

MISSOURI



**NATURAL
RESOURCES**

Modeling Protocol for Characterization of Air Quality

Federal Data Requirements Rule for the 2010 Sulfur Dioxide Standard

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September 2016

Modeling Protocol for Characterization of Air Quality Federal Data Requirements Rule for the 2010 SO₂ Standard

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 utilized the AERMOD dispersion modeling system for these purposes. 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. The submission of this protocol on June 28, 2016, fulfilled the requirement outlined in 40 CFR 51.1203(d). This protocol is a fluid document that has since been and will continue to be revised to reflect the most recent methodologies.

On August 21, 2015, the U.S. Environmental Protection Agency (EPA) published the final sulfur dioxide (SO₂) Data Requirements Rule¹ (DRR) to establish a timetable and other requirements for the characterization of current air quality around large sources of SO₂ emissions. As stated in §51.1202, sources that emitted more than 2,000 tons of SO₂ in the most recent emission year [2014] must be characterized under the DRR. The DRR details two characterization options available to sources: modeling or monitoring. Alternatively, a source may elect to adopt federally enforceable emissions limitations to less than 2,000 tons per year to forego characterization under the DRR.

In January 2016, the air program submitted a list of sources affected by the DRR around which to characterize air quality to fulfill 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. The air program used the most recent, certified emissions year to compare to the threshold established in the DRR. At the time of developing the list for submission to EPA in January 2016, the latest certified emissions year was 2014. In June 2016, the air program submitted a document detailing the method with which each of the affected sources' air quality is to be characterized. The air program concurrently submitted this modeling protocol for characterization of air quality under the federal DRR. The air program also made the annual ambient monitoring network plan available for public inspection in May 2016. These three items together fulfill the requirement outlined in §51.1203(b).

Table 1. Missouri SO₂ Sources affected by the DRR (January 2016 Submittal)

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

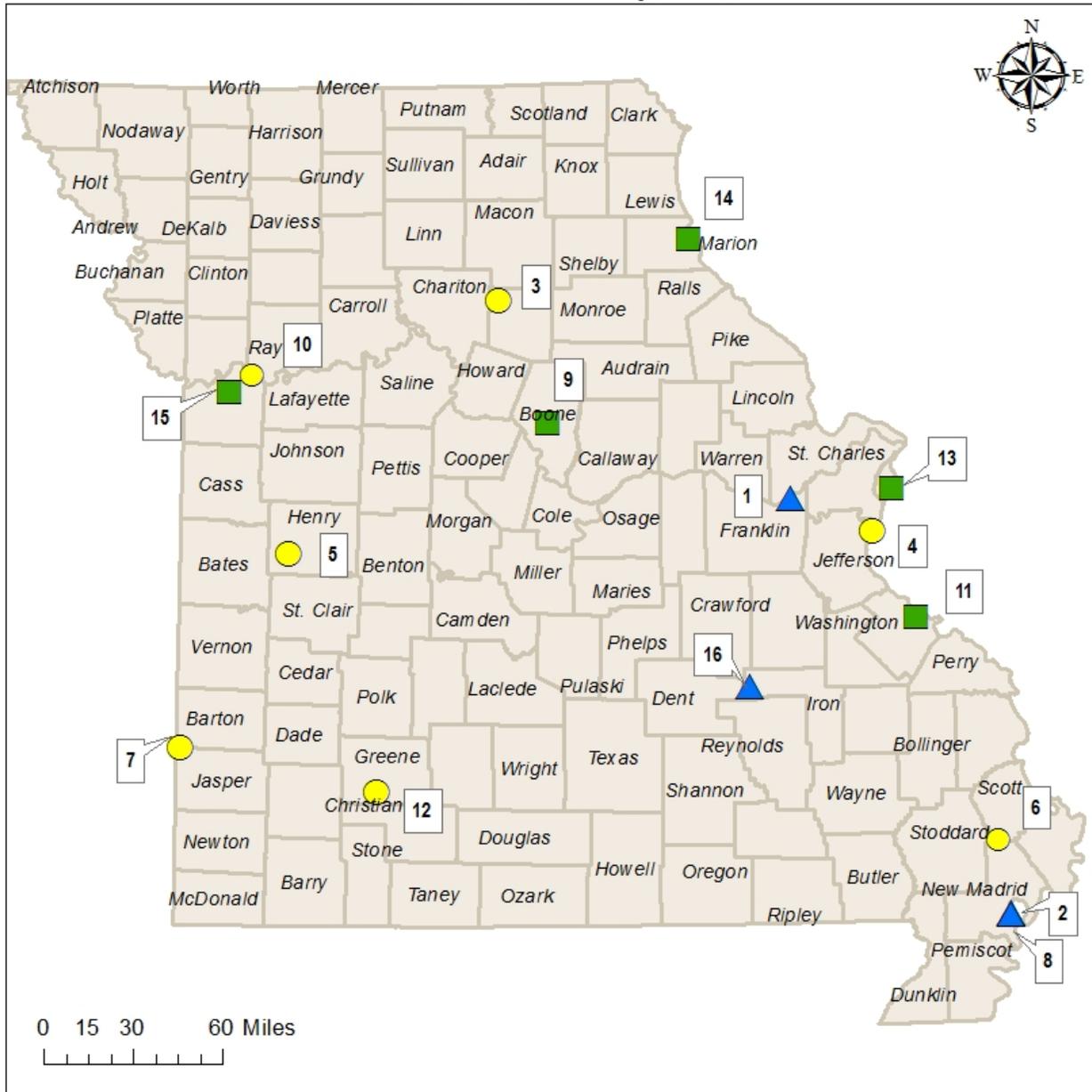
¹ EPA's Data Requirements Rule for the 2010 1-hour SO₂ Primary NAAQS; Final Rule, August 2015. <https://www.gpo.gov/fdsys/pkg/FR-2015-08-21/pdf/2015-20367.pdf>

