UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

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OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

MEMORANDUM

SUBJECT: Area Designations for the 2010 Revised Primary Sulfur Dioxide National Ambient Air Quality Standards

FROM: Stephen D. Page, Director
Office of Air Quality Planning and Standards

TO: Regional Air Division Directors, Regions I-X

This memorandum provides information on the schedule and process for designating areas for the purpose of implementing the 2010 revised primary sulfur dioxide (SO_2) national ambient air quality standard (NAAQS). In addition, it identifies factors EPA intends to evaluate in determining boundaries for areas designated nonattainment. We recommend that states and tribes consider and address these factors when identifying boundaries for their area designation recommendations. Please share this information with the state and tribal agencies in your Region.

On June 2, 2010, Administrator Jackson signed the revised primary SO_2 NAAQS (75 FR 35520, published on June 22, 2010) after review of the existing two primary SO_2 standards, promulgated on April 30, 1971 (36 FR 8187). EPA established the revised primary SO_2 standard at 75 parts per billion (ppb) which is attained when the 3-year average of the 99th percentile of 1-hour daily maximum concentrations does not exceed 75 ppb. The Administrator has determined that this is the level necessary to provide protection of public health with an adequate margin of safety, especially for children, the elderly and those with asthma. These groups are particularly susceptible to the health effects associated with breathing SO_2.

General approach and schedule. Clean Air Act (CAA) section 107(d) directs states to submit their SO_2 designation recommendations to EPA by June 3, 2011. If EPA intends to modify any state's boundary recommendation, EPA will notify the state no later than 120 days prior to its action to promulgate designations (i.e., February 2012 for designations to be promulgated in June 2012), and the state will have an opportunity to comment on EPA's intended modifications and provide additional information for EPA to consider. Section 107(d)

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requires EPA to promulgate initial area designations by June 3, 2012, which is 2 years after promulgation of the revised primary standard. While the language in section 107 specifically addresses states, we intend to follow the same process for tribes, pursuant to section 301(d) of the CAA and the Tribal Authority Rule (40 CFR Part 49). Therefore, we intend to designate tribal areas, in consultation with the tribes, on the same schedule as state designations. If a state or tribe does not submit designation recommendations, EPA will promulgate the designations that it deems appropriate.

Sections III through VI of the preamble to the final rule promulgating the revised primary SO_2 NAAQS describe the approach EPA anticipates using for designations for the 1-hour SO_2 standard. EPA anticipates taking an analytic approach that uses both air quality monitoring and modeling information for designations. Such an approach, if adopted, would be consistent with EPA's historic practices for SO_2 NAAQS implementation. In that preamble we acknowledged that in some cases, monitoring data may be the more technically appropriate information for determining compliance with the 1-hour NAAQS. (See e.g., 75 FR at 35552, n. 22). We also recognized that a single monitor may generally not be adequate to fully characterize ambient concentrations of SO_2, including the maximum ground level concentrations that exist around stationary SO_2 sources, particularly when measuring for a 1-hour standard. (See 75 FR at 35551). Refined dispersion models are able to characterize SO_2 air quality impacts from the modeled sources across the domain of interest on an hourly basis with a high degree of spatial resolution, thus overcoming the limitations of an approach based solely on monitoring.

Attachment 2 summarizes three possible designations and the criteria for initial designations of the 1-hour SO_2 primary standard that EPA expects to apply. As stated in the preamble, we do not believe it would be realistic or appropriate to expect states to complete modeling for all significant sources of SO_2 and assess the results in time for the designation recommendations the Act requires be submitted to EPA by June 3, 2011. (See 75 FR at 35570-71). Therefore, we do not generally expect states to provide refined dispersion modeling information along with their initial designation recommendations. However, EPA does intend to consider, as appropriate, available air quality monitoring and modeling information submitted by states or tribes in support of their recommendations.

States and tribes should identify areas as attainment, nonattainment or unclassifiable on the basis of available information. Given the currently limited network of SO_2 monitors, and our expectation that states will not yet have completed appropriate modeling of all significant SO_2 sources, we anticipate that most areas of the country will be designated "unclassifiable." If a state or tribe, following receipt of an EPA 120-day letter, has additional information that it wants EPA to consider with respect to a designation recommendation that EPA plans to modify, we request that such information be submitted within 60 days after receiving EPA's letter. This will help ensure that EPA can fully consider any such information prior to issuing final designations.

Also, although not required by statute, in order to consider public input in the designation process, we plan to provide a 30-day public comment period immediately following issuance of EPA's letters responding to the recommendations made by states and tribes. Attachment 1 is this anticipated schedule.

The preamble to the final NAAQS rulemaking includes a general discussion of states' statutory planning and emissions control responsibilities under each of the three possible designations. The CAA directs states with areas designated as "nonattainment" for SO_2 to develop and submit a plan within 18 months after designation providing for attainment as expeditiously as practicable, but no later than 5 years after the initial designation date. (See CAA sections 191-193). The CAA also directs states to submit by June 3, 2013, a SIP demonstrating an adequate program to implement, maintain and enforce the SO_2 NAAQS. Generally, these infrastructure plans for attainment areas are not expected to include an attainment demonstration. However, in light of the incomplete monitoring and modeling data available at the time of designations, for areas designated unclassifiable, we would expect states to include in these plans demonstrations of expeditious attainment and maintenance of the SO_2 NAAQS. EPA is developing separate guidance on developing SIP revisions for the SO_2 standard and we intend to seek public review and comment on that guidance document.

Identifying an area that is in violation of the SO_2 NAAQS. Section 107(d)(1) of the CAA defines an area as "nonattainment" if it is violating the NAAQS or if it is contributing to a violation in a nearby area. Thus, the first step in making designations is to identify through monitoring or appropriate modeling areas violating the NAAQS. In assessing whether monitoring data indicate a violation, EPA intends to use the most recent three consecutive years of quality-assured, certified air quality data in the EPA Air Quality System (AQS),[1] using data from Federal Reference Method (FRM) and Federal Equivalent Method (FEM) monitors that are sited and operated in accordance with 40 CFR Parts 50 and 58. Procedures for using monitored air quality data to determine whether a violation has occurred are given in 40 CFR Part 50 Appendix T, as revised in conjunction with the final rule for the 2010 SO_2 NAAQS. We expect that in providing their recommendations to EPA, states and tribes would review available SO_2 monitoring data from 2008 through 2010. Prior to EPA issuing letters to states and tribes concerning any intended modifications to their recommendations, data from 2011 may become available. If this is the case, EPA intends to also consider 2011 SO_2 air quality monitoring data in formulating any intended modifications to state and tribal recommendations.

Air quality monitoring data affected by exceptional events may be excluded from use in identifying a violation if they meet the criteria for exclusion, as specified in the final rule

[1] This information is available on EPA's website at www.epa.gov/ttn/airs/airsaqs/.

'Treatment of Data Influenced by Exceptional Events" (72 FR 13560; March 22, 2007) codified in 40 CFR Parts 50 and 51. In section VII.B of the SO_2 NAAQS final rule preamble, we discussed schedules for states and tribes to flag data influenced by exceptional events and submit related documentation specifically for SO_2 data collected from 2008 through 2010 used in the initial designations process. These schedules are contained in Table 1 of 40 CFR 50.14 and require initial data flagging by October 1, 2010 and detailed documentation submittal by June 1, 2011. This should assure that any exceptional events claim asserted by a state or tribe can be fully considered by EPA before final designations.

States and tribes may also choose to use available air quality modeling results to indicate a violation of the NAAQS. Attachment 3 provides further guidance on the appropriate refined dispersion modeling analysis that could be used to support designation recommendations. Such modeling could include using the AERMOD dispersion model, with allowable source emissions and emissions limitation credit for stacks no higher than good engineering practice. As noted above (and in the preamble to the final SO_2 primary NAAQS rulemaking), we recognize that it is not realistic to expect states or tribes to complete this type of modeling for all significant sources of SO_2 in the time available for providing designation recommendations. Where the time and resources to conduct refined dispersion modeling are limited, we believe it is reasonable to focus first on the most significant sources of SO_2 emissions, and on those sources that are most likely to contribute to a violation. We recognize that this approach means that all areas where SO_2 NAAQS violations may be occurring might not be identified in the initial round of area designations. States are expected to address any such areas in the course of developing the SIPs due by June 3, 2013.

Identifying attainment areas. EPA may initially designate an area as attainment if it is clear that it meets the SO_2 NAAQS. EPA does not believe it would be appropriate to do so without appropriate refined dispersion modeling and, where available, air quality monitoring data indicating no violations of the NAAQS. In the absence of information clearly demonstrating a designation of "attainment" or "nonattainment," EPA intends to designate the area as "unclassifiable."

Determining nonattainment area boundaries. As a pollutant that arises from direct emissions, SO_2 concentrations are highest relatively close to the source(s) and much lower at greater distances due to dispersion. Thus, SO_2 concentration patterns resemble those of other directly emitted pollutants like lead and differ from those of photochemically-formed (secondary) pollutants such as ozone. Accordingly, consistent with our approach under other NAAQS, we expect to consider the county line as the starting point for determining SO_2 nonattainment areas. As discussed further in Attachment 2, EPA intends to consider several factors when determining the final nonattainment boundaries. We believe it is appropriate to evaluate each potential nonattainment area on a case-by-case basis, and to recognize that area-

specific analyses conducted by states, tribes and/or EPA may support a boundary with either a larger or smaller area than the county boundary.

A nonattainment area should contain the area violating the NAAQS (e.g., the area around a violating monitor), as well as any adjacent areas (e.g., counties or portions thereof) that contain emissions sources contributing to the violation. (See CAA section 107(d)(1)(A)(i)). Consequently, we recommend that states and tribes base their boundary recommendations on an evaluation of five factors: 1) air quality data; 2) emissions-related data; 3) meteorology; 4) geography/topography and 5) jurisdictional boundaries, as well as other available data. Dispersion modeling, as discussed in Attachment 3, can be a helpful tool in this evaluation because it allows the model user to simultaneously assess multiple factors. States and tribes may identify and evaluate other relevant factors or circumstances specific to a particular area.

While EPA generally believes that in the absence of other relevant information it is appropriate to use county boundaries to define nonattainment areas, we recognize that the five-factor analysis and other information may support designating only a portion of a county as "nonattainment." For example, a topographical feature may divide a county into two separate air basins, or contributing sources may be clustered in only a portion of a county. For defining partial county boundaries, EPA recommends the use of well-defined jurisdictional lines such as township borders, immovable landmarks such as major roadways or other permanent and readily identifiable boundaries.

Determining attainment area boundaries. In areas without a violating monitor, refined dispersion modeling could be used to help determine that an area with SO_2 sources is in attainment for the 1-hour SO_2 NAAQS. An attainment area boundary cannot contain any area that exceeds the NAAQS or any area containing sources that are causing or contributing to a violating area. (See CAA section 107(d)(1)(A)(i)). County boundaries may be appropriate for defining attainment areas in the absence of other information that would help define a more specific boundary around the modeled source(s).

While we believe this memorandum provides helpful guidance on how boundaries would be determined for SO_2 designations, the guidance contained herein is not binding on states, tribes the public or EPA. The final basis for determining nonattainment area boundaries will be addressed in EPA's action to initially designate areas under the 2010 SO_2 standard. When EPA promulgates designations, those determinations will be final and binding on states, tribes, the public and EPA.

Attachment 1 is a timeline of key dates in the designations process for the revised 2010 SO_2 NAAQS. Attachment 2 identifies the primary five factors that EPA plans to consider in evaluating and making decisions on nonattainment area boundaries. Attachment 3 is the modeling guidance that states and tribes should use to support designation recommendations,

including appropriate area boundaries.

Staff members at EPA's Office of Air Quality Planning and Standards are available for assistance and consultation throughout the designations process. General questions on this guidance may be directed to Valerie Broadwell (919) 541-3310 or Doug Solomon (919) 541-4132. Modeling-related questions may be directed to James Thurman (919) 541-2703.

