American Iron and Steel Institute

25 Massachusetts Avenue, NW
Suite 800
Washington, D.C. 20001
Phone 202.452.7100
Fax 202.452.1039

www.steel.org

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Mr. George M. Bridgers
Air Quality Assessment Division
Office of Air Quality Planning and Standards
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711
Bridgers.George@epa.gov

Subject: AISI Comments on EPA's Proposed *Revision to the Guideline on Air Quality Models* (Attn. Docket ID: EPA–HQ–OAR–2015–0310)

The American Iron and Steel Institute (AISI) is pleased to submit the attached comments on EPA's proposed *Revision to the Guidelines on Air Models*, published in the *Federal Register* on July 29, 2015. AISI serves as the voice of the North American steel industry and represents 19 member companies, including integrated and electric furnace steelmakers, accounting for over three quarters the majority of U.S. steelmaking capacity with facilities located in 41 states, Canada and Mexico, and approximately 125 associate members who are suppliers to or customers of the steel industry.

We appreciate the opportunity to offer comments on the proposal and look forward to continuing to work constructively with the Agency to improve the air quality modeling system so that it more accurately predicts emissions from industrial facilities. If EPA staff has any questions or would like to discuss the comments further, please do not hesitate to ask.

Regards,

Colin P. Carroll

Colin P. Carroll
Director, Environment, Health and Safety

Attachments

AISI Comments on EPA's July 29, 2015 *Proposed Revision to the Guideline on Air Quality Models: Enhancements to the AERMOD Dispersion Modeling System and Incorporation of Approaches to Address Ozone and fine Particulate Matter*

October 27, 2015

The American Iron & Steel Institute (AISI) provides these comments to address various aspects of the proposed changes to EPAǿs modeling guidance (Appendix W)[1] published in the July 29, 2015 *Federal Register*. Due to EPAǿs inclusion of several docket items that are used in support of their proposed changes, we also provide comments on these documents, as appropriate.

OVERVIEW

1.0 BACKGROUND AND OVERARCHING COMMENTS

1.1 EPA has proposed several updates to the AERMOD modeling system, which we generally support. We provide further information to improve EPA's final rulemaking and discuss needed updates that EPA does not address.

The significant AERMOD updates include low wind speed improvements, NO_2 modeling updates, incorporation of the Buoyant Line and Point source model (BLP) into AERMOD, and a correction to better handle sources near small urban areas. We are generally supportive of these improvements, but indicate areas that need further review. We also present additional evaluation information in support of the low wind options.

1.2 EPA indicates that long-range transport (LRT) models are rarely used or needed; accordingly, EPA proposes screening approaches with short-range models and withdraws its support for the current preferred LRT model, CALPUFF. We have concerns about the proposed lack of a preferred LRT model, but welcome the continued use of a more advanced version of CALPUFF, as well as other LRT models, with an approach that does not result in permitting delays.

Our comments indicate that for at least one criteria pollutant, $PM_{2.5}$, a modeling result showing marginal NAAQS compliance near the source could likely indicate an impact above the Class I Prevention of Significant Deterioration (PSD) Significant Impact Level (SIL) for areas well beyond 50 km. This would trigger a cumulative LRT analysis that could not be handled by a short-range model like AERMOD. Therefore, EPA must reconsider its position on the need for a preferred Long-Range Transport model. If EPA does not keep CALPUFF as a preferred model, it should allow its use as a generally applicable alternative model in an advanced version for LRT analyses. Other models could also serve in this role, but EPAǿs Model Clearinghouse needs to work out an expedited procedure to approve screening LRT models such as CALPUFF version 6.42 or version 7 or other alternative models.

[1] 80 FR 45340, July 29, 2015 *Federal Register*.

1.3 To satisfy a Sierra Club request, EPA has issued several technical and policy documents regarding modeling concentrations of secondary $PM_{2.5}$ and ozone from single source emissions. We provide comments on how those procedures can be better documented and enhanced so that a workable procedure for applying these methods can be established. At the time of the EPA's proposal, modeling protocols and tools had not been adequately demonstrated to be appropriate or accurate for modeling secondarily-formed ozone and $PM_{2.5}$ for a single point source. Therefore, EPA should not implement this incomplete procedure for requiring point sources to demonstrate compliance with the ozone NAAQs until appropriate and independent peer reviewed studies have been completed.

EPAφs general procedure for single-source modeling for ozone and secondary $PM_{2.5}$ concentrations is flexible, but too preliminary at the time of the Appendix W proposal to be implemented. External peer review, like that conducted for AERMOD and CALPUFF, is needed before the procedures can be required to be used. We comment on the need for Model Emission Rates for Precursors (MERPs) to be established before the modeling procedures are finalized. We also comment on aspects of the modeling tiers that EPA has discussed in their proposal, which need much more procedural development to be able to be implemented.

1.4 EPA is proposing to expand the role of the Model Clearinghouse such that it must be consulted for all non-guideline model applications. This action may result in the Model Clearinghouse becoming overwhelmed with review requests, creating a bottleneck for proposed permit reviews.

EPA is simultaneously expanding the role of the Model Clearinghouse and the scope of non-guideline modeling applications. More non-guideline modeling applications are likely to occur due to lack of a preferred model for LRT and due to the proposed approach for single source ozone and $PM_{2.5}$ modeling. EPA has proposed elimination of a preferred LRT model while the need for LRT modeling will still be present. Additionally, the modeling procedures for single-source modeling of ozone and $PM_{2.5}$are so preliminary that all modeling procedures will, by definition, be non-guideline approaches. We are concerned that the Model Clearinghouse will be overwhelmed with review requests, resulting in permitting delays. A significant expansion in Model Clearinghouse resources or delegation of authority to the EPA Regions is likely needed to prevent delays.

1.5 EPA discusses changes to the modeling of background sources, for which we offer specific comments to clarify and improve the final rulemaking.

EPA has proposed some updates to determining background concentrations that represent improvements to the process. For nearby sources to be explicitly modeled, we note that EPA previously indicated in the March 1, 2011 Clearinghouse memorandum[2] that a 10-km distance from the source of interest would be sufficiently far to account for the peak impact of a background source. We provide comments as to why 10 km, rather than the proposed ñ10 to 20 kmò is an appropriate distance. In addition, the emission rates to be used for background sources should be actual levels for all of the emission factors listed in Table 8-2, not just one of the three factors. In addition, as in past comments, we note that regional background levels referenced to the form of the NAAQS are inherently conservative because the expected (typical) value is the average value, not an arbitrary near-peak value.

[2] http://www.epa.gov/ttn/scram/guidance/clarification/Additional_Clarifications_AppendixW_Hourly-NO2-NAAQS_FINAL_03-01-2011.pdf.

1.6 EPA mentions an urban source characterization approach for large industrial areas. We generally support source characterization refinements that were presented at the 11th Modeling Conference, which should be allowed with appropriate documentation without a non-guideline modeling review requirement.

In our comments, we note that EPA has previously indicated (see EPA comments on a non-guideline modeling application in Attachment A) that a site-specific source characterization does not constitute a model alteration, so it is not a non-guideline approach. We provide comments that support the approach recommended by the American Iron & Steel Institute, which were presented[3] at the 11th EPA Modeling Conference. These approaches include the specification of an urban characterization for a highly industrialized area, the elimination of building downwash effects for sources near buildings with fugitive heat releases, partial buoyancy enhancement for stacks in a line, and increased plume rise for sources with moist plume releases.

1.7 EPA should establish a process for timely review and adoption of model improvements. All proposed model improvements should be subject to some level of public review and comment.

Similar to the concept discussed in oral comments presented[4] by the Air & Waste Management Associationõs APM committee at the 11th Modeling Conference, a tiered structure for modeling updates would provide for timely adoption of many categories of model improvements. All tiers of model updates would provide for public review and comment. The highest tier would involve a change to Appendix W, usually associated with a model change or incorporation of new topics, which is the case with this proposal. Such a proposal would be noticed in the *Federal Register* with a 90-day comment period. Any new modeling procedures should also be subject to a full year of testing and debugging. A lower tier would be similarly available for 90-day public review and 1 year of testing for changes associated with changes to existing models that does not require an Appendix W change. The lowest tier of ñbug fixesò would simply be associated with a 90-day comment period.

1.8 EPA should allow modeling approaches that account for substantial emissions variability ‐– including the consideration of the Emissions Variability Processor (EMVAP) for New Source Review permitting.

The promulgation of 1-hour average NAAQS for SO_2 and NO_2 has created challenges with permit conditions for sources with substantial emissions variability. The SO_2 nonattainment guidance[5] has included a treatment of emissions variability by allowing a combined specification of a short-term emission rate that would be applicable for a small percentage of the time, and a longer-term emission rate that would be lower. We recommend that application of this approach for New Source Review permitting as well as for nonattainment areas. The approaches that are described in our comments include the application of the Emissions Variability Processor (EMVAP) as well as a percentage of higher short-term emissions based upon the form of the standard and a review of wind rose patterns.

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[3] http://www.epa.gov/ttn/scram/11thmodconf/presentations/2-2_AISI_NAAQS_Issues.pdf.

[4] http://www.epa.gov/ttn/scram/11thmodconf/presentations/2-10_APM_Intro_Comments_on_GAQM_2015.pdf.

[5] http://www.epa.gov/airquality/sulfurdioxide/pdfs/20140423guidance.pdf.

1.9 We support a 1-year transition period for newly promulgated modeling procedures. Additionally, modeling protocols that are part of PSD permit applications deemed complete or for which draft permits have been noticed should be grandfathered.

EPA has previously considered how to avoid an abrupt change in modeling application procedures by allowing a 1-year grandfathering period involving previously approved techniques. In the current Appendix W (70 FR 68218), EPA allowed for a continued use of the ISC model for one year beyond the effective date of the modifications that involved the use of AERMOD as the preferred short-range dispersion model. The same considerations are expected, for example, for use of CALPUFF as a preferred LRT model after the next Appendix W changes are effective if it is not allowed as an alternative model. In addition, any requirement to conduct single-source modeling of impacts on ozone and secondarily-formed $PM_{2.5}$ should be deferred for at least one year after promulgation, pending completion of an independent peer review.

1.10 We support the approach presented at the 11th Modeling Conference that refined estimation of effective fugitive dust emissions should be considered for modeling that account for local depletion and agglomeration issues.

A presentation[6] by Dr. Chatten Cowherd at the 10th EPA Modeling Conference introduced several areas of overprediction for particulate matter concentrations due to depletion effects from fugitive emission releases. These effects are due to scavenging of particles by barriers or vegetation near the source, as well as agglomeration that result in a reduction of the fraction of small particles. As noted above, EPA has determined that these effects are to be considered as source characterizations, to be accomplished outside the AERMOD model. We provide a discussion of the design of a model emission pre-processor to compute the effects of the processes that would effectively deplete the effective particulate emission rate on an hourly basis.

1.11 AISI requests that EPA includes a statement or discussion in Appendix W to clarify that model receptors should be excluded from areas where the public does not have legal or physical access (within posted and patrolled property lines). The exclusion also would apply in locations where the public access is limited in terms of frequency or duration relative to the form of the NAAQS. In addition, these receptor location exclusions should be consistently applied when conducting modeling for NAAQS attainment, State Implementation Plans, and NSR/PSD purposes.

[6] http://www.epa.gov/ttn/scram/10thmodconf/presentations/1-14-Cowherd_Presentation_March_13_2012.pdf.

SPECIFIC COMMENTS ON EPA's PROPOSED CHANGES TO APPENDIX W

In this section, we provide more detailed comments on each area identified in the overarching comments. We also provide appendices and/or attachments to support these comments, as appropriate.

2.0 PROPOSED CHANGES TO AERMOD

2.1 AERMET "ADJ_U*" option and the AERMOD "LOWWIND3" options

2.1.1 We support the adoption of AERMET "ADJ_U*" option and the AERMOD "LOWWIND3" option as regulatory default options.

EPA is proposing to adopt as default options the low wind speed improvements to AERMET (ñADJ_U*ò option) and AERMOD (ñLOWWIND3òoption). As discussed below and further demonstrated in Attachments B, C and D, these options improve model accuracy and are based on peer-reviewed studies and EPA evaluations.

In 2010, the results of an evaluation[7] of low wind speed databases for short-range modeling applications were provided to EPA by AECOM in a study funded by the American Petroleum Institute (API) and the Utility Air Regulatory Group (UARG). The study was conducted because some of the most restrictive dispersion conditions and the highest model predictions occur under low wind speed conditions, but there had been limited model evaluation for these conditions. The results of the evaluation indicated that in low wind conditions, the friction velocity formulation in AERMET results in under-predictions of this important planetary boundary layer parameter. There were several modeling implications of this under-prediction: mechanical mixing heights that were very low (less than 10 meters), very low effective dilution wind speeds, and very low turbulence in stable conditions. In addition, the evaluation study concluded that the minimum lateral turbulence (as implemented in AERMOD through sigma-v) was too low by at least a factor of 2.

In late 2012, following further review of these issues[8] at the 10th EPA Modeling Conference, EPA made some revisions to the AERMOD modeling system to correct the model deficiencies in this area. This culminated in EPA releasing AERMET and AERMOD Version 12345, which included ñbetaòoptions in AERMET for a revised u_* formulation under stable conditions and two different low wind speed options in AERMOD. After its release, a bug was found with the ñbetaòoptions. The EPA subsequently released AERMET and AERMOD Version 13350 with corrections to this issue and other updates.
Among the changes incorporated into AERMOD 13350 are updates to the AERMET meteorological processor, described in the model change bulletin at http://www.epa.gov/ttn/scram/7thconf/aermod/aermet_mcb4.txt. One of the changes provides a ñbug fixò to the friction velocity (u_*) computation, as stated in the bulletin:

ñModified subroutine UCALST to incorporate AECOM's recommended corrections to theta-star under the ADJ_U* Beta option, based on Qian and Venkatram, that was incorporated in version 12345 of AERMET.ò

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[7] Paine, R.J., J.A. Connors, and C.D. Szembek. AERMOD Low Wind Speed Evaluation Study: Results and Implementation. Paper 2010-A-631-AWMA, presented at the 103rd Annual Conference, Air & Waste Management Association, Calgary, Alberta, Canada. 2010.

[8] See the presentation at http://www.epa.gov/ttn/scram/10thmodconf/presentations/1-12-AERMOD_Low_Wind_Speed_Evaluation_Study_Paine.pdf.

In addition to the evaluation information provided by EPA for low-level releases, AECOM has conducted additional testing of the low wind options for tall stack databases. The results of the testing have been accepted as a peer-reviewed paper to be published in the November, 2015 issue of the Journal of the Air & Waste Management Association; this paper is provided in Attachment C in pre-publication form. The results of supplemental testing of the proposed options (ADJ_U* and LOWWIND3) with two tall-stack databases are presented in Attachment D.

2.1.2 Prior to promulgation of proposed Appendix W changes, use of AERMOD v15181 with the AERMET "ADJ_U*" option and the AERMOD "LOWWIND3" should be allowed as an alternative model.

EPA's discussion of the AERMET u* option at the 11th Modeling Conference indicates that it is a beta non-default option. However, in his presentation[9] at the EPA's 11th modeling conference, Mr. Roger Brode noted that since this option is based upon peer-reviewed literature and due to favorable evaluation results for this option as documented in the EPA presentation, EPA is proposing to adopt the ADJ_U* option in AERMET and the LOWWIND3 option in AERMOD as default options upon promulgation of the proposed Appendix W changes.

Based upon this action, we recommend that use of the new version of AERMET and AERMOD be allowed now as an alternative model. Attachment B includes a discussion of the criteria for acceptance of a non-guideline modeling option and demonstrates how the new low wind options meet those criteria. A separate evaluation of the low wind options in Ohio[10] indicates support of early use of these model improvements for SO_2 Consent Decree modeling.

2.2 NO_2 Modeling Options

EPA is proposing to adopt as default options various updates to NO_2 modeling: the Ambient Ratio Method 2 procedure for Tier 2 modeling, and the Ozone Limiting Method and an updated Plume Volume Molar Ratio Method ("PVMRM2") for Tier 3 modeling.

An important issue for NO_2 modeling is that in most cases, a large percentage of the nitrogen oxides that are emitted by combustion processes are in the form of nitric oxide (NO), and the rest is the criteria pollutant nitrogen dioxide (NO_2)[11]. As stated by Podrez[12] in his discussion of the ARM2 algorithm, NO in the plume mixes with the atmosphere and reacts with ozone and other oxidants to transform a portion of the NO to NO_2. While there are numerous other atmospheric reactions[13] involving NOx species, at

9 See presentation at http://www.epa.gov/ttn/scram/11thmodconf/presentations/1-5_Proposed_Updates_AERMOD_System.pdf.

10 http://www.epa.ohio.gov/portals/27/SIP/SO2/C1-Gavin.pdf.

11 See discussion in EPA/600/R-08/071 Integrated Science Assessment for Oxides of Nitrogen – Health Criteria, July 2008. EPA.

12 Podrez, M. 2015. An Update to the Ambient Ratio Method for 1-h NO_2 Air Quality Standards Dispersion Modeling. *Atm. Env.*,103: 163–170.

13 These include further oxidation of NO_2 to nitrate radical (NO_3) and nitric acid (HNO_3), as well as photo-dissociation of NO_2 back to NO through the absorption of ultraviolet radiation during the daytime.

distances ranging up to 10 km where maximum ground level NO_x occur, the principal NOx reaction[14] is NO oxidation by ozone to form NO_2. An important aspect of NO to NO_2 conversion[15] is that the oxidation of NO to NO_2 in plumes is limited by two factors, 1) the chemical kinetics that govern the reaction rate of the oxidation process and 2) the degree to which the ozone in the ambient atmosphere is entrained into the plume. Because the complexity of chemical conversion mechanisms, an analysis of ambient measurements data from the very large North American database was used to derive a conservative empirical relationship between ambient NO_2 and NO_x forming the basis for the modified Tier 2 Ambient Ratio Method (ARM2) implemented in AERMOD, as described by Podrez[11].

2.2.1 NO_2/NOx Ratio: the default minimum in-stack NO_2/NOx ratio of 0.5 is overly conservative for most sources. EPA should adopt more realistic default values that can be assigned to various source types.

A key issue for the application of the Tier 2 and 3 NO_2 modeling techniques is the specification of the in-stack NO_2/NOx ratio. The minimum ratio estimated by ARM2 represents the in-stack ratio and the in-stack ratio is explicitly specified for OLM and PVMRM For ARM2, EPAǒs proposal specifies a national default for the minimum NO_2/NOx ratio of 0.5 and a maximum ratio of 0.9. However, EPAǒs proposal also indicates that refinement to the minimum ratio is possible:

> ñthe reviewing agency may establish alternative default minimum NO_2/NOx values based on the sourceǒs in-stack emissions ratios, with alternative minimum values reflecting the sourceǒs in-stack NO_2/NOx ratios. Preferably, alternative default NO_2/NOx values should be based on source-specific data which satisfies all quality assurance procedures that ensure data accuracy for both NO_2 and NOx within the typical range of measured values. However, alternate information may be used to justify a sourceǒs anticipated NO_2/NOx in-stack ratios, such as manufacturer test data, state or local agency guidance, peer-reviewed literature, and the EPAǒs NO_2/NOx ratio database.ò

We note, as presented[16] by Richard Hamel at the 11th modeling conference, that less than 5% of the sources in EPAǒs In-Stack Ratio database have ratios at or above 0.5. Therefore, the default ratio is a placeholder that is very conservative for most sources. We expect EPA to provide procedures to states and regions to establish more realistic and much lower default ratios for several source categories. EPA should analyze the in-stack database to define the default ratio by source type. If source-specific data were available, that would be used in place of the source specific default value. EPA needs to analyze the in-stack database and evaluate what source types have in-stack ratios that approach 0.5, so that the default ratios that approach 0.5 can be restricted to those source types. This approach would eliminate the conservative nature for ARM2 default values. A more appropriate default in-stack ratio for ARM2 is 0.2.

In Attachment E, we provide a further discussion of these issues and other references (including some from EPA) that support more realistic ratios for the ISR that are often much lower than 0.5. These

[14] For more discussion, see Karamchandani, P. , A.Koo, and C. Seigneur, 1998. Reduced gas-phase kinetic mechanism for atmospheric plume chemistry. *Environ. Sci. Technol.* 32(11), 1709-1720.

[15] As discussed by Janssen, L.H.J.M., Nieuwstadt, T.F.T.M., Donze, M., 1990. Time scales of physical and chemical processes in chemically reactive plumes. *Atm. Env*. 24A (11), 2861-2874.

[16] http://www.epa.gov/ttn/scram/11thmodconf/presentations/2-5_EPA_ARM_vs_ARM2-Hamel.pdf.

references and data from various permit application submittals to EPA should be added to the ISR database.

2.2.2 ARM2 Option: We support the adoption of ARM2 as a refined Tier 2 regulatory default option, in conjunction with more realistic default in-stack NO_2/NOx ratios.

The peer-reviewed paper by Podrez[11] provides substantial evidence supporting the adoption of the ARM2 approach as an improved Tier 2 procedure for NO_2 modeling. In addition, the supporting docket item that describes the API-sponsored development and evaluation[17] of the ARM2 procedure is additional evidence supporting the adoption of ARM2 as a preferred procedure. In addition, it is evident from other investigators[18],[19] that the ARM2-developed relationship of a variation of the NO_2/NOx ratio as a function of total NOx is appropriate.

Other points that we would like to make in support of the proposed adoption of ARM2 are:

- ARM2 accuracy is based on an extensive database of actual monitoring data and the regression was conservatively established based on upper bounds of the data.

- ARM2 model accuracy is not influenced by compensating errors. NO_2 conversion is accurately coupled to NOx model projections.

While in-stack NO_2/NOx ratios are typically 0.1 or less, this information is not available to all sources, especially for new installations for which field testing is still pending. Due to these additional information requirements regarding in-stack NO2/NOx ratios that EPA is proposing for ARM2, we recommend that the current ARM approach should be retained as a screening Tier 2 approach. ARM2 should be considered as a refined Tier 2 approach with a default minimum NO_2/NOx ratio of 0.2 (as is currently coded in AERMOD version 15181).

2.2.3 Ozone Limiting Method (OLM) and Plume Volume Molar Ratio Methods (PVMRM and PVMRM2): We support the adoption of OLM and either PVMRM or PVMRM2 as approved Tier 3 techniques in AERMOD that can be used without consultation with the Model Clearinghouse.

For several years, EPA has provided support for these options, while requiring them to be approved on a case-by-case basis. EPA has provided a new Technical Support document[20] for these Tier 3 options in further support of the proposal. We concur that it is time to adopt these procedures as default options in AERMOD.

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[17] http://www3.epa.gov/ttn/scram/models/aermod/ARM2_Development_and_Evaluation_Report-September_20_2013.pdf.

[18] Scire, J. and M. Borissova, 2011. An Empirical Method for Modeling Short-Term and Annual NO2 Concentrations in Regulatory Models. TRC. Energy & Environment Conference (EUEC), Phoenix, AZ.

[19] Karamchandani, P., R. Morris, B. Brashers, L. Parker, S. Chen, E. Knipping, B. Chowdhury, I. Sykes, 2013. Using SCICHEM-2012 to Determine Single-source Secondary Impacts and Comparisons with Other Modeling Approaches. Control #45, presented at the Air & Waste Management Associationȹs Specialty Conference, Guideline on Air Quality Models: the Path Forward, Raleigh, NC. March 2013.

[20] http://www3.epa.gov/ttn/scram/11thmodconf/AERMOD_NO2_changes_TSD.pdf.

For Tier 3, EPAøs proposal indicates that a detailed screening technique, either the Ozone Limiting Method or the revised Plume Volume Molar Ratio Method, may be applied on a case-by-case basis. EPA indicates that ñbecause of the additional input data requirements and complexities associated with the Tier 3 options, their usage shall occur in consultation with the EPA Regional Office in addition to the appropriate reviewing authority.ò We concur that it is not necessary to seek EPA Model Clearinghouse approval to use these options, and we expect EPA to direct the Regional Offices to provide expeditious approval of requests to use these techniques. After promulgation of the proposed changes to Appendix W, we expect that obtaining Regional Office approval for every use of OML or PVMRM/PVMRM2 should not be needed.

