Modeling Protocol for Characterization of Air Quality

Federal Data Requirements Rule for the 2010 Sulfur Dioxide Standard

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Project # 2010-SO2-5-DRR

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1.0 Introduction

1.1 Purpose

This protocol outlines the approaches used by the Missouri Department of Natural Resources' Air Pollution Control Program (air program) in the modeling analyses performed to support the recommendations for the sources that elected to model as their preferred method of characterization or for modeling used to support siting new monitors. The air program will use the AERMOD dispersion modeling system to characterize air quality around facilities that choose modeling as their preferred method of characterization. 40 CFR Part 51.1203(d) states that for sources characterized through air quality modeling, the air agency shall submit by July 1, 2016, a technical protocol for conducting such modeling to the Regional Administrator for review. This protocol fulfills the requirement outlined in 40 CFR 51.1203(d).

On August 21, 2015, the U.S. Environmental Protection Agency (EPA) published the final sulfur dioxide (SO_2) Data Requirements Rule[1] (DRR) to establish a timetable and other requirements for the characterization of current air quality around large sources of SO_2 emissions. As stated in §51.1202, sources that emitted more than 2,000 tons of SO_2 in 2014 must be characterized under the DRR. The DRR allows for three characterization options. The source may choose which option best suits their needs. The source may elect to limit their emissions to less than 2,000 tons, model compliance, or install new ambient air quality monitors. In January 2016, the air program submitted a list of sources affected by the DRR around which to characterize the air quality. That submittal fulfilled the requirement outlined in §51.1203(a). The sources being evaluated under the DRR are listed in Table 1 and displayed graphically in Figure 1. Being concurrently submitted with this protocol is a document detailing the method with which each of the affected sources' air quality is to be characterized. This submittal will fulfill the requirement outlined in §51.1203(b).

Table 1. Missouri SO_2 Sources to be evaluated under the DRR (January 2016 Submittal)

Map ID	FID	Plant Name	2014 Annual Actual Emissions (tons)
CD 1	071-0003	AMEREN MISSOURI-LABADIE PLANT*	33,091
1	143-0004	NEW MADRID POWER PLANT-MARSTON	16,672
2	175-0001	THOMAS HILL ENERGY CENTER POWER DIVISION-THOMAS HILL	16,575
3	189-0010	AMEREN MISSOURI-MERAMEC PLANT	11,702
4	083-0001	KANSAS CITY POWER AND LIGHT CO-MONTROSE GENERATING STATION	8,604
CD 2	201-0017	SIKESTON POWER STATION-SIKESTON POWER STATION*	6,651
5	097-0001	EMPIRE DISTRICT ELECTRIC CO-ASBURY PLANT	6,318

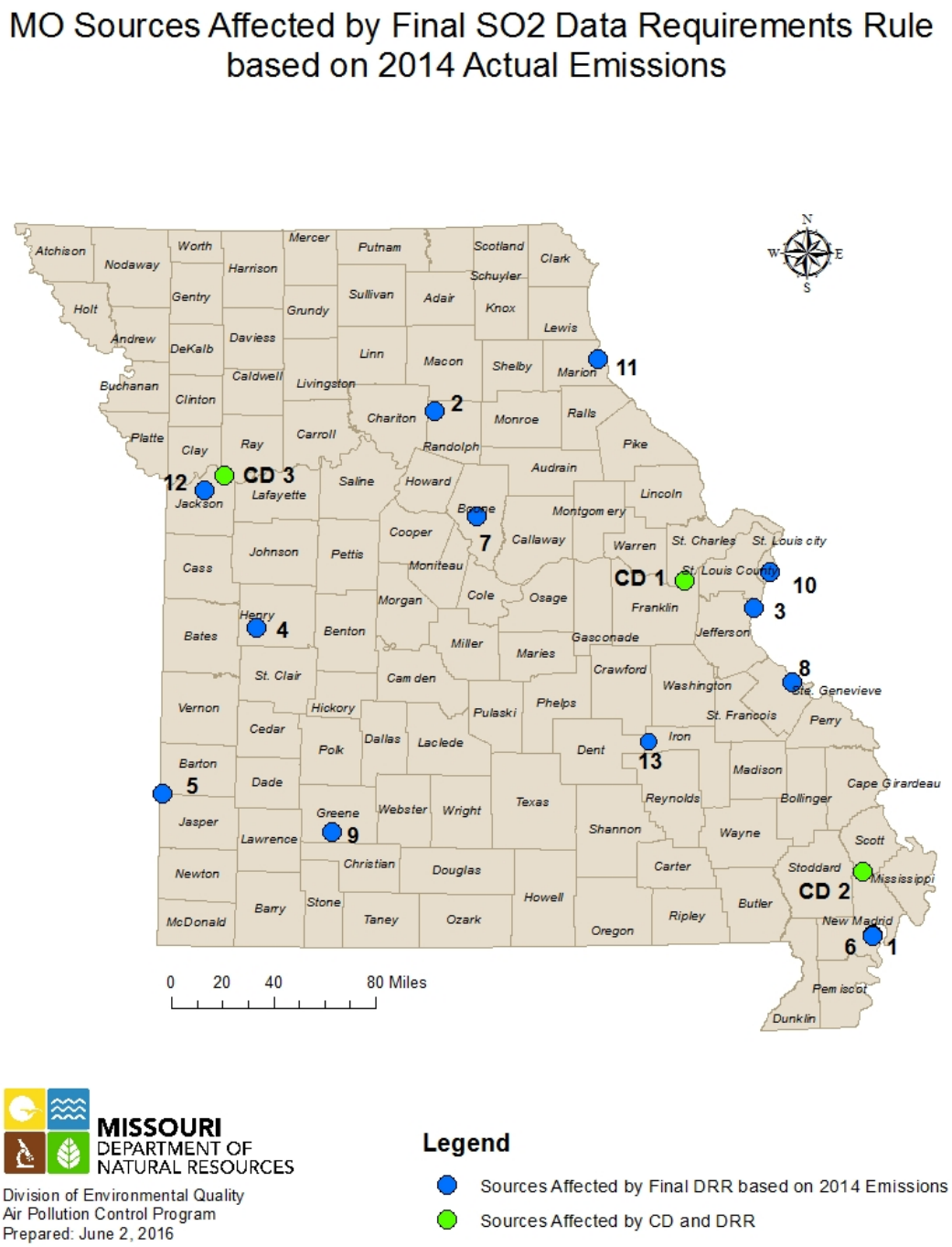
[1] EPA's Data Requirements Rule for the 2010 1-hour SO_2 Primary NAAQS; Final Rule, August 2015. https://www.gpo.gov/fdsys/pkg/FR-2015-08-21/pdf/2015-20367.pdf

6	143-0008	NORANDA ALUMINUM INC-NEW MADRID	5,323
7	019-0004	UNIVERSITY OF MISSOURI (MU)-POWER PLANT	5,171
CD 3	095-0031	KCP AND L - GREATER MO OPERATIONS-SIBLEY GENERATING STATION*	4,847
8	186-0001	MISSISSIPPI LIME COMPANY-STE. GENEVIEVE	3,285
9	077-0039	CITY UTILITIES OF SPRINGFIELD MISSOURI-JOHN TWITTY ENERGY CENTER	3,021
10	510-0003	ANHEUSER-BUSCH INC-ST. LOUIS	2,867
11	127-0001	BASF CORPORATION-HANNIBAL PLANT	2,560
12	095-0050	INDEPENDENCE POWER AND LIGHT-BLUE VALLEY STATION	2,105
13	093-0009	DOE RUN –BUICK**	1,649

*Per the final DRR, sources identified in the March 2015 federal consent decree (CD) should be included on the list of sources required for characterization under the final DRR.