Attachments: 3

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ATTACHMENT 1

TIMELINE FOR 2010 Primary SO_2 NAAQS DESIGNATION PROCESS	
Milestone	**Date***
EPA promulgates SO_2 NAAQS	June 3, 2010
States and tribes flag exceptional event-influenced SO_2 monitoring data from 2008-2009	October 1, 2010
States and tribes flag exceptional event-influenced SO_2 monitoring data from 2010; provide detailed documentation to support all 2008-2010 claims	No later than June 1, 2011
States and tribes submit recommendations for area designations to EPA	No later than June 3, 2011
EPA notifies states and tribes concerning any intended modifications to their recommendations (120-day letters)	o/a February 3, 2012 (no later than 120 days prior to final designations)
EPA publishes public notice of state and tribal recommendations and EPA's intended modifications and initiates 30-day public comment period	o/a February 20, 2012
End of 30-day public comment period	o/a March 20, 2012
States and tribes submit additional information to demonstrate why an EPA modification is inappropriate	o/a April 3, 2012
EPA promulgates final SO_2 area designations	No later than June 3, 2012

* o/a = on or about

Note: This schedule assumes EPA has sufficient information to promulgate designations within 2 years. In the event EPA determines that insufficient information is available to do so, the Clean Air Act allows EPA to extend the designation process, but no later than June 3, 2013.

ATTACHMENT 2

Determining Designations and Appropriate Area Boundaries for the 1-hour, 75 ppb SO_2 NAAQS

Nonattainment	*Attainment*	*Unclassifiable* (all other areas)
An area where monitoring data or an appropriate modeling analysis indicate a violation.	An area that has no monitored violations and which has an appropriate modeling analysis, if needed, and any other relevant information demonstrating no violations.	An area that has no monitored violations and lacks an appropriate modeling analysis, if needed, or other appropriate information sufficient to support an alternate designation.

Attainment area boundaries. Areas designated as "attainment" should be supported by information clearly demonstrating that there are no violations of the SO_2 NAAQS inside the area boundary. This could consist of appropriate air quality dispersion modeling and, where available, air quality monitoring data. As provided in Attachment 3, appropriate modeling would include using the AERMOD dispersion model, with allowable source emissions and emissions limitation credit for stacks no higher than good engineering practice. County boundaries may be appropriate for defining attainment areas in the absence of other information that would help define a more specific boundary around the modeled source(s). In the absence of information clearly demonstrating a designation of "attainment" or "nonattainment," EPA intends to designate the area as "unclassifiable."

Nonattainment area boundaries. EPA intends to use the county as the analytical starting point for assessing the appropriate geographic boundaries of a SO_2 nonattainment area. As a framework for area-specific analyses to support final boundary determinations, we intend to evaluate the five factors listed below, as well as other relevant available information. The purpose of evaluating these factors is to determine the appropriate boundaries encompassing the area meeting the CAA's definition of "nonattainment area" i.e., an area violating the SO_2 standard and any nearby areas contributing to the violating area. The modeling guidance in Attachment 3 discusses how modeling could be used to address several of these factors simultaneously. When considered as a whole, results may support nonattainment boundaries that are either larger or smaller than the analytical starting point.

1. **Air quality data.** We intend to review SO_2 air quality monitoring data, including the design value calculated for each monitor in the area, for the most recent 3-year period. Areas where monitoring data indicate a violation of the 1-hour, 75 ppb primary SO_2 standard will be designated as "nonattainment." Source-oriented modeling may also be used to assess air quality in a particular location. Attachment 3 provides further guidance on using refined dispersion modeling for this type of assessment.

2. **Emissions-related data** (location of sources and potential contribution to ambient SO_2 concentrations). We intend to examine allowable emissions of SO_2 from sources located in

and around the violating area. Significant emissions levels in a nearby area indicate the potential for the area to contribute to observed or modeled violations of the NAAQS. We intend to review data from the latest National Emissions Inventory or other relevant sources of the data, such as state inventories or inventories from other federal sources. We would also consider any additional information we receive on federally-enforceable emissions controls that are not reflected in recent inventories but which will require compliance before final designations are issued.

3. **Meteorology** (weather/transport patterns). We intend to evaluate meteorological data to help determine how weather conditions, including wind speed and direction, affect the plume of sources contributing to ambient SO_2 concentrations. Where feasible, we would consider results from source-oriented dispersion modeling.

4. **Geography/topography** (mountain ranges or other air basin boundaries). We intend to examine the physical features of the land that might affect the distribution of SO_2 over an area. Mountains or other physical features may affect the distribution of emissions, and may help define boundaries.

5. **Jurisdictional boundaries** (e.g., counties, air districts, pre-existing nonattainment areas, reservations, metropolitan planning organizations). Once the geographic area associated with the area violating the SO_2 standard and the nearby area contributing to violations are determined, we intend to consider existing jurisdictional boundaries for the purposes of providing a clearly defined legal boundary for carrying out the air quality planning and enforcement functions for the nonattainment area. If an existing jurisdictional boundary is used to help define the nonattainment area, it should encompass all of the area that has been identified as meeting the nonattainment definition. Where existing jurisdictional boundaries are not adequate to describe the nonattainment area, other clearly defined and permanent landmarks or geographic coordinates may be used.

EPA plans to consider these factors, along with any other relevant information, in determining whether to make modifications to the boundary recommendations made by states and tribes. The factors listed above, while generally comprehensive, are not intended to be exhaustive. States and tribes may submit additional information they believe is relevant for EPA to consider. Any information provided to support a boundary recommendation for a nonattainment area should show that: 1) violations are not occurring in nearby portions that are excluded from the recommended nonattainment area; and 2) the excluded portions do not contain emission sources that contribute to the monitored or modeled violation.

ATTACHMENT 3

Modeling Guidance for SO_2 NAAQS Designations

1. Purpose

On June 2, 2010, Administrator Jackson signed a final rulemaking notice that revised the primary SO_2 NAAQS (75 FR 35520, published on June 22, 2010) after review of the existing two primary SO_2 standards, promulgated on April 30, 1971 (36 FR 8187).[1] EPA established the revised primary SO_2 standard at 75 parts per billion (ppb) which is attained when the 3-year average of the 99th percentile of 1-hour daily maximum concentrations does not exceed 75 ppb. In the final rule preamble, EPA outlined an expected analytic approach to determining compliance with the new NAAQS that would include the use of both modeling and monitoring. EPA believes this analytic approach to determining compliance with the new 1-hour NAAQS would be the generally more technically appropriate and accurate means of assessing peak 1-hour SO_2 concentrations, and would be consistent with historic (past and more recent) implementation practice of using models to determine compliance with the SO_2 NAAQS.

While this guidance explains the use of modeling for NAAQS designations, it does not preclude the fact that monitoring data may be more technically appropriate than modeling in some cases. In cases where there is complete air quality data from FRM or FEM SO2 monitors, that data would be considered by EPA in designating areas as attainment or nonattainment. (See 75 FR at 35570). The guidance presented here is for cases where modeling is used in support of the designations process.

Dispersion modeling could be used in these initial designations to a limited degree (as could monitoring) but would likely be used to a larger extent subsequently as the basis for re-designation of nonattainment and unclassifiable areas to attainment. As the preamble to the rule promulgating the new 1-hour SO_2 NAAQS noted, EPA does not think it realistic or appropriate to expect states to complete modeling for all significant sources of SO_2 and assess the results in time for the designation recommendations the Act requires be submitted by June 2011. (See 75 FR at 35570-71). Therefore, we do not generally expect states to provide modeling information along with their initial designation recommendations. However, EPA does intend to consider, as appropriate, available monitoring data and modeling information submitted by states or tribes in support of their recommendations.

This guidance explains the expected application of dispersion models to support the designations process regarding:

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[1] EPA publicly disseminated a copy of the signed notice on June 3, 2010, and therefore treats June 2, 2010, as the date of the rule's promulgation, for purposes of the deadlines in CAA section 107(d).

1. the use of modeling to inform the nonattainment boundaries for areas with violating ambient air quality monitors if the presumptive county boundaries are not used (either to expand the boundaries outside the county or shrink the boundary within the county); and
2. The use of modeling in areas without a violating monitor as evidence of attainment of the NAAQS (showing no violations or contributions to violations of the standard).

This guidance is consistent with EPA's *Guideline on Air Quality Models*, or Appendix W to 40 CFR Part 51, and other relevant modeling guidance issued to support regulatory programs. When the need for interpretation of this guidance arises, the user should consult with the appropriate Regional Modeling Contact[2].

Also as indicated in the preamble of the 1-hour SO_2 NAAQS final rule, we intend to issue additional guidance describing the development of an approvable 110(a)(1) implementation plans for areas designated "unclassifiable" that will include technical direction on how to conduct refined dispersion modeling to demonstrate future NAAQS attainment.

2. Guidance on Air Quality Models

Much of this guidance is based on EPA's *Guideline on Air Quality Models*, also published as Appendix W of 40 CFR Part 51. Appendix W is the primary source of information on the regulatory application of air quality models for State Implementation Plan (SIP) revisions for existing sources and for New Source Review (NSR) and Prevention of Significant Deterioration (PSD) programs. Air quality modeling in support of this designations process would need to employ air quality dispersion models[3] that properly address the source-oriented nature of SO_2 and, thus, should rely upon the principles and techniques in Appendix W.

Appendix W was originally published in April 1978 and was incorporated by reference in the regulations for the Prevention of Significant Deterioration of Air Quality, Title 40, Code of Federal Regulations (CFR) sections 51.166 and 52.21 in June 1978 (43 FR 26382-26388). The purpose of Appendix W guidelines is to promote consistency in the use of modeling within the air quality management process. These guidelines are periodically revised to ensure that new model developments or expanded regulatory requirements are incorporated.

Clarifications and interpretations of modeling procedures become official EPA guidance through several courses of action: 1) the procedures are published as regulations or guidelines; 2)

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[2] List of Regional Modeling Contacts by EPA Regional Office is available from SCRAM website at: http://www.epa.gov/ttn/scram/guidance_cont_regions.htm

[3] Dispersion modeling uses mathematical formulations to characterize the atmospheric processes that disperse a pollutant emitted by a source. Based on emissions and meteorological inputs, a dispersion model can be used to predict concentrations at selected downwind receptor locations.

the procedures are formally transmitted as guidance to Regional Office managers; 3) the procedures are formally transmitted as guidance to Regional Modeling Contacts as a result of a Regional consensus on technical issues; or 4) the procedures are a result of decisions by the EPA's Model Clearinghouse that effectively establish national precedent. Formally located in the Air Quality Modeling Group (AQMG) of EPA's Office of Air Quality Planning and Standards (OAQPS), the Model Clearinghouse is the single EPA focal point for the review of criteria pollutant modeling techniques for specific regulatory applications. Model Clearinghouse and related Clarification memoranda involving decisions with respect to interpretation of modeling guidance are available at the Support Center for Regulatory Atmospheric Modeling (SCRAM) website.[4]

Recently issued EPA guidance of relevance for consideration in modeling for designations includes:

- "Applicability of Appendix W Modeling Guidance for the 1-hour SO_2 NAAQS" August 23, 2010—confirming that Appendix W guidance is applicable for NSR/PSD permit modeling for the new SO_2 NAAQS.
- "Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard" March 1, 2011– provides additional guidance regarding NO_2 permit modeling and also relevant to SO_2.

The following sections will provide reference to the relevant sections of Appendix W and other existing guidance with summaries as necessary. Please refer to those original guidance documents for full discussion and consult with the appropriate EPA Regional Modeling Contact if questions arise about interpretation on modeling techniques and procedures.

3. Model selection

Preferred air quality models for use in regulatory applications are addressed in Appendix A of EPA's GUIDELINE ON AIR QUALITY MODELS. If a model is to be used for a particular application, the user should follow the guidance on the preferred model for that application. These models may be used without an area specific formal demonstration of applicability as long as they are used as indicated in each model summary of Appendix A. Further recommendations for the application of these models to specific source problems are found in subsequent sections of Appendix W. In 2005, the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) was promulgated as EPA's preferred near-field dispersion modeling for a wide range of regulatory applications in all types of terrain based on extensive developmental and performance evaluation.

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[4] The Support Center for Regulatory Atmospheric Modeling (SCRAM) website is available at: http://www.epa.gov/ttn/scram/.

For area designations under the 1-hour SO_2 primary NAAQS, AERMOD should be used unless use of an alternative model can be justified (Section 3.2, Appendix W), such as the Buoyant Line and Point Source Dispersion Model (BLP). As outlined in the August 23, 2010 clarification memo "Applicability of Appendix W Modeling Guidance for the 1-hour SO_2 National Ambient Air Quality Standard", AERMOD is the preferred model for single source modeling to address the 1-hour SO_2 NAAQS as part of the NSR/PSD permit programs. AERMOD is appropriate to inform this designations process because SO_2 concentrations result from direct emissions from combustion sources so that concentrations are highest relatively close to sources and are much lower at greater distances due to dispersion. Given the source-oriented nature of this pollutant (See, e.g., 75 FR at 35570), dispersion models are the most appropriate air quality modeling tools to predict the near-field concentrations of this pollutant.