At this time, it is evident that the 90-day comment period is not sufficient to determine whether PVMRM or PVMRM2 should be ultimately recommended as a default version. We reserve the right to comment about this issue after the 90-day period has ended because further substantial testing is needed, especially for NO_2/NOx ratios at near-field distances.

As noted above, a chief concern is the default minimum NO_2/NOx ratio and would expect that this ratio will ultimately not be applicable for the majority of applications.

2.2.4 Incomplete Conversion of NO to NO_2 at Near-Field Distances: An important issue for cases where maximum modeled NO_x concentrations occur in the near-field (e.g., fence line) is that the limited transport time that is insufficient for oxidation (reaction of ozone with NO) to fully take place.

This issue is further discussed by Hanrahan (1999)[21] and also in Attachment F, and it is a feature that should be added to AERMOD on a priority basis.

To accommodate this important issue, we suggest the following additional text in Appendix W, Section 4.2.4.3f, before the last sentence: as Hanrahan (1999) indicates, current AERMOD NO_2 algorithms do ónot account for the finite reaction time of NO conversion to NO_2.ô This makes AERMOD, without consideration of this finite reaction time, óconservative at the closest receptors where this reaction time is important.ô Until AERMOD incorporates this effect, case-specific adjustments to AERMOD predictions at the closest receptors can be considered.ò

2.3 Incorporation of Plume Rise Characteristics from the Buoyant Line and Point (BLP) Model into AERMOD

We support adding the capability to model buoyant line sources in AERMOD, but more testing is required. Proposed revisions should continue to be treated as a beta version after the comment period ends due to limited user testing possible within 90 days, known bugs, and incomplete features.

EPA has incorporated the plume rise characterization available in the Buoyant Line and Point (BLP) model into AERMOD. The capability of modeling buoyant line sources in AERMOD is a needed enhancement, and we are generally supportive of its availability. The documentation provided by EPA for this installation generally shows that the algorithm is in reasonable agreement with the BLP model upon

[21] Hanrahan, P.L. 1999. The plume volume molar ratio method for determining NO2/NOx ratios in modelingô Part I: Methodology. *J. Air Waste Manage. Assoc.* 49:1324ï 31. doi:10.1080/10473289.1999.10463960

which it is based. BLP has been adapted to AERMOD by replacing stability-category-based dispersion estimates.

However, there are a number of identified issues with the BLP implementation[22], and substantially more testing of this new modeling tool is needed, extending beyond the Appendix W comment period. Proposed revisions should continue to be treated as a beta version after the comment period ends due to limited user testing possible within 90 days, known bugs (incompatible with "background" keyword), and incomplete features ("SO BLPGROUP"). Issues we have identified include:

- The sources run with this capability cannot be modeled with the Tier 3 NO_2 modeling approaches because EPA has not implemented these features yet.
- There are inconsistencies between the AERMOD BLP and the original BLP in the following areas:
- Building wakes effects in AERMOD/BLP are treated using an initial dispersion coefficient versus PRIME algorithms in AERMOD.
- The highest BLP/AERMOD predictions are much higher in the testing than the BLP concentrations, and the EPA contractor cannot explain this issue. This is not a satisfactory explanation and needs further review by EPA.

2.4 Treatment of Elevated Plumes: We support the changes to AERMOD's treatment of elevated plumes released into urban boundary layers.

EPA has altered the treatment of elevated plumes released into urban boundary layers to avoid an artificial trapping result for plumes that would be expected to rise into the nocturnal layer above the urban boundary layer. We are supportive of this change to AERMOD.

In the previous versions of AERMOD, buoyant plume rise for sources characterized as urban areas was limited to 1.25 times the urban boundary layer height, regardless of plume buoyancy. This formulation error resulted in an artificial limit to plume rise and model overpredictions, especially for small urban areas with a low urban boundary layer height.

The correction for this problem involves not limiting the plume height to 1.25 times the urban boundary layer height, but instead allowing the plume to penetrate into the stable layer above the urban boundary layer. This approach is an improvement, but we also have concerns about AERMOD's treatment of the penetrated plume, as further discussed below in Section 2.7.

2.5 AERSCREEN

EPA has proposed replacing SCREEN3 with AERSCREEN as the preferred short-range screening model. EPA has also installed a fumigation / inversion breakup algorithm into AERSCREEN.

2.5.1 EPA should consider developing a simplified version of AERSCREEN that conservatively evaluates modeled concentrations with reduced user input.

EPA's existing screening modeling tool, SCREEN3, is based on the previous Guideline Model ISCST3. SCREEN3 is designed to be run by individuals with limited knowledge of dispersion modeling, making it an attractive and effective screening tool. AERSCREEN, in contrast to SCREEN3, can only be used by a professional with specific training in dispersion modeling. This means that parties interested in

[22] Some of these issues were noted in the APM A&WMA presentation available at http://www.epa.gov/ttn/scram/11thmodconf/presentations/2-11_APM_AERMOD_Comments.pdf.

conservatively estimating a single sourceҫ impact will need to acquire specialized knowledge or undergo training in dispersion modeling or hire a qualified consultant. This in large part may limit the ability to conduct rapid assessments or sensitivity studies during the design phase of a project. The chief advantage of SCREEN3 and predecessors SCREEN and SCREEN2 is that they could be applied by a person with rudimentary computer skills, with a short list of readily available information, and that reproducible results are readily achievable. Essentially, the only aspect of SCREEN3 requiring expert judgment is the selection of rural or urban dispersion factors, whereas AERSCREEN requires the user to specify or derive rather obscure and specialized parameters such as albedo, Bowen ratio and surface roughness. Thus, running AERSCREEN essentially requires a similar level of expertise as running AERMOD, somewhat eliminating a key advantage of screening models.

In replacing SCREEN3 with AERSCREEN, EPA will be eliminating a user-friendly screening tool and replacing it with a set of programs that apply more ñadvancedò dispersion modeling concepts, but are much more data intensive and time-consuming to run, and which require expert judgment. To remedy this situation, EPA should consider developing a simplified higher-level screening version of AERSCREEN that conservatively evaluates modeled concentrations with reduced user input. Until that time, EPA should allow the use of SCREEN3 as an approved alternative screening model.

2.5.2 The dated fumigation / inversion break-up formulation in AERSCREEN is very conservative.

In addition to ease of use, there are also concerns about the modelҫ formulation, passed along from SCREEN3, regarding fumigation / inversion breakup and interpretation of building information from Building Profile Input Program. The principal use of the fumigation /inversion breakup algorithm in SCREEN3 and AERSCREEN is to determine whether these conditions are more controlling of peak concentrations than the range of conditions covered by the main dispersion model. However, it is evident that these screening models use a dated formulation taken from Turnerҫ 1970 Workbook[23], some 45 years old.

It is uncertain why EPA has not introduced a more recent formulation of shoreline fumigation or inversion breakup in AERMOD or AERSCREEN. Part of this issue may be due to the fact that these processes may require multiple hours to occur, and AERMOD is a steady-state (1 hour at a time) model. A more advanced sequential hourly model, the Shoreline Dispersion Model (SDM)[24] could be used for shoreline fumigation modeling. Relative to SCREEN3 and AERSCREEN, SDM has the most advanced treatment with a Thermal Internal Boundary Layer (TIBL) as part of the formulation, and uses meteorological data from both offshore and onshore sources, similar to the EPA-preferred Offshore and Coastal Dispersion (OCD)[25] model. The formulation in SDM has also been subjected to model evaluation review[26,27]. Therefore, it is likely that the AERSCREEN or SCREEN3 fumigation / inversion breakup predictions are very conservative and cannot be relied upon to provide credible estimates of concentrations for these

[23] Available at nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=9100JEIO.TXT. Also available in a second edition as Turner, Bruce D. Workbook of Atmospheric Dispersion Estimates: Second Edition. Boca Raton, CRC Press LLC, 1994.

[24] Available as an alternative model at http://www.epa.gov/ttn/scram/dispersion_alt.htm.

[25] Available at http://www.epa.gov/ttn/scram/dispersion_prefrec.htm#ocd.

[26] Stunder, M. and S. SethuRaman, 1986: A statistical evaluation and comparison of coastal point source dispersion models. *Atmos. Environ.*, 20, 301-315.

[27] U.S. Environmental Protection Agency, 1987: Analysis and Evaluation of Statistical Coastal Fumigation Models. EPA-450/4-87-002.

conditions. However, the comparison of the AERSCREEN predictions of fumigation / inversion breakup concentrations relative to all other conditions can be useful for ruling out the fumigation / inversion breakup as a controlling issue.

2.5.3 A coding error in AERSCREEN's use of BPIP output needs to be corrected.

Another area where AERSCREEN is more complex than SCREEN3 is the specification of the controlling building height, width, and length. SCREEN3 actually asks for the minimum and maximum horizontal dimensions to represent the length and width. Instead of simply asking the user for these same inputs, AERSCREEN forces the user to run the Building Profile Input Program to first obtain a refined-level input data set that has building dimensions for 36 directions. Then AERSCREEN takes the maximum and minimum dimensions over these directions for use in modeling the building width and length. However, since for some directions, there may be no building influence, AERSCREEN erroneously takes a zero dimension as building width; this is a coding error that needs to be fixed.

2.6 AERMOD PRIME Building Downwash Algorithm: The AERMOD PRIME building downwash algorithm was not updated; several previously identified improvements are needed.

At the 2014 Modeling Workshop, EPA identified[28] several needed updates of the AERMOD PRIME model. The areas that need updates for AERMODɠs downwash algorithm are as follows:

- For long and narrow buildings, BPIP can greatly exaggerate the buildingɠs length and width for approach flows that are not perpendicular to a building face.

- In very light wind, stable conditions, worst-case downwash concentrations can result for conditions are intuitively should not result in aerodynamic downwash.

- The PRIME model does not have a meander component capability.

- For stacks at or above GEP height, AERMOD currently considers downwash effects, but this area of the PRIME model application is mostly untested and is likely to over-predict the effects of the building wake, as noted in comments at the 11th EPA modeling conference by Ron Petersen[29].

2.7 AERMOD Penetrated Plume Formulation: For some AERMOD applications, overpredictions result from the AERMOD penetrated plume formulation. EPA should review the formulation and consider changes to address the overprediction.

It has been observed in numerous AERMOD applications for tall stacks in relatively flat terrain that the peak concentrations are dominated by convective conditions (usually the morning) with low mixing heights. Our review of modeling results with a ῭DISTANCE DEBUGὸ enhanced debugging output[30] confirm that the peak concentrations are caused by the penetrated plume.

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[28] See Roger Brodeɠs presentation at http://www.cleanairinfo.com/regionalstatelocalmodelingworkshop/archive/2014/Presentations/Tues/005-Brode_AERMOD_System_Update_PlansPriorites_AppW_Updates_RSL-SLC_05-20-2014.pdf.

[29] Available at http://www.epa.gov/ttn/scram/11thmodconf/presentations/3-6_Building_Downwash-CPP-11thMC.pdf.

[30] Available for download at the EPRI web site: http://sourceforge.net/projects/epri-dispersion/.

This condition was further discussed by Paine[31] at the 11th Modeling Conference. This result is unexpected because the penetrated plume is traditionally considered to be a condition that results in an elevated plume that mixes to the ground slowly. The previous model, ISC, considered zero ground-level concentrations for this type of condition. It is evident that AERMOD somehow mixes this plume to the ground much more rapidly than expected.

The Paine presentation noted above cites two independent evaluation studies[32,33] that both resulted in an overprediction of up to 50% for this condition, conjecturing that the vertical mixing of the plume is overstated. EPA should further review the AERMOD penetrated plume formulation and consider changes that will alleviate the overprediction error. In the meantime, EPA should state in Appendix W that controlling AERMOD predictions due to this issue should be used with caution.

[31] See presentation at http://www.epa.gov/ttn/scram/11thmodconf/presentations/2-4_Penetrated_Plume_Issues.pdf.

[32] Paine, R., O. Samani, M. Kaplan, E. Knipping, and N. Kuman, 2015. Evaluation of Low Wind Modeling Approaches for Two Tall-Stack Databases. To appear in J. Air & Waste Manage. Assoc., December 2015; provided as Attachment C.

[33] Rayner, K. 2013. Presentation to Clean Air Society of Australia and New Zealand Air Quality Conference, September 2013. Available at http://www.casanz.org.au/sigs/ModSIG%20Workshop%20Sydney%20Conference%20%208%20September%20201/Rayner_2013ModSIG_Workshop.pdf , slides 16-18.

3.0 EPA PROPOSALS FOR LONG-RANGE TRANSPORT (LRT) MODELING

EPA is proposing to remove and not replace the current preferred model for LRT modeling, CALPUFF. As outlined below, EPA indicates that most projects that meet the NAAQS in the near-field will likely show insignificant impacts at a 50-km distance, eliminating the need for LRT modeling. EPA provides in its Technical Support Document EPA-454/B-15-003[34] a method for using AERMOD to screen for long range impacts. Should LRT modeling be needed for increment assessment, EPA proposes that CALPUFF or another Lagrangian model could be used.

From the proposed rule (80 FR 45350), EPA states:

> ñThe EPA is seeking comment on its proposed screening approach to address long-range transport for purposes of assessing PSD increments; its decision to remove CALPUFF as a preferred model in appendix A for such long- range transport assessments; and its decision to consider CALPUFF as a screening technique along with other Lagrangian models to be used in consultation with the appropriate reviewing authority.ò

From the Technical Support Document for AERMOD-Based Assessments of Long-Range Transport Impacts for Primary Pollutants [EPA-454/B-15-003], EPA states:

> ñThe results from this analysis indicate that for most facility types, if the facility can confirm compliance with the short-term standards in the near-field, then there are not likely to be significant impacts at 50 km. Thus, for most facilities that show compliance in the near-field, no evaluation of LRT would be needed.ñ

3.1 EPA's proposed method of using AERMOD or other dispersion models to screen for long range impacts may not be viable for some applications such as assessment of $PM_{2.5}$.

The proposed method using AERMOD or other approved near-field dispersion model results at 50 km from the source subject to a PSD application has not been thoroughly reviewed or vetted.

One example pollutant for which this approach is not generally expected to be viable is $PM_{2.5}$. Consider that the 24-hour Class II NAAQS is 35 µg/m^3, and this is in the form of the 98th percentile value. However, the Class I 24-hour Significant Impact Level (SIL) is only[35] 0.07 µg/m^3, which is *one 500th* of the NAAQS, without even considering that the form of the SIL is the highest value. Accounting for the difference in forms means that the drop in near-field predictions for $PM_{2.5}$ would need to approach *three orders of magnitude* for the AERMOD screening method to work. None of the examples that EPA presents in any of the appendices of its TSD for AERMOD-Based Assessments of Long-Range Transport Impacts for Primary Pollutants indicates a drop in the concentrations at 50 km to even close to 2 orders of magnitude, much less 3 orders of magnitude. In addition, if secondary formation of $PM_{2.5}$ is taken into account (which actually increases with distance and which AERMOD currently cannot model), the modeled impacts at 50 km could increase further. This means that the AERMOD screening method is not workable, and an LRT model must be used.

[34] Docket Item EPA-HQ-OAR-2015-0310-0017.

[35] This particular SIL is not consistent with the annual SIL, which at 0.06 µg/m^3 is almost the same as the 24-hour SIL. It is clear that the 24-hour $PM_{2.5}$ Class I SIL is far too low. Note that the court has vacated the $PM_{2.5}$ SILs and EPA intends to issue another rulemaking to promulgate new $PM_{2.5}$ SILs, but they are still used in Class I area analysis.

3.2 The Modeling Guideline (or an EPA Clarification Memo) should include additional guidance regarding use of AERMOD or other dispersion models to screen for long range impacts.

There are also unanswered issues about how the AERMOD screening would be performed. For example, we recommend that the screening require modeling only for receptors "at or about 50 km" in directions subtending the Class I area. However, if the Class I area is further than 50 km away, the receptors should be placed at the nearest distance to the Class I area, no matter how far away. This is still conservative since the 50-km upper limit for AERMOD application is a policy decision, not based in any scientific limitation. However, for long transport times, the assumption of a persistence of the worst-case dispersion conditions for several hours and straight-line plume travel is conservative.

3.3 The Modeling Guideline should provide a streamlined process for approval of LRT screening models. EPA should establish the basic conditions in which CALPUFF and similar screening tools can be used to assess PSD increments of SO_2, PM_{10} and NO_2.

Replacement of a preferred LRT model to assess Class I area PSD increments by case-by-case determination of model applicability may lead to an involved justification process resulting in unnecessary permit denials or delays. The proposed guideline recommends "a screening approach where CALPUFF along with other appropriate screening tools and methods may be used to support long- range transport PSD increment assessments"[36]. There are presently PSD increments only for particulate matter, SO_2 and NO_2, none of which require, in most cases, detailed characterization of photochemical processes that would require application of a photochemical grid model. In these instances, consistent with the above statement, the Guideline should provide a streamlined process for the reviewing authority to approve the use of CALPUFF with advanced chemistry (or some other long-range model) as an alternative model without requiring a potential time-consuming justification and lengthy review cycle for each application, which needs to go through the Model Clearinghouse according to another EPA proposed action. We suggest that EPA establish, perhaps through a generally applicable Model Clearinghouse determination, the basic conditions in which CALPUFF and similar tools can be applied to assess PSD increments of SO_2, particulate matter, and NO_2.

Another overarching concern is that in the absence of a recommended LRT model, the recently released tiered guidance on $PM_{2.5}$ (and ozone) modeling is insufficiently developed to be useful in determining how to proceed with an air quality assessment requiring LRT modeling. This situation presents a difficult challenge to the regulated community in designing and siting a facility that is likely to meet permitting requirements. Specific issues with these approaches are discussed in separately in other areas of our comments.

3.4 We support EPA allowing use of CALPUFF as an alternative long-range transport model. EPA should also allow use of versions of CALPUFF with more advanced chemistry (e.g., version 6.42 with the ISORROPIA chemistry options).

EPA's decision to remove CALPUFF as a preferred long-range transport model appears to be mainly due to three factors: a) the ownership of CALPUFF has changed several times, making the coordination of changes and management for the model a significant challenge, b) there are concerns about the technical merits of the model, as noted in the 2012 Long Range Transport evaluation study[37]; and c) the model does not contain the complete suite of photochemical reactions.

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[36] *Federal Register* / Vol. 80, No. 145 / Wednesday, July 29, 2015 / Proposed Rules 45349.

[37] http://www.epa.gov/scram001/reports/EPA-454_R-12-003.pdf.

The ownership of CALPUFF appears to have stabilized with Exponent. We encourage EPA to work cooperatively with Exponent for ongoing CALPUFF developments as suggested in Exponentõs presentation at the 11th Conference on Air Quality Models.

The 2012 LRT evaluation study was a valuable addition to the growing sets of such analyses. The expense of taking the measurements, generally during short periods, limits the overall conclusions that one can make. At the 10th EPA conference, Mr. Joseph Scire presented information[38] that indicated that reasonable alternatives to the way CALPUFF was run could make significant changes to the evaluation results, resulting in improved performance if the alternative approaches were used.

CALPUFF is accepted as a preferred model in other countries such as Canada, Australia, and New Zealand. There is a substantially long period of acquaintance and experience with the model in the United States. Therefore, we support EPAõs proposal to allow the continued use of CALPUFF as an alternative model.

Although CALPUFF does not include photochemical reactions, the newer versions (e.g., v6.42) do include improved aqueous-phase chemistry and aerosol thermodynamics modules. If used as an alternative model and not considered an EPA-approved model, the testing and evaluation of CALPUFF using the CALPUFF Assessment Tool to determine how the model changed from the previous version is no longer appropriate or needed. Instead, the testing and evaluation should focus on whether CALPUFF, run with a specific configuration, can be determined to consistently produce conservative results relative to the highest tier 2 Chemical Transport Model (CTM) modeling approach. The results of EPAõs LRT evaluation study[39] indicate that this is the case (CALPUFF modeling estimates are conservative relative to CAMx), and thus CALPUFF meets EPA requirements for a screening model.

[38] http://www3.epa.gov/ttn/scram/10thmodconf/presentations/3-4-ETEX_10thConference_Final.pdf.

[39] ŏDocumentation of the Evaluation of CALPUFF and Other Long Range Transport Models Using Tracer Field Experiment Dataõ, available at http://www.epa.gov/scram001/reports/EPA-454_R-12-003.pdf.

4.0 METHODS FOR ADDRESSING SINGLE-SOURCE MODELING OF SECONDARY IMPACTS OF $PM_{2.5}$ AND OZONE

4.1 EPA's proposed tiered approach for assessing secondary $PM_{2.5}$ and ozone impacts needs additional development to be useable. With an incomplete conceptual framework, implementation of the proposed modeling procedures will be difficult and could lead to significant permitting delays.

EPA has added a new chapter to Appendix W to handle the modeling of secondarily-formed pollutants such as ozone and $PM_{2.5}$. The modeling approach basically has three tiers:

- If emission changes for precursor pollutants (e.g., NOx, VOCs, SO_2, etc.) from a proposed project are below the ñModel Emission Rates for Precursorsò or ñMERPsò then the project is assumed not to have a significant impact on these secondarily-formed pollutants, and modeling is not necessary.
- Otherwise, the first tier of the modeling approaches would be expected by EPA to use ñexisting empirical relationships between precursors and secondary impacts based on modeling systems appropriate for this purpose as detailed in this guidance.ò EPA goes on to state that ñIt is also possible screening approaches based on full science chemical transport modeling systems (e.g. reduced form models) could provide information to satisfy the first tier in some situations. The use of pre-existing credible technical information or a screening model for the purposes of estimating single source secondary impacts will be considered on a case-by-case basis and should be done in consultation with the appropriate permitting authority.ò
- However, there may be a need for a more refined modeling approach in some cases (a second tier analysis). EPA has issued other procedures[40] for this approach that would likely involve Chemical Transport Models.

EPA has, in its proposal, established a basic framework for addressing ozone and $PM_{2.5}$ impacts under PSD permitting. However, there are many uncertainties and undefined components in the framework, and more work is needed by EPA to develop practical and objective modeling guidance.

A regional approach to the establishment of MERPs and modelling requirements is likely necessary, and that would involve significant coordination with regional agencies and the agreement on modeling platforms. With an incomplete conceptual framework, implementation of the proposed modeling procedures will be difficult and could lead to significant permitting delays.

Modeling protocols and tools have not been adequately demonstrated to be appropriate or accurate for demonstrating compliance with the ozone NAAQS for a single point source. Therefore, EPA should not implement new requirements for single point sources to model ozone impacts until appropriate independent and formal peer-reviewed studies have been completed. In any case, a minimum 1-year transition period after promulgation of the revised Appendix W should be provided for the implementation of the single-source modeling for ozone and secondary $PM_{2.5}$ concentrations to allow the peer review to occur and to allow EPA to provide more meaningful guidance.

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[40] Environmental Protection Agency, 2015. Guidance on the use of models for assessing the impacts from single sources on secondarily formed pollutants ozone and PM2.5. Publication No. EPA 454/Pï 15ï 001. Office of Air Quality Planning & Standards, Research Triangle Park, NC. (http://www3.epa.gov/ttn/scram/11thmodconf/Draft_Guidance_SingleSource_SecondarilyFormed-07152015.pdf).

4.2 MERPs

4.2.1 In principle, we support the concept of Model Emission Rates for Precursors (MERPs). However, the usefulness of these screening thresholds cannot be assessed until the MERP levels are proposed.

As part of the proposed Appendix W revision, EPA included two memoranda[41,42] from Tyler Fox dated June 30, 2015 that discuss the proposed approach for demonstrating ozone and $PM_{2.5}$ PSD compliance. These memoranda introduce the concept of Model Emission Rates for Precursors (MERPs). If the source's ozone and/or $PM_{2.5}$ precursor emission rates are below the MERP, then the source's ozone and/or $PM_{2.5}$ impacts would be below the Significant Impact Level (SIL) so the source would not have to address, through modelling, ozone and secondary $PM_{2.5}$ issues under PSD. We support the concept of the MERPs as it will simplify PSD compliance demonstrations for ozone and secondary $PM_{2.5}$ for sources that clearly have an insignificant impact. However, it is difficult to comment on the MERP approach as EPA does not present the procedures for how the MERPs will be calculated and the ozone and $PM_{2.5}$ SILs have not yet been defined.

