The other airport and heliport sources voluntarily reported SO_2 Emissions to their respective permitting agency in their annual emission inventory questionnaire.

Figure 3-1: Locations of Point Sources within the Miami NAA and a 50-km Buffer Zone Extending from the Boundaries of the Miami Facility

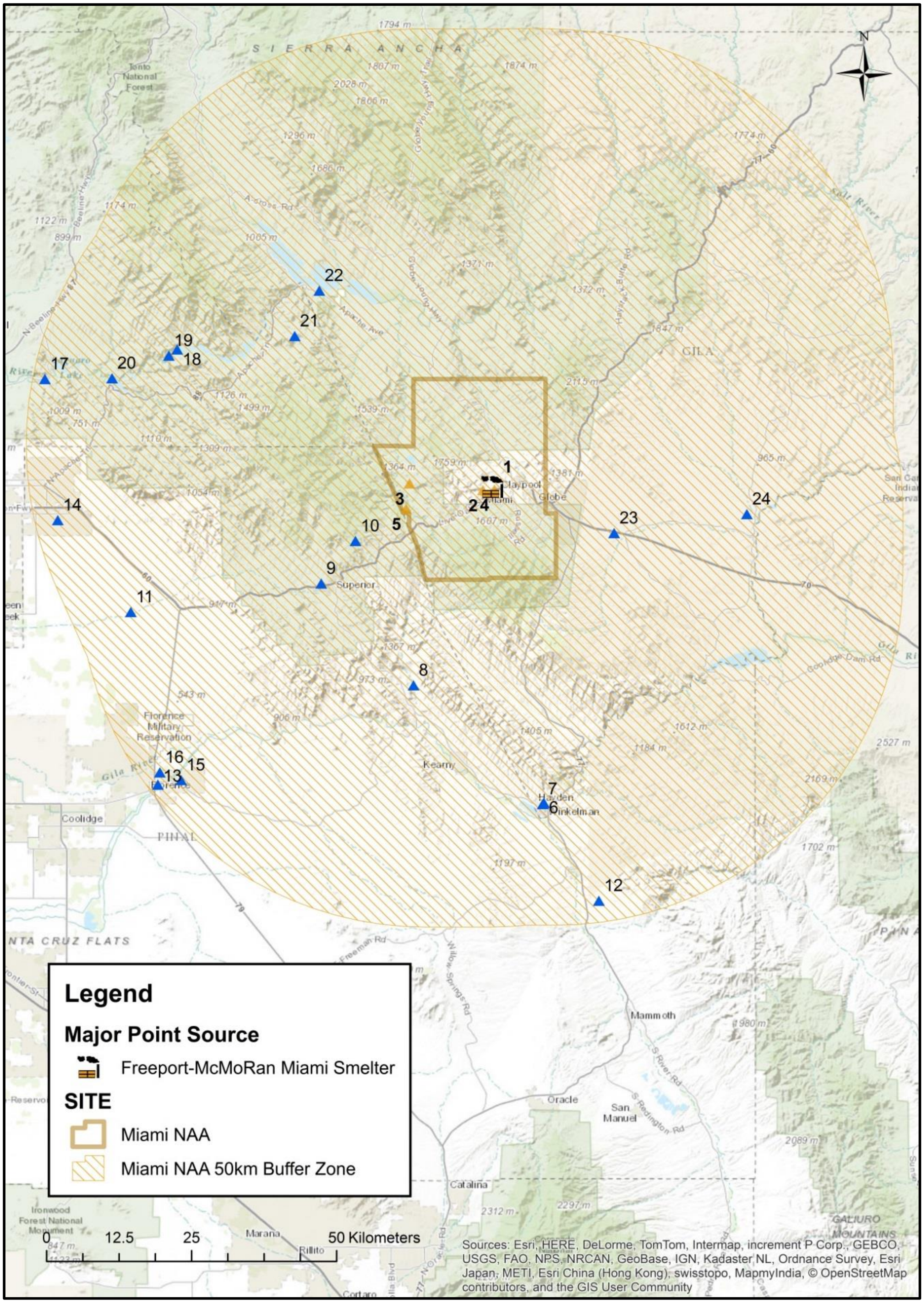


Table 3-3: Miami Nonattainment Area and 50-km Buffer Zone Point Source Map Identification Table

ID	Facility Name	ID	Facility Name
1	Freeport-McMoRan Miami Smelter	13	ACI Florence
2	Freeport-McMoRan Miami Mine	14	Apache Junction Landfill
3	BHP-Copper Valley Operations-Miami Unit	15	Eyman Prison Complex
4	Capstone Copper, Pinto Valley Unit	16	Florence Correctional Center
5	KGHM Copper Company	17	SRP-Stewart Mountain Dam
6	Asarco LLC Hayden Concentrator	18	Horse Mesa Dam NR2
7	Asarco LLC Hayden Smelter	19	Horse Mesa NR1
8	Asarco Ray Mine Complex	20	Mormon Flat Dam
9	Omya Calcium Carbonate Quarry	21	Roosevelt Dam
10	Omya Arizona Limestone Quarry	22	Tonto Ranger Station
11	Queen Creek Plant	23	San Carlos Apache
12	Winkleman Plan #546	24	San Carlos

3.1.2 Sources Impacts that Could Be Represented via Background Concentrations

Per Appendix W (U.S. EPA, 2005), background air quality includes pollutant concentrations due to: (i) natural sources; (ii) nearby sources other than the one(s) currently under consideration; and (iii) unidentified sources. As previously discussed, the Miami Smelter is the sole source that contributes to a NAAQS violation in the Miami NAA. In addition, sources that may have a potential contribution to ambient air quality in the immediate vicinity of the Miami Smelter include: emissions due to the low traffic levels and residential heating during the heating season; nearby industrial facilities; and regional sources.

To calculate the background concentration of SO_2 for the SIP modeling, ADEQ proposes using the monitoring data collected from source-oriented monitors located near FMMI Miami Smelter during the shutdown of the smelter operations.

Four point sources are located in the Miami vicinity, and while they contribute to background concentrations, the contributions of these point sources to background air quality in the immediate vicinity of the Miami Smelter are negligible because such impacts cannot be discerned from local ambient monitoring data collected during FMMI shutdown periods. These sources, all "minor sources" with respect to permitting, are:

- Capstone Copper, Pinto Valley Unit (formerly BHP Copper Pinto Valley Operations PV-Unit);
- BHP Copper, Miami Unit;
- KGHM Copper Company (formerly Carlota Copper Company-Pinto Valley Mine); and
- FMMI Mine Operations

The ASARCO copper smelter in Hayden is a "major source" located 46 km south of FMMI's operations. As discussed previously, given the distance and topography, this source is expected to be a minor contributor to background air quality. An analysis of ambient SO_2 concentrations measured at the three monitoring stations located near the Miami Smelter confirms that the Hayden Smelter is not a significant contributor to concentrations measured in the Miami NAA. Further evaluation of background air quality measured at the FMMI's monitor during periods of Miami Smelter shutdowns demonstrates that there is no distinguishable difference in background concentration with respect to wind direction, as shown in Figure 3-2.

Accordingly, ADEQ believes the background value during FMMI shutdown periods should reflect the ambient impacts from other regional/local sources on the Miami NAA (if any); in other words, the ambient impacts from these sources will be represented via background concentrations.

Based on the above discussions, the Miami Smelter facility is the only source of concern. ADEQ proposes modeling the Miami Smelter exclusively and taking the impacts from other sources into account with a representative background concentration.

3.2 Receptor Grid

FMMI has developed a modeling domain with a total coverage of approximately 24.6 kilometers by 28.7 kilometers, centered on the Miami Smelter facility and covering the Miami nonattainment area. The modeling domain covers portions of Gila County and encompasses the Miami NAA. Figure 3-3 presents the entire modeling domain on a map of the area. Figure 3-4 presents the receptors within 10 km of the facility.

FMMI placed 8,917 receptors in five nested Cartesian grids in the modeling domain, including 2,575 fence line receptors in the grid and spaced these at intervals of no more than 25 meters and two fine grids around high impact receptor locations. Receptor spacing is as follows for each of the five grids, with each centered on the Miami Smelter:

- Two fine grids = 25 meters, covering areas where the 4th highest 1-Hour (H4H) predicted concentration is greatest
- Inner grid = 100 meters, covering an area of 4,700 meters by 4,640 meters
- Second grid = 200 meters, covering an area of 11,500 meters by 11,440 meters
- Third grid = 500 meters, covering an area of 16,700 meters by 16,640 meters
- Fourth grid = 1,000 meters, covering an approximate area of 24,600 meters by 28,700 meters

The 2,575 fence line receptors follow the facility's Ambient Air Boundary (AAB), which is shown in Figure 3-3. The AAB is defined by either a physical fence or a slope greater than or equal to 3 Horizontal (H):1 Vertical (V). The majority of the facility is delineated by a fence, the exceptions include areas along the southern border of the facility (highlighted in green in Figure 3-3). These four segments are areas where the existing gradient (≥3H:1V) would preclude the public from accessing the facility.

FMMI moved receptors immediately outside of the Miami NAA to the planning area boundary to ensure the receptor grid represented the full NAA domain. FMMI also placed additional receptors at the locations of learning centers (such as schools) and existing ambient air monitoring equipment.

FMMI used EPA's AERMAP software tool (version 11103; U.S. EPA, 2011b) to estimate receptor elevations and hill heights. AERMAP is the terrain preprocessor for AERMOD (discussed in Section 4) and uses the following procedure to assign elevations to a receptor:

- For each receptor, the program searches through the U.S. Geological Survey (USGS) input files to determine the two profiles (longitude or easting) that straddle this receptor;
- For each of these two profiles, the program then searches through the nodes in the USGS input files to determine which two rows (latitudes or northings) straddle the receptor;
- The program then calculates the coordinates of these four points and reads the elevations for these four points;
- The AERMAP preprocessor uses a 2-dimensional distance-weighted interpolation to determine the elevation at the receptor location based on the elevations at the four nodes determined above.

FMMI used 10-meter USGS National Elevation Dataset (NED) data as inputs to AERMAP. The USGS produced NED data from digitized map contours or from manual or automated scanning of aerial photographs. A 10-meter NED data file consists of a regular array of elevations referenced horizontally in the UTM coordinate system, with a uniform horizontal spacing of 10 meters. The 1983 North American Datum (NAD83) was the basis of the NED data used for this analysis. ADEQ will provide AERMAP input and output files on CD-ROM per the nomenclature described in Appendix A.

Figure 3-2: Ambient SO_2 Concentrations with Respect to Wind Direction during FMMI Shutdown Periods

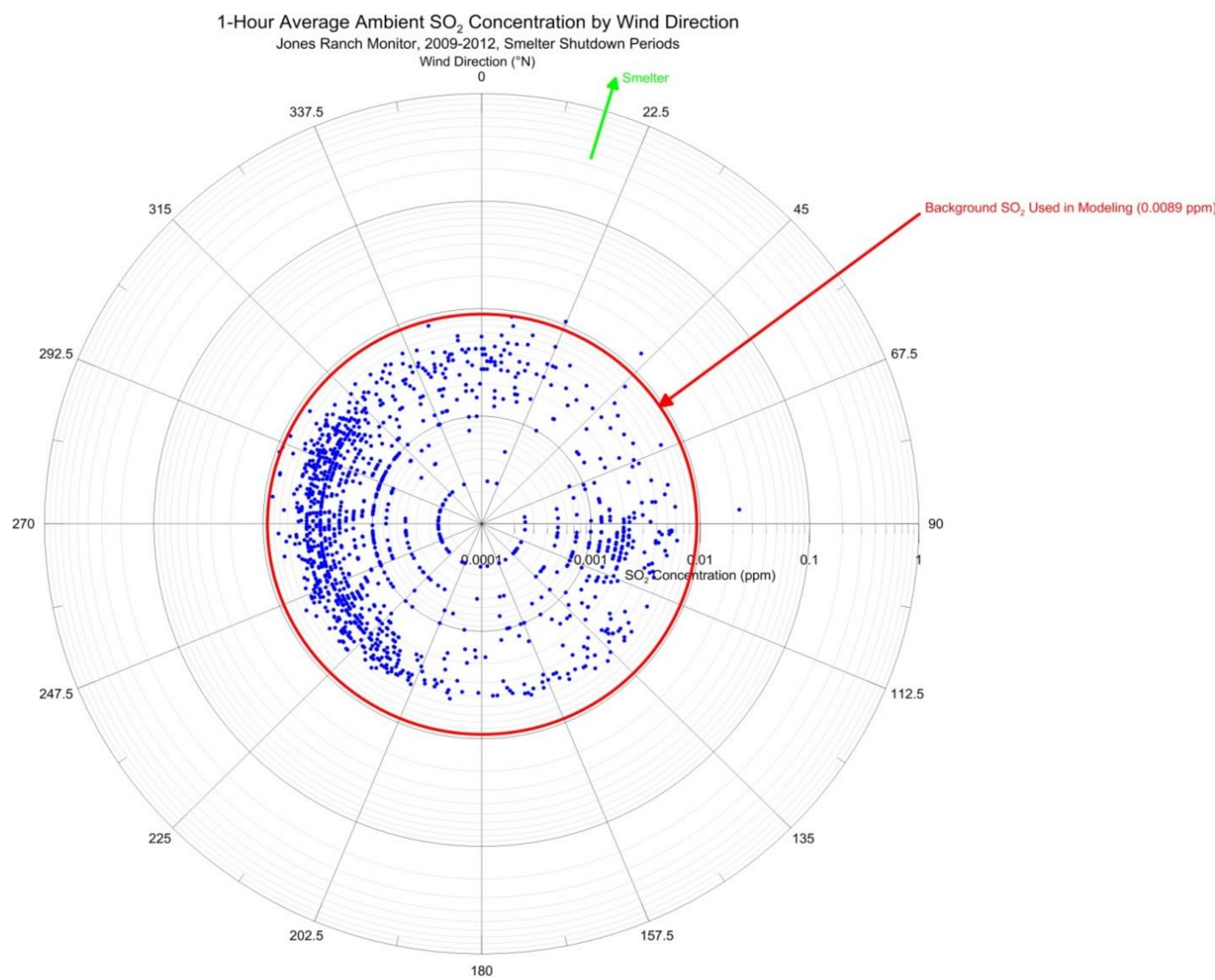


Figure 3-3: FMMI's Ambient Air Boundary

On Wednesday, February 22rd Arizona Department of Environmental Quality (ADEQ) personnel performed an on-site tour of the ambient air boundary (AAB) used for the Miami SO_2 nonattainment plan. During this tour ADEQ personnel traveled and documented the portions of the AAB that were reasonably accessible.

In general, upon visiting the site and inspecting the AAB perimeter, ADEQ has determined the boundary represents a practical ability to preclude public access. This conclusion is a result of the observations and discussions outlined in Appendix M of this modeling TSD.

Figure 3-4 Full Receptor Grid

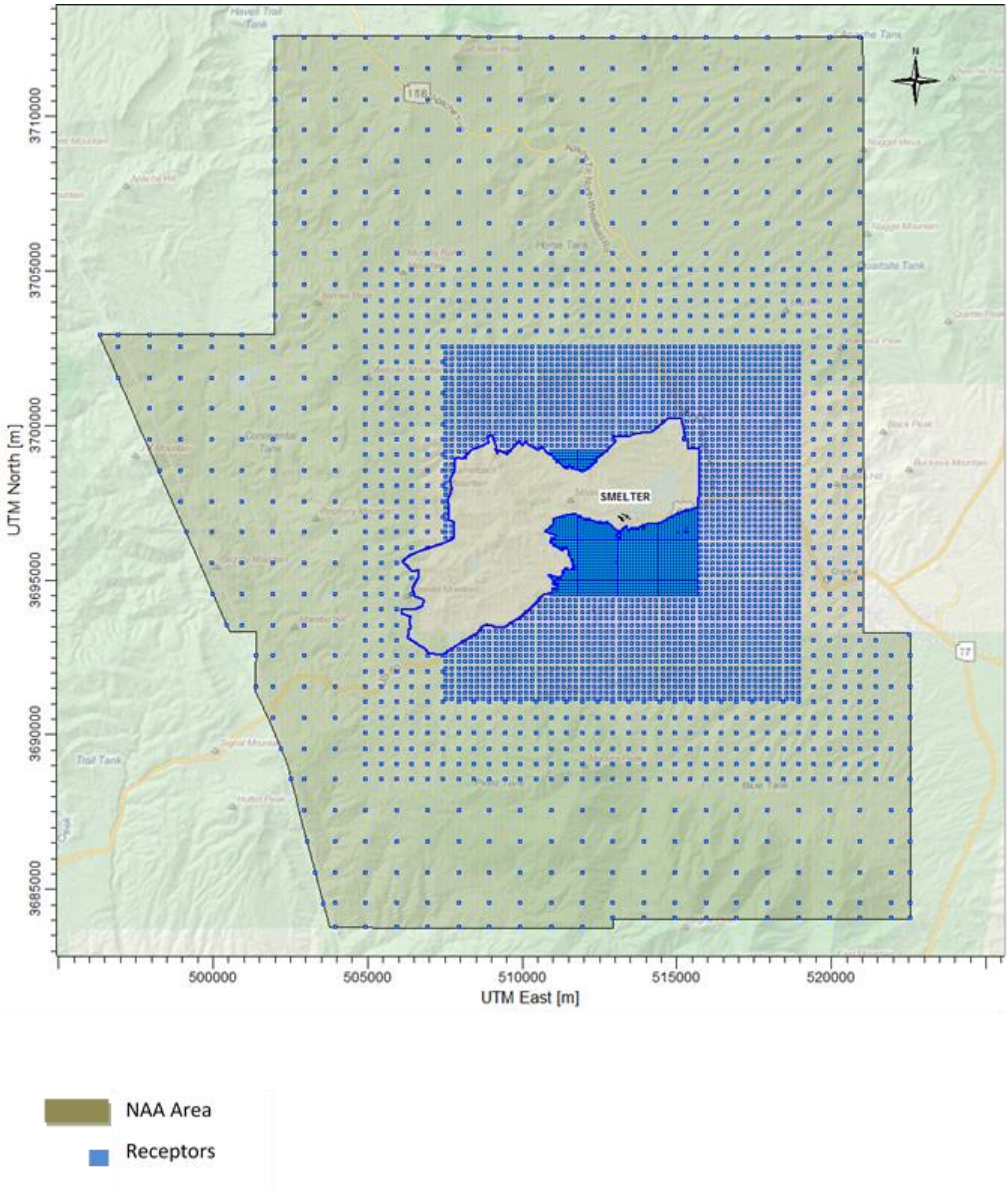
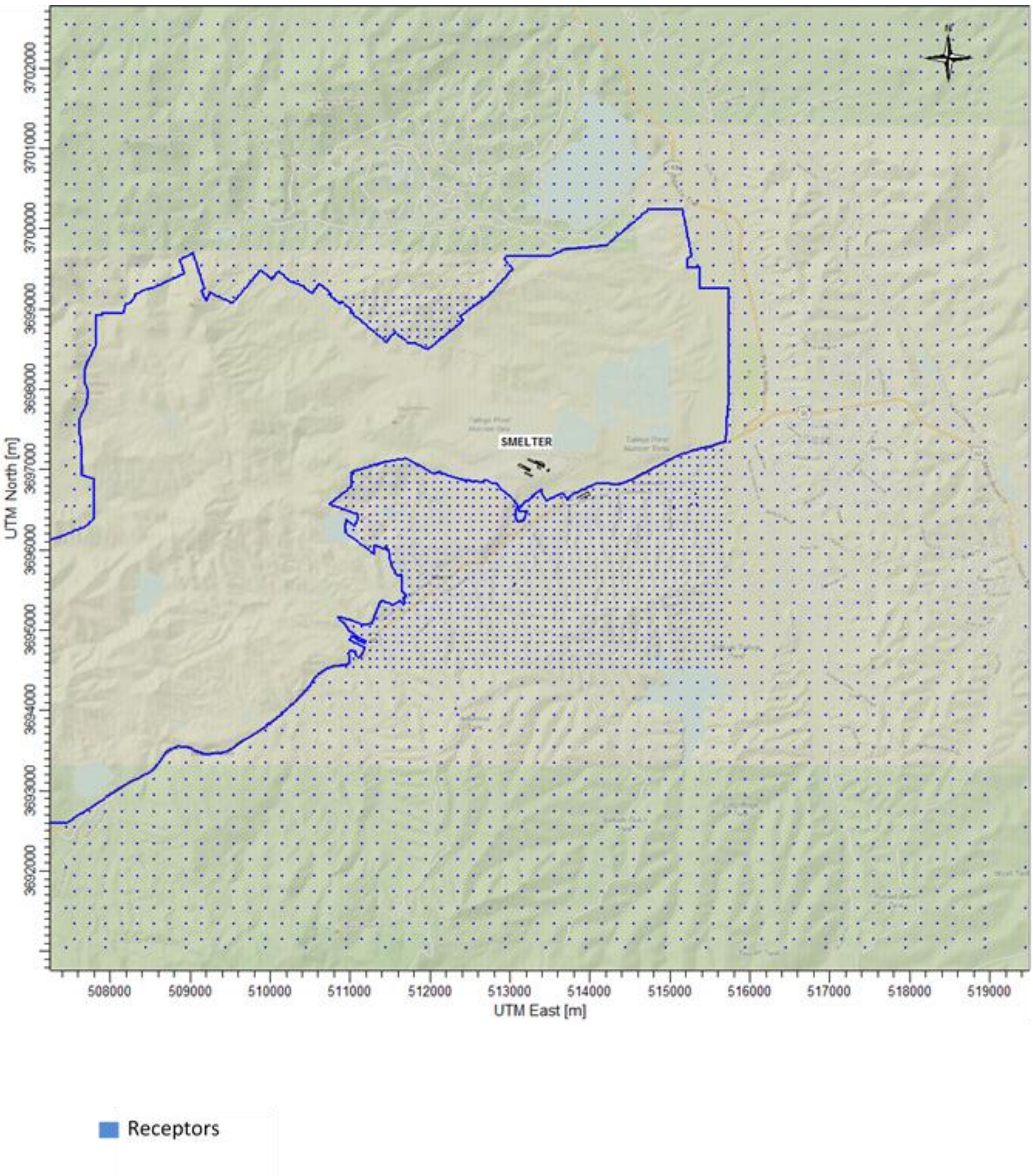


Figure 3-5: Fine Receptor Grid



4.0 Model Selection

As outlined in the EPA's Modeling Guidance for Nonattainment Areas (U.S. EPA, 2014a), for SIP development under the 2010 primary SO_2 NAAQS, American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) or one of the other preferred models in Appendix W should be used for near-field dispersion modeling unless use of an alternative model can be justified. EPA anticipates that AERMOD will be the model of choice for most applications but there may be particular applications where other preferred models, such as Buoyant Line and Point Source (BLP) model would be used.

4.1 AERMOD

FMMI used American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) (version 14134; U.S. EPA, 2014b) to predict ambient concentrations in simple, complex and intermediate terrain. AERMOD is the recommended sequential model in EPA's Guideline on Air Quality Models (GAQM) (40 CFR Pt. 51, Appendix W) (U.S. EPA, 2005) for near-field analysis.

There are two input data processors that are regulatory components of the AERMOD modeling system: AERMET (version 14134; U.S. EPA, 2014c), a meteorological data preprocessor that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, and AERMAP (version 11103; U.S. EPA, 2011b), a terrain data preprocessor that incorporates complex terrain using USGS Digital Elevation Data. Other non-regulatory components of this system include AERSURFACE (Version 13016; U.S. EPA, 2013b), a surface characteristics preprocessor; and BPIPPRIME, a multi-building dimensions program incorporating the Good Engineering Practice technical procedures for PRIME applications (U.S. EPA, 2004a). FMMI used the regulatory default option. This option commands AERMOD to:

- Use the elevated terrain algorithms requiring input of terrain height data for receptors and emission sources;
- Use stack tip downwash (building downwash automatically overrides);
- Use the calms processing routines;
- Use buoyancy-induced dispersion;
- Use the missing meteorological data processing routines.

4.2 BLP

The fugitive emissions from the roofline are one of primary sources of SO_2 emissions at the Miami Smelter. Almost half of the SO_2 emissions from the Miami Smelter are emitted from roof vents. FMMI characterizes the roofline fugitive emissions as stationary buoyant line sources as these roof vents provide for the ventilation of various smelter operations, and the temperature of the roof vent exhaust is characteristically high due to the heat of those operations. Per the GAQM (US EPA, 2005), BLP (version 99176; Schulman and Scire, 1980) is EPA's recommended sequential dispersion model for emissions from buoyant line sources such as roof vents[9]. Therefore, FMMI considered the buoyant line source technique in the modeling approach. The features of the BLP model include:

- Enhanced plume rise of buoyant line sources compared to point sources (less entrainment of ambient air);
- Plume enhancement due to multiple line sources;

[9] EPA has proposed changes to the Guideline on Air Quality Models (80 FR 45340) that would replace BLP with AERMOD as the preferred model for addressing buoyant line sources.

- Line source rise dependency on wind direction, line length, the number of parallel lines, and their spacing the number of parallel lines, and their spacing;
- Effect of vertical wind shear on plume rise; and
- Incorporation of building downwash in both plume rise and dispersion calculations.

4.3 Hybrid Modeling Approach

As noted previously, BLP is EPA's recommended sequential dispersion model for emissions from buoyant line sources such as roof vents as noted in the GAQM. Because the project includes roof vents, the buoyant line source technique was considered in the modeling approach. Although the most recent version of AERMOD (v15181) is equipped with a buoyant line source algorithm, this version was not used for modeling the roof vents in this project because:

- Version 14134 of AERMOD was the latest version available when modeling began in support of the SIP. Version 14134 is not equipped with a buoyant line source algorithm. The BLP/AERMOD hybrid approach was conducted for this reason. (see Section 4.4);
- The hybrid approach is appropriate for the Miami Smelter based on the results from the model performance study; and
- While EPA's recently proposed changes to the GAQM include replacing the BLP model with AERMOD (80 FR 45340), BLP remains the preferred model for addressing buoyant line sources and the performance of the buoyant line source algorithms in AERMOD is still under review and testing.

While AERMOD version 14134 allows for line source inputs, the line source type is neither the buoyant line source type addressed by BLP nor subject to building downwash. AERMOD directly addresses building downwash only for point source releases. For these reasons, BLP remains EPA's preferred dispersion model for emissions from buoyant line sources and was evaluated for use in the Miami Smelter modeling.

However, BLP has several limitations that may affect the accuracy of the impacts from FMMI's roof vents. For instance, BLP cannot adequately address complex terrain, presenting a major hurdle for the direct application of BLP in the FMMI case. The GAQM recommends using BLP for simple terrain (U.S. EPA, 2005) while the terrain surrounding the FMMI facility has complex features. Moreover, BLP assumes all buildings are equally long and are equally separated. BLP assumes the roof vents are aligned parallel to each other and have identical buoyancies. BLP also uses the old MPRM/RAMMET meteorological files that use the old Pasquill-Gifford (P-G) stability class procedure and BLP does not have a calms processing routine.

To handle such unique modeling problems associated with the roofline fugitive emissions, FMMI proposed a two-step hybrid approach to couple the BLP model with AERMOD:

- Use the BLP model to estimate hourly line source final plume rise and sigma-z from the Smelter roof vents based on line source buoyancy parameter(s), physical dimensions, source orientation as well as hourly meteorological conditions;
- Apply the BLP-predicted final plume heights and sigma-z in AERMOD with hourly volume source approach.

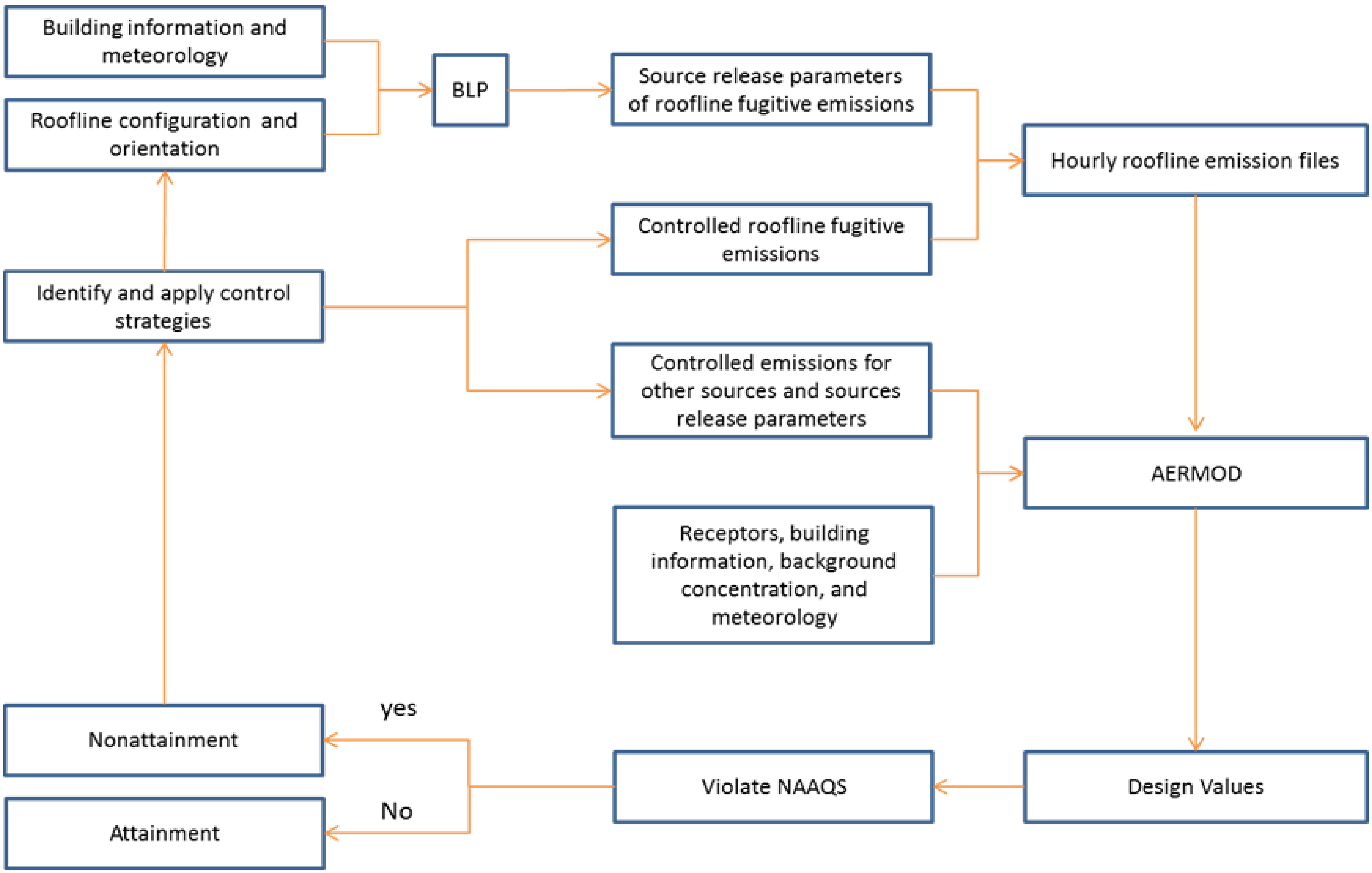
Detailed methodologies for estimating final plume heights and sigma-z are contained in Section 5.2.3.2. ADEQ determined that the hybrid approach, while resource intensive (particularly for meteorological data processing), is the best approach to address both buoyant line source characteristics and the effects of complex terrain.

This Hybrid Approach avoids use of BLP's antiquated implementation of complex terrain and meteorology, relying instead on AERMOD's implementation of complex terrain and meteorology, and incorporates EPA's preferred plume rise and building downwash calculations for buoyant line sources for which AERMOD version 14134 is not equipped to perform. The hybrid approach of BLP/AERMOD will be applied for modeling roofline fugitive emissions. AERMOD will be used for modeling all other sources, including main stacks as well as other industrial sources. Figure 4-1 presents the flowchart of proposed modeling system framework for the SIP attainment demonstration.

EPA applied a similar hybrid approach in its Residual Risk Assessment for Coke Oven National Emission Standards for Hazardous Air Pollutants (EPA, 2004b). In that assessment, EPA coupled the BLP model with the Industrial Source Complex Short Term (ISCST3) model to evaluate the fate and transport of hazardous air pollutants (HAPs) from coke oven batteries. EPA used the BLP model to estimate the plume height and then used that value as an input to the ISCST3 model. Because AERMOD has replaced ISCST3 as EPA's preferred regulatory model for near-field application, the hybrid approach ADEQ proposes is consistent with the approach EPA previously used. In addition, EPA's own assessment of AERMOD's shortcomings had led the Agency to propose the inclusion of a buoyant line algorithm for use in AERMOD (80 FR 45340) that is conceptually similar to the modeling approach that ADEQ has determined to be most appropriate in this case.

To demonstrate that the hybrid AERMOD/BLP modeling approach is the best performing model for the unique conditions present at the Miami Smelter, FMMI conducted a performance evaluation, which is provided in Section 4.4 and Appendix C. ADEQ reviewed FMMI's performance evaluation and determined that the hybrid model is a better performing model than either AERMOD or BLP alone. As a result, ADEQ concluded that the use of the hybrid model as an alternative model is appropriate for the Miami NAA.

Figure 4-1: Flowchart of Proposed Modeling System Framwork for SIP Demonstration



4.4 Performance Evaluation of the Hybrid BLP/AERMOD Approach

As discussed above, due to the physical configuration of the Smelter (i.e., the roof vents that are buoyant line sources) and the proximity of complex terrain to the Smelter, an alternative model that employs relevant and appropriate features of EPA's preferred models is expected to perform better for this facility than EPA's preferred dispersion models alone. To demonstrate that the Hybrid Approach is a better performing alternative model within the meaning of section 3.2.2 of the GAQM, FMMI executed a performance evaluation to compare predicted ambient concentrations measured at the three ambient monitoring sites listed in Table 4- 1 and shown in Figure 6-1.

Table 4-1: Coordinates for Ambient SO_2 Monitoring Sites

Monitor	UTM Easting (m)	UTM Northing (m)
Jones Ranch	512,328.4	3,694,022.4
Ridgeline	513,066.1	3,695,568.2
Miami	511,674.8	3,695,370.6

Section 3.2.2 of the GAQM provides recommendations for determining acceptability of an alternative method in lieu of a preferred method. Specifically, the GAQM identifies the following three conditions under which an alternative model may be used:

1. A demonstration that the alternative model produces concentration estimates equivalent to the estimates obtained using a preferred model;
2. A statistical performance evaluation using measured air quality data that demonstrates the alternative model performs better for the given application than a comparable preferred model; or
3. The preferred model is less appropriate for the specific application, or there is no preferred model for the specific application.

FMMI conducted a performance evaluation under the second condition, for situations where an alternative model performs better than a comparable preferred model, whereby model-predicted concentrations are compared to relevant measured air quality data. The following five modeling approaches were evaluated based on implementation of EPA's preferred BLP and AERMOD dispersion models, both of which have features relevant to modeling the Smelter:

- Additive BLP/AERMOD, Multi-Vent BLP Plume Rise
- Additive BLP/AERMOD, Single-Vent BLP Plume Rise
- Hybrid BLP/AERMOD
- AERMOD, Roof Vents with Downwash
- AERMOD, Roof Vents without Downwash

The results showed that the Hybrid BLP/AERMOD approach performed the best at the worst-case monitoring location (Jones Ranch). Accordingly, the performance evaluation demonstrates that the alternative hybrid approach is more appropriate than a preferred model alone.

A detailed discussion on the model performance evaluation methodology and results including quantile-quantile plots (q-q plots) is included in a technical memorandum provided in Appendix C.

5.0 Source Inputs

This section discusses source characterization to develop appropriate source inputs for dispersion modeling with the AERMOD/BLP modeling system.

- Section 5.1 provides an overview of Miami Smelter operations and proposed Smelter upgrade project;
- Section 5.2 provides details on current and future source configuration, source types and source release parameters;
- Section 5.3 discusses Good Engineering Practice (GEP) stack heights;
- Section 5.4 provides details on urban/rural determination of the sources.

5.1 FMMI Smelter Operations and Proposed Smelter Upgrade Project

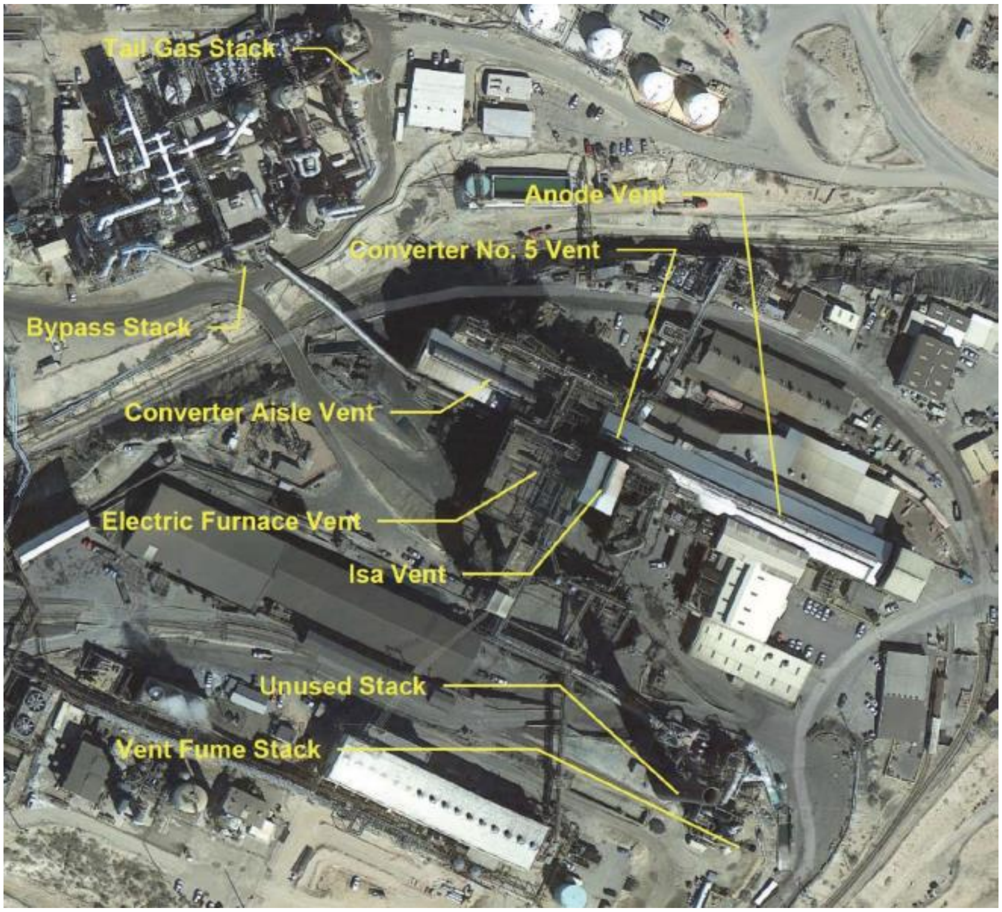
The Miami Smelter in Claypool, AZ, operated by FMMI, currently consists of five roof vents that account for a significant proportion of the Smelter's current sulfur dioxide (SO_2) emissions (approximately 44% of Smelter SO_2 emissions during the period from May 2013 through April 2014). The roof vents are located above the IsaSmelt® (Isa) vessel, the Electric Furnace (ELF), the converter aisle (2 vents), and the anode aisle. The three vents over the converter aisle and anode aisle are aligned along the length of the Smelter building. The shorter vents over the Isa and ELF are oriented perpendicular to the converter aisle and anode aisle vents. In addition to the roof vents, three stacks (Acid Plant Tail Gas Stack, Vent Fume Stack, and Bypass Stack) are located at the Smelter. The locations of the existing vents and stacks are shown in Figure 5-1.

On July 3, 2013, FMMI submitted a Class I Significant Permit Revision to ADEQ, proposing upgrades to enhance emission capture and control systems as well as the increase of operational efficiency and capacity at its Miami Smelter facility (hereafter referred to as the "Smelter Upgrade Project"). The Smelter Upgrade Project will increase the capture of process gasses and fugitive emissions. The Smelter will process the captured emissions in its upgraded acid plant or treat them using standard control methods (e.g., enhanced scrubbing, sorbent injection followed by filtration).

The Smelter's air quality permit authorizes operation with a maximum throughput of 1,000,000 tons per year of copper concentrate and the implementation of the following process and capture/control improvements:

- Upgrade the bedding plant conveyor belts and Isa furnace feed paddle mixers;
- Replace the existing Isa;
- Upgrade the Isa furnace cooling and emissions control system (i.e., lance seal, feed port hood, and tapping hood controls);
- Upgrade the converter emissions control system (i.e., reconfiguring the roofline to capture emissions and route them to a new Aisle Scrubber including stack);
- Upgrade the electric furnace emissions control system (i.e., tapping hood controls);

Figure 5-1: Miami Smelter Stacks and Roof Vents



- Upgrade the anode furnaces and utility vessel (also known as the mold barrel) emissions control system (i.e., process gas collection system, mouth covers, replacement of utility vessel, new baghouse ducted to the new Aisle Scrubber, new hydrated lime silo, and new baghouse dust return system to the electric furnace);
- Increase operational flexibility via authorization of 1,000,000 dry tons per year of New Metal Bearing Material (NMBM) throughput capacity;
- Increase Acid Plant capacity to accommodate the authorized concentrate throughput capacity (i.e., upgraded cooling system, new converter bed, new blower, and new SO_3 cooler);
- Upgrade the Vent Fume Scrubber and Acid Plant Tail Gas Scrubber to caustic use;
- Add three new Wet Electrostatic Precipitator (WESP) modules at the vent fume control system;
- Enclose the temporary on-site concentrate storage piles with an enclosed structure;
- Increase the height of the Vent Fume Stack and Tail Gas Stack; and
- Other support facility changes.

On July 21, 2014, ADEQ issued a Class I Significant Permit Revisions (No. 58409) to FMMI authorizing the Smelter Upgrade Project. FMMI has since committed to an additional modification that will direct Acid

Plant Bypass emissions to the proposed Aisle Scrubber for treatment. Thus, the Bypass Stack in the future would only be used during extraordinary emergency situations.

The future Smelter configuration will consist of four roof vents and three stacks. The roof vent located above Converters 2 through 5 will be reconfigured as part of a collection system for fugitive emissions. In addition, the anode and mold vessels will be modified to collect emissions generated during the refining of blister copper. The collected emissions from the converter roofline and anode vessel capture systems will be routed to the new Aisle Scrubber to treat the captured SO_2 emissions. The roofline above the non-functional Inspiration Converter and the Anode Aisle will still vent to the atmosphere. Additionally, Acid Plant Bypass emissions will be routed to the Aisle Scrubber for treatment prior to discharge to atmosphere.

5.2 Source Configuration, Types and Release Parameters

5.2.1 Existing Stacks (Point Sources)

Table 5-1 presents the stack and exhaust parameters modeled for existing stacks located at the facility. FMMI identified coordinates for the stacks by mapping the site plan to rectified aerial photographs of the site. FMMI projected the UTM coordinates of each stack to UTM Zone 12, NAD83. Figure 5-2 shows the location of each existing stack associated with the Smelter and the acid plant. Figure 5-3 shows the location of each existing stack in the rod plant. Figure 5-4 shows the locations for other existing stacks.

5.2.2 Existing Line Sources

Table 5-2 presents the source parameters modeled for the existing line source located at the Rod Plant. FMMI identified coordinates for the sources by mapping the site plan to rectified aerial photographs of the site. FMMI projected the UTM coordinates of each source to UTM Zone 12, NAD83. Figure 5-5 shows the line source location on the simplified plot plan.

Table 5-1: Stack and Exhaust Parameters, Existing Stacks

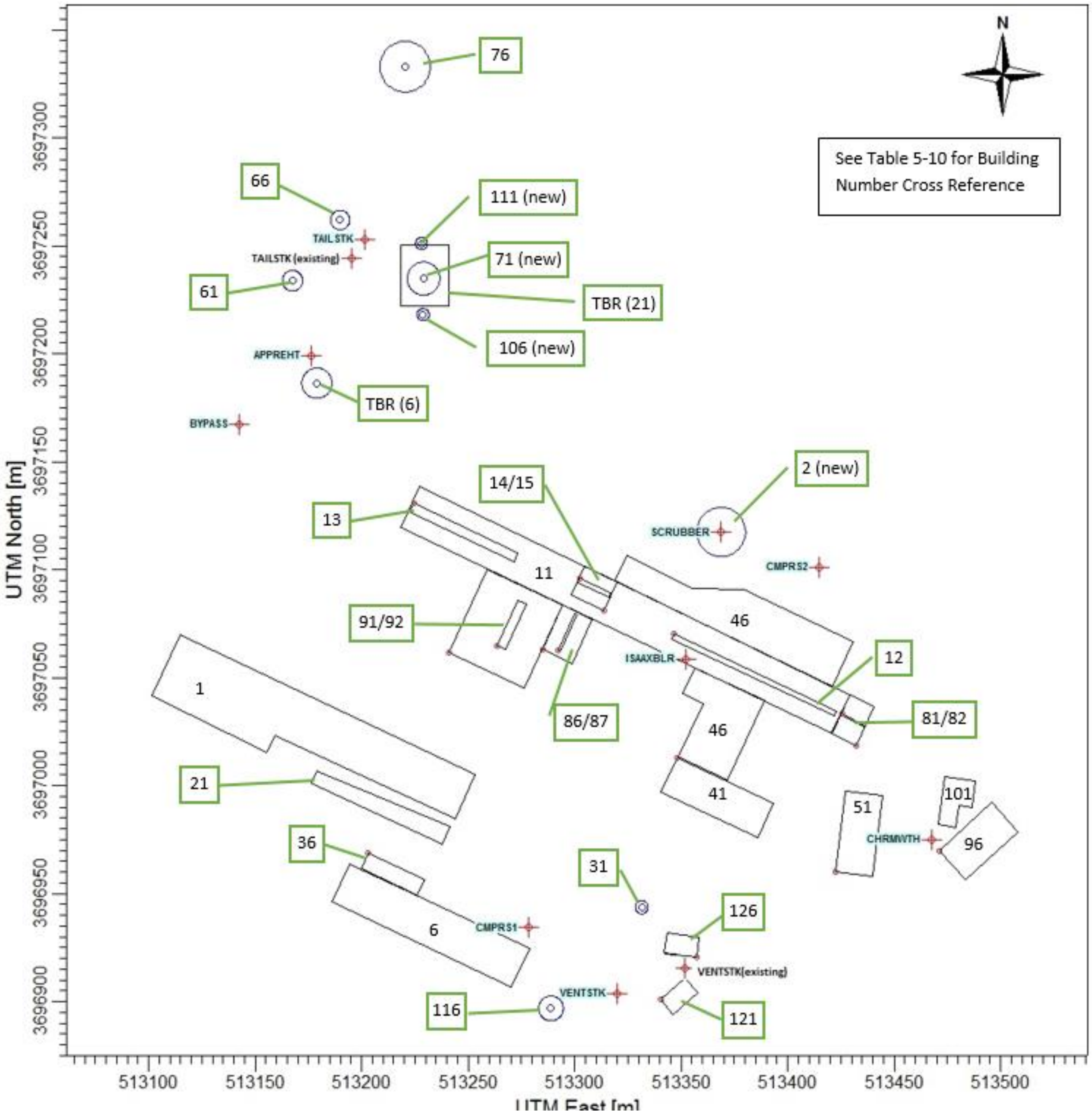
Source ID	Stack	UTM Easting (m)	UTM Northing (m)	Base Elevation (m)	Stack Height (m)	Exit Diameter (m)	Exit Velocity (m/s)	Exhaust Temp. (ºK)
TAILSTK	Tail Stack	513194.6	3697246	1081.99	60.96	1.83	24.08	323.0
VENTSTK	Vent Fume Stack	513354.5	3696918	1099.74	48.8	3.048	20.85	amb
APPREHT	Acid Plant Preheater	513175.7	3697200	1085.00	2.1	0.5	1.0	361.0
ISAAUXBLR	Isa Auxiliary Boiler	513352.3	3697058	1085.00	32.55	0.61	6.39	571.0
CHRMWTH	Change Room Water Heater	513467.6	3696975	1080.24	4.67	0.203	4.01	533.0
RPTB	Rod Plant Thermal Breaker	513933.2	3696689	1021.00	3.05	0.01	0.01	298.0
RPSFS	Rod Plant Shaft Furnace	513879.2	3696663	1021.00	19.81	1.77	7.68	644.0
CMPRS1	Diesel Compressor	513278.4	3696934	1099.46	5.0	0.3048	6.096	478.0
CMPRS2	Diesel Compressor	513414.9	3697101	1080.50	5.0	0.3048	6.096	478.0
SLAG	Slag Storage Area	512838.8	3697516	1089.70	0.0	13.3	1.45	1333
SCRNENG	Screening Engine	512620.4	3697457	1099.43	1.372	0.076	6.096	478.0
ISA_EGEN	Isa Emer. Gen.	513393.7	3697032	1085.53	3.048	0.238	6.096	477.6
SMLTEGEN	Converter Emer. Gen.	513293.6	3697165	1085.98	6.492	0.3048	6.096	477.6
EPUMP	Emergency Water Pump	513358.4	3697161	1086.32	1.372	0.128	6.096	477.6
MS_EGEN	Server Room Emer. Gen.	511771.8	3697718	1165.58	1.372	0.128	6.096	477.6
MH_EGEN	Moonshine Hill Emer. Gen.	511544.2	3697586	1221.75	1.372	0.128	6.096	477.6
CO_EGEN	Communications Emer. Gen.	514628.7	3697005	1012.00	1.372	0.128	6.096	477.6
RT_EGEN	Radio Tower Emer. Gen.	511549.2	3697592	1221.79	1.372	0.128	6.096	477.6
SGH_EGEN	Guardhouse Emer. Gen.	513744.2	3696758	1021.00	1.372	0.128	6.096	477.6
CPUMP	Hood Emer. Pump	513363.3	3697054	1086.32	1.372	0.128	6.096	477.6
BYPASS	Bypass Stack	513139.0	3697165	1084.6	60.96	2.286	12.10	-322.5[10]

Table 5-2: Source Parameters, Existing Line Sources

Source ID	Line Source	Starting UTM Easting (m)	Starting UTM Northing (m)	Ending UTM Easting (m)	Ending UTM Northing (m)	Base Elevation (m)	Release Height (m)
RPRFVENT	Rod Plant Roof Vent	513878.3	3696657	513947.6	3696687	1021	12.2

[10] Negative temperature indicates temperature above ambient, zero temperature indicates ambient temperature

Figure 5-2: Smelter Point and Acid Plant Sources and Buildings



TBR = To be removed (index corresponds to performance runs)

Figure 5-3: Rod Plant Point Sources and Buildings

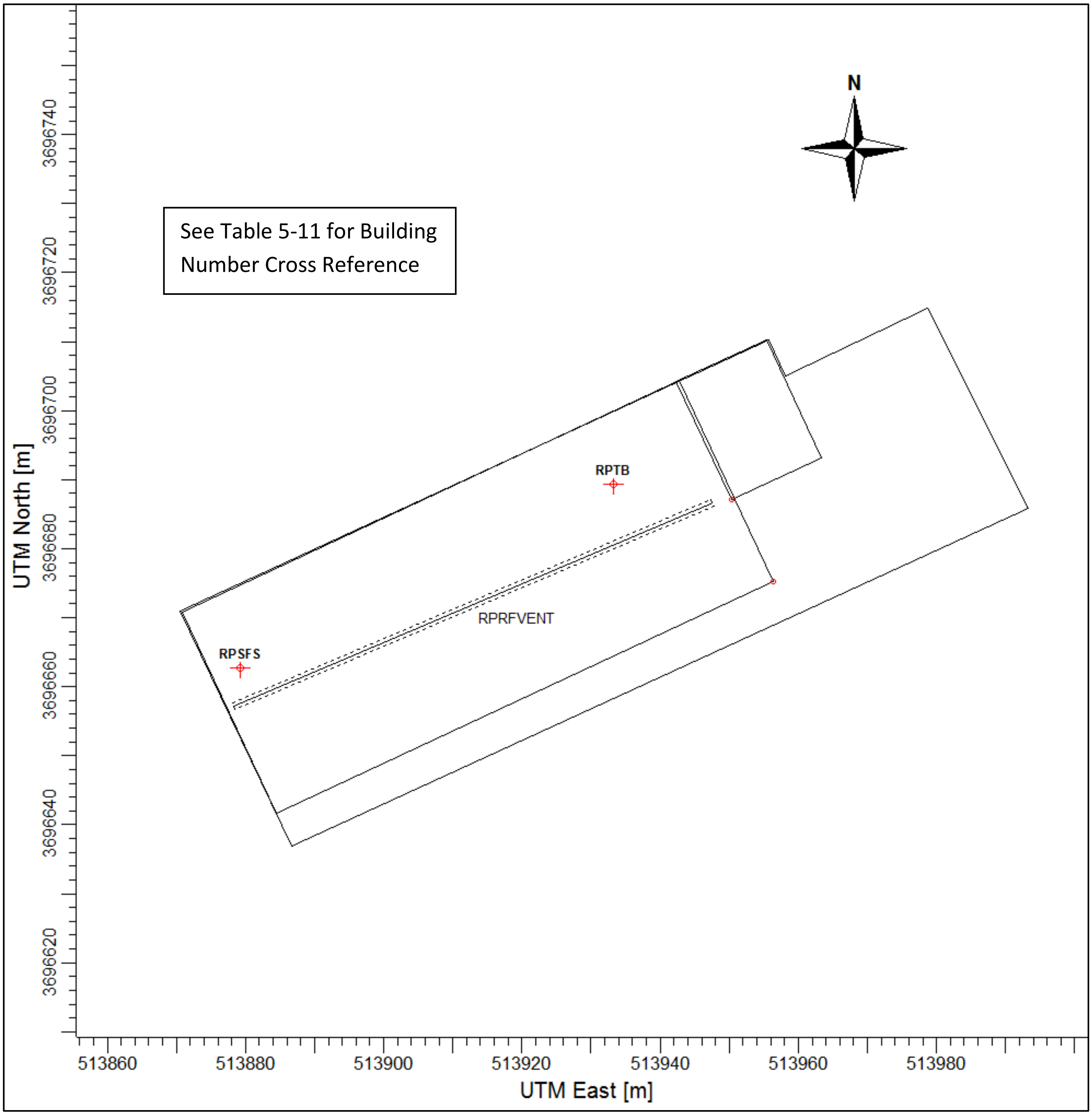
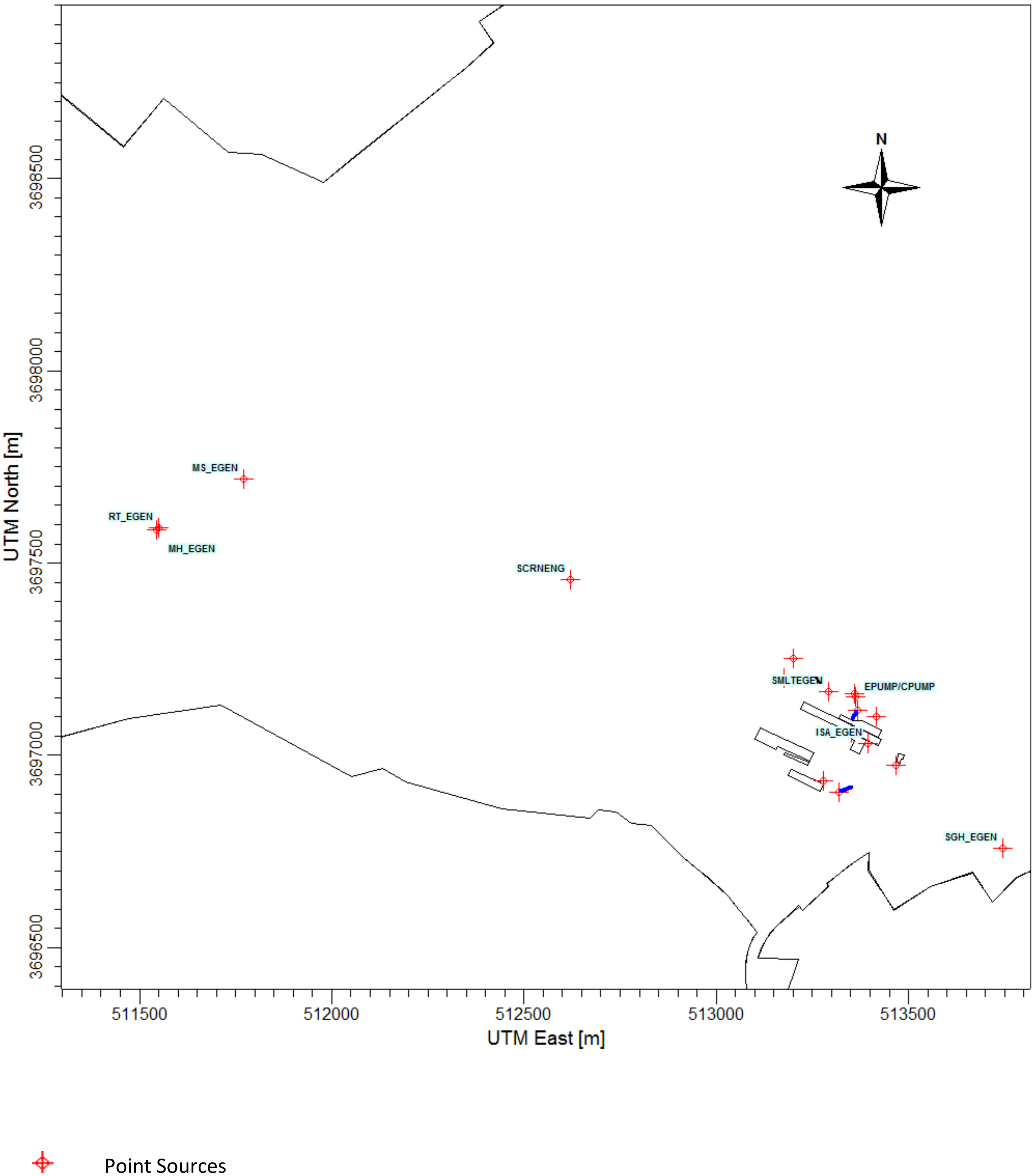


Figure 5-4: Locations of Other Existing Stacks



5.2.3 Existing Roof Vents (Buoyant Line Sources)

5.2.3.1 Roof Vents Configuration

FMMI identified coordinates for the roof vents by mapping the site plan to rectified aerial photographs of the site and adjusting the building footprint to site Computer Assisted Drafting (CAD) drawings. FMMI projected the Universal Transverse Mercator (UTM) coordinates of each vent to UTM Zone 12, 1983 North American Datum (NAD83). Figure 5-5 shows each vent location on the simplified plot plan and the representative volume source used in AERMOD. Table 5-3 lists the coordinates of each vent. Table 5-4 provides vent-specific parameters for the proposed configuration of the roof vents.