The AERMOD modeling system includes several components. The regulatory components are:

- AERMOD: the dispersion model (U.S. EPA, 2004a)
- AERMAP: the terrain processor for AERMOD (U.S. EPA, 2004b)
- AERMET: the meteorological data processor for AERMOD (U.S. EPA, 2004c)
- BPIPPRIME: the building input processor (U.S. EPA, 2004d)

and non-regulatory components are:

- AERSURFACE: the surface characteristics processor for AERMET (U.S. EPA, 2008)
- AERSCREEN: a recently released screening version of AERMOD (U.S. EPA, 2011b)

Before running AERMOD, the user should become familiar with the user's guides associated with the modeling components listed above and the AERMOD Implementation Guide (AIG) (U.S. EPA, 2009). The AIG lists several recommendations for applications of AERMOD which would be applicable for designations modeling.

4. Modeling domain

Selection of the modeling domain is important in terms of how many sources to explicitly model and what kind of receptor network to create. Two questions may arise in model domain selection:

1. Where to center the modeling domain?, and
2. How large should the modeling domain be? (i.e., in terms of the number of sources to model and size of the receptor network in order to account for the areas of impact).

If the modeling is being performed to inform the nonattainment boundary around a violating monitor, the domain should be centered on the violating monitor. If the modeling is being done to show compliance with the NAAQS in the absence of a violating monitor, the domain should be centered on the dominant source in an area, that is, the source or sources expected to contribute the most to SO_2 air quality levels. In both cases, the domain should then extend to include nearby sources that are thought to cause or contribute to a potential NAAQS violation, as explained further below in Section 4.1.

The determination of sources to include in modeling is a multi-step process. If modeling is being performed for a violating monitor, the first basic step would be to gather information and analyze the emission sources within 50 km of the monitor, which is the nominal distance at which EPA considers most steady-state Gaussian plume models are applicable. In some cases where large SO_2 sources are scattered outside of the 50 km radius, it may be necessary to extend the modeling domain beyond 50 km or conduct multiple AERMOD modeling exercises with the overall region broken down to several AERMOD runs covering different areas of the potential nonattainment area. For these situations, consultation with the appropriate EPA Regional Modeling Contact is recommended.

4.1 Determining sources to model

As stated above, the determination of sources to explicitly model is a multi-step process:

1. The spatial distribution of all sources within 50 km of the violating monitor or dominant source should be analyzed and initially assumed to be included in refined dispersion modeling. For the purposes of designations it is reasonable to initially focus on the most significant sources of SO_2 emissions, e.g., sources emitting greater than 100 tons per year. Please note, however, that sources less than 100 tons can be potential contributors to a NAAQS violation, especially sources with short stacks and/or located in complex terrain (i.e., where receptor elevation is above stack height).
2. Sources should be examined and attempts made to determine if any sources can be accounted for without explicitly modeling them, i.e., use of monitored background concentrations. Accounting for such sources through the use of a background monitor will depend upon how well that monitor reflects impacts from those sources.
3. Sources found not to be representative by monitored background should also be examined through the use of screening models to see if they should or should not be included in the refined modeling. We recommend the use of EPA's new screening model AERSCREEN (U.S. EPA, 2011b) and following recommendations based on pre-existing screening guidance (U.S. EPA, 1992). For small isolated sources, screening may be useful on a source by source basis. However, for a cluster of small sources, their cumulative impact should also be assessed. Individual sources may not be significant by themselves, but together they could cause a NAAQS violation or significantly contribute to a NAAQS violation. Although AERSCREEN does not output a design value

concentration based on the 99th percentile form of the 1-hour SO_2 standard, it does output the overall maximum 1-hour concentration which could be used as a conservative estimate for comparison with the NAAQS and EPA's suggested interim significant impact level (SIL) for the 1-hour SO_2 NAAQS of 3 ppb[5]. If the maximum 1-hour concentration output from AERSCREEN violates the NAAQS, it does not mean that the source is in nonattainment, but that the source should be evaluated using refined dispersion modeling (See Step 3 below for more details).

Figure 1 shows a hypothetical monitor with circles of 50 km and 10 km radii centered over it. Based on this figure, an example application of these three steps is described below.

Step 1: Figure 1 shows facility emissions ranging from less than one ton to over 100 tons per year within 50 km of the violating monitor. Most of the smaller facilities (less than ten tons) are located north of the violating monitor. There are two 100+ ton emitters near the monitor and two 100+ ton emitters west-southwest of the monitor. At this point, it could be initially assumed that all facilities should be included in refined modeling.

Step 2: Determine whether any source or sources can be accounted for by a representative background monitor. In Figure 1, there are two other monitors in the area, one north and one south of the violating monitor. The northernmost monitor may be representative of the facilities north (white and yellow dots) of the violating monitor and the southern monitor may be representative of the sources southeast (white and blue dots) of the violating monitor. Background concentrations should be calculated following the guidance in Section 7 below.

Step 3: Screening modeling may be used to determine additional sources or combinations of sources to be excluded from refined modeling, especially smaller sources whose impacts may be largely dependent on their stack parameters (height, exit velocity, etc.). AERSCREEN could be used to eliminate such sources through screening modeling. AERSCREEN does not output an SO_2 design value but does output the overall maximum 1-hour concentration for an individual stack. If a facility contains more than one emission point or stack, each stack should be processed in AERSCREEN and the maximum 1-hour concentrations can be added together to represent impacts from the whole facility after running AERSCREEN. While AERSCREEN can be used with the surface characteristics of the source being screened, given the documented sensitivity of AERMOD to surface characteristics (Brode et al., 2008), it may be useful to also model the source in AERSCREEN using the surface characteristics of the meteorological site being used in the refined modeling as well, to ensure that the source is below de minimis impact levels with either set of surface characteristics.

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[5] The 3 ppb interim SIL for new 1-hour SO2 NAAQS was provided by EPA for states to consider using for PSD program in the August 23, 2010 memorandum "Guidance Concerning the Implementation of the 1-hour SO2 NAAQS for the Prevention of Significant Deterioration Program"

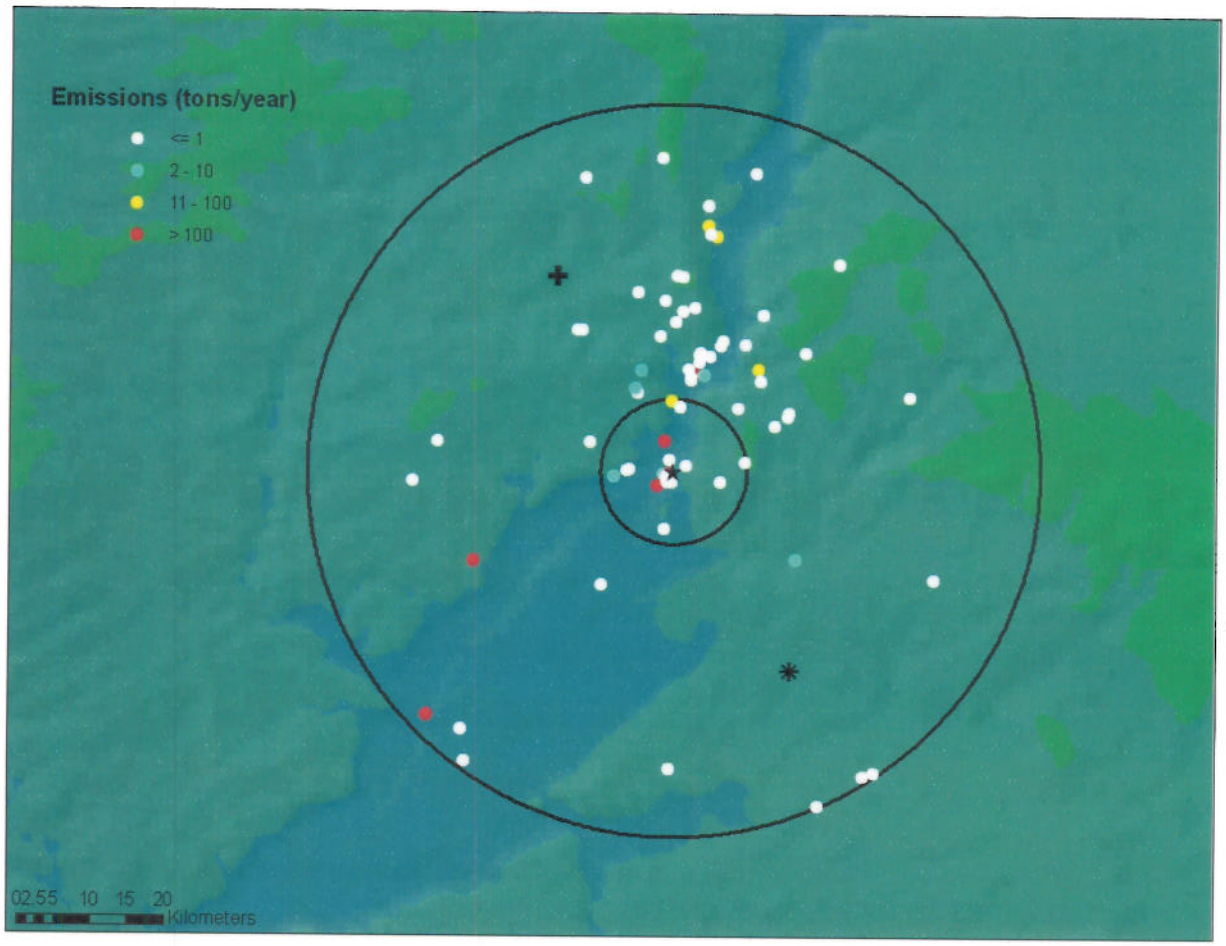

FIGURE 1. HYPOTHETICAL EXAMPLE OF VIOLATING MONITOR (STAR) WITH EMISSIONS (CIRCLES) WITHIN 50 KM (LARGE CIRCLE) AND 10 KM (INNER CIRCLE). NOTE: OTHER MONITORS ARE SHOWN BY PLUS SIGN AND ASTERISKS, WHILE SHADED CONTOURS REPRESENT TERRAIN.

When analyzing AERSCREEN output, the following general criteria could be followed:

- If the facility's maximum 1-hour concentration exceeds 75 ppb, then the source should be included in refined dispersion modeling.
- If the facility's maximum 1-hour concentration is below 75 ppb but above the suggested interim 1-hour significant impact level of 3 ppb or the state's 1-hour SIL, it should be included in the refined modeling.
- If the facility's maximum 1-hour concentration is below the suggested interim 1-hour significant impact level or the state's 1-hour SIL, that source may not have to be

included in refined modeling. However, the facility should not be excluded on the sole basis of being below the SIL without first looking at surrounding sources and their maximum 1-hour concentrations. The case may arise when there are several small sources that singularly are below the SIL but their cumulative impact may lead to concentrations that contribute to violations of the NAAQS.

In summary for the example in Figure 1, the smaller sources below 1 ton of emissions to the north of the monitor may be best represented with the use of background monitor concentrations. Other sources between 1 and 10 tons that are not represented by background monitors could be excluded based on screening results, depending on their stack parameters and terrain. The smaller sources (less than 1 ton) within 10 km of the monitor location may also screen out. The 100+ ton sources near the edge of the 50 km domain should be included in refined modeling. The largest emitters very close to the sources should be included in refined modeling as they are likely contributing to potential NAAQS violations and are not reflected in background monitors.

This is just one example of how to determine the modeling domain and sources to model. In some cases, an analysis out to 50 km may not be needed. Please consult with the appropriate EPA Regional Office modeler if there is uncertainty in deciding which sources to explicitly model, which sources to represent based on background monitoring, and/or which to exclude from refined modeling using screening modeling.

4.2 Receptor grid

The model receptor grid is unique to the particular situation and depends on the size of the modeling domain, the number of modeled sources, and complexity of the terrain. Receptors should be placed in areas that are considered ambient air (i.e., where the public generally has access) and placed out to a distance such that areas of violation can be detected from the model output to help determine the size of nonattainment areas. Receptor placement should be of sufficient density to provide resolution needed to detect significant gradients in the concentrations with receptors placed closer together near the source to detect local gradients and placed farther apart away from the source. In addition, the user should place receptors at key locations such as around facility fence lines (which define the ambient air boundary for a particular source) or monitor locations (for comparison to monitored concentrations for model evaluation purposes). The receptor network should cover the modeling domain. An example receptor grid for a single source is shown in Figure 2a with an example grid with multiple sources shown in Figure 2b. In Figure 2a, receptors are located every 50 m within one kilometer of the source and then every 100 m from one to two kilometers. From two to 10 km, the receptor spacing is 250 m and every 500 m outside of 10 km of the source. The modeling domain is centered on an isolated facility and extends out to 10 km in the east-west and north-south direction. Figure 2b shows an example grid for a multi-source area. Two sources are modeled with a fine grid of receptors 1 km (50 m spacing) around each source embedded within a 10x10

km grid (250 m spacing). The 10x10 km grid is then embedded within a 20x20 km grid with coarser spacing (500 m).