4.2.2 We reserve the right to supplement our comments on the proposed Appendix W revisions following EPA proposal of PM2.5 and ozone MERPs/SILs. Without information on MERP/SIL levels, we cannot completely assess the regulatory burden of the proposed revisions.

EPA states they intend to pursue a separate rulemaking to establish ozone and $PM_{2.5}$ SILs and MERPs. It is unfortunate that this rulemaking is separate from the current rulemaking because the magnitude of the MERPs will affect the need for modeling procedures (not clearly defined by this proposed rulemaking). We reserve the right to comment on the ozone/$PM_{2.5}$ SILs/MERPs in the future and how those values could affect the regulatory burden for newly proposed sources.

4.3 First Tier Assessments

4.3.1 The First Tier assessment procedures lack definition and specificity. EPA should develop additional guidance applicable for each region of the country, with specific examples of acceptable approaches.

The First Tier is proposed to consist of reviewing "existing empirical relationships between precursors and secondary impacts, based on modeling systems appropriate for this purpose as detailed in this guidance." EPA also notes that "it is also possible screening approaches based on full science chemical transport modeling systems (e.g., reduced form models) could provide information to satisfy the first tier in some situations." Also, "the use of pre-existing credible technical information or a screening model for the purposes of estimating single source secondary impacts will be considered on a case-by-case basis and should be done in consultation with the appropriate permitting authority." The procedures for this tier lack definition and required specificity. EPA needs to develop additional more explicit guidance applicable for each region of the country, with specific examples of acceptable approaches.

[41] "Proposed Approach for Demonstrating Ozone PSD Compliance", EPA Docket Item EPA-HQ-OAR-2015-0310-0006.

[42] "Proposed Approach for Demonstrating $PM_{2.5}$ PSD Compliance", EPA Docket Item EPA-HQ-OAR-2015-0310-0005.

4.3.2 EPA proposes that hybrid modeling approaches or "reduced form" models could be used for most of the modeling requirements for predicting single-source impacts of secondary $PM_{2.5}$ or ozone. We provide comment on two possible modeling approaches.

EPA has issued new guidance[43] for both tiers of a modeling approach for single-source impacts on ozone and secondary $PM_{2.5}$. For the first modeling tier (needed if a projectõs emissions will exceed the currently undefined MERPs), EPA offers the following discussion:

> ñUnder the first tier, existing technical information is used in combination with other supportive information and analysis for the purposes of estimating secondary impacts from a particular source. The existing technical information should provide a credible and representative estimate of the secondary impacts from the project source. In these situations, a more refined approach for estimating secondary pollutant impacts from project sources may not be necessary where agreement is reached with the permitting authority.
>
> EPA has been compiling and reviewing screening models, screening approaches, and reduced form models that are based on technically credible tools (e.g. photochemical grid models) that relate source precursor emissions to secondary impacts. A review of existing approaches detailed in peer reviewed journal articles and non-peer reviewed forms (e.g. technical reports, conference presentations) indicates a very limited number of screening approaches have been developed and fewer still have been fully documented and tested for robust application (U.S. Environmental Protection Agency, 2015). One example of a reduced form model is the development of a tool for the New South Wales (NSW) Greater Metropolitan Region in Australia (Yarwood et al., 2011)[44]. High O_3 impact days are modeled using a photochemical grid model with the higher order Decoupled Direct Method (HDDM) (Dunker et al., 2002) to calculate sensitivity coefficients for O_3 to additional NOx and VOC emissions from new hypothetical sources. The resulting O3 sensitivity coefficients then allow O_3 impacts to be estimated for other NOx and/or VOC sources within the same metropolitan area. The relevancy and applicability of a given screening technique should be discussed with the permitting authority for a determination about whether that approach would fulfill or partially fulfill a first tier assessment.ò

Note that the example of the ozone reduced form model first requires the regional-specific application of a higher tier model to develop the applicable relationships. No generic example of a procedure is given for ozone.

We comment below on two possible approaches for the first modeling tier of ozone and secondary $PM_{2.5}$ using existing techniques that could be considered as examples of screening approaches.

Ozone Screening Approach: OZIPR

EPA currently lists the Ozone Isopleth Plotting Program (OZIPR) as an alternative model, available at http://www.epa.gov/ttn/scram/dispersion_alt.htm. OZIPR is a photochemical box model that simulates the

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[43] ñGuidance on the use of models for assessing the impacts of emissions from single sources on the secondarily formed pollutants ozone and PM2.5ò Available at http://www.epa.gov/ttn/scram/11thmodconf/Draft_Guidance_SingleSource_SecondarilyFormed-07152015.pdf.

[44] A presentation for this screening procedure is available from EPAõs 10th modeling conference at http://www.epa.gov/scram001/10thmodconf/review_material/yarwood_screening_method_2011.pdf.

atmospheric photochemical reactions downwind of a source area and the change in initial ozone concentrations as a result of new emissions of ozone precursors.

In an example application of OZIPR described here, the simulated box is initialized at 8 AM of a day being analyzed with an initial concentration of ozone precursors, NOx and VOC. The top of the box, which represents the mixing depth, increases as the day progresses. OZIPR first generates isopleth plots of maximum 1-hour afternoon ozone concentrations corresponding to combinations of NOx (y axis) and VOC (x axis) initially in the box during the morning before photochemical reactions commence. The isopleths are used in the manner described below to semi-quantitatively evaluate the potential change of the maximum 1-hour ozone concentration associated with an increase in concentrations of ozone precursors due to a group of upwind sources.

In this generic example applied in the past with higher ozone and different forms of the standard, OZIPR was applied for a typical summer day for which maximum ozone production is expected. Given that sunlight is the driver for photochemical reactions, the simulation was conducted for the summer solstice. It is possible to estimate mixing heights from Holzworth (1972)[45], resulting for this example with a morning mixing height of 800 m and afternoon mixing height of 1400 m. OZIPR contains three options for chemical mechanisms; for this application, we applied the CB-4 mechanism.

OZIPR was run in this case for a new projectœ primary emission sources, consisting of maximum emission rates of 100 g/s for NOx and 5 g/s for VOCs. To estimate the average incremental concentration within the OZIPR "box", we used the morning box height of 800 m. The box width is established at a presumed area of influence about 20 km downwind; this distance can be changed in the model. At this location, the user-specified box width is 15 km, representing a fairly large horizontal plume spread in convective conditions. The assumption of unstable conditions is appropriate because ozone formation requires sunlight.

To complete the calculation of the proposed sourceœ ozone precursor concentrations in the box, we used a typical summer morning mixed layer wind speed of 4 m/sec (available from the same Holzworth 1972 reference). Initial concentrations of NOx and VOC are specified as input to OZIPR. The results from OZIPR are incremental concentrations of NOx and VOC.

The site-specific ozone isopleths are provided in Figure 1. The x-axis represents the possible values for the initial concentration of VOC in the box and the y-axis the initial concentration of NOx.

The next step in the ozone analysis was to identify the applicable ozone isopleth that is representative of present conditions (without adding the proposed source influence). Monitoring data indicated a maximum daily hourly ozone concentration is about 11 parts per hundred million (pphm). The ratio of VOC to NOx in the lower atmosphere generally ranges from about 5:1 to 15:1 as plotted in Figure 1, with the higher ratios indicative of remote forests and lower ratios indicative of populated areas.

The final step in the OZIPR process was to graphically add the source-related ozone precursor box concentrations onto the OZIPR isopleth plot. Figure 1 provides a plot of the baseline ozone precursor box concentrations (blue triangles) associated with the 11 pphm isopleth and the increased ozone precursor box concentrations (red squares) when the proposed stationary source emissions are added. The magnitude of the resultant maximum daily 1-hour ozone concentration can be approximated by the

[45] Holzworth, 1972. "Mixing Heights, Wind Speeds and Potential for Urban Air Pollution throughout the Contiguous United Statesö, Office of Air Programs. Available at http://www.eahcp.org/documents/1972_Holzworth_MixingHeights-etc.pdf.

relative location of the red squares with respect to the ozone isopleths. Because the incremental concentrations are small in comparison to the baseline concentrations of VOC and NOx, the analysis indicates that there will be a small change in peak ozone concentration. Based on the graph, the change in ozone precursor emissions could result in either a minor increase in ozone if the ambient VOC:NOx ratio is greater than about 9:1, or a minor decrease of the same magnitude in ozone if the ambient VOC:NOx ratio is less than about 9:1.

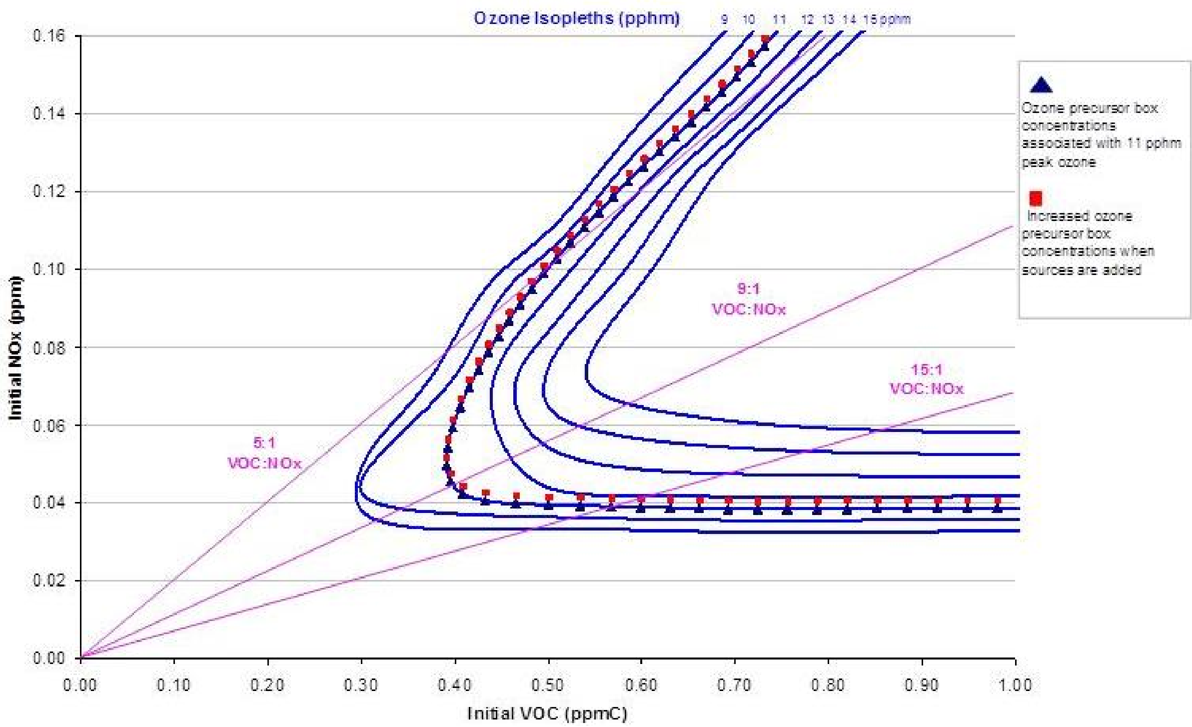
Secondary $PM_{2.5}$ Screening Approach Using AERMOD

For secondary $PM_{2.5}$ formation, it is possible to add a secondary $PM_{2.5}$ emissions or concentration component for SO_2 and NOx precursors using AERMOD to the primary component also predicted by AERMOD. This concept, designed in a tiered approach, is described in the 2013 A&WMA paper by Connors et al.[46], included as Attachment G.

The AERMOD Tier 1 screening approach calculates an effective $PM_{2.5}$ secondary emission rate at the distance of the peak primary $PM_{2.5}$ impact that can then be added to the modeled primary emission rate in order to account for secondary particulate formation at receptors of interest. The average travel time to the point of peak primary $PM_{2.5}$ impact is combined with a conservative percent per hour transformation rate of SO_2 to ammonium sulfate and/or NOx to ammonium nitrate to determine the effective conversion to secondary $PM_{2.5}$ mass. The total "converted" mass is then added to the primary $PM_{2.5}$ emissions in a second run of AERMOD. This method is conservative because it assumes an instantaneous and upper end rate of conversion of precursor gas to particle mass.

[46] Connors, J., D. Heinold, and R. Paine, 2013. Screening Approach to Account for Secondary PM2.5 in Stationary Source Modeling. Control #42, presented at the Air & Waste Management Association's Specialty Conference, Guideline on Air Quality Models: the Path Forward, Raleigh, NC. March 2013.

Figure 1 Change in Ozone Concentrations Predicted in the OZIPR Example



The Tier 2 and 3 approaches address the issue that the amount of secondary $PM_{2.5}$ formation is highly based on based on travel time for each modeled receptor/hour/source. Considering the spatial inter-relationship of the primary and secondary $PM_{2.5}$ concentrations is important because the highest primary $PM_{2.5}$ concentrations are typically modeled closest to the source while the highest secondary $PM_{2.5}$ concentration typically would occur farther from the source when long transport times allow for more transformation.

Ideally, the EPA-approved near-field model, AERMOD, would have the capability to account for secondary $PM_{2.5}$ on a time and space basis. However, AERMOD, as currently constituted, cannot account for this type of atmospheric chemistry. The Tier 2 and 3 approaches use an ñAERCHEMò post-processor to AERMOD with two levels of sophistication to account for secondary $PM_{2.5}$.

Conceptually, AERCHEM would either:

(1) under the Tier 2 approach, be able to calculate the total $PM_{2.5}$ concentration from modeled concentrations of SO_2, NOx, and primary $PM_{2.5}$ and the same look-up table of conservatively high transformation rates (developed from independent model data or research of existing field data); or

(2) under the Tier 3 approach, be able to calculate the total $PM_{2.5}$ concentration from modeled concentrations of SO_2, NOx, and primary $PM_{2.5}$ and internally calculate the hour-specific transformation rates when provided essential variables such as plume characteristics (size and travel time), background species information (ozone and ammonia), and meteorological data.

OZIPR and AERMOD with screening chemistry are two examples of reduced-form screening models that could be considered for the lower tier modeling approach in EPAôs overall plan for single-source modeling of ozone and secondary $PM_{2.5}$ concentrations.   These are not the only candidate approaches, but we provide these concepts for EPA consideration.

4.4 Second Tier Assessments

4.4.1 EPA does not have a clear implementation plan for the use of Chemical Transport Models in this tier.

A Tier 2 analysis would be used if the screening-level Tier 1 approach produces a result that implies that a more refined modeling approach is needed. The lack of MERP definitions and the nature of the Tier 1 modeling tools make it difficult to determine how often a Tier 2 modeling approach may be needed. EPAõs general approach for a Tier 2 analysis is to use an advanced model that incorporates comprehensive chemistry. However, the guidance is preliminary and there is no clear indication of a specific procedure for conducting this modeling. Due to likely regional differences in chemistry and the need for regional meteorological databases, a great deal of work by EPA and the regions needs to be done before the Tier 2 modeling can be done.

4.4.2 The relative merits of Eulerian and Lagrangian models for single-source modeling are commented on here.

EPA makes compelling technical arguments that the treatment of photochemistry is necessary to correctly simulate the single-source ozone, secondary $PM_{2.5}$ concentration and AQRV impacts. Eulerian Photochemical Grid Models (PGMs) include photochemistry, but require detailed three-dimensional inputs and need to simulate all sources, so they are computationally demanding. When performing a single-source assessment with a PGM, source sensitivity (e.g., brute force or DDM) or source apportionment needs to be used to isolate the single-source impact. Lagrangian models, on the other hand, are *designed* to simulate the impacts of single sources, so they are more computationally efficient for this purpose. Some Lagrangian models also treat photochemistry (e.g., SCICHEM), although they require three-dimension fields of background photochemical oxidants that would likely come from a PGM; that is an additional requirement beyond Lagrangian models without photochemistry. Note that for secondary $PM_{2.5}$, the use of a Lagrangian puff model or even an AERMOD post-processor (described further in Section 4.5 below) with reduced form chemistry would be a viable Tier 1 screening tool, provided it can be demonstrated that it is conservative compared to the full-science Tier 2 PGM approach.

In Section 4.7 of EPAõs draft guidelines for assessing single-source ozone and secondary $PM_{2.5}$ impacts, statements are made on the limitations of Lagrangian models that are not valid for all types of Lagrangian models. These statements appear to be based on EPAõs experience with the CALPUFF Lagrangian model, which does not include photochemistry nor does it treat chemistry in overlapping puffs. As noted, the following statements made by EPA do not apply to the SCICHEM model, which does include photochemistry. EPA states that:

- In CALPUFF, the existence of overlapping puffs that occupy the same space will independently interact with the background concentrations (ozone and ammonia in this case) thereby õdouble countingö the background concentrations. CALPUFF modeling requires a post-processor (õPOSTUTILö, which applies the Ammonia Limiting Method) to correct for this effect. However, SCICHEM performs chemistry on puff concentrations accounting for overlapping puffs, so background is only counted once.

- In CALPUFF, the Ammonia Limiting Method (ALM) is applied independently in each puff during the model simulation, which will overstate the amount of particulate nitrate and understate nitric acid while the model is running, as background ammonia may be counted multiple times. For many CALPUFF applications, the CALPUFF concentration results due to all puffs are post-processed using ALM again at the receptor where the total nitrate concentrations due to all the overlapping puffs may be converted to nitric acid, which makes the final model CALPUFF nitrate/nitric acid concentrations inconsistent with the CALPUFF simulation. Since SCICHEM is applying ALM to the overlapping puffs during the simulation, it does not suffer this limitation.

4.4.2.1 EPA's suggestion to use CTM models in an absolute sense is dependent upon these models being unbiased.

EPA suggests using a CTM model (either a Lagrangian model or a PGM) in an absolute sense for permitting new sources. This guidance is counter to the historical use of PGMs, for instance in the development of ozone SIPs where modeling results are used in a relative sense in conjunction with measurements. Interpreting the modeling results as EPA proposed removes any ability to at least partially cancel out the prediction biases inherent to these models. EPAȯs proposal to use these models for evaluating a new sourceȯs impact is dependent upon these models being unbiased. The performance evaluation of these models is very limited, as discussed in Section 4.5. With the limited model evaluation information available, one cannot come to a reasonable conclusion as to the nature and the degree of the bias, or how it may vary regionally. The limited information on model performance is an important limitation in the entire proposed modeling approach that EPA needs to continue to refine.

4.4.2.2 EPA's discussion of the use of a Lagrangian Plume-in-Grid subgrid-scale puff model within an Eulerian PGM does not consider the potential benefits of the approach.

The discussion of the use of a Lagrangian Plume-in-Grid subgrid-scale puff model within an Eulerian PGM focuses on the sampling of the puffs and the need to track the single-source impacts using a source sensitivity or apportionment tool for the grid resolved impacts of a single source. In the IWAQM Phase 3 near-source assessment, EPA states ñthe use of sub-grid plume treatment for the purposes of estimating project source impacts for PSD/NSR would typically not be recommendedò based on their limited evaluation (Baker and Kelly, 2014[47]; Kelly et al., 2015[48]). Other studies have shown that using subgrid-scale plume model in a PGM with puff sampling has performed well and provides a consistent approach to treating primary and secondary $PM_{2.5}$ (e.g., Liberty-Clairton 24-hour $PM_{2.5}$ SIP)[49]. Furthermore, one of the primary reasons for using a subgrid-scale puff module in a PGM is to properly characterize the near-source chemistry in a point source plume that is very different than the surrounding air and different than the chemistry that occurs when point source emissions are release across a grid cell. The initial high NOx concentrations within a point source plume inhibits ozone and secondary $PM_{2.5}$ formation that is correctly simulated using the subgrid-scale chemical puff module, but may not be fully accounted for if the emissions are instantaneously dispersed across a grid cell. EPA fails to consider this benefit of using a subgrid-scale Plume-in-Grid module in their discussions.

[47] Baker, K.R., Kelly, J.T., 2014. Single source impacts estimated with photochemical model source sensitivity and apportionment approaches. *Atm. Env.*, 96: 266ï 274.

[48] Kelly, J.T., K.R. Baker, S.L. Napelenok, and S.J. Roselle. 2015. Examining single-source secondary impacts estimated from brute-force, decoupled direct method, and advanced plume treatment approaches. *Atm. Env.* 111:10-19.

[49] See more details at ñApplication of an Integrated Plume to Regional Photochemical Model for the Allegheny County Liberty - Clairton $PM_{2.5}$ Attainment Demonstration Modeling ñ Control #36, presented at the 2013 Annual Meeting of the Air & Waste Management Association (authored by Ralph E. Morris, Jaegun Jung, Bonyoung Koo, and Jason Maranche); available at http://www.camx.com/files/awma_aqguidelines-36_morris_final_feb18_2013.pdf.

4.5 EPA Evaluations of Proposed Modeling Approaches – IWAQM3 Reports

4.5.1 We agree with the conclusion of the IWAQM Phase 3 summary report on near-field modeling that "additional evaluations are needed for longer time periods and more diverse environments, both physical and chemical, to generate broader confidence in these approaches for this purpose."

In the IWAQM Phase 3 summary report on near-field modeling (EPA-454/P-15-003[50]), EPA presents several studies using photochemical grid models (PGMs) and brute force and decoupled direct method (DDM) sensitivity and/or source apportionment for evaluating single-source impacts for ozone and $PM_{2.5}$. EPA concludes that ñadditional evaluations are needed for longer time periods and more diverse environments, both physical and chemical, to generate broader confidence in these approaches for this purpose.ò

The IWAQM Phase 3 near-field report discusses two types of evaluations to demonstrate that a model is appropriate for use in single-source ozone and $PM_{2.5}$ assessments: (1) evaluation that ñthe modeling system is theoretically fit for the purposeó, and (2) evaluation against ambient measurements to assess that the model is appropriate for a specific application. In the former fit-for-purpose evaluation, IWAQM presents evaluation of PGM using chemical plume measurements for just two experiments, one in Tennessee (TVA Cumberland plant) and one in Texas (Dolet Hills). These evaluations are limited to just a few days and a few plume traverses using a PGM model configuration that is likely not usable for an annual single-source PGM ozone/$PM_{2.5}$ evaluation. Although these in-plume PGM model evaluation results are encouraging, we agree with the IWAQM report that ñadditional evaluations are needed for longer time periods and more diverse environments.ò

4.5.2 The IWAQM Phase 3 LRT model evaluation results are limited in extent.

The IWAQM Phase 3 summary report on long range transport (LRT) and air quality related values (AQRVs) modeling has the same two types of evaluations to demonstrate a model is appropriate for use in single-source LRT and Air Quality Related Values (AQRV) assessments. The IWAQM Phase 3 far-field ñfit for purposeò evaluation includes the same in-plume chemistry evaluation requirements. However, it notes that ñgiven the LRT/AQRV model need to capture impacts at specific locations and timesó, some emphasis is needed on the evaluation of the spatial and temporal metrics.ò EPA addresses this aspect of the LRT/AQRV ñfit for purposeò through evaluation of LRT/AQRV models using tracer measurements from multiple atmospheric tracer field studies[51]. Although EPAôs multi-model tracer test evaluation work performed mostly during 2009-2011 represents a strong body of knowledge and a good resource, some issues with the work on the CALPUFF evaluations were raised during the 10th Conference on Air Quality Modeling that we hoped would have been addressed over the last 3 years to improve the tracer test evaluation. We also note that EPA admits that ñadditional evaluations are needed for longer time periods and more diverse environments to generate broader confidence in these approaches for this purpose.ò

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[50] ñInteragency Workgroup on Air Quality Modeling Phase 3 Summary Report: Long Range Transport and Air Quality Related Valuesó, available as EPA Docket Item EPA-HQ-OAR-2015-0310-0004.

[51] ñDocumentation of the Evaluation of CALPUFF and Other Long Range Transport Models Using Tracer Field Experiment Dataó, available at http://www.epa.gov/scram001/reports/EPA-454_R-12-003.pdf.

For the second case-specific model evaluation against ambient measurements mentioned above, the IWAQM Phase 3 report relies on the extensive evaluation procedures used for PGMs including those in EPAÕs latest modeling guidance (EPA, 2014)[52] and Simon, Baker and Philips, 2012[53].

4.5.3 The available evaluations reported by EPA for assessing single-source impacts on ozone and $PM_{2.5}$ are very limited in number and duration. EPA should conduct additional evaluations to determine the performance skill of candidate models.