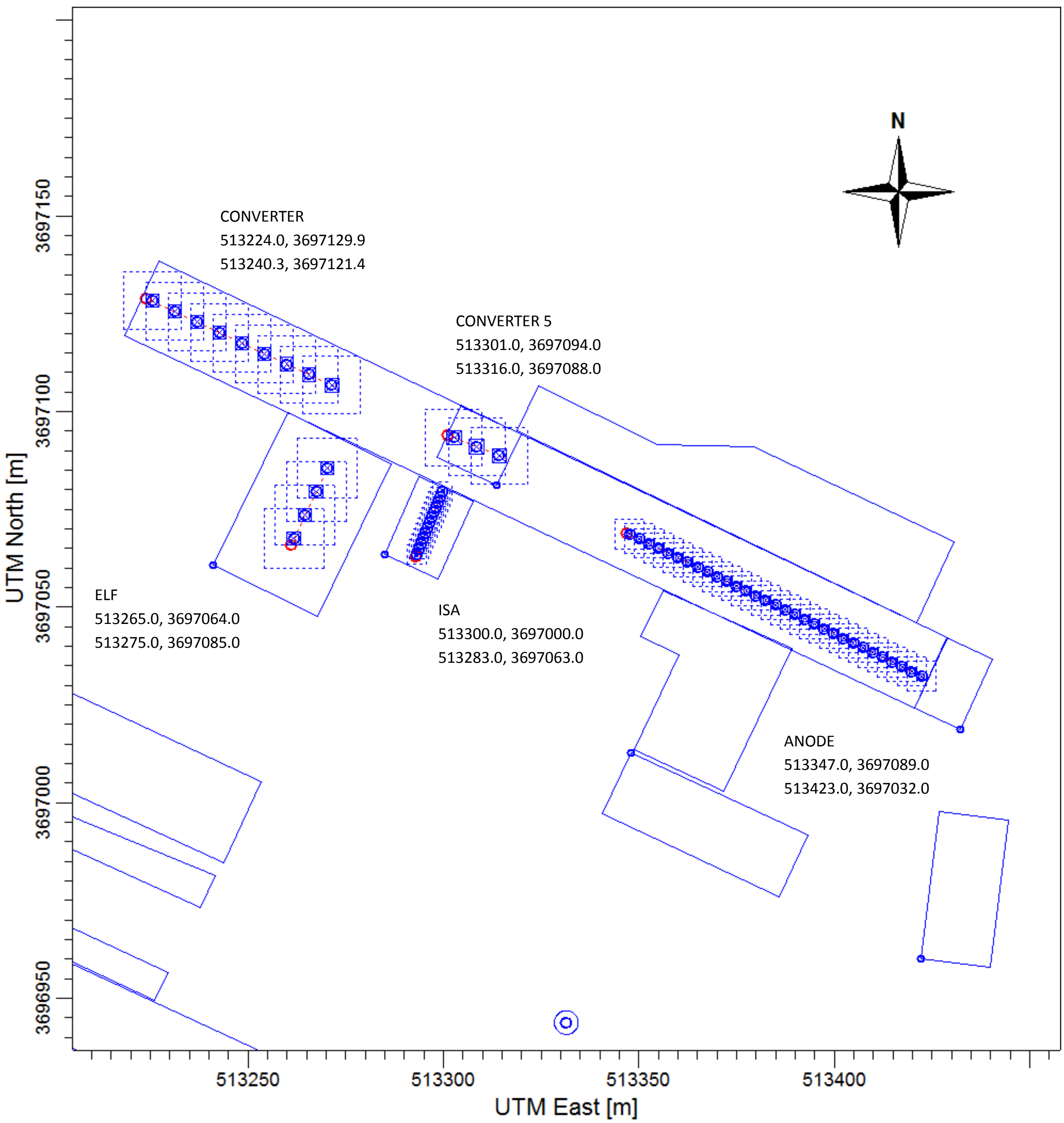
Table 5-3: Vent Coordinates for Roof Vents

Ridge Vent	Endpoint A		Endpoint B	
	UTM Easting (m)	UTM Northing (m)	UTM Easting (m)	UTM Northing (m)
Anode	513,347	3,697,069	513,423	3,697,032
Converter	513,224	3,697,129	513,273	3,697,106
Converter 5	513,301	3,697,094	513,316	3,697,088
Isa	513,293	3,697,063	513,300.5	3,697,079
ELF	513,265	3,697,064	513,275	3,697,085

Table 5-4: Vent-Specific Parameters for Roof Vents

Ridge Vent	Vent Length (m)	Vent Width (m)	Vent Height Above Ground (m)	Vent Velocity (m/s)	Vent Temperature (K)
Anode	84.53	1.42	32.55	2.508	361.3
Converter	54.13	3.66	32.70	2.352	339.9
Converter 5	16.16	3.66	37.50	2.198	339.9
Isa	17.67	0.76	53.04	11.297	313.7
ELF	23.26	3.35	40.45	1.391	320.6

Figure 5-5: Roof Line Vents and Pseudo Volume Sources



5.2.3.2 Determination of Source Release Parameters for Roof Vents

As discussed in Section 4, the roof vents located on the Smelter building were modeled using a hybrid approach with AERMOD and BLP models. BLP was used to determine the hourly ridge line final plume height and initial vertical dimension (sigma-z, σ_z) values and then the hourly emission file option in AERMOD was used to model the roof vents as elevated volume sources, using the hourly BLP-calculated final plume height as the hourly volume source release height in AERMOD. FMMI also modeled multiple volume sources for each vent, with the number of volume sources determined by the length of the vent. This approach allows for an approximation of each vent's initial lateral dimension (sigma-y, σ_y) by wind direction. Although this approach does not completely address the issues of implementing buoyant line source plume rise and dispersion in AERMOD, it does allow the use of updated dispersion algorithms in AERMOD and the calms processing algorithm. Detailed discussions are as follows:

Final Plume Rise

In BLP, the following parameters for each roof vent are required to determine plume rise for buoyant line sources:

- Coordinates of the ridge vent end points;
- Average roof vent width;
- Roof vent height;
- Average building length (same orientation as the ridge vent);
- Average building width (perpendicular orientation to ridge vent);
- Average building height;
- Average spacing between buildings that have roof vents;
- Average buoyancy parameter, which requires the following additional parameters:
    - Roof vent exit velocity,
    - Roof vent exit temperature,
    - Ambient air temperature.

As noted in the BLP User's Guide, plumes from buoyant line sources tend to rise higher when the wind aligns along the long axis of the line source than when the wind is perpendicular to the line. Plume rise from buoyant line sources also exhibits relationships with buoyancy, wind speed and distance differently than stack releases.

A key issue in calculating the plume rise for buoyant line sources is determining what roof vents to model together in the BLP model run. BLP cannot adequately address perpendicular roof vents and the code prevents FMMI from running all four vents simultaneously. Not being able to account for all vents in a single run limits BLP's computation of plume rise enhancement due to mixing of the buoyant plumes and therefore FMMI expect the calculated plume rise for each vent to be conservatively low. To resolve this issue, FMMI performed two BLP runs:

- Model the Anode and Converter Vents together in a single BLP run; and
- Model the Isa, ELF and Converter Vents together in a separate BLP run.

The AERMOD volume source height selected for the Converter Vent was taken from the BLP run that included the Anode Vent. The Converter Vent was also included in the BLP run with the Isa and ELF Vents to allow the Isa and ELF Vents to be subject to enhanced plume rise. This approach is justified on the basis that full credit for enhanced plume rise is not being taken because BLP cannot run all vents simultaneously. Therefore, FMMI expects even the highest calculated plume height to be a conservatively low estimate compared to modeling all four vents together.

One of the critical modeled inputs for BLP is the average line-source buoyancy parameter, which depends on physical dimensions (length and width), the gas temperature, and the exit velocity of roof vents as well as the ambient air temperature. To calculate the average line source buoyancy parameter, FMMI reviewed and validated the 2013 Roofline Study data, and modified the physical dimensions to reflect the actual dimensions after the Smelter Upgrade Project. Table 5-5 provides the calculated averaged parameters.

Table 5-5: Averaged Parameters for Roof Vents

Vent Width (m)	Building Length (m)	Building Width (m)	Building Height (m)	Building Separation (m)*	Buoyancy Parameter (m^4/s^3)
2.57	56.6	21.0	37.65	0.0/9.0	284.91

*The building separation between the anode and converter is zero and the building separation between the Isa and ELF is 9 meters.

FMMI also used a polar receptor grid with receptors placed every 10 degrees and 1-kilometer from the Smelter to calculate the final plume heights. FMMI selected the 1-kilometer distance to ensure that final plume heights (rather than gradual or transitional plume rise) are calculated.

<u>Sigma-z</u>

The hourly emission file created for input to AERMOD requires the sigma-z parameter for volume sources. As noted previously, FMMI used BLP to calculate hourly sigma-z values. FMMI used a polar grid with receptors placed every five degrees and 250 meters from the Smelter center. The 250-meter distance is representative minimum distance for receptors to clear the Smelter building and not overlay with a vent. This approach also ensures that the sigma-z values are properly accounting for plume interaction and downwash.

<u>Sigma-y</u>

The hourly emission file created for input to AERMOD also requires the initial sigma-y parameter for volume sources. As noted previously, FMMI modeled each ridge vent using multiple volume sources that represent the orientation and length of the vent. The purpose is to simulate the effective initial sigma-y of each vent. The series of volume sources follows the AERMOD guidance (U.S. EPA, 2014b) and FMMI separated them by two times the volume source width, which will be set to the width of the vent. FMMI provided the number of volume sources used to represent each vent in Table 5-6 based on the aforementioned approach. The initial sigma-y for each individual volume source was determined by dividing the center-to-center separation length of the volume sources by 2.13.

Table 5-6: Number of Volume Sources Used To Simulate Each Ridge Vent

Vent	Number of Volumes	Initial σ_y (m)
Anode Vent	30	1.32
Converter Vent	9	3.40
Converter 5 Vent	3	3.40
Isa Vent	12	0.71
ELF Vent	4	3.12

BLP Plume Rise and Sigma-z Analysis

EPA requested an evaluation of receptor distances used in BLP to identify final plume height and initial sigma-z. FMMI analyzed the final plume heights from receptor distances of 250 meters (m), 1 kilometer (km), 1.5 km, 2 km, 3 km, 4 km, and 5 km. These distances were evaluated for several compass directions, specifically 110 degrees (ESE), 150 degrees (SSE), 180 degrees (South), 210 degrees (SSW), and 260 degrees (WSW), from the North. These directions were selected because they align with the closest fence line receptors to the Smelter.

The BLP model was run with building downwash and normalized emission rates for each of the future vents to determine how the vent plume dynamics and terrain affected the near field results.

EPA identified several hours where the Miami Townsite monitor recorded elevated 1-hour SO_2 concentrations during the first quarter of 2014 and 2015. Two evaluations were performed to identify if building downwash or inversion breakup fumigation potentially contributed to the elevated measurements. Figures 5-6 through 5-8 provide evidence that the elevated concentrations measured at the Miami Townsite monitor are due to inversion breakup fumigation (Appendix L provides a more detailed discussion).

First, the BLP model was run with building downwash and normalized emission rates for each of the future vents to determine how the vent plume dynamics and terrain affected the near field results. As expected, BLP predicted lower plume heights when the downwash flag was turned on in BLP. However, a comparison of predicted concentrations at receptors along the FMMI fenceline did not show any differences between the downwash and non-downwash cases in BLP. This indicates that if there are any plume impacts at ground level due to downwash, the impacts occur within the fenceline or do not occur at all. The BLP model downwash comparison runs are included in the modeling DVD.

The plume height analysis results showed that the use of BLP-predicted plume heights at a 1 km receptor distance is adequate for the volume source release height input in the AERMOD model. Gradual plume rise does not need to be considered for near-field receptors because the maximum predicted 1-hour design value concentrations are located in the area where final plume rise has been achieved.

EPA also requested further information on how the sigma-y value was derived for the Hybrid Approach. BLP calculates sigma-z at each receptor point. To determine sigma-z values near the release points, a 250 meter polar grid measured from the Smelter center was used to capture sigma-z values. The 250 meter distance places the receptors beyond the northern and southern ends of the Smelter building, which is expected to allow building interactions and roof vent plume mixing to be included in the sigma-z calculation. The 250 meter distance also uses a uniform receptor grid for each source and prevents receptors from overlapping with the source, which is not allowed in BLP. Other BLP/AERMOD approaches have used sigma-z values based on the final plume rise, which likely overestimates the sigma-z value and dilutes the plume in the near field. The 250 meter distance is necessary to allow the plume and building dynamics to be addressed without diluting the plume.

The results of the sigma-z analysis showed that the use of the BLP-calculated values from the proposed 250 meter receptor grid were adequate for the volume source sigma-z input in the AERMOD model. Sensitivity analysis of the sigma-z value showed the expected range of sigma-z values had negligible effects on the predicted off-site concentrations. The details on the approach and results of the plume rise and sigma-z analysis are presented in Appendix D.

The second analysis utilized the AERSCREEN model in fumigation mode to individually evaluate each major stack and ridge vent to assess the potential contribution of inversion breakup fumigation to the elevated measurements. The analysis is provided in Appendix L and shows inversion breakup fumigation is a potential contributor to the elevated readings and that the major stack sources are the most likely source of SO_2 during these fumigation events (whereas the roof vents are not). Another potential cause of the elevated reading is the use of the Miami Fire Department's diesel-fired equipment, which is located directly across the street from the monitor. The fire department's equipment is exercised at variable frequencies, but as frequently as every other day. The level of impact from the fire department would be affected by the federal requirements on sulfur content of diesel fuel.

Figure 5-6: Measured 1-Hour Average Ambient SO_2 Concentration by Hour of Day, Townsite Monitor

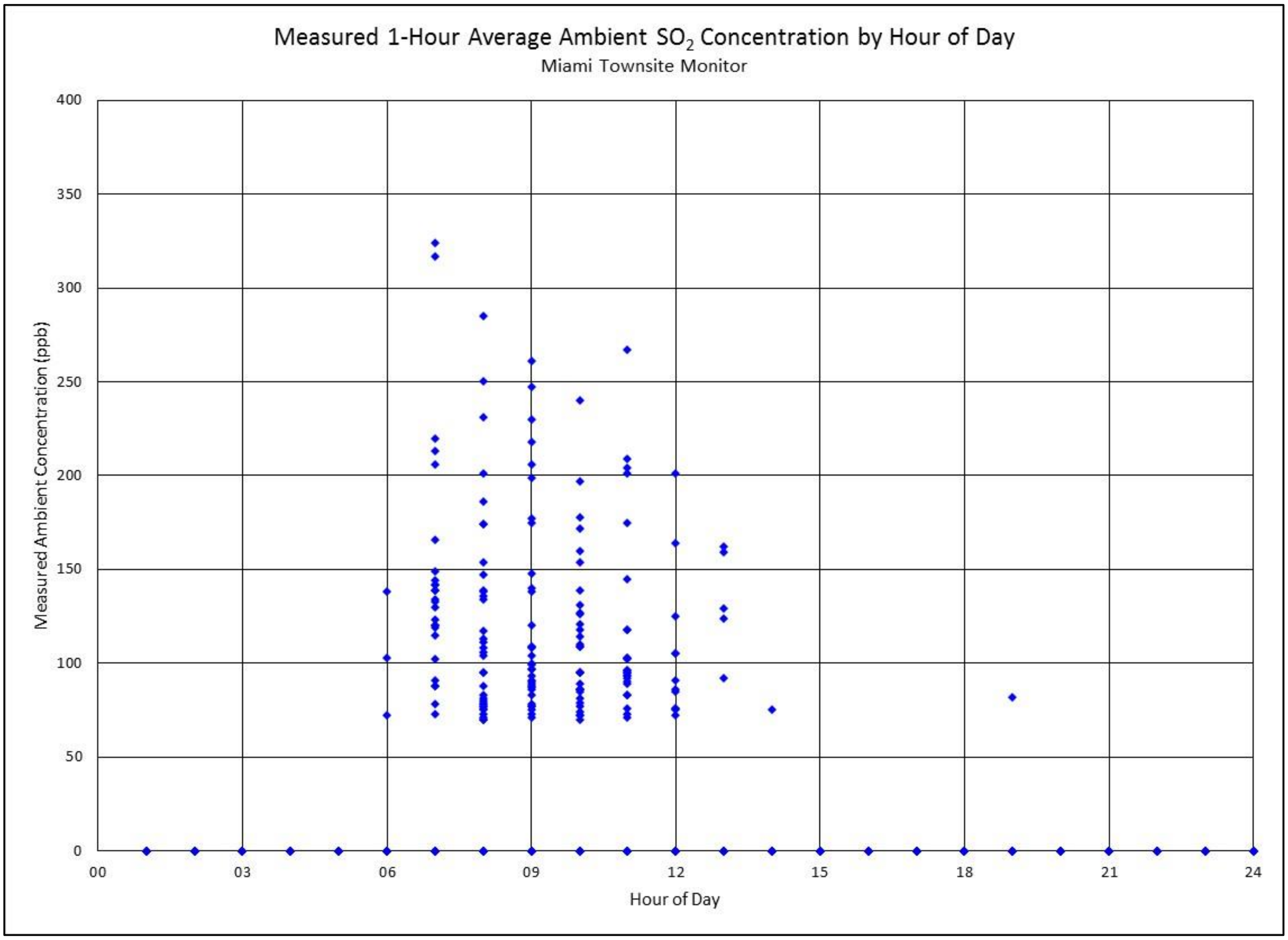


Figure 5-7: Measured 1-Hour Average Ambient SO_2 Concentration by Hour of Day, Jones Ranch Monitor

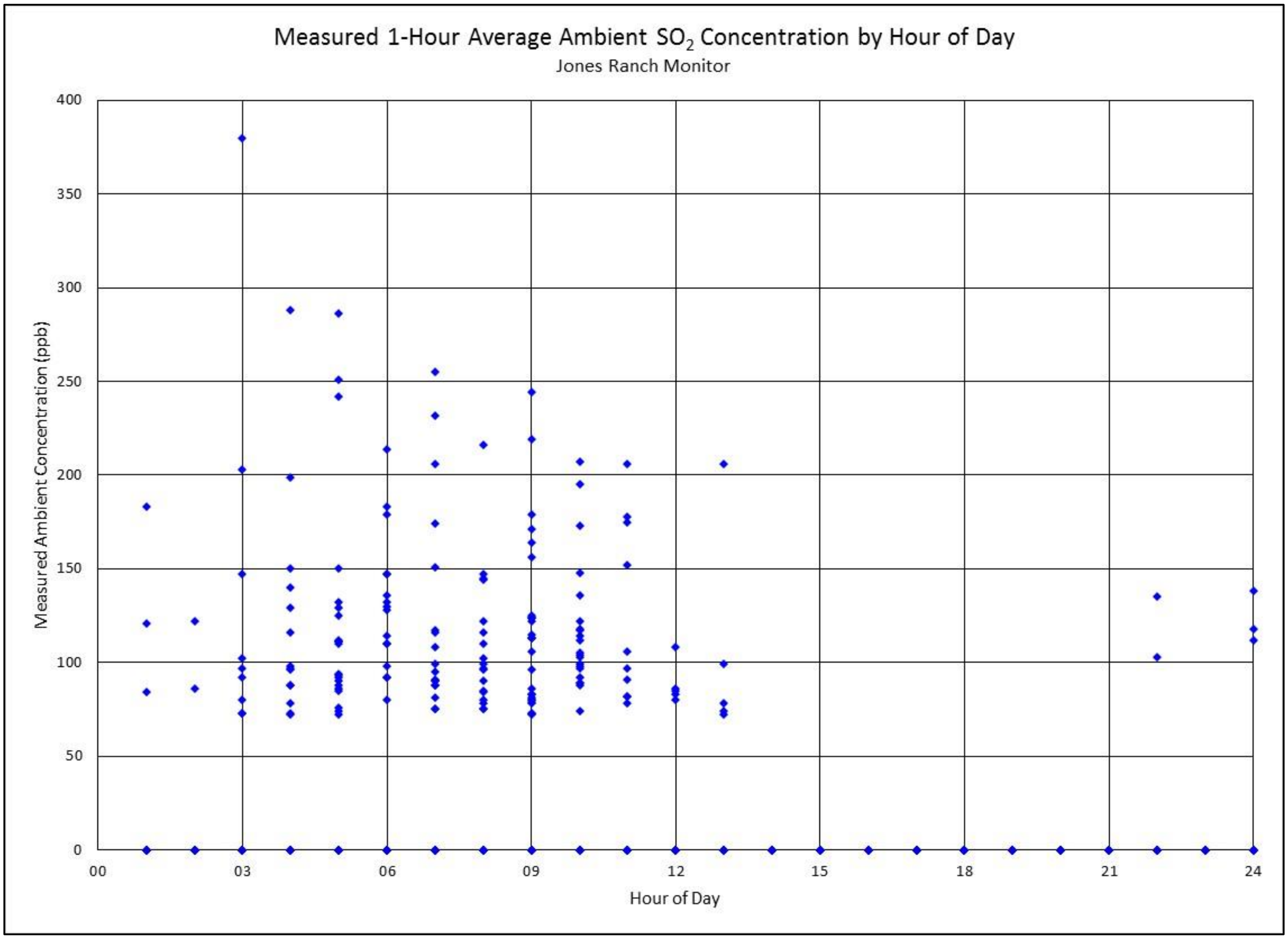
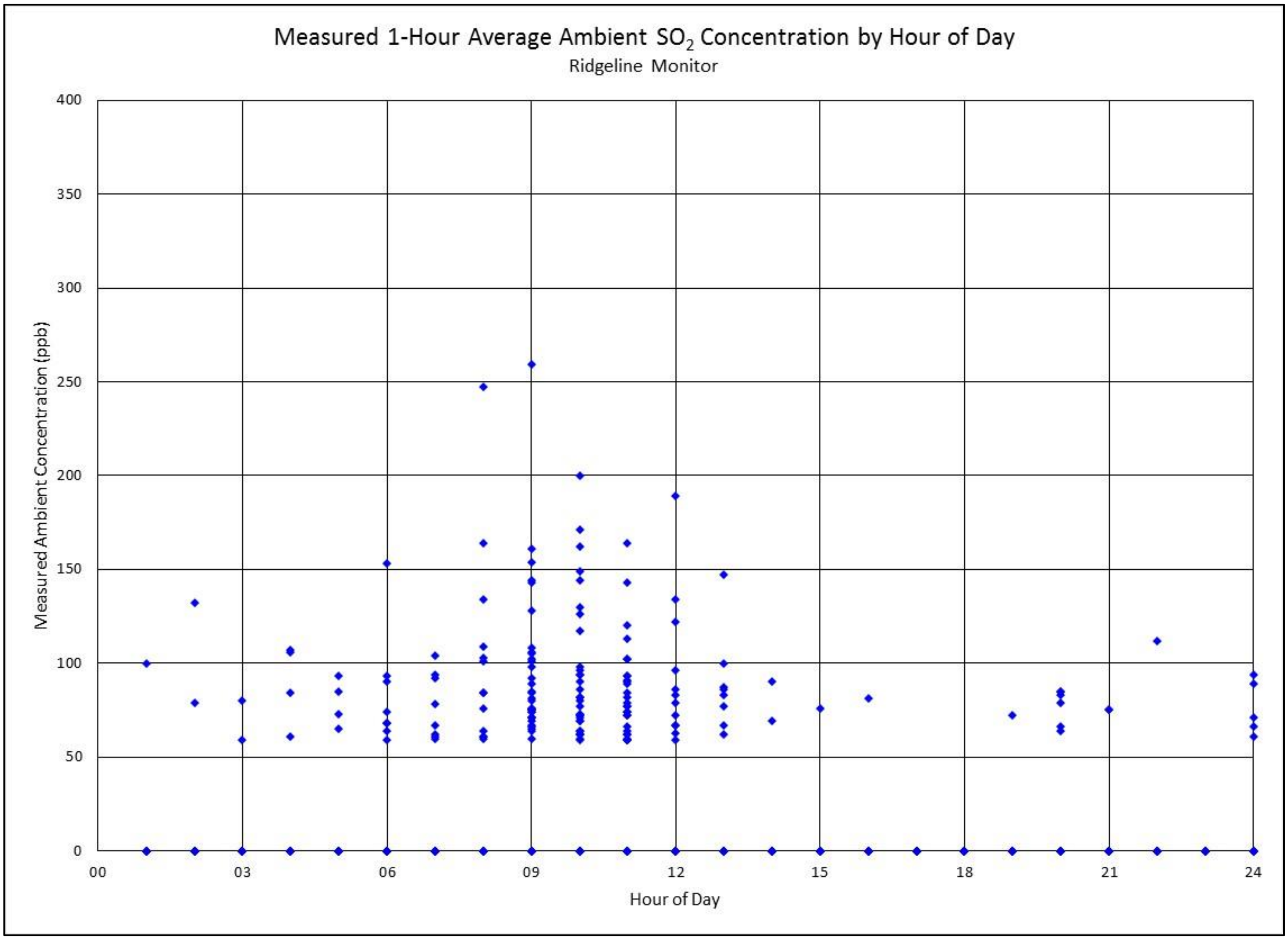


Figure 5-8: Measured 1-Hour Average Ambient SO2 Concentration by Hour of Day, Ridgeline Monitor



BLP Code Modification

Because BLP output files do not provide the estimations of hourly line source final plume rise and sigma-z, FMMI had to modify the BLP code to suit the hybrid approach application. However, these changes do not affect the dispersion algorithms within BLP and thus the preferred status. As stated in the GAQM Section 3.1.2 b (U.S. EPA, 2005):

> *"If changes are made to a preferred model without affecting the concentration estimates, the preferred status of the model is unchanged."*

ADEQ will provide modified BLP code on CD-ROM per the nomenclature described in Appendix A.

5.2.4 Fugitive Sources

Two fugitive sources of SO_2 emissions are included in the modeling effort:

- Smelter building leaks
- Slag dumping

Smelter building leaks are emissions not captured and vented through stacks or the roof vents. Rather, these emissions escape from windows, doors, and other openings in the walls of the Smelter building. While the buoyant draft of the building results in these openings serving primarily as air intakes, these openings may occasionally serve as indoor air release points. The Smelter expansion project includes a reduction in size and number of such openings, as well as the addition of emissions capture systems in the converter and anode aisles—all of which will reduce fugitive emissions considerably and further enhance the function of these openings as supplying make-up air to the working environment within the Smelter building.

The Smelter building leaks are modeled as a set of volume sources in AERMOD. FMMI identified the locations of potential building leaks, with the volume sources placed in those locations. The release height of the volume source(s) was also identified. The initial sigma-y and sigma-z parameters were assigned in accordance with EPA's AERMOD guidance.

Slag dumping is the activity of pouring molten slag from a ladle onto the slag pile located northwest of the Acid Plant. The slag pours will occur approximately 60 times per day in the post expansion scenario, with each pour taking no more than one minute to complete. The molten slag spreads across the top of the slag pile and crusts over within a minute of the pouring operation being completed, with the total time taking from two to three minutes between commencement of the slag pouring and crust formation. Fugitive SO_2 emissions are released from the molten slag during this time.

5.2.4.1 Slag Pouring Emissions Estimation

Slag pouring emissions were modeled as a pseudo point source with a stack height of zero meters. The stack diameter is the average spread area of the slag pouring, with stack placement within an area generally representative of worst-case slag emissions. The average slag temperature was used as the stack temperature inputs, with the exit velocity and plume rise inputs calculated based on differences between slag and ambient temperatures.

A smelter fugitive emission rate of 4.0 lb/ton ore concentrate, from AP-42 table 12.3-11, was used as the emissions calculation basis. While this table gives a smelter fugitive emissions factor of 4.0 lb/ton of concentrate, it indicates the factor for non-reverberatory furnaces, such as the Isa furnace at the Miami Smelter, may be lower. According to AP-42, total SO_2 emissions from the smelting furnace are distributed

90% to matte tapping and 10% to slag skimming. The slag skimming emissions are allocated 75% to the furnace area and 25% to the dumping site.

Equation 5-1: Slag Pouring Emission Calculation

$$E = Slag\ Pouring\ Emissions = E_1 \cdot E_2 \cdot FT_1 \cdot FT_2 \cdot FT_3$$

Where:

E_1= 4 lb SO_2/ton concentrate was set equal to the value identified in Table 12.3-11 of AP-42 Section 12.3 for smelting furnaces.

E_2= *Maximum tons ore concentrate processed per year (1 million post project tons NMBM)*

FT_1=*Ratio of slag* SO_2*/ton anode produced.* The value of FT_1 (0.1) was set equal to the value identified in footnote b of Table 12.3-11 of AP-42 Section 12.3, which states "*90% of total* SO_2 *emissions are from matte tapping operations, with remainder from slag skimming.*" ASARCO used the same value in their analysis of slag pouring emissions *(Compare* E_1*, which is based on reverberatory process, to lbs/ton concentrate from Isa process)*

FT_2=*Slag skimming fraction of total smelting furnace* SO_2 *emissions (10% or 0.10)*

FT_3=*Pouring fraction of total slag skimming emissions (25% or 0.25)*

For the purposes of calculating the hourly SO_2 emission rate of 3.75 lb/hr, a 1-hour New Metal Bearing Material (NMBM) maximum throughput rate of 125 tons per hour was assumed based on the annual allowable NMBM throughput limit of 1 million tons. That is, the hourly throughput rate was derived by dividing the annual allowable NMBM throughput of 1 million tons by 8,760 hours, and conservatively adding a 10% margin of safety to account for throughput variability. The Asarco El Paso Smelting facility in Texas has used this methodology to estimate slag-pouring emissions for their SIP. This methodology is analogous to the flare modeling method in ADEQ's Air Dispersion Modeling Guideline Section 3.3.6. Table 5-7 provides the modeled parameters for slag pouring:

Table 5-7: Slag Pouring Model Parameters

Parameter	Modeled Value
Stack Height (m)	0.0
Exit Diameter (m)	13.3
Exit Temperature (K)	1,333
Exit Velocity (m/s)	1.45
SO_2 Emission Rate (g/s)	0.4725

5.2.4.2 Uncaptured and Unmonitored Building Leak Emissions Estimation

The leakage through unmonitored openings was estimated at 4.5% of the future Smelter roofline fugitive emissions. These roofline fugitive emissions were calculated through Roofline Monitoring System connected to a continuous monitoring device. Expressed as a portion of total SO_2 from stacks and building fugitives, the percentages are even lower. The methodology used to determine uncaptured and unmonitored fugitive emissions from the Smelter building is based on an engineering analysis performed by Hatch for FMMI. The calculation methodology examines building leakage and building envelope surface area to determine a ratio of the above grade surface area and openings to the roof vents to determine a ratio of monitored to unmonitored emissions. Figure 5-6 illustrates the volume sources representative of building fugitive emissions. The Hatch Memo is included as Appendix B in this modeling TSD and is based on the following information:

a. A leakage factor of 32 cubic meters per hour of air leakage per square meter of building surface area, exerted at a pressure of 75 Pa (0.011 psi) was identified in Emmerich and Persily.[11]

b. Using Bernoulli's equation ($v = [2g \times \Delta p / \rho]^{0.5}$), where g is the gravitational constant, p is the exerted pressure (75 Pa), and ρ is the density of air (0.066 lb/ft^3 at Smelter elevation), an air leakage velocity of 39 ft/sec (11.9 m/sec) was derived.

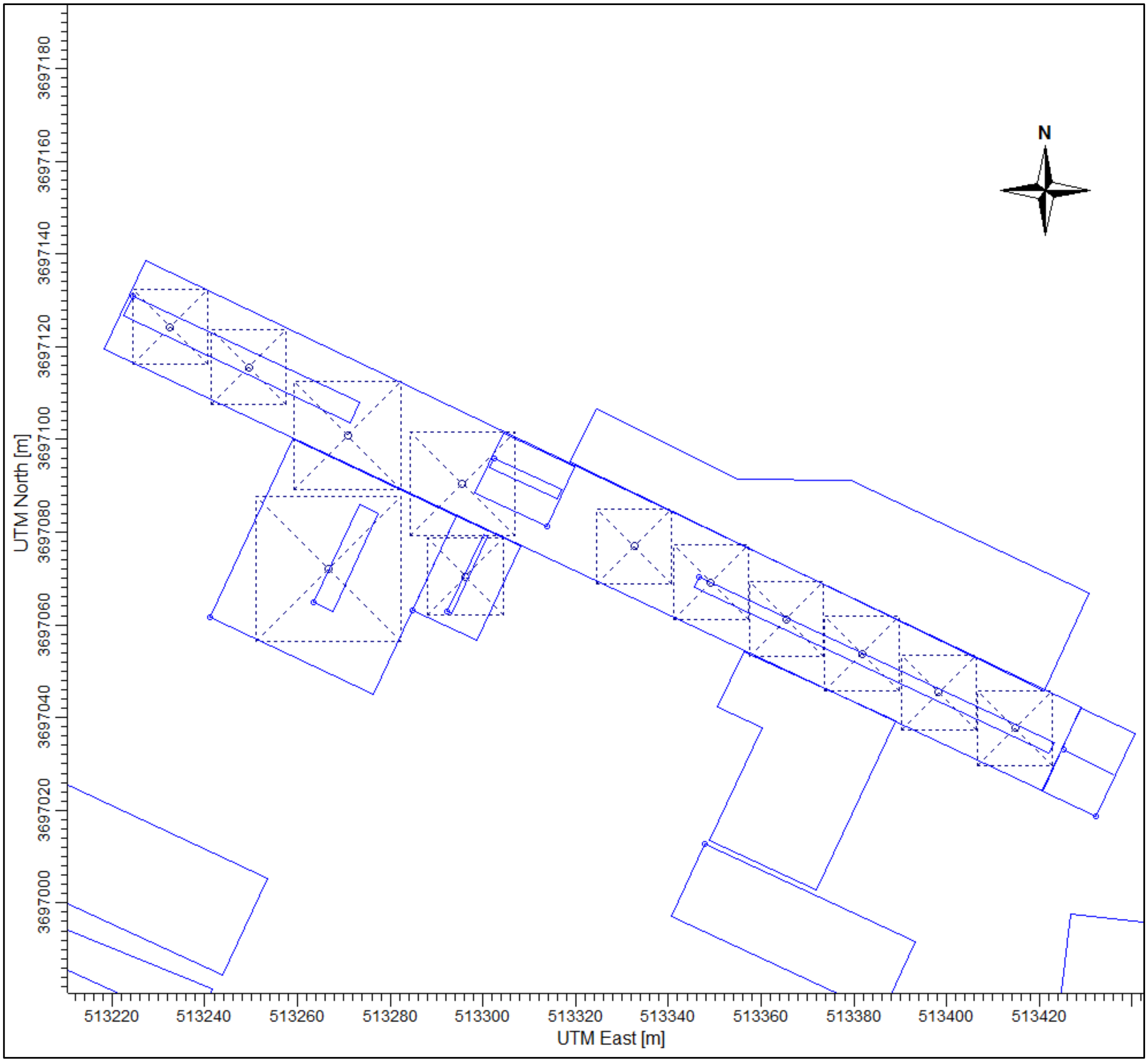
c. The fraction of the building surface area available for leakage was obtained by dividing the referenced leakage factor by the air leakage velocity. The resulting percentage of the building surface available for leakage was 0.07% (i.e., [32 m^3/hr/m^2] / [11.9 m/sec] / [3600 sec/hr]), which was rounded up to 0.1%.

d. The total surface area of the Smelter building was determined to be 205,000 ft^2. Applying the calculated fraction of building surface area available for leakage, the resulting surface area available for leakage was 205 ft^2 (i.e., 205,000 ft^2 × 0.1%).

e. After reconfiguration of the Smelter building, the roof vent area will have an opening of approximately 4,500 ft^2. The ratio of building surface area available for leakage to the roof vent area is 4.5% (i.e., 205 ft^2 / 4,500 ft^2). The SO_2 concentration in the building leakage is assumed to be the same as that vented through the roofline. Therefore, SO_2 emissions from building leakage are assumed to be equal to 4.5% of the roof vent emissions.

[11] S. Emmerich and A. Persily, "*Airtightness of Commercial Buildings in the U.S.*", Building and Fire Research Laboratory, National Institute of Standards and Technology.

Figure 5-9: Defined Volume Sources for Building Fugitive Emissions



5.2.5 Future Source Parameters

As discussed in Section 5-1, ADEQ issued a permit revision (Significant Revision 53592) on July 21, 2014 for the Miami Smelter to increase allowable production; install and upgrade control equipment; and make physical changes to the facility. Tables 5-8 and 5-9 show the new stack locations and vent parameters and figure 5-7 shows the new vent configurations.

Table 5-8: Stack and Exhaust Parameters, Project Stacks and Vents

Source ID	Stack	UTM Easting (m)	UTM Northing (m)	Base Elevation (m)	Stack Height (m)	Exit Diameter (m)	Exit Velocity[12] (m/s)	Exhaust Temp.[13] (ºK)
TAILSTK	Tail Stack	513194.6	3697246	1081.99	65.00	2.300	19.5	298.0
VENTSTK	Vent Fume Stack	513319.8	3696904	1098.02	65.00	2.900	18.5	varying
SCRUBBER	Aisle Scrubber Stack (Normal)	513368.5	3697117	1079.67	57.00	7.300	16.4	varying
	Aisle Scrubber Stack (Bypass)	513368.5	3697117	1079.67	57.00	7.300	18.53	-17.2

The exhaust temperature of the Vent Fume Stack was based on CEMS data from 2010 through 2013. The stack temperature data was averaged by hour and month to develop stack temperature inputs for the AERMOD hourly emission file. An engineering study by Hatch developed anticipated stack temperature profiles for the future aisle scrubber stack under normal operating conditions. These values were incorporated into the AERMOD hourly emission file.

Ridge Vent	Endpoint A UTM Easting (m)	Endpoint A UTM Northing (m)	Endpoint B UTM Easting (m)	Endpoint B UTM Northing (m)
Anode	513,347	3,697,069	513,423	3,697,032
Converter (future)	513,224	3,697,129	513,240.3	3,697,121.4
Isa	513,293	3,697,063	513,300.5	3,697,079
ELF	513,265	3,697,064	513,275	3,697,085

[12] Average exhaust flow design values.

[13] Negative temperature indicates temperature above ambient, zero temperature indicates ambient temperature. Varying values based on actual CEMS data and engineering analysis.

Table 5-9: Vent-Specific Parameters for Roof Vents

Ridge Vent	Vent Length (m)	Vent Width (m)	Vent Height Above Ground (m)	Vent Velocity (m/s)	Vent Temperature (K)
Anode	84.53	1.42	32.55	2.508	361.3
Converter (revised)	18.04	3.66	32.70	2.352	339.9
Isa	17.67	0.76	53.04	11.297	313.7
ELF	23.26	3.35	40.45	1.391	320.6

The changes in the vent configurations will change the buoyancy factor used in the BLP program. Table 5-10 below shows the updated averaged parameters and the revised buoyancy factor for the roof vents.

Figure 5-10: Future Vent Configuration

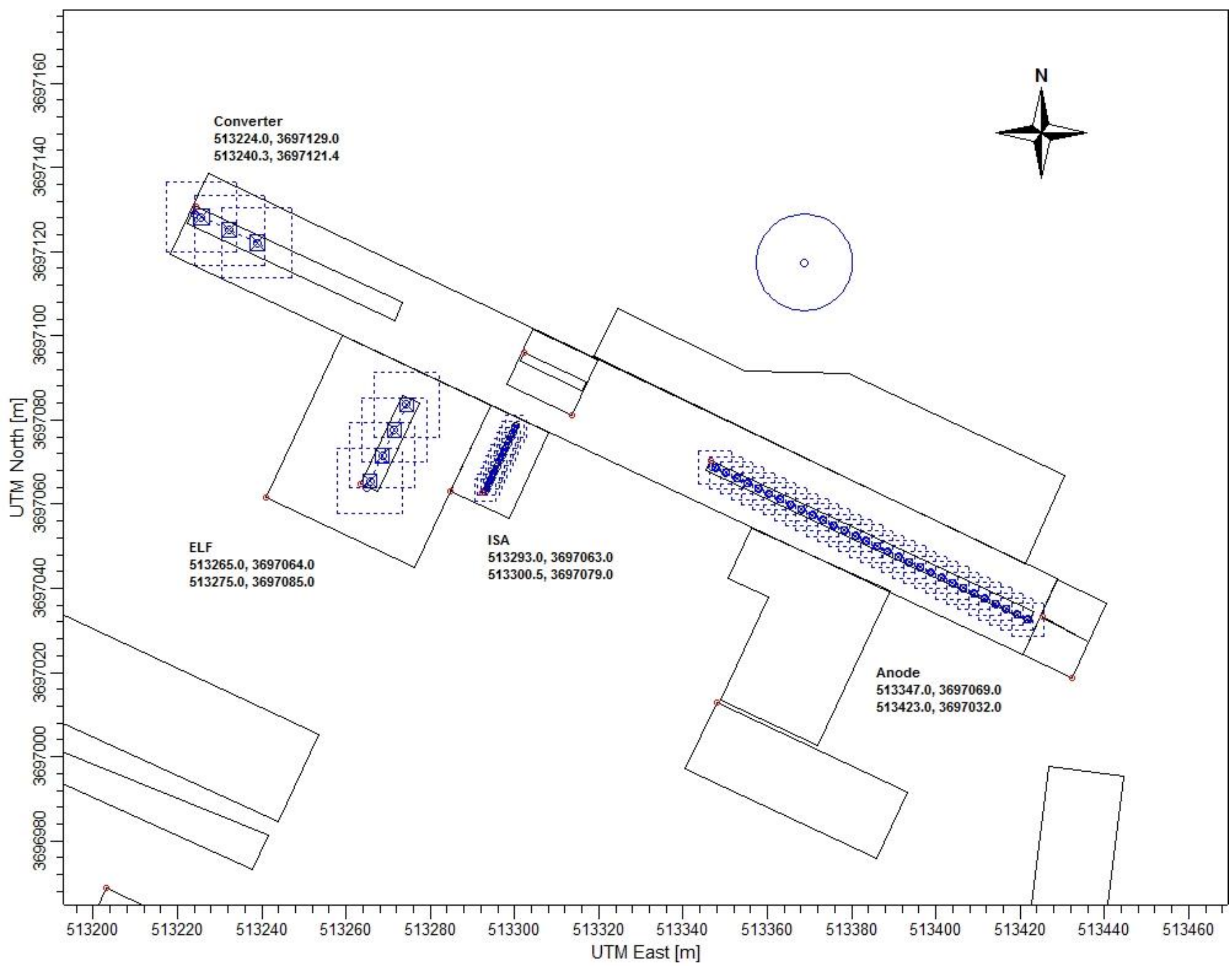


Table 5-10: Averaged Parameters for Roof Vents

Vent Width (m)	Building Length (m)	Building Width (m)	Building Height (m)	Building Separation (m)	Buoyancy Parameter (m^4/s^3)
2.30	65.75	22.5	38.07	0.0	235.49

The new stack locations, additional aisle scrubber source and vent configuration were applied in the modeling to determine the required control efficiency for demonstrating compliance with the NAAQS.

5.3 Emissions Variability and Independence Assessment

The sources associated with the Miami Smelter have highly variable SO_2 emission rates as a combination of both continuous and batch processes are present. Because of this inherent emission variability, the Smelter has historically complied with cumulative occurrence and emission limits via a Multi-Point Rollback (MPR) approach designed in collaboration with ADEQ to ensure compliance with the historic SO_2 NAAQS (3-hour, 24-hour and annual averages). The MPR approach successfully brought the planning area into attainment while allowing for a compliance demonstration procedure that accommodated the highly variable SO_2 emissions from the Smelter.

A goal for the revised SIP is to develop an approach that will both successfully achieve attainment of the maximum daily 1-hour SO_2 NAAQS and provide for a new compliance demonstration procedure that accommodates the variable emissions of the Smelter sources. EPA's SO_2 SIP guidance provides for the consideration of emission limit averaging periods as long as 30 days for sources with highly variable emission rates where hourly emission rates occasionally exceed the critical emission value (CEV) rate. Therefore, ADEQ has adopted a 30-day emission limit. ADEQ believes that a 30-day emission limit will similarly assure NAAQS attainment while accommodating the high variance of emissions. As EPA notes in their guidance (U.S. EPA, 2014a):

> *"The EPA believes that making this option available to states could reflect an appropriate balance between providing a strong assurance that the NAAQS will be attained and maintained, while still acknowledging the necessary variability in source operations and the impairment to source operations that would occur under what could be in some cases an unnecessarily restrictive approach to constraining that variability."*

Because emissions from the Smelter are highly variable, developing such a longer-term limit requires an assessment of the probability that maximal emissions from each of the individual SO_2 emissions sources at the Smelter could occur simultaneously. This probability is a function of both the variable emissions from each individual SO_2 emissions source and the likelihood that those individual sources run at the same time (the "independence" of these emissions). FMMI's analysis of continuous emissions monitoring data confirms that these SO_2 sources do not emit near their maximum rates at the same time. To fully examine this issue, FMMI performed an emissions variability and independence assessment. The assessment methodology and results are discussed in detail in Appendix E. The purpose of this technical memorandum was to provide a description of smelter operations and an analysis of individual source emissions, which demonstrate the highly variable emissions from each source and the independence of source operations. These important factors must be accounted for in developing an emissions limit for the Smelter that is protective of the NAAQS and is further discussed in Section 8 of this TSD.