6	201-0017	SIKESTON POWER STATION-SIKESTON POWER STATION*	6,651
7	097-0001	EMPIRE DISTRICT ELECTRIC CO-ASBURY PLANT	6,318
8	143-0008	NORANDA ALUMINUM INC-NEW MADRID	5,323
9	019-0004	UNIVERSITY OF MISSOURI (MU)-POWER PLANT	5,171
10	095-0031	KCP AND L - GREATER MO OPERATIONS-SIBLEY GENERATING STATION*	4,847
11	186-0001	MISSISSIPPI LIME COMPANY-STE. GENEVIEVE	3,285
12	077-0039	CITY UTILITIES OF SPRINGFIELD MISSOURI-JOHN TWITTY ENERGY CENTER	3,021
13	510-0003	ANHEUSER-BUSCH INC-ST. LOUIS	2,867
14	127-0001	BASF CORPORATION-HANNIBAL PLANT	2,560
15	095-0050	INDEPENDENCE POWER AND LIGHT-BLUE VALLEY STATION	2,105
16	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.

2010 1-hour SO₂ Standard: Round 3 and 4 Sources affected by DRR



Legend

- Modeled Sources
- ▲ Monitoring Sources
- Limited Sources



Figure 1. Map of Missouri's affected sources in Table 1

1.2 Regulatory Discussion

On June 2, 2010, the EPA established a new 1-hour primary SO₂ 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 (µg/m³). The 1-hour SO₂ NAAQS of 75 ppb replaced the 24-hour and annual primary SO₂ 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 SO₂. 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 SO₂ standard on March 20, 2012, by retaining the current secondary standard, the 3-hour SO₂ standard of 500 ppb.

EPA is taking a phased approach to designations under the 2010 SO₂ 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 monitored violations of the standard at existing monitor sites. The air program has addressed these two areas through separate nonattainment area plans submitted to EPA in 2015.

Subsequent rounds of designations are prescribed by a consent decree between EPA, the Sierra Club, and the Natural Resource Defense Council which was signed and entered by the court on March 2, 2015. The decree specifies a schedule for the EPA to complete SO₂ designations for the rest of the country in three additional rounds:

- Second round by July 2, 2016;
- Third round by December 31, 2017; and
- Final round by December 31, 2020.