Most of the testing and evaluating of air quality models presented in the proposed revision to Appendix W were conducted by EPA or their contractors. We encourage EPA to reach out to the modeling and regulated community to solicit for additional model evaluation studies. The SCICHEM presentation[54] made at the 11th Modeling Conference and the SCICHEM peer-reviewed paper[55] mention the TVA Cumberland and Dolet Hills evaluations. However, the conference presentation also mentions two additional reactive plume evaluation data sets (2013 SENEX[56] and Southeastern Aerosol Research and Characterization study ï SEARCH[57] - measurements) that EPA should investigate to increase the extent of the model evaluations.

The available evaluations reported by EPA for assessing single-source impacts on ozone and $PM_{2.5}$ are very limited in number and duration. Therefore, conclusions about the performance skill for the candidate models are preliminary and tentative. Although we are not aware of any new field study tracer data, there are numerous new aircraft field study campaigns most with enhanced ground based monitoring that can be included in the model performance evaluation tool chest. EPA should consider updating the evaluation of the reactive plume models within the next two years, in time to report results for the 12th EPA modeling conference.

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[52] Available at http://www.epa.gov/scram001/guidance/guide/Draft_O3-PM-RH_Modeling_Guidance-2014.pdf.

[53] Simon, H., Baker, K.R., Phillips, S., 2012. Compilation and interpretation of photochemical model performance statistics published between 2006 and 2012. *Atm. Env.* 61, 124-139.

[54] Available at http://www.epa.gov/ttn/scram/11thmodconf/presentations/2-16_Knipping-EPA-11th-Modeling-Conf-2015.pdf.

[55] B. Chowdhury, P.K. Karamchandani, R.I. Sykes, D.S. Henn, E. Knipping. (2015). Reactive puff model SCICHEM: Model enhancements and performance studies. *Atm. Env.* 117, 242-258.

[56] See the White Paper about Southeast Nexus at http://esrl.noaa.gov/csd/projects/senex/whitepaper.pdf.

[57] Hansen DA, Edgerton ES, Hartsell BE, Jansen JJ, Kandasamy N, Hidy GM, Blanchard CL. The Southeastern Aerosol Research and Characterization Study: part 1--Overview. *J Air Waste Manag. Assoc.* 2003 Dec; 53(12):1460-71.

5.0 ROLE OF THE EPA MODEL CLEARINGHOUSE

5.1 EPA proposes an expanded official role for its Modeling Clearinghouse (MC) in that all non-guideline modeling requests must be approved through the MC. With the increase in potential non-guideline modeling (no approved LRT model, no guideline model for secondary $PM_{2.5}$ and ozone), the resulting MC work load is likely to result in permitting delays.

EPAó Model Clearinghouse consists of a small group of scientists at the Office of Air Quality Planning and Standards (OAQPS). If the Appendix W revisions are finalized as proposed, there will be many more non-guideline modeling approaches in two new areas: long-range transport modeling, and single-source modeling of ozone and secondary $PM_{2.5}$ concentrations. We are concerned that the Model Clearinghouse may become overwhelmed with review requests, creating a bottleneck for proposed permit reviews.

5.2 A significant expansion in Model Clearinghouse resources or delegation of authority to the EPA Regions is likely needed to prevent permitting delays.

We recommend that the Model Clearinghouse consider a tiered approach to prioritize, review, and delegate certain issues that have already gone through previous Model Clearinghouse review to the EPA regions. There are several issues that should not need to go through MC review.

6.0 ESTIMATION OF BACKGROUND CONCENTRATIONS

Accounting for background concentrations is covered in Section 8.3 of Appendix W. There are two components of the background: concentrations that vary in space due to impacts from nearby sources, and regionally uniform concentrations from distant sources. These concentrations are added together, and there are multiple ways in which the background component of concentrations is overestimated.

Regional background concentrations

The regional background component is typically derived from a representative monitor. While it cannot be guaranteed that the measured concentration at the monitor is the same as would be monitored near the source, it should be remembered that the modeled component of background is added to the regional value, thus elevating the chance of counting the impacts twice if too many sources are modeled or if a skewed estimate of concentrations is used for the regional background.

The expected (average) value of the regional background is the annual average value of the monitored data. However, the general practice for the regional background is to use a value consistent with the form of the NAAQS for the pollutant of interest (e.g., 99th percentile 1-hour SO_2 concentration or 98th percentile 1-hour NO_2 concentration). This is an arbitrarily conservative choice for the background ranking; it could easily have been selected as the 90th or 95th percentile and still have a great deal of conservatism, especially with the probabilistic form of the SO_2 and NO_2 NAAQS.

EPA does provide applicants with the capability of excluding source impact concentrations from the regional background determination. The usual procedure is to use a 90-degree impact sector exclusion for a nearby source, but if there are multiple nearby sources, this becomes more difficult. Another option that EPA should allow is the use of multiple regional monitors for which a time series of the minimum concentration over all monitors is selected for each hour. Then, a ranked concentration can be selected from that time series.

In conjunction with the regional background is the added component of the spatially-varying concentration impact from nearby sources. This portion of the background has historically had two components that lead to over-prediction of impacts: a) allowable emissions are modeled, and b) sources well beyond the distance of relatively uniform concentrations were included in the modeling. Each of these issues is discussed further below.

6.1 Table 8-2 in Appendix W should allow for use of actual hourly emissions for modeling of nearby sources.

The Technical Assistance Document for modeling associated with the SO_2 NAAQS implementation has recognized that it is necessary to use actual hourly emissions to obtain unbiased estimates of concentrations. This same approach should be used for all nearby sources being modeled in addition to the specific sources being changed or newly introduced for New Source Review permitting. We suggest that Table 8-2 in Appendix W (see Figure 2 below) be changed as follows:

- For nearby sources, actual hourly emissions should be used directly in the modeling where available from CEM data.
- If hourly emissions are not available (either from a direct continuous emission monitor measurement or from indirect calculations), the emissions limit input should be maximum actual values in lb/MMBtu, NOT ñmaximum allowableò values, for both long-term and short-term modeling. In addition, operating factor for short-term averages should account for periods of

operational shut down to the extent possible (not assuming continuous operation if that is not a realistic assumption).

Figure 2 EPA-Proposed Table 8-2 of Appendix W

TABLE 8–1—POINT SOURCE MODEL EMISSION INPUT FOR SIP REVISIONS OF INERT POLLUTANTS [1]—Continued

Averaging time	Emissions limit (lb/MMBtu) [2]	×	Operating level (lb/MMBtu) [2]	×	Operating factor (e.g., hr/yr, hr/day)
Short term (≤24 hours)	Maximum allowable emission limit or federally enforceable permit limit.		Actual or design capacity (whichever is greater), or federally enforceable permit condition.[4]		Continuous operation, i.e., all hours of each time period under consideration (for all hours of the meteorological database).[5]
Nearby Source(s).[6]					
Annual & quarterly	Maximum allowable emission limit or federal enforceable permit limit.[5]		Annual level when actually operating, averaged over the most recent 2 years.[3]		Actual operating factor averaged over the most recent 2 years.[3 8]
Short term (≤24 hours)	Maximum allowable emission limit or federal enforceable permit limit.[6]		Temporally representative level when actually operating, reflective of the most recent 2 years.[3 7]		Continuous operation, i.e., all hours of each time period under consideration (for all hours of the meteorological database).[5]
Other Source(s) [8 9]					
The ambient impacts from Non-nearby or Other Sources (e.g., natural sources, minor sources and, distant major source and unidentified sources) can be represented by air quality monitoring data unless adequate data do not exist.					

6.2 The language in Appendix W regarding the distance for inclusion of background sources should be consistent with EPA's 2011 Clarification Memo, i.e., for most cases, consider nearby sources within 10 km.

The proposed distance (80 FR 45373) for including background sources to be modeled is described as follows in EPAõs proposal:

> ñThe number of nearby sources to be explicitly modeled in the air quality analysis is expected to be few except in unusual situations. In most cases, the few nearby sources will be located within 10 to 20 km from the source(s) under consideration.ò

This description is different than what EPA stated in its Clarification Memo[58] of March 1, 2011:

> ñEven accounting for some terrain influences on the location and gradients of maximum 1-hour concentrations, these considerations suggest that the emphasis on determining which nearby sources to include in the modeling analysis should focus on the area within about 10 kilometers of the project location in most cases.ò

The change between ñ10 kmò and ñ10-20 kmò is effectively a doubling of the distance coverage, quadrupling the area involved in the sources to be considered.

An analysis presented[59] by Paine at the 2011 EPA Modeling Workshop for a large variety of sources confirmed EPAõs March 1, 2011 memo approach for a 10-km upper limit on sources to include in the

[58] Available at http://www.epa.gov/ttn/scram/guidance/clarification/Additional_Clarifications_AppendixW_Hourly-NO2-NAAQS_FINAL_03-01-2011.pdf, page 16.

[59] Available at http://www.cleanairinfo.com/regionalstatelocalmodelingworkshop/archive/2011/Presentations/6-Thursday_AM/6-3_AB-3_Presentation_at_EPA_Modeling_Workshop.pdf.

background modeling in most cases. In that presentation, it was evident that the source concentration levels had leveled off by the 10-km distance (much closer in many cases).

Accordingly, we recommend that the proposed language that ñin most cases, the few nearby sources will be located within 10 to 20 km from the source(s) under considerationò should be changed to ñin most cases, the few nearby sources will be located within 10 km from the source(s) under consideration.

6.3 In the case of a monitor that shows much lower concentrations for background sources than AERMOD shows, the monitoring data should be considered in lieu of background modeled estimates.

This suggestion addresses the situation where a monitor shows much lower concentrations than modeling shows for background concentrations. In that event, EPA should offer the flexibility of using monitoring in lieu of modeling for the affected background source(s).

7.0 SOURCE CHARACTERIZATION REFINEMENTS

EPA has, in the past, stated that case-specific refinements involving source characterization does not constitute a non-guideline modeling approach. We provide further comment on the areas included in the AISI presentation at the 11th Modeling Conference.

An overview of the source characterization issues was presented[60] at the 11th EPA Modeling Conference by Robert Paine on behalf of the American Iron & Steel Institute (AISI). Much more content on these issues is presented below and in attachments to these comments. Attachment H provides a technical article submitted to Atmospheric Environment (currently under review) that discusses each of these issues in more detail.

In general, the AERMOD evaluations involve emission sources that are isolated stacks or tracer gas releases under relatively ideal conditions. Many modeling applications, however, involve sources that act to modify the local dispersion environment as well as the conditions associated with plume buoyancy and final plume rise. The source configurations that were discussed in the Paine presentation were: 1) sources with large fugitive heat releases that result in a local urbanized effect (referred to as an "industrial complex heat island"), 2) stacks on or near individual buildings with large fugitive heat releases that tend to result in buoyant "liftoff" effects counteracting aerodynamic downwash effects, 3) stacks in a line that result in at least partial plume merging and buoyancy enhancement under certain conditions, and 4) stacks with considerable moisture content, which leads to additional heat of condensation during plume rise - an effect that is not considered by AERMOD at this time.

In the case of local urbanized effects, the documentation provided below and in attachments includes discussion of a formulation to estimate the effective population associated with the heat releases that characterize large industrial areas. The characterization involves the estimation of the excess heat release, which can be determined through engineering estimates or with satellite temperature observations. An evaluation study involving industrial areas in NW Indiana will also be cited in support of this source characterization approach.

For stacks on or near buildings with large waste ("fugitive") heat releases, another effect that influences the localized plume behavior is the lifting effects of the heat that counteract downdrafts that would ordinarily be associated with building downwash. This effect can be parameterized with a dimensionless buoyancy parameter as discussed in a paper by Hanna, Briggs, and Chang[61] that introduces a scaling (weighting) factor between a full downwash and a no downwash case. The full downwash case occurs in the limit of no heating and high wind speeds, while the no downwash case occurs in the limit of large heat releases and low wind speeds.

The third effect involves a row of stacks with plumes that partially merge as they rise, resulting in an increased plume rise relative to the individual stack case. This formulation is based upon the Briggs 1984 formulation[62], which related the increase in effective plume buoyancy to the separation distance between the stacks, the angle of the approach wind to the stack line-up, and the plume rise for each individual stack (this effect changes on an hourly basis).

[60] Available at http://www.epa.gov/ttn/scram/11thmodconf/presentations/2-2_AISI_NAAQS_Issues.pdf.

[61] Hanna, S. R., G. A. Briggs, and J. C. Chang. 1998. Lift-off of ground-based buoyant plumes. *J. of Hazard. Mater.* 59(1995):123–130.

[62] Briggs, G. A. 1984. "Chapter 8." In *Atmospheric Science and Power Production*. Oak Ridge, TN; Springfield, VA: Technical Information Center, Office of Scientific and Technical Information, U.S. Dept. of Energy.

The final effect relates to increased plume rise due to moisture present in a wet plume. The moisture initially condenses as the plume cools, releasing heat of condensation. This results in an increase in the initial plume rise. The implementation in AERMOD is based upon a moist plume model (IBJpluris)[63]. This model can be used as a pre-processor to create an equivalent plume buoyancy increase in a dry plume model (AERMOD) with a change in the hourly input stack temperature.

As previously stated, these source characterization approaches do not change the AERMOD formulation, but revise the source input to better reflect the plume rise issue associated with each refinement described above.

7.1 Large Industrialized Areas Should be Considered for an Effective Urban Treatment.

The urban heat island effect is a well-known phenomenon as it relates to urban and suburban areas that experience higher temperatures when compared to their rural surroundings. The key issue for plume dispersion in an urban area is that the urban heat island prevents the boundary layer from becoming stable at night, and results in weakly convective mixing at night within a deeper layer than that which exists in rural areas.

Urban surface characteristics such as albedo and surface roughness continuously affect boundary layer parameters. However, the boundary layer structure is most influenced by these urban surface characteristics at night. At night, an urban boundary layer is created when stable rural air reaches a warmer urban surface. Because buildings and urban surfaces trap heat more efficiently than rural areas, urban areas are slower to cool at night than the rural environments.

AERMOD currently accounts for urban environments by adjusting the urban area's surface heat flux and boundary layer height based on the urban-rural temperature difference of the urban core's temperature to the neighboring rural area's temperature. To calculate the urban-rural temperature difference, ΔT_{u-r}, population information is used by AERMOD with the following relationship:

$$\Delta T_{u-r} = \Delta T_{max} \, [0.1 \ln (P/P_o) + 1.0] \qquad (1)$$

where ΔT_{max} = 12 K, P_o = 2,000,000, the population related to the maximum temperature difference, and P is the population of the urban area being modeled. AERMOD uses the population input value to simulate the height of the urban boundary layer.

To determine upward surface heat flux, H_u, resulting from the urban-rural temperature difference at night, the following relationship can be derived:

$$H_u = \alpha \rho \, c_p \, \Delta T_{u-r} \, u_* \qquad (2)$$

where α is an empirical constant (0.03) described in the AERMOD model formulation document, ρ is the density of air (about 1.2 kg/m^3), c_p is the specific heat at constant pressure (1 W-s/g-K), and u_* is on the order of 0.1 m/s (EPA, 2004). This equation can be solved for ΔT_{u-r} (in units of K):

[63] Janicke, U., and Janicke L. 2001. A three-dimensional plume rise model for dry and wet plumes. *Atm. Env.* 35(2001):877-890.

$$\Delta T_{u-r} \approx H_u/4 \quad (3)$$

where H_u is the anthropogenic heat release in units of watts per square meter in the "urban core."

A lesser known cause of urban heat island effects, and currently unaccounted for in AERMOD, but described by Hanna and Britter (2002)[64], is an industrial complex that mimics a heat signature similar to cities. Fugitive heat releases at industrial facilities can be equivalent to the level of heat trapped by urban surfaces and buildings, and contribute to the effects seen in highly industrialized areas. However, these highly industrialized areas are not considered in the traditional urban classification approaches used for AERMOD, even though Irwin (1978) suggested this approach in an internal EPA memo. The population near such areas is often much reduced because of zoning issues, and the area beyond the immediate industrial park may be rural in nature, resulting in a misleading characterization for this type of source.

We recommend an approach further discussed in Attachment H that allows consideration of a nontraditional type of urban source that is subject to urban dispersion due to industrial anthropogenic heat release rather than due to the presence of a traditional city. The model user would specify the anthropogenic heat flux resulting from the source, or an urban-rural temperature difference, if available. This would be used to determine a surrogate "effective" population value for input to AERMOD. The effective population could be calculated through the use of eq 1 if ΔT_{u-r} is specified or eqs 1 - 3 if the anthropogenic heat flux is specified. A value of ΔT_{u-r} less than 3 - 4 K is likely insufficient to support an urban designation.

In eqs 2 - 3, it is important to note that the "urban core" of a highly industrialized area heat release (H_u) depicts an area with a horizontal extent of at least a few hundred meters on a side. The anthropogenic heat release per unit area of major cities such as Indianapolis (extensively studied by the Electric Power Research Institute (EPRI) in the 1980s) would be on the order of 50 W/m^2. This value lies within the 10-100 W/m^2 range stated by Hanna et al. (2011)[65] for urban areas.

Satellite analysis and model evaluation.

A modeling study was undertaken using an evaluation database in Lake County in northwestern Indiana to test the performance of the AERMOD model for a highly industrialized area. Several AERMOD options were tested to determine the most representative scenario of 1-hour average ground-level SO_2 modeled concentrations due to emissions from industrial complexes such as steel mills with respect to ambient monitoring stations in Gary and Hammond, Indiana (Figure 1). EPA current guidance for land use characterization indicates that this area should be modeled as rural, but the heat releases from the numerous iron and steel industry sources in this area create a dispersion environment that is effectively urban with a large population.

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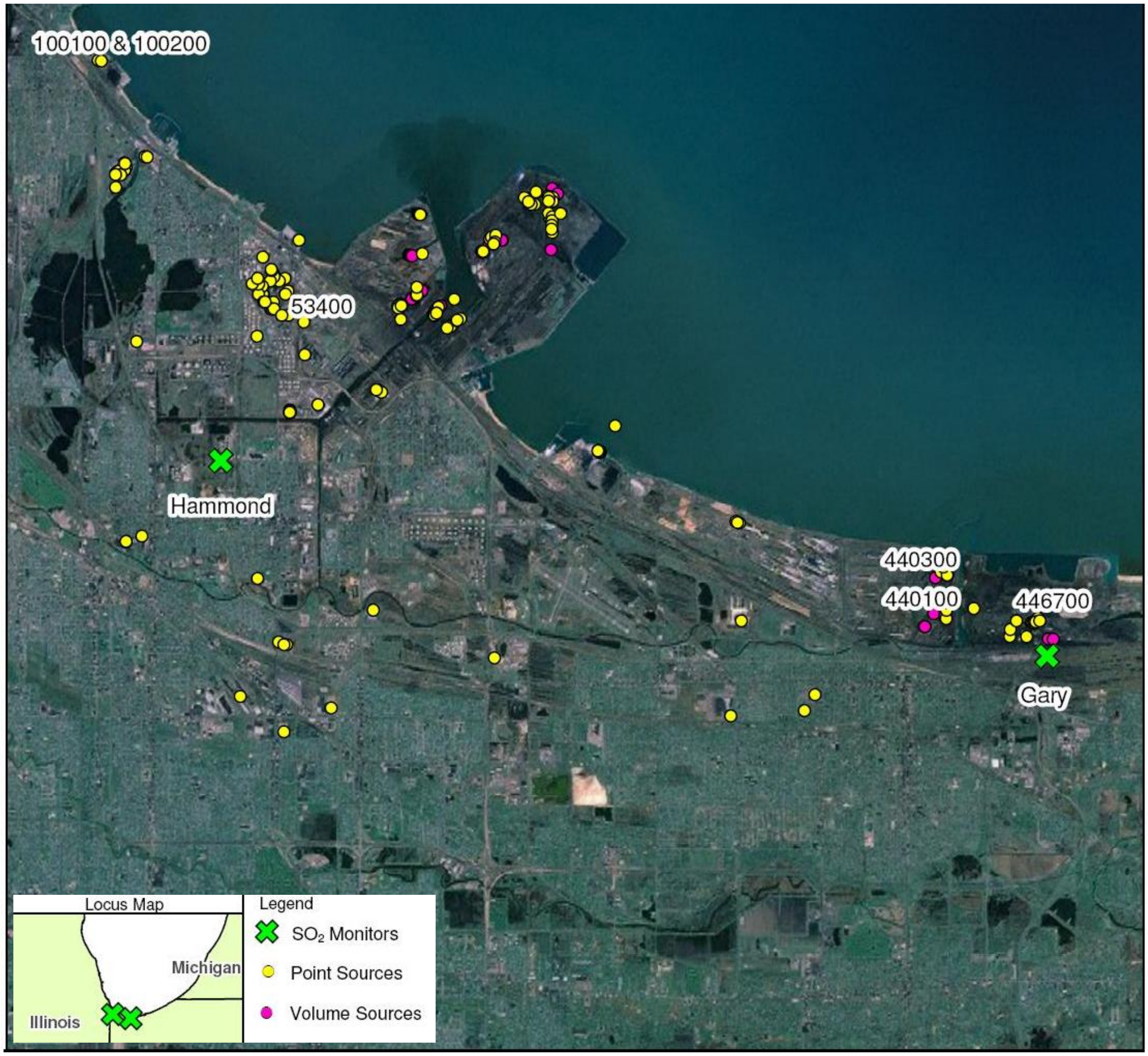
[64] Hanna, S. R. and R.E. Britter. 2002. *Wind Flow and Vapor Cloud Dispersion at Industrial and Urban Sites.* John Wiley & Sons, Inc., Hoboken, NJ, USA. doi: 10.1002/9780470935613.refs, Chapter 2.

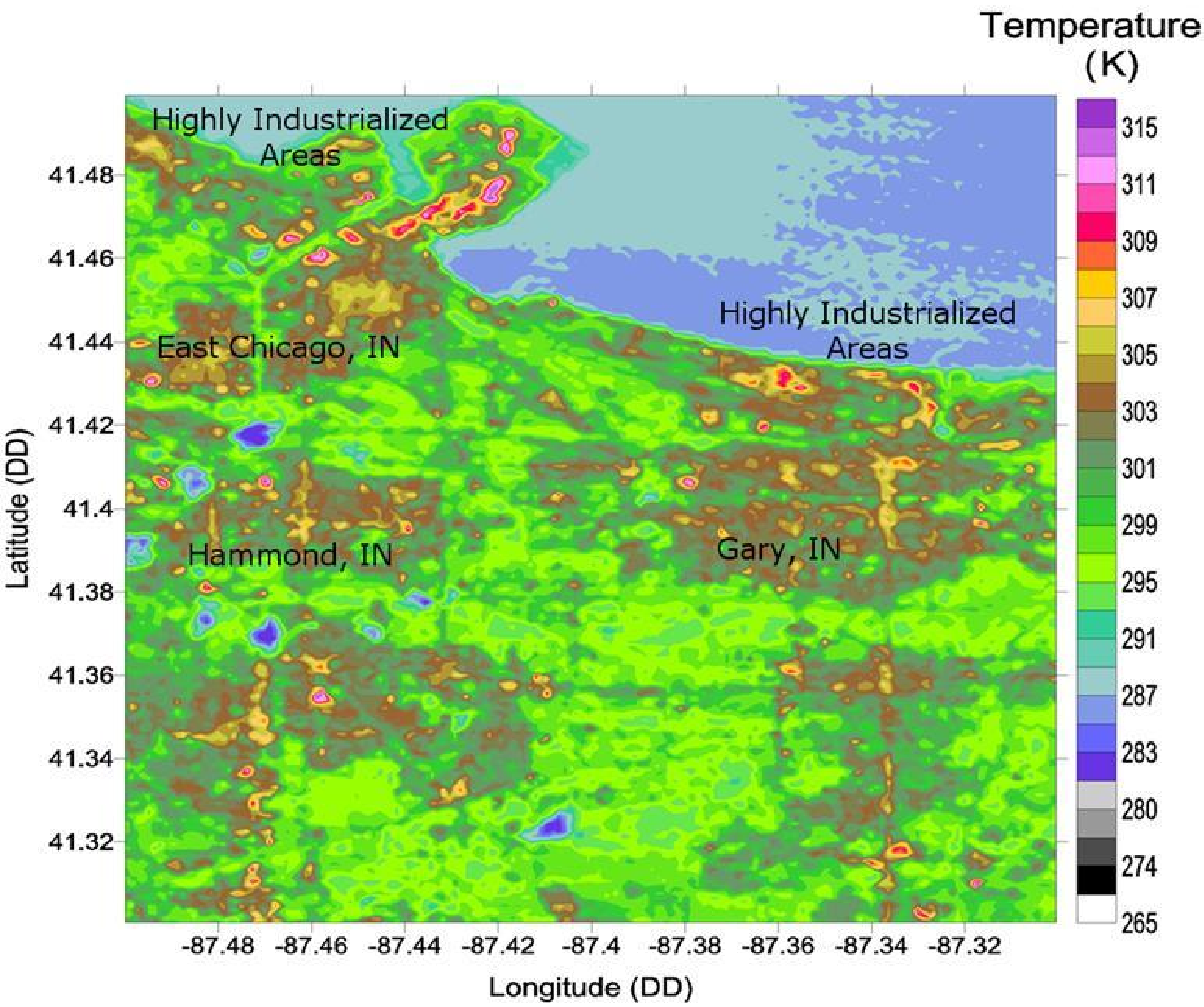
[65] Hanna, S. E. Marciotto, and R. Britter. 2011. Urban Energy Fluxes in Built-Up Downtown Areas and Variations across the Urban Area, for Use in Dispersion Models. *J. Appl. Meteorol. Clim.*, 50 (2011): 1341-1353.