**Doe Run Buick's 2014 reported emissions are currently being reviewed for accuracy which may result in a change in the annual actual emissions for this facility.

Figure 1. Map of Affected Sources in Table 1



1.2 Regulatory Discussion

On June 2, 2010, the EPA established a new 1-hour primary SO_2 National Ambient Air Quality Standard (NAAQS) of 75 parts per billion (ppb) [75 FR 35520, June 22, 2010] or approximately 196 micrograms per cubic meter ($\mu g/m^3$). The 1-hour SO_2 NAAQS of 75 ppb replaced the 24-hour and annual primary SO_2 NAAQS of 140 ppb and 30 ppb, respectively. The 1-hour standard protects the public from adverse health impacts experienced during short-term exposures to SO_2. The form of the 1-hour standard is based upon a 3-year average of the 99th percentile of the annual distribution of daily maximum 1-hour average

concentrations. The EPA finalized the secondary SO_2 standard on March 20, 2012, by retaining the current secondary standard, the 3-hour SO_2 standard of 500 ppb.
EPA is taking a tiered approach to designations under the 2010 SO_2 standard.' For the first round of designations, EPA designated 29 areas as nonattainment nationwide in July 2013. EPA designated two areas in Missouri as nonattainment, portions of Jackson and Jefferson Counties. This first round was based solely on existing monitored violations of the standard. The air program has addressed these two areas through separate nonattainment area plans submitted to EPA in 2015. The second round consists of sources affected by criteria established through a federal consent decree signed in March 2015. EPA is required to designate these areas by July 2016. The third and fourth rounds are being addressed through the federal SO_2 DRR. Modeled areas must be designated by December 2017, and all remaining areas must be designated by December 2020.

As mentioned previously, EPA established the "Data Requirements for Characterizing Air Quality for the Primary SO_2 NAAQS" in Subpart BB, §51.1200 through §51.1205. When EPA finalized the SO_2 DRR, they also released two draft guidance documents to aid state agencies in their characterization of air quality around affected sources. These two draft guidance documents are the "SO_2 NAAQS Designations Modeling Technical Assistance Document[2]" and the "SO_2 NAAQS Designations Source-Oriented Monitoring Technical Assistance Document[3]" (TAD), recently released in February 2016. Sources affected by the DRR that choose to install new ambient SO_2 monitors to characterize air quality must also rely on dispersion modeling to site the new monitoring stations. The source-oriented monitoring TAD details how dispersion modeling for monitor siting should be performed. Although similar to modeling for compliance determinations, differences do exist. These differences are explained in the applicable sections below.

EPA's draft guidance document entitled *"Guidance for 1-hour SO_2 NAAQS SIP Submissions[4]"* recommends the use of the AERMOD modeling system, EPA's preferred near-field dispersion model, for all SO_2 analyses. The EPA document titled "*Updated Guidance for Area Designations for the 2010 Primary Sulfur Dioxide National Ambient Air Quality Standard*[5]" released March 20, 2015, provides information on the recommended process for designating areas under the 2010 revised SO_2 NAAQS. This guidance also recommends the use of the AERMOD modeling system for the purpose of modeling to support area recommendations. Air program staff developed ambient air quality inputs based upon the criteria outlined in 40 CFR Part 51 Appendix W, "*Guideline on Air Quality Models*[6]." EPA provides these guidelines to ensure consistency among agencies performing modeling for various regulatory and non-regulatory purposes. Appendix W covers many different modeling applications. EPA has proposed updates to the guidelines in Appendix W but the air program will continue to follow the existing provisions until the changes have been finalized.

The state will submit final area boundary recommendations, for the areas surrounding affected sources, to EPA by January 13, 2017, for modeled areas. For areas with newly sited monitors, the recommendations will be based on quality assured data for 2017 through 2019. EPA is required by court order to finalize designations for these areas by December 31, 2017, for modeled areas, and by December 31, 2020, for all remaining areas.

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[2] EPA's draft SO_2 NAAQS Designations Modeling Technical Assistance Document, February 2016. https://www3.epa.gov/airquality/sulfurdioxide/pdfs/SO2ModelingTAD.pdf
[3] EPA's draft SO_2 NAAQS Designations Source-Oriented Monitoring Technical Assistance Document, February 2016. https://www3.epa.gov/airquality/sulfurdioxide/pdfs/SO2MonitoringTAD.pdf
[4] EPA's draft Guidance for 1-hour SO_2 NAAQS SIP Submissions, October 2011. https://www3.epa.gov/airquality/sulfurdioxide/pdfs/DraftSO2Guidance_9-22-11.pdf
[5]EPA's Updated Guidance for Area Designations for the 2010 Primary Sulfur Dioxide National Ambient Air Quality Standard, March 2015. http://www.epa.gov/airquality/sulfurdioxide/pdfs/20150320SO2designations.pdf
[6] EPA's Guideline on Air Quality Models (Appendix W), November 2005. https://www3.epa.gov/scram001/guidance/guide/appw_05.pdf

1.3 SO_2 Ambient Monitoring Sites

The department monitors ambient SO_2 levels at various locations throughout Missouri as shown in the table and map below (Table 2 and Figure 2). The department also oversees industrial monitoring sites maintained by individual facilities. These monitors are included in Figure 3. Figure 3 depicts Missouri's proposed SO_2 monitoring network, including industrial sites, as taken from the 2016 annual monitoring network plan[7], page 16. Nearby monitors in Kansas and Illinois are also included in Table 2 and Figure 2. Data from monitors in other nearby states are included in our technical evaluations when necessary.

Since the SO_2 standard was revised in 2010, EPA has voiced concern over the currently limited coverage of the SO_2 ambient monitoring network nationwide. For this reason, EPA has adopted a hybrid approach to designations under the 2010 standard, relying on both monitoring and modeling data to characterize air quality across the nation.

SO_2 is a primarily source-oriented pollutant; therefore existing regional trend monitors would not be properly placed to capture peak impacts from a single source. Historically, most monitors were sited to measure multiple pollutant concentrations and regional trends, such as ozone. A monitor sited for ozone but that has a collocated SO_2 analyzer would be beneficial but may not be properly sited to capture source-specific SO_2 impacts.

The network of department-maintained monitors is currently not extensive enough to capture peak impacts from all sources affected by the DRR; therefore dispersion modeling or new source-oriented monitors must be used to characterize air quality. EPA is requiring the use of modeling for designation purposes unless new ambient monitors can be sited to capture peak impacts.