To meet the first deadline, on June 30, 2016, EPA designated areas that contained either a newly violating monitor or a stationary source that according to the EPA's Air Markets Database:

- Emitted 16,000 tons of SO₂ in 2012; or
- Emitted 2,600 tons of SO₂ and had an average emission rate of at least 0.45 lbs. SO₂/MMBtu in 2012.

EPA designated the following areas of Missouri: portions of Jackson, St. Charles, and Franklin Counties as unclassifiable and Scott County as unclassifiable/attainment. [81 FR 45039]

The last two deadlines for EPA to complete remaining designations are December 31, 2017, and December 31, 2020. The designations completed by these later deadlines are to be made pursuant to the EPA's Data Requirements Rule (DRR) for the 1-hour SO₂ NAAQS. The final DRR was published in the Federal Register (FR) on August 21, 2015 [80 FR 51052]. The DRR establishes a timetable and other requirements for the characterization of current air quality around large sources of SO₂ emissions.

As stated in §51.1202, sources that emitted more than 2,000 tons of SO₂ in the most recent, quality assured emission year [2014], excluding sources in previously designated nonattainment areas, must be evaluated under the DRR. The DRR details two characterization options available to sources: modeling or monitoring. Alternatively, a source may elect to adopt federally enforceable emissions limitations to less than 2,000 tons per year to forego characterization under the DRR.

EPA established the "Data Requirements for Characterizing Air Quality for the Primary SO₂ NAAQS" in Subpart BB, §51.1200 through §51.1205. When EPA finalized the SO₂ 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 "SO₂ NAAQS Designations Modeling Technical Assistance Document²" and the "SO₂ NAAQS Designations Source-Oriented Monitoring Technical Assistance

² EPA's draft SO₂ NAAQS Designations Modeling Technical Assistance Document, February 2016.

<https://www3.epa.gov/airquality/sulfurdioxide/pdfs/SO2ModelingTAD.pdf>

Document³” (TAD). The purpose of the TADs is to aid in the technical aspects of using these methods for designation purposes. Sources affected by the DRR that choose to install new ambient SO₂ 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 SO₂ NAAQS SIP Submissions*”⁴ recommends the use of the AERMOD modeling system, EPA’s preferred near-field dispersion model, for all SO₂ 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 SO₂ 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 air program 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 modeled areas by December 31, 2017, and by December 31, 2020, for all remaining areas.

1.3 SO₂ Ambient Monitoring Sites

The department monitors ambient SO₂ levels at various locations throughout Missouri as shown in Table 2 and Figure 2. Nearby monitors in Kansas and Illinois are also included in the table and map. Since the SO₂ standard was revised in 2010, EPA has voiced concern over the currently limited coverage of the SO₂ 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.

SO₂ 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 SO₂ analyzer would be beneficial but may not be properly sited to capture source-specific SO₂ 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

³ EPA’s draft SO₂ 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 SO₂ 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

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. SO₂ 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
Wildwood Lane	29-077-0040	Greene	37.108959	-93.25297	1231	*
James River South	29-077-0037	Greene	37.104461	-93.253337	1227	25
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	47
Illinois Sulfur Dioxide Site Summary						
East St. Louis	17-163-0010	Saint Clair	38.612034	-90.160477	410	22
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
*Monitoring Discontinued on 5/31/2014						
**Violating Monitor						
***Began monitoring SO ₂ at this site in May 2016						