If modeling indicates elevated levels of SO_2 (near the standard) near the edge of the receptor grid, consideration of expanding the grid or conducting an additional modeling run centered on the area of concern should be investigated. As noted above, terrain complexity should also be considered when setting up the receptor grid. If complex terrain is included in the model calculations, AERMOD requires that receptor elevations be included in the model inputs. In those cases, the AERMAP terrain processor (U.S. EPA, 2004b) should be used to generate the receptor elevations and hill heights. The latest version of AERMAP (09040) can process either Digitized Elevation Model (DEM) or National Elevation Data (NED) data files. The AIG recommends the use of NED data since it is more up to date than DEM data, which is no longer updated (Section 4.3 of the AIG).

5. Source inputs

This section provides guidance on source characterization to develop appropriate inputs for dispersion modeling with the AERMOD modeling system. Section 5.1 provides guidance on use of allowable vs. actual emission levels, Section 5.2 covers guidance on Good Engineering Practice (GEP) stack heights, Section 5.3 provides details on source configuration and source types, Section 5.4 provides details on urban/rural determination of the sources, and Section 5.5 provides general guidance on source grouping, which may be important for design value calculations.

5.1 Allowable vs. Actual emissions

Consistent with past SO_2 modeling guidance (Section 4.5.2 of U.S. EPA (1994)) and regulatory modeling for other programs (Appendix W, Section 8.1), dispersion modeling for the purposes of designations should be based on the use of maximum allowable emissions or federally enforceable permit limits. Also consistent with past and current guidance, in the absence of allowable emissions or federally enforceable permit limits, potential to emit emissions (i.e., design capacity) should be used. Because of the short-term nature of the new SO_2 NAAQS, the maximum short term or hourly emission rate should be input into AERMOD for each modeled hour. As stated in the August 23, 2010 memo,

> "Since short-term SO_2 standards ($\leq$ 24 hours) have been in existence for decades, existing SO_2 emission inventories used to support modeling for compliance with the 3-hour and 24-hour SO_2 standards should serve as a useful starting point, and may be adequate in many cases for use in assessing compliance with the new 1-hour SO_2 standard since issues identified in Table 8-2 of Appendix W related to short-term vs. long-term emission estimates may have already been addressed."

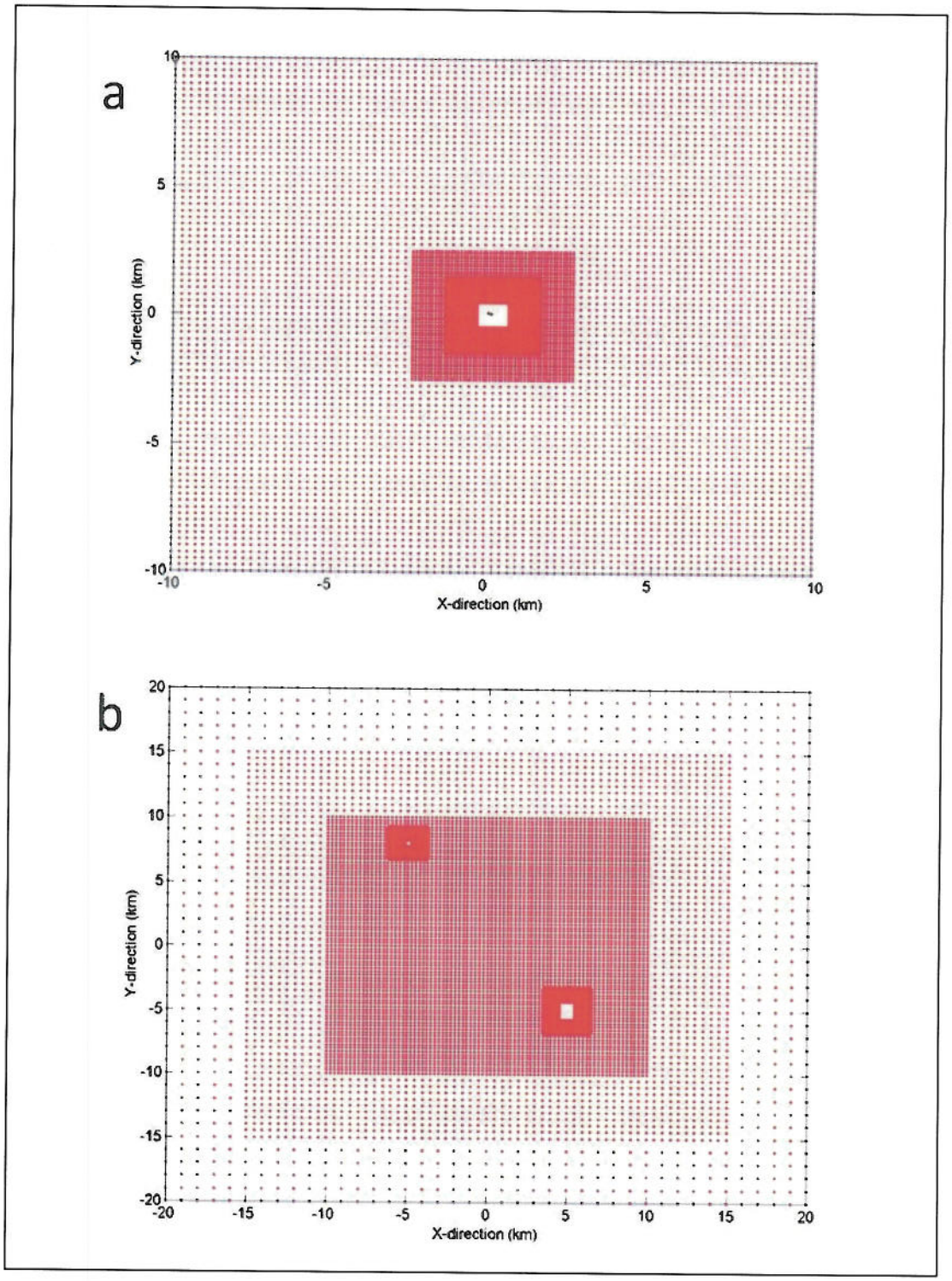

FIGURE 2. EXAMPLE RECEPTOR GRIDS WITH (A) A GRID CENTERED ON AN ISOLATED SOURCE WITH FENCELINE RECEPTORS SHOWN IN BLUE AND THE EMISSION POINTS SHOWN IN BLACK, AND (B) A GRID WITH MULTIPLE SOURCES.

The existing SO_2 inventories used for permitting or SIP demonstrations should contain the necessary emissions information for designations-related modeling. If short-term emissions are not readily available, they may be calculated using the methodology shown in Table 8-2 of Appendix W. For an example calculation of short term emissions, see the June 28, 2010 memorandum "Applicability of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard." Although the example is for NO_2, the calculation methodology would be the same for SO_2.

Regarding the use of allowable emissions and modeling of intermittent emissions sources, from such sources as emergency generators and startup/shutdown emissions, the inclusion of such emissions for the purpose of modeling for SO_2 designations should follow the recommendations in the March 1, 2011 memo "Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard." As stated in this memo, EPA believes the most appropriate data to use for compliance demonstrations for the 1-hour NO_2 NAAQS are those based on emissions scenarios that are continuous enough or frequent enough to contribute significantly to the annual distribution of maximum daily 1-hour concentrations. Although the referenced guidance in this memo is for NO_2 permit modeling, the common 1 hour averaging time and form of both the NO_2 and SO_2 standards makes this modeling guidance applicable to the 1-hour SO_2 NAAQS and, thus, applicable to SO_2 modeling in support of designations. For more details, refer to the NO_2 memo. If any questions arise regarding preparation of emissions inputs for dispersions modeling including intermittent emissions from sources, then users should consult the appropriate EPA Regional Modeling Contact.

5.2 Good Engineering Practice (GEP) stack height

Consistent with previous SO_2 modeling guidance (U.S. EPA, 1994) and Section 6.2.2 of Appendix W, for stacks with heights that are within the limits of Good Engineering Practice (GEP), actual heights should be used in modeling. Under EPA's regulations at 40 CFR 51.100, GEP height, H_g, is determined to be the greater of:

- 65 m, measured from the ground-level elevation at the base of the stack;
- For stacks in existence on January 12, 1979, and for which the owner or operator had obtained all applicable permits or approvals required under 40 CFR Parts 51 and 52

  $$H_g=2.5H$$

  provided the owner or operator produces evidence that this equation was actually relied on in designing the stack or establishing an emission limitation to ensure protection against downwash;

For all other stacks,

$$H_g = H + 1.5L,$$

where H is the height of the nearby structure(s) measured from the ground-level elevation at the base of the stack and L is the lesser dimension of height or projected width of nearby structure(s), or

- the height demonstrated by a fluid model or a field study approved by EPA or the State/local agency which ensures that the emissions from a stack do not result in excessive concentrations of any air pollutant as a result of atmospheric downwash, wakes, eddy effects created by the source itself, nearby structures or nearby terrain features.

For more details about GEP, see the Guideline for Determination of Good Engineering Practice Stack Height Technical Support Document (U.S. EPA, 1985).

If stack heights exceed GEP, then GEP heights should be used with the individual stack's other parameters (temperature, diameter, exit velocity). For stacks modeled with actual heights below GEP, building downwash should be considered as this can impact concentrations near the source (Section 6.2.2b, Appendix W). If building downwash is being considered, the BPIPPRIME program (U.S. EPA, 2004d) should be used to input building parameters for AERMOD. More information about buildings and stacks is in Section 5.3.

5.3 Source configurations and source types

An accurate characterization of the modeled facilities is critical for refined dispersion modeling, including accurate stack parameters and physical plant layout. Accurate stack parameters should be determined for the emissions being modeled. Since modeling would be done with maximum allowable or potential emissions levels at each stack, the stack's parameters such as exit temperature, diameter, and exit velocity should reflect those emissions levels. Accurate locations (i.e. latitude and longitude or Universal Transverse Mercator (UTM) coordinates and datum)[6] of the modeled emission sources are also important, as this can affect the impact of an emission source on receptors, determination of stack base elevation, and relative location to any nearby building structures. Not only are accurate stack locations needed, but accurate information for any nearby buildings is important. This information would include location and orientation relative to stacks and building size parameters (height, and corner coordinates of tiers) as these parameters are input into BPIPPRIME to calculate building

[6] Latitudes and longitudes to four decimal places position a stack within 30 feet of its actual location and five decimal places place a stack within three feet of its actual location. Users should use the greatest precision available.

parameters for AERMOD. If stack locations and or building information are not accurate, downwash will not be accurately accounted for in AERMOD.

Emission source type characterization within the modeling environment is also important. As stated in the AERMOD User's Guide (U.S. EPA, 2004a), emissions sources can be characterized as several different source types: POINT sources, capped stacks (POINTCAP), horizontal stacks (POINTHOR), VOLUME sources, OPENPIT sources, rectangular AREA sources, circular area sources (AREACIRC), and irregularly shaped area sources (AREAPOLY). Note that POINTCAP and POINTHOR are not part of the regulatory default option in AERMOD because the user must invoke the BETA option in the model options keyword MODELOPT while not including the "DFAULT" modeling option for these options to work properly. While most sources can be characterized as POINT sources, some sources, such as fugitive releases or nonpoint sources (emissions from ports, airports, or smaller point sources with no accurate locations) may be best characterized as VOLUME or AREA type sources. If questions arise about proper source characterization or typing, users should consult the appropriate EPA Regional Modeling Contact.

5.4 Urban/rural determination

For any dispersion modeling exercise, the urban or rural determination of a source is important in determining the boundary layer characteristics that affect the model's prediction of downwind concentrations. Figure 3 gives example maximum 1-hour concentration profiles for a 10 meter stack (Figure 3a) and a 100 m stack (Figure 3b) based on urban vs. rural designation. The urban population used for the examples is 100,000. In Figure 3a, the urban concentration is much higher than the rural concentration for distances less than 750 m from the stack but then drops below the rural concentration beyond 750 m. For the taller stack in Figure 3b, the urban concentration is much higher than the rural concentration even as distances increase from the source. These profiles show that the urban or rural designation of a source can be quite important.