5.4 Load Analysis

EPA and ADEQ modeling guidelines require evaluation of various operating loads for any proposed project's emission sources where varying operating conditions could affect plume rise. Load conditions are evaluated when appropriate because model-predicted concentrations from reduced load conditions can be greater than from full load conditions. This results from reduced plume rise due to reduced exhaust flow and/or reduced exhaust temperature.

Current CEMS data for the Tail Stack indicate little variation in stack temperatures and flowrate and current CEMS data for the Vent Fume Stack indicate little variation in flowrate and a small diurnal and seasonal variation in temperature. The planned upgrades to the Smelter include the addition of a new scrubber (Aisle Scrubber), changing the scrubbing reagent in the existing scrubbers, a new baghouse, and additional wet ESPs that are tied into fixed speed fans. Thus, stack exhaust flows and velocities are expected to have minimal variation. Stack temperatures will be governed by the caustic scrubbers and consequently exhaust temperature is also expected to have diurnal and seasonal variations which are accounted for in the modeling. The Aisle Scrubber will have two different exhaust condition scenarios, one during normal operation when the flow will be due to the Converter and Anode Aisle capture systems, and the other during bypass operation when the flow will be due to the Converter and Anode Aisle capture systems plus Acid Plant Bypass emissions. Thus, for the Aisle Scrubber, FMMI modeled the exhaust conditions under both operating scenarios. The roof vents are modeled using a single buoyancy factor based on averaged flowrates and temperatures to meet the input requirements of the BLP model. As such, variable exhaust conditions cannot be used for modeling the roof vents.

5.5 Good Engineering Practice (GEP) Stack Height

There are two definitions of Good Engineering Practice (GEP) stack height: (i) formula GEP stack height and (ii) regulatory GEP stack height. EPA requires sources to evaluate building downwash effects when a stack is less than formula GEP stack height (see Equation 5-2 below). Regulatory GEP stack height is either 65 meters or formula GEP stack height, whichever is greater. EPA does not allow sources to take credit for ambient air concentrations that result from stacks that are higher than regulatory GEP stack height. After implementation of recently permitted changes, FMMI will have constructed all stacks onsite after January 12, 1979.

FMMI conducted an analysis of the stack heights, with respect to GEP, in accordance with EPA's guidelines for air quality impact modeling. EPA's Building Profile Input Program for PRIME (BPIPPRM, version 04274; U.S. EPA, 2004a) was used to compute the formula GEP stack height and to generate wind-direction specific building profiles for each stack for the purpose of sequential modeling. For stacks constructed after January 12, 1979, EPA defined the Formula GEP stack height as:

Equation 5-2: GEP Stack Height Formula

$$H_{GEP} = H_B + 1.5L_B$$

Where:

H_{GEP} = GEP stack height;
H_B = Building height above stack base; and
L_B = Lesser of building's height or maximum projected width

BPIPPRM requires a digitized footprint of the facility's buildings and stacks. The source must evaluate the position and height of buildings relative to the stack position in the building wake effects analysis. FMMI obtained the building positions from a site plan of the proposed changes. FMMI identified coordinates for each of the existing building tier corners by mapping the site plan to rectified aerial photographs of the site. FMMI obtained roof heights for the proposed changes from preliminary designs of proposed facility structures and actual heights of existing structures.

Simplified layouts of the facility are provided in Figures 5-2 and 5-3. These figures also identify stack locations. This report provides the associated BPIPPRM building-tier identifications in Table 5-11.

Tables 5-12 and 5-13 provides the results of the analysis. Presented for each evaluated stack are:

- Structure(s) that defines formula GEP for the stack (controlling structure);
- Height of the controlling structure;
- Projected width of the controlling structure;
- Structure shape (i.e., squat or tall);
- Formula GEP stack height;
- Regulatory GEP stack height; and
- Actual stack height.

In all cases, the proposed stack heights are less than the calculated formula GEP height. Therefore, building wake effects will be considered in all modeling runs for these stacks. The actual stack heights will be modeled because the actual stack heights are less than or equal to the calculated GEP heights. ADEQ will provide BPIPPRM input and output files on CDROM per the nomenclature described in Appendix A.

Table 5-11: BPIPPRM Building-Tier/Site Plan Cross Reference

BPIPPRM Bldg-Tier No. for CEV runs	BPIPPRM Bldg Tier No. for Performance Runs	Site Plan Building Tier(s)	Tier Elev. Above Base (m)
1	31	BEDPLNT	8.61
6	36	PWRHS	16.78
16	46	ADMIN	23.07
21	51	TRACK5	9.35
31	56	BLACKSTACK	76.2
36	61	BLD_8	10.0
41	66	BLD_9	10.0
46	71	BLD_10	11.58
51	76	BLD_11	10.0
56	1	RODPLNT (BLD_18)	6.4
57	2	RODPLNT (BLD_18)	9.14
58	3	RODPLNT (BLD_18)	12.2
TBR	6	APTANK1	23.16
61	11	APTANK2	23.77
66	16	APTANK3	22.71
TBR	21	BLDG1	6.95
76	26	LARGTANK	12.5
96	101	CHNGRM6	6.00
101	106	MISBLG	5.79
11	41	SMELTER	31.18
12	42	SMELTER	32.55
13	43	SMELTER	32.70
14	44	SMELTER	35.98
15	45	SMELTER	37.50
81	86	CRNBLDG	52.43
82	87	CRNBLDG	52.93
86	91	ISABLDG	52.43
87	92	ISABLDG	53.34
91	96	ELFBLDG	37.50
92	97	ELFBLDG	40.45
116	111	BLD_24 (Tank)	12.7
2	--	Scrubber (new)	41.15
71	--	Bldg_1 (new)	23.16
106	--	Bld_22 (new)	54.3
111	--	Bld_23 (new)	54.3
121	--	WESP2 (new)	9.75
126	--	BLDWESP2 (new)	9.75

Table 5-12: BPIPPRM Results, Existing Stacks

Stack	Stack Height (m)	Stack-Building Base Elevation Difference (m)	Formula GEP Height (m)	Regulatory GEP Height (m)
TAILSTK	60.96	-4.01	105.14	105.14
VENTSTK	48.80	13.74	87.39	87.39
APPREHT	2.10	-1.00	102.12	102.12
RPTB	3.05	0.00	30.47	65.00
RPSFS	19.81	0.00	30.47	65.00
CHRMWTH	4.67	-4.76	98.51	98.51
ISAAUXBL	32.55	-1.00	94.75	94.75
SCRNENG	1.37	NA	NA	65.00
CMPRS1	5.0	13.46	87.67	87.67
CMPRS2	5.0	-5.50	100.58	100.58
BYPASS	60.96	-1.40	98.17	98.17
SLAG	0.00	NA	0.00	65.00

Table 5-13: BPIPPRM Results, Future Stacks

Stack	Stack Height (m)	Stack-Building Base Elevation Difference (m)	Formula GEP Height (m)	Regulatory GEP Height (m)
TAILSTK	65.00	-4.01	105.14	105.14
VENTSTK	65.00	12.02	89.10	89.10
Aisle Scrubber	57.00	-6.33	104.91	104.91

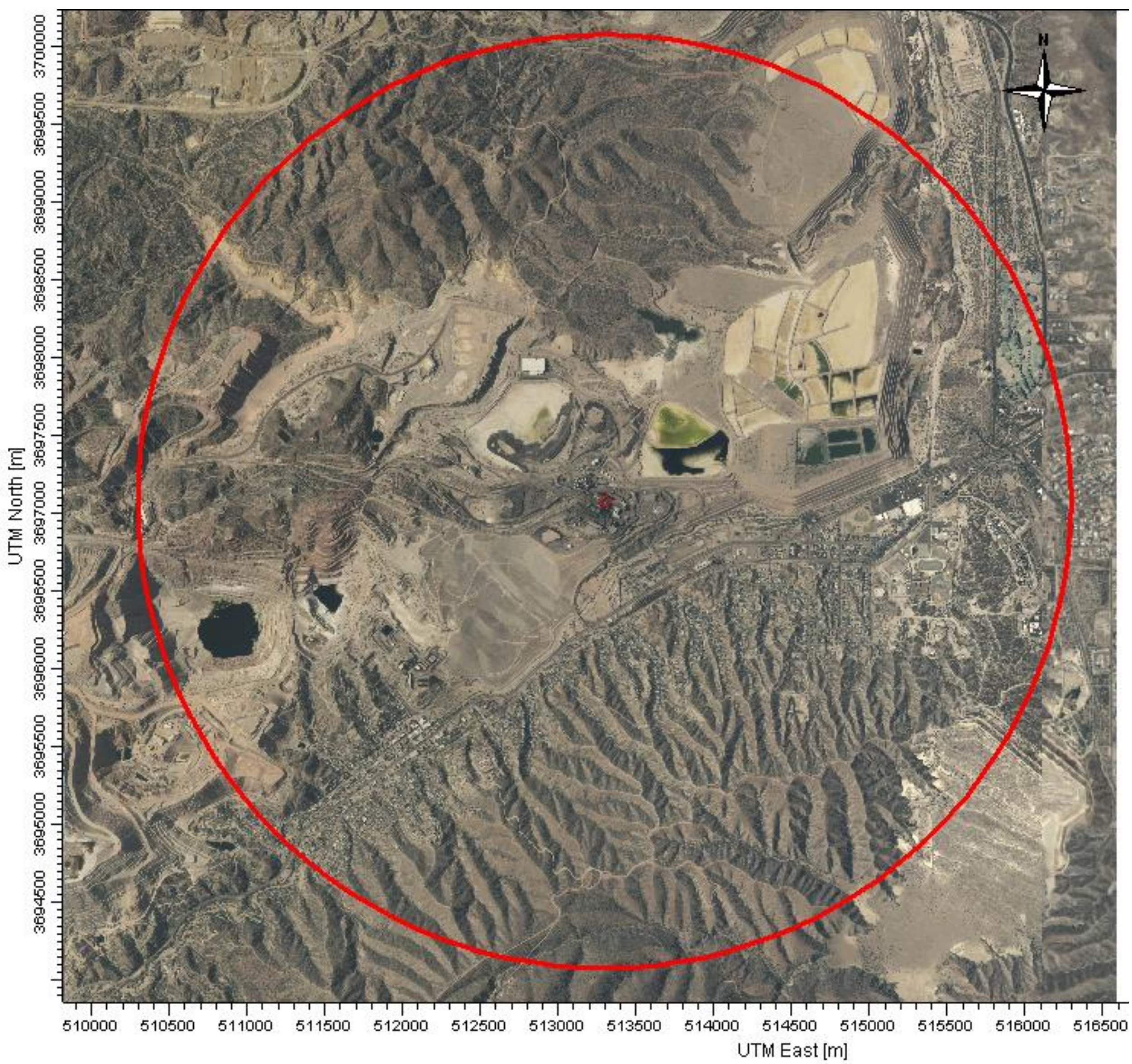
5.6 Urban/Rural Determination

Dispersion coefficients for air quality modeling are selected based on the land use classification technique suggested by Auer (Auer, 1978), which is EPAs preferred method. The classification determination involves assessing land use by Auer's categories within a 3-kilometer radius of the proposed site. A source should select urban dispersion coefficients if greater than 50 percent of the area consists of urban land use types; otherwise, rural coefficients apply.

FMMI identified land use categories for areas within the 3-kilometer radius of the facility from US Geological Survey (USGS) maps and EPA's AERSURFACE modeling tool (version 13016; EPA, 2013b). Figure 5-7 shows the 3-kilometer radius centered on the project's scrubber stack. The area within 3-kilometers of the facility is primarily rural. FMMI used AERSURFACE to confirm the land use within a 3-kilometer radius of the facility. The EPA developed AERSURFACE to identify surface roughness length within a defined radius from a specified point. In this case, FMMI input the UTM coordinates of the proposed scrubber stack to AERSURFACE and specified a 3-kilometer analysis radius. FMMI acquired USGS National Land Cover Data (NLCD) for 1992 for the area and used this data as an input to AERSURFACE per EPA guidance. FMMI calculated the rural fraction of the area to be 97.3 percent. Therefore, FMMI selected rural dispersion coefficients for the air quality modeling.

Consideration is being given by the modeling community to allow the use of urban dispersion coefficients for facilities that produce a significant heat island effect, as was discussed during EPA's 2013 modeling workshops held recently in Research Triangle Park, North Carolina. However, for the purposes of this modeling TSD, FMMI used rural dispersion coefficients.

Figure 5-11: 3-km Radius of the Smelter Facility



6.0 Meteorological Data

The proposed BLP/AERMOD hybrid approach requires the use of two types of meteorological datasets, AERMET and MPRM.

6.1 AERMET

EPA's AERMET tool (version 14134; EPA, 2014c) was used to process meteorological data for use with AERMOD. AERMET merges National Weather Service (NWS) surface observations with NWS upper air observations and performs calculations of meteorological parameters required by AERMOD. Surface observations from on-site instruments can optionally be included. The latter can be useful because the data are more relevant to the site being modeled and in cases where on-site data are collected at multiple elevations above ground, AERMET can construct a more accurate vertical profile of meteorological data. In addition to the meteorological observations, AERMET further requires the inclusion of the characteristics of land use surfaces that FMMI calculated using EPA's AERSURFACE tool.

6.1.1 Surface Observations

EPA recommends that AERMOD be run with a minimum of 5 years of NWS data or 1 year of on-site meteorological data. The meteorological data used in the sequential modeling consists of on-site hourly surface observations collected by FMMI from a 30.5-meter tower located approximately 0.32 kilometers southwest of the project site. The meteorological data used in the modeling cover the period from the second quarter of 2010 through the first quarter of 2013, with the raw on-site data provided by FMMI. The use of three years of on-site data exceeds the EPA recommendation of one year for on-site data. Figure 6-1 shows the location of the tower site relative to the proposed project.

FMMI has installed the meteorological instruments at elevations of 9.14 and 30.5 meters above ground level (AGL). The tower is equipped with the following instrumentation:

- Wind speed, wind direction, standard deviation of horizontal wind, and ambient temperature at 30.5 meters;
- Ambient temperature at 9.14 meters beginning in March of 2007;
- Atmospheric pressure; and
- Precipitation.

The installation meets the requirements of ADEQ and meets or exceeds EPA's recommendations available at the time of installation. Instrument performance is audited on a regular basis in accordance with ADEQ and EPA requirements.

Concurrent surface observations are required to provide parameters not collected by the Miami Smelter Tower, which includes relative humidity, and cloud cover data. The closest station to the Miami Smelter facility is the Remote Automated Weather Station (RAWS) network Globe station. However, this station lacks the required sky cover and surface pressure data required by AERMET. The two closest National Weather Service (NWS) stations with available cloud cover and surface pressure data are Phoenix and the Safford Airport. Although the Phoenix NWS station is slightly closer to the Miami Smelter, Safford's location is more representative of the cloud cover and relative humidity at the Miami Smelter site. The 30-year average rainfall at the RAWS Indian School (Phoenix) site between 1920 and 1975 was 7.55 inches while the Globe RAWS site had 15.9 inches on average and Safford had 9.02 inches on average for the same period. This indicates that Safford is more representative with respect to cloud cover than the Phoenix site. FMMI downloaded the Safford Integrated Surface Hourly (ISH) meteorological data from the National Oceanic and Atmospheric Administration (NOAA) website and used this data in AERMET.

Tables 6-1 and 6-2 provide the raw data completeness respectively for the Miami Smelter Tower and Safford meteorological parameters used in the modeling. The tables demonstrate three continuous years of record where EPA's data completeness guideline (U. S. EPA, 2000) for raw data of 90% exists from the 2nd quarter of 2010 through the 1st quarter of 2013. Because EPA requires only one year of data from on-site meteorological monitoring stations, this on-specific dataset is sufficient for regulatory modeling purposes. FMMI used the 3-year data set, which meets the data completeness requirements. Using this 3-year data set provides additional assurance that FMMI account for conservative meteorological conditions in the attainment demonstration. For AERMOD to calculate the 99th percentile of the maximum daily hourly impact accurately, FMMI will move the AERMET output from the 2nd quarter, 3rd quarter and 4th quarter of 2010 to year 2013 to ensure three complete years of meteorological data in the AERMOD run.

6.1.2 Upper Air Observations

FMMI obtained concurrent upper air radiosonde data for the Tucson NWS site (WBAN 23160). An analysis of the NWS FSL radiosonde data showed that many soundings did not contain the base (surface) measurements (FSL Level 9), but measurements for the balance of the sounding depths were available. ADEQ identified an alternate source of radiosonde data from the University of Wyoming which contained base measurements. ADEQ confirmed with University personnel that the source of the radiosonde data was the same as that used by NWS. The data was downloaded in a text format (non-FSL) so a short FORTRAN program was used to reformat the data into FSL format for AERMET and MIXHTS. A copy of the program is included on the attached DVD-ROM.

Figure 6-1: Geographical Representation of Ambient Monitor and Meteorological Station Locations

Table 6-1: Tower Data Percent Completeness

Year	Quarter	Wind Speed	Wind Direction	Sigma Theta	Temp. (30 feet)	Temp. (100 feet)	Pressure
2009	Q1	99.31%	98.66%	98.29%	100.00%	100.00%	100.00%
	Q2	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
	Q3	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
	Q4	100.00%	83.12%	83.12%	100.00%	100.00%	100.00%
2010	Q1	100.00%	84.81%	84.77%	100.00%	100.00%	100.00%
	Q2	99.95%	100.00%	100.00%	100.00%	100.00%	100.00%
	Q3	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
	Q4	100.00%	99.95%	99.95%	100.00%	100.00%	100.00%
2011	Q1	100.00%	99.95%	99.95%	100.00%	100.00%	100.00%
	Q2	99.73%	99.73%	99.73%	99.73%	99.13%	99.73%
	Q3	100.00%	99.86%	99.77%	100.00%	100.00%	100.00%
	Q4	100.00%	100.00%	100.00%	100.00%	98.64%	100.00%
2012	Q1	100.00%	99.91%	99.91%	100.00%	99.12%	100.00%
	Q2	100.00%	100.00%	100.00%	100.00%	99.95%	100.00%
	Q3	100.00%	100.00%	100.00%	100.00%	99.05%	100.00%
	Q4	100.00%	100.00%	100.00%	100.00%	98.73%	100.00%
2013	Q1	100.00%	100.00%	100.00%	100.00%	99.31%	100.00%
	Q2	86.86%	86.86%	86.86%	86.86%	86.68%	86.86%
	Q3	100.00%	100.00%	100.00%	100.00%	99.64%	100.00%
	Q4	100.00%	100.00%	100.00%	100.00%	99.37%	100.00%

Table 6-2: Safford Surface Station Data Percent Completeness

Year	Quarter	Cloud Cover	Relative Humidity
2009	Q1	99.26%	99.91%
	Q2	98.72%	100.00%
	Q3	99.14%	100.00%
	Q4	80.62%	99.91%
2010	Q1	86.65%	100.00%
	Q2	93.67%	100.00%
	Q3	90.84%	99.95%
	Q4	94.19%	99.95%
2011	Q1	95.74%	99.81%
	Q2	99.54%	99.95%
	Q3	99.73%	100.00%
	Q4	99.73%	99.86%
2012	Q1	99.13%	99.86%
	Q2	99.73%	99.86%
	Q3	99.98%	99.99%
	Q4	99.50%	100.00%
2013	Q1	99.35%	99.91%
	Q2	99.63%	99.86%
	Q3	80.66%	99.91%
	Q4	86.10%	99.00%

6.1.3 AERSURFACE

FMMI used EPA's AERSURFACE tool to calculate the surface roughness length, albedo and Bowen ratio inputs required by AERMET. EPA developed AERSURFACE to identify these parameters within a defined radius from a specified point. In this case, FMMI input the UTM coordinates of the on-site meteorological tower as well as the Safford site to AERSURFACE along with a 1-kilometer radius per EPA guidance. FMMI acquired USGS National Land Cover Data (NLCD) for the area, and used these data as inputs to AERSURFACE. FMMI calculated the parameters for twelve compass sectors of 30° each, and by month. FMMI assigned the seasonal categories as follows per ADEQ guidance:

- Late autumn after frost and harvest, or winter with no snow: December, January, February, March;
- Winter with continuous snow on the ground: none;
- Transitional spring (partial green coverage, short annuals): April, May, June;
- Midsummer with lush vegetation: July, August, September; and
- Autumn with un-harvested cropland: October, November.

FMMI selected surface moisture characteristics based on the annual precipitation measured at each site and compared with the 30-year average value from 1980 to 2010. Table 6-3 provides a summary of the precipitation analysis. Average surface moisture conditions were identified for all five years at both sites. Average moisture was determined to be associated with precipitation rates that fall within the middle 50th percentile of the 30-year distribution. Dry conditions would be associated the lower 25th percentile of 30-year precipitation rates, while wet conditions would be associated with the upper 25th percentile. ADEQ will provide AERSURFACE input and output files on CDROM per the nomenclature described in Appendix A.

Table 6-3: Precipitation Rates (inches)

Station	Lower 25th Percentile	Upper 25th Percentile	2009	2010	2011	2012	2013
Miami	6.62	23.71	9.01	22.45	13.06	10.54	15.10
Safford	3.22	13.79	4.47	11.15	5.37	8.11	7.52
All precipitation rates fall within the middle 50th percentile and as a result, all surface moisture conditions were considered dry.							

The Miami Smelter on-site data, cloud cover data from the Safford Airport, Tucson upper air data and AERSURFACE land use data were processed with the AERMET meteorological processor. ADEQ will provide AERMET input and output files on CD-ROM per the nomenclature described in Appendix A.

6.1.4 Processed Data Completeness

The data completeness for each year of processed data for input to AERMOD are as follows:

- 2011: 99.4 percent
- 2012: 99.2 percent
- 2013 1st quarter with 2010 2nd through 4th quarter: 95.8 percent

Figure 6-2 is a wind rose of the meteorological data from the FMMI on-site meteorological station. The wind rose demonstrates that wind direction frequency generally aligns with the orientation of the valley.

6.2 MPRM

The MPRM model combines twice-daily mixing heights, on-site meteorological data and surface meteorological data, into a BLP-compatible meteorological file. The twice-daily mixing heights are calculated using the EPA's MIXHTS program which uses FSL upper air data with wind speed in knots and surface data in SAMSON or HUSWO format.

6.2.1 Surface Observations

FMMI used the Miami Smelter meteorological data as on-site observation input to MPRM. FMMI used the Safford NWS data as additional surface observation input to MPRM as was performed with AERMET.

BLP requires complete meteorological datasets so data substitution is necessary. For missing onsite data, FMMI substituted meteorological observations from the Jones Ranch monitoring site (3-kilometers south of the Smelter tower. FMMI then applied linear interpolation for three or less consecutive missing hours in the combined tower/Jones Ranch file. In the case of missing Safford data, if one hour was missing, FMMI used the preceding hour's observation. If two or more consecutive hours of data were missing, data substitution considered past and future conditions as well as other available meteorological data fields. In most cases, FMMI applied linear interpolation between preceding and following data points for two or more missing consecutive hours of data. FMMI performed data substitution using Microsoft Excel® spreadsheets, and ADEQ will provide these to EPA for review of the data substitution performed.

6.2.2 Upper Air Observations

FMMI used the MIXHTS program to determine the twice-daily mixing heights required by MPRM. Both upper air and surface observations are required inputs for the MIXHTS program. FMMI used the upper air observations described previously for use with AERMET for input to MIXHTS. Several data issues prevented the MIXHTS program from calculating many of the morning and some of the evening mixing heights.

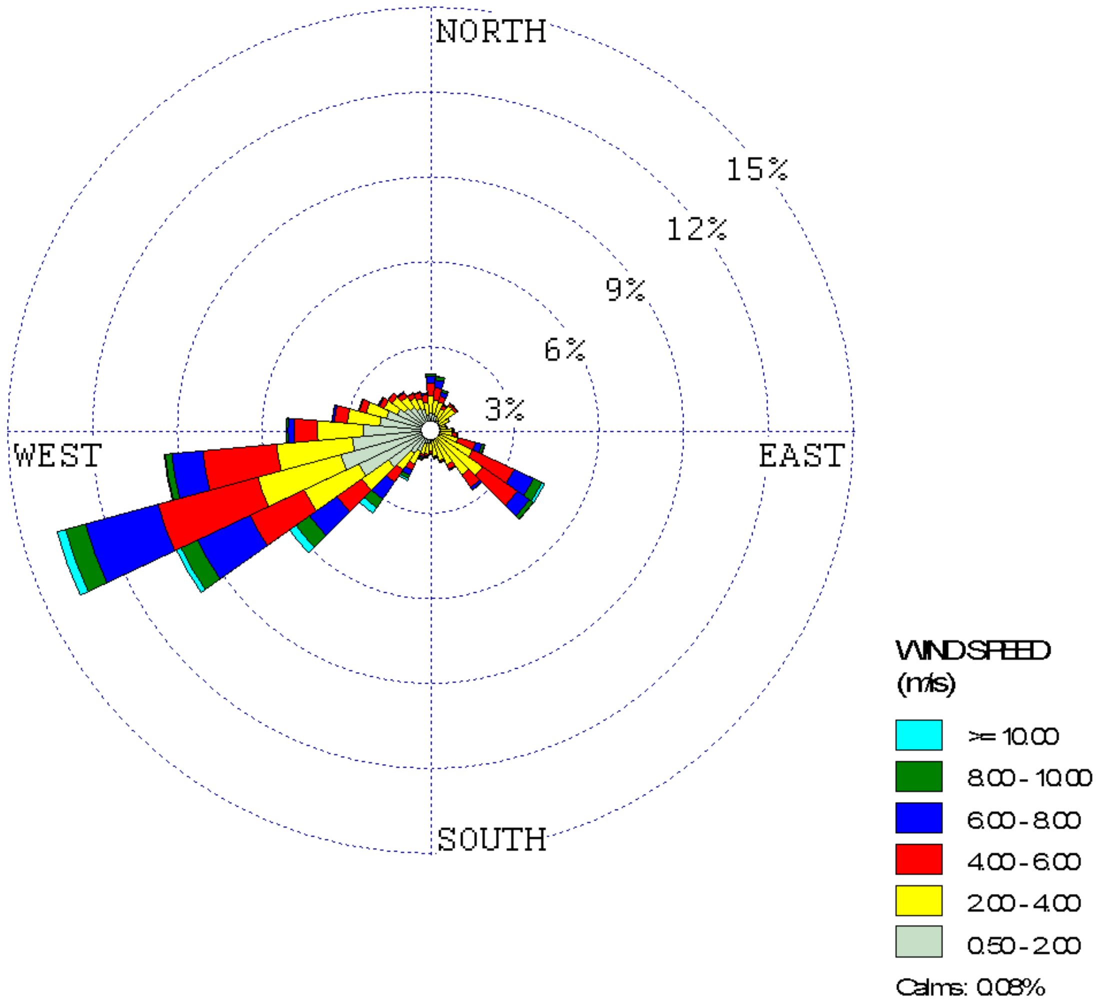
FMMI used the Tucson surface level ISH meteorological file for the surface observations input to MIXHTS. The conversion was achieved by running the AERMET Stage 1 processor and then converting the AERMET Stage 1 output into SAMSON format. FMMI then selected Tucson surface level data based on its proximity to the upper air station and the sensitivity of the MIXHTS program to surface temperature and upper air base level temperature consistency.

Next, FMMI ran MIXHTS using the datasets described above. FMMI reassigned any mixing heights that were calculated to be greater than 4000 meters by using a linear interpolation of the preceding and following values. Where there were still single mixing heights missing a simple average between the preceding and following day was used. FMMI used AERMET if more than three consecutive days of data were missing the minimum daily mixing height calculated by AERMET. In a few instances, FMMI substituted the maximum mixing height for three or more missing afternoon mixing heights.

6.2.3 MPRM Output

After running MPRM, a small number of hours in the final output file had missing wind direction data. These were associated with calm wind speed observations, in which case MPRM automatically assigns wind speed and wind direction to be 0.0 meters per second (m/s) and 0°N, respectively. Because BLP cannot run with such wind conditions, FMMI reassigned all calm wind speeds a value of 1.0 m/s and substituted missing wind direction data linear interpolation of preceding and following wind direction observations.

Figure 6-2: Wind Rose of On-site Meteorological Data



7.0 Background Air Quality

EPA requires background air quality estimates be added to modeling results for comparison to the NAAQS. FMMI based estimates of the background air quality estimates of SO_2 proposed for the dispersion modeling analysis on measured data collected from ambient air monitoring sites located in the Miami-Claypool area. FMMI used data measured at three monitoring sites for SO_2. Figure 6-1 illustrates the locations of these monitoring sites. The data used in the analysis were measured by FMMI during the 4-year period from 2009 to 2012.

Based on an initial analysis of the ambient SO_2 data, contributions from Miami Smelter operations dominate the vast majority of the measurements. FMMI confirmed this by evaluating data measured only during hours of smelter operation shutdowns, during which the three monitoring sites recorded reduced ambient air concentrations. EPA's GAQM (U.S. EPA, 2005) defines background air quality as "pollutant concentrations due to: (1) Natural sources; (2) nearby sources other than the one(s) currently under consideration; and (3) unidentified sources."

For isolated sources such as the Miami Smelter, the GAQM (U.S. EPA, 2005) specifically states, "Determine the mean background concentration at each monitor by excluding values when the source in question is impacting the monitor." FMMI shut down smelter operations during 1,322 of the hours in the 4-year period of records evaluated. While the shutdown hours represent only 3.8% of the total hours in the 4-year time period, the availability of over 1,000 hours of shutdown data provides compelling evidence of background air quality conditions in the absence of facility impacts. This is particularly true for the determination of 1-hour average SO_2 background concentrations.

Table 7-1 provides a summary of the 1-hour SO_2 concentrations for the shutdown data set. The significant difference found between the design concentrations indicates that the smelter operations dominate the ambient air quality measured at the monitors during periods of smelter operation, and consequently the data collected during shutdowns are representative of background air quality in the Miami-Claypool area. FMMI used ambient air measurements recorded during smelter shutdown as representative of background air quality for SO_2. To offset the reduced data sets, FMMI selected the maximum background concentration among the sites from the 5-year averages of the daily maximum 99th percentile 1-hour average concentrations. Table 7-2 summarizes the proposed background air quality estimates.

Table 7-1: Average 1-Hour Ambient Air Concentrations of SO_2 (ppb)

Period	Jones Ranch Monitor Shutdown 99th (N)	Townsite Shutdown 99th (N)	Ridgeline Monitor Shutdown 99th (N)
2009	3.9	5.0	4.5
2010	4.3	12.0	11.3
2011	8.8	6.0	7.5
2012	18.8	6.1	8.8
2013	4.5	4.5	4.0
5-Yr Avg.	8.1	6.7	7.2

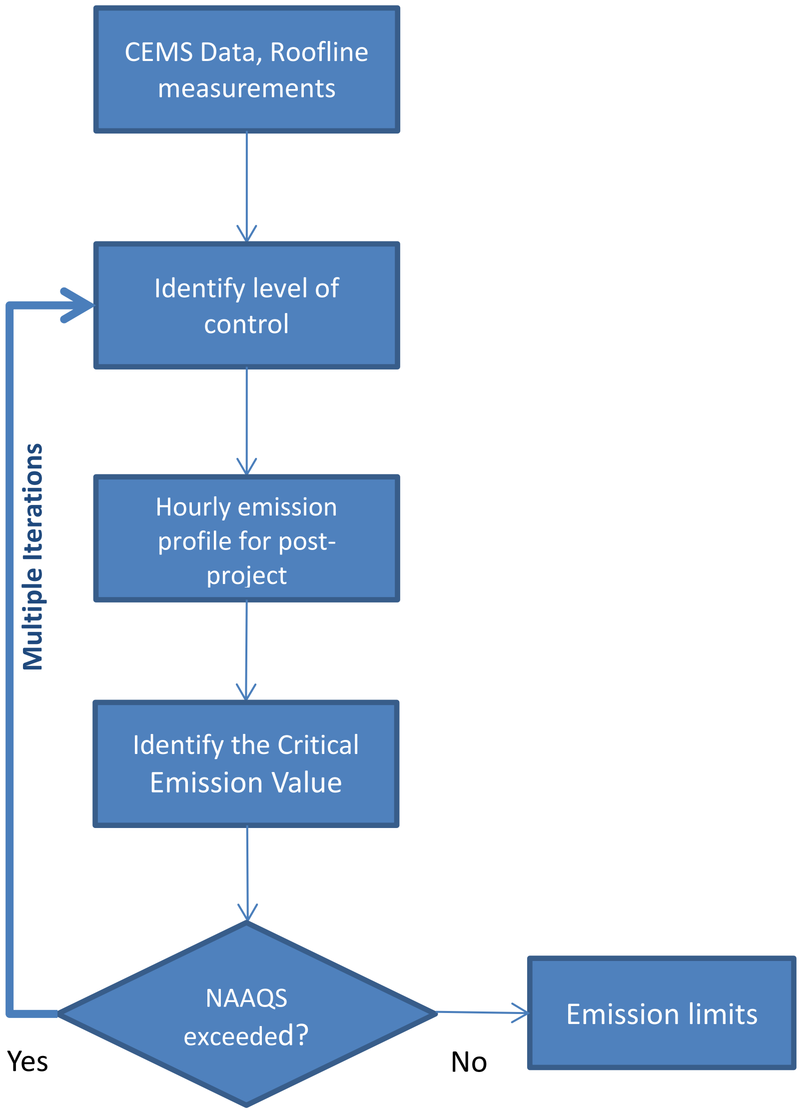
Table 7-2: Background Air Quality Estimates

Parameter	Averaging Period	Background Concentration (ppb)	Background Concentration ($\mu g/m^3$)
SO_2	1-hour	8.1	21.2

8.0 Air Quality Modeling Results and Emission Limits

This section provides a discussion on the control efficiencies, air quality modeling, and emission limits for the Miami Smelter. The methodology that was applied to define the emission limits for the Smelter is summarized in Figure 8-1 and a detailed discussion is provided throughout this section.

Figure 8-1: The Methodology to Determine Emission Limits



FMMI followed the approach presented in Figure 8-1, as follows:

When the SO_2 NAAQS was revised in 2010, FMMI contracted with a smelter design firm and dispersion modeling experts to work in partnership to develop a SO_2 emission reduction strategy for the FMMI Smelter. This partnership began by identifying design changes to reduce SO_2 emissions and obtaining air quality permits to timely authorize those changes such that the Miami area would meet the 1-hour SO_2 NAAQS attainment compliance deadline.

The initial step in the iterative design process was to identify a dispersion model that could model both roof vents and point sources (stacks) in complex terrain. Working closely with ADEQ, several modeling tools were investigated. After an examination of model performance and acceptability, FMMI and ADEQ determined that the "AERMOD/BLP Hybrid" modeling approach would provide the most representative simulation of ambient concentrations resulting from FMMI facility emissions[14].

The modeling staff then worked closely with the engineering design staff to identify emission levels that demonstrate compliance with the 1-hour SO_2 NAAQS. The modeling results and emission levels were used by the engineering team to develop facility designs that might meet the emissions and modeling criteria. Because engineering designs involved building, stack, and equipment changes, which included evaluations of different stack locations, heights, and exhaust parameters, additional model runs were performed at each step to evaluate the effect of the proposed engineering design changes and to identify alternatives if the proposed engineering designs did not meet the 1-hour SO_2 NAAQS. This process was repeated, resulting in several hundred dispersion modeling analyses, with a final result identifying an engineering design that also modeled compliance with the 1-hour SO_2 NAAQS. During this period, revisions to AERMOD and AERMET were released and the updated model performance had to be considered.

The coupled design/modeling process resulted in a proposed smelter configuration that will reduce facility-wide SO_2 emissions and bring the Miami area into attainment with the 1-hour SO_2 NAAQS while allowing for an increase in allowable smelter throughput. The proposed changes were authorized via a significant revision to FMMI's Class I air permit on July 21, 2014, and in part included:

- Increase of operational flexibility via authorization of 1,000,000 dry tons per year of New Metal Bearing Material (NMBM) throughput capacity;
- Increase of Acid Plant capacity to accommodate the authorized concentrate throughput capacity (i.e., upgraded cooling system, new converter bed, new blower, and new SO_3 cooler);
- Replacement of the existing IsaSmelt® furnace and upgrades of furnace feed, cooling and emissions control systems (i.e., lance seal, feed port hood, and tapping hood controls);
- Upgrade of the electric furnace emissions control system (i.e., tapping hood controls);
- Upgrade of the converters emissions control system (i.e., reconfiguring the roofline to capture emissions and route them to a new Aisle Scrubber including stack);
- Upgrade of the anode furnaces and utility vessel (also known as a mold barrel) emissions control system (i.e., process gas collection system, mouth covers, replacement of utility vessel, new baghouse ducted to the new Aisle Scrubber, new hydrated lime silo, and new baghouse dust return system to the electric furnace);
- Upgrade of the Vent Fume Scrubber and Acid Plant Tail Gas Scrubber to caustic use;
- Addition of two new Wet Electrostatic Precipitator (WESP) modules at the vent fume control system; Increase of the height of the Vent Fume Stack and Tail Gas Stack; and
- Other ancillary facility changes.

Beginning in 2014, ADEQ with assistance from FMMI, began developing the 1-hour SO_2 SIP for the Miami SO_2 Nonattainment Area. Starting with the emission controls developed for the significant permit revision, FMMI and their contractors reanalyzed the proposed smelter design using EPA's SO_2 Nonattainment Area

[14] The details of this approach are set forth in FMMI's August 11, 2015 Technical Memorandum included in the TSD and titled "Performance Evaluation Modeling Results for the Miami SO2 Nonattainment Area State Implementation Plan (SIP)".

SIP Guidance and incorporating the most recently approved versions of the AERMOD and AERMET models along with a more recent 3-year meteorological dataset covering the second quarter of 2010 through the first quarter of 2013. The analysis resulted in FMMI proposing controls on Bypass Stack emissions that had not been previously included in the permitted control strategy. The control strategy proposed in the TSD represents the culmination of a considerable amount of iterative engineering analysis performed for the permitting and SIP processes.

8.1 Proposed SO_2 Control Levels

As discussed above and also in Section 5-1, to address the revised 1-hour SO_2 NAAQS, FMMI will undertake a significant project to upgrade the Miami Smelter that will result in SO_2 emissions reduction. To demonstrate compliance with the NAAQS, FMMI proposed SO_2 emissions reduction for each source. The proposed SO_2 control efficiencies necessary to achieve the SO_2 emissions reduction are summarized in Table 8-1.

Table 8-1: Proposed SO_2 Control Levels

Source	SO_2 Control Efficiency	Comment
Acid Plant Tail Gas Stack	99.6% [15]	When inlet SO_2 concentration is greater than 500 ppm
	2 ppm	When inlet concentration is between 2-500 ppm
Vent Fume Stack	95.8% [15]	When inlet SO_2 concentration is greater than 95 ppm
	4 ppm	When inlet concentration is between 4-95 ppm
Aisle Scrubber Stack-Normal Operations	93.6% [15]	When inlet SO_2 concentration is greater than 16 ppm
	1 ppm	When inlet concentration is between 1-16 ppm
Aisle Scrubber Stack-Bypass Operations	34.5% [16]	When inlet SO_2 concentration is greater than 1.53 ppm
	1 ppm	When inlet concentration is between 1-1.53 ppm
Isa Roof Vent	55%	SO_2 emissions reduction of 55%
ELF Roof Vent	0%	SO_2 emissions are projected to remain unchanged due to system improvements
Converter Roof Vent	91% (capture only)	SO_2 emissions capture of 91% by Aisle Scrubber system. Control efficiency is addressed for the Aisle Scrubber as noted above.
Anode Roof Vent	93% (capture only)	SO_2 emissions capture of 93% by Aisle Scrubber system. Control efficiency is addressed for the Aisle Scrubber as noted above.
Bypass Stack	100% (capture only)	SO_2 emissions capture of 100% by Aisle Scrubber system. Control efficiency is addressed for the Aisle Scrubber as noted above.

[15] For the APTGS and VFS, which are existing units, the effective control efficiency is calculated from the future and existing PTE. For the Aisle Scrubber, which is a future unit, the effective control efficiency is calculated from the scrubber inlet loading and future PTE.

[16] The control efficiency of 34.5% for bypass operation was deemed necessary to meet the procedures provided in Appendices B and C of EPA's SO_2 Nonattainment SIP Guidance. The analysis presented in Appendix G of the TSD demonstrates that such a reduction can be achieved.

SO_2 capture or removal efficiencies were calculated based on engineering design and professional judgments. More details on SO_2 emissions calculation basis and also SO_2 capture and removal efficiencies are provided in the Hatch Memo which is included in Appendix F. Appendix G also includes information on emissions calculations and capture/removal efficiency during bypass events, which was provided by Gas Cleaning Technologies (GCT).

8.2 Proposed Future Emissions

FMMI used the actual hourly SO_2 data from continuous emissions monitoring system (CEMS) from May 2013 through October 2014 as representative emissions distributions for the Smelter's future configuration. An hourly emissions profile was developed based on engineering design concentrations. The magnitude of future emissions were based on these data records and adjusted to reflect both increased production capacity and future emissions control efficiencies required to demonstrate compliance with the NAAQS.

The future maximum potential SO_2 emission rates for the sources listed in table 8-1 result from the proposed modifications and are provided in Table 8-2. Two different emission rates are presented for the Aisle Scrubber Stack. The first represents emissions during normal smelter operations while the second represents emissions during Acid Plant bypass operations.

Table 8-2: Future Smelter SO_2 Emissions after Additional Controls

Source	SO_2 Emissions (lb/hr)
Acid Plant Tail Gas Stack	3.2 [17]
Vent Fume Stack	13.0 [17]
Aisle Scrubber Stack- Normal Operations	14.3 [17]
Aisle Scrubber Stack- Bypass Operations	275.0
Isa Roof Vent	31.8 [18]
ELF Roof Vent	14.2 [18]
Converter Roof Vent	25.6 [18]
Anode Roof Vent	8.0 [18]

The future SO_2 emissions sources at the Smelter that will remain at their existing level of control were also identified. These sources and their future maximum potential SO_2 emission rates are presented in Table 8-3.

[17] Future PTE for SO_2 provided by the engineering contractor (Hatch) for the proposed project, based on potential NMBM throughput.

[18] The Future PTE listed for the roofline vents is based on existing PTE from the 2012 roofline vent study. Subsequent continuous monitoring of the roofline vents has shown the 2012 roofline vent study to be a conservative representation of average actual emissions from the vents. For example, the 18-month continuous monitoring data set for the roofline vents includes the following average emissions: Isa = 31.1 lb/hr, ELF = 10.3 lb/hr, Converters = 117.1 lb/hr, and Anode = 58.6 lb/hr. Given these values, the 2012 roofline vent study serves as an appropriate and conservative representation of existing and future PTE from these vents.

Table 8-3: Future Smelter SO_2 Emissions Remaining at Existing Level of Control

Source	SO_2 Emissions (lb/hr)
Acid Plant Preheater	0.0198
Isa Auxiliary Boiler	0.00612
Change Room Water Heater	0.000437
Rod Plant Thermal Breaker	0.000456
Rod Plant Shaft Furnace	0.350
Screening Engine	0.00102
Compressor	0.00655
Compressor	0.00655
Rod Plant Roof Vent	0.0129
Smelter Building Leaks	3.98
Slag Storage Area	3.75
ISA emergency generator	0.001764
Smelter Emergency Generator	0.000513
Emergency Water Pump	0.000615
Main Server Emergency Generator	0.000205
Moonshine Hill Emergency Generator	0.000717
Smelter Guard House Emergency Generator	0.000041
Communications Office Emergency Generator	0.000102
Radio Tower Emergency Generator	0.001764
Hood Emergency Pump	0.002600

8.3 Identifying the Critical Emission Value

As mentioned in Section 5.3, the sources associated with the Miami Smelter have highly variable SO_2 emission rates due to a combination of both continuous and batch processes. EPA's Guidance for 1-Hour SO_2 Nonattainment Area SIP Submission (EPA, 2014) provides for the consideration of emission limit averaging periods as long as 30 days for sources with highly variable emission rates where hourly emission rates occasionally exceed the critical emission value (CEV) rate. ADEQ believes that a 30-day emission limit will similarly assure NAAQS attainment while accommodating the high variability of emissions.

FMMI followed the approach set forth in Appendix B and C of EPA's Guidance for 1-Hour SO_2 Nonattainment Area SIP Submission (EPA, 2014) to determine the longer term average emission limits. The guidance defines the critical emission value (CEV) as "…the hourly emission rate that the model predicts would result in the 5-year average of the annual 99th percentile of daily maximum hourly SO_2 concentrations at the level of the 1-hour NAAQS, given representative meteorological data for the area." To determine the critical emission value, the guidance requires conducting dispersion modeling.

The calculation of a critical emissions value for a facility with a single SO_2 emission source is not a challenging task, because the predicted design value is proportional to the modeled emission rate. However, a complex facility such as the Miami Smelter, with seven future emissions sources of consequence, requires an iterative approach. The effectiveness and cost of controlling each of the SO_2 emissions sources varies greatly, and the iterative approach must be performed to optimize the control cost required to achieve attainment.

The emission rates listed in Tables 8-2 and 8-3, along with other dispersion model inputs described in Section 4, were input to the BLP/AERMOD Hybrid model to verify that the model predicted an average of the annual 99th percentile of daily maximum hourly concentrations at the level of the 1-hour NAAQS. The resulting predicted design concentration was 172.9 µg/m^3, just within the available air quality concentration of 174.8 µg/m^3. Available air quality in the Miami nonattainment area is the difference between the NAAQS (196 µg/m$_3$) and background air quality (21.2 µg/m$_3$), or 174.8 µg/m$_3$.

Based on the dispersion model results, the facility-wide critical emissions value is the sum of the emissions presented in Tables 8-2 and 8-3, or 393 lb/hr. Appendix H presents more details on identifying the facility-wide CEV, which was provided by FMMI.

FMMI will operate nine (9) emergency generators at the Miami Smelter once the proposed Smelter modifications are operational. These engines are subject to permitted restrictions on annual operating hours (i.e., 50 hours per year for non-emergency situations and 100 hour per year total for non-emergency situations, maintenance checks and readiness testing, and emergency demand response)[19]. The engines are run on a weekly maintenance schedule, for no more than an hour at a time, to ensure unit reliability. Based on EPA guidance (EPA's September 6, 1995 Memorandum "Calculating Potential to Emit (PTE) for Emergency Generators"), potential to emit (PTE) is based on the assumption that an emergency engine could be expected to operate no more than 500 hours per year under worst-case conditions.

Given the nature of the emergency engines as intermittent emission sources, they were initially excluded from the modeling consistent with EPA's March 1, 2011, Memorandum, "Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard" ("2011 Memo") because emissions from the engines are not continuous enough or frequent enough to contribute significantly to the annual distribution of daily maximum 1-hour concentrations.

As suggested by EPA, FMMI has included these engines in the modeling analysis of the Critical Emissions Value (CEV) by assuming continuous operation at the average hourly rate (i.e., the maximum hourly rate multiplied by 500/8760), consistent with the alternative approach identified in the 2011 Memo. The emergency engines were added to the "fixed" emission sources that FMMI has accounted for in the modeling by assuming constant operation at their respective potential to emit rates. As explained in our March 30, 2016, Technical Memorandum "Contribution of Fixed Emission Sources to CEV Modeling Results Miami SO_2 Nonattainment Area State Implementation Plan (SIP)," the model-predicted SO_2 emission levels associated with these fixed sources, including the emergency engines, are insignificant contributors to the model-predicted concentrations that define the CEV. Because the contribution of the emergency engines is negligible, the emergency engines were included only in the CEV modeling analysis and not in the balance of dispersion modeling performed for the TSD.

EPA requested a contour map of BLP-AERMOD hybrid predicted Design Value concentrations to show the distribution of Design Value concentrations pre- and post-control. Figure 8-2 provides a set of design value isopleths for the post-control CEV case. Pre-control modeling was not performed for the SO_2 SIP attainment demonstration modeling and therefore a set of isopleths for the pre-control CEV case are not available.

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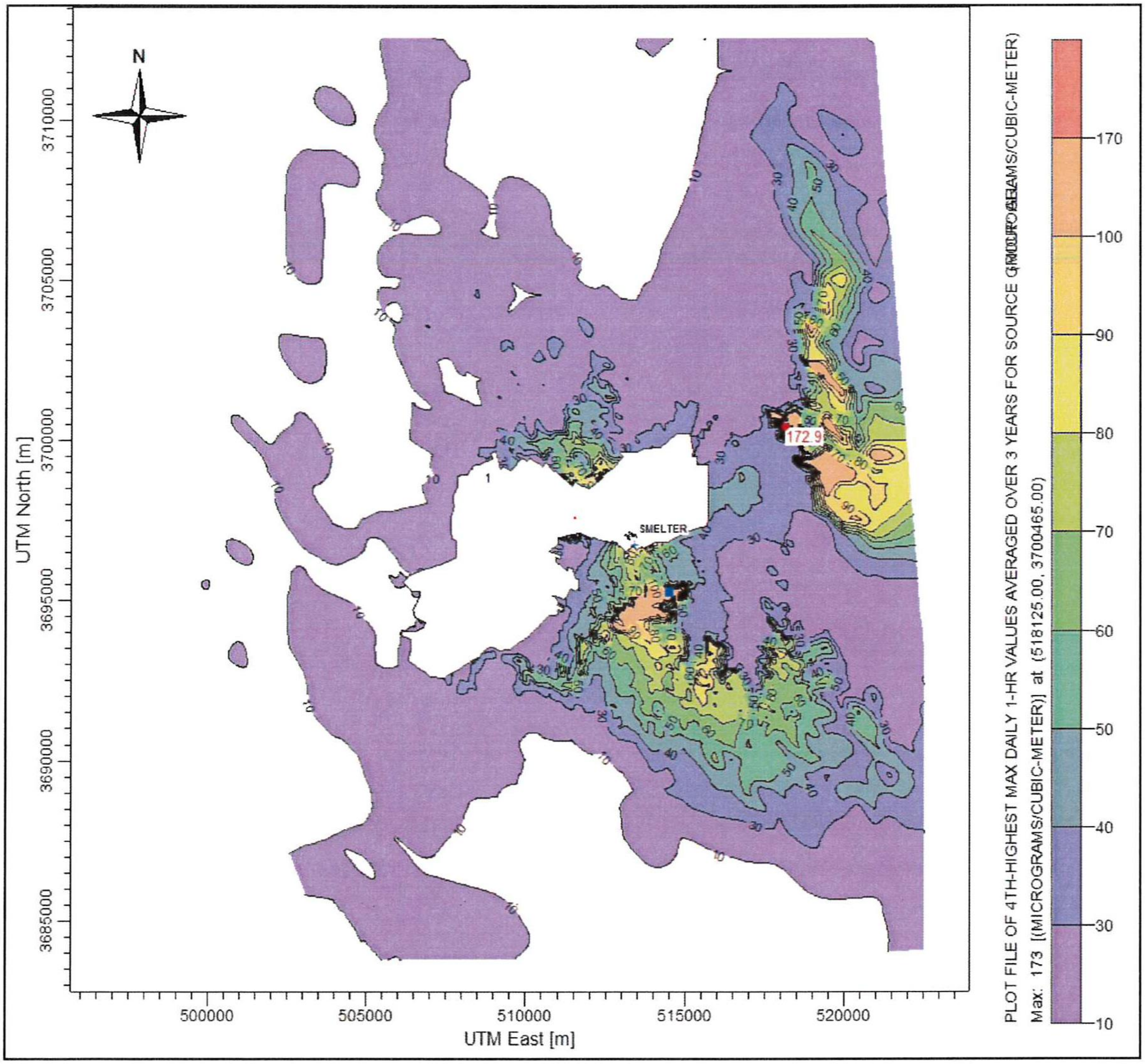
[19] Air Quality Class I Permit No. 53592, as amended by Significant Revision No. 58409 and issued on July 21, 2014.