Figure 1. Location of various emission sources in the Gary and Hammond, IN area in relation to the SO_2 ambient air monitors.



Satellite thermal imagery of the area of interest in northwest Indiana was reviewed to determine the temperature difference between the populated areas and the industrial facilities. The procedures for conducting this estimate are discussed further in Attachment I. Brightness temperature measured by the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) instrument on the Terra satellite on a summer day depicted the maximum temperatures associated with industrial facilities to be approximately 310-315 K which leads to a temperature difference of about 11-12 K (Figure 2). Note that this temperature difference measured by the satellite automatically accounts for the ñurbanizedò temperature excess of the highly industrialized area caused by the overall industrial heat releases not otherwise accounted for in the model. Using eq 1, this temperature difference was consistent with heavily populated areas with typical populations on the order of 1,000,000 instead of the regionôs U.S. Census Bureau population data of 10,000.

Figure 2. Brightness temperature from ASTER band 14 on June 10, 2008 at 11 a.m. local time.



Three scenarios for the northwestern Indiana application were run using AERMOD with default options: 1) rural land use, 2) urban land use with a small (actual) population of 10,000, and 3) urban land use with a large population of 1,000,000. The rural and small urban population modeling approaches led to AERMOD overpredictions of 1-hour SO_2 as high as a factor of 10 at two monitors ranging from 1 to 10 km from the sources being modeled. The urban, large population scenario resulted in improved model performance by reducing the atmospheric stability at night, leading to higher plume rise and a deeper mixing layer for plume dispersion. The results still indicate that AERMOD overpredicted the 99th percentile daily maximum 1-hour SO_2 ground-level concentration (which is the basis for the ambient standard in the United States) by a factor of about 2 at the Hammond and Gary monitors (Table 1). In general, these results in comparison to the other scenarios indicate that improved model performance could be obtained by using an urban dispersion approach with an effective large population (e.g., on the order of 1,000,000).

Table 1. AERMOD modeling results for rural and urban land use scenarios.

Monitor	Land Use	Population	99th Percentile of the Daily Maximum 1-hour SO_2 (µg/m^3)
Hammond (**96 µg/m^3**)	Rural	NA	290.4
	Urban	10,000	935.5
	Urban	1,000,000	179.0
Gary (**175 µg/m^3**)	Rural	NA	1298.2
	Urban	10,000	1855.9
	Urban	1,000,000	392.2

Note: 1-hour SO_2 99th percentile (4th highest) monitored values are listed in by monitor in parenthesis.

7.2 Plume Liftoff Effects Should be Considered for Industrial Complex Environments with Fugitive Heat Releases.

AERMOD estimates building downwash effects by applying its downwash model, PRIME, concentration estimates in the near-field where building wakes are predicted, while transitioning to the AERMOD estimates without building wake considerations in the far field (EPA, 2004). This transition is performed without consideration of low wind speed conditions, which can lead to poor model performance, particularly when building aerodynamic effects are estimated by the model under nearly-calm conditions. Downwash conditions in near-calm winds are not realistically expected and have not been adequately evaluated. For example, in the current AERMOD implementation using default model options on a facility with short stacks close to a nearby buildingõs height, very high 1-hour ground-level concentrations due to building downwash can be predicted even with nearly calm winds in stable conditions[66]. This is a condition for which downwash effects would not be expected. The model is assuming a plume is caught in a building wake, even in such light wind conditions, and then impacting ground-level receptors at the fenceline under very low dilution conditions.

It is also noteworthy that the PRIME and AERMOD model evaluations occurred for databases gathered during an era without widespread use of sonic anemometers and 1-minute data averaging that have resulted in very low wind speed observations for recent meteorological data sets. Therefore, the AERMOD user testing prior to its promulgation had limited exposure to the more extensive very low wind speeds (under 1 m/s) that have been routinely observed in recent years.

In light winds with significant wind meander, building wake effects are unsteady, as noted by Robins (1994)[67]. However, AERMODõs basic meander treatment for low winds only applies to non-downwash dispersion, and was never implemented in the PRIME model within AERMOD. Therefore, the building downwash impacts due to PRIME predictions do not account for the intermittency of downwash effects that would tend to reduce hourly-averaged ground-level concentrations in one location. A downwash approach that accounts for low wind speeds and the inherent intermittency of steady wake effects under such conditions is already incorporated into regulatory models similar to AERMOD such as the Danish OML model (Olesen and Genikhovich, 2000)[68] and the United Kingdom ADMS model (Robins et. al, 2013)[69].

In addition to the mistreatment of low wind conditions, a plume is able to gain buoyancy within an environment where the sourceõs buildings provide fugitive heat on a smaller scale in comparison to a highly industrialized area. AERMOD and other steady-state plume models do not consider the additional buoyancy plume uplift due to these waste heat releases (in addition to stack releases of the pollutants of interest) in the area of an emission source, especially on or around the controlling building. An example

66 As reported by Paine in an AISI presentation at the 11th EPA Modeling Conference, available at http://www3.epa.gov/ttn/scram/11thmodconf/presentations/2-2_AISI_NAAQS_Issues.pdf.

67 Robins, A., D. Apsley, and Cambridge Environmental Research Consultants, 2013. Modelling of building effects in ADMS. http://www.cerc.co.uk/environmental-software/assets/data/doc_techspec/CERC_ADMS5_P16_01.pdf.

68 Olesen, H. R., and E. Genikhovich, Ministry of Environment and Energy, 2000. Building downwash algorithm for OML atmospheric dispersion model. http://www2.dmu.dk/1_viden/2_Publikationer/3_arbrapporter/rapporter/AR123.pdf.

69 Robins, A., D. Apsley, and Cambridge Environmental Research Consultants, 2013. Modelling of building effects in ADMS. http://www.cerc.co.uk/environmental-software/assets/data/doc_techspec/CERC_ADMS5_P16_01.pdf.

of this is a cooler vent from taconite production furnaces; the vents do not release pollutants, but they duct very hot air to the building roof environment that will affect the aerodynamics around the building. For these cases with significant additional heat releases in the same vicinity, but not related to the pollutant stacks, plumes will resist downwash effects, especially in light wind cases. This resistance allows the plume to avoid downdrafts behind the building, which are nullified by ĩliftoffò conditions due to the excess heating (Hanna et al., 1998)[70].

The LIFTOFF approach

The heat flux associated with thermal releases triggering plume liftoff can be estimated and used in an alternative approach with the use of a buoyancy flux term, F_b. Hanna, Briggs, and Chang[70] suggest a combined dimensionless buoyancy flux:

$$F^{**} = F_b/(W\ U^3) \qquad (4)$$

where F_b is the buoyancy flux, U is a reference wind speed, and W is the initial plume width. An approach that can be used as a post-processor to any dispersion model such as AERMOD, called ĩLIFTOFFĝ accounts for conditions with no downdraft effects using a weighting factor between one extreme (liftoff conditions, no downwash) and non-liftoff conditions (normal downwash) modeled in separate AERMOD runs. This weighting factor, ɔ, ranges from 0 to 1 on an hourly basis (Hanna et al., 1998)[70]:

$$\text{ɔ} = \exp\ (-6F^{**0.4}) \qquad (5)$$

where with large buoyancy, the downwash weight approaches 0 and with minimal buoyancy, it approaches 1. To perform these calculations, an estimate of the heating is needed for the buoyancy flux term, F_b. To quantify the combined effects of the heat release, wind, and plume width, it is necessary to estimate these values. Once these values are obtained, the final calculation can be performed using the hourly weighting factor between modeled concentrations with and without downwash ($C_{Downwash}$ and $C_{No\ Downwash}$, respectively) to determine the final LIFTOFF concentrations, $C_{LIFTOFF}$:

$$C_{LIFTOFF} = \text{ɔ}\ C_{Downwash} + (1\ \text{ï}\ \text{ɔ})\ C_{No\ Downwash} \qquad (6)$$

To account for low wind effects, LIFTOFF reads the 10-m reference wind speed information from the AERMET SURFACE file for each hour. In combination with the heat release and plume width information, LIFTOFF applies a weighting scheme as shown in eq 6, which is similar to the dependence on the wind intermittency for the approach used in the OML model (Olesen and Genikhovich, 2000)[68]. In general, during low wind events, it is expected that the no-downwash solution will be weighted more heavily than the downwash solution. The degree of weighting is also dependent upon the magnitude of the heat release and the initial plume width which is conservatively taken to be as large as the building width.

For buoyancy effects due to source-related heat release scenarios, LIFTOFF calculates F** and applies the resulting weighting factor between the downwash and no downwash model runs. These calculations are performed for each hour using the wind direction and require building width information which serves as a conservatively large estimate of the initial plume width. Additionally, an estimation of the heating is

[70] Hanna, S. R., G. A. Briggs, and J. C. Chang. 1998. Lift-off of ground-based buoyant plumes. *J. of Hazard. Mater.* 59(1995):123ï 130.

needed for the buoyancy flux term. External heating measurements can be obtained from an engineering evaluation or by estimating the temperature excess in satellite thermal imagery data using the same procedure described to estimate ΔT_{u-r} for a highly industrialized area. This satellite-measured temperature difference is used to solve for H_u in eq 3, where the buoyancy flux, F_b, is proportional to the heat release rate, H_u.

Model evaluation case study of the LIFTOFF approach.

Model performance of the LIFTOFF procedure (user instructions are provided in Attachment J) at an industrial facility featuring process areas with considerable fugitive heat releases was assessed using data from a three-month field study with four SO_2 monitors located on-site. These SO_2 monitors were oriented around the facility's sources in areas with the highest modeled impacts occurred based on AERMOD using default options and downwash without consideration of liftoff conditions. Monitors were approximately 400-1200 m away from the point sources (Figure 3).

Using the facility's continuous emission monitor data, several model scenarios were tested including AERMOD with default options and building downwash, AERMOD with default options and no building downwash, and the LIFTOFF technique. Although the facility was located in an isolated, rural area, it had a significant source-to-ambient temperature difference of approximately 8 K as measured by satellite imagery (Figure 4). The area of fugitive heat was approximately 300 x 600 m, leading to a heat release of approximately 6 MW.

Figure 3. The industrial facility point source emissions in relation to SO_2 ambient air monitor locations.

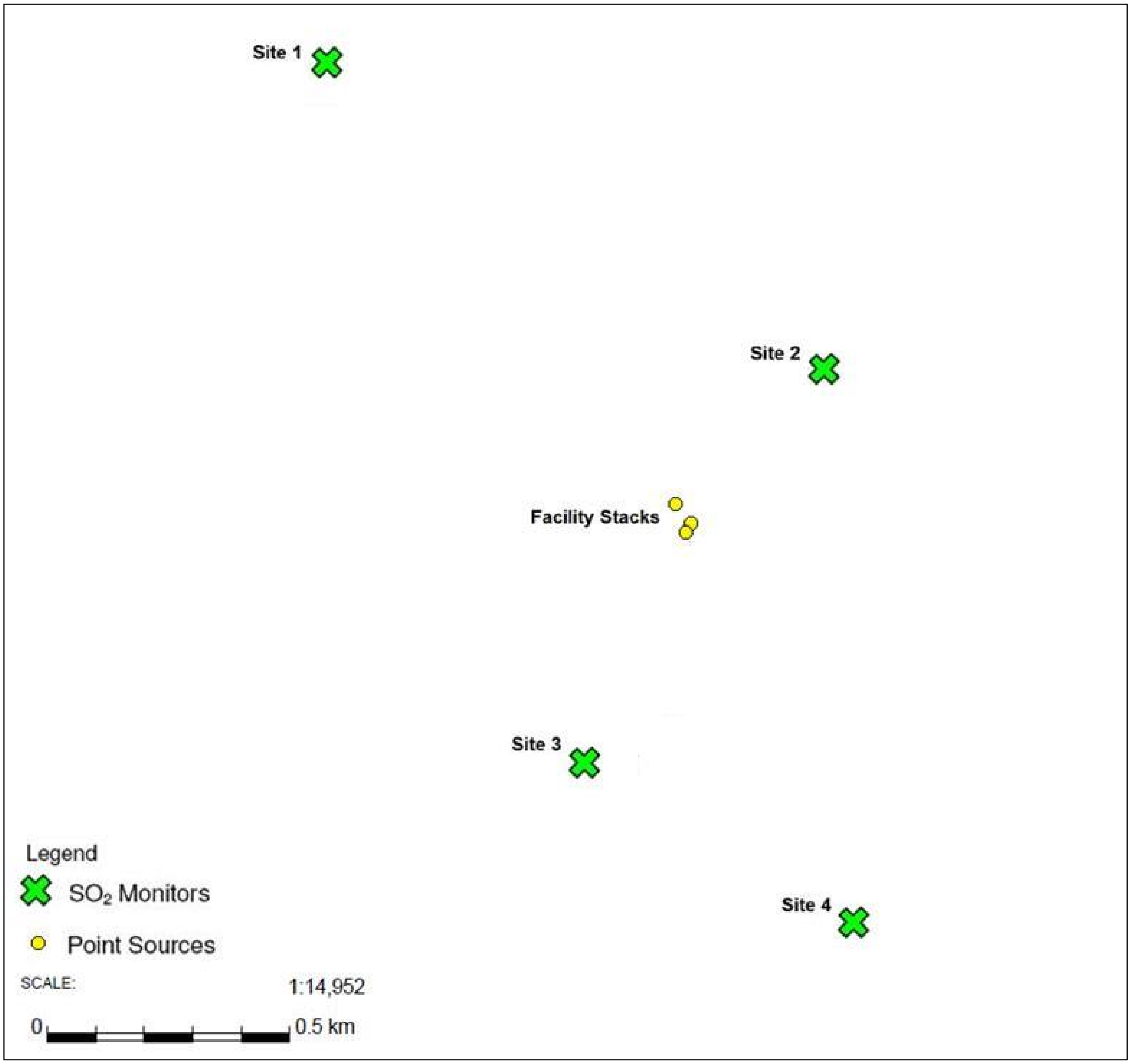
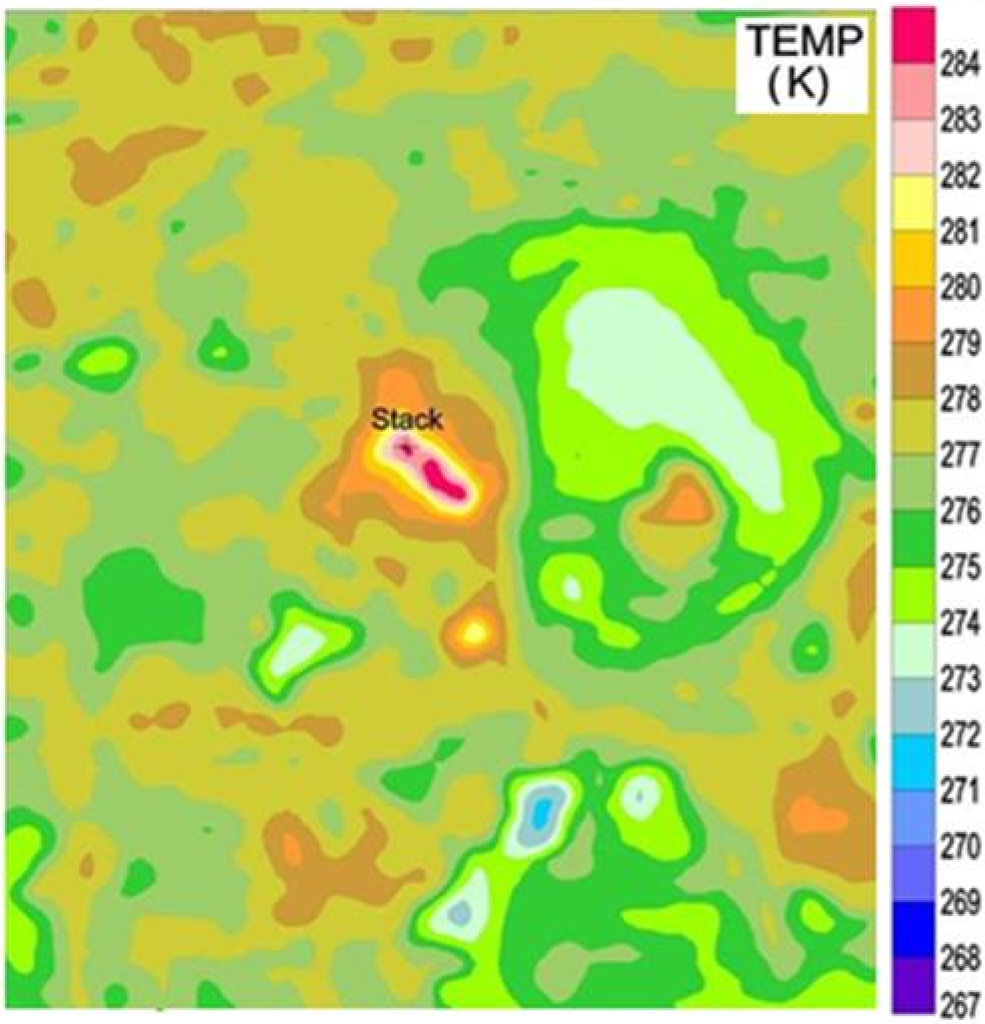
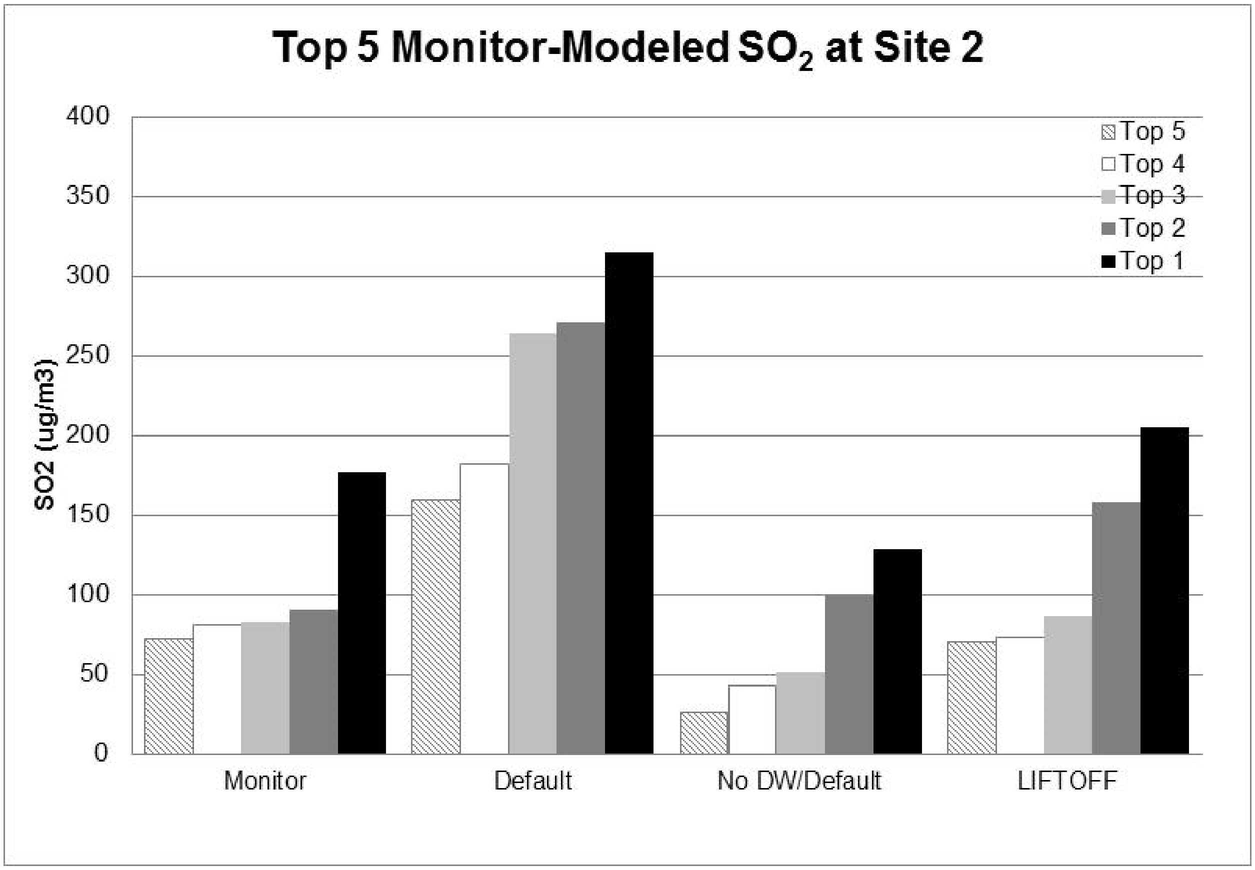


Figure 4. Brightness temperature from LandSat 8 TIR band 11 April 21, 2013 10 p.m.



Modeled and monitored 1-hour ground-level concentrations were ranked from highest to lowest and compared. In general, for the top five ranked concentrations, AERMOD with downwash indicated large overpredictions, while AERMOD without downwash exhibited a modest underprediction tendency. However, the LIFTOFF scenario (which is a weighted average of the downwash and no downwash cases computed from hourly wind and building dimension data) was relatively unbiased, and generally exhibited a modest overprediction tendency as shown by Figure 5 for Site 2. Site 2 is the location that measured the highest SO_2 concentration during the field study. At all monitors, the top five ranked LIFTOFF concentrations were generally higher than the top five ranked observations. Although the assumption of no downwash could lead to lower model predictions in this case that are sometimes not underpredicting, the somewhat higher LIFTOFF results are more likely to have a modest overprediction and still avoid the large overpredictions if no consideration is made for the fugitive heat release. More information on this model evaluation is provided in Attachment K.

Figure 5. Top 5 ranked daily maximum 1-hour SO_2 at site 2.



Notes: "Default" refers to AERMOD runs with default options and downwash. "No DW" means that building downwash effects were not exercised. The "LIFTOFF" approach weighs the downwash and no downwash effects on an hourly basis.

7.3 Buoyancy Enhancement of Stacks in a Line Should be Considered on a Case-by-Case Basis.

When adjacent stacks are positioned in a line, the individual plumes have shown to have a tendency to merge causing a buoyancy enhancement under certain conditions. This plume merging tendency is influenced by the stacks' proximity, the wind direction relative to the stack configuration, and individual stack plume rises. Briggs (1984)[71], refers to the results of wind tunnel studies for a row of identical stacks that indicate the usefulness of a merger parameter, S', to determine the effect of the angle of the wind relative to the stack alignment:

$$S' = (\Delta s \sin\theta) / [L_b^{1/3} (\Delta s \cos\theta)^{2/3}] \qquad (7)$$

where Δs is the average spacing between the aligned stacks, θ is the wind angle relative to the alignment angle of the adjacent, inline stacks, L_b is the buoyancy length scale where:

[71] Briggs, G. A. 1984. "Chapter 8." In *Atmospheric Science and Power Production*. Oak Ridge, TN; Springfield, VA: Technical Information Center, Office of Scientific and Technical Information, U.S. Dept. of Energy.