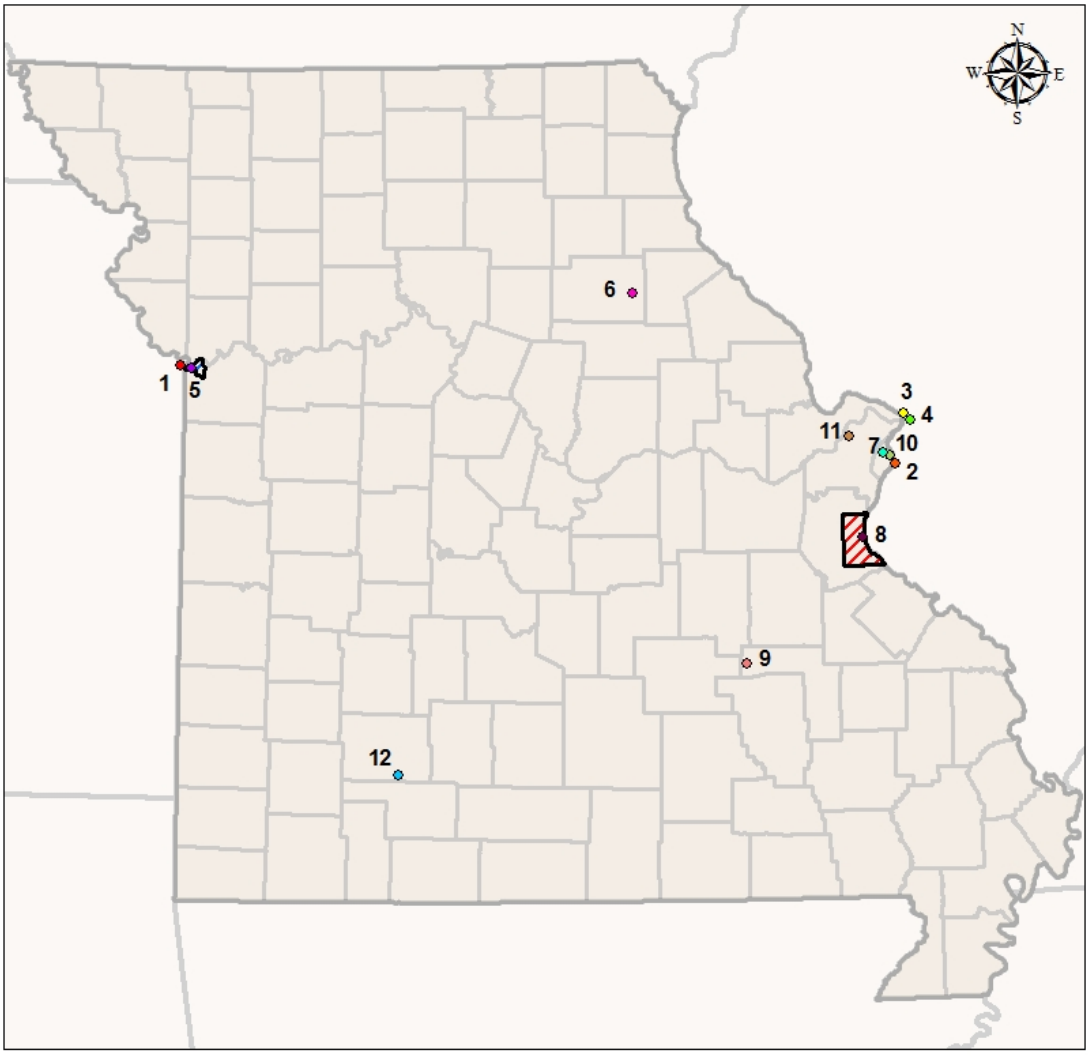
Table 2. SO_2 Ambient Monitor Network Table

Missouri Sulfur Dioxide Site Summary						
Site Name	**AQS Site I.D.**	**County**	**Latitude**	**Longitude**	**Elevation (ft)**	**Design Value 13-15 (ppb)**
Mark Twain State Park	29-137-0001	Monroe	39.48	-91.79	710	8
Buick NE	29-093-0034	Iron	37.65214	-91.11689	1458	60
Herculaneum Mott Street	29-099-0027	Jefferson	38.263394	-90.379667	468	66
Blair Street	29-510-0085	St. Louis City	38.656498	-90.198646	450	36
Margaretta	29-510-0086	St. Louis City	38.673221	-90.239166	514	19
South Charleston	29-077-0026	Greene	37.12263	-93.263353	1234	26
Troost**	29-095-0034	Jackson	39.104758	-94.570796	971	141
Rider Trail I-70 Site	29-189-0016	St. Louis	38.75264	-90.44884	488	***
Kansas Sulfur Dioxide Site Summary						
JFK	20-209-0021	Wyandotte	39.117219	-94.635605	850	46
Illinois Sulfur Dioxide Site Summary						
East St. Louis	17-163-0010	Saint Clair	38.612034	-90.160477	410	21

[7] Missouri's 2016 Annual Monitoring Network Plan, http://dnr.mo.gov/env/apcp/docs/2016monitoringnetworkplan.pdf

South Roxana Grade School	17-119-1010	Madison	38.828303	-90.058433	440	18
Wood River Water Plant	17-119-3007	Madison	38.860669	-90.105851	430	26
**Violating Monitor						
***Began monitoring SO_2 at this site in May 2016						

Figure 2. Map of Department-Maintained SO_2 Monitoring Network Sites with First Round Nonattainment Areas



0 20 40 80 Miles

Legend

- 1 JFK (KS)
- 2 ESTL (IL)
- 3 Wood River Water Plant (IL)
- 4 South Roxana (IL)
- 5 Troost
- 6 Mark Twain State Park
- 7 Margaretta
- 8 Herculaneum, Mott St.
- 9 BuickNE
- 10 Blair St.
- 11 Rider Trail
- 12 South Charleston
- Jackson County NAA
- Jefferson County NAA