Figure 8-2: Isopleths of Predicted Design Value SO_2 Concentrations, CEV Case



8.4 Emission Limits

The Following steps present the procedure defined in EPA's Guidance for establishing an emission limit for a longer than 1-hour averaging period:

Step 1: Identify the CEV

As described in Section 8.3 a facility-wide CEV of 393 lb/hr was determined using BLP/AERMOD Hybrid modeling.

Step 2: Compile future emissions profile

FMMI prepared an hourly emissions profile to reflect its emissions after the implementation of the Smelter upgrade projects based on engineering design calculations. The development of this emissions profile is described in Section 8.2 and Appendix G.

Step 3: Use the distribution of hourly emissions data obtained in step 2 to compute a corresponding distribution of longer term emission average

FMMI calculated average emissions for 3-hour, 24-hour, 7-day, 30-day, and 365-day. Based on analysis, the 3-hour, 24-hour and 7-day averaging periods were not sufficient to address emissions variability from the source.

Step 4: Calculate the 99^{th} percentile values

In this step the 99^{th} percentile of the 1-hour average emission values (compiled in step 2) and the 99^{th} percentile of the averaged values (compiled in step 3) were determined and presented in Table 8-4.

Table 8-4: 99^{th} Percentile Values of Emission Rates

Averaging Period	99^{th} Percentile of Emission Rate (lb/hr)
1-hour	276.69
3-hour	231.15
24-hour	226.20
7-day	141.13
30-day	102.40
365-day	71.58

Step 5: Calculate the ratio of the longer term average times to the 1-hour 99th Percentile

Table 8-5 shows the ratio of the longer term averaging period's 99th percentile emission rates to the 1-hour 99th percentile emission rate.

Table 8-5: Ratio of Longer Term Averaging Period to 1-hr 99th Percentile

Averaging Period	99th Percentile of Emission Rate (lb/hr)	Ratio of 99th Percentile Emission Rate to 1-hr Percentile Emission Rate
3-hour	231.15	0.84
24-hour	226.20	0.82
7-day	141.13	0.51
30-day	102.40	0.37
365-day	71.58	0.26

Step 6: Multiply the ratio by the CEV to determine the final limit

The final step in EPA's Guidance is to multiply the ratio of the 99th percentile emission rate for each averaging period to the 1-hr 99th percentile emission rate (CEV) to calculate a limit for each averaging period. The results of this step are presented in Table 8-6.

Table 8-6: Calculation of Emission Limits for Longer Term Averaging Periods

Averaging Period	Ratio of 99th Percentile Emission Rate to 1-hr 99th Percentile Emission Rate	Emission Limit (lb/hr) Product of Ratio and CEV
3-hour	0.84	328.24
24-hour	0.82	321.21
7-day	0.51	200.41
30-day	0.37	145.41
365-day	0.26	101.64

Once the emission limits were identified, the proposed limits were compared against the projected emissions distributions to determine if a proposed emissions limit would be exceeded based on its anticipated emissions profile. This analysis was performed for 12,043 total hours in proposed emission profile and is summarized in table 8-7.

Table 8-7: Exceedance Risk for Proposed Longer Term Average Limits

Averaging Period	Calculated Emissions Limit (lb/hr)	Number of Hours Exceeding Emissions Limit	Expected Frequency of Deviations
1-hour	387.0	60	0.50%
3-hour	323.23	63	0.52%
24-hour	316.31	39	0.32%
7-day	197.35	0	0.00%
30-day	143.19	0	0.00%
365-day	100.09	0	0.00%

As shown in Table 8-7, attainment with the 1-hour SO_2 NAAQS can be demonstrated using EPA's long-term emissions limit approach when the emissions limit is based on a the 30-day averaging period. ADEQ recommends the use of a 30-day limit to address the complexity and variability of emissions at the Miami Smelter.

8.5 Supporting Modeling to Demonstrate Attainment

A modeling analysis was performed on the projected future actual 1-hour emissions to demonstrate that the Miami NAA would be in compliance with the NAAQS with the proposed 30-day rolling hourly emission limit.

The modeling analysis aligned the projected future hourly emissions, which were based on the aforementioned existing measurements of hourly emissions from May 2013 through October 2014, with on-site meteorological data that were measured concurrently with the existing measurements of hourly emissions.

The hybrid BLP/AERMOD modeling approach was used consistent with the CEV modeling approach. MPRM and AERMET were run to create 2013 and 2014 hourly meteorological files for use in BLP and AERMOD, respectively. The hourly meteorological data were concurrent with the hourly emissions monitoring data.

The hourly roof vent plume heights were determined by running BLP with the 2013 and 2014 met data. The hourly roof vent plume heights along with the hourly controlled emission rates for all sources were combined into a single AERMOD compatible hourly emission rate file. AERMOD was then run to predict the design concentration at each receptor in the grid. The results at the worst-case receptor (165.2 $\mu g/m^3$) were summed with the background concentration of 21.2 $\mu g/m^3$ and resulted in a concentration of 186.3 $\mu g/m^3$ which is below the SO_2 NAAQS of 196 $\mu g/m^3$. The modeling files for this modeling run are provided on the CD.

8.6 Sensitivity of the CEV to the Variations of Predicted SO_2 Concentrations

A sensitivity analysis was performed by FMMI to demonstrate that the facility-wide CEV represents an appropriate emission rate that demonstrates compliance with the 1-hour SO_2 NAAQS even when there may be variations in the precise sources (which may affect the distribution of emissions leading to differences in emission locations, release heights, and other source parameters) at the Smelter. In other words, the purpose of this technical analysis was to demonstrate that the current facility-wide CEV is a robust value that is not sensitive to changes in the allocation of SO_2 emissions among sources within the Smelter.

FMMI evaluated the effect of varying individual source emissions while keeping the facility-wide emissions consistent. To do so, FMMI increased a single source and decreased the other major emission sources by a weighted amount, such that the CEV remained constant.

In each scenario, one individual source's emission rate was increased while the emissions from the remaining major emission sources were decreased by a proportional amount to ensure the facility-wide CEV remained constant. As a result, each source combination maintained the total emission rate constant at the facility-wide CEV of 393 lb/hr while varying the individual source rates.

The sensitivity analysis predicted concentrations that are within 1.0% of the CEV modeled design value concentration. The variation in predicted concentrations is very small when compared to the 20.8% variation in emission rates applied to the various sources for the purposes of the sensitivity analysis. Based on these results, a single facility-wide emission limit based on the CEV is appropriate for the Miami Smelter. More details on this sensitivity analysis are provided in Appendix I.

8.7 CEV Exceedance Risk Analysis

FMMI performed an analysis of the potential risk of exceeding the SO_2 NAAQS based on the proposed future configuration of the Smelter.

Because of the variability of the emission rates from the larger sources, an additional analysis was conducted to show, per EPA's SO_2 Nonattainment Area SIP Guidance (EPA, 2014), that periods of hourly emissions greater than the CEV are a rare occurrence at the source, and these periods would be unlikely to have a significant impact on air quality, insofar as they would be very unlikely to occur repeatedly at the times when the meteorology is conducive for high ambient concentrations of SO_2.

The approach entailed using the 18-month data set of projected future actual emissions paired randomly with an alternative on-site meteorological data set consisting of 3 years of hourly observations from January 2011 through December 2013 in such a way to represent 300 years of modeling (100 runs). The results indicated that for all of the 100 runs, the predicted design concentration was less than the target concentration of 174.8 $\mu g/m^3$. These results indicate that compliance with the NAAQS is predicted based on the proposed 30-day limit.

More details on the methodology and results of this analysis are included in Appendix J of this TSD.

8.8 Proposed CEV and 30-Day Emission Limit

FMMI performed an analysis of the contribution of the emissions sources listed in Table 8-3 to the model-predicted design concentrations associated with the CEV. This analysis is presented in Appendix K of this TSD. The analysis determined that the Table 8-3 emissions sources are insignificant contributors to the predicted CEV design concentration. Because the CEV presented in Section 8.3 of 393 lb/hr includes a maximum of 8 lb/hr associated with the Table 8-3 sources operating at their maximum capacity, FMMI is proposing a CEV of 385 lb/hr (i.e., 393 lb/hr minus 8 lb/hr) that applies specifically to the following emissions sources:

- Acid Plant Tail Gas Stack
- Vent Fume Stack
- Aisle Scrubber Stack (normal operations)
- Aisle Scrubber Stack (bypass operations)
- IsaSmelt® Roof Vent
- Electric Furnace (ELF) Roof Vent
- Converter Aisle Roof Vent
- Anode Aisle Roof Vent

The 30-day rolling hourly emission limit that applies specifically to these eight Table 8-2 sources is then derived in the same way as that presented in Section 8.4. The resulting 30-day emission limit is 142.45 lb/hr. By adopting this approach, compliance with the 30-day rolling hourly emissions limit is demonstrated by direct measurement of emissions from the eight Table 8-2 sources via continuous emissions monitoring. Table 8-3 emissions sources are already accounted for and therefore not included in that compliance demonstration.

9.0 References

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10.0 Appendices

10.1 Appendix A: Modeling TSD CD-ROM

Table 10-1: CD-ROM Table of Contents

Folder or File Name	Descriptions
\AERMAP\Receptors	
SIP_fittedgrid.api	AERMAP Input File
SIP_fittedgrid.ast	AERMAP Output File
SIP_FITTEDGRID.ROU	AERMAP Receptor Elevation File
MAPDETAIL.OUT	AERMAP Output File
NED_84304396.tif	NED 10-meter File
CurrentSRC.api	AERMAP Input File
CurrentSRC.AST	AERMAP Output File
CurrentSRC.SOU	AERMAP Source Elevation File
FMI1_1.dem	Onsite DEM file created from CAD File
FMI2_1.dem	Onsite DEM file created from CAD File

\AERMET	
10-13fn.PFL	AERMET Profile file (unshifted)
11-13fnc14.PFL	AERMET Profile file (shifted)
11-13fnc14.SFC	AERMET Surface file (shifted)
13-14actual.PFL	AERMET 2013-2014 Profile file for performance evaluation
13-14actual.SFC	AERMET 2013-2014 Surface file for performance evaluation
13fnc14_shift.PFL	2013 AERMET Profile file with 2010 data subbed in
13fnc14_shift.SFC	2013 AERMET Surface file with 2010 data subbed in
2010fnc14.IN1	2010 Stage 1 input file
2010fnc14.IN2	2010 Stage 2 input file
2010fnc14.IN3	2010 Stage 3 input file
2010FN.MG1	2010 AERMET Stage 1 Message File
2010FN.MG2	2010 AERMET Stage 2 Message File
2010FN.MG3	2010 AERMET Stage 3 Message File
2010FN.MRG	2010 AERMET Merge File
2010FNC.OQA	2010 Onsite QA file
2010fnc14.PFL	2010 AERMET Profile file
2010FN.RP1	2010 Stage 1 Report file
2010FN.RP2	2010 Stage 2 Report file
2010FN.RP3	2010 Stage 3 Report file
2010FN.SAX	2010 Surface Intermediate File
2010fnc14.SFC	2010 AERMET Surface File
2010FN.SQA	2010 Surface QA file
2010FN.UAX	2010 Upper Air Intermediate File
2010FN.UQA	2010 Upper Air QA file
2011fnc14.IN1	2011 Stage 1 input file

Folder or File Name	Descriptions
2011fnc14.IN2	2011 Stage 2 input file
2011fnc14.IN3	2011 Stage 3 input file
2011FN.MG1	2011 AERMET Stage 1 Message File
2011FN.MG2	2011 AERMET Stage 2 Message File
2011FN.MG3	2011 AERMET Stage 3 Message File
2011FN.MRG	2011 AERMET Merge File
2011FN.OQA	2011 Onsite QA file
2011fnc14.PFL	2011 AERMET Profile file
2011FNC14.RP1	2011 Stage 1 Report file
2011FNC14.RP2	2011 Stage 2 Report file
2011FNC14.RP3	2011 Stage 3 Report file
2011FN.SAX	2011 Surface Intermediate File
2011fn.SFC	2011 AERMET Surface File
2011FN.SQA	2011 Surface QA file
2011FN.UAX	2011 Upper Air Intermediate File
2011FN.UQA	2011 Upper Air QA file
2012fnc14.IN1	2012 Stage 1 input file
2012fnc14.IN2	2012 Stage 2 input file
2012fnc14.IN3	2012 Stage 3 input file
2012FN.MG1	2012 AERMET Stage 1 Message File
2012FN.MG2	2012 AERMET Stage 2 Message File
2012FN.MG3	2012 AERMET Stage 3 Message File
2012FN.MRG	2012 AERMET Merge File
2012FN.OQA	2012 Onsite QA file
2012fnc14.PFL	2012 AERMET Profile file
2012FNC14.RP1	2012 Stage 1 Report file
2012FNC14.RP2	2012 Stage 2 Report file
2012FNC14.RP3	2012 Stage 3 Report file
2012FN.SAX	2012 Surface Intermediate File
2012fnc14.SFC	2012 AERMET Surface File
2012FN.SQA	2012 Surface QA file
2012FN.UAX	2012 Upper Air Intermediate File
2012FN.UQA	2012 Upper Air QA file
2013fnc14.IN1	2013 Stage 1 input file
2013fnc14.IN2	2013 Stage 2 input file
2013fnc14.IN3	2013 Stage 3 input file
2013FN.MG1	2013 AERMET Stage 1 Message File
2013FN.MG2	2013 AERMET Stage 2 Message File
2013FN.MG3	2013 AERMET Stage 3 Message File
2013FN.MRG	2013 AERMET Merge File
2013FN.OQA	2013 Onsite QA file
2013fnc14.PFL	2013 AERMET Profile file

Folder or File Name	Descriptions
2013FNC14.RP1	2013 Stage 1 Report file
2013FNC14.RP2	2013 Stage 2 Report file
2013FNC14.RP3	2013 Stage 3 Report file
2013FN.SAX	2013 Surface Intermediate File
2013fnc14.SFC	2013 AERMET Surface File
2013FN.SQA	2013 Surface QA file
2013FN.UAX	2013 Upper Air Intermediate File
2013FN.UQA	2013 Upper Air QA file
2014fnc14.IN1	2014 Stage 1 input file
2014fnc14.IN2	2014 Stage 2 input file
2014fnc14.IN3	2014 Stage 3 input file
2014FN.MG1	2014 AERMET Stage 1 Message File
2014FN.MG2	2014 AERMET Stage 2 Message File
2014FN.MG3	2014 AERMET Stage 3 Message File
2014FN.MRG	2014 AERMET Merge File
2014FN.OQA	2014 Onsite QA file
2014fnc14.PFL	2014 AERMET Profile file
2014FNC14.RP1	2014 Stage 1 Report file
2014FNC14.RP2	2014 Stage 2 Report file
2014FNC14.RP3	2014 Stage 3 Report file
2014FN.SAX	2014 Surface Intermediate File
2014fnc14.SFC	2014 AERMET Surface File
2014FN.SQA	2014 Surface QA file
2014FN.UAX	2014 Upper Air Intermediate File
2014FN.UQA	2014 Upper Air QA file
allonsite-fixed(20140714).prn	Onsite Meteorology Input File with Missing Data Flags
AERSURFACE.INP	AERSURFACE input file
AERSURFACE.OUT	AERSURFACE output file
\BLP_code	
BLP-markup.docx	MS Word File Highlighting Code Changes
BLPgfortMH2.FOR	Modified BLP FORTRAN file

\MetData\Onsite	
14TWRJRCM.prn	2014 Merged Tower and Jones Ranch File
2014TWRJRCOMBO.xlsx	2014 MS EXCEL
TWRJRCOMBO.prn	2010-2013 Merged Tower and Jones Ranch File
TWRJRCOMBO.xlsx	2010-2013 MS EXCEL Merged Tower and Jones Ranch File

\MetData\Onsite\JonesRanch	
09-13allJR-fixed.prn	2009 - 2013 Jones Ranch Meteorological Data
09-13HRLYJR.xlsx	2009 - 2013 Jones Ranch Hourly Meteorological Data
09-13JR-fixed.prn	2009-2013 output from EXCEL file

Folder or File Name	Descriptions
09-13JR.inp	AERMET stage 1 file to determine hourly averages of onsite data
09-13JR.MG1	AERMET stage 1 merged file (not used)
09-13JR.OQA	AERMET stage 1 onsite QA file
09-13JR.RP1	AERMET stage 1 report file
14JR.MG1	AERMET 2014 stage 1 merged file (not used)
14JR.OQA	AERMET 2014 stage 1 onsite QA file
14JR.RP1	AERMET 2014 stage 1 report file
2009JR.xlsx	2009 Jones Ranch Meteorological Data
2010JR.xlsx	2010 Jones Ranch Meteorological Data
2011JR.xlsx	2011 Jones Ranch Meteorological Data
2012JR.xlsx	2012 Jones Ranch Meteorological Data
2013JR.xlsx	2013 Jones Ranch Meteorological Data
2014JR-HRLY.xlsx	2014 Jones Ranch Meteorological Data
Jones Ranch data January-April 2014.xlsx	2014 Jones Ranch Raw Meteorological Data

\MetData\Onsite\Tower	
09-13f.OQA	AERMET Stage 1 Onsite QA file
09-13onsite(20140714).prn	2009 -2013 Onsite Meteorological File
2009Tower.xlsx	2009 Raw Onsite Meteorological File
2010tower.xls	2010 Raw Onsite Meteorological File
2011tower.xlsx	2011 Raw Onsite Meteorological File
2012tower.xlsx	2012 Raw Onsite Meteorological File
2013Tower.xlsx	2013 Raw Onsite Meteorological File
2014F.OQA	AERMET 2014 Stage 1 Onsite QA File
2014onsite.prn	2014 Onsite Meteorological File
2014Tower.xlsx	2014 Onsite Meteorological File
2014TWR_HRLY.xlsx	2014 Onsite Hourly Meteorological File
allonsite-fixed(20140714).prn	2009 -2013 Onsite Meteorological File
allonsite-fixed.xlsx	2009 -2013 Onsite Meteorological File

\MetData\Surface	
09-13bsaf.xlsx	Safford Surface Meteorological Data
09-13f.SAX	AERMET Safford Surface Meteorological Hourly File
09-13safford.sam	SAMSON formatted Safford Meteorological File
14dm.xlsx	2014 Davis Monthan Meteorological File
14Tucson.sam	2014 Samson Formatted Tucson Meteorological File
14Tucson.xlsx	2014 Meteorological Data
2014F.SAX	2014 AERMET Safford Surface Meteorological Hourly File
2014TWRJRCOMBO.xlsx	2014 Combined Tower / Jones Ranch Meteorological Data
2014_saf.sam	2014 Safford Samson Formatted Meteorological File
2014_saf.xlsx	2014 Safford Meteorological File

Folder or File Name	Descriptions
722740-23160-2009.ISH	ISH formatted Meteorological Data
722740-23160-2010.ISH	ISH formatted Meteorological Data
722740-23160-2011.ISH	ISH formatted Meteorological Data
722740-23160-2012.ISH	ISH formatted Meteorological Data
722740-23160-2013.ISH	ISH formatted Meteorological Data
722745-23109-2014.ISH	ISH formatted Meteorological Data
722747-93084-2009.ISH	ISH formatted Meteorological Data
722747-93084-2010.ISH	ISH formatted Meteorological Data
722747-93084-2011.ISH	ISH formatted Meteorological Data
722747-93084-2012.ISH	ISH formatted Meteorological Data
722747-93084-2013.ISH	ISH formatted Meteorological Data
722747-93084-2014.ISH	ISH formatted Meteorological Data
Tucson.sam	Samson Formatted Tucson Meteorological File
TUCSON.SAX	AERMET Tucson Surface Meteorological Hourly File
Tucson.xlsx	Tucson Meteorological Data
Tucsub.sam	Tucson Meteorological Data - Substituted

\MetData\UpperAir	
10-13Tuc_new.FSL	2010-2013 Tucson FSL file in New Format
10-13Tuc_old.FSL	2010-2013 Tucson FSL file in Old Format
2010Tuc(UW).FSL	2010-2013 Tucson FSL file in New Format
2010Tuc_old.FSL	2010-2013 Tucson FSL file in Old Format
2011Tuc(UW).FSL	2010-2013 Tucson FSL file in New Format
2011Tuc_old.FSL	2010-2013 Tucson FSL file in Old Format
2012Tuc(UW).FSL	2010-2013 Tucson FSL file in New Format
2012Tuc_old.FSL	2010-2013 Tucson FSL file in Old Format
2013Tuc(UW).FSL	2010-2013 Tucson FSL file in New Format
2013Tuc_old.fsl	2010-2013 Tucson FSL file in Old Format
2014Tuc(UW).FSL	2010-2013 Tucson FSL file in New Format
2014Tuc_old.FSL	2010-2013 Tucson FSL file in Old Format
TXTtoFSLnew.F90	FORTRAN Source Code to Reformat Upper Air Data
TXTtoFSL_old.F90	FORTRAN Source Code to Reformat Upper Air Data

\MetData\UpperAir\RawData	
Apr2010Tuc.txt	Raw Upper Air Data from University of Wyoming
Apr2011Tuc.txt	Raw Upper Air Data from University of Wyoming
Apr2012Tuc.txt	Raw Upper Air Data from University of Wyoming
Apr2013Tuc.txt	Raw Upper Air Data from University of Wyoming
Apr2014Tuc.txt	Raw Upper Air Data from University of Wyoming
Aug2010Tuc.txt	Raw Upper Air Data from University of Wyoming
Aug2011Tuc.txt	Raw Upper Air Data from University of Wyoming
Aug2012Tuc.txt	Raw Upper Air Data from University of Wyoming

Folder or File Name	Descriptions
Aug2013Tuc.txt	Raw Upper Air Data from University of Wyoming
Dec2010Tuc.txt	Raw Upper Air Data from University of Wyoming
Dec2011Tuc.txt	Raw Upper Air Data from University of Wyoming
Dec2012Tuc.txt	Raw Upper Air Data from University of Wyoming
Dec2013Tuc.txt	Raw Upper Air Data from University of Wyoming
Feb2010Tuc.txt	Raw Upper Air Data from University of Wyoming
Feb2011Tuc.txt	Raw Upper Air Data from University of Wyoming
Feb2012Tuc.txt	Raw Upper Air Data from University of Wyoming
Feb2013Tuc.txt	Raw Upper Air Data from University of Wyoming
Feb2014Tuc.txt	Raw Upper Air Data from University of Wyoming
Jan2010Tuc.txt	Raw Upper Air Data from University of Wyoming
Jan2011Tuc.txt	Raw Upper Air Data from University of Wyoming
Jan2012Tuc.txt	Raw Upper Air Data from University of Wyoming
Jan2013Tuc.txt	Raw Upper Air Data from University of Wyoming
Jan2014Tuc.txt	Raw Upper Air Data from University of Wyoming
Jul2010Tuc.txt	Raw Upper Air Data from University of Wyoming
Jul2011Tuc.txt	Raw Upper Air Data from University of Wyoming
Jul2012Tuc.txt	Raw Upper Air Data from University of Wyoming
Jul2013Tuc.txt	Raw Upper Air Data from University of Wyoming
Jun2010Tuc.txt	Raw Upper Air Data from University of Wyoming
Jun2011Tuc.txt	Raw Upper Air Data from University of Wyoming
Jun2012Tuc.txt	Raw Upper Air Data from University of Wyoming
Jun2013Tuc.txt	Raw Upper Air Data from University of Wyoming
Mar2010Tuc.txt	Raw Upper Air Data from University of Wyoming
Mar2011Tuc.txt	Raw Upper Air Data from University of Wyoming
Mar2012Tuc.txt	Raw Upper Air Data from University of Wyoming
Mar2013Tuc.txt	Raw Upper Air Data from University of Wyoming
Mar2014Tuc.txt	Raw Upper Air Data from University of Wyoming
May2010Tuc.txt	Raw Upper Air Data from University of Wyoming
May2011Tuc.txt	Raw Upper Air Data from University of Wyoming
May2012Tuc.txt	Raw Upper Air Data from University of Wyoming
May2013Tuc.txt	Raw Upper Air Data from University of Wyoming
May2014Tuc.txt	Raw Upper Air Data from University of Wyoming
Nov2010Tuc.txt	Raw Upper Air Data from University of Wyoming
Nov2011Tuc.txt	Raw Upper Air Data from University of Wyoming
Nov2012Tuc.txt	Raw Upper Air Data from University of Wyoming
Nov2013Tuc.txt	Raw Upper Air Data from University of Wyoming
Oct2010Tuc.txt	Raw Upper Air Data from University of Wyoming
Oct2011Tuc.txt	Raw Upper Air Data from University of Wyoming
Oct2012Tuc.txt	Raw Upper Air Data from University of Wyoming
Oct2013Tuc.txt	Raw Upper Air Data from University of Wyoming
Sep2010Tuc.txt	Raw Upper Air Data from University of Wyoming

Folder or File Name	Descriptions
Sep2011Tuc.txt	Raw Upper Air Data from University of Wyoming
Sep2012Tuc.txt	Raw Upper Air Data from University of Wyoming
Sep2013Tuc.txt	Raw Upper Air Data from University of Wyoming

\MPRM	
09-13saf.sam	Safford Samson Meteorological File
10-13MXS.txt	2010-2013 Mixing Height File
11-13shift.met	2011-2013 MPRM output with 2010 moved to 2013
MERGE.MRG	MPRM Merged Output File
MPRM.MET	MPRM Output file
MPRMsnw.MET	MPRM Output file with substitutions
MPRMsubnew.xlsx	MPRM EXCEL file showing Substitutions
OS.OQA	MPRM OQA file
S1OS.ERR	MPRM Error File
S1OS.INP	MPRM Stage 1 Onsite Input File
S1OS.RPT	MPRM Stage 1 Onsite Report File
S1SF.ERR	MPRM Stage 1 Surface Error File
S1SF.INP	MPRM Stage 1 Surface Input File
S1SF.RPT	MPRM Stage 1 Surface Report File
S1UA.ERR	MPRM Stage 1 Upper Air Error File
S1UA.INP	MPRM Stage 1 Upper Air Input File
S1UA.RPT	MPRM Stage 1 Upper Air Report File
S2.ERR	MPRM Stage 2 Error File
s2.INP	MPRM Stage 2 Input File
S2.RPT	MPRM Stage 2 Report File
S3.ERR	MPRM Stage 3 Error File
s3.INP	MPRM Stage 3 Input File
S3.RPT	MPRM Stage 3 Report File
SF.IQA	MPRM Stage 1 Output File
SF.OQA	MPRM Stage 1 Output File
STAGE1N2.EXE	MPRM Executable
STAGE3.EXE	MPRM Executable
TWRJRCOM.prn	Combined Tower and JR Meteorological Data
UA.IQA	MPRM Stage 1 Output File
UA.OQA	MPRM Stage 1 Output File

\MPRM\MIXHTS	
10-13MXHT.prn	Mixing Height File
10-13MXHT.TXT	Mixing Height Output File
10-13MXHT.xlsx	Mixing Height Substitution File

Folder or File Name	Descriptions
10-13MXHTS.txt	Mixing Height Output File with Substitutions
10-13old.FSL	FSL File with 8 Character Name
10-13Tuc_old.FSL	FSL File
2010Tuc_old.FSL	2010 Tucson FSL File
2011Tuc_old.FSL	2011 Tucson FSL File
2012Tuc_old.FSL	2012 Tucson FSL File
2013Tuc_old.FSL	2013 Tucson FSL File
aermet.xlsx	Mixing Heights from AERMET Used for Substitutions
MIXHTS.EXE	Mixing Height Executable
MIXHTS.INP	Mixing Height Input File
MIXHTS.LOG	Mixing Height Log File
Tucsub.sam	Tucson Samson File

\MPRM14	
14MPRMs.MET	2014 MPRM Output File with Substitutions
14TRJRCM.prn	2014 Combined Onsite and JR Meteorological File
2014_saf.sam	2014 Safford Surface Meteorological File
MERGE.MRG	MPRM Merge File
MPRM.MET	MPRM Output File
MPRMsub.xlsx	MPRM Substitution File
MXHTdmS.TXT	MPRM File with Davis Monthan Surface Data
OS.OQA	MPRM QA File
S1OS.ERR	MPRM Error File
S1OS.INP	MPRM Stage 1 Onsite Input File
S1OS.RPT	MPRM Stage 1 Onsite Report File
S1SF.ERR	MPRM Stage 1 Surface Error File
S1SF.INP	MPRM Stage 1 Surface Input File
S1SF.RPT	MPRM Stage 1 Surface Report File
S1UA.ERR	MPRM Stage 1 Upper Air Error File
S1UA.INP	MPRM Stage 1 Upper Air Input File
S1UA.RPT	MPRM Stage 1 Upper Air Report File
S2.ERR	MPRM Stage 2 Error File
s2.INP	MPRM Stage 2 Input File
S2.RPT	MPRM Stage 2 Report File
S3.ERR	MPRM Stage 3 Error File
s3.INP	MPRM Stage 3 Input File
S3.RPT	MPRM Stage 3 Report File
SF.IQA	MPRM Surface QA File
SF.OQA	MPRM Onsite QA File
STAGE1N2.EXE	MPRM Executable
STAGE3.EXE	MPRM Executable
UA.IQA	MPRM Stage 1 Output File

Folder or File Name	Descriptions
UA.OQA	MPRM Stage 1 Output File

\MPRM14\MIXHTS	
14dm.sam	2014 Davis Monthan Samson Meteorological File
14Tucold.FSL	2014 Tucson Upper Air FSL File
MIXHTS.EXE	Mixhts Executable
MIXHTS.INP	2014 Mixhts Input File
MIXHTS.LOG	2014 Mixhts Log File
MXHTdm.TXT	Mixhts Output File
MXHTdmS.TXT	Mixhts Substituted Output File

\Model Performance Evaluation\BLP-AERMOD-Additive (SingleVent and MultiVent)	
13A_JR_P.INP	BLP input file for Anode at Jones Ranch monitor for 2013
13A_MI_P.INP	BLP input file for Anode at Miami monitor for 2013
13A_RL_P.INP	BLP input file for Anode at Ridgeline monitor for 2013
13C_JR_P.INP	BLP input file for Converter at Jones Ranch monitor for 2013
13C_MI_P.INP	BLP input file for Converter at Miami monitor for 2013
13C_RL_P.INP	BLP input file for Converter at Ridgeline monitor for 2013
13C5_JRP.INP	BLP input file for Converter5 at Jones Ranch monitor for 2013
13C5_MIP.INP	BLP input file for Converter5 at Miami monitor for 2013
13C5_RLP.INP	BLP input file for Converter5 at Ridgeline monitor for 2013
13E_JR_P.INP	BLP input file for ELF at Jones Ranch monitor for 2013
13E_MI_P.INP	BLP input file for ELF at Miami monitor for 2013
13E_RL_P.INP	BLP input file for ELF at Ridgeline monitor for 2013
13I_JR_P.INP	BLP input file for Isa at Jones Ranch monitor for 2013
13I_MI_P.INP	BLP input file for Isa at Miami monitor for 2013
13I_RL_P.INP	BLP input file for Ridgeline monitor for 2013
14A_JR_P.INP	BLP input file for Anode at Jones Ranch monitor for 2014
14A_MI_P.INP	BLP input file for Anode at Miami monitor for 2014
14A_RL_P.INP	BLP input file for Anode at Ridgeline monitor for 2014
14C_JR_P.INP	BLP input file for Converter at Jones Ranch monitor for 2014
14C_MI_P.INP	BLP input file for Converter at Miami monitor for 2014
14C_RL_P.INP	BLP input file for Converter at Ridgeline monitor for 2014
14C5_JRP.INP	BLP input file for Converter5 at Jones Ranch monitor for 2014
14C5_MIP.INP	BLP input file for Converter5 at Miami monitor for 2014
14C5_RLP.INP	BLP input file for Converter5 at Ridgeline monitor for 2014
14E_JR_P.INP	BLP input file for ELF at Jones Ranch monitor for 2014
14E_MI_P.INP	BLP input file for ELF at Miami monitor for 2014
14E_RL_P.INP	BLP input file for ELF at Ridgeline monitor for 2014
14I_JR_P.INP	BLP input file for Isa at Jones Ranch monitor for 2014

Folder or File Name	Descriptions
14I_MI_P.INP	BLP input file for Isa at Miami monitor for 2014
14I_RL_P.INP	BLP input file for Ridgeline monitor for 2014
13A_JR_P.OUT	BLP output file for Anode at Jones Ranch monitor for 2013
13A_MI_P.OUT	BLP output file for Anode at Miami monitor for 2013
13A_RL_P.OUT	BLP output file for Anode at Ridgeline monitor for 2013
13C_JR_P.OUT	BLP output file for Converter at Jones Ranch monitor for 2013
13C_MI_P.OUT	BLP output file for Converter at Miami monitor for 2013
13C_RL_P.OUT	BLP output file for Converter at Ridgeline monitor for 2013
13C5_JRP.OUT	BLP output file for Converter5 at Jones Ranch monitor for 2013
13C5_MIP.OUT	BLP output file for Converter5 at Miami monitor for 2013
13C5_RLP.OUT	BLP output file for Converter5 at Ridgeline monitor for 2013
13E_JR_P.OUT	BLP output file for ELF at Jones Ranch monitor for 2013
13E_MI_P.OUT	BLP output file for ELF at Miami monitor for 2013
13E_RL_P.OUT	BLP output file for ELF at Ridgeline monitor for 2013
13I_JR_P.OUT	BLP output file for Isa at Jones Ranch monitor for 2013
13I_MI_P.OUT	BLP output file for Isa at Miami monitor for 2013
13I_RL_P.OUT	BLP output file for Ridgeline monitor for 2013
14A_JR_P.OUT	BLP output file for Anode at Jones Ranch monitor for 2014
14A_MI_P.OUT	BLP output file for Anode at Miami monitor for 2014
14A_RL_P.OUT	BLP output file for Anode at Ridgeline monitor for 2014
14C_JR_P.OUT	BLP output file for Converter at Jones Ranch monitor for 2014
14C_MI_P.OUT	BLP output file for Converter at Miami monitor for 2014
14C_RL_P.OUT	BLP output file for Converter at Ridgeline monitor for 2014
14C5_JRP.OUT	BLP output file for Converter5 at Jones Ranch monitor for 2014
14C5_MIP.OUT	BLP output file for Converter5 at Miami monitor for 2014
14C5_RLP.OUT	BLP output file for Converter5 at Ridgeline monitor for 2014
14E_JR_P.OUT	BLP output file for ELF at Jones Ranch monitor for 2014
14E_MI_P.OUT	BLP output file for ELF at Miami monitor for 2014
14E_RL_P.OUT	BLP output file for ELF at Ridgeline monitor for 2014
14I_JR_P.OUT	BLP output file for Isa at Jones Ranch monitor for 2014
14I_MI_P.OUT	BLP output file for Isa at Miami monitor for 2014
14I_RL_P.OUT	BLP output file for Ridgeline monitor for 2014
13MPRMs	BLP MET file for 2013
14MPRMs	BLP MET file for 2014
13A_JR_P.UF2	BLP unformatted output file for Anode at Jones Ranch monitor for 2013
13C_JR_P.UF2	BLP unformatted output file for Converter at Jones Ranch monitor for 2013
13C5_JRP.UF2	BLP unformatted output file for Converter5 at Jones Ranch monitor for 2013

Folder or File Name	Descriptions
13E_JR_P.UF2	BLP unformatted output file for ELF at Jones Ranch monitor for 2013
13I_JR_P.UF2	BLP unformatted output file for Isa at Jones Ranch monitor for 2013
13JRPOST.INP	Input file for post processor application
13JRPOST.MAX	Output file from additive processor with maximum daily concentrations
14A_JR_P.UF2	BLP unformatted output file for Anode at Jones Ranch monitor for 2014
14C_JR_P.UF2	BLP unformatted output file for Converter at Jones Ranch monitor for 2014
14C5_JRP.UF2	BLP unformatted output file for Converter5 at Jones Ranch monitor for 2014
14E_JR_P.UF2	BLP unformatted output file for ELF at Jones Ranch monitor for 2014
14I_JR_P.UF2	BLP unformatted output file for Isa at Jones Ranch monitor for 2014
14JRPOST.INP	Input file for post processor application
14JRPOST.MAX	Output file from additive processor with maximum daily concentrations
JRRECT.TXT	Receptors information for Jones Ranch monitor
1314JRNOVENTS.TXT	AERMOD post file for sources rather than the buoyant line sources for Jones Ranch monitor
13A_MI_P.UF2	BLP unformatted output file for Anode at Miami monitor for 2013 for Jones Ranch Monitor
13C_MI_P.UF2	BLP unformatted output file for Converter at Miami monitor for 2013
13C5_MIP.UF2	BLP unformatted output file for Converter5 at Miami monitor for 2013
13E_MI_P.UF2	BLP unformatted output file for ELF at Miami monitor for 2013
13I_MI_P.UF2	BLP unformatted output file for Isa at Miami monitor for 2013
13MIPOST.INP	Input file for post processor application
13MIPOST.MAX	Output file from additive processor with maximum daily concentrations
14A_MI_P.UF2	BLP unformatted output file for Anode at Miami monitor for 2014
14C_MI_P.UF2	BLP unformatted output file for Converter at Miami monitor for 2014
14C5_MIP.UF2	BLP unformatted output file for Converter5 at Miami monitor for 2014
14E_MI_P.UF2	BLP unformatted output file for ELF at Miami monitor for 2014
14I_MI_P.UF2	BLP unformatted output file for Isa at Miami monitor for 2014
14MIPOST.INP	Input file for post processor application

Folder or File Name	Descriptions
14MIPOST.MAX	Output file from additive processor with maximum daily concentrations
MIRECT.TXT	Receptors information for Miami monitor
1314MINOVENTS.TXT	AERMOD post file for sources rather than the buoyant line sources for Miami monitor
13A_RL_P.UF2	BLP unformatted output file for Anode at Ridgeline monitor for 2013 for Jones Ranch Monitor
13C_RL_P.UF2	BLP unformatted output file for Converter at Ridgeline monitor for 2013
13C5_RLP.UF2	BLP unformatted output file for Converter5 at Ridgeline monitor for 2013
13E_RL_P.UF2	BLP unformatted output file for ELF at Ridgeline monitor for 2013
13I_RL_P.UF2	BLP unformatted output file for Isa at Ridgeline monitor for 2013
13RLPOST.INP	Input file for post processor application
13RLPOST.MAX	Output file from additive processor with maximum daily concentrations
14A_RL_P.UF2	BLP unformatted output file for Anode at Ridgeline monitor for 2014
14C_RL_P.UF2	BLP unformatted output file for Converter at Ridgeline monitor for 2014
14C5_RLP.UF2	BLP unformatted output file for Converter5 at Ridgeline monitor for 2014
14E_RL_P.UF2	BLP unformatted output file for ELF at Ridgeline monitor for 2014
14I_RL_P.UF2	BLP unformatted output file for Isa at Ridgeline monitor for 2014
14RLPOST.INP	Input file for post processor application
14RLPOST.MAX	Output file from additive processor with maximum daily concentrations
RLRECT.TXT	Receptors information for Ridgeline monitor
1314RLNOVENTS.TXT	AERMOD post file for sources rather than the buoyant line sources for Ridgeline monitor
1314_1vent.TXT	The actual hourly emission profile for rooflines
COMBPERF.EXE	The additive processor application to combine BLP UF2 files with AERMOD post files
COMBPERF.F95	Fortran program to combine BLP UF2 files with AERMOD post files

\Model Performance Evaluation\AERMOD-Only	
JR-AERMOD-Only.ADI	Input file for AERMOD run with downwash for Jones Ranch monitor
JR-AERMOD-Only.ADO	Output file for AERMOD run with downwash for Jones Ranch monitor
MI-AERMOD-Only-DW.ADI	Input file for AERMOD run with downwash for Miami monitor

Folder or File Name	Descriptions
MI-AERMOD-Only-With-DW.ADO	Output file for AERMOD run with downwash for Miami monitor
RL-AERMOD-ONLY-DW.ADI	Input file for AERMOD run with downwash for Ridgeline monitor
RL-AERMOD-ONLY-DW.ADO	Output file for AERMOD run with downwash for Ridgeline monitor
JR-AERMOD-Only-No-DW.ADI	Input file for AERMOD run without downwash for Jones Ranch monitor
JR-AERMOD-Only-No-DW.ADO	Output file for AERMOD run without downwash for Jones Ranch monitor
MI-AERMOD-Only-No-DW.ADI	Input file for AERMOD run without downwash for Miami monitor
MI-AERMOD-Only-No-DW.ADO	Output file for AERMOD run without downwash for Miami monitor
RL-AERMOD-ONLY-No-DW.ADI	Input file for AERMOD run without downwash for Ridgeline monitor
RL-AERMODONLY-No-DW.ADO	Output file for AERMOD run without downwash for Ridgeline monitor
1314hrlypts.TXT	Hourly emission profile for all sources run in AERMOD
13-14actual.PFL	AERMET 2013-2014 profile file
13-14actual.SFC	AERMET 2013-2014 surface file

\Model Performance Evaluation\Hybrid-Approach	
JR-Perf-Eval-Oct15.ADI	AERMOD input file for Jones Ranch monitor
JR-Perf-Eval-Oct15.ADO	AERMOD output file for Jones Ranch monitor
MI-Hybrid-Perform-Evaluation.ADI	AERMOD input file for Miami monitor
MI-Hybrid-Perform-Evaluation.ADO	AERMOD output file for Miami monitor
RL-Hybrid-Perform-Evaluation.ADI	AERMOD input file for Ridgeline monitor
RL-Hybrid-Perform-Evaluation.ADO	AERMOD output file for Ridgeline monitor
1314HRLY(14Oct15)	Hourly emission profile including plume heights calculated by BLP

\FMMI-CEV-Determination-7-07-2016	
FMMI_CEV(07072016).ADI	AERMOD input file for CEV calculation
FMMI_CEV(07072016).ADO	AERMOD output file for CEV calculation
FMMI_hrly_delT(05292016).txt	Hourly emission profile including the plume heights calculated by BLP and temperature variations for Scrubber and Vent Fume Stack
11-13fn.PFL	AERMET 2011-2013 profile file
11-13fn.SFC	AERMET 2011-2013 surface file

\7-07-2016-Attainment-Demonstration	
1314prop(07112016).ADI	AERMOD input file
1314prop(07112016).ADO	AERMOD output file

Folder or File Name	Descriptions
1314HRPROP_MAR16.TXT	Hourly emission profile for projected emission rates after applying controls, based on actual emission data from May 2013 through April 2014.

\CEV-Emission-Sensitivity-Analysis	
CV_1H-Jul16.ADI	AERMOD input file for increasing the Tail Stack emissions
CV_1H-Jul16.ADO	AERMOD output file for increasing the Tail Stack emissions
HRLY11-13_CV1_H-May16.TXT	Hourly emission profile including buoyant source parameters calculated by BLP
CV_2H-Jul16.ADI	AERMOD input file for increasing the Vent Fume Stack emissions
CV_2H-Jul16.ADO	AERMOD output file for increasing the Vent Fume Stack emissions
HRLY11-13_CV2_H-May16.TXT	Hourly emission profile including buoyant source parameters calculated by BLP
CV_3H-Jul16.ADI	AERMOD input file for increasing the Aisle Scrubber emissions
CV_3H-Jul16.ADO	AERMOD output file for increasing the Aisle Scrubber emissions
HRLY11-13_CV3_H-May16.TXT	Hourly emission profile including buoyant source parameters calculated by BLP
CV_4H-Jul16.ADI	AERMOD input file for increasing the Converter roofline emissions
CV_4H-Jul16.ADO	AERMOD output file for increasing the Converter roofline emissions
HRLY11-13_CV4_H-May16.TXT	Hourly emission profile including buoyant source parameters calculated by BLP
CV_5H-Jul16.ADI	AERMOD input file for increasing the Anode roofline emissions
CV_5H-Jul16.ADO	AERMOD output file for increasing the Anode roofline emissions
HRLY11-13_CV5_H-May16.TXT	Hourly emission profile including buoyant source parameters calculated by BLP
CV_6H-Jul16.ADI	AERMOD input file for increasing the Isa roofline emissions
CV_6H-Jul16.ADO	AERMOD output file for increasing the Isa roofline emissions
HRLY11-13_CV6_H-May16.TXT	Hourly emission profile including buoyant source parameters calculated by BLP
CV_7H-Jul16.ADI	AERMOD input file for increasing the ELF roofline emissions
CV_7H-Jul16.ADO	AERMOD output file for increasing the ELF roofline emissions
HRLY11-13_CV7_H-May16.TXT	Hourly emission profile including buoyant source parameters calculated by BLP

\CEV-Exceedance-Risk-Analysis	
EXDRSK-Jul16-AA-AZ	Proposed hourly emissions and AERMOD input and output files for exceedance risk analysis-scenario #1-26

Folder or File Name	Descriptions
EXDRSK-Jul16-A-Z	Proposed hourly emissions and AERMOD input and output files for exceedance risk analysis-scenario #27-53
EXDRSK-Jul16-BA-BZ	Proposed hourly emissions and AERMOD input and output files for exceedance risk analysis-scenario #54-79
EXDRSK-Jul16-CA-CU	Proposed hourly emissions and AERMOD input and output files for exceedance risk analysis-scenario #80-100

\FMMI-AppendixD-Model-Files	
11ACdw.INP	2011 BLP input file for anode and converter vents with downwash
11ACdw.OUT	2011 BLP output file for anode and converter vents with downwash
11ACdw.UNF	2011 BLP output file for anode and converter vents with downwash
11ACdwP.OUT	2011 BLP Post output file for anode and converter vents with downwash
11ACndw.INP	2011 BLP input file for anode and converter vents without downwash
11ACndw.OUT	2011 BLP output file for anode and converter vents without downwash
11ACndw.UNF	2011 BLP output file for anode and converter vents without downwash
11ACndwP.OUT	2011 BLP Post output file for anode and converter vents without downwash
11IEdw.INP	2011 BLP input file for ISA and ELF vents with downwash
11IEdw.OUT	2011 BLP output file for ISA and ELF vents with downwash
11IEdw.UNF	2011 BLP output file for ISA and ELF vents with downwash
11IEdwP.OUT	2011 BLP Post output file for ISA and ELF vents with downwash
11IEndw.INP	2011 BLP input file for ISA and ELF vents without downwash
11IEndw.OUT	2011 BLP output file for ISA and ELF vents without downwash
11IEndw.UNF	2011 BLP output file for ISA and ELF vents without downwash
11IEndwP.OUT	2011 BLP Post output file for ISA and ELF vents without downwash
11shft.met	2011 MPRM meteorology
12ACdw.INP	2012 BLP input file for anode and converter vents with downwash
12ACdw.OUT	2012 BLP output file for anode and converter vents with downwash
12ACdw.UNF	2012 BLP output file for anode and converter vents with downwash
12ACdwP.OUT	2012 BLP Post output file for anode and converter vents with downwash
12ACndw.INP	2012 BLP input file for anode and converter vents without downwash

Folder or File Name	Descriptions
12ACndw.OUT	2012 BLP output file for anode and converter vents without downwash
12ACndw.UNF	2012 BLP output file for anode and converter vents without downwash
12ACndwP.OUT	2012 BLP Post output file for anode and converter vents without downwash
12IEdw.INP	2012 BLP input file for ISA and ELF vents with downwash
12IEdw.OUT	2012 BLP output file for ISA and ELF vents with downwash
12IEdw.UNF	2012 BLP output file for ISA and ELF vents with downwash
12IEdwP.OUT	2012 BLP Post output file for ISA and ELF vents with downwash
12IEndw.INP	2012 BLP input file for ISA and ELF vents without downwash
12IEndw.OUT	2012 BLP output file for ISA and ELF vents without downwash
12IEndw.UNF	2012 BLP output file for ISA and ELF vents without downwash
12IEndwP.OUT	2012 BLP Post output file for ISA and ELF vents without downwash
12shft.met	2012 MPRM meteorology
13ACdw.INP	2013 BLP input file for anode and converter vents with downwash
13ACdw.OUT	2013 BLP output file for anode and converter vents with downwash
13ACdw.UNF	2013 BLP output file for anode and converter vents with downwash
13ACdwP.OUT	2013 BLP Post output file for anode and converter vents with downwash
13ACndw.INP	2013 BLP input file for anode and converter vents without downwash
13ACndw.OUT	2013 BLP output file for anode and converter vents without downwash
13ACndw.UNF	2013 BLP output file for anode and converter vents without downwash
13ACndwP.OUT	2013 BLP Post output file for anode and converter vents without downwash
13IEdw.INP	2013 BLP input file for ISA and ELF vents with downwash
13IEdw.OUT	2013 BLP output file for ISA and ELF vents with downwash
13IEdw.UNF	2013 BLP output file for ISA and ELF vents with downwash
13IEdwP.OUT	2013 BLP Post output file for ISA and ELF vents with downwash
13IEndw.INP	2013 BLP input file for ISA and ELF vents without downwash
13IEndw.OUT	2013 BLP output file for ISA and ELF vents without downwash
13IEndw.UNF	2013 BLP output file for ISA and ELF vents without downwash
13IEndwP.OUT	2013 BLP Post output file for ISA and ELF vents without downwash

Folder or File Name	Descriptions
13shft.met	2013 MPRM meteorology

\FMMI-AppendixK-Model-Files	
FMMI_CEV(07142016)_noslag2.ADI	AERMOD input file including different scenarios to exclude the fixed emission sources from CEV calculation
FMMI_CEV(07142016)_noslag2.ADO	AERMOD output file including different scenarios to exclude the fixed emission sources from CEV calculation
FMMI_hrly_(05292016).TXT	Hourly emission profile including the plume heights calculated by BLP and temperature variations for Scrubber and Vent Fume Stack
\FMMI-AppendixL-Model-Files\SCREEN3	
AnodExst.inp	SCREEN3 fumigation analysis input file for existing anode plume height
AnodExst.out	SCREEN3 fumigation analysis output file for existing anode plume height
AnodExst.lst	SCREEN3 fumigation analysis list file for existing anode plume height
AnodFutr.inp	SCREEN3 fumigation analysis input file for future anode plume height
AnodFutr.out	SCREEN3 fumigation analysis output file for future anode plume height
AnodFutr.lst	SCREEN3 fumigation analysis list file for future anode plume height
CNV5Exst.inp	SCREEN3 fumigation analysis input file for existing CONVERTER 5 plume height.
CNV5Exst.out	SCREEN3 fumigation analysis output file for existing CONVERTER 5 plume height
CNV5Exst.lst	SCREEN3 fumigation analysis list file for existing CONVERTER 5 plume height
ConvExst.inp	SCREEN3 fumigation analysis input file for existing Converter plume height
ConvExst.out	SCREEN3 fumigation analysis output file for existing Converter plume height
ConvExst.lst	SCREEN3 fumigation analysis list file for existing Converter
ConvFutr.inp	SCREEN3 fumigation analysis input file for future Converter plume height plume height
ConvFutr.out	SCREEN3 fumigation analysis output file for future Converter plume height
ConvFutr.lst	SCREEN3 fumigation analysis list file for existing Converter plume height
ELFExst.inp	SCREEN3 fumigation analysis input file for existing ELF plume height
ELFExst.out	SCREEN3 fumigation analysis output file for existing ELF plume height
ELFExst.lst	SCREEN3 fumigation analysis list file for existing ELF plume height