- $L_b = F_b/U^3$,
- F_b is the buoyancy flux where $F_b = g\ V_s^2 D_s^2/4\ [(T_p - T_a)/T_p]$,
- U is the wind speed at plume height,
- V_s is the stack gas exit velocity,
- T_p is the stack gas temperature,
- T_a is the ambient temperature, and
- D_s is the stack diameter.

By definition, Sôis undefined when the wind is exactly normal to the alignment angle, so in practice for that case, an angle not exceeding 89.99 degrees is used in the approach described in the next section.

Wind tunnel studies using neutral conditions showed that Sôless than 2.3 results in buoyancy enhancement while values above 3.3 indicate no enhancement (Briggs, 1984). Intermediate values would indicate partial enhancement. For those wind angles that allow plume merging, a formulation for the buoyancy enhancement accounting for other factors noted above due to the merging of adjacent plumes can be taken from the Manins implementation (Manins et al., 1992)[72] of the Briggs formulation:

$$E = (n+S)/(1+S) \qquad (8)$$

$$S = 6\ \{[(n-1)\ \text{qps}]/(n^{1/3}\ \text{qph})\}^{3/2} \qquad (9)$$

where E is the buoyancy enhancement factor, n is the number of stack in the row, S is a separation factor, and qph is the plume rise for one stack. While the buoyancy flux would be enhanced, the momentum flux should be unchanged. The formula for the momentum flux in AERMOD and many other dispersion models is:

$$F_m = (T_a/T_p)\ V_s^2\ D_s^2/4 \qquad (10)$$

Therefore, the buoyancy enhancement would increase T_p and V_s in a manner to provide the appropriate multiplier to F_b while retaining F_m by retaining the ratio of V_s^2/T_p.

Several investigators noted in Briggs (1984) have studied and reported buoyancy enhancement for only two stacks. Briggs noted that ñall of the authors referenced in this section compared the predictions of their models, at least for n = 2, with the semi-empirical results of Briggs (1974)[73] and concluded that, as different as these approaches seem, their predictions were very similar.ò Additionally, the plume rise enhancements plotted in neutral conditions by Anfossi (1985)[74] indicated that even for stacks separated by 77 m, some enhancement was observed in conditions of substantial buoyancy.

Additional supporting evidence for plume merging from two stacks is available from more recent journal articles. These articles are consistent in reporting an angular dependence on the extent of the merging.

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[72] Manins P., J. Carras, and D. Williams. 1992. Plume rise from multiple stacks. Clean Air (Australia) 26(2):65 - 68.

[73] Briggs, G.A. 1974. Cooling Tower Environment - 1974: Plume Rise from Multiple Sources (CONF-740302). Springhill, VA: ERDA Symposium Series, National Technical Information Services, U.S. Dept. of Commerce.

[74] Anfossi, D. 1985. Analysis of plume rise data from five TVA steam plants. *J. Appl. Meteorol Clim.* 24:1225-1236. doi: 10.1175/1520-0450(1985)024<1225:AOPRDF>2.0.CO;2.

Macdonald, Strom, and Slawson (2002)[75] indicated that there is a definite enhancement for flow parallel to the line of stacks. For larger angles, due to dual rotors from plumes (clockwise looking downwind on the right side and counterclockwise on the left side), there can sometimes be some plume rise suppression between two closely spaced stacks for wind angles approaching a perpendicular to the line of stacks. These authors also noted plume rise enhancement for power plant stacks separated by a distance of more than 1 km, providing support for no arbitrary distance cutoff for this algorithm. The Briggs algorithm will automatically reduce the plume rise enhancement as the distance between the stacks increases.

Furthermore, Overcamp and Ku (1988)[76] conclude that ñtests with azimuthal angles of 0º and 30º showed enhanced riseò Tests with azimuthal angles of 60º and 90º did not appear to exhibit enhanced rise (Overcamp and Ku, 1988), information that was incorporated into the Briggs formulation. Similar confirmation of plume merging effects from two identical, separated stacks is documented by Contini et al. (2006)[77]. The dependence of the enhanced buoyancy on the approach angle to the stacks is similar to findings by the other investigators.

The AERLIFT technique

The AERLIFT technique (see user instructions in Attachment L) has been developed to account for potential merging of plumes from aligned emission sources and the resulting partial to full enhanced plume buoyancy. This intermediate processor, run outside of the AERMOD modeling system for this implementation, creates an enhanced hourly emissions file using information from an initial model run with information for effective stack exhaust characteristics of the partially merged plumes. The model is then run a second time using the adjusted source parameters.

To define the parameters necessary for calculating the buoyancy enhancement on an hourly basis, the initial dispersion model run for the stacks involved is set up to run with a 10-km ring of 360 receptors set 1° apart in flat terrain. Next, the AERLIFT processor takes the meteorology and the model output data (i.e., the hourly and source specific final plume rise and effective wind speed) to determine first whether plume merging occurs, and if so, by how much.

The maximum enhancement factor applied to the buoyancy flux is the number of stacks in the line. The AERLIFT processor applies the enhancement factor to the original stack velocity and temperature, and derives an altered set of parameters that increases the buoyancy flux by the appropriate factor while preserving the momentum flux. This is done to conservatively apply the enhancement to only the buoyancy component. During stable hours, AERLIFT uses the plume rise directly in eq 9. For added degree of conservativeness, during unstable hours for when the stack top is less than the mixing height, AERLIFT selects the minimum between the final plume rise and the mixing height, which is defined as the maximum of the mechanical and convective mixing heights, for use in eq 9.

[75] Macdonald, R.W., R. K. Strom, and P.R. Slawson. 2002. Water flume study of the enhancement of buoyant rise in pairs of merging plumes. *Atmos. Environ*. 36(29):4603-4615. doi: 10.1016/S1352-2310(02)00464-8.

[76] Overcamp, T.J. and T. Ku. 1988. Plume rise from two or more adjacent stacks. *Atmos. Envi*ron. 22(4):625-637.

[77] Contini, D., P. Hayden, and A. Robins. 2006. Concentration field and turbulent fluxes during the mixing of two buoyant plumes. *Atmos. Environ.* 40(40):7842-7857. doi: 10.1016/j.atmosenv.2006.07.024.

Finally, a second dispersion model run is performed using the appropriate terrain options and modeling receptors for the emission source as well as the enhanced hourly emission file from AERLIFT.

Evaluation of AERLIFT.

AERMOD has been tested with the AERLIFT approach with a model evaluation field study conducted by Eastman Chemical Company in Kingsport, Tennessee, USA (described by Paine et al, 2013[78]; Szembek et al., 2013[79]). This study featured a 1-year monitoring period with 4 monitors featuring a line of 5 coal-fired boiler stacks. The inclusion of the AERLIFT approach significantly reduced AERMOD overpredictions, as noted by Szembek et al., 2013. This was due to the effect of AERLIFT on plume rise and the attendant effect on predicted concentrations.

7.4 Effects of a Moist Plume on Plume Rise Calculations Should be Accounted For.

The final plume rise formula in AERMOD and most other dispersion models is based on the assumption of a dry plume, where the stack plume is far from being saturated and carries essentially no liquid water load. However, in many cases for moist plumes, the effect on plume rise can be significant due to heat of condensation and should be accounted for, particularly for emission sources that operate flue gas desulphurization equipment, or scrubbers, designed to remove several pollutants from combustion plumes. The scrubbing process acts to partially or fully saturate exhaust gases while minimizing any liquid ñdriftò emerging from the scrubber to minimize chemically erosive processes. This process acts to cool the plume relative to the unscrubbed exhaust, resulting in a reduction of plume rise. However, the moist plume exits the stack and the heat of condensation released by the liquid water particles acts to make the plume gases warmer, giving the plume additional buoyancy. Some of this buoyancy is lost as the droplets evaporate on mixing, but a net gain in plume rise is realized from the heating/cooling process. The largest net rise is realized for the situation where the ambient air itself is near saturation.

A validated, moist plume rise model called ñIBJplurisò has been found to accurately predict the final rise of a moist plume (Janicke and Janicke, 2001)[80] and can be used to complement the dispersion modeling process when moisture content can be a significant factor. The IBJpluris model formulation includes a general solution for bent-over moist (initially saturated) chimney plumes (Janicke and Janicke, 2001). The model was reviewed by Presotto et al. (2005)[81], which indicated that despite a number of entrainment formulas available, IBJpluris possessed the physical capability of representing the impacts of heat of condensation on symmetric chimney plume rise. This model was selected to serve as a test bed for

[78] Paine, R., F. Tringale, and S. Gossett. 2013. Resolution of 1-hour SO_2 Non-attainment Area in Kingsport, TN: Advanced Meteorological and Monitoring Study. Control #7, Air & Waste Management Association Specialty Conference, Guideline on Air Quality Models: The Path Forward, Raleigh, NC. March 2013.

[79] Szembek, C., R. Paine, and S. Gossett. 2013. Resolution of 1-hour SO_2 Non-attainment Area in Kingsport, TN: Model Evaluation Analysis Results to Date. Control #8, Air & Waste Management Association Specialty Conference, Guideline on Air Quality Models: the Path Forward, Raleigh, NC. March 2013.

[80] Janicke, U., and Janicke L. 2001. A three-dimensional plume rise model for dry and wet plumes. *Atmos. Environ*. 35(2001):877-890.

[81] Presotto, L., R. Bellasia, and R. Bianconi. 2005. Assessment of the visibility impact of a plume emitted by a desulphuration plant. *Atmos. Enviro*n. 39(4):719-737.

developing and applying a simple adjustment method to the standard Briggs (1975)[82] plume rise formula used by AERMOD to account for thermodynamic modification of plume rise.

The moist plume pre-processor

A method (see Attachment M for technical details) has been developed and incorporated into a pre-processor called ñAERMOISTò (see Attachment N for the AERMOIST user instructions, which includes the IBJpluris user manual), whereby adjustments can be made to better simulate the rise of a moist plume using a dry plume model like AERMOD. This is done by performing IBJpluris model runs for both the actual moist plume and a dry plume so that the adjustments for the difference can be made and transferred to hourly plume input data. By assuming the ambient environment that the plume rises through is identical for both a dry and wet plume, a reasonable assumption is that the ratio of the wet to dry plume rise for IBJpluris can be used to adjust the dry dispersion model plume rise to a moist plume rise prediction:

$$[\text{æh}_w\,(\text{model})] / [\text{æh}_d\,(\text{model})] = [\text{æh}_w\,(\text{IBJpluris})] / [\text{æh}_d\,(\text{IBJpluris})] \qquad (11)$$

where æh is the change in final plume rise, and subscripts ñwò and ñdò correspond to moist and dry plumes, respectively. The approach assumes that this scaling ratio is independent from changes in wind speed and stability, although the variations in rise may be rather large. This assumption is reasonable since the rise is functionally related to the sum of exiting buoyancy and vertical momentum fluxes and the difference between dry and moist rise depends mainly on buoyancy, which is primarily temperature- and relative humidity-dependent.

The rising plume, by analogy, can be treated as if it were a rising moist thermal and cloud dynamic process. Concepts such as the buoyancy factor (Jacobson, 2005)[83] can be applied since this same buoyancy factor appears in the Briggs dry plume rise. The major difference is that the cloud buoyancy depends on the virtual temperature, which depends on temperature, pressure, and relative humidity of both the plume and the environment. The buoyancy factor, F_b, for both plume and cloud water as normalized density can be expressed by the difference between plume temperature and ambient temperature, divided by the plume temperature, when virtual temperature is equal to dry bulb temperature. The approximate term appears in Briggs final plume rise formula for the dry buoyancy flux term. The final rise æh_f is a power law function of F_b, where the power is ó1/3ô as derived by Briggs (1975). Following Jacobson, the moist buoyancy can be expressed in terms of the virtual temperatures and water vapor partial pressures of the plume and the ambient environment as T_{va}, T_{vp}, and $P_{a,}$ P_{wa}, P_{wp}, where P_{wp} is assumed to be saturated, P_s. The virtual temperature, T_v, can be expressed in terms of dry bulb temperature, T (Arya, 2001)[84]:

$$T_v = T(1 + 0.608\ q_v) = T\{1 + 0.608[0.622\ (RH)\ P_s/(P_{da} + 0.622\ (RH)\ P_s)]\} \qquad (12)$$

[82] Briggs, G. A. 1975. ñPlume Rise Predictions.ò In *Lectures on Air Pollution and Environmental Impact Analyses*. Boston: American Meteorological Society.

[83] Jacobson, M. Z. 2005. *Fundamentals of Atmospheric Modeling*. New York: Cambridge University Press.

[84] Arya, S. 2001. ñChapter 5: Air temperature and humidity in the PBL.ò In *Introduction to Micrometeorology*. Oxford, UK: Academic Press

where q_v is the mixing ratio in kg of moisture per kg of dry air, P_{da} is the dry atmosphere pressure, and RH is relative humidity as a fraction. For a plume exit temperature of 325 K, the virtual temperature of a saturated plume is 390 K. As the saturated plume temperature increases, so do the effects of virtual temperature, especially for higher stack temperature and relative humidity.

Using a relationship for estimating the saturation vapor pressure of water derived from the Clausius-Clapeyron equation (Ayra, 2001), the relative humidity of a plume can be estimated from the moisture content (%) at the plume exit temperature:

$$P_s = 6.112 \exp \{6816 [(1/273.15) \text{ ï } (1/T)] + 5.1309 \ln (273.15/T)\} \quad (13)$$

where all pressures are in hectopascals (millibars). For example, a moisture content of 10% implies an approximate water vapor pressure of 100 hPa. At 325 K, the saturation vapor pressure is 134.24 hPa. This would suggest that such a plume is sub-saturated. The IBJpluris model has the ability to treat sub-saturated plumes as long as the plume emission temperature is held constant. Using eq 13 and the moisture content of the exiting plume, the relative humidity of the plume can be estimated. Although the exiting plume flux is sub-saturated, the plume rise gain can still be estimated. There is one additional effect that comes into play and that is the role of relative humidity on the adiabatic processes involved in moving the plume from one pressure level to another. As the ambient air retains more moisture, the plume travels higher before reaching equilibrium with the ambient air.

Equivalent dry plume temperature approach.

It can be shown that a simple, but effective approach for representing moisture in plumes is to adjust only the plume temperature rather than changing both plume and ambient temperatures, which would be required if virtual temperature were to be used directly. This revised plume temperature is generated by AERMOIST and can be referred to as an ñequivalent dry plume temperatureò, and it is always greater than the original plume temperature and does not equal the virtual temperature. This hourly equivalent plume temperature is input to a dispersion model such as AERMOD in an hourly emissions input file so that the moist plume rise is more accurately modeled. The scaling relationship based on the right hand side of eq 11 forms the first part of the adjustment model. The plume height scaling parameter is given by the moist over the dry buoyancy flux:

$$\text{ƀ} = (\text{qp}h_w{}^3 / \text{qp}h_d{}^3) \quad (14)$$

where subscripts w and d refer to moist and dry buoyancy fluxes, respectively.

The computation of the ñequivalent plume temperatureò for use by a dry model like AERMOD that describes the difference in the final plume rise due to heat of condensation, water vapor pressure excess, and the increased rise due to a moist rather than a dry adiabat. Two equations relating final rise to equivalent plume and ambient temperature are:

$$\text{qp}h_d{}^3 = \text{ə}F_{bdry} = \text{ə}[(T_p \text{ ï } T_a)/T_p] \quad (15)$$

$$\text{qp}h_w{}^3 = \text{ə}F_{bwet} = \text{ə}[(T_p{}^{eq} \text{ ï } T_a)/T_p{}^{eq}] \quad (16)$$

The exponent of 3 in eq 14 is due to the Briggs plume rise dependence on the buoyant flux, F_b, to the ñ1/3ò power. As the vertical momentum flux becomes a larger fraction of the total flux, the effective exponent for the buoyant rise becomes smaller because the momentum plume rise is proportional to the momentum flux, F_m, to the 1.5 power. In AERMOIST, the exponent is treated as a user input to be conservative (< 3) when the total plume rise may have appreciable momentum at release. A smaller buoyant rise exponent, such as 2.5, would insure that the model is always conservative and the plume rise is not overstated.

From the equations stated above, the equivalent plume temperature, T_p^{eq}, can be solved for directly as:

$$T_p^{eq} = T_p T_a/[(1 - ƀ)T_p + ƀT_a] \quad (17)$$

The ratio, ƀ, is a function of both humidity and temperature and is found by the dry and moist IBJpluris simulations. As ƀ goes to 1, the equivalent plume temperature approaches the dry plume temperature, T_p.

To provide the hourly equivalent temperature to AERMOD, a simple interpolation bilinear model is constructed using a series of ƀs across a range of temperature and relative humidity. At the end points of each range, ƀ is calculated using IBJpluris and applied in a Taylor first-order expansion to create a bilinear model for the wet to dry ratio of plume rise within each range, ƀ(T_a,RH_a). The model assumes that ambient air at stack exit will be in the range from 253 - 313 K. Ambient temperatures outside of this range are clipped. The ambient relative humidity is assumed to lie between 0% and 95%. Values above 95% are clipped because these lie in a range of extreme sensitivity to conditional instability.

In AERMOIST, the IBJpluris model is exercised in both dry and wet mode for each range and an array of temperatures and humidity over the range of possible values, ƀ(T_i,RH_j) ratios, is saved for each stack that is modeled and are used to estimate the model adjustment coefficients, $C_{i,j}$ and $D_{i,j}$. The continuous model for the moist to dry plume rise ratio becomes:

$$ƀ(T_a,RH_a) = ƀ(T_i,RH_j) + (T_a - T_i)\, C_{i,j} + (RH_a - RH_j)\, D_{i,j} \quad (18)$$

The ƀ(T_a,RH_a) are used in eq 17 to estimate the equivalent hourly plume temperatures for input to the dispersion model for each hour of emissions. By modifying only the plume temperature, multiple sources can be included in the model run, each with their own series of equivalent hourly plume temperatures. Dry plumes can also be modeled with standard, constant input data.

Moist plume rise testing.

The IBJpluris model was exercised for a typical saturated, scrubbed power plant, with characteristics as listed in Table 2. The exiting plume moisture content for this test stack is 13.4%, and for a surface pressure of 1000 hPa, P_s = 134 hPa which, according to eq 12, translates into a saturated plume (RH_p = 100%) for an observed stack temperature of 325 K. The source's plume characteristics suggest that such an observed temperature (dry bulb) is actually near 340 K in terms of the virtual temperature for the saturated plume.

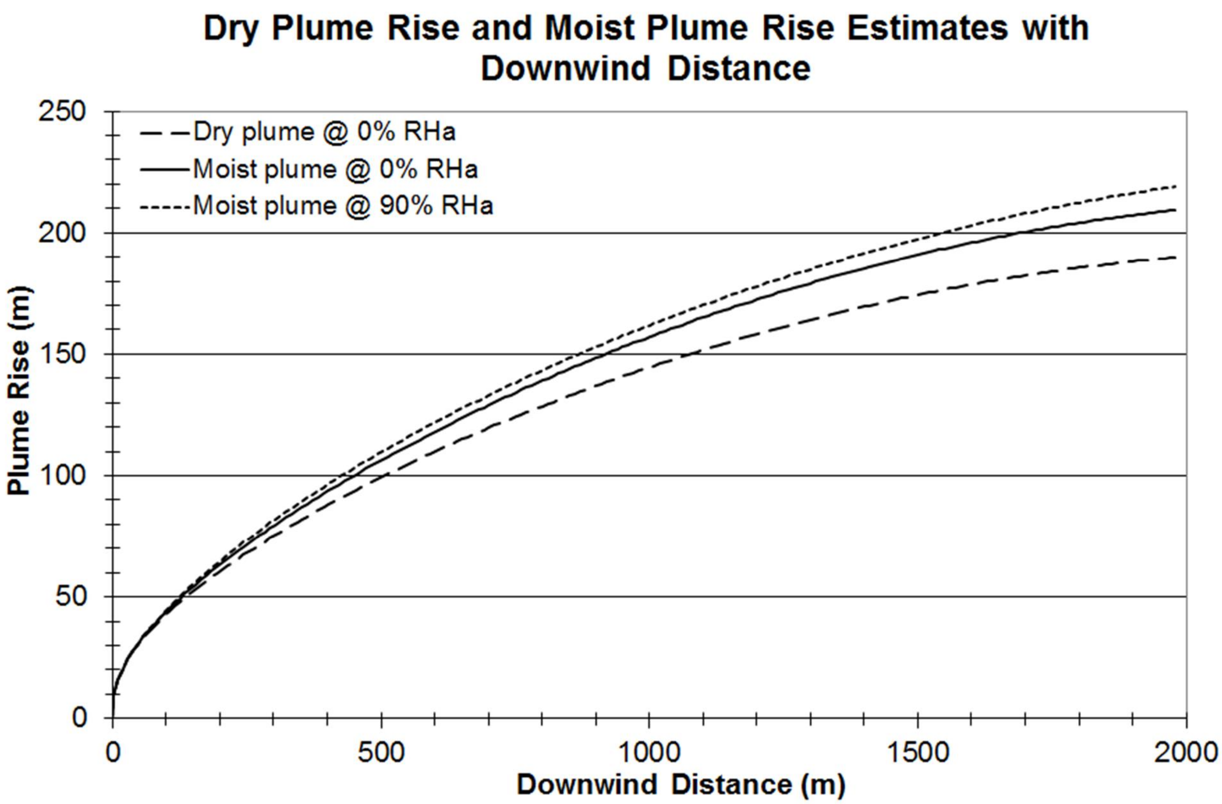
Table 2. Moist plume characteristics used in the test case.

Stack Height (m)	Exit Diameter (m)	Exit Temperature (K)	Exit Velocity (m/s)
171.45	14.23	325.37	15.16

The profile used by AERMOIST assumes neutral conditions with a height constant humidity and turbulence profile. For a given environmental humidity value, the plume was modeled with dry humidity

(0%) and a moist humidity based on the actual moisture content of the plume. The resulting plume rises as a function of downwind distance are illustrated for the dry (0% RH_p) and the moist (100% RH_p) plume cases with a dry ambient humidity (0% RH_a), and for a saturated plume emitted into a nearly saturated environment in Figure 6. The rise at 2000 m downwind is 189.8 m for the dry plume and dry environment, 209.3 m for a saturated plume in a dry ambient environment, and 219 m for the saturated plume rise in a 90% constant RH environment. At an ambient temperature of 293 K, the percent increase over the dry case is 10.3% and when a moist environment is considered, it is 15.4%.

Figure 6: Plume rise as a function of downwind distance for dry rise and an initially saturated plume by the test source for two constant relative humidity environmental conditions.



AERMOIST systematically exercises IBJpluris for each of the temperatures and relative humidity ranges (bins). Assuming final rise estimates at 2000 m downwind for a select set of temperature and relative humidity ranges, it is apparent that the largest rise of the saturated plume occurs at 90% humidity environmental conditions for the cooler ambient temperatures. The dependency on ambient humidity of final rise at any ambient temperature is rather small for a dry plume, allowing for ambient RH to be ignored for dry plumes. However, moist plume rise will increase substantially as the ambient humidity approaches saturation with an increase of over 10% from dry, cool air to moist cool air. Using virtual temperature by itself does not explain this effect. As the ambient temperature increases and the buoyancy factor decreases, the change in plume rise with humidity is reduced. The resulting effective stack temperatures for use in dispersion modeling generated by AERMOIST, which relies on the validated IBJpluris plume rise model, produce improved plume rise estimates for moist plumes.

8.0 PUBLIC COMMENT ON MODEL UPDATES

8.1 EPA should include in Appendix W a framework for implementing model changes in a faster manner than the current system provides. We provide a suggested 3-tier approach that streamlines the process for incorporation of technical model advances while still providing for public review.

Since AERMOD was promulgated as a Guideline model in 2005, it has undergone numerous revision, some versions correcting fixes and others providing improved parameterizations. EPAǻs current policy is that new model capabilities are treated as ñbeta optionsò and can only be used on a case-by-case basis until a change in Appendix W is promulgated. It will be over 10 years between the current proposed action and the previous Appendix W revision, and in this time period there have been many advancements in modeling technology. To allow for modeling advances to enter the regulatory arena faster, EPA should develop a structure for implementing model changes, similar to that presented at the 11^{th} Modeling Conference in the first APM A&WMA presentation[85]. Such a framework would streamline the process for incorporation of technical model advances while still providing for public review.