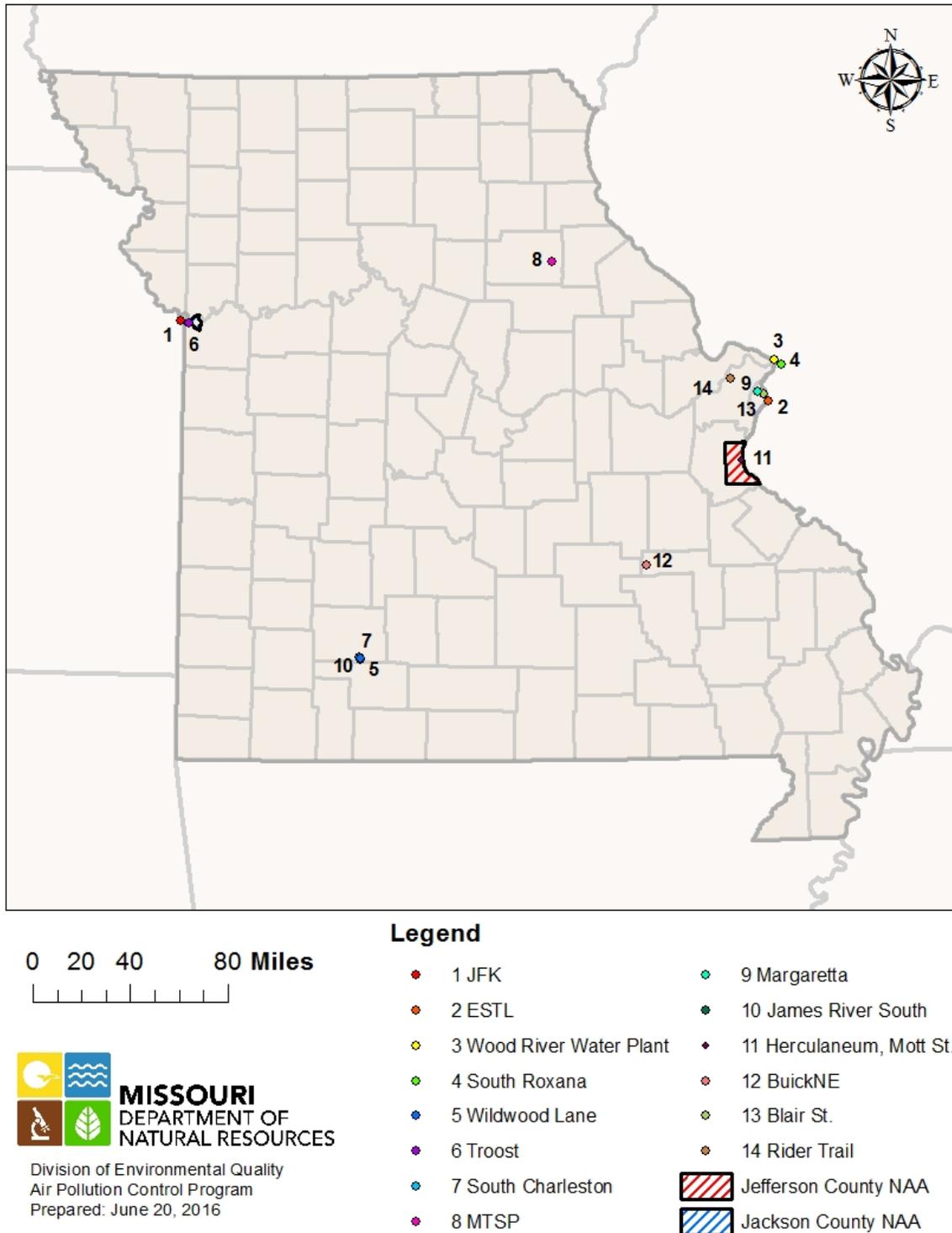


Figure 2. Map of Department-Maintained SO₂ Monitoring Network Sites

1.4 SO₂ Implementation

The preamble of the 1-hour SO₂ 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 SO₂ 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 SO₂ 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 (SO₂) 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>
- “SO₂ NAAQS Designations Modeling Technical Assistance Document,” draft released August 2016. <https://www.epa.gov/sites/production/files/2016-06/documents/so2modelingtad.pdf>
- “SO₂ NAAQS Designations Source-Oriented Monitoring Technical Assistance Document,” draft released February 2016. <https://www.epa.gov/sites/production/files/2016-06/documents/so2monitoringtad.pdf>
- “Updated Guidance for Area Designations for the 2010 Primary Sulfur Dioxide National Ambient Air Quality Standard,” March 20, 2015. <https://www.epa.gov/sites/production/files/2016-06/documents/20150320so2designations.pdf>
- “Guidance for 1-Hour SO₂ Nonattainment Area State Implementation Plan (SIP) Submissions,” memorandum from Stephen D. Page, April 23, 2014. https://www.epa.gov/sites/production/files/2016-06/documents/20140423guidance_nonattainment_sip.pdf
- “Guidance Concerning the Implementation of the 1-hour SO₂ NAAQS for the Prevention of Significant Deterioration Program,” memorandum from Stephen D. Page, August 23, 2010 <https://www.epa.gov/sites/production/files/2015-07/documents/appwso2.pdf>
- “Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO₂ 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
- 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 SO₂ 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