Folder or File Name	Descriptions
ELFFutr.inp	SCREEN3 fumigation analysis input file for future ELF plume height
ELFFutr.out	SCREEN3 fumigation analysis output file for future ELF plume height
ELFFutr.lst	SCREEN3 fumigation analysis list file for future ELF plume height
ISAExst.inp	SCREEN3 fumigation analysis input file for existing ISA plume height
ISAExst.out	SCREEN3 fumigation analysis output file for existing ISA plume height
ISAExst.lst	SCREEN3 fumigation analysis list file for existing ISA plume height
ISAFutr.inp	SCREEN3 fumigation analysis input file for future ISA plume height
ISAFutr.out	SCREEN3 fumigation analysis output file for future ISA plume height
ISAFutr.lst	SCREEN3 fumigation analysis list file for future ISA plume height
\FMMI-AppendixL-Model-Files\AERSCREEN	
AnodFutr.inp	AERSCREEN fumigation analysis input file for future Anode
AnodFutr.out	AERSCREEN fumigation analysis output file for future Anode
AnodFutr.log	AERSCREEN fumigation analysis log file for future Anode
Anodexst.inp	AERSCREEN fumigation analysis input file for existing Anode
Anodexst.out	AERSCREEN fumigation analysis output file for existing Anode
Anodexst.log	AERSCREEN fumigation analysis log file for existing Anode
APTGFutr.inp	AERSCREEN fumigation analysis input file for future APTGS
APTGFutr.out	AERSCREEN fumigation analysis output file for future APTGS
APTGFutrlog	AERSCREEN fumigation analysis log file for future APTGS
APTGexst.inp	AERSCREEN fumigation analysis input file for existing APTGS
APTGexst.out	AERSCREEN fumigation analysis output file for existing APTGS
APTGexst.log	AERSCREEN fumigation analysis log file for existing APTGS
CNV5exst.inp	AERSCREEN fumigation analysis input file for existing CONVERTER 5
CNV5exst.out	AERSCREEN fumigation analysis output file for existing CONVERTER 5
CNV5exst.log	AERSCREEN fumigation analysis log file for existing CONVERTER 5
ConvFutr.inp	AERSCREEN fumigation analysis input file for future Converter
ConvFutr.out	AERSCREEN fumigation analysis output file for future Converter
ConvFutrlog	AERSCREEN fumigation analysis log file for future Converter

Folder or File Name	Descriptions
Convexst.inp	AERSCREEN fumigation analysis input file for existing Converter
Convexst.out	AERSCREEN fumigation analysis output file for existing Converter
Convexst.log	AERSCREEN fumigation analysis log file for existing Converter
ELFFutr.inp	AERSCREEN fumigation analysis input file for future ELF
ELFFutr.out	AERSCREEN fumigation analysis output file for future ELF
ELFFutr.log	AERSCREEN fumigation analysis log file for future ELF
ELFexst.inp	AERSCREEN fumigation analysis input file for existing ELF
ELFexst.out	AERSCREEN fumigation analysis output file for existing ELF
ELFexst.log	AERSCREEN fumigation analysis log file for existing ELF
ISAFutr.inp	AERSCREEN fumigation analysis input file for future ISA
ISAFutr.out	AERSCREEN fumigation analysis output file for future ISA
ISAFutr.log	AERSCREEN fumigation analysis log file for future ISA
ISAexst.inp	AERSCREEN fumigation analysis input file for existing ISA
ISAexst.out	AERSCREEN fumigation analysis output file for existing ISA
ISAexst.log	AERSCREEN fumigation analysis log file for existing ISA
SCRBFUTR.inp	AERSCREEN fumigation analysis input file for future Aisle Scrubber
SCRBFUTR.out	AERSCREEN fumigation analysis output file for future Aisle Scrubber
SCRBFUTR.log	AERSCREEN fumigation analysis log file for future Aisle Scrubber
VFSFutr.inp	AERSCREEN fumigation analysis input file for future VFS
VFSFutr.out	AERSCREEN fumigation analysis output file for future VFS
VFSFutr.log	AERSCREEN fumigation analysis log file for future VFS
VFSexst.inp	AERSCREEN fumigation analysis input file for existing VFS
VFSexst.out	AERSCREEN fumigation analysis output file for existing VFS
VFSexst.log	AERSCREEN fumigation analysis log file for existing VFS
\FMMI-AppendixL-Model-Files\SCREEN3\HighBuoyancy	
AnodExst.inp	SCREEN3 fumigation analysis input file for existing anode plume height with high buoyancy
AnodExst.out	SCREEN3 fumigation analysis output file for existing anode plume height with high buoyancy
AnodExst.lst	SCREEN3 fumigation analysis list file for existing anode plume height with high buoyancy
AnodFutr.inp	SCREEN3 fumigation analysis input file for future anode plume height with high buoyancy
AnodFutr.out	SCREEN3 fumigation analysis output file for future anode plume height with high buoyancy
AnodFutr.lst	SCREEN3 fumigation analysis list file for future anode plume height with high buoyancy

Folder or File Name	Descriptions
CNV5Exst.inp	SCREEN3 fumigation analysis input file for existing CONVERTER 5 plume height. with high buoyancy
CNV5Exst.out	SCREEN3 fumigation analysis output file for existing CONVERTER 5 plume height with high buoyancy
CNV5Exst.lst	SCREEN3 fumigation analysis list file for existing CONVERTER 5 plume height with high buoyancy
ConvExst.inp	SCREEN3 fumigation analysis input file for existing Converter plume height with high buoyancy
ConvExst.out	SCREEN3 fumigation analysis output file for existing Converter plume height with high buoyancy
ConvExst.lst	SCREEN3 fumigation analysis list file for existing Converter plume height with high buoyancy
ConvFutr.inp	SCREEN3 fumigation analysis input file for future Converter plume height plume height with high buoyancy
ConvFutr.out	SCREEN3 fumigation analysis output file for future Converter plume height with high buoyancy
ConvFutr.lst	SCREEN3 fumigation analysis list file for existing Converter plume height with high buoyancy
ELFExst.inp	SCREEN3 fumigation analysis input file for existing ELF plume height with high buoyancy
ELFExst.out	SCREEN3 fumigation analysis output file for existing ELF plume height with high buoyancy
ELFExst.lst	SCREEN3 fumigation analysis list file for existing ELF plume height with high buoyancy
ELFFutr.inp	SCREEN3 fumigation analysis input file for future ELF plume height with high buoyancy
ELFFutr.out	SCREEN3 fumigation analysis output file for future ELF plume height with high buoyancy
ELFFutr.lst	SCREEN3 fumigation analysis list file for future ELF plume height with high buoyancy
ISAExst.inp	SCREEN3 fumigation analysis input file for existing ISA plume height with high buoyancy
ISAExst.out	SCREEN3 fumigation analysis output file for existing ISA plume height with high buoyancy
ISAExst.lst	SCREEN3 fumigation analysis list file for existing ISA plume height with high buoyancy
ISAFutr.inp	SCREEN3 fumigation analysis input file for future ISA plume height with high buoyancy
ISAFutr.out	SCREEN3 fumigation analysis output file for future ISA plume height with high buoyancy
ISAFutr.lst	SCREEN3 fumigation analysis list file for future ISA plume height with high buoyancy
\FMMI-AppendixL-Model-Files\SCREEN3\HighMomentum	
AnodExst.inp	SCREEN3 fumigation analysis input file for existing anode plume height with high momentum
AnodExst.out	SCREEN3 fumigation analysis output file for existing anode plume height with high momentum

Folder or File Name	Descriptions
AnodExst.lst	SCREEN3 fumigation analysis list file for existing anode plume height with high momentum
AnodFutr.inp	SCREEN3 fumigation analysis input file for future anode plume height with high momentum
AnodFutr.out	SCREEN3 fumigation analysis output file for future anode plume height with high momentum
AnodFutr.lst	SCREEN3 fumigation analysis list file for future anode plume height with high momentum
CNV5Exst.inp	SCREEN3 fumigation analysis input file for existing CONVERTER 5 plume height. with high momentum
CNV5Exst.out	SCREEN3 fumigation analysis output file for existing CONVERTER 5 plume height with high momentum
CNV5Exst.lst	SCREEN3 fumigation analysis list file for existing CONVERTER 5 plume height with high momentum
ConvExst.inp	SCREEN3 fumigation analysis input file for existing Converter plume height with high momentum
ConvExst.out	SCREEN3 fumigation analysis output file for existing Converter plume height with high momentum
ConvExst.lst	SCREEN3 fumigation analysis list file for existing Converter plume height with high momentum
ConvFutr.inp	SCREEN3 fumigation analysis input file for future Converter plume height plume height with high momentum
ConvFutr.out	SCREEN3 fumigation analysis output file for future Converter plume height with high momentum
ConvFutr.lst	SCREEN3 fumigation analysis list file for existing Converter plume height with high momentum
ELFExst.inp	SCREEN3 fumigation analysis input file for existing ELF plume height with high momentum
ELFExst.out	SCREEN3 fumigation analysis output file for existing ELF plume height with high momentum
ELFExst.lst	SCREEN3 fumigation analysis list file for existing ELF plume height with high momentum
ELFFutr.inp	SCREEN3 fumigation analysis input file for future ELF plume height with high momentum
ELFFutr.out	SCREEN3 fumigation analysis output file for future ELF plume height with high momentum
ELFFutr.lst	SCREEN3 fumigation analysis list file for future ELF plume height with high momentum
ISAExst.inp	SCREEN3 fumigation analysis input file for existing ISA plume height with high momentum
ISAExst.out	SCREEN3 fumigation analysis output file for existing ISA plume height with high momentum
ISAExst.lst	SCREEN3 fumigation analysis list file for existing ISA plume height with high momentum
ISAFutr.inp	SCREEN3 fumigation analysis input file for future ISA plume height with high momentum
ISAFutr.out	SCREEN3 fumigation analysis output file for future ISA plume height with high momentum

Folder or File Name	Descriptions
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\FMMI-AppendixL-Model-Files\AERSCREEN\HighBuoyancy	
AnodFutr.inp	AERSCREEN fumigation analysis input file for future Anode with high buoyancy
AnodFutr.out	AERSCREEN fumigation analysis output file for future Anode with high buoyancy
AnodFutr.log	AERSCREEN fumigation analysis log file for future Anode with high buoyancy
Anodexst.inp	AERSCREEN fumigation analysis input file for existing Anode with high buoyancy
Anodexst.out	AERSCREEN fumigation analysis output file for existing Anode with high buoyancy
Anodexst.log	AERSCREEN fumigation analysis log file for existing Anode with high buoyancy
CNV5exst.inp	AERSCREEN fumigation analysis input file for existing CONVERTER 5 with high buoyancy
CNV5exst.out	AERSCREEN fumigation analysis output file for existing CONVERTER 5 with high buoyancy
CNV5exst.log	AERSCREEN fumigation analysis log file for existing CONVERTER 5 with high buoyancy
ConvFutr.inp	AERSCREEN fumigation analysis input file for future Converter with high buoyancy
ConvFutr.out	AERSCREEN fumigation analysis output file for future Converter with high buoyancy
ConvFutrlog	AERSCREEN fumigation analysis log file for future Converter
Convexst.inp	AERSCREEN fumigation analysis input file for existing Converter with high buoyancy
Convexst.out	AERSCREEN fumigation analysis output file for existing Converter with high buoyancy
Convexst.log	AERSCREEN fumigation analysis log file for existing Converter with high buoyancy
ELFFutr.inp	AERSCREEN fumigation analysis input file for future ELF with high buoyancy
ELFFutr.out	AERSCREEN fumigation analysis output file for future ELF with high buoyancy
ELFFutr.log	AERSCREEN fumigation analysis log file for future ELF with high buoyancy
ELFexst.inp	AERSCREEN fumigation analysis input file for existing ELF with high buoyancy
ELFexst.out	AERSCREEN fumigation analysis output file for existing ELF with high buoyancy
ELFexst.log	AERSCREEN fumigation analysis log file for existing ELF with high buoyancy
ISAFutr.inp	AERSCREEN fumigation analysis input file for future ISA with high buoyancy

Folder or File Name	Descriptions
ISAFutr.out	AERSCREEN fumigation analysis output file for future ISA with high buoyancy
ISAFutr.log	AERSCREEN fumigation analysis log file for future ISA with high buoyancy
ISAexst.inp	AERSCREEN fumigation analysis input file for existing ISA with high buoyancy
ISAexst.out	AERSCREEN fumigation analysis output file for existing ISA with high buoyancy
ISAexst.log	AERSCREEN fumigation analysis log file for existing ISA with high buoyancy
\FMMI-AppendixL-Model-Files\AERSCREEN\High Momentum	
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AnodFutr.out	AERSCREEN fumigation analysis output file for future Anode with high buoyancy
AnodFutr.log	AERSCREEN fumigation analysis log file for future Anode with high buoyancy
Anodexst.inp	AERSCREEN fumigation analysis input file for existing Anode with high buoyancy
Anodexst.out	AERSCREEN fumigation analysis output file for existing Anode with high buoyancy
Anodexst.log	AERSCREEN fumigation analysis log file for existing Anode with high buoyancy
CNV5exst.inp	AERSCREEN fumigation analysis input file for existing CONVERTER 5 with high buoyancy
CNV5exst.out	AERSCREEN fumigation analysis output file for existing CONVERTER 5 with high buoyancy
CNV5exst.log	AERSCREEN fumigation analysis log file for existing CONVERTER 5 with high buoyancy
ConvFutr.inp	AERSCREEN fumigation analysis input file for future Converter with high buoyancy
ConvFutr.out	AERSCREEN fumigation analysis output file for future Converter with high buoyancy
ConvFutrlog	AERSCREEN fumigation analysis log file for future Converter
Convexst.inp	AERSCREEN fumigation analysis input file for existing Converter with high buoyancy
Convexst.out	AERSCREEN fumigation analysis output file for existing Converter with high buoyancy
Convexst.log	AERSCREEN fumigation analysis log file for existing Converter with high buoyancy
ELFFutr.inp	AERSCREEN fumigation analysis input file for future ELF with high buoyancy
ELFFutr.out	AERSCREEN fumigation analysis output file for future ELF with high buoyancy
ELFFutr.log	AERSCREEN fumigation analysis log file for future ELF with high buoyancy

Folder or File Name	Descriptions
ELFexst.inp	AERSCREEN fumigation analysis input file for existing ELF with high buoyancy
ELFexst.out	AERSCREEN fumigation analysis output file for existing ELF with high buoyancy
ELFexst.log	AERSCREEN fumigation analysis log file for existing ELF with high buoyancy
ISAFutr.inp	AERSCREEN fumigation analysis input file for future ISA with high buoyancy
ISAFutr.out	AERSCREEN fumigation analysis output file for future ISA with high buoyancy
ISAFutr.log	AERSCREEN fumigation analysis log file for future ISA with high buoyancy
ISAexst.inp	AERSCREEN fumigation analysis input file for existing ISA with high buoyancy
ISAexst.out	AERSCREEN fumigation analysis output file for existing ISA with high buoyancy
ISAexst.log	AERSCREEN fumigation analysis log file for existing ISA with high buoyancy

10.2 Appendix B: Hatch Memo Regarding Building Capture and Control

HATCH

Project Memo

H377000

November 18, 2014

To: C. West

From: J. Nikkari

cc: **FCX**
A. Binegar
J. Spehar
T. Weaver

Hatch
I. Carruthers
R. Sullivan

Freeport-McMoRan Inc. (FCX)
Miami Smelter Expansion Project

Estimate of Unmeasured Smelter Building SO2

1. Introduction

Freeport-McMoRan Inc. (FCX) is undertaking a project at their Miami copper smelter in Arizona to increase production capacity and to ensure the smelter's operation does not cause or contribute to a violation of the new National Ambient Air Quality Standard (NAAQS) for Sulfur Dioxide of 75 ppbv (1-h).

The Feasibility Study SO_2 mitigation scope and current permit application are based on a 3-4 day sampling campaign completed in June 2012. To account for sampling variability and unmeasured emissions from other building openings, Hatch included, and FCX adopted in its permit application, a 20% design (safety) factor for annual smelter building fugitive SO_2 emissions on top of the measured June 2012 baseline SO_2 emissions. This design (safety) factor, however, is not directly related to ADEQ's current request.

This response specifically addresses an ADEQ request for the estimated unmeasured SO_2 emissions which leak through small openings in the building shell and are not captured or reported via the roofline monitoring system.

2. Conclusions

The leakage through unmeasured openings is estimated at 4.5% of the future reported smelter roofline fugitive emissions. Expressed as a portion of total SO_2 from stacks and building fugitives, the percentages are even lower.

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Page 1

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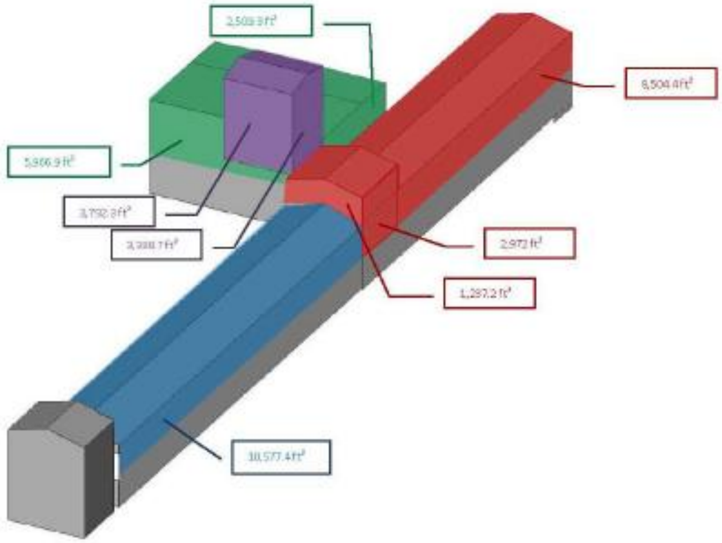
HATCH



Area Measurements: taken from model

Summary of Surface Area:

Converter Aisle (ft^2)	Anode Aisle (ft^2)	ELF (ft^2)	Smelting (ft^2)	Total (ft^2)
18,037.8	9,760.5	5,990.4	3,463.00	
18,037.8	26,073.4	29,006.6	2,918.04	
5,453.9	26,073.4	4,387.8	2,918.04	
8,504.4	10,577.4	2,509.3	3,423.18	
1,970.4		5,966.9	3,388.70	
1,237.2			3,792.30	
3,766.5				
3,766.5	72,484.8	47,861.0	19,903.3	205,232.6
2,972.0				
1,237.2				
64,983.6				

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10.3 Appendix C: Performance Evaluation of BLP/AERMOD Hybrid Approach

Technical Memorandum
Performance Evaluation Modeling Results for the
Miami SO_2 Nonattainment Area State Implementation Plan (SIP)
August 11, 2015

This memo presents the model performance evaluation results for five air quality dispersion model approaches for use in the Arizona Department of Environmental Quality's (ADEQ) Miami sulfur dioxide (SO_2) Nonattainment Area State Implementation Plan (SIP) submittal to the U.S. Environmental Protection Agency (EPA). Performance modeling is an important step in determining the best model to predict offsite impacts from emission sources. Freeport-McMoRan Miami Inc. (FMMI) is performing modeling to support the SIP submittal.

Smelter SO_2 Emissions Configuration

The FMMI Smelter is configured with five roof vents, which account for a significant proportion of the Smelter's current SO_2 emissions (approximately 44% of Smelter SO_2 emissions during the period from May 2013 through April 2014). The roof vents are located above the IsaSmelt® (Isa) vessel, the Electric Furnace (ELF), the converter aisle (2 vents), and the anode aisle. The three roof vents over the converter aisle and anode aisle are aligned along the length of the Smelter building. The shorter roof vents over the Isa and ELF are oriented perpendicular to the converter aisle and anode aisle roof vents. In addition to the roof vents, three stacks are located at the Smelter. The locations of the roof vents and stacks are shown in Figures 1 and 2.

The EPA's Buoyant Line and Point Source (BLP) model is EPA's preferred dispersion model for buoyant line sources such as the roof vents. However, the BLP model employs antiquated methods for addressing complex terrain and meteorology when compared to EPA's more modern AERMOD dispersion model. Although AERMOD implements contemporary treatment of complex terrain and meteorology, it is not equipped with EPA's preferred treatment of buoyant line sources as of the date the modeling analysis was completed using AERMOD Version 14134, the most up-to-date version of AERMOD available at the time.

SO_2 is emitted from each roof vent at an elevated temperature and with a convective velocity. As noted in the BLP User's Guide, plumes from buoyant line sources tend to rise higher when the wind aligns along the long axis of the roof vent than when the wind is perpendicular to the roof vent. Plume rise from buoyant line sources also exhibits relationships with buoyancy (dependent on plume temperature and velocity), wind speed, distance, and building downwash that are different from those of stack releases, therefore AERMOD will not adequately predict roof vent plume rise. The reduced plume rise calculated by AERMOD would tend to result in over-predicted concentrations.

A key issue in calculating the plume rise for buoyant line sources is determining which roof vents to model together in the BLP model run. BLP cannot adequately address perpendicular roof vents and the code prevents all five roof vents from being run simultaneously. Not being able to account for all roof vents in a single run limits BLP's computation of plume rise enhancement due to mixing of the buoyant plumes. The result is that the calculated plume rise for each roof vent is conservatively low because the full benefit of plume rise enhancement is not accounted for. The reduced plume rise enhancement would be expected to result in over-predicted concentrations.

Figure 1. Aerial Photograph of Miami Smelter, Showing Stacks and Roof Vents

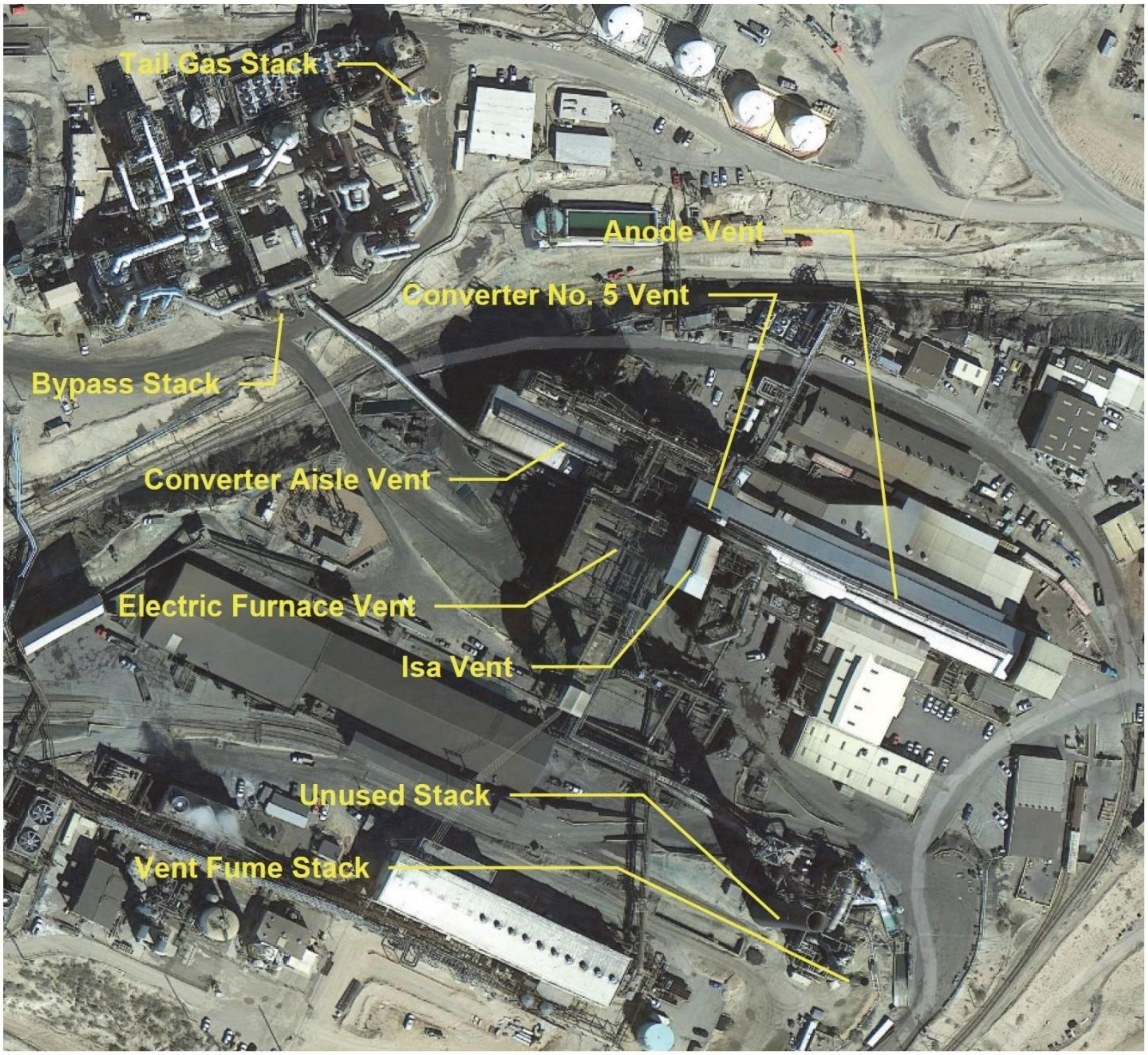

Figure 2. Photograph of Miami Smelter, Showing Stacks and Visible Roof Vents

Photograph taken at the Jones Ranch Ambient SO_2 Monitoring Station

Dispersion Model Options

EPA has asked ADEQ to examine the performance of several modeling approaches. Due to the physical configuration of the Smelter (i.e., the roof vents that are buoyant line sources) and the proximity of complex terrain to the Smelter, an alternative model that employs relevant and appropriate features of EPA's preferred models is expected to perform better for this facility than EPA's preferred guideline dispersion models alone. EPA's recent proposal to include the BLP plume rise treatment for buoyant line sources in AERMOD is indicative of EPA's recognition that AERMOD alone (Versions 14134 and earlier) is not appropriate for facilities with buoyant line sources, specifically roof vents that release hot building air such as those located at the Miami Smelter.

Section 3.2.2 of the GAQM provides recommendations for Regional Administrators to find that an alternative model is more appropriate than a preferred model. Section 3.2.2 identifies three conditions under which a model may be approved for use:

1. A demonstration that the alternative model produces concentration estimates equivalent to the estimates obtained using a preferred model;

2. A statistical performance evaluation using measured air quality data that demonstrates the alternative model performs better for the given application than a comparable preferred model; or

3. The preferred model is less appropriate for the specific application, or there is no preferred model for the specific application.

The purpose of this technical memo is to present a performance evaluation under the second condition, for situations where an alternative model performs better than a comparable preferred model, whereby model-predicted concentrations are compared to relevant measured air quality data. FMMI evaluated the following five modeling approaches based on implementation of EPA's preferred "BLP"[1] and "AERMOD"[2] dispersion models, both of which have features relevant to modeling the Smelter:

- Additive BLP/AERMOD, Multi-Vent BLP Plume Rise
- Additive BLP/AERMOD, Single-Vent BLP Plume Rise
- Hybrid BLP/AERMOD
- AERMOD, Roof Vents with Downwash
- AERMOD, Roof Vents without Downwash

While the BLP model implements EPA's preferred approach for modeling buoyant line source plume rise, it does not implement EPA's preferred approach for modeling sources located in complex terrain. In contrast, AERMOD implements EPA's preferred approach for modeling sources located in complex terrain, but it does not implement EPA's preferred approach for modeling buoyant line source plume rise.

With regard to complex terrain, BLP implements a plume/terrain interaction strategy of using stability-dependent plume path coefficients. For neutral and unstable conditions, the plume is lifted one-half of the difference between the elevation of the receptor and the base elevation of the source, with the additional constraint that the plume always be at least half the height above ground that it would be with no topography. For stable conditions, the plume is lifted approximately one-third of the difference between the elevation of the receptor and the base elevation of the source, with the additional constraint that the plume always be at least one-third the height above ground that it would be with no topography.

The AERMOD dispersion model, in contrast, implements EPA's preferred strategy for addressing plume/terrain interaction by identifying a dividing streamline to determine weighting assigned to two

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[1] BLP is a Gaussian plume dispersion model designed to handle unique modeling problems associated with industrial sources where buoyant plume rise and downwash effects from stationary line sources are important. With EPA's proposed changes to AERMOD, EPA is also proposing to delist BLP as a preferred model.

[2] AERMOD is a steady-state plume model that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain.

extreme plume states: plume impacting terrain or plume following terrain. In stable conditions, plume impacting terrain is more heavily weighted, whereas in neutral and unstable conditions, plume following terrain is more heavily weighted. The total concentration predicted by AERMOD is the weighted sum of these two extreme possible plume states. BLP is not equipped to predict concentrations in complex terrain in accordance with EPA's preferred approach to complex terrain. Again, EPA's recent proposal to include the BLP plume rise treatment for buoyant line sources in AERMOD is indicative of EPA's recognition that BLP alone is not appropriate for the Smelter's proximity to complex terrain.

A brief discussion of each approach follows. Detailed discussion of implementation is provided in Attachment A to this memo.

Multi-Vent Additive BLP/AERMOD. This approach uses the BLP dispersion model to predict hourly ambient concentrations resulting from roof vent emissions, and the AERMOD dispersion model to predict hourly ambient concentrations resulting from stack emissions. BLP is implemented to incorporate enhanced plume rise due to interacting roof vent plumes, per EPA guidance. BLP and AERMOD results are added receptor-by-receptor, hour-by-hour, to calculate the facility-wide predicted concentration. This approach relies on BLP's antiquated implementation of complex terrain and meteorology.

Single-Vent Additive BLP/AERMOD. This approach uses the BLP dispersion model to predict hourly ambient concentrations resulting from roof vent emissions, and the AERMOD dispersion model to predict hourly ambient concentrations resulting from stack emissions. Contrary to EPA guidance, BLP is implemented to run each source separately, thereby eliminating from consideration the enhanced plume rise due to interacting roof vent plumes. BLP and AERMOD results are added receptor-by- receptor, hour-by-hour, to calculate the facility-wide predicted concentration. This approach relies on BLP's antiquated implementation of complex terrain and meteorology.

Hybrid BLP/AERMOD. This approach uses the BLP dispersion model to predict hourly plume height and vertical spread (sigma-z) resulting from roof vent emissions. AERMOD is used to predict hourly ambient concentrations resulting from stack and roof vent emissions. The roof vent emissions are input to AERMOD as volume sources, with release height and initial sigma-z (vertical dispersion) inputs set at the BLP-calculated plume height and sigma-z. This approach avoids use of BLP's antiquated implementation of complex terrain and meteorology, and incorporates EPA's preferred plume rise and building downwash calculations for buoyant line sources. Of the approaches evaluated, this approach treats plume rise most consistently with EPA's recently proposed change to AERMOD (80 FR 45340), which would incorporate the BLP plume rise algorithms directly into AERMOD.

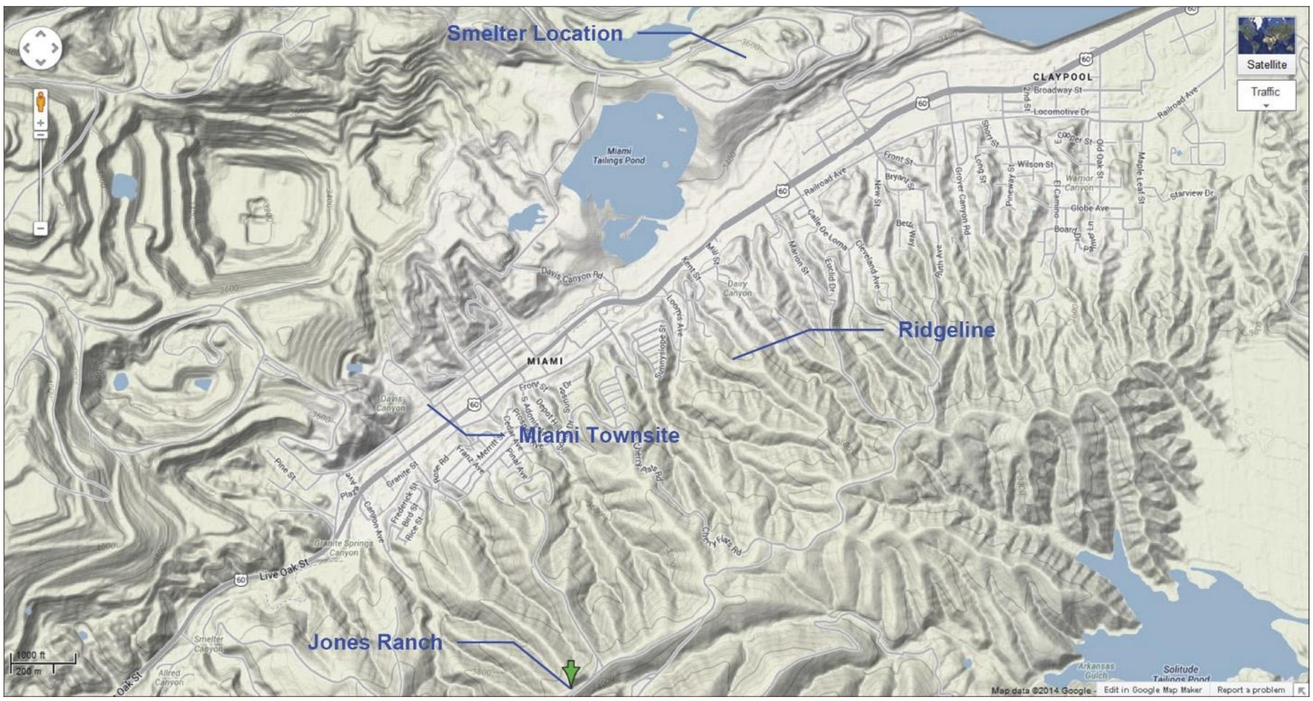
AERMOD, Roof Vents with Downwash. AERMOD is used to predict hourly ambient concentrations resulting from stack and roof vent emissions. The roof vent emissions are input to AERMOD as a series of point sources placed along the length of the roof vents. Building Profile Input Program for PRIME (BPIPPRM) downwash parameters for the roof vent sources are included in the AERMOD input. BPIPPRM is EPA's program used for identifying building dimensions to be used in AERMOD's plume downwash calculations. This approach avoids use of BLP's antiquated implementation of complex terrain and meteorology, but does not address buoyant line source plume rise and building downwash from the roof vents in accordance with EPA guidance.

AERMOD, Roof Vents without Downwash. AERMOD is used to predict hourly ambient concentrations resulting from stack and roof vent emissions. The roof vent emissions are input to AERMOD as a series of point sources placed along the length of the roof vents. BPIPPRM downwash parameters for the roof vent sources are not included in the AERMOD input. The approach avoids use of BLP's antiquated implementation of complex terrain and meteorology, but does not address buoyant line source plume rise and building downwash from the roof vents in accordance with EPA guidance.

Ambient Monitor Locations

Three ambient SO_2 air quality monitors operate around the FMMI facility: Jones Ranch, Ridgeline, and Miami Townsite. Their locations are shown in Figure 3, which also references the Smelter location.

Figure 3. Ambient Monitor Locations Relative to the Miami Smelter



The Jones Ranch monitor is located atop a ridgeline approximately 3 kilometers across the valley south-southwest of the Smelter at an elevation of 4,075 feet (1,242 meters) above sea level (ASL). The Jones Ranch monitor consistently measures the highest design value with respect to the 1-hour SO_2 National Ambient Air Quality Standard (NAAQS). The Jones Ranch monitor has been operated by ADEQ since February 1, 2013.

The Ridgeline monitor is located on a slope of the same ridge as the Jones Ranch monitor, approximately 1.6 kilometers south of the Smelter at an elevation of 3,560 feet (1,085 meters) ASL. Despite the monitor location's name, it is located at an elevation 300 feet below the top of the ridge. The Ridgeline monitor was used by ADEQ in establishing the nonattainment designation for the area as it was the only ADEQ-run SO_2 monitor in the Miami Planning Area at the time of designation. The Ridgeline monitor has been operated by ADEQ since October 5, 1995.

The Miami Townsite monitor operates approximately 2 kilometers southwest of the Smelter within the town of Miami at the bottom of the valley at an elevation of 3,419 feet (1,042 meters) ASL. The Miami Townsite monitor consistently measures the lowest design value with respect to the 1-hour SO_2 NAAQS. The Miami Townsite monitor has been operated by ADEQ since February 1, 2013.

By comparison to the ambient monitor elevations, the Smelter is located at a base elevation of approximately 3,560 feet (1,085 meters) ASL. In consideration of the release height of emissions (107 to 213 feet above ground level) and subsequent buoyant and momentum plume rise, the Jones Ranch site would be expected to measure higher concentrations than the other locations due to its elevation being 475 feet higher than the base elevation of the Smelter, and most likely to be subject to direct plume impaction. For the year of record used in the model performance evaluation (May 2013 through April 2014), the 4th highest daily maximum concentration measured at the Jones Ranch monitor location was considerably greater than the concentration measured at the other two sites, as is evident by the measured values presented in Table 1.

Table 1. Measured 4th Highest Daily Maximum Ambient SO_2 Concentrations (µg/m^3) May 2013-April 2014

Jones Ranch	540
Ridgeline	364
Miami Townsite	285

The measured concentrations presented in Table 1 illustrate the importance of the Jones Ranch site in establishing model performance. Despite the greater distance of the Jones Ranch monitor from the Smelter, the higher concentrations measured there are indicative of the monitor being located at an elevation that is representative of Smelter plume heights.

Modeling Protocol

Smelter Emissions

FMMI's modeling evaluation was based on continuous hourly emissions measured from May 2013 through April 2014. Data include hourly emission rate, plume temperature, and plume velocity or flow rate. The AERMOD dispersion model allows for the input of hourly emissions, facilitating analyses that use hourly emissions monitoring data. In all of the modeling approaches, the actual hourly emissions data were input to AERMOD using an hourly emission rate file.

The BLP model is not equipped to read an hourly emission rate file, but it can produce an output of hourly predicted concentrations for each receptor. For the Additive BLP/AERMOD approaches, BLP was run with roof vent sources set to a normalized emission rate of 1 gram per second (g/s). Because BLP's predicted concentrations are linearly related to emission rate, model post processing was performed to apply the actual hourly emission rates to the hourly predicted concentrations. The buoyancy factor is fixed in BLP so averaged values of plume temperature and velocity were used in the BLP runs.

Receptors

EPA model performance guidelines and several published articles recommend a domain-wide comparison of model results to monitor values to account for wind variability, which is more pronounced in short term averaging periods such as 1-hour or 3-hour periods. EPA's 1992 *Protocol for Determining the Best Performing Model* states that for pollutants such as SO_2, where short-term ambient standards exist, the statistic of interest involves the network-wide highest concentrations:

For a pollutant such as SO_2 for which short-term ambient standards exist, the statistic of interest involves the network-wide highest concentrations. In this example, the precise time, location and meteorological condition is of minor concern compared to the magnitude of the highest concentrations actually occurring.

EPA further elaborates in its performance evaluation of the AERMOD dispersion model (EPA, 2003):

Operational performance of models for predicting compliance with air quality regulations, especially those involving a peak or near peak value at some unspecified time and location, can be assessed with quantile-quantile (Q-Q) plots (Chambers et al., 1983). Q-Q plots are created by sorting by rank the predicted and the observed concentrations from a set of predictions initially paired in time and space. The sorted list of predicted concentrations are then plotted by rank against the observed concentrations also sorted by rank. These concentration pairs are no longer paired in time or location. However, the plot is useful for answering the question, "Over a period of time and over a variety of locations, does the distribution of the model predictions match those of observations?" Scatterplots, which use data paired in time (and / or space), provide a more strict test, answering the question: "At a given time and place, does the magnitude of the model prediction match the observation?" It is the experience of model developers (e.g., Weil, et al., 1992 and Liu and Moore, 1984) that wind direction uncertainties can and do cause disappointing scatterplot results from what are otherwise well-performing dispersion models. Therefore, the Q-Q plot instead of the scatterplot is a more pragmatic procedure for demonstrating model performance of applied models. Venkatram et al. (2001) makes a cogent argument for the use of Q-Q plots for evaluating regulatory models.

Based on the EPA guidance, ADEQ and FMMI agreed to place a set of receptors within 100 meters of each monitor location for the purpose of conducting the performance evaluation. The BLP model is limited to 100 receptors so each modeling approach was run with a set of 100 receptors located within a 100 meter radius of each monitor location. Additionally, a larger receptor grid identified in the modeling protocol was used to predict domain-wide concentrations.

Meteorological Data

Hourly meteorological data collected at the Smelter tower during the May 2013 through April 2014 period were used as on-site observation inputs for AERMET (the meteorological data processor for AERMOD) and MPRM (the meteorological data processor for BLP). Additional surface observations (cloud cover, atmospheric pressure) for the period were obtained for the National Weather Service (NWS) site located in Safford, Arizona. Upper air observations for the period were obtained for the NWS site located in Tucson, Arizona. Missing data substitution procedures followed those identified in the modeling protocol.

Results

The EPA SO_2 NAAQS specifies that the design value is calculated by first identifying the 99^{th} percentile of the 1-hour daily maximum concentrations for each of three years, and then by averaging those three values.

The 99th percentile value for each year is represented by the 4th highest value of the 365 daily 1- hour maximum values over the year. In the case of AERMOD, the predicted 4th highest daily value for each year of meteorological data input to the model is retained for each receptor, and these values are then averaged to compute the predicted design value. For the performance evaluation, these predicted design values are compared to the measured design values.

Table 2 provides a comparison of both measured and model-predicted ambient design values at the monitoring stations (Jones Ranch, Ridgeline and Miami). EPA guidance identifies an acceptable result as a predicted concentration that is within a factor of two of the observed concentration (EPA, 1992). As Table 2 shows, some, but not all, model results fall into this range and their performance varies with monitoring station. The Jones Ranch monitor location is of particular importance because the highest SO_2 design concentrations in the area are consistently measured there. The Ridgeline monitor is also important because ADEQ uses that monitor to designate the attainment status of the area. The colors and bold text are provided in Table 2 to emphasize the importance of the Jones Ranch and Ridgeline monitor locations in evaluating model performance. In contrast, the Miami monitor location consistently has the lowest measured design concentration. A comparison of predicted concentrations is provided for the Miami location, but is not considered in evaluating model performance.

The model results show that the Hybrid BLP/AERMOD approach is the one that performs best for the Jones Ranch location, and is within a factor of two at the Ridgeline location. In contrast, the Additive BLP/AERMOD approaches substantially over-predict measured concentrations at both locations.

While the AERMOD-only options are each within a factor of 2 at the Jones Ranch location, these options cannot be justified from a technical perspective. The modeling results demonstrate that buoyant line source plume rise is an important consideration for the Smelter, particularly for the Ridgeline monitor comparison where the AERMOD-only approach with downwash substantially over-predicts measured concentrations. The AERMOD-only approach with downwash is calculating significantly reduced plume rise, due both to the model's inability to address enhanced plume rise due to the buoyant line source configuration and the mixing of plumes from adjacent vents, as well as the application of point source building downwash to the roof vent sources.

Figures 4 through 6 provide Q-Q plots for the three monitor locations and five modeling approaches. The bold black line represents a perfect fit between the monitor and the model. The dashed lines represent the acceptable range (within 2 times) for the model performance. The Q-Q plots present comparisons of daily maximum 1-hour concentrations predicted by each modeling approach against those measured at each monitor. The Q-Q plots therefore provide a more in-depth evaluation of model performance because the design value is only a subset of the plot. Nevertheless, the plots confirm the results provided in Table 2.

Table 2. Summary Comparison of Measured and Predicted Ambient SO_2 Concentrations ($\mu g/m^3$)

Description	Ambient Monitor Location			Highest Modeled Ground Level Concentration
	Jones Ranch	**Ridgeline**	Miami *	
	Monitor With Highest Measured Concentration	***Monitor Used for Miami Attainment Designation***	*Monitor With Lowest Measured Concentration*	
Observed, Actual Measurements	**540**	**364**	285	NA
Predicted, Multi-Vent Additive BLP/AERMOD	**1370**	**879**	175	6362
Predicted, Single-Vent Additive BLP/AERMOD	**1487**	**1850**	283	7981
Predicted, Hybrid BLP/AERMOD	**512**	**228**	79	1752
Predicted, AERMOD, Roof Vents with Downwash	**333**	**1484**	363	3830
Predicted, AERMOD, Roof Vents without Downwash	**313**	**278**	112	2108

Notes:

- Listed concentrations are the 4th highest daily 1-hour concentration in a 1-year period.
- "Highest Modeled Ground Level Concentration" refers to the highest predicted concentration for all ambient air beyond the facility fenceline, not just the ambient monitor locations.
- Green shading indicates model result is within a factor of 1.5 of observation.
- Orange shading indicates model result is within a factor of 2 of observation.
- Red shading indicates model result is beyond a factor of 2 of observation.

* Comparison provided for Miami, but because the measured design concentration at Miami is much lower than at Jones Ranch, the results are not considered in evaluating model performance.

Selected Approach

The Hybrid Approach is the selected approach for identifying the Smelter critical emissions value because the model performs best at the worst-case monitoring location (Jones Ranch). The two Additive BLP/AERMOD approaches considerably over-predict concentrations at both the Jones Ranch and Ridgeline monitor locations and are unacceptable. The AERMOD-only approaches are unacceptable because they do not properly account for plume rise from buoyant line sources.

Additional Discussion

While the Hybrid Approach is selected for the Miami Smelter, a question has been asked about the differences between the Miami Smelter and the Hayden Smelter because the Hayden Smelter selected the EPA-preferred AERMOD approach. The key difference between the facilities is that the Hayden Smelter's emissions are predominantly emitted from their single stack with a 1,000 foot height above ground elevation. Emissions from the Hayden Smelter's roof vents are negligible by comparison, comprising less than 2 percent of the facility's SO_2 emissions. As noted previously in this memo, the

Miami Smelter's roof vent emissions comprise nearly half of the facility's SO_2 emissions (44% for the period evaluated).