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Division of Environmental Quality
Air Pollution Control Program
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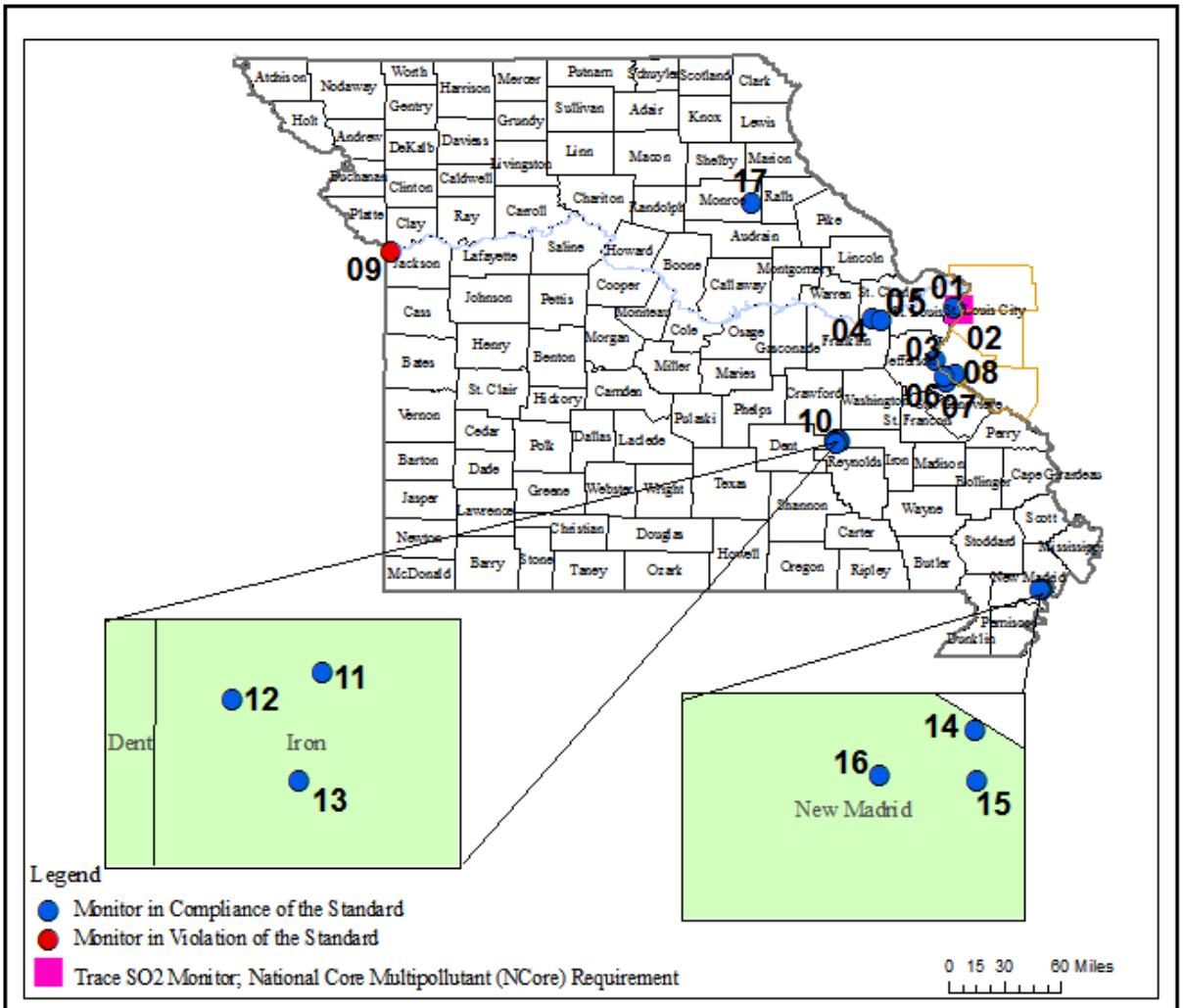
Figure 3. Map of Proposed SO_2 Monitoring Network Sites in Missouri from the 2016 Network Plan



Site# SiteName (13-15 DV*)	Site# SiteName (13-15 DV*)	Site# SiteName (13-15 DV*)
St. Louis Area, MO	Kansas City Area, MO	Outstate Area, MO
01 Margaretta (19)	09 Troost **(141)**	14 Noranda Site 1^**
02 Blair Street (36)	Outstate Area, MO	15 Noranda Site 2^**
03 Herc, Mott Street (66)	10 Buick NE (60)	16 Noranda Site 3^**
04 Ameren-Northwest^ ~(28)	11 Hwy 32 Northeast^**	17 Mark Twain State Park (8)
05 Ameren-Valley^~(34)	12 County Road 75^**	
06 Ameren-Weaver-AA^~(13)	13 West Entrance^**	
07 Ameren-Natchez^~(24)		
08 Ameren-Fults, IL^~~		

**Quality assured data through December 31st, 2015*
^Industry Monitor
~Began Monitoring in 2015 (99th Percentile)
~~Began Monitoring in 2016
***Site not operating and still under review*
Red & Bold: Violation of the standard

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1.4 SO_2 Implementation

The preamble of the 1-hour SO_2 NAAQS rule states that SIPs must be submitted for all areas—whether designated attainment, nonattainment, or unclassifiable—demonstrating they are attaining and maintaining the standard through permanent and enforceable measures. The first round of designations was based solely on existing monitored violations. The two first round nonattainment areas in Missouri are addressed through their respective nonattainment area plans that were submitted to EPA in 2015. EPA has acknowledged that the existing SO_2 monitoring network is limited in its scope so the agency adopted a new approach to designate areas as attaining or not attaining the standard. As previously mentioned, the final DRR and associated TADs detail the methods with which EPA expects to designate remaining areas under the 2010 1-hour SO_2 standard.

To date, EPA has provided the memoranda and guidance documents listed below to assist with implementation of this standard:

- Final Rule, "Data Requirements Rule for the 1-Hour Sulfur Dioxide (SO_2) Primary National Ambient Air Quality Standard (NAAQS)," published in the Federal Register on August 21, 2015. https://www.gpo.gov/fdsys/pkg/FR-2015-08-21/pdf/2015-20367.pdf
- "SO_2 NAAQS Designations Modeling Technical Assistance Document," draft released February 2016. https://www3.epa.gov/airquality/sulfurdioxide/pdfs/SO2ModelingTAD.pdf
- "SO_2 NAAQS Designations Source-Oriented Monitoring Technical Assistance Document," draft released February 2016. https://www3.epa.gov/airquality/sulfurdioxide/pdfs/SO2MonitoringTAD.pdf
- "Updated Guidance for Area Designations for the 2010 Primary Sulfur Dioxide National Ambient Air Quality Standard," March 2015. http://www.epa.gov/airquality/sulfurdioxide/pdfs/20150320SO2designations.pdf
- "Guidance for 1-Hour SO_2 Nonattainment Area State Implementation Plan (SIP) Submissions," memorandum from Stephen D. Page, April 23, 2014. http://www.epa.gov/airquality/sulfurdioxide/pdfs/20140423guidance.pdf
- "Guidance Concerning the Implementation of the 1-hour SO_2 NAAQS for the Prevention of Significant Deterioration Program," memorandum from Stephen D. Page, August 23, 2010 http://www.epa.gov/region07/air/nsr/nsrmemos/appwso2.pdf
- "Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard," memorandum from Tyler Fox, March 1, 2011 http://www.epa.gov/ttn/scram/guidance/clarification/Additional_Clarifications_AppendixW_Hourly-NO2-NAAQS_FINAL_03-01-2011.pdf
- "Area Designations for the 2010 Revised Primary Sulfur Dioxide National Ambient Air Quality Standards," memorandum from Stephen D. Page, March 24, 2011 http://www.epa.gov/air/sulfurdioxide/pdfs/20110411so2designationsguidance.pdf
- Draft "Guidance for 1-hour SO_2 NAAQS SIP Submissions", (76 FR 61098, October 3, 2011) http://www.epa.gov/air/sulfurdioxide/pdfs/DraftSO2Guidance_9-22-11.pdf
- Guideline on Air Quality Models, 40 CFR Part 51, Appendix W http://www.epa.gov/ttn/scram/guidance/guide/appw_05.pdf
- "Applicability of Appendix W Modeling Guidance for the 1-hour SO_2 National Ambient Air Quality Standard," memorandum from Tyler Fox, August 23, 2010 http://www.epa.gov/ttn/scram/guidance/clarification/ClarificationMemo_AppendixW_Hourly-SO2-NAAQS_FINAL_08-23-2010.pdf

This protocol adheres to all EPA guidance available at this time.