In addition, for SO_2 modeling, the urban/rural determination is important because AERMOD invokes a 4-hour half life[7] for urban SO_2 sources. This would only be done for urban sources when the POLLUTID keyword in AERMOD is set to "SO2" and the MODELOPT keyword includes the DFAULT option. Rural sources within the same AERMOD run would not be affected. If the DFAULT option is not included with the MODELOPT keyword, the 4-hour half life would not be used and the user would specify the 4-hour half life using the HALFLIFE or DCAYCOEFF keywords in order to account for the chemical transformation. See Section 3.2.6 of the AERMOD User's Guide (U.S. EPA, 2004a) for more details about these keywords. If the user invokes the HALFLIFE or DCAYCOEEF option, then any rural sources included in

[7] Over a 4-hour period, SO_2 concentrations decrease by half from the initial value.

the modeling would need to be run in separate AERMOD runs so that they are not subject to the 4-hour half life. Note that if the DFAULT option is used, the rural sources would not need to be in a separate run from the urban sources. Determining whether a source is urban or rural can be done using the methodology outlined in Section 7.2.3 of Appendix W and recommendations outlined in Sections 5.1 through 5.3 in the AIG (U.S. EPA, 2009). In summary, there are two methods of urban/rural classification described in Section 7.2.3 of Appendix W.

The first method of urban determination is a land use method (Appendix W, Section 7.2.3c). In the land use method, the user analyzes the land use within a 3 km radius of the source using the meteorological land use scheme described by Auer (1978). Using this methodology, a source is considered urban if the land use types, I1 (heavy industrial), I2 (light-moderate industrial), C1 (commercial), R2 (common residential), and R3 (compact residential) are 50% or more of the area within the 3 km radius circle. Otherwise, the source is considered a rural source. The second method uses population density and is described in Section 7.2.3d of Appendix W. As with the land use method, a circle of 3 km radius is used. If the population density within the circle is greater than 750 people/km^2, then the source is considered urban. Otherwise, the source is modeled as a rural source. Of the two methods, the land use method is considered more definitive (Section 7.2.3e, Appendix W).

Caution should be exercised with either classification method. As stated in Section 5.1 of the AIG (U.S. EPA, 2009), when using the land use method, a source may be in an urban area but located close enough to a body of water or other non-urban land use category to result in an erroneous rural classification for the source. The AIG in Section 5.1 cautions users against using the land use scheme on a source by source basis, but advises considering the potential for urban heat island influences across the full modeling domain. When using the population density method, Section 7.2.3e of Appendix W states, "Population density should be used with caution and should not be applied to highly industrialized areas where the population density may be low and thus a rural classification would be indicated, but the area is sufficiently built-up so that the urban land use criteria would be satisfied..." With either method, Section 7.2.3(f) of Appendix W recommends modeling all sources within an urban complex as urban, even if some sources within the complex would be considered rural using either the land use or population density method.

Another consideration that may need attention by the user and is discussed in Section 5.1 of the AIG relates to tall stacks located within or adjacent to small to moderate size urban areas. In such cases, the stack height or effective plume height for very buoyant sources may extend above the urban boundary layer height. The application of the urban option in AERMOD for these types of sources may artificially limit the plume height. The use of the urban option may not be appropriate for these sources, since the actual plume is likely to be transported over the urban boundary layer. Section 5.1 of the AIG gives details on determining if a tall stack should be modeled as urban or rural, based on comparing the stack or effective plume height to the urban boundary layer height. The 100 m stack illustrated in Figure 3b, may be such an example as the urban boundary layer height for this stack would be 189 m (based on a

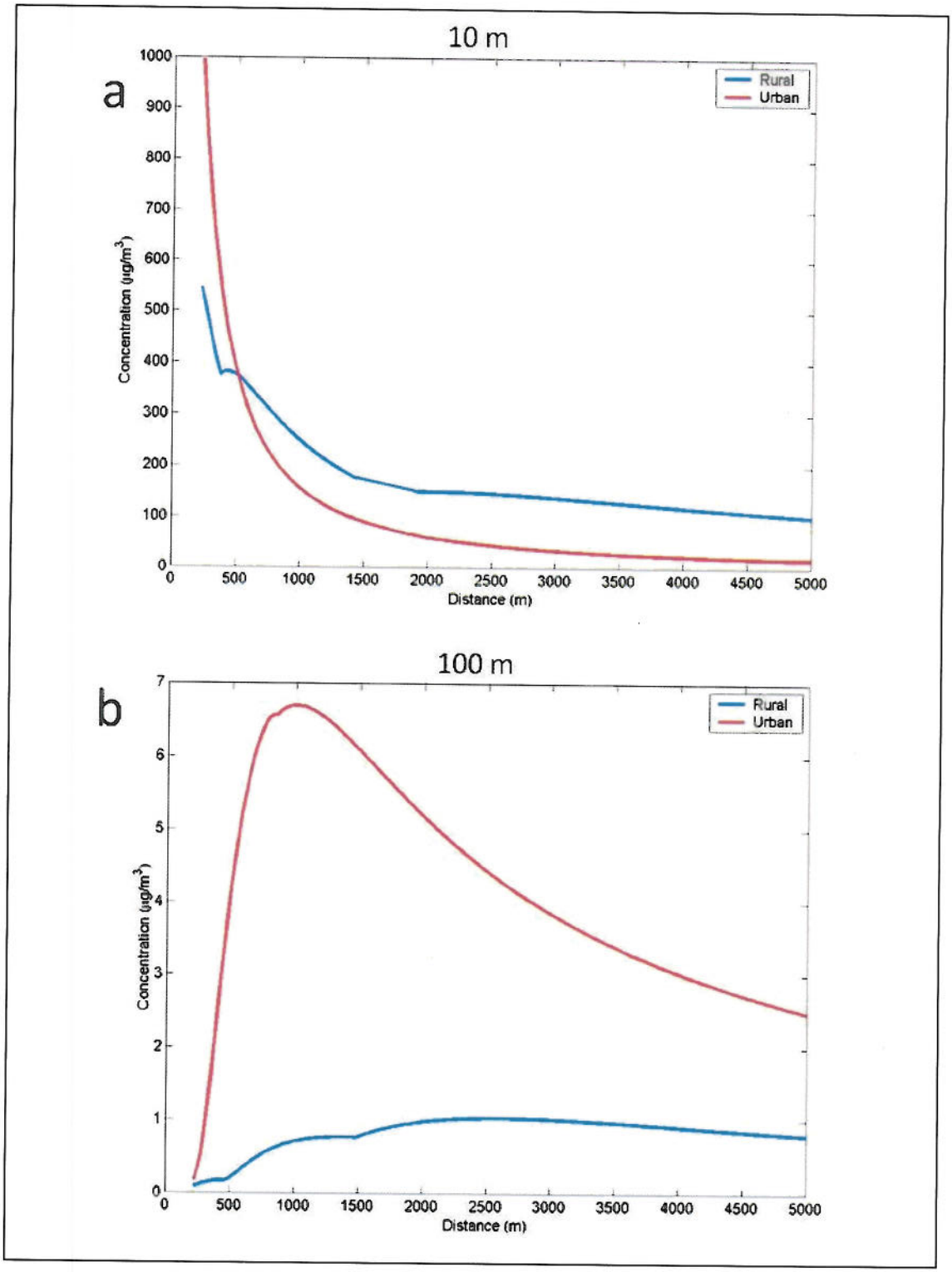

FIGURE 3. URBAN (RED) AND RURAL (BLUE) CONCENTRATION PROFILES FOR (A) 10 M BUOYANT STACK RELEASE, AND (B) 100 M BUOYANT STACK RELEASE.

population of 100,000) and equation 104 of the AERMOD formulation document (Cimorelli, et al., 2004). This equation is:

$$z_{iuc} = z_{iuo}\left(\frac{P}{P_o}\right)^{1/4} \quad (1)$$

where z_{iuo} is a reference height of 400 m corresponding to a reference population P_o of 2,000,000 people.

Given that the stack is a buoyant release, the plume may extend above the urban boundary layer and may be best characterized as a rural source, even if it were near an urban complex. Exclusion of these elevated sources from application of the urban option would need to be justified on a case-by-case basis in consultation with the appropriate EPA Regional Modeling Contact.

AERMOD requires the input of urban population when utilizing the urban option. Population can be entered to one or two significant digits (i.e., an urban population of 1,674,365 can be entered as 1,700,000). Users can enter multiple urban areas and populations using the URBANOPT keyword in the runstream file (U.S. EPA, 2004a). If multiple urban areas are entered, AERMOD requires that each urban source be associated with a particular urban area or AERMOD model calculations will abort. Urban populations can be determined by using a method described in Section 5.2 of the AIG (U.S. EPA, 2009).

5.5 Source groups

In AERMOD, individual emission sources' concentration results can be combined into groups using the SRCGROUP keyword (Section 3.3.11 of the AERMOD User's Guide (U.S, EPA, 2004a). The user can automatically calculate a total concentration (from all sources) using the SRCGROUP ALL keyword. For the purposes of designations and design value calculations, source group ALL should be used, especially if all sources in the modeling domain are modeled in one AERMOD run. Design values should be calculated from the total concentrations (all sources and background). For the purposes of designations modeling, individual source contributions outputs to the total concentration may not be necessary. However, if individual facility contributions are needed for deciding which facilities to include in the nonattainment or attainment area, source groups by facility should be used. To avoid any confusion, source groups that are used to calculate the design value concentrations or determine source contributions to design values should be mutually exclusive (i.e. an emission source should not be in two source groups). This would be especially important if the design value concentrations are calculated outside of AERMOD by adding the individual groups together to calculate a total concentration (See Section 8.1 of this document for examples). If individual source groups that are used in design value concentrations are not mutually exclusive, there would be double

counting of concentrations when calculating design values either in AERMOD or outside of AERMOD.

6. Meteorological data

Section 6 gives guidance on the selection of meteorological data for input into AERMOD. Much of the guidance from Section 8.3 of Appendix W is applicable to designations modeling and is summarized here. In Section 6.2.1, the use of a new tool, AERMINUTE (U.S. EPA, 2011a), is introduced. AERMINUTE is an AERMET pre-processor that calculates hourly averaged winds from ASOS (Automated Surface Observing System) 1-minute winds.

6.1 Surface characteristics and representativeness

The selection of meteorological data that are input into a dispersion model should be considered carefully. The selection of data should be based on spatial and climatological (temporal) representativeness (Appendix W, Section 8.3). The representativeness of the data is based on: 1) the proximity of the meteorological monitoring site to the area under consideration, 2) the complexity of terrain, 3) the exposure of the meteorological site, and 4) the period of time during which data are collected. Sources of meteorological data are: National Weather Service (NWS) stations, site-specific or onsite data, and other sources such as universities, Federal Aviation Administration (FAA), military stations, and others. Appendix W addresses spatial representativeness issues in Sections 8.3.a and 8.3.c.

Spatial representativeness of the meteorological data can be adversely affected by large distances between the source and receptors of interest and the complex topographic characteristics of the area (Appendix W, Section 8.3.a and 8.3.c). If the modeling domain is large enough such that conditions vary drastically across the domain then the selection of a single station to represent the domain should be carefully considered. Also, care should be taken when selecting a station if the area has complex terrain. While a source and meteorological station may be in close proximity, there may be complex terrain between them such that conditions at the meteorological station may not be representative of the source. An example would be a source located on the windward side of a mountain chain with a meteorological station a few kilometers away on the leeward side of the mountain. Spatial representativeness for off-site data should also be assessed by comparing the surface characteristics (albedo, Bowen ratio, and surface roughness) of the meteorological monitoring site and the analysis area. When processing meteorological data in AERMET (U.S. EPA, 2004c), the surface characteristics of the meteorological site should be used [Section 8.3.c of Appendix Wand the AERSURFACE User's Guide (U.S. EPA 2008)]. Spatial representativeness should also be addressed for each meteorological variable separately. For example, temperature data from a meteorological station several kilometers from the analysis area may be considered adequately representative, while it may be necessary to collect wind data near the plume height (Section 8.3.c of Appendix W).

Surface characteristics can be calculated in several ways. For details see Section 3.1.2 of the AIG (U.S. EPA, 2009). EPA has developed a tool, AERSURFACE (U.S. EPA, 2008) to aid in the determination of surface characteristics. The current version of AERSURFACE uses 1992 National Land Cover Data. Note that the use of AERSURFACE is not a regulatory requirement but the methodology outlined in Section 3.1.2 of the AIG should be followed unless an alternative method can be justified.