Figure 4. Q-Q Plot, Jones Ranch Monitor

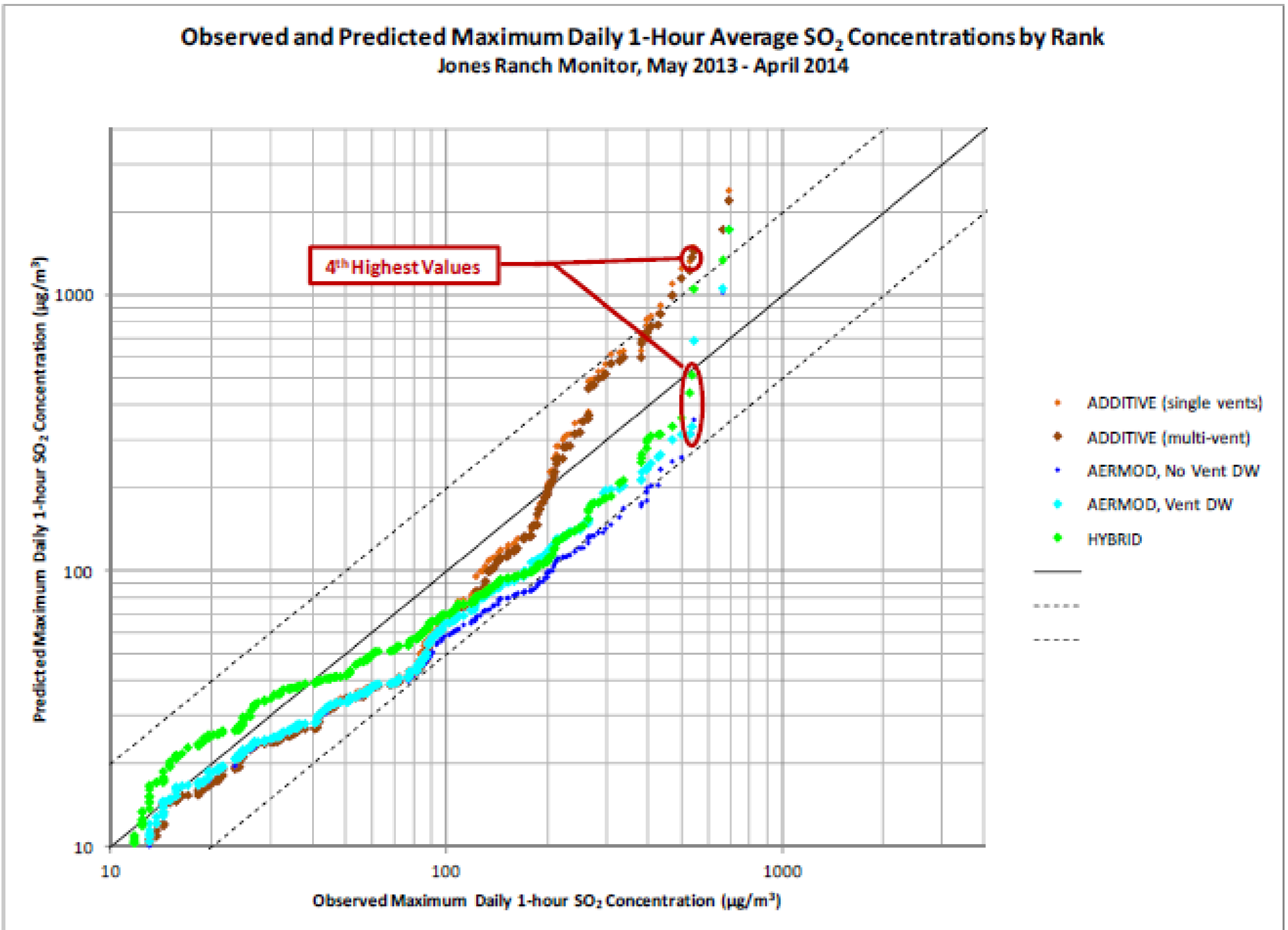


Figure 5. Q-Q Plot, Ridgeline Monitor

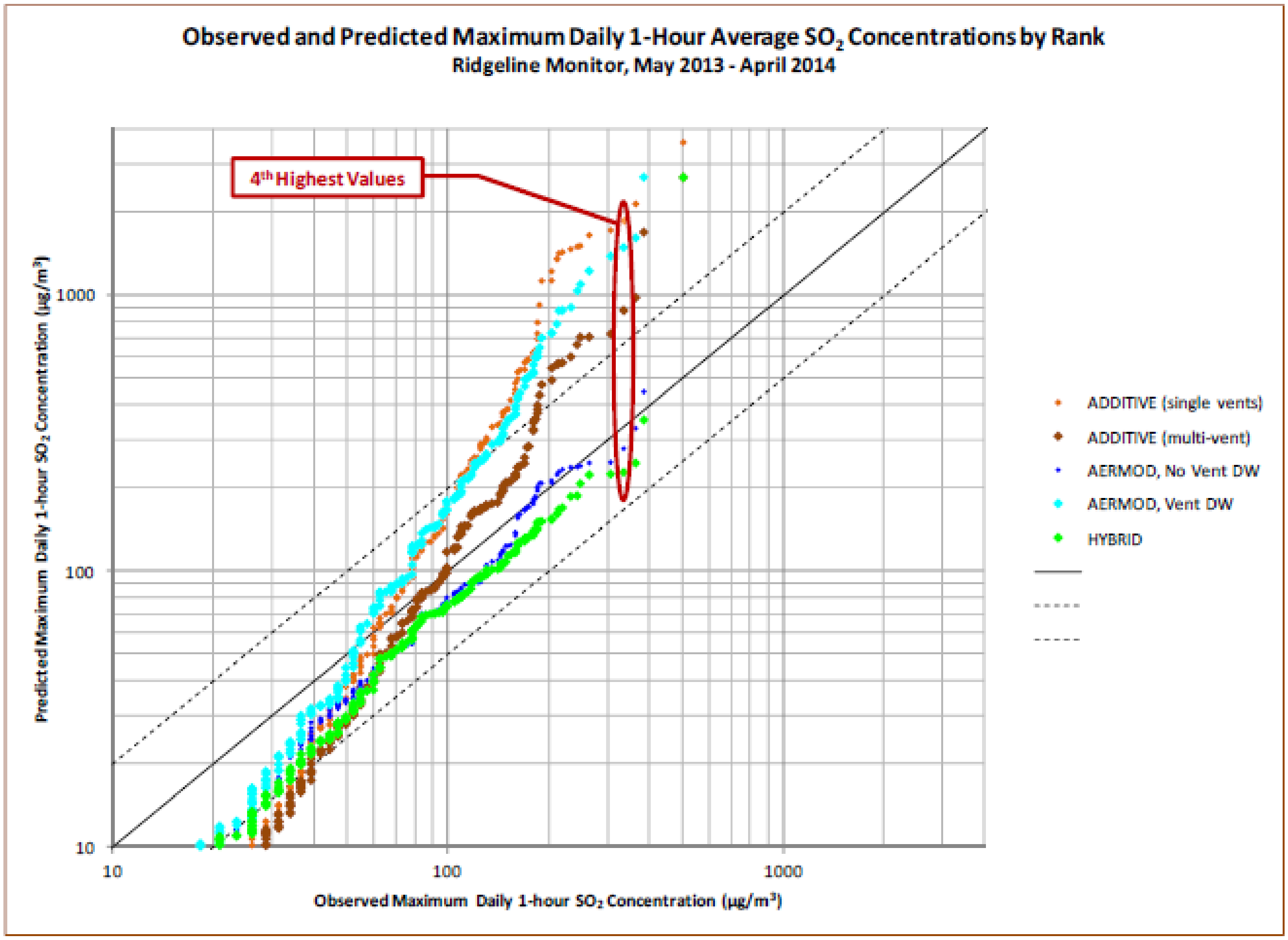
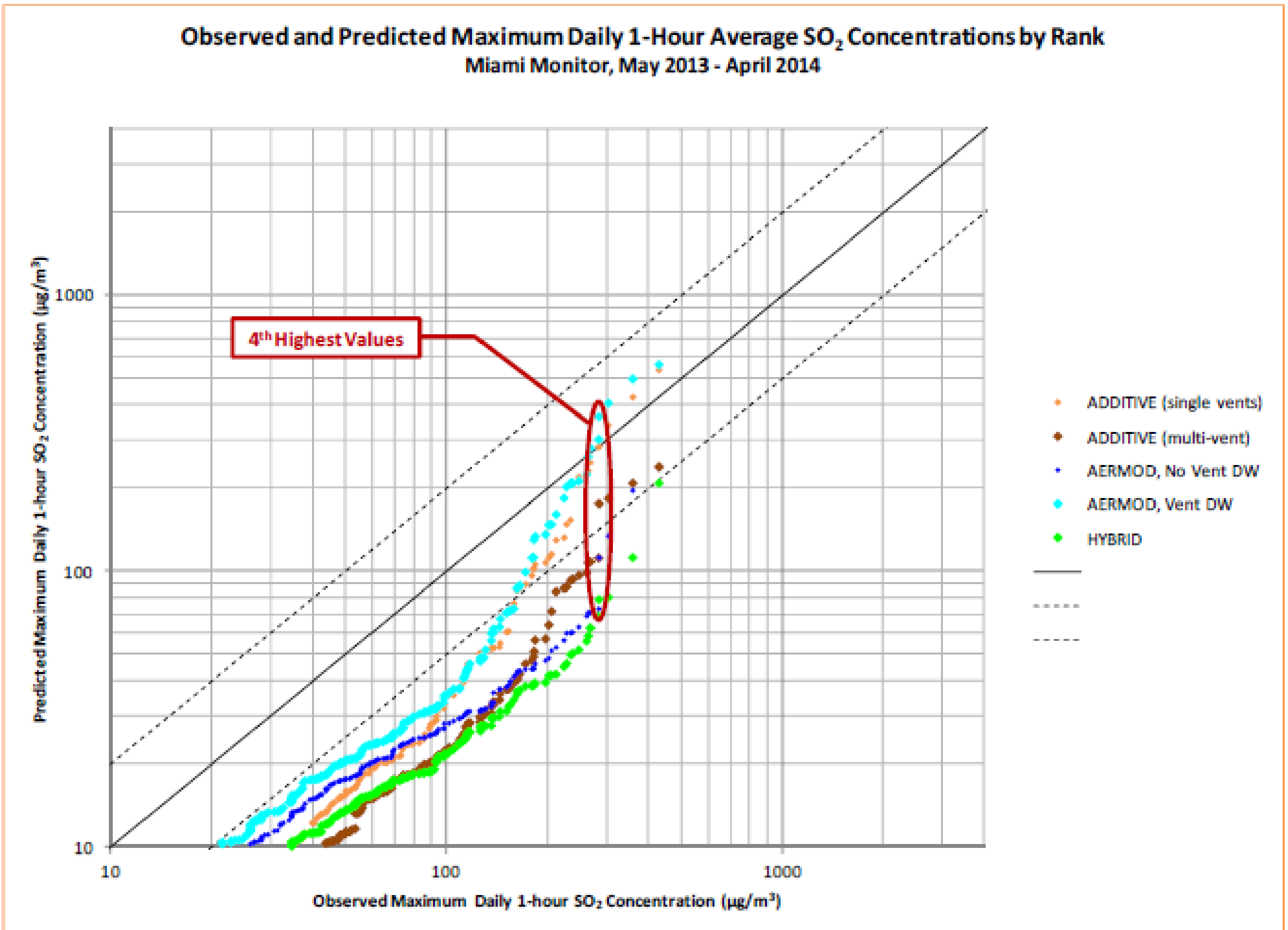


Figure 6. Q-Q Plot, Miami Townsite Monitor



10.4 Appendix D: BLP Plume Rise and Sigma-z Analysis

Technical Memorandum
BLP Plume Rise and Sigma-Z
Miami SO_2 Nonattainment Area State Implementation Plan (SIP)
July 28, 2015

Nearly half of the SO_2 emissions from Freeport-McMoRan Miami, Inc.'s (FMMI) primary copper smelter are emitted from roof vents in its current operational configuration. These roof vents provide for the ventilation of various smelter operations, and the temperature of the roof vent exhaust is characteristically high due to the heat of those operations. The U.S. Environmental Protection Agency's (EPA) Buoyant Line and Point Source (BLP) model is EPA's preferred dispersion model for buoyant line sources such as the roof vents. However, the BLP model employs antiquated methods for addressing complex terrain and meteorology when compared to EPA's more modern AERMOD dispersion model. Although AERMOD implements contemporary treatment of complex terrain and meteorology, it is not equipped with EPA's preferred treatment of buoyant line sources[1]. Given the complex terrain and meteorology in the immediate vicinity of the Smelter, and given the importance of the roof vents in the assessment of SO_2 impacts from the Smelter, a Hybrid BLP/AERMOD dispersion modeling approach (Hybrid Approach) has been proposed for the Miami SO_2 Nonattainment Area State Implementation Plan (SIP) being prepared by the Arizona Department of Environmental Quality (ADEQ). This memo presents the results of a study evaluating the roof vent plume rise and vertical plume spread calculated by the BLP dispersion model.

Proposed Modeling Approach

The proposed Hybrid Approach uses AERMOD to predict hourly ambient concentrations resulting from stack and roof vent emissions. The roof vent emissions are input to AERMOD as volume sources, which requires input of volume release height (center of volume) above ground level and the initial horizontal and vertical dimensions of the volume (i.e., initial sigma-y and initial sigma-z, respectively). In the Hybrid Approach, the BLP model is used to calculate hourly plume height and hourly initial sigma-z. The BLP-calculated hourly plume height is assigned to the AERMOD volume source's release height. Similarly, the BLP-calculated hourly initial sigma-z is assigned to the AERMOD volume source's initial vertical dimension. This Hybrid Approach avoids use of BLP's antiquated implementation of complex terrain and meteorology, relying instead on AERMOD's implementation of complex terrain and meteorology, and incorporates EPA's preferred plume rise and building downwash calculations for buoyant line sources which AERMOD is not equipped to perform.

Plume Rise Analysis

Approach

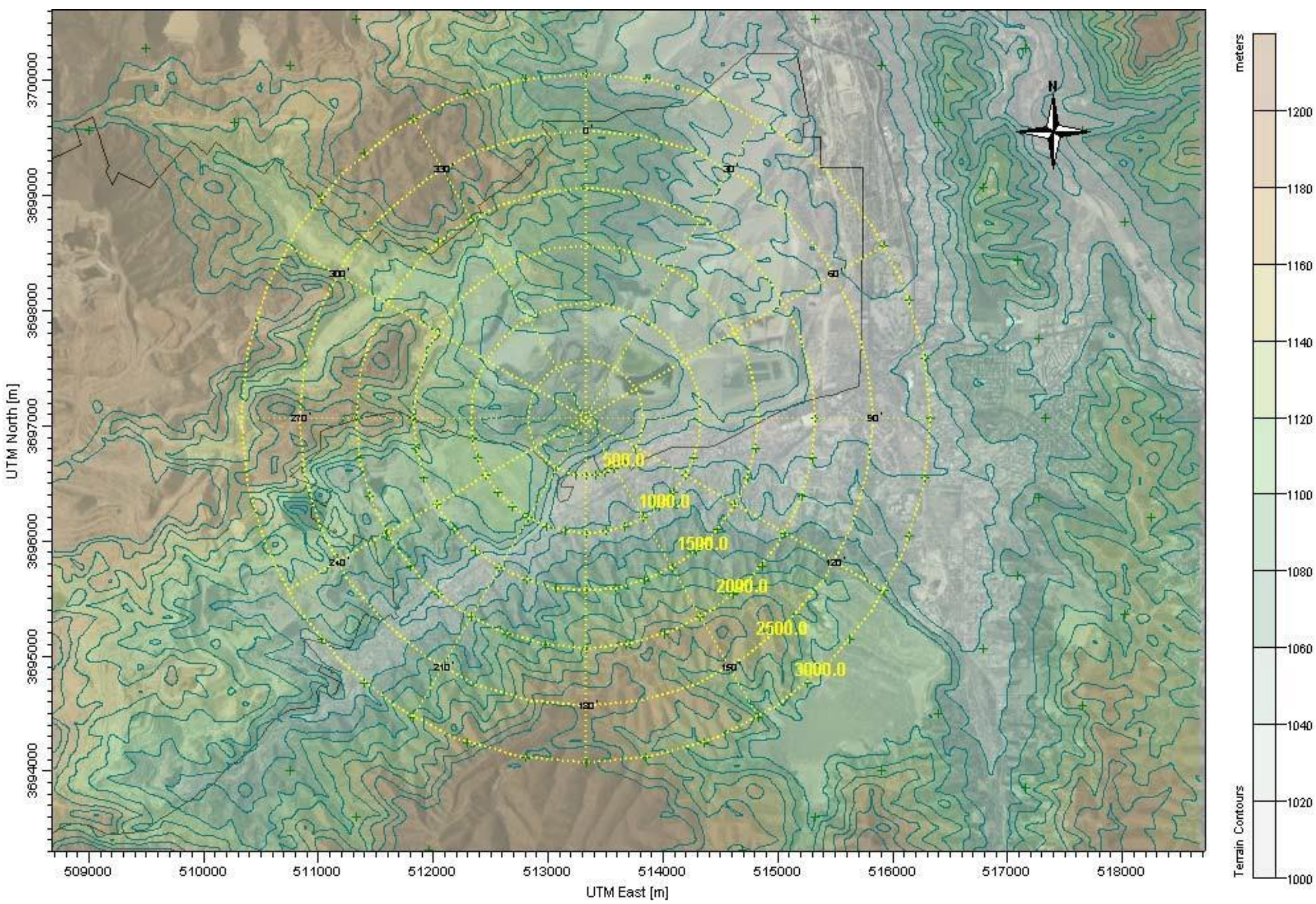
EPA requested an evaluation of receptor distances used in BLP to identify final plume height and initial sigma-z. FMMI analyzed the final plume heights from receptor distances of 250 meters (m), 1 kilometer (km), 1.5 km, 2 km, 3 km, 4 km, and 5 km. These distances were evaluated for several compass

[1] EPA proposed changes to 40 CFR 51 Appendix W, Guideline on Air Quality Models (80 FR 45340). The proposed changes include a BETA implementation of the BLP plume rise algorithms in AERMOD (version 15181), which was not available when the TSD modeling work was initiated.

directions, specifically 110 degrees (ESE), 150 degrees (SSE), 180 degrees (South), 210 degrees (SSW), and 260 degrees (WSW), from the North. These directions were selected because they align with the closest fence line receptors to the Smelter.

As Figure 1 shows, the Smelter is located on a hill at an elevation of 1085 meters. The bottom of the valley located in the near field area to the south has an approximate elevation of 1030 meters. For emissions from the vents to impact the near field (valley) area, the plume would need to be subject to building downwash at or beyond the fence line. The BLP model was run with building downwash and normalized emission rates for each of the future vents to determine how the vent plume dynamics and terrain affected the near field results.

Figure 1. Topography in the Vicinity of the Smelter, Showing Distance from the Smelter



Further discussion of BLP implementation, including source configurations, is provided in the modeling protocol developed for the SIP submittal.

Results

A large difference in predicted plume heights is observed between the 250 m and 1 km receptors with the 250 m receptor case significantly under-predicting the final plume height. A slight difference between the 1 km and 1.5 km receptors is observed with the Isa/ELF/Converter modeling case showing higher differences than the Converter/Anode modeling case. The predicted plume rise does not change beyond the 1.5 km receptor. Therefore, the analysis shows the final plume rise occurs between 1 km and 1.5 km downwind from the Smelter. A summary of the BLP-predicted plume heights for the Isa/ELF/ Converter and Converter/Anode modeling cases are presented in Tables 1A and 1B, respectively.

Table 1A. Results of BLP Plume Rise Evaluation, Anode / Converter Run

	Anode / Converter Vent Plume Heights						
Distance	**250m**	**1 km**	**1.5 km**	**2 km**	**3 km**	**4 km**	**5 km**
Average	64.29	110.51	111.11	111.10	111.10	111.10	111.10
75th percentile	78.60	126.04	126.78	126.78	126.72	126.72	126.72
Median	60.97	80.67	81.13	81.12	81.12	81.12	81.12
25th Percentile	39.82	64.14	64.38	64.37	64.37	64.37	64.37

Table 1B. Results of BLP Plume Rise Evaluation, Isa / ELF / Converter Run

	Isa / ELF / Converter Vent Plume Heights						
Distance	**250m**	**1 km**	**1.5 km**	**2 km**	**3 km**	**4 km**	**5 km**
Average	74.70	127.56	134.52	134.52	134.52	134.52	134.52
75th percentile	87.52	134.33	142.10	142.10	142.10	142.10	142.10
Median	69.91	94.57	98.54	98.54	98.54	98.54	98.54
25th Percentile	54.84	79.28	80.96	80.96	80.96	80.96	80.96

A sensitivity analysis was performed with the Hybrid Approach using the critical emissions values (CEV) to determine if predicted concentrations are sensitive to the use of BLP-predicted plume heights for the 1 km and 1.5 km receptors. The highest 1-hour and 4^{th} highest 1-hour design value concentrations for both plume heights were identical, indicating negligible effect on the maximum predicted design value concentration when the slightly higher 1.5 km final plume rises were applied.

The Hybrid Approach results were also evaluated to assess the near-field effect of gradual plume rise. The results, as provided in Table 2, demonstrate that receptors located within the valley below the Smelter had much lower predicted design values than those receptors at or above the Smelter elevations. The majority of the receptors located at or above Smelter elevation (1085 m) are located more than 1.5 km from the Smelter, indicating that these receptors with the highest predicted design value concentrations are located in areas where maximum plume height has been achieved.

Table 2. Results of Near-Field Evaluation of Gradual Plume Rise

Distance	ESE		SE		S		SW		WSW	
(meters)	Conc.	Height	Conc.	Height	Conc.	Height	Conc.	Height	Conc.	Height
500			11.9	1021.9	11.5	1021.9				
1000	4.5	1014.3	3.9	1050.2	6.4	1021.9	42.2	1101.3	62.1	1105
1500	4.4	1020.9	41.9	1096.8	22.7	1080.7	4.4	1035.3	27.1	1114*
2000	4.5	1037.8	89.5	1160.4	110	1145.5	13.1	1071.5	18.7	1076*
3000	3.3	1028.5	115.7	1030.7	165	1239.5	46	1124.9		

Conc. = Predicted 1-Hour Design Value Concentration (μg/m^3)
Height = Receptor height (m)
Blank cells in the table indicate that receptor distances are located within FMMI's fence line.
* Receptor heights adjusted after review of Google Earth aerials which showed recent modifications to the land contours.

Conclusion

The plume height analysis presented here shows the use of BLP-predicted plume heights at a 1 km receptor distance is adequate for the volume source release height input in the AERMOD model. Gradual plume rise does not need to be considered for near-field receptors because the maximum predicted 1-hour design value concentrations are located in the area where final plume rise has been achieved.

Sigma-Z Determination

Approach

EPA also requested further information on how the sigma-z value was derived for the Hybrid Approach. BLP calculates sigma-z at each receptor point. To determine sigma-z values near the release points, a 250 meter polar grid measured from the Smelter center was used to capture sigma-z values. The 250 meter distance places the receptors beyond the northern and southern ends of the Smelter building which is expected to allow building interactions and ridge vent plume mixing to be included the sigma-z calculation. The 250 meter distance also uses a uniform receptor grid for each source and prevents receptors from overlapping with the source which is not allowed in BLP. Other BLP/AERMOD approaches have used sigma-z values based on the final plume rise, which likely overestimates the sigma-z value and dilutes the plume in the near field. The 250 meter distance is necessary to allow the plume and building dynamics to be addressed without diluting the plume.

Results

A sensitivity analysis was performed by constructing a tight rectangular receptor grid around the anode and converter vents and the ISA and ELF vents. BLP was run with receptor grids at distances of 10m, 20m, 50m and 100m and the sigma-z values were extracted and compared. The results are provided in Tables 3A and 3B.

Table 3A. Results of BLP Sigma-Z Evaluation, Anode / Converter Run

	Sigma-Z (m) for Anode / Converter Vents				
Receptor Distance	10m	20m	50m	100 m	250 m (polar)
Average	23.13	24.42	25.06	27.22	29.49
75th Percentile	30.65	30.89	31.89	33.32	35.49
50th Percentile	30.41	30.43	30.58	30.8	31.325
25th Percentile	14.35	17.16	17.18	20.06	21.11

Table 3B. Results of BLP Sigma-Z Evaluation, Isa / ELF / Converter Run

	Sigma-z (m) for ISA/ELF Vents				
Receptor Distance	10m	20m	50m	100 m	250 m (polar)
Average	24.86	25.36	26.42	28.28	31.72
75th Percentile	30.76	31.09	32.02	33.4	36.25
50th Percentile	30.42	30.48	30.65	30.89	31.46
25th Percentile	19.84	20.39	21.6	23.72	27.15

A sensitivity analysis was performed with the Hybrid Approach using the critical emissions values to determine if predicted concentrations are sensitive to the use of BLP-predicted sigma-z values for the 10 m and 250 m receptors. The difference between the sigma-z values at the 10m and 250m distances is 0.38% or 1.6 µg/m^3 for the highest 1-hour and 1.6% or 2.7 µg/m^3 for the 4th highest 1-hour design value concentrations. The use of sigma-z values determined from a 250m polar grid has negligible effects on the modeled impact.

Table 4. Results of Hybrid Approach Sensitivity Analysis to Sigma-Z

Averaging	CEV Case with 10 meter Receptor Grid	CEV Case with 250 m Receptor Grid
H1H (µg/m^3)	427.3	425.7
H4H (µg/m^3)	166.1	163.4

Conclusion

The sigma-z analysis presented here shows the use of the BLP-calculated values from the proposed 250 m receptor grid are adequate for the volume source sigma-z input in the AERMOD model. Sensitivity analysis of the sigma-z value show the expected range of sigma-z values have negligible effects on the predicted off-site concentrations.

10.5 Appendix E: Emission Variability and Independent Assessment

Technical Memorandum
Emissions Variability and Independence Assessment for the
Miami SO_2 Nonattainment Area State Implementation Plan (SIP)
July 28, 2015

This technical memorandum presents Freeport-McMoRan Miami Inc.'s (FMMI) emissions variability and independence assessment for use in the Arizona Department of Environmental Quality's (ADEQ) Miami SO_2 Nonattainment Area State Implementation Plan (SIP) submittal to the U.S. Environmental Protection Agency (EPA). As explained in more detail below, evaluating emissions variability and independence is an important step in identifying an SO_2 emission limit for FMMI's primary copper smelter. FMMI is performing dispersion modeling to support the SIP submittal.

Introduction

The SO_2 National Ambient Air Quality Standard (NAAQS) is based on the 3-year average of the annual 99th percentile of the maximum daily 1-hour SO_2 concentration. The NAAQS could be implemented through an hourly emissions limit set at the critical emissions value, but as EPA has acknowledged in its SO_2 Nonattainment Area SIP Guidance (EPA, 2014), such an hourly emissions limit is excessively stringent in many cases. As a result, EPA allows SIPs to set emission limits longer than 1-hour (up to 30 days), provided that the longer term emission limit is protective of the NAAQS and comparably stringent to the critical emissions value.

Because emissions from the Smelter are highly variable, developing such a longer-term limit for the Smelter requires an assessment of the probability that maximal emissions from each of the individual SO_2 emissions sources at the Smelter could occur simultaneously. This probability is a function of both the variable emissions from each individual SO_2 emissions source and the likelihood that those individual sources run at the same time (the "independence" of these emissions). FMMI's analysis of continuous emissions monitoring data confirms that these SO_2 sources do not emit near their maximum rates at the same time. The purpose of this technical memorandum is to provide a description of smelter operations and an analysis of individual source emissions, which demonstrate the highly variable emissions from each source and the independence of source operations. These important factors should be taken into account in developing an emissions limit for the Smelter that is protective of the NAAQS.

Smelter SO_2 Emissions Configuration

SO_2 Emissions Release Points

The FMMI Smelter is currently configured with five roof vents, which account for a significant proportion of the Smelter's current SO_2 emissions (approximately 44% of Smelter SO_2 emissions during the period from May 2013 through December 2014). The roof vents are located above the IsaSmelt® (Isa) vessel, the Electric Furnace (ELF), the converter aisle (2 vents), and the anode aisle. In addition to the roof vents, three stacks (Acid Plant Tail Gas Stack, Vent Fume Stack, and Bypass Stack) are located at the Smelter. The locations of the existing vents and stacks are shown in Figures 1 and 2.

Figure 1. Aerial Photograph of Miami Smelter, Showing Stacks and Roof Vents

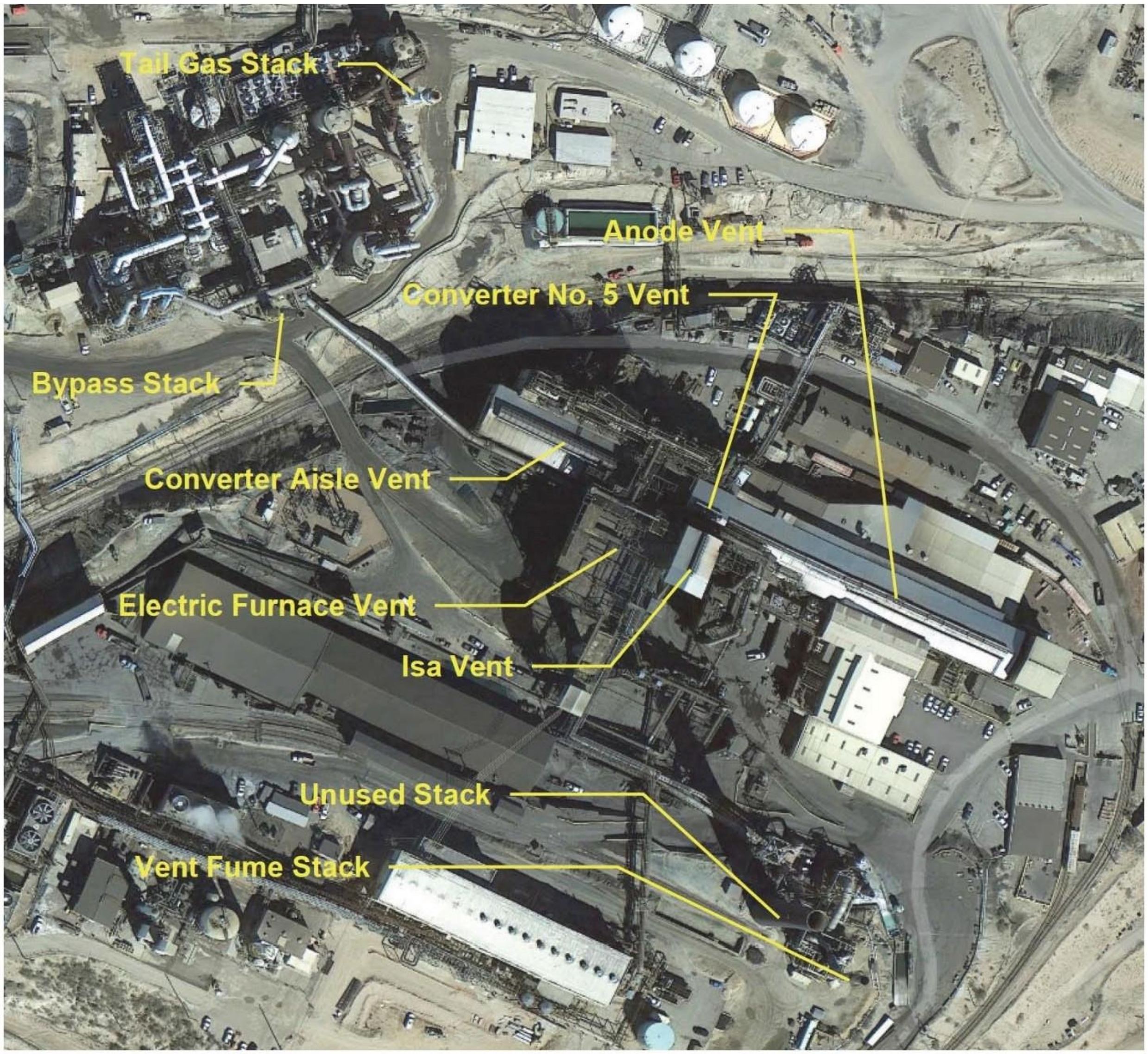


Figure 2. Photograph of Miami Smelter, Showing Stacks and Visible Roof Vents

Photograph taken at the Jones Ranch Ambient SO_2 Monitoring Station

The future Smelter configuration will consist of four roof vents and three stacks. The roof vent located above Converters 2 through 5 will be reconfigured as part of a collection system for fugitive emissions. In addition, the anode and mold vessels will be modified to collect emissions generated during the refining of blister copper. The collected emissions from the converter roofline and anode vessel capture systems will be routed to the new Aisle Scrubber to treat the captured SO_2 emissions. The roofline above the non-functional Inspiration Converter and the Anode Aisle will still vent to the atmosphere. Additionally, Acid Plant Bypass emissions will be routed to the Aisle Scrubber for treatment prior to discharge to atmosphere. FMMI is proposing additional changes to the Smelter configuration, as set forth in greater detail in the separate modeling protocol document.

Smelter Processes and Relationship to SO_2 Emissions Release Points

The Smelter process includes multiple steps, most of which are performed in batches. The episodic nature of these batches causes significant variability in SO_2 emissions over time.

IsaSmelt® (Isa) Bath-Smelting Furnace

Unlike the conventional flash smelting or reverberatory furnace technology used at other copper smelters, FMMI processes copper concentrates using an IsaSmelt® (Isa) bath-smelting furnace. Ore concentrates, fluxes and reverts are fed into the Isa though a feed port and mixed with oxygen enriched air and fuel (natural gas). The resulting bath of copper matte and slag is transferred in batches from the Isa to the Electric Furnace (ELF) using one of two available launders.

Process off-gases produced in the Isa vessel are captured and exhausted to the Smelter's Acid Plant for conversion of SO_2 to sulfuric acid, with unconverted SO_2 vented to the Acid Plant Tail Gas Stack. The Isa process off-gases are merged with emissions from other units at the Smelter. While the Isa process off-gas emissions are continuous in nature, the SO_2 concentration varies significantly due to the variable sulfur content of the concentrate feed.

Most gases released from the launder during the batch Isa to ELF transfers (i.e., tapping) are captured and exhausted to the Vent Fume Stack via the Vent Fume System. These SO_2 emissions are merged with emissions from other units at the Smelter. The Isa tapping emissions to the Vent Fume Stack are variable due to the batch nature of the process (i.e., Isa tapping only occurs for approximately 15 minutes of every hour) and the variable sulfur content of the concentrate feed.

Uncaptured emissions are released to atmosphere via the roof vent located above the Isa vessel. These emissions are highly variable over time due to the batch nature of the process (i.e., the periodic nature of the tapping process).

Electric Furnace (ELF)

The ELF serves as a slag separation device. The copper matte settles to the bottom of the ELF, from where the copper matte is tapped in batches into ladles and transported by crane to one of four Hoboken converters. Typically, three converters are operable and one is undergoing major maintenance at any given time. The slag on the top of the bath is removed in batches via a slag tapping launder and transported by slag hauler truck to the slag storage area.

Process off-gases released from the ELF are captured and exhausted to the Smelter's Acid Plant for conversion of SO_2 to sulfuric acid, with unconverted SO_2 vented to the Acid Plant Tail Gas Stack. The ELF process off-gases are merged with emissions from other units at the Smelter. The off-gas emissions are continuous in nature, but are relatively minor compared to the emissions from the other units at the Smelter.

Most gases released from the launders during the batch slag and matte transfers are captured and treated in the Vent Fume Scrubber prior to being exhausted to the Vent Fume Stack. These SO_2 emissions are merged with tapping emissions from the Isa. Uncaptured emissions are released to atmosphere via the roof vent located above the ELF. Both the emissions from the Vent Fume Stack and the uncaptured emissions are highly variable over time due to the batch nature of the process (i.e., the periodic nature of the tapping process).

Hoboken Converters

At FMMI, the converters perform a batch operation scheduled to operate in cycles. The cycle consists of receiving matte from the ELF, performing a slag blow to remove iron and other impurities, followed by a copper blow to remove sulfur from the remaining bath. Upon completion of the copper blow, the product (blister copper) is transferred in batches into ladles which are transported to one of two anode vessels by crane. Converter slag is transferred in batches into ladles which are transported by crane to the electric furnace for recovery of residual copper values.

Process off-gases are vented from the converters to the Smelter's Acid Plant for conversion of SO_2 to sulfuric acid, with unconverted SO_2 vented to the Acid Plant Tail Gas Stack. The converter process off-gases are merged with emissions from other units at the Smelter. Uncaptured emissions are released to atmosphere via the roof vent located above the converters. Both the off-gas and the uncaptured emissions are highly variable due to the batch nature of the converter cycle (i.e., the periodic nature of the converting process).

Planned upgrades to the Smelter will include a canopy roof collection system to capture converter aisle emissions, which will be treated with a scrubber and released to atmosphere via a stack (the future Aisle Scrubber). Uncaptured emissions will be considerably reduced, but not eliminated, by the canopy roof collection system.

Anode Furnaces

Anode vessels perform a batch operation scheduled to operate in cycles that refine the blister copper to anode copper. The cycle consists of oxidizing the bath to remove the trace sulfur in the blister, reducing the bath using a mixture of steam and natural gas to remove oxides, casting, and skimming slag. The anode copper is poured into molds (casting) in batches to produce copper anodes, the end product for the Smelter. Anode slag is transferred in batches into ladles which are transported by crane to the converters for recovery of any residual copper values.

Emissions from the Anode Aisle operations are not presently captured. Rather, Anode Aisle emissions are released to atmosphere via the roof vent located above the anode furnaces. These emissions are highly variable over time due to the batch nature of the process (i.e., the periodic operation of the anode process).

Planned upgrades to the Smelter will include a collection system to capture most of the Anode Aisle emissions, which will be treated with a scrubber and released to atmosphere via a stack (the future Aisle Scrubber). Uncaptured emissions will be considerably reduced, but not eliminated, by the collection system.

Uniqueness of Smelter Operations

The process description set forth above demonstrates that smelter operations are nothing like power plant operations which are the focus of EPA's SO_2 Nonattainment Area SIP Guidance (EPA, 2014). The batch nature of the smelter process is a striking difference to the continuous nature of power plant operations. Furthermore, the feasibility of capturing and controlling SO_2 emissions depends on the unique configuration of each process vessel and transfer point (i.e., launders and ladles) within the Smelter, unlike a power plant where the units are either identical or very similar in nature and emissions are generated in a confined device (e.g., a boiler) which enhances the feasibility of emissions capture for control.

FMMI's evaluation of the feasibility of capture and control options for the future smelter operations required independent analysis of each specific operation. Existing control systems, specifically the Acid Plant and the Vent Fume System, were evaluated for upgrades to improve emissions reductions. Each of these control systems is unique. Emissions to the roof vents were evaluated for capture and control options. The equipment configuration (e.g., crane rails and vessel placement) and the quantity of emissions in each process area are also unique and require careful consideration. As addressed in the technical memorandum that covers the derivation of the critical emissions value, the effectiveness and cost of controlling each of the SO_2 emissions sources varies greatly, and an iterative approach must be performed to optimize the control cost required to achieve attainment.

Sequencing of Batch Smelter Operations

The sequencing of the batch operations at the Smelter dictates the variable nature of SO_2 emissions from the Smelter, which is highly variable due to the changing nature, length, and scheduling of operations and the multiple process units working at any one time. At FMMI, the converter operational cycle dictates the sequencing of the various batch operations within the Smelter as a whole. The operational cycles of the primary smelter processes are summarized below.

Converter Cycle

The converter operational cycle ranges from 10 to 15 hours in duration and results in variable SO_2 emissions levels to different points in the Converter Aisle at different times in the cycle. To illustrate, during this cycle a single converter performs the following operations:

- Transfer of copper matte from the ELF to a converter (up to 8 ladles, approximately 1.5 hours). During this time, SO_2 is emitted through the Converter Aisle Roof Vents as each ladle moves through the Converter Aisle (no emissions to the Acid Plant).

- Conversion of copper matte to blister copper, consisting of slag blowing and copper blowing phases (approximately 6 to 8 hours). Slag skimming occurs during the slag blowing phase, with the skimmed slag returned to the ELF. Anode slag is also returned to the converter during the slag blowing phase. The slag transfers in ladles contribute variable SO_2 emissions to the Converter Aisle Roof Vents. During the slag blowing and copper blowing phases, SO_2 is vented to the Acid Plant, reducing SO_2 emissions to the Converter Aisle Roof Vents. In the future, converter mouth covers will be in place after slag skimming is completed, further reducing SO_2 emissions to the Converter Aisle Roof Vents.

- Transfer of blister copper to the anode vessels (between 0.5 to 1 hour). During this time, low levels of SO_2 are emitted through the Converter Aisle Roof Vents as each ladle moves through the Converter Aisle (no emissions to the Acid Plant).

- Converter turn-around (4 to 8 hours). During this time, minimal amounts of SO_2 are emitted through the Converter Aisle Roof Vents (no emissions to the Acid Plant).

During any given day, three of the four converters are run through the cycle on a staggered schedule such that six converter cycles are typically completed (as many as eight cycles may be completed if turn- around time is short). No more than two converters can be blowing at the same time due to a limitation of the gas handling system. The transfers from converters to anode furnaces are governed by this cycle, as are the transfers from the ELF to the converters. Normally, one converter is undergoing major maintenance and is not operational.

Anode Cycle

The anode cycle ranges from 15 to 18 hours in duration and results in variable SO_2 emissions levels to the Anode Aisle Roof Vent at different times in the cycle. To illustrate, during this cycle a single anode furnace performs each of the following operations:

- Transfer of blister copper to the anode vessels (between 0.5 to 1 hour) from the converter, with 2 charges required to fill a vessel. During this time, minimal levels of SO_2 are emitted through the Anode Aisle Roof Vent as each ladle moves through the Anode Aisle.
- Oxidation of blister copper to remove the trace sulfur (approximately 1 hour). During this time, elevated SO_2 levels are emitted through the Anode Aisle Roof Vent.
- Reduction of blister copper to remove oxides (approximately 1 hour). During this time, reduced SO_2 levels are emitted through the Anode Aisle Roof Vent.
- Casting of anode copper (approximately 5 to 6 hours). During this time, minimal amounts of SO_2 levels are emitted through the Anode Aisle Roof Vent.
- Idle operation (approximately 7 to 10 hours). During this time, the anode vessels are charged with blister copper and temperature is maintained using a burner. Slag skimming is performed at this time with the skimmed slag returned to an operating converter. Minimal amounts of SO_2 are emitted through the Anode Aisle Roof Vent.

During any given day, the two anode furnaces are run through the cycle on a staggered schedule such that two or three casting operations are performed.

Isa and ELF Cycles

The Isa and ELF continuously maintain a bath, and consequently process off-gas is continuously directed to the Acid Plant and SO_2 emission leaks from the vessels are continuously emitted through the Isa or ELF Roof Vent. In the future, emissions that escape from the Isa feedport will be captured and routed to the Vent Fume System. The variable SO_2 emissions from this area are due to the batch transfer of material in and out of the ELF, as follows:

- Isa tapping approximately every 45 minutes, with a duration of 15 minutes typical for each tap.
- Slag tapping 45 times per day, with a duration 7 to 12 minutes typical for each tap.
- Matte tapping 60 times per day, with a duration of 10 minutes typical for each tap.

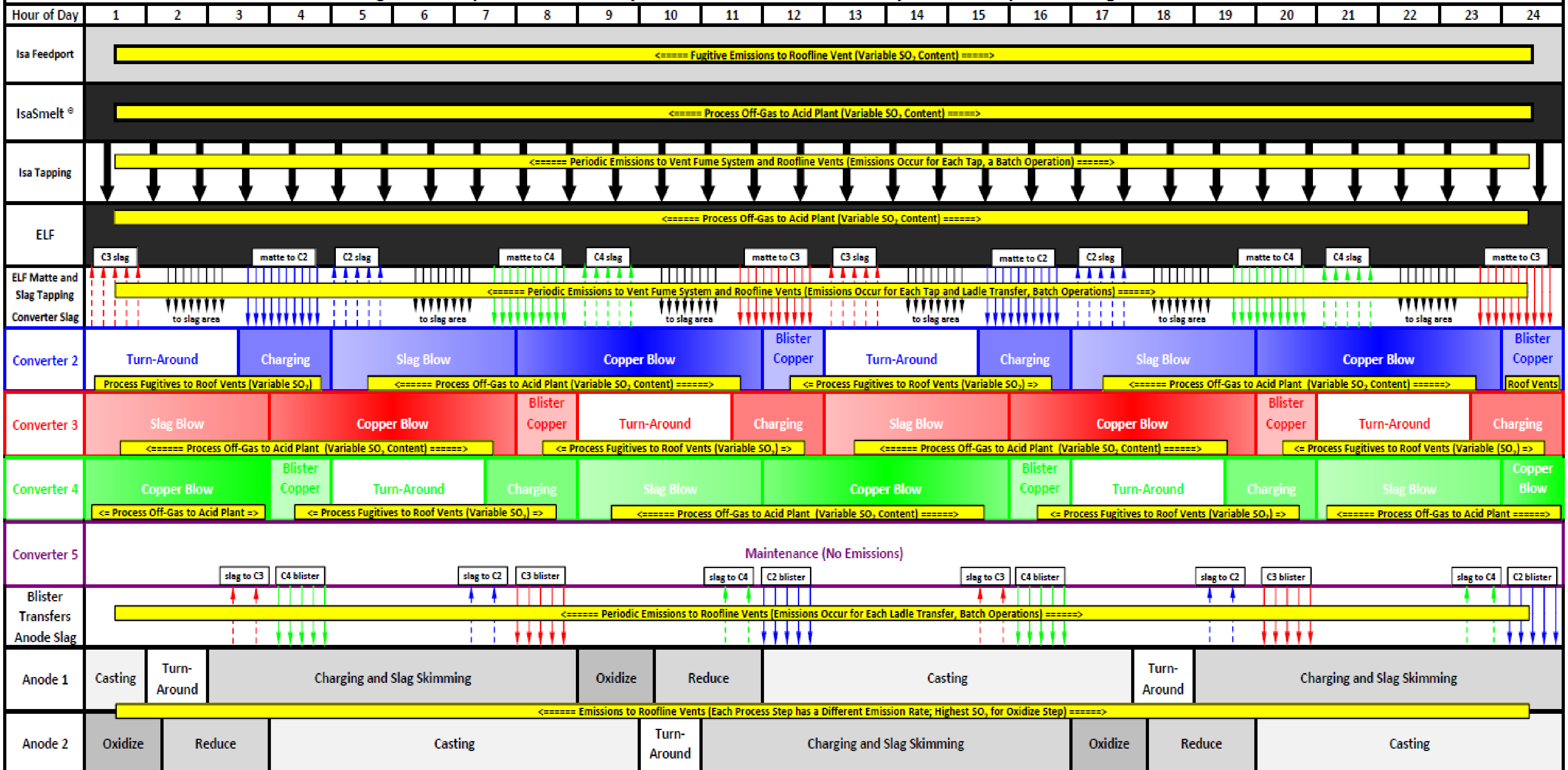
The resulting variable SO_2 emissions from these batch operations are captured by the Vent Fume System.

Independence of Process Cycles

The operational cycles identified above are depicted in Figure 3, which shows representative daily smelter production cycles. Each step in the process has variable SO_2 emissions, and the sequencing of the steps minimizes the occurrence of simultaneous maximal SO_2 emissions from the various processes. Working from top to bottom in the figure, the following factors into the variability of SO_2 emissions and the independence of SO_2 emissions from each source:

- The Isa process off-gases are continuously routed to the Acid Plant. SO_2 concentration in the off-gas varies based on the sulfur content of the concentrate fed to the vessel.
- Isa tapping occurs approximately every 45 minutes, with a duration of 15 minutes for each tap. Each arrow in the figure signifies an individual tap. SO_2 emissions cycle according to the tapping schedule and are routed to the Vent Fume System.
- The ELF process off-gases are continuously routed to the Acid Plant. SO_2 concentration in the off-gas varies based on the sulfur content of the bath inside the vessel. Changes in sulfur content lag in time compared to sulfur content changes in the Isa vessel.
- ELF matte and slag tapping occurs in cycles, with matte tapping approximately 60 times per day at 10 minute durations, and slag tapping approximately 45 times per day at 7-12 minute durations. Matte is tapped when a converter becomes available for charging. Slag is tapped when the slag layer is sufficiently high above the tap hole in the furnace. Each arrow in the figure signifies an individual matte tap to the converter charge. SO_2 emissions cycle according to the tapping schedule and are routed to the Vent Fume System. Matte transfer emissions from ladles report to the roof vents.
- The production cycle of each converter is shown as: (1) charging; (2) slag blowing; (3) copper blowing; (4) copper blister transferring; and (5) turn-around. Converter off-gas is routed to the Acid Plant during slag blowing and copper blowing. Some off-gas during converter charging is also captured and routed to the Acid Plant to reduce SO_2 emissions to the roof vent. SO_2 concentration in the off-gas increases as the slag blow progresses, peaks during the copper blow, and then decreases as the blowing cycle is completed. SO_2 emissions to the roof vent cycle according to the converter charging cycle. SO_2 emissions to the roof vent during molten metal transfers and converter turn-around are minimal.
- Transfers of converter slag back to the ELF occur only during slag blowing. Each arrow in the figure signifies an individual slag transfer. SO_2 emissions cycle according to the transfer schedule and are routed to the roof vents.
- The production cycle of each anode furnace is shown, including charging, slag skimming, oxidizing, reducing, and casting. SO_2 emissions are greatest during the oxidizing step and are routed to the roof vent. SO_2 emissions to the roof vent during the balance of operations are minimal.

Figure 3. Representative Daily Smelter Production Batch Cycles and Impact on SO_2 Emissions



Notes:

- This chart must be viewed in the original color format and cannot be properly interpreted if printed in grayscale or black and white.
- Each arrow signifies a transfer and is representative of a single ladle load or individual tapping.
- Gradation shown for slag blowing is intended to show SO_2 emissions increase as slag blow moves to completion.
- Gradation shown for copper blowing is intended to show peak SO_2 emissions toward middle of step.
- Converter 1 is not operable and therefore is not listed.
- Production cycle is representative of existing and future operations. Some emissions points will be reconfigured as noted below.
- Most of Converter and Anode emissions to Roofline Vents will be captured and routed to the Aisle Scrubber in the future configuration.
- Isa Feedport emissions to Roofline Vent will be captured and routed to the Vent Fume System in the future configuration.

Legend

- Solid arrows represent material transfers moving forward through the process (e.g., matte, blister).
- Blue, red, green arrows represent transfers to and from Converters 2, 3, and 4, respectively.
- Dashed arrows represent returning material transfers (e.g., slag).

Figure 3 demonstrates that it is highly improbable for all SO_2 sources to be emitting near their maximum rates at the same time. As set forth below, analysis of continuous emissions monitoring data confirms that SO_2 sources do not emit near their maximum rates at the same time.

While the smelter emissions capture and controls will be undergoing considerable changes to bring about compliance with the NAAQS, the processes shown in Figure 1 will remain fundamentally unchanged. Therefore, SO_2 emissions produced by the various process areas will continue to cycle in accordance with the process schedules.

Acid Plant Bypass Events

In addition to the normal smelter operations described above, Acid Plant bypass events must also be considered in addressing the variable nature of SO_2 emissions from the Smelter. Acid Plant bypass events occur as a result of either planned maintenance or unplanned power loss and Acid Plant malfunctions. For planned maintenance, smelter operations are shut down and process off-gas is run through the Acid Plant until SO_2 concentration in the off-gas is less than 0.5 percent. At this point, the Bypass Stack is opened and the low-strength process off-gas is emitted through the Bypass Stack. Gases from the ELF are routed to the VFS, unless the hot gas fans are down for maintenance.

Occasionally, an unplanned malfunction occurs at the Acid Plant, during which the process off-gases bypass the Acid Plant and are routed to the Bypass Stack. Such a malfunction initiates the shutdown of all smelter operations, resulting in uncontrolled SO_2 emissions being quickly reduced.

Because a smelter shutdown is initiated for bypass events, SO_2 emissions from the Bypass Stack are independent of SO_2 emissions from other smelter sources.

Analysis of Continuous Emissions Monitoring Data

To support the above discussion, an analysis of continuous SO_2 emissions monitoring data for the period from May 2013 through October 2014 was performed. The period of record includes over 13,000 hours of normal and Acid Plant bypass operations.

A set of scatterplots was prepared to show the independence of SO_2 emissions between multiple pairs of SO_2 emissions sources. The scatterplots are provided in Attachment A. Examination of the scatterplots reveals no correlation of SO_2 emissions between source pairs. Further examination reveals that the simultaneous occurrence of maximal SO_2 emissions is a very rare occurrence between source pairs. Maximal SO_2 emissions shown on the scatterplots tend to be plotted near the horizontal and vertical axes, demonstrating that emissions from one source tend to be low when emissions from the other source are high.

The continuous SO_2 emissions monitoring data were further examined to evaluate the probability of simultaneous occurrence of maximal emissions for all SO_2 emissions sources combined. This additional analysis was performed only for normal operations and did not include Acid Plant bypass events because Bypass Stack SO_2 emissions are distinctly independent of emissions from other sources, as could be seen in the scatterplots and as expected based on the nature of Acid Plant bypass events.

The probability of simultaneous occurrence of maximal emissions from all SO_2 emissions sources combined is provided in Table 1. The left column in the table represents the percentile level of SO_2 emissions from an individual source, with the first row in the table specifically evaluating the simultaneous occurrence of the SO_2 emission rate of each source being at 99^{th} percentile or greater levels of emissions. The results indicate that there was never an hour in the period of record where all of the emissions sources were simultaneously emitting at 99th percentile levels or greater.

The analysis demonstrates that the simultaneous occurrence of maximal emissions for all SO_2 emissions sources at the Smelter is exceedingly rare, further supporting the previous discussion of the sequencing of smelter processes. For example, the simultaneous occurrence of 95th percentile level emissions and greater is never expected to occur, while 90th percentile level emissions from each source are expected to occur only 1 hour in a year. These results must be considered in the identification of longer term emission limits for the Smelter.

Table 1. Probability of Simultaneous Occurrence of Maximal Emissions from Smelter SO_2 Sources [a]

Emissions Percentile	Probability of Simultaneous Occurrence at Stated Percentile	Expected Hours of Simultaneous Occurrence in a Year [b]
99th	0%	0
95th	0%	0
90th	0.01%	1
75th	0.07%	6

Notes:

[a] Sources evaluated were the Acid Plant Tail Gas Stack, Vent Fume Stack, Isa Roof Vent, ELF Roof Vent, Converter Roof Vent, and Anode Roof Vent.

[b] Expected hours considers 8760 potential hours of operation in a year.

Establishing a Longer Term Emission Limit

EPA allows SIPs to set emission limits longer than 1-hour (up to 30 days) provided that the longer term emission limit can be demonstrated to be protective of the NAAQS and comparably stringent to the critical emissions value. Such longer-term limits require FMMI to assess the probability that maximal emissions from each of the SO_2 emissions sources at the Smelter occur simultaneously, which is a function of both the highly variable emissions from each individual SO_2 emissions source and the likelihood those individual sources are to run at the same time (the “independence” of these emissions). FMMI’s analysis of hourly emissions data from the Smelter demonstrates that it is rare for all of these sources to be emitting near their maximum rates at the same time.

Appendix B to EPA’s nonattainment area SIP guidance offers an approach to identifying longer-term emission limits for simple facilities that have highly variable emissions from a single emission source. The accompanying Appendix C to EPA’s guidance provides an example power plant implementation of Appendix B, and specifies a 6-step process for identifying a 30-day emission limit:

1. Determine critical emissions value with dispersion modeling,
2. Develop 1-hour emissions frequency distributions for each future source,
3. Develop 30-day emissions frequency distributions for each future source,
4. Determine the 99th percentile emission rate for the 1-hour and 30-day distributions,
5. Calculate the ratio of the two 99th percentile values, and
6. Multiply the calculated ratio of 99th percentile values by the critical emissions value (CEV) to determine the 30-day emission limit.

The approach can be adapted for facilities with multiple similar sources, such as a power plant with three identical units that could be equipped with similar control technologies. Unfortunately, the guidance does not address how the Appendix B approach is to be applied for complex facilities such as the Smelter, which has multiple SO_2 sources to be considered with batch operations that operate independently of each other, and each of which are sufficiently different that alternative control strategies must be evaluated independently for each of them.

While FMMI identified several Appendix B approaches that can be devised for the Smelter, the most appropriate method is to sum the hourly continuous emissions for the multiple future sources to produce facility-wide 1-hour and 30-day emissions frequency distributions. The 99th percentile values are then determined for the facility-wide 1-hour and 30-day distributions and the ratio of the two values is calculated and multiplied by the CEV. This approach inherently considers the joint frequency distribution of SO_2 emissions from the individual sources, including Bypass Stack emissions. The independence of the sources' SO_2 emissions is accounted for, and the resulting facility-wide emissions variability is used to calculate the ratio.

Other approaches to Appendix B have inherent flaws. For example, one could develop the 1-hour and 30-day emissions frequency distributions and determine the 99th percentile values for *each* future source and then sum the 99th percentile values to determine facility-wide 1-hour and 30-day values.