2.0 Air Quality Model

The AERMOD system was developed through a collaborative effort between the American Meteorological Society (AMS) and the EPA. AERMOD is a steady-state plume model that employs Gaussian and bi-Gaussian probability density functions to characterize the structure of the planetary boundary layer. AERMOD can predict the concentration distribution of pollutants from surface and elevated releases located within simple or complex terrain. The model allows for the input of multiple sources, terrain elevations, structure effects, various grid receptors, wet and dry depletion calculations, urban or rural terrain, and averaging periods ranging from one hour to one year.

The AERMOD modeling system will be used to determine compliance with the 1-hour SO_2 NAAQS. AERMOD is the preferred model for determining pollutant impacts from industrial source complexes where emissions are released from a variety of source types. The most recent model versions (v) will be used in these analyses. The most recent versions, as of the time of protocol development, are as follows: AERMOD v15181, AERMET v15181, AERMAP v11103, AERSURFACE v13016, AERMINUTE v15272, and BPIP v04274.

In the event that the use of an alternative model is required, the air program will contact EPA Region VII for guidance and approval. If necessary, the protocol document will be updated to include alternate modeling procedures. Updates to the modeling protocol will be submitted to EPA Region VII for guidance and approval.

2.1 Modeling Conditions

Staff will execute AERMOD and its corresponding preprocessors in a disk operating system (DOS) windows interface. Regulatory default options within the modeling system are set using the MODELOPT keyword contained within the control pathway of the air quality model. Staff will include terrain elevation data and stack-tip downwash calculations.

AERMOD contains a modeling option for urban areas that experience a nighttime heat island effect that creates a “convective-like” boundary layer with increased dispersion. The Guideline on Air Quality Models, Appendix W (November 2005) section 7.2.3 instructs users to define the urban or rural classification of the area considering land use and population density. The land use procedure in Appendix W 7.2.3(c) classifies urban areas based on industrial, commercial, and residential land use over 50% within a 3 km radius of the source. The population density threshold of the 3 km radius surrounding each facility is compared to the urban threshold of 750 people per square kilometer. Both the land use and population density guidelines in Appendix W will be used to assess the urban characteristics of the area surrounding each facility.

The AERMOD Implementation Guide (March 2009) section 5.1 guides users to apply the urban option as in Appendix W, but provides additional guidance. Urban complexes should be considered together when making the urban determination, even if single sources would be considered rural. When the urban heat island effect is expected to influence the full modeling domain, the urban option is recommended to capture the regional nature of the nighttime dispersion effect. The guidance also considers tall stacks to be transported above an urban heat island boundary layer height. Both Appendix W and the Implementation Guide will be considered when determining whether to use rural or urban nighttime dispersion characteristics to represent a facility’s surroundings.

3.0 Modeling Database Development

Refined air quality analyses will include SO_2 sources, within each modeling domain, determined to have an impact near the area of interest and that are not accounted for as part of the regional background

concentration. All permitted SO_2 sources, located within 20 km (and up to 50 km) of each affected source, will be evaluated for a potential impact on the area being modeled based on the level of their actual emissions and their proximity to the primary source. The following paragraphs outline the procedures used to ensure consistent and comprehensive air quality reviews. The modeling source inventories and source parameters used in the modeling evaluations for each area will be detailed in the final boundary recommendation document. All pertinent modeling files (or excerpts) will be included as attachments to the final area recommendation document. Unless otherwise noted, the modeled source inventories are based on emission years 2013-2015, which will be the most recent 3-year period available at the time of our recommendations. The following paragraphs outline the assumptions employed by air program staff in the development of the model input files.

3.1 Base Run Analysis for Affected SO_2 Sources

A base run model analysis will be performed for each source identified in Table 1 that has elected to model. The base run model analysis will reflect current actual emissions for each SO_2 source to be included in the model. Actual emissions will be used in the modeling to act as a surrogate for monitored data where no monitors currently exist. The goal of the DRR is to characterize the actual, current, ambient air quality surrounding each of the affected sources.

Permanent and enforceable emission rates may alternatively be used in designations modeling if a source elects to do so. This would avoid any ongoing verification requirements. In addition, a combination of actual and enforceable emission rates can be used. Actual emissions will be used unless otherwise noted, and the specifics of emission rates used will be detailed in the final boundary recommendation document.

Affected sources and any nearby interactive sources will be contacted to confirm the accuracy of site specific model input information on a case-by-case basis. Detailed information characterizing applicable sources will be collected and confirmed. This information may include the following:

1. Facility wide SO_2 equipment list,
2. Actual reported emissions (or Potential to Emit (PTE)) for each piece of equipment identified in item #1, including information regarding varying load scenarios, if applicable,
3. A description of equipment usage in order to identify sources that fall into the intermittent source category,
4. Identification of federally enforceable limits contained within construction permits, operating permits, consent decrees or other state and federal rules (if applicable),
5. Release parameters and source locations for each process unit or stack,
6. Property boundary, and
7. Building locations and heights.

3.2 Source Emission Rates

As laid out in EPA's draft modeling TAD, modeling for designation purposes should be done using actual emissions to act as a surrogate for monitoring. Hourly emissions, recorded by Continuous Emissions Monitoring Systems (CEMS), are the best option for source characterization, but for sources without hourly recorded emissions, additional justification is required.

Unless otherwise noted, the emission rates utilized in the air quality model reflect recent actual emissions for the affected sources. If available, actual hourly emissions will be obtained through CEMS data reported to EPA's Clean Air Markets Division (CAMD) and paired with corresponding hourly meteorological data to simulate actual conditions. Hourly varying emission rates will be input into the model using the SO HOUREMIS keyword. AERMOD has several options for emissions to temporally vary within the model, not only on an hourly basis. If hourly measured emissions are not available,

variable emission factors can be used based on production or operating schedules. Additional information on how varying emission rates/factors can be used in AERMOD can be found in the EPA's SO_2 Modeling TAD.

Interactive sources, if applicable, were modeled using annual actual emissions as reported to the Missouri Emissions Inventory System (MoEIS) for 2014, unless variable emission rate data was available or as otherwise noted. If a source chooses to model using permanent and enforceable emission rates, this deviation will be noted in the final boundary recommendation document.

Modeling for siting monitors is also performed using actual emissions as its basis. However, the monitoring TAD details using normalized emission rates for all sources, and this method will be used when possible. Normalized emission rates are a relative percentage of actual emissions. Modeling of normalized emission rates results in normalized design values (NDVs) at each receptor. This allows the user to focus the analysis on peak impact areas.

3.3 Emission Release Parameters

Accurate emission release parameters are required inputs to the air quality model to predict pollutant dispersion. The document titled "User's Guide for the AMS/EPA Regulatory Model AERMOD" outlines the source classification system that is used by the AERMOD modeling system in order to characterize emission releases within the input file.

In these SO_2 modeling analyses, the majority of emissions releases are stack driven releases with parameters based upon information provided by the facility or obtained from the MoEIS. Units required to operate CEMS for SO_2 emissions also record certain release parameters on an hourly basis. Sources affected by 40 CFR Part 75, Part 60, or other regulations that require CEMS, are also required to record volumetric flow rates (usually submitted in units at standard conditions) to the EPA's database. Sources also typically record hourly stack temperature. This allows the standard condition flow rates to be converted to actual condition flow rates. Actual condition flow rates can be used to obtain hourly varying exit velocities. The hourly emissions file for AERMOD allows the input of hourly varying stack exit temperature and exit velocity. Using hourly varying parameters allows for the most accurate approximation of actual conditions, and will be used when available. Otherwise, static release parameters as reported to MoEIS will be used.