6.2 Meteorological inputs

Appendix W states in Section 8.3.1.1 that the user should acquire enough meteorological data to ensure that worst-case conditions are adequately represented in the model results. Appendix W states that 5 years of NWS meteorological data or at least one year of site-specific data should be used(Section 8.3.1.2, Appendix W) and should be adequately representative of the study area. If one or more years (including partial years) of site-specific data are available, those data are preferred. While the form of the SO_2 NAAQS contemplates obtaining three years of monitoring data, this does not preempt the use of 5 years of NWS data or at least one year of site-specific data in the modeling. The 5-year average based on the use of NWS data, or an average across one or more years of available site specific data, serves as an unbiased estimate of the 3-year average for purposes of modeling demonstrations of compliance with the NAAQ (See the August 23, 2010 Clarification Memorandum on "Applicability of Appendix W Modeling Guidance for the 1-hour SO_2 National Ambient Air Quality Standard"). See the memorandum for more details on the use of 5 years of NWS data or at least one year of site-specific data and applicability to the NAAQS.

6.2.1 NWS data

NWS data are available from the National Climatic Data Center (NCDC) in many formats, with the most common one in recent years being the Integrated Surface Hourly data (ISH). Most available formats can be processed by AERMET. As stated in Section 6.1, when using data from an NWS station alone or in conjunction with site-specific data, the data should be spatially and temporally representative of conditions at the modeled sources.

A recently discovered issue with ASOS is that 5-second wind data that are used to calculate the 2-minute average winds are truncated rather than rounded to whole knots. For example, a wind of 2.9 knots is reported as 2 knots, not 3 knots. To account for this truncation of NWS winds (either standard observation or AERMINUTE output), an adjustment of ½ knot or 0.26 m/s is added to the winds in stage 3 AERMET processing. For more details refer to the AERMET User's Guide (U.S. EPA, 2004c) and/or the appropriate EPA Regional Modeling Contact.

6.2.1.1 AERMINUTE

In AERMOD, concentrations are not calculated for variable wind (i.e., missing wind direction) and calm conditions, resulting in zero concentrations for those hours. Since the SO_2 NAAQS is a one hour standard, these light wind conditions may be the controlling meteorological circumstances in some cases because of the limited dilution that occurs under low wind speeds which can lead to higher concentrations. The exclusion of a greater number of instances of near-calm conditions from the modeled concentration distribution may therefore lead to underestimation of daily maximum 1-hour concentrations for calculation of the design value.

To address the issues of calm and variable winds associated with the use of NWS meteorological data, EPA has developed a preprocessor to AERMET, called AERMINUTE (U.S. EPA, 2011a) that can read 2-minute ASOS winds and calculate an hourly average. Beginning with year 2000 data, NCDC has made freely available, the 1-minute winds, reported every minute from the ASOS network. The AERMINUTE program reads these 2-minute winds and calculates an hourly average wind. In AERMET (U.S. EPA, 2004c), these hourly averaged winds replace the standard observation time winds read from the archive of meteorological data. This results in a lower number of calms and missing winds and an increase in the number of hours used in averaging concentrations. For more details regarding the use of NWS data in regulatory applications see Section 8.3.2 of Appendix W and for more information about the processing of NWS data in AERMET and AERMINUTE, see the AERMET (U.S. EPA, 2004c) and AERMINUTE User's guides (U.S. EPA, 2011a).

6.2.2 Site-specific data

The use of site-specific meteorological data is the best way to achieve spatial representativeness. AERMET can process a variety of formats and variables for site-specific data. The use of site-specific data for regulatory applications is discussed in detail in Section 8.3.3 of Appendix W. Due to the range of data that can be collected onsite and the range of formats of data input to AERMET, the user should consult Appendix W, the AERMET User's Guide (U.S. EPA, 2004c), and Meteorological Monitoring Guidance for Regulatory Modeling Applications (U.S. EPA, 2000). Also, when processing site-specific data for an urban application, Section 3.3 of the AERMOD Implementation Guide offers recommendations for data processing. In summary, the guide recommends that site-specific turbulence measurements should not be used when applying AERMOD's urban option, in order to avoid double counting the effects of enhanced turbulence due to the urban heat island.

6.2.3 Upper air data

AERMET requires full upper air soundings to calculate the convective mixing height. For AERMOD applications in the U.S., the early morning sounding, usually the 1200 UTC (Universal Time Coordinate) sounding, is typically used for this purpose. Upper air soundings can be obtained from the Radiosonde Data of North America CD for the period 1946-1997. Upper air soundings for 1994 through the present are also available for free download from the Radiosonde Database Access website. Users should choose all levels or mandatory and significant pressure levels[8] when selecting upper air data. Selecting mandatory levels only would not be adequate for input into AERMET as the use of just mandatory levels would not provide an adequate characterization of the potential temperature profile.

7. Background concentration

The inclusion of ambient background concentrations to the model results is important in determining cumulative impacts. The modeled contribution to the cumulative analysis should follow the form of the standard and be calculated as described in Section 2.6.1.2 of the August 23, 2010 clarification memo on "Applicability of Appendix W Modeling Guidance for the 1-hour SO_2 National Ambient Air Quality Standard." This memo suggested a "first tier" approach to including a uniform monitored background contribution based on adding the overall highest hourly background SO_2 concentration from a representative monitor to the modeled design value. We recognize that this approach could be overly conservative in many cases and may also be prone to reflecting source-oriented impacts, increasing the potential for double-counting of modeled and monitored contributions. As discussed in EPA's March 1, 2011 memo "Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 Ambient Air Quality Standard," we recommend a less conservative "first tier" approach for a uniform monitored background concentration based on the monitored design values for the latest 3-year period, regardless of the years of meteorological data used in the modeling. Adjustments to this approach may be considered in consultation with the appropriate EPA Regional Modeling Contact with adequate justification and documentation of how the background concentration was calculated.

Section 8.2.2 of Appendix W gives guidance on background concentrations for isolated single sources and is also applicable for multi-source areas. One option is, as described in Section 8.2.2.b:

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[8] By international convention, mandatory levels are in millibars: 1,000, 850, 700, 500, 400, 300, 200, 150, 100, 50, 30, 20, 10,7 5, 3, 2, and 1. Significant levels may vary depending on the meteorological conditions at the upper-air station

"Use air quality data in the vicinity of the source to determine the background concentration for the averaging times of concern. Determine the mean background concentration at each monitor by excluding concentrations when the source in question is impacting the monitor… For shorter time periods, the meteorological conditions accompanying concentrations of concern should be identified. Concentrations for meteorological conditions of concern, at monitors, not impacted by the source in question, should be averaged for separate averaging time to determine the average background value. Monitoring sites inside a 90° degree sector downwind of the source may be used to determine the area of impact."

When no monitors are located in the vicinity of the sources being modeled a "regional site" (i.e., one that is located away from the area of interest but is impacted by similar natural and distant man-made sources) may be used to determine background (Section 8.2.2.c, Appendix W). In multi-source areas, background includes two components, nearby sources and other sources (Section 8.2.3 of Appendix W). Nearby sources are those sources that are expected to cause a significant concentration gradient in the vicinity of the source or sources under consideration, and should be explicitly modeled. Identification of nearby sources calls for professional judgment and consultation with the appropriate EPA Regional Modeling Contact. For other sources, such as natural sources, minor sources and distant major sources, the methodology of Section 8.2.2 should be used.

EPA's March 1, 2011 memo "Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 Ambient Air Quality Standard," describes an appropriate methodology of calculating temporally varying background monitored concentrations by hour of day and season (excluding periods when the source in question is expected to impact the monitored concentration). The methodology for NO_2 is to use the 98^{th} percentile concentration for each hour of the day by season and average across three years. This same methodology is applicable to SO_2 designations modeling based on use of the 99^{th} percentile by hour of day and season for background concentration excluding periods when the dominant source(s) are influencing the monitored concentration (i.e., 99^{th} percentile, or 4^{th} highest, concentrations for hour 1 for January or winter, 99^{th} percentile concentrations for hour 2 for January or winter, etc.). Recent updates included in AERMOD allow for the inclusion of temporally varying background concentrations in the design value calculation in combination with modeling results.

An illustrative example is shown in Figure 4. Shown are the NAAQS standard concentration, the monitor's 3-year average design value, and 3-year averages of the 99^{th} percentile concentrations by season and hour of day. To calculate the 99^{th} percentile concentration for a season and hour of day combination, the second highest concentration for that combination should be selected. Also shown are 3-year averages of the 99^{th} percentile concentration by hour of day (across all seasons), and the average concentration by hour of day

across the three years[9]. In this example, the winter background concentrations show a distinct diurnal variability, with less for each of the other seasons.

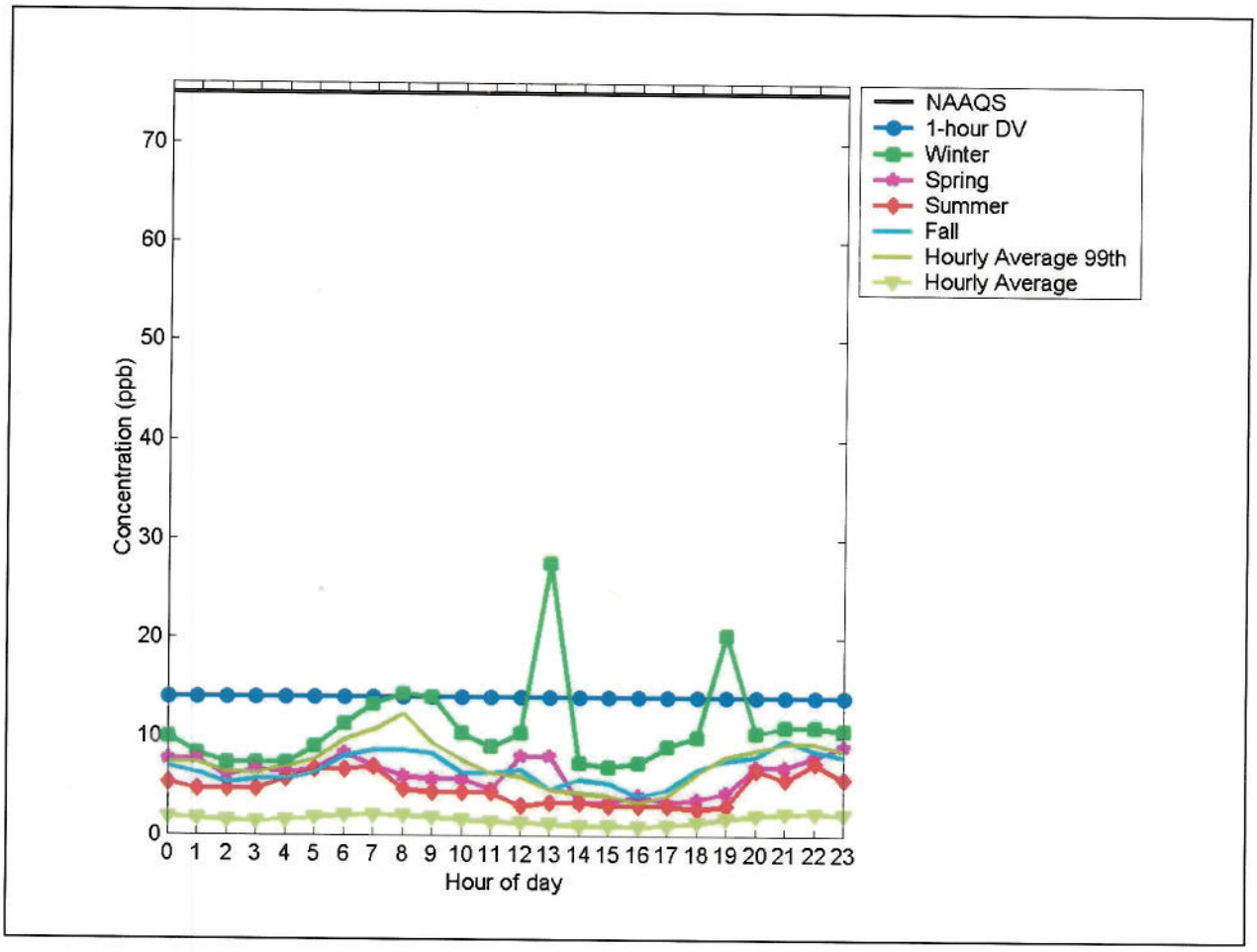

FIGURE 4. SO_2 MONITORED CONCENTRATIONS FOR VARIOUS AVERAGING TIMES.

It should be also noted here that the conventions regarding reporting time differ between ambient air quality monitoring, where the observation time is based on the hour-beginning convention, and meteorological monitoring where the observation is based on the hour-ending time. Thus, ambient monitoring data reported for hour 00 should be paired with meteorological data for hour 01, etc. This is important when incorporating time-varying background

[9] Modelers should use the 1st-highest value for more detailed pairings, such as month by hour-of-day or season by hour-of-day and day-of-week

concentrations in the AERMOD calculations, which allow for temporally varying background concentrations.