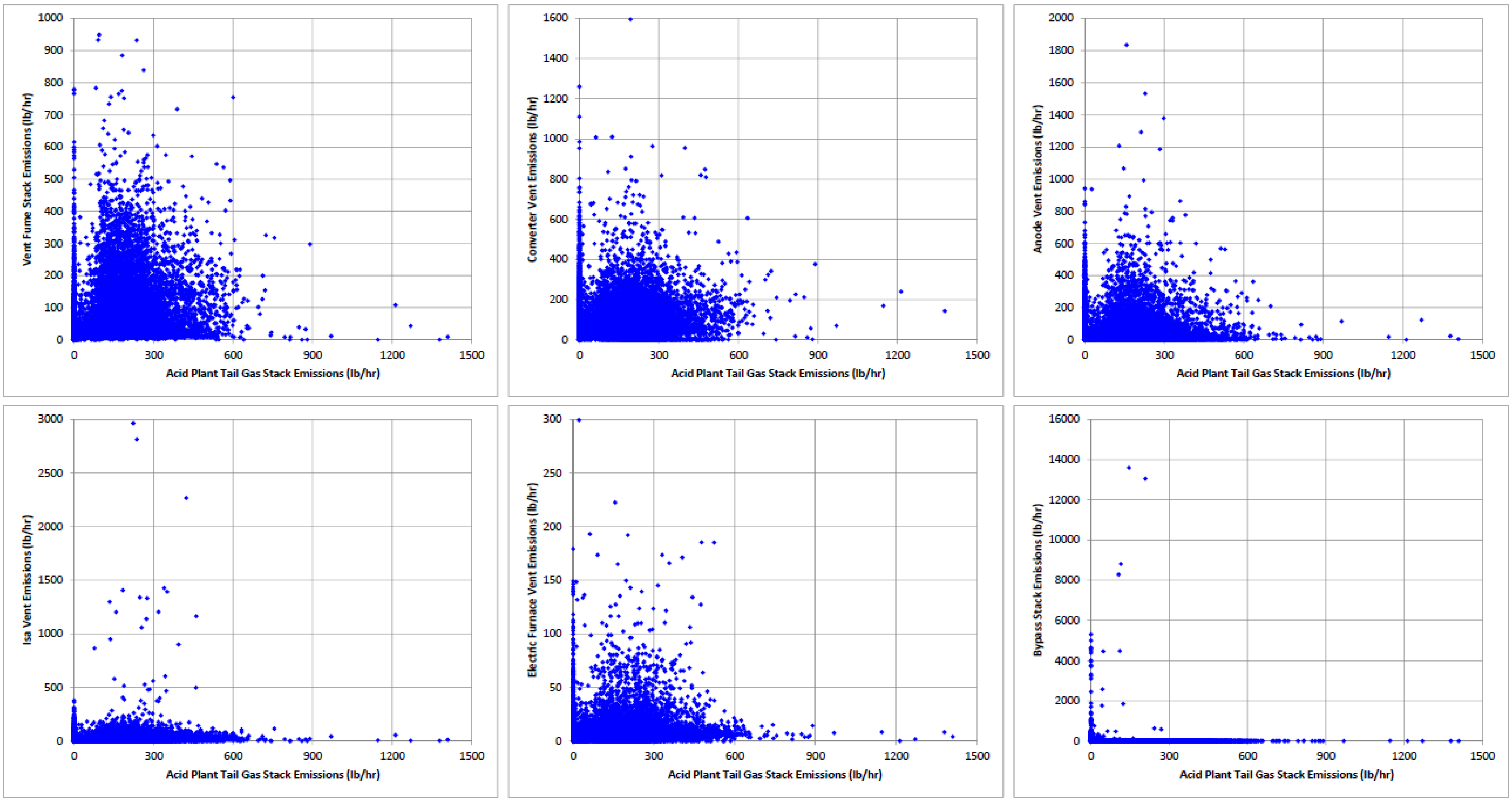
This approach is flawed because it assumes that high emissions from the sources can simultaneously occur (i.e., the 99th percentile emissions from each source are summed, including 99th percentile emissions from the Bypass Stack). As was summarized in Table 1, such a scenario is extremely unlikely to occur. No such events were identified over a 20-month period of smelter operating time. Due to the high variability of SO_2 emissions from each source, this approach would produce an unrealistically low ratio, which in turn would result in an unrealistic 30-day emission limit.

For the reasons identified in this technical memorandum, the Appendix B approach was implemented by summing the hourly continuous emissions for the expected future emissions of the sources that will be in place after the Smelter modifications are completed. The results of the analysis to establish longer term emission limits are provided in Section 8-2 to 8-4 of ADEQ's Technical Support Document (TSD) for the SIP submittal.

Scatterplots of Hourly Emission Rates
Showing Independence of Operations

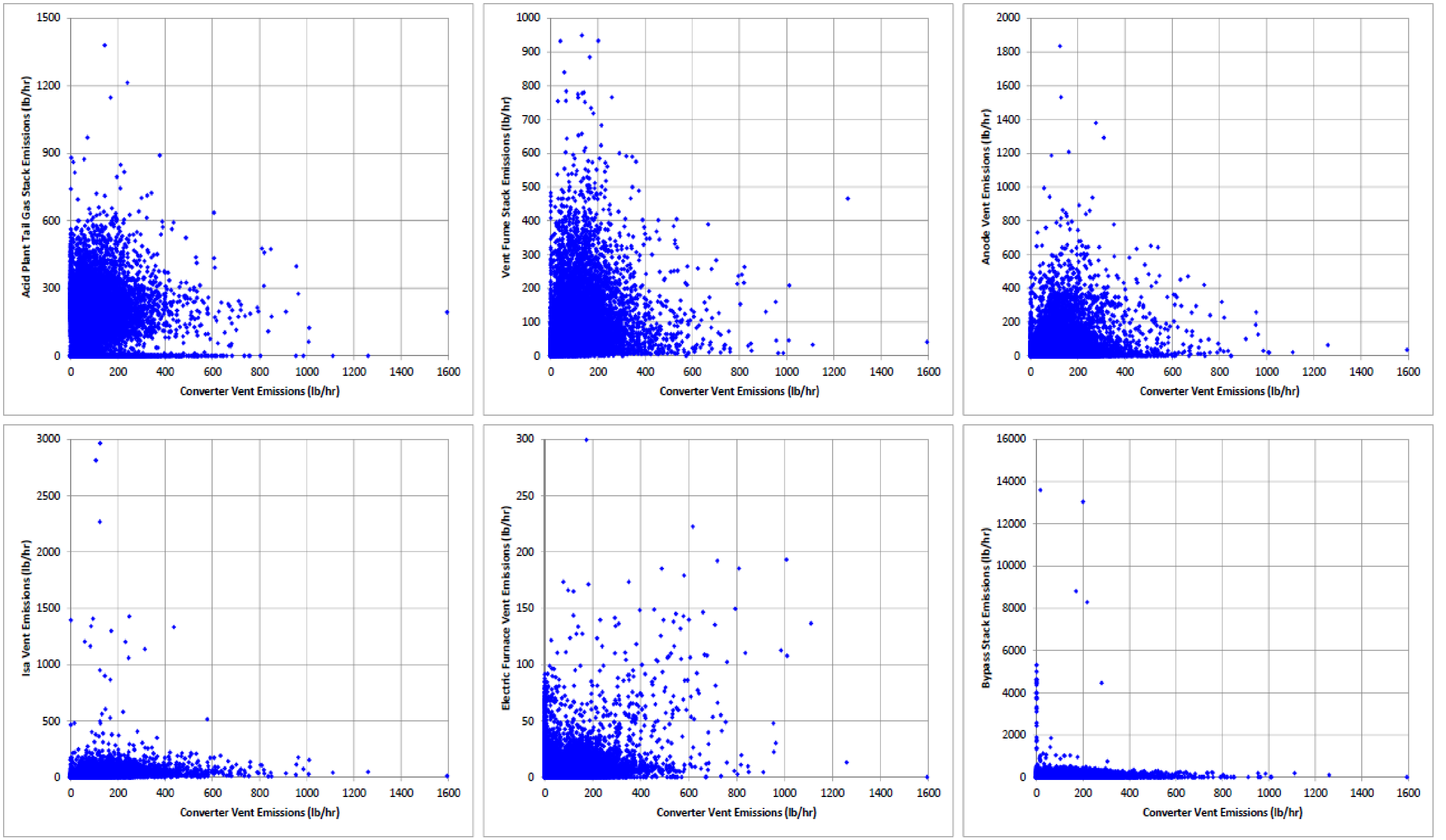
Scatterplots of Hourly Emission Rates Showing Independence of Operations

Acid Plant Tail Gas Stack



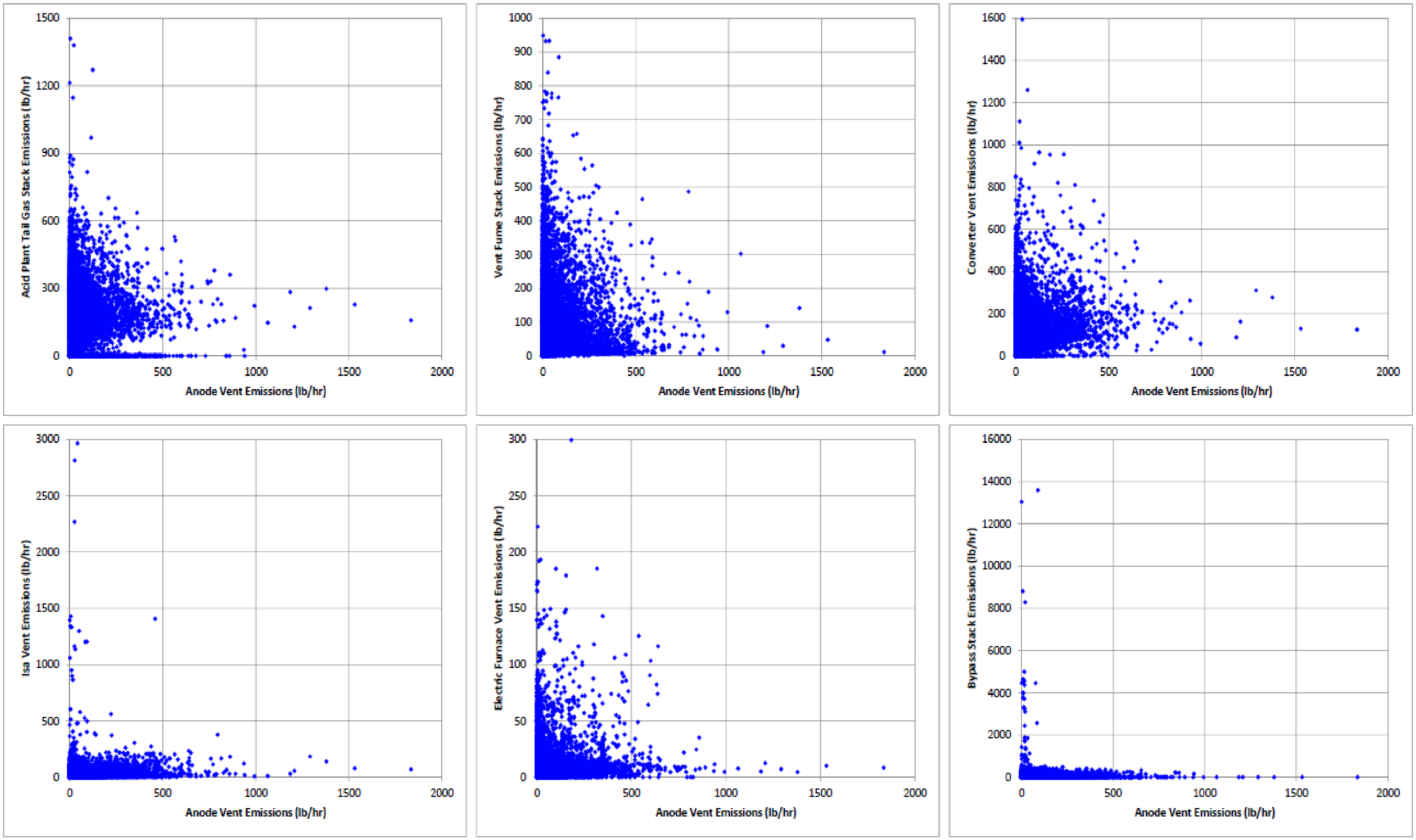
Scatterplots of Hourly Emission Rates Showing Independence of Operations

Converter Vent



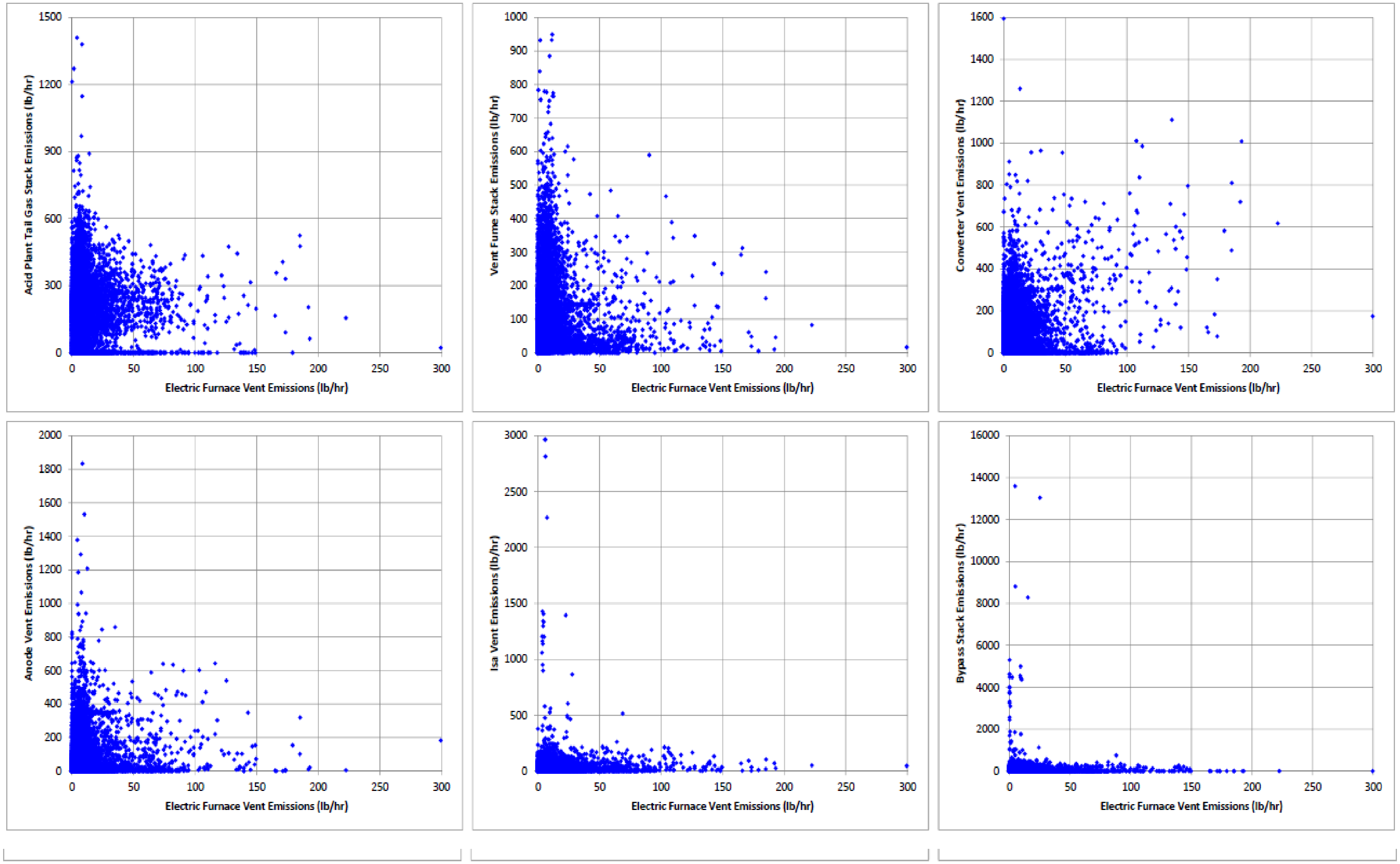
Scatterplots of Hourly Emission Rates Showing Independence of Operations

Anode Vent



Scatterplots of Hourly Emission Rates Showing Independence of Operations

Electric Furnace Vent



10.6 Appendix F: HATCH Memo Regarding Verification of SIP SO2 Emission Basis and Capture/Removal Efficiency

HATCH

Project Memo

H377000

August 28, 2015

To: C. West

From: J. Nikkari

cc: **FMMI**
A. Binegar
J. Spehar
T. Weaver

Hatch
I. Carruthers
R. Sullivan

Freeport-McMoRan Miami Inc. (FMMI)
Miami Smelter Project

Verification of SIP SO2 Emission Basis

1. Introduction

In response to the revised 1-hour sulfur dioxide (SO_2) National Ambient Air Quality Standard (NAAQS), the Freeport-McMoRan Miami Inc. (FMMI) copper smelter in Miami, Arizona (Miami Smelter) will undertake a significant project to upgrade the smelter that will result in reduced SO_2 emissions.

In support of FMMI's ongoing efforts to demonstrate that the proposed upgrade of the Miami Smelter will result in attainment of the 1-hour SO_2 NAAQS, Hatch has been asked to provide an engineering justification for the SO_2 emission levels used in FMMI's dispersion modeling to represent the post construction condition, from the following sources:

- Vent fume scrubber (VFS) stack
- Tail gas scrubber (TGS) stack
- Aisle scrubber stack
- Residual smelter building roofline (fugitive) emissions

2. SO_2 Emissions Calculation Basis

The basis for current plant annual SO_2 emissions was established in an earlier phase of this project based on plant operating data provided by FMMI. Baseline emissions from the VFS and TGS stack were based on FMMI's 2010 reported annual emissions from the continuous emission monitoring systems (CEMS). Smelter building annual roofline SO_2 emissions were based on direct measurements in June 2012, with adjustments to reflect baseline throughput.

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Page 1

This assessment of baseline SO_2 emissions at the smelter building roofline did not provide sufficiently detailed data on the emission contribution from numerous operations within the smelter to determine which combination of controls would be required to achieve the necessary SO_2 capture. As a result, Hatch refined the baseline inventory using the following:

- **Smelter Roofline SO_2 Emissions:** Average total SO_2 measured from each building was scaled to reflect future annual throughput and operating hours.
- **Emission Contribution from Individual Sources:** A qualitative assessment of the relative SO_2 emission contribution from individual sources within each smelter building, while operating/active, was performed using professional judgement and visual observations from both Hatch and FCX personnel.
- **Process Data:** Where possible, process modeling data was used to translate emissions while operating to annual operating average emissions. This included the frequency and duration of batch operations over a typical year at higher throughput. Process data was also used to estimate an increase on the order of 5% in annual operating hours at higher throughput.

Based on this analysis and FMMI's dispersion modeling for residual emissions from each source, Hatch determined the necessary controls to reduce the Miami Smelter's annual operating average SO_2 emissions to a level that will be consistent with a demonstration of attainment for the Miami area. The following emission controls contributed to reduced SO_2 emissions:

- Conversion of the VFS and TGS from magnesium hydroxide to caustic, along with increased recirculation flows
- Upgrades to the acid plant required to achieve increased throughput that will also result in improved conversion efficiency
- Installation of mouth covers on all 4 Hoboken converters
- Installation of a roofline capture system above the 4 operating converters, directed to a new aisle SO_2 scrubber
- Installation of mouth covers on all vessels operating as anode furnaces
- Installation of new process gas hoods on all anode furnaces, directed to the new aisle SO_2 scrubber
- Installation of a smelting furnace lance seal and charge port hood

For each of these controls, Hatch calculated the expected reduction in SO_2 emissions, as described below.

The Miami Smelter upgrade will include conversion of the VFS and TGS to use caustic reagent, at higher recirculation flow rates. Extensive upgrades to local piping systems are included. New packing will be installed in the VFS. The TGS will now be used at all times. Compared to the current scrubbers operating with magnesium hydroxide, SO_2 removal efficiencies will be increased from roughly 80% to 98%. Hatch based its estimate of SO_2 scrubber removal efficiency on mass transfer calculations for the upgraded VFS and TGS.

Upgrades to the acid plant will be required to achieve higher throughput. While the acid plant package has not yet been awarded, information obtained from a vendor indicated that the average conversion efficiency would be improved from roughly 99.8% to 99.9% via improved catalyst selection and equipment sizing. Combined with the upgraded TGS efficiency of 98%, total process gas capture in the acid plant is roughly 99.998%. Effectively all SO_2 contained in process gas from the converters, smelting furnace and electric furnace is captured in the acid plant during normal operation.

Mouth covers installed on each converter will be closed at all times when hot except during charging and tapping operations (slag skimming, blister copper transfer, etc.). This is expected to reduce the amount of fugitive SO_2 emissions to the converter aisle by 80% when closed and improve capture of process gas from each blowing converter to the acid plant. The mouth cover capture efficiency is based on conservative Hatch engineering judgement.

To provide additional control of SO_2 emissions from the converter end of the aisle, FMMI will install a roofline capture system above the 4 operating converters. All gas collected will be directed to a new Aisle SO_2 scrubber for treatment. Hatch calculated capture efficiency for the roofline capture system using extensive Computational Fluid Dynamics (CFD) modeling, for 3 different converter operating modes: blowing, charging, and tapping. Additional cladding was required on the smelter buildings to maximize capture of roofline SO_2 emissions. Performance of the Aisle SO_2 scrubber is based upon vendor guarantees, limited to a practical minimum outlet SO_2 concentration of roughly 1 ppmv for most operating conditions. For average annual inlet SO_2 loads, the resulting efficiency is on the order of 85%.

Upgrades to the Miami Smelter will include addition of a refractory lined process gas hood and mouth cover on each anode furnace, with process gas directed to a new baghouse and the Aisle SO_2 scrubber. Each anode furnace mouth cover will be closed at all times when hot except during charging and slag skimming operations. The same capture was used as the converter mouth covers. The new refractory lined process hoods are expected to capture 90% of process gas to the aisle scrubber system, with most SO_2 emissions from the anode furnaces occurring during the oxidation cycle. The mouth cover and process hood capture efficiencies are based on conservative Hatch engineering judgement.

The installation of a new Smelting Furnace lance seal air system is expected to reduce emissions around the lance that ultimately contribute to roofline emissions by roughly 80%. Effectively all SO_2 contained in the Smelting Furnace is captured in the acid plant system. The installation of a new Smelting Furnace charge port hood is expected to reduce emissions from the charge port by 80%, with all gas directed to the upgraded VFS system (98% SO_2 removal). For each of these controls, Hatch made conservative estimates of capture efficiencies based on its own smelter engineering experience.

The resulting SO_2 capture and removal efficiencies are summarized in Table 2-1.

Table 2-1: SO_2 Capture and Removal Efficiency Assumptions

Project Scope	Capture or Removal Efficiency (%)
Stacks:	
Acid Plant Conversion Efficiency	99.9%
Upgraded Scrubber Efficiency (VFS, TGS)	98%
New Aisle Scrubber Efficiency	1 ppmv exit (~85%)
Roofline Fugitives:	
New Mouth Covers – Converters and Anode Furnaces	80%
Anode Furnace Process Hoods	90%
Electric Furnace Slag Returns	Per CFD - Charging
Electric Furnace Matte Tapping	Per CFD - Skimming
Crane/Ladle Movements – Converter End of Aisle	75%
Smelting Furnace Lance Seal	80%
Smelter Furnace Charge Port Hood	80%

To determine the resulting facility-wide emission rates at future throughput, these projected removal efficiencies were applied to relevant activities and contributing sources. Table 2-2 provides a summary comparison of the baseline annual emissions for current operation to the emissions at increased throughput with all above mitigations in place. The can be converted to lb/h average operating emissions using the appropriate operating hours for each source.

Table 2-2: Current vs. Future SO_2 Annual Emissions

Source	Current Emission (st/y)	Expected Post Construction Emission (st/y)	Overall Reduction (%)
Smelter Buildings*	**1031**	**311**	**70%**
Stacks	**1746**	**112**	**94%**
VFS	331	46	86%
TGS	1415	11	99%
Aisle Scrubber	--	55	--

*Total emissions from converter/anode aisle, smelting furnace building and electric furnace building.

3. Conclusion

Upgrades proposed for the Miami Smelter will include significant controls to reduce SO_2 emissions. The application of these controls results in projected facility-wide annual operating average SO_2 emission rates that are consistent with the facility-wide emission rates used in FMMI's dispersion modeling analysis. This comparison is summarized in Table 3-1.

Table 3-1: SO_2 Emission Comparison – Annual Operating Average

Source	Project Emission Estimate (lb/h)	FMMI Modeling Basis (lb/h)***
Smelter Buildings*	77	79.6
Stacks**	27	30.5

*Total emissions from converter/anode aisle, smelting furnace building and electric furnace building.
**Vent fume, tail gas and aisle scrubber stack.
***Data provided by AMEC Foster Wheeler July 24, 2015.

J. Nikkari

10.7 Appendix G: GCT Memo Regarding Emissions calculations and Capture/Removal Efficiency during Bypass Events

GCT
Metallurgical Process Specialists

Gas Cleaning Technologies, LLC
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Telephone +1 214 613 1785
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September 2, 2015

MEMORANDUM

Chris West
Chief Environmental Engineer
Miami Operations
Freeport-McMoRan Miami, Inc.
P.O. Box 4444
Claypool, Arizona 85532-4444

Re: Acid Plant Bypass Emissions SO_2 Treatment

Dear Chris,

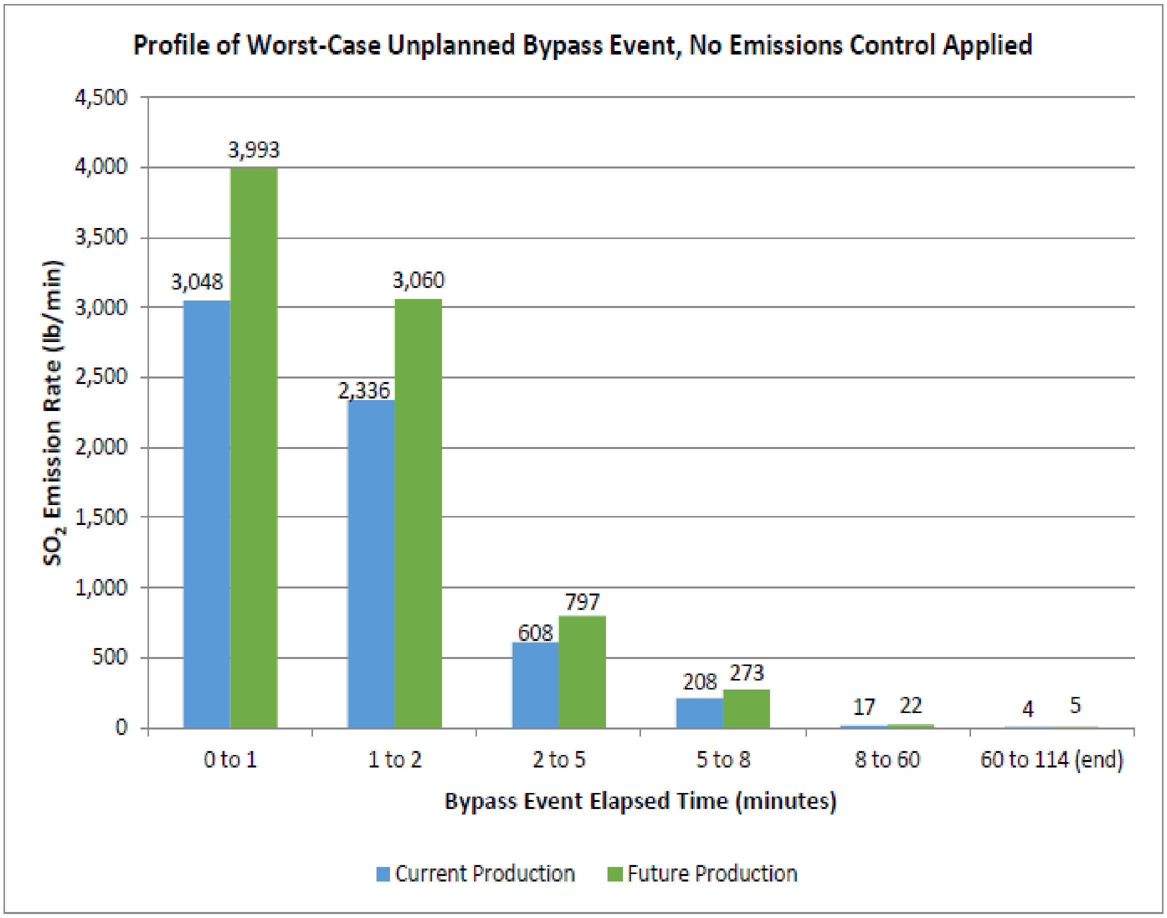
GCT evaluated potential treatment options for addressing Acid Plant bypass emissions of sulfur dioxide (SO_2) from the bypass stack during startup, shutdown, and emergency events at the Freeport-McMoRan Miami, Inc. (FMMI) Smelter. GCT's analysis, set forth in more detail below, evaluated the feasibility of using SO_2 control devices to provide partial control of the SO_2 emissions from the bypass stack. Both the emissions control equipment currently installed at the Smelter and equipment included in FMMI's Significant Permit Revision (No. 58409) were considered, as were other options. Based on our analysis, GCT concludes that use of the planned converter aisle vent scrubber (Aisle Scrubber) is a technically feasible solution for treating bypass emissions.

Analysis of Emissions Data

GCT's analysis examined planned and unplanned bypass events from 2010 through 2012 using CEMS data provided by FMMI. Unplanned bypass events, due to their greater emissions, dictate the feasibility of applying emissions controls to bypass emissions in general and therefore our analysis focused on the worst-case unplanned bypass event. GCT reviewed 22 unplanned bypass events in the above mentioned data set, averaging 7 unplanned events per year, with a maximum of 11 unplanned events in 2011. Of the unplanned events, GCT found that the worst case event lasted 1 hour and 54 minutes and emitted a total of 8,884 pounds of SO_2 on November 10, 2011. FMMI has obtained a significant permit revision that will permit it to increase annual concentrate throughput by 31%. In an attempt to provide a conservative estimate of the worst-case emissions scenario under these future operating conditions, GCT projected future unplanned bypass stack emissions by linearly scaling the provided existing emissions. As such, the scaled worst case, unplanned and untreated bypass event could be expected to emit a total of 11,638 pounds of SO_2.

For the purpose of evaluating control options, an emissions profile for the worst case event can be developed over the duration of an event as shown in Figure 1 below for both current and future production levels.

Figure 1.



As illustrated above, most of the emissions occur in the first five to eight minutes of the bypass event, with approximately 34% of the emissions occurring in the first minute. Because emissions are greatest at the beginning of an unplanned bypass event and then decline quickly, significant reductions of unplanned bypass emissions can only be achieved by technologies that are available to control emissions from the bypass stack within 2 minutes of the beginning of an unplanned bypass event. In contrast, a planned bypass event has much lower emissions throughout, and significant reductions can be achieved through the duration of the event.

GCT
Metallurgical Process Specialists

Evaluation of Options for Control of Bypass Emissions

GCT's evaluated the potential of each of the existing and planned SO_2 emissions control devices to treat SO_2 from the bypass stack. GCT considered the following options:

- Use of the Acid Plant Tail Gas Scrubber, with and without the existing Wet Gas Cleaning Plant (WGCP) located within the Acid Plant. This is not technically feasible due to existing scrubber size;
- Use of the Vent Fume Scrubber, with and without the existing WGCP. This is not technically feasible due to existing scrubber size;
- Use of the Aisle Scrubber, with and without the existing WGCP. Selected option, further discussion below;
- Use of Bionatur adsorbent. Rejected due to excessive cost compared to the selected option;
- Dry sorbent injection. Rejected due to generation of solid waste and need for additional particulate matter (PM) emission control as well as excessive cost compared to the selected option;
- Amine absorbent such as CANSOLV®. Rejected due to excessive cost compared to the selected option;
- Hydrogen peroxide. Rejected due to excessive cost compared to the selected option.

GCT's analysis concluded that the most feasible solution to control an unplanned bypass event is to route the bypass emissions to the planned Aisle Scrubber. Under normal average operating conditions, the amount of caustic reagent (129 lb./min) in the recirculating sprays in the Aisle Scrubber has the capacity to absorb 90 to 100 lb./min of SO_2. Therefore, the reduction capacity of the Aisle Scrubber in the first eight minutes would be limited at this design level of caustic reagent. After the first eight minutes, this design level of caustic reagent would be able to achieve the expected design reduction capability of the scrubber. Assuming a 95% reaction efficiency of the limiting component (caustic in first several minutes, SO_2 for the remainder of the event), the Aisle Scrubber would reduce total worst case unplanned bypass event emissions in the first hour by approximately 16 to 18% if the normal caustic recirculation rate is used. Improved reduction efficiencies would be expected for both planned bypass events and lesser unplanned bypass events.

To achieve higher scrubbing efficiency in the first several minutes of an unplanned bypass event, additional caustic would need to be introduced to the sprays. To achieve the quantity of caustic required, FMMI would have to pump 20 wt% caustic makeup solution directly to the scrubber spray header at a rate of 2,500 to 3,000 gpm (i.e., 5,000 to 6,000 lb./min NaOH), in addition to the normal recirculating liquor for the first several minutes of a worst-case unplanned bypass event. To achieve the higher caustic flow rates, additional pumping equipment and controls to deliver the caustic to the sprays would be required. Reduced volumes of additional caustic would be needed for planned bypass events and lesser unplanned bypass events.

Once sufficient caustic is provided in the sprays, a scrubbing efficiency of 95% can likely be achieved. However, there is a concern regarding any delay between when the bypass gas reaches the scrubber and when caustic makeup pumps could ramp up and deliver the high caustic rate to the sprays. If 95% efficiency is assumed once the high caustic rate reaches the sprays, then the expected reduction efficiency in the first hour of a worst-case unplanned bypass event would depend on the length of that initial delay as summarized in Table 1 below, assuming the minimum estimated time of 10 seconds for the bypass emissions to transit the ductwork from the bypass valve and reach the scrubber.

Table 1
Worst Case Unplanned Event SO_2 Reduction Efficiency in First Hour versus Delay in High Caustic Addition

Delay Time	SO_2 Reduction Efficiency
10 second delay after Bypass commences:	95%
40 second delay after Bypass commences:	79%
70 second delay after Bypass commences:	63%
100 second delay after Bypass commences:	50%
130 second delay after Bypass commences:	38%

As Table 1 demonstrates, supplemental high caustic addition can be added to the Aisle Scrubber system to provide additional SO_2 control if the Aisle Scrubber as designed is not adequate to allow for compliance with ambient air quality standards. We stress that this analysis is based on a worst-case unplanned bypass event, and such events are uncommon based on our review of the data set provided to us. The Aisle Scrubber as designed will provide for better SO_2 emissions control than shown herein for planned and lesser unplanned bypass events.

Sincerely,

Matt Russell
Senior Process Engineer
Gas Cleaning Technologies, LLC
4953 N. O'Connor Rd
Irving, Texas 75062

10.8 Appendix H: Technical Memo Regarding Calculation of CEV

Technical Memorandum
Critical Emissions Value Assessment for the
Miami SO_2 Nonattainment Area State Implementation Plan (SIP)
March 30, 2016

This memo presents the critical emissions value assessment for use in the Arizona Department of Environmental Quality's (ADEQ) Miami SO_2 Nonattainment Area State Implementation Plan (SIP) submittal to the U.S. Environmental Protection Agency (EPA). Establishing the critical emissions value is an important step in identifying an SO_2 emission limit for Freeport-McMoRan Miami Inc.'s (FMMI) primary copper Smelter. FMMI is performing dispersion modeling to support the SIP submittal.

Introduction

The EPA's Guidance for 1-Hour SO_2 Nonattainment Area SIP Submissions (EPA, 2014) defines the critical emissions value as "*…the hourly emission rate that the model predicts would result in the 5-year average of the annual 99th percentile of daily maximum hourly SO_2 concentrations at the level of the 1-hour NAAQS, given representative meteorological data for the area.*"

To determine the critical emissions value, EPA guidance specifically states that dispersion modeling be used. Due to the physical configuration of the Smelter (i.e., the roof vents that are buoyant line sources) and the proximity of complex terrain to the Smelter, EPA's preferred guideline dispersion models do not directly apply. Consequently, any modeling approach requires EPA approval per 40 CFR Appendix W (Air Quality Modeling Guidelines). As identified in a separate technical memo, a performance evaluation was conducted of five dispersion modeling approaches for the Miami Smelter and the Hybrid BLP/AERMOD approach was selected for determining the critical emissions value.

The Hybrid BLP/AERMOD approach uses the BLP dispersion model to predict hourly plume height and vertical spread (sigma-z) resulting from roof vent emissions. AERMOD is used to predict hourly ambient concentrations resulting from stack and roof vent emissions. The roof vent emissions are input to AERMOD as volume sources, with release height and initial sigma-z (vertical dispersion) inputs set at the BLP-calculated plume height and sigma-z. This approach avoids use of BLP's antiquated implementation of complex terrain and meteorology, and incorporates EPA's preferred plume rise and building downwash calculations for buoyant line sources.

Smelter SO_2 Emissions Configuration

The FMMI Smelter is currently configured with five roof vents, which account for a significant proportion of the Smelter's current sulfur dioxide (SO_2) emissions (approximately 44% of Smelter SO_2 emissions during the period from May 2013 through April 2014). There are five roof vents on the Smelter building. The roof vents are located above the IsaSmelt® (Isa) vessel, the Electric Furnace (ELF), the converter aisle (2 vents), and the anode aisle. The three vents over the converter aisle and anode aisle are aligned along the length of the Smelter building. The shorter vents over the Isa and ELF are oriented perpendicular to the converter aisle and anode aisle vents. In addition to the roof vents, three stacks (Acid Plant Tail Gas Stack, Vent Fume Stack, and Bypass Stack) are located at the Smelter. The locations of the existing vents and stacks are shown in Figures 1 and 2.

Figure 1. Aerial Photograph of Miami Smelter, Showing Stacks and Roof Vents

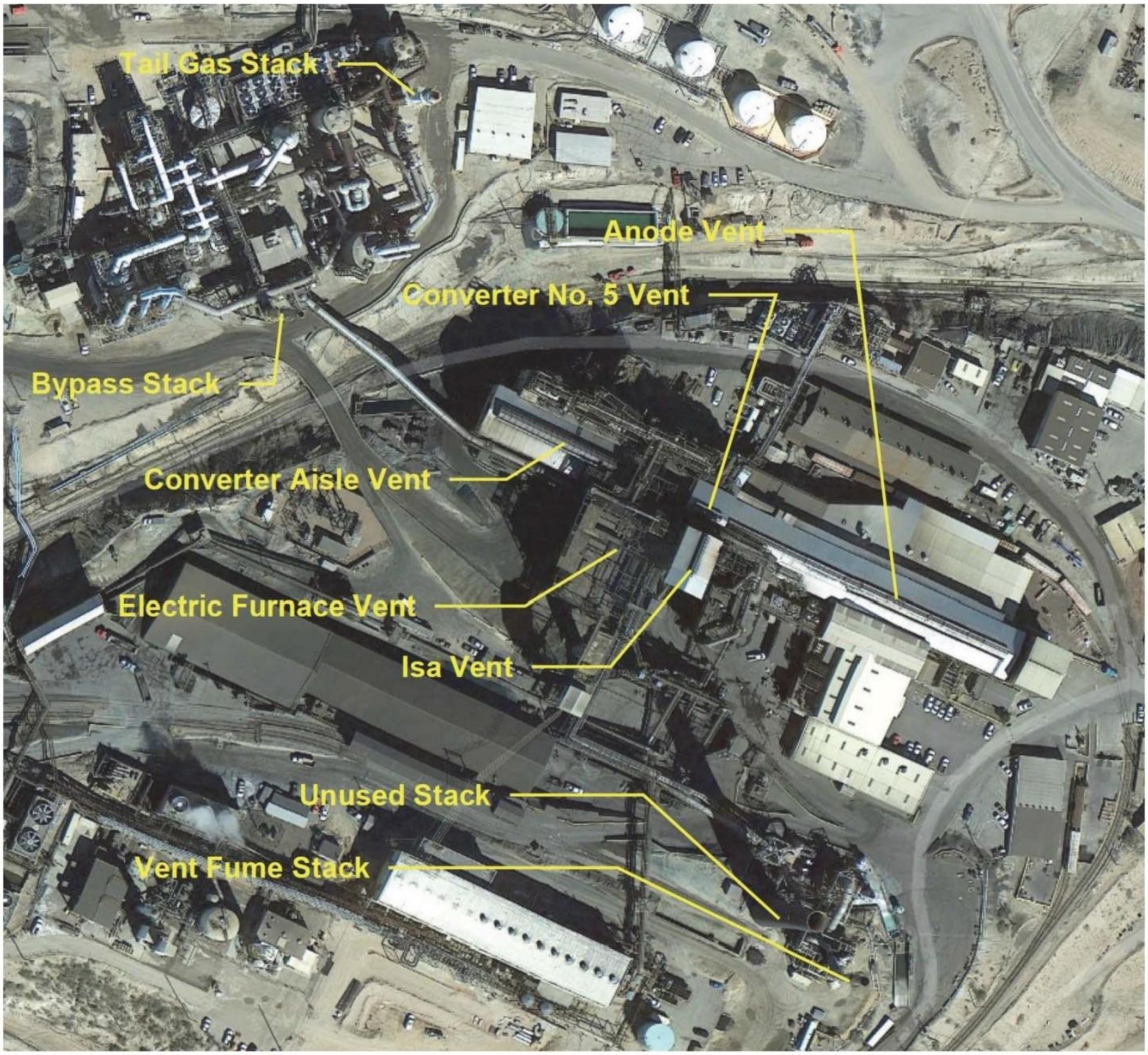


Figure 2. Photograph of Miami Smelter, Showing Stacks and Visible Roof Vents

Photograph taken at the Jones Ranch Ambient SO_2 Monitoring Station

The future Smelter configuration will consist of four roof vents and three stacks (Acid Plant Tail Gas Stack, Vent Fume Stack, and Aisle Scrubber). The roof vent located above Converters 2 through 5 will be reconfigured as part of a collection system for fugitive emissions. In addition, the anode and mold vessels will be modified to collect emissions generated during the refining of blister copper. The collected emissions from the converter roof and anode vessel capture systems will be routed to the new Aisle Scrubber to treat the captured SO_2 emissions. The roof above the non-functional Inspiration Converter and the Anode Aisle will still vent to the atmosphere. Additionally, Acid Plant Bypass emissions will be routed to the Aisle Scrubber for treatment prior to discharge to atmosphere. FMMI is proposing multiple additional changes to the Smelter configuration, as set forth in greater detail in the separate modeling protocol document.

Determination of Critical Emissions Value

The calculation of a critical emissions value for a facility with a single SO_2 emission source is a simple task, because the predicted design value is proportional to the modeled emission rate. The ratio of the available air quality (i.e., the difference between the NAAQS and background concentration plus interactive source contribution) to the predicted design value is calculated and then multiplied by the modeled emission rate to determine the critical emission value. In contrast, a complex facility such as the Smelter, with seven future emissions sources of consequence, requires an iterative approach. The effectiveness and cost of controlling each of the SO_2 emissions sources varies greatly, and the iterative approach must be performed to optimize the control cost required to achieve attainment.

Identification of Available Air Quality

The first step in the assessment is to identify the available air quality for the Smelter. As described in the modeling protocol report, interactive sources are not required to be modeled. Therefore, available air quality in the Miami nonattainment area is simply the difference between the NAAQS (196 $\mu g/m^3$) and background air quality (21.2 $\mu g/m^3$), or 174.8 $\mu g/m^3$.

Identification of Future SO_2 Emissions Sources for Consideration of Additional Control

The next step in the assessment is to identify the candidate future SO_2 emissions sources at the Smelter for consideration of additional control, all of which are listed in the modeling protocol report. In anticipation of the nonattainment designation, FMMI worked to redesign and identify potential upgrades to the Smelter's emissions capture and control systems to better control SO_2 and other emissions as part of proposed changes to increase operational efficiency and capacity. FMMI engaged in a significant engineering study, incorporating multiple iterations of dispersion modeling, and proposed the following Smelter modifications in its air permit application filed with ADEQ in July 2013 (the permit was subsequently issued by ADEQ on July 21, 2014):

- Upgrade the bedding plant conveyor belts and IsaSmelt® (Isa) furnace feed paddle mixers;
- Replace the existing Isa;
- Upgrade the Isa furnace cooling and emissions control system (i.e., lance seal, feed port hood, and tapping hood controls);
- Upgrade the electric furnace emissions control system (i.e., tapping hood controls);
- Upgrade the converters emissions control system (i.e., reconfiguring the roofline to capture emissions and route them to a new Aisle Scrubber including stack);
- Upgrade the anode furnaces and utility vessel (also known as a mold barrel) emissions control system (i.e., process gas collection system, mouth covers, replacement of utility vessel, new baghouse ducted to the new Aisle Scrubber, new hydrated lime silo, and new baghouse dust return system to the electric furnace);
- Increase operational flexibility via authorization of 1,000,000 dry tons per year of New Metal Bearing Material (NMBM) throughput capacity;
- Increase Acid Plant capacity to accommodate the authorized concentrate throughput capacity (i.e., upgraded cooling system, new converter bed, new blower, and new SO_3 cooler);
- Upgrade the Vent Fume Scrubber and Acid Plant Tail Gas Scrubber to caustic use;
- Add three new Wet Electrostatic Precipitator (WESP) modules at the vent fume control system;
- Enclose the temporary on-site concentrate storage piles with an enclosed structure;

- Increase the height of the Vent Fume Stack and Tail Gas Stack; and
- Other support facility changes.

FMMI has also committed to an additional modification that will direct Bypass emissions to the proposed Aisle Scrubber for treatment. This will effectively eliminate the use of the Bypass Stack except under rare emergency conditions.

The future maximum potential SO_2 emission rates for these sources resulting from the proposed modifications are provided in Table 1. Two different emission rates are presented for the Aisle Scrubber Stack. The first represents emissions during normal smelter operations while the second represents emissions during Acid Plant bypass operations.

Table 1. Future Smelter SO_2 Emissions Sources Considered for Additional Control

Source	SO_2 (lb/hr)
Acid Plant Tail Gas Stack	3.2
Vent Fume Stack	13.0
Aisle Scrubber Stack (normal ops)	14.3
Aisle Scrubber Stack (bypass ops)	275.0
Converter Aisle Roof Vent	25.6
Anode Aisle Roof Vent	8.0
Isa Roof Vent	31.8
Electric Furnace Roof Vent	14.2

Identification of Future SO_2 Emissions Sources to Remain at Existing Level of Control

The next step in the assessment is to identify the future SO_2 emissions sources at the Smelter that will remain at their existing level of control, all of which are listed in the modeling protocol report. These sources and their future maximum potential SO_2 emission rates are listed in Table 2.

Dispersion Model Results

The identified emissions, along with other dispersion model inputs described in the modeling protocol, were input to the Hybrid BLP/AERMOD model to verify that the model predicted an average of the annual 99^{th} percentile of daily maximum hourly SO_2 concentrations at the level of the 1-hour NAAQS. The resulting predicted design concentration was 172.9 $\mu g/m^3$, just within the available air quality of 174.8 $\mu g/m^3$.

Critical Emissions Value Results

Based on the dispersion model results, the facility-wide critical emissions value is the sum of the emissions presented in Tables 1 and 2, or 393 lb/hr.

Table 2. Future Smelter SO_2 Emissions Sources Remaining at Existing Level of Control

Source	SO_2 (lb/hr)
Acid Plant Preheater	0.0198
Isa Auxiliary Boiler	0.00612
Change Room Water Heater	0.000437
Rod Plant Thermal Breaker	0.000456
Rod Plant Shaft Furnace	0.350
Screening Engine	0.00102
Compressor	0.00655
Compressor	0.00655
Rod Plant Roof Vent	0.0129
Smelter Building Leaks	3.98
Slag Storage Area	3.75

Note: Emergency Generators are not included in the 1-hour impact modeling per EPA guidelines (U.S. EPA, 2013). All emergency generators operate less than 500 hours per year.

10.9 Appendix I: Technical Memo Regarding CEV Sensitivity Analysis

Technical Memorandum
Sensitivity of Predicted Concentrations to CEV Variations Miami
SO_2 Nonattainment Area State Implementation Plan (SIP)
June 5, 2016

This memorandum presents a sensitivity analysis of the critical emissions value (CEV) developed for the Freeport-McMoRan Miami Inc. (FMMI) primary copper smelter (Miami Smelter), located in Miami, Arizona. The CEV was identified as part of the air quality dispersion modeling conducted in support of the Arizona Department of Environmental Quality (ADEQ) Miami SO_2 Nonattainment Area State Implementation Plan (SIP) submittal to the U.S. Environmental Protection Agency (EPA). As explained in more detail in a separate memorandum [Critical Emissions Value Memo, 2015], the CEV is the hourly emission rate that the model predicts would result in the 5-year average of the annual 99th percentile of daily maximum hourly SO_2 concentrations at the level of the NAAQS. Because ADEQ's draft SIP contemplates the use of a facility-wide emission limitation that covers all of the emissions sources at the Miami Smelter, additional technical analysis is necessary to demonstrate that the facility-wide CEV represents an appropriate emission rate that demonstrates compliance with the 1-hour SO_2 NAAQS even when there may be variations in the precise emissions sources—which may affect the distribution of emissions leading to differences in emission locations, release heights, and other source parameters—at the Smelter.

Accordingly, the purpose of this memorandum is to demonstrate that the current facility-wide CEV is a robust value that is not sensitive to changes in the allocation of SO_2 emissions among sources within the Smelter. This memorandum documents the technical analysis undertaken by FMMI to make this demonstration.

Approach

To demonstrate that the facility-wide CEV is not sensitive to the variability of emissions among sources within the Smelter, FMMI evaluated the effect of varying individual source emissions while keeping the facility-wide emissions consistent. To do so, FMMI increased a single source and decreased the other major emission sources by a weighted amount, such that the CEV remained constant.

In each scenario, one individual source's emission rate was increased by 20.8 percent while the emissions from the remaining major emission sources were decreased by a proportional amount to ensure the facility-wide CEV remained constant. As a result, each source combination maintained the total emission rate constant at the facility-wide CEV of 387 lb/hr while varying the individual source rates.

FMMI determined the 20.8 percent value by evaluating the distribution of non-bypass facility-wide future projected hourly emissions. The upper tail of that distribution, defined as those facility-wide emissions levels that are in the upper 1% of facility-wide emissions, were first identified. The minimum value of the upper tail (178 lb/hr) and the median value of the upper tail (275.4 lb.hr) were then identified. The minimum value represents the 99^{th} percentile of the hourly emissions distribution. Due to the skewness of the emissions distribution in the upper tail, the median was selected as being representative of the expected emissions value within the upper tail. The percent difference between the two values, is 20.86% which is representative of the emissions variability in cases where non-bypass facility-wide emissions are near the CEV.

Only the major stacks (*i.e.,* the aisle scrubber stack during normal operations, tail stack and vent fume stack) and roof vent sources were varied in this sensitivity analysis. Other sources (*e.g.*, compressors, water heaters, engines) are included in the modeling analyses, but were not varied because their potential emissions are too small to have an appreciable impact on the modeling outcomes and therefore assessing them would not be informative. The Bypass Stack emissions were not included in this sensitivity analysis as they operate independently of the other sources' emissions as demonstrated in the emissions independence analysis provided separately.

To evaluate the impact of changing the emission rates at various sources while holding the facility-wide CEV constant, each combination of emission rates was used as a series of inputs to the Hybrid BLP/AERMOD model. The results of these model runs were compared to the design concentration of 196 µg/m^3, with a target concentration of 174.8 µg/m^3 when background is considered.

Results

Tables 1 and 2 present the emission rates modeled and results for the source combinations described above.

Table 1 provides the scenarios where the individual stack emissions were increased by 20.8%. Predicted design value concentrations range from 172.5 to 172.8 µg/m^3, all less than the design value concentration of 172.9 µg/m^3 predicted when using the CEV.

Table 2 provides the scenarios where the individual vent emissions were increased by 20.8%. Predicted design value concentrations range from 172.2 to 174.5 µg/m^3, all within 1% of the design value concentration of 172.9 µg/m^3 predicted when using the CEV.

Conclusion

The sensitivity analysis results demonstrate that predicted design value concentrations range from 172.5 to 174.5 µg/m^3. Modeling of the CEV presented in the SIP submittal results in a predicted concentration of 172.9 µg/m^3. Thus, the sensitivity analysis predicts concentrations that are within 1.0% of the CEV- modeled design value concentration. The variation in predicted concentrations is very small when compared to the 20.8% variation in emission rates applied to the various sources for the purposes of the sensitivity analysis. Based on these results, a single facility-wide emission limit based on the CEV is appropriate for the Miami Smelter.