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 was used to determine compliance with the 1-hour SO₂ 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) were

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 BPIPPRIME v04274.

2.1 Modeling Conditions

Staff executed 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 included 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 were 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 were 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 included SO₂ 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 SO₂ sources, located within 20 km (and up to 50 km) of each affected source, were 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 are detailed in the final boundary recommendation document. All pertinent modeling files (or excerpts) are included as attachments to the final area recommendation document. Unless otherwise noted, the modeled source inventories are based on emission years 2013-2015, which is the most recent 3-year period available at the time of 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 SO₂ Sources

A base run model analysis was performed for each source identified in Table 1 that elected to model. The base run model analysis reflects current actual emissions for each SO₂ source to be included in the model. Actual emissions were 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. In addition, a combination of actual and enforceable emission rates can be used. Actual emissions were used unless otherwise noted, and the specifics of emission rates used are detailed in the final boundary recommendation document and appendices.

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

1. Facility wide SO₂ 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 given.

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) database 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 SO₂ Modeling TAD. If variable emission rates are not available, annual reported emissions must be used. The air program will evaluate whether a reduced or variable load emission rate would be more accurate to represent actual conditions. If a source chooses to model using permanent and enforceable emission rates, this deviation was noted.

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.

Modeling performed for the purpose of siting monitors is also performed using actual emissions. However, the monitoring TAD details using normalized emission rates for all sources, and this method was used where 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 SO₂ 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. Sources affected by 40 CFR Part 75, Part 60, or other regulations that require CEMS, may also be required to record volumetric flow rates (submitted in units of measure at standard conditions) to the EPA’s database. These sources also record hourly stack temperature. The hourly recorded temperatures allow the standard condition flow rates to be converted to actual condition flow rates. Actual condition flow rates are 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. Certain facilities record exit velocity directly which bypasses the need for additional conversions or calculations. In that case, directly measured velocity was utilized in the modeling. However, as noted, most facilities only record and report flow in units of measure at standard conditions. To convert from standard to actual flow conditions the air program used 293 Kelvin (or 20 degrees Celsius) for standard temperature. This is referenced in Section 6 of Appendix F to 40 CFR Part 75⁷.

When gaps in hourly recorded data occur, the variable release parameter values were filled by averaging the surrounding hours’ measurements when nonzero emissions are reported. When emissions are zero, the release parameters may also be zero without consequence. These substitutions are performed in the calculation spreadsheet for each facility unless otherwise noted.

Using hourly varying parameters allows for the most accurate approximation of actual conditions, and was used where available. Otherwise, static release parameters were used. Any available release parameters were evaluated for use including: MoEIS reported values, stack testing values, and representative emission release parameters obtained through other trustworthy avenues. When necessary, the air program also considered variable or reduced load scenarios to ensure the most representative release parameters were 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 were verified and are included in appendices to the final boundary recommendation document. AERMOD and its preprocessors require all inputs to be in the metric system so parameters were converted to metric where necessary.

When specific stack data is unavailable, the release point was 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 were assigned, such as emergency generators, heaters, etc. The model input files included as appendices to the final recommendation document detail the specific parameters utilized.