8. Determining design value metrics

Designations modeling will provide predictions of SO_2 design values at each receptor that includes contributions from all modeled sources and background. Based on the form of the 1-hour SO_2 NAAQS, the design value should be calculated as the average of the 99th percentile of the annual distribution of daily maximum 1-hour concentrations averaged across the modeled years.

8.1 Design value calculation methodology

Whether design values are calculated within AERMOD or outside of AERMOD, to calculate a design value to compare against the standard, the following steps should be followed:

1. At each receptor, for each hour of the modeled period, calculate a total concentration across all sources including background concentrations if applicable. This can be done in AERMOD using SRCGROUP ALL or by adding individual source groups outside of AERMOD, using hourly POSTFILEs. If the user is totaling the concentrations outside of AERMOD, the source groups need to be mutually exclusive, i.e. no one source should be in multiple source groups.
2. From the total concentrations calculated in step 1, obtain the 1-hour maximum concentration at each receptor for each modeled day.
3. From the output of step 2, for each year modeled, calculate the 99th percentile (4th highest) daily maximum 1-hour concentration at each receptor. If modeling 5 years of meteorological data, this results in five 99th percentile concentrations at each receptor.
4. Average the 99th percentile (or 4th highest) concentrations across the modeled years to obtain a design value at each receptor.
5. Modeled source contributions to a NAAQS violation can be determined by analyzing the hourly concentrations from the individual source groups corresponding to the same hour as the 4th daily maximum 1-hour concentration from each year. (See 75 FR at 35540). For example, a receptor has a 5-year average design value of 200.8 mg/m^3 (or approximately 77 ppb) and AERMOD was modeled for the period January 1, 2005 through December 31, 2009 for four source groups. From the AERMOD output, the user can determine the date of the 4th highest daily maximum 1-hour concentrations that are used to calculate the 5-year average design value. Table 1 shows the 4th highest daily maximum 1-hour concentrations for each year and associated dates that are used in the design value calculation.

TABLE 1. 4TH HIGHEST DAILY MAXIMUM 1-HOUR CONCENTRATIONS (μG/M^3) FOR 2005-2009.

Date (YYMMDDHH)	Concentration
05080101	200.1
06073105	201.5
07080403	207.1
08072705	197.1
09080104	198.1
5-YEAR AVG.	200.8

If output by source group is available, the user can extract each source group's concentration at each of the hours listed in Table 1. Table 2 shows example source contributions for each hour shown in Table 1 and indicates that Source 1 is the main contributor to the design value for all hours.

TABLE 2. SOURCE CONTRIBUTIONS TO 4TH HIGHEST DAILY MAXIMUM 1-HOUR CONCENTRATIONS (μG/M^3) AND 5-YEAR AVERAGE DESIGN VALUES.

Date (YYMMDDHH)	TOTAL	SOURCE 1	SOURCE 2	SOURCE 3	SOURCE 4
05080101	200.1	155.1	25.1	1.5	18.4
06073105	201.5	157.4	26.2	0.5	17.4
07080403	207.1	161.5	20.5	2.1	23.0
08072705	197.1	159.2	23.1	1.7	13.1
09080104	198.1	155.3	22.6	2.0	18.2
5-YEAR AVG.	200.8	157.7	23.5	1.6	18.0

8.2 Running AERMOD and implications for design value calculations

Recent enhancements to AERMOD include options to aid in the calculation of design values for comparison with the SO_2 NAAQS. These enhancements include:

- The output of daily maximum 1-hour concentrations by receptor for each day in the modeled period for a specified source group. This is the MAXDAILY output option in AERMOD.
- The output, for each rank specified on the RECTABLE output keyword, of daily maximum 1-hour concentrations by receptor for each year for a specified source group. This is the MXDYBYYR output option.
- The MAXDCONT option, which shows the contribution of each source group to the high ranked values for a specified target source group, paired in time and space. The user can specify a range of ranks to analyze, or specify an upper bound rank, i.e. 4th highest, and a lower threshold value, such as the NAAQS for the target source group. The model will

process each rank within the range specified, but will stop after the first rank (in descending order of concentration) that is below the threshold, specified by the user. A warning message will be generated if the threshold is not reached within the range of ranks analyzed (based on the range of ranks specified on the RECTABLE keyword). This option may be needed to aid in determining which sources to include in a nonattainment area.

Ideally, all explicitly modeled sources, receptors, and background should be modeled in one AERMOD run for all modeled years. In this case, the use of the one of the above output options can be used in AERMOD to calculate design values for comparison to the NAAQS and determine the area's attainment status and/or inform attainment/nonattainment boundaries. The use of these options in AERMOD allows AERMOD to internally calculate concentration metrics that can be used to calculate design values and therefore lessen the need for large output files, i.e. hourly POSTFILES.

However, there may be situations where a single AERMOD run with all explicitly modeled sources is not preferred. These situations often arise due to runtime or storage space considerations during the AERMOD modeling. Sometimes separate AERMOD runs are done for each facility or group of facilities, or by year, or the receptor network is divided into separate sub-networks. In some types of these situations, the MAXDAILY, MXDYBYYR, or MAXDCONT output option may not be an option for design value calculations, especially if all sources are not included in a single run. If the user wishes to utilize one of the three output options, then care should be taken in developing the model inputs to ensure accurate design value calculations.

Situations that would effectively preclude the use of the MAXDAILY, MXDYBYYR, and MAXDCONT option to calculate meaningful AERMOD design value calculations include the following examples:

- Separate AERMOD runs for each source or groups of sources.
    - Designations modeling includes 10 facilities for five years of NWS data and each facility is modeled for five years in a separate AERMOD run, resulting in 10 separate AERMOD runs.
- Separate AERMOD runs for each source and each modeled year.
    - 10 facilities are modeled for 5 years of NWS data. Each facility is modeled separately for each year, resulting in fifty individual AERMOD runs.

In the two situations listed above, the MAXDAILY, MXDYBYYR, or, MAXDCONT option would not be useful as the different AERMOD runs do not include a total concentration with contributions from all facilities. In these situations the use of hourly POSTFILES, which can be quite large, and external post-processing would be needed to calculate design values.

Situations that may use the MAXDAILY, MXDYBYYR, or, MAXDCONT option but may necessitate some external post-processing afterwards to calculate a design value include:

- The receptor network is divided into sections and an AERMOD run, with all sources and years, is made for each network.
    - A receptor network of 20,000 receptors is divided into four 5,000 receptor sub-networks. Ten facilities are modeled with five years of NWS data in one AERMOD run for each receptor network, resulting in four AERMOD runs. After the AERMOD runs are complete, the MAXDAILY, MXDYBYYR, or, MAXDCONT results for each network can be re-combined into the larger network.
- All sources and receptors are modeled in an AERMOD run for each year.
- Ten facilities are modeled with five years of NWS data. All facilities are modeled with all receptors for each year individually, resulting in five AERMOD runs. MAXDAILY, MXDYBYYR, or, MAXDCONT output can be used and post-processed to generate the necessary design value concentrations. The receptor network is divided and each year is modeled separately for each sub-network with all sources.

    Ten facilities are modeled with five years of NWS data for 20,000 receptors. The receptor network is divided into four 5,000 receptor networks. For each sub-network, all ten facilities are modeled for each year separately, resulting in twenty AERMOD runs. MAXDAILY, MXDYBYYR, or, MAXDCONT output can be used and post-processed to generate the necessary design value concentrations.

9. Use of modeling results to inform nonattainment/attainment boundaries

Dispersion modeling is a tool that could be used to examine the spatial extent of potential violations of the 1-hour SO_2 NAAQS. Thus, in accordance with this guidance, refined dispersion modeling could be used to inform boundary determinations in support of the SO_2 designations process, i.e.

1. For an area that contains a violating monitor, modeling could be used to inform decisions on the appropriate nonattainment boundary in conjunction with other factors listed in Attachment 2.
2. For an area without a violating monitor, modeling could be used as evidence of an area's attainment status and also to inform decisions on the appropriate (attainment or nonattainment) boundary.

The shape and size of the nonattainment or attainment area is recommended by the state and either adopted or modified by EPA. For initial designations, it is expected that states will focus on areas with violating monitors. If a county contains a violating monitor, that county would be

considered in nonattainment. If there are no violating monitors and no dispersion modeling results to show attainment or nonattainment, that county would generally be considered unclassifiable.

9.1 Nonattainment area boundaries

For nonattainment areas (those with a violating monitor), modeling could be used to refine the nonattainment area boundaries from the presumptive county boundaries in conjunction with other factors such as those listed in Attachment 2. This could include reducing the nonattainment area from the presumptive county to a smaller area or expanding the boundary beyond the county if sources outside the county contribute to a NAAQS violation in the county. A nonattainment area boundary should contain the area that exceeds the NAAQS and include sources that may cause or contribute to a NAAQS exceedance. Figure 4 shows a hypothetical example of modeling of an area that exceeds the NAAQS (either through monitoring or modeling). In each panel of Figure 5, the black dot represents the emission source. In Figure 5a, the contours in orange and red are design values that exceed the NAAQS. Figures 5b-5d show different approaches to establishing the nonattainment boundary so that the orange and red contours are within the boundary. In Figure 5b, the hypothetical nonattainment boundary is a circle, centered on the area shown as violating the NAAQS, while Figure 5c shows the hypothetical nonattainment boundary as a rectangle. Finally, Figure 5d shows a hypothetical nonattainment boundary as an irregular polygon in shape, perhaps based on jurisdictional boundaries or other landmarks such as roads.

Figure 6 illustrates a hypothetical example for a multi-source situation that is in nonattainment. In the example, there are five sources (denoted by blue dots) in a modeling domain that covers four counties (A, B, C, and D). The modeling domain is centered on the violating monitor (star). The orange contour represents concentrations above the NAAQS. As in the single source example shown in Figure 5, the nonattainment area could be circular, rectangular, or irregularly shaped using jurisdictional boundaries. In this example, the hypothetical nonattainment boundary would be defined by the northern portion of County A and the southern portion of County C. Since multiple sources are involved, the hypothetical nonattainment boundary should be extended to cover those sources that cause or contribute to a NAAQS violation. In this hypothetical example, Sources 2 and 5 are the largest contributing sources to the potential NAAQS violation so the nonattainment boundaries would include those two sources.

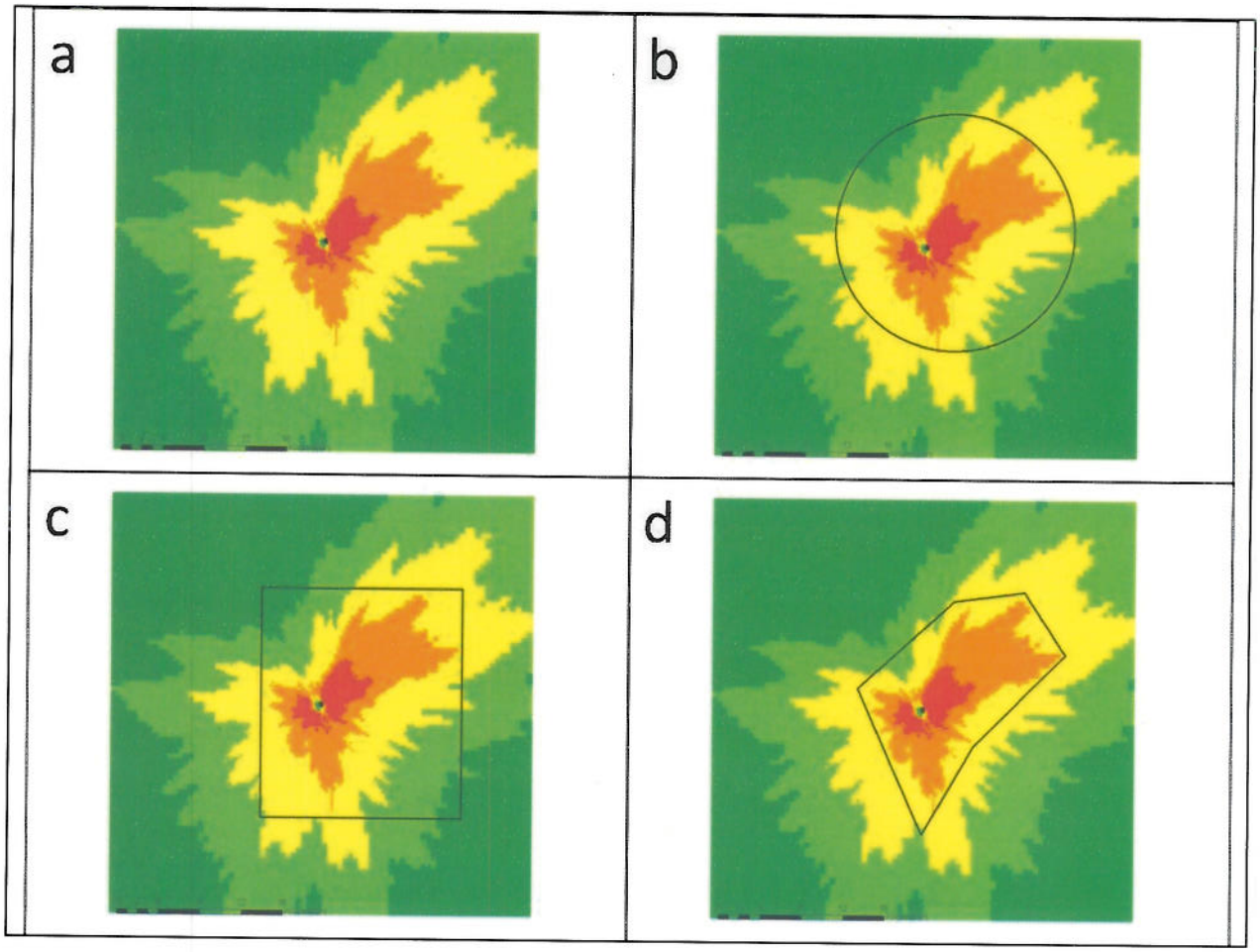

FIGURE 5. HYPOTHETICAL EXAMPLE OF A MODELED NAAQS VIOLATION (RED AND ORANGE CONTOURS) AND POSSIBLE NONATTAINMENT AREA BOUNDARIES DEFINED BY (B) CIRCLE, (C) RECTANGLE, AND (D) AN IRREGULAR POLYGON.