TABLE 1. Sensitivity Analysis of Stack Critical Emissions Values

Major Emission Sources	PTE g/s	STACKS					
		CV1 H APTGS(+)		CV2 H VFS(+)		CV3 H AS(+)	
		change (g/s)	Emission (g/s)	change (g/s)	Emission (g/s)	change (g/s)	Emission (g/s)
Acid Plant - Tail Gas Stack	0.4034	0.0839	0.4873	-0.0112	0.3922	-0.0126	0.3908
Vent Fume System	1.6350	-0.0102	1.6248	0.3401	1.9751	-0.0509	1.5841
Aisle Scrubber (normal)	1.8072	-0.0112	1.7960	-0.0502	1.7570	0.3759	2.1831
Anode	1.0089	-0.0063	1.0026	-0.0280	0.9809	-0.0314	0.9775
Converter	3.2285	-0.0201	3.2084	-0.0896	3.1389	-0.1005	3.1280
ISA	4.0105	-0.0250	3.9855	-0.1113	3.8992	-0.1248	3.8857
ELF	1.7908	-0.0111	1.7797	-0.0497	1.7411	-0.0557	1.7351
Bypass	34.6490		34.6490		34.6490		34.6490
Total emissions g/s			48.5333		48.5333		48.5333
H4H ($\mu g/m^3$)			172.8		172.5		172.5

TABLE 2. Sensitivity Analysis of Roof Vent Critical Emissions Values

Major Emission Sources	PTE g/s	Vents							
		CV4 H CONV(+)		CV5 H Anode (+)		CV6 H ISA(+)		CV7 H ELF (+)	
		change (g/s)	Emission (g/s)	change (g/s)	Emission (g/s)	change (g/s)	Emission (g/s)	change (g/s)	Emission (g/s)
Acid Plant - Tail Gas Stack	0.4034	-0.0254	0.3779	-0.0066	0.3968	-0.0341	0.3693	-0.0124	0.3909
Vent Fume System	1.6350	-0.1030	1.5320	-0.0266	1.6083	-0.1381	1.4969	-0.0504	1.5846
Aisle Scrubber (normal)	1.8072	-0.1139	1.6933	-0.0295	1.7777	-0.1527	1.6545	-0.0557	1.7515
Anode	1.0089	-0.0636	0.9453	0.2099	1.2188	-0.0852	0.9237	-0.0311	0.9778
Converter	3.2285	0.6715	3.9000	-0.0526	3.1759	-0.2728	2.9557	-0.0994	3.1291
ISA	4.0105	-0.2527	3.7578	-0.0654	3.9451	0.8342	4.8447	-0.1235	3.8870
ELF	1.7908	-0.1129	1.6779	-0.0292	1.7616	-0.1513	1.6395	0.3725	2.1633
Bypass	34.6490		34.6490		34.6490		34.6490		34.6490
Total emissions g/s			48.5333		48.5333		48.5333		48.5333
H4H (mg/m3)			172.2		172.7		174.5		173.1

10.10 Appendix J: CEV Exceedance Risk Analysis

Technical Memorandum

SO_2 NAAQS Exceedance Risk Analysis for Proposed Miami Smelter Configuration Miami SO_2 Nonattainment Area State Implementation Plan (SIP)

June 5, 2016

This memorandum presents an analysis of the potential risk of exceeding the sulfur dioxide (SO_2) national ambient air quality standard (NAAQS) based on the proposed future configuration of the Freeport-McMoRan Miami Inc. (FMMI) primary copper smelter (Miami Smelter), located in Miami, Arizona. The Miami Smelter operates with batch processes as explained in the *Emissions Variability and Independence Assessment Memorandum* [July 2015] prepared in support of the Arizona Department of Environmental Quality (ADEQ) Miami SO_2 Nonattainment Area State Implementation Plan (SIP) submittal to the U.S. Environmental Protection Agency (EPA). Because of the variability of the emission rates from the larger sources, additional analysis was undertaken to show, per EPA's SO_2 Nonattainment Area SIP Guidance (EPA, 2014), that periods of hourly emissions greater than the critical emission value (CEV) are a rare occurrence at a source, and these periods would be unlikely to have a significant impact on air quality, insofar as they would be very unlikely to occur repeatedly at the times when the meteorology is conducive for high ambient concentrations of SO_2.

Based on the analysis performed per EPA's guidance to establish the 30-day rolling emission limit, projected future actual 1-hour facility-wide emissions would be greater than the facility-wide CEV approximately 0.50 percent of the hours in a year (approximately 44 hours out of the potential 8,760 hours in a year). FMMI believes that a frequency of 0.50% constitutes a rare occurrence. The analysis was based on applying a proposed control strategy to an 18-month data set of existing actual hourly emissions measured from May 2013 through October 2014.

A modeling analysis was performed on the projected future actual 1-hour emissions and demonstrated that the Miami Smelter would be in compliance with the NAAQS with the proposed 30-day rolling hourly emission limit. The modeling analysis aligned the projected future hourly emissions, which were based on the aforementioned existing measurements of hourly emissions from May 2013 through October 2014, with on-site meteorological data that were measured concurrently with the existing measurements of hourly emissions. Clearly, in this particular analysis, the periods where hourly emissions were greater than the CEV did not align with meteorological conditions that were conducive for predicted high ambient concentrations of SO_2.

ADEQ subsequently expressed concern that the 18-month period of record for the hourly emissions data and concurrent 18-month period of hourly meteorological data may not be adequate to address the pairing of high emissions with meteorological conditions that are conducive for high ambient concentrations of SO_2. Accordingly, FMMI performed additional analysis to assess the probability that exceedances of the NAAQS would occur. This memorandum documents the technical analysis undertaken by FMMI to make this demonstration.

Approach

The approach entailed using the 18-month data set of projected future actual emissions paired with an alternative on-site meteorological data set consisting of 3 years of hourly observations from April 2010 through March 2013. Development of this 3-year on-site meteorological data set is described in the modeling protocol submitted with ADEQ's SIP documentation, and this data set was used in performing the CEV modeling.

The approach randomized the pairing of the emissions data set with the meteorological data set in such a way to represent almost 300 years of modeling. The hourly sequence of emissions and meteorology were retained in the analysis. To perform the pairings, a program was developed to randomly pick an hour within the meteorological data set against which the first hour of the emissions data set would be aligned. Each subsequent hour was then assigned such that the sequence of hourly emissions and meteorology was maintained. Because the hourly emission data set was smaller than the meteorological data set, the hourly emission data was repeated to complete a 3-year emission file. The first 3-year analysis did not incorporate the random alignment; in this case, the first hours of both data sets were aligned. The hourly emission data was repeated as described above to complete a 3-year emission file.

After the first 3-year data set was prepared, the randomized alignment was then repeated 99 times to create 99 additional 3-year data sets. A total of 100 paired data sets were prepared, which corresponds to 300 years of analysis. These pairings of emissions and meteorology were then input to the AERMOD dispersion model, which was run in accordance with the methods described in the modeling protocol submitted with the SIP documentation. The hourly plume heights for the roof vents, based on the use of the Hybrid Approach, were provided in a separate AERMOD input file.

Results

Table 1 presents the predicted design concentrations for each of the 100 runs. The results for each year of analysis are shown to evaluate the contribution of a given year of meteorological data to the 3-year average. The background concentration of 21.2 $\mu g/m^3$ is not included in the results, and therefore the results are to be compared to a target concentration of 174.8 $\mu g/m^3$ (i.e., the NAAQS of 196 $\mu g/m^3$ minus the background concentration of 21.2 $\mu g/m^3$). For all 100 3-year runs, the predicted design concentration was less than the target concentration of 174.8 $\mu g/m^3$. These results indicate that for all 3-year periods, compliance with the NAAQS is predicted based on the proposed 30-day limit.

Conclusion

An analysis was performed to evaluate periods of hourly emissions greater than the critical emission value (CEV). The data set of projected future actual emissions indicates that periods of emissions greater than the CEV are expected to be rare, with an expected frequency of 0.50% of the operating hours in a year. A modeling analysis which included this expected emissions frequency was then performed to assess the effect on ambient air quality. The results of that analysis indicate that these periods would not have a significant impact on air quality, insofar as the joint pairing of high emissions with meteorology conducive for high ambient concentrations of SO_2 would be very unlikely to occur repeatedly.

TABLE 1. Predicted 4th Highest Maximum Daily 1-Hour SO_2 Concentration

Case ID	Random Starting Index	1-Hour H4H $\mu g/m^3$
BASE	1	110.6
A	5077	97.4
B	3519	92.1
C	8216	105.0
D	4992	110.4
E	1091	98.3
F	5467	121.7
G	6407	92.3
H	5097	106.0
I	7627	77.2
J	4161	120.3
K	7887	92.1
L	3174	107.5
M	8753	77.3
N	3201	100.0
O	3005	112.6
P	7059	138.3
Q	1955	98.2
R	239	96.4
S	5452	109.8
T	7142	95.7
U	2067	130.0

Case ID	Random Starting Index	1-Hour H4H µg/m³
V	6418	121.9
W	1285	96.0
X	7609	129.6
Y	6787	83.7
Z	3365	120.3
AA	3646	98.0
AB	4600	78.8
AC	1400	99.8
AD	6170	109.0
AE	1821	91.4
AF	2955	125.9
AG	1016	99.7
AH	3480	110.4
AI	8569	106.6
AJ	4836	84.3
AK	809	86.2
AL	1856	108.1
AM	4515	123.5
AN	2142	132.0
AO	3504	101.2
AP	4854	106.7
AQ	492	86.9
AR	4302	138.0

Case ID	Random Starting Index	1-Hour H4H µg/m^3
AS	2837	104.0
AT	3769	129.2
AU	2607	97.4
AV	1468	137.5
AW	2646	104.4
AX	3879	94.0
AY	1147	90.3
AZ	6958	89.6
BA	1793	84.9
BB	1752	118.7
BC	4928	115.2
BD	8408	102.3
BE	6988	103.8
BF	4751	94.6
BG	1359	91.5
BH	8056	82.5
BI	4919	92.5
BJ	4217	81.6
BK	791	96.4
BL	8701	86.1
BM	7314	74.2
BN	6271	124.2
BO	5286	94.8

Case ID	Random Starting Index	1-Hour H4H μg/m^3
BP	2718	98.9
BQ	4118	92.6
BR	1968	108.4
BS	5284	119.1
BT	5006	105.4
BU	4094	104.5
BV	1835	103.6
BW	2343	87.7
BX	7553	95.6
BY	1572	80.2
BZ	3038	84.8
CA	8129	85.8
CB	2184	115.3
CC	1564	115.2
CD	4857	100.7
CE	952	90.6
CF	6296	92.6
CG	8568	92.7
CH	7699	84.2
CI	2450	110.6
CJ	3164	88.2
CK	7004	98.5
CL	676	124.2

Case ID	Random Starting Index	1-Hour H4H $\mu g/m^3$
CM	8009	94.3
CN	384	110.6
CO	4223	100.3
CP	3356	94.4
CQ	1991	94.1
CR	3021	102.4
CS	3693	96.9
CT	1860	86.4
CU	6387	119.5

10.11 Appendix K: Contribution of Fixed Emission Sources to CEV Modeling Results

Technical Memorandum

Contribution of Fixed Emission Sources to CEV Modeling Results
Miami SO_2 Nonattainment Area State Implementation Plan (SIP)

March 30, 2016

This memorandum presents an analysis of the contribution of the assumed "fixed source" sulfur dioxide emissions on the model-predicted concentrations associated with the critical emission value (CEV) developed for the Freeport-McMoRan Miami Inc. (FMMI) primary copper smelter (Miami Smelter), located in Miami, Arizona. The CEV was identified as part of the air quality dispersion modeling conducted in support of the Arizona Department of Environmental Quality (ADEQ) Miami SO_2 Nonattainment Area State Implementation Plan (SIP) submittal to the U.S. Environmental Protection Agency (EPA). As explained in more detail in a separate memorandum [Critical Emissions Value Memo, 2016], the CEV is the hourly emission rate that the model predicts would result in the 5-year average of the annual 99th percentile of daily maximum hourly SO_2 concentrations at the level of the NAAQS.

The purpose of this memorandum is to demonstrate that the fixed source emissions have been accounted for in the development of the 30-day rolling hourly SO_2 emission limit and therefore those emissions need not be part of the limit's compliance demonstration via continuous emissions monitoring. The model-predicted concentrations associated with the fixed sources are insignificant contributors to the model-predicted concentrations that define the CEV.

Background

As identified in the CEV Memo, eleven fixed emissions sources at the Miami Smelter were included in the modeling analysis to ensure their contribution to ambient SO_2 air quality impacts were accounted for in the development of the 30-day rolling hourly SO_2 emission limit. Most of these sources (e.g., the 9 emergency generators) are small combustion units, and in all of these cases the combustion units are assumed to operate at their maximum potential heat input capacity and to emit at their maximum potential SO_2 rate at all times. The other two fixed emissions sources are intermittent fugitive releases of SO_2, one being the slag storage area and the other being smelter building leaks. Derivation of the emissions from these two intermittent fugitive sources is described in Section 5.2.4 of the Technical Support Document (TSD). These two intermittent fugitive emission sources are assumed to emit at the calculated SO_2 emission rate at all times. The modeled SO_2 emission rates for the fixed emissions sources are provided in Table 1.

Dispersion Modeling

To demonstrate that the facility-wide CEV is not sensitive to the fixed emissions sources, FMMI evaluated the effect of fixed emissions sources on the predicted SO_2 design concentration at the CEV emission rate. The cases specifically evaluated include:

- All SO_2 emissions sources located at the Miami Smelter (i.e., the CEV model run described in the TSD);
- The above CEV run with the two non-combustion fugitive fixed sources excluded from the analysis (i.e., the slag storage area and smelter building leaks were excluded);
- The above CEV run with all fixed emissions sources excluded (i.e., all sources listed in Table 1 were excluded);
- Slag storage area fugitive emissions only; and
- Smelter building leaks fugitive emissions only.

The dispersion model results are presented in Table 2 and Figures 1 through 5. Table 2 shows that the contribution from the fixed emissions sources to the predicted design concentration amounts to an insignificant level of 0.7 $\mu g/m^3$, and this contribution is due to the two fugitive fixed sources. In evaluating these two fugitive sources individually, their maximum predicted design concentrations are small (as can be seen in Table 2) and their locations of maximum predicted design concentration are far removed from the locations associated with the larger smelter emissions sources (as can be seen in Figures 1 through 5).

Table 1. Future Smelter Fixed SO_2 Emissions Sources

Source	SO_2 (lb/hr)
Acid Plant Preheater	0.0198
Isa Auxiliary Boiler	0.00612
Change Room Water Heater	0.000437
Rod Plant Thermal Breaker	0.000456
Rod Plant Shaft Furnace	0.350
Screening Engine	0.00102
Compressor	0.00655
Compressor	0.00655
Rod Plant Roof Vent	0.0129
Smelter Building Leaks	3.98
Slag Storage Area	3.75
Total Fixed Source Emissions	8.13
Note: Emergency Generators are not listed as their contribution and impacts are negligible.	

Table 2. Predicted Design Concentrations for Evaluation of Fixed Source Emissions

Scenario	Predicted Design Conc. (μg/m³)	General location of H4H impact
CEV Run	172.9	Approximately 5.9 km NE of Smelter
CEV Run, Excluding Fugitive Fixed Sources	172.2	Approximately 5.9 km NE of Smelter
CEV Run, Excluding All Fixed Sources	172.2	Approximately 5.9 km NE of Smelter
Slag Storage Area Only	1.3	Approximately 2 km NW of Smelter
Smelter Building Leaks Only	28.4	Approximately 0.25 km S of Smelter

Discussion

The analysis demonstrates that the fixed emissions sources have negligible impact on the predicted design concentration that defines the CEV for the Miami Smelter. As a consequence, these sources need not be included in the derivation of the proposed 30-day rolling hourly average emission limit. For the purposes of the CEV calculation of 393 lb/hr presented in Section 8.4 of the TSD, the fixed emissions sources contribute a maximum of 8 lb/hr. Based on the analysis described herein, a CEV of 385 lb/hr (i.e., 393 lb/hr minus 8 lb/hr) should instead be based on the following Smelter emissions sources:

- Acid Plant Tail Gas Stack
- Vent Fume Stack
- Aisle Scrubber Stack (normal operations)
- Aisle Scrubber Stack (bypass operations)
- Converter Aisle Roof Vent
- Anode Aisle Roof Vent
- Electric Furnace (ELF) Roof Vent
- IsaSmelt® Roof Vent

The resulting 30-day rolling hourly average measured emission limit for the above Smelter emissions sources amounts to 142.45 lb/hr.

Conclusion

FMMI proposes a 30-day rolling hourly average emission limit of 142.45 lb/hr and a CEV of 385 lb/hr based on the results of the foregoing analysis, which shows that emissions from the fixed emissions sources are insignificant contributors to the predicted CEV design concentration. Because the fixed emission sources have been accounted for in the development of the proposed limit, those sources are not part of the limit's compliance demonstration. Compliance with the 30-day rolling hourly average emissions limit is demonstrated by direct measurement of emissions from the eight Smelter sources (identified above) via continuous emissions monitoring.

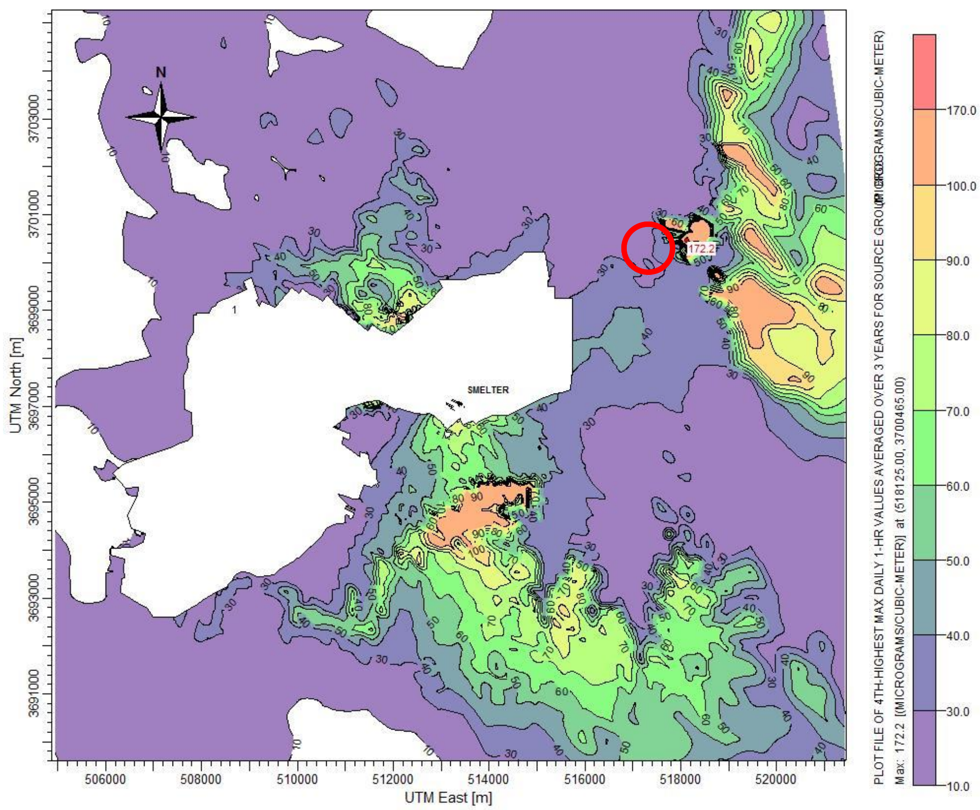


Figure 1: Predicted Design Concentrations, CEV Run

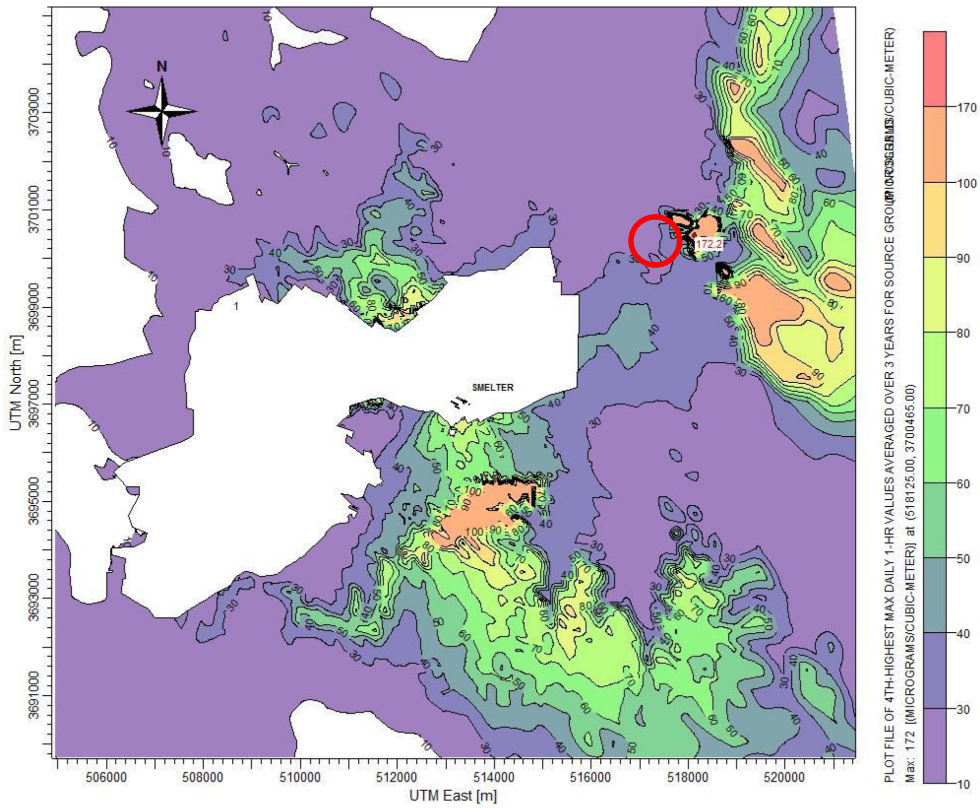


Figure 2: Predicted Design Concentrations, CEV Run Excluding Fugitive Fixed Emissions Sources

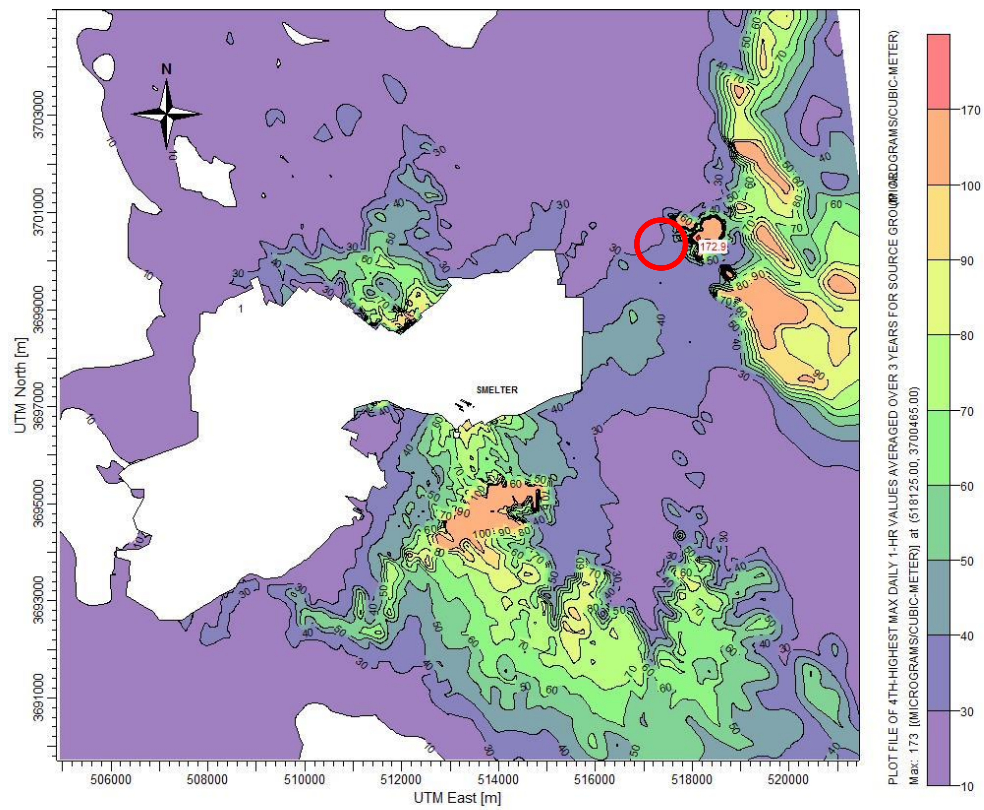


Figure 3: Predicted Design Concentrations, CEV Run Excluding All Fixed Emissions Sources

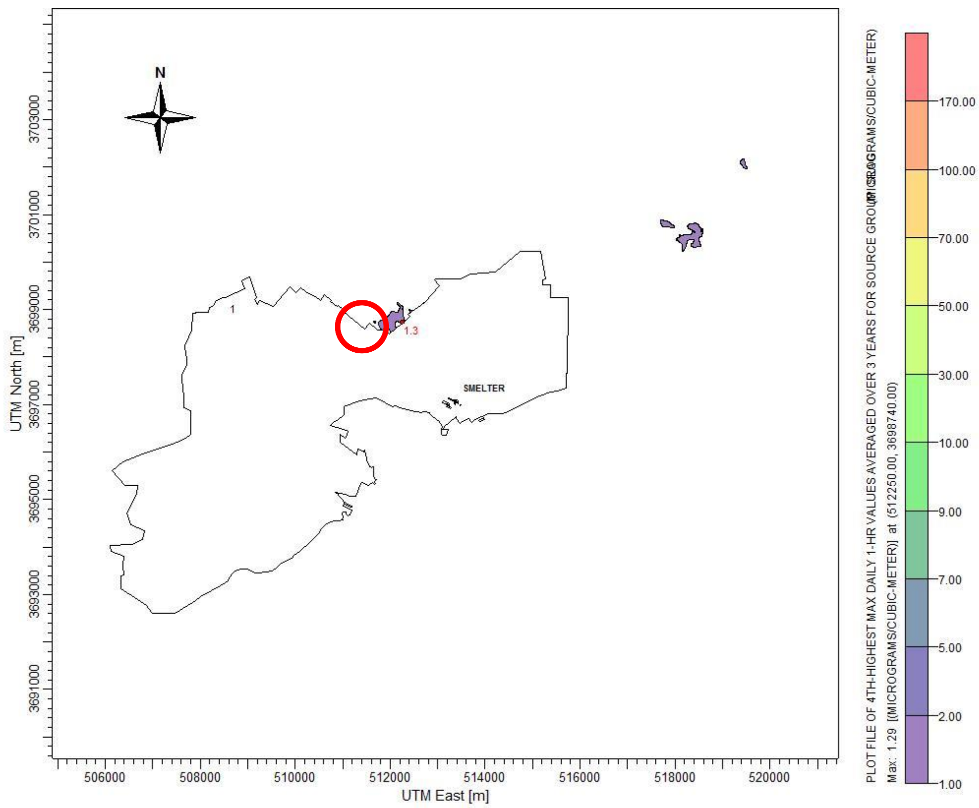


Figure 4: Predicted Design Concentrations, Slag Storage Area Only

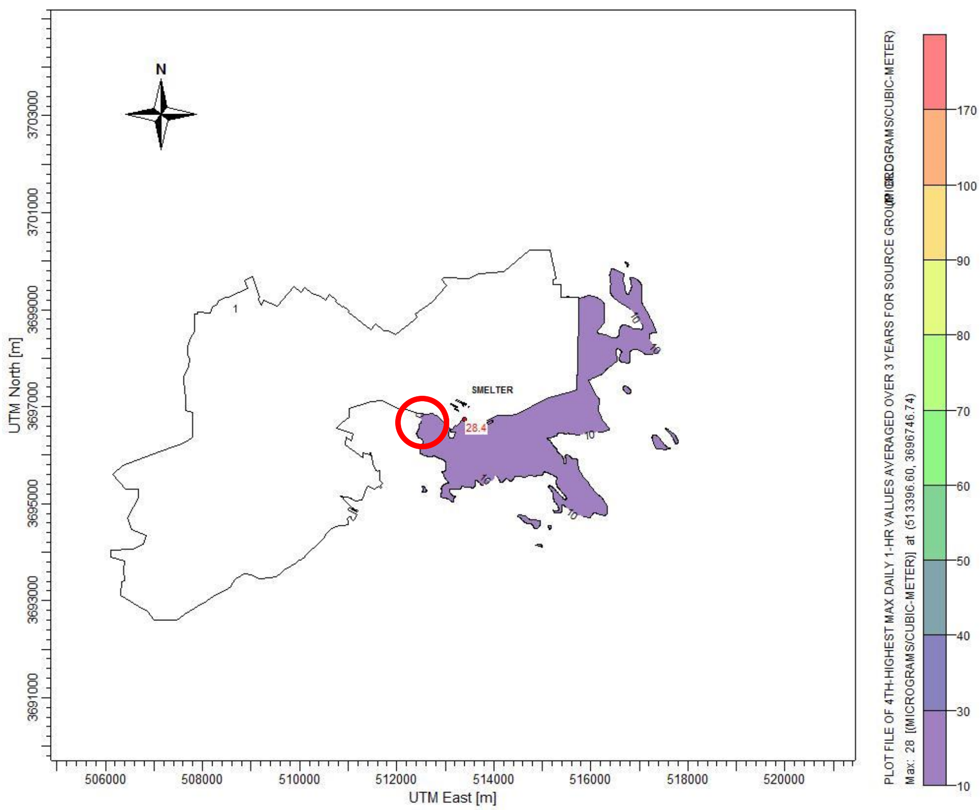


Figure 5: Predicted Design Concentrations, Smelter Building Leaks Only

10.12 Appendix L: Fumigation Analysis

Technical Memorandum
Inversion Breakup Fumigation Evaluation
Miami SO_2 Nonattainment Area State Implementation Plan (SIP)
August 24, 2016

This memorandum presents an evaluation of inversion breakup fumigation for individual sources located at the Freeport-McMoRan Miami Inc. (FMMI) primary copper smelter (Miami Smelter) in Miami, Arizona. The Environmental Protection Agency (EPA) requested an evaluation that identified which sources were most likely to contribute to the ambient SO_2 concentrations observed at the Miami Townsite monitor.

Only EPA's AERSCREEN and SCREEN3 models address inversion breakup fumigation conditions. Because these models are limited to evaluation of single sources and because of other limitations of these screening models, this evaluation is inherently a screening level evaluation of the source contributions. The modeling procedure and results are presented herein.

Enclosed with this memorandum is a CD-ROM provided by ADEQ that includes modeling files associated with the inversion breakup fumigation evaluation.

Background

The fumigation evaluation does not involve a specific modeling domain. AERSCREEN determines the point of maximum impact under fumigation conditions for distances out to 100 kilometers (km).

The evaluated sources include:

- The proposed aisle scrubber stack
- The existing and proposed vent fume stack (VFS);
- The existing and proposed acid plant tail gas stack (APTGS);
- The IsaSmelt® (Isa) building roofline vent;
- The electric furnace (ELF) building roofline vent;
- The existing and proposed converter building roofline vent; and
- The anode building roofline vent;

Model Selection

EPA's Guideline on Air Quality Models (GAQM) at 40 CFR Part 51, Appendix W, Section 7.2.8.a.i states:

> *There are no recommended refined techniques to model th[e] phenomenon [of fumigation]. There are, however, screening procedures that may be used to approximate the concentrations. Considerable care should be exercised in using the results obtained from the screening techniques.*

The EPA screening procedures cited by the GAQM are an EPA guideline dated October 1992 (EPA, 1992). The screening procedures for inversion breakup fumigation provided in the 1992 guideline have been incorporated in the SCREEN3 and AERSCREEN models.

AERSCREEN has replaced SCREEN3 as EPA's preferred screening model (EPA, 2011) and therefore, AERSCREEN was used to evaluate the relative contributions of smelter emissions sources to the inversion breakup fumigation conditions observed at the Miami Townsite monitor.

Existing Smelter Sources

The current and proposed FMMI smelter operations and the upgrade project are discussed in detail in the modeling protocol included in the TSD. Table 1 presents the stack and exhaust parameters modeled for existing stacks located at the facility.

Table 1. Stack and Exhaust Parameters, Existing Stacks

Source ID	Stack	Stack Height (m)	Exit Diameter (m)	Exit Velocity (m/s)	Exhaust Temp. (K)
TAILSTK	APTGS	60.96	1.83	23.19	323.0
VENTSTK	VFS	48.8	3.048	20.85	amb

Table 2 provides vent-specific parameters for the existing configuration of the roofline vents.

Table 2. Actual Vent-Specific Parameters, Existing Roofline Vents

Roofline Vent	Vent Length (m)	Vent Width (m)	Vent Velocity (m/s)	Vent Temperature (K)
Anode	84.53	1.42	2.508	361.3
Converter	54.13	3.66	2.352	339.9
Converter 5	16.16	3.66	2.198	339.9
Isa	17.67	0.76	11.297	313.7
ELF	23.26	3.35	1.391	320.6

The modeling of the roofline vents in AERSCREEN for inversion breakup fumigation evaluation presents a unique problem. AERSCREEN is not equipped with a buoyant line source type, so the roofline vents cannot be explicitly modeled. Furthermore, the fumigation algorithms apply only to point type sources, so the Hybrid Model approach of modeling the roofline vents as volume sources cannot be applied. To provide the most accurate representation of FMMI roofline vents within the limitations of the inversion breakup fumigation calculation technique, the roofline vents were modeled as point sources, with effective stack parameters iteratively developed until the calculated final plume heights matched those calculated by BLP and used in the Hybrid Model for the CEV analysis. The approach used is described in the following paragraphs and the results presented in Tables 3 and 6.

The ambient monitoring data collected at the Miami Townsite monitor indicates that inversion breakup fumigation conditions are most likely to be observed during the 9:00 am hour and in the month of April. The plume heights predicted by BLP for hour 9 during the month of April for the 2010 – 2013 analysis years were extracted from the Hybrid Model CEV run and averaged.

An iterative analysis was then performed to identify effective point source parameters for the roofline vents that result in a predicted plume height within 1 percent of the BLP-predicted plume height. EPA's screening procedures specify "stack height" meteorological conditions of Pasquill-Gifford stability class F and a wind speed of 2.5 m/s in performing inversion breakup fumigation evaluations, so the iterative roofline vent plume height analysis was performed with this specific meteorological condition. AERSCREEN would ideally be used for this iterative plume height analysis, but the model does not allow for the input of a specific meteorological condition (i.e., AERSCREEN would need to be re-coded to allow for such input). In contrast, SCREEN3 does allow the input of a specific meteorological condition so it was used to perform the iterative plume height analysis to identify effective point source parameters for the roofline vents. These point source parameters were then input to the AERSCREEN model to perform the inversion breakup fumigation evaluation.

The effective point source parameters resulting from the iterative plume height analysis are presented in Table 3. The release heights were set equal to the roofline vent heights.

Table 3. SCREEN3-Identified Point Source Parameters, Existing Roofline Vents

Roofline Vent	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temperature (K)	Release Height (m)	SCREEN3 Predicted Plume Height (m)	Averaged BLP Predicted Plume Height (m)
Anode	14.8	28.6	515.8	32.55	372.51	372.40
Converter	18.1	25.9	439.6	32.70	377.44	375.81
Converter 5	11.6	35.5	604.2	53.95	383.16	382.13
Isa	7.4	64.2	1,007	53.34	385.34	386.60
ELF	12.8	33.0	528.8	40.45	371.03	369.19

Future Smelter Sources

ADEQ issued a permit revision for the Miami Smelter to increase allowable production, install and upgrade control equipment, and make physical changes to the facility. The physical changes include the relocation of the APTGS at the Acid Plant and the VFS. Structural changes will shorten the roofline vent on the Converter Building and remove the Converter 5 roofline vent. Additionally, some of the emissions from the roofline vents on the smelter buildings will be exhausted through a new scrubbing system and stack (Aisle Scrubber). Tables 4 and 5 show the stack and vent parameters used in the CEV analysis.

Table 4. Stack and Exhaust Parameters, Future Stacks

Source ID	Stack	Stack Height (m)	Exit Diameter (m)	Exit Velocity[1] (m/s)	Averaged Exhaust Temp.[2] (K)
TAILSTK	APTGS	65.00	2.300	19.5	298.0
VENTSTK	VFS	65.00	2.900	18.5	-1.53
SCRUBBER	Aisle Scrubber	57.00	7.300	16.4	-0.11

The vent fume stack and aisle scrubber stack exhaust temperatures are expected to vary by season and hour of day as ambient conditions and scrubber water temperatures change. A single exhaust temperature value was determined by averaging the expected exhaust temperatures for hour 9 for the

[1] Average exhaust flow design values.

[2] Negative temperature indicates temperature above ambient, zero temperature indicates ambient temperature. Normal operation vent stack temperature is 2.3 K above ambient.

month of April. The average temperatures were 0.11K and 1.53K above ambient for the aisle scrubber and vent fume stack, respectively, and these are presented in Table 4.

Table 5. Vent-Specific Parameters, Future Roofline Vents

Roofline Vent	Vent Length (m)	Vent Width (m)	Release Height (m)	Vent Velocity (m/s)	Vent Temperature (K)
Anode	84.53	1.42	32.55	2.508	361.3
Converter	18.04	3.66	32.70	2.352	339.9
Isa	17.67	0.76	53.04	11.297	313.7
ELF	23.26	3.35	40.45	1.391	320.6

The same iterative plume height analysis described above was used to identify point source parameters for the roofline vents. The effective point source parameters resulting from the iterative plume height analysis are presented in Table 6. The release heights were set equal to the roofline vent heights.

Table 6. SCREEN3-Identified Point Source Parameters, Future Vents

Roofline Vent	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temperature (K)	Release Height (m)	SCREEN3 Predicted Plume Height (m)	Averaged BLP Predicted Plume Height (m)
Anode	14.2	26.5	478.9	32.55	344.78	344.95
Converter	11.7	32.6	554.6	32.70	345.97	347.54
Isa	8.0	74.0	1,161	53.34	424.68	425.71
ELF	13.6	37.2	597.0	40.45	415.09	413.32

Source Emission Rates and Land Use Type

All AERSCREEN runs used a normalized emission rate of one gram per second (g/s). The fumigation algorithms will only run with a rural land use type. This is consistent with the determination established for the Hybrid Model.

Meteorological Settings

The AERSCREEN inversion breakup fumigation algorithms are performed with built-in conditions of a stable atmosphere (Pasquill-Gifford Stability Class F) and a wind speed of 2.5 meters per second. No meteorological inputs are required by the AERSCREEN fumigation calculations.

Results

The results are presented in Table 7 for both existing and future sources. The highest predicted 1-hour concentrations for each source are presented and are based on the normalized emission rate of 1 g/s. The predicted distance to maximum impact is also presented for each source.

The results for the stacks are one to two orders of magnitude greater than the results for the roofline vents. The results therefore indicate the stacks are likely the primary contributors of smelter-emitted SO_2 to the existing and future inversion breakup fumigation conditions. The roofline vents are likely negligible contributors of SO_2 to existing and future inversion breakup fumigation conditions.

Table 7. AERSCREEN Inversion Breakup Fumigation Results for Normalized 1 g/s Emission Rates

Source	Existing Configuration		Future Configuration	
	Predicted Maximum 1-Hour Average Conc. ($\mu g \cdot m^{-3}/g \cdot s^{-1}$)	Predicted Distance to Predicted Maximum Conc. (m)	Predicted Maximum 1-Hour Average Conc. ($\mu g \cdot m^{-3}/g \cdot s^{-1}$)	Predicted Distance to Predicted Maximum Conc. (m)
APTGS	8.53	2,340	10.2	1,970
VFS	228	100	150	100
Aisle Scrubber	NA	NA	182	100
ISA Roofline Vent	0.122	64,100	0.091	79,900
ELF Roofline Vent	0.134	59,900	0.096	77,000
Converter Roofline Vent	0.162	41,600	0.204	35,300
Converter 5 Roofline Vent	0.116	66,300	NA	NA
Anode Roofline Vent	0.167	40,700	0.221	33,300

Potential SO_2 emissions from the stack sources combined will be reduced from 1,132 lb/hr to 30.5 lb/hr as summed from the values presented in the TSD. This represents a reduction of 97.3 percent of SO_2 emissions potentially contributing to inversion breakup fumigation conditions. Such a reduction, when applied to the existing ambient concentrations measured at the Miami Townsite monitor, demonstrates attainment will be achieved at the Miami Townsite monitor.

Sensitivity Analysis

A sensitivity analysis was performed to evaluate the method used for assigning point source parameters to the roof vents. Two additional evaluations were performed. The first scenario identified point source parameters that resulted in higher plume momentum and lower plume buoyancy than considered for the initial analysis. This was accomplished by increasing both the cross-sectional area of the "stack" exit and the exit velocity by 10%. The exit temperature was then iteratively reduced until the SCREEN3-predicted plume height matched the BLP-predicted plume height within 1 percent.

The second scenario identified point source parameters that resulted in lower plume momentum and higher plume buoyancy than considered for the initial analysis. This was accomplished by decreasing both the cross-sectional area of the "stack" exit and the exit velocity by 10%. The exit temperature was then iteratively increased until the SCREEN3-predicted plume height matched the BLP-predicted plume height within 1 percent.

Table 8 presents the identified point source parameters for the high momentum, low buoyancy scenario. Table 9 presents the identified point source parameters for the low momentum, high buoyancy scenario. The percent increases and decreases relative to the initial analysis are presented alongside the parameter values.

Table 8. SCREEN3-Identified Point Source Parameters
High Momentum, Low Buoyancy Scenario

Roofline Vent	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temperature (K)	SCREEN3 Predicted Plume Height (m)	Averaged BLP Predicted Plume Height (m)
Isa (existing)	7.8 (+4.9%)	70.6 (+10%)	704.6 (-30%)	384.97	386.60
ELF (existing)	13.4 (+4.9%)	36.3 (+10%)	460.0 (-13%)	369.50	369.19
Converter (existing)	18.9 (+4.9%)	28.5 (+10%)	400.0 (-9%)	374.04	375.81
Converter 5 (existing)	12.1 (+4.9%)	39.1 (+10%)	501.5 (-17%)	380.51	382.13
Anode (existing)	15.5 (+4.9%)	31.4 (+10%)	453.9 (-12%)	371.72	372.40
Isa (future)	8.3 (+4.9%)	81.4 (+10%)	789.2 (-32%)	426.92	425.71
ELF (future)	14.3 (+4.9%)	41.0 (+10%)	495.5 (-17%)	411.58	413.32
Converter (future)	12.3 (+4.9%)	35.9 (+10%)	482.5 (-13%)	346.71	347.54
Anode (future)	14.9 (+4.9%)	29.2 (+10%)	431.0 (-10%)	344.66	344.95

Table 9. SCREEN3-Identified Point Source Parameters
Low Momentum, High Buoyancy Scenario

Roofline Vent	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temperature (K)	SCREEN3 Predicted Plume Height (m)	Averaged BLP Predicted Plume Height (m)
Isa (existing)	7.0 (-5.1%)	57.8 (-10%)	2,500 (+148%)	386.30	386.60
ELF (existing)	12.1 (-5.1%)	29.7 (-10%)	639.8 (+21%)	369.44	369.19
Converter (existing)	17.1 (-5.1%)	23.3 (-10%)	492.3 (+12%)	375.52	375.81
Converter 5 (existing)	11.0 (-5.1%)	32.0 (-10%)	791.5 (+31%)	382.20	382.13
Anode (existing)	14.0 (-5.1%)	25.7 (-10%)	629.3 (+22%)	372.74	372.40
Isa (future)	7.6 (-5.1%)	66.6 (-10%)	4,000 (+244%)	425.48	425.71
ELF (future)	12.9 (-5.1%)	33.5 (-10%)	770.2 (+29%)	413.23	413.32
Converter (future)	11.1 (-5.1%)	29.4 (-10%)	715.4 (+29%)	347.45	347.54
Anode (future)	13.5 (-5.1%)	23.9 (-10%)	560.4 (+17%)	344.31	344.95

The parameters presented in Tables 8 and 9 were input to AERSCREEN to examine the sensitivity of the inversion breakup fumigation result to the parameters. The results for each scenario are provided in Tables 10 and 11.

Table 10. AERSCREEN Inversion Breakup Fumigation Results for Normalized 1 g/s Emission Rates High Momentum, Low Buoyancy Scenario

	Existing Configuration		Future Configuration	
Source	Predicted Maximum 1-Hour Average Conc. ($\mu g \cdot m^{-3}/g \cdot s^{-1}$)	Predicted Distance to Predicted Maximum Conc. (m)	Predicted Maximum 1-Hour Average Conc. ($\mu g \cdot m^{-3}/g \cdot s^{-1}$)	Predicted Distance to Predicted Maximum Conc. (m)
ISA Roofline Vent	0.120	64,600	0.088	81,500
ELF Roofline Vent	0.132	60,400	0.096	76,800
Converter Roofline Vent	0.177	39,100	0.208	34,700
Converter 5 Roofline Vent	0.116	66,200	NA	NA
Anode Roofline Vent	0.174	39,400	0.231	32,300

Table 11. AERSCREEN Inversion Breakup Fumigation Results for Normalized 1 g/s Emission Rates Low Momentum, High Buoyancy Scenario

	Existing Configuration		Future Configuration	
Source	Predicted Maximum 1-Hour Average Conc. ($\mu g \cdot m^{-3}/g \cdot s^{-1}$)	Predicted Distance to Predicted Maximum Conc. (m)	Predicted Maximum 1-Hour Average Conc. ($\mu g \cdot m^{-3}/g \cdot s^{-1}$)	Predicted Distance to Predicted Maximum Conc. (m)
ISA Roofline Vent	0.122	63,900	0.091	79,500
ELF Roofline Vent	0.138	58,500	0.099	75,300
Converter Roofline Vent	0.158	42,300	0.197	36,100
Converter 5 Roofline Vent	0.119	65,200	NA	NA
Anode Roofline Vent	0.161	41,700	0.214	34,000

Comparing the Table 7 results to those of Tables 10 and 11, the AERSCREEN-predicted calculations for inversion breakup fumigation are clearly insensitive to the identified point source parameters and the result is not a function of momentum-dominated or buoyancy-dominated plume rise. Given that the plume height dictates the inversion breakup fumigation result in the screening procedure, the lack of sensitivity is expected.

References

40 CFR 51, Appendix W. Guideline on Air Quality Models: 40 CFR Part 51, Appendix W. Research Triangle Park, North Carolina.

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10.13 Appendix M: Ambient Air Boundary

1. Overview

On Wednesday, February 22nd Arizona Department of Environmental Quality (ADEQ) personnel performed an on-site tour of the ambient air boundary (AAB) used for the Miami SO_2 nonattainment plan. During this tour ADEQ personnel traveled and documented the portions of the AAB that were reasonably accessible. Figure 1-1 illustrates the current ambient air boundary and the stretches of AAB that were inspected (F1-F4 and T1-T3). Section 2 provides ADEQ staff notes and observations from the inspection, as well as, images taken during the inspection of the specific segments.

The area of most interest to both EPA and ADEQ was the facilities southern boundary. This portion of the AAB is adjacent to the population centers of Claypool and Miami AZ.

The objectives of ADEQ's inspection were as follows:

1. Assess if the map provided by FMMI, which illustrates the AAB, accurately depicts the situation at the facility. The inspection should be focused on the border between the towns of Claypool/Miami and the facility. This border is an aggregation of segments F1-F4 and T1-T3.
2. Document the fencing at the facility.
3. Document the terrain FMMI is using to justify the AAB.
4. Determine if the combination of fencing and terrain reasonably precludes public access to the facility.

Due to being overly inaccessible, AAB segments other than F1-F4 and T1-T3 were not reviewed. As a note, the remaining portions of the AAB not reached during the inspection are fenced, and not delineated by terrain.

In general, upon visiting the site and inspecting the AAB perimeter, ADEQ has determined the boundary represents a practical ability to preclude public access. This conclusion is a result of the observations outlined in section A2 below.

Figure 1-1: Current Ambient Air Boundary

2. Inspection Notes

- Fencing Segment F1

Segment F1 starts roughly 2000 feet east of the most eastern tailings pile. There is a road and gate that allows access into the facility at the start of this segment (going from east to west), and can be seen in Figure 2-1. In addition to the fencing and gate, a channel with high sloping sides also separates the facility from Claypool and U.S. Route 60 (the yellow line segment in Figure 1-1). This channel can be seen in the background of Figure 2-2.

Other obstacles along F1, between U.S. Route 60 and the facility, include FMMI administrative buildings and local businesses. Figure 2-3 shows the transition from FMMI's fencing to the fencing of a local business. As seen in the figure, the lots on which these buildings sit are also fenced, which add further to the prevention of trespassing.

Finally, Figure 2-4 shows where the AAB transitions from F1 to T1. Specifically, in the distance, where the hill transitions from no ground cover to vegetation.

Figure 2-1: F1 Eastern Origin

Figure 2-2: F1 Continued

Figure 2-3: Facility and Local Business

Figure 2-4: F1 Termination

- Fencing Segment F2

The entirety of segment F2 was not inspected due to exceedingly rocky terrain and distance from any road. In addition, BHP Copper's facility sits between U.S Route 60 and fencing segment F2. Given this, the combination of BHP's facility, terrain, and fencing along this portion of the ambient air boundary inhibits public access to the facility.

- Fencing Segment F3

Like Segment F2, the entirety of F3 was not inspected due to the difficult terrain. However, the fencing that was visible (Figures 2-5 through 2-7) was deemed acceptable. Again, like Segment F2, the combination of rugged terrain and fencing along this stretch of the AAB reasonably precludes public access to the facility.

However, one portion of this segment could be seen as a vulnerability, which is the FMMI's training area. The training area is accessed via a road coming off U.S Route 60 at the western end of this segment. At the intersection of this road and the fencing there was no gate. However, the training area appeared to be busy with activity. Given this, any trespassers, which would likely not be in the proper PPE/attire, would stand out and be escorted out of the facility.

Figure 2-5: Fencing F3 Segment 1

Figure 2-6: Fencing F3 Segment 2

Figure 2-7: Fencing F3 Segment 3

- Fencing Segment F4

  The majority of Segment F4 was visible for inspection and was found to be adequate (Figure 2-9). A possible weak spot was found where the boundary transitions from T3 to this segment (Figure 2-8). However, this transition from terrain to fencing was heavily vegetated and not visible from the road. In addition, continuing the fencing east into the facility could prove difficult due to the increasingly rugged terrain, which itself reasonably precludes public access to the facility.

Figure 2-8: F4 Eastern Origin

Figure 2-9: Fencing F4 Segment

- Terrain Segment T1
  Segment T1 runs along a rail line at the top of a tailings pile. The slope leading up to this segment is sufficiently steep and moderately vegetated. Like much of the AAB, to access T1 an individual would need to pass over fencing which runs along U.S Route 60, and then cross several highly sloped channels. This combination, in addition to the slope of the tailings pile, was found to inhibit access to the facility. Figure 2-4 shows this elevated terrain segment in the background.

- Terrain Segment T2
  Segment T2 runs through one of FMMI's open pits. As shown in Figure 2-10, T2 is made up of steep man made ridges that extended down to a holding pond. This portion of the AAB was certainly the most rugged segment. Again, like most segments, additional rugged terrain and fencing would need to be traversed to reach T2.

Figure 2-10: Terrain Segment T2

- Terrain Segment T3
  This segment runs adjacent to U.S Route 60 and is made up of particularly steep terrain. ADEQ feels this segment clearly restricts public access.

Figure 2-11: Terrain T3 Segment 1

Figure 2-12: Terrain T3 Segment 2