Point source emissions are vented through stacks or isolated vents. In order to assign the point source release parameters, the model requires the following information regarding the location and the nature of the emission releases:

1. Stack height,
2. Stack exit temperature,
3. Stack exit velocity, and
4. Stack diameter.

Stack parameters provided by affected sources and all modeled facilities will be verified and included as an attachment to the final boundary recommendation document. AERMOD and its preprocessors require all inputs to be in the metric system so parameters will be converted to metric where necessary.

When specific stack data is unavailable, the release point will be characterized as a volume source within the model input file. Each volume source release is limited to the size of openings from which emissions escape, such as doorways. If no site-specific release characteristics are available, parameters for common volume sources will be assigned, such as emergency generators, heaters, etc. The model input files included with the final recommendation document will detail the specific parameters utilized.

3.4 Model Domain & Receptor Grid

The modeling domain will be centered on each affected source/area. This is to determine the interactive contribution from surrounding sources. Each modeling domain will extend sufficiently far in an effort to define the impact from any source that may cause or contribute to a violation of the 1-hour SO_2 NAAQS. All NAAQS compliance determinations will consider the maximum impact area and may require the addition of alternative domain configurations. The modeling domain will be determined on a case-by-case basis in order to properly address interactive source impacts.

The air program will develop the receptor grid for input into the air quality model. It will be resolved enough to adequately identify the area of maximum impact from fugitive and point source releases and will encompass the full extent of any NAAQS violations that are predicted to occur. For each affected source/area, receptors will be placed at 50-meter (m) intervals along the property/area boundary. From the domain origin, a multi-tier grid of varied receptor spacing will be used to account for both nearby and distant concentration gradients. For these analyses, onsite receptors (i.e. areas located inside a plant boundary or which are precluded from public access) are not defined as ambient air, therefore are not compared to the NAAQS.

Receptors will be spaced as follows:

- Center to 1 kilometer (km), receptors will be placed at 100m intervals
- 1km to 3.5km, receptors will be placed at 250m intervals
- 3.5km to 10km, receptors will be placed at 500m intervals
- 10km to 20km, receptors will be placed at 1000m intervals

The receptor grid, like the domain, is centered on the affected source/area. If necessary, additional receptors will be placed upon each area of maximum impact that is identified.

When determining compliance with the NAAQS, the EPA requires that, at a minimum, all nearby sources be modeled. Historically, nearby has been defined as any source that is expected to cause a significant concentration gradient in the vicinity of a monitor/source that is under review. The air program has deemed 20 kilometers a sufficient distance to capture impacts from all nearby sources that are expected to cause or contribute to violations near an affected source/area. This is consistent with recently issued notification letters EPA sent to states regarding the federal consent decree and affected sources. In these letters, EPA referenced 20 km as a threshold for indicating if an affected source was 'nearby' a neighboring state.[8] If special instances arise they will be reviewed on a case-by-case basis.

Actual emissions from SO_2 sources, located within 20km of an affected source/area, will be used to determine inclusion in the model. A one (1) ton per year emissions threshold will be the basis to determine if a source should be explicitly included in the modeling inventory. The data needed to execute the air quality analysis will be obtained from MoEIS. Since the model domain has the potential to extend beyond the state boundary, interactive source inventories will be obtained from bordering states, and the data will be incorporated into the air quality analysis as necessary.

The receptor grid for modeling for monitor siting is similar but less rigid since the modeling is not being used for compliance determinations. The grid would be comprised of receptors spaced at 250 m from the origin to 10 km and receptors spaced at 500 m from 10 km to 20 km. Receptors may be removed where a monitor could not feasibly be sited, such as bodies of water.

[8] https://www.epa.gov/sulfur-dioxide-designations/so2-designations-round-2-state-recommendations-and-epa-responses
https://www.epa.gov/sites/production/files/2016-04/documents/states-tribes-within-20km-of-cd-source.pdf

Special considerations for each area's receptor grid will be detailed in the final recommendation document.

3.5 Terrain Elevations

In addition to assigning receptor locations, the AERMOD system allows the user to input information regarding the terrain surrounding the facility. AERMOD is capable of calculating air pollutant concentrations for terrain that can be classified as simple, flat, complex, or mountainous land. To calculate concentrations in complex or mountainous terrain situations, AERMOD must have information about the surrounding terrain and its features. To aid in the definition of the terrain features, EPA developed a pre-processor, AERMAP (version 11103) to search terrain data for base elevations and features that may influence the dispersion of pollutants within the modeling domain. Outstanding features are assigned an elevation that is referred to as the hill height scale and that value must be included in the AERMOD input file.

The air program will use National Elevation Data (NED) in the GeoTIFF format from the United States Geological Survey (USGS) Seamless Data Server, processed through the AERMAP program, to obtain the base elevation for each receptor and source within the modeling domain. In addition, the hill height scale for each receptor will be extracted to determine terrain influences within the modeling domain. All source, receptor, and terrain elevation data will be converted to UTM Zone 15 in the NAD83 geodetic datum.

3.6 Determination of Surface Characteristics & Meteorological Data Selection

Because AERMOD does not accept raw meteorological data, it must be processed through AERMET (version 15181), the meteorological data pre-processor for the AERMOD modeling system. AERMET extracts and processes meteorological data to calculate the boundary layer parameters that are used to estimate pollutant concentrations within the atmosphere.

To accurately calculate the boundary layer parameters in AERMET, the meteorological model must have information about the land use that surrounds the meteorological site, specifically: surface roughness, albedo, and Bowen ratio. To provide a consistent method for determining surface characteristics, the EPA developed a mathematical tool, AERSURFACE, to determine surface roughness, Bowen ratio, and albedo values for input into AERMET. The AERSURFACE user guide[9] describes how these three surface characteristics relate to approximating convective and thereby dispersion conditions,

"The surface roughness length is related to the height of obstacles to the wind flow and is, in principle, the height at which the mean horizontal wind speed is zero based on a logarithmic profile. The surface roughness length influences the surface shear stress and is an important factor in determining the magnitude of mechanical turbulence and the stability of the boundary layer. The albedo is the fraction of total incident solar radiation reflected by the surface back to space without absorption. The daytime Bowen ratio, an indicator of surface moisture, is the ratio of sensible heat flux to latent heat flux and, together with albedo and other meteorological observations, is used for determining planetary boundary layer parameters for convective conditions driven by the surface sensible heat flux."

Air program staff will execute AERSURFACE (version 13016) with the default values described below:

Bowen ratio

- Ten kilometer by ten kilometer domain centered on the site.

Albedo

- Ten kilometer by ten kilometer domain centered on the site.

[9] AERSURFACE User's Guide, January 2008.
https://www3.epa.gov/scram001/7thconf/aermod/aersurface_userguide.pdf

Surface roughness length

- Default upwind distance of one kilometer centered on the site.
- Twelve, 30 degree meteorological sectors.