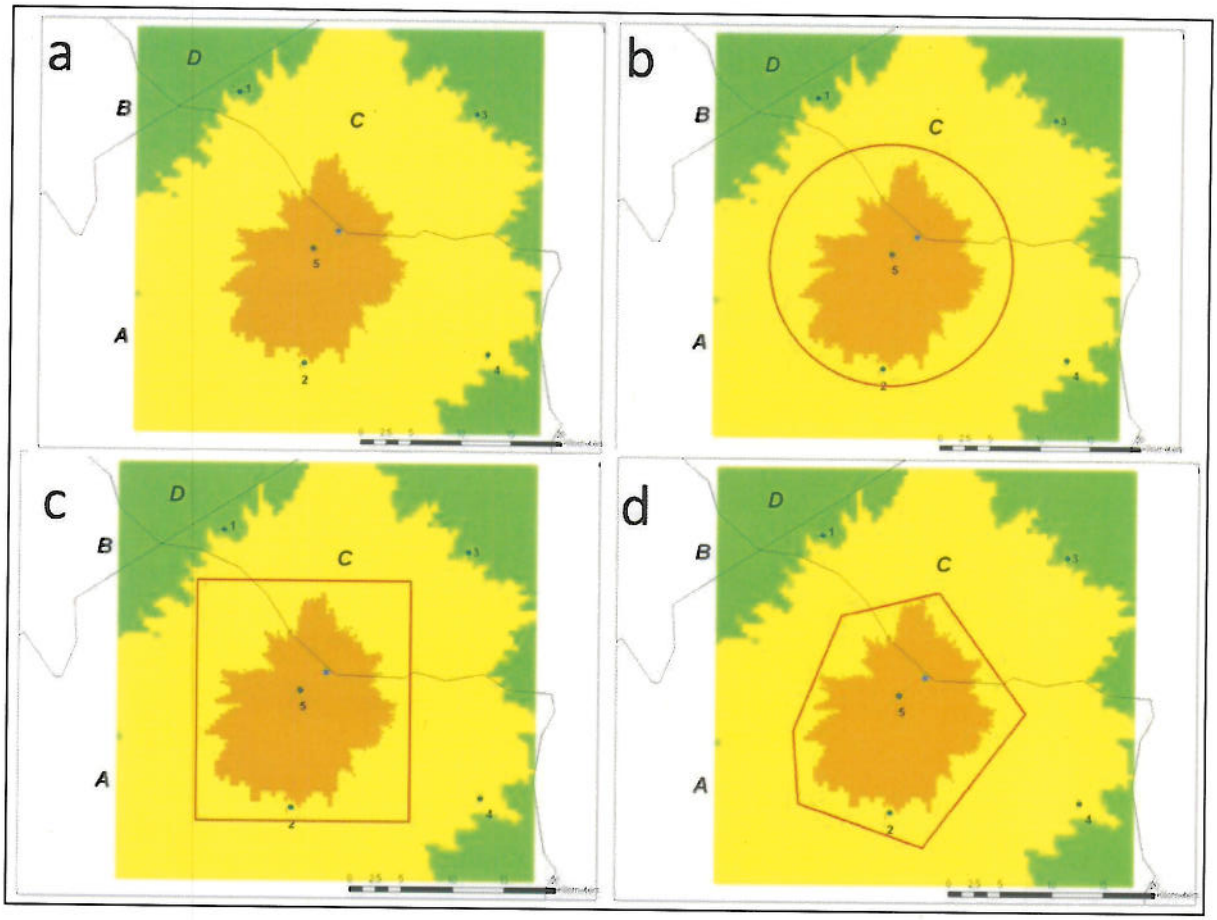

FIGURE 6. HYPOTHETICAL EXAMPLE OF A MULTI-SOURCE AREA WITH MODELED NAAQS VIOLATIONS (ORANGE CONTOUR) AND POSSIBLE NONATTAINMENT AREA BOUNDARIES DEFINED BY (B) CIRCLE, (C) RECTANGLE, AND (D) AN IRREGULAR POLYGON.

9.2 Attainment area boundaries

In areas without a violating monitor, modeling could be used to help determine that an area with SO_2 emitting sources is in attainment for the 1-hour SO_2 NAAQS. An attainment area boundary could not contain any area that exceeds the NAAQS or any area containing sources that are causing or contributing to a violating area. When considering attainment area boundaries, there will be no predicted area of violation from dispersion modeling so that other factors would need to be considered if the boundary is not determined by using the county presumptive boundary. Figure 7 illustrates a group of sources where a monitored design value does not exceed the NAAQS and modeling also does not show any concentration levels in excess of the NAAQS. In this case, the state could recommend that county A be considered attainment, since the monitor and modeling do not show violations of the NAAQS. Also, if there are other

sources in the remaining three counties (i.e., B, C, or D) and their modeled concentration levels do not show violations of the NAAQS, then these counties could also be recommended as part of the attainment area.

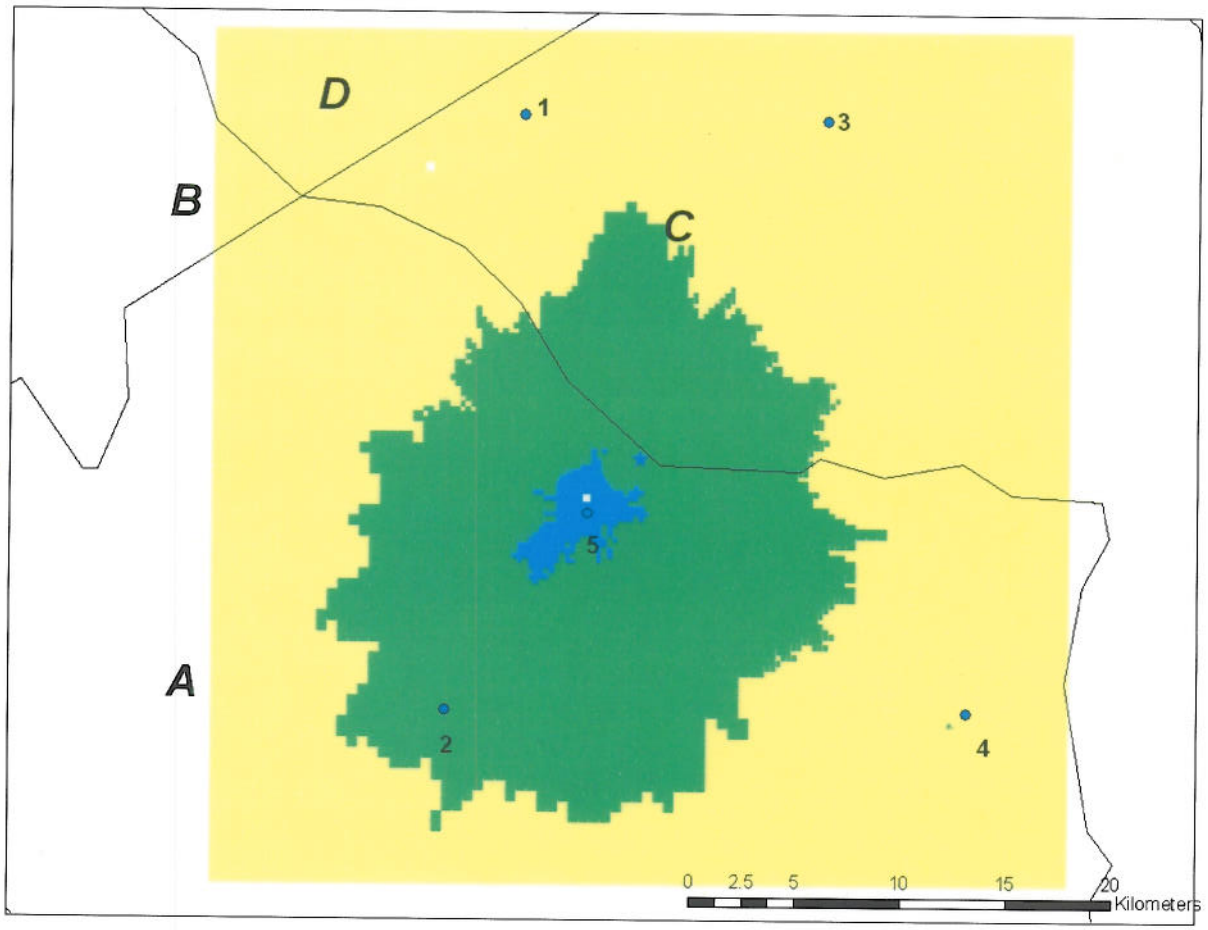

FIGURE 7. HYPOTHETICAL EXAMPLE FOR AN AREA WITH A MONITOR (STAR) THAT DOES NOT VIOLATE THE NAAQS AND MODELING RESULTS FOR SOURCES (BLUE DOTS) THAT DO NOT SHOW A VIOLATION OF THE NAAQS.

10. Documentation

It is expected that the state would submit a modeling and analysis protocol that details the methodology and model inputs before commencement of the modeling exercise. This information should support the states' recommended designations, and provide a basis for EPA's evaluation of the recommendations. The protocol should include the following:

- Characterization of the nonattainment problem or characterization of the modeled area in absence of a violating monitor,
- An emissions analysis around the violating monitor or area under consideration for designations in absence of a violating monitor, and
- Methodology for preparing air quality and meteorology inputs including choice of meteorological data and representativeness of the data.

Additionally, the documentation should include:

- Summary and analysis of modeling results, and
- Provision of modeling data inputs and outputs in electronic form.

A meeting with the appropriate EPA Regional Modeling Contact and other technical and planning staff to discuss the modeling and analysis protocol is recommended before submitting the protocol and beginning any refined modeling.

11. Summary

In summary, we emphasize the following key points of this modeling guidance:

- AERMOD is EPA's preferred near-field dispersion model for regulatory applications and is applicable for SO_2 designations modeling consistent with EPA's *Guideline on Air Quality Models*, also published as Appendix W of 40 CFR Part 51.
- Sources should be modeled with maximum allowable 1-hour or short-term emission rates in the designations modeling based on continuous operations at the source.
- Modeling should be done with five years of representative NWS meteorological data or at least one year of site specific meteorology.
- Background concentrations can be included as:
    - "First tier" approach based on monitored design values added to modeled design values; or
    - Temporally varying based on the 99th percentile monitored concentrations by hour of day and season added to modeled design values.
- Dispersion modeling results could be used to inform the nonattainment or attainment areas in conjunction with other designations factors.
- States should submit a modeling and analysis protocol that details the methodology and model inputs before commencement of the modeling exercise. This information should support the states' recommended designations, and provide a basis for EPA's evaluation of the recommendations.

- At any time during the designations process when there are questions regarding modeling or interpretation of this guidance, the appropriate EPA Regional Modeling Contact should be consulted.

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