⁷ 40 CFR Part 75 Appendix F. <https://www.gpo.gov/fdsys/pkg/CFR-2014-title40-vol17/pdf/CFR-2014-title40-vol17-part75-appF.pdf>

3.4 Model Domain & Receptor Grid

The modeling domain is centered on each affected source/area. This is to determine the interactive contribution from surrounding sources. Each modeling domain extends sufficiently far in an effort to define the impact from any source that may cause or contribute to a violation of the 1-hour SO₂ NAAQS. All NAAQS compliance determinations considered the maximum impact area and the addition of alternative domain configurations if necessary. The modeling domain was determined on a case-by-case basis in order to properly address interactive source impacts.

The air program developed the receptor grid for input into the air quality model. It is resolved enough to adequately identify the area of maximum impact from fugitive and point source releases and encompasses the full extent of possible modeled NAAQS violations. For each affected source/area, receptors are placed at 50-meter (m) intervals along the property/area boundary. From the domain origin, a multi-tier grid of varied receptor spacing was 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 were spaced as follows:

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

In certain cases, the receptor grid was extended to cover an entire geographic area, such as a full county or group of counties to aid in the setting of attainment area boundaries that are made up of easily identifiable jurisdictional boundaries. When the receptor grid varies from as outlined above, it is noted in the final recommendation document and appendices.

The receptor grid, like the domain, is centered on the affected source/area. If necessary, additional receptors were placed upon each area of maximum impact that is identified. These 'hot spot analyses' were performed when necessary to ensure maximum impacts were properly captured.

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 Where special instances arise they were reviewed on a case-by-case basis.

Actual emissions from SO₂ sources, located within 20 km (or up to 50 km) of an affected source/area, were used to determine inclusion in the model. A one (1) ton per year emissions threshold was the basis to determine if a source should be explicitly included in the modeling inventory. The data needed to execute the air quality analysis was obtained from MoEIS. Since the model domain extended beyond the state boundary in certain analyses, interactive source inventories were obtained from bordering states, and the data was incorporated into the air quality analysis as necessary.

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>

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.

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 used 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 was extracted to determine terrain influences within the modeling domain. All source, receptor, and terrain elevation data was 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 guide⁹ 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 executed AERSURFACE (version 13016) with the default values described below:

Bowen ratio

- 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

Albedo

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

Surface roughness length

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

Air program staff executed AERSURFACE using default options, including seasonal assignment intervals. Where onsite meteorological data are collected for the facility being modeled, no additional surface characteristics analysis is needed. For the modeled sources to be designated by December 2017, sufficient onsite data is not currently available. Therefore, the air program determined the most representative 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 executed AERSURFACE for each affected source/area for input into the excel template described above. The most representative surface and upper air reporting sites were then selected for each source/area (see Section 3.7 for selection details).

3.7 Meteorological Data

As laid out in the SO₂ 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 SO₂ standard.

Air program staff selected meteorological data based upon the spatial and temporal characteristics of each affected source/area. Ultimately, site selection considers 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. Most NWS meteorological datasets include 1-minute Automated Surface Observing System (ASOS) wind data. The 1-minute ASOS data is 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 was processed through AERMINUTE (v15272) prior to input into the AERMET processor. Where possible the air program used minute-level ASOS data.

It is important to note that the Bowen ratio characteristics applied in Stage 3 AERMET processing are 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. Each of the weather reporting stations in Missouri has a climatological comparison site in cases where the historical precipitation record is not available for the required full 30 year comparison. The comparison sites are noted in the AERSURFACE template along with the full precipitation record.

The map contained in Figure 3 visually depicts the regional choices available for surface and upper air reporting sites.