Where onsite meteorological data are collected for the facility being modeled, no additional surface characteristics analysis is needed. For the modeled sources to be evaluated for December 2017 designations, sufficient onsite data is not currently available. Therefore, the air program will determine the nearest meteorological stations operated by the National Weather Service (NWS) for evaluation.

Because the surface characteristics significantly influence the dispersion profiles within AERMOD, the user must determine if the surface characteristics at the meteorological site are representative of the conditions at the facility site. To accomplish this, air program staff developed surface characteristics for multiple airports across the state for each moisture condition: average, dry, and wet conditions. The results from the AERSURFACE analysis for each airport were summarized in an excel template developed by the air program to help analyze NWS data. This template enables the user to input facility surface characteristics from AERSURFACE for comparison to each airport based upon characteristics of surface roughness, albedo, Bowen ratio, land use classifications, proximity, and aerial photography.

Air program staff will execute AERSURFACE for each affected source/area for input into the excel template described above. The most representative surface and upper air reporting sites will then be selected for each source/area (see Section 3.7 for selection details).

3.7 Meteorological Data

As laid out in the SO_2 Modeling TAD, the most recent three (3) years of representative meteorological data is to be used with concurrent emissions data (hourly as available) to act as a surrogate for monitoring data for designations purposes under the 1-hour SO_2 standard.

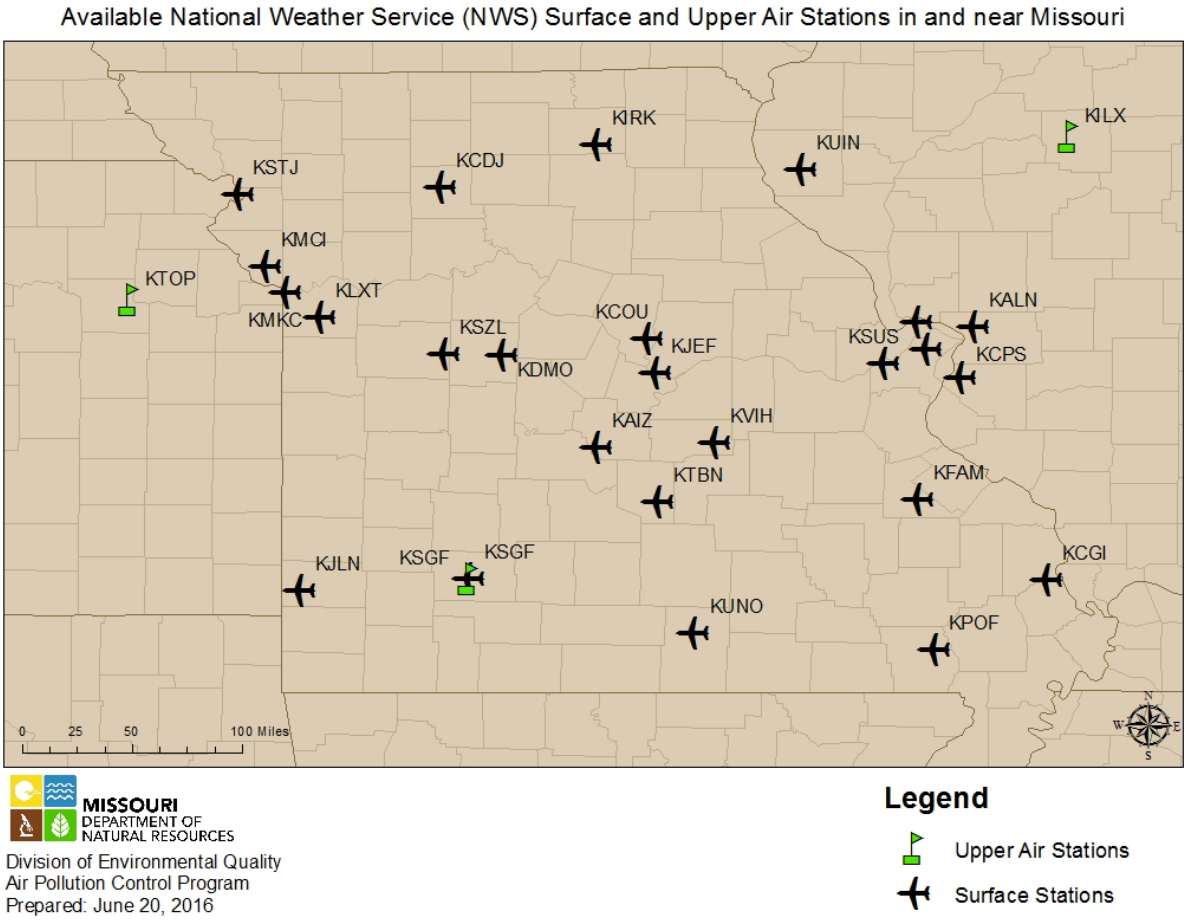
Air program staff will select meteorological data based upon the spatial and temporal characteristics of each affected source/area. Ultimately, site selection will consider the proximity of the collection site to the area of interest, the complexity of the terrain in the area surrounding the source/area, the exposure of the meteorological sensor, and temporal variations in the local climate.

Meteorological data is collected by NWS reporting stations located at most large airports. Usually NWS meteorological datasets include 1-minute Automated Surface Observing System (ASOS) wind data. The 1-minute ASOS data will be obtained from the National Climatic Data Center in the TD-6405 data format that includes the 2-minute average wind speed and direction for each minute within an hour. The use of 1-minute ASOS data more accurately depicts the average hourly wind flow than single instantaneous readings of wind speed and direction. The 1-minute ASOS data will be processed through AERMINUTE (v15272) prior to input into the AERMET processor. Where possible the air program will use minute-level ASOS data.

It is important to note that the Bowen ratio characteristics applied in Stage 3 AERMET processing will be determined based upon the precipitation totals from the meteorological record for the time period being processed. For example, if the meteorological period reported above-average precipitation totals for 2015, the Bowen ratio values for wet surface moisture will be chosen for Stage 3 processing in AERMET for 2015.

The map contained in Figure 4 visually depicts the regional choices available for surface and upper air reporting sites.

Figure 4. Surface and Upper Air Reporting Sites



The air program will provide separate documentation for each affected source/area detailing the selection of the most representative meteorological station for use in the modeling demonstration, along with all supporting evidence. An air program staff meteorologist will perform the meteorological evaluation for each source/area and develop a recommendation memorandum for the chosen meteorological dataset. These memorandums will be made available for review upon request or included as attachments to the final recommendation document.

3.8 Building Downwash

Building downwash is calculated using the Building Profile Input Program (BPIP) with plume rise model enhancements (PRIME), version 04274. Information required to execute BPIP PRIME includes the heights and locations of structures which may contribute to building downwash and the stack locations in relation to these structures. Based upon facility configuration, the air program will determine if a stack is subjected to wake effects from a surrounding structure(s). If structure wake effects are evident, flags will be set to indicate which stacks are affected by building wake zones. For stacks influenced by a structure, BPIP PRIME calculates the building heights and widths to be included in the dispersion model so that building downwash effects are considered. Staff will evaluate building parameter information for all pertinent sources in the modeling analyses.