The framework and process should be included in Appendix W. A suggested approach is as follows:

A Level 1 change to Appendix W models represents a major change in formulation or new capability in an Appendix W model that would require a formal public comment process (*Federal Register* notice and a public hearing). Previous examples of this type change would be changing from the Huber-Snyder to Scire-Schulman downwash algorithms in ISC and addition of ARM2 in AERMOD. This could include a 90-day comment period and more time (several months) for testing and debugging any code changes before the proposal is finalized. However, the proposed changes could be approved on an interim, case-by-case basis.

A Level 2 change involves a refinement to an existing model formulation. Examples would be the low wind speed options in AERMOD or building downwash changes to AERMOD. These changes would require public review with a 90-day comment period and a longer period for code testing, but would not require a public hearing or change in Appendix W. During the testing period, these proposed changes could be approved for use on a case-by-case basis and once changes are finalized, they would available for routine regulatory applications.

A Level 3 change represents a correction to coding or logic errors to an Appendix W model. The corrected version could be released for a 90-day comment period and would then be finalized for general use.

Incorporating this type of approach in Appendix W would lessen the requirements for case-by-case determinations of model applicability and the subsequent burden on reviewing agencies and the Model Clearinghouse.

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[85] Available at http://www.epa.gov/ttn/scram/11thmodconf/presentations/2-10_APM_Intro_Comments_on_GAQM_2015.pdf.

9.0 EMISSIONS VARIABILITY

9.1 EPA should allow for consideration of emissions variability for New Source Review modeling, similar to the consideration provided for SO_2 nonattainment modeling. The Emissions Variability Processor (EMVAP) is an available tool.

In the April 2014 "Guidance for 1-Hour SO_2 Nonattainment Area SIP Submissions"[86], EPA suggests that an air agency may adopt longer-term emissions limits for variable emission sources. For example, rather than setting a single 1-hour "not-to-exceed" emission limit, EPA acknowledges that for statistically-based standards, such as the 1-hour SO_2 standard (99th percentile daily maximum concentration per year averaged over three consecutive years), an emission limit based on a 30-day average could be set that would provide adequate assurance that the NAAQS would be achieved. We agree that this is a reasonable concept and endorse its application to attainment demonstration modeling conducted for New Source Review (NSR). Heretofore, the standard practice in NSR modeling has been to model the proposed or modified sources at a permitted emission rate commensurate with the averaging time of the NAAQS. This has been a suitably conservative practice because a compliant source will necessarily operate at lower emission rates in order to avoid permit violations. Also, averaging times for pollutants such as SO_2 and NO_2 were longer than 1 hour in the past.

For deterministic NAAQS such as the 1-hour standard for carbon monoxide, which is based on the second-highest concentration over a year, this approach is not considered to be overly conservative. However, given that for SO_2 the form of the NAAQS is a 99th percentile peak daily maximum concentration, the standard practice of never allowing an excursion of the permitted emission rate can be unreasonably restrictive for sources for which emissions are highly variable. The same argument applies to NO_2 and $PM_{2.5}$ for which the short-term NAAQS is based on the 98th percentile (8th-highest) daily value.

EPA's suggestion to air agencies in setting emission limits in State Implementation Plans (SIPs) is to conduct modeling for the source to be permitted at a continuous emission rate, so that when accounting for measured and modeled background sources, the total impact results in design concentration equal to the 1-hour NAAQS concentration. This continuous emission rate value is called the "critical emission rate" or "critical value." In Appendix C of the 2014 Guidance, EPA provides an example whereby a 30-day compliant emission limit is computed by multiplying the critical emission limit by the ratio of the 99th percentile 30- day rolling average emissions and the 99th percentile hourly emissions, based on a long-term record of continuous emissions monitoring.

The incorporation of emissions variability into a compliance demonstration for a new source is equally legitimate as it is for an existing source, and should be incorporated into NSR modeling procedures as described in Appendix W. For NSR, in contrast to the SIP process, it is necessary to demonstrate NAAQS compliance for a given permitted emission rate rather than back-calculate an emission rate. In theory, if a new source is identical to an existing source, the continuous emission monitoring (CEM) data for the existing source could be used as a surrogate. In that case, an approach parallel to the 2014 Nonattainment Guidance Appendix C SIP modeling guidance[87] could be followed. This would be done in reverse order where the continuous emission rate to be modeled is set equal to the product of the 30-day permit limit and the ratio of the 99th percentile 1-hour emission rate and the 99th percentile 30-day emission rate.

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[86] http://www.epa.gov/airquality/sulfurdioxide/pdfs/20140423guidance.pdf.

[87] http://www3.epa.gov/airquality/sulfurdioxide/pdfs/20140423guidance.pdf.

The challenge is greater when emissions of a new source are known to be highly variable, but no established emissions frequency distribution is applicable. To account for emissions variability in modeling, a way of tracking hourly emissions needs to be implemented. If the Appendix C method of incorporating emission variability is followed, then a two-part permit limit could be developed, consisting of a 30-day rolling average limit coupled with a limit on the peak emission rate that could be related to the 30-day limit by the 99th percentile 1-hour to 99th percentile 30-day emission rate ratio.

Although EPAõs Appendix C example seems to be reasonable, it may not always provide a rigorous statistical assurance of compliance because the frequency of the peak emission rate needs to be better established. We describe two approaches for this frequency in the following discussion. In this case, assume that the ratio of the 30-day to peak emission rate is a factor of 2 and the 30-day and peak emission rates are 100 and 200 g/s, respectively. Also assume that modeling indicates that the critical value emission rate is higher than 100 g/s, but lower than 200 g/s.

a) The frequency of the 200 g/s emission rate could be limited to a value that accounts for the form of the standard and the wind frequency in any given direction. For example, for the 1-hour SO_2 NAAQS, emissions could exceed the critical value at least 1% of the time without endangering the NAAQS due to the 99th percentile form of the NAAQS. On top of this, assume that the wind does not blow in any given direction (say, defined by a 10-degree sector, which is comparable to plume width[88,89]) more than 20% of the time for the most frequent sector. In this case, a 5% frequency width for the peak emission rate would protect the NAAQS because an emission rate higher than the critical value could not affect a given location more than 20% times 5%, or 1% of the time.

b) The frequency of the peak emission rate could be tested rigorously with a statistical post-processor. To respond to the need to account for emissions variability in addressing probabilistic 1-hr ambient air quality standards for SO_2 and NO_2, EPRI has developed[90] a statistical technique, the Emissions Variability Processor (EMVAP), which can account for emissions variability in dispersion modeling through Monte Carlo sampling from a specified frequency distribution of emission rates. EMVAP provides a conservative and statistically robust estimate of SO_2 and NO_2 design concentration based on hourly frequency distribution of emissions. EMVAP is inherently conservative because it randomly samples hourly emissions from a specified distribution and thus spreads out the highest emission rates over a larger number of days than in reality. This results in an overestimate of the number of high daily maximum concentrations. The conservatism of EMVAP has been demonstrated when compared to SO_2 modeling with actual emissions for coal-fired power plants. A federally enforceable permit limitation could be established for the frequency width of emission levels above the critical value consistent with the input to EMVAP. An example of this approach was provided in the presentation[91] by Szembek and Paine given at the 11th EPA modeling conference.

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[88] Pooler, F. and Niemeyer, L. E., 1970, Dispersion from Tall Stacks: An Evaluation, Proceedings of the 2nd International Clean Air Congress, 1049ï 1056.

[89] Carpenter, S.B. , T. L. Montgomery , J. M. Leavitt , W. C. Colbaugh, and F. W. Thomas, 1971. Principal Plume Dispersion Models: TVA Power Plants. Journal of the Air Pollution Control Association, 21:8, 491-495, DOI:10.1080/00022470.1971.10469560.

[90] Paine R, Szembek C, Heinold D, Knipping E, Kumar N. Emissions variability processor (EMVAP): design, evaluation, and application. *J Air Waste Manag. Assoc.* 2014 Dec: 64(12):1390-402.

[91] http://www.epa.gov/ttn/scram/11thmodconf/presentations/3-5_2015EPA_11th_Modeling_Conference-EMVAP-Szembek_Paine.pdf.

10.0 GRANDFATHERING OF MODELING PROCEDURES

10.1 We support a 1-year transition period for newly promulgated modeling procedures

In the 2005 Appendix W, EPA provided permit applicants with the option to either adopt the new modeling procedures immediately, or to continue to use the previously preferred short-range model, ISC3, for a full year after promulgation. This transition period allows for a learning curve for any new modeling process as well as a continuation without interruption of permitting activity already well underway.

We recommend that EPA allow the same option for a one-year transition period for modeling approaches in the current Appendix W when the new Appendix W is promulgated, such as the use of CALPUFF as a preferred long-range transport model. In general, if modeling protocols using the older procedures are proposed and accepted within a year of promulgation, then the procedures should be allowed.

10.2 After promulgation of the new Appendix W, modeling protocols can use either the old Appendix W or new Appendix W procedures up to 1 year after promulgation if the protocols are approved in writing before that date.

After a modeling protocol has been approved by the appropriate reviewing authority, the modeling procedures described therein are valid (grandfathered) during the permitting process (unless both parties agree to a change), such that subsequent changes in Appendix W or other EPA-issued modeling guidance or requirements will not apply for that permit application.

This transition period allows for continuity of work in progress and avoids needless re-doing of modeling work.

11.0 REFINEMENT OF FUGITIVE DUST EMISSION ESTIMATES FOR MODELING

11.1 The Unacceptable Performance of EPA's Models and Emission Factors When Applied to Fugitive Particulate Emissions and Dust Is Well Known and Documented.

The inability of EPA's models to demonstrate acceptable performance when applied to fugitive particulate emissions is a longstanding, well-documented fact. Indeed, problems arising from modeling such emissions became so controversial during the 1980s that Congress finally directed EPA to resolve the problems with modeling those emissions. EPA was never able to successfully respond to its congressional mandate. Therefore, AISI believes that any discussion of EPA's current approach for modeling fugitive PM_{10} and $PM_{2.5}$ emissions must necessarily begin with EPA's statutory mandate from the Clean Air Act Amendments of 1990 that remains applicable.

Prior to EPA's 2005 adoption of the AERMOD model as the preferred model for fugitive particulate emissions and dust, the Industrial Source Complex (ISC) model was the Agency's preferred model for such applications. During the 1980s, air quality management of economic development throughout the Nation was significantly hampered by the ISC model's overly conservative predictions of ambient impacts from fugitive emissions of particulate matter. In particular, ISC's severe over-predictions of impacts from surface coal mining operations threatened to prohibit development of that industry in Wyoming's Powder River Basin. As a consequence, Senator Alan Simpson (R-WY) sponsored the following provision that Congress enacted as section 234 of the Clean Air Act Amendments of 1990:

> SEC. 234. FUGITIVE DUST
>
> (a) Prior to any use of the Industrial Source Complex (ISC) Model using AP-42 Compilation of Air Pollutant Emissions Factors to determine the effect on air quality of fugitive particulate emissions from surface coal mines, for purposes of new source review or for purposes of demonstrating compliance with national ambient air quality standards for particulate matter applicable to periods of 24 hours or less, under section 110 or parts C or D of title I of the Clean Air Act, the Administrator shall analyze the accuracy of such model and emission factors and make revisions as may be necessary to eliminate any significant over-prediction of air quality effect of fugitive particulate emissions from such sources. Such revisions shall be completed not later than 3 years after the date of enactment of the Clean Air Act Amendments of 1990. Until such time as the Administrator develops a revised model for surface mine fugitive emissions, the State may use alternative empirical based modeling approaches pursuant to guidelines issued by the Administrator.

Clean Air Act Amendments of 1990, Pub. L. No. 101-549, § 234, 104 Stat. 2399 (1990).

The basis for that amendment and its interim effect on modeling of surface mines until EPA made the necessary model and emission factor revisions were explained as follows:

> This amendment was meant to direct the EPA Administrator to develop more accurate models for fugitive dust emissions from coal surface mines. Currently, EPA employs a model which was developed for a point source and it does not accurately predict real world emissions from coal surface mines which are not point sources in the classical sense. EPA must develop this model in a timely fashion and while the model is being developed, existing mines may continue to use empirical forms of modeling and monitoring to comply with the EPA regulations. Existing mines may also use State-adopted emission factors.

> New mines or mine expansions which are permitted after the date of enactment must use the old model until EPA develops the new model and may continue to use State-approved emission factors. Any mine expansion or new mine that has begun the permitting process prior to the date of enactment shall be considered an existing mine under this amendment. In developing a new model, EPA must take into account the fact that mining operations move from point to point and that there may be various sources of dust within the boundaries of a mined area which may also move from time to time.

S. REP. No. 228, 101st Cong., 2nd Sess. (1990), *reprinted in* 4 Library of Congress, Environment and Natural Resources Policy Div., A Legislative History of the Clean Air Act Amendments of 1990, at 7216 (1993).

In response to its congressional directive, EPA developed several study plans and conducted a variety of reviews, field tests and model performance evaluations during the first half of the 1990s.[92] Upon EPAǫs completion of its field studies and subsequent revisions to both the ISC model and certain emission factors, EPA found that

> the improved ISC3 model performs better than the original ISC2 model at predicting ambient concentrations of PM_{10} and TSP from a surface coal mine; the improved ISC3 model performed better for TSP than PM_{10}; model performance improved with the use of the new emission factors versus the existing AP-42 emission factors; model performance when the roadways were treated as area sources was indistinguishable from model performance when the roadways were modeled as volume sources; the ISC3 model with emission rates averaged by shift over the length of the study (lowest emission resolution) performed better that the others; and that there were statistically significant differences among pairs of models.

EPA, *Modeling Fugitive Dust Impacts from Surface Coal Mining Operations – Phase III (Evaluating Model Performance)*, EPA-454/R-96-002, 20-21 (Dec. 1995).

Nevertheless, at the end of the day, EPA had to conclude that ñin spite of the improved performance of the ISC3 model, the model significantly over-predicts (as defined in the protocol) for PM_{10}, but not for TSP.ò *Id.* at 21 (emphasis added). In other words, EPA did not successfully respond to its congressional mandate to correct the problems with its emission factors and ISC model that combined consistently to seriously over-estimate ambient impacts of fugitive PM_{10} emissions from surface coal mining.

EPAǫs acknowledgment of that failure and the Agencyǫs resulting commitments are particularly telling. As EPA explained,

> [I]n spite of the improved performance [due to certain revised emission factors coupled with improvements to the model], however, at this time the model does not meet the evaluation criteria that we, the industry, and the State of Wyoming had jointly agreed to. There is still a tendency for over-prediction of air concentrations for particulate matter less than 10

[92] EPA, *Review of Surface Coal Mining Emission Factors,* EPA-4564/R-95-007 (July 1991); EPA, *Development of a Plan for a Surface Coal Mine Study*, EPA-454/R-95-008 (Oct. 1991); EPA, *Surface Coal Mine Study Plan,* EPA-454/R-95-009 (Mar. 1992); EPA, *Surface Coal Mine Emission Factor Field Study*, EPA-454/R-95-010; EPA, *Modeling Fugitive Dust Impacts from Surface Coal Mining Operations – Phase I*, EPA-454/R-94-024 (July 1994); EPA, *Modeling Fugitive Dust Impacts from Surface Coal Mining Operations – Phase II (Model Evaluation Protocol)* , EPA-454/R-94-025 (Oct. 1994); EPA, *Modeling Fugitive Dust Impacts from Surface Coal Mining Operations – Phase III (Evaluating Model Performance)*, EPA-454/R-96-002 (Dec. 1995).

> micrometers (PM10). The same over-prediction does not appear for total suspended particulate matter (TSP). The causes of the over-prediction for this particular class of sources are as yet undetermined. This model, however, has been evaluated for other sources and been found accurate within accepted norms.
>
> Since the model still appears to over-predict the impacts of surface coal mines, the Agency does not plan to use it for regulatory applications involving these sources. As a consequence, the regulatory procedures currently in place will remain in effect.[93] . . . We believe that these procedures provide adequate protection for the environment and are also acceptable to the stakeholders. At this time, we and the various stakeholders believe that the interim procedures work well, and therefore we do not currently plan any further analyses. If in the future EPA is able to correct the modelœ tendency to over-predict as described above, it may, of course, review these regulatory procedures.

Letter from John S. Seitz, Director of EPAœ Office of Air Quality Planning and Standards, to The Honorable Alan K. Simpson, United States Senate, of June 26, 1996 (hereinafter %Seitz Letter+).

Many of the details regarding the origin of CAA § 234, EPAœ unsuccessful attempt to respond to that statutory mandate, and the Agencyœ eventual concession not to use the ISC model and unproven emission factors for regulatory purposes involving surface coal mines have been lost over time. A footnote in the AP-42 section for western surface coal mines acknowledges EPAœ policy decision not to use its model and emission factors for regulatory applications involving those sources. But even with that Agency policy statement, EPAœ caveat makes clear that %no better alternative data are currently available[,]+implying that future use of the emission factors (and models) for assessment of surface coal minesqimpacts would not be frowned upon by the Agency. Aside from that single, vague statement about limitations on regulatory applications of EPAœ models and emission factors to surface coal mines (which seems to have received little more than lip service for fifteen years), regulatory modeling of fugitive PM_{10}, and more recently of fugitive $PM_{2.5}$, emissions appears to have continued since the 1990 Amendments as if CAA § 234 never existed.

AISI strongly believes that EPA must re-visit that statutory prohibition and mandate before either EPA or the States require future modeling of PM_{10} and $PM_{2.5}$ emissions from similar operations. The mere fact that EPA has since abandoned the ISC3 model in favor of the AERMOD model does not render section 234 of the Act as either irrelevant or no longer applicable. Furthermore, given the acknowledged problems with application of EPA models and emission factors to surface coal mines, the Agency has no reasonable basis for concluding that the same models and the same or similar emission factors nevertheless produce acceptable results for ambient impacts from similar emission sources, including iron and steel sources, and mining operations other than coal.

Improvement of fugitive dust emission factors and their representation by dispersion models in order to better represent phenomena that tend to reduce predicted near-field concentrations of particulate matter (PM) from ground-level fugitive dust sources have been discussed over the past several years.[94] Emitted particulate from ground-level fugitive dust sources that reach ambient air locations is affected and often partially removed by physical processes that occur between the point of release and the affected receptors. These processes include, for example, scavenging by vegetation or other physical barriers,

[93] In the mid-1990s the State of Wyoming and EPA had executed a memorandum of agreement allowing the State to conduct monitoring in lieu of short-term modeling for assessing coal-related impacts in the Powder River Basin. *See, e.g.,* 60 Fed. Reg. 47,290 (Sept. 12, 1995).

[94] The Role of Vegetation in Mitigating Air Quality Impacts from Traffic Emissions, EM January 2011, A&WMA, 30-33.

coagulation or electrostatic agglomeration that changes the size distribution and accelerates deposition, and the effects of intermittent (rather than steady) traffic for dispersion of roadway emission sources. Because these PM removal processes are not well accounted for in emissions estimates and modeling analyses, significant over predictions of ambient PM_{10} and $PM_{2.5}$ concentrations can occur.

EPA has known for decades that surface mines cannot typically make successful NAAQS demonstrations for PM_{10} due to overly conservative predictions that inherently result from past and present dispersion models coupled with past and present AP-42 emission factors for mining activities. EPA fell short of an improved model and improved emission factors in the mid-90s that would improve the accuracy of dispersion model estimates for fugitive PM_{10} and $PM_{2.5}$ emissions. Meanwhile, regulatory needs for NAAQS compliance demonstrations have become more prevalent, and the nature of such demonstrations has become far more comprehensive and complex. In the absence of such model and emissions improvements, and consistent with the legislative history of CAA § 234, AISI believes that EPA must allow similar sources of fugitive emissions to use alternative measures for demonstrating compliance with the short-term PM_{10} and $PM_{2.5}$ NAAQS. Recommended alternative methods to facilitate such improvements are addressed below.

Previous investigations have explored how to correct limitations in standard dispersion modeling approaches for fugitive dust emissions that can materially contribute to the tendency of modeling to overestimate ambient concentrations of PM_{10} and $PM_{2.5}$ by using emission reduction factors.[2,95] Specifically, Dr. Cowherd proposed emission reduction factors for certain PM removal processes and model deficiencies as shown in Table 3. AISIõs comments focus on two fugitive model deficiencies: 1) source characterization improvements to correct the lack of representation of enhanced near-source agglomeration and near-source deposition effects and 2) the misrepresentation of roads as continuously emitting line sources.

Table 1. Modeling Deficiencies for Dust Dispersion Analysis[96]

	Modeling deficiency	Estimated over-prediction	Principal Investigator-[Ref.]	Comments
1	No representation of enhanced near-source agglomeration and deposition, especially in stilling zones behind wind barriers	Up to a factor of 6, depending on wind and groundcover	Cowherd (MRI)-[10,11] Etyemezian (DRI)-[6]	Based on field tests of near-source impacts of unpaved road emissions with various adjacent groundcover types
			Yayi Dong (Idaho DEQ)-[13]	Based on modeling comparisons and field validation
2	Misrepresentation of roads as continuously emitting ñlineò sources	Factor of 2	Randy Reed (NIOSH)-[22]	Based on algorithm comparisons for moving point source vs. line source depictions

<u>Revisions Are Readily Available to Account for Certain AERMOD Deficiencies</u>.

Surface mining is not the only generic category of stationary sources that has been burdened for many years by overly conservative estimates of ambient impacts based on inappropriate applications of flawed Agency dispersion models and unreliable emissions factors from AP-42. EPAõs most recent preferred

[95] Cowherd, C., Jr. ñTransportability Assessment of Haul Road Dust Emissions,ò Submitted by Midwest Research Institute to EPA. August 21, 2009.

[96] American Iron and Steel Institute draft document ñEmission Preprocessing Protocol to Achieve Realistic Modeled Impacts of Industrial Fugitive Dust Emissionsò, provided to AECOM by Tim Hunt of the American Forest and Paper Association (AF&PA).

model, AERMOD, like its predecessor (ISCST3), has been primarily designed to model steady-state or constant emission rates from unobstructed stacks. This representation of emissions does not reflect actual operation of typical facilities and activities in the iron, steel, mining and smelting industries. Facilities and activities in those industries are generally spread-out over a large site, and their fugitive emissions are often characterized by spatial and/or temporal variations. In addition, because these facilities and activities typically release their fugitive emissions near ground level dispersion of those emissions is often strongly affected by surrounding obstructions to air flow, e.g., nearby buildings and storage structures. Consequently, applications of EPA's dispersion models to predict ambient impacts from these low, laterally disperse sources of fugitive emissions in those industries have been documented time and time again to result in significant over-predictions of the ambient impacts of those fugitive emissions.[97]

AISI understands EPA's preference for demonstrating compliance with NAAQS by using the Agency's dispersion models with EPA-approved emission estimates. However, EPA's currently approved version of AERMOD does not have the ability to accurately and reliably predict ambient air impacts of PM_{10}, $PM_{2.5}$ or SO_2 emissions from the mining, iron and steel industries. Until appropriate corrections are made, AISI requests EPA to authorize alternative modeling approaches to demonstrate NAAQS compliance for the mining and iron and steel industries that more accurately predict real-world concentrations in ambient air, and thus provide a meaningful comparison between impacts of the emissions from regulated facilities and the ambient standards that EPA selected in its various NAAQS rulemaking proceedings.

During EPA's 10th and 11th Conference on Air Quality Modeling and on several prior occasions as well, EPA has been presented with recommended revisions that would "cure" some of the AERMOD deficiencies that currently result in the model's consistent over-prediction of ambient impacts. AISI respectfully requests EPA to provide near-term relief to its members confronted with the need to demonstrate compliance with the NAAQS by adopting the revisions to AERMOD discussed below. In addition, AISI requests that EPA consider a longer-term solution that would further amend Appendix W through notice-and-comment rulemaking to incorporate models that produce results that better reflect actual ambient air impacts.

11.2 Source characterization approaches are needed for fugitive dust emissions to account for capture by barriers or agglomeration effects. These "source characterization" approaches should be considered for routine application without a need for a non-guideline model approval if adequate documentation of the effects is provided.