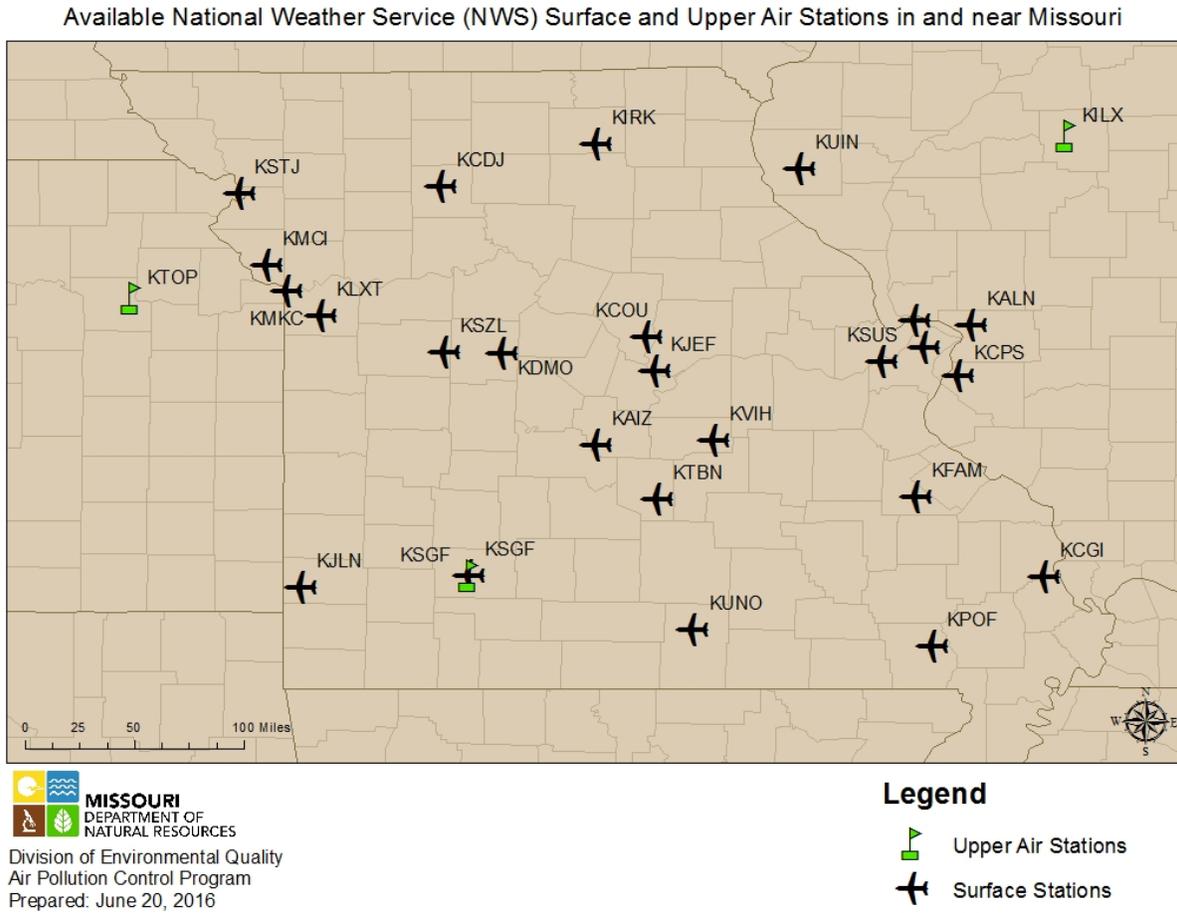


Figure 3. Surface and Upper Air Reporting Sites

The air program provides 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 performed the meteorological evaluation for each source/area and developed a recommendation memorandum for the chosen meteorological dataset. Excerpts of these memorandums are included in the respective appendices to the recommendation document and are available in full for review upon request.

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 determined 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 evaluated 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 is used. However, as outlined in the SO₂ modeling TAD, when modeling for designation purposes using actual emissions; actual stack height is used to allow the model to act as a surrogate for monitoring.

If GEP stack height was determined, air program staff referenced 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 are then incorporated into the model results. The following paragraphs outline the procedures that were 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 in the future 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 SO₂ 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 is discussed in the final boundary recommendation document and appendices 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.

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>

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 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 SO₂ 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 SO₂ 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 SO₂ NAAQS. A monitoring site near but outside the immediate area of source impact, that has SO₂ 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 SO₂ 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 SO₂ emissions. EPA's monitoring TAD 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 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 provides a list of receptor locations, ranked in general order of desirability with regard to potential siting of permanent source-oriented SO₂ monitors. Lower numerical scores indicate higher probability of capturing peak 1-hour SO₂ 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.