3.9 Good Engineering Practice Stack Height

Good engineering practice (GEP) stack height refers to the height at which emission releases from isolated stacks or vents will not cause excessive ground level concentrations in the immediate vicinity of a source due to building downwash effects, or complex terrain. Section 123 of the CAA limits the modeling stack height to GEP when performing air quality analyses in an effort to prevent facilities from installing excessively tall stacks to meet air quality standards. When modeling permanent and enforceable (or potential-to-emit) emission rates, GEP stack height will be used. However, as outlined in the SO_2 modeling TAD, when modeling for designation purposes using actual emissions; actual stack height will be used to allow the model to act as a surrogate for monitoring.

If GEP stack height must be determined, air program staff will reference EPA's *Guideline for Determination of Good Engineering Practice Stack Height (Technical Support Document for the Stack Height Regulations)*[10].

4.0 Background Concentrations

4.1 Background Concentrations Analysis

According to 40 CFR Part 51, Appendix W, background concentrations must be considered when determining compliance with the NAAQS. To account for natural source impacts, sources that are not explicitly modeled, and unidentified sources: recent monitoring data is to be used to establish background concentrations. Established background concentrations will then be incorporated into the model results. The following paragraphs outline the procedures that will be used to determine representative background concentrations.

The air program developed and submitted to EPA Nonattainment Area (NAA) plans for the two first round NAAs: portions of Jackson and Jefferson Counties. During the development of these plans, thorough background concentration analyses were performed. These analyses yielded an urban background concentration of 13 ppb used for Jackson County and a rural background concentration of 9 ppb used for Jefferson County. These established 'rural' and 'urban' concentrations may be used for areas of each respective classification. The land use classification procedure is discussed in section 2.1 Modeling Conditions of this protocol. The choice of background SO_2 concentration is dependent on many factors other than the urban heat island effect (or land use classification). The outstate monitor located in Mark Twain State Park (AQS Site ID: 29-137-0001) may also be used to represent background concentrations in model analyses. The three year design value for the Mark Twain State Park monitor for 2013-2015 is 8 ppb. Background concentration analyses and their corresponding justification are specific to each modeled area therefore explicit documentation of the chosen background concentration will be discussed in the final boundary recommendation document for each area separately.

4.2 Monitor Analysis

The following paragraphs detail the procedures used in establishing the background concentrations used in the first round nonattainment area plans. These concentrations may also be used for model analyses of other areas if deemed representative.

EPA guidance notes that ambient air quality data should generally be used to account for background concentrations. During NAA plan development, staff used 1-hour design value data for the most recent 3-year period, at that time, (2010-2012) to develop background concentrations and to perform a thorough

[10] EPA's Guideline for Determination of Good Engineering Practice Stack Height (Technical Support Document for the Stack Height Regulations), June 1985. https://www3.epa.gov/scram001/guidance/guide/gep.pdf

background analysis using monitored values. Monitored background values are based on the design value of the nearest representative air quality monitor that is the least influenced by nearby SO_2 sources.

Background concentrations include impacts attributable to natural sources, nearby sources (excluding primary and interactive modeled sources), and unidentified sources. This derived background concentration accounts for all sources of SO_2 not already included in the model runs. Emissions from nearby point source facilities that are included in the model run as an interactive source will not be included in the background concentration.

In general, the background value was calculated similarly to design values at air quality monitors, in order to be comparable to the SO_2 NAAQS. A monitoring site near but outside the immediate area of source impact, that has SO_2 concentrations and wind direction measurements for the most recent certified three-year period, was selected for further analysis. Threshold concentrations were used to limit the monitored value sample size (and associated back trajectories). Statistical analyses including an Excel pivot table and chart were performed to visualize the frequency of the measured concentrations from certain wind directions. This is helpful in targeting a sector with the least amount of monitored days above the threshold concentration, which can most likely be attributed to the primary source(s). Using the Linux-based Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model script, back trajectories were plotted to show where certain air parcels originated on days that monitored concentrations are above the threshold concentration. Impacts from primary sources are evident with groupings of trajectories. A sector with little to no source influence was chosen for further analysis. Considering measured concentrations from the chosen sector, the fourth highest (or 99th percentile) value is chosen as representative of the area's background concentration.

Due to the limited number of SO_2 air quality monitoring sites located within Missouri, staff reviewed the regional characteristics within five kilometers of the area to determine what monitoring station best represents the observed land use in and around each nonattainment area.

Since an urban monitor site was selected for both background analyses, staff determined which meteorological corridors are not influenced by explicitly modeled sources. The meteorological corridors are defined according to ten degree wind direction sectors. Staff reviewed the 1-hour profile for each meteorological corridor in order to determine a representative background value. As mentioned, statistical measures were employed in the determination of each background concentration.

For more detailed explanation of the methods used to approximate background concentrations for the first round nonattainment area plans, please refer to the full submittals located here: http://dnr.mo.gov/env/apcp/sips.htm#sulfurdioxide

5.0 Post-processing for Siting Monitors

Specific post-processing of model results is performed to determine where new ambient air quality monitors should be sited to properly characterize areas of high impacts due to the primary source's SO_2 emissions. EPA's monitoring TAD[11] details how the model results should be used to site new ambient air quality monitors. Modeling of normalized emission rates results in normalized design values (NDVs) at each modeled receptor location. These NDVs are then analyzed to determine the most desirable siting locations. In the TAD, the post-processing includes using the MAXDAILY output option in AERMOD for the highest concentration receptors, for example the highest 300 receptors can be used. This output option allows us to determine the frequency with which a receptor registers a daily maximum concentration. The MAXDAILY option gives the maximum 1-hour concentration for each receptor for each day. This output is used to rank the areas by the total number of days that an individual receptor has

[11] EPA's SO_2 NAAQS Designations Source-Oriented Monitoring Technical Assistance Document, February 2016. https://www3.epa.gov/airquality/sulfurdioxide/pdfs/SO2MonitoringTAD.pdf

a 1-hour daily maximum concentration for the modeled time period. Sorting by this frequency/number of occurrences is one way to determine a desirable monitoring site location.

The monitoring TAD also describes a method of scoring to determine possible monitoring locations. The scoring method creates a relative prioritized list of receptor locations for monitor siting using both NDVs and 1-hour daily maximum concentration frequencies. This strategy will provide a list of receptor locations, ranked in general order of desirability with regard to potential siting of permanent source-oriented SO_2 monitors. Lower numerical scores indicate higher probability of capturing peak 1-hour SO_2 concentrations in the modeled domain. The score is the best way to determine potential monitoring site locations as it accounts for both modeled high concentrations and the frequency with which a receptor models high concentrations.

All the post-processing as described was utilized to determine the most desirable monitor site locations for sources that elected to install new ambient air quality monitors. Once the modeling analysis was complete, the site locations were visited and reviewed for siting criteria. Quality Assurance Project Plans (QAPPs) were also required to be submitted prior to final site approval. All monitors being sited to comply with the DRR are included in Missouri's 2016 annual Monitoring Network Plan. The network plan undergoes public inspection and must be submitted to EPA annually. The air quality analysis section of the air program oversees this effort and worked closely with the planning section as the monitors were being sited. All monitors being sited to comply with the DRR must be operational no later than January 1, 2017. Should any new monitors not be operational by that date, the source will move to the modeling pathway to characterize air quality and the analysis will follow this protocol for modeled sources.