Scavenging of particulate though deposition onto obstacles and dense vegetation is an important particulate removal mechanism in near-road environments. In this context, it is useful to differentiate the deposition from particulate that is directly simulated in dispersion models such as AERMOD and that which is not: near-field scavenging and agglomeration. In dispersion models, "dry deposition" refers to the removal particles at the interface of the plume and the underlying surface. Although models such as AERMOD can simulate deposition throughout the modeling domain, the deposition algorithm does not simulate scavenging by vegetation (such as a stand of trees adjacent to a roadway) which can remove particles from part or all of the entire vertical extent of the dust cloud as it is carried down wind. Because vegetative scavenging potentially removes particles from the entire plume rather than just from the surface, it can be addressed by applying a factor that effectively reduces the emission rate.

[97] Emissions and Air Quality modeling Analysis for the Birmingham $PM_{2.5}$ Non-Attainment Area, Jefferson County Department of Health and Alabama Department of Environmental Management, prepared by ENVIRON and Alpine Geophysics, 2007.

In addition to deposition and scavenging, agglomeration has been discussed as a possibly significant effect influencing fugitive particulate at the source where concentrations are high, and smaller particles collide and combine into larger particles. This effect results in the fraction of emitted particulate to shift from smaller to larger particle size categories before being transported downwind. Thus, some of the particles that are initially $PM_{2.5}$ at the point of generation would be transformed into coarse particles (between $PM_{2.5}$ and PM_{10}) and some of the coarse particles could shift into sizes greater than PM_{10}. This phenomenon may have some dependency on the type of dust particle and its affinity for the electrostatic effects.

Because scavenging and agglomeration both affect concentrations in the dust cloud, measurement studies will generally not be able to separate the contribution of the two phenomenon, but rather address the combined reduction. As indicated in Table 1, the neglect of these near-field particle removal mechanisms are indicated to result in an over prediction factor of up to 6 for both PM_{10} and $PM_{2.5}$. This over prediction factor was found in two investigations that Dr. Cowherd conducted for the U.S. Army Construction Engineering Research Laboratory, and a third study for the Idaho Department of Environmental Quality.[98,99] These documents described field studies of PM_{10} and $PM_{2.5}$ in a forested area and over an open field. As noted, a factor of 4 over prediction was indirectly referred to in a 2003 report by Pace and Cowherd.[100] A presentation at the Western Regional Air Partnership (WRAP) Dust Forum by the Idaho Department of Environmental Quality provided a discussion of urban-scale and regional grid modeling challenges with fugitive dust. A factor of 2 to 6 over prediction by regional models was described in which deposition is represented as occurring too slowly (underestimated by a factor of 8 to 64).[101]

The representation of deposition in dispersion models was explored by Etyemezian et al. (2003).[102] This study examined several deposition velocity estimation techniques by comparing deposition velocity measurements with predictions including predictions by the Slinn model, which is similar to the AERMOD deposition algorithms. The model predictions of the deposition velocity were an order of magnitude lower than measurements. These large underestimates of deposition velocity by the Slinn model would lead to significant over prediction of PM concentrations.

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[98] Cowherd, C. Jr., 2006a. "Validation and Modeling of Dust/PM Capture by Vegetative Groundcover Bordering Emission Sources." Midwest Research Institute Report to U.S. Army Construction Engineering Research Laboratory, Champaign IL. June 30, 2006.

[99] Cowherd, C. Jr., 2006b. "Vegetation Capture of Dust in Arid and Semiarid Systems: Refinement of Capture Algorithms for Incorporation into Regulatory Dispersion Models". Midwest Research Institute Report to U.S. Army Construction Engineering Research Laboratory, Champaign IL. August 31, 2006.

[100] Pace, T.G.; Cowherd, C. Jr.: "Estimating PM-2.5 Transport Fraction Using Acreage-Weighted Country Land Cover Characteristics-Examples of Concept," In Proceedings of the 96th Annual Meeting of the Air and Waste Management Association: San Diego, CA, June 2003.

[101] Dong, Y., and R. Hardy, W. Zhang, M. McGown, Idaho Department of Environmental Quality. "An Approach for Correcting Coarse Particle Prediction in Urban Air Quality Models", Western Regional Air Partnership Dust Forum, August 2005.
http://www.wrapair.org/forums/dejf/meetings/051115m/Road_dust_WRAP_dustforum_Nov15_2005_03.pdf.

[102] Etyemezian, V., H. Kuhns, J. Gillies, M. Green, M. Pitchford and J. Watson (2003). "Vehicle-based road dust emission measurement: I - methods and calibration." *Atmos. Envir.* 37(32): 4559-4571.

11.2.1. Emission Reduction Factors for Enhanced Deposition and Agglomeration

As described by Pace, dispersion models applied on a regional scale have been shown to significantly over-predict particulate matter (Pace 2005). In the development of the county-level transportable fractions, Pace has allowed regional modeling to better account for enhanced deposition. The concept of applying a transportable fraction factor may be a viable approach for use with short-range dispersion modeling as well. Transportable fraction is described in the following equation:

TF = [SE ï (SE * CF)] / SE (2)

where TF is the transportable fraction, SE is the source emissions term, and CF is the capture fraction.

Backed by the particulate matter capture efficiency relationship to vegetation determined by Cowherd (2003) and Etyemezian et al. (2003), Pace created recommendations of capture fraction ranges for five land cover types (Table 2). These capture fraction ranges could be applied for use in AERMOD to simulate enhanced near-field deposition. The lower range is proposed for use as a level of conservatism unless justification exists to vary from this percentage. This approach could be applied as an emission reduction factor as a pre-processor. For a given modeling application, specification of case-specific capture fractions is needed. This can be addressed through a new pre-processor that reviews land use data within the near-field modeling domain, and determines on an hourly basis the removal efficiency for particulate emissions for each source being modeled. This pre-processor would also evaluate the particulate agglomeration potential (likely a function of temperature and humidity) and compute an effective emission reduction due to this factor as well.

Another way to parameterize the capture fraction could be to apply the deposition velocity estimation technique presented by Raupach and Leys (1999).[103] The benefits of this technique would employ parameters such as friction velocity (u*), wind speed at a reference height (u_r), and width of canopy elements where particles impact (d_c). It is anticipated that this technique could be used to estimate a capture fraction-like multiplier for use as an emission reduction term.

Table 2. Capture Fraction (%) for Five Land Cover Types (Pace 2005) for Regional Modeling

Land Cover Type	Average Height (m)	Recommended CF (%)	Estimated CF Range (%)	Comment
Forest	18 – 20	100%	80 – 100%	Forested areas will capture dust effectively
Urban	5 – 50+	50%	25 – 75%	Structures are interspersed with open areas
Scrub, Sparsely Wooded & Grasses	1 – 2	25%	10 – 40%	Portion of plume is below sparse vegetation
Agricultural	1 – 2	25%	10 – 40%	Portion of plume is below crop (seasonally)
Barren / Water	0	0%	0 – 10%	Impediment-free surfaces are ineffective to capture dust

[103] Raupach, M.R. and F.L. Leys 1999 The Efficacy of Vegetation in Limiting Spray Drift and Dust Movement. Report Prepared for the Department of Land and Water Conservation, Gunnedah, Australia by CSIRO, Canberra, Australia.

AISI also recommends that EPA should include a statement or discussion in the Appendix W (or the AERMOD Implementation Guide) regarding source characterization refinements to these effective emission rates. The discussion for fugitive dust modeling would indicate that methods to more accurately characterize effective fugitive dust emissions from roadways and other fugitive emissions sources (e.g, storage piles, other fugitive material handling sources) can account for physical phenomena that reduce the above-mentioned overestimation tendencies of fugitive $PM_{2.5}$ and PM_{10} model estimates. These "source characterization" approaches should be considered for routine application without a need for a non-guideline model approval if adequate documentation of the effects is provided.

11.3 Misrepresentation of Roadways as a Continuously Emitting Source

Roadway dust generated by moving traffic and emissions are associated with on-site movement of trucks and equipment. It has been suggested that the representation of these types of sources as continuously emitting line sources may overestimate near-field concentrations because this simplification does not account for the intermittency of emissions. As shown in Table 1, this effect has been shown to result in an over prediction by a factor of 2 at receptors close to the fence line, where models indicate the highest modeled particulate matter concentrations. This factor stems from the characteristics of lateral dispersion from a line source, which does not account for the fact that the source is actually a series of discrete and intermittent moving point sources. The magnitude of this effect is expected to relate to the intermittency of truck traffic and distance from the roadway.

Dr. Cowherd cites Reed (2005)[104] to support a factor of 2 emission reduction to account for over prediction due to the misrepresentation of roads as continuous line sources based on Reed (2005) [105]. Reed (2005) discusses earlier work in which an ISC3-like dispersion model called the Dynamic Component program (DCP) [106] was tested against ISC3 and PM_{10} measurements from field studies. The DCP uses the ISC3 Gaussian dispersion equation for point sources to simulate the hourly average concentration that would result from a series of separated moving point sources representing dust generated by individual moving vehicles rather than a "stationary" line source or series of volume sources, as is typically used in modeling. The DCP and ISC3 models were tested against two field studies at operating mine sites, a stone quarry and a coal preparation plant. Overall, the DCP (using moving, separated point sources) showed 85% improvement in modeled concentrations from ISC3 predictions (using stationary, connected volume sources) when compared with PM_{10} measurements.[107] While an 85% improvement over ISC3 results was also cited in Reed (2005), Reed and Westman (2005) indicated a slightly different percent improvement of 77%. Furthermore, Reed (2003) showed some under predictions by the DCP at the coal preparation plant. To AECOM's knowledge, the DCP has not been directly applied

[104] Reed, W.E. Significant Dust Dispersion Models for Mining Operations. Information Circular 9478. National Institute for Occupational Safety and Health, Pittsburgh PA. September 2005.

[105] EPA, 1994. Modeling fugitive dust impacts from surface coal mining operations: phase II – model evaluation protocol. Research Triangle Park, NC: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Technical Support Division, EPA publication No. EPA–454/ R–94–025.

[106] Reed, W. R. and E. C. Westman. A model for predicting the dispersion of dust from a haul truck. International Journal of Surface Mining, Reclamation and Environment, Vol. 19, No. 1, March 2005, 66-74.

[107] Reed, W. R., 2003. An improved model for prediction of PM_{10} from surface mining operations [Dissertation]. Blacksburg, VA: Virginia Polytechnic Institute and State University, Department of Mining and Minerals Engineering.

in the context of the current regulatory guideline model, AERMOD, of which the most recent release includes several refinements proposed by EPA and discussed at the 11th Modeling Conference.[108]

In 2009, EPA formed a workgroup of federal, state, and local government dispersion modelers to explore haul road characterization issues and recommend a modeling methodology to the dispersion modeling community. This workgroup focused on air quality modeling issues and did not address fugitive dust emissions factors. The outcome was the Haul Road Workgroup Final Report which provides recommended modeling procedures of haul road fugitive emissions with AERMOD.[109] Within the report, haul roads were modeled as the following source types: adjacent volume, alternate volume, area, and point sources. Based on sensitivity modeling, the workgroup generally recommends the use of adjacent volume sources to represent haul roads. Furthermore, volume and area source characterizations were compared with a limited field study of PM_{10} measurements where the volume source performed better. With the release of AERMOD 12345 and subsequent versions, a line source type is now supported. However, the line source type has been shown to produce very similar results to the source type found to predict the highest maximum concentrations, the area source, in one recent study.[110] Unfortunately, the study group did not address the intermittency of traffic on model estimates.

At the 11th Modeling Conference, David Heinold of AECOM, on the behalf of the American Forest and Paper Association and the American Wood Council, provided information[111] about modeling refinements that are presently viable to modeling fugitive dust roadway sources. Refinements to the modeling approach for these types of sources have become increasing necessary with the recent tightening of the annual average $PM_{2.5}$ NAAQS. Specifically, the presentation indicated that one of the factors in the overestimation of downwind concentrations is associated with using uniformly emitting line sources (either represented as a series of line or volume sources) to represent haul roads for which truck movement is, in actually, characteristically intermittent. Previous studies have shown that this could lead to a high degree of overestimation within 100 m of a roadway, where the peak impacts are expected to occur. Thus, refinements are most needed at locations where these types of roadways are close to model receptors.

As previously noted, Dr. Cowherd indicated, a factor of 2 reduction can be applied to account for the misrepresentation of haul roads as continuously emitting non-point sources, not enough information could be found to support this specific reduction factor.

To implement this effect in AERMOD, it would be first required to modify Reedõs Dynamic Component Program for use with AERMOD instead of ISC3. The updated model would then be applied in a sensitivity analysis covering a range of traffic intermittency (trucks per hour), meteorological conditions and downwind distances to compare with AERMOD using elongated line segments or adjacent volume sources. The sensitivity results would be analyzed to develop a parameterization that computes hourly emission reduction factors.

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[108] http://www3.epa.gov/ttn/scram/11thmodconfpres.htm

[109] EPA Memo, ñHaul Road Workgroup Final Report Submission to EPA-OAQPSò, March 2, 2012. http://www.epa.gov/scram001/reports/Haul_Road_Workgroup-Final_Report_Package-20120302.pdf.

[110] Kurzenhauser, K. and T. Bowie, H. Wong. ENVIRON. Evaluation of Source Configuration Impacts for Modeling Fugitive Dust from Roads in AERMOD. A&WMA 107th Annual Conference, June 24-27, 2014.

[111] The presentation is available at http://www.epa.gov/ttn/scram/11thmodconf/presentations/3-3_Issues_with_Modeling_Low-Level_Sources_11_Mod_Conf-Heinold.pdf.

A benefit of this approach will not require any code modifications to AERMOD. Once the range of influence of this effect is determined, the affected nearby receptors would be identified and modeled separately. The concept would be model the roadways as elongated area source segments or volume sources in AERMOD with hourly emission rates scaled by the reduced hourly emission reduction factor.

12.0 MODELING ISSUES FOR RECEPTORS

AISI requests that EPA includes a statement or discussion in Appendix W for excluding receptors from certain areas such as waterways, roadways, and within property lines where the public is excluded by law or practicality for remaining in a given location. In addition, these receptor locations exclusions should be consistently applied when conducting modeling for NAAQS attainment, State Implementation Plan, and NSR/PSD purposes.

12.1 Roadways and waterways should be excluded as receptor locations.

12.1.1 EPA's Most Recent Technical Assistance Document for the 2010 1 Hour SO_2 NAAQS excludes receptor locations where monitors cannot feasibly be placed.

In December 2013, U.S. EPA issued a draft SO_2 NAAQS Designations Modeling Technical Assistance Document (ñModeling TADò), which sets out the agencyõs recommendations on ñhow an air agency might appropriately and sufficiently model ambient air in proximity to an SO_2 emission source to establish air quality data for comparison to the SO_2 NAAQS for the purposes of designations.ò

With respect to development of a receptor grid, the Modeling TAD notes that generally receptors are placed where there is ñambient air,ò but then states that ñ[f]or the purposes of modeling for SO_2 designations, the receptor placement strategy differs since the modeling is acting as a surrogate for monitoring. In areas where it is not feasible to place a monitor (water bodies, etc.), receptors can be ignored or not placed in those locations.ò

The Modeling TAD and Updated Guidance represent EPAõs most recent views on attainment designation modeling. As a result, while they expressly apply only to modeling for purposes of determining an attainment area in compliance with the 2010 primary SO_2 NAAQS, the same reasoning can be applied to exclude these receptors from other modeling demonstrations, particularly when the reason a monitor cannot be placed at that location is also a reason that a person would not reasonably be able to remain in a specific location. Since a person is not expected to remain in a single location on either a roadway (or similar transport route such as railway) or on a body of water, the possibility of an exposure to concentrations in the frequency and duration associated with a NAAQS is exceedingly low., Therefore, receptors at these locations would not provide data relevant to the effect of emissions on the human health protected by the NAAQS. As a result, consistent with EPAõs most recent guidance, AISI requests clarification into Appendix W that transportation routes such as roadways and waterway locations should be excluded from receptor placement.

12.1.2 AERMOD does not account for plume dispersion caused by motor vehicle traffic.

The ultimate purpose of modeling is to ensure compliance with the NAAQS, which are designed to protect the public health and welfare. 42 U.S.C. § 7409(b). To perform this function, a model should correlate to real-world results. *See* 40 CFR Part 51 Appendix W at 1.0(d) (stating that EPA always seeks ñ[t]he model that most accurately estimates concentrations in the area of interestò). For this reason, agencies have the authority to exclude modeling that will not produce accurate results[112] and EPA has approved

[112] *See Sierra Club v. United States DOT*, 310 F. Supp. 2d 1168, 1188 (D. Nev. 2004) (ñFHWA does not act arbitrarily and capriciously by not evaluating a project-specific impact for which the then-current scientific modeling and available information could not provide meaningful findings on which to base a decision.ò); *Duke City Lumber Co. v. New Mexico Envt'l. Improvement Bd.*, 102 N.M. 8, 10 (New Mexico 1984) (requiring a ñrational basisò for the reliability of modeling studies); *Sierra Club v. Wyo. Dep't of Envtl. Quality*, 2011 WY 42 (Wyoming 2011) (affirming DEQõs decision not to

discarding data when its results cannot be scientifically justified. *See* 40 CFR Part 51 Appendix W at 8.3.4.1(a) (approving the treatment of hours of low wind at area sources in AERMOD as ñmissing dataò because ña steady-state Gaussian plume model does not apply during calm conditionsò and ñour knowledge of wind patterns and plume behavior during these conditions does not, at present, permit the development of a better techniqueò).

The air dispersion model currently approved for use at stationary sources is AERMOD, a Gaussian plume dispersion model. 40 CFR Part 51 Appendix W at Appendix A. Like any model, AERMOD has its limitations.[113] First, AERMOD is designed to assess ñplume impacts from *stationary* sources.ò 70 FR 68218 at 68219 (November 9, 2005) (emphasis added). It does not account for the plume dispersion effects from mobile sources due to the initial turbulence and dispersion caused by their movement. In fact, there is currently no EPA-approved way to model the dispersive effects of traffic. *See* Guideline for Modeling Carbon Monoxide from Roadway Intersections at 2-1 (July 19, 1993)[114] (noting that ñvehicle turbulence does not allow current models to make valid concentration estimatesò within three meters of roadways). Second, AERMOD is a steady-state plume model, meaning it ñassumes that concentrations at all distances during a modeled hour are governed by the temporally averaged meteorology of the hour.ò AERMOD: Description of Model Formulation, EPA-454/R-03-004 at 40 (September 2004). As a result, even if turbulence from vehicular traffic could be measured, AERMOD would not be able to accurately account for it without EPA first developing a mathematical approximation that could be incorporated into AERMODôs 1-hour steady-state estimates. *See id.* at 55 (discussing the need for an approximation of plume meander because ñas a simple steady state model, AERMOD is not capable of producing such informationò).

AERMODôs difficulty modeling the turbulence from mobile sources affects both roadways and waterways. In both cases, the primary contact with the general public will occur when there is traffic (either from cars and trucks on the road, or boats on the lake). Moreover, there is no reason to model either roadways or waterways when there is no traffic, since people will generally not be exposed to pollutants on them during those times. *See* Guideline for Modeling Carbon Monoxide from Roadway Intersections at 2-1.

In its 2013 Transportation Conformity Guidance for Quantitative Hot-Spot Analyses in $PM_{2.5}$ and PM_{10} Nonattainment and Maintenance Areas, EPA-420-B-13-053 (Nov. 2013) (ñTransportation Conformity Guidanceò), at § 7.6.2, EPA itself recommended placing receptors for modeling the impacts of certain transit and highway projects generally no closer than five meters from the edge of a traffic lane or a source in a terminal, cautioning that, ñif AERMOD is used to create a standardized receptor network (e.g., using AERMODôs Cartesian or polar grid functions), receptors may inadvertently be placed within five meters of a project, and subsequently modeled. Such receptors should not be used when calculating design values in most cases.ò Similarly, EPA has rejected the use of roadway receptors in another model, CALINE-3. *See* Guideline for Modeling Carbon Monoxide from Roadway Intersections at 2-1 (ñRoadways are not potential receptor sites.ò).

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model short-term fugitive particulate matter impacts with AERMOD because ñsuch models ódo not produce realistic resultsô and can significantly overestimate short-term impacts.ò).

[113] ñThere is no one model capable of properly addressing all conceivable situations even within a broad category such as point sources.ò 40 CFR Part 51 Appendix W.

[114] USEPA, 1993. Guideline for Modeling Carbon Monoxide from Roadway Intersections. EPA-454/R-92-005. http://www3.epa.gov/scram001/guidance/guide/coguide.pdf.

12.2 Properly posted property boundaries should be treated in the same manner as physical barriers for the purpose of excluding receptors.

The federal Clean Air Act does not define ñambient air.ò U.S. EPA regulations, however, define ñambient airò as ñthat portion of the atmosphere, external to buildings, to which the general public has access.ò 40 CFR § 50.1(e). This definition was not part of EPAôs initially-proposed National Ambient Air Quality Standards. *See* 36 FR 1502 (January 30, 1971) and 36 FR 5867 (March 26, 1971). Rather, it was added to the final rule without comment. 36 FR 8186 (April 30, 1970). As a result, there is no official gloss on what constitutes ñaccess to the general public.ò

In the context of the ñgeneral publicò being restricted from accessing a site for modeling receptor exclusion purposes, EPA should consider a facilityôs property line to be the ambient air boundary if a facility can demonstrate that public access is effectively precluded via physical barriers, posting of ñno trespassing signs,ò reasonable patrol of the property, a facilityôs remote location, lack of reasonable access to the property, or other means of communication to the general public regarding the facilityôs boundary.

Individuals who voluntarily and/or maliciously breach property boundaries and/or physical barriers meant to exclude the general public should no longer be considered to be the ñgeneral public.ò In addition, EPA has the authority to exclude *de minimis* events from even statutory requirements. *Alabama Power Co. v. Costle*, 636 F.2d 323, 360 (D.C. Cir. 1979) (holding that EPA may invoke a *de minimis* exemption as ña tool to be used in implementing the legislative designò). Moreover, EPA has used this authority to excuse from the definition of ñambient airò those areas to which the public has only brief or infrequent access. Property trespass events, especially at remote, large industrial facilities, occur very rarely and are brief events. Accordingly, the potential for property trespass should be treated as a *de-minimis* event. [115]

AISI requests that EPA clarify in Appendix W that trespassers of properly controlled property lines are not considered ñgeneral publicò and that properly controlled property lines should be treated in the same manner as property boundaries that are delineated by physical barriers.

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[115] EPAôs decision that airport runways and grassy strips between the runways do not create ñambient air,ò for example, was made without discussion of whether people would be allowed to walk across the runways (for example to board a plane that did not taxi all the way to a gate); *see also* Guideline for Modeling Carbon Monoxide from Roadway Intersections at 2-2 (noting that modeling sidewalks presents a ñproblemò because ñthe general public is unlikely to occupy a relatively small portion of the walkway continuously.ò). Similarly, EPA has allowed facilities to employ monitoring in lieu of physical barriers, which inherently recognizes that brief exposure (the time from discovery of a trespasser to removal of the trespasser) should not give rise to ñambient air.ò *See* Mn Iron & Steel, Record No. 99-V-02 (August 25, 1999) (Draft) (stating that the Clearinghouse was aware of a Utah company that used horseback patrols in lieu of a physical barrier); Anderson Windows, Record No. 99-V-03 (September 13, 1999) (allowing video surveillance in lieu of a physical barrier); Letter from S. Riva, Chief Permitting Section, Region 2 to L. Sedefian, New York State Department of Environmental Conservation re: Ambient Air for the Offshore LNG Broadwater Project (October 9, 2007) (allowing Coast Guard radar detection and radio warning systems in lieu of a physical barrier). Even events that would be expected to result in prolonged exposure to the outside air have been found not to give rise to ñambient air,ò provided they are infrequent. *See* Memorandum from Stephen Page, Director Office of Air Quality Planning and Standards to Regional Air Division Directors re: Interpretation of ñAmbient Airò in Situations Involving Leased Land (June 22, 2007) (stating that an annual fair or infrequent sporting event within a facilityôs fence line would not create ñambient airò).

13.0 SUGGESTED TEXT CHANGES TO THE PROPOSED APPENDIX W

In attachment O, we provide the Appendix W text as proposed by EPA, with AISI-proposed edits that are consistent with the comments provided above. For clarity, Appendix P shows a ñcleanò Appendix W text with edits accepted.